FOUNDRYMAN

NSQF LEVEL - 3

TRADE THEORY

SECTOR : CAPITAL GOODS AND MANUFACTURING

(As per revised syllabus July 2022 - 1200 of hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : Capital Goods & Manufacturing

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National Instructional Media Institute
Post Box No.3142
Guindy, Chennai - 600 032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Foundryman - Trade Theory - NSQF Level - 3 (Revised 2022) in Capital Goods & Manufacturing Sector under** Annual pattern. The NSQF Level - 3 (Revised 2022) Trade Theory will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

Addl.Secretary / Director General (Training)
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Foundryman - NSQF Level - 3** (Revised 2022) under the **Capital Goods & Manufacturing** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. S. Baskaran	-	Asst. Training Officer, Govt. I.T.I North Chennai
Shri. J. Senthil kumar	-	Junior. Training Officer, Govt.I.T.I Hosur.
Shri. P. Harikrishna Kumar	-	Junior. Training Officer, Govt. I.T.I Tricy.

NIMI - COORDINATORS

Shri. Nirmalya Nath	-	Deputy Director, NIMI, Chennai - 32.
Shri. V. Gopalakrishnan	-	Manager, NIMI, Chennai - 32.

NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 3 (Revised 2022) syllabus are covered.

The manual is divided into Eighteen modules.

Module 1	Safety	20 Hrs
Module 2	Tools, Equipments and Raw Materials	20 Hrs
Module 3	Sand Preparation & Testing	50 Hrs
Module 4	Mould, Core, Casting Practice	225 Hrs
Module 5	Wood Working and Pattern Making	25 Hrs
Module 6	Mould with loose piece pattern and core with loos core box	25 Hrs
Module 7	Metal Working	25 Hrs
Module 8	Melting Induction Furnace	25 Hrs
Module 9	Moulding Process	100 Hrs
Module 10	Fettling (Casting Yield Percentage)	50 Hrs
Module 11	Core Making	25 Hrs
Module 12	Mould & Gating System	92 Hrs
Module 13	Thick Casting with Larger Feeder Head	33 Hrs
Module 14	Furnace for Melting Cast Metal	25 Hrs
Module 15	Oil Sand & No bake core	25 Hrs
Module 16	Mould without Pattern (Trammelling Method)	25 Hrs
Module 17	Gravity Die Casting	25 Hrs
Module 18	Investment Casting	25 Hrs

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual, a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Foundryman** Trade Theory NSQF Level - 3 (Revised 2022) in **Capital Goods & Manufacturing**. The contents are sequenced according to the practical exercise contained in NSQF Level -3 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self-learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ex.No
1	Categorize different types of tools, equipment & raw material used in foundry following safety precautions. (NOS:ISC/N9453)	1.1.1 - 1.2.15
2	Prepare sand mix for moulding. (NOS:ISC/N9454)	1.3.16 - 1.3.19
3	Perform different types of sand testing & find out result. (NOS:ISC/N9455	1.3.20 - 1.3.24
4	Produce green sand moulds by using appropriate hand tools. (NOS:ISC/N9456)	1.4.25 - 1.4.29
5	Produce different casting components by different metal with different moulding,process and finish the casting as per requirement. (NOS:ISC/N9457)	1.4.30 -1.4.42
6	Make pattern and repair defective pattern and core boxes. (NOS:ISC/N9458)	1.5.43 - 1.5.44
7	Prepare mould with loose piece pattern and loose piece core box. (NOS:ISC/N9459)	1.6.45
8	Perform metal working such as marking, sawing, filling, grinding, drilling etc. (NOS:ISC/N9460)	1.7.46 - 1.7.48
9	Make casting of aluminum by melting on Induction furnace & identify defects. (NOS:ISC/N9461)	1.8.49
10	Prepare mould by different moulding process, make cast iron castings identify defects. (NOS:ISC/N9462)	1.9.50 - 1.9.65
11	Make a casting, fettle the casting & calculation yield percentage. (NOS:ISC/N9463)	1.10.66- 1.10.72
12	Prepare complete core by joining half cores. (NOS:ISC/N9464)	1.11.73 - 75
13	Make mould by various types of gate to produce different type of metal casting. Find out defects and visit industry to show different operation for casting making. (NOS:ISC/N9465)	1.12.76 - 1.13.90
14	Make an extra thick casting & finish it. (NOS:ISC/N9466)	1.13.91 - 93
15	Reline & prepare different types of furnaces for melting cast metals. (NOS:ISC/N9467)	1.14.94 - 99
16	Make core by using linseed oil &IVP oils. (NOS:ISC/N9468)	1.15.100 - 101
17	Prepare mould without pattern & with sweep pattern (NOS:ISC/N9469)	1.16.102 - 103
18	Make casting by die casting process & yield percentage of casting. (NOS:ISC/N9470)	1.17.104 - 105
19	Make casting by investment casting process & binder less process. (NOS:ISC/N9471	1.18.106 -107

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 40Hrs; Professional Knowledge 08 Hrs	Categorize different types of tools, equipment & raw material used in foundry following safety precautions. (NOS:ISC/ N9453)	1.Importance of trade training, List of tools & Machinery used in the trade.(01 hr) 2.Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE).(04 hrs) 3.First Aid Method and basic training. (02 hrs) 4.Safe disposal of waste materials like cotton waste, metal chips/burrs etc. (02 hrs) 5.Hazard identification and avoidance. (02 hrs) 6.Safety signs for Danger, Warning, caution & personal safety message. (01 hr) 7.Preventive measures for electrical accidents & steps to be taken in such accidents. (02 hrs) 8. Use of Fire extinguishers. (03 hrs) 9.Practice and understand precautions to be followed while working in fitting jobs. (02 hrs) 10.Safe use of tools and equipment used in the trade. (01 hr)	All necessary guidance to be provided to the newcomers to become familiar with the working of Industrial Training Institute system including store's procedures. Soft skills, its importance and job area after completion of training. Importance of safety and general precautions observed in the in the industry/shop floor. Introduction of First aid. Operation of electrical mains and electrical safety. Introduction of PPEs. Response to emergencies e.g. power failure, fire, and system failure. Importance of housekeeping & good shop floor practices. Introduction to 5S concept & its application. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations & regulations as applicable. Basic understanding on Hot work, confined space work and material handling equipment. (04 hrs.)
		11. Video show of large foundry industries in India.(04 hrs.) 12. PPT show of various tools & equipment used in foundry. (04 hrs.) 13. Identify each and every tools &equipment as per desired specification. (04 hrs.) 14. PPT show of various raw materials used in foundry.(04 hrs.) 15. Identify each raw materials used in foundry.(04 hrs.)	History of Foundry Industries, development of foundry in India. Importance of foundry Industries. Types of foundries, Advantage of metal casting importance of quality and quality awareness. Different tools &equipment used in foundry. Different raw materials used in foundry Industries. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Prepare sand mix for moulding. (NOS:ISC/ N9454)	16. Sieve the used sand with the help of riddle & shovel. (06 hrs) 17. Sieve the used sand with power riddle. (06 hrs) 18. Make Green sand mixture with tempering by shovel. (06 hrs) 19. Make green sand mixture with tempering or moisturing by sand muller. (07 hrs)	Specification tools &equipment. Procedure of use of different tools &equipment. Special casting process definition materials used composition, the process; use advantages and disadvantage of CO2 process and shell moulding process. (04 hrs.)

Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Perform different types of sand testing & find out result. (NOS:ISC/N9455	20. Test moisture content of green sand with the help of moisture teller or infrared dryer. (05 hrs) 21. Find out clay content of sand. (05 hrs) 22. Find out permeability test of green sand with permeability tester. (05 hrs) 23. Find out strength test with universal testing machine. (05 hrs) 24. Find out grain fineness no. of moulding sand with sieve shaker tester. (05 hrs)	Sand testing different methods of moisture content test permeability test, clay content test, strength test, sand grain fineness test, refractoriness test of moulding sand. Common types of natural & synthetic moulding sand as per IS 3343-1965 properties of moulding sand. (04 hrs.)
Professional Skill 50 Hrs; Professional Knowledge 14 Hrs	Produce green sand moulds by using appropriate hand tools. (NOS:ISC/N9456)	25. Ramming practice in moulding boxes with hand rammers to obtain desire green hardness such as 70, 80, 90 by green hardness tester. (12 hrs)	Ramming procedure of rammer and other tools used in making mould. Importance of hardness test. (04 hrs.)
		26. Cut channel on rammed boxed with cross section such as trapezoid & triangular and finish with cleaner & double ender etc. (08 hrs) 27. Prepare unit sand and prepare mould for block such as square, Rectangular and round.(05 hrs)	Different types of Gate cutting system with different tools used & repairs of gates. principle ingredients in moulding sand & their effect on physical properties special additives in moulding sand & their effect unit sand. (04 hrs.)
		28. Prepare facing and backing sand and simple moulds with top run gates. (12 hrs) 29. Prepare mould with self-leaving core pattern by using parting line gates. (13 hrs)	Facing sand, baking sand Composition of various moulding sand. Types of mould- advantage and disadvantage of sand mould and metal mould. Moulding boxes [As per IS 1280-1958] Crucible [As per IS 1748-1961] (06 hrs.)
Professional Skill 175Hrs; Professional Knowledge 30Hrs	Produce different casting components by different metal with different moulding process and finish the casting as per requirement. (NOS:ISC/N9457)	30. Prepare green sand mould by using split pattern for aluminium casting. Use natural moulding sand melt aluminium in different furnace and pour the same into moulds, fettle aluminium casting. (25 hrs)	Definition of green sand Advantage and disadvantage of green sand mould, loam sand mould and cement bonded sand mould. Construction, operation and maintenance of pit furnace. (04 hrs.)
		31. Level the floor with sprit level and straight edge and prepare open sand mould. (25 hrs)	Moulding process – bench moulding different methods advantages, disadvantages and their application. (04 hrs.)
		32. Prepare bedded in mould without core with parting line gate. (12 hrs) 33. Prepare bedded in mould with core and bottom run gate. (13 hrs)	Moulding process floor moulding. Different methods; advantage and disadvantages and their application machine moulding different types of moulding machines and slinger. (05 hrs.)

		34. Prepare mould with vertical core. (10 hrs) 35. Prepare mould with horizontal core and assemble in the mould.(10 hrs) 36. Prepare chair core and assemble in the mould. (05 hrs)	Core: Uses and types, composition of various cores sand mixtures. Types of core boxes core venting and re-in forcing of core-core baking – core making machines. (10 hrs.)
		37. Prepare moulds for copper andcopper base alloys melts copper alloy in oil fired furnace & pour & fettle the casting. (25 hrs)	Construction: Operation &maintenance of oil fire furnace pattern- pattern materials. Difference between wooden pattern and metal pattern. (05 hrs.)
		38. Prepare mould with draw back method & false check method. (10 hrs) 39. Prepare dry sand mould with skeleton pattern. (08 hrs) 40. Prepare black wash & coat on mould. (07 hrs)	Pattern – types of patterns- allowance on pattern colouring of pattern as per IS 1513-1959 care & maintenance of pattern. (05 hrs.)
		41. Prepare stack mould with steeped gate. (13 hrs) 42. Prepare snap flask mould. (12 hrs)	Different types of coating on mould cores. (01 hr.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Make pattern and repair defective pattern and core boxes. (NOS:ISC/N9458)	43. Prepare simple pattern. (15 hrs) 44. Repair wooden patterns & core boxes. (10 hrs)	Methods of repairing the pattern & core boxes. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Prepare mould with loose piece pattern and loose piece core box. (NOS:ISC/N9459)	45. Prepare mould with loose piece pattern & core with loose piece core box. (25 hrs)	Prerequisites of gating system. Riser: Feeders & directional solidification, exothermic materials. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Perform metal working such as marking, sawing, filling, grinding, drilling etc. (NOS:ISC/N9460)	46. Metal working – Marking and sawing on straight line – chipping and filling to desired size on different metals. (10 hrs) 47. Grinding the metals to desire size by pedestal grinder and flexible shaft grinder. (10 hrs) 48. Drilling on various metals. (05 hrs)	Description, specification and use of common, marking measuring, sawing, chipping and filing instruments used in metal work. Types of grinders – Brief information about other metal cutting equipments. Various types of drill bits and drilling machine. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Make casting of aluminum by melting on Induction furnace & identify defects. (NOS:ISC/N9461)	49. Prepare induction furnace for charging, prepare charges for charging, operate and melt aluminium and pour aluminium into the mould and identify defects. (25 hrs)	Induction furnace types- construction, operation and maintenance. (04 hrs.)
Professional Skill 100Hrs; Professional Knowledge 24 Hrs	Prepare mould by different moulding process, make cast iron castings identify defects. (NOS:ISC/N9462)	50.Prepare dry sand mould with odd sided pattern and make casting. (10 hrs) 51.Fettle the casting (07 hrs) 52. Find out defect. (08 hrs)	Description of dry sand mould. Brief description types, advantages & disadvantages of die casting, centrifugal casting and ceramic moulding process. (04 hrs.)

		53.Prepare a loam sand mould for pan shape casting. (10 hrs)	Slush casting process, continuous casting process, permanent mould casting process; Nishiyama process (by using ferrosilicon powder) common casting defects appearance-causes and remedies- salvaging of casting. (06 hrs.)
		54. Prepare a pit mould on foundry floor. (05 hrs) 55. Prepare a mould with pattern having cover core print, assemble cover core in mould and cast by cast iron. (10 hrs) 56. Find out all defects. (02 hrs)	Slush casting process, continuous casting process, permanent mould casting process; Nishiyama process (by using ferrosilicon powder) common casting defects appearance-causes and remedies- salvaging of casting. (06 hrs.)
		57.Prepare simple CO2 mould.(07 hrs) 58. Prepare simple CO2 core. (08 hrs) 59.Assemble in CO2 mould core.(05 hrs) 60.Make a casting by C.I. (02 hrs) 61. Fettle the casting. (02 hrs) 62.List out casting defects. (01 hrs)	Fettling of casting knock out and removal and removal of casting from mould removal of gates & risers; Fins & unwanted projection – surface cleaning trimming and finishing. Inspection of casting – destructive method – non-destructive materials used in foundry and their grades as per I.S. (04 hrs.)
		63. Prepare mould for setting "Balancing core" and set balanced core in mould with the help of chaplets. (18 hrs) 64. Make an aluminium casting using pit furnace. (03 hrs) 65.Fettle the casting. (02 hrs)	Binders - Common binders used in foundry and their application and their grades as per I.S. Common "Facing Materials" used in foundry and their application and their grades as per I.S. Casting design functional design, simplification of foundry practice. Metallurgical design, economic consideration. (04 hrs.)
Professional Skill 50Hrs; Professional Knowledge 08 Hrs	Make a casting, fettle the casting & calculation yield percentage. (NOS:ISC/N9463)	66. Prepare a mould for setting "Hanging core and set hanging core in mould with the help of chaplets". (15 hrs) 67. Make a casting. (05 hrs) 68.Fettle the casting.(03 hrs) 69. Find out yield percentage. (02 hrs)	Common "Fluxes" used in foundry and their application. Specification (04 hrs.)
		70. Prepare a mould using chills, densers. (20 hrs) 71. Make a casting. (04 hrs) 72. Show a video chart of ferrous & non-ferrous metals. (01 hr)	Function of chills, densers. Different between ferrous &non-ferrous metals. Physical & mechanical properties of metals. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Prepare complete core by joining half cores. (NOS:ISC/N9464)	73. Prepare core halves. (15 hrs) 74. Bake the core halves. (05 hrs) 75. Join the core halves by different methods. (05 hrs)	Classification of iron ores & its treatments. (04 hrs.)

Professional Skill 100Hrs; Professional Knowledge 20Hrs	Make mould by various types of gate to produce different type of metal casting. Find out defects and visit industry to show different operation for casting making. (NOS:ISC/N9465)	76. Prepare mould with pencil gate. (10 hrs) 77. Prepare mould with finger gate. (07 hrs) 78.Make casting with aluminium. (05 hrs)	Common cost iron-alloys. (04 hrs.)
		79. Prepare mould with wedge gate. (07 hrs) 80.Prepare mould with ring gate (07 hrs) 81. Make casting with copper base alloy. (07 hrs)	Effect of alloying elements for ferrous metals. Inoculation: Purpose of inoculation. (04 hrs.)
		82. Prepare mould with branch gate mould with match plate pattern. (10 hrs) 83.Make casting with cast iron.(07 hrs) 84. Fettle the casting. (02 hrs)	Steel manufacturing process by arc furnace. classification common steel alloys and use. (04 hrs.)
		85. Prepare mould with relief sprue gate. (07 hrs) 86. Prepare mould with skim bob gate. (07 hrs) 87. Make a casting with cast iron. (07 hrs) 88. Find out defects. (01 hr)	Advantages of sprue gate & skim bob gates. Wrought iron-manufacturing process-uses. Copper manufacturing process – properties use. (04 hrs.)
		89. Prepare mould with horn gate[Gear wheel type pattern]. (08 hrs) 90. Industrial visit to observe the special casting process machine moulding process, operation of different furnaces sand reconditioning process, inspection of casting, fettling process etc. (08 hrs))	Manufacturing process propertiesand use of aluminium. Properties of grey iron. Microstructure, fracture, mechanical test-tensile test, hardness test etc. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 06 Hrs	Make an extra thick casting & finish it. (NOS:ISC/N9466)	91. Prepare mould for extra thick casting with large feeder heads. (18 hrs) 92.Make casting with cast iron.(04 hrs) 93.Fettle the casting. (03 hrs)	Manufacturing process of copper base alloys, aluminium base. Brief information about cupola furnace. (06 hrs.)
Professional Skill 25Hrs; Professional Knowledge 10Hrs	Reline & prepare different types of furnaces for melting cast metals. (NOS:ISC/N9467)	94. Reline the pit furnace. (06 hrs) 95. Show a video show for operation of blast furnace. (01 hrs) 96. Relining the oil fired furnace. (06 hrs)	Brief information about blast furnace, Brief information about open hearth furnace, air furnace, paddling furnace and convertors. (06 hrs.)

		97. Reline of ladle. (03 hrs) 98. Pre heat of ladle. (01 hrs) 99.Reline of muffle furnace.(08 hrs)	Heat treatment of casting. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04 Hrs	Make core by using linseed oil &IVP oils. (NOS:ISC/N9468)	100.Prepare simple oil sand core by using linseed oil. (15 hrs) 101.Prepare oil sand core by IVP oils. (10 hrs)	Calculation of ferrostatic pressure. Calculation of weight required on a mould. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04Hrs	Prepare mould without pattern & with sweep pattern (NOS:ISC/N9469)	102.Prepare simple, regular shape mould without pattern (by cutting practice). (12 hrs) 103.Make mould by ram up core. (13 hrs)	Calculation of molten metal required for different size mould (Aluminium, brass, copper, C.I. etc.) (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04Hrs	Make casting by die casting process & yield percentage of casting. (NOS:ISC/N9470)	104.Prepare simple casting by gravity die casting. (22hrs) 105.Calculationyield percentage.(03hrs)	Cost estimate of simple castings of different metals. Low pressure, high pressure, gravity die casting process. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 04Hrs	Make casting by investment casting process & binder less process. (NOS:ISC/N9471	106.Prepare simple casting by investment casting process.(13hrs) 107.Prepare simple casting with binder less dry sand process. (12hrs)	Foundry mechanization- layout of a small foundry- list of material handling equipments and their use. (04 hrs.)

Familiarization with the working of Industrial Training Institute system including stores procedures

Objectives: At the end of this lesson you shall be able to
- **know the staff structure of the institute**
- **know the available trades in the institute and their activities**
- **state the concept of training skill to be acquired**
- **state the employability aspect of the training.**

The Industrial Training Institute throughout India follow the same syllabus pattern given by the National council for Vocational Training (NCVT). In India there are about 13,350 Government ITIs and Private ITI 's as per the Govt. of India, Ministry of Skill Development and Entrepreneurship (MSDE) Annual report of 2016-2017. The Government Industrial Training Institute in each state work under the Directorate of Employment and Training which is a department under the Labour Ministry in most of the states.

The Head of the industrial training institute is the Principal, under whom there is one vice-principal, Group Instructor(s) Training officers and a number of Vocational Instructor(s) Assistant Training Officer(s) and Junior Training Officer and so on as shown in the Organisation Chart of ITI.(Fig1)

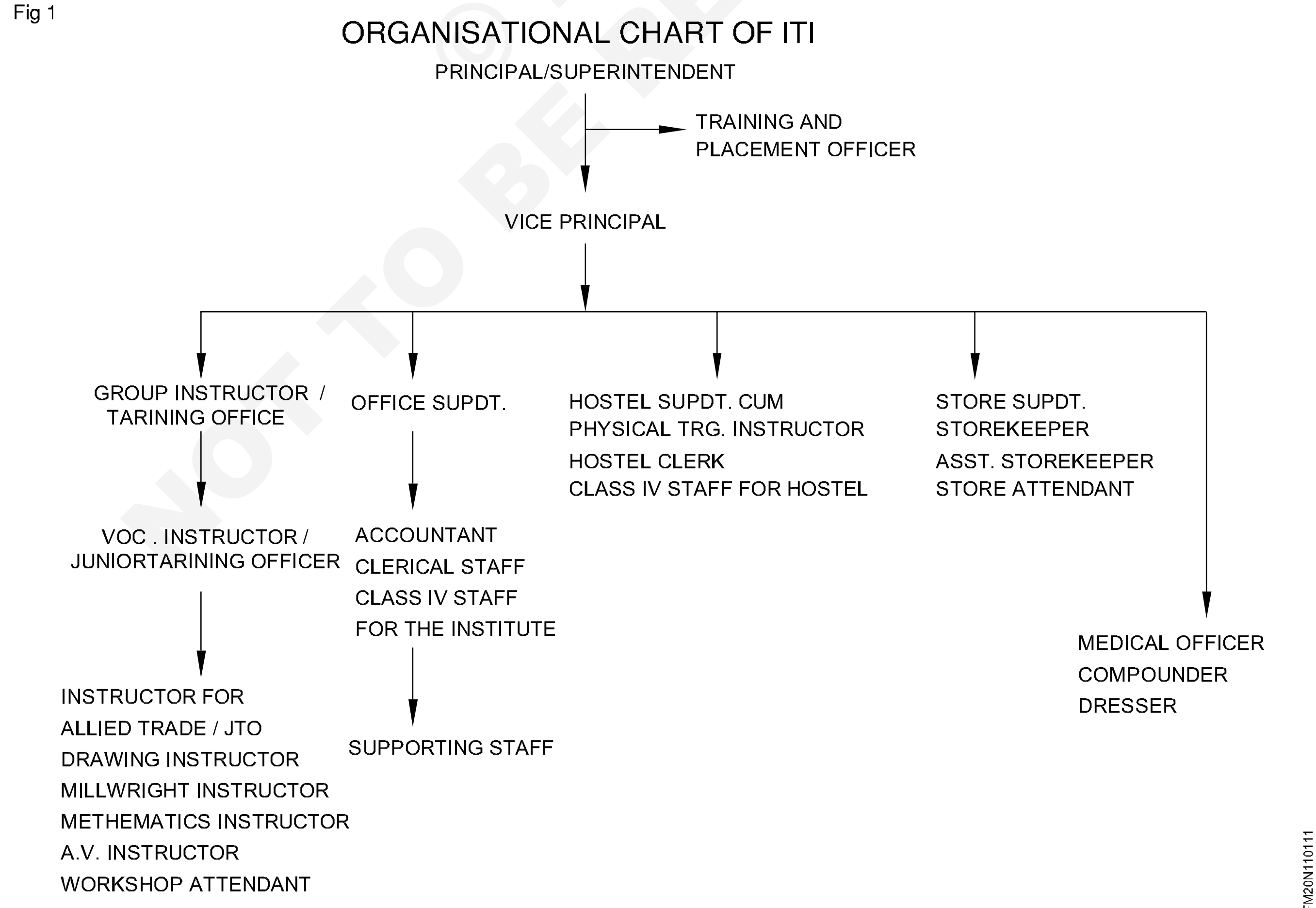
In every industrial training institute there is a store and the in charge of the store is storekeeper for inward and outward movement of tools, equipment and consumables. The instructor will indent the training requirement on receiving from stores, the instructor will issue the training requirement to the trainees according to the graded exercises as per syllabus.

The basic moto of providing industrial training is to give hands to training to the new trainees so as to make them as skilled labour/industrial workers/or self-employed entrepreneur.

The function of stores in the ITI is to provide the raw material and machine tool equipments and to take care of machine and their maintenance.

Instructor gets the raw material and the tool equipments from the stores and issue to the trainees for training and to carry out the job.

Fig 1



Familiar with industrial training institute

Objectives: At the end of this lesson you shall be able to
- **explain about DGT affiliated institutions under MSDE**

Introduction

Directorate General of Training (DGT)

Directorate General of Training (DGT) in Ministry of Skill Development & Entrepreneurship is an apex organization for development and coordination of the vocational training including Women's Vocational Training of the employable youth in the country and to provide skilled manpower to the economy.

Two directorate general of employment and training working under Deputy Director General (Training) & Deputy Director General (Apprenticeship Training) along with their support systems were transferred to Ministry of Skill Development & Entrepreneurship (MSDE).

DGT affiliated institutions offers a wide range of training courses catering to the needs of different segments in the Labour market. Courses are available for school leavers, ITI pass outs, ITI instructors, industrial workers, technicians, junior and middle level executives, supervisors/foremen, women, physically disabled persons and SC/STs.

It also conducts training oriented research and develops instructional media packages for the use of trainees and instructors etc.

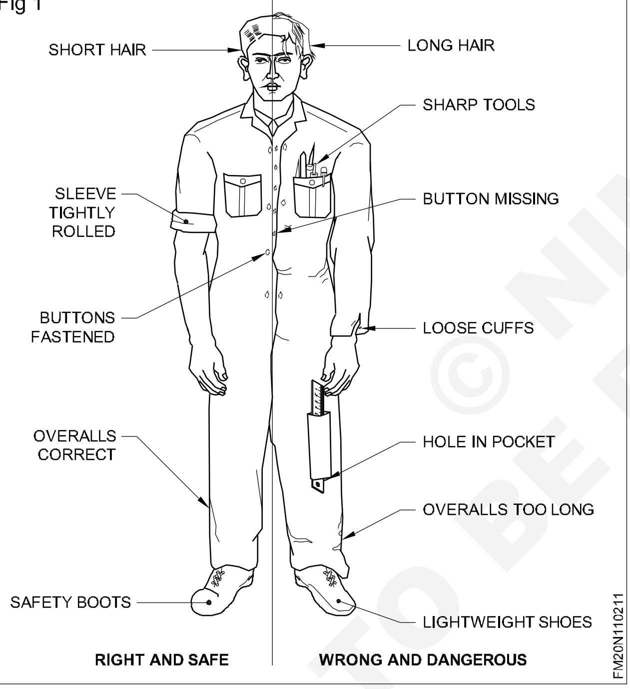
DGT acts as a secretariat and implementing arm of National Council for Vocational Training (NCVT).

Importance of safety and general precautions to be observed in the industry/ shop floor

Objectives: At the end of this lesson you shall be able to
- **state the importance of safety**
- **list out the safety precautions to be observed in an industry/shop floor**
- **list out the personal safety precautions to be observed in machine shop**
- **list out the safety precautions to be observed while working on the machines.**

Generally, accidents do not happen; they are caused. Most accidents are avoidable. A good craftsman, having a knowledge of various safety precautions, can avoid accidents to himself and to his fellow workers and protect the equipment from any damage. To achieve this, it is essential that every person should follow safety procedure. (Fig 1)

Fig 1



Safety in a workshop can be broadly classified into 3 categories.

- General safety
- Personal safety
- Machine safety

General safety

Keep the floor and gangways clean and clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

Don't touch or handle any equipment/ machine unless authorised to do so.

Don't walk under suspended loads.

Don't cut practical jokes while on work.

Use the correct tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

Never direct compressed air at yourself or at your co-worker.

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal safety

Wear a one piece overall or boiler suit.

Keep the overall buttons fastened.

Don't use ties and scarves.

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

Don't remove guards when the machine is in motion.

Don't use cracked or chipped tools.

Don't start the machine until

- the work piece is securely mounted
- the feed machinery is in the neutral
- the work area is clear.

Don't adjust clamps or holding devices while the machine is in motion.

Never touch the electrical equipment with wet hands.

Don't use any faulty electrical equipment.

Ensure that electrical connections are made by an authorised electrician only.

Concentrate on your work. Have a calm attitude.

Do things in a methodical way.

Don't engage yourself in conversation with others while concentrating on your job.

Don't distract the attention of others.

Don't try to stop a running machine with hands.

Machine safety

Switch off the machine immediately if something goes wrong.

Keep the machine clean.

Replace any worn out or damaged accessories, holding devices, nuts, bolts etc as soon as possible.

Do not attempt operating the machine until you know how to operate it properly.

Do not adjust tool or the work piece unless the power is off.

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off.

Check the oil level before starting the machine.

Never start a machine unless all the safety guards are in position.

Take measurements only after stopping the machine.

Use wooden planks over the bed while loading and unloading heavy jobs.

Safety is a concept, understand it. Safety is a habit, cultivate it.

Approach on soft skills

Objectives: At the end of this lesson you shall be able to
- **state the concept of soft skill**
- **list the important common soft skills**
- **brief the employability aspect of training**
- **brief the further learning scope.**

Concept

Soft skills - refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that mark people to varying degrees. The same can also be defined as-ability to interact communicate positively and productively with others. sometimes called "character sills".

More and more business is considering soft skills as important job criteria. Soft skills are used in personal and professional life. Hard skills/technical skills so not consider without soft skills.

Common soft skills

Strong work ethic

Positive attitude

Good communication skills

Interpersonal skills

Time management abilities

Problem-solving skills

Team work

Initiative, Motivation

Self-confidence

Loyalty

Ability to accept and learn from criticism

Flexibility adaptability

Working well under pressure

Job are completion of training: This highlights the employability aspect completion of training. The trainee should be aware of various prospects available in present market scenario along with scope for self-employment. For example , a trainee with NTC engineering trade may opt for.

Various job available in different industries in India and abroad

After successful completion of ITI training in any one of the engineering facile one can see appointment in engineering workshop/factories (Public sector, private sector and Government industries) In India and Abroad as technician/skilled worker.

Self employment

One can start his own factory/ancillary unit or design products manufacture and become an entrepreneur.

Further leaning scope

Apprentice training in designated trade.

Craft instructor certificate course

Diploma in Engineering

Opportunity of job after training

After completion of training there are so many companies & industries has offer to the trainees like Fitter, Turner, Machinist, Electrician and so many kinds of semi -skilled worker, according to the demand there.

Therefore, after training the future of trainee is so bright, he have many type of opportunity for selecting their carrier.

Some type of commericial popular industries like as. Maruti Ashok Leyland, Mahindra and Mahindra, TATA, NTPC, NLC, HAL, BHEL, BEL, industries under Defence & Atomic Energy depts. and state transport undertakings etc....

Personal Protective Equipment (PPE)

Objectives: At the end of this lesson you shall be able to
- **state what is personal protective equipment and its purpose**
- **name the two categories of personal protective equipment**
- **list the most common type of personal protective equipment**
- **list the conditions for selection of personal protective equipment.**

Personal Protective Equipment (PPE)

Devices, equipments, or clothing used or worn by the employees, as a last resort, to protect against hazards in the workplace. The Factories Act, 1948 and several other labour legislations 1996 have provisions for effective use of appropriate types of PPE. Use of PPE is very important.

Ways to ensure workplace safety and use personal protective equipment (PPE) effectively.

- Workers to get up-to date safety information from the regulatory agencies that oversees workplace safety in their specific area.
- To use all available text resources that may be in work area and for applicable safety information on how to use PPE best.
- When it comes to the most common types of personal protective equipment, like goggles, gloves or bodysuits, these items are much less effective if they are not worn at all times, or whenever a specific danger exists in a work process. Using PPE consistently will help to avoid some common kinds of industrial accidents.
- Personal protective gear is not always enough to protect workers against workplace dangers, knowing more about the overall context of your activity can help to fully protect from anything that might threaten health and safety on the job.
- Inspection of gear thoroughly to make sure that it has the standard of quality and adequately protect the user should be continuously carried out.

Categories of PPE-Small's'

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories.

Non- respiratory: Those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts

Respiratory: Those used for protection from harm due to inhalation of contaminated air.

They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

Table 1

No	Title
PPE1	Helmet
PPE2	Safety footwear
PPE3	Respiratory protective equipment
PPE4	Arms and hands protection
PPE5	Eyes and face protection
PPE6	Protective clothing and coverall
PPE7	Ears protection
PPE8	Safety belt harness

Proper use of PPEs

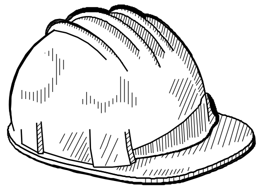
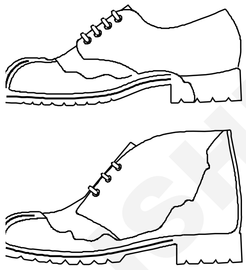
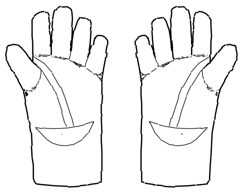
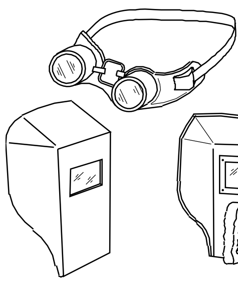
Having selected the proper type of PPE, it is essential that the workman wears it. Often the workman avoids using PPE. The following factors influence the solution to this problem.

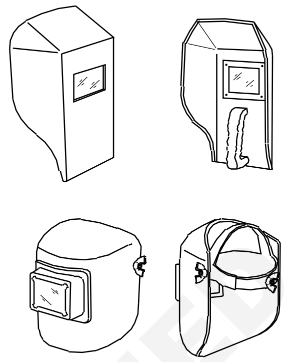
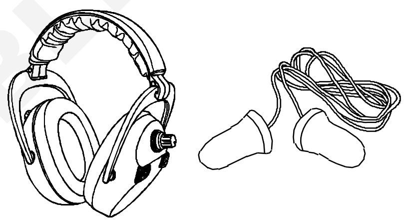
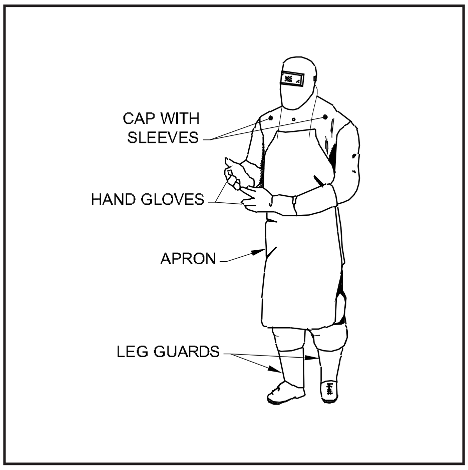
- The extent to which the workman understands the necessity of using PPE
- The ease and comfort with which PPE can be worn with least interference in normal work procedures
- The available economic, social and disciplinary sanctions which can be used to influence the attitude of the workman
- The best solution to this problem is to make wearing of PPE' mandatory for every employee.
- In other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time.

Quality of PPE's

PPE must meet the following criteria with regard to its quality-provide absolute full protection against possible hazard and PPE's be so designed and manufactured out of materials that it can withstand the hazards against which it is intended to be used.

Personal protective equipments and their uses and hazards are listed in **Table**

Types of protection	Hazards	PPE to be used
Head protection	1. Falling objects 2. Striking against objects 3. Spatter	Helmets 
Foot protection	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots 
Nose	1. Dust particles 2. Fumes/gases/ vapours	Nose mask 
Hand Protection	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves 
Eye protection	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible	Goggles, Face shield Face shield radiation Hand shield, Head shield 

Types of protection	Hazards	PPE to be used
Face protection	1. Spark generated during Welding, grinding 2. Welding spatter striking 3. Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders Screen for welders 
Ear protection	1. High noise level	Ear plug Ear muffs 
Body protection	1. Hot particles	Leather aprons 

Selection of PPE's requires certain conditions

- Nature and severity of the hazard
- Type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air
- Expected activity of workman and duration of work, comfort of workman when using PPE
- Operating characteristics and limitation of PPE
- Easy of maintenance and cleaning
- Conformity to Indian / International standards and availability of test certificate.

First-aid

Objectives: At the end of this lesson you shall be able to
- **state what is first aid**
- **list the key aims of first aid**
- **explain the ABC of the first aid**
- **brief how to give first-aid for a victim who need first aid.**

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/ hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

First aid procedure often consists of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points:

- **Preserve life:** If the patient was breathing, a first aider would normally place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm:** Also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous.
- **Promote recovery:** First aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

Training

Basic principles, such as knowing to use an adhesive bandage or applying direct pressure on a bleed, are often acquired passively through life experiences. However, to provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require cardiopulmonary resuscitation (CPR); these procedures may be invasive, and carry a risk of further injury to the patient and the provider. As with any training, it is more useful if it occurs before an actual emergency, and in many countries, emergency ambulance dispatchers may give basic first aid instructions over the phone while the ambulance is on the way. Training is generally provided by attending a course, typically leading to certification. Due to regular changes in procedures and protocols, based on updated clinical knowledge, and to maintain skill, attendance at regular refresher courses or re-certification is often necessary. First aid training is often available through community organization such as the Red cross and St. John ambulance.

ABC of first aid

ABC stands for airway, breathing and circulation.

- **Airway:** Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency.
- **Breathing:** Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next steps. There are several methods practiced in first aid.
- **Circulation:** Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods.

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first aid to sick and injured.

1 **Not to get panic**: Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking and causes mistakes. First aider need calm and collective approach. If the first aider himself is in a state of fear and panic gross mistakes may result. It's far easier to help the suffering, when they know what they are doing, even if unprepared to encounter a situation. Emotional approach and response always lead to wrong doing and may cloud one to do wrong procedures. Hence be calm and focus on the given instruction. Quick and confident approach can lesser the effect of injury.

2 **Call medical emergencies**: If the situation demands, quickly call for the medical assistance. Prompt and quick approach may save the life.

3 **Surroundings play vital role**: Different surroundings require different approach. Hence first aider should study the surrounding carefully.

4 **Do no harm**: Patients often die due to wrong FIRST AID methods, who may otherwise easily survive. Do not move the injured person unless the situation demands. It is best to make him lie wherever he is because if the patient has back, head or neck injury, moving him would causes more harm. If the first aider is not confident of correct handling it is better not to intervene of do it. Hence moving a trauma victim, especially an unconscious one, need very careful assessment. Removals of an embedded objects (Like a knife, nail) from the wound may precipitate more harm (e.g. increased bleeding). Always it is better to call for help.

5 **Reassurance**: Reassure the victim by speaking encouragingly with him.

6 **Stop the bleeding**: If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

7 **Golden hours**: India have best of technology made available in hospitals to treat devastating medical problem viz. head injury, multiple trauma, heart attack, strokes etc. but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly. This period is referred to as Golden period. By the time the patient reach hospitals, they would have passed that critical period. First aid care come handy to save lives. It helps to get to the nearest emergency room as quickly as possible through safe handling and transportation. The shorter that time, the more likely the best treatment applied.

8 **Maintain the hygiene**: Most importantly, first aider need to wash hands and dry before giving and first aid treatment to the patient or wear gloves in order to prevent infection.

9 **Cleaning and dressing**: Always clean the wound thoroughly before applying the bandage lightly wash the wound with clean water.

10 **Not to use local medications on cuts or open wounds**: They are more irritating to tissue than it is helpful. Simple dry cleaning or with water and some kind of bandage are best.

11 **CPR (Cardio-Pulmonary Resuscitation) can be life-sustaining**: CPR can be life sustaining. If one is trained in CPR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. But some people do it wrong. This is a difficult procedure to do in a crowded area. Also there are many studies to suggest that no survival advantage when bystanders deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right maneuver in wrong places. But CPR, if carefully done by highly skilled first aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

12 **Declaring death**: It is not correct to declare the victim's death at the accident site. It has to be done by qualified medical doctors.

How to report an emergency?

The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc., all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A crime, especially one that is currently in progress. If you're reporting a crime, give a physical description of the person committing the crime.
- A fire - If you're reporting a fire, describe how the fire stated and where exactly it is located. If someone has already been injured or is missing, report that as well.
- A life-threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.
- A car crash - Location, serious nature of injures, vehicle's details and registration, number of people involved etc.

1 **Call emergency service:** The emergency number varies - 100 for Police, 101 for fire and 108 for Ambulance.

2 **Report your location**: The first thing the emergency dispatcher will ask is where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

3 **Give the dispatcher your phone number:** This information is also imperative for the dispatcher to have, so that he or she is able to call back if necessary.

4 **Describe the nature of the emergency**: Speak in a calm, clear voice and tell the dispatcher why you are calling. Give the most important details first, then answer the dispatcher's follow-up question as best as you can.

5 **Do not hang up the phone**: Until you are instructed to do so. Then follow the instructions you were given.

Basic first aid

Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first aiders

1 **Evaluate the situation**: Are there things that might put the first aider at risk. When faced with accidents like fire, toxic smoke, gasses, an unstable building, live electrical wires or other dangerous scenario, the first aider should be very careful not to rush into a situation, which may prove to be fatal.

2 **Remember A-B-Cs**: The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

3 **Avoid moving the victim**: Avoid moving the victim unless they are in immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

4 **Call emergency services**: Call for help or tell someone else to call for help as soon as possible. If alone in at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

5 **Determine responsiveness**: If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin. (Fig 1)

Fig 1

6 **Look, listen and feel for signs of breathing**: Look for the victim's chest to raise and fall, listen for sounds of breathing.

If the victim is not breathing, see the section below

- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

7 **Check the victim's circulation**: Look at the victim's colour and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jaw bone). If the victim does not have a pulse, start CPR.

8 **Treat bleeding, shock and other problems as needed**: After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding. Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock, a loss of blood flow from the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives

Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness (COMA)

Unconscious also referred as Coma, is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing. If unattended it may lead to death.

The condition arises due to interruption of normal brain activity. The causes are too many.

The following symptoms may occur after a person has been unconscious:

- Confusion
- Drowsiness
- Headache

- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (palpitation)
- Stupor

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway. Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position with the neck extended. Never give anything by mouth to an unconscious casualty.

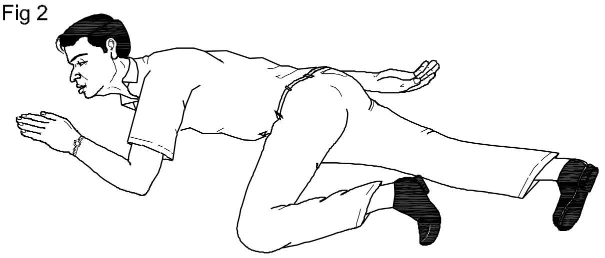
How to diagnose an unconscious injured person?

- **Consider alcohol:** look for signs of drinking, like empty bottles or the smell of alcohol.
- **Consider epilepsy:** are there signs of a violent seizure, such as saliva around the mouth or a generally disheveled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?
- **Think about drugs:** was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?
- **Consider trauma:** is the person physically injured?
- **Look for signs of infection:** redness and/ or red streaks around a wound.
- **Look around for signs of Poison:** an empty bottle of pills or a snakebite wound.
- **Consider the possibility of psychological trauma:** might the person have a psychological disorder of some sort
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

First aid DO'S

- Call EMERGENCY number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.

Fig 2



FM20N110312

- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious.

DONT'S

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

Shock (Fig 3)

A severe loss of body fluid will lead to a drop in blood pressure. Eventually the blood's circulation will deteriorate and the remaining blood flow will be directed to the vital organs such as the brain. Blood will therefore be directed away from the outer area of the body, so the victim will appear pale and the skin will feel ice cold.

Fig 3

FM20N110313

Guidelines for good shop floor maintenance

Objectives: At the end of this lesson you shall be able to
- **list the benefits of a shop floor maintenance**
- **state what is 5S**
- **list the benefits of 5S**

Benefits of a shop floor maintenance

Some of the benefits which may be derived from the utilization of a good Shop Floor Maintenance are as follows:

- Improved Productivity
- Improved operator efficiencies.
- Improved support operations such as replenishment moves and transportation of work in process and finished goods
- Reduction of scrap
- Better control of your manufacturing process
- More timely information to assist shop floor supervisors in managing their assigned production responsibilities.
- Reduction of down time due to better machine and tool monitoring.
- Better control of Work in Progress inventory, what is and where it is improved on time schedule performance.

5S Concept

5S is a Japanese methodology for works place organisation. In Japanese it stands for seiri (SORT), seiton (SET), seiso (SHINE), seiketsu (STANDARDIZE), and shitsuke (SUSTAIN).

The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

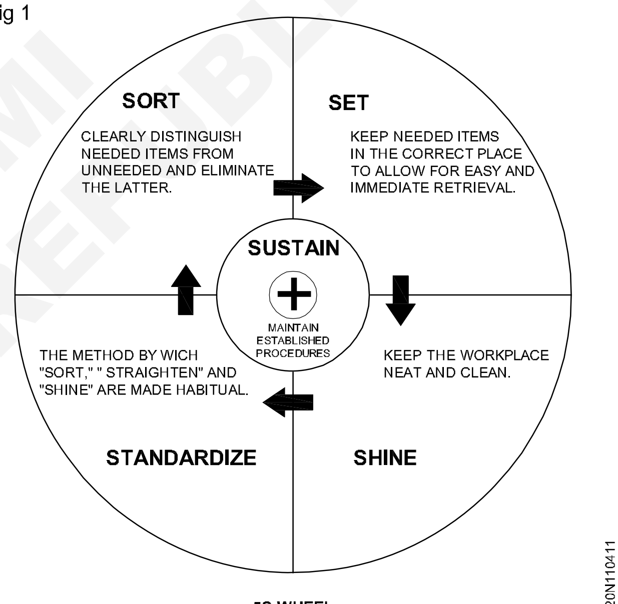
The list describes how to organize a work space for efficiency and effectiveness by identifying and stroing the items used, maintaining the area and items, and sustaining the new order.

5S Wheel

The Benefits of the 5s system

- Increase in productivity
- Increase in quality
- Reduction in cost

Fig 1



5S WHEEL

Importance of housekeeping

Objectives: At the end of this lesson you shall be able
- **list the steps involved in house keeping**
- **state good shop floor practices followed in industry**

House keeping

The following activities to be performed for better up keep of making environment:

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of machines:** Reduce accidents by keeping machines cleaned well
- **Prevention of leakage and spillage:** Use splash guide in machine and collecting tray
- **Disposal of scrap:** Empty scrap, wastage, swarf from respective containers regularly
- **Tools storage -** Use special racks, holders for respective tools

- **Storage spaces:** Identify storage areas for respective same do not leave any material in gangway
- **Filling methods-** Do not overload platform, floor and keep material at safe height.
- **Material handling:** Use forklifts, conveyors and hoist according to the volume and weight of the package.

Good shop floor practices followed in industry

- Good shop floor practices are motivating action plans for environment of the manufacturing process.
- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety result compared to achievements.
- workers are trained on written product quality standards
- manufactured parts are inspected to ensure adherence to quality standards.
- production processes are planned by engineering to minimize product variation.
- 5s methods are used to organize the shop floor and production lines.
- workers are trained on plant safety practices in accordance with occupational safety Health (OSH) standards.
- Workers are trained on "root cause" analysis for determining the causes of not following.
- A written preventive maintenance plan for upkeep of plant, machinery & equipment
- Management meets with plant employees regularly to get input on process improvements
- Process improvement Teams are employed to implement "best practices"

Disposal of waste material

Objectives: At the end of this lesson you shall be able to
- **state what is waste material**
- **list the waste materials in a work shop**
- **explain the methods of disposal of waste material.**
- **state advantage of disposal of waste material.**

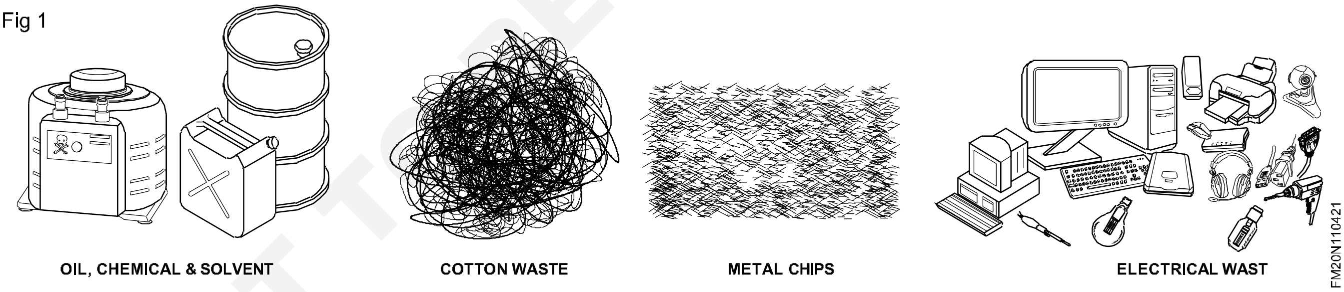
Waste material

industrial waste is the waste produced by industrial activity such as that of factories, mills and mines.

List of waste material (Fig 1)

- Cotton waste
- Metal chips of different material.
- Oily waste such as lubricating oil, coolant etc.
- Other waste such electrical, glass etc.

Fig 1



Methods of waste disposal

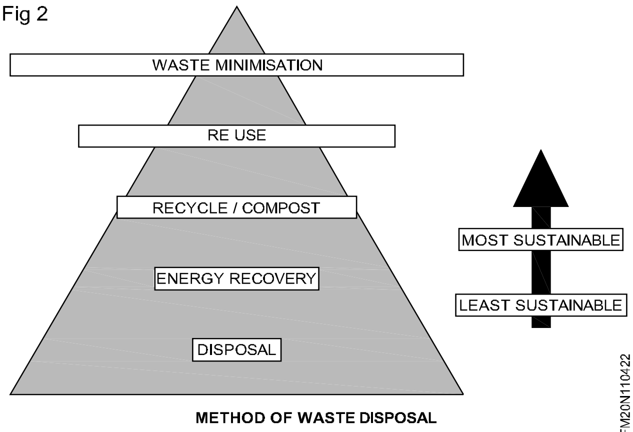
Recycling

Recycling is one of the most well-known method of managing waste. It is not expensive and can be easily done by you. If you carry out recycling. you will save a lot of energy, resources and thereby reduce pollution.

Composting

This is a natural process that is completely free of any hazardous by-products. This process involves breaking down the materials into organic compounds that can be used as manure.

Fig 2



Landfills

Waste management through the use of landfills involves the use of a large area. This place is dug open and filled with the waste.

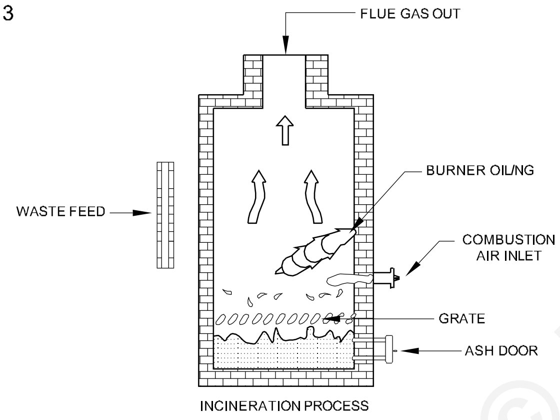
Burning the waste material

If you cannot recycle or if there are no proper places for setting up landfills, you can burn the waste matter generated in your household. Controlled burning of waste at high temperatures to produce steam and ash is a preferred waste disposal technique.

Advantage of waste disposal:

- Ensures workshop neat & tidy
- Reduces adverse impact on health
- Improves economic efficiency
- Reduces adverse impact on environment

Fig 3



Incineration (Fig.3)

It is the process of controlled combustion of garbage to reduce it to incombustible matter, ash, waste gas and heat. It is treated and released into the environment (Fig 3). This reduces 90% volume of waste, some time the heat generated used to produce electric power.

Waste compaction

The waste materials such as cans and plastic bottles compact into blocks and send for recycling. This process need space thus making transportation and positioning easy.

Colour code for bins for waste segregation given in Table-1

Table-1

Sl.No.	Waste Material	Color code
1	Paper	Blue
2	Plastic	Yellow
3	Metal	Red
4	Glass	Green
5	Food	Black
6	Others	Sky blue

Occupational safety and health

Objectives: At the end of this lesson you shall be able to
- **define safety**
- **state the goal of occupational health and safety**
- **explain need of occupational health and safety**
- **state the occupational hygiene**
- **explain occupational hazards**

Safety

Safety means freedom or protection from harm, danger, hazard, risk, accident, injury or damage.

Occupational health and safety

- Occupational health and safety is concerned with protecting the safety, health and welfare of people engaged in the work or employment.
- The goal is to provide a safe work environment and to prevent hazards.
- It may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are affected by the workplace environment.
- It involves interactions among many related areas, including occupational medicine, occupational (or industrial) hygiene, public health, and safety engineering, chemistry, and health physics.

Need of occupational health and safety

- Health and safety of the employees is an important aspect of a company's smooth and successful functioning.
- It is a decisive factor in organizational effectiveness. It ensures an accident-free industrial environment.
- Proper attention to the safety and welfare of the employees can yield valuable returns.
- Improving employee morale
- Reducing absenteeism
- Enhancing productivity
- Minimizing potential of work-related injuries and illnesses
- Increasing the quality of manufactured products and/ or rendered services.

Occupational (Industrial) hygiene

- Occupational hygiene is anticipation, recognition, evaluation and control of work place hazards (or) environmental factors (or) stresses
- This is arising in (or) from the workplace.
- Which may cause sickness, impaired health and well being (or) significant discomfort and inefficiency among workers.

Anticipation (Identification): Methods of identification of possible hazards and their effects on health

Recognition (Acceptance): Acceptance of ill-effects of the identified hazards

Evaluation (Measurement & Assessment): Measuring or calculating the hazard by Instruments, Air sampling and Analysis, comparison with standards and taking judgement whether measured or calculated hazard is more or less than the permissible standard.

Control of workplace hazards: Measures like Engineering and Administrative controls, medical examination, use of Personal Protective Equipment (PPE), education, training and supervision

Occupational hazards

"Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these".

Types of occupational health hazards

- Physical Hazards
- Chemical Hazards
- Biological Hazards
- Physiological Hazards
- Mechanical Hazards
- Electrical Hazards
- Ergonomic Hazards.

1 Physical hazards

- Noise
- Heat and cold stress
- Radiation (ionising & Non-ionising)
- Vibration
- Illumination etc.,

2 Chemical hazards

- Inflammable
- Explosive
- Toxic
- Radioactive
- Corrosive

3 Biological hazards

- Bacteria
- Virus
- Fungi
- Plant pest
- Infection.

4 Physiological

- Old age
- Sex
- Ill health
- Sickness
- Fatigue.

5 Psychological

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
  - absenteeism
  - disobedience
  - aggressive behaviours
- Accident proneness etc.
- Emotional disturbances
  - violence
  - bullying
  - sexual harassment

6 Mechanical

- Unguarded machinery
- No fencing
- No safety device
- No control device etc.,

7 Electrical

- No earthing
- Short circuit
- Current leakage
- Open wire
- No fuse or cut off device et.

8 Ergonomic

- Poor manual handling technique
- Wrong layout of machinery
- Wrong design
- Poor housekeeping
- Wrong tools etc.

Safety Slogan

A Safety rule breaker, is an accident maker

Identification of safety sign

Objectives: At the end of this lesson you shall be able to
- **list three kinds of road sign**
- **describe the marking line on the road**
- **describe the various police traffic hand signal and light signal**
- **list the collision causes.**

In older days road locomotive carried a red flag by day and red lantern by night. Safety is the prime motive of every traffic.

Kinds of road signs

- Mandatory
- Cautionary and
- Informatory

Mandatory sign (Fig 1)

Violation of mandatory sign can lead to penalties. Ex. Stop, give way limits, prohibited, no parking and compulsory sign.

Fig 1

Cautionary signs (Fig 2)

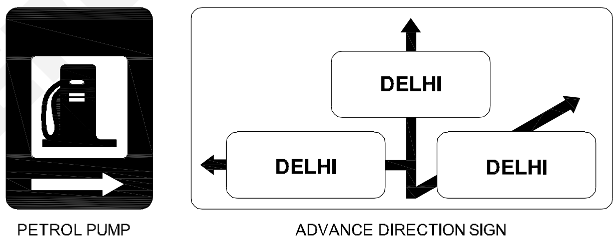
Cautionary/ warning signs are especially safe. do's and don'ts for pedestrians, cyclists, bus passengers and motorists.

Information signs (Fig 3)

Information signs are especially beneficial the passengers and two wheelers.

Fig 2

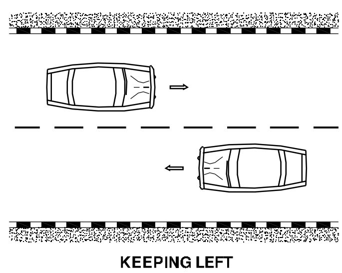
Fig 3



Marking lines on road (Fig 4)

- Marking lines are directing or warning to the moving vehicles, cyclist and pedestrians to follow the law.
- Single and short broken lines in the middle of the road allow the vehicle to cross the dotted lines safely overtake whenever required.
- When moving vehicle is approaching pedestrian crossing, be ready to slow down or stop to let people cross.
- Do not overtake in the vicinity of pedestrian crossing.

Fig 4



Police signals

To stop a vehicle approaching from behind. Fig 5(1)

To stop a vehicle coming from front. Fig 5(2)

To stop vehicles approaching simultaneously from front and behind. Fig 5(3)

To stop traffic approaching from left and wanting to turn right. Fig 5(4)

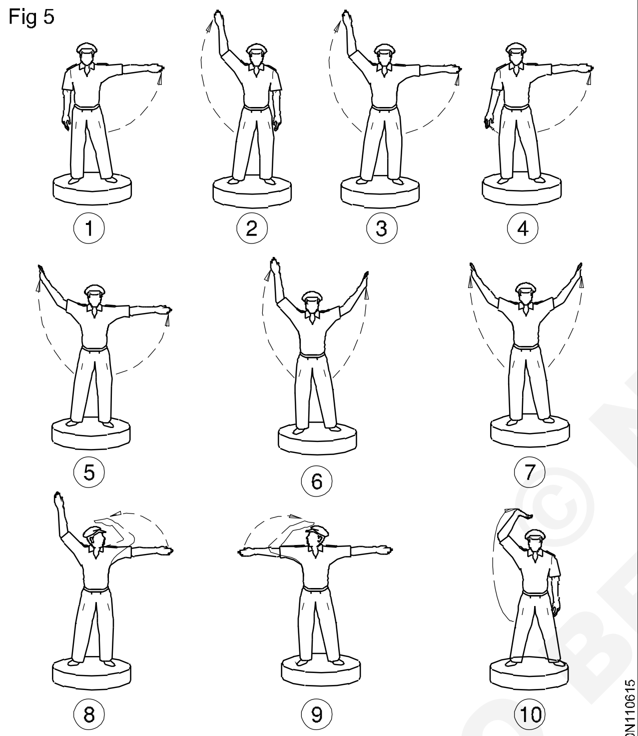
To stop traffic approaching from the right to allow traffic from left turn right. Fig 5(5)

To allow traffic coming from the right and turning right by stopping traffic approaching from the left. Fig 5(6)

Warning signal closing all traffic. Fig 5(7)

Beckoning on vehicles approaching from left. Fig 5(8)

Fig 5



POLICE SIGNALS

Beckoning on vehicles approaching from right. Fig 5(9)

Beckoning on vehicles from front. Fig 5(10)

Traffic light signals

Red means stop. Wait behind the stop line on the carriage way. Fig 6(1)

Red and amber also means stop. Do not pass through or start until green shows. Fig 6 (2)

Green means you may go on if the way is clear. Take special care if you mean to turn left or right and give way to pedestrians who are crossing. Fig 6(3)

Amber means stop at the stop line. you may only go on if the amber appears after you have crossed the stop line or so close to it that to pull up may not be possible. Fig 6(4)

Green arrow means that you may go in the direction shown by the arrow. You may do this whatever other lights may be showing. Fig 6(5)

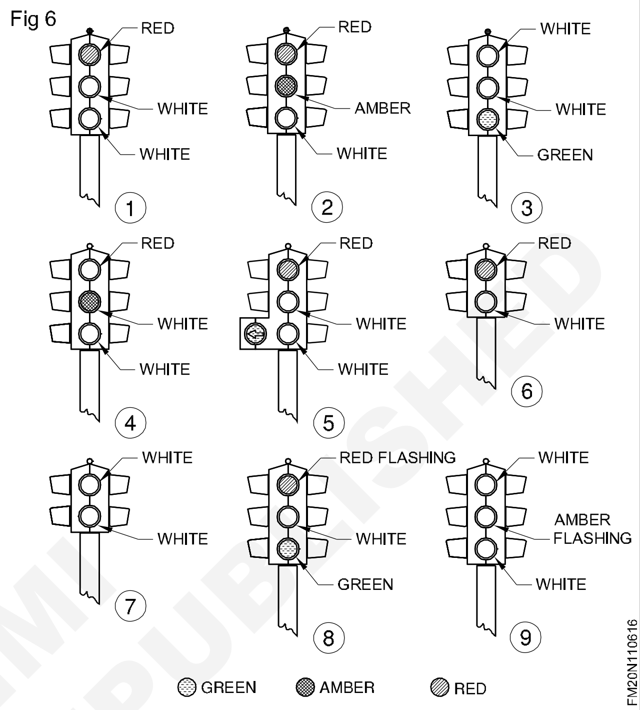
Pedestrians - do not cross. Fig 6(6)

Pedestrians - cross now. Fig 6(7)

Flashing red means stop at the stop line and if the way is clear proceed with caution. Fig 6(8)

Flashing amber means proceed with caution. Fig 6(9)

Fig 6



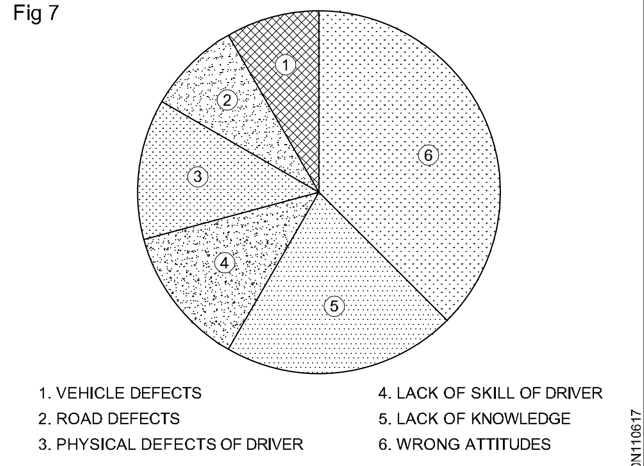
Collision causes

Three factors are responsible for collision

- Roads
- Vehicles and
- Drivers.

The (Fig 7) shows approximately proportionate causes of collision.

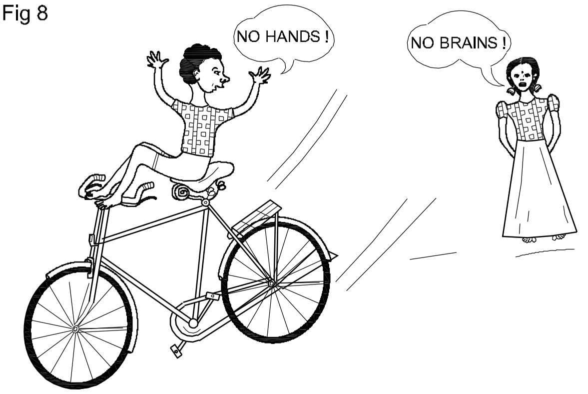
Fig 7



COLLISION CAUSES

In wrong attitudes avoid foolish acts at the wheel. Driving time is not play time. (Fig 8)

Fig 8



Safety practice

Objectives: At the end of this lesson you shall be to
- **state the responsibilities of employer and employees**
- **state the safety attitude and list the four basic categories of safety signs.**

Safety

The state of being safe, freedom from the occurrence or risk of injury, danger or loss.

Responsibilities

Safety doesn't just happen - it has to be organised and achieved like the work-process of which it forms a part. The law states that both an employer and his employees have a responsibility in this behalf.

Employer's responsibilities

The effort a firm puts into planning and organising work, training people, engaging skilled and competent workers, maintaining plant and equipment, and checking, inspecting and keeping records - all of this contributes to the safety in the workplace.

The employer will be responsible for the equipment provided, the working conditions, what the employees are asked to do, and the training given.

Employee's responsibilities

You will be responsible for the way you use the equipment, how you do your job, the use you make of your training, and your general attitude to safety.

A great deal is done by employers and other people to make your working life safer; but always remember you are responsible for your own actions and the effect they have on others. You must not take that responsibility lightly.

Rules and procedure at work

What you must do, by law is often included in the various rules and procedures laid down by your employer. They may be written down, but more often than not, are just the way a firm does things - you will learn these from other workers as you do your job. They may govern the issue and use of tools, protective clothing and equipment, reporting procedures, emergency drills, access to restricted areas, and many other matters. Such rules are essential and they contribute to the efficiency and safety of the job.

Safety signs

As you go about your work on a construction site you will see a variety of signs and notices. Some of these will be familiar to you - a 'no smoking' sign for example; others you may not have seen before. It is up to you to learn what they mean - and to take notice of them. They warn of the possible danger, and must not be ignored.

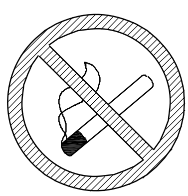
Safety signs fall into four separate categories. These can be recognised by their shape and colour. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

The four basic categories of signs are as follows:

- prohibition signs (Fig 1 & Fig 5)
- mandatory signs (Fig 2 & Fig 6)
- warning signs (Fig 3 & Fig 7)
- information signs (Fig 4)

Fig 1

PROHIBITION SIGNS



SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FM20N110621

Fig 2

MANDATORY SIGNS

SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

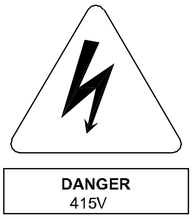
MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FM20N110622

Fig 3

WARNING SIGNS



SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

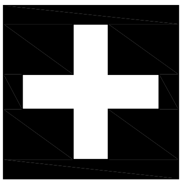
MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FM20N110623

Fig 4

INFORMATION SIGNS



SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

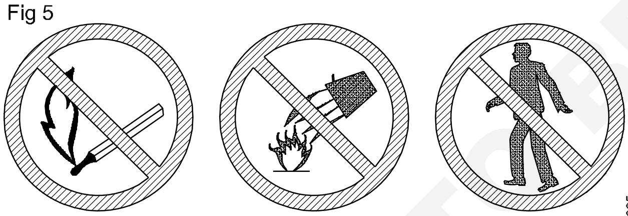
MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FM20N110624

Prohibition signs

Fig 5



FM20N110625

Question about your safety

Do you know the general safety rules that cover your place of work?

Are you familiar with the safety laws that govern your particular job?

Do you know how to do your work without causing danger to yourself, your workmates and the general public?

Are the plant, machinery and tools that you use really safe? Do you know how to use them safely and keep them in a safe condition?

Mandatory signs

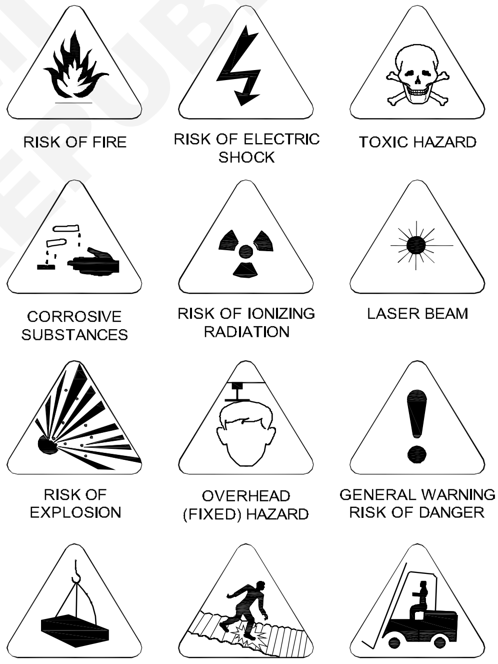
Fig 6

MANDATORY SIGNS

FM20N110626

Warning signs

Fig 7



WARNING SIGNS

FM20N110627

Do you wear all the right protective clothing, and have you been provided with all the necessary safety equipment?

Have you been given all the necessary safety information about the materials used?

Have you been given training and instruction to enable you to do your job safely?

Do you know who is responsible for safety at your place of work?

Do you know who are the appointed 'Safety Representatives'?

Response to emergencies - Power failure, System failure & Fire

Objectives: At the end of this lesson you shall be able to
- **state the reason of emergency power failure**
- **state the cause of system failure**
- **state the fire safety and immediate actions.**

1 If there is a power failure, start the emergency generator. This provides power to close the shutter, which is the first priority. The generator will also keep the UPSs and the cryogenic compressors running,

- Get a flash light.
- Look out for power transfer switch and switch over to normal power to emergency power by pressing the latch.
- Check the fuel valves open or not - Open the valves.
- Check to see that the main breaker switch ON the generator is in OFF position.
- Move the starter switch of the generator to run position. The engine will start at once.
- Allow few minutes to warm up the engine.
- Check all the gauges, pressure, temperature, voltage and frequency.
- Check the "AC line" and "Ready" green light on the front panel.

2 System failure

- If the bug or virus, invades the system. The system failure happens.
- Several varieties of bugs are there

1. Assassin bug
2. Lightening bug
3. Brain bug

For more details, refer instruction manual for "System failure".

3 Fire failure

When fire alarm sounds in your buildings

1. Evacuate to outside immediately.
2. Never go back
3. Make way for fire fighters and their trucks to come
4. Never use an elevator
5. Do not panic

Reporting emergency

Objectives: At the end of this lesson you shall be able to
- **explain and report an emergency**

Report an emergency

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevails at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passerby would like to get involved to assist the victims. The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc. all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure that the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured, missing, report that as well.
- A life - threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.

Call emergency service

The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location

The first thing the emergency dispatcher will ask where you are located, so that the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information like landmarked etc.

Operation of electrical mains/ Circuit breakers and electrical safety

Objectives: At the end of this lesson you shall be able to
- **explain the operation of electrical mains/circuit breaker**
- **state the importance of electrical safety.**

Electrical safety

Electric shock

If a person happens to come in contact with an electrical live wire and if he has not insulated himself, then electric current flows through his body. Since the human body cannot withstand current flow more than a few tens of milliamps, the human body suffers a phenomenon generally known as electric shock. Electric shock may turn out to be hazardous to some of the parts of the human body and sometimes even to the life of the person.

The severity of an electric shock depends on:

– the level of current passing through the body

– how long does the current keep passing through the body?

Therefore, the higher the current or longer the time, the shock may result in a causality.

In addition to the above factors, other factors which influences the severity of shock are:

– age of the person receiving a shock

– surrounding weather condition

– condition of the floor (wet or dry)

– voltage level of electricity

– insulating property of the footwear or wet footwear, and so on.

Effects of electric shock

The effect of electric shock at very low voltage levels (less than 40 V) may only be an unpleasant tingling sensation. But this shock itself may be sufficient to cause someone to lose his balance and fall, resulting in casualty.

At higher voltage levels the muscles may contract and the person will be unable to break off from the contact by himself. He may lose consciousness. The muscles of the heart may contract spasmodically (fibrillation). This may even turn out to be fatal.

At an excessive level of voltage, the person receiving a shock may be thrown off his feet and will experience severe pain and possibly burns at the point of contact. This in most cases is fatal.

Electric shock can also cause burning of the skin at the point of contact.

Action to be taken in case of an electric shock

If the victim of an electric shock is in contact with the supply, break the contact of the victim making with the electricity by any one or more of the following.

– Switch off the electric power, insulate yourself and pull away the person from the electrical contact

or

Remove the mains electric plug. Avoid direct contact with the victim. Wrap your hands using dry cloth or paper, if rubber gloves are not available.

or

Remove the electric contact made by wrenching the cable/equipment/point free from contact using whatever is at hand to insulate yourself such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled up newspaper, non-metallic hose, PVC tubing, baked paper, tube etc. and break the contact by pushing or pulling the person or the cable/equipment/point free

or

Stand on some insulating material such as dry wood, rubber or plastic, or whatever is at hand to insulate yourself and break the contact by pushing or pulling the person or the cable/equipment/point free.

> **If you are uninsulated, do not touch the victim with your bare hands. Otherwise you also will get a shock and become a victim.**

If the victim is aloft (working on a pole or at raised place), take suitable measures to prevent him from falling or at least ensure that his fall is safe.

Treatment to be given for the victim of electric shock

Electric burns on the victim may not look big/large. But it may be deep rooted. Cover the burnt area with a clean, sterile dressing. Get a doctor's help to treat him as quickly as possible.

If the victim is unconscious after an electric shock, but is breathing, carry out the following first aid:

– loosen the clothing at the neck, chest and waist

– place the victim in the recovery position.

– Keep a constant check on the breathing and pulse rate. If you find them feeble, immediately give artificial respiration and press the lower rib to improve the heartbeat.

– Keep the casualty warm and comfortable.

– Send for a doctor immediately.

Do not give an unconscious person anything through the mouth.

Do not leave a unconscious person unattended.

A person having received electric shock may also have burn injuries. DO NOT waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally unaided.

Treatment to be given in case of burns, severe bleeding

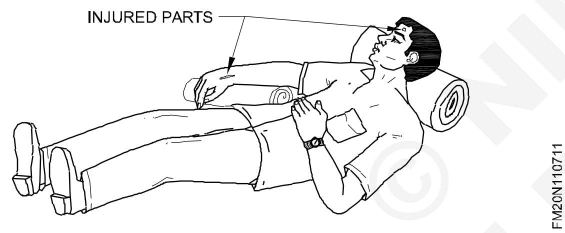
Burns caused due to electrical shock are very painful. If a large area of the body is burnt, clean the wound using clear water, or with clean paper, or a clean shirt. This treatment relieves the victim of pain. Do not give any other treatment on your own. Send for a doctor for further treatment.

A wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive a doctor's attention. As an immediate first aid measure, carry out the following;

– make the patient lie down and rest

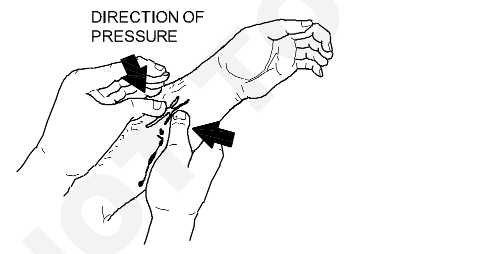
– if possible, raise the injured part above the level of the body as shown in Fig 1.

Fig 1



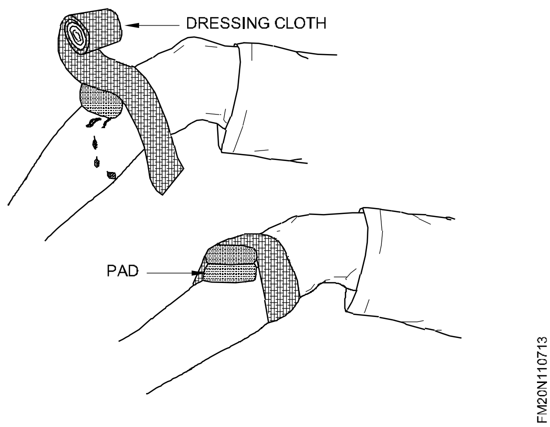
Squeeze together the sides of the wound as shown in Fig 2. Apply pressure as long as it is necessary to stop the bleeding.

Fig 2



When the bleeding stops temporarily, put a dressing over the wound using sterilized cotton, and cover it with a pad of soft material as shown in Fig 3.

Fig 3



If the wound is in the abdominal area (stab wound), caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

General procedural steps to be adopted for treating a person suffering from an electrical shock

1 Observe the situation. Choose the appropriate method (listed in earlier paragraphs) to release the person from electrical contact.

Do not run to switch off the supply that is far away or start searching for the mains switch.

2 Move the victim gently to the nearest ventilated place.

3 Check the victim's breathing and consciousness. Check if there are injuries in the chest or abdomen. Give artificial respiration/applying pressure on the heart if found necessary (refer in this lesson/exercise).

Use the most suitable method of giving artificial respiration depending upon the injuries if any on the chest/abdomen.

4 Send for a doctor.

Till the doctor arrives, you stay with the victim and render help as best as you can.

5 Place the victim in the recovery position.

6 Cover the victim with a coat, socks or any such thing to keep the victim warm.

Actions listed above must be taken syst ematically and briskly. Delay in treating the patient may endanger his life.

Area of control of switches - operation on emergency

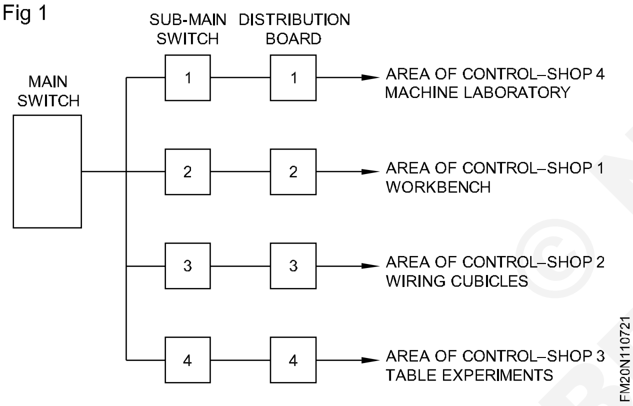
Objectives: At the end of this lesson you shall be able to
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON & OFF in case of iron clad switches, MCB and ordinary house hold stitches.**

An emergency is an unexpected occurrence and requires immediate action. In a place like a workshop such a situation can arise when a person gets a shock due to electrical current or a person gets injured by the rotating part of a machine.

In such situations, switching off the supply will be the first and best solution to avoid further damage to the victim. For this, every person involved in the workshop should know which switch controls the area where the victim of shock remains.

Normally the total wiring in a workshop is controlled by a main switch and the different areas within the workshop may have two or more sub-main switches as shown in Fig.1.

Fig 1



To ascertain the area of the sub-main control, switch off one of the sub-main switches and try to switch 'on' the lights, fans and power points in that suspected area. If they do not work, then the area covered by the fan, light and power points are controlled by the sub-main switch. One after another, switch off the sub-main switches and locate their area of control. Mark the area of control of the switch in the plan of the wireman's section.

In a well organised workshop, the main switch, the sub main switches and distribution ways will have clear marking to show their area of control. (Fig 1) If this is not found, do this now. However, if you are not sure about the area of control the sub-main of the switches it is always better to switch 'off' the main switch itself.

The handle of iron clad switches and the knob of MCB should be pushed down to switch 'off ' the circuits as shown in Fig 2. whereas in the ordinary switches, the switch off the circuit should be done by pushing the switch to upward position. (Fig 3)

Fig 2

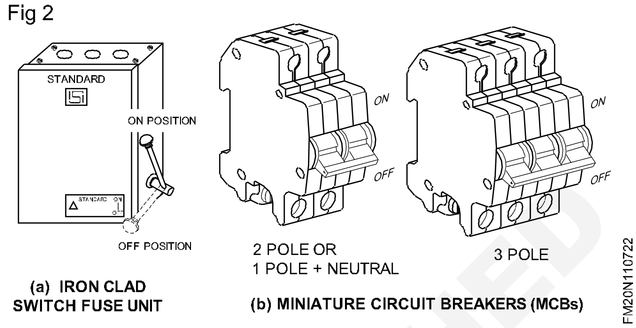
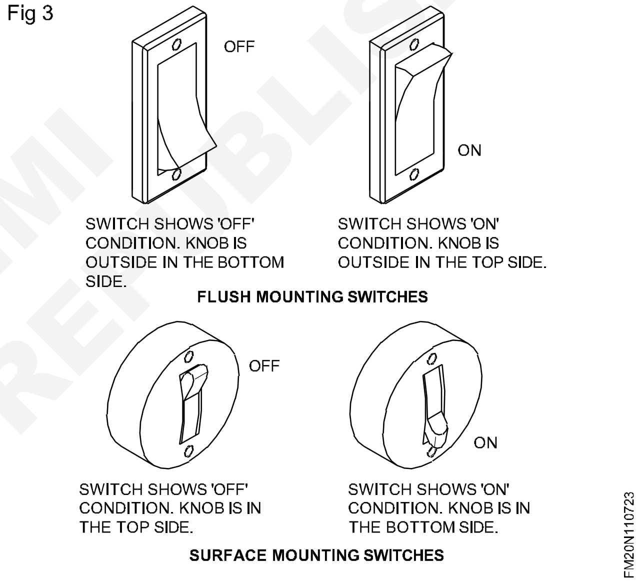


Fig 3



The emergency situations could happen even at home Hence, identify the area of control of the switch and mark them in the main/sub-main/ distribution bound of your house switch board as a safety measure. Educate the intimates of the house how to switch off the circuit in case of any emergency.

- Never place your hands on any moving part of rotating machine and never work around moving shafts or pulleys of motor or generator with loose shirt sleeves or dangling neck ties.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Run cables or cords through wooden partitions or floor.

Safety rules on electrical equipments

Objectives: At the end of this lesson you shall be able to
- **explain the necessity of adopting the safety rules**
- **list the safety rules and follow them.**

Safety Rules

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material. Unsafe working habits always end up in loss of production and profits, personal injury and even death. The safety hints given below should be followed by Electrician to avoid accidents and electrical shocks as his job involves a lot of occupational hazards.

The listed safety rules should be learnt, remembered and practiced by every electrician. Here an electrician should remember the famous proverb, "Electricity is a good servant but a bad master".

Safety rules

- Only qualified persons should do electrical work
- Keep the workshop floor clean, and tools in good condition.
- Do not work on live circuits, if unavoidable, use rubber gloves rubber mats, etc.
- Use wooden or PVC insulated handle screwdrivers when working on electrical circuits.
- Do not touch bare conductors.
- When soldering, place the hot soldering irons in their stand. Never lay switched 'ON' or heated soldering iron on a bench or table as it may cause a fire to break out.
- Use only correct capacity fuses in the circuit. If the capacity is less it will blow out when the load is connected. If the capacity is large, it gives no protection and allows excess current to flow and endangers men and machines, resulting in loss of money.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combusitble material coming in contact with hot bulbs.
- Use accessories like sockets, plugs and switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI). (Necessity using BIS (ISI) marked accessories is explained under standardization.
- Never extend electrical circuits by using temporary wiring.
- Stand on a wooden stool, or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs. In all the cases, it is always goog to open the main switch and make the circuit dead.
- Stand on rubber mats while working/ operating switch panels, control gears etc.
- Position the ladder, on fim ground.
- While using a ladder, ask the helper to hold the ladder against any possible slipping.
- Always use safety belts while working on poles or high rise points.
- Connections in the electrical apparatus should be tight. Loosely connected cables will heat up and end in fire hazards.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display 'Men on line' board on the switchboard.
- Do not meddle with inter locks of machines/switch gears
- Do not connect earthing to the water pipe lines.
- Do not use water on electrical equipment.
- Discharge static voltage in HV lines/equipment and capacitors before working on them

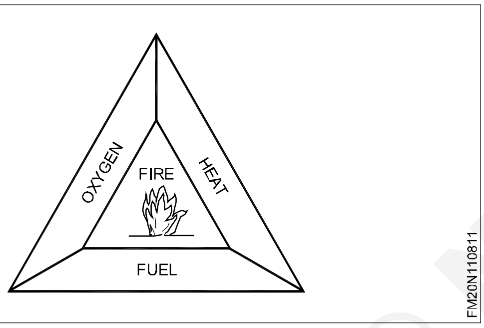
Fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **state the effects of a fire breakout**
- **state the causes for fire in the workshop**
- **state the conditions required for combustion relevant to fire prevention**
- **state the general precautionary measures to be taken for fire prevention.**

Fire is the burning of combustible material. A fire in an unwanted place and on an unwanted occasion and in uncontrollable quantity can cause damage or destroy property and materials. Fires injure people, and sometimes, cause loss of life. Hence, every effort must be made to prevent fire. When a fire outbreak is discovered, it must be controlled and extinguished by immediate correct action.

Is it possible to prevent fire? Yes, by eliminating anyone of the three factors that cause fire. (Fig 1)

Fig 1



The factors that must be present in combination for a fire to continue to burn are as follows.

Fuel Any substance, liquid, solid, or gas will burn if given oxygen and high enough temperature.

Heat Every fuel will begin to burn at a certain temperature. Solids and liquids give off vapour when heated and it is this vapour which ignites. Some liquids give off vapour even at normal room temperature say 15^{o}C, eg. petrol.

Oxygen Usually it exists in sufficient quantity in air to keep a fire burning.

Extinguishing of fires

Isolating or removing any of these factors from the combination will extinguish the fire. There are three basic ways of achieving this.

- Starving the fire of fuel by removing the fuel in the vicinity of fire.
- Smothering - i.e by isolating the fire from the supply of oxygen by blanketing it with foam, sand etc.
- Cooling - i.e. by using water to lower the temperature.

Preventing fires

The majority of fires begin with small outbreaks which burn unnoticed until they become big fires of uncontrollable magnitude. Most of the fires could be prevented with more care and by following some rules of simple commonsense.

Accumulation of combustible refuse (cotton waste soaked with oil, scrap wood, paper, etc.) in odd corners are of fire risk. Refuse should be removed to collection points.

The cause of fire in electrical equipment is misuse or neglect. Loose connections, wrongly rated fuses or cables, overloaded circuits cause over heating which may in turn lead to fire. Damage to insulation between conductors in cables also causes fire.

Clothing and anything else which might catch fire should be kept well away from heaters. Make sure the heater is shut off at the end of a working day.

Highly flammable liquids and petroleum mixtures (Thinner, Adhesive solutions, Solvents, Kerosene, Spirit, LPG Gas etc.) should be stored in a separated place called the flammable material storage area.

Blowlamps and torches must not be left burning when they are not in use.

Classification of fires and recommended extinguishing agents.

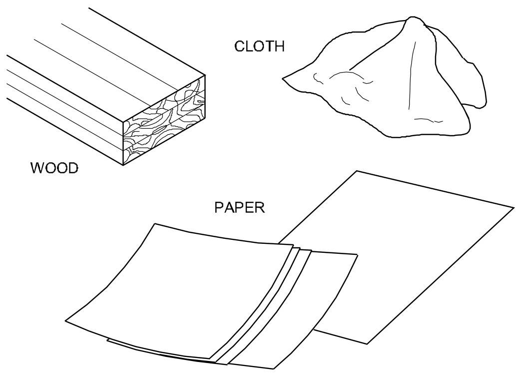
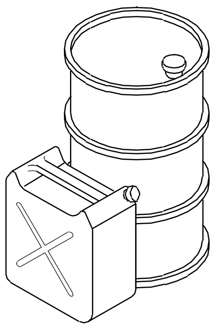
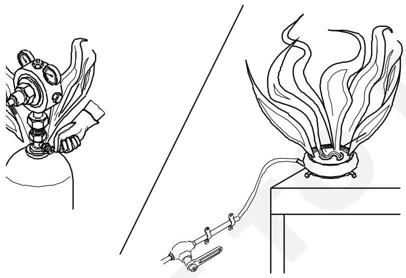
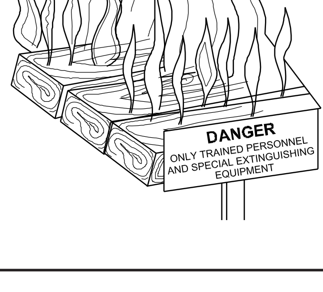
Fire are classified into four types in terms of the nature of fuel.

Different types of fire have to be dealt with different ways and with different extinguishing agents.

An agent is the material or substance used to put out the fire, and is usually (but not always) contained in a fire extinguisher with a mechanism for spraying into the fire.

It is important to know the right type of agent for a particular type of fire. Using the wrong one can make things worse.

There is no classification for 'electrical fires' as such since these are only fires in materials where electricity is present.

<table>
<tr><th>Fuel</th><th>Extinguishing</th></tr>
<tr><td>CLASS 'A' Fire Wood, paper, cloth etc. Solid materials

</td><td>Most effective i.e. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.</td></tr>
<tr><td>CLASS 'B' Fire Flammable liquid. liquefiable solids
</td><td>Should be smothered. The aim is to cover the ent ire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire.
Water should never be used on burning liquids.
Foam, dry powder or CO_2 may be used on this type of fire.</td></tr>
<tr><td>CLASS 'C' Fire Gas and liquefied gas
</td><td>Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden spreading of fire in the entire vicinity. If an appliance fed from a cylinder catches fire - shut off the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel.
Dry powder extinguishers are used on this type of fire.
Special powders have now been developed which are capable of controlling and/or extinguishing this type of fire</td></tr>
<tr><td>CLASS 'D' Fire Involving metals

</td><td>The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires.
Fire on electrical equipment.
Carbon dioxide, dry powder and vapourising liquid (CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (e.g. Water) extinguisher must not be used on electrical equipment under any circumstances.</td></tr>
</table>

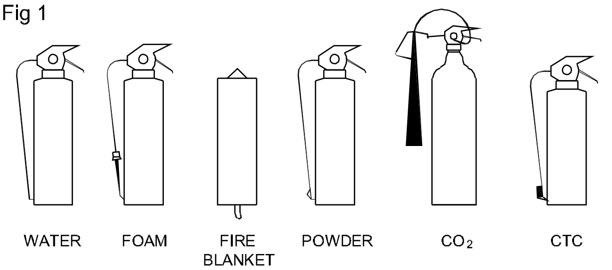
Types of fire extinguishers

Objectives : At the end of this lesson you shall be able to
- **described different types of fire extinguishers**
- **explain about correct type of fire extinguisher to be used based on the class of fire**
- **describe the general procedure to be adopted in the event of a fire.**

A fire extinguisher, flame extinguisher or simply extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situation. It is not intended for use on and out of control fire.

Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

Fig 1

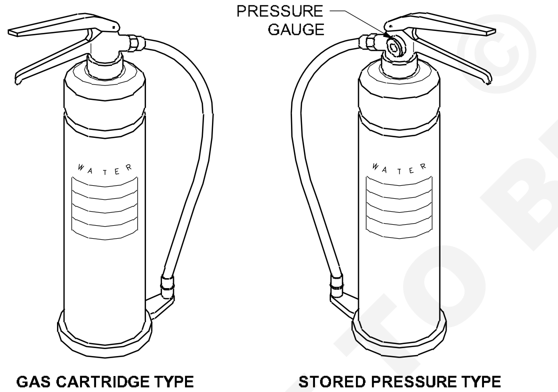


Water-filled extinguishers

There are two methods of operation. (Fig 2)

- Gas cartridge type
- Stored pressure type

Fig 2



With both methods of operation, the discharge can be interrupted as required, conserving the contact and preventing unnecessary water damage.

Foam extinguishers (Fig 3)

These may be of stored pressure or gas cartridge types.

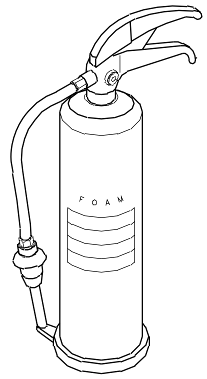
Always check the operating instructions on the extinguisher before use.

Foam extinguishers are most suitable for:

- Flammable liquid fires
- Running liquid fires

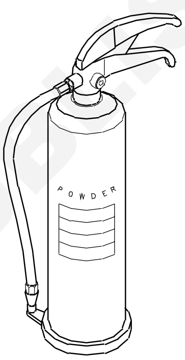
Must not be used where electrical equipment is involved.

Fig 3



Dry powder extinguishers (Fig 4)

Fig 4

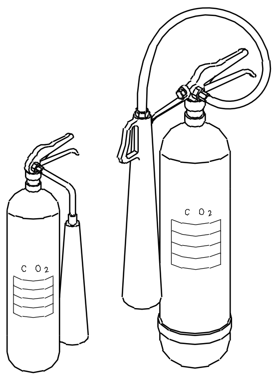


Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type. Appearance and method of operation is the same as that of the water-filled one. The main distinguishing feature is the fork- shaped nozzle. Powders have been developed to deal with class D fires.

Carbon dioxide (Co_2)

This type is easily distinguished by the distinctively shaped discharge horn. (Fig 5)

Fig 5

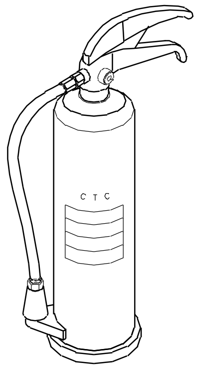


Suitable for class B fires. Best suited where contamination by deposits must be avoided. Not generally effective in open air.

Always check the operating instructions on the container before use, available with different gadgets of operation such as -plunger, lever trigger etc.

Halon extinguishers (Fig 6)

Fig 6



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Theses extinguishers may be filled with carbon tetrachloride and bromochlorodifluoro methane (BCF).

They may be of either gas cartridge or stored pressure type.

They are more effective in extinguishing small fires involving pouring liquids. These extinguishers are particularly suitable and safe to use on electrical equipment as the chemicals are electrically non-conductive.

The fumes given off by these extiguishers are dangerous, expecially in confined space.

General procedure to be adopted in the event of a fire to be adopted.

– Raise an alarm.

– Turn off all machinery and power (gas and electricity).

– Close the doors and windows, but do not lock or bolt them. This will limit the oxygen fed to the fire and prevent its spreading.

– Try to deal with the fire if you can do so safely. Do not take risk, getting in trapped.

– Anybody not involved in fighting the fire should leave calmly using the emergency exits and go to the designated assembly point. Failure to do this may mean that some person is unaccounted for and others may have to put themselves to the trouble of searching for him or her at risk to themselves.

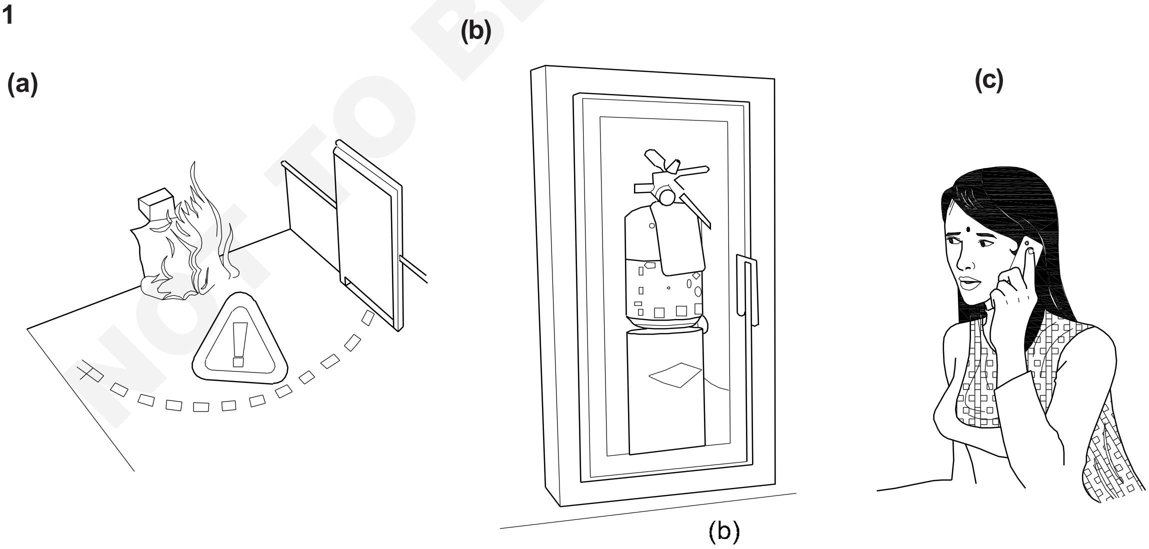
Working on fire extinguishers

Objectives: At the end of this lesson you shall be able to

- **state about the seleout off controlction of the fire extinguishers according to the type of fire**
- **state the method of operation of the fire extinguishers**
- **explain how to extinguish the fire.**

- Alert people surrounding by shouting fire, fire, fire when observe the fire (Fig 1a& b)

Fig 1



- Inform fire service or arrange to inform immediately. (Fig 1c)
- Open emergency exit and ask them to go away. (Fig 1d)
- Put "off" electrical power supply.

Don't allow people to go nearer to the fire.

(d)

- Analyze and identify the type of fire. Refer Table 1.

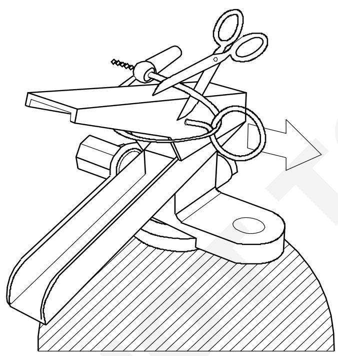
Table 1

Class 'A'	Wood, paper, cloth, solid material
Class 'B"	Oil based fire (grease gasoline, oil) liquefiable gases
Class 'C'	Gas and liquefiable gases
Class 'D'	Metals and electrical equipment

Assume the fire is 'B' Type (flammable liquafiable solids)

- Select CO_2 (Carbon di oxide) fire extinguisher.
- Locate and pick up co_2 fire extinguisher. Click for its expiry date.
- Break the seal (Fig 2)

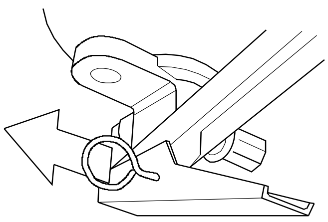
Fig 2



BREAK THE SEAL

- Pull the safety pin from the handle (Pin located at the top of the fire extinguisher) (Fig 3)

Fig 3

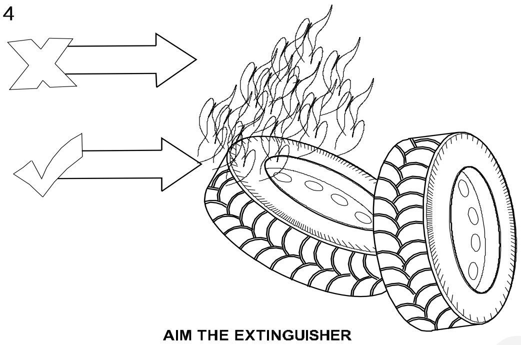


PULL THE SAFTY PIN

- Aim the extinguisher nozzle or hose at the base of the fire (this will remove the source of fuel fire) (Fig 4)

Keep your self low

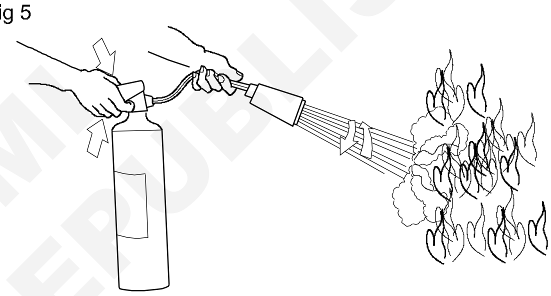
Fig 4



AIM THE EXTINGUISHER

- Squeeze the handle lever slowly to discharge the agent (Fig 5)
- Sweep side to side approximately 15 cm over the fuel fire until the fire is put off (Fig 5)

Fig 5



Fire extinguishers are manufactured for use from the distance.

Caution

While putting off fire, the fire may flare up

Do not be panicked before it is put off promptly.

If the fire doesn't respond well after you have used up the fire extinguisher move away yourself away from the fire point.

Do not attempt to put out a fire where it is emitting toxic smoke leave it for the professionals.

Remember that your life is more important than property. So don't place yourself or others at risk.

In order to remember the simple operation of the extinguisher, remember P.A.S.S. This will help you to use the fire extinguisher.

P for Pull

A for Aim

S for Squeeze

S for Sweep

Safety, health and environment guidelines

Objectives: At the end of this lesson you shall be able to
- **state safety, health and environment guidelines.**
- **state various section provided in factories act, 1948 on occupational safety and health.**

Safety, Health and Environment guidelines as per

Rules & regulations followed in India are listed as follows:

1 The Environment (Protection) Act, 1986
2 The Environment (Protection) Rules, 1986
3 Environmental Impact Assessment of Development Projects 1994
4 The Prevention and control of pollution (uniform consent procedure) Rules,1999
5 Manufacture, Storage and Import of Hazardous chemicals Rules, 1989
6 Manufacture, Storage and Import of Hazardous chemical (Amendment) Rules, 2000
7 Hazardous Wastes (Management and Handling) Rules, 1989
8 Bio-Medical Waste (Management and Handling) Rules, 1998
9 Batteries (Management & Handling) Rules, 2000
10 Ozone Depleting Substances (Regulation) Rules, 2000
11 The Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987
12 The Air (Prevention and Control of Pollution) Act, 1982
13 The Air (Prevention and Control of Pollution) Rules, 1982
14 The Tamil Nadu Air (Prevention and Control of Pollution) Rules, 1983
15 Noise Pollution (Regulation and Control) Rules, 2000
16 The Water (Prevention and Control of Pollution) Act, 1974 as amended in 1978 & 1988
17 The Tamil Nadu Water (Prevention and Control of Pollution) Rules,1983
18 The Water (Prevention and Control of Pollution) Cess Act, 1977 as amended by Amendment Act, 1991.
19 The Water (Prevention and Control of Pollution) Cess Rules, 1978
20 Factories Act, 1948
21 Tamilnadu Factories Rules, 1950
22 The Gas Cylinders Rules, 1981
23 The Indian Electricity Act, 1910
24 The Indian Electricity Rules, 1956
25 The Petroleum Act, 1934
26 The Petroleum Rules,1976
27 The Public Liability Insurance Act, 1991
28 The Public Liability Insurance Rules, 1991
29 Hazardous Wastes (Management and Handling) Rules,2000

Poor working conditions affect a worker's health and safety. Unsafe or unhealthy working conditions are not isolated to industries and can be anywhere. Whether inside or outside, the workshop workers may face many health and safety hazards. It also affects the environment of the workers. Occupational hazards have harmful effects on workers, their families, and other people in the community, as well as on the physical environment around the workplace.

The provisions made in as applicable to the Factories Act, 1948 (Act No.63 of 1948), as amended by the Factories (Amendment) Act, 1987 (Act 20 of 1987) are as follows:

Occupational safety and health

various sections provided in factories act, 1948 are under the following headings:

- Fencing of machinery
- Work on or near machinery in motion
- Employment of young persons on dangerous machines
- Striking gear and devices for cutting off power
- Self-acting machines
- Casing of new machinery
- Prohibition of employment of women and children near cotton-openers
- Hoist and lifts
- Lifting machines, chains, ropes and lifting tackles
- Revolving machinery
- Pressure plant
- Floors, stairs and means of access
- Excessive weights
- Protection of eyes

- Precautions against dangerous fumes, gases, etc.
- Precautions regarding the use of portable electric light
- Explosive or inflammable dust, gas, etc.
- Precautions in case of fire
- Power to require specifications of defective parts or test of stability
- Safety of buildings and machinery
- Maintenance of buildings
- Power to make rules to supplement this Chapter
- Cleanliness
- Disposal of wastes and effluents
- Ventilation and temperature
- Dust and fume
- Artificial humidification
- Overcrowding
- Lighting
- Drinking water
- Latrines and urinals
- Spittoon

Precaution to be followed while working in foundry

Objective: At the end of this lesson you shall be able to
- **list the precaution followed while working in foundry.**

- Shop safety rules
- Safety glasses with side shields or goggle are to be worn at the times while in the shop.
- No loose filling clothing are allowed.
- Two persons must be in shop to operate will unless authorized.
- Door must be open while using shop.
- All users must sign in before using shop.
- Users must clean up area used every time work is finished.
- Users must return all tools to proper location when finished.
- No tools one to remove from shop without permission
- No horse play allowed and do not distract anyone using equipments.
- Safety in the to top priority when using the shop.
- Never attempt to use equipments you have not received training on.
- Report any broken tools or machines immediately to main shop.

Basic understanding on hot work, confined space work and material handling equipment

Objectives: At the end of this lesson you shall be able to
- **state what is hot working**
- **brief confined space work**
- **state the material handling equipments.**

Hot work

Hot work is defined as forging, gas cutting, welding, soldering and brazing operations for construction, maintenance/repair activities.

Hot work fire and explosive hazards. Workers performing hot work such as welding, gas cutting, brazing, soldering are exposed to the risk of fires from ignition or flammable or combustible materials in the space, and from leaks of flammable gas into the space, from hot work equipment.

A confined space also has limited or restricted means for entry or exist and is not designed for continuous occupancy. It includes but are not limited to tanks, vessels, silos, storage bins, hoppers, vaults, pits, manholes, tunnels, equipment housings, duct work, pipelines, etc.

Materials handling equipment

Materials handling equipment is a mechanical equipment used for the movement, storage, control and protection / protecting of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal.

Different types of material handling equipment

- Tools
- Vehicles
- Storage units
- Appliance and accessories

Racks

Pallet racks, drive-through or drive-in racks, push back racks, and sliding racks.

Truck/Trolley

Conveyor system

- Fork lift
- Cranes
- Pallet truck

Lifting and handling loads

Objectives: At the end of this lesson you shall be able to
- **state the types of injury caused by the improper method of lifting and carrying loads and how to prevent them**
- **state the 6 points in the process of manual lifting methods.**

Many of the accidents reported involve injuries caused by lifting and carrying loads. An Electrician may need to install motors, lay heavy cables, do wiring, which may involve a lot of lifting and carrying of loads. Wrong lifting techniques can result in injury.

A load need not necessarily be very heavy to cause injury The wrong way of lifting may cause injury to the muscles and joints even though the load is not heavy.

Further injuries during lifting and carrying may be caused by tripping over and object and falling or striking an object with a load.

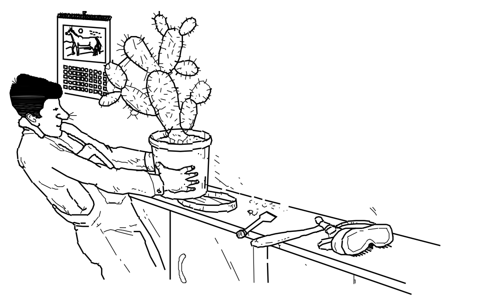
Type of injury and how to prevent them?

Cuts and abbrasions

Cuts and abbrasions are caused by rough surfaces and jagged edges:

By splinters and sharp or pointed projections. (Fig 1)

Fig 1



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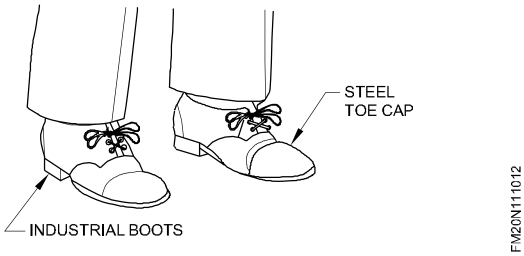
Leather hand gloves will usually be sufficient for protection, but the load should be checked to make sure of this, since large or heavy loads may invole body contact as well.

Crushing of feet or hands

Feet or hands should be so positioned that they will not be trapped by the load. Timber wedges can be used when raising and lowering heavy loads to ensure fingers and hands are not caught and crushed.

Fig 2



Safety shoes with steel toe caps will protect feet (Fig 2)

Strain to muscles and joints

Strain to muscles and joints may be result of:

- Lifting a load which is too heavy, or lifting incorrectly.

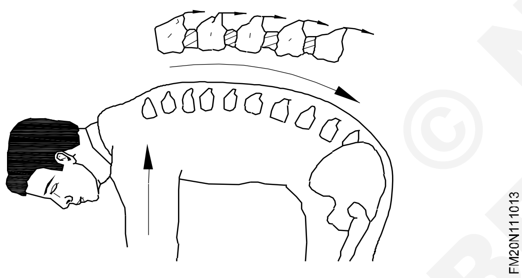
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

Stop lifting'-lifting from a standing position with the back rounded increases the chance of back injury.

The human spine is not an efficient weight lifting machine and can be easily damaged if incorrect techniques are used.

The stress on a rounded back can be about six times greater than if the spine is kept straight. Fig 3 shows and example of stoop lifting.

Fig 3



Preparing to lift

Before lifting or handling any load ask youself the following questions.

What has to be moved?

Where from and where to?

Will assistance be required?

Is the route through which the load has to be moved is clear of obstacles?

Is the place where the load has to be kept after moving is clear of obstacles?

Load which seems light enough to carry at first will become progressively heavier, the further you have to carry it.

The person who carries the load should always be able to see over or around it.

The weight that a person can lift will vary according to:

- Age
- Physique, and Condition

It will also depend on whether one is used for lifting and handling heavy loads.

What makes an object difficult to lift and carry?

1 Weight is not the only factor which makes it difficult to lift and carry.

2 The size and shape can make an object awkward to handle.

3 Loads high require the arms to be extended in front of the body, place more strain on the back and stomach.

4 The absence of hand holds or natural handling points can make it difficult to raise and carry the object.

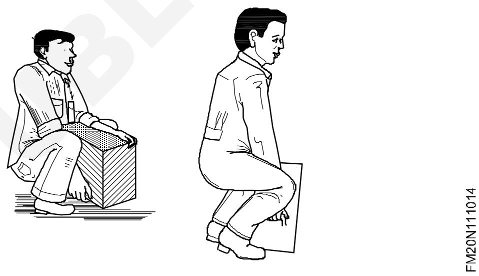
Correct manual lifting techniques

1 Approach the load squarely, facing the direction of travel

2 The lift should start with the lifter in a balanced squatting position, with the legs slightly apart and the load to be lifted held close to the body.

3 Ensure that a safe firm hand grip is obtained. Before the weight is taken, the back should be straightended and held as near the vertical position as possible. (Fig4)

Fig 4



4 To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones.

5 Look directly ahead, not down at the load while straightening up, and keep the back straight, this will ensure a smooth, natural movement without jerking or straining . (Fig 5)

Fig 5

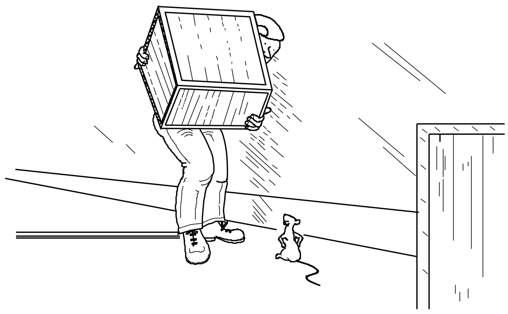
6 To complete the lift, raise the upper part of the body to the vertical position. When a load is nearer to an individual's maximum lifting capacity it will be necessary to lean back on the hips slightly (to counter balance the load) before straightening up. (Fig 6)

Fig 6

Keeping the load well near to the body, carry it to the place where it is to be set down. When turning, avoid twisting from the waist- turn the whole body in one movement.

Lowering the load

Fig 7



Make sure the area is clear of any obstructions. (Fig 7)

Bend the knees to a semi- squatting position, keep the back and head erect by looking straight ahead, not down at the load. It may be helpful to rest the elbows on the thighs during the final stage of lowering.

Moving heavy equipment

Objectives: At the end of this lesson you shall be able to
- **explain the methods followed in industry to move heavy equipment**
- **describe the procedure to be followed for moving heavy equipment on layers and rollers**
- **list the safety consideration while raising a load and moving a load.**

Heavy equipements are moved in industry using any of the following methods.

- Crane and slings
- Winches
- Machine moving platforms
- Layers and rollers

Using crane and slings

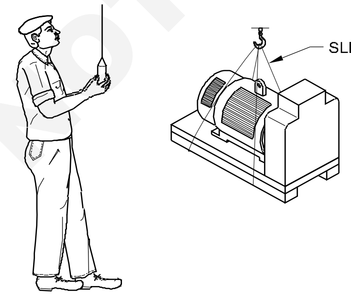
This method is used whenever loads are to be lifted and moved. (Fig 1)

Examine the steel rope sling for any cut, abrasion, wear fraying or corrosion.

Damaged slings must not be used.

Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 1)

Fig 1



Keep the slings as near to vertical as possible.

Winches

Winches are used to pull heavy loads along the ground. They may be power-driven (Fig 2) or hand operated. (Fig3)

Fig 2

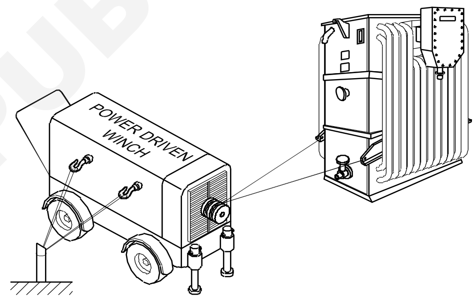
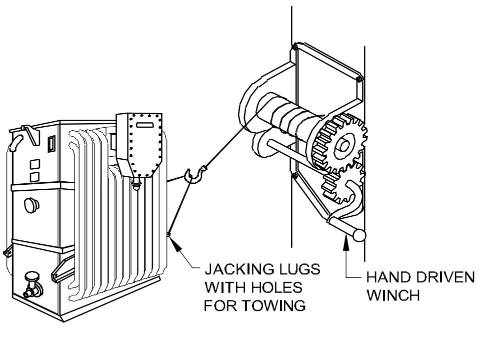


Fig 3



Ensure that the safe working load (SWL) of the winch is adequate for the task.

Secure the winch to a structure which is strong enough to with stand the pull.

Ensure that the safe working load (SWL) of the Winch is adequate for the task.

Secure the Winch to a structure which is strong enough to withstand the pull

On open ground, drive long stakes into the ground and secure the winch to them.

Choose a suitable sling and pass it around the base of the load. Secure it to the hook of the winch.

Some heavy items have special legs welded to them for jacking and towing purposes.

Safety consideration

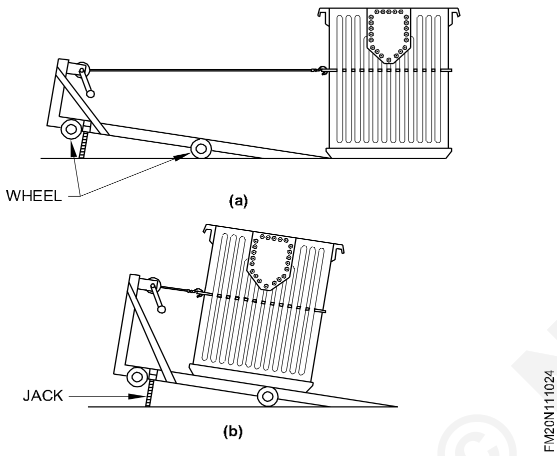
Before using any winch, check that the brake and ratchet mechanism are in working order. Practise how to use the brakes.

Keep hands and fingers well away from the gear wheels.

Keep the bearings and gears oiled or greased.

Machine moving platforms: This is a special device made to move heavy equipment in industry. Fig 4 shows the method of loading a heavy transformer.

Fig 4



Pass a suitable sling round the load at a convenient height.

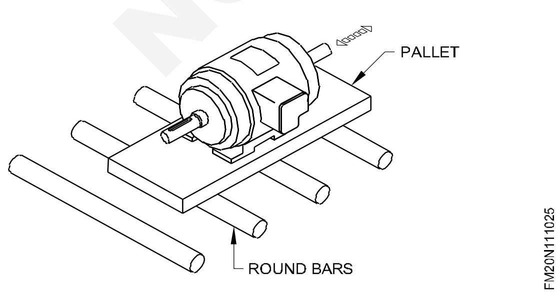
Attach the sling to the hook of the winch and draw the load on the platform until its centre of gravity lies between the front and rear wheels.

Lower the jacks so that the platform rests on its wheels.

For unloading follow the procedure in the reverse order.

Using layers and rollers: Sometimes a load cannot be moved along the ground because of the irregular shape of its base or because it is not rigid enough. Place such a load on a flat-bottomed pallet or 'layer' resting on the round bars. (Fig 5)

Fig 5



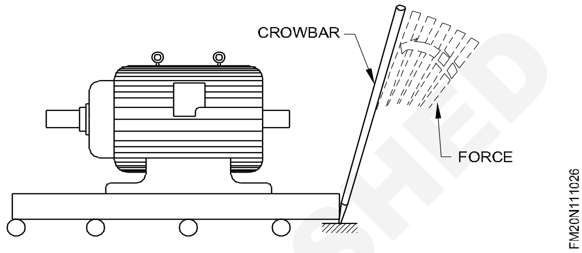
Ensure the bars (rollers) are long enough to project at each side of the load, for ease of handling.

They should be large enough to roll easily over any uneven surface along the route but should be small enough to be handled easily.

Two or three bars of equal diameter are sufficient for most loads but if four or more are used, the load may be moved faster as there is no delay when moving the rear bar to the front. (Fig 5)

Move the load by using a crowbar as shown in Fig 6. Keep the crowbar at the end of the pallet with an angle and a firm grip on the ground. Apply the force at the top of the bar as shown.

Fig 6



Caution

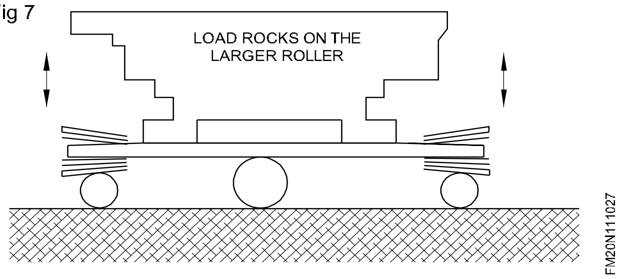
When a load is on rollers, only shallow slopes can be negotiated.

Hold the load in check all the time if it is on the slope.

Use a winch with an effective brake for this operation.

To negotiate a corner on rollers: For a moderate load, insert one roller a little larger in diameter than the others as the corner is approached. When this roller is under the centre of gravity of the load, the load can be rocked to and fro on the roller and swiveled around sideways. (Fig 7)

Fig 7



For heavier loads: Stop the load on the roller at the beginning of the corner.

Twist the load round on the rollers by pushing the sides with crowbars until the load is just over the ends of the rollers. (Fig 8)

Place some rollers at an angle to the front of the load. (Fig 9)

Push the load forward on to these rollers.

Twist the load further round and place the freed rollers in front of and at an angle to the load.

Continue until the load is pointing in the desired direction.

Fig 8

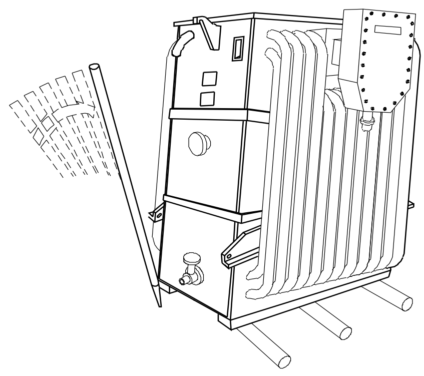
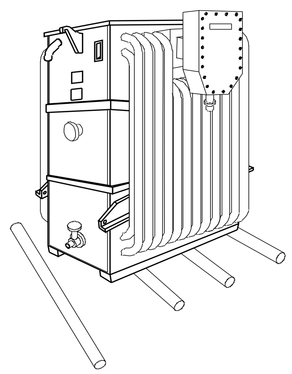


Fig 9



Safety consideration

Moving heavy loads with crowbars or jacks

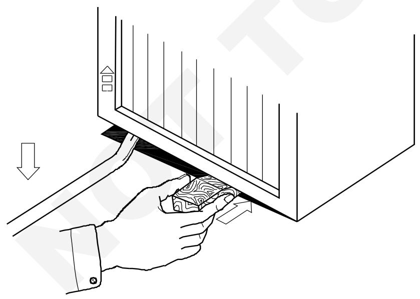
Make sure your hands are clear of the load before lowering it on to the packing or rollers.

Do not use your hands underneath the packing when positioning it. Use a push block.

Place the packing on the floor and push it under the load. (Fig 10)

Hold it by its side faces keeping the fingers well away from the lower edge of the load and from the floor. (Fig 10)

Fig 10



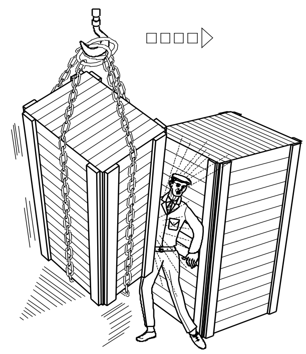
Raising a load: Check that the slings are correctly secured to the load and to the hook. Ensure they are not twisted or caught on a projecting part of the load.

Before starting to lift a load, if you cannot see an assistant on the far side of the load, verify that he is ready to lift the load and ensure that his hands are clear of the slings.

Warn nearby workers that the lifting is about to begin.

Lift slowly: Take care to avoid being crushed against other objects as the load rises. (Fig 11) It may swing or rotate as it leaves the ground.

Fig 11

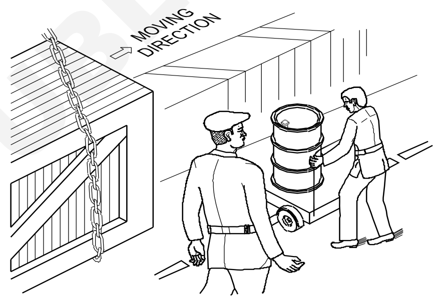


Minimize such movement by locating the hooks as accurately as possible above the centre of gravity of the load.

Keep the floor clear of unnecessary objects.

Moving a load: Check that there are no obstacles in the way of the crane and load. (Fig 12)

Fig 12



Stand clear off the load and move it steadily.

Be prepared to stop the load quickly if somebody moves into its path. Allow for the natural swing of the load when changing speed or direction.

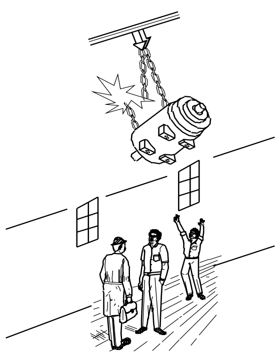
Ensure that the load will not pass over the head of other people. (Fig 13)

The tackle or sling may fall or slip.

Warn other workers to stand clearly away from the route of the load.

Remember that accidents do not happen, they are caused.

Fig 13



History of Foundry

Objectives: At the end of this lesson you shall be able to
- **state the History of foundry**
- **explain the safety precaution to be absorbed in foundry shop.**

History of Foundry

Foundry engineering deals with the process of making casting in moulds formed in either sand or some other suitable materials. In this foundry Engineering is one of the oldest manufacturing process which dates back to approximately 4000 BC. The manufactured and use of casting can be traced both is ancient and medieval history.

Even in pre-historic times as per back as 5000 BC. Metallic objects (or) components in the form of knifes, coins arrows and house hold articles were in use as observed from the excavations of MOHANJADARA AND HARAPPA. Earlier casting were probably made out of Gold, Copper, Silver Bronze etc. Particularly they are made in religious upheavals and metals began to be used for status of god and goddesses. Bronze was still the most popular metal. Subsequently, a still greater application of metals figured in armory, guns and war materials.

The first foundry center came into existence in the days of the Shang dynasty (1766-1122 BC) in China.

In about 1540, VINNOCCIO BIRINGUCCIO wrote on metal founding. He was the first true foundryman. In 1730 Mr.Shri.ABRAHAM DARBY got succeeded in smelting in the coke blast furnace and this opened a route for the massive use of cast iron in construction.

John Wilkinson of England has invented the cupola furnace in 1794.

1 Foundry Industry started approximately 4000 years ago.

2 First metal found in Black sea area at Russia.

3 In the early day's the people of this area use the forged weapons of copper and by chance they melt the stage of casting copper articles.

4 Gold was known before, but due to large availability, copper was cast first.

5 Open moulds are first made in sand, stone chips and the clay to produce the shape of cast articles for the tools of war and agriculture.

6 Melting was done in clay lined hole in the ground then this was done in refractory lined hollow log. After that the permanent melting furnaces are developed gradually.

7 In China, the foundry man began the casting of iron about 600 BC.

8 In India, cast sheet was first produced about 500 BC. It was later discovered and rediscovered in England.

9 Closed moulding process developed in Eg.

10 In the middle age period blast furnace for smelting the ore, reverberatory furnace for smelting the non-ferrous ores. In this period has developed the loam moulding.

11 The first true foundry man "Mr.Vanacio Binigucco" was in the middle age period and he was started and produce Gun Barrels. "Mr.Vanacio" is the father of foundryman. He is an American.

12 In 1730, Abraham Darby of England introduced coke as fuel for foundry for industry.

13 In 1794. Mr.John Wilkinson of England (produced) Discovered cupola furnace for melting iron.

14 The first foundry in the new world was established about 1642 in America.

Safety in Foundry Shop

The action with causes for avoiding the accident, fall under same rules. They are called as a safety rules (or) safety precautions. It is not planned, it happened due to unsafe action.

They are classified as three groups:

1 Personal Safety Precautions.

2 General Safety Precautions.

3 Section Safety Precautions.

1 Personal Safety Precautions

Do not try to lift excessive weight

- Must be careful while working under welding, grinding and furnace operation (Take that Safety dress also).
- Do not use loose and torn out garments.
- Do not use Watches; Rings and ties while working.
- Do your work, before plan it one.

2 General Safety Precautions:

- We must be careful every time - Carelessness is main reason for accident.
- Do not walk-bare footed in work shop
- Do not use Loose and torn out garments.
- Must be careful while working under ladder and wet ground.
- Hammer handle should not be loose, too long or short
- Do not use file without handle.
- Do not use Mushroomed headed chisel.

Development of foundry in India

Objectives: At the end of this lesson you shall be able to
- **state the development of foundry inductor**
- **list out the large foundry in India.**

The Indian foundry industries in well established according to the recent world censor of castings long modern castings, USA India rank an 2nd largest casting producer producing estimated 7.44 million MT of various grader of castings a per international standards. There are approx. A 500 units out of which 80% can be classified as small scale units and 10% each as medium and large scale units. Approx 500 units are having international quality.

Large foundry industries in India

- Electro steel castings ltd
- Rail wheel factory
- Nel cast ltd
- Hinduja Foundries
- Jayaswals neco ltd + Neco castings
- TATA motor's jamshedpur
- Ashok iron works
- Brakes India Ltd
- DCM engineering products.
- Indo shell mould ltd.

Types of Foundry

Objectives: At the end of this lesson you shall be able to
- **state about the types of foundry**
- **state the development of foundry**
- **state the sand formation.**

Types of Foundries

Foundries are classified according to the nature of work. They undertake any frame of work of their organization. Foundry may be classified as following:-

A Captive Foundry:

It is an integral part of some manufacturing organization. It makes casting for the own use only and all the castings made in a captive foundry are consumed mainly in the products, being manufactured by the organization.

Jobbing foundry:

Normally products small numbers of casting of a given type for different customers, such foundries sometimes also having facilities for mass production.

Production Foundry:

It's highly machanised and can produce casting economically on mass scale.

Semi-Production Foundry

It's a combination of jobbing and a production foundry as regards its nature of work is concerned. In other word's a semi production, foundry accepts both production and job work.

Foundries nay also be classified as two groups:

1 Ferrous Foundry.

2 Non-Ferrous Foundry.

1 Ferrous Foundry:

- Steel Foundry.
- Gray Iron Foundry.
- Malleable Foundry.
- Ductile Iron Foundry.

2 Non-Ferrous Foundry:

- Aluminium and Magnesium, foundry Alloy (or) light metal foundry.
- Copper, Brass and Bronze Foundry.
- Lead, Tn and Zinc Base Foundries.

Foundry Development in India

At about 500BC survey of Indian history shows Madhya Pradesh was having about 234 Blast furnaces. In India addition to that Bengal, Orissa, Rajasthan and Tamil Nadu states also having Blast furnace. In 1830. India started manufacturing iron ore in commercial level. Steps had been taken to manufacturing Iron and steel at (POOTHANOR) North Arcot District.

In 1875 Barker Iron and steel company started Manufacturing iron and steel in Bengal.

In 1907 TATA Iron and steel Company started Manufacturing iron and steel. Later Indian Iron and Steel Works, Mysore iron and steel Works and Hindustan Iron and Steel Works were started manufacturing Iron and Steel.

Formation of Sand

Introduction

Sand is the basic principle of Moulding Materials used by foundry men, wheather it is for iron, steel, non-ferrous or light alloys casting.

Moulding Sand

The moulding sand is the mixture of heat resisting sand and clay made from silica sand and water, all the sand is located and formed by breaking up of rocks due to the action of natural forces such as wind, rain, heat, thunder, lightning and water current.

Wind Blow

When the wind blow it take the atone particles from one place to another rolling of small quartz changes into sand.

River Sand

Due to the action of water on rocks cutting them small particles and forming them into sand grains. It is sharp grains.

Lake Sand

Generally, it is found grains and pure.

River Mouth Sand

It consists of sand clay. It is good for moulding. This is natural moulding sand. The sand used for moulding is just natural sand formed along river banks or on lake beds. Generally mixed with clay, lime, Magnesium and potash. Iron oxide and coal dust, in small quantity.

Composition of Moulding Sand

The Composition of moulding sand is given by many chemists 90% to 90% of Silica sand 6% to 10% of clay (Alumina) and small percentage of alkali substances which reduces the melting point of Silica sand, clay which is intermingled with them.

Lime is the most common one of the Moulding sand. Sand is less in quantity and it has got greater effects in reducing the melting point, to make a successful casting. The Foundry men use some suitable composition. If the clay percentage in the moulding sand is increased, therefore the strength of the moulding sand is increased and the porosity of the sand decreased.

Advantages of Metal Castings

Objectives: At the end of this lesson you shall be able to
- **state advantages of metal castings**
- **state the casting in manufacturing in foundry.**

Advantages of Metal Casting

Casting is one of the most versatile manufacturing processes. It provides the greatest freedom of design in terms of shape and desired size and the product quantity. Casting imparts uniform directional solidification properties and better vibration damping capacity to the cast parts. A product may be cast as some solid piece (or) Block, thereby eliminating the need of material joining process, which or otherwise difficult to get fabricated may the cast.

The growing demand of high precision casting and the intricate design at lower costs has helped considerably in the development of foundry industry

Importance of Foundry

The following industries demand on high precision casting of indicates designs of lower cost. It helps the important and development of casting process

The transport vehicle has got more than 70% cast compounds and other requirements got more than 70%

1 Machine tool beds.

2 Turbine vanes.

3 Power Generator.

4 Railway engine and track.

5 Air craft industry.

6 Agricultural (Requirement) equipments.

7 Sanitary fitting.

8 Pump fitter and valve.

9 Sugar, cement and cotton mills machinery parts.

Communication, construction and atomic energy application depends upon foundry industry. Hence the Foundry get an important role in engineering fields.

Tools, Equipments & Raw materials

Objective: At the end of this lesson you shall be able to
- **list out the raw materials used in foundry.**

Raw Materials for Foundry.

Raw materials for foundry are:

(a) Metals and alloys

(b) Fuels (for melting metals)

(c) Fluxes

(d) Refractories.

(e) Metals and alloys commonly used in foundries

Metals exist in the crust of the earth as metal oxides, sulphides and carbonates in the form of ore. The ore is smelted to obtain metals and alloys in comparatively purer form in which they can be used for casting purposes.

Casting metals and alloys can be classified under two main headings.

(a) Ferrous

(b) Non-ferrous

(c) Ferrous:

1 CAST IRONS:

a) Gray cast Iron

b) Malleable cast Iron

c) Ductile or Nodular (spheroidal) cast Iron

d) White Cast Iron

2 STEELS:

a) Plain carbon steel

b) Low alloy steel

c) High alloy steel including heat resisting, and

d) Stainless steels

b) Non-Ferrous:

a) Copper alloys

b) Aluminum alloys

c) Zinc alloys

d) Nickel alloys

Fuels for melting metals

1 Coal

Characteristics - (i) Bituminous coal of long flame type.

(ii) Powdered, anthracite lump or in the form of briquettes.

Metal to be melted : Cast Iron

Furnace used : Cupola, Air furnace and Rotary Furnace (pulverized coal).

2 Coke

Characteristic. **(i)** Inferior type is used for beating mounds and cores.

(ii) Hard coke which is a superior brand is used in Blast furnaces and Cupolas. It should contain less than 1% S, and less than 10% of ash.

Coke should be dry (with less than 0.2% moisture). It should have an above 90% fixed carbon.

It should not shatter owing to rough handling during trans potation or while it is burning in a cupola under a lot of weight of cupola charge (pig iron, fluxes etc.)

Not more than 5% of the hard coke should have size less than 50mm.

Metals to be melted and the furnaces to be Employed.

(i) Hard Coke is used for melting cast Iron in cupola.

(ii) Hard coke is used for melting non-ferrous metals in crucible furnaces.

3 Gas

(i) Coal gas is used for melting non-ferrous metals in crucible furnaces.

(ii) Raw producer gas is used for melting steel in open hearth furnace.

4 Oil

(i) Oil is used for melting non-ferrous metals in crucible furnaces.

(ii) Oil is used for melting iron, steel in open hearth furnace.

(iii) Oil is used in rotary furnaces.

5 Electricity.

(i) It is expensive as compared to other fuels.

(ii) The use of electricity keeps furnace neat and clean.

(iii) Electric furnaces normally can operate up to 1700°C.

(iv) Electric-Induction type furnaces can melt almost all foundry metals.

(v) Electric-resistance heating furnaces are used for melting non-ferrous metals.

(vi) Electric-Direct Arc furnaces operating upon, two or three phases are used for melting cast iron and steel.

(vii) Electric-indirect Arc furnaces are employed for melting cast iron and non-ferrous foundry metals and their alloys.

Fluxes

Definition and concept.

(i) A flux is a low melting point material.

(ii) When heated up, it melts and combines with ash, viscous slag, sand, metallic oxides etc., and makes a fluid and easy flowing slag.

(iii) This slag being lighter comes on to the surface of the molten metal from where it can be easily skimmed, tapped or removed before pouring the metal into the mould.

(iv) Slag protects molten metal from furnace atmosphere.

Types of Fluxes

(i) Limestone is used as a flux in cupola when melting cast Iron

(ii) Sodium carbonate when used with limestone as a flux in cupola gives rise to a slag which can remove sulphur from cast iron.

(iii) Nitrogen, Helium and Chlorine are used as gaseous fluxes in aluminum foundry for removing dissolved hydrogen and the entrapped dross. Dross consists of oxides of aluminum, magnesium, silicon, copper etc. which may float on the surface of molten aluminum or sink, depending upon their specific gravity.

Fluxes separate molten metal and dross.

Besides gaseous fluxes, solid fluxes of some compositions of chlorides of aluminum and zinc are also employed to separate metal and dross. Solid fluxes are easy to use as compared to gaseous ones.

(iv) Flux used for melting Magnesium alloys consist of KCl2 Mgo, MgCl2, CaF2, BaCl2 and MnCl2.

Besides other functions, fluxes prevent the burning of magnesium alloys. Nitrogen (gaseous flux) may be bubbled slowly through the molten magnesium for removing hydrogen.

(v) In copper-alloy foundry practice, charcoal is used to prevent the molten metal from being oxidized, and some commercially available fluxes may be employed to cleanse the metal ie., to separate it from dross.

Refractories

Introduction

(i) Refractories are heat resistant materials.

(ii) They can withstand high temperatures without being fused.

(iii) Crucibles and furnace sides and bottoms containing molten metal are made up of refractories.

(iv) Refractories are used as ladles for pouring metal into the mould.

(v) Refractories constitute furnace walls and roof and thus minimize heat losses.

(vi) The main constitute of foundry refractories are MgO, SiO2, Al2O3 and their mixtures.

(vii) The newer refractory materials are magnesia and zirconia. Properties.

(i) Refractories should be heat, corrosion and abrasion resistant.

(ii) They should possess high fusion temperatures.

(iii) They should possess low thermal coefficient of expansion.

(iv) They should not have chemical affinity with the molten metal they hold.

(v) They should be able to withstand high temperatures and pressures (due to the weight of the molten charge).

(vi) They should possess heat and electric insulating properties.

Classification. Refractories may be grouped into following three categories.

1 Acid Refractories.

2 Basic Refractories.

3 Neutral Refractories.

1 Acid Refractories. They are

Type	Approx. fusion Temperature
(i) Silica	
(ii) Aluminum silica	$(46\% Al_2O_3+54\% SiO_2)$
(iii) Alumina	(Al_2O_3)
(iv) Silimanite	$(63\% Al_2O_3+37\% S_1O_2)$
(v) Basic Refractories.	They are
(i) Magnesia	

Bauxite and dolomite are also basic refractories.

Neutral Refractories

(i) Chromite

(ii) Graphite

Refractory materials

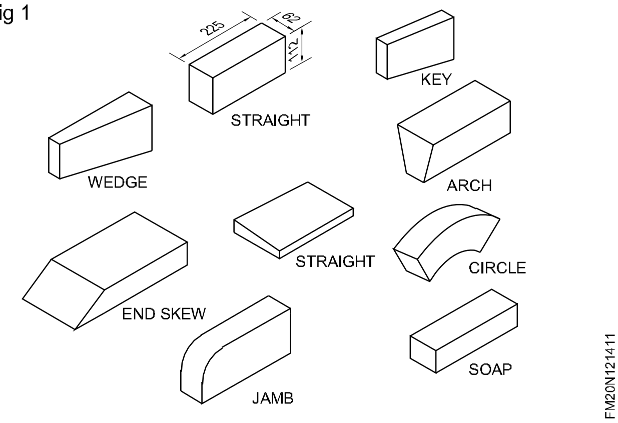
(i) Refractories are obtained from ores of Silica or those of Silica and Alumina.

(ii) After mining or chemical production and claiming. refractory materials are crushed, ground and prepared to size. They are then mixed with other materials and shaped as bricks (Fig 1) bricks are used for lining melting and other furnaces. Bricks of acid basic and neutral refractoriness and of different shapes are available for furnace construction.

(iii) Bricks during construction work are bonded and cushioned with the help of a mortar consisting of chrome, silicon carbide, silica and alumina. mortar may be specified by the brick by the brick manufacturer.

(iv) Brick work may be coated with thin mortar for further protecting the same during furnace operation.

Fig 1



Specification tools equipments procedure of use of different tools and equipment.

Objectives: At the end of this lesson you shall be able to
- **state about hand tools**
- **list out the type of tools**
- **explain the type of tools and uses.**

List out the types of tools:

- Measuring and marking tools
- Cutting tools
- Moulding hand tools
- Casting hand tools
- Fettling tools
- Special tools.

Explain the types of tools

Measuring and marking tools.

Generally a job should be done by measuring and marking purpose using the tools called as measuring and marking tools.

Example: Outside caliper, inside caliper, steel rule, divider, try square, Four -fold wooden rule.

Cutting tools:

An unwanted portion of the job should be cutting (Removed) by using the tools are called as cutting tools.

Example: flat chisel, diamond point chisel, cross cut chisel, hack saw frame.

Moulding hand tools:

In hand moulding process all the operations are performed by hand in the tools are called as moulding hand tools.

The following are the moulding hand tools.

1 Trowel
2 Cleaner
3 Rammers
4 Vent wire
5 Draw spike
6 Draw screw and rapping plate
7 Leveller
8 Spirit level
9 Hand bellow
10 Foundry brush
11 Mallet
12 Swab
13 Gaggers
14 Hand showel
15 Sprue pegs
16 Mirror
17 Four -fold wooden rule
18 Brass rule
19 Riddle
20 Water sprinkler
21 Smoothers
22 Hammers
23 Calipers
24 Blow lamp (or) Air stove
25 Dust bag and spray gun
26 Spray gun
27 Gate cutter

1 Trowels

IT is used to finish flat surface of the mould, cut ingrate, make joints (or) parting and repair moulds.

It should be prepared by steel plate on blade and welded by handle of the shoulder, in that shoulder obtain the wooden handle also. (Fig 1)

Example

They are different types of trowels have been used by moulding work square narrow, tapper, long heart and broad heart trowels.

2 Cleaner (or) lifter

It lifts dirt (or) loose sand from the mould and used for repairing and finishing the sand mould cavity.

3 Rammer

It is used to ram the moulding sand in and around the flask. Sit is mainly divided into many types are is peen wedge.

(i) Peen rammer
(ii) Hand rammer
(iii) Floor rammer
(iii) Flat rammer

Fig 1

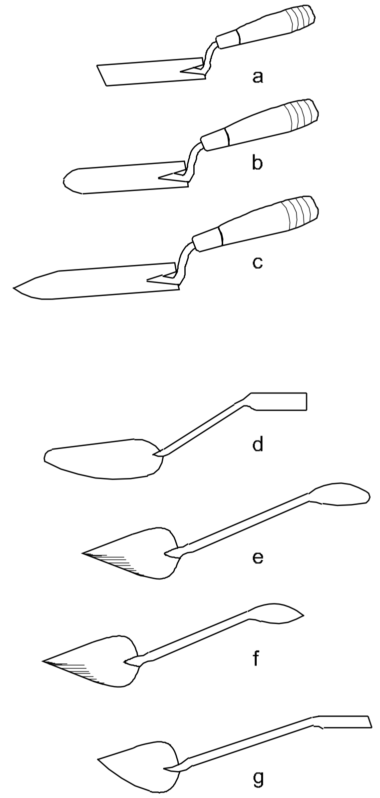


Fig 2

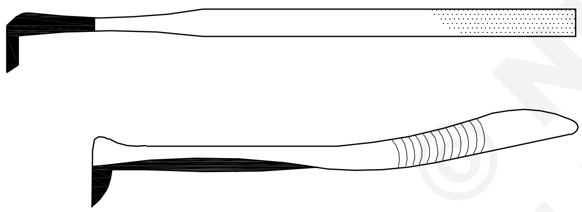
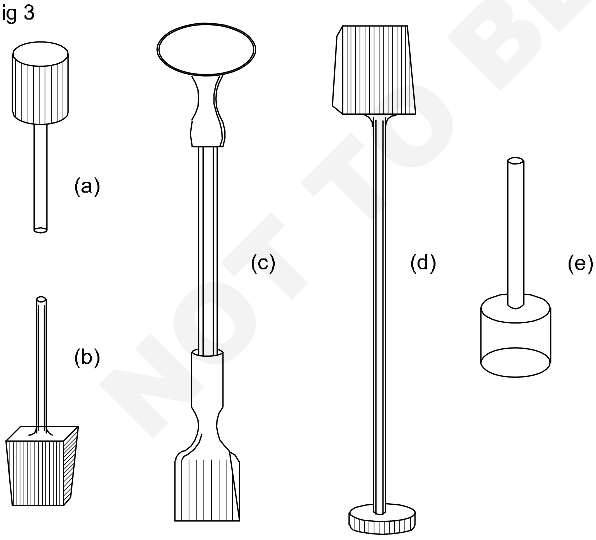


Fig 3

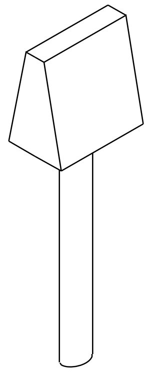


Peen wedge rammer: It is useful for ramming sand in pockets and corner (Fig 4)

It is useful after ramming the pockets and corners also and finally use levelling the top of the box.

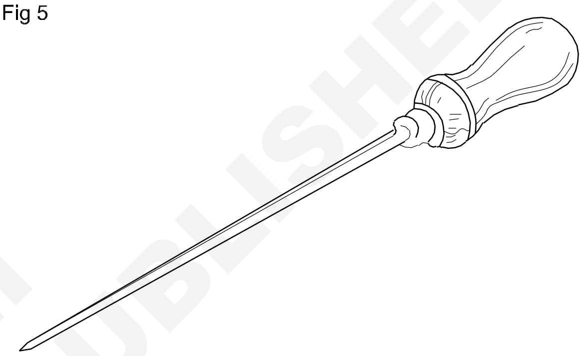
Both the rammers are also made by M.S.

Fig 4



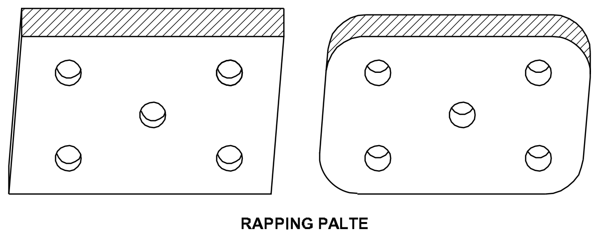
Vent wire: It is spiked tool fitted with a handle. It is used for perking holes in the rammed sand to permit easy escape of mould gases generated during pouring. (Fig 5)

Fig 5



Rapping plate: A rapping plate is used for lift the large and heavy pattern from the mould. It is a steel plate and firmly fixed to the top of the pattern by means of bolts and screw. Rapping plates are available in many shapes (Fig 6)

Fig 6



Draw spike: It is sharp pointed tapered metal rod with when driven into a pattern embedded in the sand, can rap and draw the pattern from the mould. (Fig 7)

Draw screw: Draw screw it has a loop at one end and screws at another end. they are used to draw big pattern from the mould. (Fig 7)

Leveller (Or) Strike off Bar:

It is wooden (or) metal bar having one edge beveled.

It is used to remove excess sand from the top of a rammed moulding box, thereby making surface plane. (Fig 8)

Sprit level: It is used to check whether the sand bed or moulding box horizontal plane (or) not. (Fig 9)

Fig 7

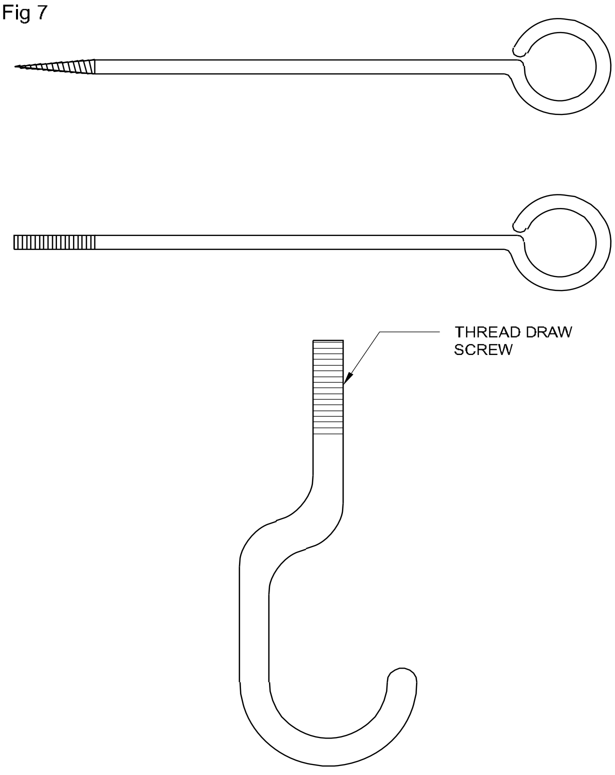


Fig 8

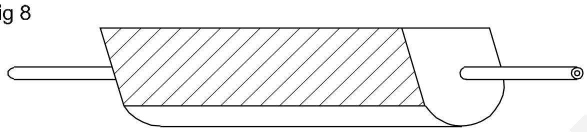
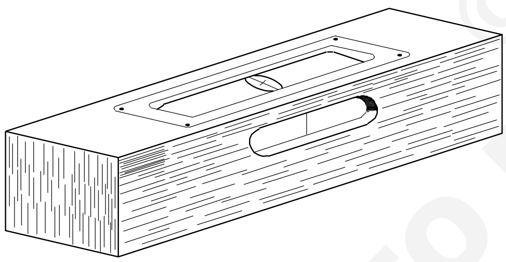
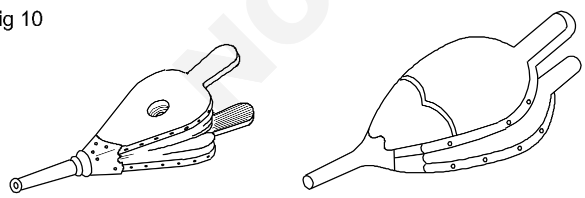


Fig 9



Hand bellow: A bellow is used to blow loose sand particles from around the pattern and the mould cavity. (Fig 10)

Fig 10

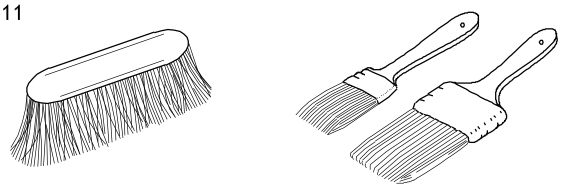


HARD BELLOW

Foundry brush: A brush is used sweep away the dust etc. from the pattern (or) parting sand from the moulding joint . (Fig 11)

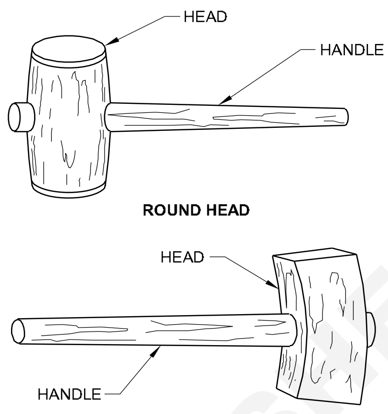
Mallet: It is a wooden hammer, both face has flat on the surface of face with handle. (Fig 12)

Fig 11



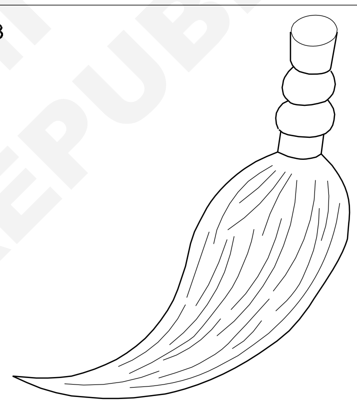
BRUSHES

Fig 12



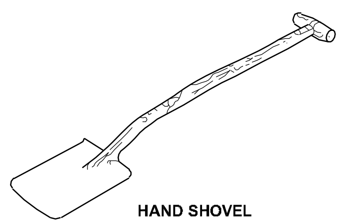
SWAB: It is flax (or) hemp fiber brush. It is used for moistening the sand around a pattern. (Fig 13)

Fig 13



Hand shovel: An shovel is used to transfer moulding sand from pile to the place of use. Mix and temper the moulding sand, its steel plate to be made so should be kept clean. (Fig 14)

Fig 14



HAND SHOVEL

Sprue pegs: It's tapered wooden rod which is placed in cope while the cope is being rammed. (Fig 15)

The long cavity thus left is called sprue through which the molten metal is poured so as to reach the mould cavity.

Mirror: It is normally household appliance used to clean the deep mould cavity to reflect the lighting purpose and also find out the internal cracks of the mould cavity. (Fig 16)

Fig 15

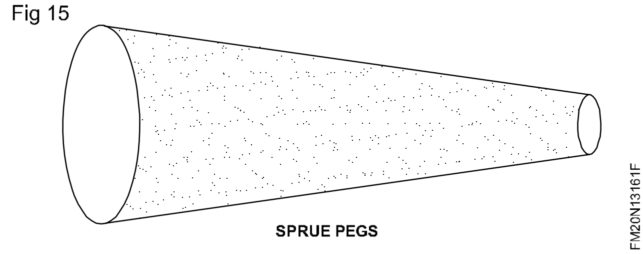
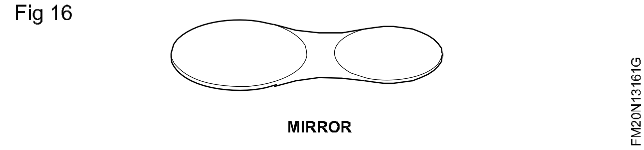
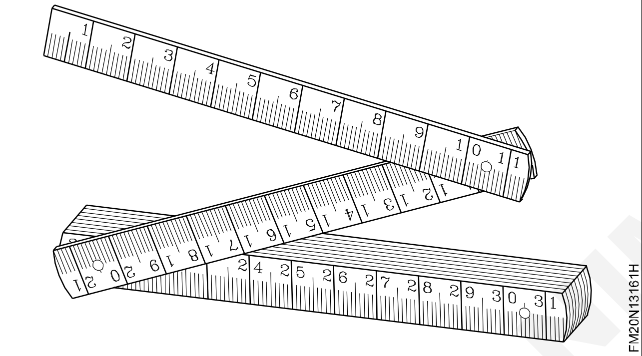


Fig 16



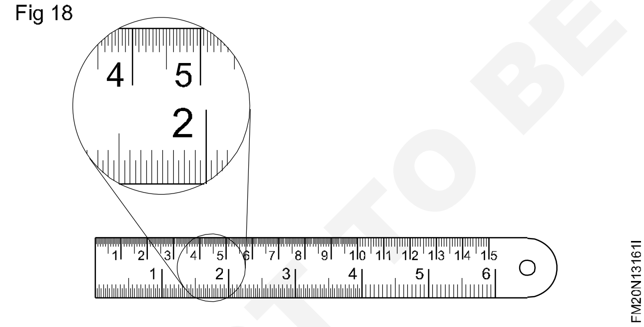
Four- fold wooden rule: It is measuring scale. In this scale folding by 4 equal place. It is total measurement is covered by 1 feet. (Fig 17)

Fig 17



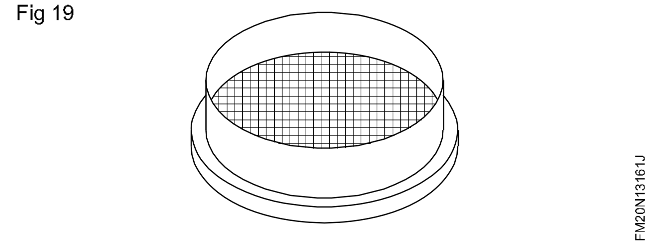
Brass Rule: In this a simply a strip of fairly head braes accurately machined and marked. (Fig 18)

Fig 18



Riddle: It is made out of wire (or) metal screen with wooden frame according to the area of the holes of the wire mesh the sieve are classified with numbers such as No. 8,12, 20, 40, 80, 120, 150, 300 etc. sieves are used to sieve the sand and other moulding materials in the foundry. (Fig 19)

Fig 19



Water sprinkler: It is help of mix and tempers the moulding sand by sprinkling the water. It is consist by G.I. sheet. (Fig 20)

Smoothers: these are made out of metal sheet, these are available in different shape and size, according to the shape and the place of use these are called as, egg smoother, smoothers round corner, smoother square comer etc. These are used to repair and finish the intricate shape places of the mould cavity. (Fig 21)

Fig 20

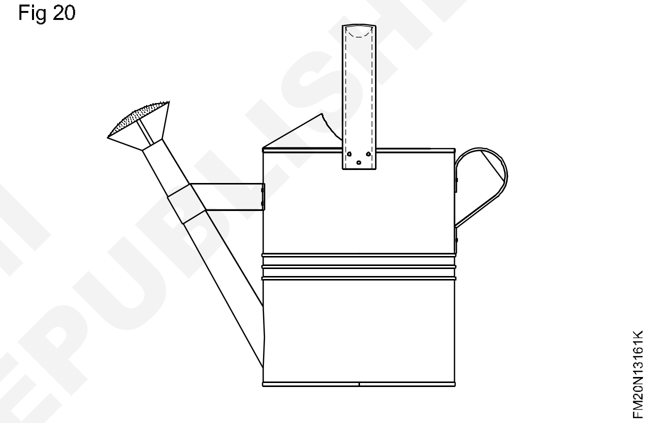
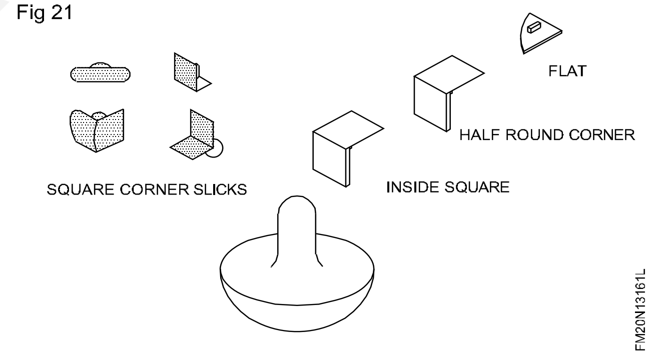


Fig 21

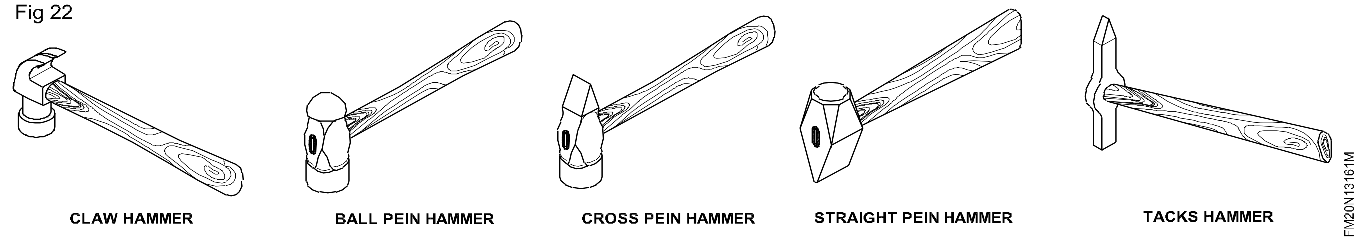


Hammer: It's several types are used in foundry work.

(Fig 22)

E.g. Sledge hammer, Ball peen hammer etc.

Fig 22



Calipers: It is an indirect measuring tools, they are outside caliper, inside caliper. (Fig 23)

Dust bag: It is used for dusting parting compound on the parting surface etc. (Fig 24)

Fig 23

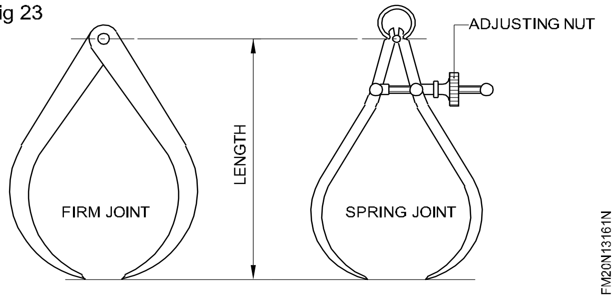
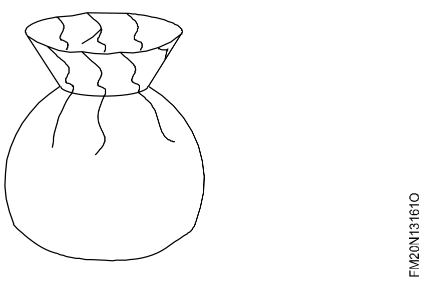
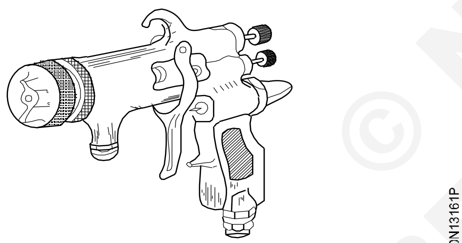


Fig 24



Spray gun: It is used to spray coating materials on mould and core. (Fig 25)

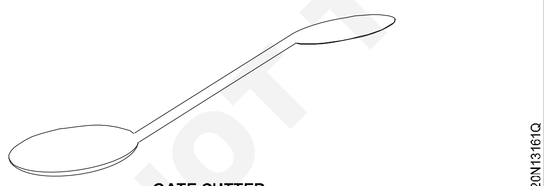
Fig 25



SPRAY GUN

Gate cutter: it is a shaped piece of sheet metal it is used to cut the gate runner etc., (Fig 26)

Fig 26

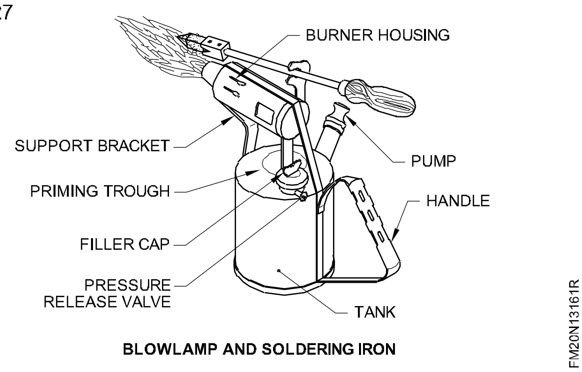


GATE CUTTER

Blow lamp or air stove: it is used for applying heat to mould cavity and core surface for dry the mould or core. (Fig 27)

Ladle: Ladles are used to carry the liquid metal from the furnace of the mould. Ladles are made with M.S. sheet. Inside is lined with refractory materials. Beaks are provided for the easy pouring shanks are provided for the easy handling and pouring.

Fig 27



BLOWLAMP AND SOLDERING IRON

According to the provision of pouring arrangement ladles are classified into three groups.

1 Lip pouring ladle

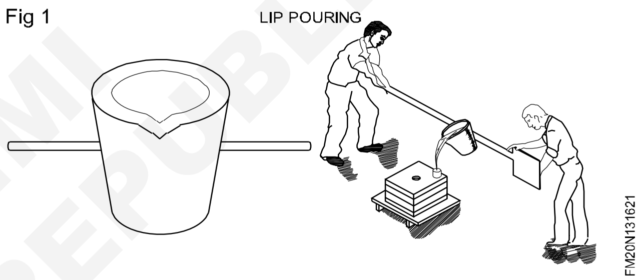
2 Tea pot pouring ladle.

3 Bottom pouring ladle.

1 LIP Pouring ladle

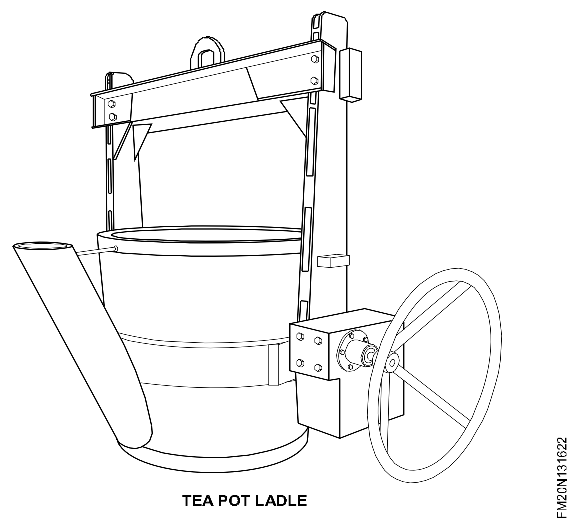
In the lip pouring ladle beaks are arranged and pouring is done through the beak. it is difficult to control the slag while pouring the metal from this ladle.

Fig 1



2 Tea pot pouring ladle

Fig 2



TEA POT LADLE

A second hole provision will be made at the side just like tea pot and metal will be porured through this hole. while tilting the liquid metal enters into the pouting hole (tea pot) through the side of the bottom only pure moullten metal cornes out and trapping the slag is easy.

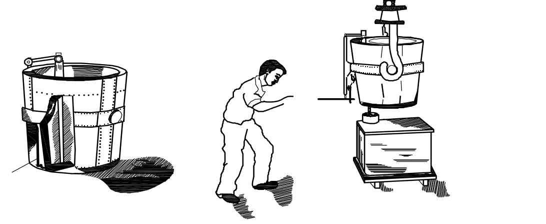
3 Bottom pouring laddle

In this type of ladle the pouring hole will be arranged at the centre of the bottom. The opening end closing of this hole will be controlled by a conical refractory plug attached to a refractory rod which is controlled by a lever.

Generally the refractory plug and rod are made out of graphite (or) carbon. Since the metal possess through the bottom of the ladle the slag will be perfectly trapped. (Fig 3)

Fig 3

BOTTOM POURING



According to the handling provision (shank) ladles are again classified into three groups.

1 Hand ladle (or) One man ladle

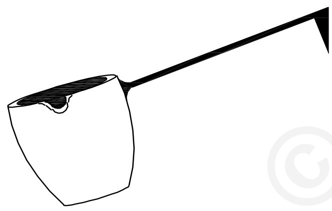
2 Bull ladle (or) Two man ladle

3 Crane ladle

1 Hand ladle (or) one man ladle

One man ladle is also called as Single shank ladle. It is very small ladle which will be carried by one person and it will have one side shank. (Fig 4)

Fig 4



ONE MAN LADLE

2 Bull (or) two man ladle (or) shank ladle

It will have the shank on both sides and it will be carried by two persons. Medium size ladles are made with this position.

3 Crane Ladle

In large ladles, provision are made to lift it by crane, there will be a steering and gear system for the moments of the ladles.

The refractory lining in the ladle can be with fire clay and silica sand as monolithic lining to the small ladles. Refractory brick linings are given to the large ladle. After brick linings, the inside surface is plastered with the fire clay and silica sand to obtain a gap free surface. After the lining and plastering the surface it is to be coated with facing materials.

Sand Muller (Fig 5)

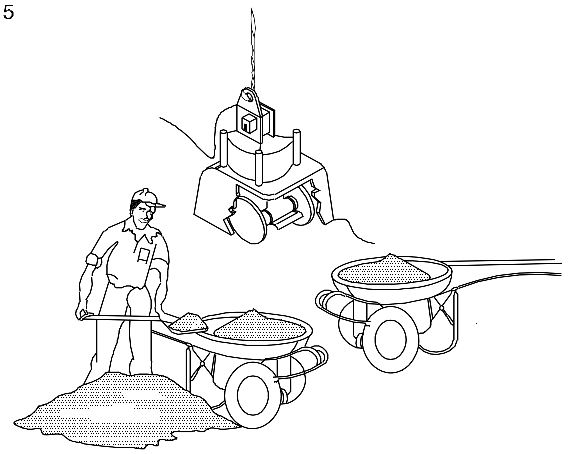
Sand Muller condition the moulding sand.

Distributing the ingredients into a homogenous mixture.

The muller generally consists of a cylindrical pan in which two heavy rollers roll in a circular path.

Two ploughs are also carries with the rollers which scrap the sand from the side and bottom

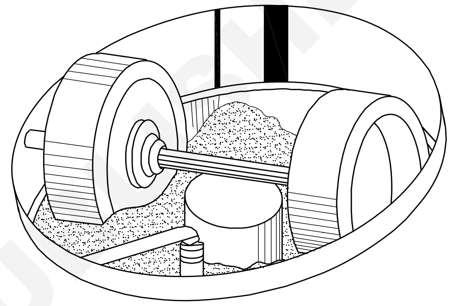
Fig 5



Types of muller

Portable muller (Fig 6)

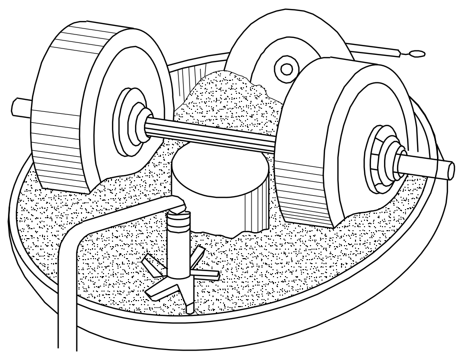
Fig 6



SAND MULLER ROTATING PAN

Sand muller (stationers pan) (Fig 7)

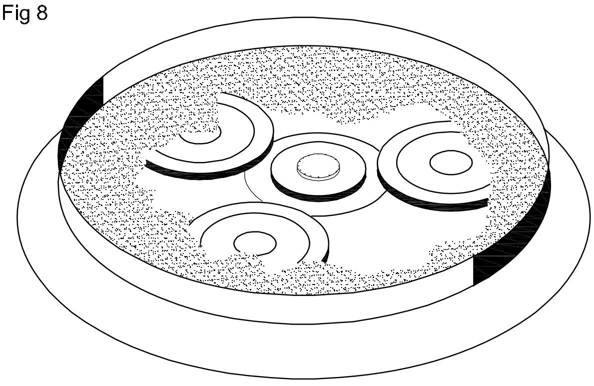
Fig 7



SAND MULLER ROTATING PAN

Sand muller rotating pan (Fig 8)

Fig 8



HIGH SPEED MULLER

Special casting process

Objectives: At the end of this lesson you shall be able to
- **list out the name of special casting process**
- **explain the special casting process**
- **advantages of special casting process.**

Special casting process

There is certain other limitation also processed by conventional sand casting technique which necessitated the development of special casting process

Advantages

a Special casting technique possess following advantages over conventional sand casting.

b Greater dimensional accuracy.

c Higher metallurgical quality.

d Lower production cost (in certain cases)

e Ability to cast extremely thin sections.

f High production rates.

g Better surface finish on the casting; therefore, low labour and finishing costs.

h Minimum need for further machining of castings.

i Castings may possess a denser and finer grain structure.

j Casting are slightly strong and more ductile than sand mould made castings.

Special casting technique

Classification

(a) Metal mould casting

(i) Gravity or permanent mould casting

(ii) Die casting = Hot chamber process
Cold chamber process

(iii) Slush casting

(b) Non-metallic mould casting

(i) Centrifugal casting = True centrifugal casting
Semi centrifugal casting
centrifuging casting

Carbon dioxide moulding

Investment mould casting last wax process

Shell moulding

Plaster moulding

Continuous casting = Reciprocating moulds
Draw casting
Stationary moulds
Direct sheet casting

CO_2 process

Objectives: At the end of this lesson you shall be able to
- **state about Co_2 process**
- **state the advantages and disadvantages of Co2 process.**

CO_2 Molding

CO_2 Casting is a kind of sand casting process. In this process the sand molding mixture is hardened by blowing CO_2 gas over the mold. This process is faboured by hobby metal casters because a lot of cost cutting can be done. In addition, one can be sure of getting dimensionally accurate castings with fine surface finish. But, this process is not economical than green sand casting process.

The highly flowable mixture of pure dry silica sand and sodium silicate binder is rammed or blown into the mold or corebox.

Carbon-dioxide gas at a pressure of about 1.5kg./cm^2 is diffused through the mixture (of sand and sodium silicate) to initiate the hardening reaction which takes from a few seconds to a few minutes depending upon the size of core or mold.

Passage of carbon-dioxide through the sand containing sodium silicate produces carbonic acid in the acqueous solution; this causes a rise in the SiO_2-Na_2O ratio and the formation of a colloidal silica gel, which hardens and forms a bond between the sand grains. This reaction is represented by the following equation;

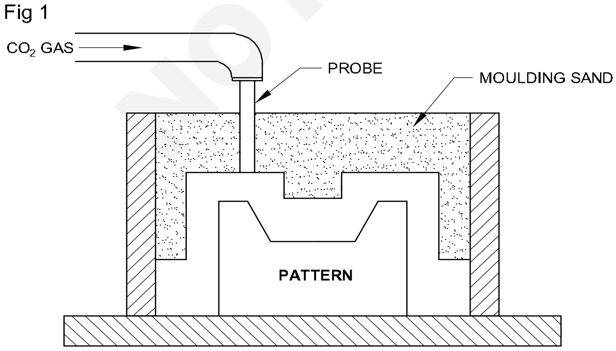
$Na_2SiO_3 + CO_2 - Na_2CO_3 + SiO_2$

Sod.Silicate Silica gel

Operation

The mold material consists of pure dry silica sand (free from clay) and 3 to 5% sodium silicate liquid (water) base binder, mulled for about 3 to 4 minutes. The moisture in the mixture is generally less than 3%, small amounts of starch or clay may be added to improve green strength of the mix.

Fig 1



CARBON - DI - OXIDE PROCESSESS

After the molding mixture has been mulled, it is rammed around the pattern in the molding boxes or core boxes by means of hand ramming, machine mounlding (jolt-squeezing) or by core blowers.

Carbon dioxide gas is forced into the mold or core at about 1.4 to 1.5kg/cm^2.

After gassing the mould or core to used for further processes. Over gassing should be avoided as it reduces the strength.

Advantages of CO_2 moulding

The molds and cores produced by the carbon dioxide molding process are strong and hard as compared to other processes.

There is no costly heating system used for hardening the sand molds. It's just carbon dioxide gas and sodium silicate which hardens the sand molds.

The CO_2 moulding process is easy and it can be done by semi skilled workers.

CO_2 moulding process is speedy and the molds and cores can be produced and used for casting work immediately after they are hardened.

The molds prepared by CO_2 moulding have good dimensional accuracy.

The process can be automated which can increase the production rate with less human interference.

This process can be used for casting the ferrous metals as well as non-ferrous metals.

Disadvantages of CO_2 moulding

In CO_2 moulding process, once the sand is used in moulding, it cannot be reclaimed back for rescue.

The bench life of sand mixtures is comparatively shorter than other mold and core mixes.

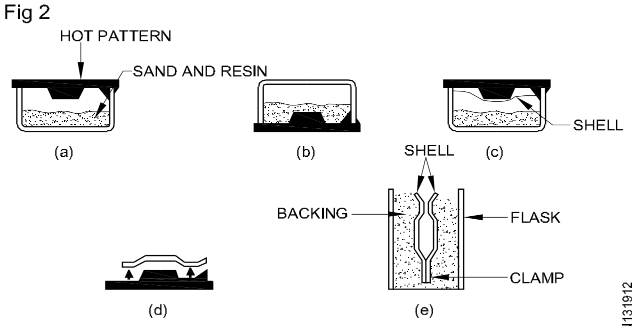
Shell moulding process:

The shell moulding process consists of making a thin mould around a heated metal pattern. The moulding material used is a mixture of dry fine silica sand and 3 to 8 percent of a thermosetting resin like phenol-formaldehyde or urea formaldehyde.

Specially prepared resin-coated sands are also used. The mixture for moulding must be dry and free flowing. Conventional dry-mixing techniques are used for obtaining the moulding mixture.

The procedure of making shell mould is as follows:

Fig 2



SHELL MOULDING PROCESS

1 A heated metal pattern (about 180C to 375C) is clamped over a moulding box.

2 The heated metal pattern with moulding box is inverted for short period of time of about 0.5 to 1 minutes. The mixture when comes into the contact with hot metal pattern, a shell of about 6mm thick is formed around the pattern. (Fig 2b)

3 The moulding box along with pattern is again inverted to brought it into original position. The shell formed with resin bonded sand mixture, is retained on the surface of pattern, while the unaffected sand mixture falls down into box. In order to cure the shell completely, it must be heated at 230C to 350C for about 1 to 3 minutes, in oven. (Fig 2c)

4 The shell is then released from the oven and the shell is stripped from the pattern by ejector pins, sometimes, a silicone release agent is applied to the pattern before clamping it to the box, to prevent sticking of the shell. (Fig 2d)

5 The shell halves are joined with clamps and supported in a flask with backing material. Now the shell cavity is ready to pouring the molten metal to be case. (Fig 2e)

Shell moulding is suitable for mass production of thin-walled, gray cast iron castings having a maximum weight up to 20kg. However, castings weighing up to 450kg can be produced by this method. This method is also used for producing aluminium alloy casting.

Advantages of shell moulding;

1 Good dimensional tolerance of about + 0.2mm is achieved.

2 Good surface finish is generally obtained.

3 This process itself suitable for automation.

Disadvantages of shell moulding;

1 The moulding mixture contains thermosetting resin blinder, which are more expansive than other binders.

2 Only suitable for metallic pattern and not for wooden or plastic patterns.

3 Cost of whole unit is high as compared to green sand moulding method.

Simple physical test for determining the moisture content of the sand.

Objectives: At the end of this lesson you shall be able to
- **state the necessity of testing moisture content of the moulding sand**
- **state the simple physical test for determining the moisture content of the sand**

Necessity of testing moisture content of the moulding sand

The strength, plasticity, and flowability of the moulding sand depends on the moisture content. Too much, or too low, moisture always reflects on the soundness of the castings, as regards their finish, hardness, mechinability, etc. An experienced moulder judges the sand by feel, but in the production shop all moulders may not possess the required experience, and moreover a physical test is not a reliable test, hence, particularly in production shops where castings are done in tons per day, do not take the risk on physical judgement, but rely on a laboratory test. This reduces the number of defective castings.

Number of instruments are used, but the most commonly used instruments used are 1) hot chamber machine and 2) speedy moisture teller. The speedy moisture teller is light and handy. The moisture content can be read directly on an indicator, which is calibrated in the percentage of moisture.

Simple physical tests for determining the moisture content of the sand

General Information - This test is carried out in job foundries.

Material - Tempered Sand

1 Take a palmful of moulding sand in your palm.

2 Press it with four fingers with sufficient force to form a lump

Test Procedure

1 If the sand sticks to your palm and fingers, it is an indication of more moisture. Add old moulding sand (remedy).

If the sand lump crumbles, it indicates less moisture - add more moisture.

2 Throw the pressed lump briskly on the floor. If the sand does not spread out freely all around where it strikes the ground, then it indicates that the sand contains more moisture than necessary.

If all the sand spreads, with very little lump of sand sticking to the floor, it indicates that the sand sticking to the floor, it indicates that the sand contains less moisture than necessary.

It is very difficult to state the exact percentage of moisture in the sand by this method. However, with several years of experience on gains the ability to gauge the fitness of the sand for preparing the mould by this method. More exact scientific methods for measuring the moisture content of the sand will be deal with later on in the course.

Speedy moisture tester

Objective: At the end of this lesson you shall be able to
- **State the test for determining the moisture content test**

Moisture content can be determined by using direct reading moisture teller.

This makes use of reaction

$CaC_2 + 2\ H_20 = Ca\ (OH)_2 + C_2\ H_2$

Calcium carbide reacts with the moisture content of the molding sand and generator acetylene gas. The pressure of C2 H2 provides a direct reading of the water content on the pressure gauge.

Using infrared heating

Test procedure

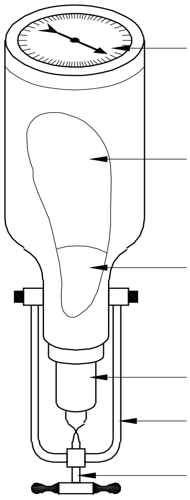
1 20 to 50gms of prepared sand is placed in the pan and heater by an infrared heater bulb for 2 to 3 minutes

2 The moisture in the molding sand is evaporated

3 Molding sand is taken out of the pan and reweighted

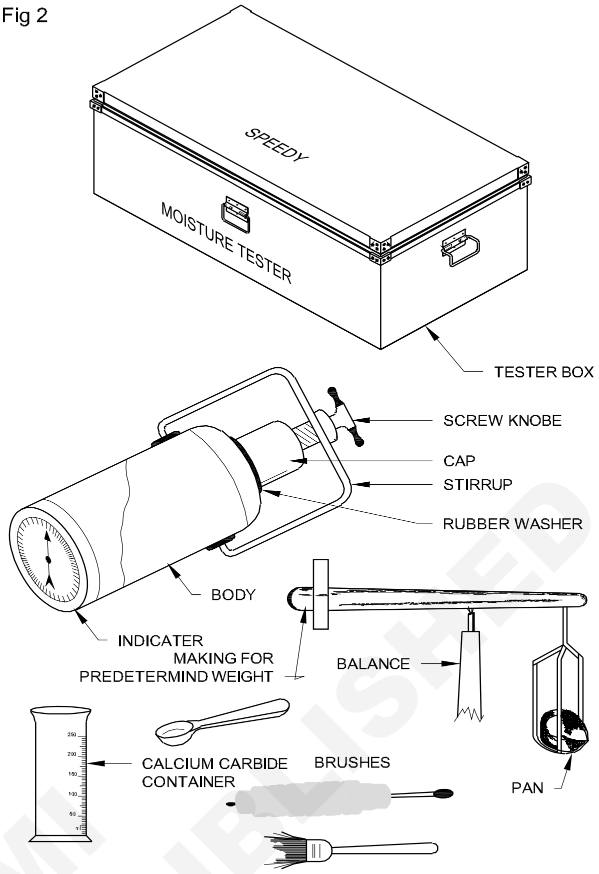
4 The % of moisture can be calculated from the difference in the weights of the original moisture and the consequently dried sand sample.

Fig 1



MOISTURE TELLER USING CALCIUM CARBIDE

Fig 2



MOISTURE TELLER USING CALCIUM CARBIDE

Clay tester

Objectives: At the end of this lesson you shall be able to
- **state its necessity of clay tester.**

State the necessity of clay tester

The clay which is used for binding the grains of the sand should be well mixed in the molding sand. A well proportionally mixed clay in the sand gives desired strength, flowability. The compactness of the sand depends on the percentage of clay and the method of ramming. Too hard rammed mould decreased permeability and offers resistance to the shrinkage of the casting while its ending, thus causing defects in the castings.

There are two methods for determining the percentage of the clay. In both the methods a dilute solution of the sodium hydroxide is used. (10 grams in 100 ccm of water). In rapid sand washer only one sample can be tested and it takes hardly 20 to 25 minutes. In the second method more time is required but two to four samples can be tested. The sodium hydroxide (Caustic soda) will separate clay from the solution which can be siphoned out easily, leaving sand grains at the bottom cover.

Classification of clay as per clay content is denoted by alphabet and it is as follows.

A -

B -

C -

D -

E -

F -

G -

H -

I -

J -

Standard Rammer

Objectives: At the end of this lesson you shall be able to
- **state the function of standard rammer.**

In order to find out the permeability, green and dry strength, flowability, refractoriness and the durability of the moulding sand, specimens are prepared in the standard sizes (Fig 2). The weight of the specimen may vary depending on the size, shape of the sand binder, and moisture used in the preparation of the sand. The specimens are rammed in a specimen tube 2" dia. x 5" in height. The weight of the sand may vary between 150 grams to 170 grams. The sand is placed in the specimen tube and rammed by impact with three blows of a 14 lb. weight. The sample height can be checked on the indicator attached to the rammer pillar. Always use samples of correct height. If the height of the sample is above or less than 0.005, than discard the sample and prepare a new one. The sample can be removed from the specimen tube with help of the stripping post which is slightly greater in length than the specimen tube.

Fig 1

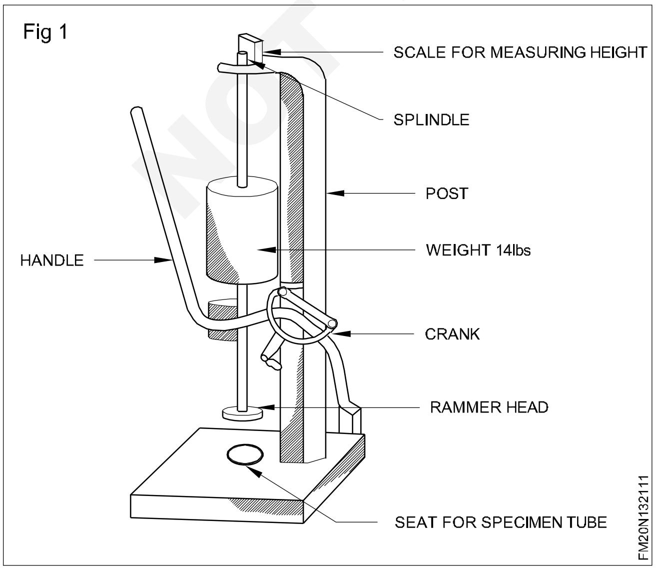
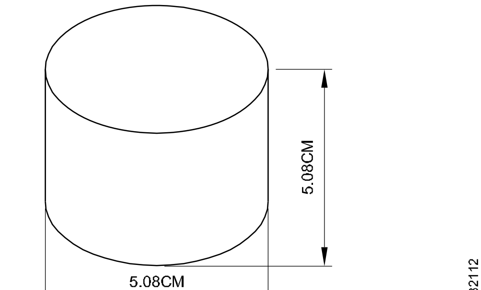


Fig 2



STANDARD SIZE OF SAND SPECIMEN

Permeability tester

Objective: At the end of this lesson you shall be able to
- **state the purpose of permeability tests.**

To test moulding sand for permeability

The capacity in the rammed mould to allow the gases to permeability is the property by which we can know the ability of molding sand to transmit gases from the mould or core permeability is a number only. It is determined by the rate flow of air under standard pressure through 2" dia. x 2" sand sample. A moulding sand or a core sand having good permeability has good venting qualities. The permeability depends on:

1 Sand grain size.

2 Sand grain Shape.

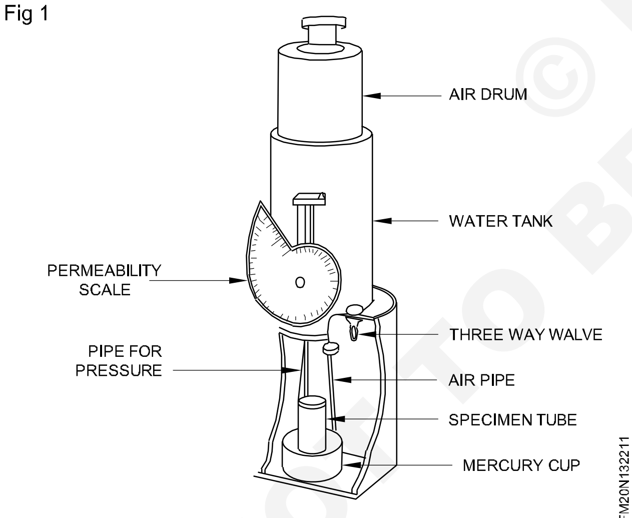
3 Type of bonding material used.

4 Density to which the sand is rammed.

The permeability may be tested when the sand is green or in dry state, and is known as green permeability and dry respectively.

Various types of permeability testers are used. The most common one is shown in the (Fig 1)

Fig 1



In this machine 2000 cu. centimeters of air is allowed to pass through a standard sand specimen, under a presssure of 10 grams per sq. cm. The time required to pass the air is recorded. The permeability number is calculated by the following formula:

$$P = \frac{V \times H}{pAT}$$

Where P = Permeability number

V = Volume of air = 2000 c.cm

H = Height of speciment 2" or 5.08 cm.

A = Area of the cross section of the specimen in sq.cm 20.268 sq. cm

p = Air pressure (gm/cm2) recorded by the manometer.

t = Time in minutes

$$\text{hence } P = \frac{2000 \times 5.08}{20.268 \times p \times t} \quad \text{(t - unknown)}$$

Strength tester

Objective: At the end of this lesson you shall be able to
- **state the purpose of strength test.**

State the purpose of Strength test

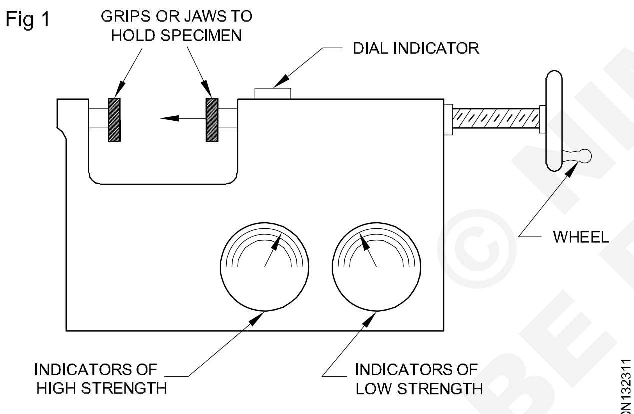
The strength of moulding sand is determined by compressive, shear, and tensile tests. The tests are carried out to find out whether the mould will be able to bear all the above stresses, when it is assembled for casting. The mould is also subjected to the ferrostatic pressure in all directions. Hence the strength of the sand should be tested. If the sand is weak, the shape of the mould may cramble, or the sand may wash due to the flow of the molten metal, or the mould may get cracks during the baking process.

The strength of the sand depends on the:

1 The size and the shape of the sand grains.

2 Binder used in the sand

Fig 1



STRENGTH TESTING EQUIPMENT

3 Moisture percentage in the sand.

4 Ramming of the mould.

If the prepared sand is weak or very strong it will directly reflect on the Quality of sound castings.

In modern days a motor driven dead weight type of machine is used for determining compressive strength of green sand specimen. With proper accessories this machine may also be used for dry strength as well as for determining the shear and transverse strengths. The strength is indicated in lbs. per square inch. kg/cm^2, gm/cm^2

Fineness of moulding sand grains

Objective: At the end of this lesson you shall be able to
- **state the necessity of finess of moulding sand grain.**

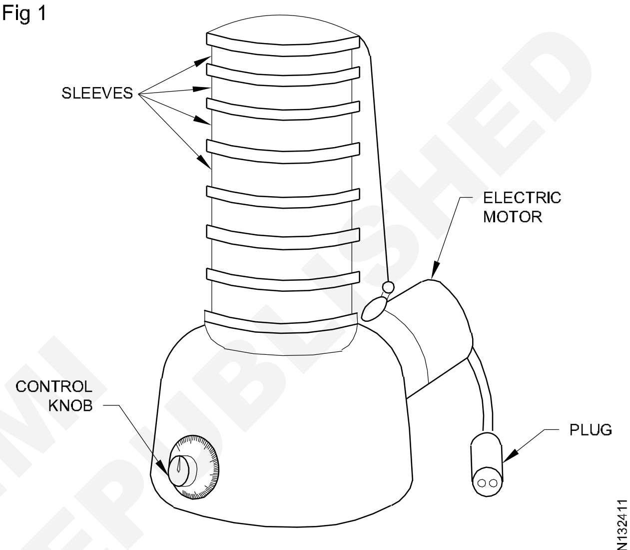
Necessity of finess of moulding sand grain.

If a palmful of sand is taken, and is examined through a microscope, it will be noticed that it is of assorted sizes. It is not possible to classify the sand by checking the size of one of the grains. Therefore, the finess of sand is found out by finding out the average size of the sand grains.

The sand grain size has a lot of bearing on the production of the casting. Large grain size sand is more porous, but gives rough surface to the mould. The cooling range of the casting can be controlled by selecting the proper size of the sand. Fine sand is generally used in the facing sand, but medium or coarse sand may be used as backing sand. If the casting sets cool in less time than required it may become hard, or if a very large casting takes a very long time to cool, it may develop porosity. Therefore in production shops, the finneess of the sand is always tested before starting the production of a particular job.

To test the fineness, a stock of sieves in numbers is used. The sieve used in a shaker has 8" dia. and 1" height. It has phosphorus bronze mesh at the bottom. A coarse mesh sieve is placed at the top, and a finer mesh sieve is placed at the bottom, of the sieve stock. Below the bottom sieve a pan is fixed to collect the dust particles or very fine sand grains. The main shakers are 1) Rotap 2) Vibrato 3) Combs. These are run according to the specifications of the designer. The sand to be used for this test, will be the retained sand (from 50 grams) after moisture a clay test. The fineness is denoted in number and is classified in numbers from 1 to 100.

Fig 1



GRAIN FINENESS TESTER

Refractoriness tester

Objectives: At the end of this lesson you shall be able to
- **state the purpose of refractoriness test**
- **working principles of refractoriness tester**

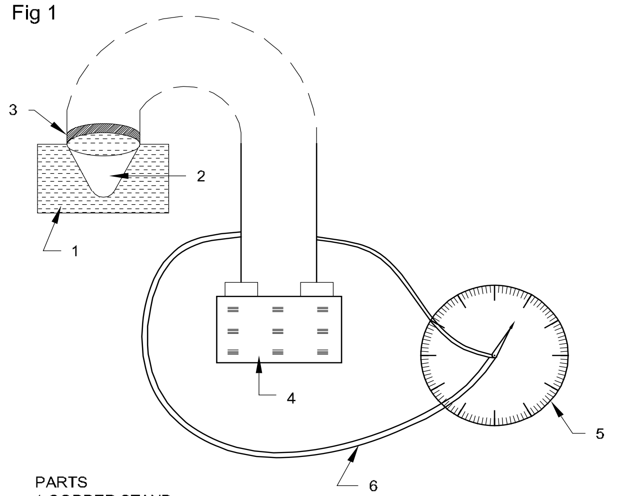
Refractoriness tester

Refractoriness is the one of the most important property of moulding sand. While pouring melten metal into the mould, sand resisting the heat, sand is not burn is called refractoriness.

Working principles of refractory tester

A specimen to be tested refractoriness placed in between curved platinum strip against the periphery of cylindrical sand specimen. It is fired for 2 hours at the 1500°c appearance is absorbed and dimensional changes can also be noted. A good refractory sand will retained the shape the less refractory specimen will shirnk and distort.

Fig 1



PARTS
1.COPPER STAND
2.SAND SAMPLE
3.REFRACTORY MATERIAL (OR) PLATINUM TAPE
4.BATTERY
5.GALVANAMETER
6.WIRE

Types of Sand

1 Natural Sand

2 Synthetic Sand

Synthetic sand

It is artificially prepared sand in the shop. It is unbonded silica by the addition of suitable binding clay with this the sand are controlled according to the need. These sand are mostly used in all kinds of foundry. The cost of synthetic sand is high.

Natural Sand: It is available from the earth is can be used directly from the earth more impurities are associated like alkalic substance like Mica. It is used for making small size casting because of more temperature the sand may be fused. The cost of the sand is less. It consists of 5 to 20% of clay. (Refer about natural sand in standard IS 3343-1965)

Difference between the Natural and Synthetic Sand

Natural Sand	Synthetic Sand
1 Available in nature	1 Prepared Synthetically.
2 Contain more impurities.	2 Impurities are not there.
3 Cost is less.	3 Cost is more.
4 Difficult to control	4 Easy to control.
5 Clay percentage cannot be controlled.	5 Clay percentage can be controlled.
6 It is used for making small size casting only.	6 It may be used for all size and shape of casting

Properties of Moulding Sand

1 Refractoriness

The property by which the sand can withstand the high temperature of molten metal, when we pour the molten metal into the mould.

Definition: Molten metal is very hot and will wear away the wall of the mould. It is also liable to attack the sand chemically like acid on cloth. The ability to withsand this is called Refractoriness.

2 Permeability

Permeability is the volume of air pass through the unit area of the sand under unit pressure in unit time. Air can pass through some materials and cannot pass through some materials. The air which pass through some materials is known as permeability.

Definition: Permeability is the ability to allow the gases to pass through,

3 Plasticity

The property by which the sand maintain the shape of the mould after withdrawn the pattern from the mould. After it can be shifted from one place to another without any damage. This is the clay, sand water working together to make the sand to form any shape without cutting. Plasticity is sometimes called as mouldability.

Definition: Plasticity is the ability to be formed any shape without cutting.

4 Green Strength

This is the strength of moulding sand to keep the shape of the pattern in the mould after withdrawing the pattern.

Definition: Green strength is the ability to keep the shape of the pattern after moulding.

5 Dry Strength

This is the strength of the clay when the water dried out of the sand. This means that when we cast metal into the mould the water will evaporate the clay get harder and harder as more as metal is poured.

Definition: Dry strength is the ability of moulding sand to get strength as the water get dried.

6 Adhesiveness

If two particles of dissimilar materials, attracting each other is known as adhesiveness.

7 Cohesiveness

When the two particles of same materials attracting each other is known as cohesiveness.

8 Moisture Content

Clay without water is a hard strong material water make it soft and plastic. The moisture content of moulding sand is to make workable sand.

Too much moisture gives a weak sand with less permeability too little moisture will not make the moulding sand workable.

Definition: Moisture content is the amount of water needed to make the moulding sand workable.

9 Flowability

This is the property by which the sand should flow in each and every corner of the pattern and core box to make the correct shape of the patterns at the time of Ramming.

10 Durability

It is the property by which the same sand can be used number of times in moulding and core making.

11 Hot strength

This is the ability of moulding sand to keep its strength when metal is in the cavity. If the sand is not having sufficient strength when the metal is poured in the mould cavity, the sand will lose its strength and the shape of the cavity will be changed.

12 Chemical Resistance

The moulding sand does not react chemically or combined with molten metal. This property is known as chemical resistance or inheritiness.

Ramming procedure

Objective: At the end of this lesson you shall be able to
- **state the different types of ramming procedure**
- **state the necessity of hardness tester**
- **state the working principle of hardness tester.**

Methods of ramming moulds:

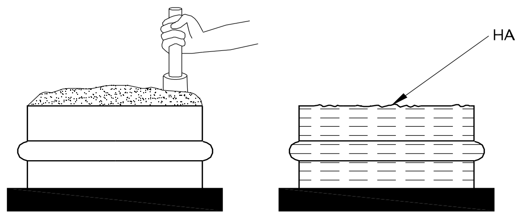
The different methods ramming moulds are given below.

1 Hand ramming

2 Machine ramming

Hand ramming: (Fig 1)

Fig 1

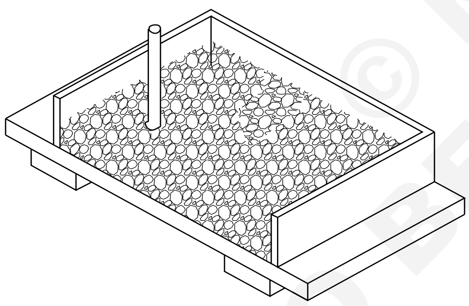


HAND RAMMING

In this method two types of rammers are used, they are

Peg rammer. (Fig 2)

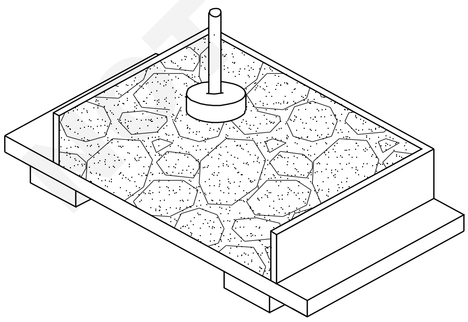
Fig 2



PEG RAMMER

Flat/Butt rammer. (Fig 3)

Fig 3



FLAT / BUTT RAMMER

Other different types are

Peen wedge rammer

Floor rammer

Pneumatic rammer

(i) Ramming is done by hand.

(ii) It is laborious, slow and time consuming.

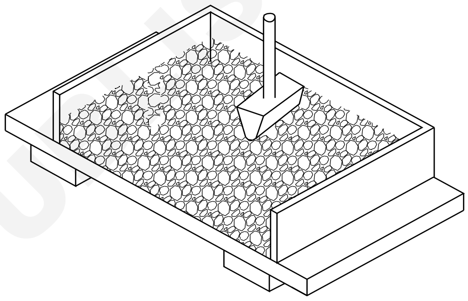
(iii) It produces variable (non uniform) hardness.

(iv) The main advantage of the hand moulding is no expenditure

(v) Certain intricate and artistic ramming cannot be done by other ramming procedure.

Peen wedge rammer: (Fig 4)

Fig 4



PEEN WEDGE RAMMER

It has a wedge shaped construction formed at the bottom of a metallic rod. It is generally used in packing the moulding sand in pockets and corner.

Floor rammer (Fig 5)

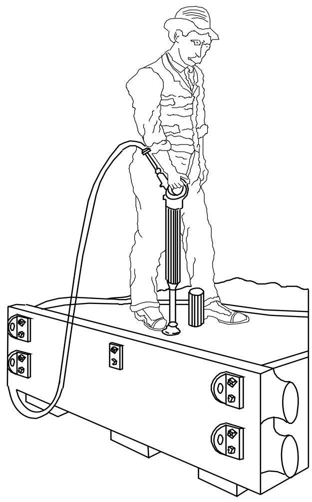
Fig 5

FLOOR RAMMER

It consists of a long steel bar carrying a peen at on the end a flat portion on the other. It in heavier and larger in comparison to hand rammer. It's specific used in floor moulding for ramming the sand for larger moulds. Due to its large length, the foundry man can operate it in standing position.

Pneumatic rammer (Fig 6)

Fig 6



PNEUMATIC RAMMER

Pneumatic rammer is operated by compressed air they save considerable time and labor and one used for making large mould.

Machine ramming

Different types of machine ramming are:

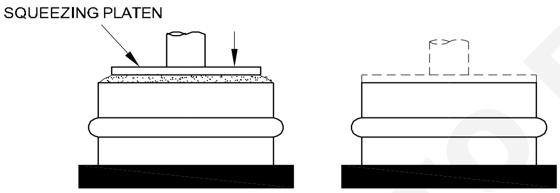
1 Squeezing

2 Jolting

3 Sand slinging

Squeezing: (Fig 7)

Fig 7

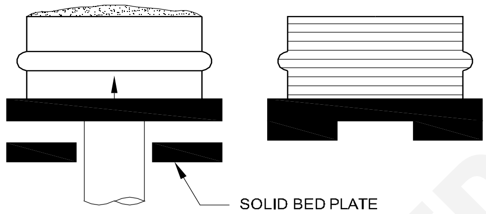


SQUEEZING

In this method flask is filled with loose sand. A squeezing platen which can closely enter the flask, contacts the upper surface of the loose sand filled in the flask. an air pressure is applied with the help of piston cylinder arrangement the squeezing platen moves down, press the sand filled in the flask and compacts it. Squeezing is suitable for small work only. Sand is more compact in upper portion of the flask as compared to its lower portion.

Jolting (Fig 8)

Fig 8

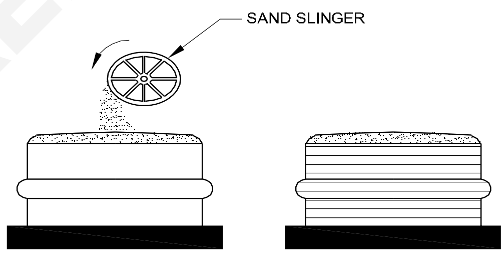


JOITING

In this process flask is filled with loose sand. Flask is fastened on a platen which is raised to certain height and allowed to drop under its own weight against a solid bed plate. This action of raising and dropping the molding box continues till adequate mold hardness is achieved. Jolting is best for ramming horizontal surfaces. Jolting is best for ramming horizontal surfaces. It however, produces uneven density of rammed sand. Sand is more compact in the bottom portion of the flask as compared to its upper portion. Jolting proves hard on equipment.

Sand Slinging (Fig 9)

Fig 9



SAND SLINGING

A sand slinger does,

(i) Fast ramming

(ii) Uniform ramming, but involves

(iii) High initial cost.

Hardness Tester

Objective: At the end of this lesson you shall be able to
- **state the necessity of hardness tester**
- **state the working principle of hardness tester.**

Importance of hardness tester

Check the ramming of the mould whether ramming is loose or hard.

Hard ramming causes defects occur in the casting like blow holes and pin holes.

Loose ramming causes defects occur in the casting like sand wash and scab.

Avoid these defects use hardness tester.

Working principles of hardness tester

The hardness of the mould is affected by the proportion of ingredients in the sand and the degree of ramming. It is tested by an instrument resembling a dial gauge and having a plunger protruding from a flat base when the tester is placed base down on the mould surface, the plunger gets pressed and forced in to the sand. The distance through which it moves depends on the mould hardness. The movement of the plunger actuates a spring and is indicated on a dial which is graded from zero to hundred.

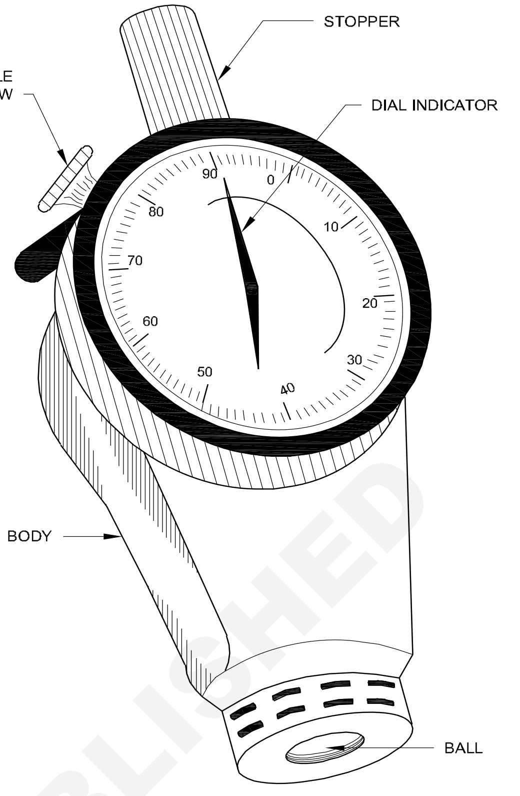
40 - Loose ramming

50 - Medium ramming

80 - Hard ramming

90 - Too hard ramming

Fig 1



MOULD HARDNESS TESTER

Gating system

Objective: At the end of this lesson you shall be able to
- **state about the gating system**
- **state about the different types of gates.**

Gating system:

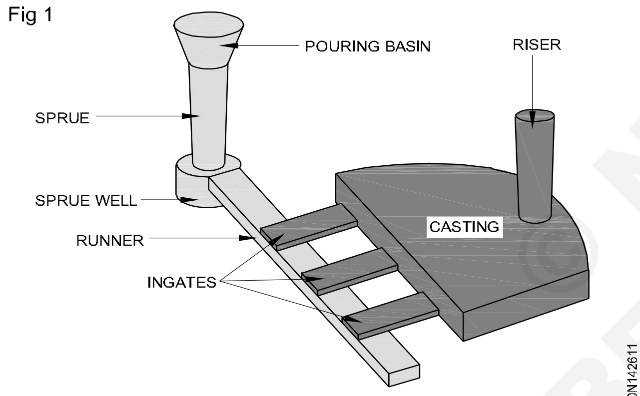
The opening or the passage which are cut or formed in a mould to direct the liquid metal in to the mould cavity is known as a gating system. The gating system consists of pouring cup, down sprue, runner or channel, choke ingate and riser.

Gating system elements:

By maintaining a constant level of molten metal in its basin, the cavity is filled in the prescribed time. To regulate the flow rate in the system, the choke controls the rate at which molten metal passes through it.

The following factors are taken into account when determining the dimension and shape of various elements.

Fig 1



GATING SYSTEM ELEMENTS

1 Sprue:

The circular cross-section that minimize heat loss and turbulence is the sprue, its area is calculated from the choke area and the gating ratio. Sprues should preferably be small at the bottom and big at the top.

2 Sprue well:

Sprue well is designed to limit free fall metals, as it directs the metals in a proper arc towards the runner. Having a sprue well will help minimize turbulence and aspiration. In the ideal case, it should have a cylinder-like shape with a diameter twice as large as the sprue exit and a depth twice as large as that of the runner.

3 Runner

The purpose of the device is primarily to slow down the flow rate of molten metal during its free fall from the above-mentioned channel to the ingate. Runner cross-sections should not only be larger than sprue exits but should also be able to fill the molten metal, before letting it pass through the ingates. In a gating system that has more than one ingate, the cross-section area should be lowered after each ingate connection in order to ensure smooth metal flow.

4 Ingate:

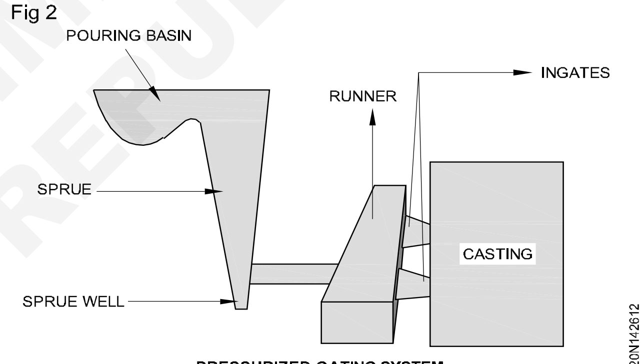
This is the component that directs the liquid into the cavity of the mould. casters recommend designs of ingates that minimize metal velocity; the design has to facilitate easy fettling, must not create hot spots, and must ensure that molten metal flow is proportional to the cast volume.

Types of gating system

There are two types of gating systems: Pressurized Gating System and Unpressurized Gating system. Choosing the right casting system with the correct area ratio will define the quality of the casting.

1 Pressurized gating system

Fig 2



PRESSURIZED GATING SYSTEM

Pressurized gating system

The pressurized gating system is a gating system whose cross-sectional surface area decreases gradually towards the mold cavity (smaller than the narrowest down sprue runner area). The in-gate area is minimized to put pressure on the system. At the gates the flow rate of liquid metal is almost equal.

Sprue is always full of metal creating back pressure, which reduces air aspiration.

Here metal that is always running at high speeds becomes more chaotic and it is easy to create eddy currents in gates leading to erosion.

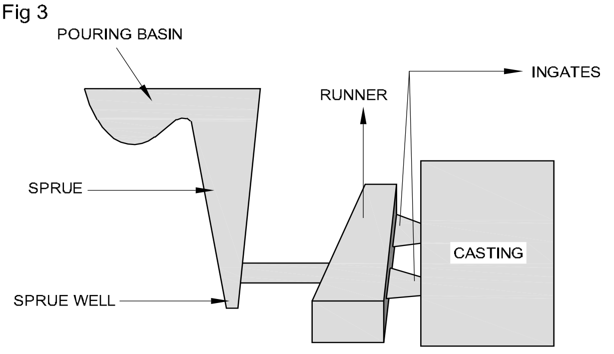
This system gives special priority to injection molding with cast iron materials.

2 Un-Pressurized gating system

Unpressurized gating system

The Un-Pressurized gating system is a gating system whose total surface area of the doors increases gradually towards the mold cavity (larger than the narrowest down sprue area). Liquid metal flow at gates is different.

Fig 3



UN-PRESSURIZED GATING SYSTEM

Gating ratio:

Gating ratio is the ratio between the cross-sectional area of the sprue to the total cross sectional area of the runners to the total cross-sectional area of the ingates.

The formula for the gating ratio is AS:AR:AG.

With the pressurized Gating system, the gating ratio is usually 1:2:1 or 1:0.75:0.5. This system is called a "Gate control system" because ingates control the flow of the metal.

With the unpressurized gating system, the gating ratio is usually 1:2:2 or 1:3:3 or 1:1:3. This system is called a "Choke control system" because the choke controls the flow of the metal.

Design of gating system

1 Objectives achieved from a good design:

- To fill the mould cavity rapidly without breaking the flow of liquid metal and without using very high pouring temperatures.
- To avoid erosion of cores and mould cavity.
- To stop scum, slag, dross and eroded sand particulars from entering the mould cavity.
- To minimize turbulence and dross formation.
- To prevent aspiration of air or mould gases in the liquid metal stream.
- To obtain favourable temperature gradients to promote directional solidification.

Defects occurring due to improper design of gating system:

- Oxidation of metal
- Inclusion of slag, dross and other foreign matters.
- Cold shuts.
- Mold erosion.
- Rough surfaces.
- Shrinkage
- Porosity
- Entrapped gases
- Misruns
- Penetration of liquid metal into mould walts

Classification of gates

The gates are classified into three groups.

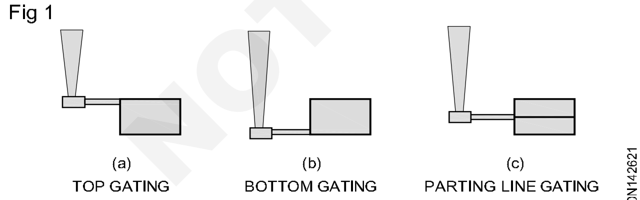
They are given below.

1 Top run gate (Fig 1a)

2 Parting line gate (Fig 1b)

3 Bottom run gate (Fig 1c)

Fig 1



CLASSIFICATION OF GATES

Top run gate

In this gating system the down sprue is placed on the top surface of the cavity. The metal is allowed to enter into the cavity directly. This type of gating system minimizes the wastage of metal. It helps to the thin section castings filled without cold tap. Cold shut. Misrun etc. there is least facilities to trap the slag. This type of gating system is preferable for thin section casting.

The top run gating system is further classified into:

1 Pop or pencil gate

2 Finger gate

3 Wedge gate

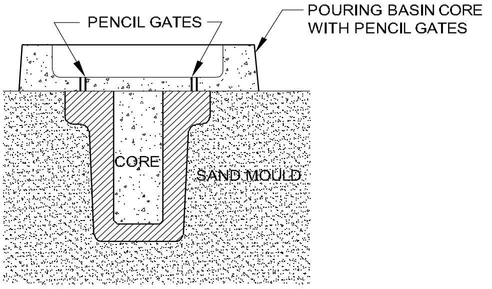
4 Ring gate

5 Strainer core gate etc.,

1 Pop or pencil gate:

Number of small down sprues will be placed over the cavity according to the size of the casting. All these will be connected to one pouring cup. These down sprues also will act as riser as well as feeder, since the metal is entering into the cavity number of small cylindrical holes the thin place size castings will get filled easily and slag also will flow out through these. This type gate is mainly preferable for hollow circular thin castings.

Fig 2



TOP GATING THROUGH PENCIL GATES

2 Finger gate

The finger gate is so called because it resembling human finger.

The finger gate is the modification of wedge gate.

It is so designed the metal allowed to reach the mould in a number of streams.

Finder gate is more easily broken than the wedge gate. It is used for thin walled casing of ferrous & non-ferrous.

Fig 3

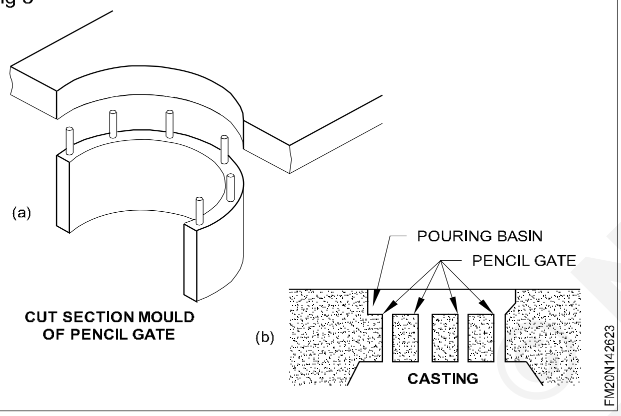
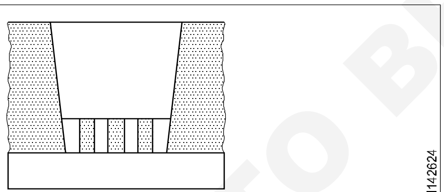


Fig 4

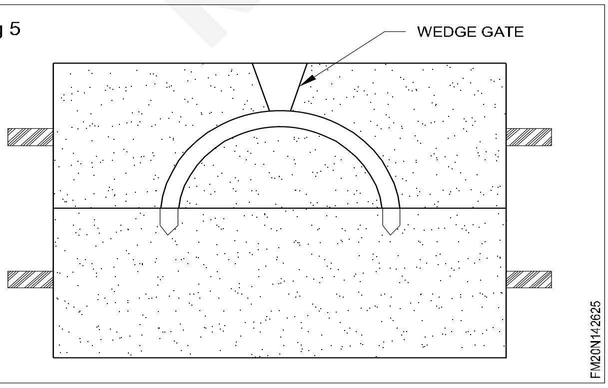


FINGER GATE

3 Wedge gate

Wedge gate is a types of top pouring gate. This is the simplest of the gating system. It is so called edge gate knife edge gate. (Fig 5)

Fig 5



Uses

Thin and light casting

Advantages

The chokes keep the slag is back.

After the cooling the gate is easily broken without damage.

4 Ring gate

Purpose of ring gate

- It is a top-run gate.
- It is a modification of ring.
- Ring gates delivers metal rapidly from the pouring basin.
- Strain the slag at the top
- Easy to fettle the casting.
- Ring gates are mostly used for copper base alloy casting.

5 Strainer core gate

In this gating system there will be only one down sprue. In the down sprue in between the pouring cup and the ingate there will be a core which will have number of small holes. The metal poured in the cup passes through the number of holes and again joins together just above the ingate in the sprues. By using the type of gating system the slag can be completely trapped.

Advantages of top run gating

1 Simplicity for moulding

2 Low consumption of additional metal.

3 Generation of favourable temperature gradients to enable directional solidification from the casting towards the gate which serves as riser too.

Disadvantages of Top run gating

1 The dropping liquid metal stream erodes the mould surface.

2 Dropping metal does cutting action, lifts portions of the surface and causes scab.

3 Splashing of molten metal associated with the liquid metal stream increases chances of oxidation.

4 There is lot of turbulence and pickup of air and other gases.

5 Top gate is not suitable for alloys which are sluggish or prone to rapid oxidation.

6 Top gate is not favoured for non-ferrous casting (Aluminum and magnesium) because of the tendency of dross formation.

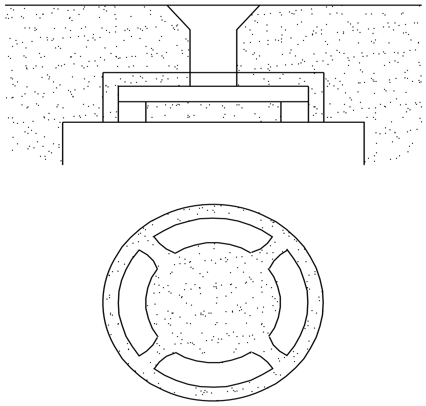
Application of top run gating

1 Top gates are used for gray iron castings of simple designs.

2 Castings with heavy bosses (like railway driving wheel centres) and hollow cylinders (vertically cast) employ top (pencil or pop) gates.

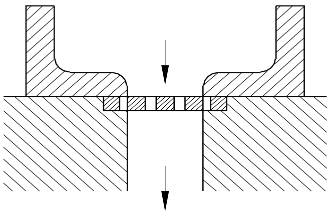
3 Mould made up of erosion resistant materials such as preformed refractory tiles employ top gates.

Fig 6



RING GATE

Fig 7



STRAINER CORE GATE

Parting line run gate

In this gating system the gate is made of the parting surface of the mould. Since the metal is not directly entering into the cavity this type of gate helps for easy trap of slag. Further the flow of the liquid metal breaks and the pressure of the liquid metal is reduced. So the sand wash and sand erosion can be reduced. This type of gating system is preferable for small and medium size castings. Parting line run gates are further classified into:

1 Skim bob gate
2 Shrink bob gate
3 Release or relief sprue gate
4 Branch gate
5 Whirl gate, etc.,
6 Tangential gate
7 Horse shoe gate.

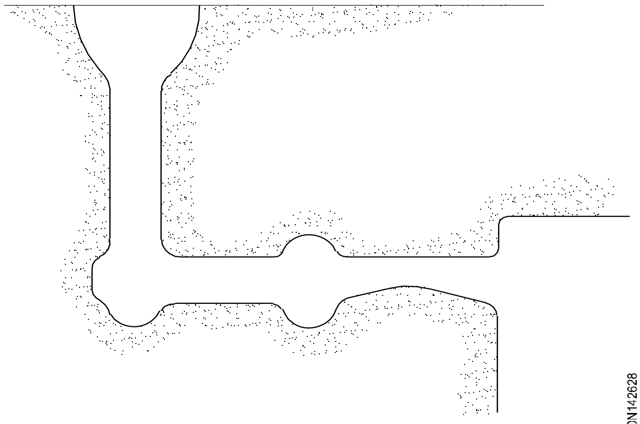
1 Skim bob gate

In this gating system near to the ingate a bob is made on the choke in the top box. This helps for the slag trapping and feeding. (Fig 8)

2 Shrink bob gate

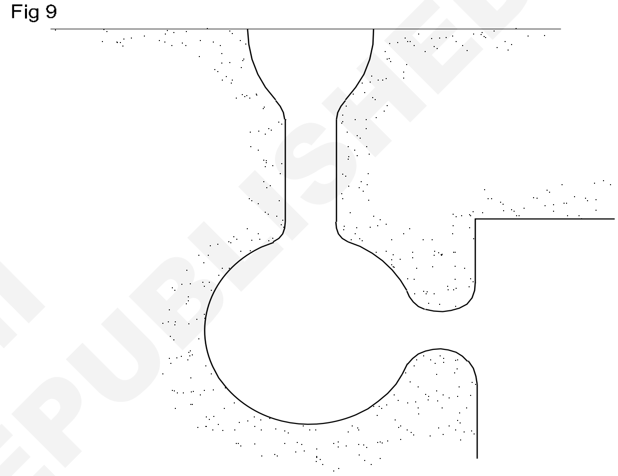
In this gate a bob in the spherical shape is made at the pouring base. This may remain both in drag and cope. This bob helps for the complete slag trapping and ensures full on complete feeding. (Fig 9)

Fig 8



USE OF SKIM BOB & STROKE

Fig 9

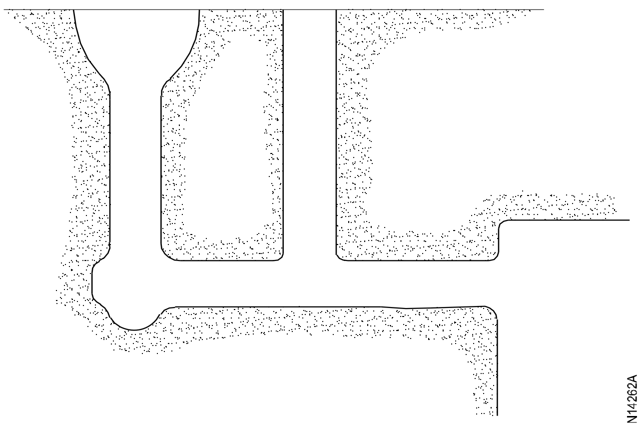


SHRINK BOB

3 Release or relief sprue gate

Next in the down sprue one more sprue (bigger in cross sectional area) will be provided. The down sprue and relief sprue will be connected with the channel. The metal enters into the relief sprue from the down sprue and then delivered to the main channel. The additional sprue helps for the slag to flow up and acts as a feeder. (Fig 10)

Fig 10

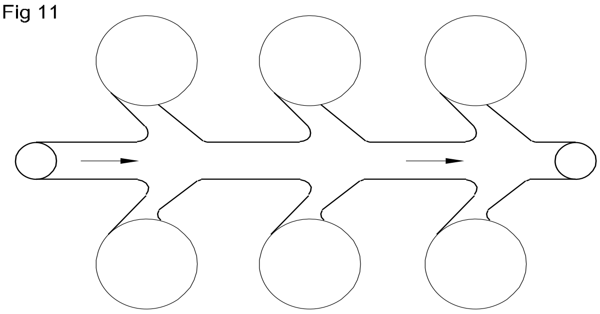


USE OF RELIEF SPRUE OR SKIMMING GATE

4 Branch gate

There will be a channel from the down sprue. The channel and the cavity will be connected with a series of ingates. The metal enters into the cavity through number of ingates. So the thin section castings will get easily filled without cold shut, cold tap, misrun etc. (Fig 11)

Fig 11

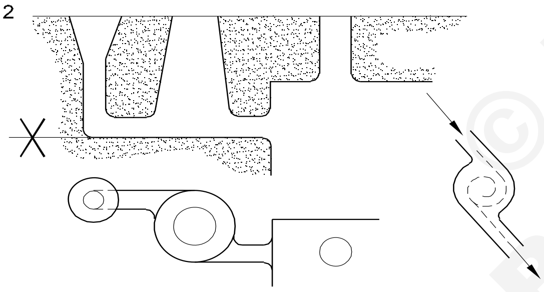


BRANCH GATE

5 Whirl gate, etc.,

In this gating system a pool is made in between the down sprue and ingate. The sprue with pool and the pool with ingate will be connected in opposite direction. The metal from the down sprue enters into the pool and a whirling action takes place in the pool before it is delivered to the ingate. Because of the whirling action the slag comes to the centre of the pool and casting becomes free from slag inclusion. (Fig 12)

Fig 12

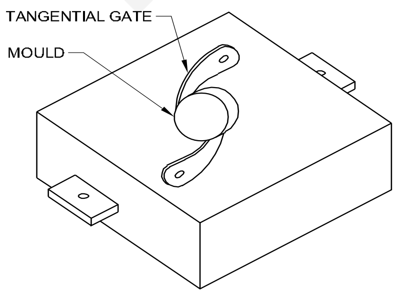


WHIRL GATE

6 Tangential gate

- Parting - line gate
- Mostly used for circular type
- But gate to arrest the slag entering into mould
- It is very commonly used in foundry work.
- It is very easy to prepare.

Fig 13



7 Horse shoe gate

Horse shoe gate is a parting line gate. It is provided particularly to the mould having core in the centre. It is so called horse shoe gate because it resemble like a horse shoe.

Purpose of horse shoe gate

Horse shoe gate fills the molten metal in the mould cavity facility & quickly without turbulence.

The molten metal enters into the mould with centrifugal force, without damaging the core and mould walls.

It is also helps to remove impurities which flow along with the molten metal and trap the slag & dross.

Advantages of parting line gating

1 Parting line gates are simple to construct

2 Parting line gates are very fast to make.

3 Parting line gates produce very satisfactory results when drag is not very deep.

4 Parting line gating makes best compromise between moulding convenience and the ideal gating arrangements.

5 a) A parting line gate proves to be very advantage when it can be fed directly into the riser.

b) In this system, the hottest metal reaches the riser thereby promotion directional solidification.

c) Cleaning costs of castings are reduced by gating into risers, because no additional gate is required to connect the mould cavity with riser.

Disadvantages of parting line gating

1 In case, the parting line is not near the bottom of the mould cavity or the drag portion is deep, some turbulence will occur as the liquid metal falls into the mould cavity.

2 Cascading of molten metal from a height in the mould cavity will cause erosion or washing of the mould.

3 Cascading in non-ferrous metals will promote dross and air pick-up by the liquid metal and thus result in an inferior casting.

4 Turbulence created by cascading can be reduced by slowing down the rate of the molten metal flow with the help of a choke.

Bottom - Run - Gate

In this gating system the metal enters into the cavity either through the bottom surface of the Cavity or through the bottom of a side. Because the metal enters through the bottom of the cavity the pressure of the liquid metal is reduced. So the chances for the sand erosion and the defects due to the turbulence of the liquid metal are totally avoided. This type of Gating System is preferable for large Castings.

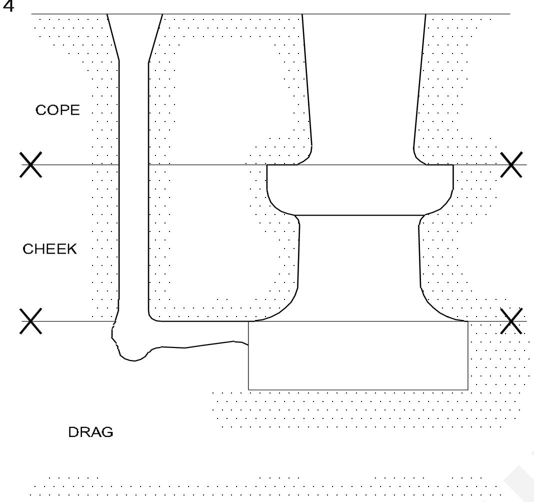
The bottom run gates are further classified into:

1) Simple bottom run gate.
2) Bottom run gate with slag trap
3) Horn gate
4) Draw-in-runner gate
5) Bottom run gate with additional run gate or step gate.

Simple bottom run gate

In this gating system the down sprue will reach upto the bottom of the Cavity and the Gate will provided at the bottom of the side. (Fig 14)

Fig 14

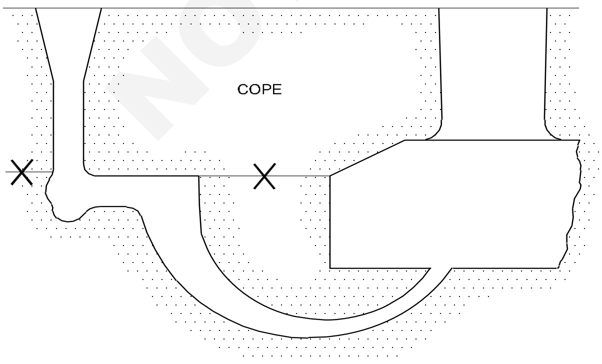


BOTTOM GATE

FM20N14262E

Horn Gate: The shape of the ingate will be like a cow's horn performed ingate, pieces are used to form such ingate will be placed exactly at the bottom surface of the pattern and other and will be placed below the down sprue. After withdrawing the pattern, the ingate piece will be removed through the cavity. Since the liquid metal enters into the Cavity through the bottom surface develops pressure and even the thinner castings also get filled without turbulence. This type of Gating System is gently preferable for the castings which does not possess a regular shape of external surfaces. (The castings are like gear wheel). (Fig 15)

Fig 15



HORNGATE

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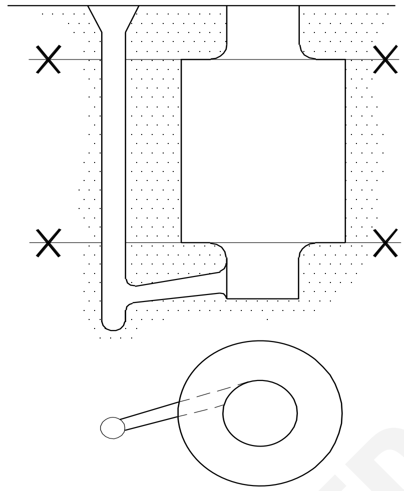
Draw in Runner Gate (Fig 16)

Fig 16



DRAW - IN RUNNER

FM20N14262G

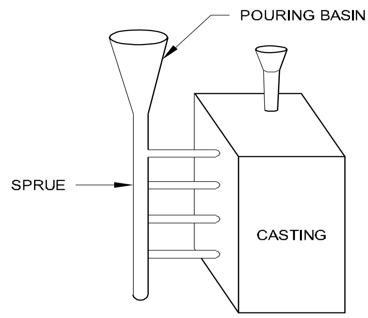
In this Gating System the down sprue will reach upto the bottom side of Cavity and a performed ingate piece will be placed under the down sprue connecting to the Cavity. After the withdrawal of the pattern and down sprue the ingate piece will be withdrawn through the mould Cavity. This type of Gating system is made in the foundry floor.

Step gate

Step gating serves mainly the purpose of directional solidification. During feeding, the metal flowing into the uppermost gate is the hottest and is cooler in the successive gates being the coolest in the lowest gate. Hot metal is, therefore, continually supplied to the top.

If the casting to promote directional solidification (Fig 17).

Fig 17



STEP GATING

FM20N14262H

1 In the step gate the top riser will always contain hottest metal and thus promote direction solidification.

2 Unluckily step gates do not function in the ideal manner described above.

3 Consider the step gates shown in Fig 2, the mold cavity is filled only through bottom-most gate. The upper ingates may even be subject to flow in the reverse direction. i.e. They may even tend to empty the mold cavity by draining the liquid metal back into the sprue to the liquid metal reaches at their level.

4 To solve this difficulty and if each ingate has to function properly during its intended stage of operation, certain measures such as shown in Fig 18.

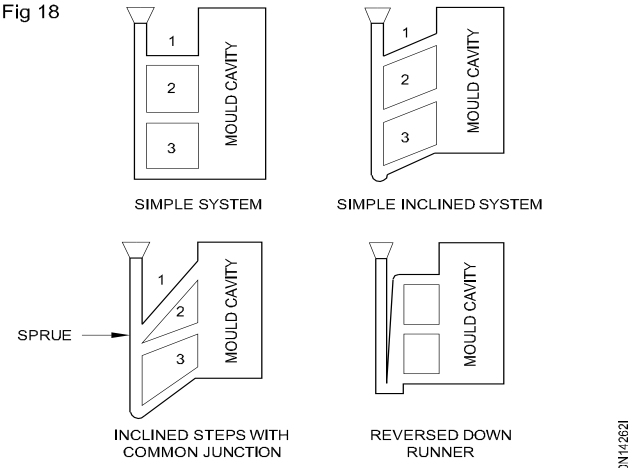
a Simple system

b Simple inclined steps

c Inclined steps with common junction

d Reversed down runner

Fig 18



STEP GATES

Another basic type of multiple ingate system is of step gating for the introduction of liquid metal at progressively higher levels in the mold cavity.

Step gates improve the adverse temperature distribution achieved in bottom gating and at the same time enjoy the good features of the same.

Metal enters the mold cavity through the bottom most ingate until the mold is filled to the level of next higher ingate (No.2); at this point liquid metal is expected to enter through this gate and similarly through ingate No.1 as the metal level in the mold cavity further rises.

Therefore, unlike bottom gate, in step gate the top riser will always contain hottest metal and thus promote directional solidification.

Unluckily step gates do not function in the ideal manner as described above.

Consider the step gate shown in Fig 1 a, the mold cavity is filled only through bottom-most gate (i.e. No.3). The upper ingates may even be subject to flow in the reverse direction they may even tend to empty the mold cavity by draining the liquid metal back into the sprue as the liquid metal reaches at their level.

To solve this difficulty and if each ingate has to function properly during its intended stage of operation, certain measures such as shown in Fig 1b, c and d are required to be taken.

Advantages of bottom gating

1 There is no scouring and splashing in the bottom gate.

2 As compared to top gate, a bottom gate involves little turbulence and meal erosion.

3 Bottom gate produces good casting surfaces.

Disadvantages of Bottom gating

1 In bottom gates, liquid metal enters the mould cavity at the bottom. If freezing takes place at the bottom, it could choke off the metal flow before the mould is full.

2 A bottom gate creates an unfavourable temperature gradient and makes it difficult to achieve directional solidification especially when the bottom gate has a riser at the top of the casting.

3 A bottom gate involves greater complexity of moulding.

4 The liquid metal cools as it rises the mould walls and results in cold metal and cold mould near the (top) riser and hot metal and hot mould near the gate. Rather, the riser should contain hottest metal so that it is last to solidfy and can continuously feed metal to all other comparatively colder, solidifying portions of the casting.

These difficulties can however be overcome by

1 Using excessive padding of casting sections towards (top) risers so that they do not cool fast,

2 Using extra large (top) risers.

3 By pouring some hot metal from the ladle directly into top risers.

4 By using blind risers,

5 By employing side risers.

Ingrediants of Moulding sand and additives

Objectives: At the end of this lesson you shall be able to
- **state the ingrediants of Moulding Sand**
- **list out the size & shape effects of sand grains**
- **state about special additives**
- **list out the effects of special additives.**

Ingrediants of Moulding Sand

1 Silica sand

2 Clay

3 Water

Silica Sand

Silica sand imparts Refractoriness, chemical Resistivity and permeability.

Clay

The amount of clay is important in two ways for green sand process. Clay is less refractory than Silica sand, therefore the more clay we mix Silica Sand the less refractory our moulding sand will be. The clay is the binder of moulding sand as it binds the silica sand. Clay content is the amount of the binder clay. The clay use to give the smooth surface correct strength and refractoriness. Too much clay, too much strength and too little refractoriness. Too little clay, too little strength and too much refractoriness. For resin sand moulding process, clay content should be as minimum as possible 2 % max.

Water

Clay without water is a hard strong material, water will make it soft and plastic. We call it has soft and plastic state. The moisture content of the moulding sand is to make it workable sand.

Too little moisture does not make the moulding sand workable. Moisture content is the amount of water needed to make the moulding sand workable.

Grain shape

There are four types of shape Sand Grains

1 Round Grains.

2 Angular Grains.

3 Sub-Angular Grains.

4 Compound Grains.

Effects of Round Grains

a It makes the sand highly permeable to escape the gases.

b These have least contact with one another in rammed structure.

c Impart smooth surface.

d Low strength.

e It will not resist corrosive action, after the mould dry the sand will fall.

Effects of Angular Grains

a It gives comparatively less permeable that round grains.

b Higher strength than Round Grains.

c Helps to make edges for mould.

Effects of Sub-Angular Grains

a More strength

b Less Corrosive action

c Less permeability

d Fine surface finish

Effects of Compound Grains

a They have tendency breakdown at high temperature.

b It gives desirable shape to the mould

c Controlled permeability.

d Sufficient strength.

Size of Silica Sand Grains

If the grains are larger and regular in shape, the sand more pores but weak. While grains are in equal size and shape gives strength and structure to the mould. Fine sand gives fine surface to the mould. Hence is generally used.

For small casting small grains are required. While heavy casting is to be made course grains are required to allow the gases to pass through easily. The grains size and shape effects the strength and character of sand. Mixture of the various size grains is called "Distribution". IT has considerable effects on strength.

Grains Size

The grains size of sand is important in foundry. How much clay is needed to reach good green strength, large grains, needed more clay than small grains for the same green strength.

Section of Course, Medium and fine Grains

Course, medium and fine grains are measured by sieving numbers, means the number of equal square, per square inch on the sieve.

Course	-	30 to 60 mesh.
Medium	-	60 to 80 mesh.
Fine	-	80 to 100 mesh.

The shape of the grains no matter the size has bearing on how much clay is needed to make a good green strength. Round grains require more clay than an angular grain. The angular or Sub-angular will interlock. The round grains will give the better casting fine finish and more refractory.

Additives

The materials which are added in moulding sand to improve some special feature without affecting permeability and bonding action is called special additives.

Special Additives

1 Coal dust
2 Saw dust
3 Cow dung
4 Silica Flour
5 Zircon Flour
6 Soap Stone Powder
7 Horse manure.

Why the additives are used?

To improve certain properties like porosity refractoriness collapsibility etc.

The shape of the grains no matter the size has bearing on how much clay is needed to make a good green strength. Round grains require more clay than an angular grain. The angular or Sub-angular will interlock. The round grains will give the better casting fine finish and more refractory.

Effects of special Additives

Additives are available as fine grains. It gives good surface to the mould and castings. These materials burn at high temperature, so after burning the space occupied by the grains become empty, hence porosity increase while burning materials like coal dust produces a thin gap and thus form a thin film coating between mould. Well and casting. Adhering the sand on the casting surface reduces because the burning these material collapsibility increases.

Advantages of using coal dust

1 It will give the smooth surface to the mould cavity
2 Surface of the casting get good finishing.
3 Avoid fusion of sand because the coal dust will burn and forms a film gap between the casting and the mould wall.
4 Permeability increases due to burn.
5 Easy to knock out of the casting from the mould.
6 Mould does not crack due to expansion of sand.

Effects of less coal dust:

1 Not getting the smooth surface of the mould.
2 Casting surface will be rough.
3 Difficult to knock out the casting.

Effects of More Coal Dust:

1 While pouring it burns and forms excess gas.
2 Carbon mix with metal and change the properties.

Facing sand & backing sand

Objectives: At the end of this lesson you shall be able to
- **state about facing sand**
- **state about backing sand**
- **state about unit sand**
- **state about various composition of moulding sands.**

Facing sand

The sand which is applied over the pattern 12mm to 25mm thickness is known as facing sand. This is having less permeability and high strength by applying sand on the surface casting used to get good finish due to less permeability. This sand is not used to make complete mould.

Backing sand

The sand which is used to fill up the mould after applying the facing sand is called backing sand. This sand is prepared out of course grains this increases the permeability. But reduces surface finish to the mould as well as to the casting. So this sand is not used to make complete mould.

Unit sand

The sand used for facing sand and backing sand is called unit sand. This sand will be prepared by reconditioning plant usually medium size grains are used to prepare this sand for mass production.

For grey cast iron casting weight from 35 0 100kg

Silica sand AFs finesse 60-75	-	500 kg
Clay	-	40 the 42.5 kg
Coal dust or sea coal	-	35kg
Wood flour	-	4kg
Water	-	17 to 20kg.

Steel casting green sand mould (for 100 kg)

A medium grain silica sand	-	96%
Bentonite	-	3.5%
Dextrin	-	0.5%
Moisture	-	3 to 4%

Dry sand moulding

Medium grain silica sand	-	94.5%
Bentonite	-	5%
Dextrin	-	0.5%
Moisture	-	5 to 6%

Aluminium alloys

Silica sand AFS fineness 140	-	77%
Clay	-	7.7%
Moisture	-	8%

Synthetic sand

Silica sand AFS fineness 130	-	92%
Bentonite	-	4 to 5%
Water	-	3.5 to 4.5

Magnesium alloy

Silica sand AFS fineness 65	-	89%
Bentonite	-	4%
Sulphur	-	1.5 to 2%
Boric acid	-	1.5 to 2%
Diethylene glycol	-	0.75 to 1.25%
Pottassium fluoroborate	-	0.5%
Water	-	2%

Mould

Objectives: At the end of this lesson you shall be able to
- **state about the mould**
- **list out the types of mould**
- **state about the sand mould**
- **advantages and disadvantages of sand mould**
- **state about the metal mould**
- **advantages and disadvantages of metal mould**

Mould

A mould is a performed refractory sand or metal container into which liquid metal is poured and allowed to solidify to get desired shape of the casting.

The mould is mainly classified into two types according to the materials used for making the moulds. They are:

1 Sand mould

2 Metal mould

Sand mould

The sand mould is a performed sand container into which the molten metal is poured and allowed to solidify. Sand moulds are made by using silica sand, clay, water and special additives. Natural moulding sand is also used for making sand moulds.

Advantages

1 Basic material is cheap and easily available anywhere.

2 All metals and alloys can be cast by sand mould.

3 Any size and shape of castings can be prepared by sand mould.

4 The same sand can be used repeatedly by adding little percentage of binders and special additives.

Disadvantages

1 Out of one mould only one casting can be prepared.

2 There are possibilities to get defects due to sand and moisture

3 The strength of the mould is less so more caution should be taken while handling.

4 The dimensional accuracy and surface finish is less.

5 It requires more floor space, labour and time to produce the castings.

Metal Mould

This is known as "Die". It is made out of metal. Out of one mould thousands of castings can be prepared. This can be used only to produce small castings.

Advantages

1 Thousands of castings can be produced from one mould.

2 It does not require baking. So drying materials, time and labour are required less.

3 No possibilities of casting defects due to sand and moisture.

4 It requires less floor (space) area and less skill to produce the castings

5 It gives high dimensional accuracy and surface finish.

6 Quick production and the cast of the product is reduced.

Disadvantages

1 Only limited size castings can be produced.

2 Extra equipments required to get the thin sections filled.

3 The casting surface gets more chilling effect so machining is difficult.

4 it is not at all possible to produce large castings

Molding boxes

Objectives: At the end of this lesson you shall be able to
- **state about the moulding box**
- **list out the types of moulding box.**

Molding boxes

A molding box or flask is a container which imparts rigidity and strength to the sand rammed in it, hold molten metal till the same solidifies.

A molding box may be in two or three parts. The top part is called cope, the middle part is called cheek, and the lower part is termed as drag

Moulding box can be made of

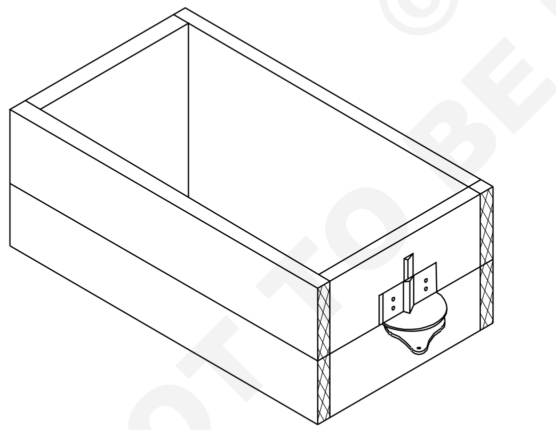
- Wood
- Metal
- Fabricated from steel sections

The main types of moulding box (flask) are:

1 Box flask
2 Snap flask
3 Tight or box flask (or) frame flask.
4 Tappered snap flask

Box flask (Fig 1)

Fig 1



BOX FLASK

A box flask is made up of metal or wood

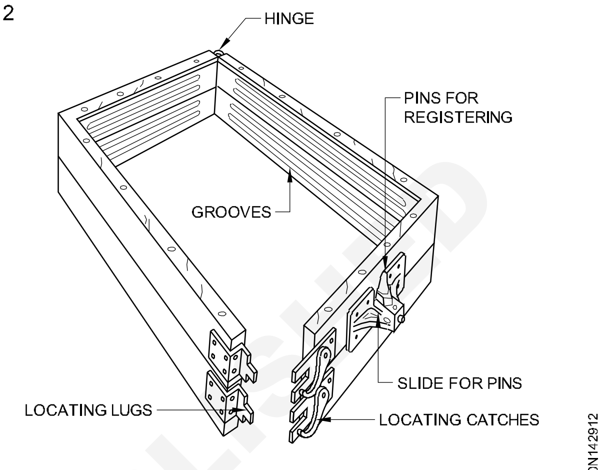
It is very useful for making small to medium size molds.

A box flask is removed from the rammed mold only after the casting has got solidified

Snap flask (Fig 2)

It has hanger on the corner. The opposite corner has latches to lock the flaks in position. The flask is locked and mould made. Then the latches are unlocked and the flask is opened out. The flask is removed from the mould. Thus the number of moulds can be prepared using a single snap.

Fig 2



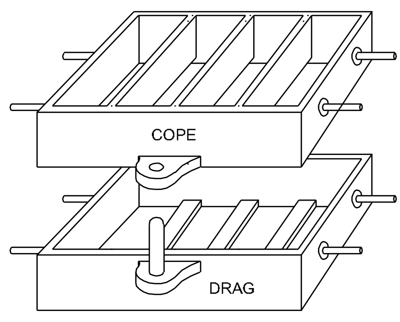
SNAP FLASK

Tight (or) box flask (Fig 3)

It is a box shaped container without top or bottom, it is usually made in two (or) three parts. The box is usually made of meal. The upper part is called as cope, lower bottom section of a mould are called as drag. It is originally called as newel. In between drag and cope is called as cheek.

Those two parts are held in position by dowel pins (or) bolt and nuts. The box remains in the mould till the pouring operation is completed. Box flask made of wood used in floor moulding.

Fig 3



TIGHT FLASK

Tappered slip flask (Fig 4)

Single flask helps to make many moulds

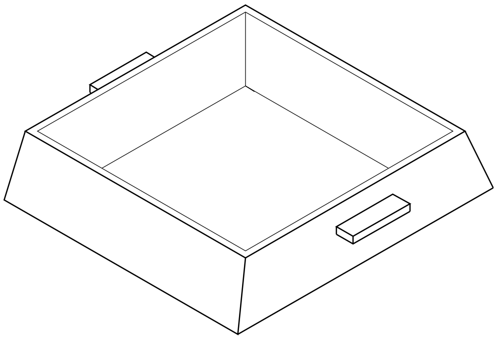
Used for mass production of small mould.

Before removing the flask, you must ensure that the ingate and gating are complete.

Jaget is slided after the tapered slip flask is removed.

Jaget are used to avoid flask out.

Fig 4



TAPPERED SLIP FLASK

Moulding boxes and clamping method

1 A moulding box is a container for the sand

2 Moulding boxes are usually made from cast Iron or aluminum rolled steel section with welded lug etc.

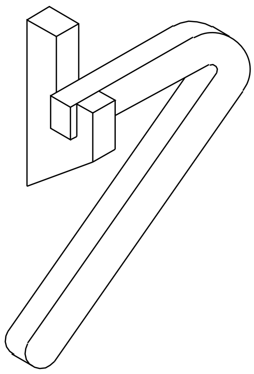
3 Common woods are used for making moulding boxes for small nonferrous casting in the cottage industries.

4 Alignment are essential for moulding boxes its avoid defeat shift / miss-match in the casting.

5 For this purpose the following types of clamps used

Earn clamp (Fig 5)

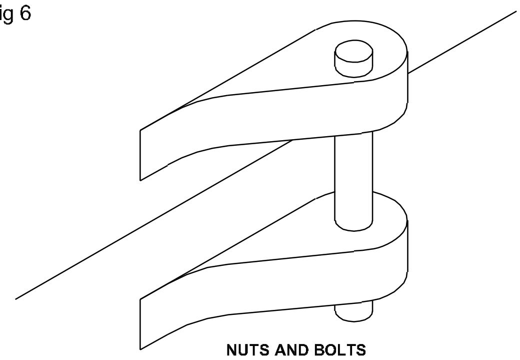
Fig 5



EARN CLAMP

Nuts and bolts (Fig 6)

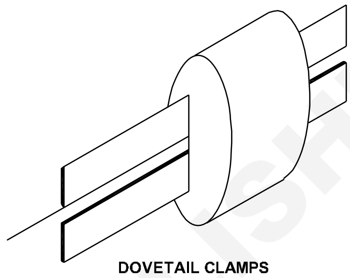
Fig 6



NUTS AND BOLTS

Dovetail clamps (Fig 7)

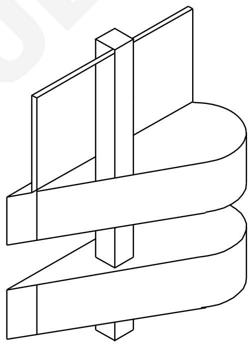
Fig 7



DOVETAIL CLAMPS

Pins and cotters (Fig 8)

Fig 8



PINS AND COTTERS

Refer standard IS - 1280 - 1958 for other moulding boxes specifications.

Crucible

Objectives: At the end of this lesson you shall be able to
- **state about the crucible**
- **list out the types of crucible**
- **state the care and maintenance of crucible.**

Crucible:

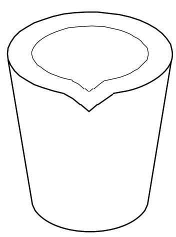
A pot of refractory material used to hold metal during its melting and pouring process (Fig 1)

It is made by using graphite, fire clay and silicon canbide.

Crucible are classified with number eg.no.10, 20, 40, 60, 80, 100…400 etc.

These numbers are given according to the capacity each number values 142ml.

Fig 1



CRUCIBLE

i.e. no.10 Crucible will have a volume equal to 1420 milliters.

Crucible should have ability of refractoriness resistance to thermal shock. Resistance to erosion by the solid stage and resistance to chemical attack by metals fluxes and slag a good mechanical strength

Advantages

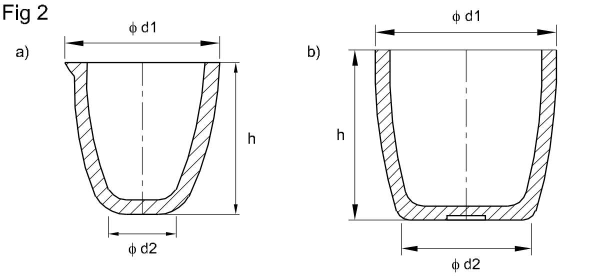
Uniform heating of the charge, Flexibility the ability to change alloys low metting loss.

Types of crucible as per IS 1748-1961

1 A shape crucible

2 Basin type crucible (B Type)

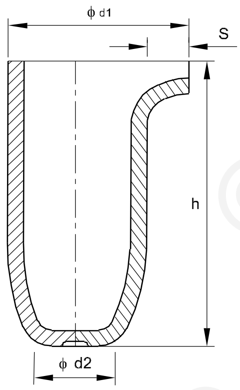
Fig 2



'A' SHAPE CRUCIBLE   BASIN TYPE CRUCIBLE

3 Spouted tilting type crucible (TP Type)

Fig 3

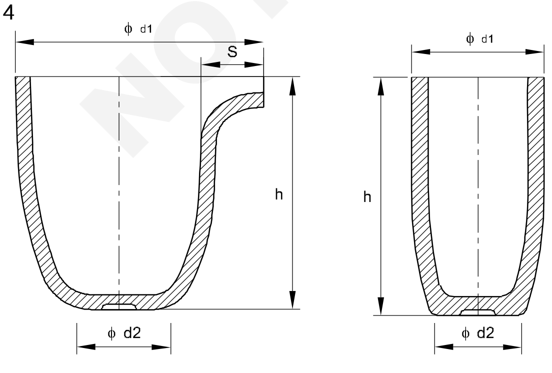


SPOUTED TILTING TYPE CRUCIBLE

4 Spouted basin type crucible (TPB Type)

5 Top - pour type crucible (TPT Type)

Fig 4

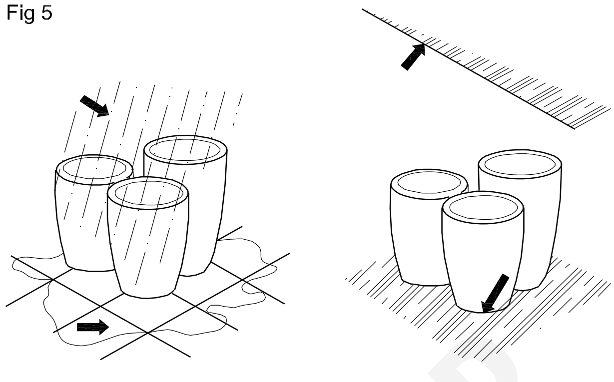


SPOUTED BASIN TYPE CRUCIBLE   TOP-POUR TYPE CRUCIBLE

Care and maintanance

- Observe dry storage preheat before individual usage. (Fig 5)

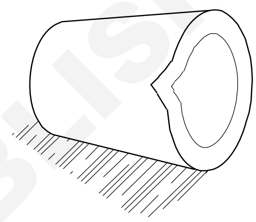
Fig 5



INCORRECT   CORRECT

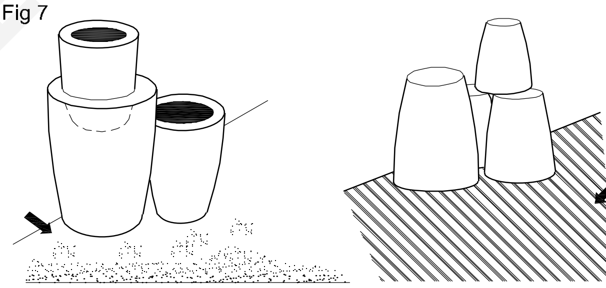
- Do not roll or subject to rough treatment. (Fig 6)

Fig 6



- Do not store one crucible in another stack inverted it place is short (Fig 7)

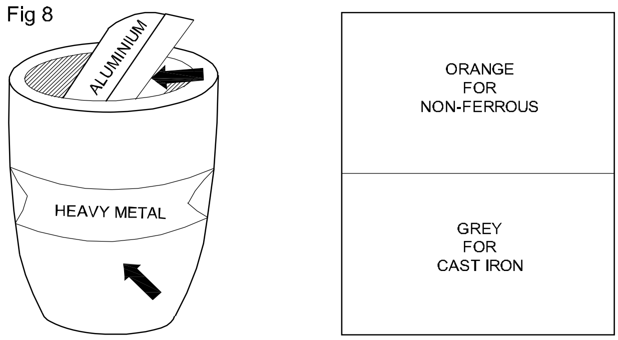
Fig 7



INCORRECT   CORRECT

- Use the correct formulated crucible for optimum unit. (show Fig 8)

Fig 8



CORRECT

Refer the standard 1S-1748 - 1961 for other crucible specifications.

Different sand mould

Objective: At the end of this lesson you shall be able to
- **state the types of sand mould and advantages/disadvantages**

Type of sand moulds

According to the composition of the materials used for making the moulds, sand moulds are classified into:

1 Green Sand Mould

2 Loam Sand Mould

3 Cement Bonded sand mould etc.,

1 Green Sand Mould

The mould which is prepared by using the sand which possess the moisture and the casting is done in the moist stage itself that is without drying the mould is called as "Green sand Mould".

Advantages:

- The materials are cheap.
- No need of baking, so the materials, time and the labour required for the baking is not required.
- Since the mould can be cast immediately the floor space and number of boxes required are less.
- Quick production and the cast of the production reduces. (less)

Disadvantages

- Only small and medium size castings can be made.
- There are possibilities to get defects due to moisture.
- Chilling effect increases and surface hardness increases so machining is difficult.
- Mould is not so strong so more care requires while handling.
- Mould should not be stored for long time. It should be cast on the same day or in the next day or strength will be reduced.

Application of Green Sand Mould

It is generally applied for producing the castings which do not require machining such as machine beds, body of the machines, water supply and drainage pipes, grates, manhole covers, pillars, etc. It is also used for making small and medium size castings. It is also used for making small and medium size castings. It is difficult to make intricate shape castings.

Loam Sand Mould

The mould which is prepared by using the loam sand mixture is called as loam sand mould.

Advantages:

- Mould is so strong. So easy to prepare large castings.
- Work ability of the sand is too high so shaping the cavity without pattern is easy.
- Mould can be stored for very long time.

Disadvantages:

- Requires extra time, labour and materials for drying the mould.
- It takes more time for making the mould.

Application:

This sand is used for preparing sweep moulds and cores for large castings. All metals and their alloys can be cast.

Cement Bonded Sand Mould

The mould which is prepared by using cement as a binder known as cement bonded sand mould. Generally , upto 8% cement will be used.

Advantages:

- Since the cement is self-setting agent, it does not require baking.
- It provides very high strength so large castings can be easily made without sand erosion.

Disadvantages

- Cost is very high.
- No durability to the sand.
- Not possible to make minor repairs after the mould is set.

Application:

This mould is used for making large size ferrous castings

Pit furnace (Crucible furnace)

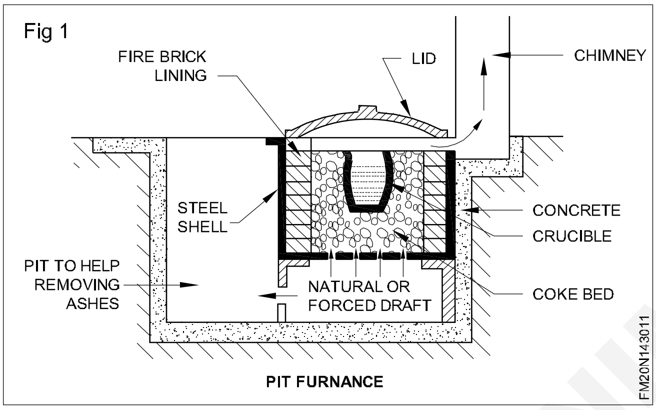
Objectives: At the end of this lesson you shall be able to
- **prepare construction of pit furnace**
- **state the operation and maintenance of pit furnace.**

Use of pit furnace

1. The furnace prepared pits below the grand soil is mostly called pit furnace.
2. Used for melting small quantity of non- ferrous metal
3 Small quantity of ferrous metals such as below 100 kg also melted in this type of furnace.
4 Steel also can be melted in crucibles in pit furnaces using coke, oil or gas fired units.

Prepare construction of pit furnace (Fig 1)

Fig 1



1 Depth of pit furnace is 152cm
2 Diameter of pit furnace is 100cm
3 This furnace has a cylinder steel shell, lined on the inner side with refractory bricks closed at the bottom.
4 The furnace is covered at the top with a removable lid.
5 The furnace involves kindling a deep bed of coke and allowing it to burn until a state of attained.

Operation and maintenance of pit furnace

1 A pit furnace has crucibles placed in a pit below the ground level (Fig 1)
2 It maybe coke, oil or gas fired furnace, but usually it is fired with coke.
3 Enough coke is packed round and above the crucible pot so as to melt and superheat the metal charge.
4 Since molten metal does not come in contact with fuel, there is no pick up of elements by the metal from the coke and a very little compositional change occurs in the metal charge.
5 Coke fired pit furnace (Fig 1) is employed for melting cast iron and non-ferrous metals and alloys.
6 The metal charge consists of pig iron, foundry returns and broken castings.
7 The coke bed (Fig 1) is formed, ignited and allowed to burn. Once it reaches the state of maximum combustion, coke from the centre of coke bed is shifted towards sides to make space for the crucible containing the metal charge.

– The crucible is surrounded from all sides with the coke and its top is covered (With a lid).
– A blower is used to provide the necessary air for the combustion of coke while the charge is melting.
– As the charge melts and attains the required pouring temperature crucible is brought out of the furnace with the help of tongs etc., and is taken to the place of pouring.

Maintenance

- Periodically check the blower function
- Periodically check the furnace wall lining if any damage found relining the lining and coat.
- Check the proper removal for aushes
- Periodically check the air tubes

Crucible

- Store the crucibles in dry place
- Do not roll
- Do not store one crucible in another
- Use the correct formulated crucible

Types of moulding process

Objective: At the end of this lesson you shall be able to
- **state the types of sand mould.**

Moulding Process

The mould can be made by different process. According to the set up of the arrangements and the operations carried out, moulding process is mainly classified into two groups.

1 Hand Moulding

2 Machine Moulding

Hand Moulding

According to the arrangements made for the moulding, hand moulding can be classified into two groups.

Types of hand moulding process

- Bench Moulding
- Floor Moulding

In these processes the entire operations are carried out by manpower.

Bench Moulding

Objectives: At the end of this lesson you shall be able to
- **describe the bench moulding**
- **state the types of bench mould.**

Bench Moulding

In this process the entire mould is prepared in boxes with the help of manpower. Generally these moulds are prepared on bench. The height of the bench is depending upon the convenience of the moulding. The entire mould prepared in this process can be shifted anywhere.

Types of Bench moulding

1 Two box (Method) Mould

2 Three box (Method) Mould

3 Stack Mould

4 Moulding with false Cheek

5 Odd side Mould or

6 Plate Mould

7 Draw Back Method

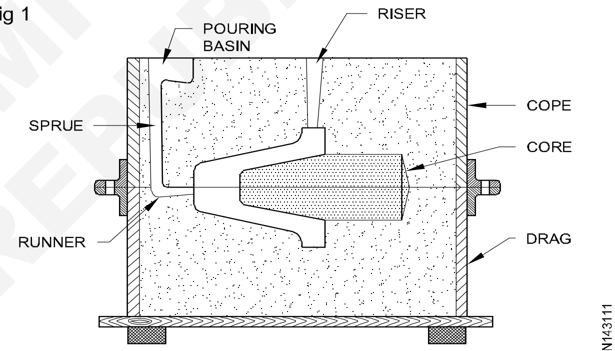
1 Two box Mould

In this process the entire mould is made in two boxes. The bottom box is known as drag and the top box is known as cope. The entire cavity may remain either in drag or in cope. This method is used for making the mould with regular shape, one piece or two piece pattern is used. (Fig 1)

2 Three Box Mould

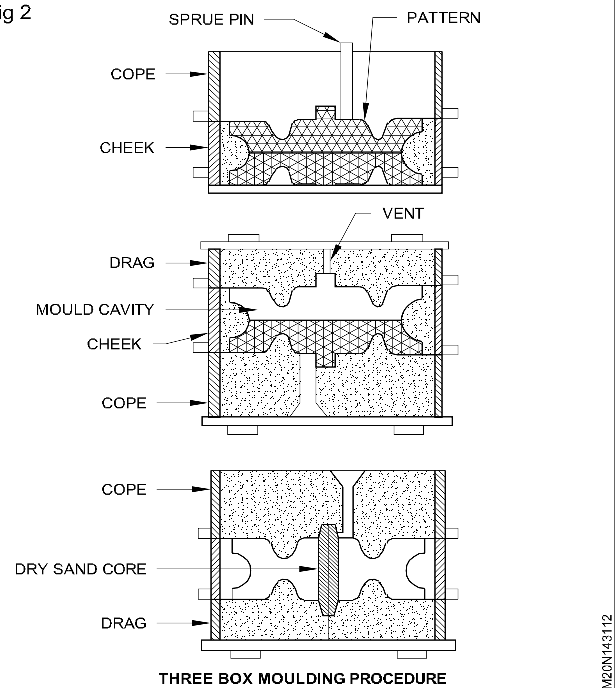
In this process the entire mould is made in three boxes. The cavity may remains in two boxes and sometimes in all three boxes. It will have two parting lines. This method is applied for making the mould out of the pattern which requires two parting line. The middle box is known as "Cheek". (Fig 2)

Fig 1



TWO-BOX BENCH MOULDING

Fig 2

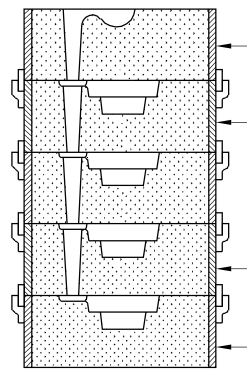


THREE BOX MOULDING PROCEDURE

3 Stack Mould

In this process number of boxes will rammed come over the other. Except the extreme top or extreme bottom each box will have individual cavities. All these cavities will be connected with a single down sprue. This method is applied for making small castings on mass production. (Fig 3)

Fig 3



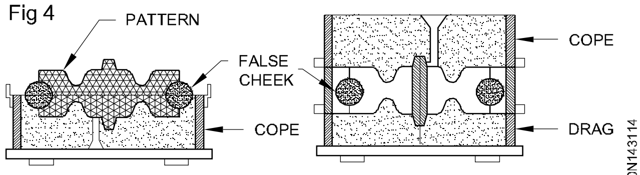
Advantages

- Less number of boxes required.
- Less moulding sand required.
- Less time and labour required.
- Quick production.
- The wastage of the metal in the form of runner, riser, etc. Are less. So the yield is high.

4 Moulding with false cheek

In this process a rammed unit of sand will act as cheek in between the drag and cope. This unit will not be adhering on any box. This method is applied for making the mould with two part pattern which required two parting lines (like rope pulley or chain pulley etc.). This method is applicable only to produce limited number of castings. (Fig 4)

Fig 4



MOULDING WITH FALSE CHEEK

5 Odd side mould

This method is applied to produce a mould with a solid pattern which do not have a regular parting line. In order to get a regular parting line, one box will be rammed and a portion of the pattern will be pressed into the sand to obtain a regular parting line. Then the drag is made and turned down. The first box which rammed is destroyed and then cope is made. This method is applied when a limited number of castings are to be produced.

6 Plate Mould

In this process, the halves of the pattern will be fitted on either sides of a plate. By using this, both drag and cope is prepared. When the drag and cope is made the pattern plate will be withdrawn. This method is applied for mass production of small castings by hand moulding process.

7 Draw Back Mould

In the pattern is single piece and it has a groove all round (like rope pulley), this method is used to make limited number of castings. A false cheek will be prepared on lifting plate in between the drag and cope during the process of moulding. After the cope is turned over the core like portion on the lifting plate will be parted into two or more number of pieces and drawn back after making suitable markings, to get sufficient clearance to withdraw the pattern from the drag. After the withdrawal of pattern the halves of the cored portion will be brought to its original position and the cope is assembled.

Floor moulding process

Objectives: At the end of this lesson you shall be able to
- **list the classification of floor moulding process**
- **describe the bedding - in - method**

Moulding Process
- Hand Moulding
  - **Bench Moulding**
    - Two box (method) mould
    - Three box (method) mould
    - Stack mould
    - Moulding with false cheek
    - Odd side mould or false box method
    - Plate Mould
    - Draw back method
  - **Floor Moulding**
    - Open Sand mould
    - Floor mould with cope or bedding in mould
    - Pit mould
    - Sweep mould
- Machine Moulding

Bedding - in - method (Floor moulding)

- Bedding - in - method is a floor moulding process.
- Foundry floor with act as a drag.
- Medium, very large casting are casted in their process.
- Rough, unmachined casting like man hole square and round block are can be done.
- Ferrous and non-ferrous casting done.
- The pattern is embedded in the foundry floor then sand is rammed properly around the pattern. Parting sand in sprinkle on the pattern and drag.

  Cope flask in placed on the drag and in rammed. Runner gates, etc are cut after removing the cope.

  Pattern in withdrawn and cope and drag are assembled for pouncing.

Floor moulding process:

In this process mould is prepared in foundry floor. Foundry floor will act as drag. All size and shape mould can be prepared by this process, but generally floor moulding process is employed for making large castings. The number of boxes required is less, in the same time extra housekeeping is required floor moulding is further classified into.

1 Open sand mould
2 Floor mould with cope or bedded mould
3 Pit mould
4 Sweep mould

1 Open sand mould

In this process the mould is prepared in the foundry floor. There will be no cope. The cavity will be kept open towards atmosphere. The molted metal is poured directly to the mould cavity.

This process is applicable only to make regular shape rough castings.

The main advantages:

1 No need of box
2 It requires less time and less labour.

Disadvantages:

1 The casting surface gets extra chilling effect and becomes more hard so machining is difficult.
2 There are possibilities to get slag and sand inclusion in the casting

3 It is not possible to make irregular shape castings.

4 It is difficult to prepare hollow castings.

2 Floor mould with cope:

In this process the mould is prepared in foundry floor and the floor acts as drag. Cope is prepared on the floor. All size and shape castings can be made by this process.

The main advantages:

Easy to trap (Filtering) the slag.

Sand inclusion can be easily avoided

Chilling efect on the casting is reduced.

3 Pit mould

This process is adopted of employed for making extra large castings. 1 First a pit is made in the foundry floor with a dimension equal to 1.1/2 to 2 times of the casting size. The bottom of the pit is grouted. Brick wall is prepared all arond the pit upto the floor level. Over the grouting a layer of cinder bed is prepared with the help of burned coke or cupola slag. Two or four vent pipes are placed at the corner. The bottom of the vent pipe will be placed on the cinder bed and the top will reach for about 6" above the floor level. A small layer of straw (or gunny bag is placed over the cinder bed. About 6" height silica sand will be placed over the straw shed). Then a layer of backing sand towards the cinder bed. A layer of facing sand will be placed over the backing sand and the pattern will be kept and rammed. The top level of the pattern may be equal to the foundry floor. Then the cope will be prepared by normal process.

The main advantages

Very large castings can be prepared easily without metal erosion.

Disadvantages:

- It require more time. Labour, and extra materials.
- Separate pits may have to prepared for different shape castings.
- More floor space requires.

4 Sweep mould

The process is introduced for producing large and heavy castings of uniform shape which requires limited numbers. To produce the mould, sweep pattern or strickle board is used. To produce regular shape block.

Castings single stickle board and for regular shape hollow castings, two strickle boards are used. One strickle board will be forming the external surface and the other one will form internal surface.

In the floor is suitable pit will be made and at the centre a base plate will be placed. A spindle will be placed on the base plate and the whole pit will be rammed. The suitable size cope will be prepared over the floor by keeping the spindle at the centre. After the cope is turned over the strickles board will be connected to the collar of the spindle and rotated. Now the sand board and the cavity is formed.

The main advantages.

1 There is no need of pattern

2 To prepare the stricle board less time, less labour and less materials are required.

Disadvantages:

It requires more time and labour to prepare the mould.

Machine moulding

Objectives: At the end of this lesson you shall be able to
- **define machine moulding**
- **list the types of machine moulding**
- **state the advantages and disadvantages of different types of machine moulding**

Machine Moulding

The process of making the mould with the help of moulding machine is known as machine moulding. Machine moulding is employed for the mass production of small and medium size castings. The operations such as ramming the same, shaking the pattern, withdrawing the pattern and turn over the boxes are done by moulding machines. Machine moulding is generally employed in a mechanized foundry where sand reconditioning plant, conveyors and shake out machine are available.

Advantages:

- Machine moulding offers high production rate.
- It gives good surface finish to the mould and castings.
- It provides high dimensional accuracy.
- It requires less labour, less time, less skill and less floor space.
- The pattern plate and pattern used for the machine moulding gives long life.
- The castings produced by machine moulding requires less machining allowance therefore the wastage of metal reduces and the cost machining is also less.

Disadvantages

- Machine moulding cannot be employed for producing large and complex shape castings.
- The initial cost of the equipment are high.
- It can be employed only for mass production of similar castings.

Types of Moulding Machines:

Moulding machines are broadly classified into two groups:

1 Hand operated moulding machines

2 Power operated moulding machines.

1 Hand operated Moulding machines

The operations such as ramming withdrawal of the pattern are done by machines. These operations are obtained by moving the parts of the machine with the help of levers and pedals. Hand moulding machines are further classified into:

1 Plain stripper type machine.

2 Pin lift or push off type machine.

3 Roll over type machine.

2 Power Operated Moulding Machine:

All the operations such as ramming, shaking the pattern withdrawal of the pattern and roll over the box etc. Are done by these machines these operations are carried out electric magnetic force. A combination of pneumatic pressure and electro magnetic force or hydraulic pressure and obtained by jolting and squeezing action.

Power operated moulding machines are further classified into :

1 Squeeze machine

2 Jolt Machine

3 Jolt Squeeze machine

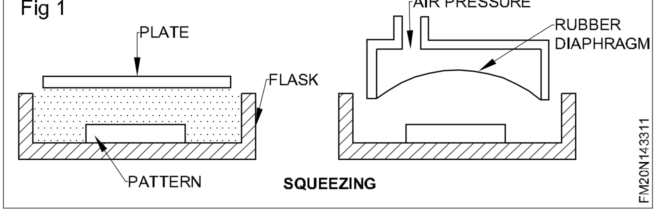
4 Jolt squeeze pin lift machine

5 Jolt squeeze roll over (Pattern) Machine

1 Squeeze machine

In squeeze machine the ramming is obtained by the squeezing the sand either by lifting the table with moulding box or by lowering the head of the machine. By this operation, the flat ramming will be obtained. The hardness near to the pattern will be less and the other side will be more. So getting uniform hardness will be difficult. (Fig 1)

Fig 1



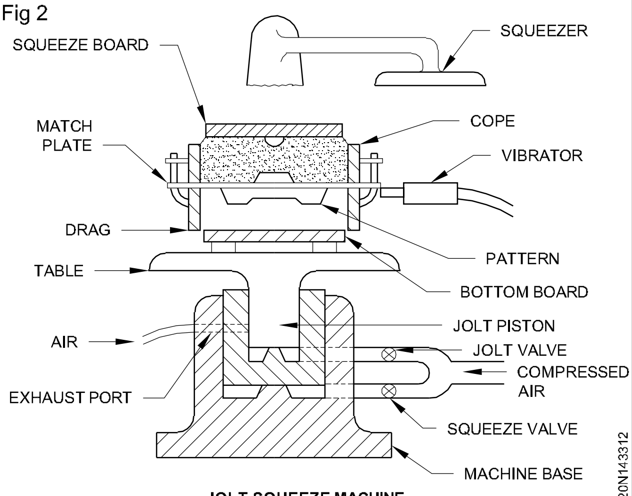
2 Jolt Machine

In a jolting machine the ramming operation is obtained by vibrating the table of the machine. In this case, the hardness near to the pattern will be more and the hardness at the external surface will be less.

3 Jolt Squeeze machine

In a jolting squeeze machine the ramming operation is done by both jolting and squeezing. So it provides uniform hardness all over the mould. (Fig 2)

Fig 2

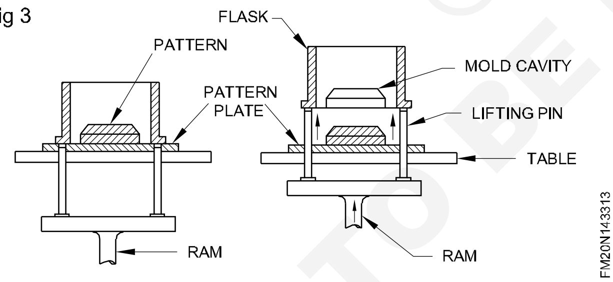


JOLT SQUEEZE MACHINE

4 Jolt squeeze pin lift machine

In this machine, after jolting and squeezing the box is lifted and parted from the pattern by lifting the pins. (Fig 3)

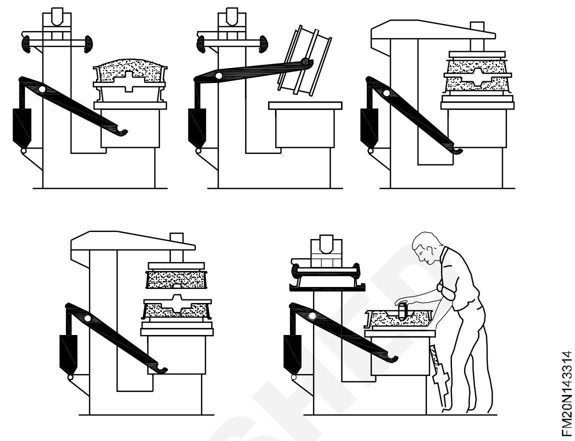
Fig 3



5 Jolt squeeze roll over Machine

In a jolt squeeze roll over machine ramming is done by both jolting and squeezing. Then the table and head of the machine rolled to upside down and then the box is lowered or the table is lifted to get pattern withdrawn and the box is removed. (Fig 4)

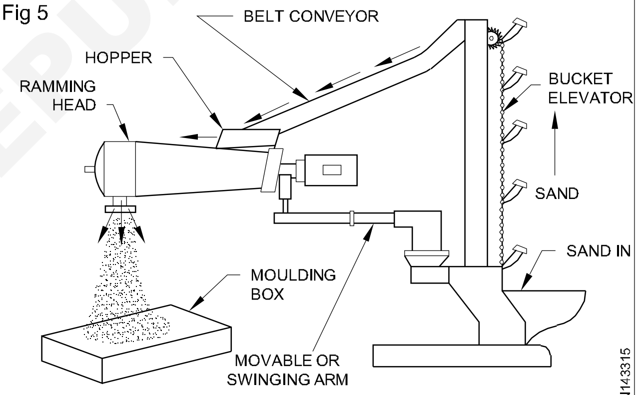
Fig 4



6 Sand slinger

A sand slinger consists of a stand on a base and sand bucket elevator, a swinging or movable arm, a sand impeller. (Fig 5)

Fig 5



SAND SLINGER

Core

Objectives: At the end of this lesson you shall be able to
- **state the steps involved in core making**
- **explain the core sand preparation.**

Steps involved in core making

1 Core sand preparation

2 Core making

3 Core baking

4 Core finishing

Core Sand Preparation

Uniform and satisfactory mixing of core sand is not possible by hand and therefore for better and uniform properties the core sands are generally mixed with the help of mechanical core muller/mixer are used.

There are two types of machine common by used.

1 Roller muller

2 Core sand mixer

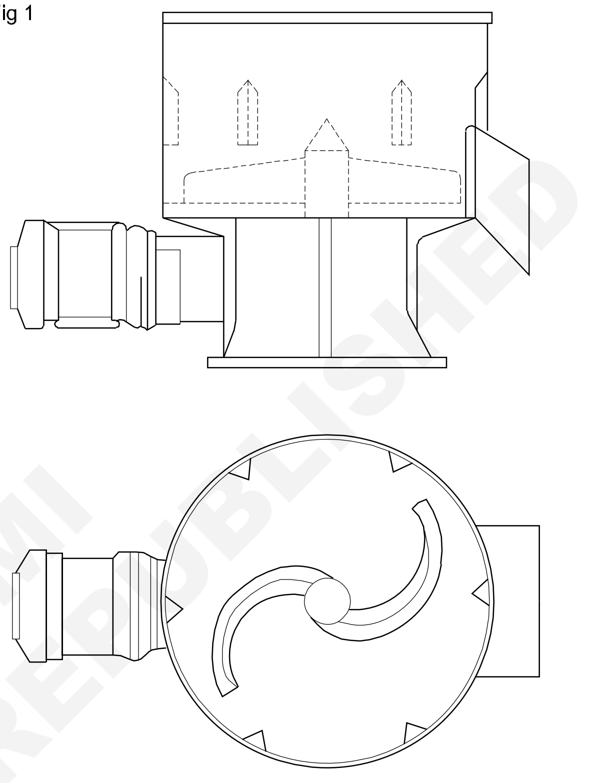
i) Vertical revolving arm type

ii) Horizontal paddly type

In the case of roller muller, the rolling action of the mullers along with the turning over action caused by ploughs gives a uniform and homogeneous mixing.

Roller muller are suitable for core sands containing cereal binders, whereas the core sand mixer is suitable for all types of core binders. These machines perform the mixing of core sand mixture thoroughly. Core sand mixer shown in the Fig. 1.

Fig 1



Characteristic of Core Sand

Objectives: At the end of this lesson you shall be able to
- **describe characteristics of good core sand**
- **state the core mixture for casting ferrous & non ferrous metals and alloys.**

Characteristics of Core Sand

Core must be possess

1 Sufficient strength to support itself and to get handled without breaking.

2 High permeability to let the mould gases escape through the mould walls.

3 Smooth surfaces to ensure a smooth casting.

4 High refractoriness to with stand the action of hot molten metal (metal penetration etc.)

5 High plasticity in order to assist to form a core box internal cavity.

6 Ingredient should not produce more gases.

Core sand mixtures for casting common metals and alloys.

A Core Sand mixtures for general purposes

medium silica sand	-	100 %
Starch	-	1.5 %
Core oil	-	1.5 %
Water	-	2.5 %
Permeability	-	200 cc/min
Green compression Strength	-	1/7 kg/cm2
Dry compression strength	-	17kg/cm2

A Core sand mixture for small to medium size Steel Castings

Silica sand	- 1000 kg
Silica flour	- 70 kg
Resin	- 50 kgs
Bentonite	- 6 to 8 kg
Dextrine	- 8 to 10 kg

A Core sand mixture for light grey iron castings

Silica (AFS Fineness 56)	- 113 parts
Core oil	- 2 parts

A core sand mixture for large grey iron castings

Silica sand	- 100 kgs
Bentonite	- 1.5 kg
Burnt core sand (AES finess 45)	- 360 kg
pitch	- 2.5 kg
Water	- 4.5 to 5.5%

A Core sand mixture for Bronze and Brass castings

Silica Sand	- 1000 kg
Core oil binder	- 9 litres

A Core sand mixture for small aluminum castings

Silica sand	- 50 parts
Burned core sand (AFS finess 85 to 90)	- 50 parts
Core oil	- 1 part
dextrine	- 1 part
Water to tempur	

A Core sand mixture for lights medium size malleable iron castings

Lake sand	- 20 parts
Burned core sand (99 AFS finess)	- 75 parts
Core oil	- 1 part
Cereal	- 2.5 parts
Water	- 4.2 %
Green permeability	- 44 cc/min
Green compression Strength	- 0.08 kg/cm2
Baked tensile strength	- 5.5 kg/cm2

Binders

Objectives: At the end of this lesson you shall be able to
- **state the purpose of core binders**
- **list out the core binders.**

Purpose of core binders

The main purpose of core binder is to bind the sand grain together.

The core binder impart strength and collapsibility.

List out the core binders

Core oil

Oil core binders are used for fine casting finish, strength and impart collapsibility.

It is very easy to handed the core and shifts from one place to other.

Core oil are prepared from vegetable oil, mineral oil, animal oil, small & medium cores can be prepared from core oil.

Core oil usually having less green strength more dry strength.

Eg. Linseed oil, whale oil (mineral oil used for diluting vegetable and marine animal oils).

Molasses

Molasses are used as a core binder for ornamental casting.

Little water is added with molasses to get green strength.

Cereal binders

They develop good green strength, baking strength and collapsibility.

The amount of binders various from 0.25 to 2 % by weight of the sand. Eg. Dextrine.

Protein binders

They increase the collapsibility of core.

Eg. Casein, Glue.

Pitchs

Pitch is added to core as a binder to get hot strength.

Since the pitch is harmful for health mostly it is avoided in work shop.

Thermo setting resin

Mostly all the foundry is using thermo setting binders. It has become very popular. They give high strength, collapsibility and the evolve minimum amount of gases.

The most commonly two types of thermo setting binder are used :-

- Phenol formal dehyde
- Urea formal dehyde usually employed for shell core.

Sulphite Binders

Sulphite binders are rarely used and they used along with certain amount of clay.

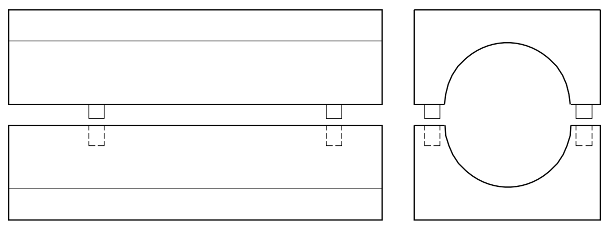
Core - Uses - Types

Objectives: At the end of this lesson you shall be able to
- **describe the core**
- **state uses of core**
- **list out the types of cores.**

Core

Core is a unit of rammed sand mass which is made separately and assembled in the mould to get hollow portion or internal profile in the casting.

Fig 1

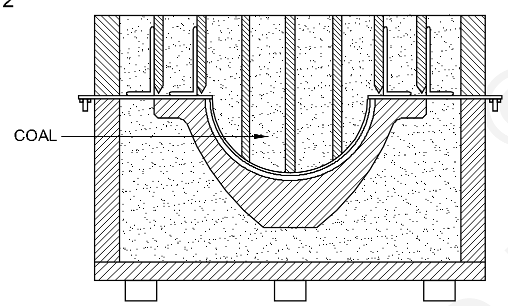


CORE BOX

COD

The self leaving unit of sand mass formed during the process of moulding which causes to produce the hollow in the casting is known as cod. It is otherwise known as self leaving core.

Fig 2



Uses of core

- Cores are used to produce hollow castings or to obtain internal surface in the castings.
- Core may form a part of the mould.
- Core may be employed to improve the mould surface.
- Core may be provide external under cuttings.
- Core may be used for getting entire mould cavity.
- Core may be used to form the gating system.
- Cores may be used to trap the slag in the gating system while pouring the liquid metal.

Types of Cores

Types of cores

1 According to position of fixing.

2 According to use of materials.

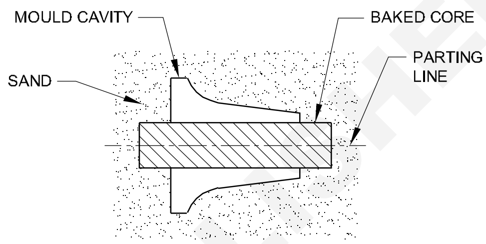
1 According to position of fixing

According to the position of setting the cores in a mould cavity cores may be classified as:

Horizontal Core

A horizontal core is positioned in a mould cavity horizontally. Both ends of the core will be seated on core prints. The core prints for these cores will be at the parting line. Image is missing.

Fig 3

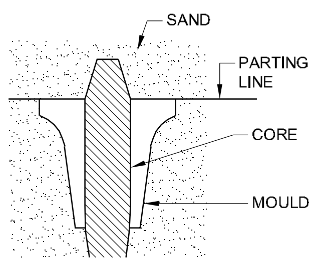


HORIZONTAL CORE

Vertical Core

The Core which is position in the vertical position in a mould is known as vertical core. Both ends of the core will be seated in core prints. One core print will be in the drag and the other will be in the cope.

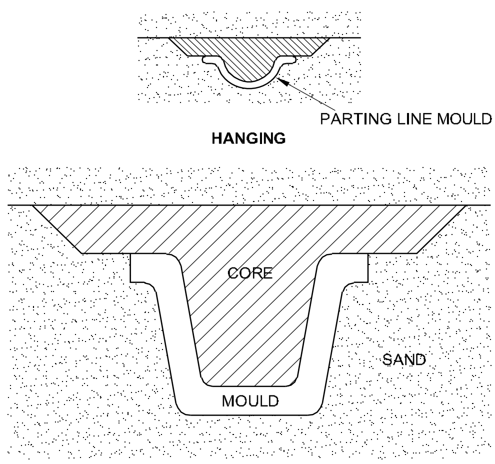
Fig 4



VERTICAL CORE

Hanging core

Fig 5



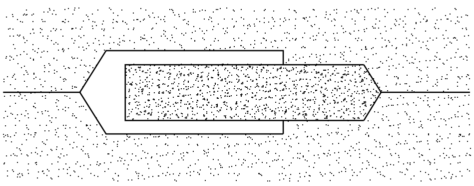
HANGING CORE

The core which is made to hang in the mould cavity. i.e. the core will not be touching of the bottom surface of the cavity is known as handing core. Only one core print will be available in the cope and the core will be seated in it. It is a large core chaplets may be used to support from the bottom side.

Balanced core

A balanced core will be seated in horizontal position in the mould cavity but, it will be seated in only one core print, which located in one side. The other end of the core will be covered by liquid metal. To get proper balancing the portion of the core volume which will be seated in the core print must be higher than the volume of core projecting into the cavity. In case of large core, the balanced portion of the core will be supported by chaplets.

Fig 6



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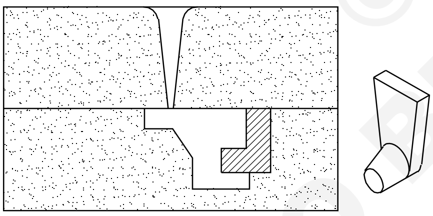
Drop or Stop-off core and chair core

A stop off core is employed to make a cavity (in the casting) which cannot be made with other types cores. It is used when a hole, recess or cavity required in a casting is not in line with the parting surface, rather it is above or below the parting lines of the casting. Depending upon its shape and use, a stop off core may also be known to all core, saddle core or chair core etc.,

Fig 7



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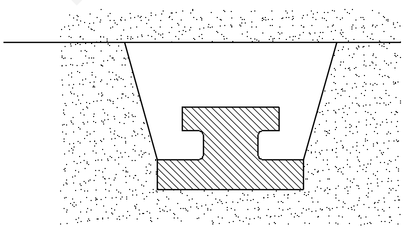
Ram up core

The core which is placed along with the pattern and ramming of mould is done is known as ram up core. Generally large volume of regular shape core is made in this way. It helps to make internal and external details in a casting.

Fig 8



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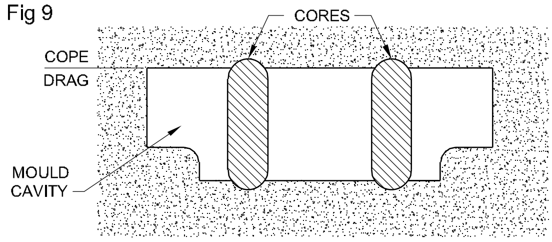
Kiss core or touch core

A kiss core does not require core seats for getting supported. A kiss core is held in position between drag and cope due to the pressure exerted by cope and on the drag. A number of kiss cores can be simultaneously positioned in order to obtain a number of holes in a casting.

2 According to use of materials

Fig 9



KISS CORE

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According to use of materials means which materials used for core making i.e. is called according to use of materials.

Green sand cores

- Green sand cores are formed by the pattern it self
- A green sand core is a part of the mould.
- A Green sand core is made out of the same sand from which the rest of the mould has been made i.e the moulding sand.

Dry sand cores

- Dry sand cores, unlike green sand cores are not produced as a part of the mould.
- Dry sand cores are made separately and independent of the mould.

A dry sand core is made up of core sand which differs very much from the sand out of which the mould is constructed.

A dry sand core is positioned in the mould on core seats formed by core prints on the patterns.

A dry sand core is inserted in the mould before close up the same.

Oil bonded cores

1 Conventional sand cores are produced by mixing silica sand with a small percentage of linseed oil.

2 Oil bonded cores base themselves on the principle of the oxidation and polymerization of a combination of oils containing chemical additives which, when activated by an oxygen bearing material, set in a pre-determined time.

Resin-bonded Cores

- Phenol resin bonded sand is rammed in a core box.

The core is removed from the core box and baked in a core oven at 375 to 450°F to harden the core. (up to 250°C)

Shell cores

1 Shell cores can be made manually.

2 Shell cores can also be produced on machines.

3 Shell cores possess very smooth surfaces.

4 Shell core are possess this dimensional accuracy.

5 Shell core making process can be mechanized and several shell core making machines are commercially available.

6 High permeability is achieved in shell cores.

7 Shell cores can be easily stored for future use.

8 Shell core are costly as compared to cores produced by other methods.

Co_2 cores - sodium silicate

Fig 10

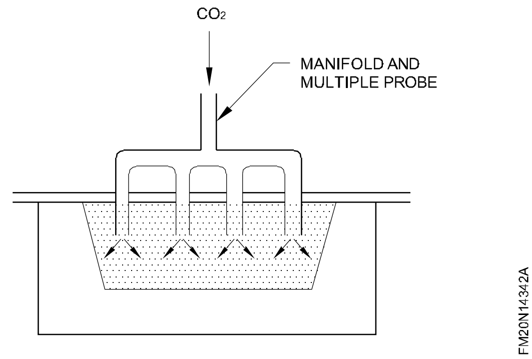
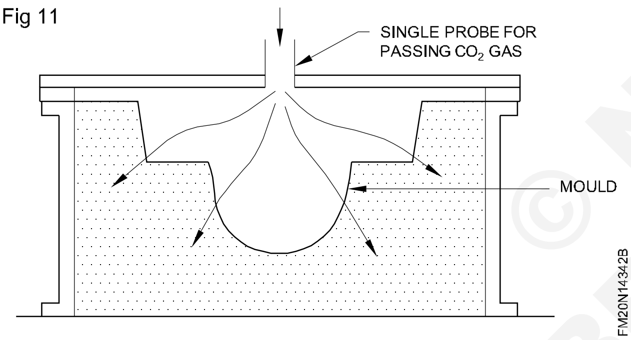


Fig 11



1 These cores use a core material consisting of clean, dry sand mixed with a solution of sodium silicate.

2 The sand mixture is rammed in to the core box.

3 The rammed core while it is in the core box is gassed for several seconds with carbon-di-oxide gas. As a result a silica gel forms which binds sand grains in to a strong, solid form. (Fig 9 & 10)

4 Cores thus formed usually no baking

5 Core drier is not required.

The hot box process

1 It uses heated core boxes for the production of cores.

2 The core box is made up of cast Iron, steel or aluminum and possess vents and ejectors for removing core gases and stripping core from the core box respectively.

3 Core box is heated from 350 to 500^{o} F.

4 Heated core boxes are employed for making shell cores from dry resin bonded mixtures.

5 Hot core boxes can also be used with core sand mixtures employing liquid, resin binders and a catalyst.

Advantages

- Saving in labour
- High accuracy and good surface finish
- Productivity is high
- Less time and production is more
- Reduce machining allowance

The cold set process

While mixing the core sand, an accelerator is added to the binder

1 The sand mixture is very flowable and is easily rammed.

2 Curing begins immediately with the addition of accelerator and continues until the core is strong to be removed from the core box.

3 A little heating of the core hardens it completely.

4 Cold set process is employed for making large cores.

5 Cold set process is preferred for jobbing production.

Castable sand process

1 A setting or hardening agent such as dicalcium silicate is added to sodium silicate at the time of core sand mixing.

2 The sand mixture possesses high flowability and after being paired in the core box, it chemically hardens after a short interval of time.

3 As compared to co_2 process, where it may not be possible to gas the full core uniformly and to obtain uniformly hardened cores, castable sand process produces much better and uniform results.

4 Castable sand process is best suited to large jobbing work.

Nishiyama process

1 It uses sodium silicate bonded sand, which is mixed with 2 % finely powdered ferrous silicon.

2 Hardening occurs because of exothermic reaction of silicon with NaOH produced by hydrolysis in the solution of sodium silicate.

3 Cores thus made possess short bench life.

Furan - No bake system

1 The core sand mixture contains washed and dried sand with clay content less than 0.5% furan no-bake resin 1 to 2% and phosphoric acid 0.5 to 1.1 %.

2 The basic reaction between the furan resin and phosphoric acid results in an acid dehydration of the resin.

3 The core sand mixture high flowability and needs reduced rodding (to handle to core)

4 Uniform core hardness, exact core dimensions better fitting cores, lower machining and layout costs, and reduction of oven baking are some of the good characteristics of cores made by Firan no bake system.

Oil No/bake process

- The process employs a synthetic - oil binder which when mixed with basic sands and activated chemically produces cores that can be cured at room temperature.

Composition of oil bake system

Washed and dried sand	-	500 kg
Oil no bake binder and catalyst	-	7 kg
Oil no bake cross linking agents	-	1.4 kgs

It process the polymerization reaction results in a complete core sand mass.

This process assures better depth of set, fast baking, easier core-withdrawal and lower production costs as compared to furan or oil bonding processes.

Core - Uses - Core Box

Objectives: At the end of this lesson you shall be able to:
- **state the core box**
- **list out the types of core boxes**
- **describe the core boxes.**

Core box

- A core box is basically a pattern for making cores.
- Core boxes are employed for ramming cores in them.
- Core boxes impart the desired shape to the core sand.

Core boxes range from simple wooden structures to precision metal assemblies which possess long life under exacting condition.

Types of Core boxes

According to the construction the core boxes are classified as follows:

1 Half core box

2 Slab or dump core box

3 Split core box

4 Gang core box

5 Loose piece core box

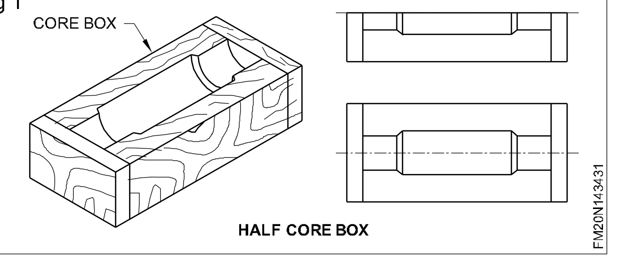
6 Left and right hand core box

7 Strickle core box

1 Half Core box

This core box will be exactly half the portion of a full core box. Generally, half core boxes are used to make the core of regular shape like cylinders, by using a core box two pieces of core will be made. After drying these halves will be assembled by pasting and used as a full core, by using half core box the material requirement reduces and labour charge also reduces.

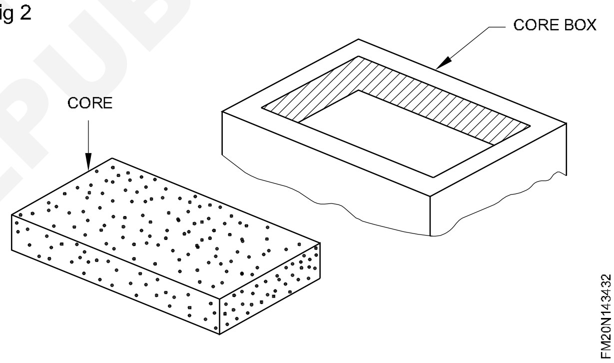
Fig 1



2 Dump or Slab Core Box

Dump core box will be just like a frame having all the four sides covered with top and bottom open. By using this core box full core is made but the shapes like rectangular, square etc., can be made.

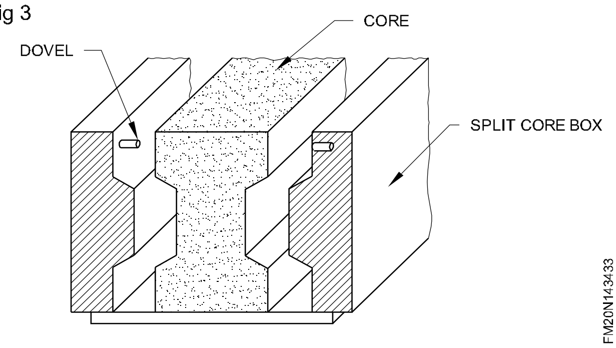
Fig 2



3 Split Core Box

The split core box will be made in two parts, before making the core, these parts assembled together and clamped. The obtain correct location dowel pins and holes will be provided. The core will be stripped off by separating the halves of the core box.

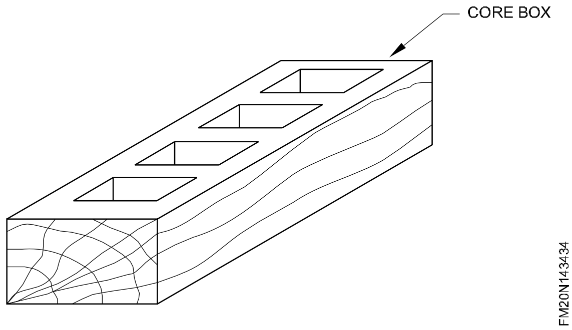
Fig 3



4 Gang Core Box

A gang core box may contain member of similar holes. Once the core box is filled, rammed and stripped off number

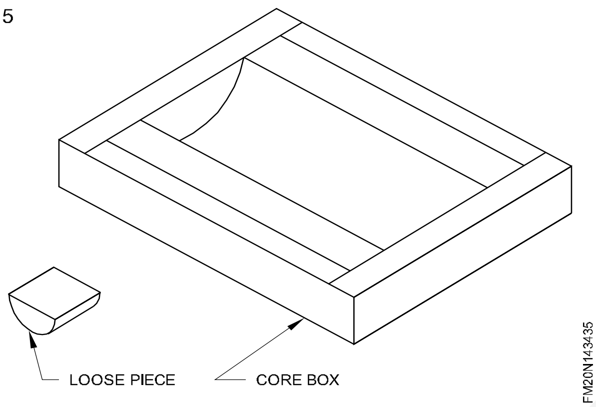
Fig 4



of cores, can be taken. This type of core box can be used for small cores which have regular surfaces for mass production.

5 Loose Piece Core Box

Fig 5



This core box may be of split type, to get the depression on the core surface loose pieces will be provided. After ramming the core, the main body of the core box will be stripped off. Then the loose pieces will be removed. This type of core boxes are used to produce irregular shape cores.

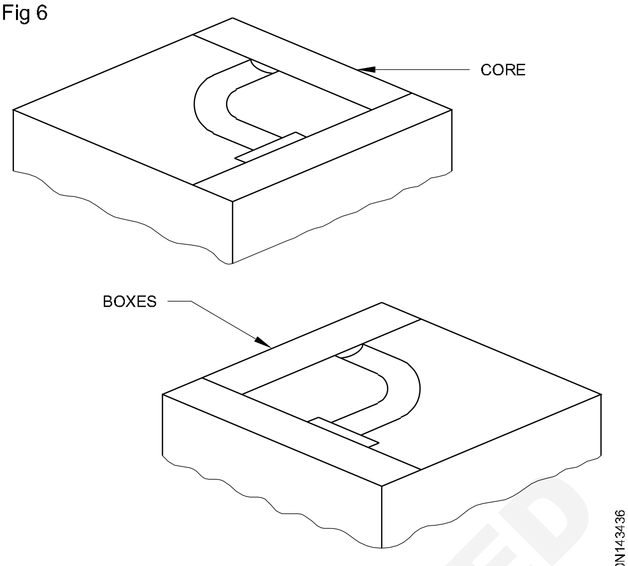
6 Right and Left Hand Core Box

Just like the half core box, two halves will be made separately. By using this halves of core box separately halves of the cores are made and assembled together to form the full core after it is dried.

7 Strickle or Sweep Core Box

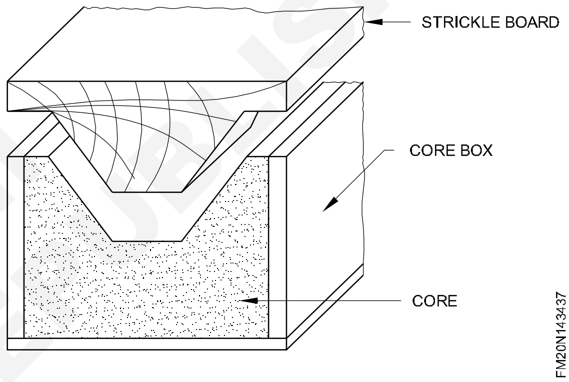
After the sand is rammed in a dump core box strickle boards are used to obtain the correct shape of the core on the other hand the core will be made just like the sweep moulding.

Fig 6



LEFT AND RIGHT HAND CORE-BOXES

Fig 7



Core Print: The projections provided on the patterns for the seating of the core is known as core print. A core print may be provided on the horizontal parting line of the pattern on both sides or in the drag and cope portion or in any one side of the pattern.

Re-inforcement of Cores

Objectives: At the end of this lesson you shall be able to:
- **state the feature and reinforcement of core**
- **list out the different types of re-inforcement used for cores**
- **state the quality of re-inforcement.**

Purpose of re-inforcement

1 Re-inforcement is given to get the extra strength to the core.

2 It protects the core, except for very small cores.

3 Every core is internally reinforced with core wires or core rods for medium cores and with cast iron or fabricated steel devices known as core grids or bars for long cores.

4 Reinforcement is very essential for cores.

5 By re-in forcing the core the core can be lifted safety to drying plate and after backing lowered accurately in the mould

6 Re-inforcement imparts extra strength to cores to withstand lifting forces caused by molten metal.

List out the types of re-inforcement used for cores

1 Soldiers

2 Gaggers

3 Springs

4 Head nails

5 GI wire

6 Rod

7 Arbors

1 Soldiers

Wooden pieces used as a reinforcement is known as soldiers. This may be used only for small self leaving core in the mould or cod.

2 Gaggers

'L' & 'Z' shape MS rods used as a reinforcement for self leaving cores in a mould is known as gaggers.

3 Springs

Spring "Shape" re-inforcement used in a core as well as in the mould surface are known as spring. These are made by metal sheets i.e roughly stamped metal sheet. It improves the strength of the large mould & core walls.

4 Head nails

Head nails are used as re-inforcement to increase the core & mould strength. Head nails also used for self core reinforcement.

5 GI wire

For small and straight core GI wires are used.

6 Rods

For medium core geometrical types cores rod are used for re-inforcement.

7 Arbor

Larger cores the reinforcement provides as anchoring point for lifting staples used handling and setting in the mould.

An arbour is a skeleton frame like structure made of steel or cast iron and provides support.

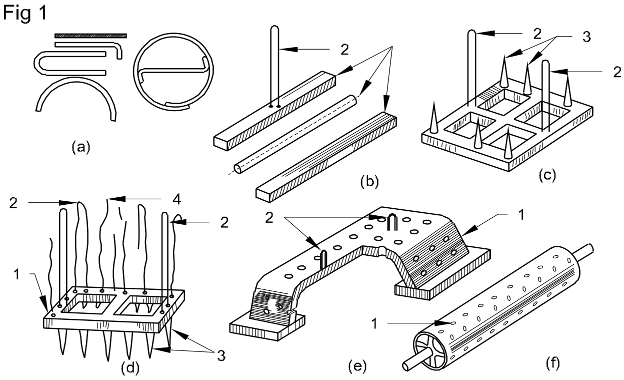
Quality of re-inforcement

Re-inforcement should have sufficient strength.

Re-inforcement should not expand or shrink it length due to heat.

Non-ferrous metal should not be used because non ferrous metals changes its dimensions when contacted by heat and the core may collapse.

Fig 1



(a) FOR SMALL CORS
(b) FOR SMALL CYLINDRICAL CORES
(c) FOR SMALL CORS
(d) FOR HEARY CORS
(e) FOR PRISMATIC CORS
(f) FOR LARGE CYLINDRICAL CORE

(1) BASE
(2) LIFTING ARRANGEMENT
(3) CAST IN PINS
(3) WIRE ELEMENTS

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Venting of Cores

Objectives: At the end of this lesson you shall be able to:
- **state purposes of core venting**
- **list out different types of core venting.**

Purpose of core venting

Core venting is done to improve the permeability of the core. It helps for the higher collapsibility also.

When the molten metal is poured into the mould a majority portion of the surface of the core is covered by liquid metal due to contact of the liquid metal, the special additives and certain minerals in the sand burn and produces hot gases.

These gases should be allowed to pass out or it may cause for casting defect. So the venting of core is essential.

Types of core venting

1 Pierced venting

2 String venting

3 Wax venting

4 Venting by cutting channel

5 Venting by perforated pipes

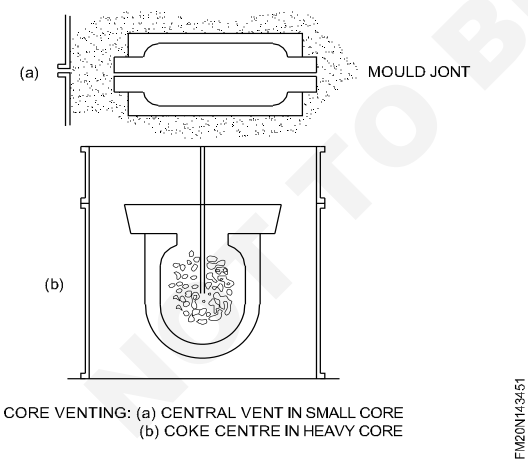
6 Coke and ash venting

7 Gallery venting

1 Pierced venting

After preparing the core venting is done by piercing a sharp edged rod or wire. This method is used only for small regular type cores. (Fig 1)

Fig 1



CORE VENTING: (a) CENTRAL VENT IN SMALL CORE
(b) COKE CENTRE IN HEAVY CORE

2 String venting

A string or rope is placed in between the two halves of core than assembled in green stage. After clamping the halves, the string is removed and thus the vent hole is formed. Such type of venting is preferred for the cores like bend, elbow and 'T' shape.

3 Wax string venting

A string of wax is prepared and placed in the core at the places required. While drying the core the wax melts and flows out by leaving the vent holes. This type of venting is done on irregular shape cores.

4 Venting by cutting channel

When two halves of the cores are made separately and assembled together after drying, such method is followed channels are cut at the joining surface of the core halves before assembling such method is preferable for irregular shape cores such as "T", "Y", "X" etc.,

5 Venting by perforated pipe

A perforated pipe is used as reinforcement and the same acts as a vent. Before applying the sand over the pipe a layer of straw rope is winded. This type of venting is done for large regular shape cores. When it is made by sweep core making process.

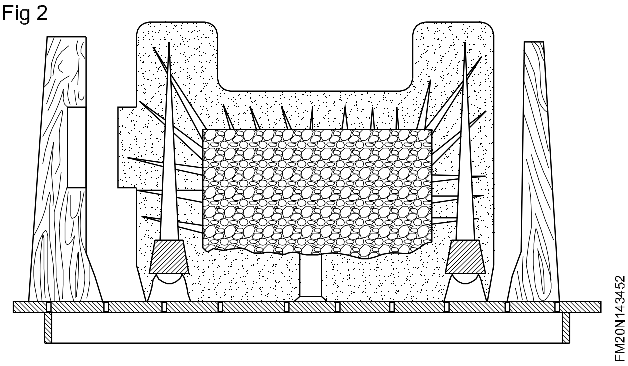
6 Coke and ash venting (Cinder Venting)

When large cores of regular shape to be made the coke and ash are placed at the centre of the core and a small opening will be made towards the core prints. Such venting is otherwise called as cinder venting.

7 Gallery venting

This method is used in a core if the core has got a zig zag shape. After ramming the core the venting will be made in the shape of a galaxy by piercing the vent wire or by cutting channel.

Fig 2



Cores Making Machine

Objectives: At the end of this lesson you shall be able to:
- **state the purpose of core making machine**
- **classification of core making machine**
- **name the core blowing machine**
- **name the core ramming machine**
- **state briefly the application of each machine.**

Core making machine

Core making machine are employed for mass production of small cores rapidly and accurately. Core making machine are employed in mechanized foundry.

Core making operation is performed by machine similar to those used for making moulds.

Classification of core making machine

Core making machine are broadly classified as :-

1 Core blowing machines

2 Core ramming machine

3 Core drawing machine

1 Core blowing machine

The basic principle of core blowing consists of filling core sand into the core box using the medium comprised air. The velocity of compressed air is kept ensuring their deposit in the remote corner in the core box.

Name the core blowing machine

- Small bench blowers
- Large flour blowers

2 Name the core ramming machine

- Jolting
- Squeezing
- Slinging

Application of core ramming and core blowing machine

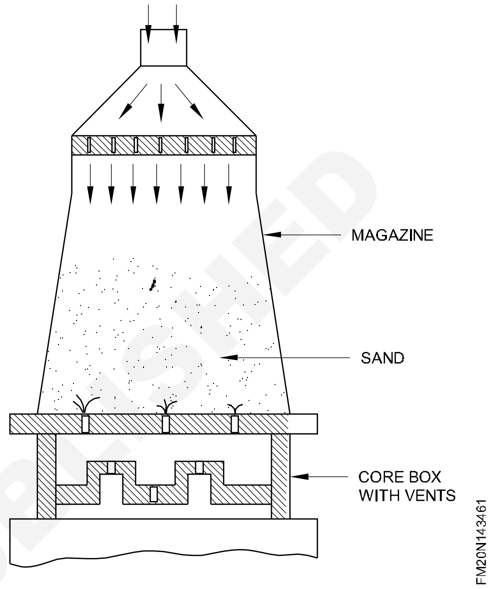
- Core blowing machine
- Jolting machine
- Sand Slinger
- Core extrusion or continuous core making Machine
- Core drawing machine
- Shell core machine
- Core roll over machine

Core blowing machine: Core sand are compressed in the aluminum box with help of high velocity to produce the core.

There are the types usually employed to work at the bench & floor. Core boxes contain wires which automatically provide vent holes in the core as they are blown.

Jolting Machine: The core box is raised upto some distance and then dropped. This operation is continuous due this action sand get filled in the core box.

Fig 1



Sand Slinger: Sand slinger machine fill and ram the core at same time. The ramming of core obtained by the impact of sand which moves at a very high velocity with help of rotating impelly. Sand is thrown over the core with high velocity into core box filling and ramming the sand at the same time.

Sand slinger are faster in operation used for mass production.

There are two types of sand slinger.

- Stationary types sand slinger
- Mobile sand slinger (tractor mounted)

Core extrusion or continuous core making machine

A core extrusion machine has a hopper through which the core sand is fed to a horizontal spiral conveyor.

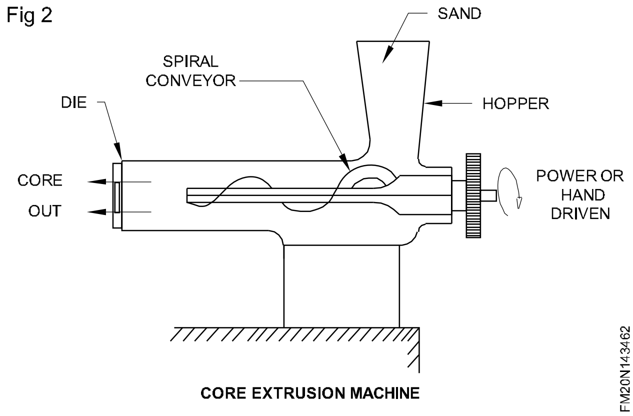
A spiral conveyor is rotated it forces core sand through a die of specified shape.

Round, square, oval, hexagonal, core with uniform cores sector. Regular shape are produce d rapidly on a core extraction machine.

3 Core drawing machine

This machine is preferred when the core boxes have deep draws. After ramming sand in it, the core box is placed on the core plate supported on the machine bed. A rapping action on the core box is produced by a vibrating vertical plate. The rapping action helps in drawing off the core box from the core.

Fig 2



CORE EXTRUSION MACHINE

After rapping the core box is raised leaving the core on the core plate.

Shell core machine

Phenol formal dehyde or urea formal dehyde mixed with silica flour blown into pre heated metal core. The resin allowed to melt due to heat. The resin get cured

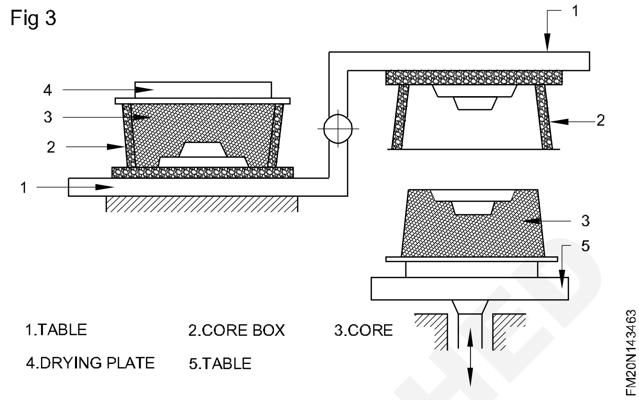
The hardness core extracted from the core box.

Shell core possess high tolerances, high permeability can be stored for future use.

Roll-over machine

This machine is used to roll over the core an core plates. The whole assembly can be rotated through 180° can be used in mass production of small core.

Fig 3



Core Baking Ovens

Objectives: At the end of this lesson you shall be able to:
- **state the purpose of core baking ovens**
- **name the equipments used for core baking**
- **describe the different types of core-baking equipments.**

Purpose of core baking ovens

Cores are used for producing hollow place in the castings. Before setting in the mould the core is backed conventionally with the help of core ovens to remove the moisture from the cores.

In order to evaporate the moisture from the cores and to increase its dry strength, to oxidize the oil binders and drive off all volatile matters core are baked in the core baking oven.

Batch types oven

- Drawer type
- Rack type

Continuous type oven

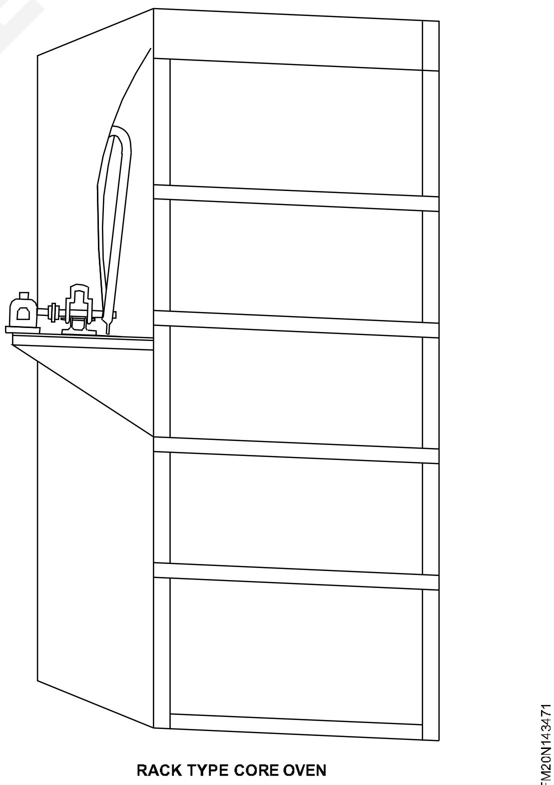
Continuous type core baking ovens having racks with continuous rotating conveyor. The conveyor is continuously moves slowly. The prepared core is loaded at one side. Baked cores unloaded or removed from other side.

Both the side of core ovens opened at convenient height for loading and unloading cores are placed at the conveyor and it moves slowly up and comes down.

The core is baked in between this movement.

The baking time is controlled by the oven temperature and speed of the conveyors.

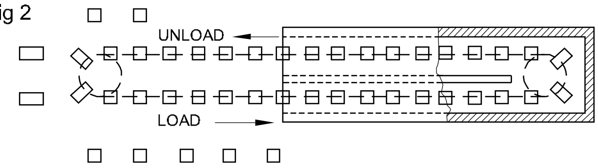
Fig 1



RACK TYPE CORE OVEN

Continuous type ovens are preferred for large scale baking of cores of approximately same size. In order to save floor space continuously core-baking arrangements may be built over head.

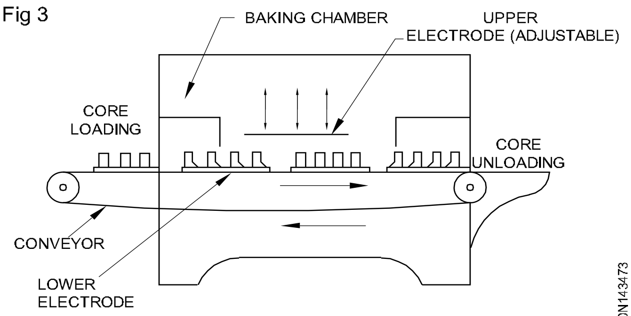
Fig 2



CONTINUOUS CORE-BAKING ARRANGEMENT

Di-electric core ovens: Moden foundries are employed for high quality cores using plastic binders and petroliem binders.

Fig 3



CONTINUOUS CORE-BAKING ARRANGEMENT

Finishing of Cores

Objective: At the end of this lesson you shall be able to:
- **state stages of core finishing.**

Uses of Core Finishing

- Baked cores are finished before they set in the mould.
- Hollow portion of casting smooth finish and accuracy most important for core to minimize the fettling cost. Cores are finished before setting in the mould core finishing classified as follows.

  1 Cleaning

  2 Sizing

  3 Core assembly

1 Cleaning

Cleaning involves

Trimming

Trimming means removing fins and other sand projection from the cores by rubbing them with file or abrasive tool.

Brushing:

Brushing moves loose sand from the cores.

Coating:

coating produce smooth core surfaces and make cores resistant to molten metal penetration

A fine refractory coating may be applied by dipping swabbing or spraying

Core coating materials are finely ground graphite, silica and zircon flour.

Coating materials are held in suspension in water by a suitable emulsifier

A torch or burner may be used to dry the coated core surfaces. Core coatings have been discussed

Mudding

Mudding is a localised coating which is applied to make core surface completely smooth.

A typical mud can be made with 94% silica flour, 3% bentonite 3% dextrin and moisture.

The mud thus made is rubbed in to the cavities in the cores and smooth off.

Mud is dried in an oven

2 Sizing

Sizing means making a core dimensionally accurate

Core shape and dimensions are checked with the help of templates and gauges.

Cores can be corrected to size by grinding, filing or scraping

Initially while making cores can be given a sizing allowance ie cores may be made a little oversized. This excess material will be consequently removed during sizing

3 Core assembly

Core assembly means joining together by pasting, leading or bolting two or more component parts of the core before the core can be set in the mould.

Core paste can be applied over the core with the help of finger, by brushing or dipping a core paste may be formed out or talc, dextrin, molasses flour, water etc.

Core pieces after being pasted are assembled pressed and left to dry.

Leading is the process of joining core parts with molten lead. Lead on freezing forms a strong joint leading is preferred for making small core assemblies.

Large core parts are assembled by nuts and bolts. Nuts and bolts are of course covered with mud after joining the core parts.

Oil fired furnace

Objectives: At the end of this lesson you shall be able to
- **state about the oil fired furnace**
- **state operation and maintenance of oil fired furnace.**

Tilting furnace

Tilting furnace is tilting type furnace compared to pit furnace, crucible is stationary large amounts of metal are melted.

Shell is made from M.S. plate cylindrical shape with refractory lining.

Parts of tilting furnace (Fig. 1)

1 Stand
2 Worm gear with shaft
3 Tilting handle
4 Crucible stand
5 Burner
6 Air pipe
7 Oil pipe with oil filter
8 Motor with blower
9 Furnace cover with lifting handle
10 Spout
11 Emergency spout
12 Tilting mechanism
13 Oil Control valve
14 Shell
15 Crucible

1 Stand

It is made out of mild steel resist the whole furnace. It has shaft attached with bearing.

2 Worm gear with shaft

Worm gear made out of cast iron. It helps tilt the furnace and pour the molten metal into the ladle easily.

3 Tilting Handle

Ease of operating the tilting furnace

4 Crucible stand

It is made out of mild steel having in the centre of the furnace place the crucible on the crucible stand. Support the packing material around the crucible.

5 Burner

It is made out of brass or bronze. It helps to mix air and oil proportionately to send to furnace for combustion.

6 Air pipe

It connects from blower to furnace for pumping air continuously upto melting.

7 Oil Pipe with filter

It has the fill of oil for burning in the burner.

While melting the metal, the flame is corrected from escape by the cover. Also the handle in used for ease or removal of cover.

8 Motor with blower

It is made out of cast iron. Make air with the help of power which comes through wind pipe into the tilting furnace.

9 Furnace cover with handle:

It is made from mild steel round plate inside the refractory lining. While melting the metal, the flame is arrested from escape by the cover. Also the handle is used for ease of removal of cover.

10 Spout

It is made out of steel and shall form 'v' shape fitted in the top level of the furnace with refractory lining. While tilting the furnace molten metal is easily poured into the lined ladle.

11 Emergency spout:

It is made out of steel and shall form 'v' shape fitted in the bottom level of the furnace with refractory lined.

Any emergency at melting time to take out molten metal in the lined laddle.

12 Tilting mechanism:

Ease to the tilt bush and bearing having inside the place of the tilt.

13 Oil Control value:

Control of oil supply to the burner.

14 Shell

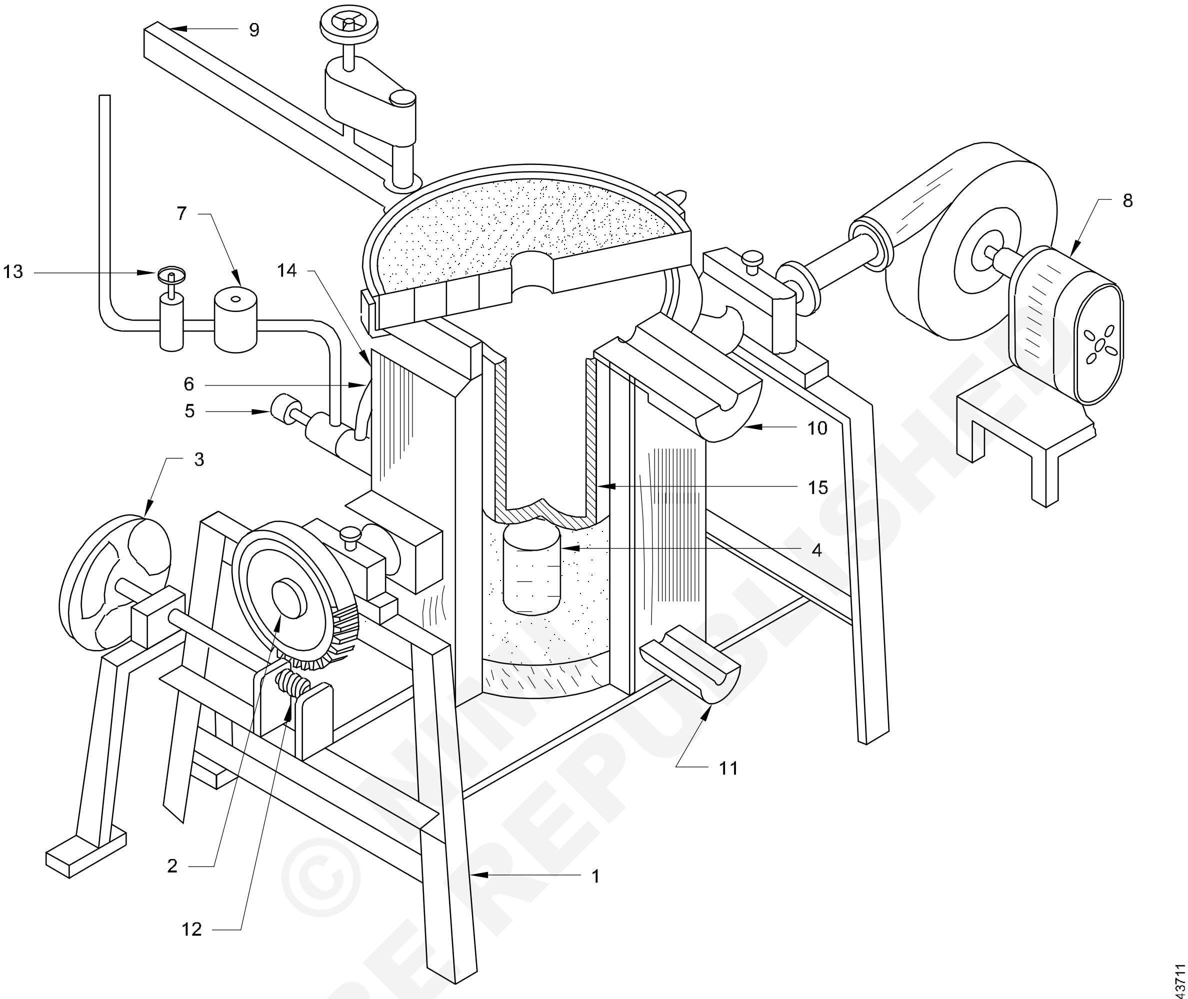
It is made out of M.S. place make round shape in side the refractory lining.

Advantages of Tilting Furnace

- There is no wastage of fuel; no sooner is the metal ready than the supply of oil or gas can be stopped. The fuel supply can also be regulated while working tosuit the requirements.

- The output in a given time is greater due to higher efficiency.
- Better temperature control can be maintained.
- Less contamination of metal takes place.
- Saving in floor space is achieved.
- As stocking is not required, labour cost is reduced.

Fig 1



PARTS OF TILTING FURNACE

Operation of oil fired furnace.

This furnace makes use of oil as fuel for heating the crucible. The furnace is cylindrical in shape and the flame produced by the combustion of oil with air is allowed to sweep around the crucible and uniformly heat it.

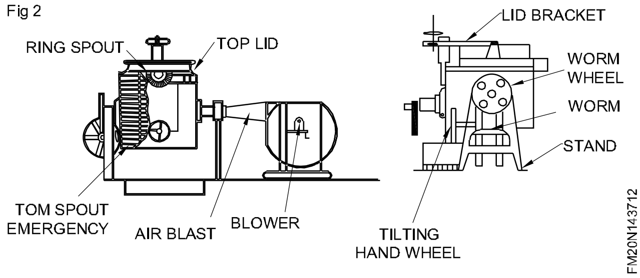
Atomised fuel oil is fed through a manifold. It enters the furnace tangentially where it ignites and swirls upwards between the crucible and the refractory lining. The metal is charged through the opening in the centre of the head. Modern oil fired furnaces are equipped for automatic proportioning. The produce a natural flame by regulating the fuel and air ratio the temperature is controlled thermostatically.

The oil fired furnace are generally the tilting or the bale-out type. The tilting type of furnace raised above floor level mounted on two pedestals and rotated by means of a geared hand wheel the tilting gear is customarily so designed that the furnace tilts on a central axis.

Maintenance:

- Periodically check the below parts
- Inspect oil burner
- Clean heat exchanger
- Inspect and replace oil nozzle
- Replace filter
- Check fuel lines for leak
- Check the furnace lining and reline it

Fig 2



Pattern

Objectives: At the end of this lesson you shall be able to
- **state about pattern**
- **name the different types of pattern making materials**
- **state the advantages and dis-advantages of wooden pattern**
- **state the advantages and disadvantages of wooden pattern**
- **state about the pattern acccessories.**

Patterns

Pattern is the same replica of a required casting. It is also known as moulding forming tool.

Pattern Materials: Patterns are made by different materials taking into consideration of

1 Number of casting to be produced.

2 The dimensional accuracy and the surface finish required to the casting.

3 The moulding process to be employed.

4 The method of moulding.

5 The size and shape of the casting to be produced.

Taking into consideration of the above factors, the following materials are used for making the patterns for foundry.

1 Metal

2 Wood

3 Plastic and plastic compounds

4 Plaster of Paris

5 Wax

6 Polythrene foam

7 Epoxy resin

8 Old castings

Metal: Metal is used for making patterns for mass production of limited size. Especially metal patterns are used for machine moulding. The common metals used for making patterns are copper, brass, bronze, gun metal, Aluminum alloys etc.,

The main advantages of the metal patterns:

1 It can be used for longer period

2 It gives high dimensional accuracy and surface finish.

3 It will not absorb the moisture from the mould or atmosphere and get damaged.

4 Stronger than other materials.

5 It will withstand rough handling.

6 It will not be attracted by insects and get damaged.

7 It will not warp and loose its tolerance under slight temperature variations.

The main disadvantages of the metal patterns:

1 Expensive than other materials.

2 Carving and shaping are difficult.

3 Heavier than other materials.

4 Repairing is difficult.

Operation

Wood: The most common material for making patterns for sand casting is the wood.

Advantages:

Inexpensive,

1 Easily available in large quantities

2 Easy to machine and shape to different configurations and forms

3 Easy to join to acquire complex and large pattern shapes

4 Light in weight.

5 Easy to obtain good surface finish

6 Wooden patterns can be preserved for quite long times with the help of suitable wood preservatives (shellac etc.)

7 Resin acid glues criminate the necessity of joining wood by nails and screws and produce very strong joints.

8 Wood laminate patterns possess high strength to weight ratio:

9 Are strong and tough and possess longer life as compared to ordinary wood patterns.

10 Wooden patterns can be repaired easily.

Disadvantage

1 Wooden patterns are susceptible to shrinkage and swelling

2 They possess poor wear resistance

3 They are abraded easily by sand action

4 The absorb moisture, consequently get warped and change shape and size.

5 They cannot withstand rough handling

6 They are weak as compared to metal patterns.

Plastic

Advantages

1 Durable

2 Provides a smooth surface.

3 Moisture resistant

4 A plastic pattern does not involve any appreciable change in its size or shape.

5 Light weight

6 Good strength

7 Wear and corrosion resistant.

8 Provides good surface finish

9 A plastic pattern does not stick with mold material and can be easily taken out without spoiling the mold cavity

10 It possesses low solid shrinkage.

11 Plastic patterns are easy to make

12 They possess good compressive and flexural strength

13 Abrasion resistant.

14 Better impact strength than wood

15 Good resistance to chemical attack

16 Better adhesive qualities

Disadvantages

1 Plastic patterns are fragile and thus light sections may need metal reinforcements.

2 Plastic patterns may not work well when subject to conditions of severe shock as in machine molding (Jolting).

Plaster

Advantage

1 It can be easily worked by using wood working tools.

2 Intricate shapes can be cast without any difficulty

3 It has high compressive strength (up to 285 kg/cm2)

4 Unlike metals, it expands while solidifying

5 In case of a plaster (pattern) having suitable coefficient of expansion no shrinkage allowance may be given on the pattern.

Wax

Advantage

1 Wax patterns provide very good surface finish

2 They impart high accuracy to the castings

3 After being molded, the wax pattern is not taken out of the mold like other patterns; rather the mold is inverted and heated; the molten wax comes out and/or is evaporated. Thus is no chance of the mold cavity getting damaged while removing the pattern.

Wax patterns are made in water cooled two piece metal mold or a die.

Difference between wood pattern and metal pattern

	Wood pattern	Metal pattern
1	Weight is low-so they are used for large pattern	Weight is high compared to wood so they are used for small and medium pattern
2	Easy to shape	Hard to shape
3	Change in dimension due to absorption of moisture	No changes in dimension due to absorption of moisture
4	High dimension tolerance needed compared to metal	Low dimension tolerance needed compared to wood
5	Very difficult to give fine details of surface	Easy to give fine details of surface
6	Low strength	High strength
7	Moderate surface finish	Smooth surface finish
8	Deform while in storage	So not deform while in storage
9	Repairing the pattern is easy	Repairing the pattern is hard
10	Repairing cost low	Repairing cost high
11	Wood patterns are not liable to rust	Metal patterns are liable to rust
12	Low cast	High cost '
13	Not suitable for large scale production	Suitable for large scale production
14	Types of wood used for pattern making a Mahogany b Teak c deodars d Pine etc.,	Types of metals used for pattern making a Cast iron b Steel c Brass d Alumin um e Gan metal etc.,

Types of Pattern

Objectives: At the end of this lesson you shall be able to
- **state about the types of pattern**
- **list out the types of pattern**
- **state about the different types of patterns**
- **state about the self core pattern.**

Types of Patterns

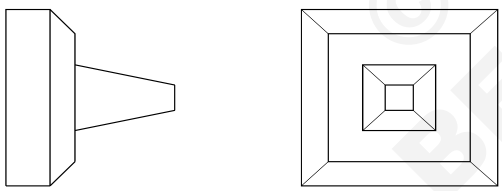
According to the construction of the patterns. The patterns are classified into:

1 One piece or solid pattern.
2 Split pattern
3 Loose piece pattern
4 Match plate pattern
5 Sweep pattern
6 Gated pattern
7 Segmental pattern
8 Follow board pattern
9 Stop-off-pattern
10 Master pattern
11 Skeletion pattern
12 Self core pattern

1 Solid pattern

It is the simplest form the pattern and made as one piece whatever may be the shape and size. Generally it will have taper to one direction and in certain cases to both directions from the middle. (Fig 1)

Fig 1

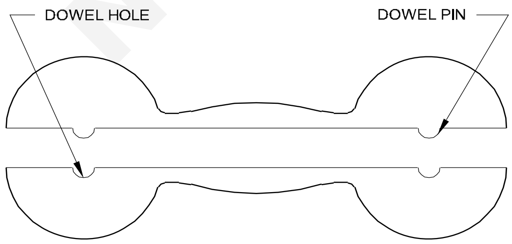


SOLID PATTERN

2 Split Pattern

The pattern which have the taper to different directions and complicated shape will be made as separate pieces and assembled to the main body of the pattern. These pieces will not be at the parting line or in the withdrawal direction.

Fig 2

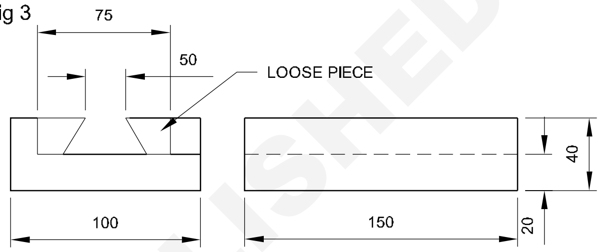


SPLIT PATTERN

3 Loose Piece Pattern

Certain pattern may have projections (boss) and irregular shape, such portions will be made as separate pieces and assembled to the main body of the pattern. These pieces will not be at the parting line or in the withdrawal direction.

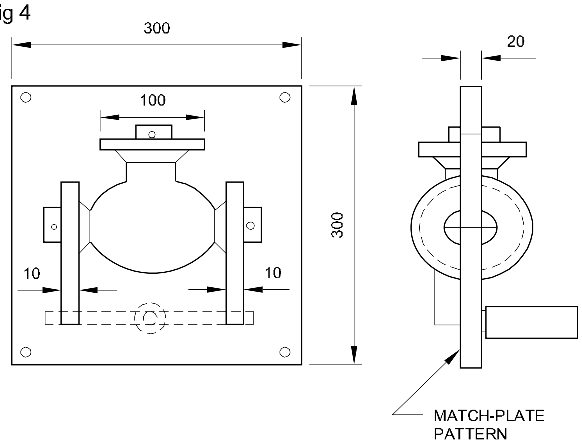
Fig 3



4 Match Plate pattern

The pattern will be made in two halves and assembled on either side of a plate. The match plate will have the provision for locating the pins while assembling the moulding box in correct position. The mould halves will be made from the either sides of the pattern assembly. When these boxes are assembled, the full mould will be obtained. Generally, the channel and ingates are also arranged on the plate. This is mainly used for machine moulding.

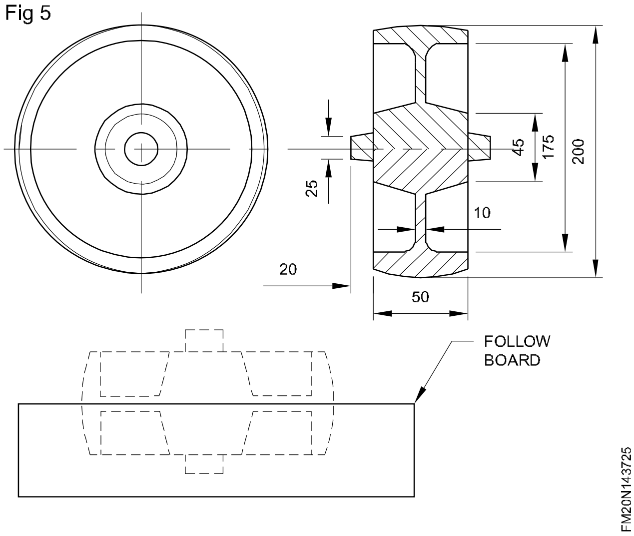
Fig 4



5 Follow Board Pattern

The follow board pattern is a wooden board used to place the pattern which may not have a regular parting line. By keeping the pattern over the follow board arrangement parting line will be obtained. Hence the process of making false box or odd-side will not arise.

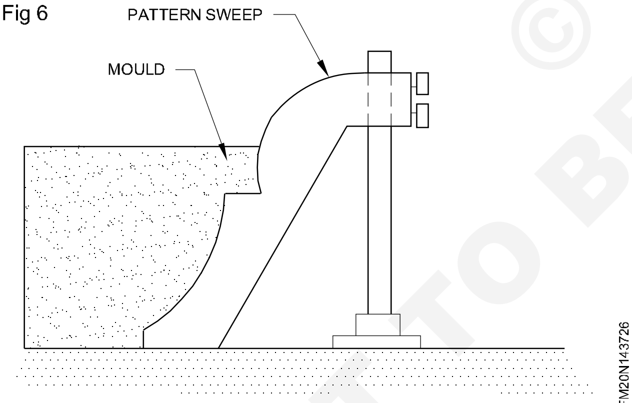
Fig 5



6 Sweep Pattern:

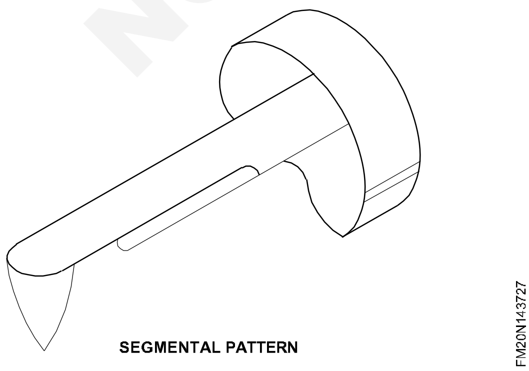
The sweep patterns are made to make large moulds. Sweeps are made with wood or any other suitable materials just like small strips. These strips are used to cut and remove the sand from a rammed platform. Sweeps will be fitted with a rotating arm which are connected to a spindle for the movement. By using the sweep patterns the material required for pattern making and the cost for making the pattern are reduced. But this can be used only for the castings which have a regular shape.

Fig 6



7 Segmental Pattern

Fig 7



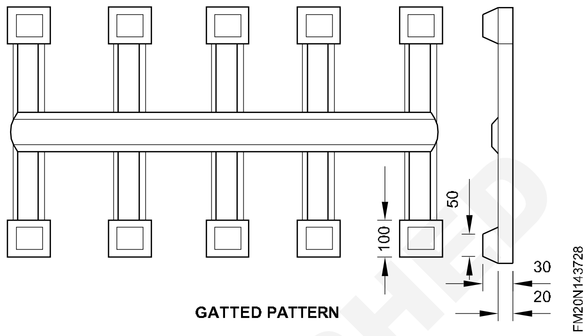
SEGMENTAL PATTERN

To produce large circular shape castings a segment of the pattern will be made. Mould cutting and finishing slightly bigger cavity by keeping the segmental pattern in different positions the shape of the casting is obtained.

8 Gated Pattern

In this pattern the channel ingate etc. Also will be fixed with the same material. While withdrawing the pattern the channel and in gates are also formed.

Fig 8

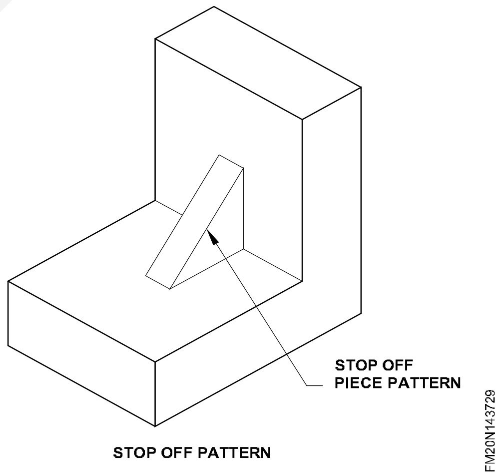


GATTED PATTERN

9 Stop Off Pattern

Certain patterns will have very thin sections. This may cause for warping and even damage during the process of moulding. Such portions are supported with extra thick strips or plates. After withdrawing the pattern the cavity formed by the extra strip or plate are sealed off with a suitable core or by moulding sand. Such patters are known as stop off piece patterns.

Fig 9



STOP OFF PATTERN

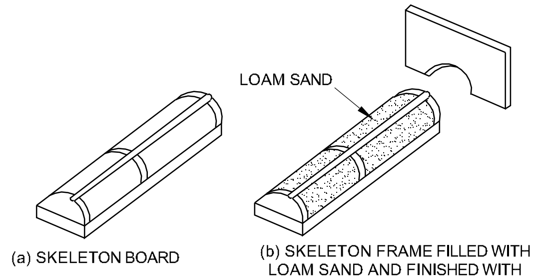
10 Master Pattern

Master pattern can be made by any one of the pattern materials. It will have all allowance in double, it is used for making metal patterns.

Skeleton Patterns

To produce large regular shape castings instead of preparing the full patterns, the patterns will be made with a Central Board and some collars at suitable pieces. The gap in between the collars will be filled with sand or any other suitable materials before use. Such patern are known as skeleton patterns. By using this pattern large amount of pattern making materials will be saved.

Fig 10



SKELETON PATTERN

Self Core Pattern

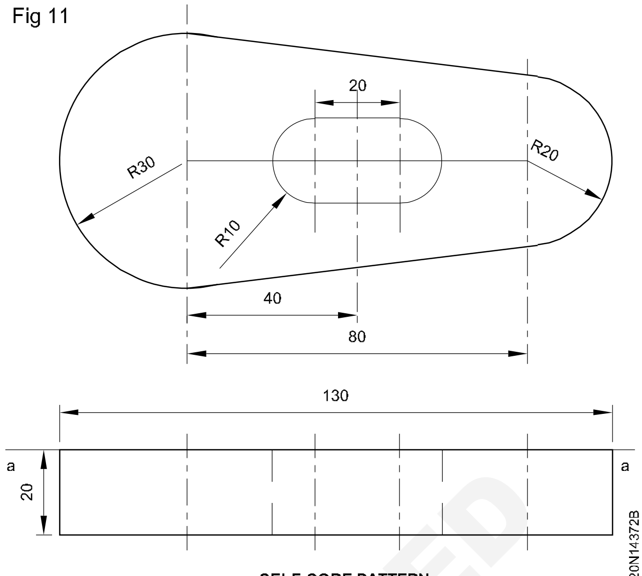
The pattern are made in one piece with self core in its construction is called self core pattern.

Self core may be one or number of self core.

Self core does not required core box.

Core print is not required.

Fig 11



SELF CORE PATTERN

Pattern Accessories

Objectives: At the end of this lesson you shall be able to
- **list out the pattern accessories**
- **explain brief the uses of pattern accessories.**

Pattern Accessories

1 Stop-off piece

2 Dowel pin

3 Lifting plates

4 Rapping plate

5 Stripping plate

6 Fillet

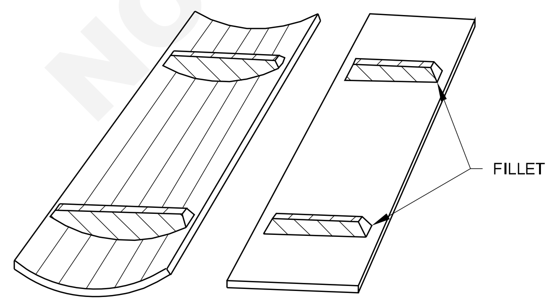
Uses of pattern accessories

Stop - off piece

Stop-off-piece is accessories of pattern which is not to casting. It is attached to stronger the portion of pattern.

The impression left by the stop-off-piece is filled with moulding sand before pouring. (Fig 1)

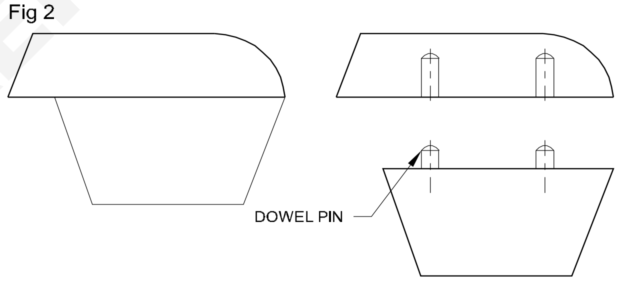
Fig 1



Dowel Pins / Dowel holes

Dowel pins / Dowel holes are attached to locate the pattern. It is practiced with the different sizes of pins fitted at equal distances. Uses of three dowel pins entirely eliminate the possibility of mix matching the pattern part.

Fig 2

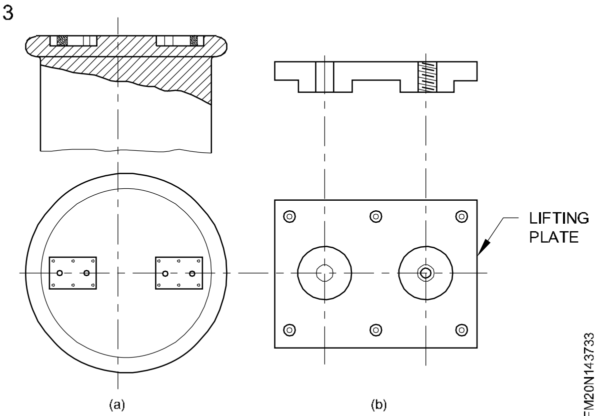


REQUIRED CASTING SPLIT PATTERN

Lifting Plate

Large and strong plate attached to heavy pattern so that the pattern can be safely lifted by the help crane. There plates are called lifting plate. (Fig 3)

Fig 3



Pattern allowances

Objectives: At the end of this lesson you shall be able to
- **state the meaning of pattern allowances**
- **state the different types of allowances used in patterns.**

Pattern allowance is one of the most important characteristics of pattern design to obtain defect free casting.

The patterns are not made the exact size as the desired casting because such a pattern would produce under size casting.

A pattern is always made larger than the required size of the casting in order to allow for various factors such as shrinkage, machining, distortion, rapping and drafting etc.

The selection of correct allowances helps in reduction in...

- Rejection of casting.
- Machining costs and
- Salvage and repair of pattern.

The following allowance are provided in a pattern contraction.

1 Shrinkage or contraction allowance
2 Machining or finishing allowance
3 Drafting or taper allowance
4 Rapping or shaking allowance
5 Distortion allowance

1 Shrinkage or contraction allowance

All the metals used for casting contracts and shrink in size after solidification and cooling in the mould

To compensate for this the pattern must be made larger than the finished casting by an amount known as contraction/ shrinkage allowance.

The pattern maker is provided with a special rule or scale called contraction steel rule.

The amount of contraction varies with different metals and therefore their corresponding allowance also differ.

The contraction of metal is always volumetric, but the contraction allowance are always expressed as linear measure.

2 Machining or finishing allowance

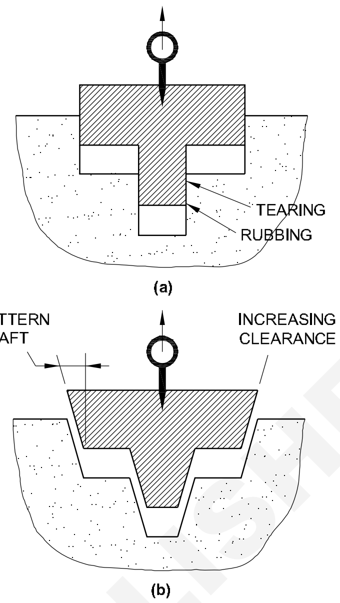
Many parts of the machine required machining to get accurate size components.

Machining or finishing allowance is the extra material added to the certain part of the casting to enable their finishing or machining to the required size and accurate surface finishing.

3 Draft or taper allowance. (Fig 1)

The draft or taper allowance is provided on all vertical surfaces of the pattern.

Fig 1



EXAMPLE OF PATTERN TAPER
(TAPER EXAGGERATED FOR ILLUSTRATION)

FM20N143741

It can be expressed either in degree or in measurements.

It is provided on both internal (hollow) and external surfaces of the pattern.

The amount of draft on internal surface of the pattern is more than external surface of the pattern.

The purpose of providing this taper or draft is to facilitate easy withdrawal of pattern from the mould without damaging the surfaces and edges of the mould.

For general casting the draft on external surface is about 10 mm to 15 mm per meter and internal surface is about 25 mm to 40 mm per meter.

4 Rapping or shanking allowance

When the pattern is rapped or shaken for easy withdrawal, the cavity in the mould gets slightly increased in size.

This causes the size of casting also to increase.

To compensate for this increase the pattern should be initially made slightly smaller than the required size.

In small and medium size of casting this allowance can be ignored, but for the large sized casting this allowance should be provided by making the pattern slightly smaller than the required size.

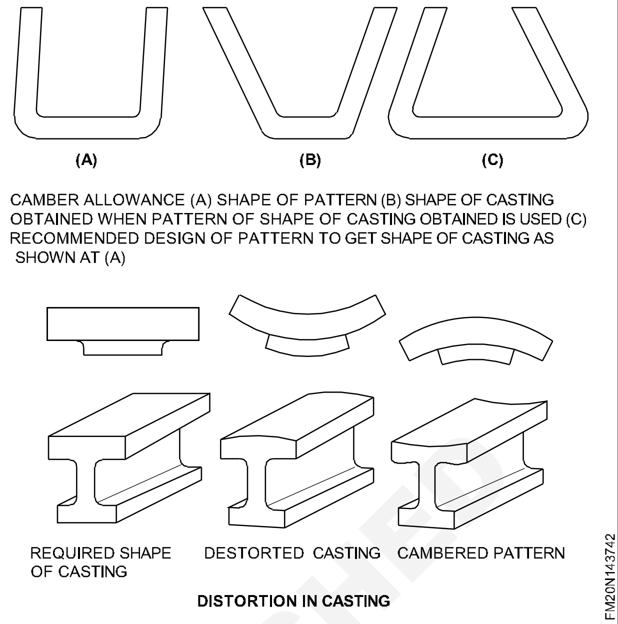
5 Distortion allowance. (Fig 2)

Sometimes the casting gets warp or distored during cooling due to their size, shape and type of metal.

This is due to uneven shrinkage, uneven metal thickness or one surface being more exposed than the other and casting it to cool more rapidly.

This allowance is considered only for casting having an irregular shape and which have tendency to get distored (e.g.) long flat casting, casting with unequal arm.

Fig 2



S.No.	Metal	Allowance mm/metre	Contraction percentage%
1	Cast iron (grey)	7.00 to 10.5	0.7 to 1.05
2	Cast iron (white)	21.00	2.1
3	Malleable iron	10.00 to 15.00	1.5
4	Steel	20.00 to 21.00	2.00
5	Brass	14.00 to 16.00	1.4
6	Bronze	10.5 to 21.00	1.05 to 2.0
7	Aluminum	16.00 to 18.00	1.8
8	Zinc	24.00	2.5
9	Lead	24.00	2.4
10	Copper, Nickel and magnesium	16.00	1.6
11	Silver	10.00	1.0
12	Aluminum alloys	13.00 to 16.00	1.3 to 1.6
13	Manganese steel	26.5	2.65

Pattern colour code as per BIS (ISI)

Objectives: At the end of this lesson you shall be able to
- **state the colouring code of pattern as per BIS (ISI)**
- **state the advantages of colouring code as per the BIS (ISI) in the pattern.**

Standard colours have been recommended for the finish of wooden pattern and core boxes.

For identification of their different parts of pattern and core boxes, are coloured with standard shades (colours).

Advantages of colour code

- Preserve the pattern and core box from moisture and fungi attack.
- Easy identification of different part of pattern and core box for proper or type of moulding
- Maintain the shape and size of pattern.
- Easy withdrawal of pattern from mould sand.
- Durability of pattern and core box.
- Good appearance of pattern and core box.

The following will serve as a useful guide both for pattern and core box construction

The pattern colour scheme recommended by IS : 1513-1971

Surface	Colour/Mark
Surface to be left as unmachined	Blue (steel)
	Red (Grey cast iron)
	Grey (Malleable cast iron)
	Orange (Heavy metal castings)
	Brown (Light metal castings)
Surfaces to be machined	Yellow
Coreprints for unmachined opening and end prints	
Periphery	Black
Ends	Black
Coreprints for machined openings	
Periphery	Yellow strips or black
Ends	Black
Pattern joints (split patterns):	
Cored section	Black
Metal section	Clear varnish
Touch core	
Core shape	Black
Legend	“Touch”
Seats of and for loose core prints:	**Green**
Stop-offs:	Diagonal black strips or clear varnish
Chilled surfaces:	
Outlined in legend	Black “chill”
Fillets:	Black broken line
Master pattern	Green

Coatings

Objectives: At the end of this lesson you shall be able to
- **state about the coating on mould and core**
- **list out the types of coatings used in moulds and cores.**

Coating on mould & cores:

- Mould or core coating are also known as mould or core washer, dressing, facings, blacking etc.,
- Core or mould surfaces may be coated with a heat resistant paint made up of blacking,plumbago, silica flour magnesite etc., mixed to a paste with a clay slurry,dectrine and water.
- Core coating may be applied by dusting, dipping, spraying and brushing.
- It may be water or alchohol base paint.

Type of coating for mould and core.

1 **Powder base**

example - french chalck powder - green sand mould - non ferrous metal

graphite powder - green sand mold ferrous metal

2 **water base**

example - plumbage powder + water - sand mould

Zircon, graphite, aluminium silicate for sand mould and cores.

3 **solvent base**

zircon. graphite magnesite silicate refractory material (plus simple) solvent

used for sand mould and cored.

Pattern making

Objectives: At the end of this lesson you shall be able to
- **state the meaning of pattern making**
- **state the difference between pattern making and casting.**

A pattern may be defined as a "Replica" or "Fascimile" model of anything constructed in such a way that it can be used for forming an impressing a cavity called `Mould' in damp sand or other suitable material.

When this mould cavity is filled with molten metal produces the desired casting after solidification of the poured metal.

The process of making a pattern is called 'Pattern making'

The process who makes the pattern is known a "Pattern maker".

When the molten metal or substance that solidify in mould cavity, there is a reproduction of pattern called casting.

A pattern is slightly larger than in dimension than the casting.

Contraction allowance of about 1mm to 2 mm per 100 mm is added in pattern.

Machining or finishing allowance for finishing the surfaces are added in pattern construction.

Drafting allowance of 1° for external and 3° for internal surface is given in pattern.

Core prints are provided with pattern construction.

Casting is a single piece, where as pattern may be two or more pieces.

Pattern may be differ in material of which it (the pattern) is made.

Pattern making hand tools

Objective: At the end of this lesson you shall be able to
- **state the contraction details and uses of pattern making hand tools.**

Wood working hand tools are listed as per the following:

1 Marking and testing tools

2 Holding and supporting tools

3 Measuring tools

4 Cutting tools

5 Planning tools and other types of tools also used.

Classification and uses of marking tools

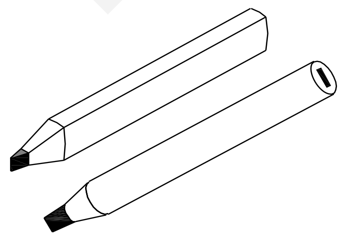
Objectives : At the end of this lesson you shall be able to
- **state the different type of marking tools**
- **explain the use of marking tools**
- **brief constructional features of marking tools.**

Marking off or layout is carried out to indicate the location of operation to be done and provide guidance during sequence of operations.

– Marking out is done with pencil or scriber etc.,

Carpenter's pencil (Fig 1)

Fig 1



– Carpenter's pencil usually is an oval cross-section.

– It is sharpened with a chisel.

– The pencil is not used for an accurate work.

– Suitable pencil hardness for marking out on 'HB', 'H' and 'F'

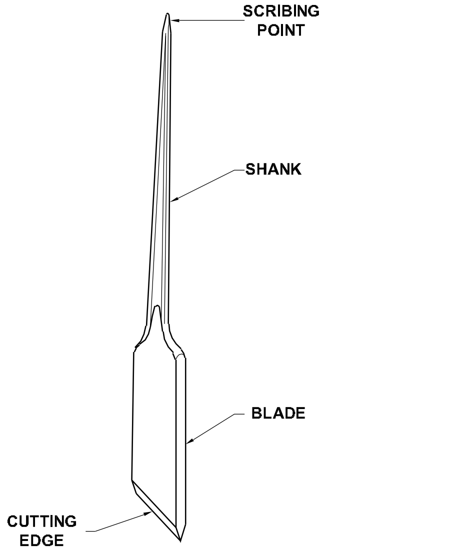
Marking knife (Fig 2)

It is made of steel fashioned to a point at one end and a sharp blade at the other end to form a cutting edge. The blade or knife is used for marking cut lines where a vertical shoulder is to be cut with a saw or chisel. The point is used for marking distances and scribing lines.

Steel scriber (Fig 3)

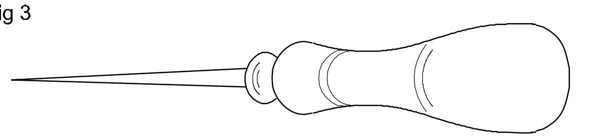
A steel scriber should be sharp at its point. It is used for scribing lines on which a chisel cut or a saw cut is made.

Fig 2



MARKING KNIFE (OR STRIKING KNIFE)

Fig 3

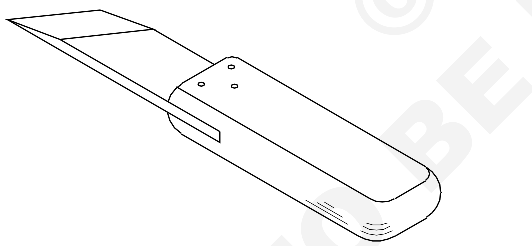


STEEL SCRIBER

The scriber should not be used as an awl. Do not strike the handle with a hammer.

Marking knife is also used for marking and scribing . It is a steel blade fixed in a wooden handle. it serves the same purpose as that of scriber. (Fig 4)

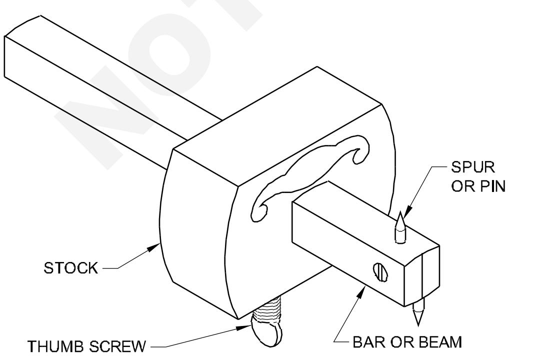
Fig 4



MARKING KNIFE

Marking gauge (Fig 5)

Fig 5



Making gauge is used for marking lines parallel to a face and edge (e.g.) gauging width and thickness.

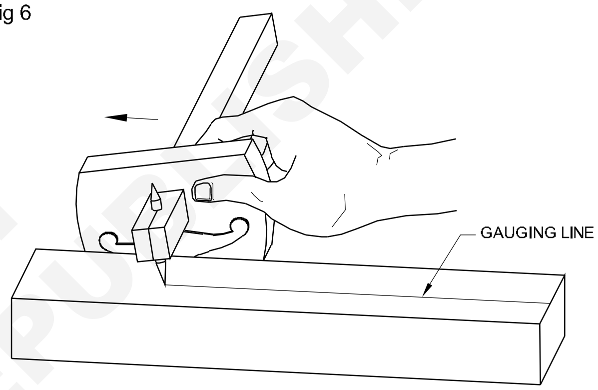
The marking gauge can be made of wood or steel. The gauge consists of square, wooden bar or beam on which wooden block or stock is sliding. This block can be fastened at any required measurement by use of a thumb screw.

In better form of gauges the stock is protected from wear by a piece of brass set flush with surface. The bar is graduated in millimeter and provided with a spur or steel point at the end. It is always advisable to measure the distance from the spur to the face of the block, with an 'ordinary rule'.

The gauge is set by losing the screw and the stock is shifted to the distance required from the spur. Measurement are taken from a rule.

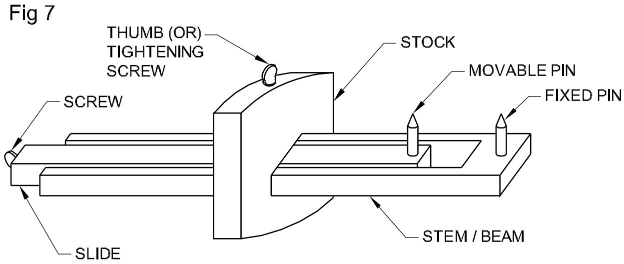
After setting the screw is tightened while gauging the stock is firmly help against the wood and pushed in forward direction. (Fig 6)

Fig 6



Mortise gauge (Fig 7)

Fig 7



MORTISE GAUGE

A mortise gauge is a making gauge with two spurs. The two spurs can be spaced at different distances and mark two parallel lines at a time.

This is made of hard wood and has an adjusting screw in the end of the beam.

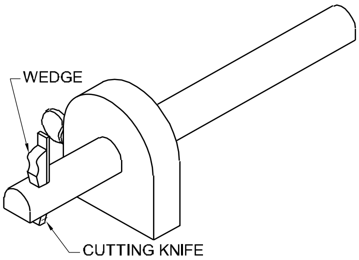
The screw moves one of the spurs up and down or as desired. The other side of the beam is fitted with a single point as no the ordinary marking gauge.

The gauge is used for marking mortises and tenons, and similar joints using parallel lines.

Stem/beam and stock made of beech wood. Thumb screw made of box wood. Pin or spur made of steel.

Cutting gauge (Fig 8)

Fig 8



CUTTING GAUGE

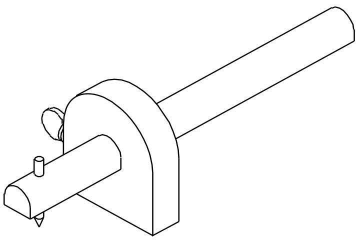
This is just the construction of a marking gauge.

At the end of the stem scribing knife is fixed with aid of one weddge. By loosening the wedge, the length of knife may be increased or decreased. In broad planks scribing marks can be marked with this gauge.

Deep marks can be scribed with this cutting gauge for making grooves, rebates and dovetails. It is possible to cut thin strips of timber and plywood upto 3mm thick.

Panel gauge (Fig 9)

Fig 9

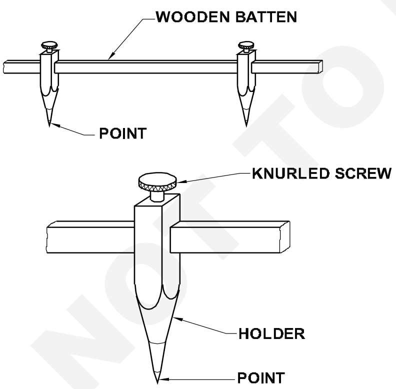


PANEL GAUGE

This is just like single marking gauge but the stem and stock are long. The length of stem is 450mm. In planks longer than 150mm scribing marks are made with the panel gauge.

Trammel points (Fig 10)

Fig 10



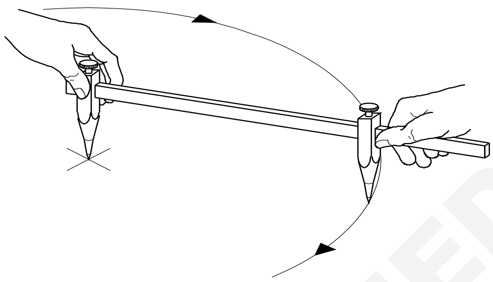
TRAMMEL POINTS

Trammel points are used for laying out larger circles and arcs.

Two sliding points are fastened to a wooden batten or a steel rod at any distance required from each other by turning the knurled screw. The point is fastened to the batten or steel rod.

Sometimes one of the points can be replaced by a pencil lead. (Fig 11)

Fig 11



USING THE TRAMMEL POINT

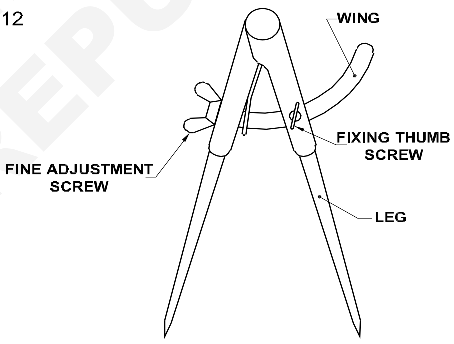
Wing compass

If consists of a pair of dividers (legs) made of steel.

The legs are sharpened to points and at the top they are rivettd or screwed.

They are fixed at the required radius by means of a set screw. (Fig 12)

Fig 12



WING COMPASSES

Uses

1 For setting out arcs of circles.

2 To transfer the measurement from the steel rule to the job.

3 To mark curves.

Measuring and testing tools

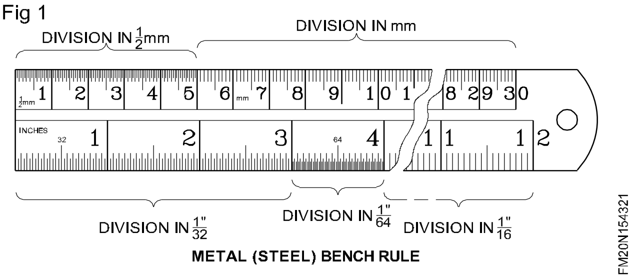
Objectives: At the end of this lesson you shall be able to
- **state the different types of measuring and testing tools**
- **explain the use of measuring and testing tools**
- **brief the constructional and features of measuring and testing tools.**

The Rule (Steel) (Fig 1)

– In the workshop wooden or steel rules are used

– The division in cm is 30cm long and sub divided in mm (2) and half mm (3).

Fig 1



– The division in inches is 12 inches (12") long twelve inches equals one English foot 12" = 1'

– The Sub division is accurate in 1/16" (4) in 1/32" (5) and In 1/64" (6).

– For the conversion of parts of an Inch in to the metric system (with units: m, cm, mm) a conversion table might be useful.

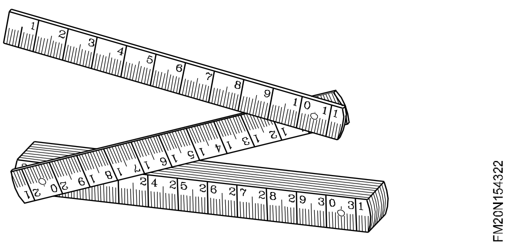
1/16"	=			1.6 mm
2/16"	=	1/8"	=	3.2 mm
3/16"	=			4.8 mm
4/16"	=	1/4"	=	6.35mm
5/16"	=			8.0mm
6/16"	=	3/8"		9.5mm
7/16"	=			11.1mm
8/16"	=	1/2"	=	12.7mm
9/16"	=			14.3mm
10/16"	=	5/8"	=	15.9mm
11/16"	=		=	17.5mm
12/16"	=	3/4"	=	19.05mm
13/16"	=		=	20.6mm
14/16"	=	7/8"	=	22.2mm
15/16"	=		=	23.8mm
16/16"	=	1"	=	25.4mm

Collapsible Carpenter's rule (Zig-Zag) (Fig 2)

It is also called Zig-Zag rule. It consists of 10 pieces each loosely riveted to one another. Each piece is 10cm long and total length is 1 metre.

Longer distances can be measured with this rule. Some times it contains British system measurements on the other side.

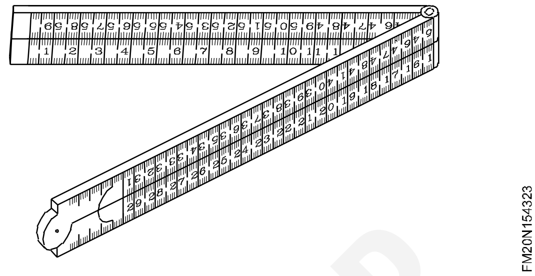
Fig 2



Folding Rule (Foot rule) (Fig 3)

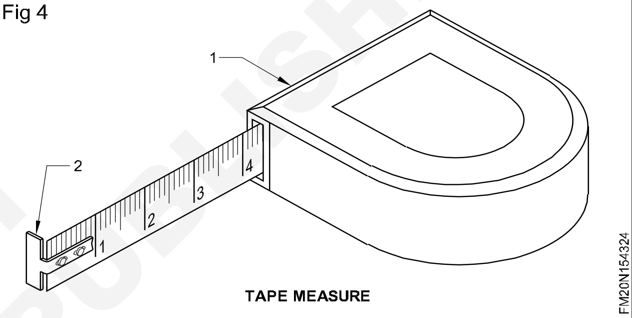
It is also called foot rule. It has four folds each of which is 6 inches or 150mm long. It is joined in a plastic a metallic hinge. After taking measurement, keep the scale folded and free from dust. It is easily carried in packets. Metal clip is provide at the end of this rule to avoid wear and tear.

Fig 3



Tape measurement Rule (Fig 4)

Fig 4



Tape measures are used for longer measurements. The tape is made of steel and is durable and accurate. When not in use, the tape should be kept in the box. Division are made in centimeters or in inches.

Tape measure has a sliding end piece for inside and outside measurement.

Combination set

Combination sets can be used for different types of work, like layout work, measurement and checking of angles.

The combination set has a (Fig 5)

– protractor head (1)

– square head (2)

– centre head (3)

– rule (4)

Protractor Head

The protractor head can be rotated and set to any required angle.

The protractor head is used for marking and measuring angles within an accuracy of 1°. The spirit level attached to this is useful for setting jobs in a horizontal plane. (Fig 6)

Fig 5

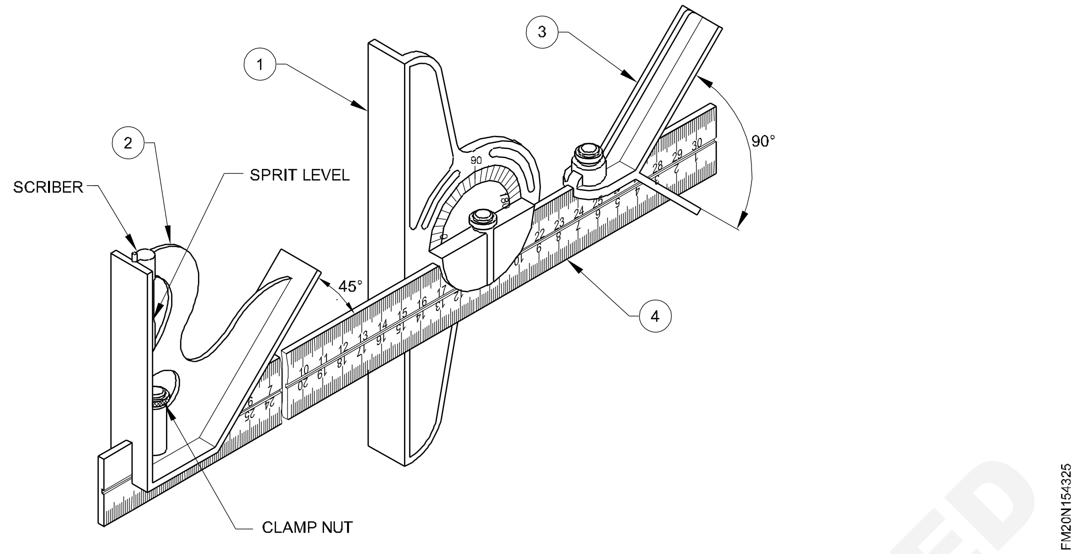
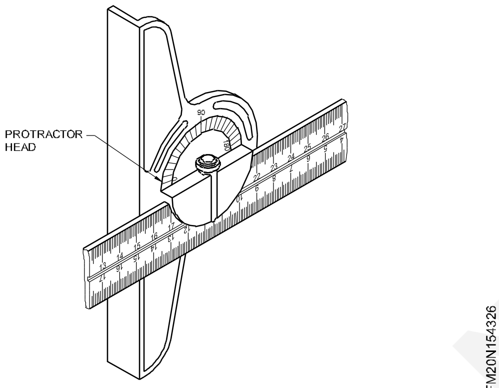


Fig 6



Square head

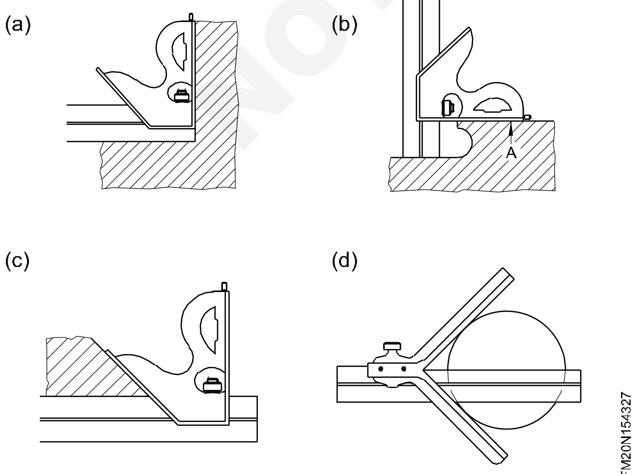
The square head has one measuring face at 90° and another at 45° to the rule.

It is used to mark and check 90° and 45° angles. It can also be used to set work pieces on the machines and measure the depth of slots. (Figures 7 (a, b, c)).

Centre Head

This along with the rule is used for locating the centre of cylindrical jobs. (Fig 7d)

Fig 7



For ensuring accurate results, the combination set should be cleaned well after use and should not be mixed with cutting tools, either while using or storing.

Calipers

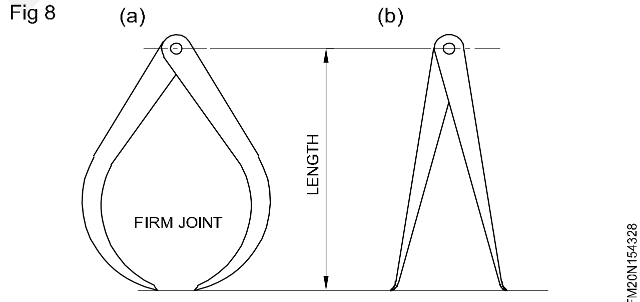
Calipers are simple measuring instruments used to transfer measurements from a steel rule to objects, and vice versa.

Calipers are of different types depending on the type of the joint and the shape of the leg.

Types of Joints: The commonly used calipers are firm joint calipers and spring joint calipers.

Firm Joint Calipers (Fig 8 a,b)

Fig 8



In the case of firm joint calipers, both legs are pivted at one end. To take measurements of a work piece, the caliper is opened roughly to the required size. Fine setting is done by tapping the caliper lightly on a wooden surface.

Types of calipers

Outside and inside calipers are differentiated by the shape of the legs.

Calipers used for outside measurements are known as outside calipers. (Fig 9). The calipers used for internal measurements are known as inside calipers.(Fig 10 a,b)

Spring Joint calipers (Fig 10)

For this type of calipers, the legs are assembled by means of a pivot loaded with a spring. For opening and closing the caliper legs, a screw and nut are provided.

Fig 9

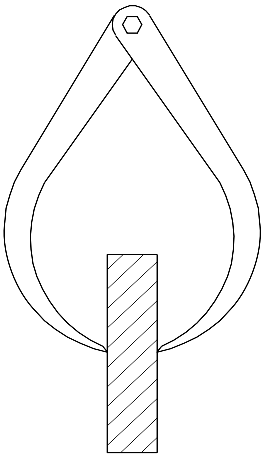
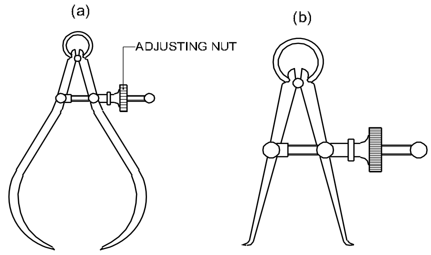


Fig 10



Spring joint calipers have the advantage of quick setting. The setting made will not change unless the nut is turned. The size of a caliper is specified by its length, which is the distance between the pivot centre and the tip of the leg.

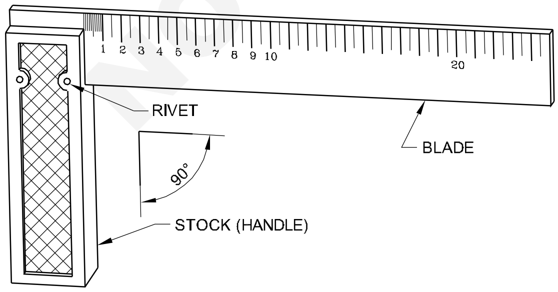
The accuracy of the measurement taken depends very much on the sense of 'feel' or 'touch' while measuring the job. You should get the feel when the legs are just touching the surface.

Try square

The try square is a precision instrument.

- Which is used to check squareness of a surface.
- the accuracy of measurements by a try square about 0.002mm per 100mm length.
- Which is accurate enough for most work shop purposes.
- The blade is fixed to the stock at 90°.(Fig 12)

Fig 11

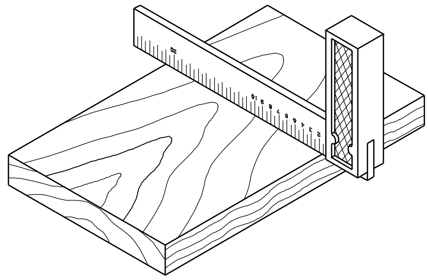


Uses

The try square is used

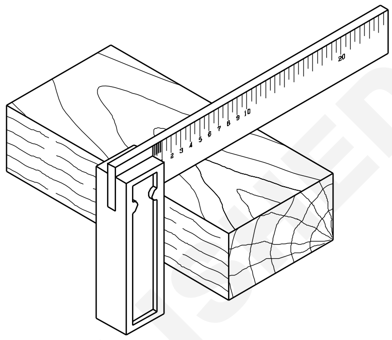
- to check the flatness of the surface.(Fig 13)

Fig 12



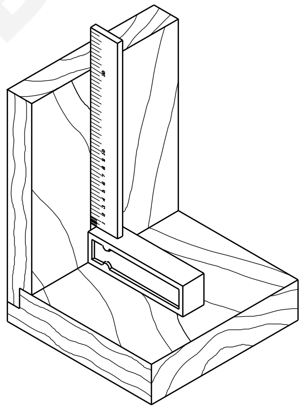
- To check the squareness of edge.(Fig 14)

Fig 13



- To check the inside squareness. (Fig 15)

Fig 14

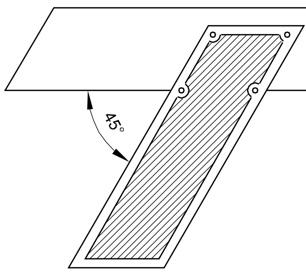


- The blade of try squares are made of hardened steel.
- The stock is made of seasoned hard wood or cast iron, mild steel and aluminum.
- If it is made of wood it must be well seasoned timber.
- To prevent the wooden stock from wearing a brass plate is fixed to the inside edge.
- The try squares are specified according to their blade lengths.
- Try square blade lengths are available in 100,150, 200, 250 mm and 300mm.

Mitre square (Fig 16)

- To mark 45° and to test 45° by mitre squaree is used at the end of its stock and at the cutting of the blade. It is fixed permanently by rivets, the length of its blade is 200mm to 350mm. There are graduations on its blade.

Fig 15



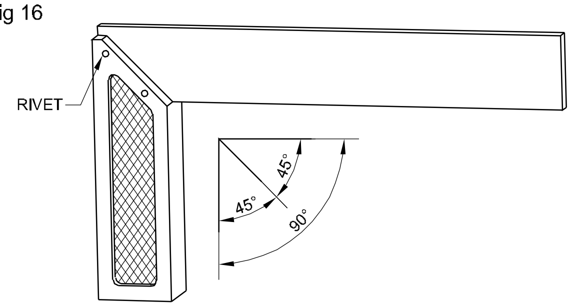
MITRE SET OR SQUARE

– The only difference between try square and mitre square is that the blade and stock are fixed at 90° in the try square and 45° in the mitre square.

Try and Mitre square

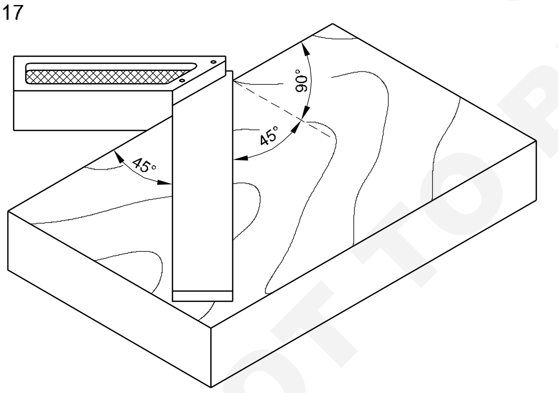
– The try square and mitre square is also useful for angle 45°,90° and 135°(Fig 17)

Fig 16



– The try and mitre square is useful for setting out mitres at 45 testing chamfers and other work 45° or 135°. (Fig 18)

Fig 17



– The blade is permanently fixed so the stock is at an the length of the blade which is 200mm to 350mm.

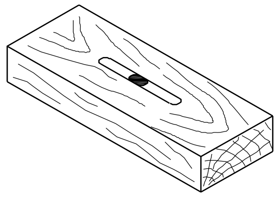
Uses

This is used for carpentry works and for building construction works. Large and wide planks are used to scribe the works.

Spirit level (Fig 20)

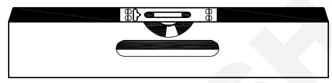
A spirit level is used principally by the carpenter. It consists of a piece of wood (common wood for spirit level is Teak wood) or aluminum into which a spirit level glass is fastened horizontally and vertically. As the glass tube is not filled, a bubble always remains, when the bubble is in the centre of glass indicated by lines marked on it, the structure on which the level rests is absolutely horizontal or vertical.

Fig 18



In some spirit level there will be two glass tubes perpendicular to the horizontal glass tube. This will be called as plumb glass and is used to test the perpendicularly of walls and windows. (Fig 21)

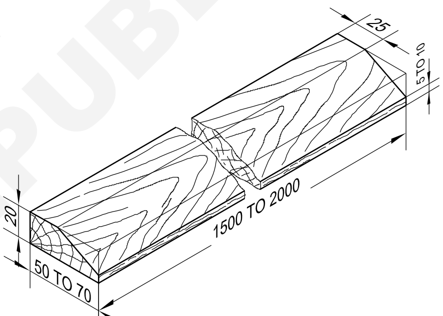
Fig 19



CARPENTER LEVEL

Straight edge (Fig 22)

Fig 20



STRAIGHT EDGE

Straight edge made of steel or wood with perfectly straight parallel edges, although some times has only one straight edge.

Uses: For testing the straightness of surface and edges.

Its length is 1500mm to 2000mm breadth 50mm to 70mm and thickness 20mm.

'T' bevel or bevel square

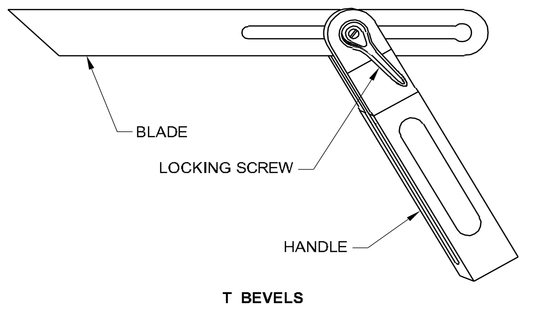
The T- bevel is used to test and transfer angles other than right angles. The bevel is called sliding bevel because it has an adjustable sliding blade. The blade may be locked by a wing nut or set screw.

The required angle is set from a straight edge and the degrees are measured against a protractor.

Uses

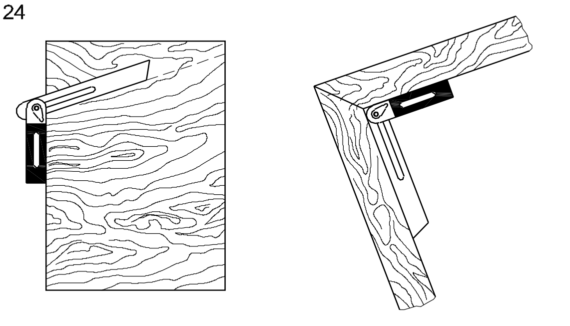
The sliding bevel is used for laying out dovetails, side rails for chairs, chamfers, bevels and for transferring angles from the drawing to the work piece. The Parts of the bevel square. (Fig 23 & 24)

Fig 21



T BEVELS

Fig 24



Handle

Handle is made of hard wood, cast iron and aluminum. The top edge is half rounded and there is a slot to fix the bevel square.

Blade

One edge of the blade is half rounded and their other edge is cut at 45°. There is a longitudinal slot. The handle is fitted with the wing nut in the slot or with a machine screw. The slotted blade passes through a slot in the stock.

On loosening the wing nut the blade can be shifted to any angle. And also the blade can be extended for further length if necessary.

Locking nut

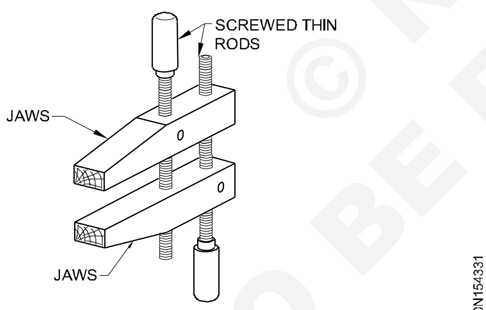
This may be a wing nut or a set screw used for loosening or tightening the blade.

Work holding devices

Objectives: At the end of this lesson you shall be able to
- **explain the uses of Hand screw**
- **state the uses of Bar clamp or 'C' clamp**
- **brief the uses of bench hold fast and the cleat.**

Hand screw (Fig 1)

Fig 1



HAND SCREW

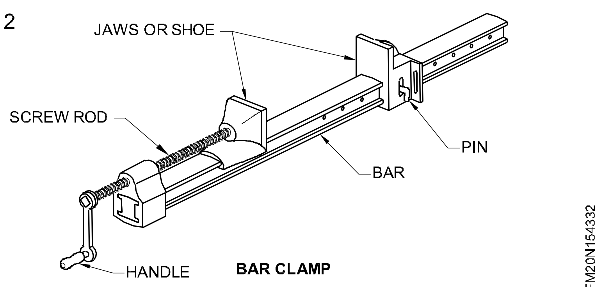
The hand screw is a clamp consisting of a pair of jaws. This is made of either in steel or wood.

It has two jaws one in left and the other in right side. Both the jaws are connected by two screwed thin rods, as shown in figure. Both the screws are to be screwed equally when clamping the job.

This is useful for small jobs and in gluing works.

Bar clamp (Fig 2)

Fig 2



BAR CLAMP

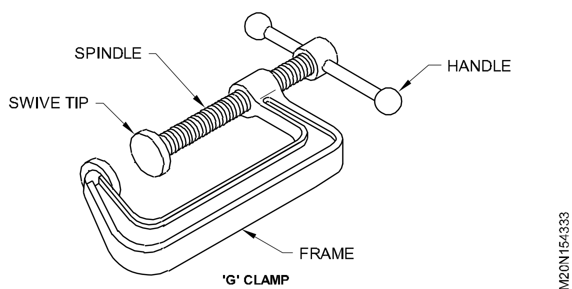
Steel bar clamps are used generally in pairs for gluing purposes. The bar may be of rectangular or 'T' shape.

T-bar clamps are heavier. Extra pressure can be applied to the job by this device. It has two sliding shoes. One shoe is attached to the screw rod and the other is pinned where it is necessary. The screw rod has a strong square thread. These are used for clamping up wide works and large frames.

T-clamps are available in clamping capacity of 160mm to 2500mm.

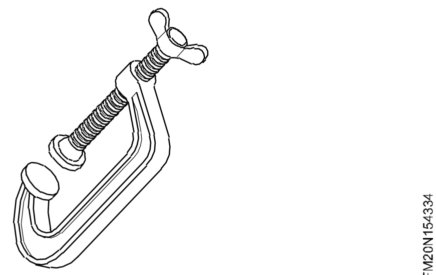
'G' or 'C' clamp (Fig 3 & 4)

Fig 3



'G' CLAMP

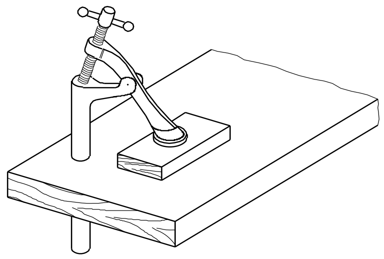
Fig 4



These are frequently used for smaller jobs and where the two hands are employed clamps have 'H' section iron and resists any tendency to distortion. The screw has a strong square thread and a round shoe on a ball which is socked joint in addition to the above there are several other clamps such as Corner clamp, Rope clamp, Flexible band clamps, Wooden gluing device etc.

Bench hold fast (Fig 5)

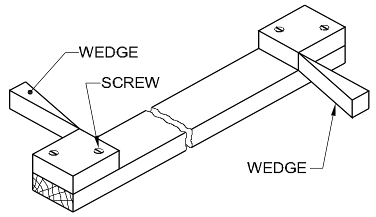
Fig 5



In wooden planks to make holes the planks are help tightly with out moving by this equipment. The stem is made of cast iron, screw rod, handle, hand one made of steel. This may be fixed in holes of the work table and planks can be tightened.

The cleat (Fig 6)

Fig 6



This is made of hard wood. This is 50mm longer than the plank to be tightened. Along with this two wooden pieces are screwed on both the ends. The wood to be placed and tightened is kept in between the wooden pieces and the wedges are tightly inserted. The plank to be lightened is now tightly held.

Type of bench vice and their uses

Objectives: At the end of this lesson you shall be able to
- **state the constructional features various types of bench vices**
- **explain the uses quick release vice and saw vice**
- **brief the uses of bench vice.**

Wood must be held steadily. If it is to be accurately sawn, chiselled and planed.

- For this reason carpenter's work bench consist different types of vice.
- Most commonly fitted bench vice consist of two metal Jaws to hold the work
- One Jaw of the vice is fixed to the work bench
- The other Jaw is movable parallel to the fixed jaw
- To operate this there is a threaded shaft and a handle.
- Two wooden blocks are used inside the Jaws to protect the work from damage

There are three types of vice

1 Quick release vice (or) wood worker's vice.

2 Saw vice

2 Bench vice

Quick release vice

- In the quick release vice moveable jaw is quickly released and get clamped with fixed Jaw.
- A box nut is provided in its threaded shafts for the quick release system . (Fig 1).
- The jaw is made of cast iron.
- The threaded shaft is made of steel.
- The vice is specified by the width of the Jaw.

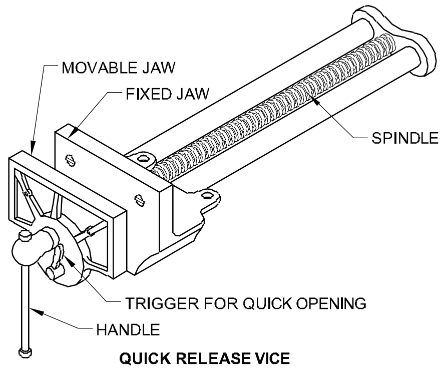
Precautions

1 Vices should not be used as ANVIL.

2 The thread shaft and box nut should lubricated.

3 The handles should not be hammered to tighten the jaw.

Fig 1

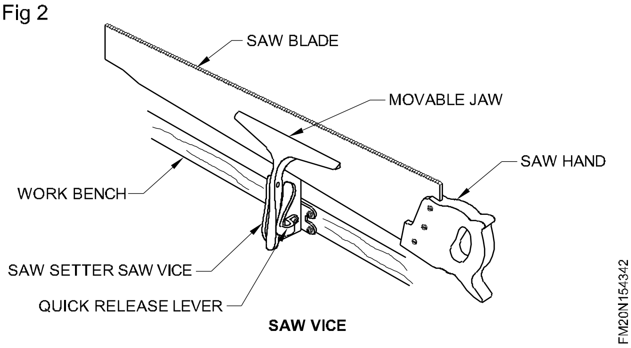


QUICK RELEASE VICE

Saw vice (Fig 2)

- It is made of wood or steel the Jaws are long enough to hold the saws while sharpening as teeth.
- The Jaws are hinged so as to make ways to close and open the Jaw.
- It is not useful for any other kind of works.

Fig 2



SAW VICE

Purpose of Saw vice

- The sharpening of saw teeth the shaping of saw teeth and setting of teeth are done with the aid of this vice
- The Jaws of the saw clamp , should grip the saw 2-3 mm below gullet teeth.

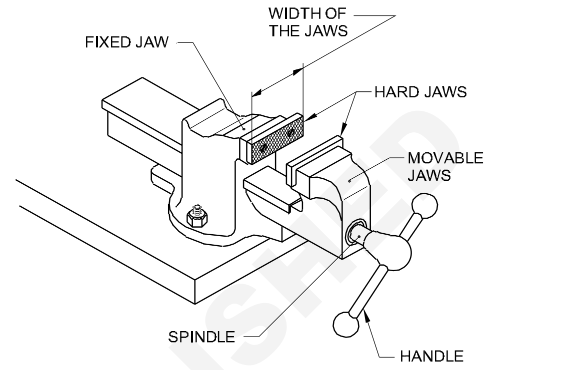
Bench vice (Fig 3)

Vice are used for holding work pieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer's vice.

A bench vice is made of cast iron or cast steel and it is used to hold work for filing, sawing, threading and other hand operations.

The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice.

Fig 3



Introduction of different saws and their uses

Objectives: At the end of this lesson you shall be able to
- **state the various types of saws**
- **explain the purpose of various types of saws**
- **brief the specific uses of straight cutting saws.**

There are several types of saws for cutting wood. some are used to make straight cuts and others are used make curved cuts. As its name suggests, a cross cut saw is used cut wood perpendicular or at an angle to the wood grain.

Types of Saw

1 Straight cutting saws

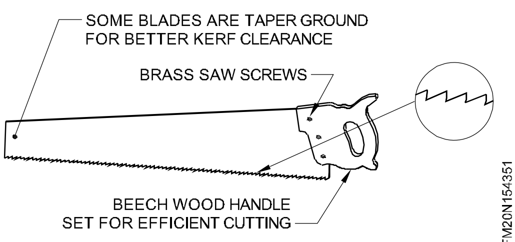
2 Curve cutting saws (or) special saws.

Straight cutting saws

1 Rip saw
2 Cross cut saw
3 Hand saw
4 Panel saw
5 Tenon saw
6 Dove tail saw.

Rip Saw (Fig 1)

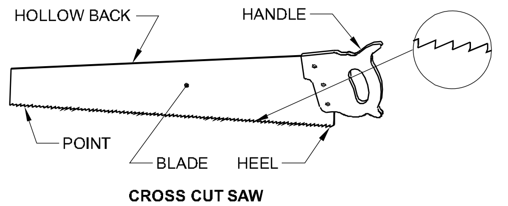
Fig 1



- Blade is made of thin spring steel.
- Used for sawing along the grain
- Blade is fixed to the wooden handle by riveting or screwing
- Teeth of rip saw vary in size as per the need of the fitness of work to be done
- Handle is made of beech (or) apple wood
- It has two teeth per centimetre length
- length of the blade is 60 to 70cm
- Specified by its length
- Teeth angle is less than 90^0
- It has 3 to 6 teeth per 25mm.

Cross cut saw (Fig 2)

Fig 2



CROSS CUT SAW

- Used for cutting across the grains of timber
- Length of blade is 56 to 70cm

– It has 5 to 9 teeth per 25mm

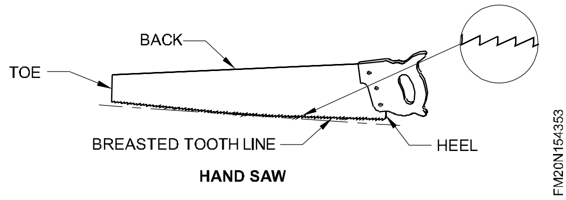
– Cutting angle of the teeth 90^0

– Teeth has different shape to that of rip saw

– Finer pitch blade is preferred for hard wood. Blade with course pitch is used for soft wood.

Hand Saw (Fig 3)

Fig 3

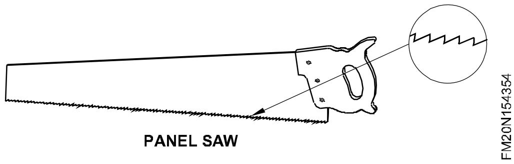


– Length of the blade is less in hand saw than in the rip saw.

– Which is used for lighter work.

Panel Saw (Fig 4)

Fig 4



It is the most commonly used saw

– It is available in many sizes

– It has 10 to 12 teeth per 25mm

– length is 50cms

– Specifically used for cutting panels for door shutters.

Tenon Saw (Fig 5)

– It is rectangular in shape

– Length is 25 to 40cm long

– It has 12 to 14 teeth per 25mm.

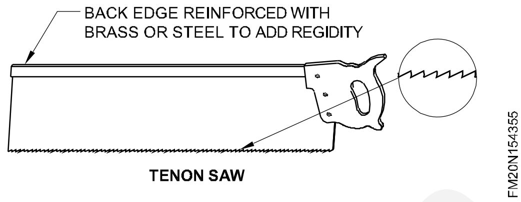
– It is used for finer works like tenon

– Main use is making short and straight cuts

– A reinforcing strip on back is provided at the top to avoid bending of blade.

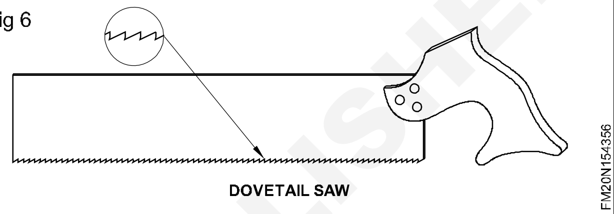
– Closed handle.

Fig 5



Dove tail saw (Fig 6)

Fig 6



– By appearance is like tenon saw

– Its blade is thinner and narrower

– Its wooden handle is open and free to move to full length of blade

– It is used for finer work

– Specifically used for cutting tongues for dove tail joints

– Length of blades is 20 to 30cm and carries 6 points/cm.

Different type of chisels

Objectives: At the end of this lesson you shall be able to
- **name various types of chisels commonly used**
- **state the uses of various types of chisels**
- **specify the chisels.**

Chisel are used for shaping and finishing the parts of wood joints. They are also used for shaping different profiles in wood work. The size of the chisel is determined by width of the blade and type.

All chisels consist of four main parts

1 The handle

2 The blade

3 Tang

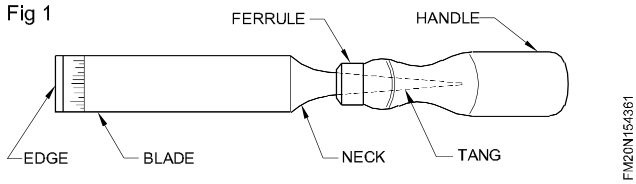
4 Ferrule

The blade of a chisel is made of forged tool steel The cutting angle is 25°.

Types of chisels

1 Bench firmer chisel (Fig 1)

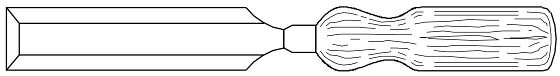
Fig 1



This is used for general chiselling purposes. Strongly made, it can be used for light chiselling with a mallet. The blade is rectangular in section. The handle is made of beech or ash. It has a brass ferrule. Tang is fixed inside the ferrule. It is available from 3mm to 50mm.

2 Bevel edge firmer chisel (Fig 2)

Fig 2



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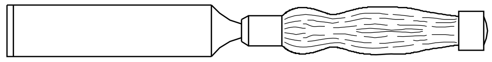
It is more convenient for lighter works and paring works, and in place were ordinary firmer chisel cannot be used such as cleaning up corners and joints. Bevel edge firmer chisel has two edges bevelled along its length which makes it lighter and the edges thinner. size varies from 3 mm to 50mm.

3 Registered firmer chisel (Fig 3)

Fig 3



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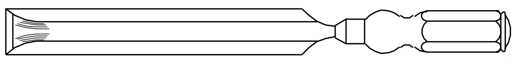
It is used for heavy work such as mortising. The use of mallet is necessary here. It is stronger than ordinary firmer chisel. It has a thicker blade and iron ferrule, at both ends of handle. A leather washer is provided between the shoulder of the blade and the handle to act as shock absorber when the chisel is hit by the mallet.

4 Paring chisel (Fig 4)

Fig 4



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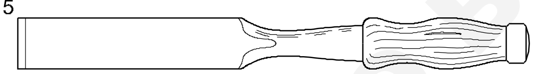
It is most suitable for all paring work such as finishing off joints. It has an extra long thin blade with bevelled edges. It should never be used with a mallet. The handle is made of beech and octagonal in section.

Size varies from 3mm to 50mm.

5 Socket firmer or socket mortise (Fig 5)

Fig 5



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It is used for extra heavy work, the blade is thicker and stronger than other chisels. It is able to withstand the blows of the mallet, and level out the cover of mortises. The ash handle provided with ferrule is fitted in socket in the blade. Size varies from 3mm to 50mm.

Chisels are blades of circular section called as Gouges or Hollow chisels.

According to the position of the cutting bevel on the blade, there are two main types

Inside bevelled gouge (Fig 6) outside bevelled gouge. (Fig 7).

Fig 6

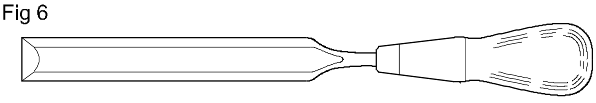

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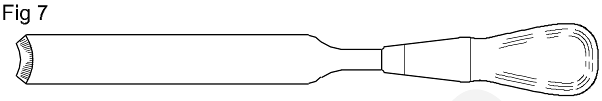
Fig 7



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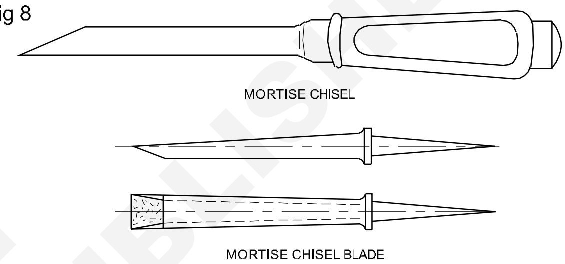
Mortise chisel (Fig 8)

Fig 8



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The mortise chisel is designed to with stand hard, rough wear and the thickness of the blade permits the leverage necessary to clear the mortise and keep the blade true.

It has strong handle and the blade is fitted into it by a tang as with the socket and tang chisel.

Common sizes of mortise chisels are 3,4, 5, 6, 8, 10,12, 14,16, 20 mm in width.

The chisel blade is ground slightly taper from the face towards the back and from the cutting edge towards the handle to avoid friction.

Mortise chisels are used to mainly for chopping mortises and are driven with heavy blows of the mallet.

The test mortise chisels have a tough leather washer between the shoulder of the tang and the handle to help absorb the shock of repeated blows.

Wood working planes

Objectives : At the end of this lesson you shall be able to
- **name the various types of planes**
- **state the uses of the various planes**
- **state constructional feature of various planes**
- **specify the planes.**

A plane is a hand tool used for smoothing or shaping pieces of wood.

Common types are

1 Jackplane

2 Smoothing plane

3 Trying plane

4 Toothing plane

5 Finishing plane

6 Router plane

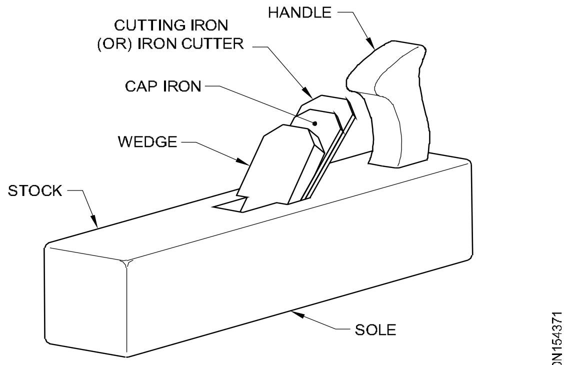
7 Plough plane

8 Adjustable metal jack plane.

1 Jack plane (Fig 1)

This plane is used for planning the job to size quickly and truly. Stock is made of wood or steel. Handle is fixed behind the cutting iron.

Fig 1

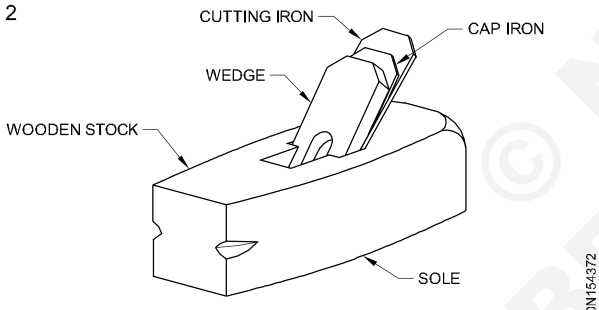


WOODEN JACK PLANE

The size is 240 mm x 66mm x 47mm. The angle of cutting iron is 45° and the cutting iron is sharpened in a curve. The mouth of the plane is big enough to accommodate thicker wood shavings. The cutting iron further projects outside than in other planes.

2 Smoothing plane (Fig 2)

Fig 2



SMOOTHING PLANE

This is used when the surface has to be planed further to smoothness.

- The size is 240 x 66 x 65mm
- The width of cutting iron is 48mm
- The cutting edge is sharpened slightly oval across the iron. The angle of the cutting iron is 30°. The wooden smoothing plane has no handle.

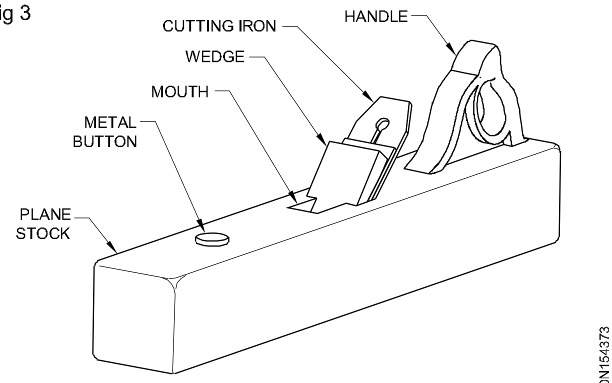
3 Trying plane (Fig 3)

It is larger and longer than other planes. Its length is 600 to 700mm. The blade is 46 to 56mm wide. It has double iron. This is used for producing a true and straight surface. The handle of wooden stock is usually of the closed type.

4 Toothing plane (Fig 4)

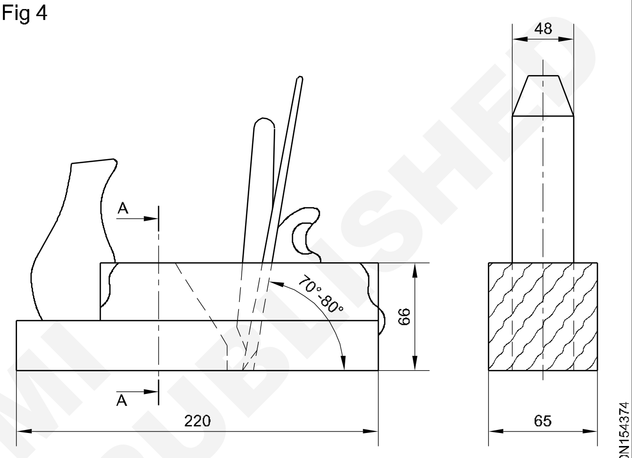
The purpose of this is to prepare a rough gluing surface. The cutting angle is set at 70° to 80°. The cutting edge is a series of teeth formed like 'V'. The plane is used diagonally across the work in both directions and in along the grain.

Fig 3



TRYING PLANE

Fig 4

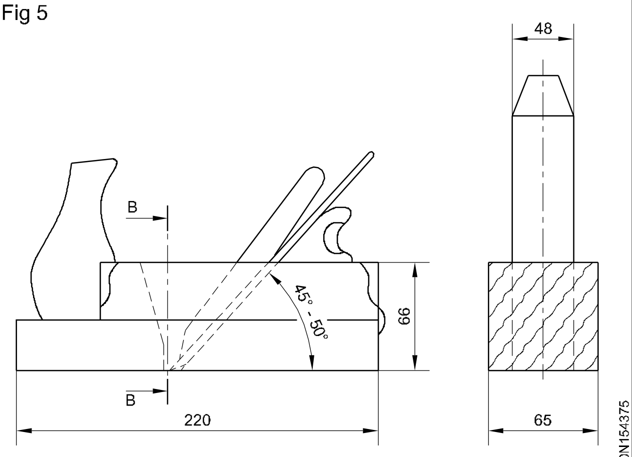


TOOTHING PLANE

5 Furnishing plane/Finishing plane (Fig 5)

This is slightly smaller than smoothing plane. Its cutting angle is 45 to 50°. It prevents the tearing of wood and gives a good finish. This is also called reform-finishing planes.

Fig 5

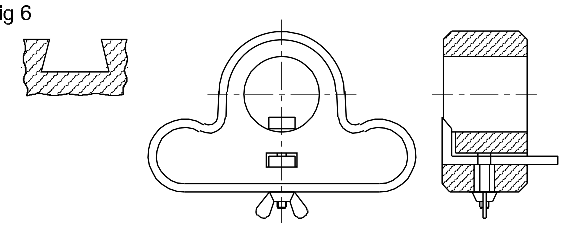


FINISHING PLANE

6 Router planes (Fig 6)

It is used to clean and level grooves and recesses. It is used across the grain. The cutting iron is lowered after each cut until required depth is reached.

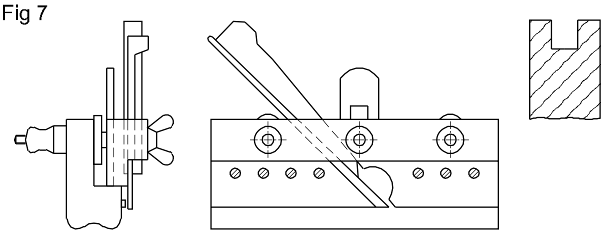
Fig 6



ROUTER PLANE

7 Plough plane (Fig 7)

Fig 7

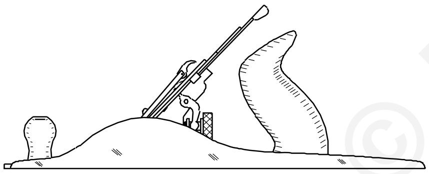


PLOUGH PLANE

This is used to form grooves parallel with grain. The cutting-irons are available from 3mm to 16mm wide. It has no cap iron. The depth of groove can be adjusted by a thumb screw. A guide parallel to the plane controls the distance of the groove from the edge of the work.

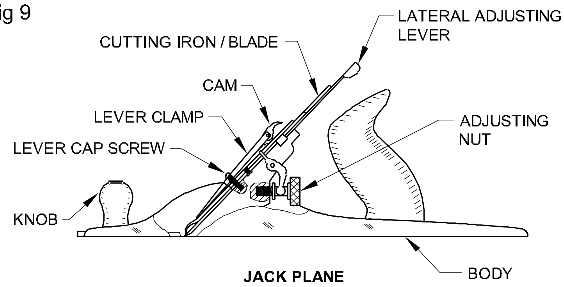
8 Adjustable metal jack plane (Fig 8 & Fig 9)

Fig 8



JACK PLANE

Fig 9



JACK PLANE

- This is just like wooden jack plane but the cutting iron adjustable.
- This plane is used for planning of timber to bring the size nearer to the required measurements.
- The size is body length 360mm and cutter width 50mm.

These parts are made of different materials as listed below.

Body	- Cast iron
Handle	- Rose wood
Knob	- Rose wood
Cutting iron/blade	- Tungsten steel
All other parts	- Metal

Advantages of adjustable metal bench plane

- Easier to use than wood plane owing to low position of handle.
- Simple adjustments by means of adjustment screw and lateral adjustment lever.
- Cutting iron thinner speeding up grinding and sharpening.
- Body retains shape little wear.

A smear oil or wax on the sole of the plane reduces friction and makes planing easier.

The mallet

Objectives: At the end of this lesson you shall be able to
- **state the constructional feature of mallet**
- **explain the use of mallets**
- **state specification of mallets.**

The mallets are made of hard wood and it is used in place of hammer. But the difference is head only.

Mallet are used for driving wood chisels and for adjusting wooden planes. It is used for assembling and dismantling wooden works and for adjusting stop dogs in the work bench.

The handle is made of beech or ash with straight grained fibres. The head is made of hard wood with twisted fibres. This prevents splitting of the wood.

A special type of mallet is made of 'Ligno stone' which is made of special wood that is treated with heat and high pressure.

Some mallets have removable handles (Fig 1) which can be taken out of the head easily so that parts can be stored easily. (Fig 2)

Fig 1

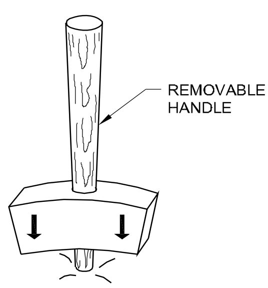
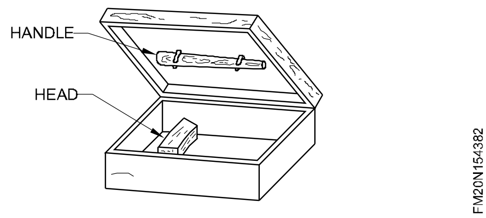
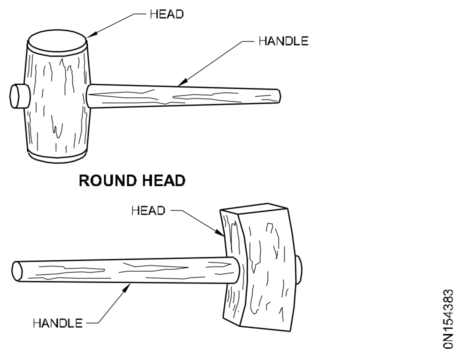


Fig 2



The striking faces of mallet heads are so bevelled so that they can hit the chisel. For most purposes a head of 110 mm long, 80mm wide and 60 mm thick is suitable. The handle is driven in from the top and is tapered in its width. Its head is either round or square. (Fig 3)

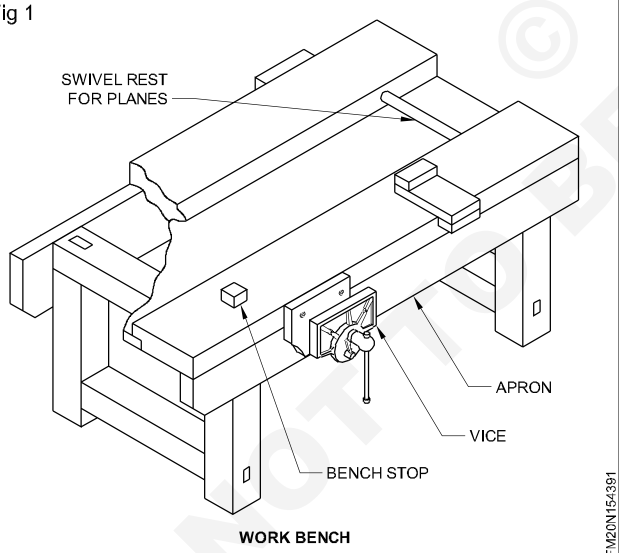
Fig 3



The mallet is held upside down and dropped once or twice on the work bench, the head of the mallet will be tightened on the handle.

Work bench (Fig 1)

Fig 1



It is a heavy table of rigid construction made of hard wood. Two or four carpenters vices are fitted on the opposite sides to hold the jobs. One Jaw of the vice is secured to the table and the other is kept movable.

Shelves or racks can also be provided on the table.

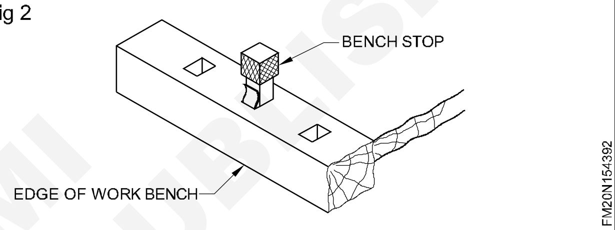
The length is 120cm to 180 cm and width 90 cm for single man work bench and the width is 120 cm for double man work bench.

The bench is mostly useful to cut and saw the woods, to plane the woods, ripping tenons, chiselling out wastes and for all other wood working purposes.

The tool well is in the middle for the work bench and is slightly in lower level to accommodate the working tools.

To avoid slipping while planning operation s a bench stop is fixed which can be raised or lowered. Bench stops are made of wood pieces and has teeth at its one end. It is used for supporting the work during wood working operations. (Fig 2)

Fig 2



Swivel rest is provided to keep the planes when it is idle and not in use.

Apron is the longer piece of wood nailed on the longer side of the work bench for rigidity.

The level of the work bench surface would be uniform and even.

Care should be taken to see that while nailing sawing and chiselling there would not be any marks left on the surface.

Saw horse or trestle

Objectives: At the end of this lesson you shall be able to
- **state constructional feature of saw horse**
- **state application of a saw horse.**

– Saw horse is used when sawing long reapers.

– It is made of hard wood.

– It consists of two wide piece of timber joined at a top closely and at the bottom widely as shown in Fig 1.

– Long piece of timber or wood piece by placing piece on the trestle as shown Fig 2, along the grain.

– For short planks a single horse or Trestle can be used by clamping or across the grains.

Fig 1

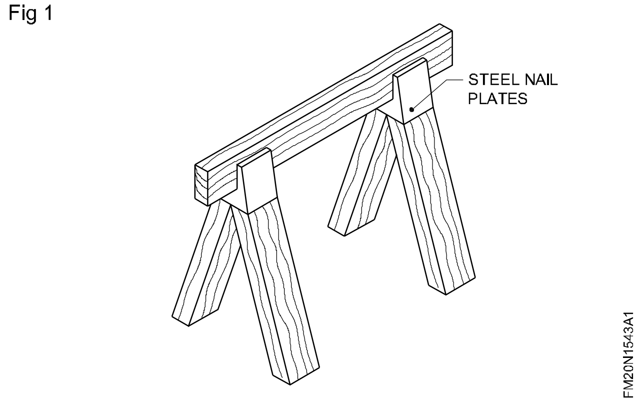
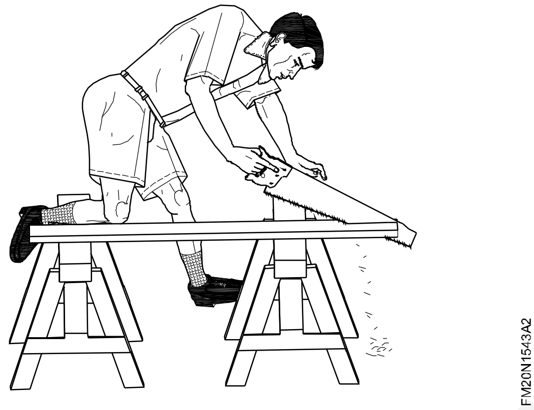
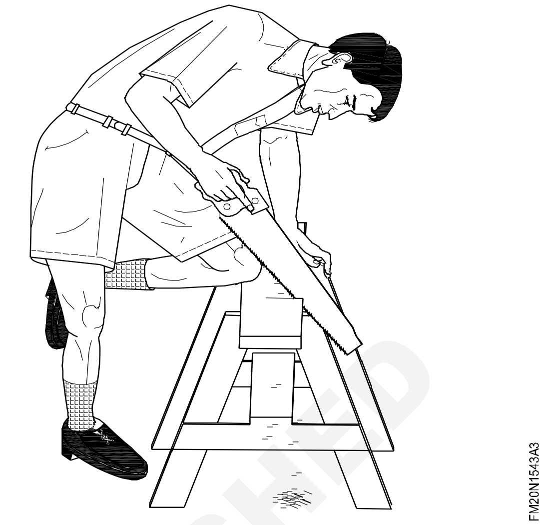


Fig 2



- Holding steady with a knee or foot shown in Fig 3.
- When sawing thinner planks across the grains use more support between the trestles.

Fig 3

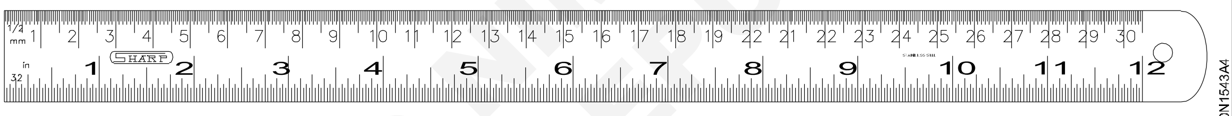


Contraction steel rule. (Fig 1)

This rule is sometimes called as shrinkage rule.

This rule is used only by the pattern maker.

Fig 4



CONTRACTION RULE OR SCALE

All the metals used for casting shrink in size after solidification and cooling in the mould.

To compensate this the finished size of the pattern should be made larger than the finished size of the casting.

This amount of the allowance is known as contraction or shrinkage allowance when added to the ordinary scale, it gives the contraction scale.

The pattern maker is provided with a special rule is called pattern maker's contraction steel rule.

There may be different contraction rules for different casting metals but generally a rule is used on each side of which, there are two scales, total number of scales being four for four commonly cast metals like steel, cast iron, brass and aluminum. With the help of this rule the pattern layout is directly prepared and the necessary amount of shrinkage allowance gets included automatically in all the dimensions.

This (rule) eliminates the trouble of adding this allowance everytime a dimension is set.

Thus a lot of time and labour can be saved and chances of mistakes are eliminated.

Pattern layout

Objectives: At the end of this lesson you shall be able to
- **state the meaning of pattern layout**
- **state the advantages of pattern layout.**

Layout is a full scale drawing with complete details of pattern including allowances, core prints, core boxes, parting lines and loose pieces etc.

This layout is prepared in the same manner for both pattern and core box by using the appropriate contraction steel rule.

The construction of pattern consist of two different stages.

First stage is to prepare a layout including all the allowances as per the dimension given in drawing.

The second stage is to shape the different parts of pattern as per the layout.

The layout preparation is consist of measuring, marking, and setting all the dimensions on layout board including all the allowances.

Study the working drawing carefully and prepare the suitable layout board to accommodate the views of the same on full size scale.

Lines are drawn with scriber so that they are permanent and dimensions may be accurately transferred on the pattern by using divider.

Advantages of pattern layout

- List the required material to prepare the pattern.
- Method of construction of pattern becomes known on seeing the layout.
- Locate loose piece, core prints are clear and understandable.
- Decides the type of pattern for casting.
- Easy to prepare the pattern and core box.
- Avoid mistake in construction of pattern and save the materials
- Saves money
- Saves time
- Decide type of joints.
- It becomes easy for the pattern maker to make the pattern.
- It is useful in subsequent checking of the pattern.
- Minimize the defect in casting
- Minimize the cost of casting
- Calculation of the cost of pattern becomes easier.
- Chances of erring in construction of pattern are much reduced.

Blue print reading

Objectives: At the end of this lesson you shall be able to
- **state the meaning of blue print reading in pattern construction**
- **state the important points of blue print reading in pattern construction.**

To understand the shape and size description of objects, components in the filed of preparing the layout.

A pattern maker should be able to understand the size description of the pattern construction.

The blue print reading is having the following important points to understand by the pattern maker to prepare the layout and to prepare the pattern.

- Selection of contraction scale as per the metal given in the drawing.
- Machining symbol for the type of finishing the surface of the casting/object.
- Type of material to be used for the construction of pattern (number casting required).
- Type of pattern to be prepared for easy moulding (solid, split or loose-piece pattern etc.)
- Method of moulding to be done by the moulder using the pattern.
- Type of core print and core box for the preparations of core.
- Painting the pattern as per the ISI colour code.

Methods of repairing the pattern & core boxes

Objectives: At the end of this exercise you shall be able to
- **name the method of repairing pattern & core boxes**
- **reasons for damage of pattern & core boxes**
- **state the advantage of repairing pattern and core boxes.**

The tools used in pattern making are same these used in general carpentry work except few.

The method of repairing pattern and core boxes

There are two methods are employed for making wood and metal pattern.

Machines are used for making pattern.

Hand method are employed for making wooden pattern with general carpentry tools.

Reason for damage

Pattern & core boxes are damaged due to

- Normal wear and tear
- Breakage during transportation.
- Careless moulding work.
- Falling of slag or molten metal.
- Seasonal effects
- Improper placement when not in use.
- Sub-stand materials.
- Wrong design & weak construction.

Advantages of repairing the pattern & core boxes

- It gives long life
- Repairing pattern & core boxed saves money.
- Material and time can be saved.

Pre requisites of gatting system

Objectives : At the end of this exercise you shall be able to
- **state about gatting the requisites of gatting system.**

Prerequisites of gathering system raiser, feeder & directional solidification chill, chapters denseners and exothermic materials.

PRE-REQUISITES OF GATING SYSTEM:

1 The liquid metal should be able to flow through the gating system with minimum turbulence and aspiration of mould gases.

2 The metal should be so introduced into the mould cavity that the temperature gradients estabilished on the mould surfaces within the metal should facilitate the directions/ solidification towards a riser.

3 The cavity should be completely fill within a shortest time.

4 The gating system should produce a minimum wastage of metal (scrap).

5 Loose sand, exides and slag should be prevented from entering into the mould cavity by providing proper skimming action.

6 The gating system should so arranged that the rate of entry of entry of liquid metal into the mould cavity properly regulated.

Riser

Objectives: At the end of this lesson you shall be able to
- **state about the riser**
- **state about the types of riser**
- **state about feeder/directional solidification.**

Riser: A riser is a hole which is cut or formed in the cope to permit the liquid metal to rise above the highest portion of the casting. Riser can be placed either at the extreme top of the cavity or at the side. It enables the pourer to understand whether the cavity is completely filled or not.

The riser helps for the easy ejection of the air in the mould cavity at the time of pouring. The riser will serve as a feeder if it will have sufficient dimensions.

Choosing the size and shape of the riser will have a direct impact on its feeding effect. The spherical shape is the best and then the cylindrical shape, the square shape will give the next effect. The ratio between the diameter and the height of the riser should be 1 : 1 to 1 : 1.5. The riser which possess the above ratio in dimensions will provide effective feeding.

The risers are mainly classified into two groups.

1) Open riser 2) Blind riser.

1 Open Riser

The riser which have the head open towards the atmosphere is known as open riser.

2 Blind Riser

The riser which will not have an opening towards the atmosphere is known as blind riser. The blind riser will give effective feeding but the pourer will not be able to understand whether the cavity is filled or not.

Riser Location Depends Upon

1 The design and complexity of casting.
2 Type of cast metal.
3 Number of risers.
4 Size and number of heavy (casting) sections.
5 Easy of moulding.
6 Easy of riser removal after the casting has solidified.

Feeder

Feeder is a hold which is cut or formed in the mould to receive the excess liquid metal at the time of pouring and feed at the time of solidification to avoid shrinkage in the casting. The feeder must be the least part of the casting to freeze or solidify. It should cover completely the sectional thickness of the casting which requires feeding. The feeder must maintain the temperature of the liquid metal to have sufficient feeding to the casting. So that the metal can penetrate into the mould cavity at the time of solidification. The feeder must help for directional solidification and it should be the least cooling point. The cross sectional area of the factor should be higher than the section thickness of the casting where feeding is required.

Directional Solidification

It is the natural tendency of the liquid metal is a mould cavity to solidify from the external surface towards the core (centre) of the casting. Also the thin sections will get solidified quicker than the thick section. Hence the shrinkage occurs at the centre of the casting it is not at all possible to feed and overcome such defect. To avoid this, the casting may be made to solidify from the core of the casting last cooling point happens to be at the external surface, feeders can be provided to overcome the occurrence of shrinkage defect. This process of making the external surface of a casting as the last cooling point is known as directional solidification.

The directional solidification can be obtained by the following methods.

1 By designing proper gating system including large feeder heads will make the last cooling point at the external surface. But the wastage of metal is more.

2 By using exothermic materials as a special ingredient to the facing sand of mould, core and the gating system. These exothermic materials produce heat and makes the liquid metal to remain as liquid for long time at the external surfaces. So the solidification starts from the core of the castings.

3 Directional solidification also can be obtained by using denseners. The denseners will be placed at the centre of the cavity before pouring. This metal piece absorb the temperature for the liquid metal and makes to solidify immediately. Thus the directional solidification is obtained.

Exothermic materials

1 Exothermic materials are those which create considerable amount of heat by exothermic reaction.

2 Exothermic compounds are essentially mixtures of a metal (Ni, Co, Cu, Mn, Fe) oxide and aluminum,

3 The basis for exothermic feeding is expressed in the typical thermit reaction between a metal oxide and finely divided aluminum $4\ Fc_2\ O_3 + 8\ A_1 = 4A1_2O_3 + 8Fe + 4500°\ F$ (heat).

4 When an exothermic compound is placed on the surface of the metal in an open riser, chemical reaction (as above) starts and intense heat is generated which superheats the liquid metal in the riser metal can be kept in the liquid state as long as the riser is required to feed the casting (for avoiding shrinkage defects).

5 It is said that the composition of the superheated molten metal product of reaction should match that of casting.

This however does not appear to be essential because the density of the very hot reaction product being less than of the metal of the casting the two metals do not mix thoroughly.

6 The use of exothermic compounds improve efficiency about 70% and the riser needs a size one-third that of a normal riser

7 Exothermic compounds may be employed in many ways.

8 In the first of these, the compound is added directly over the liquid metal in the riser (like the insulating powder)

9 Moldable exothermic materials may be shaped into sleeves for lining risers.

10 Besides sleeves pads may also be molded both exothermic sleeves and pads are used in the same manner as the insulating sleeves and pads.

11 Exothermic compounds may also be employed as inserts in the mold

12 Cores made up of exothermic materials can also be used for the purpose.

13 Exothermic compounds may be mixed with mold dressing and applied at desired places.

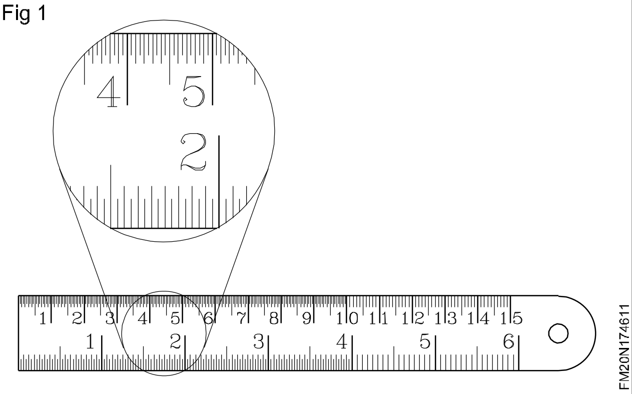
Different types of tools and instruments used in metal working

Objectives: At the end of this lesson you shall be able to
- **state different types of tools and instruments used in metal working.**

Steel rule:

Engineer's steel rule (Fig 1) are used to measure the dimensions of work pieces.

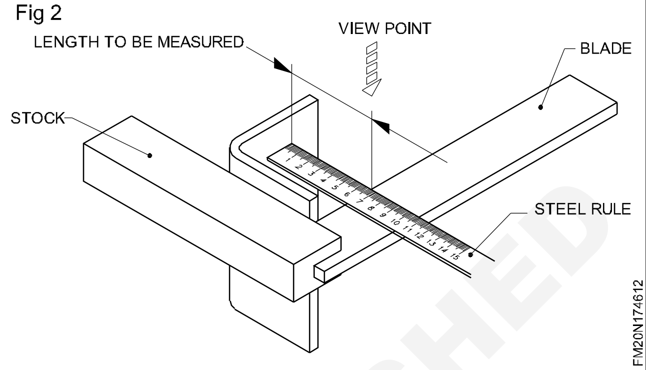
Fig 1



Steel rules are made of spring steel or stainless steel. m. The reading accuracy of steel rule is 0.5 mm and 1/64 inch.

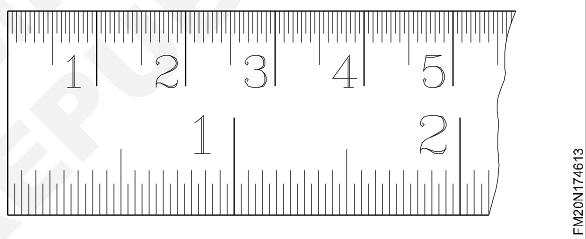
For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 2)

Fig 2



Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 3)

Fig 3



Measurement of length

Metric		British	
Micron 1μ	= 0.001 mm	Thousandth of an inch	= 0.001"
Millimetre 1 mm	= 1000μ	Inch	= 1"
Centimetre 1 cm	= 10 mm	Foot 1 ft	= 12"
Decimetre 1 dm	= 10 cm	Yard 1yd	= 3 ft
Metre 1 m	= 10 dm	1 furlong 1 fur	= 220 yds
Decametre 1 dam	= 10 metre	1 mile	= 8 fur

Scribers

Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

Scribers

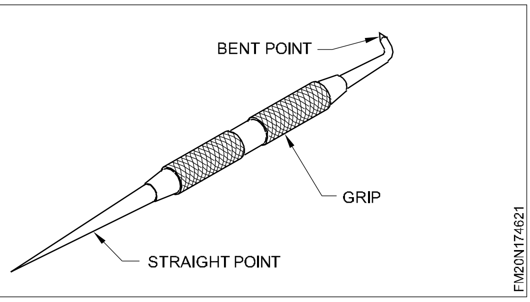
In lay out work it is necessary to scribe lines to indicate the dimensions of the workpiece to be filed or machined. The scriber is a tool used for this purpose. It is made of high carbon steel and is hardened. For drawing clear and sharp lines, the point should be ground and honed frequently for maintaining its sharpness.

Scribers are available in different shapes and sizes. The most commonly used one is the plain scriber. (Fig 1)

While scribing lines, the scriber is used like a pencil so that the lines drawn are close to the straight edge. (Fig 2)

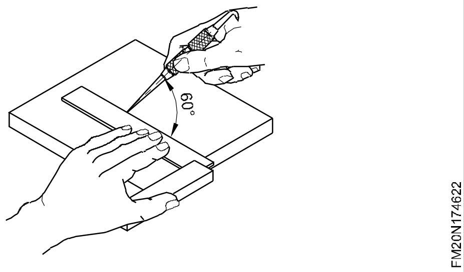
Scriber points are very sharp; therefore, do not put the plain scriber in your pocket.

Fig 1



Place a cork on the point when not in use to prevent accidents.

Fig 2

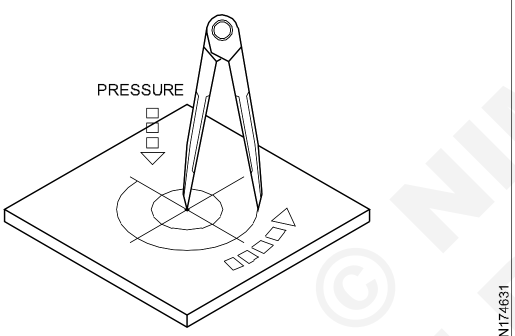


Dividers

Objectives: At the end of this lesson you shall be able to
- **name the parts of a divider**
- **state the uses of dividers**
- **state the specifications of dividers**
- **state the important hints on divider points.**

Dividers are used for scribing circles, arcs and for transferring and stepping off distances. (Fig 1,2 and 3)

Fig 1



FIRM JOINT DIVIDER

Dividers are available with firm joints and spring joints. (Figs 1 & 4). The measurements are set on the dividers with a steel rule. (Fig 2)

The sizes of dividers range between 50 mm to 200 mm.

Fig 2

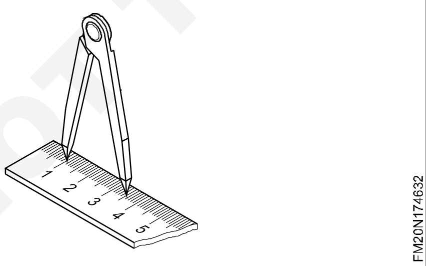
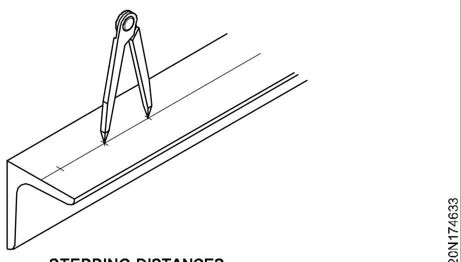


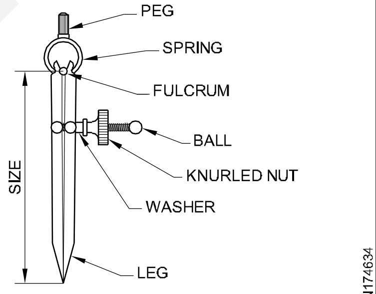
Fig 3



STEPPING DISTANCES

The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

Fig 4

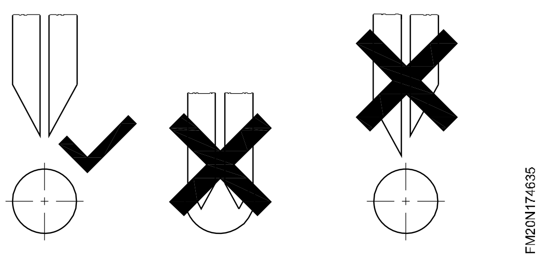


SPRING JOINT DIVIDER

For the correct location and seating of the divider point prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5) Dividers are specified by the type of their joints and length.

Fig 5



The divider point should be kept sharp in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding. Sharpening by grinding will make the points soft.

Calipers

Objectives: At the end of this lesson you shall be able to
- **name the commonly used calipers**
- **state the advantages of spring joint calipers.**

Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

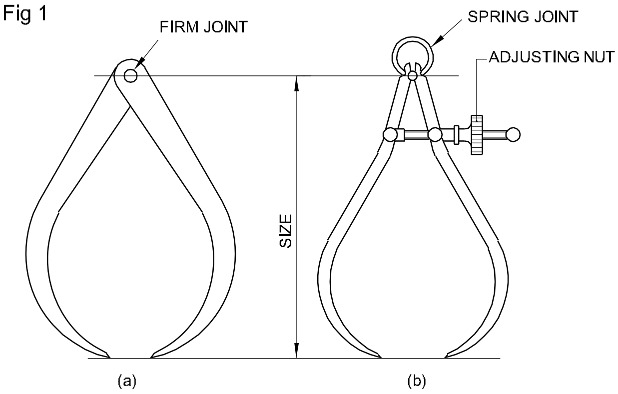
Calipers are classified according to their joints and their legs.

Joint

– Firm joint calipers (Fig 1a)

– Spring joint calipers (Fig 1b)

Fig 1



Legs

– Inside caliper for internal measurement. (Fig 2)

– Outside caliper for external measurement. (Fig 3)

Fig 2

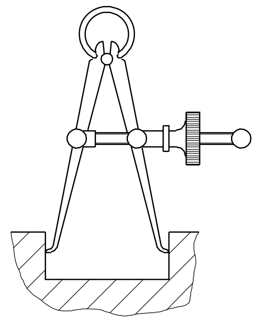
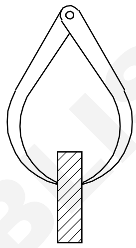


Fig 3



Calipers are used along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using calipers with sensitive feel.

Spring joint calipers have the advantage of quick setting with the help of an adjusting nut. For setting a firm joint caliper, tap the leg lightly on a wooden surface.

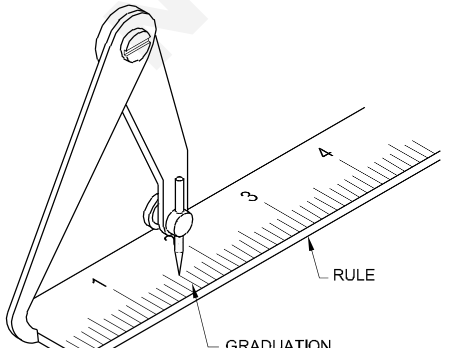
Jenny calipers

Objectives: At the end of this lesson you shall be able to
- **state the uses of a jenny caliper**
- **state the two types of legs of a jenny caliper.**

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300 mm.

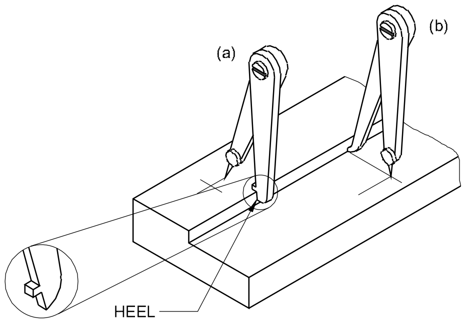
Jenny calipers are used

Fig 1



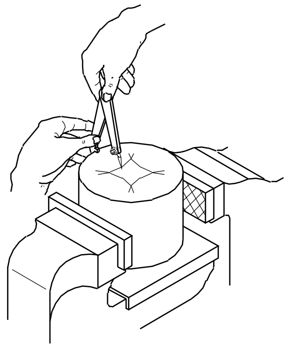
– For marking lines parallel to the inside and outside edges (Fig 2)

Fig 2



– For finding the centre of round bars. (Fig 3)

Fig 3



These calipers are available with the usual bent leg or with heel.

Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge, and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

The other names for this caliper are:

- hermaphrodite calipers

- leg and point calipers

- odd leg caliper

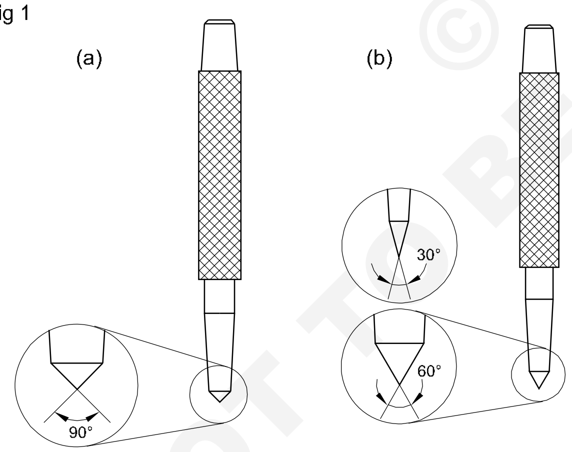
Types of marking punches

Objectives: At the end of this lesson you shall be able to
- **name the different punches in marking**
- **state the features of each punch and its uses.**

Punches are used in order to make certain dimensional features of the layout permanent. There are two types of punches. They are centre punch and prick punch made of high carbon steel, hardened and ground.

Centre Punch: The angle of the point is 90° in a centre punch. The punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes. The wide punch mark gives a good seating for starting the drill. (Fig 1a, b)

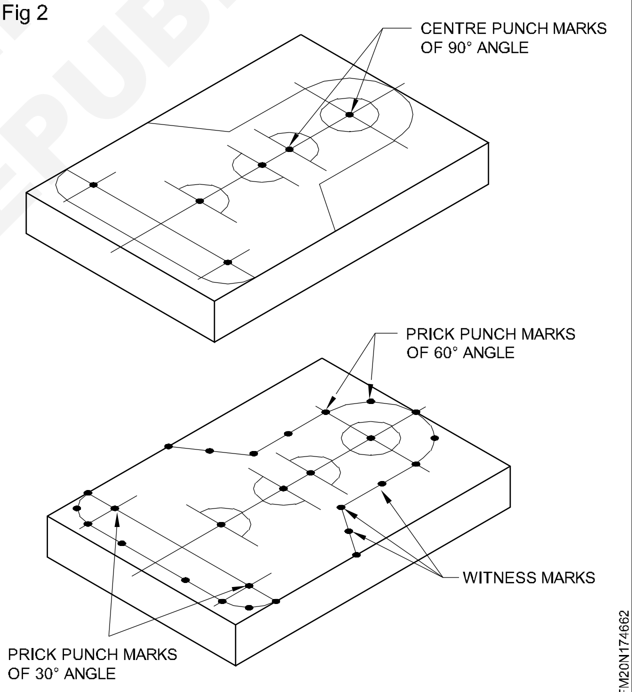
Fig 1



Prick Punch/Dot punch: The angle of the prick punch is 30° or 60°. (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

The witness marks should not be too close to one another.

Fig 2



Hammers

Objectives: At the end of this lesson you shall be able to
- **state the uses of an engineer's hammer**
- **identify the parts of an engineer's hammer**
- **name the types of engineer's hammer**
- **specify the engineer's hammer.**

An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging or riveting.

Major parts of a hammer: The major parts of a hammer are the head and the handle.

Hammer is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer-head are the face (1), pein (2), cheek (3) and the eyehole (4).

Face: The face is the striking portion. A slight convexity is given to it to avoid digging of the edge. It is used for striking while chipping, bending, punching, etc.

Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting and bending. The pein is of different shapes such as:

- ball pein (Fig.2a)
- cross-pein (Fig.2b)
- straight pein. (Fig 2c)

Fig 1

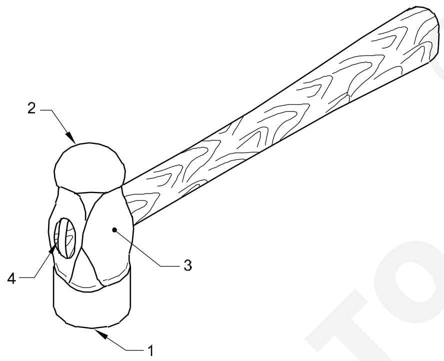
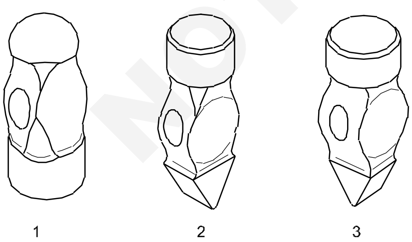


Fig 2



The face and the pein are case hardened.

Cheek: The cheek is the middle portion of the hammer-head. The weight of the hammer is stamped here.

This portion of the hammer-head is left soft.

Eyehole: The eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eyehole. (Figs 3 and 4)

Fig 3

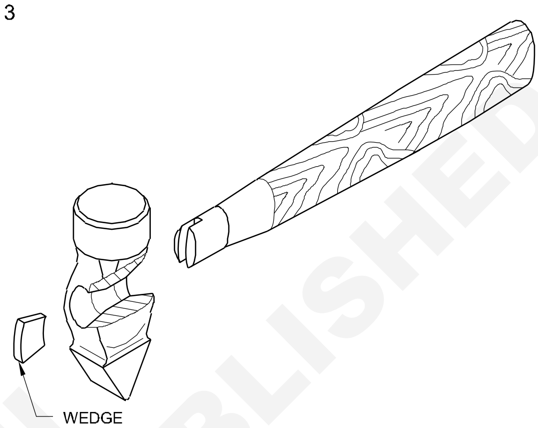
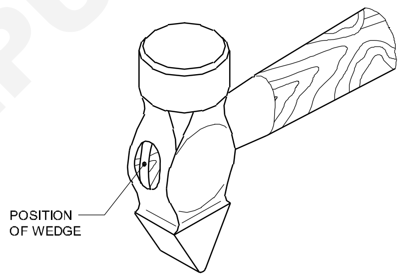
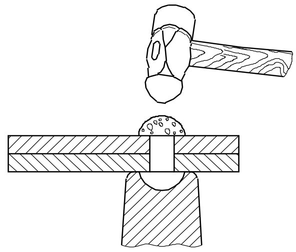


Fig 4



Application of hammer pein: The ball pein is used for riveting. (Fig 5)

Fig 5



The cross-pein is used for spreading the metal in one direction. (Fig 6)

The straight pein is used at the corners. (Fig 7)

The ball pein hammer is used for driving a chisel in parting metal. (Fig 8)

Fig 6

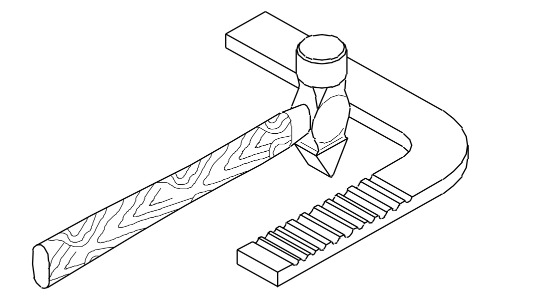


Fig 7

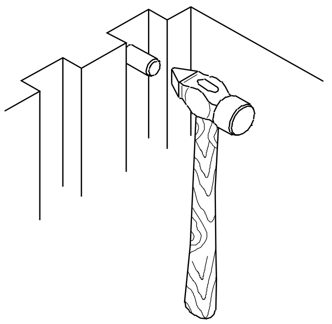
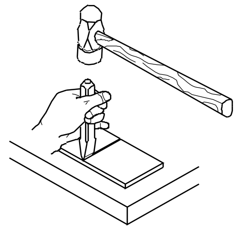


Fig 8



Specification: An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750 gms.

The weight of an engineer's hammer, used for marking purposes, is 250 gms.

The ball pein hammers are used for general work in a machine/ fitting shop.

Before using a hammer

- make sure the handle is properly fitted
- select a hammer with the correct weight suitable for the job
- check the hammer head and handle whether any crack is there
- ensure that the face of the hammer is free from oil or grease.

Marking off and marking off table

Objectives: At the end of this lesson you shall be able to
- **state why marking off is necessary**
- **state the function of witness marks**
- **state the features of marking tables**
- **write the uses of marking tables**
- **state the maintenace aspects concerning marking tables.**

Marking off

Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

Witness marks

The line marked on metal surfaces is likely to be erased due to handling. To avoid this, permanent marks are made by placing punch marks at convenient mark intervals along the marked line. Punch marks act as a witness against inaccuracies in machining and hence, they are known as witness marks.

Marking off table (Figs 1 and 2)

A marking table (marking-off table) is used as a reference surface for marking on workpieces.

Marking tables are of rigid construction with accurately finished top surfaces. The edges are also finished at right angles to the top surface.

Fig 1

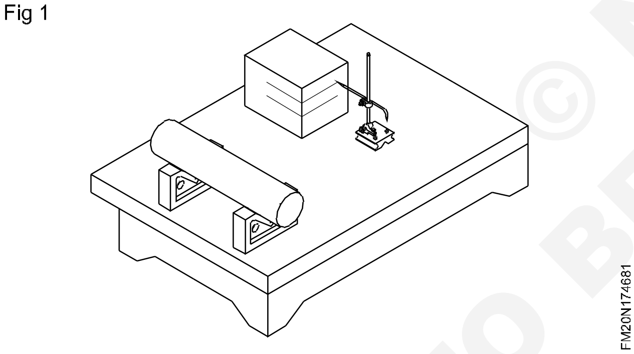
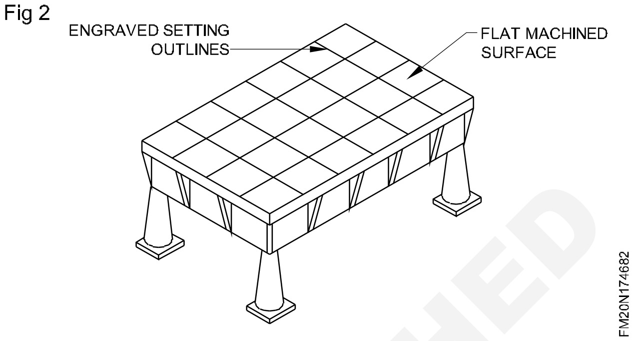


Fig 2



Marking tables are made of cast iron or granite, and are available in various sizes. These tables are also used for setting measuring instruments, and for checking sizes, parallelism and angles.

Care and maintenance

A marking table is very precise equiment, and should be protected from damage and rust.

After use, the marking table should be cleaned with a soft cloth.

The Surface of the marking table, made of cast iron, should be protected by applying a thin layer of oil.

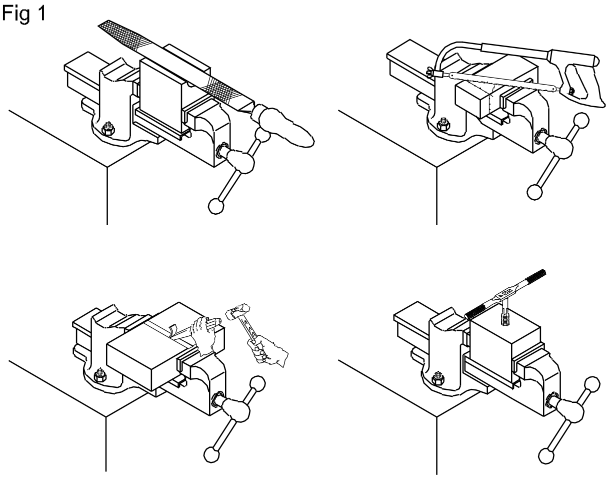
Bench vice

Objectives: At the end of this lesson you shall be able to
- **state the uses of bench vice**
- **specify the size of the bench vice**
- **name the parts of the bench vice**
- **state the uses of vice clamps.**
- **mention the care and maintenance of vices**

Vices are used for holding the workpieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer's vice.

A bench vice is made of cast iron or cast steel and it is used to hold work for filing, sawing, threading and other hand operations. (Fig 1)

Fig 1

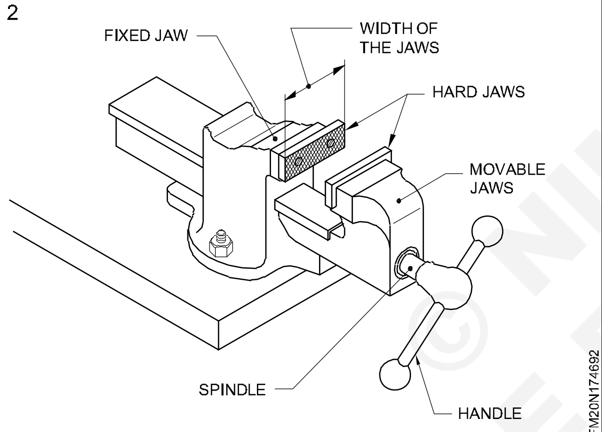


The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice

Parts of a bench vice (Fig 2)

The following are the parts of a vice.

Fig 2



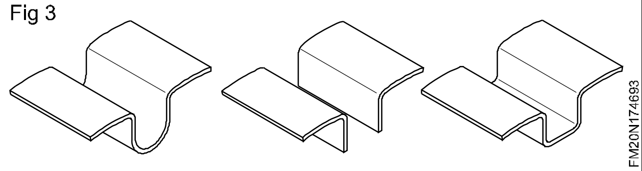
Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a vice.

The box-nut and the spring are the internal parts.

Vice clamps or soft jaws (Fig 3)

To hold a finished work use soft jaws (vice clamps) made of aluminum over the regular jaws. This will protect the work surface from damage.

Fig 3



Do not over-tighten the vice as, the spindle may be damaged.

Care and maintenance of vices

- Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
- Make sure to oil and lubricate the joints and sliding parts.
- To oil the sliding section, open the jaws completely and apply a layer of grease to the screen.
- Remove the rust if appears on the vice using rust remover chemical.
- When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
- Avoid striking the handle of the vice by a hammer for tightening fully, otherwise the handle will become bend or damaged.

Hacksaw frames and blades

Objectives: At the end of this lesson you shall be able to
- **name the different types of hacksaw frames**
- **specify hacksaw blades**
- **name the different type of hacksaw blades**
- **describe the method of sawing**

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections, and is specified by the type and maximum length of the blade that can be fixed.

Example

Adjustable hacksaw frame - tubular - 250 - 300mm or 8" - 12"

Types of hacksaw frames

Solid frame (Fig 1a)**:** Only a blade of a particular standard length can be fitted to this frame. e.g 300 mm or 250 mm.

Adjustable frame (flat type)**:** Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

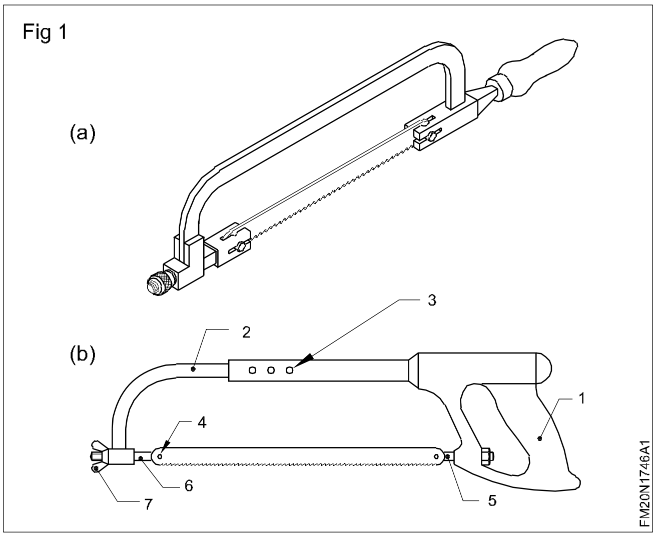


Fig 1

Adjustable frame (tubular type) (Fig 1b)**:** This is the most commonly used type. It gives a better grip and control, while sawing.

Parts of a hacksaw frame

1 Handle

2 Frame

3 Tubular frame with holes for length adjustment

4 Retaining pins

5 Fixed blade-holder

6 Adjustable blade-holder

7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)

1 Back edge

2 Side

3 Centre line

4 Pin holes

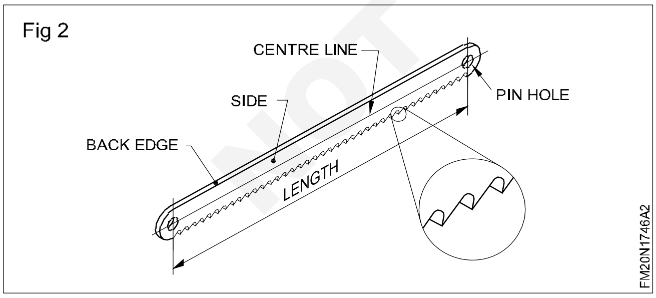


Fig 2

Type of hacksaw blades

All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3)**:** The distance between adjacent teeth is known as the 'pitch' of the blade.

Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

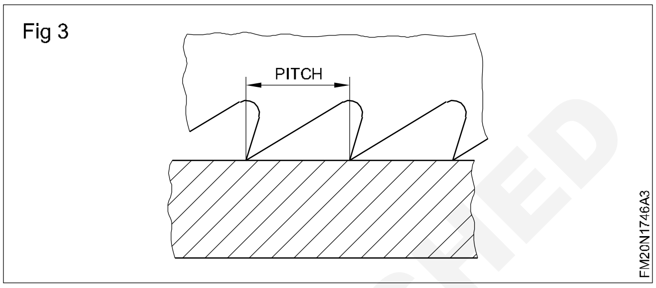


Fig 3

Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

Example

300 x 1.8 mm pitch LA all-hard blade.

To prevent the hacksaw blade binding when penetrating into the material, and to allow free movement of the blade, the cut is to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

Staggered set (Fig 4)**:** Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

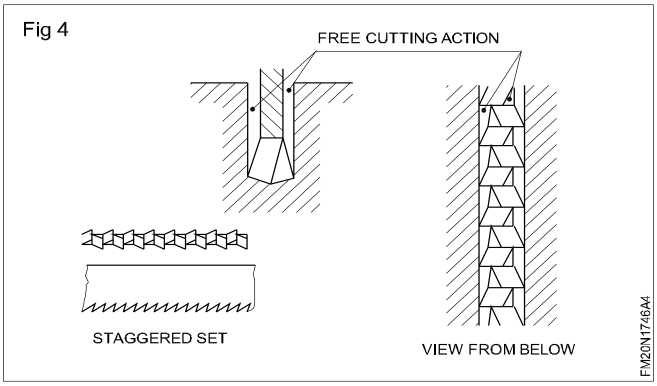
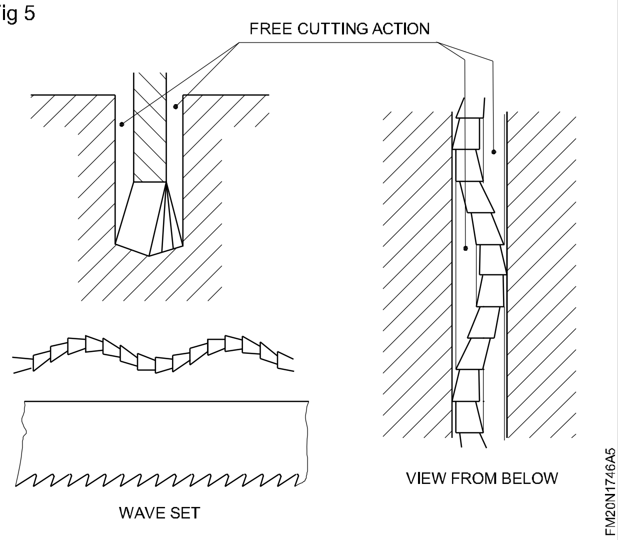


Fig 4

Wave set (Fig 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

Fig 5

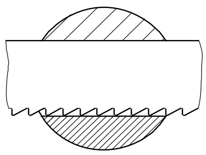


For the best results, the blade with the right pitch should be selected and fitted correctly.

Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

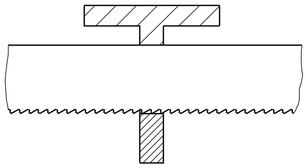
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



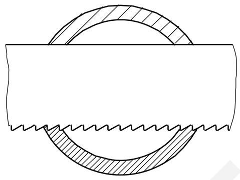
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

Fig 7



For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)

Fig 8



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

Select the correct number of teeth / inch the general rule is that atleast 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

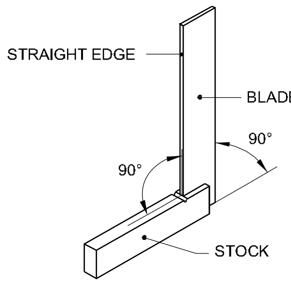
Try square

Objectives: At the end of this lesson you shall be able to
- **name the parts of a try square**
- **state the uses of a try square.**

The try square (Fig 1) is an instrument which is used to check squareness (angles of 90°) of a surface.

The accuracy of measurement by a try square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces. The blade is fixed to the stock at 90°.

Fig 1



Try squares are made of hardened steel.

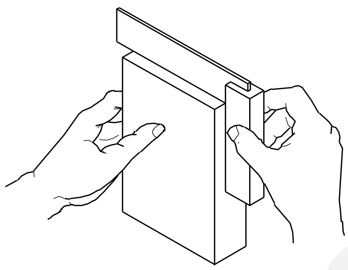
Try squares are specified according to the length of the blade i.e. 100 mm, 150 mm, 200 mm.

Uses:

The try-square is used to:

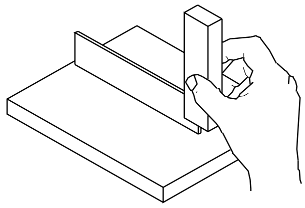
– check the squareness (Fig 2)

Fig 2



– check the flatness (Fig 3)

Fig 3



– mark lines at 90° to the edges of workpieces (Fig 4)

– set workpieces at right angles. (Fig 5)

Fig 4

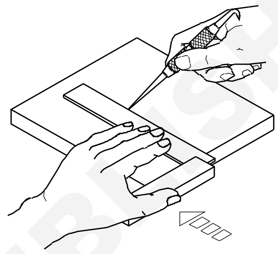
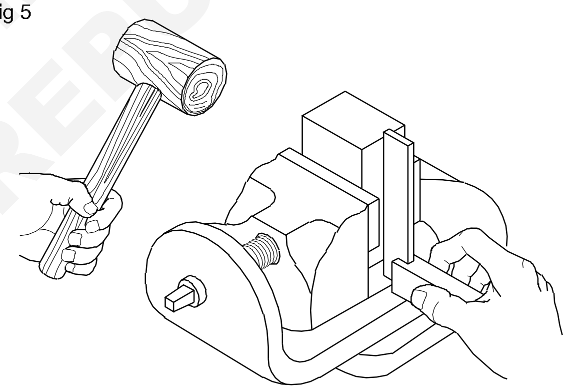


Fig 5



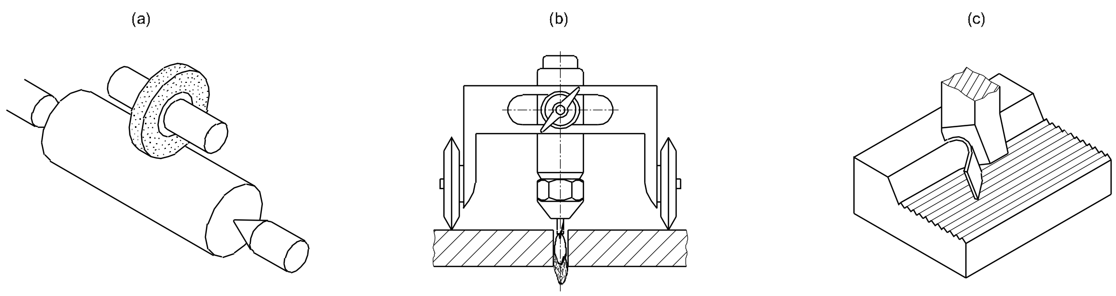
Elements of a file

Objectives: At the end of this lesson you shall be able to
- **name the parts of a file**
- **state the material of a file.**

Methods of material cutting

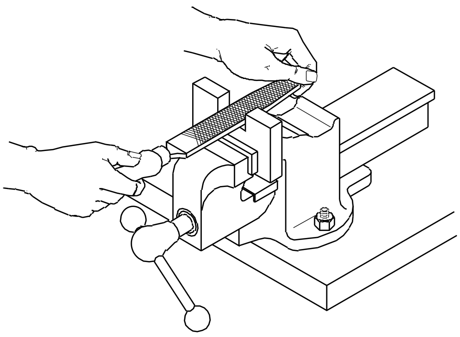
The three methods of metal cutting are abrasion (Fig.1), fusion (Fig 2) and incision (Fig 3)

Fig 1



Filling is a method for removing excess material from a workpiece by using a file which acts as a cutting tool. Figure 4 shows how to hold a file. Files are available in many shapes and sizes.

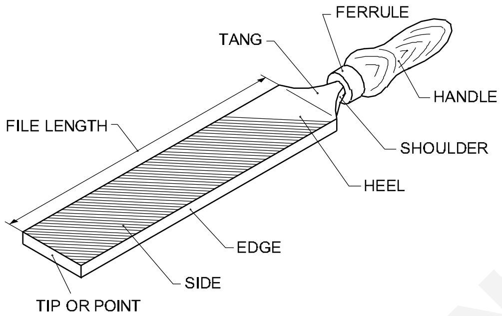
Fig 2



Parts of a file (Fig 5)

The parts of a file can be seen in figure 5, are

Fig 3



Tip or Point

the end opposite to tang

Face or side

The broad part of the file with teeth cut on its surface

Edge

The thin part of the file with a single row of parallel teeth

Heel

The portion of the broad part without teeth

Shoulder

the curved part of the file separating tang from the body

Tang

The narrow and thin part of a file which fits into the handle

Handle

The part fitted to the tang for holding the file

Ferrule

A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardened.

Cut of files

Objectives: At the end of this lesson you shall be able to
- **name the different cuts of files**
- **state the uses of each type of cut.**

The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

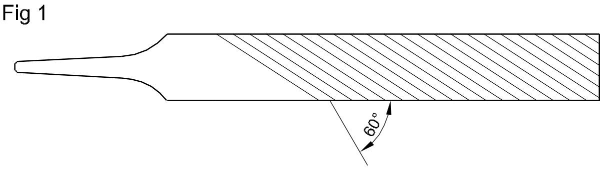
Types of cuts

Basically there are four types.
Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1)

A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60^0 to the centre line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

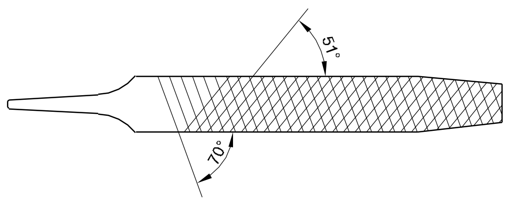
Fig 1



Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

Double cut file (Fig 2)

Fig 2



A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70°. The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51°. This removes stock faster than the single cut file.

Rasp cut file (Fig 3)

The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

Fig 3

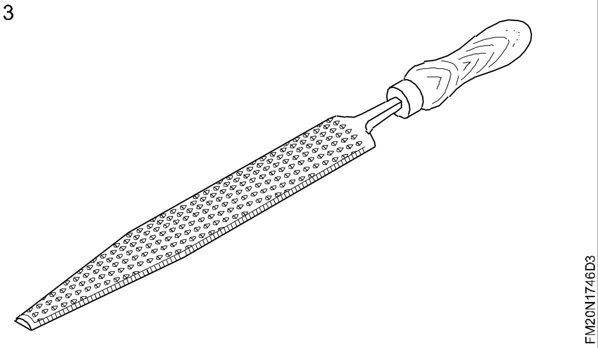
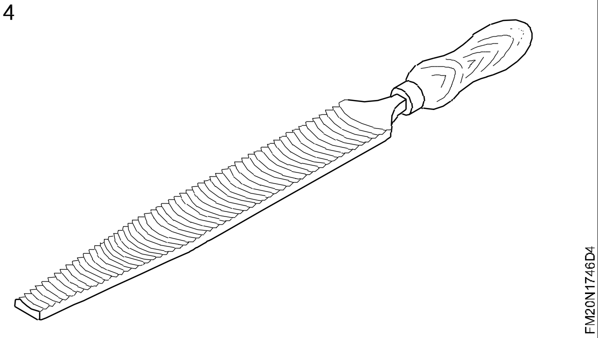


Fig 4



Curved cut file (Fig 4)

These files have deeper cutting action and are useful for filing soft materials like - aluminum, tin, copper, and plastic.

The curved cut files are available only in a flat shape.

The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws, are also of single cut.

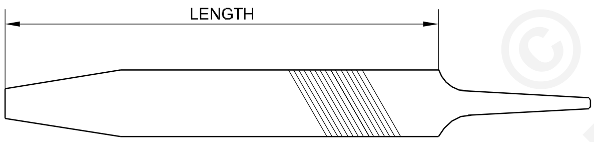
File specifications and grades

Objectives: At the end of this lesson you shall be able to
- **state how files are specified**
- **name the different grades of files**
- **state the application of each grade of file.**

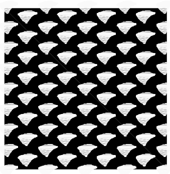
Files are manufactured in different types and grades to meet the various needs.

Files are specified according to their length, grade, cut and shape.

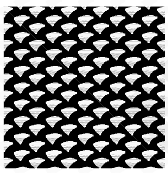
Length is the distance from the tip of a file to the heel.



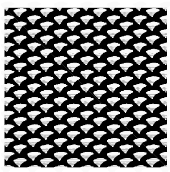
File grades are determined by the spacing of the teeth.



A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

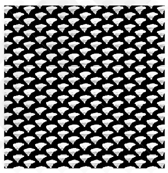


A **bastard file** is used in cases where there is a heavy reduction of material

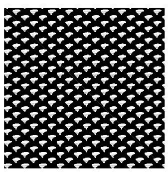


A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.



A **smooth file** is used to remove small quantity of material and to give a good finish.



A **dead smooth** file is used to bring the material to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the the grades recommended by the bureau of Indian standards (BIS)

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

Table 1

Grade of files (Number of cuts over the length of 10mm)

Length of file	Rough	Bastard	Second cut	Smooth	Deadsmooth
150mm	8	13	17	24	33
200mm	7	11	16	22	31
250mm	6	10	15	20	30
300mm	5	9	14	19	28

Pinning of files

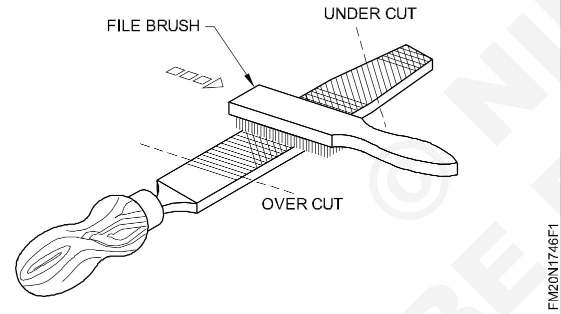
Objective: At the end of this lesson you shall be able to
- **clean the files.**

During filing, sometimes the metal chips (filings) will clog between the teeth of files. This is known as 'pinning' of files.

Files which are pinned will produce scratches on the surface being filed, and also will not bite well.

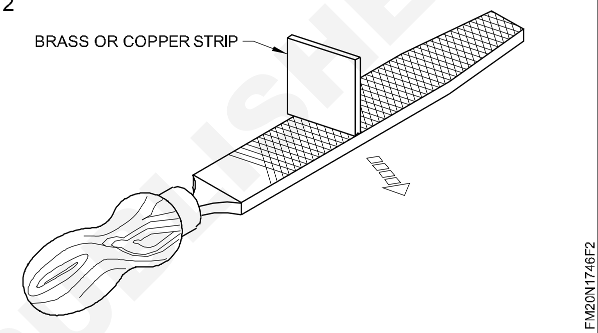
Pinning of the files is removed by using a file brush also called a file card, (Fig 1) with either forward or backward stroke.

Fig 1



Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 2)

Fig 2



For new files, use only soft metal strips (brass or copper) for cleaning. The sharp cutting edges of the files will wear out quickly if a steel file card is used. When filing a workpiece to a smooth finish more 'pinning' will take place because the pitch and depth of the teeth are less.

Application of chalk on the face of the file will help reduce the penetration of the teeth and 'pinning'.

Clean the file frequently in order to remove the filings embedded in the chalk powder.

Care and maintenance

Objective: At the end of this lesson you shall be able to
- **write the care and maintenance of file.**

- Do not use files having the blunt cutting edge
- Remember that files cut on the push stroke. Never apply the pressure on the pull stroke, or you could crush the file teeth, blunt them or cause them to break off.
- Prevent from pinning.
- Giving your files teeth a light brush with oil during long storage.
- Normally do not apply any oil while filing.
- Files should be stored separately so that their faces cannot rub against each other or against other tools.

Convexity of files

Objective: At the end of this lesson you shall be able to
- **list the reasons for convexity on files.**

Most files have the faces slightly bellied lengthwise. This is known as convexity of a file. This should not be confused with the taper of a file. A flat file has faces which are convex and it also tapers slightly in width and thickness.

Purpose: If the file is parallel in thickness, all the teeth on the surface of the work will cut. This would require more downward pressure to make the file 'bite' and also more forward pressure to make the file to cut.

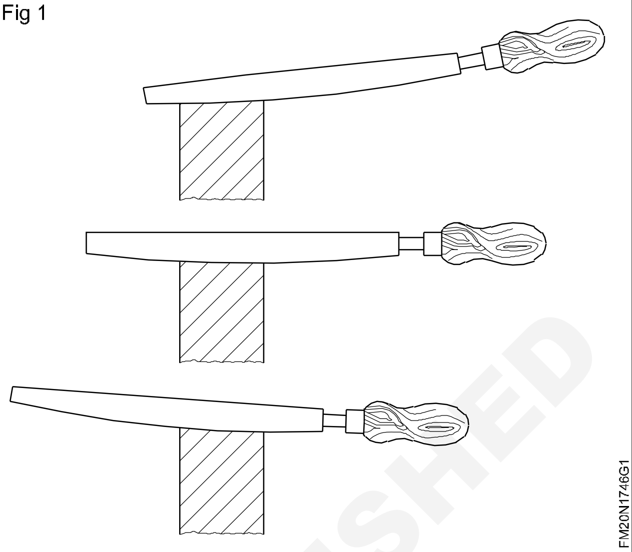
It is more difficult to control a file of uniform thickness.

To produce a flat surface with a file of parallel thickness, every stroke should be straight. But it is not possible due to the see-saw action of the hand.

If the file is made with parallel faces, while giving heat treatment, one face may warp and become concave, and the file will be useless for flat filing.

Excessive chip removal at the front or rear workpiece edge is prevented and filing of the flat surface is made easier because of the convexity on the cutting faces. (Fig 1)

Fig 1



Chisel

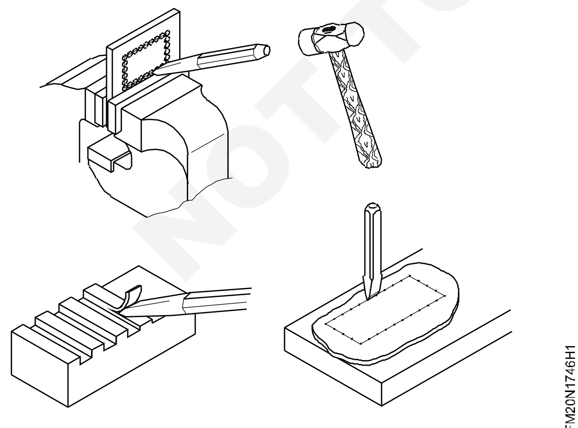
Objectives: At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **name the parts of cold chisel**
- **state the different types of cold chisels.**

Methods of material cutting

The cold chisel is a hand cutting tool used by fitters for chipping and cutting of operations (Fig 1)

Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filling.

Fig 1

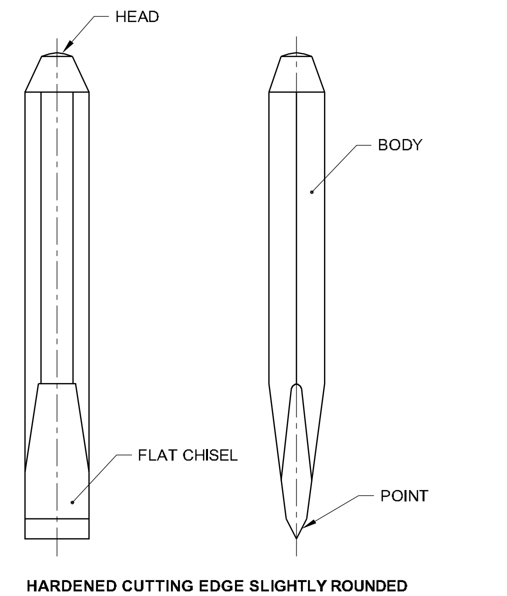


Parts of a chisel (Fig 2)

A chisel has the following parts.

- Head
- Body
- Point or cutting edge

Fig 2



Chisels are made from high carbon steel or chrome vanadium, steel the cross section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and tempered.

Common types of chisels

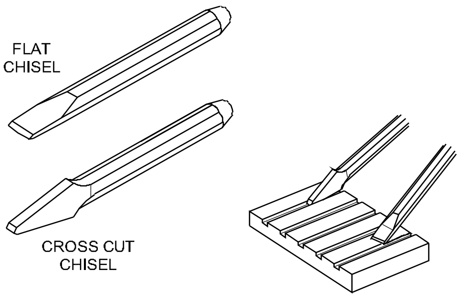
There are four common types of chisels.

- Flat chisel
- Cross cut chisel
- Half round nose chisel
- Diamond point chisel.

Flat chisels (Fig 3)

They are used to remove metal from large flat surfaces and chip excess metal of weld joints and castings.

Fig 3



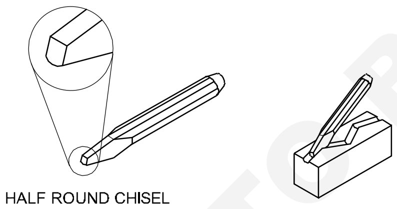
Cross- cut or cape chisels (Fig 3)

These are used for cutting keyways, grooves and slots.

Half round nose chisels (Fig 4)

They are used for cutting curved grooves (oil grooves)

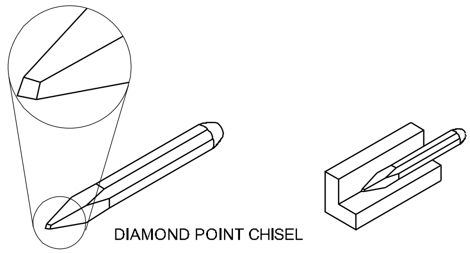
Fig 4



Diamond point chisels (Fig 5)

These are used for squaring materials at the corners.

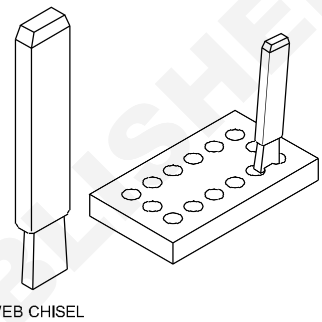
Fig 5



Web chisels/punching chisels (Fig 6)

These chisels are used for separating metals after chain drilling.

Fig 6



Chisels are specified according to their

- Length
- Width of cutting edge
- Type
- Cross section of body

The length of the chisels ranges from 150mm to 400mm the width of the cutting edge variers according to the type of chisels.

Angles of chisels

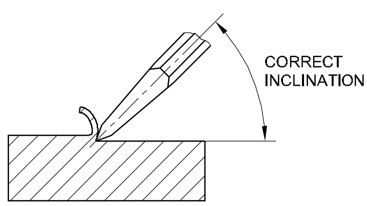
Objectives: At the end of this lesson you shall be able to
- **select the point angles of chisels for different materials**
- **name the parts of cold chisel**
- **state the different types of cold chisels.**

Point angles and materials

Correct point/ cutting angle of the chisel depends on the material to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

The correct point angle and angle of inclination generate the correct rake and clearance angles. (Fig 1)

Fig 1



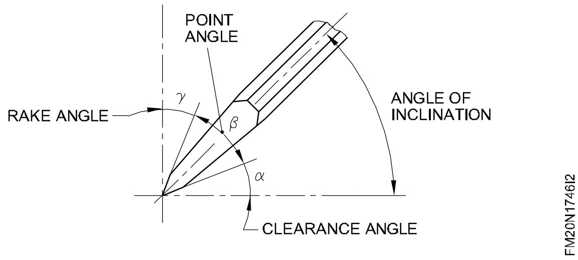
Rake angle

Rake angle g is the angle between the top face of the cutting point, and normal to the work-surface at the cutting edge (Fig 2)

Clearance angle

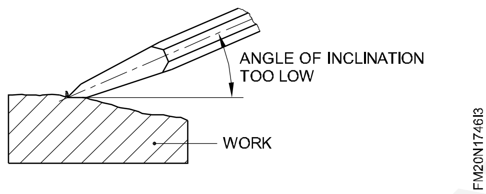
Clearance angle a is the angle between the bottom found the point and tangent to the work-surface originating at the cutting edge. (Fig 2)

Fig 2



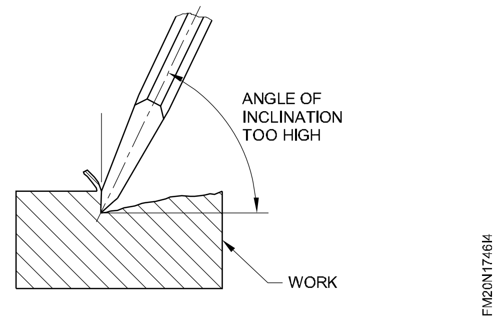
If the clearance angle is too low or zero. The rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)

Fig 3



If the clearance angle is too great, the rake angle reduces. The cutting edge digs in, and the cut progressively increases. (Fig 4)

Fig 4



Material to be cut	Point angle	Angle inclination
High carbon steel	65°	39.5°
Cast iron	60°	37°
Mild steel	55°	34.5°
Brass	50°	32°
Copper	45°	29.5°
Aluminium	30°	22°

Types of grinders

Objectives: At the end of this lesson you shall be able to
- **state the purposes of off-hand grinding**
- **name the machines with which off-hand grinding is done**
- **state the features of bench and pedestal grinders.**

Off-hand grinding is the operation of removing material which does not require great accuracy in size or shape. This is carried out by pressing the work piece by hand against a grinding wheel.

Off-hand grinding is performed for rough grinding of jobs and resharpening of

Scribers

Punches

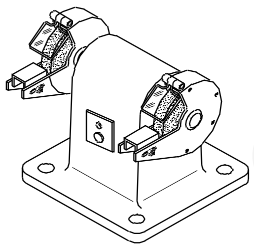
Chisels

twist drill

single point cutting tools etc.,

Off-hand grinding is performed with a bench or pedestal grinder (Fig 1)

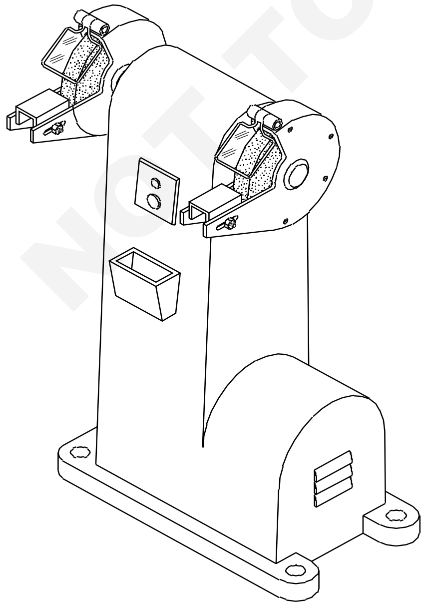
Fig 1



BENCH GRINDER

Bench grinders

Fig 2



PEDESTAL GRINDER

Bench grinders are fitted to a bench or table, and are useful for light duty work

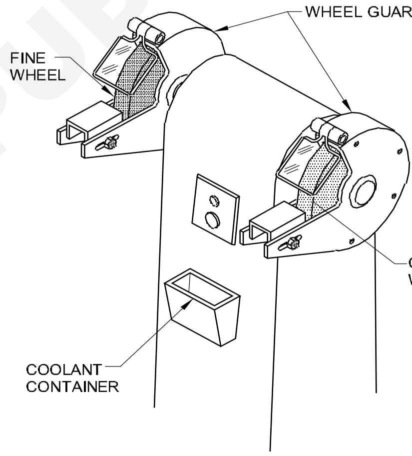
Pedestal grinders

Pedestal grinder are mounted on a base (Pedestal) which is fastened to the floor. They are used for heavy duty work

These grinders consist of an electric motor and two spindles for moulding grinding wheels. On one spindle a coarse-grained wheel is fitted, and on the other, a fine grained wheel. For safety, while working wheel guards are provided. (Fig 3)

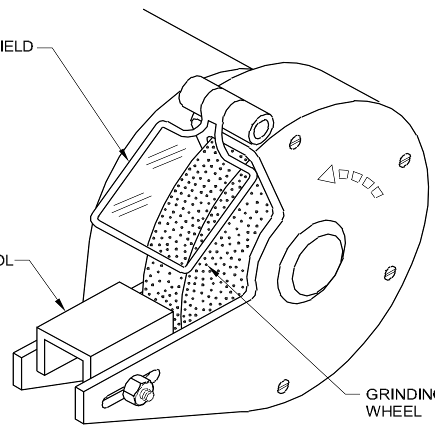
A coolant container is provided for frequent cooling of the work. (Fig 3)

Fig 3



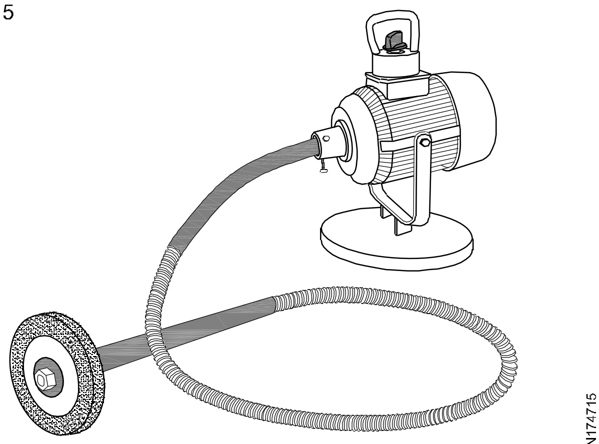
Adjustable work-rests are provided for both wheels to support the work while grinding. These work rests must be set very close to the wheels. (Fig 4)

Fig 4



Extra eye-shields are also provided for the protection of the eyes. (Fig 4)

Fig 5



FLEXIBLE SHAFT GRINDER

Flexible shaft grinder:

Which is a high speed hand held rotary with grinding wheel they are driven with a small electric motor directly or via flexible shift.

Other grinding machine:

1 Hand grinder

2 Swing frame grinding machine

3 Abrasive belt grinding

Other metal cutting equipments

- Power hack saw
- Flame cutting
- Lathe
- Milling machine
- Boring machine
- Machining center etc.,

Drilling machines, and drill bits types, use and care

Objectives: At the end of this lesson you shall be able to
- **name the various types of drilling machines**
- **name the parts of the bench and pillar type drilling machines**
- **compare the features of the bench and pillar type drilling machines.**

The principle types of drilling machines are

– the sensitive bench drilling machine

– the pillar drilling machine

– the column drilling machine

– the radial arm drilling machine (radial drilling machine).

(You are not likely to use the column and radial type of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here)

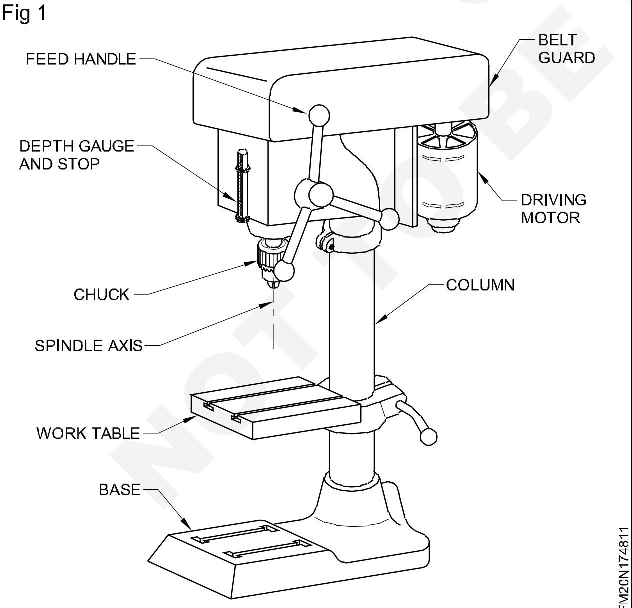
The sensitive bench drilling machine (Fig 1)

The simplest type of the sensitive drilling machine is shown in the figure with its various parts marked. This is used for light duty work.

This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

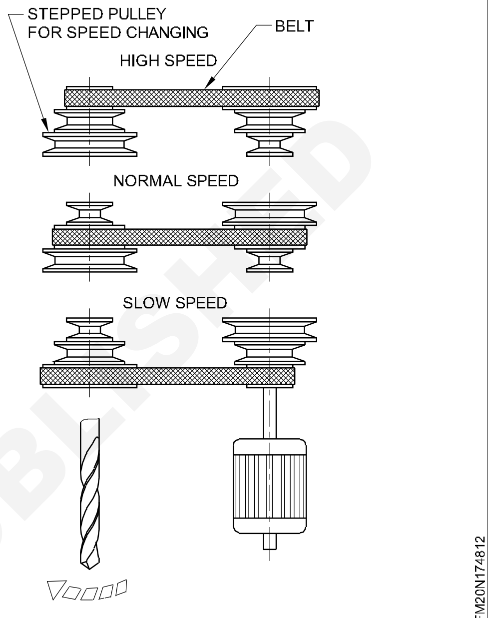
For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangemented is shown in Fig.1)

Fig 1



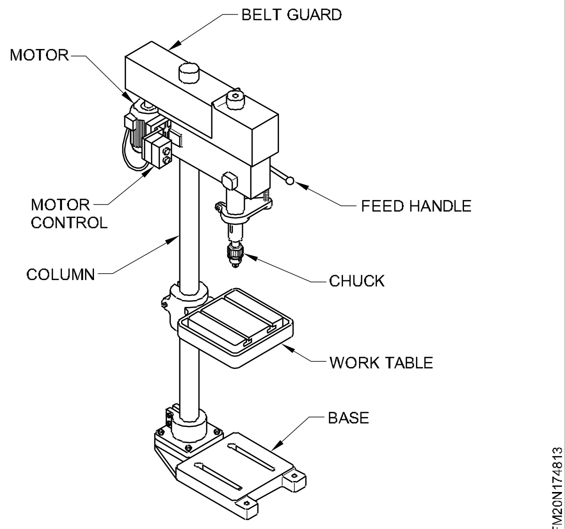
Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

Fig 2



The pillar drilling machine (Fig 3)**:** This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.

Fig 3



They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Drill - Holding devices

Objectives: At the end of this lesson you shall be able to
- **name the types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes on materials, the drills are to be held accurately and rigidly on the on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill Chuck

Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knureld ring.

The drill chucks are held on the machine spindle by means of an arbor fitted on the drill chuck. (Fig 1)

Taper Sleeves and Sockets (Fig 1)

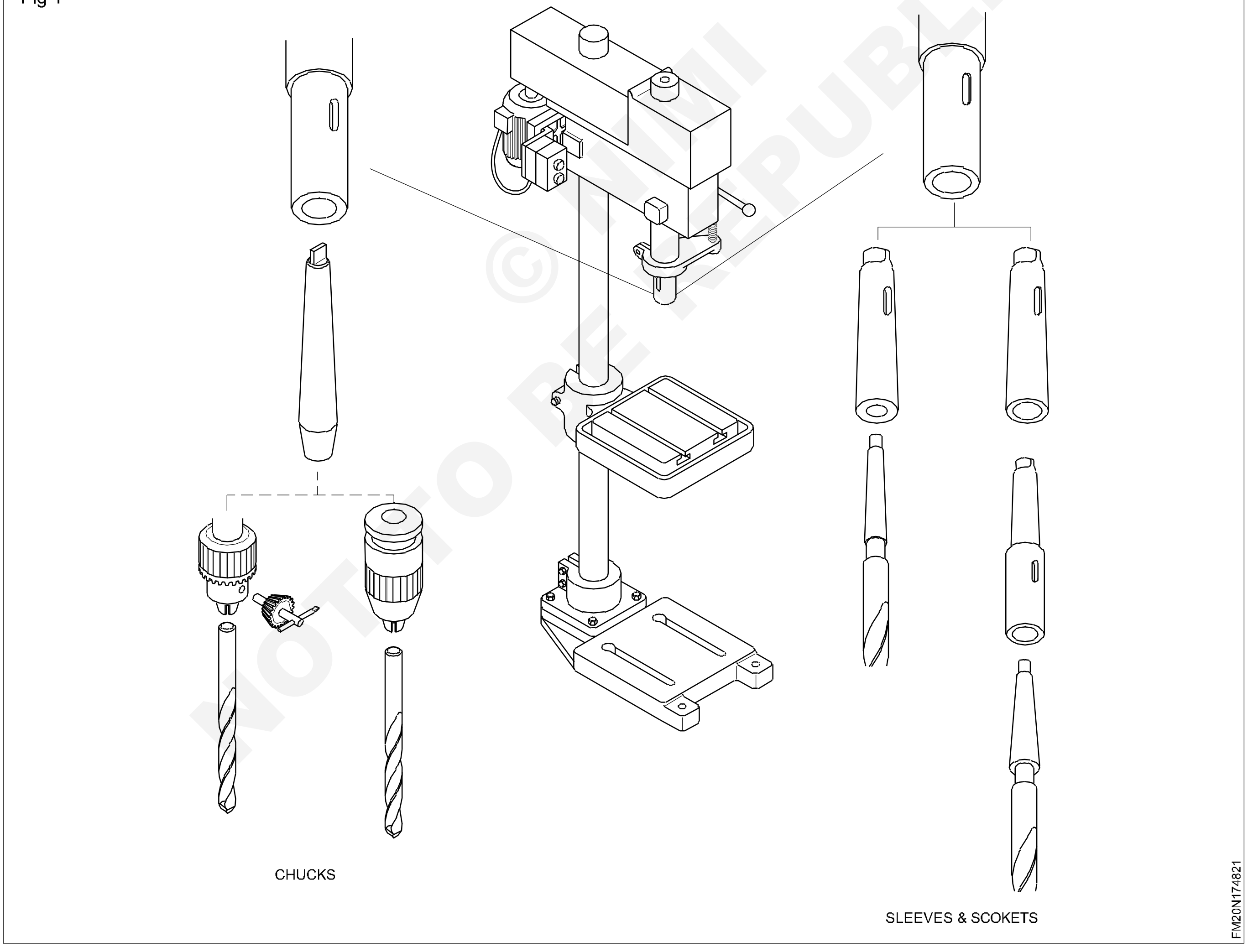
Taper shank drills have a morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedding action. Due to this reason morse tapers are called self-holding tapers.

Drills are provided with five different sizes of morse tapers, and are numbered from MT1 to MT5.

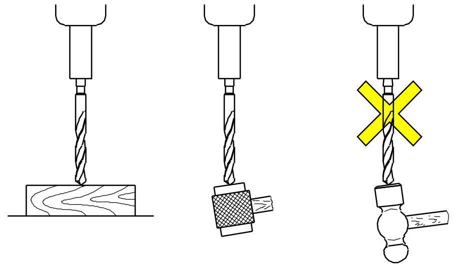
In order to make up the difference in sizes between the shanks of the drills and the type of machine spindies, sleeves of different sizes are used. When the drill taper shank is bigger than machine spindle, taper sockets are used. (Fig 1)

Fig 1



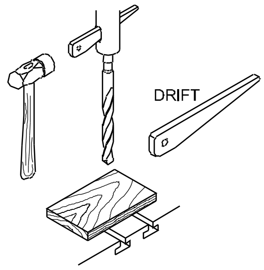
While fixing the drill in a socket or sleeve, the tang portion should align in the slot. (Fig 2) This will facilitate the removal of drill or sleeve from the machine spindle.

Fig 2



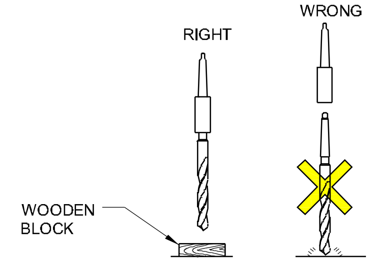
Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

Fig 3



While removing the drill from the sockets/ sleeves, don't allow it to fall on the table or jobs. (Fig 4)

Fig 4



REMOVING A TAPER SHANK DRILL

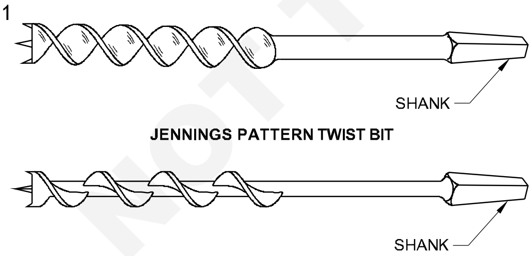
Various different types of drill bits for wood and metal working

Objectives: At the end of this lesson you shall be able to
- **list the types of drill bits**
- **state the uses of drill bits**
- **state the sizes of drill bits.**

- Bits having been designed for boring holes under special conditions.
- There are many varieties of bits available for different uses.
- Made of high carbon steel or high speed steel.

Twist bit (Fig 1)

Fig 1



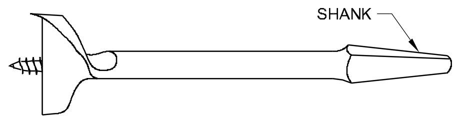
- Some times called an auger bit.
- This bit has both twisted point and a twisted shank.
- The twisted point draws the bit into the wood.
- Two varieties are made just one for hardwood (without spurs or scriber).
- Second one for soft wood with spur.
- For boring deep holes in hardwood or soft wood.
- Particularly useful when boring in end grain,

The long twisted shank will keep the hole straight and throw out the waste.

Size f6mm to f45 mm.

Centre bit (Fig 2)

Fig 2



CENTRE BIT

This bit differs from other bits as regards to shape.

Its cutting action is similar to the twist bit.

- The centre point guides the bit
- The cutting points some times threaded.
- Spur or scriber (slightly shorter than the point) cuts the rim of the hole.
- Router or cutter (Slightly shorter than the point) cut the waste portions.
- These bits are suitable for boring shallow holes or holes through thin timber only.

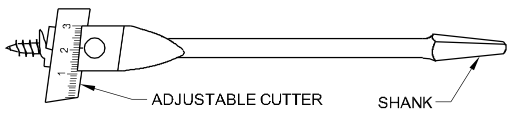
- There is no guiding shank to keep the boring straight
- Size 6mm to 50mm

  upto 25 mm = 16 Nos

  25 mm to 50mm = 8 Nos.

Expansion bit (Fig 3)

Fig 3

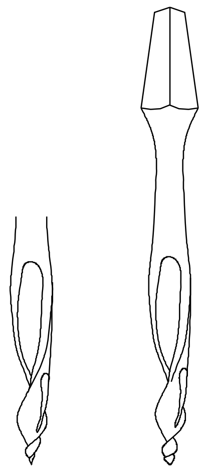


EXPANSION BIT

- This bit is able adjust to cut holes from 12 mm to 75 mm
- Its cutting action is similar to the centre bit.
- For boring shallow holes through thin wood.

Cobra bit (Fig 4)

Fig 4

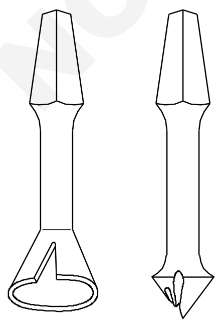


NAIL BIT / SCREW BIT / COBRA BIT

- Has a twisted point which draws the bit into the wood.
- Care must be taken not to split the timber while boring near the end.
- For boring small holes for nails and screws.
- Size 2 mm to 10 mm.

Dowel bit (Fig 5)

Fig 5

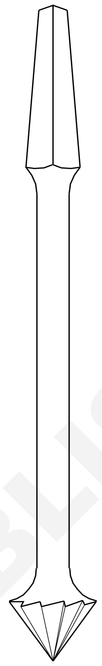


DOWEL ROUNDER OR SHARPENER

- Similar to the twist bit.
- It is shorter than twist bit.
- For boring holes for dowels and preliminary boring out waste of mortises.
- Size 6 mm to 15 mm.

Counter sink bit (Fig 6)

Fig 6



COUNTER SINK BIT OR ROSE BIT

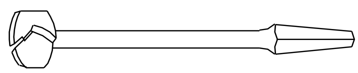
- These bits have tapered cutting point which enlarge the tops of holes.
- This process is called counter sinking
- For counter sinking the tops of holes to receive the head of counter sunk head screws.

The snail pattern is most “suitable for hard woods.

- Size 6mm to 20 mm.

Forstner bit (Fig 7)

Fig 7

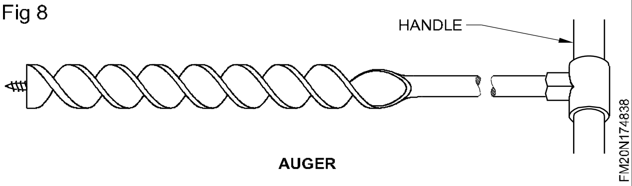


FORSTNER BIT

- This bit differs from other bits, is guided not by a centre point but by its circular rim.
- It can be used to bore at any angle to the surface of the work regardless of the direction of the grain.
- For boring skewed holes (called pocketing) for screws (Rails of the table)
- Flat bottomed boles in pattern making and recessed carving designs.
- Size from 6mm to 40mm.

Auger (Fig 8)

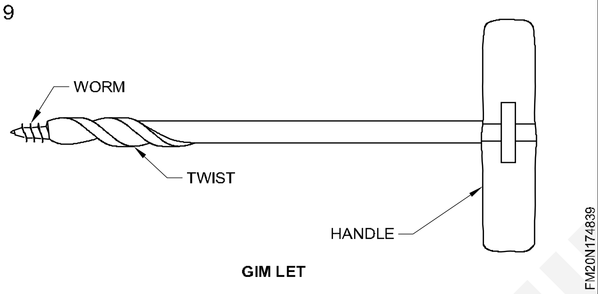
Fig 8



- A twisted bit with a long shank.
- The head being shaped with an eye for fitting a cross bar or handle to give greater leverage.
- For boring large, deep holes for bolts etc in hard wood.
- Where the brace is not strong enough to turn a bit.
- Some times called as hand auger.
- Size f6mm to f25 mm

Gimlet (Fig 9)

Fig 9



- Similar to a nail bit
- Has a twisted point which draws the bit into the wood
- Has a small cross handle for hand boring
- For boring small holes for screws and nails where the brace cannot be used.
- The gimlet must be used with care; it will split the timber.

Bradawl (Fig 10)

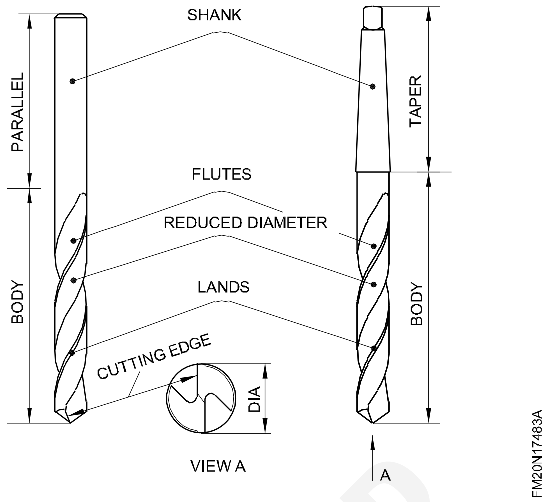
- Consist of a thin steel rod which is flattened to a mall cutting edge at one end.
- The tang fitted into a box wood handle at the other end.
- The flat cutting edge is placed across the grain and forced into the timber while being twisted back and forth. so that the fibres are cut this making a small hole.
- For making small holes where the brace and bit is not necessary.

Size 3 mm to 12 mm.

Twist drill

Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flues formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Twist drills are available in standard sizes. Parallel shank twist drills are available below 13mm size. (Fig 10)

Fig 10

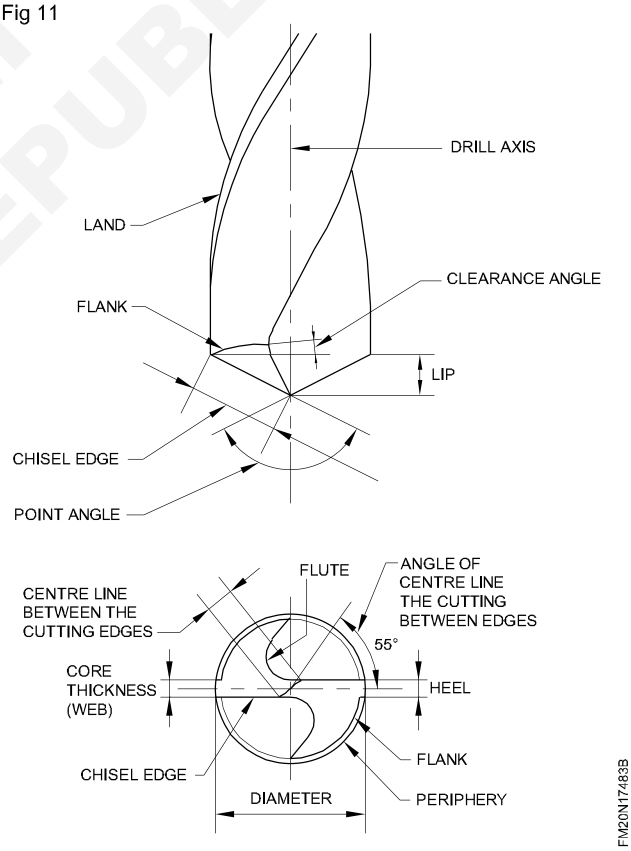


Parts of a twist drill

Drills are made from high speed steel. The spiral flutes are machined at an angle of 271/2° to its axis.

The flutes provide a correct cutting angle which provides an escape path for the chips. It carries the collant to the cutting edge during drilling. (Fig 11)

Fig 11



The portions left between the flutes are called 'lands'. The size of a drill is determined and governed by the diameter over the lands.

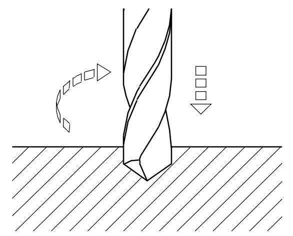
The point angle is the cutting angle, and for general purpose work, it is 118°. The clearance angle serves the purpose of clearing the back of the lip from fouling with the work. It is mostly 8°.

Drill (Parts and Functions)

Objectives: At the end of this lesson you shall be able to
- **state the functions of drills**
- **identify the parts of a drill**
- **state the functions of each part of a drill.**

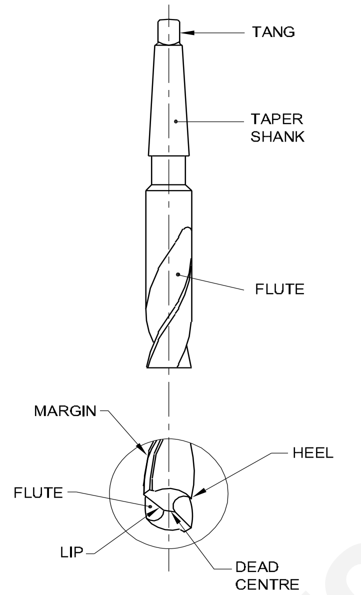
Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate into the material. (Fig 1)

Fig 1



Parts of a Drill (Fig 2)

Fig 2



The various parts of a drill can be identified from figure 2.

Point

The cone shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

Shank

This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills. (Fig 3)

Tang

This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body

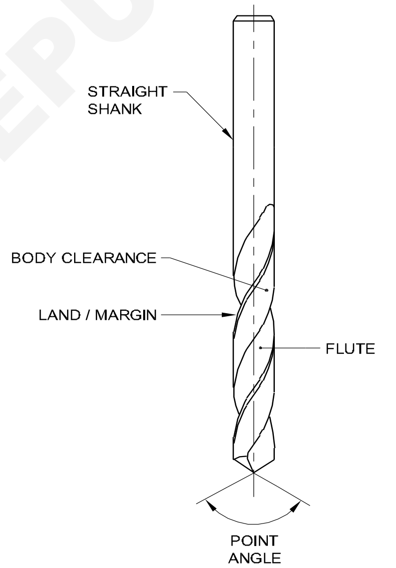
The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Flutes (Fig 3)

Flutes are the spiral grooves which run to the length of the drill.

Fig 3



Induction furnace (Electric melting)

Objectives: At the end of this lesson you shall be able to
- **state the working principle of induction furnace**
- **name the type of induction furnace**
- **state the advantages and disadvantages of induction furnace.**

Working principle

1 A high frequency current is passed through the water cooled copper coil which act as the primary of a transformer and the metal charge the secondary

2 The heat is developed in the stem metal charge reaches inside by conductor and melts the charge.

Name the types of induction furnace

Induction furnace

Core type (low frequency) Induction furnace	Core less High frequency Induction furnace

Coreless type (or High frequency) induction furnace

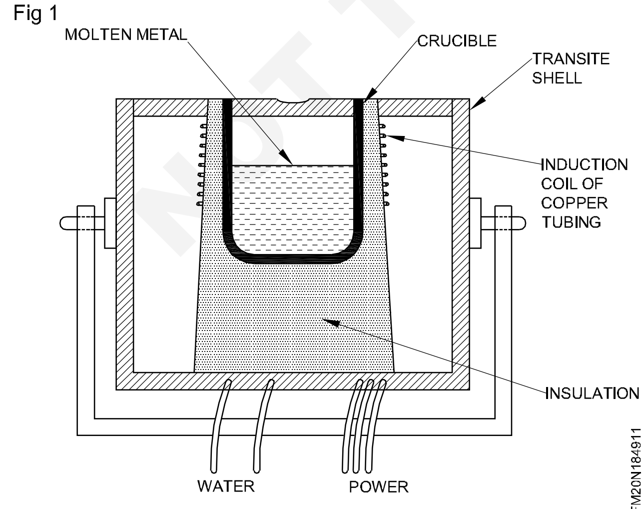
Construction

1 A high frequency induction furnace consists of a refractory placed centrally inside water cooled copper coil and packed into position by ramming dry refractory (insulation) tightly between the curable and the copper coil which is recovered with wet refractory dried into a hard mass.

2 A high frequency induction furnace can be of two types as regards tapping of the melt is concerned.

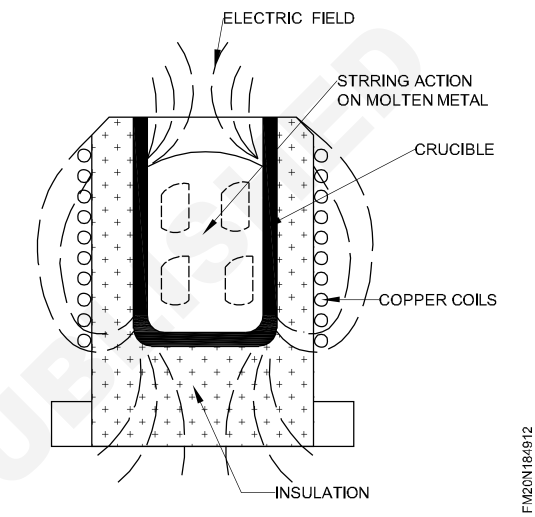
- A tilting type (Fig 1)

Fig 1



- A lift coil type is which the furnace shell along with the coils can be lifted up to leave aside crucible in its position (Fig 2)

Fig 2



Principle of operation

1 Steel scrap is placed in the furnace as metal charge

2 A high frequency current is passed through the water cooled copper coils which act as the primary of a transformer and the metal charge becomes the secondary.

3 Heavy alternating secondary currents thus induced in the metal charge by electromagnetic induction create heat because the metal charge offers resistance to the passage of secondary currents.

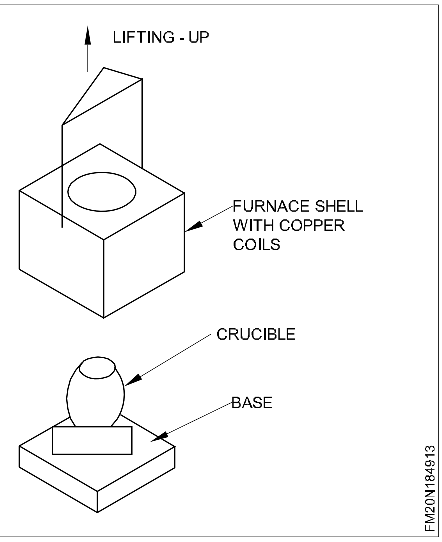
4 This heat developed in the skin of metal charge reaches inside by conduction and melts the charge.

5 The secondary current associates with it a magnetic field which provides a magnetic stirring action on the molten metal (refer fig 3) speeds up the melting process and mixes up the metal charge uniformly.

6 The time taken by the charge to melt is short

7 Once melted the metal is deoxidized and poured into ladle either by tiling the furnace or by lifting away the furnace shell along with the coils (Fig 3)

Fig 3



High frequency current required for the operation of the furnace is produced by using

- Motor generator set (frequencies ranging from 500 to 10,000 cycles/second) in case of large capacity furnaces;
- Spark gap converters (frequencies ranging from 20,000 to 80,000 cycles/second) in case of smaller furnaces (with ratings from 3 to 40 KW)

It is also possible of melt metals in larger high frequency induction furnaces using 60 cycle electric current directly from the line (with a capacitor bank to balance power factor)

- 60 cycle current furnaces are efficient, melt metal at faster rate and prove to be economical if the furnace is not completely emptied during tapping, rather some liquid metal heel is left when new charge is placed in the furnace for the next heat.
- Since 60 cycle current involves violent stirring of molten, metal, the additional metal charge (even small scrap metal pieces) placed in the furnace (having some liquid metal) is melted rapidly.
- In the absence of (heel of) liquid metal left in the furnace from the previous heat, for a 60 cycle unit to work properly, the metal charge should consist of relatively large billets or ingot. A high frequency furnace, here claims advantage over the 60 cycle unit because it can easily and rapidly melt even small pieces of metal charge and does not require any liquid meta to be left from the previous heat.
- A high frequency induction furnace is preferred where different metals/alloys are required to be melted in small amounts.

Advantages

1 An induction furnace can melt relatively small quantities (from 1.5kg up to 12 tons) of a wide variety of metals and alloys quickly conveniently and cleanly.

2 Magnetic stirring of the melt produces excellent uniformity of the melt composition

3 A high frequency induction furnace has a simpler construction as compared to core type (low frequency) induction furnace because it eliminates the laminated iron core and the need for the channels of molten metal.

However, a coreless (i.e. high frequency) induction furnace possesses lower thermal efficiency (say up to 60%) as compared to core type furnace because of energy losses within motor generator set or spark gap converter.

4 Rate of energy input can be readily controlled

5 Furnace atmosphere can be easily controlled

6 High frequency induction furnaces do not need a warming up

7 A number of alloys one after the other can be easily melted in this type of furnace

8 Additions of elements like Ni, Co, Cr, W, Mo, V etc. can be made easily and conveniently

Disadvantages

1 The initial cost of the furnace and its auxiliary equipment being high, it is limited to melting high quality metals and in smaller quantities.

2 Due to the speed with which the process of melting is completed there is little time available for analyzing the melt composition.

3 Thus the melt charge should be carefully selected and it should be of required chemical composition.

Application

High frequency induction furnace is very useful for melting general, special, alloy and High quality steels in small quantities.

Core type (or low frequency) induction furnace

Introduction

1 A core type induction furnace operates as an ordinary trans former

2 The primary coil has many turns and is wound on a laminated steel core whereas the secondary of the transformer has one turn which is a channel or loop of liquid metal within the furnace.

3 The furnace uses an a.c supply of 60 cycles per second

4 Secondary currents (having high current values at low voltage) are induced in the metal bath around the core and the heat is generated due to the electrical resistance of the metal (Charge) to the flow of second ary currents

5 Channel of molten metal around the coil connect to the main metal container above, which holds the metal charge

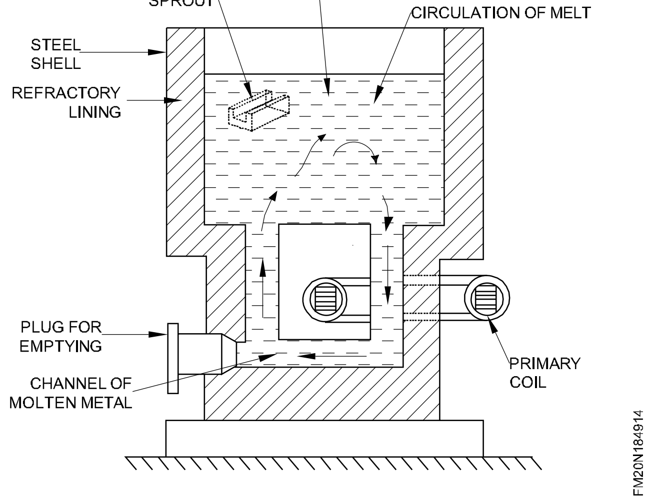
6 The metal in the channel gets heated, circulates through and sties the metal in the container and thus the melting process (of the metal charge) proceeds

7 Once the melt reaches the required pouring temperature it can be ladled out from the pouring spout (refer Fig 4)

Advantages

- A core type induction furnace is most efficient of the inductive melting furnaces.

Fig 4



- It has thermal efficiency of about 80%
- Melting is rapid and clean
- Since melting is rapid and no combustion products are present, losses are at a minimum
- Melt can be accurately controlled as regards its composition and temperature
- Magnetic stirring of the melt ensures uniformity of the metal
- The furnace operation is economical

Disadvantages

- Furnace cannot be operated on solid metal charge furnace operation can be started only after filling the channels with molten metal procured from some other furnace.
- If once by chance metal gets solidified in the channels, it cannot the remitted by the heat created in the secondary coil
- Core type furnace is more or less restricted to melt one alloy and continuously so that liquid metal heel can always be maintained in the channels
- For melting another alloy, the furnace should be emptied thoroughly cleaned and restarted with the new molten alloy.
- A core type furnace, thus is not suitable for intermittent operations.

Applications

1 A core type furnace is used primarily for remelting non-ferrous metals and their alloys and where relatively long periods of continuous operation are required.

2 Since a core type furnace can easily control the temperature of the metal, it is as well employed as a holding furnace for permanent mold and die casting

3 It can be used for producing malleable cast iron also

Specifications

1 Normally the capacities of core type induction furnaces range up to about 5tons

2 Low frequency furnaces in sizes ranging from 60 to 500 kW at frequencies below 1000 cycles per second with pouring capacities of 100 to 2500kg aluminum are available to melt 2.0 to 3.5kg per hour per kw rating of the furnace.

Description of dry sand mould. Brief description types, advantages & disadvantages of centrifugal casting and ceramic moulding process

Objectives: At the end of this lesson you shall be able to
- **state the function of dry sand mould.**

Dry sand mould

The mould which is prepared by using moist sand and the casting is done after the moisture is completely withdrawn (dried) is known as "Dry Sand Mould".

Advantages

1 There is very less chance to get defects due to moisture.

2 Casting gets better surface finish.

3 Mould is strong so handling is easy.

4 Metal erosion is very less.

5 The chilling effect is very less so machining is easy.

Disadvantages

It is requires extra time labour and materials for drying so more expensive.

Application

This mould can be used for all metals and its alloys. It can be used for all size and shape castings. All types of cores can be used.

Skin dry sand mould

The mould which is prepared by using dry sand mixture as facing sand and green sand mixture as backing sand and casting is done after the surface of the mould cavity is dried. Such mould is known as "Skin Dry Sand Mould".

Application

This mould can be used for all metals and their alloys. It is generally used for small and medium size castings.

Odd side mould

Objectives: At the end of this lesson you shall be able to
- **state the function of odd side mould.**

In case where the solid or one piece pattern does not have flat surface to rest on the moulding board and where it cannot be conveniently made into to split pattern an odd side pattern prepared.

The odd side will reduce the moulding box space and mould can be made with a set of box.

A dummy flase box is prepared and half the pattern is embedded after filling in the sand. The sand is pressed hard all around the pattern by hand is rammed.

The real drag part is then placed over these and made odd side, and the half mould is the drag is formed in usual way. After the drag is separate it is rolled over the assembly, and put on a board.

The pattern is then removed from the odd side and placed in the drag cavity.

The odd side reduce the space time, materials.

Some of the odd side mould

The false box can be broken or can kept for prepare another mould.

For making number of casting a wooden box, plaster of paris mould can be prepared.

Centrifugal mould casting

Objectives: At the end of this lesson you shall be able to
- **state centrifugal casting**
- **types of centrifugal casting.**
- **state the advantages and disadvantages of centrifugal casting**

Centrifugal casting

Centrifugal casting is done by pouring molten metal into a rotating mould.

The centrifugal force acting on the mould helps in feeding and positioning the metal in the mould.

Mould rotation is continued till after the metal is solidified.

Centrifugal casting results in denser and cleaner metal as heavier metal is thrown to parts of the mould away from the centre of rotation and the lighter impurities like slag, oxides and inclusion are squeezed out to the centre.

The castings produced have a close grain structure, good detail, high density and superior mechanical properties.

There is also a considerable saving of material.

Type of centrifugal casting

Centrifugal casting can be divided into three categories namely true centrifugal casting, semi centrifugal casting and centrifuging.

True centrifugal casting

The true centrifugal method of casting is used to produce hollow castings with a round hole.

The characteristics feature of this process is that the hole is produced by the centrifugal force alone and no cores are used.

The mould is rotated about the axis of the hole with the axis held horizontal, inclined or vertical.

The outside surface of the job may be round, square, hexagonal etc. and should be symmetrical with the hole axis.

The central hole should be round to be formed without cores.

Long castings like cast iron soil pipes are cast with the moulds rotated about a horizontal axis.

Castings with relatively short lengths are poured with moulds rotated about an inclined or vertical axis.

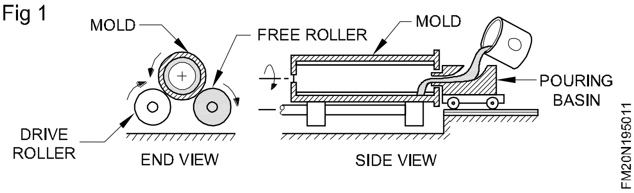
Rotation about the vertical or inclined axis is convenient but the central hole produced will be slightly paraboloid with smaller diameter at the bottom because the metal has a tendency to settle down due to gravity.

Fig 1 gives a schematic diagram for a true centrifugal casting process.

The speed of rotation for true centrifugal casting should be high enough to hold the metal on to the mould wall till it solidifies.

A low speed of rotation would result in raining or slipping of the metal inside the mould.

Fig 1



Too large a speed of rotation on the other hand may result in internal stresses and possible hot tears.

A speed which would provide a centrifugal force of 60 to 75 times the force of gravity on horizontal moulds and 100 times force of gravity for vertical moulds is found to be suitable.

The moulds used for the process may be metal moulds or refractory or sand lined moulds.

Common products produced by true centrifugal casting include pipes, oil engine cylinders, piston ring stock, gear blank stock, bearing bushes and the like.

Semi - centrifugal casting

In semi centrifugal casting process no attempt is made to produce a hole without a core.

The centrifugal force resulting from rotation of the mould is used to properly feed the casting to produce a close grained clean casting.

The process is suitable for large axis -symmetrical castings like gear blanks, fly wheel and track wheels.

Any hole round or otherwise is made with the use of a core. The mould is clamped to turn table with casting axis along the axis of rotation.

The metal is poured along or near the axis to feed the points farthest from the axis rotation under pressure. If made solid the central portion tends to be porous and with inclusion which and removed in subsequent machining.

Fig 2 shows a typical semi-centrifugal casting setup for the production track wheels.

Centrifuge casting

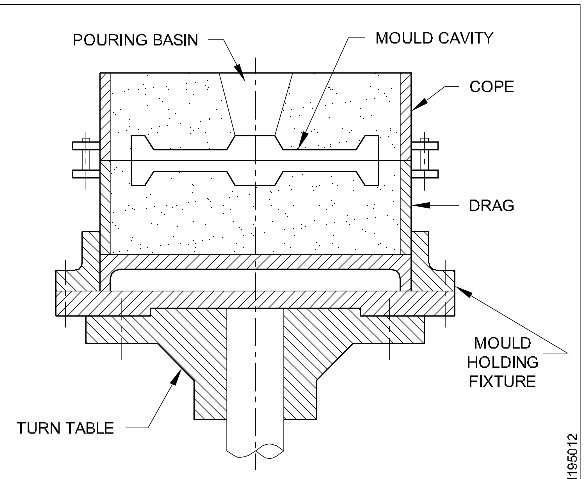
Centrifuging or centrifuge casting is employed to force metal under pressure into moulds of small castings or castings not symmetrical about any axis of rotation.

The moulds are made around a central axis of rotation, to balance each other.

The metal is poured along this axis of rotation through a central sprue and made of flow into mould cavities through radial ingates cut on the mould interface.

Centrifuging helps in proper feeding of castings resulting in clean, close grained castings.

Fig 2

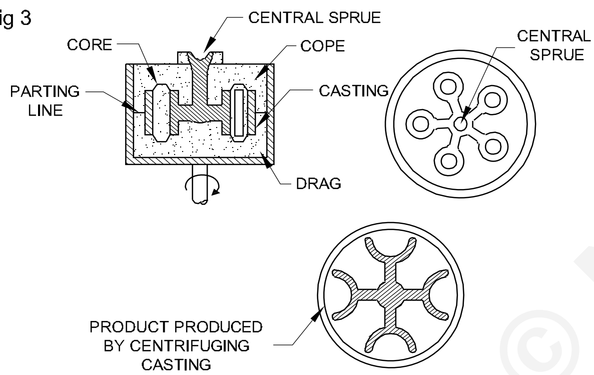


SEMI-CENTRIFUGAL MOULD READY FOR POURING

Stack moulds can be used to advantage in centrifuging of castings required in very large numbers.

A schematic diagram of a centrifuge casting set-up with stack moulds is given in Fig 3.

Fig 3



CENTRIFUGING CASTING SETUP

Advantages of Centrifugal Casting:

1 Relatively very light impurities move inwards the center. So, they can be removed easily thus helping in producing sound castings.

2 Gates and risers are not needed.

3 This technique is best suited for the mass production of symmetrical objects and castings yield is very hight in some cases it is even equal to 100%

4 Castings acquire hight density, hight mechanical strength, and fine-grained structure.

5 Inclusions and impurities are lighter.

6 These castings have a directional solidification starting from outside to inside.

Disadvantages of Centrigual Casting:

1 Skilled labors are to be employed for this process.

2 An inaccurate diameter of the inner surface of the casting.

3 Only some shapes can be generated by this casting process.

4 Not all alloys can be case in this way.

5 Centrigual castings require very high investments.

Applications of Centrifugal Casting:

1 Bush bearings.

2 Clutch plates.

3 Paper making rollers.

4 Piston rings.

5 Cylinder liners.

6 Pipes of water gas sewage.

Ceramic mould casting

Objectives: At the end of this lesson you shall be able to
- **state the ceramic mould casting**
- **list out the advantages of ceramic mould casting.**

Ceramic mould casting (Fig 4)

Ceramic mould casting method uses a ceramic slurry prepared by mixing fine grained refractory powders of Zircon ($Zr\,SiO_4$), alumina ($Al_2\,O_3$), fused silica (SiO_2) and a pointed liquid chemical binder (alcohol based silicon ester) for making the mould.

The patterns used are split gated metal patterns usually mounted on a match plate. Unlike the patterns in investment casting these patterns are reusable.

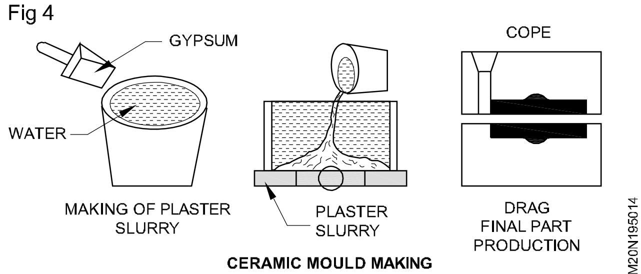
The slurry is applied over the patterns surfaces to form a thin coating around it. The slurry fills up all cavities and recesses by itself and no ramming or vibration of the mould is required.

The pattern is withdrawn after it sets in about 3 to 5 minutes.

The mould is removed from the flasks, treated with a hardener to promote chemical stabilization and transferred to an oven for heating to about 100°C.

The mould is ready to take molten metal

Fig 4



CERAMIC MOULD MAKING

The advantage of the process include

1 High precision and very good surface finish.

2 The process does not required any rise ring, venting or chilling because the rate of cooling is very slow.

3 Any patterns made of wood, metal or plastic can be used.

4 The process can be used for all types of metals including highly reactive titanium or uranium.

The method can be used for producing precision parts like dies for drawing, extrusion, casting, forging etc., pump impellers, components of nuclear reactors and air craft. The main short comings of the process are its high cost and the difficulty in controlling dimensional tolerances across the parting line.

Advantage of Ceramic Mold Casting:

- High temperature pours possible therefore suitable for steels and other alloys
- Creative complex designs can be made.
- Can be used for mass production.
- Little machining is required therefore difficult-to machine alloys can be cast.
- Supports both iudustry and home foundry operations.
- Complicate and innovative designs can be casted.

Applications of Ceramic Mold Casting:

Using stainless steel and bronze, ceramic mold casting is best suited for casting a wide variety of products ranging from house hold goods to industrial tools. Some of casted products are kitchen wares like kettles, industrial products products like impellers, complex cutting tools, plastic mold tooling etc.

Slush casting process

Objective: At the end of this lesson you shall be able to
- **state the slush casting process.**

Slush casting

Slush cashing is a special type of permanent mould casting process used for producing hold castings for toys and novelties.

In this process a metal mould is filled with molten metal and allowed to cool for some time.

After a thin skin of the metal is formed along the mould walls, the mould it turned upside down. The metal which is still in liquid state pours out leaving a hollow casting in the mould.

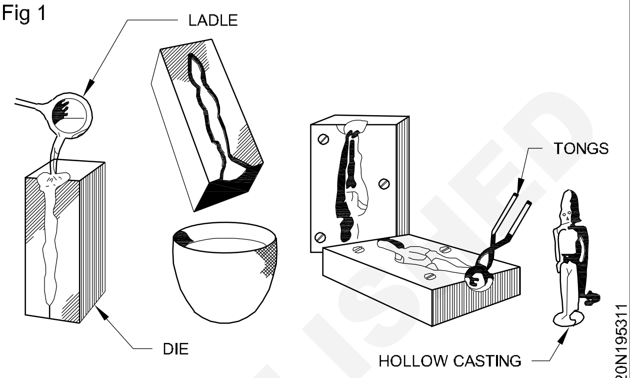
The thickness of the shell depends upon the chilling efficiency of the mould and the time allowed for solidification before the mould is turned over.

The method is used for making toys, statutes and ornamental objects from lead, tin and zinc alloys.

The castings are often given decorative coating to improve their appearance.

Slush casting normally takes longer than die casting but for small quantity production the method is cheaper because of relatively lower die costs.

Fig 1



SLUSH CASTING

Continuous casting process

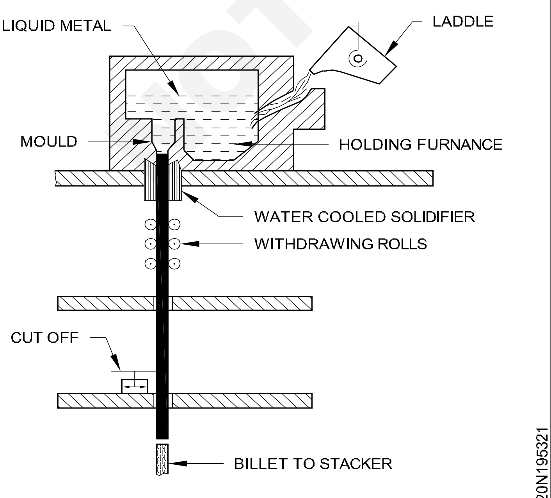
Objectives: At the end of this lesson you shall be able to
- **state the continuous casting process**
- **application of continuous casting process.**

Continuous casting

This process essentially consists of pouring molten metal into the upper opening of a vertical mould open at both ends, cooling it rapidly with water and removing the solidified product continuously from the other end.

This process is shown schematically in (Fig 1) which shows the Asarco process for continuous casting of copper and bronze.

Fig 1



ASARCO PROCESS OF CONTINUOUS CASTING

As shown in the figure the molten metal to be used for casting is stored in a holding furnace from which it is fed continuously to the mould.

The pouring die and cooling water jacket are made integral with the holding furnace.

The molten metal is fed to the mould from near the bottom of the furnace so that the impurities and slag are left out. As the metal flows into the mould it is rapidly cooled by the water circulating in the cooling water jacket surrounding the mould.

The solidified casting is pulled out at a controlled speed by withdrawing rolls shown.

A cut of station may be provided to cut the metal into required lengths by sawing or flame cutting.

Metals like iron and steel may not solidify completely while in the mould. They are sprayed with water even after they leave the mould till they are solidified completely.

The moulds may be vibrated or reciprocated in some cases to prevent sticking of the casting.

They may also be curved to bring the casting to horizontal position.

In same set ups the cast product is continuously passed through a series of roll stands to give it a desired size before being collected at the other end.

Continuous casting moulds are made of copper and graphite and are cheap.

The product has uniform properties throughout its length and waste is eliminated.

The surface finish and properties of casting are comparable to those of permanent mould castings.

Application of continuous die casting process

The process can be used for copper, brass, bronze, aluminium and to a limited extent for iron and steel.

Many common shapes like round, square, rectangular, hexagonal can be produced. The main limitations of the process is its high initial cost.

Permanent mould casting process

Objective: At the end of this lesson you shall be able to
- **state the permanent mould casting process.**

Permanent mould casting

1 Permanent mould casting also sometimes called gravity die casting employs moulds which can be used more than once and hence are permanent.

2 These moulds are usually made in more than one piece to facilitate removal of the finished casting or die.

3 The mould is assembled; and held together by clamps, screws or toggles during pouring.

4 In the assembled position the parts of the mould make a complete mould with sprues, runners, gates, vents and blind risers.

5 Vent channels may be provided for escape of entrapped air if it is found that the air within the mould cavity cannot escape properly during pouring through the space between parting surfaces.

The moulds are preheated at the start of the run to avoid thermal shock to the moulds.

A refractory parting coat is given to the mould once in each cycle by spraying or brushing.

French chalk or calcium carbonate suspended in sodium silicate binder is the commonly used refractory coat for aluminium and magnesium castings.

It protects the mould and promotes casting ejection from the die (or) metal mould.

During operation the mould temperature should be controlled to remain within a close range depending on the metal poured to produce good castings.

Permanent moulds are usually made of close grained alloy cast iron which is resistant to heat and repeated changes in temperature.

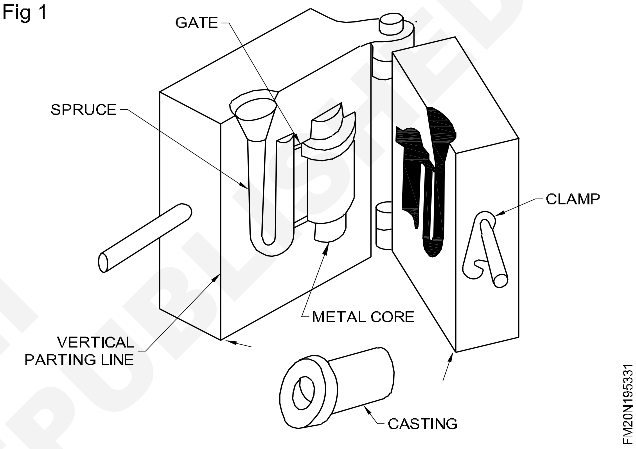
Bronze moulds may be used for casting lead, tin and zinc and wrought alloy steel moulds for some bronzes.

Cores are usually made of alloy steel.

Sometimes sand or plaster cores may be used in which case the process is called semi-permanent mould casting.

Sand and plaster cores are cheaper but the structure, surface finish and dimensional accuracy of cored openings are only as good as that of sand or plaster casting.

Fig 1



Metals commonly cast by the permanent mould casting process include lead, tin, zinc, aluminum, magnesium alloys, certain bronzes and cast iron.

Some typical products include refrigerator compressor cylinder block heads, connecting rods, gear blanks, automobile pistons, kitchen ware and type writer parts.

Weight of castings produced may very from a few grams to 150 kg but generally range below 25 kg.

The life of the moulds varies from 3000 to 10000 castings for cast iron to as many as 10000 castings with softer materials.

Advantages of permanent mould casting process

The advantages of permanent mould casting process over sand casting include production of a fine grained structure, smoother surfaces, closer dimensional tolerances, lower floor space requirement and an economical production for large quantities.

The fine grain structure produced results from the chilling action of the metal moulds and imparts better mechanical properties to the casting.

The surface finish obtained in permanent mould castings ranges from 2.5 to 3 microns RMS and dimensional accuracy produced is of the order 0.25 to 1.25 mm / mm across a parting line.

Small cored holes upto 6 mm diameter can be produced with metal cores.

1 Production rate of the order of 15 to 30 castings per hour per mould can be attained.

2 The limitations of the process are higher mould cast, restriction of size and shape of the castings and the lack of flexibility in making any changes in the gating and risering systems.

Nishiyama process

Objective: At the end of this lesson you shall be able to
- **state the nishiyama process.**

A modification of the sodium silicate CO_2 process has been to incorporate additives in the sodium - silicate, silica sand mix with would cause self hardening in the rammed moulds and cores.

That is gassing of moulds and cores will be unnecessary.

Ferro silicon process

The Additive employed is very fine ferro silicon and hardening appears to occur by an exothermic reaction causing gelatin of the sodium silicate.

There production of iron and steel casting.

Silica sand containing 6.5% of Sodium Silicate, 2% of ferrosilicon (75/25 - BS - 300 mesh) and 3.0% if sodium silicate, 0.5% of water, 1% if ferrosilicon is used.

Higher strength, when the amount of additives is increased.

Strength - standing time relationship for FESI and CASI

However, event at 1% ferrosilicon addition, the mould material is more expensive than CO_2 process assuming a gas consumption of 3% of wt of the total sand.

The bench life of the mix is poor. If ferro silicon bonded sand appears to give some what superior collapsibility to carbon dioxide hardened core. Some the sand will harden and become powderly in the mixer. It is important that the moulds are allowed to stand in air to dehydrate, the standing time may be of the order or 24 hr.

Bonded sands

Standing time	Compressive strength lb/in²)				
	Fe-Si%			Ca-Si%	
	0.5	1.0	1.5	0.5	1.0
0	-	-	-	2.0	-
1/2	-	-	90	16.5	-
1	12	85	195	48	35
11/2	17	152	250	54	-
2	-	-	275	72	51
21/2	-	-	-	-	-
3	-	-	-	93	90
31/2	145		-	-	-
4	-	345	-	120	90
5	210	-	-	-	91
6	-	-	-	279	-

Freshly cast moulds cause dangers bubbling of moulds the cores produced by the process become friable if the bubbles produced by the teepol solution are excessively core. The size of the bubbles can be controlled by adding a trace amount of coconut diethanolamide a lather booster.

Common casting defects

Objective: At the end of this lesson you shall be able to
- **state the casting defect.**

Casting defects

Casting defects are usually not accidents, they occur because some step in the manufacturing cycle does not get properly controlled and some where goes wrong.

Logical classification of casting defects presents great difficulties because of the wide range of contributing causes. However a rough classification may be made by grouping the defects under certain broad of origin such as:

a Defects caused by patterns and moulding box equipments.

b Defects due to improper moulding and core - making materials

c Defects due to improper a sand mixing and distribution.

d Defects caused by moulding; core and gating providing.

e Defects due to improper mould drying and core baking

f Defects occurring while closing and pouring the moulds.

g Defects caused by mouton metal

h Defects occurring during fettling etc.

i Defects due to faulty heat - treatment.

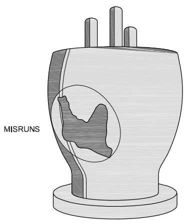
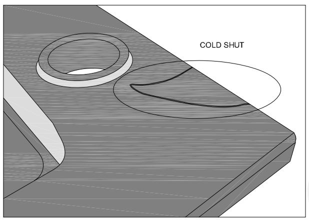
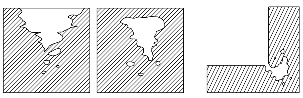
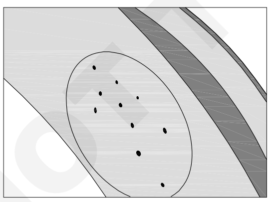
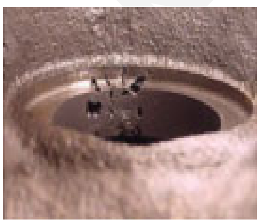
j Defects due to cast metal.

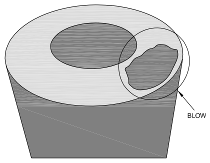
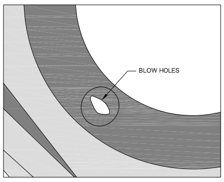
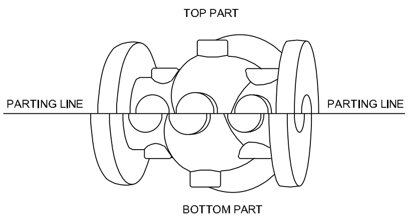
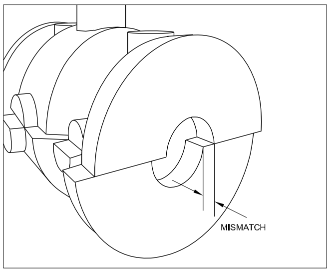
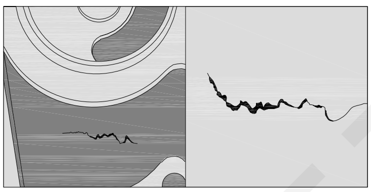
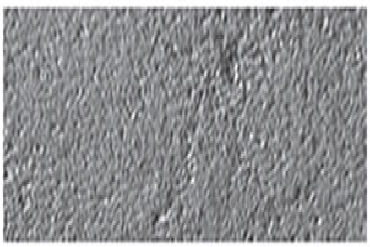
k Warpage

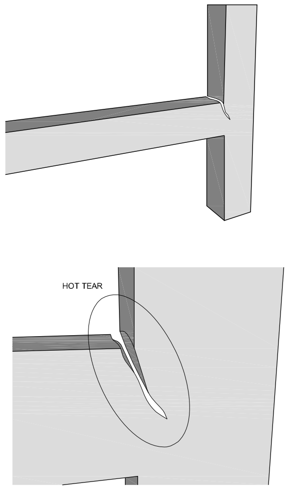
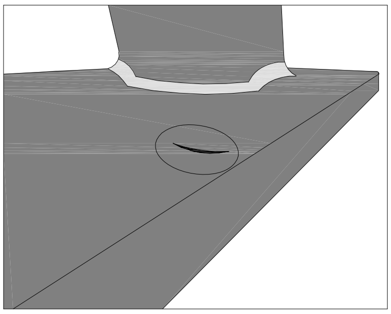
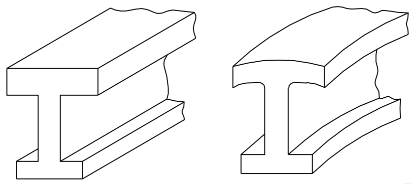
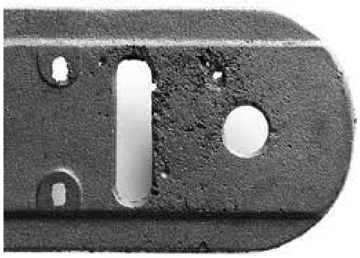
Classification of Casting Defects

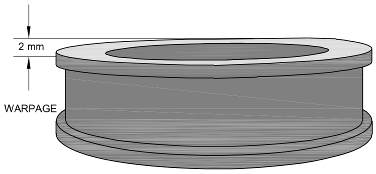
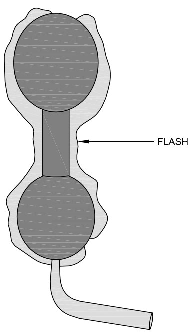
some of the common defects are described below:

1 Misrun
2 Cold shuts
3 Shrinkage
4 Porosity
5 Blow holes
6 Mismatch
7 Cracks
8 Rough surfaces
9 Hot tear
10 Scabs
11 Distortion
12 Slag
13 Sand inclusion
14 Warpage
15 Fins or Flash

Defects	Appearance	Cause	Remedies
Misruns 	Cavity due to incomplete filling, mainly found in thin section of casting	1 Low pouring temperature 2 Low fluidity 3 Inadequate vending 4 Faulty pouring practice	1 Provide hotter metal at furnace spout; 2 Reduce heat losses in ladles by using flux coverings.
Cold shuts 	White dividing zone where streams of melt fails to merge in molten condition	1 Low pouring temperature 2 Lack of fluidity if alloy. 3 Too much Gas forming material in the facing sand.	1 Modify system of moulding. 2 Ensure correct pouring temperature for the alloy.
Shrinkage 	Rough cavities at heavy sections, or at joints at which there is change of sections	1 Incorrect gating and feeding	1 Use separate risers to feed heavy sections. 2 Ensure that they are filled with hot metal.
Porosity  	Cavities appear in Machined surfaces	1 Wrong composition of metal. 2 Improper running and feeding. 3 Use of impermeable mould.	1 Reduce sulphur and phosphorus content of the charge. 2 Improve venting of mould.

Blow holes  	Outer surfaces of the thicker sections of the cast shows rough shaped holes	1 High moisture content of the mould sand. 2 Low permeability of the mould sand. 3 Insufficient venting. 4 Hard ramming.	1 Reduce moisture content. 2 Improve permeability using proper venting. 3 Avoid excess ramming.
Mismatch  	Two or more sections of the cast product fail alignment.	1 Improper positioning of cope and drag patterns. 2 Worn or loose dowels in patterns. 3 Worn out, loose, bent or ill fitting moulding box clamp.	1 Take more care in placing cope on the drag. 2 Use appropriate pattern dowel pins. 3 Tight fit the box pins
Cracks 	Hairline cracks on casting are found when broken discoloration shows that crack was produced while casting was hot. No discoloration shows cold crack.	1 High dry strength of sand. 2 Cores too hard. 3 Casting strains. 4 Mechanical reasons.	1 Ram softer to allow casting to contract. 2 Reduce oil in cores.
Rough surfaces 	Casting surface rough.	1 Too open moulding sand. 2 Low coal dust content. 3 Uneven ramming. 4 Metal penetration.	1 Use finer sand or increase mould dressing. 2 Add addition of coal dust. 3 Ram sand more evenly,

Hot tear 	Ragged irregular internal and external cracks appear immediately after the metal have solidified.	1 Poor casting design. 2 Abrupt change in section at different parts.	1 Place proper gates and risers. 2 Ensure correct pouring temperature.
Scabs 	Rough incrustation of sand & metal on surface of castings mainly on heavy section.	1 Uneven ramming. 2 Incorrect gating. 3 Improperly dried moulds. 4 High clay content in moulding sand.	1 Ram more evenly. 2 Select the proper gate for even flow metal. 3 Avoid too rapid drying.
Distortion  REQUIRED SHAPE OF CASTING DISTORTED CASTING	Casting shows swelling on surface.	1 Uneven ramming due to insufficient ramming to withstand metal pressure. 2 Poor weighting practice.	1 Ram evenly and firmly. 2 Increase weight on moulds and ensure it is distributed evenly.
Slag 	Similar to appearance for shrinkage and draws defect. Cavities are generally more saucer shaped and smoother.	1 Dirty metal. 2 Incorrect gating.	1 Remove all slag from metal before pouring. 2 Incorporate skim gates or strainer cores in runner systems.
Sand inclusion 	It is the holes created on the external surface or inside the casting.	1 Loose ramming of the sand. 2 Rapid pouring of the molten metal into the mold results in wash away of sand from the mold and a hole is created. 3 Improper cleaning of the mold cavity.	1 Proper ramming of the sand. 2 Molten metal should be poured carefully in the mold. 3 Proper cleaning of the molten cavity eliminates sand holes.

Warpage  	The changes dimension of final product.	1 Due to different rates of solidification of different sections. This induces stresses in adjoining walls and result in warpage. 2 Large and flat sections or intersecting section such as ribs are more prone to these casting defects.	1 It can be prevented by producing large areas with wavy, corrugated construction, or dd sufficient rib- like shape, to provide equal cooling rates in all areas. 2 Proper casting designs can reduce these defects more efficiently.
Fins or Flash  	A thin projection of metal in casting.	1 Incorrect assembling of mold and cores. 2 Insufficient weight of the mold or improper clamping of the flask may produce the fins.	1 Correct assembly of the mold and cores. 2 There should be sufficient weight on the top part of the mold so that the two parts fit together tightly.

Solvaging of Casting

Objectives : At the end of this lesson you shall be able to
- **State the solvaging of casting**
- **Explain about the various salvaging techniques.**

- Salvaging means to save waste (or defective) material (say casting) for utilisation.

- All castings cannot be produced defect free at all times. Therefore at some stage or the other in a foundry, the question arises as whether to scrap a casting or to make it serviceable by repair.

- In the mass production of light castings, defective castings can be scrapped and replaced because the cost of doing so is less than the cost and inconvenience of salvaging the defective castings.

- In a jobbing foundry producing few large complex castings, the cost of replacement of a defective casting may be very high and thus there is a strong incentive to make the casting serviceable by repair.

- Salvage and rectification of castings is undertaken for following reasons

1 To restore properties and service performance of the defective casting to a standard equivalent to that if no defect were present.

2 To improve casting appearance in cases where performance is in any case unimpaired.

- Repairs of castings are widely accepted as a matter for consultation between manufacturer and user, provision for this being recognised in many specifications and conditions of sale.

FACTORS AFFECTING SALVAGE OF CASTINGS

i Composition of casting alloy.

ii Size and shape of casting.

iii Relative cost of new casting versus repairing the defective casting.

iv Difficulty of salvaging the defective casting.

v Availability of repair equipments and methods.

vi Quality requirements.

vii Performance level of salvaged castings.

viii Any agreement between manufacturer and user for salvaging the defective casting.

SALVAGING TECHNIQUES

Various salvaging techniques employed for repairing defective castings are:

a Welding (the most common technique).

b Brazing, braze welding and soldering.

c Burning on.

d Patches and plugs.

e Caulking and impregnation.

a Welding

- Steel castings are almost universally repaired by welding.

- With the availability of modern welding techniques and equipment in recent years, welding reparir has been extended more and more to iron and high alloy castings.

- Welding is superior over other methods of salvage because it achieves a true metallurgical union between the casting and the filler metal.

- A casting repaired by welding and suitably post-heat-treated possesses properties fully equivalent to those of a new casting.

- Filler metal plays a major role in matching characteristics of weld with parent casting as regards corrosion resistance, chemical composition, mechanical properties and appearance.

- Welding processes commonly employed for repairing defective castings are

1 Flux shielded metal arc welding (using stick eletrodes).

2 TIG welding.

3 MIG welding.

4 Gas welding.

Procedure

i Before carrying out welding repairs,

- the defective areas in the casting are prepared by chipping, grinding, gouging, etc. in case of ferrous alloys.

- Non-ferrous alloy castings require defect removal by mechanical means such as filling or grinding. Cracks should be completely removed before welding.

ii Using welding processes named above, castings are welded to repair the defects.

Flux shielded metal arc welding makes use of flux covered stick electrodes. By using an a.c. or d.c. power source, an electric arc is struck between the electrode metal. Welding electrode should preferably be of almost same composition as that of the casting.

In Tungsten-inert-gas (i.e., TIG) welding, an electric is struck between a tungsten/alloy tungsten electrode and the defective casting. Argon, helium or any other gas inert to the cast alloy can be used for shielding the arc and the molten metal pool formed during repairing the defects. A separate filler metal of the same composition as that of the casting is employed to fill and repair the casting defects.

In Metal-inert-gas (MIG) welding, an electric arc is struck between a continuous electrode (rolled on the spool and of the same composition as that of the metal/alloy of the cast part) and the defective casting.

This process is similar to flux shielded metal arc welding except that it

- Uses a continuous electrode rather than a stick electrode which needs to be replaced every time an electrode consumes; theresore MIG welding is a faster process.

- Uses an inert gas rather than flux. MIG welding electrode does not have a flux coating on it.

Gas welding makes use of oxygen and acetylene gases to produce flame at the tip of gas welding torch, which is used as the heat source to repair the defective castings.

Like TIG welding, a separate filler rod of almost same chemical composition as that of the casting is employed to rectify the casting defects.

Gas welding is extensively applied to repair defects in non-ferrous metal castings; the softer and more diffuse heat source is especially suitable for alloys of relatively low melting point.

b Brazing, Braze Welding and Soldering

- Brazing and Braze welding join metals by applying heat to a non-ferrous filler metal which melts above 800° F but below the melting point of the metal of the casting.

- Brazing and Braze welding differ as regards.

  i Joint design.

  ii Joint preparation.

  iii Method of filler metal distribution.

- Brazing and Braze welding offer some advantages in repairing the castings, which are:

  1 Elimination of warping in castings.

  2 Reduced effects of expansion, contraction and distortion.

  3 Little chances of developing stresses.

  4 Reduced expenses.

  5 Highly suitable for joining dissimilar metals, repairing gray iron casting etc.

Soldering

- Soldering is similar to brazing in the sense that non-ferrous filler metal is used for joining two metals. It, however, differs from brazing because the filler metal i.e., solder melts below 800°F. In both soldering and brazing, casting metal is not melted.

- Soldered joints are weaker than those produced by either brazing or braze welding.

The key to successful brazing and soldering is the achievement of perfect contact between filler metal and casting through wetting of the casting surface.

c Burning On

It is essentially a welding process but is carried out in the foundry by a molder. A cavity is prepared in the casting kat the place of defect.

- Defective casting is embedded in the sand and a sand mold is built up to surround the prepared cavity in the casting and it provides a reservoir of liquid.

- Super heated molten metal of desired composition is brought from an external source and is run through the mold. As soon as the surface of casting is heated to a high temperature, the outlet is plugged and hot metal pouring is continued until the mold is full to the riser level (Fig 37.1).

- Large castings can be successfully salvaged by this technique.

d Patches and Plugs

- The defective zone in the casting is drilled out; a patch or plug either cast or machined out of bar stock is threaded and inserted into the drilled hole in the casting. The insert is finished by peening over or tack welding.

e Caulking and Impregnation

- Under (hydraulic) pressure testing, if a ductile casting shows local leakage, it can be salvaged by caulking.

- Caulking involves hand or pneumatic hammering in order to close the leak by plastic deformation.

- Caulking is restricted to the repair of minor leaks in low pressure equipment only.

- Impregnation is use to seal more widespread porosity.

- Castings are treated with a sealing compound into the pores in the casting is assisted by pressure alone or by a combination of pressure and vaccum treatment.

- The sealing compound is finally cured, normally by thermal treatment.

- Synthetic resins, sodium silicate, linseed oil etc., are commonly used impregnants.

- Sodium silicate treatment consists in immersing the casting in a sodium silicate at 150 to 200° F for 2 to 4 hours. Castings are washed and air dried or baked at 215 to 300°F. Sodium silicate can be more effectively applied with pressure.

- High strength non-metallic materials such as epoxy and acrylic resins. araldite and M-seal[1], capable of adhering strongly to metals, are used to fill up the defects such as blowholes in castings. Though repairs of appreciable strength can be made with the help of these non-metallic filling compounds, yet they are not considered much suitable for most structural repairs because they possess properties very much different from the cast metals.

Fettling

Objectives: At the end of this lesson you shall be able to
- **state shake out (or) knock out of solidified casting**
- **state removal of fins & flashes from solidified casting**
- **state removal of gates and risers**
- **state surface cleaning**
- **state finishing of casting.**

Fettling and finishing of casting

Fettling includes following steps

i Shake out (or) knock out

ii Removal of moulding sand and cores from the casting.

iii Removal of adhering sand and oxide scale from the casting surface (surface cleaning).

iv Removal of gates, risers, runners, etc. from the casting.

v Removal of fins and other unwanted projections from the castings.

vi Finishing of casting.

i Shake out / Knock out

When the casting has solidified, its removed from the moulding flask and in this operation are called as shake out/knock out. Shake out functions include separation of mould and sand from flask casting from sand core from castings.

1 The casting can then be pulled out the sand with a hook bar. This is manually carried shake out. Break the sand around the casting with heap of crow bar (or) Pneumatic rammer.

2 The casting can be separated from band by power operated (mechanical vibrating table) shake out also.

3 In modern developments, so many equipments are developed to separate casting from sand moulds is making significant contributions to better productivity in sand foundries modern equipments.

4 Punch out machines.

5 Shake out tables and decks.

6 Vibrating shake out conveyors.

ii Removal of sand from the castings

It may be difficult to remove dry sand and hardened cores in the absence of suitable equipment.

Hammering (or) vibrations imparted to cores does loosen and break them up.

Sand projections sticking inside the castings are removed by pocking action using a metal roof.

Cores from larger castings may be removed effectively by pneumatic rapping and hydro blasting.

iii Cleaning of casting surfaces

The outside and inside surfaces of castings are cleaned of adhering refractory sand and oxide scale and they look smooth and pleasing.

Sand may be removed from the surfaces of castings using hand methods (or) mechanical equipments.

Hand methods

1 Wire brush

2 File

3 Pick

4 Crow bar

Hand methods are slow tedious and costly especially when the number of castings to be cleaned is large.

A wire brush consists of hardened steel wire embedded into a block of wood.

Its primarily used non-ferrous production where the normal clean strip is sufficient and full cleaning operation may be avoided.

Mechanical equipment methods

1 Thumbling.

2 Air blasting - Sand blasting
- Shot blasting

3 Wheelabrator system.

4 Hydro blasting.

5 Chemical cleaning

Thumbling

Its used for removing adhering sand from the casting. Its employs a rotating iron drum, cylindrical in section. The barrel is filled with castings. Star shaped iron pieces, small pieces of gates and runners granite chips, pieces of graphite electrode, etc.

The barrel ends are closed and the barrel is rotated at about 30 r.p.m.

As the barrel rotates, castings thumble over each other rub, off the adhering sand and the surfaces of the casting are burnished.

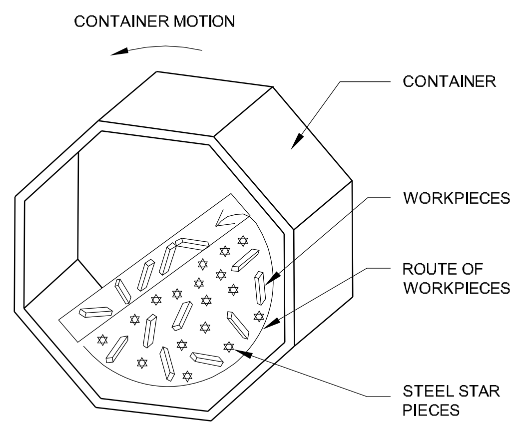


Fig 1 THUMBLING PROCESS

Air blasting

Sand blasting

Air blasting process makes use of a high pressure steam of air, carries sand sand strike against the surface of casting the process is known as sand blasting.

On the other hand if the steam of air performs the same operations but carries shots of metal, the process is identified as air shot blasting.

In sand blasting the sand particles are introduced into the air stream by means of suction caused by compressed air jet gravity feed dirty pressures on the abrasive.

Sand particles feed into the high velocity air jet are responsible for the abrasive action on the casting surfaces which in turn get cleaned.

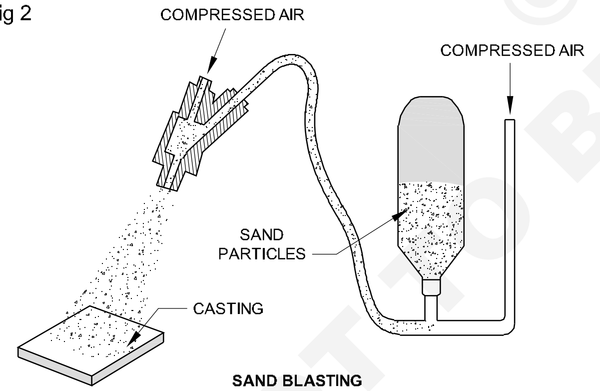


Fig 2 SAND BLASTING

Shot blasting:

Shot blasting provides a higher rate of output than tumbling process when sand burns on and heat-treatment scale has to be removed from the casting surfaces. Abrasives are flung at the castings by means of compressed air.

Abrasives include;

Cut wire pellets

Steel shot

White cast iron shot

Malleable iron grit

White cast iron gift

Chilled iron grit

Slag, alumina and silicon carbide.

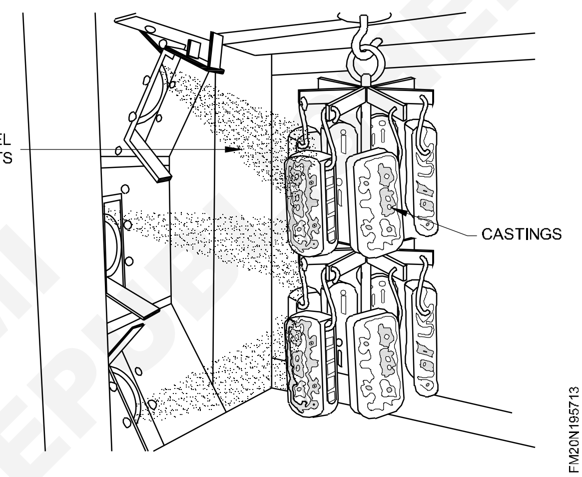
(Grit is made by crushing shot. It has irregular sharp edges which act as thousands of tiny chisels and produce more of a scrubbing action than shots).

Size of shot grill may range upto 3 mm. and over in maximum dimension.

Small size shots are used for cleaning very light casting. Intermediate sizes for gray - iron and malleable iron castings and a coarse shot for steel castings.

The air pressure .7 kg/cm^2 and the abrasive particles leaving the nozzle possess a velocity ranging from 2150 to 4600 m/ min.

Fig 3



Wheel abrator system

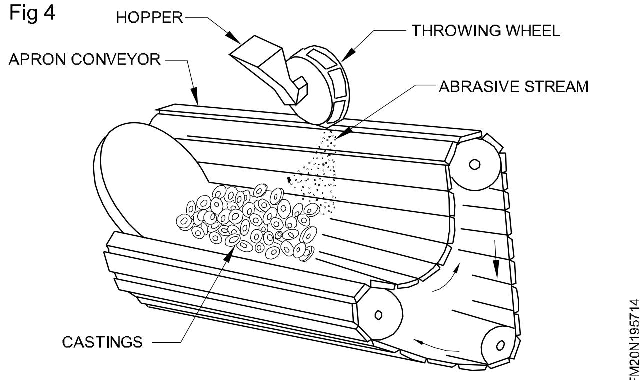
Its a resembles air shot blasting with the only difference that instead of air, the abrasives are mechanically blasted with high speed centrifugal impellers.

Abrasives through of hopper are fed into the throwing wheel at its centre.

A typical throwing wheel is 40 cm. In 9 meter had eight blades for impelling action and was removing 2350 r.p.m.

Shot velocities of the order of 81 meter per second can be attained in commercial equipments.

Fig 4



Hydro blasting

Sand blasting had the disadvantages of creating dry silica dust problems and thus an increased danger to the operator.

Instead of an air jet, water stream carrier sand and thus silica dust is suppressed. Its an applicable for larger castings.

Water is supplied to the gun at a pressure of about 140 kg./cm^2 and the stream velocities upto 6500 m/mins.

Chemical cleaning

Chemical cleaning methods utilise baths of moulten caustic soda containing other additional reagents to react with and break the surface oxide layer. This loosens adhering sand also.

The electrolytic method involves the application of electric current; oxide (layer) is reduced by nascent sodium liberated at the casting (casting is cathode in the circuit)

Pickling maker use of dilute acids for removing sand from the surfaces and inaccessible pockets of the castings.

Hydrofluoric acid attacks sand on the casting where as sulphuric acid attacks casting metal and thus loosens the sand sticking to the castings.

Pickling involves immersing the casting in acid(kept in acid proof tank) for quite long time. Then the casting is taken out and the acid on it is neutralised by dipping the casting in lime water. The casting is finally rinsed in water.

Brass casting are pickled in Nitric acid.

Ferrous casting are pickled in Hydrofluoric acid.

(48% Hydrofluoric acid 1 part and 25 parts of water)

iv Removal of gates and risers

Numerous methods are available for removing feeding and gating systems. The choice of a particular method depends upon.

- The type of metal.
- Size of the casting.
- Size of runners, gates and risers.

A few commonly used methods are given below:

1 Chipping by hammers.

2 Flogging

3 Shearing

4 Sawing
- Bend saw
- Hack saw
- Circular saw etc.

5 Abrasive wheel slitting

6 Machining

7 Flame cutting

8 Plasma cutting

I Chipping by hammers

The material of chisel, sharpness of cutting bit, geometry of the chisel tip and its inclination to the casting influence cutting efficiency of the chisel.

II Flogging

Flogging implies removing gates and risers from a casting by impact by striking with a hammer or sledge hammer in very suitable for brittle materials.

III Shearing

Shearing of feeding and gating system carried out on a shear or shearing machine. It has a heavy frame and steel blades working past one another by a fly wheel and cam assembly. A shearing machine may have a punch-die-system also.

Shearing machines can take up only small regular jobs. The operations is fast and economical.

Brass and bronze, aluminum, magnesium soft, medium hard steel, malleable iron also can do

IV Sawing

Many kinds of saws are used removing runners, gates and risers from the castings.

V Abrasive wheel slitting

Wheels commonly employed for the purpose are from 3 mm. thickness to 500 mm diameter. Wheel peripheral speed range from 48 to 81 m/s.

The wheel is mounted in a fixed position and the casting is pushed along the work rest by hand, alternatively the casting may be clamped on the table and wheel brought into contact (with the casting).

VI Machining

Machining method is very suitable for removing large feeder heads and those where a continuous cut can taken.

VII Flame cutting

Feeder heads larger in size and or irregular shapes. On steel castings are very conveniently removed by oxyacetylene cutting torches.

The torches can be easily manipulated at different angles and positions in order to remove feeder heads completely.

Flame cutting which was once used for those metals (such as steel, gray cast iron, malleable iron and ductile cast iron).

Which could be oxidised by flame can be now employed to cut even stainless steel.

Stainless steel is cut by using principles of powder cutting in which stream of iron powder dispensed through the torch into the flame.

Removal of fins and other unwanted projections from castings

Castings are trimmed to remove fine, chaplets, wires, parting line flash, pads, and the stumps of feeder heads and ingates. All these unwanted projections are dressed flush with the surface.

To remove unwanted projections from the castings are followed process by

1 Chipping

2 Sawing

3 Flame cutting

4 Flame gouging and flame scarfing

5 Grinding

6 Abrasive belt machine

7 Rotary tools

8 Trimming and sizing

a Finishing of casting

Finishing of casting is a later stage in cleaning of the castings. Once the embedded sand, gates, risers and other unwanted projections have been removed from the casting, finishing is resorted in order to.

Smooth the areas of the casting from where gates and risers have been removed.

Remove an excess metal if left on the casting.

Improve surface finish and appearance.

Different finishing operation carried out on castings are described below:

b Grinding

Both, grinding wheels and abrasive belts are available in different sizes, shapes, grits, grit size and binders.

Grinding machines are of stationary (or) portable type. Portable machines are preferred for finishing large castings.

c Rotary filing

Softer metals are finished by rotary files instead by grinding, a rotary file is actually a grinding wheel made up of hardened steel.

d Machining

As per their requirements, castings may be given a finish treatment on lathe, shaper, milling machine etc.

e Chemical treated

Both ferrous and non-ferrous castings may be given a chemical treatment to make their surfaces attractive. A molten salt bath of sodium hydroxide 95% sodium nitrates and nitrites 5% at 800^0F is used for cleaning gray iron castings.

f Polishing

Castings may be polished in order to obtain smooth surface finish. Polishing can be carried out an abrasive belt machine using a finer grit (80 to 400 mesh).

g Brushing

Brushing imparts a smooth surface finish to castings. Rotary wire or fibre brushes may be employed to remove burrs and grinding marks from the surfaces of a castings.

h Buffing

Buffing provides an exceptionally higher luster on cast surfaces. A buff is disk of muslin sewn together and mounted on the axle of a buffing machine, a buffing machines resembles a grinder with the difference that a buff exists in a place of the grinding wheel.

The face of the buff is rubbed with a fine abrasive mixed with a grease binder.

The castings is fed to the buff wheel in order to acquire fine finish.

Inspection of casting

Objectives: At the end of this lesson you shall be able to
- **state the necessity of inspection of casting**
- **state the method of inspection of casting followed in foundry.**

1 Necessity of Inspection of casting

Quality is one of the keys to survival in the foundry industry. To implement on effective quality assurance programme of manufacturing.

After solidification the casting have been cleaned they are inspected to check if they will perform specified functions during service (or) acceptability of the manufactured product.

Inspection serves the following purpose

In separates defective castings from non-defective once and thus ensure the adequate quality of the castings. Its not only to detect flaws in the castings but also to prevent the occurrence of defect in casting to be produced in future.

2 Method of Inspection followed in foundry

Its ensure them follows to types once in defective method, and non-defective method. Its aims at finding both surface on defects in the castings.

Inspection of castings broadly covers a large number of methods and techniques used to check the quality of castings. These methods may be classified into two group.

1 Dimensional inspection.

2 Destructive method

3 Non-destructive method

1 Dimensional inspection

Dimensional control is usually required for all types of castings. When the casting are found to be consistently within the tolerance, spot checks, together with a regular checking the patterns and dies being used may be sufficient.

Dimensional inspection of castings may be carried by various methods. By using measuring instruments like rule, vernier, calipers, gauge.

By using templates.

By using limit gauge.

By using special fixture.

2 Destructive method

In this type of test, the specimen is destroyed in the process of testing, that means the test specimen cannot be used any further. The result of the test becomes important information for the engineers.

3 Non Destructive method

In this type of test, the work piece becomes the test specimen, as a result, it is not destroyed in the process of testing, that means the test be used in specimen can practical field for which it has been made. Testing for crack, blow hole, porosity etc. is few examples of such type of test.

Destructive method

Destructive testes are now conducted in foundries to examine the castings.

1 Mechanical testing.

2 Chemical testing.

1 Mechanical testing

All foundries should have facilities for determining the mechanical properties, the mechanical properties, of cast metal and its chemical composition.

Mechanical testing methods include certain procedures which require a standard type of equipment. They are.

a Tensile test

b Impact test

c Hardness test

d Fatigue test

Tensile test

Tensile test to determine the tensile strength. Yield strength, percentage elongation.

Impact test

This test may be destructive or non-destructive in nature, depending on the quality of testing. Moreover, it cannot be used in all cases as it can damage the casting.

A hammer of appropriate size is used to strike (or) fall on certain members of the castings where the defect is suspected. It is expected that the casting containing harmful defects will break and will thus be automatically rejected. Where as those that are faultless will stand the test.

Other method involves dropping the casting from a specified height into the steel base. In this best not very reliable and some times even the defect free castings may break.

Hardness test

Which can indicate the strength and ductility of the metal.

Fatigue test

Applied in case where an appraisal of the life of the casting in service is to be known.

2 Chemical Testing

- Chemical composition is usually determined on separately cast samples or before casting by drawing a sample of molten metal from the ladle or holding furnace.

- To be truly representative, the sample of metal should be drawn at the same time when the molds are going to be poured because losses of volatile or other oxidizable elements may incur changes in chemical composition.

- The development and use of spectrograpic, and X-ray fluorescence techniques (which replace wet analysis) enable a comprehensive range of elements to be determined simultaneously and rapidly.

Non-Destructive Methods

Nondestructive testing, popularly referred to as NDT is the test methods to examine an object, material or system without destroying the object or impairing its future Usefulness. Non-destructive testing is often required to verify the quality of a product or a system

Commonly used techniques for Non Destructive Testing are

i Visual Testing (or Visual Inspection)

ii Pressure and Leak Testing

iii Dye Penetrant Testing

iv Magnetic Particle Testing

v Eddy Current Method

vi Radiographic Testing

vii Ultrasonic Testing

Visual Testing (or Visual Inspection)

Visual testing or inspection is probably the most widely used NDT technique. Even though a material is to be undergone other non-destructive testing method, it should be given a good visual examination. Adequate illumination is absolutely necessary for visual examination.

Pressure and Leak Testing

In this method, defects are revealed by flow of liquid or gas into or through the defects. Generally hollow test objects are tested by this method. The hollow test object is filled with gas at a pressure greater than the pressure of surrounding air. Under this condition, the test object is immersed in water. Bubbles are formed at the leaky portion of the object.

Dye Penetrant Testing

This technique is applied to locate discontinuities on material surfaces or internal flaws which extend to the surface of the test object. This method is applicable to both magnetic and non-magnetic materials. Penetrants may be of two kinds: dye penetrant and fluorescent penetrant. In case of dye penetrant, the dye is issolved in a liquid penetrant. In fluorescent, fluorescent material is dissolved in the penetrant. The liquid substance, in which dye or fluorescent materials are dissolved, is called developer. The basic steps in this method are described in Fig:

i Clean the surface of the material

ii Apply the penetrant throughout the surface; the liquid is pulled into the surface breaking defects by capillary action.

iii Remove excess penetrant

iv Apply developer to pull the trapped penetrant back to the surface

v Allow sufficient time, developer along with penetrant spreads out and form an indication of the location of the defect

vi The indication is much easier to see than actual defect. Inspect and interpret the observation.

Fig 1

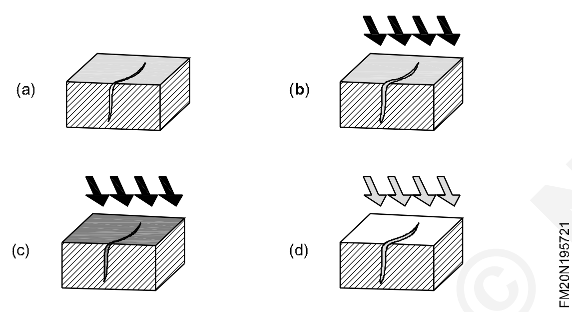


Fig: Different stages of dye penetrant testing

1 A crack appears on the surface of a work piece, but the location of the crack is not so much visible

2 Penetrant is applied on the surface of the work piece

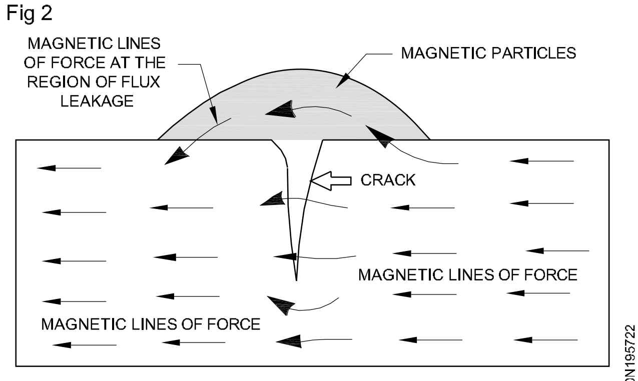
3 Excess penetrant is removed from the surface

4 Developer is applied, crack becomes visible.

Magnetic Particle Testing

This method is applicable to magnetic materials only. Inhomogeneities in the work piece such as blow holes, cracks, and inclusions can be well detected by this method as shown in Fig . If the work piece is put under the influence of magnetic field, the path of the magnetic flux is distorted. This happens because the inhomogeneities exhibit different properties than the surrounding material. To make the inhomogeneities visible, some particles or powder of magnetic material (for example, iron fillings) is spread over the surface of the test object. Defects such as cracks or voids present in the work piece cannot support as much flux as its surrounding homogeneous part can. As a result, it forces some of the flux outside the work piece. This phenomenon is known as flux leakage. The magnetic powder is attracted and held by the magnetic flux created at the defective portion. This forms a visible location of the defect and its extent.

Fig 2

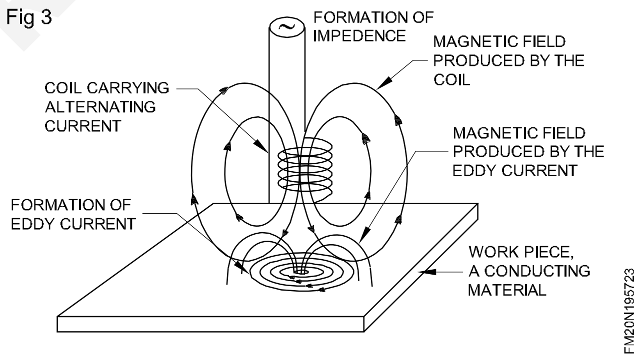


MAGNETIC PARTCLE TESTING

Eddy Current Method

This technique is applied to electrically conducting materials for finding defects like cracks, voids, and inclusions near the surface of the material (Fig). When a coil carrying alternating current is brought near a metal object, eddy currents are induced in the metal. The magnitude of eddy current is affected by the presence of discontinuities or inhomogeneities in the metal object. The eddy currents induced in the metal object set up a magnetic field which opposes the original magnetic field. This condition favours the formation of impedance (and is termed apparent impedance). The path of the eddy current is affected due to the presence of a defect. This causes a change in impedance. This change in impedance can be measured and gives an indication of presence of a defect.

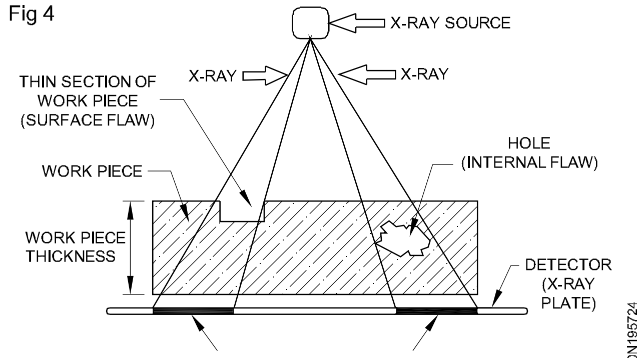
Fig 3



Radiographic Testing

The NDT procedures stated so far are helpful to detect surface flaws. But blow holes, cracks etc. may remain inside the work piece. Such type of flaws is very dangerous and fracture of the work piece may occur without any indication. In order to detect such internal defects, radiographic testing is used (Fig). The work piece is placed between the radiation source and detector. Amount of radiation depends upon the thickness and density if the work piece. The density and thickness of in the blow hole or cracked area is different from those of surrounding area of the work piece. As a result, amount of radiation needed for these areas are different from the other area. This variation in radiation produces an image of the blow hole or crack on the detector. This helps in finding the actual location of the blow hole or crack.

Fig 4

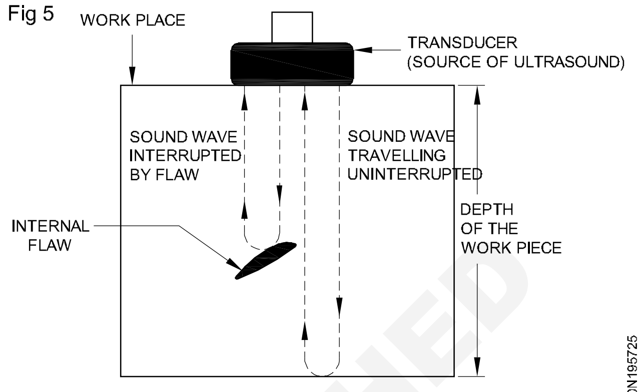


DETECTION OF SURFACE AND INTERNAL FLAWS

Ultrasonic Testing

Ultrasonic testing (Fig) is generally employed to detect internal flaws. High frequency sound wave is created by a device called 'transducer'. Transducer is fitted at one end of the work piece and high frequency sound is released. The sound wave travels through the thickness of the work piece and returns back. This returned sound wave is either received by the same transducer of a second one. If there is any flaw inside the work piece, the sound wave returns from there. The amount of energy transmitted or received, and the time span between release of sound energy and receipt of the same, is analysed to determine the location of the flaw.

Fig 5



ULTRASONIC TESTING

Refractories

Objectives: At the end of this lesson you shall be able to
- **Explain about refractories.**
- **State the types and applications of refractories.**

The word refractory came from the French word réfractaire, meaning "high-melting". Thus, a refractory material is one that is able to retain its strength at high temperatures. Refractory materials are used in linings for furnaces, kilns, incinerators etc. They are also used to make crucibles.

Following are the general properties exhibited by refractory materials:

i High strength (i.e. high value of Young's modulus)

ii High melting point (above 2,200°C)

iii Density ranges from 130 kg/m3 to 2300 kg/m3.

iv Chemically inert (do not react with other components in contact with them in a melting process) and therefore, resistant to corrosion.

v Resistant to thermal shock

vi Both high and low thermal conductivity refractories are available and applied according to the application.

vii Resistant to abrasion

Types Refractory materials and their Applications

The most common classification of refractory materials is based on their chemical composition which is described below:

Acidic Refractories: Acidic refractories are stable to acidic environment but are attacked by alkalis. The main raw materials for this type of refractories are silica (SiO2), zirconia (ZrO2), semi-silica, luminosilicate etc. This group is familiar as RO2 group, where R denotes the metallic part of the compound.

Natural Refractories: Neutral refractories used in areas where slags and atmosphere may be either acidic or basic. The common examples of these materials are alumina (Al2O3), chromia (Cr2O3) etc. This group of refractories generally referred to as R2O3 group.

Basic Refractories: Basic refractories are used in areas where slags and atmosphere are basic. The main raw materials are magnesia (MgO), dolomite and chrome magnesia. This group of refractories generally referred to as RO group.

Binder & additives

Objectives: At the end of this lesson you shall be able to
- **state the common binders and additives**
- **state the application of binders & additives**
- **list out the functions of facing & dressing materials**

Binders

Definition:

Binders are the materials which mixed with moulding or core making sand to get the sand mixture better plasticity.

Types of binder

It is classified in two forms.

a Organic binder

b Inorganic binder

Types of organic binders

I Dextrine

It is obtained from starch substance less soluble mostly used in core sand mixture. Present good plasticity.

II Molasses

Obtained from sugar can. Dissolved in water. Mostly used in core sand mixture good dry bond.

III Sulphite lye

It is waste product of paper industry, easily soluble in water. Have good bonding capacity.

IV Linseed oil

Obtained from flax seed used for core sand mixture.

V Pitch

Product of coal industry use this type of binders is limited.

Inorganic binders

It is also used in manufacturing of crucible.

I China clay

This is refractory binders, have low plasticity used largely in pottery making and other industry, softening point is over 1700^{0}C.

II Ball clay

This is plastic refractory clay used in synthetic sand mixture. It is also used in manufacturing of crucible.

III Fire clay

It is highly refractory clay and used particularly in furnace construction, brick making, crucible making, also sometimes used in synthetic moulding sand of steel foundry.

IV Bentonite

It is finer plastic binder than others. Refractoriness is good and fusion point 1800^{0}C. Its water absroption power is more, widely used in synthetic moulding sand to increase plasticity.

Cereal

It is corn product. It increases green strength, dry strength and collapsibility of the moulding sand composition. It can be added up to 2% with sand.

Additives

Moulding sand mixture composed of silica, clay and moisture. Besides these are used certain secondary materials in the moulding sand to obtain desired working properties as per nature of work these secondary materials are known as "Additives".

Some of the additives as discussed below:

i Saw dust

Saw dust are used with the sand mixture to increase collapsibility, maximum 2% can be mixed with the moulding sand.

ii Silica flour & iron oxide

These additives are used with the sand mixture to increase hot strength of the moulding sand. These are also help the mould or core to improve surface smoothness of castings.

Silica flour specially used upto 35% for steel castings maximum 1% iron oxide added with the mixture.

iii Fuel oil

It mixes with the sand mixture in place of moisture. Brunt mobile oil is used as fuel oil for good surface appearance of nonferrous castings up to 3% with the sand moisture.

iv Sea coal

It is finely powdered bituminous coal. It is used with the sand mixture in powder form. It increases thermal stability and solidification rate of the metal during pouring.

v Coal dust

It is extensively used with the sand mixture for cast iron, casting. Bituminous cool is used for this purpose. It is used in green sand moulding up to 5% depends on the size of the casting. Excess quantity will produce gas holes in the casting.

Function of coal dust

i It increases thermal stability of the sand mixture.

ii In the time of pouring carbon gases deposit on the sand grain increase refractoriness.

Deposited carbon gas makes thin film in between metal and mould for which casting surface become very smooth.

Facing / Dressing material

Definition

Materials which are used in foundry to give protection to the moulds or cores surface against the action of liquid metal during pouring are called surface dressing materials.

Functions

i It helps to produce smooth skin on the casting.

ii It prevents metal penetration of the mould face during pouring.

iii Surface dressing are protect mould from sand fusion, which may reduce the fettling cost.

Application

i It can be used on the mould or core surface by dusting or rubbing in dry or powder form.

ii It may be used on the mould or core surface in liquid state by spraying or painting.

Classification

Dressing are classified in two form

1 Carbonaceous or graphite dressings.

2 Non-Carbonaceous dressings.

1 Carbonaceous

This is carbon content dressing, black in colour. It is used in moulds for ferrous casting.

a Graphite

b Plumbago

c Lamp back

d Char coal dust

e Anthracite coal powder etc.

2 Non carbonaceous

This type of dressing are normally used in non-ferrous foundry work. Non carbonaceous dressing are:

a French chalk powder

b Soap stone powder

c China clay

d Chalmette and siliminate

e Zircon flour-used in steel casting

f Silica flour - highly refractory (used in steel casting).

Casting design

Objectives: At the end of this lesson you shall be able to
- **list out the consideration while design the casting**
- **list out the bad & good design**

1 Design considerations

1 Section thickness should be uniform as far as possible. Variations, if necessary, should be gradual. The aim should be to reduce hot spots. Specific design rules for different cast metals can be taken from casting design hand books.

2 Concentration of metal may be avoided by making cored openings in webs and ribs.

3 Ribs or webs can be staggered, if design permits, to eliminate hot spots.

4 Thin ribs should not be joined to thick sections; they will freeze first and pull away from the heavier mass.

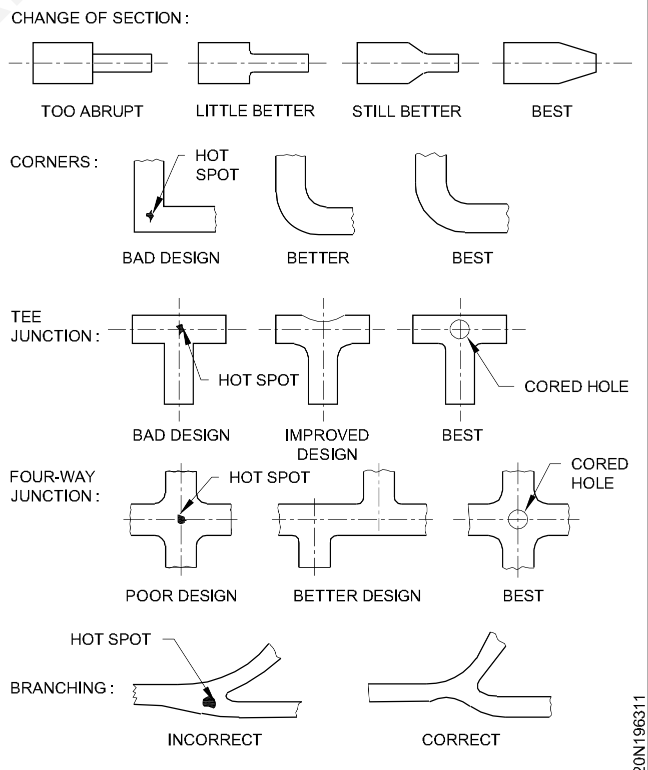
5 Ribs should be used only in compression.

6 In the case of an L or V section, radius at junctions should be so provided as to make the section thinner than the principal width at the junction.

7 Cored holes in the ribs or webs should be rather oval than rectangular with longer dimension in the direction of the stress.

8 Extremely thin sections will present difficulties in pouring and filling. The minimum thickness will depend on the alloy to be cast and the casting method used. Thin sections, moreover, can be run only over a limited distance. The general recommendations for minimum casting thickness(mm) are listed in Table 1.

Fig 1



COMMON DESIGN CONSIDERATIONS

Table 1

Metal	Sand casting	Die castings large areas	Die castings small areas	Permanent mould castings	Plaster moulded castings
Al-alloys	3 - 4.5	2.0	1.2	3	1.0 - 2.5
Cu-alloys	2.5	2.5	1.5	3	1.5
Grey cast iron	3 - 6	-	-	4.5	-
Lead alloys	-	2.0	1.0	-	-
Mg-alloys	3.5	2.0	1.25	3.5 - 4.5	-
Malleable iron	3	-	-	-	-
Steel	4.5	-	-	-	-
Tin alloys	-	1.5	0.75	-	-
White cast iron	3	-	-	-	-
Zn-alloys	-	1.2	0.40	-	-

9 Proper dimensional tolerances should be provided on castings so that the correct method of production can be selected, machining allowances be kept to minimum values, correct matching between components while assembling be ensured, and right size of chucking tools, jigs, and fixtures be used. Figure shows schematically the common design considerations.

Tolerances on a casting dimension depend on several factors

a Design of casting

b Material and condition of patterns and core boxes;

c Clearance on bushes and pins on moulding boxes and pattern plates;

d Moulding materials and moulding characteristics.

e Rapping or stripping of pattern.

f Deformation in mould cavity due to mould enlargement.

g Fettling process; and

h Heat treatment.

Design of a new casting

Steps involved

1 Prepare drawing of the casting.

2 Analyse the forces acting upon the cast part while in service.

3 Carry out stress-analysis and decide the section thickness to bear the service loads.

4 Prepare a pattern layout.

5 Make the pattern.

6 Make a trial casting; inspect and test it.

7 Locate areas experiencing high stresses and measures the stresses by using strain gages.

8 Change casting design to spread stresses over a larger area.

9 Produce these modified castings for more tests and trials.

10 Test the castings for further modifications, if any.

11 Release castings for normal production.

Flux

Objectives: At the end of this lesson you shall be able to
- **state the flux**
- **state the types of flux**
- **advantages of flux.**

Flux

A flux is a low melting point material.

When heated up it melts and combine with ash, viscous slags sand, metallic oxides etc and makes a fluid and easy flowing slag.

This slag being lighter comes on to the surface of the molten metal from where it can be easily skimmed.

Slag protects molten metal from furnace atmosphere.

Type

a **Primary fluxes**

i Lime stone

ii Dolomite

b **Secondary flux**

i Sodium carbonate

ii Calcium carbide

iii Borax

iv Glass

v Charcoal

vi Clean silica sand

vii Degasser

Types of fluxes used in melting cast iron

1 **Lime stone**

Lime stone 2-3% is used as a flux in cupola when melting cast iron . A certain temperature about 1050°C lime stone is breaking out into lime and carbon dioxide.

$CaCo_3$ -> CaO + Co_2

2 **Sodium carbonate (Na_2CO_3)**

Sodium carbonate (Na_2CO_3) can be added in the form of lumps, fused pigs, or pellets and will add a further fluidity to the slag. Sodium carbonate is also used as a slag treatment as its relatively low melting point allows it to melt higher in the stack and to drip down over the coke, reacting with any viscous slag

3 **Calcium fluoride (CaF_2):**

Calcium fluoride (CaF_2) is known to improve slag fluidity and is also a powerful fluxing agent which is sometimes used in small amounts along with limestone.

4 **Calcium carbide**

Calcium carbide is a fluxing agent and has a lower fusion and combustion temperature which allows it to melt and burn in the cupola bed. Its effect is to increase the melting rate, produce hotter iron and therefore reduce the coke requirements.

Dolomite

It is used in the steel melting practice. it also produces slag in the molten metal.

Melting Alumunium	:	Nitrogen, Helium and chlorine are used in aluminium foundry for removing dissolved hydrogen and the entropped dross. (degaser tablet).
Melting copper base alloy	:	Cuprit block, deoxidising tube, charcoal
Megnisium alloy	:	KCI, MgO, $MgCI_2$, CaF_2, $BaCI_2$ and $MnCI_2$

Other common fluxes used in melting

Common salt (NaCl)

It is also used as secondary flux for the important of fluidity of molten metal while it is taken into the ladle.

Borax and glass

Borax and glass are used as secondary flux in the non ferrous molten metal for produces slag in the molten metal

Charcoal

In copper alloy foundry practice charcoal is used to prevent the molten metal from being oxidized.

Clean silica sand

Clean silica sand is used on the surface of the molten metal to protect the molten metal from oxidation to the atmosphere.

Specification of fluxes

Covering flux

The melts are usually protected by a covering flux (a mixture of chlorides) which reduces oxidation.

Cleaning flux

A cleaning flux is added mainly to react with oxides and impurities, and to carry them into a dross on the top of the liquid metal cleaning fluxes usually contain fluorides, cryolite (Na_3AIF_6) for instance.

Drossing flux

A drossing flux may then be added. This flux makes the dross powdery, easy to remove and free from metal particles.

Grain refining flux

Grain refining fluxes are added prior to pouring. They contain compounds of titanium, zirconium and boron. They promote a fine grained structure in the casting.

(A commercial flux may, however, perform more than one function and should be used according to the manufacturer's instructions.)

Advantages of flux

When heated the flux it melts and combines with ash, viscous slags, sand metallic oxides etc and makes a fluid and easy flowing slag.

Chills and densers

Objectives: At the end of this lesson you shall be able to
- **state about chills**
- **state about densers**
- **state the location of chills to prevent porosity at casting friction**
- **state the different between chills & densers.**

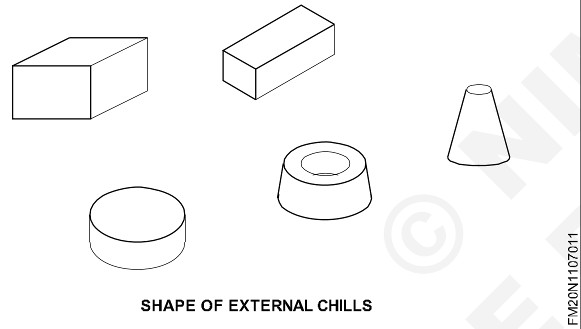
Chills

Chills are the metal pieces used at the external surface of the mould cavity where extra hardness to the casting is required chills are made of a metal which will have higher melting temperature than the metal which will be cast.

Chills may be coated with the refractory facing materials.

The chills helps the thick sections of the castings to start solidifications at par(equal) with the thin surface and helps the thick sections of the castings to start solidifications at par(equal) with the thin surface and helps for the uniform rate of cooling. (Fig 1)

Fig 1



SHAPE OF EXTERNAL CHILLS

Types of external chills

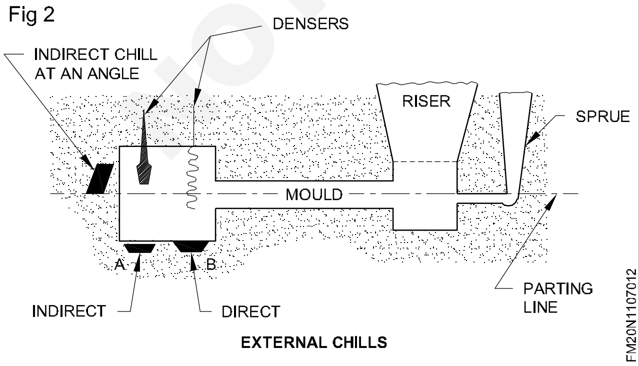
1 External chills

2 Indirect external chills

1 Direct external chills

A direct external chills is flush with the mould cavity and comes in direct contact with the liquid metal. Fig 2(A)

Fig 2



EXTERNAL CHILLS

Indirect external chills

Indirect external chills is rammed and embeded behind the moved cavity wall.

An indirect chills does not come in direct contact with the liquid metal. (Fig 2(B))

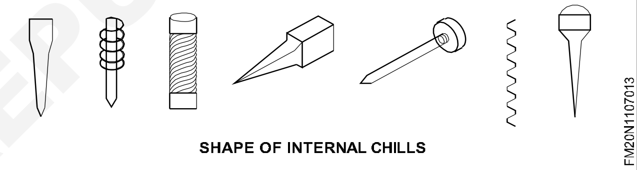
Densers or internal chills

The internal chills are known as densers, these are made of the same metal which will be poured.

These pieces are placed with the help of chaplets which is also made out of the same metal.

After the solidification these places will remain inside the casting. Most probably these will melt and join. The liquid metal gets immediate cooling at the place where denseners are placed and hence the directional solidification is obtained. The densers should be free from scales, rust, dirt, oil, paint, grease, etc. (Fig 3)

Fig 3



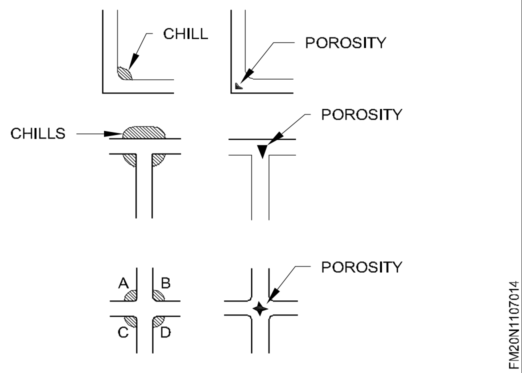
SHAPE OF INTERNAL CHILLS

Location chills to prevent porocity at casting junction

The external chills were effectively at junction or other portions of the casting, which are difficult to feed by riser.

Proper junction are of places may be chosen to locate chills to prevent formation of porocity in the casting. (Fig 4)

Fig 4



Different between chills and densers

Chills	Densers
1 External chills are called chills.	Internal chills are called densers.
2 Rammed up in the mould wall.	Densers are fixed inside the mould cavity and fuse while casting remain hanging in the mould cavity.
3 Excellent controlling colling rate in the critical regions of casting.	Densers less commonly are used because of structural homogenity and improper fusion of densers.
4 Chills is flush with mould cavity wall and comes in direct contact with the liquid metal.	Densers fuse into and become part of the casting.
5 Chills are generally madeup Iron, Steel, Copper and block graphite.	Densers are fuse with the casting, therefore should be made of the same metal of the casting.
6 Chills are very safe and reliable.	Densers are fuse with the casting, therefore should be made of the same metal of the casting.
7 In order to get sound casting chills should be clean, dry free from moisture, oil, grease and rust.	Densers should be clean, dry free from moisture oil, grease and rust.
8 Chills should be sand blasted and pre heated before use.	Densers should be sand blasted and pre heated before use.

Chaptlets (Fig 5)

1 Chaplets consist of metallic supports or spacers used in a mold to maintain cores, which are not self-supporting, in their correct position during the casting process.

2 They are not required when a pattern has a core print or prints which will serve the same purpose.

3 The pattern is drilled, wherever a chaplet is needed.

Use of chaplets

Chaplets are often required to be placed between the mould wall or base and core, in order to avoid deflection of the core and achieve the exact section thickness of the casting. As far as possible, chaplets should be of the same composition as the cast metal so that a homogenous structure is obtained and no internal flaws are developed. For ferrous castings, steel chaplets are available as hardware items in different shapes and sizes. IS : 5904-1978 covers the requirements for steel chaplets and gives dimensions of 11 types of chaplets as follows:

Type 1 : Single column chaplets, round-headed, with or without collars, with or without groove in columns.

Type 2 : Single-column chaplets, with round or rectangular column and square heads.

Type 3 : Two-column chaplets with flat rectangular or flat radial heads.

Type 4 : Three-column chaplets with round or rectangular columns and rectangular heads.

Type 5 : Four-column chaplets with round or rectangular heads.

Type 6 : Stem chaplets with flat-plate or curved-plate heads, stem being plain or grooved.

Type 7 : Two-column chaplets with flat, rectangular, stamped heads.

Type 8 : Bridge-type chaplets made from steel plates by pressing in one piece.

Type 9 : Spring-back chaplet, made in C shape in one piece by pressing.

Type 10: Box-type chaplets, rectangular or radial, with inserting end or central rib.

Type 11: Wire chaplet with single or double supporting spiral.

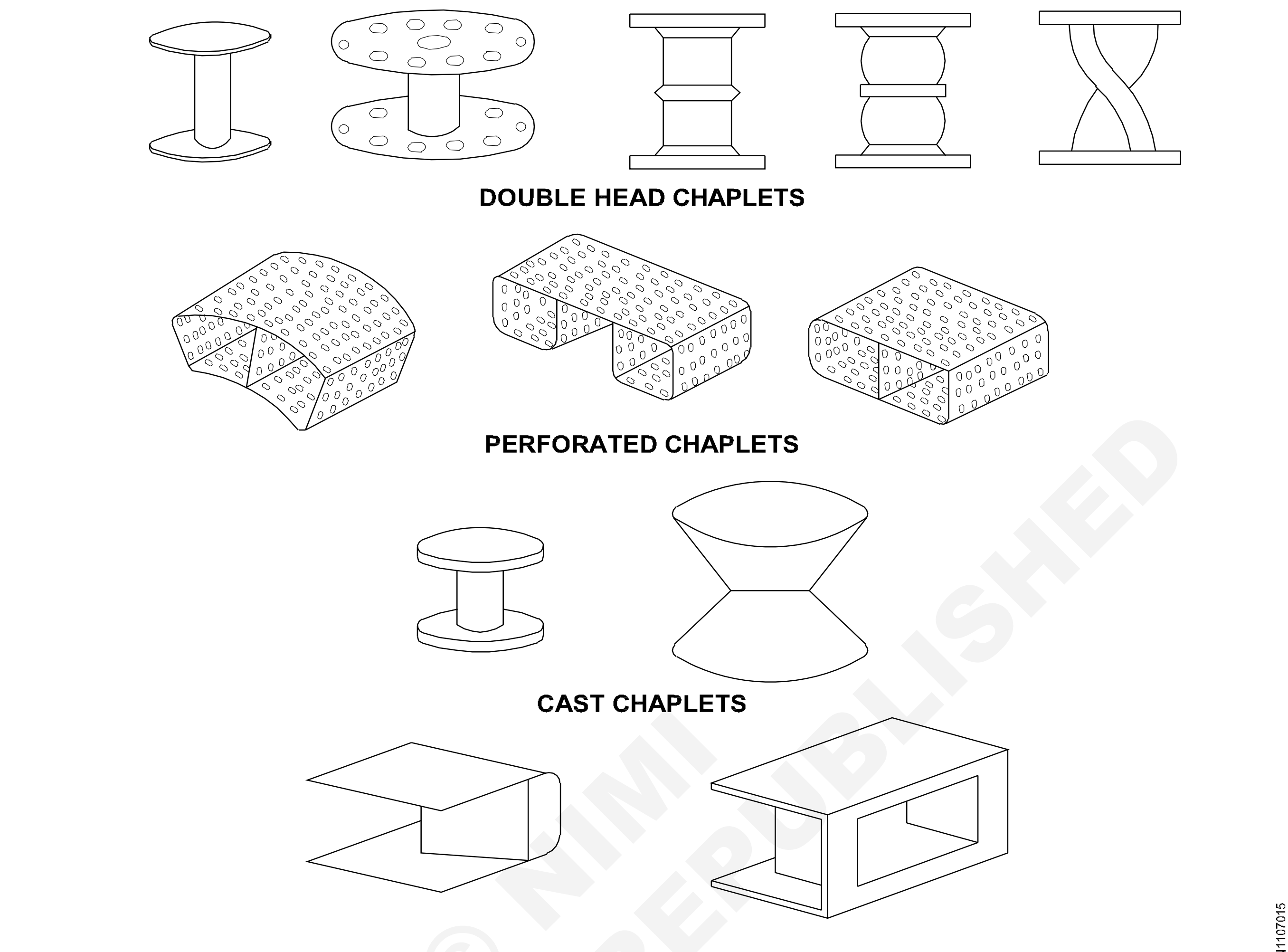


Fig 5

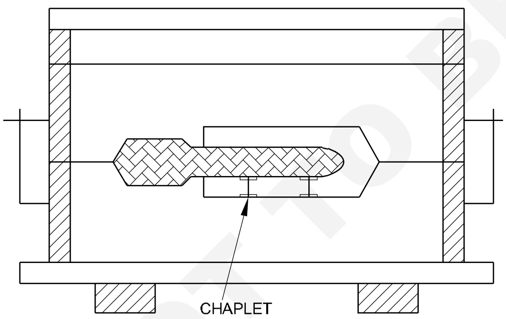


Fig 6 CORE WITH CHAPLETS

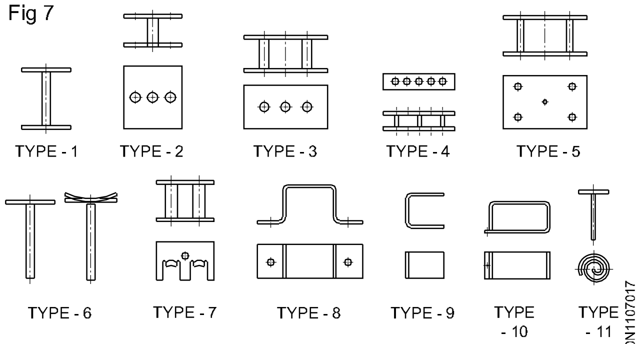


Fig 7 VARIOUS TYPES OF CHAPLETS USED IN FOUNDRIES

Ferrous and non ferrous metal

Objectives: At the end of this lesson you shall be able to
- **state ferrous and non ferrous metal**
- **difference between ferrous and non ferrous metal**

Ferrous metal

All metals that contain any amount of iron in it basic form considered a ferrous metal. because of the only ferrous element in iron component such as many percentage. They are a ferrous metal. Ex. Stainless steel, iron, carbon steel and wrought iron.

Non ferrous metal

Non ferrous metal are the opposite properties of the ferrous metals. Do not contain any iron all the metals in the periodic table with the exceptional iron. Ex: Aluminum, brass, copper.

Difference between ferrous and nonferrous metal

Ferrous metal	Non ferrous metal
1 Ferrous metals mostly contain iron	Do not contain iron
2 Ferrous metals are including magnetic power	Non ferrous metals are not magnetic power
3 Resistance and corrosion increasing	More resistant and corrosion than ferrous metal
4 High melting point	Low melting point
5 Heavy weight than non ferrous	Weight less, light match
6 Cost is less	Cost is more
7 Highly fluidity	Low fluidity
8 Ferrous metal is non ductility property	Including ductile and malleable property
9 Ferrous metal is magnetic element	Non ferrous non magnetic element
10 Reduce light colour	Increase the light colour
11 Sound is less	Sound is more
12 Example pig iron, steel	Example copper, lead, etc

- **Show a video chart of ferrous & non-ferrous metal**

Properties of metal

Objective : At the end of this lesson you shall be able to
- **state the physical & mechanical properties of metals**
- **list out the melting point of metal.**

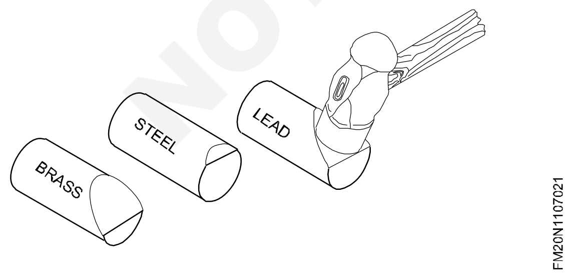
Physical and mechanical properties of metals

Understanding the physical and mechanical properties of metals has become increasingly important for a foundry man since he has to make various components to meet the designed service requirements against factors, such as the raise of temp, tensile, compressive and impact loads etc. A knowledge of different properties of materials will help him to do his job successfully. If proper material/metal is not used it may cause fracture or other forms of failures, and endanger the life of the component when it is put into function.

Fig 1 shows the way in which the metals get deformed when acted upon by the same load.

Note the difference in the amount of deformation.

Fig 1



Physical properties of metals

- Colour
- Weight/specific gravity
- Structure
- Conductivity
- Magnetic property
- Fusibility

Colour

Different metals have different colours. For example, copper is of a distinctive red colour. Mild steel is of blue/ black sheen.

Weight

Metals may be distinguished, based on their weights for a given volume. Metals like aluminium weigh lighter (Sp. gr.2.8) gm/cc and metals like lead have a higher weight. (Sp.gravity 9) gm/cc

Structure (Figs 2 and 3)

Generally metals can also be differentiated by their internal structures while seeing the cross-section of the bar through a microscope. Metals like wrought iron and aluminum have a fibrous structure and metals like cast Iron and bronze have a granular structure.

Fig 2

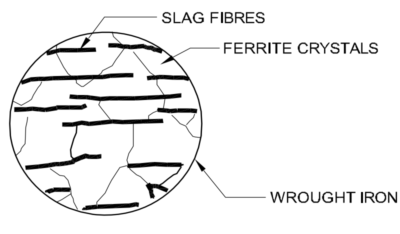
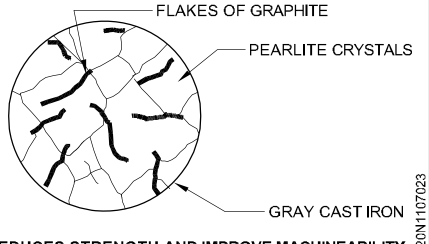


Fig 3



FLAKES OF GRAPHITE REDUCES STRENGTH AND IMPROVE MACHINEABILITY

Conductivity (Figs 4 and 5)

Thermal conductivity and electrical conductivity are the measures of ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal. Copper and aluminum are good conductors of heat and electricity.

Fig 4

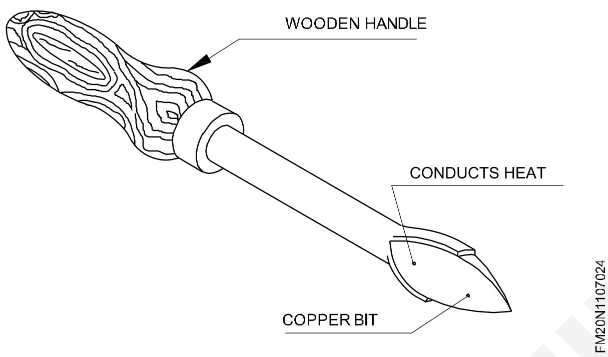
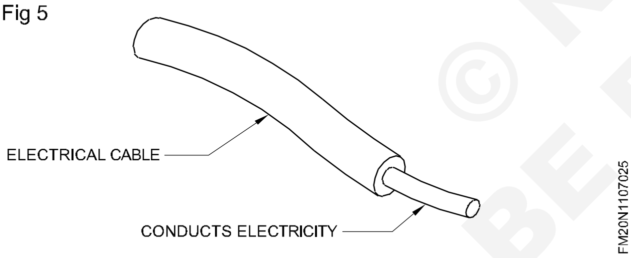


Fig 5



Magnetic property

A metal is said to possess a magnetic property if it is attracted by a magnet.

Almost all ferrous metals, except some types of stainless steel, can be attracted by a magnet, and all non-ferrous metals and their alloys are not attracted by a magnet.

Fusibility (Fig 6)

It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to transformation in the shape (i.e) from solid to liquid at different temperatures. Lead has a low melting temperature while steel melts at a high temperature.

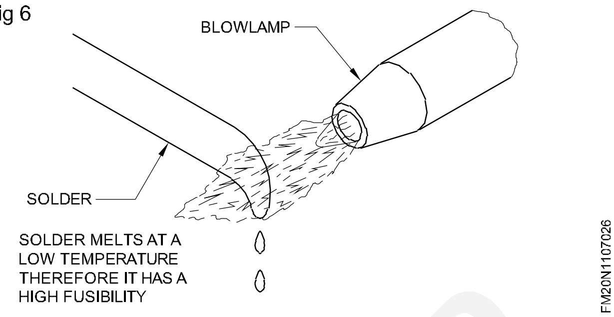
Tin melts at 232°C.

Tungsten melts at 3370°C.

Mechanical properties

- Ductility
- Malleability
- Hardness
- Brittleness
- Toughness
- Tenacity

Fig 6

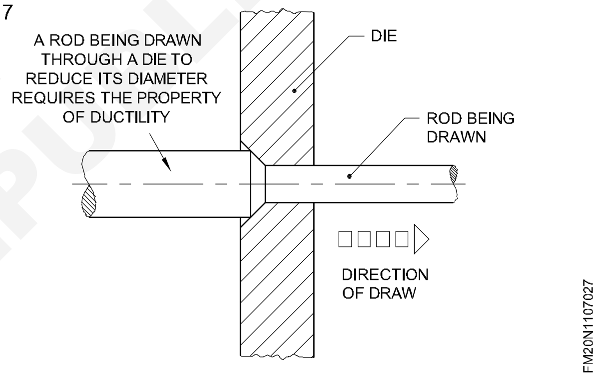


- Elasticity

Ductility (Fig 7)

A metal is said to be ductile when it can be drawn out into wires under tension without rupture. Wire drawing depends upon the ductility of a metal. A ductile metal must be both strong and plastic. Copper and aluminum are good examples of ductile metals.

Fig 7



Malleability (Figs 8 and 9)

Malleability is that property of a metal by which it can be extended in any direction by hammering, rolling etc. without causing rupture. Lead is an example of a melleable metal.

Fig 8

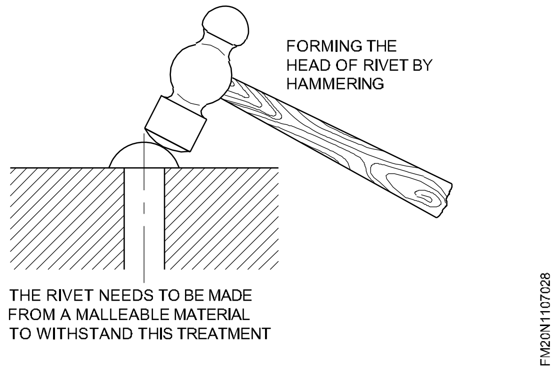
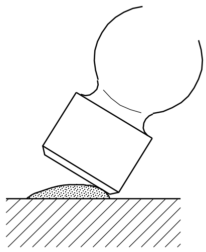


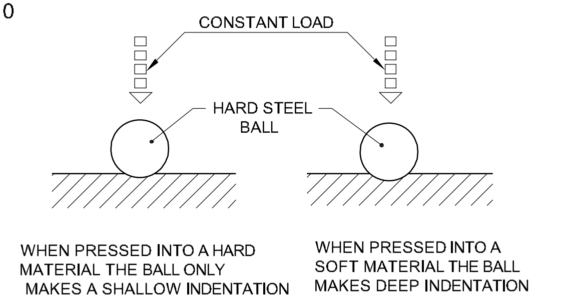
Fig 9



Hardness (Fig 10)

Hardness is a measure of a metal's ability to withstand scratching, wear and abrasion, indentation by harder bodies. The hardness of a metal is tested by marking by a file etc.

Fig 10



Brittleness (Fig 11)

Brittleness is that property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal which will break rather than bend under shock or impact.

Toughness (Fig 12)

Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness. Wrought iron is an example of a tough metal.

Tenacity

The tenacity of a metal is its ability to resist the effect of tensile forces without rupturing. Mild steel, Wrought Iron and copper are some examples of tenacious metals.

Fig 11

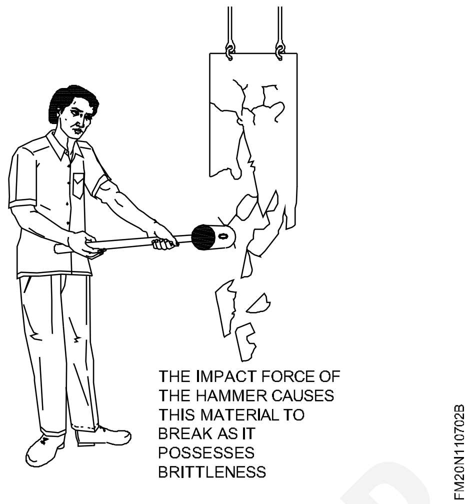
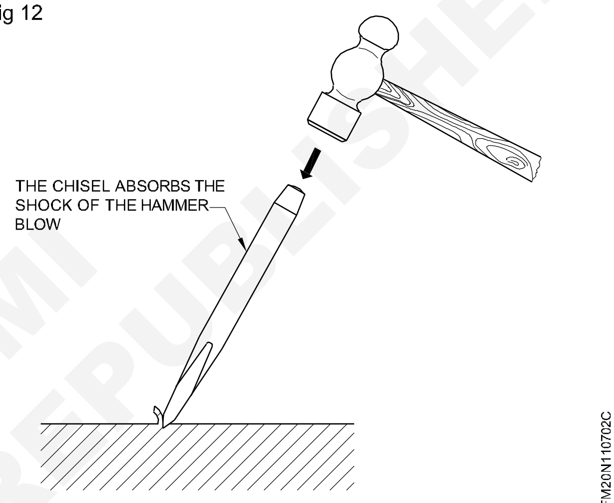


Fig 12



Elasticity

Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example for elasticity.

List out melting point of metal

Melting point of metal

Elements	Symbol	Melting point °C	Melting point °F
1 Aluminum	Al	660	1220
2 Antimony	Sb	630	1166
3 Carbon	C	3727	6741
4 Chromium	Cr	1875	3407
5 Cobalt	Co	1495	2723
6 Copper	Cu	1083	1982
7 Gold	Au	1063	1946
8 Iron	Fe	1536	2797
9 Lead	Pb	327	621
10 Magnesium	Mg	650	1202
11 Manganese	Mn	1245	2273
12 Nickel	Ni	1453	2647
13 Phosphorus	P	44.1	112
14 Platinum	Pt	1774	3225
15 Silicon	Si	1410	2570
16 Silver	Ag	960.8	1761
17 Sulphur	S	119	237
18 Tin	Sn	232	450
19 Tungsten	W	3410	6170
20 Zinc	Zn	419.4	787

Iron ore

Objectives: At the end of this lesson you shall be able to
- **state the iron ore and its types**
- **name the chief iron ores and its uses**
- **state about engineering metals.**

Iron ore

Iron is found in nature in the form of ores which are oxides, carbonates, silicates and sulphides of iron and from which the metal can be extracted. Ores in the form of iron and from which the metal can be extracted. Ores in the form of iron oxides are most important source of iron.

The iron ores are in crude form when extracted from earth and contain varying amounts of clay, limestone, quartz, and other earthly matter called gangue. The grade of ore ie its percentage of metallic iron tha t occurs in the ore is an important factor.

The chief iron ores used are

1 Hematite

2 Magnetite

3 Limonite

4 Siderite

Hematite

It is important of all the iron ores. It is ferric oxide of iron and in pure condition contains about 70% of iron. Its colour varies from dark red to grey or black. It is found mainly in bihar and orissa. Its specific gravity is 4.9 to 5.3.

Magnetite

In pure state it contains about 72% iron. It is black in colour and possesses metallic lustre. It displays magnetic properties. It is found in barakar hills gaya and Tamilnadu. Its specific gravity is nearly 5.1

Limonite

It is yellow colour. It contains about 35 to 50% iron. It is found in west Bengal. Its specific gravity varies from 3.5 to 4.

Siderite

It is of gray or brown colour and contains about 48% iron. It is also known as spathic iron.

Pre treatment of iron ore

Calcination: Calcination is done on the ore to remove excessive moisture and CO_2.

Concentration: Concentration in done to remove the iron ore.

Roasting : Roasting in done to remove the volatile matter.

Wheathering : Wheathering is on the one to remove the excessive sulphur will be washed away by rain.

Engineering metals

Ferrous Metals

Metals which contain iron as a major content are called ferrous metals. Ferrous metals of different properties are used for various purposes.

The ferrous metals and alloys used commonly are:

- Pig-iron
- Cast Iron
- Wrought Iron
- Steels and Alloy steels

Different processes are used to produce iron and steel.

Pig-iron (Manufacturing process)

Pig-iron is obtained by the chemical reduction of iron ore. This process of reduction of the iron ore to Pig-iron is known as SMELTING.

The main raw materials required for producing Pig-iron are:

- Iron ore
- Coke
- Flux

Iron ore

The chief iron ores used are:

- magnetite
- hematite
- limonite
- carbonate

These ores contain iron in different proportions and are naturally available.

Coke

Coke is the fuel used to give the necessary heat to carry on the reducing action. The carbon from the coke in the form of carbon monoxide combines with the iron ore to reduce it to iron.

Flux

This is the mineral substance charged into a blast furnace to lower the melting point of the ore, and it combines with the non-metallic portion of the ore to form a molten slag.

Limestone is the most commonly used flux in the blast furnace.

Blast furnace (Fig 1)

The furnace used for smelting iron ore is the blast furnace. The product obtained from smelting in the blast furnace is pig-iron. The main parts of the blast furnace are:

- throat
- stack
- bosh
- hearth
- double bell charging mechanism
- tuyeres

Smelting in a blast furnace

The raw materials are charged in alternate layers of iron ore, coke and flux in the furnace by means of a double bell mechanism.

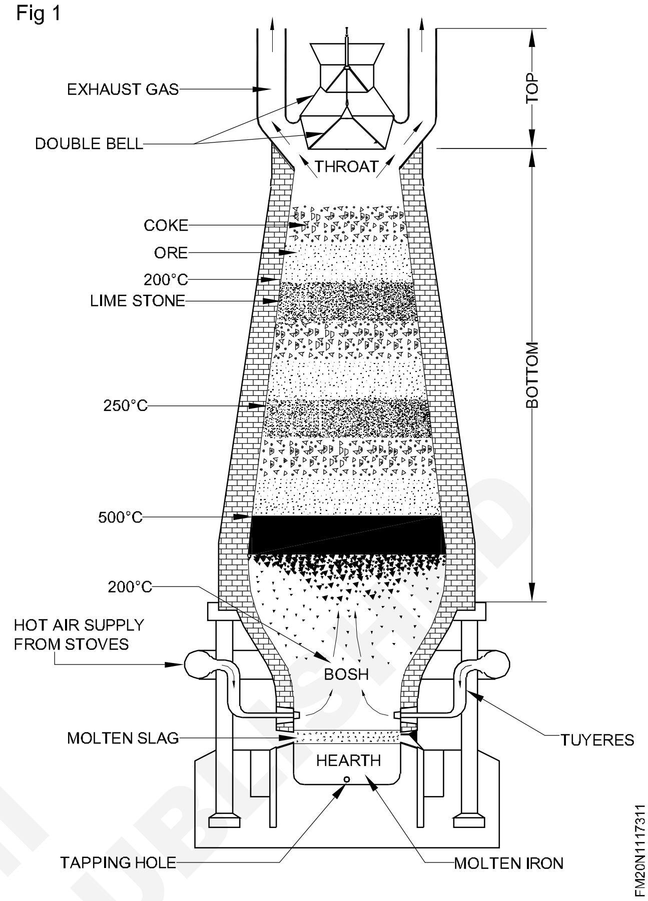
The hot blast is forced into the furnace through a number of nozzles called tuyeres.

The temperature of the furnace just above the level of the tuyeres (melting zone) is between 1000° C to 1700° C when all the substances start melting.

The limestone, which serves as a flux, combines with the non-metalic substances in the ore to form a molten slag which floats on the top of the molten iron. The slag is tapped off through the slag hole.

The molten iron is tapped at intervals through a separate tapping hole.

Fig 1



The molten iron may be cast in pig beds or used in other processing plants for steel making.

Common cast iron alloys

Objectives: At the end of this lesson you shall be able to
- **State about common cast iron alloys.**

CAST IRON

The term cast iron, like the term steel, encompasses a family of ferrous alloys gray iron, alloy iron, white iron, malleable iron, ductile iron. Wide variations in properties can be achieved by varying the balance between carbon and silicon by alloying and by applying various types of heat treatment.

The machinability of most gray irons is superior to that of virtually all other cast ferrous alloys.The dispersion of graphite flakes acts as lubricant in the metal that breaks the chips. Acceptable machining depends; However, on the microstructure and hardness.

Types of cast iron.

A Gray Cast Iron

B Malleable cast iron

C Nodular cast iron

D White cast iron (Mottled iron)

A. Gray Cast Iron

Characteristics

Gray Iron basically is an alloy of carbon and silicon with iron It is readily cast into a desired shape in a sand mould.

It contains 2.5-3.8%C, 1.1-2.8% SI, 0.4-0% Mn,0.15% P and 0.10% S.It is marked by the presence of flakes of graphite in a matrix of ferrite, pearlite or austenite. Graphite flakes occupy about 10% of the metal volume. Length of flakes may vary from 0.05 mm to 0.1mm.

When fractured a bar of Gray Cast Iron gives gray appearance. Gray-Iron possesses lowest melting point of the ferrous alloys. Gray Cast Iron possesses high fluidity and hence it can be cast into complex shapes and thin sections.It possesses machinability better than steel.

It has high resistance to wear (Including sliding wear). It possesses high vibration damping capacity gray iron has low ductility and low impact strength as compared with steel.

Gray cast iron has a solidification range of 2400-2000°F. It has shrinkage of a inch/foot (1mm/100mm). It associates low cost combined with hardness and rigidity Gray Cast Iron possesses high compressive strength. Gray cast iron possesses excellent casting qualities for producing simple and complex shapes.

Applications

1 Machine tool structures.

2 Gas or water pipes for underground purposes.

3 Manhole covers.

4 Cylinder blocks and heads for I.C.Engines.

5 Tunnel segment.

6 Frames for electric motors.

7 Ingot moulds.

8 Sanitary wares.

9 Piston rings.

10 Rolling mill and general machinery parts.

11 Household appliances etc.

B. Malleable Cast Iron

Characteristics

Malleable cast iron is one which can be hammered and rolled to obtain new shapes. Malleable cast iron is obtained from hard and brittle wihte iron through a controlled heat conversion process.

A ferritic malleable cast iron has FERRITE matrix. A pearlitic malleable cast iron has PEARLITE matrix. An alloy malleable cast iron contains chromium and nickel and possesses high strength and corrosion resistance.

Malleable cast iron possesses high yield strength. It has high young's modulus and low coefficient of thermal expansion. It possesses good water resistance and vibration damping capacity.

It can be used from -60 to 1200°F. It has a solidification range of 2550-2065°F. It has shrinkage of 316 inch per foot(1.5mm/100mm). It has low to moderate cost. (Malleable cast iron contains 2.3% Cm0.6-1.3% SI, 0.2-0.6% Mn, 0.15% P and 0.10% S.

Uses

1 Automotive industry.

2 Rail road.

3 Agricultural implements.

4 Electrical line hardware.

5 Conveyor chain links.

6 Gear case

7 Universal joint yoke.

8 Rear axle banjo housing.

9 Truck tandem axle assembly parts.

10 Automotive crankshaft.

11 Crankshaft sprocket etc.,

C. Nodular Cast Iron

Characteristics

Unlike long flakes as in gray cast iron graphite appears rounded particles or nodules or spheroids in Nodular Cast Iron. Nodular Cast Iron is also known as **Nodular Iron-Ductile Iron-Spheroidal graphite Iron.** The spheroidizing elements when added to melt eliminate sulphur and oxygen (from the melt), which change solidification characteristics and possibly account for the nodulization. Nodular cast iron can be turned at very high feeds and speeds.

The properties of Nodular Cast Iron contains 3.2-4.2% C,1.1-3.5% SI, 0.3-0.8 % Mn ,0.08% P, and 0.02% S.

Uses

1 Paper industries machinery.

2 Internal combustion engines.

3 Power transmission equipment.

4 Farm implements and tractors.

5 Earth moving machinery.

6 Valves and filings.

7 Steel mill rolls and mill equipment.

8 Pipes.

9 Pumps and compressors.

10 Construction machinery.

D. White Cast Iron (Mottled Iron)

Characteristics

White cast iron derives its name from the fact that its freshly broken surface shows a bright white fracture. Unlke gray iron. White cast iron has atmost all its carbon. Chemically bonded with the iron as iron carbide, Fe_3C.Iron carbide is a very hard and brittle constituent, Thus white iron possesses excellent abrasive wear resistance. White iron under normal circumstances is brittle and bot machinable. By using a fairly low silicon content, cast iron mayy be made to solidity as white iron. White iron castings can be made in sand moulds.

White iron can also be made on the surface of a gray iron casting provided the material is of special composition. It iron of proper composition is cooled rapidly, the free carbon will go in the combined formand give rise to white iron casting. The white iron contains 1.8-3.6% C, 0.5-2.0 % SI , 0.2-0.8% Mn, 0.18% P, and 0.10% S.

The solidification range of white iron is 2550-2065°F. Shrinkage is 8 inch per foot (1mm/100mm).

(xii) White iron (of a particular chemical composition) is the first step in the production of malleable iron castings.

Uses:

1 For producing malleable iron castings.

2 For manufacturing those component parts which require a hard, and abrasion resistant material.

Chilled cast iron

When the outer surface of the casting is desired to have great hardness to resist wear. chilling of the surface is done.Chilling is the process of quick cooling. Castings are chilled at their outer surface by bringing them in contact wiht the cool sand in the mould. Chilling gives a hard outer surface white the interior of the casting remains gray. The technique of chilling is most commonly used in making hard the running surface of the wheel of a railway carriage and also used in casting of rolls.

Effects of alloying element for ferrous metals

Objectives : At the end of this lesson you shall be able to
- **name the alloying elements on iron and steel and effects**
- **describe the effects of alloying elements.**

Effects of alloying elements

The properties of iron and steel to a large extent depend upon the amount of silicon, sulphur, phosphorus and manganese present in it. The effect of these elements on mechanical properties will depend largely upon the way in which these impurities are distributed throughout the structure of steel.

Name the alloying materials

The various alloying elements and their respective effects are as follows

1 Silicon
2 Sulphur
3 Phosphorus
4 Manganese
5 Nickel
6 Chromium
7 Vanadium
8 Tungston
9 Cobalt

Effects of alloying elements of steel

Silicon

Silicon promotes the formation of free graphite and imparts fluidity to steel and therefore it becomes soft and easily machinable. The amounts of silicon in steel various from 0.05 to 0.40% It improves elastic limit.

Sulphur

It reduces ductility and its maximum content permissible is nearly 0.45% it occurs in steel in the form of iron sulphide.

Phosphorus

Presence of phosphorus in steel is quite harmful and if the amount exceeds 0.1% it makes the steel brittle under shock called cold shortness. In sheets and strips used for deep drawing and stamping operations the phosphorus content is about 0.04%

Manganese

The presence of manganese in steel is useful. Its amount various from 0.2 to 1% manganese is added to ladle when the metal is tapped from the furnace in order to deoxidise the steel manganese takes up sulphur and therefore neutralizes the harmful effect of this element. It improves strength and toughness.

Nickel

Nickel increases toughness and strength of steel is increases. It makes the steel corrosion resistant. It improves the ductility. It is generally added to low and medium carbon steels. The amount added may be up to 36%

Chromium

Chromium is added to steel to increase the depth to which the steel may be hardened. The amount added may be up to 18% . Steel containing up to 1.5% chromium possesses more tensile strength and hardness.

Vanadium

It acts as a deoxidiser and helps in degasification of steel in molten state. The addition of vanadium up to 0.2% in low and medium carbon steels increases tensile strength and elastic limit without loss in ductility.

Tungsten

Addition of tungsten makes the steel hard, tough and wear resistant. The amount added varies from 0.5 to 1.5% High percentage of tungsten makes the steel to retain its hardness even when highly heated 6 to 18% tungston is added in high speed steels. High speed steel is used for cutting tools, dies, drills, reamers and milling cutters.

Manganese

It acts as a deoxidizer and counter acts the undesirable effect of sulphur. Addition of manganese from 1 to 1.5% makes the steel strong and tough when added from 11 to 14% in steel containing carbon 0.8 to 1.5 makes the steel very hard and tough.

Cobalt

It refines grains and improves hardness toughness and tensile strength. It is added from 1 to 1.27 % in high speed steel. It improves magnetic properties of steel

Effects of alloying elements on iron.

Element	Normal level	positive effect	Negative effective
Sillicon (SI)	Cast Iron - 2.5 - 4.0 % White iron - 1.8 - 3.6 % Nodular iron -1.8-4.0 %	Reduce chill tendency. Increase the castability,.Increase strength. Helps make sound castings.	Increasing level the mechanical strength decreases. Increases giving lower impact strength on Nodular iron.
Sulphur (S)	Cast Iron- upto 0.25% White iron - 0.06 - 0.2 % Nodular iron -Upto 0.03 %	It will together with MN,influence the strength of the iron.	It can lead to a hard and brittle iron. A high 5 content increases problems with slag and danger for slag related defects. Increasing level, reduced consistency of the Mg treatment on Nodular Iron.
Phosphorus (P)	Cast Iron - upto 0.10% White iron - 0.06 - 0.2 % Nodular iron -Upto 0.03 %	Increases the fluidity of the cast iron, Increases the wear resistance. Increases hardness and strength on nodular iron.	Makes the cast iron harder and more brittle. Increase tendency to form micro shrinkages. Increasing level,decreases ductility of nodular iron.
Manganese (Mn)	Cast Iron - 0.2 - 1.0 % White iron - 0.25 - 0.8 % Nodular iron - 0.1 - 2.0 %	Improves machinability and grain size. Improves the strength.Improves hardenability on nodular iron	Too high level can increase slag. Forming, Increasing level, reduce mechanical strength and can promote shrinkage on nodular iron.
Nickel (Ni)	Cast Iron - upto 0.5% Nodular iron - Upto 0.2 %	Increases strength, hardness and elongation. Improve corrosion properties. Increases hardenability and reduce the chilling effect on nodular iron.	High levels can increase the hardness in thin sections.
Chromium (Cr)	Cast Iron - upto 0.5% Nodular iron - Upto 0.1 %	Give higher hardness and better wear resistance. Improve corrosion properties on nodular iron.	Increased tendency for micro shrinkages and chilling effect.
Vanadium (V)	Cast Iron - upto 0.10% Nodular iron - Upto 0.02 %	Improve the strength and hardness. Improved wear resistance.	Increases chilling tendency.

Inoculation

Objectives : At the end of this lesson you shall be able to
- **state about inoculant**
- **state the common inoculation treatment of alloys**
- **state the purpose of inoculation of cast iron.**

An inoculant

An addition is made to molten metal after melting operation for modifying the solidification structure and properties of the cast metal and alloys is called inoculant.

Common inoculation treatments are

Alloys	Typical inoculants
Steel	Al,Ti
Aluminium base	Ti,B,Nb,Zr
Magnesium base	C,D
Mg,Ai	C

Purpose of inoculation of cast iron

Inoculation of molten cast iron

1 Modify the structure or graphite formation.

2 Change of graphite type may be obtained

3 Improve mechanical & physical properties

4 It favour graphite formation and prevent chilling and consequently avoids the formation of white iron in their section.

Steel manufacturing process by arc furnace

Objectives: At the end of this lesson you shall be able to
- **state about steel**
- **state the manufacturing process of steel in arc furnaces**
- **state about direct arc furnace**
- **state about indirect arc furnace**
- **state about other manufacturing process of steel**

Steel

Steel is basically an alloy of iron and carbon with a small percentage of other metals such as mickel, chromium, aluminum, cohalt, molybdeum, tusgton etc.

Steel is a hard ductile and mealable solid and its probably the most solid materials after plastic and iron.

Types of steel

- low carbon steel
- Medium carbon steel
- High carbon steel

Carbon is a important alloying element of steel based on the carbon content present in the different types of steel is given the below table 1

Table 1

Name	Group	Carbon content %	Examples of uses
Dead mild steel	Plain carbon steel	0.1 to 0.15	Sheet for pressing out such shapes as motor car body panels. Thin wire, rod, and drawn tubes.
Mild steel	Plain carbon steel	0.15 to 0.3	General purpose workshop bars, boiler plates, girders.
Medium carbon steel	Plain carbon steel	0.3 to 0.5 0.5 to 0.8	Crankshaft forgings, axles. Leaf springs, cold chisels.
High carbon steel	Plain carbon steel	0.8 to 1.0 1.0 to 1.2 1.2 to 1.4	Coil springs, chisels used in woodwork. Files, drills, taps and dies. Fine edge tools (knives etc).

Manufacturing process of steel in arc furnace

The type of arc furnace are given below.

1 Direct arc furnace

2 Indirect arc furnace

DIRECT ARC FURNACE

Introduction

It is the most widely used remelting unit in steel foundries.it remelts steels of widely differing compositions. The largest direct arc furnaces have capacities of about 125 tons. Direct arc furnace has its diameter upto 6 meters. Rating of the transformers supplying power to the arc ranges from 800 KVA to 40,000 KVA.. A 50 ton direct arc furnace may require arc current of the order of 25000 Amps and arc voltage of about 250 volts.

Construction

A direct arc furnace consists of a heavy steel shell lined with refractory brick and silica for acid lined furnace and magnetic for basic lined furnaces.

1 Acid lining is preferred when good steel scrap low in sulphur and phosphoras is available so that removal of these two elements is not required, the heats are produced much faster

2 A basic lined furnace is advantageous because inferior

scrap may be used to make good steel, the basic process removes S & P from the metal. However the heats take longer time than in acid lind furnace.

3 Moreover, basic refractories are costlier than acid refractories.

The roof of the direct arc furnace consists of a steel roofing in which silica bricks are fixed in position.

1 The direct arc furnace may be charged either from the charging door which also serves for removing slag from the (top of the) molten metal or front the furnace roof which is made to lift off and swing clear of the furnace.

2 A few spare roofs can be made available at all times as the roof does not have a very long life.

Depending upon whether it is a two phase of three phase electric furnace, two or three graphic electrodes are inserted through the holes in the roof into the furnace.

1 Electrode can be raised up or down.

2 For a 50 ton furnace,each electrode carries a current of the order of 25000 amperes.

Electrode guides placed on the furnace roof (not marked) are water cooled to discipate damaging heat.All arc furnaces rest in bearings on their two sides and bearings in turn are mounted in trunnions, thus arc furnace can be tilted backward or forward for charging running off the slag and pouring the molten metal into the ladle.

Operation

The interior of the furnace (i.e. refractory linings, etc.) is pre heated before placing the metal charge in the furnace.

1 Preheating is done by alternatively striking and breaking the arc between the (vertical) electrode and used electrode pieces kept on the hearth.

2 After preheating the electrode pieces placed on the hearth are removed.

The furnace is charged either by swinging over the roof or through the charging door.

1 For melting cast iron (the furnace is acid lined and) a large proportion of the metal charge consists of cast iron foundry (return) scrap having sand adhered to it.

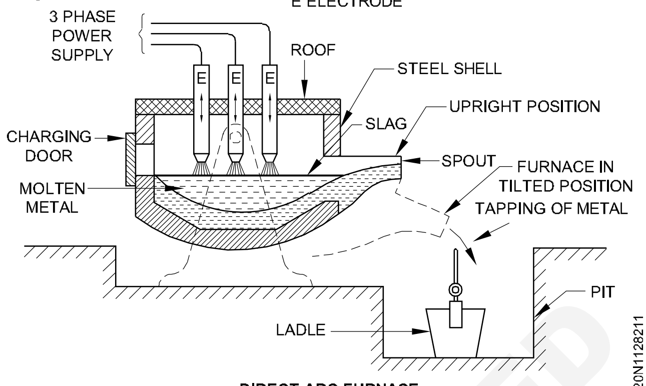
2 For melting steel the charge is usually steel scrap and depending upon its Sulphur and Phosphorus content,an acid or basic lined furnace is employed

3 Besides remelting purposes a direct arc furnace can also be used for making steel the charge in this case will consists of pig iron and steel scrap. Steel is made by using the same method as described for open hearth furnace.

Once the cold charge has been placed on the hearth of the furnace, electric arc is drawn between the electrodes and the surfaces of the metal charge by lowering the electrodes down till the current jumps the gap between the electrodes and the charge surface.

The arc gap between the electrode and the charge is regulated by automatic controls which raise of lower the electrode and maintain desired arc gap (or arc length) by maintaining constant arc voltage.

Fig 1



DIRECT ARC FURNACE

1Smaller arc lengths produce more intense heat, however there is a little fear of contaminating molten metal with graphite (the electrode material)

Metal charge melts because of the heat radiation from the arc and the hot refractory walls of the jurnace and conduction from the hot refractory (wall) linings when the furnace rocks and molten metal rolls over the same.

An indirect arc furnace is used for melting

1 cast iron

2 Steel

3 Copper and its alloys

An indirect arc furnace obtains lower temperatures and has less efficiency as compared to a direct arc furnace.

Construction

An indirect arc furnace consists of a barrel type shell made up steel plates, having refractory lining inside.

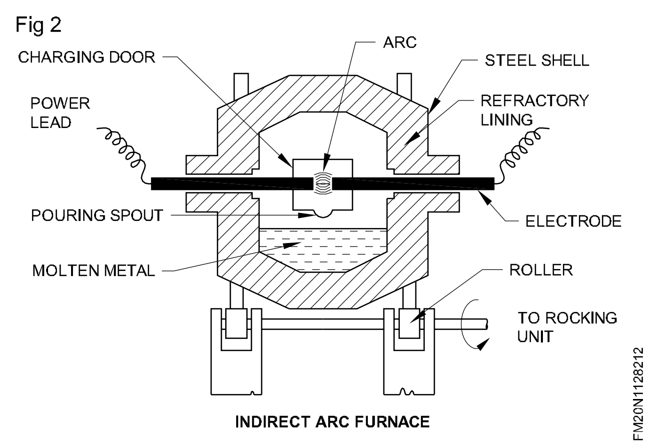
There are three openings two for the two graphic electrodes and the third id the charging door for feeding the metal charge into the furnace. Built up with the charging door is pouring spout

Furnace is mounted on the rollers (Refer Fig.13.11) which are drawn by a rocking drive unit to rock the furnace hack and forth during melting.

1 While the furnace rocks, liquid metal washes over the heated refractory linings and absorbs heat from them. In addition, during rocking, metal charge constituents get mixed up thoroughly.

2 Rocking of furnace speeds up melting, stirs the molten metal, avoids refractory linings from getting over heated and then increases their life.

3 The angle of rocking of furnace is adjusted in such a manner that the liquid metal level remains below the pouring spout.



Operations

First of all pig iron is charged in the furnace.

Above pig iron, scrap is placed.

With electric power on graphite electrodes are brought nearer current jumps and on electric are is set up between them.

Three arcs burning simultaneously produce a temperature of the order of 11000°F and and readily melt the flux, sand (embedded on the surface of the charge) and the metal scrap.

1 The slag formed due to melting of flux, sand etc.covers the molten pool of metal.

2 Slag present on the top of the molten metal bath reduces its oxidation.

3 Refines the metal and

4 Protects roof and side walls from the large amount of heat radiated from the molten metal

5 The molten pool increases in size with the passage of time till the whole of the scrap in melted.

Before pouring the liquid metal into the ladle,the furnace is tilted backward and the slag is poured off from the charging door.

The furnace is then tilted forward (refer Fig 13.10) and the molten metal is emptied into ladles.

Hearth, side walls and roof of the furnace are repaired with the help of suitable refractory materials after each heat.

Advantages of Direct Arc Furnace

1 Unlike crudible furnaces direct arc furnaces undertake a definite metal refining sequence.

- Additions to the charge are made so as to form slags which have a refining action on the metal
- Molten metal is refined to a proper analysis and is heated in a suitable pouring temperature.

2 Electric furnaces lend themselves to close temperature and heat control.

3 Analysis of melt can be kept to accurate limits.

4 A direct arc furnace has a thermal efficiency as high as about 70%

5 It is not difficult to control the furnace atmosphere above the molten metal.

6 Alloying elements like Cr.Ni, and W can be recovered from the scrap with little losses

7 It can make steel directly from pig iron and steel scrap.

As compared to an induction heating furnace.

8 Arc furnace is larger and its electrical equipment is cheaper to install

9 An arc furnace is preferred for its

- quicker readiness for use,
- longer hearth life,
- ease of repair,
- greater independence of the quality of the charge

Limitations

1 Heating costs are higher than for other (say crucible) furnaces. This however can be adjusted to extent by using low cost scrap turnings or borings as metal charge.

Uses

In general high quality carbon steels and alloy steels in bulk are made in electric direct arc furnace.

INDIRECT ELECTRIC ARC FURNACE (OR ROCKING FURNACE)

Introduction

An indirect electric arc furnace has a capacity ranging from a few kg up to 2 tons

It is preferred for producing smaller melts as compared to direct arc furnace.

Unlike direct arc furnace an electric arc is struck between two graphic electrodes and the metal charge does not form a part of the electric circuit.

An indirect electric arc furnace is of rocking type because it rocks back and forth during the melting process. The metal thus come in contact with hot refractory lining and picks up heat for melting from the linings

As soon as some metal has melted the furnace is set to rock to and fro. Rocking helps better heat exchange between refractory linings, molten metal and solid metal.

Rocking of furnace and adjustment of arc gap between the graphite electrodes is automatically controlled.

When the melting is complete, the furnace is tilted mechanically (but not informatically) farther than for rocking to permit liquid metal to flow out the pouring spout (tap hole) into the ladle.

Advantages

1 Metal charge does not form a part of electrical circuits

2 Rocking of furnace

- avoid overheating and thus damaging of refractory linings,
- stris and thus provides a melt of uniform compositions
- speeds up melting

3 Low cost scrap metal can be used in an indirect arc furnace.

4 Operations and control of the furnace are simple.

Other Manufacturing processes of steel

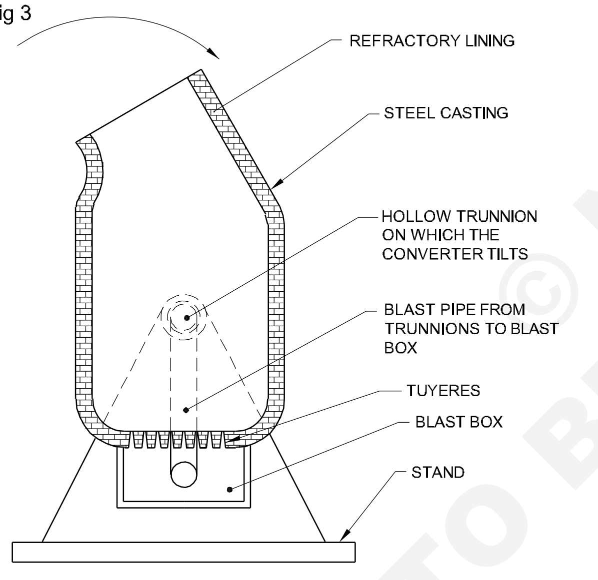
The other different manufacturing processes of steel are listed below.

- Bessemer process
- Open hearth process
- The high frequency furnace

Bessemer process

Sir Henry Bessemer, a British engineer invented this process of converting molten pig-iron to steel using a large pear-shaped container. This is called the Bessemer converter. (Fig 1)

Fig 3



It is a method of producing steel by blasting compressed air through molten iron and burning out the excess carbon and other impurities. This does not use any source of heat other than that obtained from the oxidising process used to remove carbon and other impurities.

The three stages of this process are:

- the preliminary stage

  (slag formation)
- the boil stage

  (the brilliant flame blowing period)
- the finishing stage

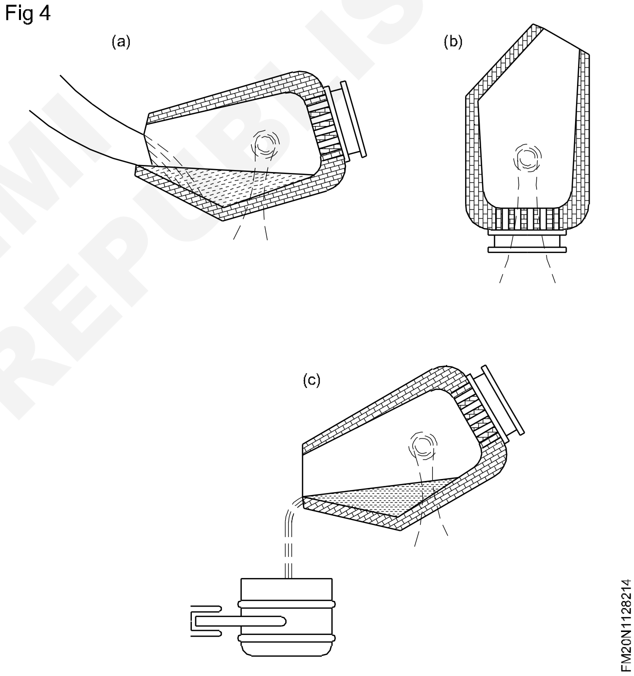
  (the reddish smoke period).

The molten pig-iron from the blast furnace is poured into the converter. (Fig 2) Then a blast of air at 150 to 250 KN/m2 (kilo newton /m2) is directed into the molten metal, and the converter is rotated into an upright position (Fig 3). The conversion stage commences now.

At the preliminary stage, the oxygen of the blast oxidises the iron to ferrous oxide. As a slag, the ferrous oxide mixes with the metal. The silicon and manganese, due to their affinity for oxygen, are separated as oxides and go into the slag. During this reaction, a large amount of heat is generated which increases the temperature from 1250°C to 1525°C. This stage lasts for 3 to 4 minutes.

The 2nd stage helps the burning of carbon from the molten bath. The dissolved carbon is oxidised by the ferrous oxide of the slag. At the same time, carbon monoxide will be burning at the nose of the converter with a dazzling white flame. This elimination of carbon takes place for about 8 to 12 minutes. The 3rd stage starts with the subsiding of the flame. It means that the carbon has been practically removed from the charge. This stage lasts for one or two minutes. Then the converter is brought to a horizontal position. (Fig 4)

Fig 4



To eliminate oxygen and to bring silicon, manganese and carbon content of the steel to a specific limit, de-oxiders like ferro-manganese, ferro-silicon or aluminum are added to the metal bath.

The Bessemer process has the following disadvantages.

The steel produced by the Bessemer Process will have an increased oxygen content which will impair its mechanical properties. Due to this reason, it cannot be used for producing cutting tools, springs and parts subject to impact, load etc.

When the Bessemer converter is lined with silicous refractory material, this process is called Acid process.

When the converter is lined with a basic refractory,it is called a basic process or Thomas process.

Steel manufacturing by open-hearth process

This process eliminates the disadvantages of the Bessemer process. Most of the steel in our country is produced by SIEMENS-MARTIN process using an open-hearth furnace.

Open-hearth furnace

An open-hearth furnace is a reverberatory furnace, having a melting chamber built with refractory materials, bounded at the top by the roof, and at the bottom by the hearth. The charging doors are provided at the side walls. The melting area is connected with regenerators through ports.

Fuel for this process is the producer gas generated by a plant which can be fed to the hearth through two generating chambers. The air, which forms a combustible mixture, may be fed the same way through the other two chambers.

Heating through producer gas and air is the characteristic of the open-hearth furnace.

For the chemical reaction of the charge, intense heat is required. This can be achieved through regenerating chambers.

The process

The hearth is first prepared and heated well up to 1500°C. The charge is a mixture of pig-iron and steel scrap in different proportions as required according to the class of steel to be manufactured.

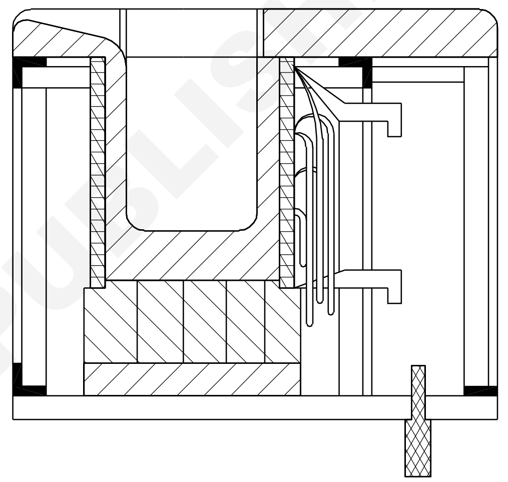
The ratio of pig-iron to scrap varies from 1:4 to 4:1. A reasonable ratio is 3:2. After the charging is over, the gas is allowed in to the melting chamber. During melting, part of the carbon, most of the silicon and manganese are removed by oxidation. More carbon will be oxidised away at the boil- stage by adding iron ore to the charge. When the bath reaches the requisite percentage of carbon, the furnace is allowed for tapping. While the metal is flowing into the ladle, a de-oxidiser is added to the steel to remove air, and ensure soundness in the metal.

The high frequency furnace (Fig 5)

This furnace consists of a crucible made of refractory materials, surrounded by an inductor coil which carries the alternating current, and is insulated and water-cooled. The outer ring is made of special magnetic iron laminations, and it shields the casing from getting too hot. It also serves as a magnetic shield to increase the magnetic flux in the coil. The charge used consists of steel scrap and iron oxide.

The steel is further refined by re-melting and addition of the required alloying elements. Steel, produced by these processes, is used for making press tools, cutting tools and precision measuring instruments.

Fig 5



Alloy steels

Objectives : At the end of this lesson you shall be able to
- **state the alloy steel**
- **describe the alloy steels, type and its uses.**

Alloy steels are those which contains in addition to carbon and iron, alloying elements such as nickel, chromium, vanadium, tungsten, molybdenum, cobalt, manganese or silicon. Each of these alloying elements gives a typical property to the steel. (wear and tear, corrosion an abrasive action)

Listout of common elements

1 Nickel steel

2 Chromium steel

3 Stainless steel

4 High speed steel

Nickel steels

In these steels nickel is the principal alloying element the amount added may be up to 36%

Steels having carbon 0.2 to 0.35% and nickel upto 5% are tough, resistant to fatigue and have more tensile strength nickel steel containing 36% is called invar. It has least co-efficient of expansion

Uses nickel steels:

1 Storage cylinders for liquiefied gases

2 Heavy forgings

3 Turbine blades

4 Highly stressed screws,bolts and nuts

5 Shafts, gears,propeller shafts, and keys

6 Springs

7 Connecting rods and their bolts.

8 Crankshafts

9 Rolling element

10 Bearings

11 Measuring instruments

Chromium steels

In these steels chromium is the principal alloying element. Addition up to 2% makes the steel more strong and hard but the ductility is reduced. Addition of both nickel and chromium improves the ductility of steel

Uses of chromium steels:

1 Surgical instruments

2 Drills

3 Files

4 Wrenches

5 Shaving blades

6 Cutting machine parts

Stainless steel

These steels contain mainly chromium and nickel and are classified as follows.

Martensitic stainless steels

They contain approximately 12 to 14% chromium and 0.1% to 0.3% carbon. These steels can be cold worked and work hardened.

Uses

1 Cutlery

2 Springs

3 Steam turbine blades

4 Ball bearings

Ferritic stainless steel

They contain chromium from 15 to 30% and cannot be heat-treated. They are resistant to corrosion and have great strength.

Uses

1 Cutlery

2 Surgical instruments

3 Automobile parts

4 Brewery industry equipments

5 Industrial equipments (e.g.paper mills, chemical plants,water treatment)

6 Construction material in large buildings

7 Chemical industry equipments

Austenitic stainless steel

These steels contain chromium and nickel. They contain 15 to 20% chromium and 8 to 10% nickel 18/8 (chromium = 18%) and nickel 8%. Steel is most commonly used. These steels cannot be hardened by heat treatment.

Uses

1 Storage tanks

2 Food industry equipments

3 Dairy equipments

4 Heat exchangers

High speed steels

High speed steels can withstand high temperature without losing hardness. Therefore they are used for making tools. The tools made up of high speed steels can be run at high speeds as compared to tools made up of carbon steels. Drills, milling culters tools for lath and shaper are made up of high speed steels. The various high speeds steels are as follow.

Tungston high speed steel

It is also known as 18 - 4 - 1high speed steel as it control tungsten 14% chromium 4% and vanadium 1% such steels contain carbon 0.7%

Molybdenum high speed steels

It contains molybdenum 6% tungston 6% chromium 4% vanadium 2%

Cobalt high speed steels

In these steels the amount of cobalt is upto 15% A typical cobalt high speed steel has the following composition

Carbon - 0.8%

Tungston - 14%

Chromium - 4%

Vanadium - 2%

Cobalt - 8%

Molybdenum - 0.5%

Uses of high speed steel

1 Cutting tools

2 Drills

3 Taps

4 Milling cutters

5 Tool bits

6 Hobbing (Gear) cutters

7 Saw blades

8 Planer and jointer blades

9 Router bits etc.,

10 Punches and dies

Advantages of sprue gate and skim bob gates

Objectives: At the end of this lesson you shall be able to
- **state the advantages of sprue gate and skim bob gate.**

Advantages of sprue gate

1 Good liquidity.

2 Simple construction.

3 Wide range of applicable risers.

4 Material filling is good.

5 Surface of molded products shrinks less.

6 Omit processing of flow path.

7 Less pressure loss.

8 It can form large or deeper molded products.

Advantages of skim bob gate

1 Its traps heavier impurities in the horizontal flow.

2 Its traps the dross (Lighter) impurities.

3 Its relief the pouring pressure.

4 It's used for metal reservoir to feed the casting.

5 Holding the sand tightly.

Wrought iron

Objectives: At the end of this lesson you shall be able to
- **state the manufacturing of wrought iron**
- **state the puddling process.**

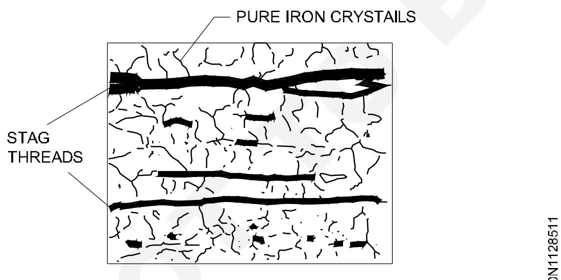
Wrought iron is the purest form of iron Fig 1. The analysis of Wrought iron shows as much as 99.9% of iron. (Fig 2) When heated, wrought iron does not melt, but only becomes pasty and in this form it can be forged to any shape.

Modern methods used to produce wrought iron in large quantities are the

– puddling process

– aston or Byers process

Fig 1



MICROSTRUCTURE OF WROUGHT IRON

Puddling process

Wrought iron is manufactured by refining pig-iron.

By refining pig-iron silicon is removed completely, a great amount of phosphorus is removed, and graphite is converted to combined carbon.

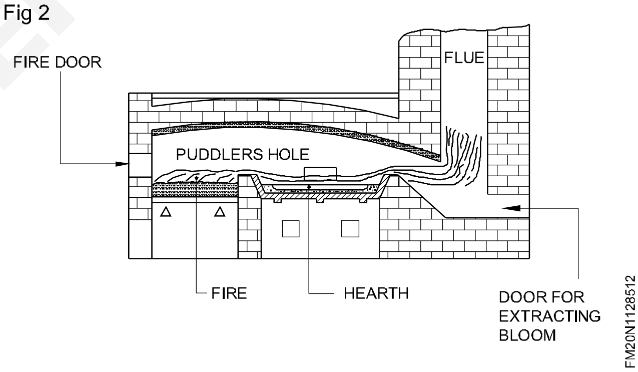
The above process is carried out in a puddling furnace.

Puddling furnace

This furnace is a coal-fired reverberatory furnace. (Fig 2)

The term reverberatory is applied because the charge is not in actual contact with the fire, but receives its heat by reflection from the dome shaped furnace roof.

Fig 2



The product obtained is taken out from the furnace in the form of balls (or blooms) having a mass of about 50 kgs.

The hot metal is then passed through grooved rollers which convert the blooms into bars called MUCK BARS or PUDDLE BARS.

These bars are cut into short lengths, fastened together in piles, reheated to welding temperature and again rolled into bars.

Aston process

In this process molten pig-iron and steel scrap are refined in a Bessemer converter.

The refined molten metal is poured into an open hearth furnace in the iron silicate stage. This removes most of the carbon.

The slag cools the molten metal to a pasty mass which is later squeezed in a hydraulic press to remove most of the slag. Rectangular blocks known as blooms are formed from this mass.

The hot bloom is immediately passed through rolling mills to produce products of wrought iron of different shapes and sizes.

Composition of wrought iron		
Carbon	-	0.02 to 0.03%
Silicon	-	0.1 to 0.2%
Manganese	-	0.02 to 0.1%
Sulphur	-	0.02 to 0.04%
Phosphorous	-	0.05 to 0.2%
Iron	-	the rest of the %

Properties and uses of wrought iron

Properties	Uses
Malleable and ductile.It can neither be hardened nor tempered.	Architectural works.
Tough, shock-resistant fibrous structure; easy for forge welding. Ultimate tensile strength of about 350 newtons per sq. mm.	Crane hooks, chain links, bolts and nuts & railway couplings.
No effect in salt water .	Marine works.
Will not retain the magnetism.	Temporary magnets. Core of dynamos.
Corrosion resistant.	Agricultural equipment
Easy to forge - wide temperature range 850°C to 1350°C.	Pipes, flanges, etc.

Copper

Objectives: At the end of this lesson you shall be able to
- **state the manufacturing of copper.**

Copper

Copper is a very soft and extensible material with a good conductivity of heat and electricity, fire proof quality and an extraordinary resistance to atmospheric influence. Copper has an adhesion force to steel and is a versatile metal easily to forge and to solder.

Copper is molten from copper ores. Apart from copper, copper ores frequently also contain sulphur and oxygen. Copper ores have different carbon content.

Species of ore		Copper content	Places of finding
red copper ore copper-oxygen compound		88%	mainly in the USA congo, spain
copper glance	Copper sulphuric compound	80%	to some extend also in Germany (Mansfeld, Hesse, Rhine province)
variegated copper ore		58%	
yellow copper ore		35%	

In dry process copper is obtained by the roasting - reducing method. The sulphur is eliminated from the copper ores: copper glance and yellow copper ore by roasting in the calciner. First of all oxide of copper comes into existence (red copper ore is not roasted).

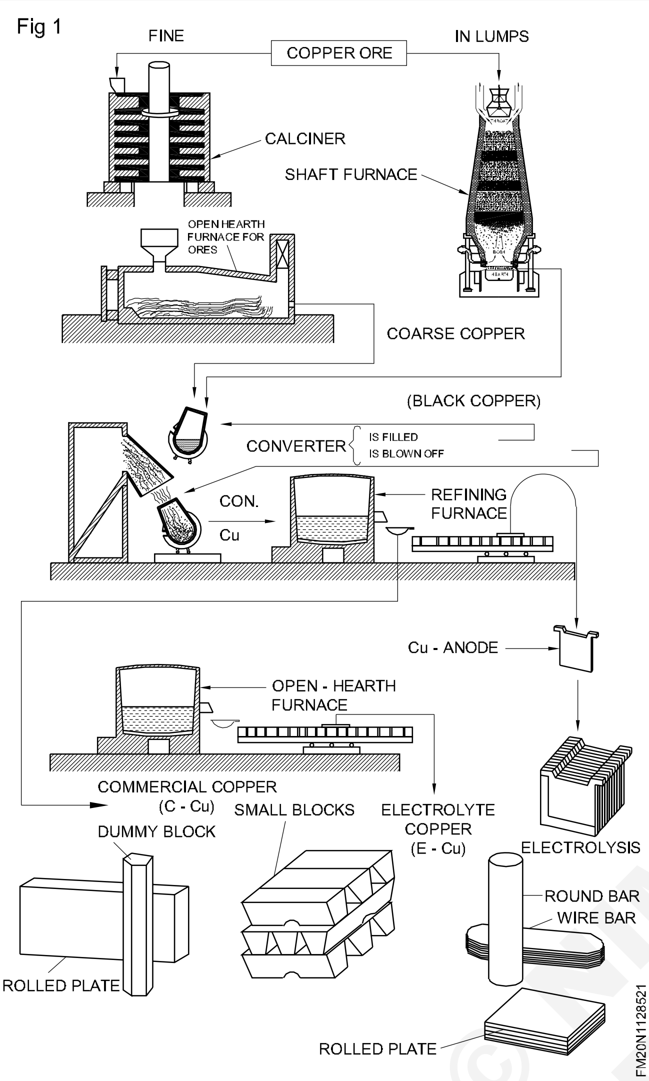
Oxygen is separated from oxide of copper by a reducing melting process in the shaft furnace. The resulting products is coarse copper or commercial copper. Pure copper is produced by repeated remelting (refining).

In wet process copper ores are washed in sulphuric or hydrochloric acid.

Copper of highest purity (99 to 99.99% of purity grade) is obtained by the electrolytic process. A plate of coarse copper forms the positive pole (anode), and a sheet of pure copper forms the negatice pole (cathode), both placed in a solution of sulphuric acid (electrolyte).

The coarse copper dissolves, the impurities fall down and the pure copper deposites on the negative pole under the effect of the electric current. (Fig 1)

The liquefied copper is cast to blocks or bars. By rolling and drawing blocks can be worked to semi-products such as sheets, bands, wires, rods, tubes, forged and pressed parts. Their shapes and dimensions are standardized.



Copper properties

- Good electrical conductivity
- Good thermal conductivity
- Corrosion resistance
- East to alloy
- Ductile
- Toughness
- Non-magnetic
- Easily machining

Uses of copper

1 Plumping components

2 Electric components

3 Roof coverings

4 Industrial machinery (Heat exchangers)

5 wires

Manufacturing process, properties and use of aluminium

Objectives : At the end of this lesson you shall be able to
- **state the manufacturing process of aluminium**
- **state the properties and applications of aluminium.**

Aluminum

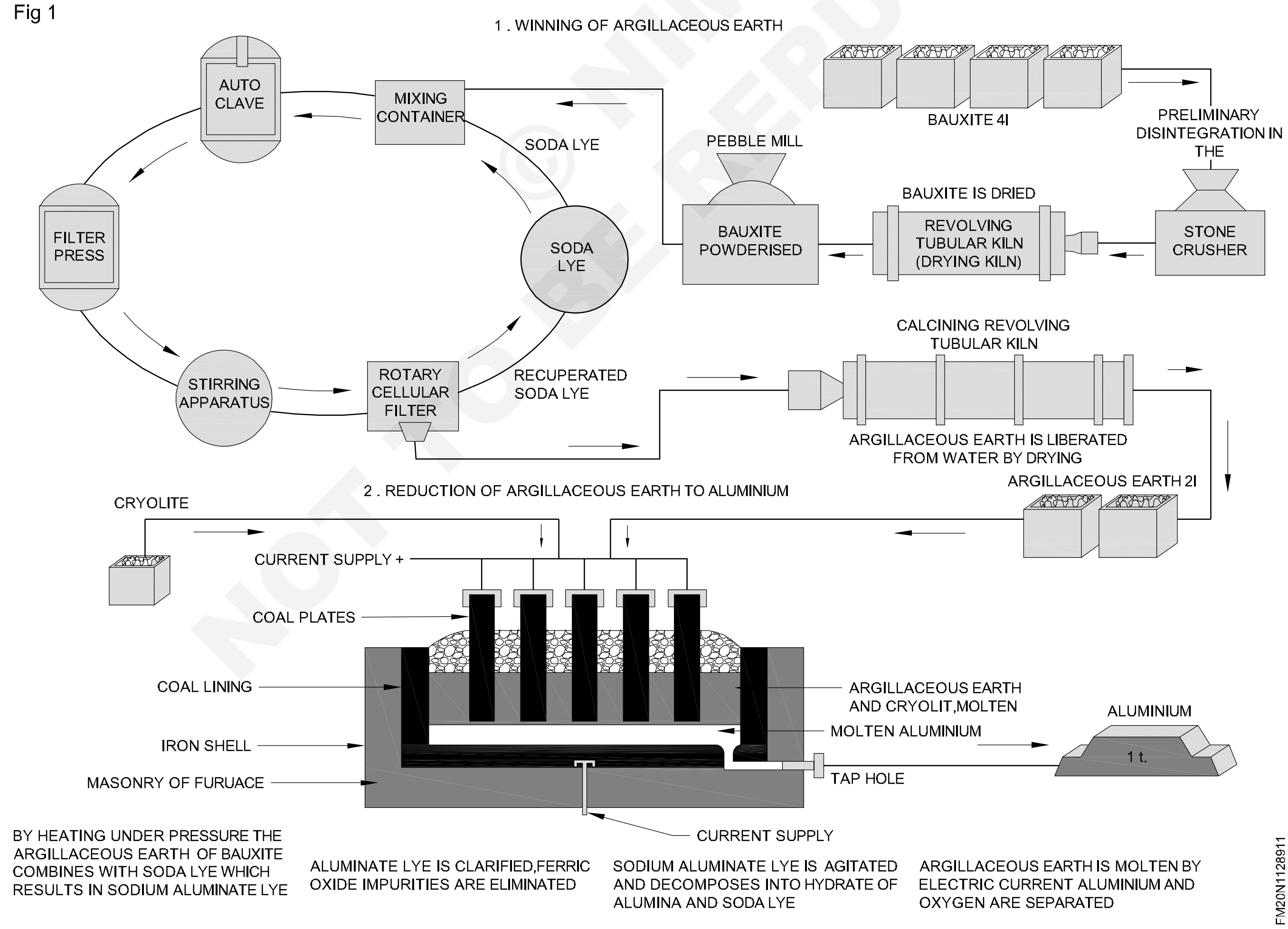
Aluminum is a very soft and extensible material with property of conducting heat and electricity. It is highly resistant to corrosion and is easily alloyable.

Production of aluminum. Bauxite is the most important basic material for the production of aluminum. First of all argillaceous earth is extracted from bauxite: thereafter aluminium is won from argillaceous earth. Bauxite contains 55 to 60% of argillaceous earth (Al_2O_3 = oxide of aluminum). The other advisements are ferric oxide, water and silicic acid. (Fig 1)

Principle places of finding: Southern France, Hungary, Russia, Istria, Dalmatia, India, Arkansas, Guiana. The placers in Germany, near Fludia, are insignificant.

In the bayer process, bauxite is dried and ground. Then it is mixed with soda lye and boiled in autoclaves which are pressure tight boilers at a pressure of 7 atmospheres and 180°C to separate the additaments. The argillaceous earth is filtered from this ley and gives a pure oxide of aluminum after having been dried in the revolving tubular kiln at 1300°C. Then pure aluminum is won from the treated oxide of aluminum of electrolysis. For this purpose, the pure argillaceous earth must be separated in aluminum and oxygen by electric current. In order to reduce the high melting point of the argillaceous earth (2000°C) the latter is molten in the electrolysis furnace under addition of cryolite. This is a mineral which become liquid at about 900°C and of which there are rich deposits in Greenland but which can also be produced artificially. (Fig 1)

Fig 1



Electrolysis furnaces consist of iron tanks lined with coal and operating in series and forming the negative pole (cathode). A number of coal electrodes acting as positive pole (anode) immerse into said tanks. An electric current potential of 5 to 6 V and an intensity of 20000 to 70000 amperes are needed for the melting process for the production of aluminum. The liquefied aluminum of 1000°C separated from the oxygen is collected on the bottom of the tank from where it is sucked and molten into small ingots (chills) which are processed later on to castings or rollings. The obtained aluminum has a high purity.

Absolutely pure aluminium, purity percentage 99.99 is of the highest resistance to corrosion.

Sheets and bands of pure aluminum are rolled, tubes and wires are drawn, solid profiles are produced either by extrusion moulding or by continuous casting. In the continuous casting process, for the production of very solid profiles, the mould is vertically moved upward during the casting process.

Properties

1 It is silvery white in colour

2 It is light in weight. Specific gravity is 2.7 gm/cc

3 It is non corrosive

4 It has very good thermal and electrical conductivity

5 It has good reflectivity of light

6 It can be die cast, forged, blanked, drawn, formed and machined.

7 Its melting point is 660°c.

8 It is very much malleable and ductile.

9 Aluminum is not magnetic

10 It has high tensile strength.

11 It weight - strength ratio is better than steel.

12 It has good machinability.

13 It can be worked both in cold state and hot state.

14 Its strength can be improved by cold working

15 Aluminium is non toxic and non sparking

16 Although this metal has poor resistance to atmospheric corrosion, the formation of aluminum oxide on the surface, protects it from corrosion

17 Aluminum is easily attacked by acids. Alkalies and salts

Application

1 Aluminum is used for making electrical conductors cables, and bus bars

2 It is used for making domestic utensils and appliances

3 Used for reflectors, mirrors and telescopes.

4 Because of its light weight. Aluminum is used in aircraft industry and automobile industry.

Properties of Grey Cast Iron

Objectives: At the end of this lesson you shall be able to

- **state the properties of grey cast iron.**

Grey Cast Iron

Grey Cast Iron is made by remelting pig iron. It is an alloy of Carbon and Iron. Small amounts of Silicon, Phosphorus, Manganese and Sulfur are also present in it. The reasons behind its popularity are: ability to make complex structures and low cost. In addition, the excellent properties of Grey Cast Iron have made it one of the most widely used alloys. Its properties are as follows:

High Compressive Strength

This strength is defined by the endurance of any metal or alloy to withstand its compressive forces. Grey Cast Iron has a high compressive strength and that's why, it is widely used in posts and columns of buildings. In addition, their compressive strength can be as high as that of some Mild Steels.

Tensile Strength

There are different varieties of Grey Cast Iron and their tensile strength varies accordingly. Some varieties show the tensile strength of 5 tons per square inch, some show 19, but on an average their strength is 7 tons per square inch. However, addition of vanadium can increase the strength of Grey Cast Iron.

Hardness

The hardness of gray cast iron can meet the wear-resistant requirements of general engineering machinery parts. The higher the hardness, the better the wear resistance.

Modulus of elasticity

The modulus of elasticity of gray cast iron is not a fixed value, but a variable. There is no straight line in the stress-strain curve, because the existence of graphite makes the gray cast iron produce plastic deformation even under a small stress. The elastic modulus of gray cast iron is related to its strength. The higher the grade is, the greater the elastic modulus is.

Impact toughness

Grey cast iron is a brittle material with low toughness and plasticity. It is not recommended to use grey cast iron as a material bearing impact load.

Damping property

Gray cast iron has good damping property and damping property, which is widely used in machine tool castings and internal combustion engine castings with damping requirements.

Wear resistance

Gray cast iron has good wear resistance under sliding condition, widely used in brake pads, brake drums, cylinder liners, piston rings, machine bed with guide rails and other parts.

Heat fatigue resistance

Grey cast iron has good heat fatigue resistance, which is widely used in automobile cylinder, cylinder head, ingot mold and other castings.

Compactness

The existence of graphite destroys the continuity and compactness of the matrix, but it can still maintain a certain compactness through a variety of control factors, so that the gray cast iron is widely used in hydraulic parts, cylinder, pump body, compressor and other pressure and leakage resistant parts.

Resistance to Deformation

Grey Cast Iron is highly resistant to deformation and provides a rigid frame. However, if there is some construction related problem, then even Grey Cast Iron made structure can breakdown.

Low Melting Point

Grey Cast Iron has low melting point - 1140 ºC to 1200 ºC.

Resistance to Oxidation

Grey Cast Iron is highly resistant to rust, which is formed by the reaction of oxygen and Iron. It is a perfect solution to avoid the problem of corrosion

Casting properties

- Gray cast iron has good fluidity and can be used to produce thin-walled and complicated parts.
- The shrinkage of gray cast iron is reduced due to graphitization expansion during solidification, which can be fully utilized in production to reduce shrinkage and residual stress.
- The casting stress of gray cast iron is composed of thermal stress, transformation stress and mechanical resistance stress, Among them, the thermal stress is the main factor, and the casting stress is the main cause of the cold crack and deformation of gray iron castings.
- Because of the different wall thickness and composition segregation of each part of the casting, the structure of each part of the casting is different, resulting in the great difference in the strength and hardness of each part of the casting. This difference is called section sensitivity. The more complex the structure, the more uneven the wall thickness, the greater the section sensitivity.

Machinability

The flake graphite in the structure of gray cast iron cuts the metal matrix, so it has good machinability. However, with the increase of strength and hardness, the machinability decreases. When cementite appears in the structure, the machinability deteriorates sharply.

Microstructural analysis

Objectives: At the end of this lesson you shall be able to
- **state the function of microstructural analysis**
- **state the microstructure of different metals.**

Microstructure

Microstructure is the very small scale structure of a material, defined as the structure of a prepared surface of material as revealed by an optical microscope above 25× magnification.

Microstructural analysis

Microstructural analysis is used widely to evaluate products and materials. a microstructural analysis is performed in order to evaluate the microstructure in a metal alloy.

The observation is made at different magnifications depending on the observation to be made.

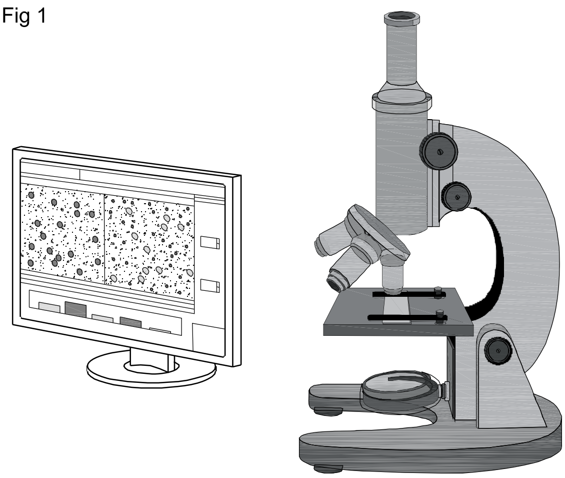
The microstructure of a material allows evaluating the state of supply and the possible presence of metallurgical defects.

The sample should observe how the characteristics vary as a function of thickness.

To perform this analysis it is sufficient to have samples of small dimensions (a few mm2), although it would be ideal performing these on most representative areas be collected from a section of the piece under analysis in order to include both an observation at core and on the surface.

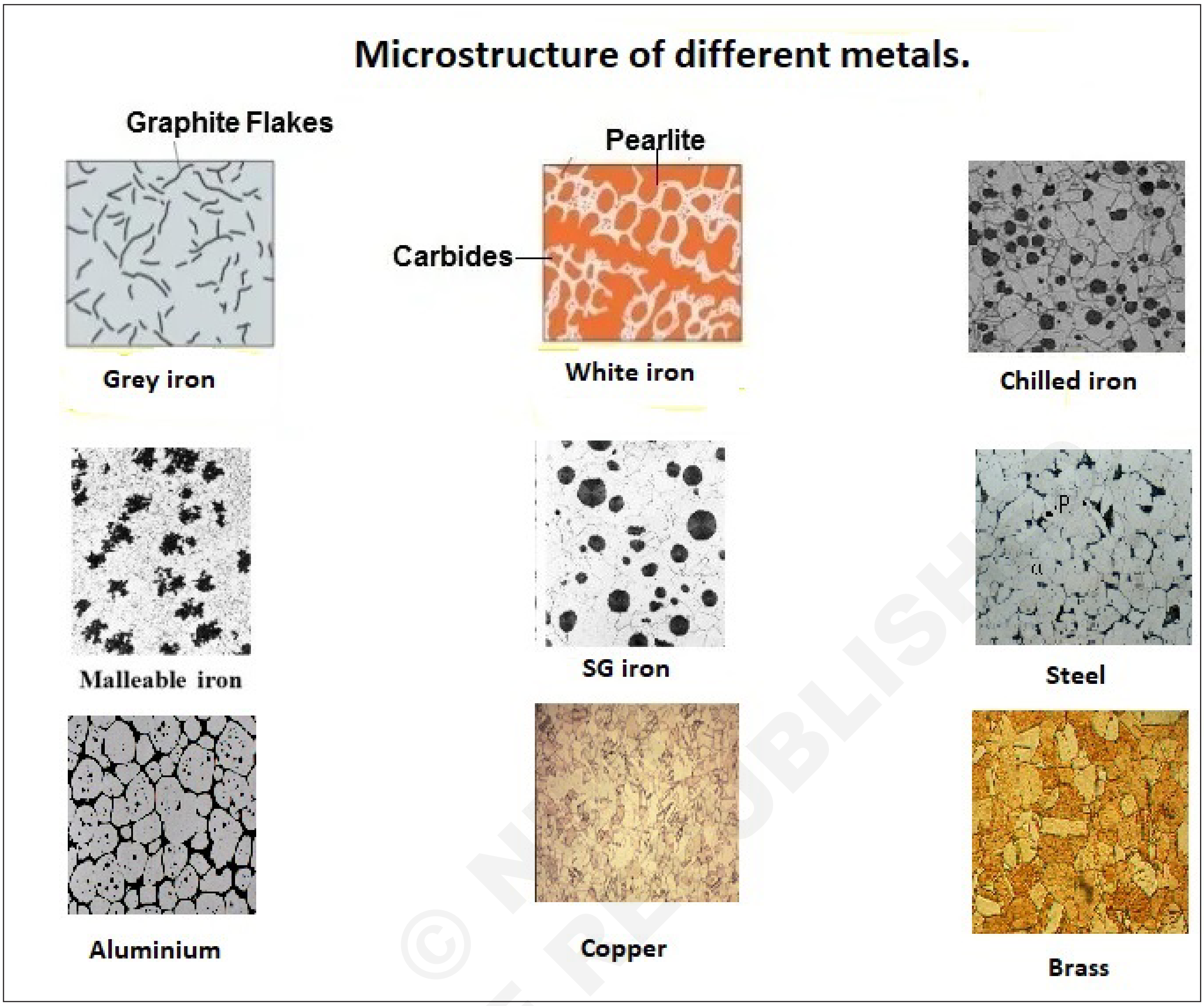
Metallurgical Microscope

Fig 1



METALLURGICAL MICROSCOPE

FM20N1128921



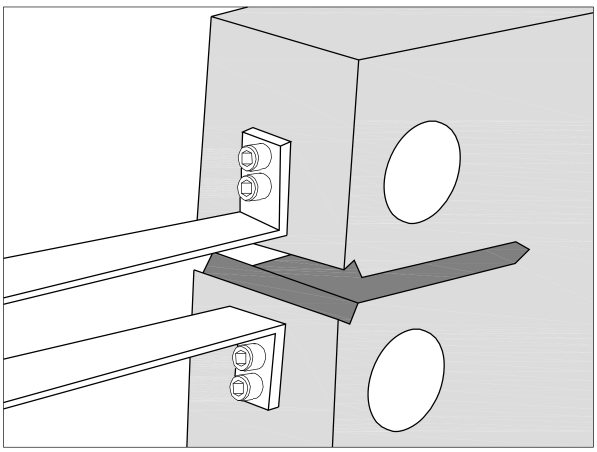
Fracture test

Objectives: At the end of this lesson you shall be able to
- **state the function of the fracture test.**

Fracture test:

Fracture toughness tests measure a material's ability to resist the growth or propagation of a pre-existing flaw. The flaw or defect may be in the form of a fatigue crack, void, or any other inconsistency in the test material. Fracture toughness tests are performed by machining a test sample with a pre-existing crack and then cyclically applying a load to each side of the crack so that it experiences forces that cause it to grow. The cyclic load is applied until the sample's crack grows. The number of cycles to fracture is recorded and used to determine the material's fracture growth characteristics.

Fig 1



FRACTURE TEST

FM20N1128931

Purpose of fracture toughness testing

Fracture toughness is the stress that causes a pre-existing crack or flaw to grow or propagate. It is an important material property in the manufacturing industry, since the presence of flaws is not completely avoidable.

The stress intensity factor, which is a function of the flaw size, geometry, and loading, is used to determine a material's fracture toughness. A material's stress intensity factor and fracture toughness are related to one another in the same manner that stress and tensile stress are related to each other.

Types of fracture toughness tests

For the majority of fracture toughness tests there are three different modes of fracture for crack propagation. Mode 1 requires that the applied load be in the normal direction of the crack plane. In mode 2 the load is applied along the length of the crack plane. Finally, for mode 3 the load is applied across the width of the crack plane. Generally there are two different configurations for the test sample: single edge notch bend (three point bending) and compact tension. A three point bending specimen has the initial crack located at the midsection on the opposite side from the point where the midsection load is applied with opposing points of force located at each end on the same side as the crack. A compact tension specimen is oriented so the load is applied on each side of the crack in a way that extends the width of the crack.

Types of materials tested with fracture toughness tests

Nearly all manufactured materials will contain a defects, flaws or cracks to some magnitude and may experience fracture due to these inconsistencies and when or if this does occur the fracture toughness of that material will be exhibited. The materials that are most commonly tested for fracture toughness are similar to those tested in fatigue tests but have slightly different orientations. These materials include metals, plastics, ceramics and composites among others as well as many other rigid substrates that may contain defects.

Tensile test

Objectives: At the end of this lesson you shall be able to
- **state the function of tensile testing machine.**

Tensile testing

Tensile Testing is a form of tension testing and is a destructive engineering and materials science test whereby controlled tension is applied to a sample until it fully fails.

This is one of the most common mechanical testing techniques. It is used to find out how strong a material is and also how much it can be stretched before it breaks. This test method is used to determine yield strength, ultimate tensile strength, ductility, strain hardening characteristics, Young's modulus and Poisson's ratio.

Test Properties

Yield Strength

The yield strength is the point at which plastic deformation occurs under stress. This is determined during testing over a measured gauge length via the use of devices known as extensometers. The devices may be either be mechanical clip on or video where non-contact is a limitation, e.g. elevated temperature testing.

Ultimate Tensile Strength (UTS)

The UTS is the maximum stress that a specimen is exposed to during testing. This may differ from the specimen's strength when breaking depending on if it is brittle, ductile or has properties of both. These material properties can change depending on environment, for example in extreme hot or cold conditions.

Ductility

Ductility relates to the elongation of a tensile test. The percentage of elongation is calculated by the maximum gage length divided by the original gage length. It is commonly described

Strain Hardening

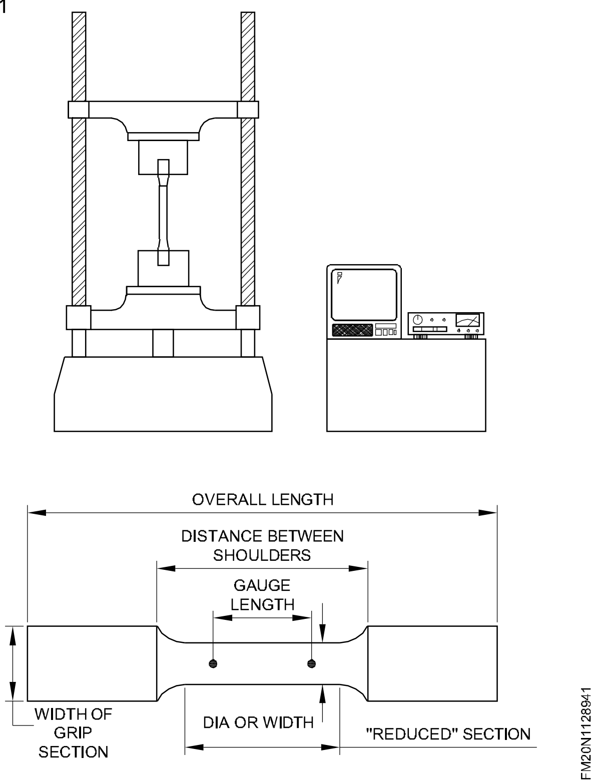
How much it harderns with plastic deformation.

Modulus of Elasticity

The modulus of elasticity also known as Young's modulus measures the stiffness of a specimen whereby the material will return to its original condition once the load has been removed. Once the material has been stretched to the point where it no longer returns to its original length and permanent deformation is shown, Hooke's Law no longer applies. This is known as the elastic or proportional limit (also the yield strength).

Tensile testing machine

Fig 1



Hardness test

Objectives: At the end of this lesson you shall be able to
- **state the function of hardness test**
- **state the different type of hardness testings.**

Hardness test

The hardness test is a mechanical test for material properties which are used in engineering design, analysis of structures, and materials development. The principal purpose of the hardness test is to determine the suitability of a material for a given application, or the particular treatment to which the material has been subjected. The ease with which the hardness test can be made has made it the most common method of inspection for metals and alloys.

Hardness

Defined as the resistance of a material to permanent deformation such as indentation, wear, abrasion, scratch. Principally, the importance of hardness testing has to do with the relationship between hardness and other properties of material. For example, both the hardness test and the tensile test measure the resistance of a metal to plastic flow, and results of these tests may closely parallel each other. The hardness test is preferred because it is simple, easy, and relatively nondestructive. There are many hardness tests currently in use. The necessity for all these different hardness tests is due to the need for categorizing the great range of hardness from soft rubber to hard ceramics.

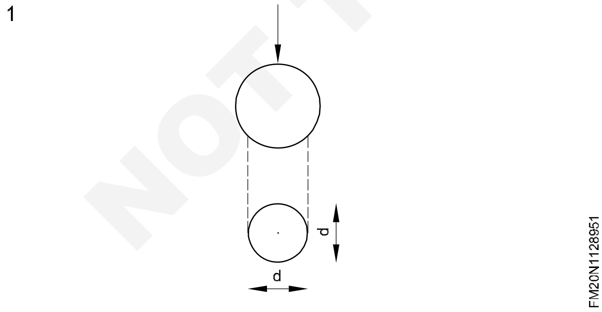
Types of Hardness testes

1 Brinell hardness test
2 Rockwell hardness test
3 Vickers hardness test
4 Knoop hardness test

Brinell hardness test

The Brinell hardness test is used for hardness testing larger samples in materials with a coarse or inhomogeneous grain structure. The Brinell hardness test (HBW) indentation leaves a relatively large impression, using a tungsten carbide ball. The size of the indent is read optically.

Fig 1

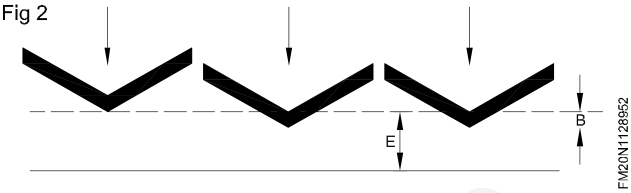


- Used for materials with a coarse or inhomogeneous grain structure
- Used for larger samples
- Suitable for forgings and castings where the structural elements are large

Rockwell hardness test

Rockwell is a fast hardness test method developed for production control, with a direct readout, mainly used for metallic materials. The Rockwell hardness (HR) is calculated by measuring the depth of an indent after an indenter has been forced into the specimen material at a given load.

Fig 2



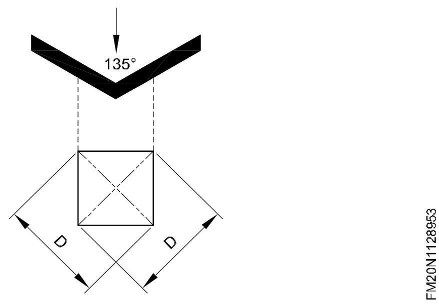
- Generally used for larger sample geometries
- A 'quick test' mainly used for metallic materials
- Can be used for advanced tests, such as the Jominy (end quench) test (HRC)

Vickers hardness test

Vickers is a hardness test for all solid materials, including metallic materials. The Vickers Hardness (HV) is calculated by measuring the diagonal lengths of an indent in the sample material left by introducing a diamond pyramid indenter with a given load. The diagonals of the indent are measured optically in order to determine the hardness, using a table or formula.

- Used for hardness testing of all solid materials, including metallic materials
- Suitable for a wide range of applications
- Includes a sub-group of hardness testing of welds

Fig 3

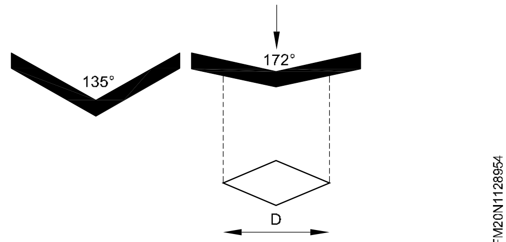


Knoop hardness test

Knoop (HK) is an alternative to the Vickers test in the micro hardness testing range. It is mainly used to overcome cracking in brittle materials, as well as to facilitate the hardness testing of thin layers. The indenter is an asymmetrical pyramidal diamond, and the indent is measured by optically measuring the long diagonal.

- Used for hard and brittle materials, such as ceramics
- Suitable for small elongated areas, such as coating

Fig 4



Copper base alloys

Objectives: At the end of this lesson you shall be able to
- **state the manufacturing process properties and uses of copper base alloys.**

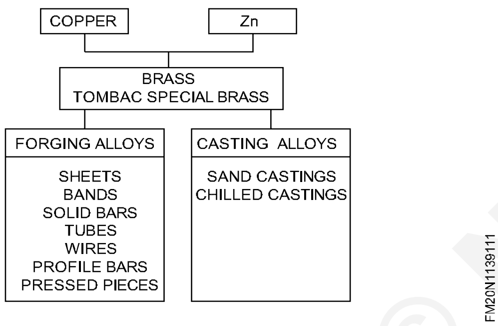
Copper alloys

Properties of the base metal copper are improved by alloying which is an allegation of two or more metals which are in liquefied state. Alloying results in an increase in strength and hardness as well as in the cutting and casting properties and in the meltability. Depending on the nature and the added quota of alloying metals, copper alloys have a colour different to that of copper. The most important copper alloys are brass, bronze and gunmetal.

Brass

Brass is a copper-zinc containing at least 50% of copper (Fig 1).

Fig 1



Copper -zinc alloys with more than 67% of Cu (copper) are occasionally called tombac. Special brass is used for high stresses. Besides copper and zinc, it also contains parts of manganese, aluminum, iron, nickel, silzium and tin. There are cast brass and rolled brass (casting alloys and forging alloys).

Properties of brass

- Ductility
- Wear resistance
- Thermal conductivity
- Corrosion resistance
- Good machinability

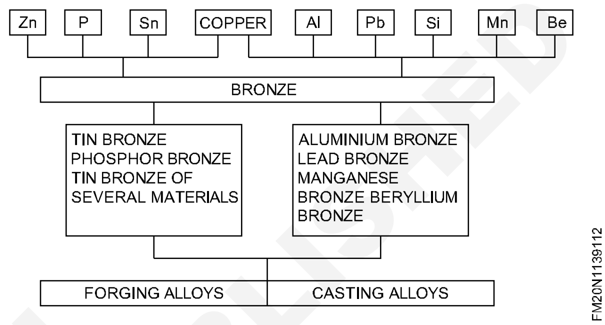
Use of brass

- Electrical sockets and switches
- Electrical and plumbing application
- Musical instrument
- House hold things sculptures etc…

Bronze

Bronzes are alloys composed of at least 60% of copper and of one or more alloying metals. When in the alloying process tin, aluminum, lead, silicon, manganese, nickel, or beryllium are added to copper, the resulting product is tin bronze, aluminum bronze, lead bronze, silicon bronze, manganese bronze, nickel bronze, and beryllium bronze (Fig 2). They are soft to hard, can be cast and cut without any difficulty and have a high resistance to corrosion as well as good running qualities.

Fig 2



Bronzes can be classified as two-or several material alloys and can be cast or rolled.

According to the manufacturing method, cast bronzes are called casting alloys while rolled bronzes are called forging alloys.

Properties of bronze

- Reddish -brown colour
- Hardness and brittleness
- Corrosion resistance
- High electrical conductivity
- Low-friction properties

Uses

- Marine and fishing
- Sculptures
- Musical instruments
- Electrical connecters and springs
- Bushings and bearings

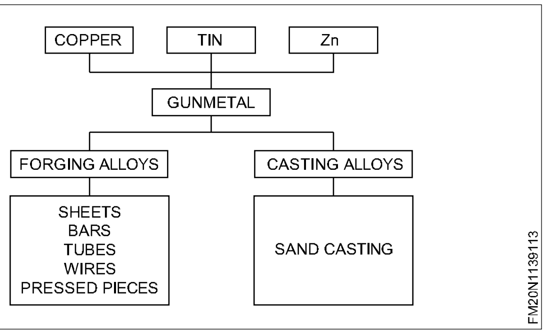
Gun metal

Gun metal, also known as red brass, it's an alloy of copper, tin, and zinc. Proportions vary but 88% copper, 8-10% tin, and 2-4% zinc is an approximation. Originally used chiefly for making guns, it has largely been replaced by steel.

Production of Gun metal

Gun metals are alloys composed at least 80% of copper,8-10 % of tin and 2-4% zinc. the raw materials are first mixed and then melted, so as to obtain an alloy with specific mechanical and chemical characteristics for each production.

Fig 3



Properties

1 It is, highly strong, can resist explosion, hard & tough.,

2 It, gives better casting,

3 More, corrosion resistant

Uses

It is used, for hydraulic fittings, high pressure steam plants, marine pumps, water, fittings, etc.

Aluminium alloys

Objectives: At the end of this lesson you shall be able to

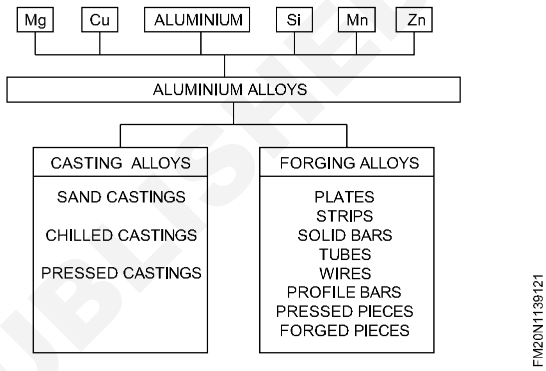
- **state the manufacturing process, applications of aluminum alloys.**

Aluminium alloys

If other metals e.g. copper, manganese, silicon, mangansium are added to aluminium (Fig 1) aluminum alloys will result. They hae a high strength and hardness, whereas workability and conductibility of electricity decrease. Aluminum alloys are of greatest versatility. Some aluminum alloys, for instance cupriferous alloys, can be temper-hardened . With this processing, the alloy obtains the strength of good steel. There are aluminum-forging alloys which are worked to semi-products by forging, and aluminum-casting alloys for semi-products obtaining their shape by casting.

Aluminum casting alloys are worked into sand castings, chilled castings and pressed castings. Chilled castings are produced by pouring the liquefied metal into moulds of grey cast iron. They have a better dimensional accuracy and strength than sand castings. Pressed castings are made by pressing the liquefied metal under high pressure in accurately shaped moulds of steel.

Fig 1



Forgings alloys - The abbreviation AlMg$_3$ means: Al = aluminum alloy: Mg$_3$ = average magnesium content = 3%

Abbreviations (characteristic colour	Characteristic properties	tensile strength kg/mm^2	Shapes and conditions when delivered	Application
AlCuMg (dark red) commercially available as duralumin and bondur	high-strength alloy; temper hardenable, age-harden at ambient temperatures, very high strength; when plated highest resistance to corrosion particularly against sea water; can be anodized,	18 to 45	plates, bands, plate and band profiles, plated and non-plated tubes, solid bars, wires, profilated bars, pressed parts and forged pieces. Delivery state of these semi-products can be soft, age-hardened or hard pressed.	high class structural material for highly stessed structural members with high requirements of resistance to corrosion
AlCuMgP$_b$ (black)	good machining properties; age hardenable; anodizable; high-strength alloy. Specific gravity 2.8 kg/m^3	33 to 38	strips, tubes, bars pressed parts, forged pieces	for machining drilled and turned parts

AlMgSi (white) commercially available as pantal, anticorodal	Age-hardenable, limited age-hardening at tool temperatures warm age-hardenable, moderate strength, well workable polishable, good resistance to corrosion, weldable specific gravity 2.7 kg/m^3	11 to 32	plates, bands, plate and band profiles, tubes, solid bars, pressed parts and forged pieces	structural members, moderately stressed good resistance to chemicals
$AlMg_3$ Si (green- white) commercially available as pantal, anticoradal	Very god weldability, very good resistance to chemicals, specific 2.7 kg/m^3		plates, bands, solid bars, wires, profilated bars, pressed parts forged pieces.	structural members moderately stressed, high resistance to atmospheric corrosion; tank construction
$AlMg_3$ Si (green-yellow) commercially available as hydronalium	same properties as $AlMg_5$ and $AlMg_7$. Specific gravity 2.65 kg/m^3	17 to 26	plates, bands, tubes, solid bars, wires, profilated bars, pressed parts and forged pieces plates, tubes, solid bars, pressed parts and forged pieces	preferably used for decorative anodizing and same as $AlMg_5$ and $AlMg_7$
$AlMg_5$ (green- black) commercially available as hydronalium	higher resistance to sea water and low alkaline solutions than pure aluminium and other unplated alloys; very good polishable, anodizable, weldable. Specific gravity 2.6 kg/m'	22 to 25		moderately and highly stressed structural members; high resistance to corrosion and sea water; mainly used for naval constructions, in the chemical and food industries
$AlMg_7$ (green- red) commercially available as hydronalium		30 to 35		
AlMgMn (green)	Good weldability, resistant to sea water. Specific gravity 2.7 amd 2.75 kg/m'	18 to 26	plates, tubes, solid bars, pressed parts and forged pieces	vehicle facings, ship building, chemical and food industries
AlMn (violet)		9 to 15		

II Aluminium casting alloys

Sand and chilled castings

Abbreviations (characteristic colour	Tensile strength kg/mm^2	Specific gravity kg/m^3	Characteristic properties	Application
G Al Si (blue-white)	17 to 26	2.65	Good resistance to chemicals, excellent casting property, good weldability	Chemically stressed castings, also for the food industry; for intricate thin-walled castings liquid-tight and resisting to shocks and vibrations.
G AlSi (Cu) (blue)	15 to 26	2.65	Very good casting property, weldable	Intricate and thin-walled highly stressed liquid-tight castings of all kinds.
G Al Si Mg (blue-yellow-white)	18 to 32	2.65	Good resistance to chemicals, excellent casting property, good weldability, age-hardenable	Intricate and thin-walled highly stressed liquid-tight castings of all kinds. In case of castings subject to wear: Si 11 to 11 to 13%
G Al Si Mg (Cu) (blue-yellow)	18 to 32	2.7	Excellent casting property, good weldability, age-hardenable	Intricate and thin-walled highly stressed castings of all kinds.
G Al Si_5 Cu 1 (blue-red)	16 to 30	2.8	Very good casting property, good weldability, age-hardenable	
G Al Si_9 (Cu) (blue-red-blue)	15 to 22	2.7	Very good casting property, weldable	Intricate thin-walled highly-tight castings

G Al Mg Mn (white-yellow-white)	14 to 33	2.7	very good chemical resistance to sea water; of higher stability than pure aluminum; good polishable anodizing and age hardenable acc. to Si-content	for castings that are subject to medium and high stresses used in: ship building and marine engineering, fire protection, building, chemical and food industries
G Al Mg_3 (yellow-white)	14 to 33	2.7		
G Al Mg_3 (Cu) (yellow)	14 to 20	2.7	good resistance to chemicals, well polishable and anodizable	for medium stressed castings: building, fittings, instruments
G Al Mg_5 (yellow-white-yellow)	16 to 25	2.6	very good chemical resistance to sea water; good properties for polishing, anodizing and age hardening	intricate castings susceptible to corrosion for architechture and interiro decorating, food and chemical industries
G Al Si_5 (yellow-green-yellow)	15 to 30	2.7	good casting properties, age hardenable, well polishable, good resistance to chemicals	hardware and fittings as well as for castings of the chemical and food industries.
G Al Si_6 Cu_3 (red)	16 to 22	2.75	good casting properties weldable	for thin-walled castings of all kinds, medium and high stresses
G Al Cu Si (red-red)	16 to 22	2.8	good casting properties, non-resistant to shocks, good workablility	for normally stressed castings of all kinds

The uses of aluminum alloys are given below

1 In transpratation industry, these alloys are used for structural frame work, engine parts, decoratives hardwares, doors, window frames, tanks, furnishing and fittings.

2 For over head cables and heat exchanger components.

3 In food processing industry as pans, refrigeration and storage containers and bakery equipment.

4 For making lighting fixtures, grills, gratings, roofings and fastened.

5 In chemical industries fixtures, grills, gratings, roofings etc.

Cupola furnace

Objectives : At the end of this lesson you shall be able to
- **state about the cupola furnace**
- **explain the parts and its function of cupola furnace**
- **listout the zones of cupola furnace.**

Cupola furnace

Cylindrical furnace normally lined with refractors for melting in direct contact with fuel by forcing air under pressure through tuyeres.

Parts of cupola the parts of cupola shown in Fig 1

1 Foundation
2 Propping rod
3 Cupola legs
4 Bottom plate
5 Bottom door
6 Metal spout
7 Breast hole
8 Slag spout
9 Tuyeres
10 Wind box
11 Blast pipe
12 Shell
13 Charging platform
14 Charging door
15 Spark areaster

Construction

Foundation & legs

Foundation steel columns +connect concrete with bolts and nut it resists the cupola.

Bottom plate

A plate on which cupola shell in erected.

Propping rod

An iron rod or pipe used to support the bottom doors of a cupola.

Bottom door

The bottom door is hinged and can swing freely when opened it is held closed by a vertical prop it is made out of mild steel.

Metal spout

An opening in the furnace to let out the molten metal way to ladle which is lined with refractory material.

Breast hole

It is the way for the lighting cotton waste and fire wood.

Slag spout

An opening in the cupola furnace letout the molten slag way to slag tank.

Tuyeres

Tuyeres which is used for an opening in a cupola shell and refractory lining through which the air is forced for compustion

Wind box

It equlinzes the volume and pressure of blast and delivers it to tuyeres.

Blast pipe

Pipe for conduction air under pressure ,usually refers to section between blower or fan and cupola air belt.

Shell

It consists of a vertical, cylindrical shell made out of shell which is atleast 12mm thickness .it acts as a safety wall inside of a refractory lining.

Charging platform

Charging materials keep on the platform it is used for charging into the cupola.

Charging door

It is used for charge the materials into the furnace.

Spark areaster or chimney

A device over the top of the cupola to prevent emission of spark.

Zones of cupola furnace

1 Crucible zone of wall zone

2 Tuyeres zone

3 Compustion zone

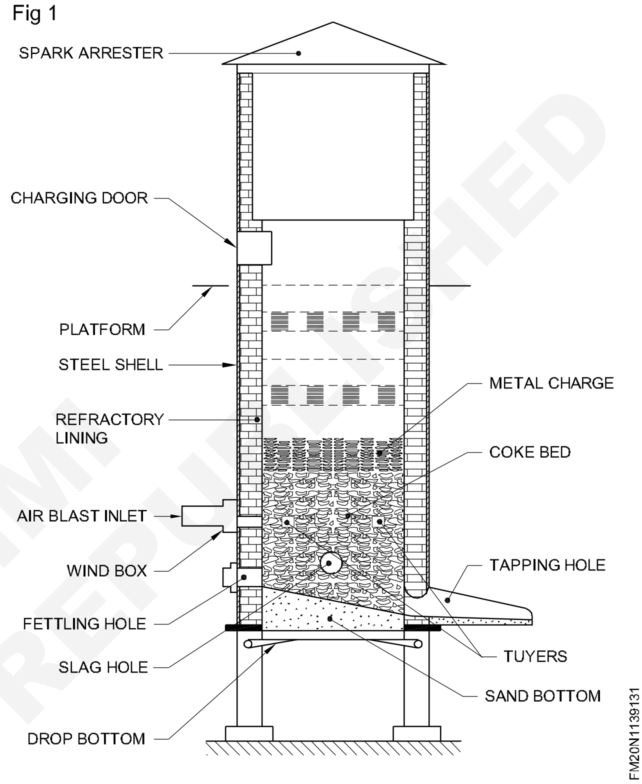
4 Reduing zone

5 Melting zone

6 Preheating zone

7 Stack zone

Fig 1



Zones in a cupola

Objectives: At the end of this lesson you shall be able to
- **state the well or crucible zone**
- **state the tuyeres zone**
- **state the oxidizing zone or combustion zone**
- **state the reducing zone or protective zone**
- **state the melting zone**
- **state the preheating zone**
- **state the stack zone.**

Well or crucible zone

Locate the portion between the lower edge of the tuyeres and the bottom of the cupola no combustion takes place in this zone.

Tuyere zone (B)

50cm above tuyeres and 50cm lower tuyers. This is the space occupied by the tuyers.

Oxidising zone or combustion zone

Situate normally 15cm to 30cm above the top of the tuyers.

All the oxygen in the air blast is consumed here owing to the actual combustion taking place in the zone.

Lot of heat is liberated and supplied from here to other zones. Oxidation of manganese and silicon evolve still more heat.

The chemical (ie exothermic) reactions which occur in this zone are

$C + O_2$ (from air) -> CO_2 + Heat - (i)

$2Mn + O_2$ (from air) -> MnO_2 + Heat - (ii)

$Si + O_2$ (from air) -> SiO_2 + Heat - (iii)

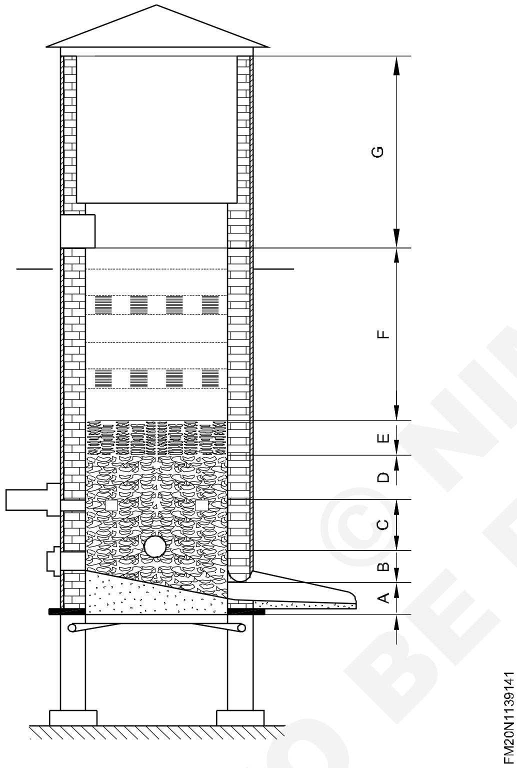
The exothemic reaction produces 14452 Btu of heat per pound of carbon in the coke .

The temperature of the combustion zone varies from 1550^{0}C.

Reducing zone or protective zone (D)

Extends from the top of combustion zone to the coke bed.

Fig 1



Reducing atmosphere and thus protects from oxidation, the metal charge above and that dropping through it.

An endothermic reaction takes place in this zone in which some of hot CO_2 moving upward through hot coke get reduced.

CO_2 + C(coke) -> 2CO - heat

Reduces the heat in the reducing zone and consequently it has a temperature only of the order of 2910 BTU / pound of total carbon in the coke.

Melting zone (E)

Melting zone starts from the first layer of metal charge above the coke bed and extends upto a height of 90cm or less.

Melt iron charge in this zone and trickle down through the (initial) coke bed to the well zone.

The temperature in the melting zone is around or above 1600^{0}C.

Following reaction taking place in this zone, the molten iron picks up carbon.

$3Fe + 2CO$ -> $Fe_3C + CO_2$

Pre heating zone (F)

Start preheating zone is from above the melting zone and extends upto the bottom of the charging door.

Preheating zone contains cupola charge as alternate layers of coke, limestone and metal.

Gases like CO_2, CO and N_2 rising upwards from combustion and reducing zones preheat the cupola to above 1100^0 C.

Preheat charges gradually moves down in the melting zone.

Stack zone (G)

Extend the stack zone from above the preheating zone to where the cupola shell ends and spark arrester is attached escape hot gases from cupola pass through the stack zone and escape to atmosphere stack gases (ie gases passing through stack zone) will normally contain about equal amounts of CO_2 and CO which is 12% each and the rest 76% is nitrogen associated with the cupola zones is the heat balance for the cupola.

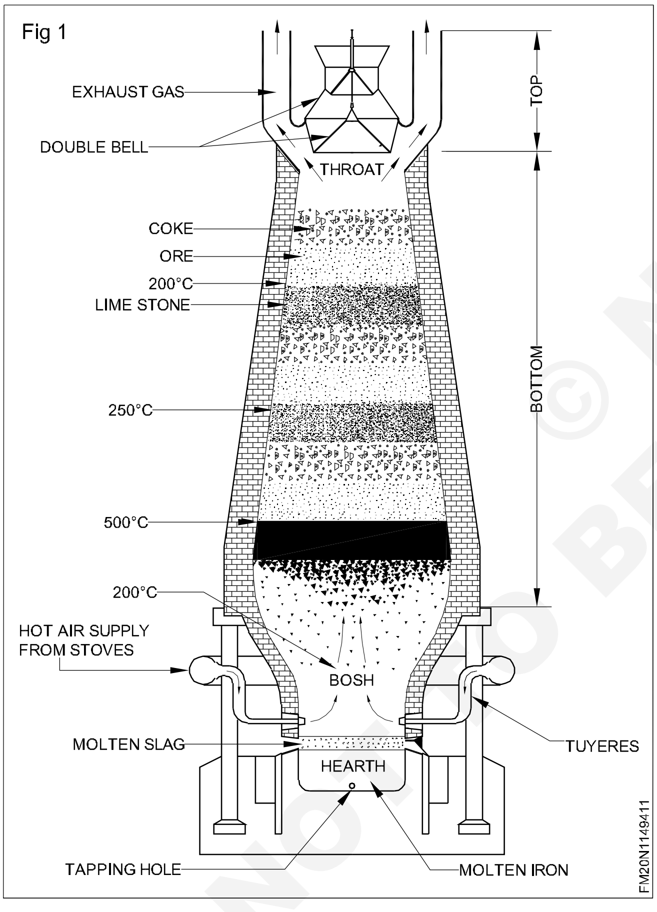
Blast furnace

Objectives: At the end of this lesson you shall be able to
- **state about blast furnace**
- **state about construction and operation of blast furnace**

Blast Furnace:

Blast Furnace, a vertical shaft furnace that produces liquid metals by the reaction of a flow of air introduced under pressure into the bottom of the furnace with a mixture of metalic ore, coke, and flux fed into the top. Blast furnace are used to produce pig iron from iron ore for subsequent processing into steel, and they are also employed in processing lead, copper, and other metals. Rapid combustion is maintained by the current of air under pressure.

Fig 1



Shaft or stack

The furnace mainly consist of a tall structure about 30 meters height and 10 meters diameter at the widest section.It is made of two cones with their bases together the upper one being longer(known as stack and shaft). The height of the shaft is about three fifth of that of the whole furnace. The stack diameter increases down words gradually. For allowing easy descent of the charge which expends due to increasing heat downwards.

The upper frustum is supported on 12 or 16 cast iron pillared all around the furnace.

Bosh

The lower frustum of cone is known as bosh. It is much smaller in height, the hottest part of the furnace forming the main melting zone. Its diameter narrows down from about 10 to 8 meter in a vertical height of about 5 meter from junction with the stack.

Well or hearth

The bosh rest on a short cylindrical section called hearth or well. The well has some diameter at that of the lower and of the bosh. Its height is three fourth to seven-eight of its diameter.It serves as a vessel for collecting molten iron and slag.It rests on strong concrete foundation covered with several layers of fire bricks.

Lining

Stack, bosh and heart are lined with suitable thickness of refractory the bricks.

The bricks used for stack are of high alumina graphite and chromate bricks used in the bosh and heart regions of with stand both the high temperature scouring action.

Tapping & Slag hole

Slag is mich lighter than metal. Its floats on tap of the molten iron so slag hole is provided at a higher level than the tap hole molten metal is tapped off periodically (say every six hours) and cast in to pigs of about 40kg. Each or taken direct to the steel making furnace.

Blast pipe & Tuyers

A circular main called bustle pipe carries bur blast of air to the furnace it to 12 smaller pepes called "TUYERS" are attached to the bustle pipe. Air is led into furnace through the tuyers.

Blast stove

Air is pre heated (to about 800°C) in heaters known as "Blast stove" before introducing it is in the furnace.

Cooling system

Continuous stream of cold water is circulated through numerous cooling boxes distributed in the brick work to protect the walls of furnace bosh and well regions against high temperature about 20 to 25 million liters of water per day are required for cooling a blasst furnace.

Operation :

Blast furnaces produce pig iron from iron ore by the reducing action of carbon (supplied as coke) at a high temperature in the presence of a fluxing agent such as limestone.Iron making blast furnaces consists of several zones: a crucible-shaped hearth at the bottom of the furnace; an intermediate zone called a bosh between the hearth and the stack, a vertical shaft (the stack) that extends from the bosh to the top of the furnace and the furnace top, which contains a mechanism for charging the furnace. The furnace charge, or burden, of iron bearing materials(e.g, iron ore pellets and sinter). coke, and flux (e.g,limestone) descends through the shaft, where it is preheated and reacts with ascending reducing gases to produce liquid iron and slag that accumulate in the hearth.Air that has been preheated to tempeatures from 900 to 1250°C (1650 and 2300°F), together with injected fuelsuch as oil or natural gas, is blown into the furnace through multiple tuyeres (nozzles0 located around the circumference of the furnace near the top of the hearth, these nozzles may number from 12 to as many as 40 on large furnaces.

The preheated air is in turn, supplied from a bustle pipe a large-diameter pipe encircling the furnace. The preheated an reacts vigorously with the preheated coke. resulting in both the formation of the reducing gas (carbon monoxide) that rises through thr furnace and a very high temperature of about 1650°C (3000°F) that produces the liquid iron and slag.

The bosh is the hottest part of the furnace because of its close proximity to the reaction between air and coke. Molten iron accumulates in the hearth, which has a tap hole to draw off the molten iron and higher up, a slag hole to remove the mixture of impurities and flux.The hearth and bosh are thick-waled structures lined with carbon-type refractory blocks, while the stack is lined with high quality fireclay brick to protect the furnace shell.

The stack is kept full with alternating layers of coke,ore and limestone admitted at the top during continuous operation. Coke is ignited at the bottom and burned rapidly with the forced air from the tuyeres. The iron oxides in the ore are chemically reduced to molten iron by carbon and carbon monoxide from the coke. The slag formed consists of the limestone flux, ash from the coke, and substances formed by the reaction of impurities in the ore with the flux. It floats in a molten state on the top of the molten iron. Hot gases rise from the combustion zone, heating fresh material in the stack and then passing out through ducts near the top of the furnace.

Open hearth furnace

Objectives: At the end of this lesson you shall be able to
- **state the operation of open hearth furnace.**

Open hearth furnace

1 An air furnace does not develop temperature enough to melt steel because a good amount of heat generated by the combustion of fuel is lost in the hot waste gases which pass up the chimney.

2 For this reason, open hearth furnaces, which were earlier used in connection with steel making only, are now widely used in large steel foundries.

3 Approximately 65% of the yearly tonnage of steel castings in U.S.A. is produced in open hearth furnace.

4 For use in steel foundries, open hearth furnaces range from 5 to 100 tons capacity, the popular being a 25 ton furnace.

   - Most of the open hearth furnaces are stationary but some of the units are of tilting type also.

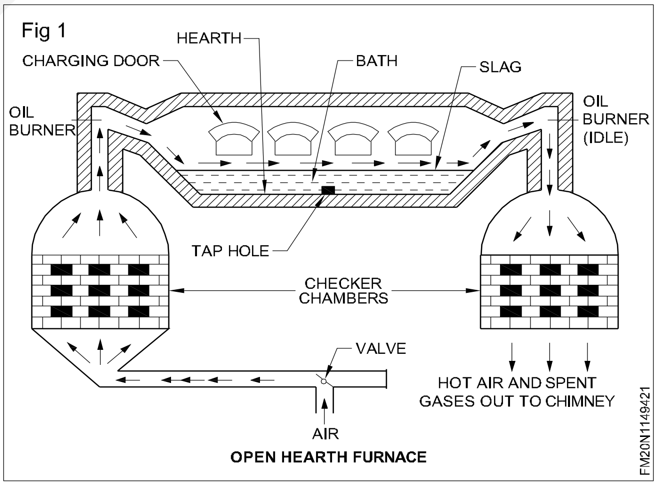
5 An open hearth furnace consists of a long shallow basin called the hearth (about 4.5 m wide, 12m long and half metre deep) which is lined with dolomite etc. in case of a basic (O.H.furnace) process and with silica fire brick if the process is acidic.

6 Scrap metal, pig iron and flux are charged into the furnace through charging doors.

7 Heating is done by burning gaseous fuel (ie natural gas, producer gas or atomised oil)

   - Fuel is fired through nozzles (ie. burners working alternatively for 20 to 30 minutes from opposite ends of the hearth. One of the burners thus remains idle for all times)

Fig 1



OPEN HEARTH FURNACE

8 The hot gases formed pass over the hearth to its opposite end. In doing so, the metal charge supported on the hearth is openly exposed to the flames and is converted into molten metal.

   - Besides being directly exposed to the flames, metal charge is also heated by the radiations from the walls and low hot ceiling of the furnace.

9 After passing over the hearth, the products of combustion pass through one checker chamber and heat it.

- The process (after about 20 to 30 minutes) then reverses, the idle burner fires the fuel, flame passes over the hearth from the opposite direction and the initially active burner becomes idle.
- The products of combustion after sweeping over the metal charge enter the second checker chamber and heat it up. Thus each checker chamber is heated up alternatively.

10 For its working, an open hearth furnace needs air and gaseious fuel. If this air and gaseous fuel can be preheated before firing, the flame temperature can be sufficiently increased.

- The two checker chambers ie. honeycombs of checker-work firebricks serve to preheat the air needed for combustion. Two more such checkers can be provided, adjacent to those shown in Figure to heat the gaseous fuel also.
- Checker chambers (ie. regenerators) store and release large quantities of heat which otherwise would have escaped to the atmosphere and thus wasted.
- This system of preheating air and fuel known as regenerative system, heats air to about 2400^0F before it reaches the furnace proper. The regenerative system, because of its alternative action speeds up the melting of metal and develops temperatures enough to melt steel.

11 On the other side of it, the open hearth furnace has a tap hole in the lowest part of the hearth which remains closed with a refractory plug until the metal is ready to be poured.

12 Before tapping the molten metal into the ladle, a sample of the same may be tested as regards its chemical composition.

13 Whereas metal in large open hearth furnaces is tapped through tap holes, small open hearth furnaces can be tilted for pouring.

14 Besides melting steels, an open hearth furnace may be used for melting Al, Cu and their alloys also in large quantities.

15 Both acid and basic linings are used in open hearth furnaces depending upon the type of steel to be produced and the type of metal charge.

Acid open hearth process	Basic open hearth process
1 It uses acid furnace lining (silica firebricks) and utilizes acid slags for metal refining.	It uses basic lining, ie., of dolomite, crushed magnesite, etc.
- Since excess phosphorus or silicon cannot be removed by an acid slag, the amount of these elements charged into the open hearth furnace should be controlled.	- Steel scrap and pig iron of lower grades can be charged into basic lined furnaces because impurities such as excessive amounts of eliminated (by the slag).
2 The metal charge should contain low phosphorous and low sulphur pig iron and scrap if it is to be used in acid open hearth furnace. Limestone is required to keep the slag fluid.	The metal charge consists of pig iron and scrap iron. Limestone is needed to form slag. Iron ore (iron oxide) may be added to burn excess carbon if present.
3 Acid refractories are cheaper as compared to basic refractories	Basic refractories are more costly.

Air furnace (or) reverberatory furnace

An air furnace is an acid-lined reverberatory type furnace used for the production of malleable iron and high-test gray iron castings.

An air furnace consists of a long, rectangular structure having removable arched roof sections (called bugs) over a shallow hearth made up of refractory sand dampened with clay wash.

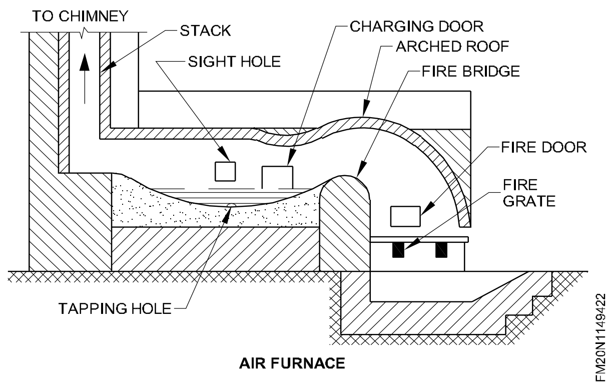
It resembles open hearth furnace except for a few difference namely.

1 It does not have any regenerative chambers for preheating the incoming air.

2 Metal is charged through the bungs.

3 Temperature is less than that in the open hearth furnace.

Fig 2



AIR FURNACE

Oil or pulverized bituminous lump coal is used as the fuel for heating and melting the metal.

Air and fuel are blow through one end of the furnace so that the flame passes over the metal charge lying in the hearth of the furnace.

The flame and hot gases (as in open hearth furnace) heat up the air furnace roof and walls. The heat reflected and radiated from the roof and walls is utilised for melting and superheating the metal charge.

Acid slag above the molten metal protects it from direct exposure to the flame and furnace atmosphere.

An air furnace is charged by removing bungs and then dropping the charge (ie. scrap, pig iron, etc.) through the hole; the bungs are then replaced and sealed with clay.

The entire charge ie. entire amount of raw materials is put into the furnace at a time, melted in one batch and drawn off when the correct composition (found after analysis) and temperature have been obtained.

Difference between cupola and air furnace

In air furnace, time is available for analyzing samples of molten iron and thus proper additions, such as pig iron or ferro alloys, can be made if necessary. In air furnace, considerable amount of control can be exercised over the chemical composition and hence the quality of the melt.

Whereas, cupola is continuously tapped and thus there is no time for analyzing and controlling the chemical composition of the melt before tapping.

Unlike cupola, in air furnace only the flame and not the fuel comes in contact with the molten iron and thus transfer of certain elements such as carbon and sulphur from the coke and into the melt is eliminated.

Since an air furnace permits good control of metal composition, it is often used in a duplexing operation, with a cupola which (quickly and efficiently) melts and supplies molten cast iron and the same is then transferred to an air furnace for refining and adjusting its composition.

A melting (metal to fuel) ration in air furnace is of 2:1 but that of 1:1 is also not unusual.

Since this ration is generally 10"1 or 8:1 in cupola, a cupola involves lower working costs as compared to an air furnace.

Since cupola provides a small but continuous supply of cast iron, which simplifies its disposal throughout the foundry, a large number of small castings can be easily produced.

On the other hand an air furnace supplies molten metal in large quantities in batches (at intervals of time) therefore it facilitates the production of large castings such as rolls, etc.

Besides the working cost, the initial cost of air furnace is also higher than that of a cupola and for this reason air furnace does not find wide applications except for producing malleable iron castings.

The capacity of air furnaces varies from 5 to 50 tons per heat; a heat implies the amount of melted at one time.

Puddling process

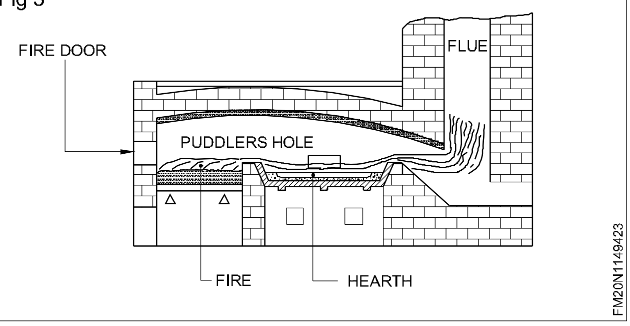
The term reverberatory is applied because the charge is not in actual contact with the fire, but receives its heat by reflection from the dome shaped furnace roof.

The product obtained is taken out from the furnace in the form of balls (or blooms) having a mass of about 50 kgs.

The hot metal is then passed through grooved rollers which convert the blooms into bars called MUCK BARS or PUDDLE BARS.

These bars are cut into short lengths, fastened together in piles, reheated to welding temperature and again rolled into bars.

Fig 3



Heat treatment of casting

Objectives: At the end of this lesson you shall be able to
- **describe the different types of heat treatment process of castings.**

Heat treatment and its purpose

The properties of steel depend upon its composition and its structure. These properties can be changed to a considerable extent, by changing either its composition or its structure. The structure of steel can be changed by heating it to a particular temperature, and, then, allowing it to cool at a definite rate. The process of changing the structure and thus changing the properties of steel, by heating and cooling, is called 'heat treatment of steel'.

Structure of steel when heated

If steel is heated, a change in structure commences from 723^{0}C. The new structure formed is called 'AUSTENITE'. Austenite is non - magnetic. If the hot steel is cooled slowly, the old structure is retained and it will have fine grains which makes it easily machinable.

If the hot steel is cooled rapidly the austenite changes into a new structure called 'MARTENSITE'. This structure is very fine, very hard and magnetic. It is extremely wear resistant and can cut other metals.

Critical temperatures

Lower critical temperature

The temperature at which the change of structure to austenite starts - 723^{0}C, is called the lower critical temperature for all plain carbon steels.

Upper critical temperature

The temperature at which the structure of steel completely changes to AUSTENITE is called the upper critical temperature. This varies depending on the percentage of carbon in steel. (Fig 1&2)

Example

0.57% and 1.15% carbon steel. In these cases the lower critical temperature is 723^{0}C and the upper critical temperature is 800^{0}C.

For 0.84% carbon steel, both LCT and UCT are 723^{0}C. This is called eutectoid steel.

Three stages of heat treatment

1 Heating

2 Soaking

3 Quenching

When the steel on being heated reaches the required temperature. It is held in the same temperature for a period of time. This allows the heating to take place throughout the section uniformly. This process is called soaking

Fig 1

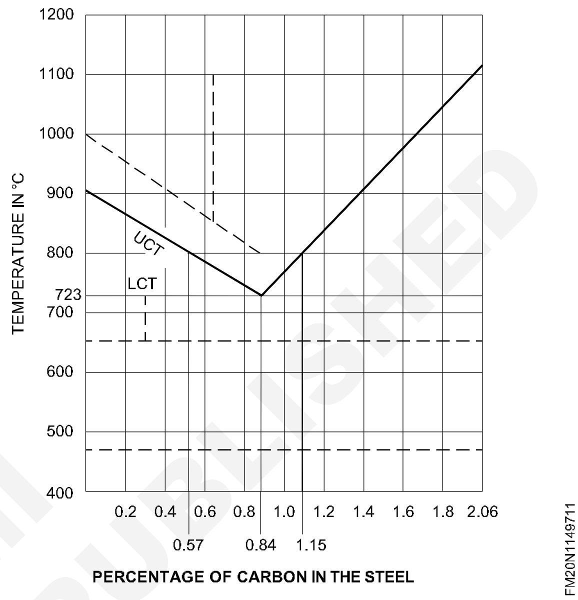
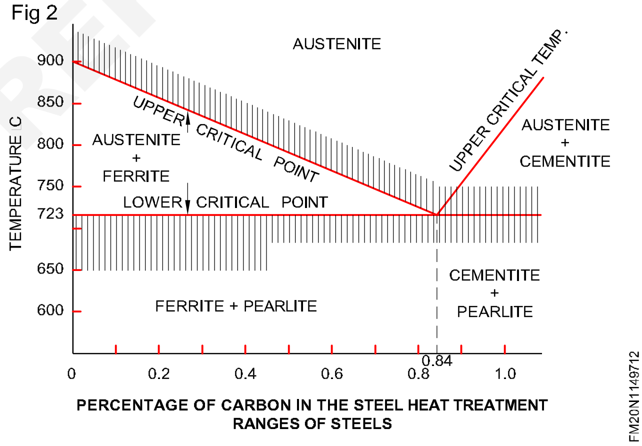


Fig 2



Soaking time

This depends upon the cross - section of the steel, its chemical composition, the volume of the charge in the furnace and the arrangement of the charge in the furnace. A good general guide for soaking time in normal conditions is five minutes per 10mm of thickness for carbon and low alloy steels, and 10 minutes per 10mm of thickness for high alloy steels.

Heating the steel

This depends on the selection of the furnace, the fuel used for heating, the time interval and the regulation in bringing the part up to the required temperature. The heating rate and the heating time also depend on the composition of the steel, its structure, the shape and size of the part to be heat-treated etc.

Preheating

Steel should be heated at low temperatures up to 600^{0}C as slowly as possible.

Quenching

Depending on the severity of the cooling required, different quenching media are used.

The most widely used quenching media are:

- brine solution
- water
- oil
- air

Brine solution gives a faster rate of cooling while air cooling has the slowest rate of cooling.

Brine solution (Sodium Chloride) gives severe quenching because it has a higher boiling point than pure water and the salt content removes the scales formed on the metal surfaces due to heating. This provides a better contact with the quenching medium and the metal being heat treated.

Water is very commonly used for plain carbon steels. While using water, as a quenching medium, the work should be agitated. This can increase the rate of cooling.

The quenching oil used should be of low viscosity. Ordinary lubricating oils should not be used for this purpose. Special quenching oils, which can give rapid and uniform cooling with less fuming and reduced fire risk, are commercially available. Oil is widely used for alloy steels where the cooling rate is slower than plain carbon steels.

Cold air is used for hardening some special alloy steels.

Heat treatment processes and purposes

Because steel undergoes changes in structure on heating and cooling, its properties may be greatly altered by suitable heat treatment.

The following are the various heat treatments and their purposes.

Hardening :	To add cutting ability. To increase wear resistance.
Tempering :	To remove extreme brittleness caused by hardening to an extent. To induce toughness and shock-resistance.
Annealing :	To relieve strain and stress. To eliminate strain / hardness. To improve machinability. To soften the steel.
Normalizing :	To refine the structure of the steel.

Annealing and normalising

The treatments that produce equilibrium conditions are annealing and normalising.

The treatments that produce non-equilibrium conditions are hardening and tempering (usually done in conjunction with each other)

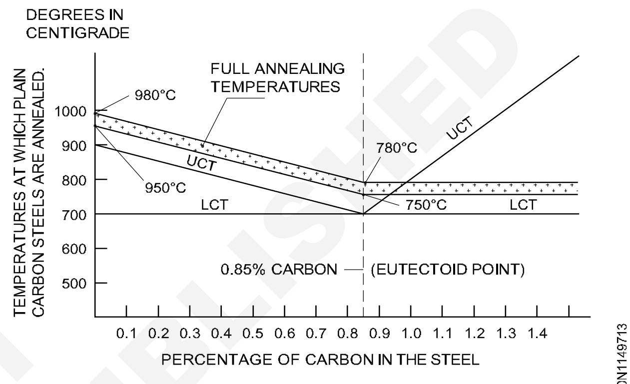
Annealing

In this process, steel is heated to a suitable temperature depending upon its carbon content and is held at that temperature for sufficient time, and then slowly cooled to room temperature.

The heating, soaking (holding at that temperature) and slow cooling cause the grains to become large, and in the process, produce softness and ductility.

For annealing, the hypo eutectoid steel is heated to 30^{0}C to 50^{0}C above the upper critical temperature, and it is 50^{0}C above the lower critical temperature for hypereutectoid steel. (Fig 3)

Fig 3



ANNEALING TEMPERATURES FOR PLAIN CARBON STEELS

The soaking time at this temperature is 5 mts/10 mm of thickness for carbon steel.

The cooling rate for carbon steel is 100^{0}C to 150^{0}C/hour.

The cooling is done in the furnaces itself by switching off the furnace or the steel is covered either in sand or dry lime and dry ash.

Purpose of annealing

Annealing is done

1. to obtain softness
2. to improve machinability
3. to increase ductility
4. to relieve internal stresses
5. to reduce or eliminate structural in homogeneity
6. to refine grain size and to prepare the steel for subsequent heat treatment processes.

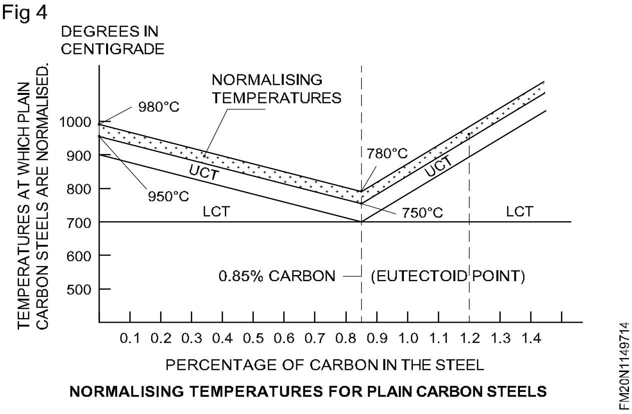
Normalising

Due to continuous hammering or uneven cooling, strains and stresses are formed in the internal structure of steel. These should be removed from forgings or castings; otherwise, they may fail at any time while in use.

Normalising is done to produce a fine grain for uniformity of structure and for improved mechanical properties.

The normalising process: In this process, steel is heated to a suitable temperature depending upon its carbon content, (Fig 4) and held at the same temperature, and then, cooled freely in air.

Fig 4



NORMALISING TEMPERATURES FOR PLAIN CARBON STEELS

Normalising is usually done before machining and before hardening, to put the steel in the best condition for these operations.

The steel is heated to a temperature (30 to 40°C above the upper critical temperature) at which all austenite is present even in the case of high carbon steel. This is because this process is the first step towards producing the final properties, and it is necessary to start with austenite to ensure uniformity.

The heated piece for normalising should not be kept at a wet place, in wet air or kept in forced air as they will induce some hardness.

Hardening & Tempering

If a piece of steel is heated to a sufficiently high temperature, all the carbon will be dissolved in the solid iron to form the solid solution, austenite of the steel. When it is slowly cooled, the change in the arrangement of the iron atoms will cause a solid solution called ferrite to be produced. The solid solution can only contain up to 0.006% carbon, and so the excess carbon will be forced to leave the solid solution, and produce cementite. This will, with ferrite, form a laminated structure called pearlite.

The principle of hardening: If steel is cooled rapidly (quenched) the excess carbon will not have sufficient time to leave the solid solution with the result that it will be trapped in the iron, and so cause an internal distortion. This internal distortion is the cause for the increase in the hardness of steel with a corresponding reduction in its strength and ductility. This is the basis of the hardening process.

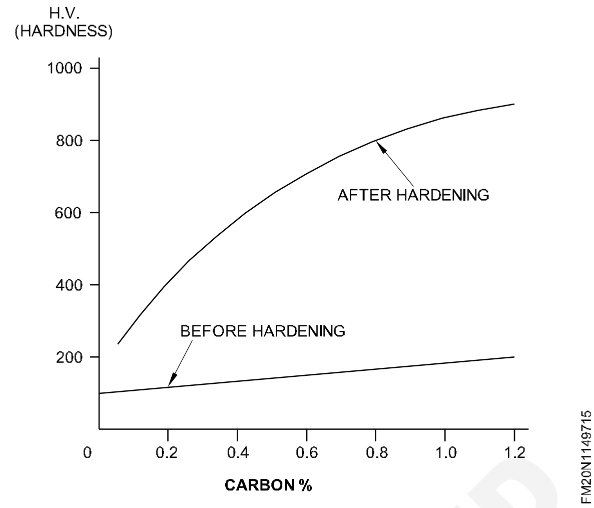
The mechanical properties produced as a result of this treatment will depend upon:

– the carbon content of the steel
– the temperature to which it is heated
– the duration of heating
– the temperature of the steel at the start of quenching
– the cooling rate produced by quenching.

The effect of carbon content upon the hardness produced by the process is illustrated in Fig 5.

The increase in carbon content will result in an increase in the hardness produced by the treatment.

Fig 5



Steel with less than about 0.15% carbon will not respond to this treatment.

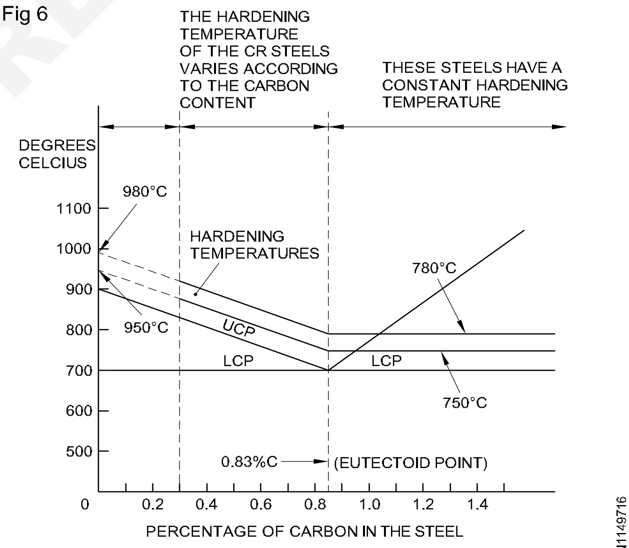
Process of hardening: In order to produce the desired effect, sufficient carbon must be put into the solid solution to cause internal distortion when it is trapped in the iron by quenching.

When the carbon content is less than 0.83%, the steel is heated to only just above its upper critical point (heating).

When its carbon content is more than 0.83% the steel is heated only to just above its lower critical point (heating).

Fig 6 illustrates the temperatures to which steels are heated before quenching.

Fig 6



HARDENING OF PLAIN CARBON STEELS

Soaking time: After heating, the steel is held at that temperature for some time. Normally 5 mm are allowed as soaking time for 10 mm thickness of steel.

Cooling: Then the steel is cooled in a suitable quenching medium at a certain minimum rate called the critical cooling rate. The critical cooling rate depends upon the composition of the steel. This cooling transforms all the austenite into a fine, needle-like structure called marten site, the appearance of which is shown in Fig 6.

The structure of steel treated this way is very hard and strong, but very brittle.

The quenching medium: The quenching medium controls the rate of cooling.

For rapid quenching a solution of salt or caustic soda in water is used.

For very slow quenching a blast of air is sufficient.

Oil gives an intermediate quenching.

Water and oil are the most common quenching media used.

Air quenching is suitable only for certain special alloy steels.

Tempering: After hardening, steel is usually reheated to a suitable temperature below the lower critical point (heating) to improve its toughness and ductility but it is done at the expense of hardness and strength. It is done in order to make the steel more suitable for service requirements.

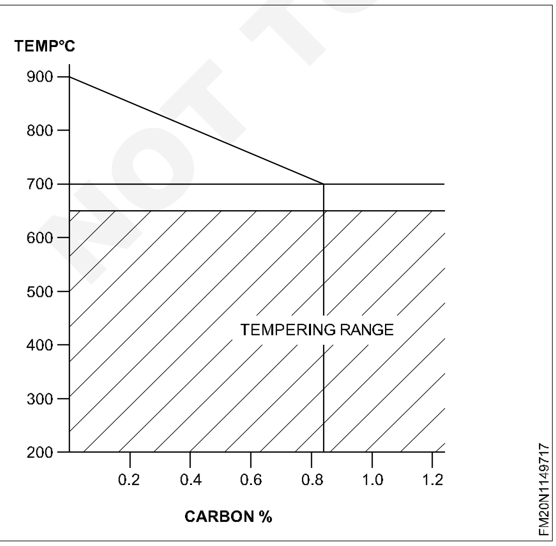
Purpose of tempering the steel: Steel, in its hardened condition, is generally too brittle and too severely strained. In this condition, steel cannot be used, and hence it has to be tempered.

The aims of tempering are:

- to relieve the steel from internal stresses and strains
- to regulate the hardness and toughness
- to reduce the brittleness
- to restore some ductility
- to reduce shock resistance.

Process of tempering: The tempering temperature depends upon the properties required, but it is between 180°C and 650°C. (Fig 7) The duration of heating depends upon the thickness of the material. Tools are usually tempered at a low temperature. The temperature itself is judged by the colour of the oxide film produced upon heating. (See Table 1)

Fig 7



This method is not, however, suitable for accurate temperature assessment.

In a manufacturing plant, when heat treating is done on a production basis, modern methods are used. Tempering is done in controlled-atmosphere furnaces with the temperatures controlled by modern instruments. In such conditions, it is possible to obtain accurate and uniform results in any number of pieces.

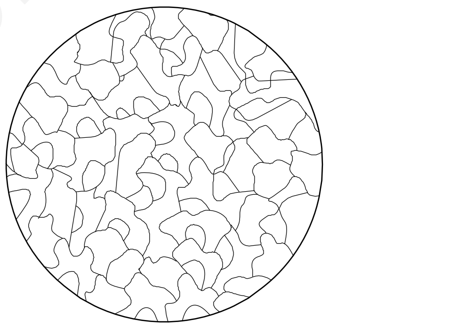
Table 1

Tempering temperature

Temper colour	Temperature in °C
Pale straw	230
Dark straw	240
Brown	250
Brownish purple	260
Purple	270
Dark purple	280
Blue	300

Fig 8 illustrates the appearance of the microstructure of hardened and tempered steel.

Fig 8

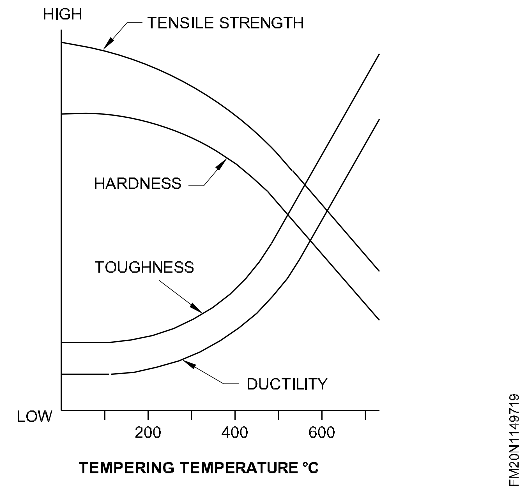


THE MICROSTRUCTURE OF HARDENED AND TEMPERED STEEL

Generally, tempering in the lower temperature range for an increased time provides greater control in securing the desirable mechanical properties. Such heat treatment may not be feasible under all conditions. For precision work, where results justify the method, and for certain combination of mechanical properties, tempering for long periods of time in a lower temperature range provides a reliable method of getting the desired results.

Fig 9 illustrates how the mechanical properties of hardened steel can be modified by tempering.

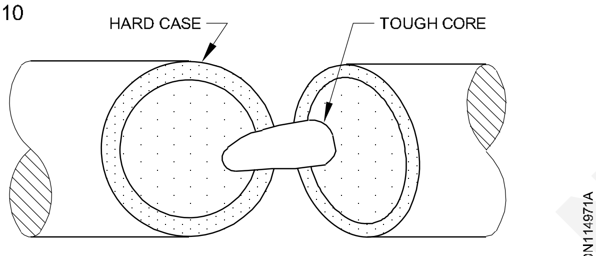
Fig 9



Surface hardening of steels

Most of the components must have a hard, wear-resisting surface supported by a tough, shock-sesisting core for better service condition and longer life. This combination of different properties can be obtained in a single piece of steel by surface hardening. (Fig 10)

Fig 10



TYPES OF SURFACE HARDENING

Types of surface hardening

- Case hardening
- Nitriding
- Flame hardening
- Induction hardening

Surface hardening processes can be classified as:

- processes in which the whole component is heated,

  Eg. case hardening and nitriding.

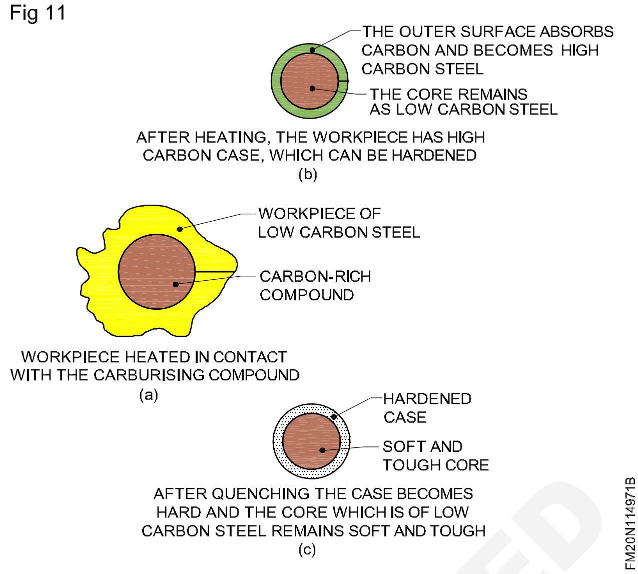
- processes in which only the surface of the component is heated,

  Eg. flame hardening and induction hardening.

Case hardening: Parts to be hardened by this process are made from a steel with a carbon content of 0.15% so that they will not respond to direct hardening. The steel is subjected to treatment in which the carbon content of the surface layer is increased to about 0.9%.

When the carburised steel is heated and quenched, only the surface layer will respond, and the core will remain soft and tough as required. (Fig 11)

Fig 11



The surface which must remain soft can be insulated against carburising by coating it with a suitable paste or by planting it with copper.

- Case hardening takes place in two stages.
- Carburising in which the carbon content of the surface is increased.
- Heat treatment in which the core is refined and the surface hardened.

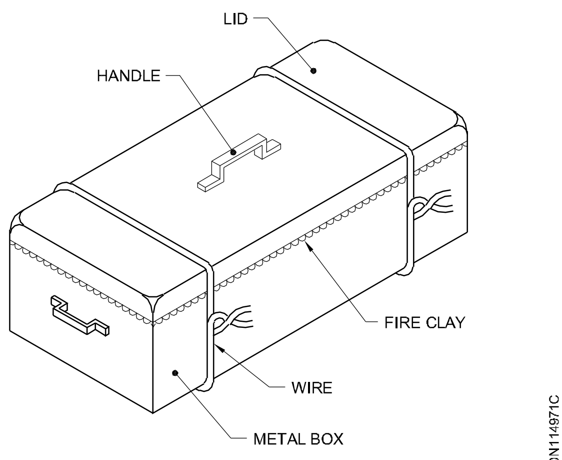
Carburising: In this operation, the steel is heated to a suitable temperature in a carbonaceous atmosphere, and kept at that temperature until the carbon has penetrated to the depth required.

The carbon can be supplied as solid, liquid or gas.

In all cases, the carbonaceous gases coming from these materials penetrate (diffuse) into the surface of the workpiece at a temperature of 880°-930°C.

Pack carburising (Fig 12): The parts are packed in a suitable metal box in which they are surrounded by the carburising medium. The lid is fitted to the box and sealed with fireclay and tied with a piece of wire so that no carbon gas can escape and no air can enter the box to cause decarburisation.

Fig 12



PACK CARBURISING

The carburising medium can be wood, bone, leather or charcoal, but an energiser, such as barium carbonate, is added to speed up the process.

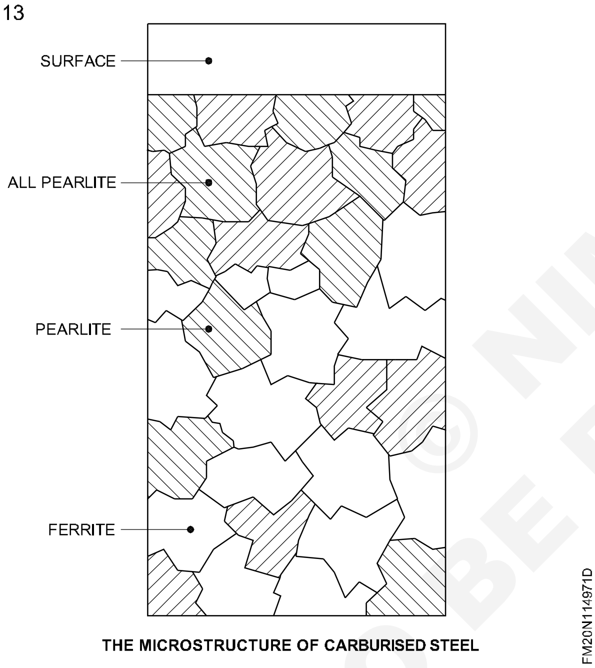
Liquid carburising: Carburising can be done in a heated salt-bath. (Sodium carbonate, sodium cyanide and barium chloride are typical carburising salts.) For a constant time and temperature of carburisation, the depth of the case depends on the cyanide content.

Salt-bath carburising is very rapid, and is not always suitable because it produces an abrupt change in the carbon content from the surface to the core. This produces a tendency for the case to flake.

This is suitable for a thin case, about 0.25 mm deep. Its advantage is that heating is rapid and distortion is minimized.

Fig 13 illustrates the appearance of the structure across its section produced by carburising.

Fig 13



THE MICROSTRUCTURE OF CARBURISED STEEL

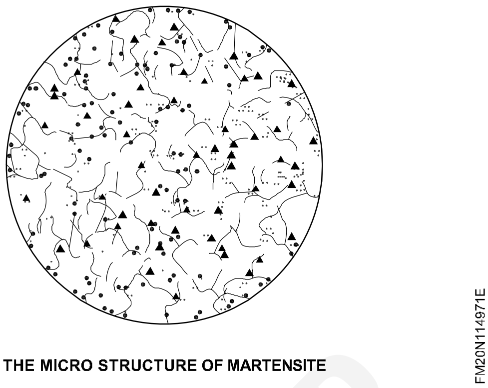
Heat treatment: After the carburising has been done, the case will contain about 0.9% carbon, and the core will still contain about 0.15% carbon. There will be a gradual transition of the carbon content between the case and the core.

Owing to the prolonged heating, the core will be coarse, and in order to produce a reasonable toughness, it must be refined.

To refine the core, the carburised steel is reheated to about 870°C and held at that temperature long enough to produce a uniform structure, and is then cooled rapidly to prevent grain growth during cooling.

The temperature of this heating is much higher than that suitable for the case, and, therefore, an extremely brittle marten site will be produced. (Fig 14)

Fig 14



THE MICRO STRUCTURE OF MARTENSITE

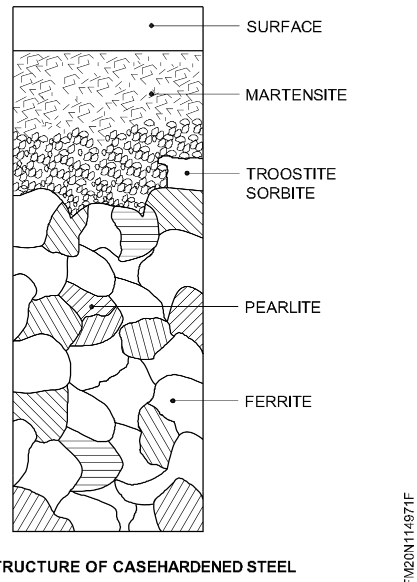
The case and the outer layers of the core must now be refined. The refining is done by reheating the steel to about 760°C, to suit the case, and quenching it.

Tempering: Finally the case is tempered at about 300°C to relieve the quenching stresses.

If the part is not required to resist shock, it is necessary to carry out the core refining operation; in these conditions, a coarse marten site at the surface may not cause trouble, and so this part may be quenched directly after carburising.

Fig 15 illustrates the appearance of the structure across its section produced by case hardening.

Fig 15



THE MICROSTRUCTURE OF CASEHARDENED STEEL

Nitriding

In the nitriding process, the surface is enriched *not* with carbon, but with nitrogen. There was two systems in common use, gas nitriding and salt bath nitriding.

Gas nitriding

The gas nitriding process consists of heating the parts at 500°C in a constant circulation of ammonia gas for up to 100 hours.

During the gas nitriding process, the parts are in an externally heated gas-tight box, fitted with inlet and outlet bores for the ammonia gas which supplies the nitrogen. At the completion of the 'soaking' the ammonia is still circulated until the temperature of the steel has fallen to about 150°C. when the box is opened, and the cooling completed in air. Nitriding causes a film to be produced on the surface but this can be removed by a light buffing.

Nitriding in salt bath

Special nitriding baths are used for salt-bath nitriding. This process is suitable for all alloyed and unalloyed types of steel, annealed or not-annealed, and also for cast iron.

Process

The completely stress-relieved workpieces are pre-heated (about 400°C) before being put in the salt bath (about 520-570°C). A layer 0.01 to 0.02 mm thick is formed on the surface which consists of a carbon and nitrogen compound. The duration of nitriding depends on the cross-section of the workpiece (half an hour to three hours). (It is much shorter than gas nitriding.) After being taken out of the bath, the workpieces are quenched and washed in water and dried.

Advantages:

The parts can be final-machined before nitriding because no quenching is done after nitriding, and, therefore, they will not suffer from quenching distortion.

In this process, the parts are not heated above the critical temperature, and, hence warping or distortion does not occur.

The hardness and wear-resistance are exceptional. There is a slight improvement in corrosion-resistance as well.

Since the alloy steels used are inherently strong when properly heat-treated, remarkable combinations of strength and wear-resistance are obtained.

Flame hardening

In this type of hardening, the heat is applied to the surface of the workpiece by specially constructed burners. The heat is applied to the surface very rapidly and the work is quenched immediately by spraying it with water. (Fig 16 & 17) The hardening temperature is generally about 50°C higher than that for full hardening.

Fig 16

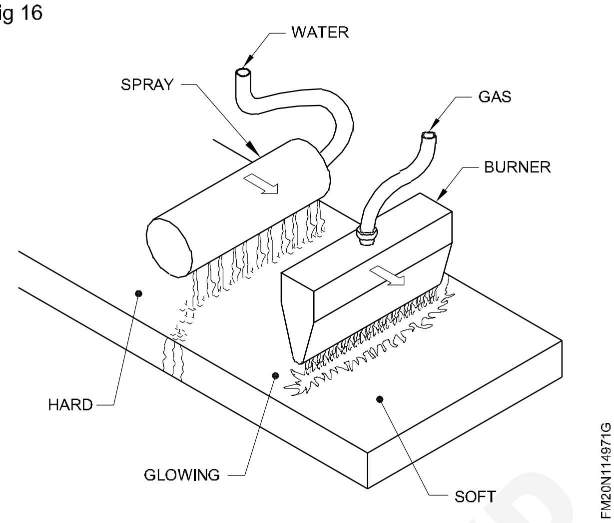
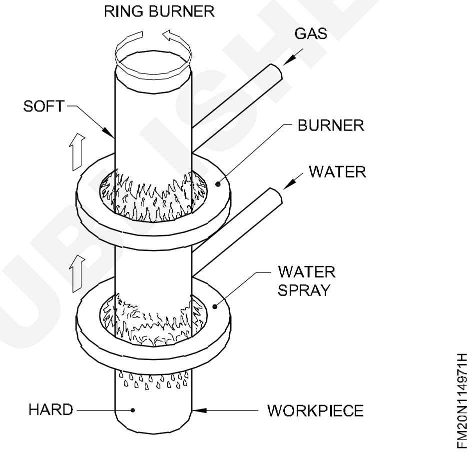


Fig 17



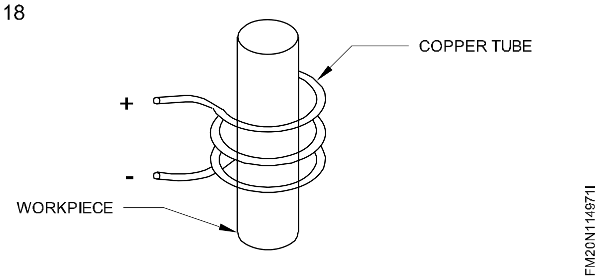
The workpiece is maintained at the hardening temperature for a very short period only, so that the heat is not conducted more than necessary into the workpiece.

Steels used for surface-hardening will have a carbon content of 0.35% to 0.7%.

Induction hardening

This is a production method of surface-hardening in which the part to be surface-hardened is placed within an inductor coil through which a high frequency current is passed. (Fig 18) The depth of penetration of the heating becomes less, as the frequency increases.

Fig 18



The depth of hardening for high frequency current is 0.7 to 1.0 mm. The depth of hardening for medium frequency current is 1.5 to 2.0 mm. Special steels and unalloyed steels with a carbon content of 0.35 to 0.7% are used.

After induction-hardening of the workpieces, stress-relieving is necessary. The following are the advantages of this type of hardening. The depth of hardening, distribution in width and the temperature are easily controllable. The time required and distortion due to hardening are very small.

The surface remains free from scale. This type of hardening can easily be incorporated in mass production.

Heat treatment of high speed steel

High speed steels get their name from the fact that they may be operated as cutting tools at much higher speeds than is possible with plain carbon tool steel. Since the maximum hardness of high speed steel obtained on tempering at high temperatures, it can be operated as a cutting tool in the same temperature range without loss of hardness. That is, the rise in temperature due to friction will not reduce the temper of the tool point as it cuts into the steel. Tool steels are often annealed for softening before machining or forming, and also for obtaining grain refinement.

Annealing

Soak at 900°C for about four hours. Then cool slowly not more than 20°C per hour to 600°C. It may then be cooled to room temperature in still air.

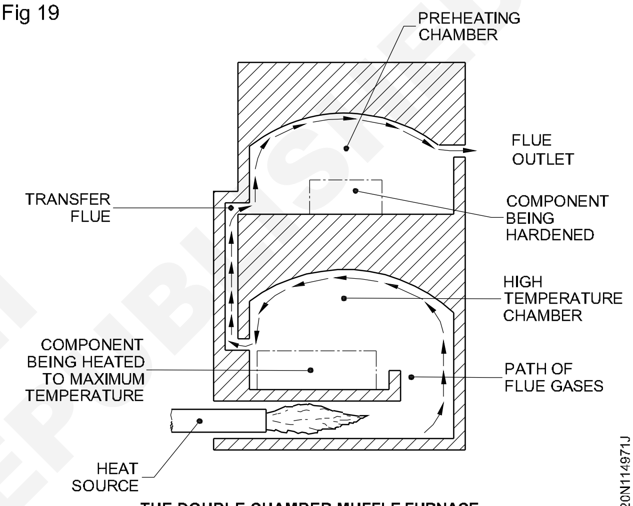
Hardening

Preheat to 850°C slowly to prevent cracking. The heat rapidly in a salt-bath furnace approximately 1250°C depending upon the alloy used. This rapid heating in a salt-bath furnace reduces grain growth and prevents oxidation of steel during heating. Quench in a air blast or oil depending on the mass of the component. When a salt bath furnace is not available, this can be minimised in a double chamber muffle furnace (Fig 19) by using the excess fuel to give a carburising atmosphere. However, this reduces the combustion efficiency, and there may be some difficulty in reaching the hardening temperature. With high temperature salt available, modern practice favours the use of the salt-bath furnace.

Secondary hardening

This is sometime called tempering. However, this term is not strictly true. Not only does secondary hardening increase the toughness of the steel, it also increases the hardness whereas tempering increases the toughness at the expense of hardness. The effect of secondary hardening helps these steels to work effectively at highest temperatures than plain carbon tool steels.

Fig 19



THE DOUBLE CHAMBER MUFFLE FURNACE

Ferrostatic pressure

Objectives: At the end of this lesson you shall be able to
- **state the ferrostatic pressure**
- **state the downward, sideway & upward pressure.**

Ferrostatic pressure

All fluids exerts pressure to all direction. The pressure exerted by the gas is known as “gas pressure”. The pressure exerted by the water is known as hydrostatic pressure. Similarly the pressure exerted by the liquid metal is known as “errostatic pressure” or metalostatic pressure. The liquid metal exerts liquid pressure to all directions such as downwards, side ways and upwards. It is necessary to find out each pressure to provide sufficient rigidity to the mould to avoid the possibility of lifting the top box while pouring.

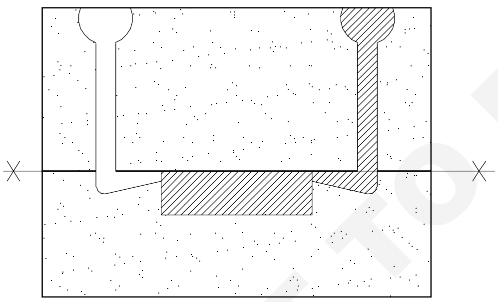
Downward pressure (Fig 1)

The pressure extorted by the liquid metal in a mould cavity to downward is known as downward pressure. To overcome this pressure the mould should be made rigid and the total pressure will be resisted by the earth. The downward pressure can be calculated by using the following formula.

Downward pressure = Head of the metal x Density of the metal x Area of the bottom surface of the mould cavity.

In this case the head of the metal = Height of the sprue and height of the mould cavity.

Fig 1



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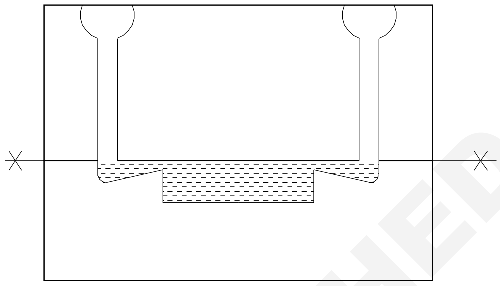
Side way pressure (Fig 2)

The pressure exerted by the liquid metal in a mould cavity towards the sides of the mould wall is known as side way pressure. The side way pressure is resisted by the rigidity of the mould walls and the moulding box. The sideway pressure is calculated for each sides separately by using the following formula.

Side way pressure = Head of the metal x Density of the metal x Area of the side of the mould cavity.

In this case the head of the metal = Height of the sprue + 1/2 height of the cavity.

Fig 2



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Upward pressure (Fig 3)

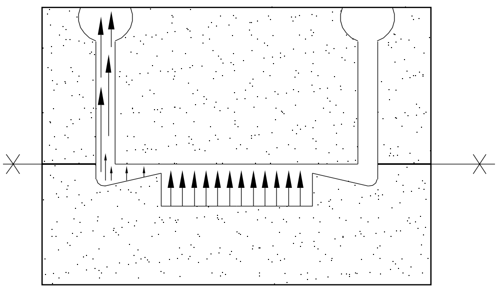
The pressure exerted by the liquid metal in a mould cavity to upward is known as upward pressure. This pressure is resisted by the rigidity of the mould and by providing clamping system to top box or by placing weight over the cope. The upward pressure is calculated by using the following formula.

Upward pressure = Head of the metal x Density of the metal x Area of the top surface of the mould cavity.

In this case the head of the metal = Only height of the sprue.

The weight required to place over the cope to resist the upward pressure should be more than the upward pressure. ie. The weight of the cope including the rammed sand and the weight placed over the cope should be more than the upward pressure.

Fig 3



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Calculation of weight required on a mould

In a foundry process where in moulds are formed on the basis of a sand - to -metal ratio of at least 4 :1.

Good sand metal ratio is 4:1.

4:1 Sand to metal ratio means 25 volumes for each casting volume of sand to metal poured.

Example

The casting weight = 5 kg

No.of . cavities per mould = 4

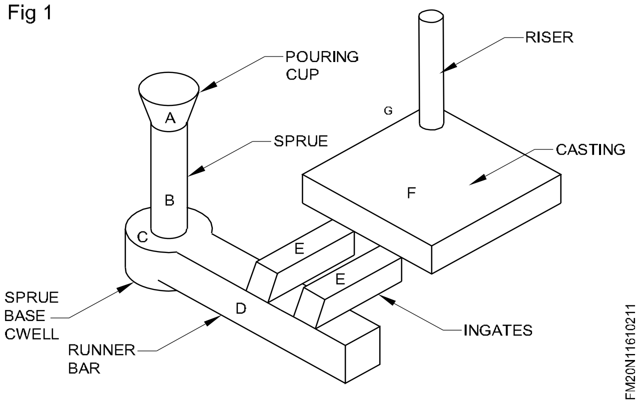
The mould (sand) weight = 5 x 4 x 4 = 80 kg.

Calculation of molten metal required for different size mould (Aluminum, brass, copper, C.I. etc.)

Objectives: At the end of this lesson you shall be able to
- **estimation of molten metal required for mould**
- **list the various metal's density.**

Calculation of molten metal

Fig 1



Weight calculation

Total molten metal weight = Total volume in cc x Density of metal in gm/cc.

Total volume = Pouring cup volume (A) + Sprue volume (B) + Sprue base volume (C) + Runner bar volume (D) + Ingate volume (E) + Casting volume (F) + Riser volume (G)

Example calculation

i Pouring cup volume

Maximum dia (ϕ) = 60 mm = 6 cm

(r) = 30 mm = 3 cm

height = 100 mm = 10 cm

Volume = $\pi r^2 h$

= π x 3 x 3 x 10

Pouring cup volume (A) = 283 CC

(Maximum dia)

Pouring cup volume

Minimum dia (ϕ) = 40 mm = 4 cm

(r) = 20 mm = 2 cm

height = 100 mm = 10 cm

Volume = $\pi r^2 h$

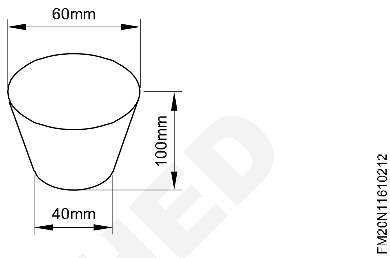
= π x 2 x 2 x 10

Pouring cup volume (minimum dia) (ϕ) = 126 CC

Average Volume = $\frac{283 + 126}{2}$

Average Pouring cup Volume (A) = 205 CC

Fig 2



ii Sprue volume (B)

dia (ϕ) = 40 mm = 4 cm

(r) = 20 mm = 2 cm

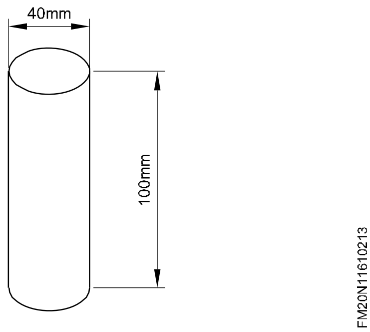
height = 100 mm = 10 cm

Volume = $\pi r^2 h$

= π x 2 x 2 x 10

Sprue volume (B) = 126 CC

Fig 3



iii Sprue base volume (C)

dia (ϕ) = 60 mm = 6 cm

(r) = 30 mm = 3 cm

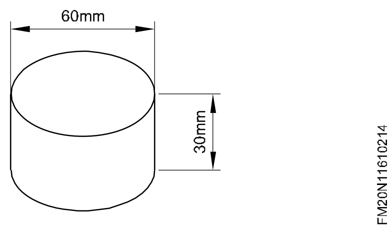
height = 30 mm = 3 cm

Volume = $\pi r^2 h$

= π x 3 x 3 x 3

Sprue base volume (C) = 85 CC

Fig 4



iv Runner bar volume (D)

Side = a = 30 mm = 3 mm

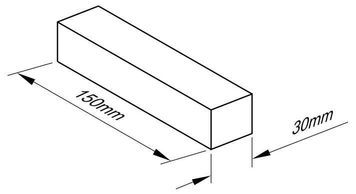
length (L) = 150 mm = 15 cm

Volume a^2 x l

= 3 x 3 x 15

Runner bar volume (D) = 135 CC

Fig 5



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v Ingate volume (E)

Side = a = 20 mm = 2 mm

length (L) = 40 mm = 4 cm

Volume a^2 x l

= 2 x 2 x 4

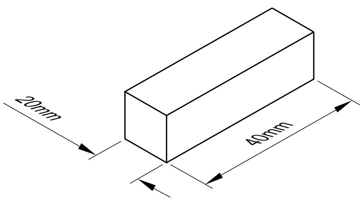
= 16 CC

No. of in gates = 2

= 2 x 16

Ingate volume (E) = 32 CC

Fig 6



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vi Casting volume (F)

length (l) = 130 mm = 13 cm

breath (b) = 180 mm = 18 cm

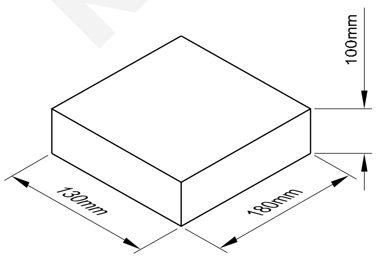
height (h) = 100 mm = 10 cm

Volume = l x b x h

13 x 18 x 10

Casting Volume (F) = 2340 CC

Fig 7



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vii Riser volume (G)

dia (ϕ) = 20 mm = 2 cm

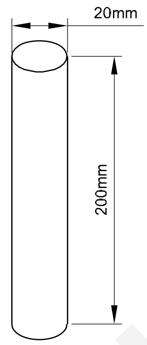
height (h) = 200 mm = 20 cm

Volume = $\pi r^2 h$

= π x 1 x 1 x 20

Riser volume (G) = 63 CC

Fig 8



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Total volume = A + B + C + D + E + F + G

= 205 + 126 + 85 + 135 + 32 + 2340 + 63

Total volume = 2986 CC

Total molten metal weight = Total volume x Density of metal

Metal = Aluminum

Density = 2.7 gm/cc

Total molten metal weight = 2986 x 2.7

= 8062 gm = $\frac{8062}{1000}$ = 8.06 kg

Total molten metal weight = 8.06 kg

Design of getting system should be changed for different types of moulding process.

Table 1 - Density of various metals

S.No.	Metals	Density
1	Aluminium	2.7 gm/cc
2	Brass	3.5 gm/cc
3	Copper	3.96 gm/cc
4	Lead	11.3 gm/cc
5	Grey cast iron	6.9 gm/cc
6	Bronze	8.8 gm/cc
7	Steel	8.05 gm/cc
8	Gunmetal	8.72 gm/cc
9	Magnesium	1.74 gm/cc
10	Tin	7.17 gm/cc

Cost and estimation of simple casting by different metals

Objectives: At the end of this lesson you shall be able to
- **estimate cost costimation is done in respect of a casting**
- **list the various sections that will be normally found in a foundry shop**
- **list the various elements of cost involved in the total cast of manufacturing a casting**
- **explain what are overhead expenses**
- **calculate the total cost of a cast component.**

Cost estimation in foundry shop

Foundry is a metal casting process in which the metal is melted and poured into the moulds to get the components in desired shape and size. Castings are obtained from a foundry shop.

Generally, a foundry shop has the following sections:

1 Pattern making Section

In this section the patterns for making the moulds are manufactured. The machines involved in making the patterns are very costly and small foundries may not be able to afford these machines. In such cases the pattern are got made for outside parties who are specialists in pattern making. Patterns are made either from wood or from a metal.

2 Sand - mixing section

In this section raw sand is washed to remove clay etc., and various ingredients are added in the sand for making the cores and moulds.

3 Core - making section

Cores are made in this section and used in moulds to provide holes or cavities in the castings.

4 Mould making section

This is the section where moulds are made with the help of patterns. The moulds may be made manually or with moulding machines.

5 Melting section

Metal is melted in the furnace and desired composition of metal is attained by adding various constituents. Metal may be melted in a cupola or in an induction or in an arc furnace. In some cases pit furnace is also used for melting the metals.

6 Fettling section

The molten metal after pouring in the moulds is allowed to cool and the casting is then taken out of mould. The casting is then cleaned to remove sand and extra material and is shot blasted in fettling section. In fettling operation risers, runners and gates are cut off and removed.

7 Inspection section

The castings are inspected in the inspection section before being sent out of the factory.

Estimation of cost of castings

The total cost of manufacturing a component consists of following elements.

1 Material cost.

2 Labour cost.

3 Direct other expenses.

4 Overhead expenses.

1 Material cost

a Cost of material required for casting is calculated as follows:

i From the component drawing, calculate the volume of material required for casting. This volume multiplied by density of material gives the net weight of the casting.

ii Add the weight of process scrap i.e. weight of runners, gates and risers and other material consumed as a part of process in getting the casting.

iii Add the allowance for metal loss in oxidation in furnace, in cutting the gates and runners and over runs etc.

iv Multiply the total weight by cost per unit weight of the material used.

v Subtract the value of scrap return from the amount obtained in step to get the direct material cost.

> **The casting drawing is made by adding various allowances like - shrinkage, draft and machining allowance, etc., to the dimensions of finished component.**

b In addition to the direct material, various other materials are used in the process of manufacture of a casting. Some of the materials are:

i Materials required in melting the metal, i.e., coal, limestone and other fluxes etc. The cost of these materials also is calculated by tabulating the value of material used on per tonne basis and then apportioned on each item.

ii. Material used in core shop for making the cores, i.e., oils, binders and refractories etc. The cost of core materials is calculated depending upon the core size and method of making the core. Similarly, the cost of moulding sand ingredients is also calculated.

The expenditure made on these materials is generally expressed as per kg of casting weight and is covered under overhead costs.

2 Labour cost

Labour is involved at various stages in a foundry shop. Broadly it is divided into two categories:

i The cost of labour involved in making the cores, baking of cores and moulds is based on the time taken for making various moulds and cores.

ii The cost of labour involved in firing the furnace, melting and pouring of the metal. Cleaning of castings, fettling, painting of castings etc., is generally calculated on the basis of per kg of cast weight.

3 Direct other expenses

Direct expenses include the expenditure incurred on patterns, core boxes, cost of using machines and other items which can be directly identified with a particular product. The cost of patterns, core boxes etc., is distributed on per item basis.

4 Overhead expenses

The overheads consist of the salary and wages of supervisory staff, pattern shop staff and inspection staff, administrative expenses, water and electricity charges etc. The overheads are generally expressed as percentage of labour charges.

The cost of a cast component is calculated by adding the above constituents.

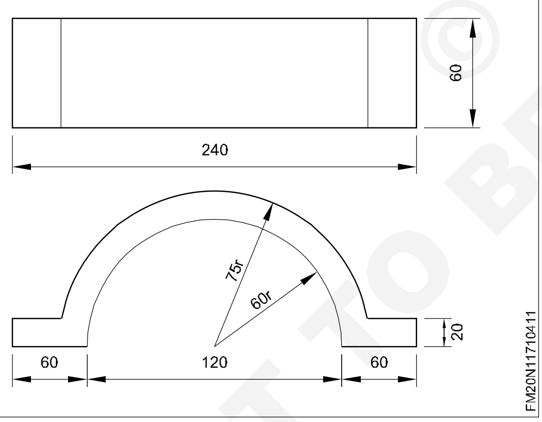
Example 1: Calculate the total cost of CI (Cast Iron) cap shown in Fig. 1, from the following data:

Cost of molten iron at cupola spout	= Rs. 30 per kg
Process scrap	= 17 percent of net wt. of casting
Process scrap return value	= Rs. 5 per kg
Administrative overhead charges	= Rs. 2 per kg of metal poured.
Density of material used	= 7.2 gms/cc

The other expenditure details are:

Process	Time per piece	Labour charges per hr	Shop overheads per hr
Moulding and pouring	10 min	Rs. 30	Rs. 30
Casting removal, gate cutting etc.	4 min	Rs.10	Rs. 30
Fettling and inspection	6 min	Rs. 10	Rs. 30

Fig 1



Solution: To calculate material cost:

Volume of the component = (2 x 6 x 2 x 6) + ½ x p [(7.5)^2 - (6)^2] 6

= 335 cc

Net weight of the casting = 335 x 7.2

= 2,412 gms

= 2.4 kgs

Process scrap	= 2.4 x 0.17 = 0.4 kg
Metal required per piece	= 2.4 + 0.4 = 2.8 kgs
Material cost/piece	= 2.8 x 30 = Rs. 84
Process return	= 0.4 x 5 = Rs. 2
Net material cost per piece	= 84 -2 = Rs. 82

i Calculate labour cost and overheads

Process	Time per piece	Labour charges per piece (Rs.)	Shop overheads per piece (Rs.)
Moulding and pouring	10 mins	$\frac{10}{60}$ x 30 = 5	$\frac{30 \times 10}{60}$ = 5
Casting removal, gate cutting, etc.	4 mins.	$\frac{4}{60}$ x 10 = 0.67	$\frac{30 \times 4}{60}$ = 2
Fettling and inspection	6 mins.	$\frac{6}{60}$ x 10 = 1	$\frac{30 \times 6}{60}$ = 3
Total		**Rs. 6.67**	**Rs. 10**

Labour charges = Rs. 6.67 per piece

Shop overheads = Rs. 10 per piece

Administrative overheads= 2 x 2.8 = Rs. 5.6

Total cost per piece = 82 + 6.67 + 10 + 5.6

= Rs. 104.27

Example 2

A cast iron component is to be manufactured as per Fig 2. Estimate the selling price per piece from the following data:

Density of material = 7.2 gms/cc

Cost of molten metal at cupola spout= Rs. 20 per kg

Process scrap = 20% of net Wt.

Scrap return value = Rs. 6 per kg

Administrative overheads = Rs. 30 per hour

Sales overheads cost = 20% of factory

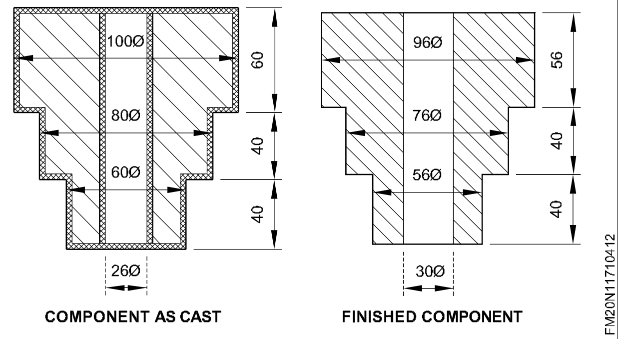
Profit = 20 %of factory cost

The component shown is obtained after machining the casting. The pattern which costs Rs. 5,000 can produce 1,000 pieces before being scrapped. The machining allowance is to be taken as 2 mm on each side.

Solution

Fig. 2 (b) shows the component in finished condition. Fig 2 (a) has been drawn by adding the machining allowance of 2 mm on each side.

Fig 2



Net volume of cast component =

$(10^2 \times 6 + 8^2 \times 4 + 6^2 \times 4 - 2.6 \times 14)$

= 711 cc

Net weight of cast component = 711 x 7.2 = 5.117 kg

Process scrap = 20% of 5.117 kg

= 0.2 x 5.117 = 1.02 kg.

Total metal required per component = 5.12 + 1.02 = 6.14 kg.

Cost of metal poured = 6.14 x 20 = Rs. 122.8

Process return value = 1.02 x 6 = Rs. 6.12

Material cost per component = 122.8 - 6.1 = Rs. 116.7

ii Labour cost and factory overheads:

Labour cost = Rs 6.83

Shop overheads = Rs 22.33

Other expenditures are:

Operation	Time (min)	Labour cost /hr (Rs.)	Shop overheads/hr (Rs.)
Moulding and pouring	15	20	60
Short blasting fettling	5	10	40
Fettling	6	10	40

iii Factory cost per component = 116.70 + 6.83 + 22.33

= Rs. 145.86

iv Administrative overhead $= \frac{30 \times 26}{60}$ = Rs.13

v Sales overheads = 0.2 x 145.86

= Rs. 29.17

Profit = 0.2 x 145.86

= Rs. 29.17

vi Selling price per component = Factory cost + Administrative overheads + Sales overheads + Profit

= 145.86 + 13 + 29.17 + 29.17

= Rs. 217.2

Process	Time per piece (Mins.)	Labour cost per piece (Rs.)	Shop overheads per piece (Rs.)
Melting & Pouring	15	5.00	15.00
Shot blast	5	0.83	3.33
Fettling	6	1.00	4.00
Total	**26 min**	**6.83**	**23.33**

Low pressure and high pressure die casting process

Objectives: At the end of this lesson you shall be able to
- **state die casting & pressure die casting**
- **explain function of cold chamber process & hot chamber process**
- **state low pressure die casting**
- **state the high pressure die casting.**

Die casting

The process of die casting consists of producing near net shape castings by pouring molten metal in metallic die cavities. The dies are usually machined from hot die steels.

The technical advantages of die casting are many. The process produces a structure which is superior to that of a sand casting. Fast solidification results in a very fine grained structure, which contributes to higher strength than is generally obtainable in a sand casting. Superior dimensional tolerance and a very good surface finish are other interesting features of die casting. However, alloys which have high shrinkage coefficients and/or a long freezing time are unsuitable for die casting. Because of the high cost of initial tool and maintenance, the die casting process will be economically possible only if a large number of castings are required.

Pressure die casting

Die casting provides the foundry man with one of the fastest means of producing castings with a much higher degree of accuracy than that normally obtained by conventional sand casting. In fact, this method is unexcelled for mass production work as numerous castings can be produced very rapidly at low cost. Further, the castings can be made to very close tolerances and with a fine surface finish. The process is however suited only to certain non-ferrous metals and for small-sized castings.

Die casting dies

Die castings are prepared by forcing molten metal under high pressure into a metal should called a "die'. The die resembles the common type of permanent mould in that it too has two halves which open and close along a vertical parting. On a die-casting machine, the die half called the "cover die" is stationary. The other die half, which opens and closes, is known as the "ejector die".

Die-casting dies are usually made of an alloy steel, which should be dimensionally stable, withstand heat checking, not get soldered to the cast alloy, be tough, and resist erosion.

Die cavities have to be machined with great accuracy. Sometimes die cavities are machined by a process known as hobbing. A hardened steel master, called a "hob", is forced into an annealed alloy-steel die block. Once a hob has been made, a number of die cavities can be duplicated from it. Since no coating is applied to the die cavities, this method produces smoother castings and maintains closer tolerances than those resulting from permanent mould casting.

Die casting machines

The major functions of die casting machines are as follows:

Closing the two halves of the die by moving the movable half (ejector die) towards the fixed half (cover die);

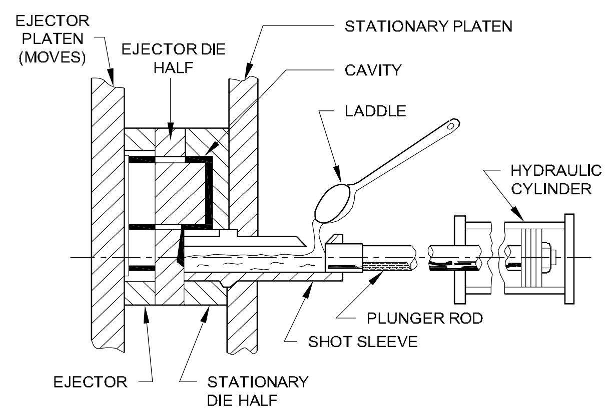
Securing the two die halves firmly together, so that they do not separate due to the pressure of molten metal;

Pressure pouring facility casts steel wheels.

Cold chamber process

In this machine a charge of metal sufficient for a single casting is poured into the sleeve adjoining the die. The plunger then forces the charge through the runner channels into the die cavity itself. Iron contamination is much lower in this process (Fig 1)

Fig 1



COLD CHAMBER DIE CASTING

A die-casting machine must have a sturdy frame designed to support and open the die halves in correct alignment. The frame must be of lasting strength, since the weight of an assembled die often exceeds several tonnes. Further, the locking force required to hold the die halves together must adequately exceed the maximum force developed by the molten metal to ensure leak-proof clamping at the die parting. In some modern die-casting machines, the locking force may approximate as much as 1000 tonnes, depending upon the die size and the molten metal pressure employed.

The maximum force tending to open a die will equal the maximum molten metal pressure times the total projected area of the mould cavity and gating.

Methods used for closing and locking the dies

The methods used to close and lock dies may be straight hydraulic, hydraulic and mechanical, or purely mechanical.

1 **Straight hydraulic -** When hydraulic clamping is directly applied to the dies and maintained continuously line pressure constantly backs up the die when it is closed.

2 **Hydraulic and mechanical -** Here, the die is closed both by hydraulic pressure and considerable impact caused by the simultaneous straightening out of the togging links which are set in motion by the movement of the piston in the hydraulic cylinder. Thus, as long as the toggle clamping mechanism is correctly adjusted, in dies can be kept securely locked.

3 **Mechanical -** The mechanical method does not make use of any hydraulic pressure but relies wholly on a mechanical facility for closing and locking the dies

Low pressure casting is applied in the manufacture of automobile and air craft components, impellers for pumps, and rain water fittings. For example, in a plant where aluminum alloy pump impellers of about 250mm diameter are produce a pressure of 0.75 is maintained for a period of 30 - 45 seconds. The dies and dies, cores are pre-heated to about 250°c before use. The holding down pressure on the dies, about 30 kg/mm2 is applied pneumatically. The cores are made in plaster. This result, in castings with vanes of 1mm thickness, a high degree of quality. Accuracy, and finish, and hardly 2% rejection rate.

Types of die casting machines

The machines for feeding metal into dies under pressure are:

1 Hot chamber machine;

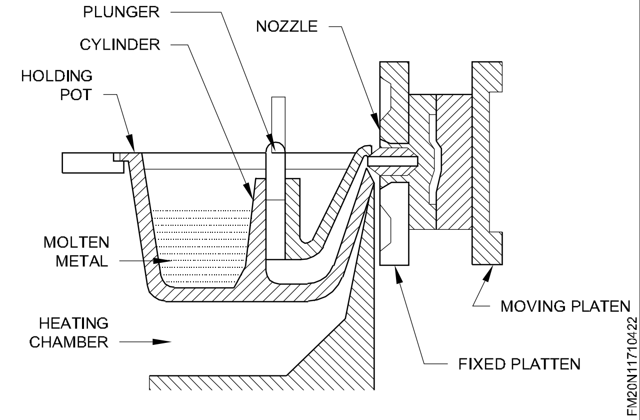
2 Cold chamber machine, and

3 Air-blown or goose-neck machine.

1 Hot chamber machine

This machine (Fig 2) has a suitable furnace for melting and holding the metal. Submerged below the surface of the molten metal.

Fig 2



Plunger operates within a cylinder. When the plunger is raised, it uncovers an opening or port in the cylinder wall through which the metal spills into the cylinder. After the cylinder is filled, the plunger is forced downwards, pneumatically or hydraulically closing the opening and then forcing the confined metal up through a channel and nozzle into the die. After a predetermined time, the plunger is again raised, allowing the surplus molten metal in the channel and nozzle to drop back into the cylinder. The die is then opened and the solidified die casting ejected. Metal injection speeds and pressures are controllable to suit different metals and castings.

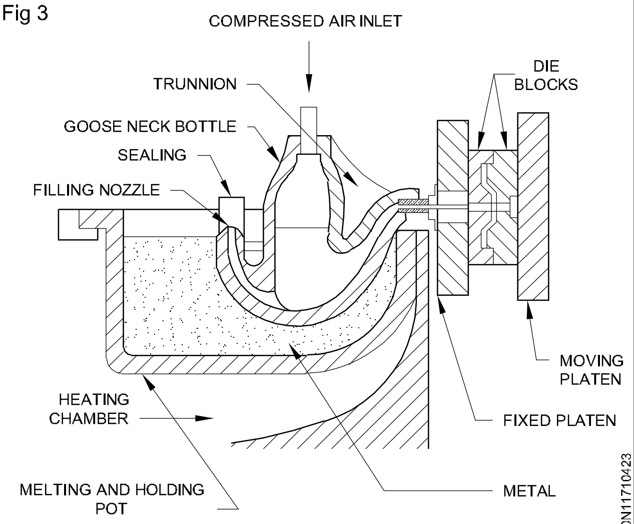
Generally, these machines work at pressures below 150 kg/cm2 as higher pressure have not proved advantageous. In order to attain uniformity and maximum speed of operation, it is necessary to use a predetermined and automatically controlled cycle for various operations. The operator is however required to manually remove the casting from the die, and inspect and sometimes lubricate it.

Air-blown or goose-neck machine

This machine differs from the hot chamber machine in that it makes use of compressed air to force the liquid into the dies (Fig. 3). Since the bottle has a goose-neck shape, it can be tilted about ruunions from the air-blowing position to the filling position and vice versa. The metal can thus be simply filled into the bottle.

The air-blown machine is much simpler in operation and construction than the plunger type as it has no moving parts. However, it requires greater attention from the operator since the work is mostly manual. It is being largely replaced by the hot chamber machine which currently records a much higher rate of production and is favoured primarily because of its easy adaptability to mass production.

Fig 3



AIR BLOWN TYPR DIE CASTING MACHINE

Metals for die casting

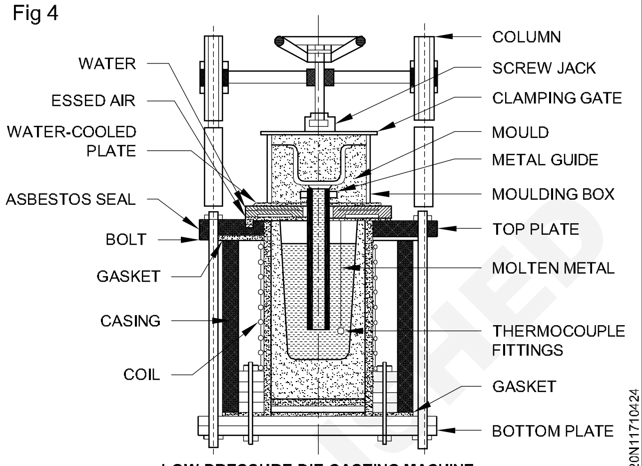
Due to lack of die material that can withstand the high pouring temperature of molten metal, it is not practicable to die cast metals such as iron and steel, which are otherwise suitable for the job. So far, only non-ferrous alloys have been die cast. Zinc alloys with melting point around 380°c are most easily die cast. Other die casting alloys are in order of importance, aluminum, magnesium, copper-base alloys, tin-base alloys, and lead.

Low pressure die casting

Low pressure die casting has been lately developed to enable production of castings that are flawless, have very thin sections, and register a yield approaching 100% even in metals such as aluminum and magnesium. The mould, which is made in metal (usually cast iron), is filled by upward displacement of molten metal from a scaled melting pot or bath (Fig 4). This displacement is effected by applying relatively low pressure of dry air (0.5 ~1.0 kg/mm2) on the surface of the molten metal in the bath.

The pressure causes the metal lo rise through a central cast iron tube and move into the die cavity. The dies are provided ample venting to allowable escape of air. The pressure is maintained till the metal is solidified; then it is released enabling the excess liquid metal to drain down the connecting tube back into the bath. Since this system of upward filling requires no runners and risers there is hardly any wastage of metal. As positive pressure is

Fig 4



LOW PRESSURE DIE CASTING MACHINE

maintained to force the metal to fill recesses and cavities, casting with excellent surface quality, finish, and soundness are produced. Low pressure on the metal completely eliminates turbulence and air aspiration. Cores, if required, can be used in the dies: they may be of sand or shell.

Gravity die casting:

The permeanent mould casting is also called Gravity die casting. The same has been discussed under section in permeanent mould casting process.

(R.T.E - 1.9.53-56)

Foundry mechanization

Objectives: At the end of this lesson you shall be able to
- **state foundry mechanization**
- **list flow operation for modernization of foundry include**
- **state their advantages & disadvantages of foundry mechanization.**

1 State the foundry mechanization

When the number of castings required from a given foundry increases, it becomes increasingly economical to resort to mechanical equipments.

Production of castings in large quantities does not depend solely on the use of handling equipment, it also needs special techniques (i.e. modernization) to obtain maximum benefit from the equipment.

Thus, for economical and quality production on mass scale in foundries, both modernization and mechanization play a major role.

2 Modernization of foundries

1 Changing over to better and newer foundry equipments;

2 Employing newer, better and more economical molding, melting and casting techniques

3 Removing conditions which make a foundry dirty, dusty and smoke filled i.e. improving working conditions in foundries, providing adequate illumination, air circulation, dust extraction etc.

Modernization helps

1 Improving quality of the castings,

2 Boosting production,

3 Reducing production cost,

4 Increasing safety to the workers,

5 Making working conditions pleasant and less tiring.,

6 Building up morale of the workers,

Mechanization

1 Mechanization implies the utilization of machinery to accomplish the work previously done by hand.

2 Mechanized foundries range between simple roller-track systems to very complex and partially automatic installations.

3 Mechanized foundries deal with large quantities and seek for every small economy to reduce the final cost.

4 Foundry mechanization could become possible because of the following two developments,

   a Machines were designed and fabricated for sand mixing, molding and core-making.

   b These machines were integrated with material handling equipments so that continuous processing could be accomplished in the foundries.

3 Advantages of foundry mechanization

a Increased production from a given foundry floor space.

b Castings possess closer dimensional tolerances, improved surface finish and higher accuracy.

c Both time and labour are saved since heavy lifting and other laborious operations are carried out mechanically.

d More hygienic and healthy working conditions in foundries.

e Minimized casting defects.

f Production of sound castings.

g Faster rate of production.

h Reduced production costs.

i Increased earnings for the foundry workers.

4 Disadvantages of foundry mechanization

1 Uneconomical for jobbing foundries producing casting in small quantities and not expecting repetitive orders.

2 Increased chances of unemployment.

The extent to which a foundry can be mechanized depends upon:

1 Quantities of various castings to be produced. For a small job shop foundry producing only one or two of a casting with little or no repetitive orders, only a minimum of mechanization is necessary, whereas a foundry making automobile parts with its repetitious mass production can go for the highest degree of mechanization.

2 The amount of flexibility desired in producing different castings.

3 The methods used to perform various steps in making a casting.

4 The need to improve working conditions.

Mechanized foundry

Fig 1 is the diagram of a typical mechanized foundry

1 Castings are knocked out of the molds on a vibratory grid at knock out station.

2 Sand passes down into a hopper through the grid and the castings vibrate off into the cooling trays.

3 The sand on a conveyor passes through the reconditioning chamber, and mixing plant and is then

delivered by an overhead belt conveyor into hoppers situated above the molding machines.

4 After the molds (i.e., cope and drag) and cores have been assembled, again on a conveyor, they are carried to casting station where the molten metal is poured by the ladles suspended from light cranes running along monorail runways.

5) Molds filled with molten metal are cooled as they pass through cooling tunnel (CT) and eventually reach the knock out station and a new foundry cycle starts.

Processing steps in mechanized foundries

Different processing steps in foundries which lend themselves to mechanization are given below:

1 Mold shake out.

2 Sand reclamation and sand preparation.

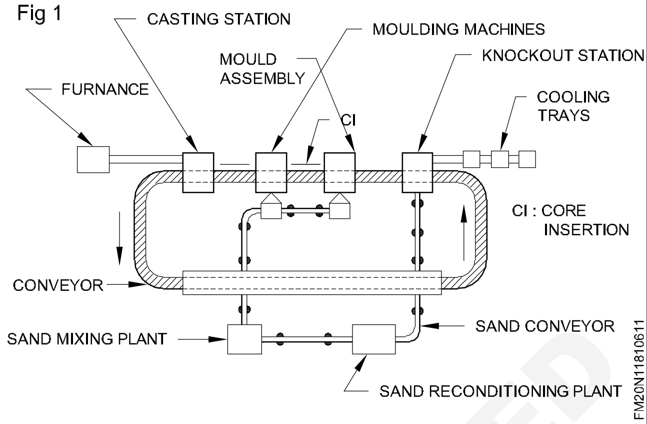
3 Molding machines.

4 Core-making machines.

5 Melting and pouring.

6 Material handling systems.

Fig 1



Layout of small foundry

Objective: At the end of this lesson you shall be able to
- **lay of foundry flowchart operation.**

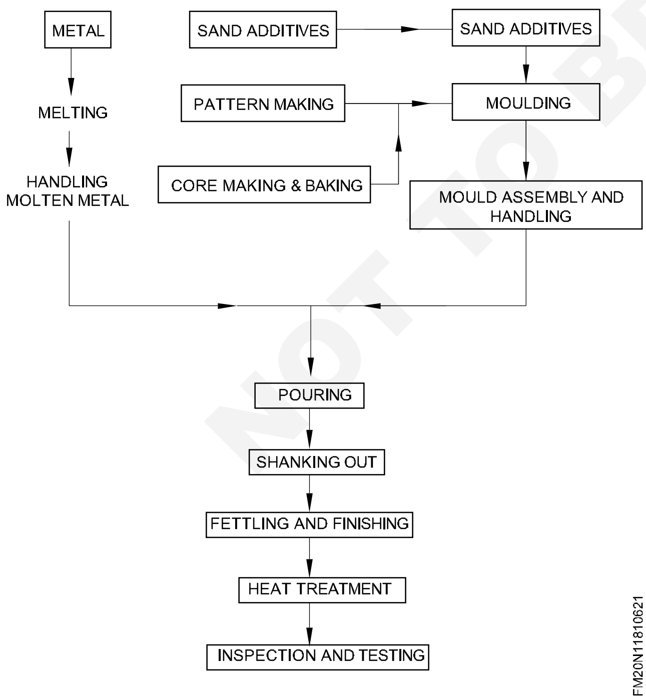
Different sections of a foundry

Shows ten different sections of a foundry in sequence in making a sand casting.

Foundry layout (Fig 1)

Figure Shows the layout of a manual foundry and give the layout of mechanized foundry.

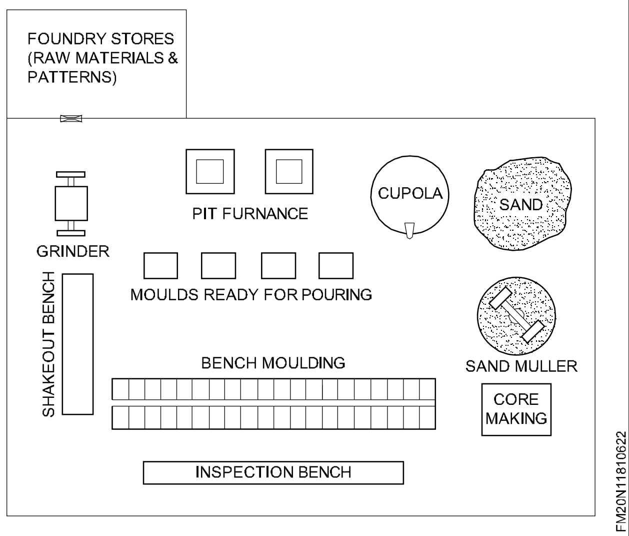
Fig 1



In a mechanized foundry, sand is prepared in a separate unit from where it reaches the hopper just above the moulding machine. Empty moulding boxes are transported (on roller conveyor) to the moulding machines where they are rammed, assembled and (on roller conveyor)

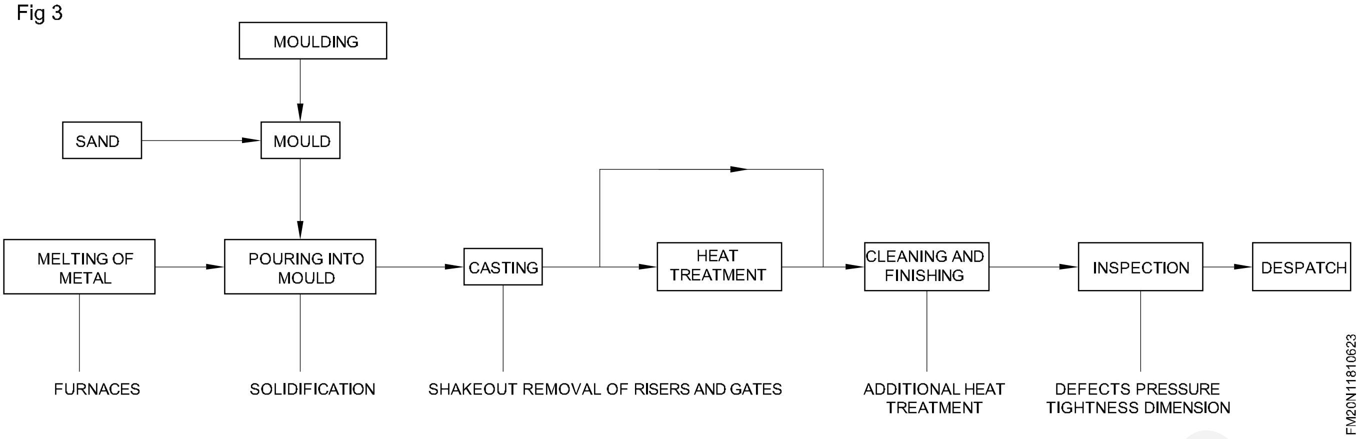
Moved to pouring station (marked cupolas in Fig 2). after the molten metal has solidified, the moulds pass through cooling zone and ultimately at shake out station castings are taken out of the moulds. Castings go for fettling and finishing whereas empty cooled moulding boxes are roller conveyed to the moulding machines and the new casting cycle begins.

Fig 2



Process flow chart of foundry. (Fig 3)

Fig 3



List of material handling equipments and their uses

Objectives: At the end of this lesson you shall be able to
- **state the important of materials handling equipments is a mechanized foundry**
- **classify of material handling equipments.**

Material handling equipments in a mechanized foundry

1 Material handling equipments are the heart of a mechanized foundry for its effective, efficient and successful operation.

2 Especially in large scale production foundries, material handling equipments help keep production costs low. This is because, flow of materials etc. is accelerated and thus man-hours are effectively saved.

3 Different materials and equipments of a foundry which need to be transported or handled are

i Sands, both molding and core sands.

ii Molding boxes both empty and rammed.

iii Furnace metal charge, fuel and fluxes.

iv Molten metal.

v Castings.

Sands are handled and transported from one place to another with the help of following material handling equipments in a mechanized foundry.

- From knock out unit to magnetic separator (apron conveyor).
- From magnetic separator to riddles for screening (Apron conveyor).
- From screens to sand reconditioning unit (belt conveyor).
- From sand store to sand mixing plant (belt conveyor, crane, hoist or industrial trucks).
- From sand reconditioning plant to sand mixing plant (belt conveyor).
- From mixing plant to overhead hoppers situated above the molding machines (overhead belt conveyor).

Empty molding boxes and molds are handled as follows:

- From knock out station to cooling trays (Apron conveyor).
- From cooling trays to molding machines (Roller conveyor).
- From molding machines to casting station (belt or roller conveyor).

Molds and molding boxes may also be transported by pallet conveyors or overhead conveyors.

Castings: Castings are transported from the knock out station to fettling and finishing section. The following material handling equipments may be utilized for the purpose.

- Apron conveyor
- Roller conveyor
- Overhead chain conveyor, etc.

Different material handling equipments such as cranes, conveyors, and industrial trucks etc.,

Melting and pouring

Melting and pouring operations in a mechanized foundry involve,

i Melting furnaces.

ii Mechanisms for material and fuel (i.e.. coke, etc.) transport.

iii Mechanical devices for changing fuel and raw materials.

iv Mechanically operated ladles.

1 Devices for transporting coke, flux and metal charge etc. from their store to the furnace are:

- Cranes.
- Lift trucks.
- Belt or bucket conveyors.

2 Devices employed for supplying metal charge into the furnace are

- **Cranes:** A crane picks up a bottom-discharge bucket full of metal charge, positions it over the charging door and permits charge to fall through the bottom of the bucket.
- **Skip hoist:** A bucket full of metal charge is raised along the vertical or inclined track by a motor with the help of a cable.

The bucket is made to invert as it enters the furnace charging door so as to drop the charge into the furnace.

3 Mechanically operated ladles such as crane or monorail ladles etc., used to pour molten metal into molds in a mechanized foundry

Classification of material handling equipments

Material handling costs in metal casting operations account variously for 20 to 40% of the total cost of producing castings. Studies in sand foundries, for example, show that 70 - 80 tons of materials (melt charge metals, molten metal, new and reclaimed sand, binders, molds, cores, shakeout sand, returns, etc.) must be lifted, conveyed, blown, hauled, set down, and otherwise handled to produce 1 ton of castings.

When a production cost figure moves into the 20-40% range, financial managers in any foundry need to ask how or where costs can be cut. A 5-10% reduction in operating costs, or a 5-10% reduction in operating cost, ora 5-10% reduction in operatiry cost or a 5-10% increase in productivity, might double or triple a foundry profitability.

- a) Industrial trucks
  - Manual-wheeled type
  - Powdered
    - Platform type
      - Low lift
      - High lift
    - Pallet lift
    - Fork lift truck
- b) Cranes
  - Overhead bridge crane
  - Jib crane
  - Gantry crane
- c) Hoists
  - Chain type (manual)
  - Pneumatic
  - Electrical
- c) Conveyors
  - Belt conveyor
  - Bucket conveyor
  - Chain conveyor
  - Apron conveyor
  - Flight conveyor
  - Pallet conveyor
- d) Slides and chutes
  - Straight
  - Spiral
  - Vibrating
- f) Tractors and trailers
- g) Robots