TURNER

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR: CAPITAL GOODS & MANUFACTURING

(As per revised syllabus July 2022 - 1200 Hrs)

कौशलं बलम्

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**

Duration : **2 Years**

Trade : **Turner - 1st Year - Trade Theory - NSQF level - 4 (Revised 2022)**

Developed & Published by

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First Edition : October 2022 Copies : 1000

Rs.320/-

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 **Turner - 1st Year - Trade Theory -** NSQF Level - 4 (Revised 2022) in **CG & M Sector** under **Yearly Pattern.** The NSQF Level - 4 (Revised 2022) Trade Practical 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 - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (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 syllabus 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 **Turner - 1st Year- NSQF Level - 4 (Revised 2022)** under the **CG & M** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

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NIMI - CO-ORDINATORS

Shri. Nirmalya Nath	_	Deputy Director NIMI - Chennai - 32
Shri. V. Gopala Krishnan	_	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 intented to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Turner** trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022) syllabus are covered.

This manual is divided into Eight modules. The Eight modules are given below.

Module 1	-	Occupational Safety
Module 2	-	Basic fitting
Module 3	-	Turning
Module 4	-	Taper turning
Module 5	-	Eccentric turning
Module 6	-	Thread cutting
Module 7	-	Other form thread
Module 8	-	Special jobs maintenance

The skill training in the shop floor is planned through a series of practical exercises centred 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 **Turner** Trade Theory NSQF Level - 4 (Revised 2022) in CG & M. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on TradeTheory 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 the 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	Ref.Ex.No
1	Plan and organize the work to make job as per specification applying different types of basic fitting operations & check for dimensional accuracy following safety precautions.[Basic Fitting Operation - Marking, Hack sawing, filing, drilling, taping etc.] **(NOS:CSC/N0304)**	1.1.01 - 1.2.21
2	Set different shaped jobs on different chuck and demonstrate conventional lathe machine operation observing standard operation practice. [Different chucks: - 3 jaws & 4 jaws, different shaped jobs: - round, hexagonal, square] **(NOS: CSC/N0110)**	1.3.22 - 1.3.26
3	Prepare different cutting tool to produce jobs to appropriate accuracy by performing different turning operations. [Different cutting tool - V tool, side cutting, parting, thread cutting (both LH & RH), Appropriate accuracy: - ±0.06mm, Different turning operation - Plain, facing, drilling, boring (counter & stepped), grooving, Parallel Turning, Step Turning, parting, chamfering, U -cut, Reaming, internal recess, knurling. **(NOS: CSC/N0110)**	1.3.27 - 1.3.45
4	Test the alignment of lathe by checking different parameters and adjust the tool post. [Different parameters - Axial slip of main spindle, true running of head stock, parallelism of main spindle, alignment of both the centres.] **(NOS: CSC/N0110)**	1.3.46 - 1.3.48
5	Set different components of machine & parameters to produce taper/ angular components and ensure proper assembly of the components. [Different component of machine: - Form tool, Compound slide, tail stock offset, taper turning attachment. Different machine parameters- Feed, speed, depth of cut.] **(NOS: CSC/N0110)**	1.4.49 - 1.4.54
6	Set the different machining parameter & tools to prepare job by performing different boring operations. [Different machine parameter- Feed, speed & depth of cut; Different boring operation - Plain, stepped & eccentric] **(NOS: CSC/N0110)**	1.5.55 - 1.5.59
7	Set the different machining parameters to produce different threaded components applying method/ technique and test for proper assembly of the components. [Different thread: - BSW, Metric, Square, ACME, Buttress.] **(NOS: CSC/N0110)**	1.6.60 - 1.6.81
8	Set the different Machining parameter & lathe accessories to produce components applying techniques and rules and check the accuracy. [Different machining parameters: - Speed, feed & depth of cut; Different lathe accessories: - Driving Plate, Steady rest, dog carrier and different centres.] **(NOS: CSC/N0110)**	1.7.82 - 1.7.83
9	Plan and perform basic maintenance of lathe & grinding machine and examine their functionality. **(NOS: CSC/N0110)**	1.8.84 - 1.8.86

SYLLABUS FOR TURNER

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 145 Hrs.; Professional Knowledge 30 Hrs.	Plan and organize the work to make job as per specification applying different types of basic fitting operations & check for dimensional accuracy following safety precautions.[Basic Fitting Operation - Marking, Hack sawing, filing, drilling, taping etc.] **(NOS:CSC/N0304)**	1. Importance of trade training, List of tools & Machinery used in the trade. (1 hr.) 2. Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE). (5 hrs.) 3. First Aid Method and basic training. (2 hrs.) 4. Safe disposal of waste materials like cotton waste, metal chips/burrs etc. (2 hrs.) 5. Hazard identification and avoidance. (2 hrs.) 6. Safety signs for Danger, Warning, caution & personal safety message. (1 hr.) 7. Preventive measures for electrical accidents & steps to be taken in such accidents. (2 hrs.) 8. Use of Fire extinguishers. (5 hrs.) 9. Practice and understand precautions to be followed while working in fitting jobs. (2 hrs.) 10. Safe use of tools and equipments used in the trade. (1 hr.)	All necessary guidance to be provided to the newcomers to become familiar with the working of Industrial Training Institute system including stores 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. 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. (02 Hrs.)
		11. Identification of tools &equipments as per desired specifications for marking & sawing (Hand tools, Fitting tools & Measuring tools) (2 hrs.) 12. Selection of material as per application Visual inspection of raw material for rusting, scaling, corrosion etc. (1 hr.) 13. Marking out lines, gripping suitably in vice jaws, hack sawing to given dimensions, sawing different types of metals of different sections. (10 hrs.) 14. Practice on hammering, marking out, chipping, chisel grinding. (6 hrs.)	Measurement, line standard and end standard, steel rule- different types, graduation and limitation. Hammer and chisel- materials, types and uses. Prick punch and scriber. (05 Hrs.)

		15. Filing practice on plain surfaces, right angle by filing. (45 hrs.) 16. Use of calipers and scale measurement. (3 hrs.)	Vice - types and uses, Files- different types of uses, cut, grade, shape, materials etc. Try square-different types, parts, material used etc. Calipers- types and uses (firm joint). (10 Hrs.)
		17. Filing at right angle, marking & hack sawing. (25 hrs.)	Vee - block, scribing block, straight edge and its uses. Hacksaw-their types & uses. (05 Hrs.)
		18. Marking operation on flat & round job. (8 hrs.) 19. Drilling operation: Drill on flat, square bar and round bar of different material (Sensitive drill machine). (10hrs.)	Center punch- materials, construction & material uses. Drill machine-different parts. Hacksaw blades- sizes, different Parts. Hacksaw blades-sizes, different pitch for different materials. Nomenclature of drill. (04 Hrs.)
		20. Different threading (BSW, BSP, BA, Metric, UNC, UNF) with the help of taps and dies both external & internal (including pipes) using collet chuck. (10 hrs.) 21. Extraction of broken tap. (2hrs.)	Surface plate its necessity and use. Tap - different types (Taper 2nd and bottoming) care while tapping. Dies different types and uses. Calculation involved to find Out drill size (Metric and Inch). (04 Hrs.)
Professional Skill 40 Hrs.; Professional Knowledge 08 Hrs.	Set different shaped jobs on different chuck and demonstrate conventional lathe machine operation observing standard operation practice. [Different chucks: -3 jaws & 4 jaws, different shaped jobs:- round, hexagonal, square] **(NOS: CSC/N0110)**	22. Identify & function of different parts of lathe. Practice on operation of lathe (dry/idle run). (15 hrs.) 23. Setting lathe on different speed and feed. (5 hrs.)	Getting to know the lathe with its main components, lever positions and various lubrication points as well. Definition of machine & machine tool and its classification. History and gradual development of lathe. (04 Hrs.)
		24. Mounting of chuck on machine spindle and unloading -3-jaw chuck & 4- jaw chuck. (10 hrs.) 25. Setting practice on round & square/ hexagonal bar. (3 hrs.) 26. Dismantling and assembling of 3 jaw and 4 jaw chucks. (7 hrs.)	Classification of lathe in Function and construction of different parts of Lathe. (04 Hrs.)
Professional Skill 210 Hrs.; Professional Knowledge 45 Hrs.	Prepare different cutting tool to produce jobs to appropriate accuracy by performing different turning operations. [Different cutting tool - V tool, side cutting, parting, thread cutting (both LH & RH), Appropriate accuracy:-±0.06mm, Different turning operation - Plain, facing, drilling, boring (counter & stepped), grooving, Parallel Turning, Step Turning, parting, chamfering, U -cut, Reaming, internal recess, knurling. **(NOS: CSC/N0110)**	27. Turning of round stock and square/hexagonal as per availability on 4-jaw independent chuck. (15 hrs.) 28. Turning of round stock on 3-jaw self centering chuck. (10hrs.)	Types of lathe drivers, merit and demerit. Description in details-head stock-cone pulley type- all geared type-construction & function. Tumbler gear set. Reducing speed-necessary & uses. Back Gear Unit-its construction use. (05Hrs.)

		29. Grinding of R.H. and L.H., V-tool, side cutting tools, parting tool. (10 hrs.) 30. Checking of angles with angle gauge / bevel protractor. (1 hr.) 31. Grinding of "V" tools for threading of Metric 60- degree threads. (9 hrs.)	Lathe cutting tool-different types, shapes and different angles (clearances and rake), specification of lathe tools. (05 Hrs.)
		32. Facing operation to correct length (5 hrs.) 33. Centre drilling and drilling operation to required size. (05 hrs.) 34. Make square block by turning using 4-jaw chuck and perform drilling, boring and grooving operation. (10 hrs.)	Combination drill- appropriate selection of size from chart of combination drill. Drill, chuck- its uses. Lathe accessories, chuck independent, self-centering, collet, magnetic etc., its function, construction and uses. (05 Hrs.)
		35. Parallel turning, step turning, parting, grooving, chamfering practice. (38 hrs.) 36. Measurement with scale and outside caliper to ± 0.5 mm. accuracy. (2 hrs.)	Vernier caliper-its construction, principle graduation and reading, least count etc. Digital vernier caliper. Outside micrometer -different parts, principle, graduation, reading, construction. Digital micrometer. Cutting speed, feed depth of cut, calculation involved-speed feed R.P.M. etc. recommended for different materials. (10 Hrs.)
		37. Step turning within ± 0.06 mm with different shoulder, U/cut on outside diameter. (15 hrs.) 38. Drilling on Lathe-step drilling, drill grinding practice. (10 hrs.)	Different types of micrometer, Outside micrometer. Vernier scale graduation and reading. Sources of error with micrometer & how to avoid them. Use of digital measuring instruments. (05Hrs.)
		39. Boring practice-Plain. Counter& step, internal recessing. (20 hrs.) 40. Reaming in lathe using solid and adjustable reamer. (15 hrs.) 41. Make bore by trepanning (10 hrs.) 42. Drill grinding. (5 hrs.)	Drills-different parts, types, size etc., different cutting angles, cutting speed for different material. Boring tool. Counter - sinking and Counter boring. Letter and number drill, core drill etc. Reamers-types and uses. Lubricant and coolant-types, necessity, system of distribution, selection of coolant for different material: Handling and care. (07 Hrs.)
		43. Turning practice-between centres on mandrel (Gear blanks). (15 hrs.) 44. Fitting of dissimilar materials- M.S. in brass, aluminium, in cast iron etc. (10 hrs.) 45. Knurling practice in lathe (Diamond, straight, helical & square). (5hrs.)	Knurling meaning, necessity, types, grade, cutting speed for knurling. Lathe mandrel- different types and their uses. Concept of interchangeability, Limit, Fit and tolerance as per BIS: 919-unilateral and bilateral system of limit, Fits- different types, symbols for holes and shafts. Hole basis & shaft basis etc. Representation of Tolerance in drawing. (08 Hrs.)

Professional Skill 25 Hrs.; Professional Knowledge 05 Hrs.	Test the alignment of lathe by checking different parameters and adjust the tool post. [Different parameters - Axial slip of main spindle, true running of head stock, parallelism of main spindle, alignment of both the centres.] **(NOS: CSC/N0110)**	46. Checking alignment of lathe centres such as Levelling, axial slip of main spindle, true running of head stock centre, parallelism of the main spindle to saddle movement, alignment both the centres. (20 hrs.) 47. Adjustment of tool post. (3 hrs.) 48. Mounting job in between centres. (2 hrs.)	Driving plate. Face plate & fixed & traveling steadies- construction and use. Transfer caliper-its construction and uses. Lathe centers-types and their uses. Lathe carrier-function types & uses. Mandrel - Different types and its use. Magnetic stand dial indicator, its used and care. (05 Hrs.)
Professional Skill 65 Hrs.; Professional Knowledge 10 Hrs.	Set different components of machine & parameters to produce taper/angular components and ensure proper assembly of the components. [Different component of machine:- Form tool, Compound slide, tail stock offset, taper turning attachment. Different machine parameters-Feed, speed, depth of cut.] **(NOS: CSC/N0110)**	49. Make taper turning by form tool and compound slide swivelling. (20 hrs.)	Taper - different methods of expressing tapers, different standard tapers. Method of taper turning, important dimensions of taper. Taper turning by swiveling compound slide, its calculation. (05 Hrs.)
		50. Male and female taper turning by taper turning attachment, offsetting tail stock. (22 hrs.) 51. Matching by Prussian Blue. (2 hrs.) 52. Checking taper by bevel protector and sine bar. (1 hr.) 53. Make MT3 lathe dead centre and check with female part. (Proof machining) (20 hrs.)	Bevel protector & Vernier bevel protractor-its function & reading. Method of taper angle measurement. Sine bar-types and use. Slip gauges-types, uses and selection. (5 Hrs.)
Professional Skill 65 Hrs.; Professional Knowledge 05 Hrs.	Set the different machining parameter & tools to prepare job by performing different boring operations. [Different machine parameter- Feed, speed & depth of cut; Different boring operation - Plain, stepped & eccentric] **(NOS: CSC/N0110)**	54. Turning and boring practice on CI (preferable) or steel. (22 hrs.)	Basic process of soldering, welding and brazing. (05 Hrs.)
		55. Eccentric marking practice. (2 hrs.) 56. Perform eccentric turning. (15 hrs.) 57. Use of Vernier height Gauge and V-block. (1 hr.) 58. Perform eccentric boring. (15 hrs.) 59. Make a simple eccentric with dia. of 22mm and throw/offset of 5mm. (10 hrs.)	Vernier height gauge, function, description & uses, templates- its function and construction. Screw thread-definition, purpose & its different elements. Driving plate and lathe carrier and their usage. Fundamentals of thread cutting on lathe. Combination set-square head. Center head, protractor head- its function construction and uses. (5 Hrs.)
Professional Skill 210 Hrs.; Professional Knowledge 40 Hrs.	**Set the different** machining parameters to produce different threaded components applying method/ technique and test for proper assembly of the components. [Different thread: - BSW, Metric, Square, ACME, Buttress.] (NOS: CSC/N0110)	60. Screw thread cutting (B.S.W) external (including angular approach method) R/H & L/H, checking of thread by using screw thread gauge and thread plug gauge. (14 hrs.) 61. Screw thread cutting (B.S.W) internal R/H & L/H, checking of thread by using screw thread gauge and thread ring gauge. (14 hrs.)	Different types of screw thread- their forms and elements. Application of each type of thread. Drive train. Chain gear formula calculation. Different methods of forming threads. Calculation involved in finding core dia., gear train (simple gearing) calculation. Calculations involving driver- driven, lead screw pitch and thread to be cut. (08 Hrs.)

		62. Fitting of male & female threaded components (BSW) (4hrs.) 63. Prepare stud with nut (standard size). (10hrs.)	
		64. Grinding of "V" tools for threading of Metric 60- degree threads and check with gauge. (3 hrs.) 65. Screw thread cutting (External) metric thread- tool grinding. (10 hrs.) 66. Screw thread (Internal) metric & threading tool grinding. (14 hrs.) 67. Fitting of male and female thread components (Metric) (2 hrs.) 68. Make hexagonal bolt and nut (metric) and assemble. (10 hrs.)	Thread chasing dial function, construction and use. Calculation involving pitch related to ISO profile. Conventional chart for different profiles, metric, B.A., With worth, pipe etc. Calculation involving gear ratios and gearing (Simple & compound gearing). Screw thread micrometer and its use. (08 Hrs.)
		69. Cutting metric threads on inch lead screw and inch threads on Metric Lead Screw. (20 hrs.) 71. Cutting Square thread (External) (11 hrs.) 72. Cutting Square thread (Internal). (18 hrs.) 73. Fitting of male and female Square threaded components. (2 hrs.) 74. Tool grinding for Square thread (both External & Internal). (2 hrs.) 75. Make square thread for screw jack (standard) for minimum 100mm length bar. (12 hrs.)	Calculation involving gear ratios metric threads cutting on inch L/S Lathe and vice-versa. (03Hrs.) Tool life, negative top rake-its application and performance with respect to positive top rake (03 Hrs.) Calculation involving tool Thickness, core dia., pitch proportion, depth of cut etc. of sq. thread. (08 Hrs.)
		76. Acme threads cutting (male & female) & tool grinding. (08 hrs.) 77. Fitting of male and female threaded components. (7 hrs.) 78. Cut Acme thread over 25 mm dia. rod and within length of 100mm. (10 hrs.)	Calculation involved - depth, core dia., pitch proportion etc. of Acme thread. Calculation involved depth, core dia., pitch proportion, use of buttress thread. (05 Hrs.)
		79. Buttress threads cutting (male & female) & tool grinding. (11 hrs.) 80. Fitting of male & female threaded components. (2 hrs.) 81. Make carpentry vice lead screw. (5 hrs.)	Buttress thread cutting (male & female) & tool grinding(05 Hrs.)

Professional Skill 40 Hrs.; Professional Knowledge 08 Hrs.	Set the different Machining parameter & lathe accessories to produce components applying techniques and rules and check the accuracy. [Different machining parameters: - Speed, feed & depth of cut; Different lathe accessories: - Driving Plate, Steady rest, dog carrier and different centres.] **(NOS: CSC/N0110)**	82. Make job using different lathe accessories viz., driving plate, steady rest, dog carrier and different centres. (25hrs.) 83. Make test mandrel (L=200mm) and counter bore at the end. (15 hrs.)	Different lathe accessories, their use and care. (8 Hrs.)
Professional Skill 40 Hrs.; Professional Knowledge 9 Hrs.	Plan and perform basic maintenance of lathe & grinding machine and examine their functionality. **(NOS: CSC/N0110)**	84. Balancing, mounting &dressing of grinding wheel (Pedestal). (10hrs.) 85. Periodical lubrication procedure on lathe. (10 hrs.) 86. Preventive maintenance of lathe. (20 hrs.)	Lubricant-function, types, sources of lubricant. Method of lubrication. Dial test indicator use for parallelism and concentricity etc. in respect of lathe work Grinding wheel abrasive, grit, grade, bond etc.(9 Hrs.)

Familiarisation industrial training institute in India

Objectives: At the end of this lesson you shall be able to
- **state what is ITI and brief the objectives of ITI**
- **describe the organizational chart**
- **list out the infrastructure available in ITI**
- **explain the job opportunities and carrier development after completion of courses**
- **brief the examination pattern and soft skills.**

Introduction to ITI

ITI stands for Industrial Training Institutes. These institutes function under the Directorate General of Training (DGT), the Ministry of Skill Development and Entrepreneurship and the Union Government. Come under the Craftsman Training Scheme (CTS)

The objectives of an ITI

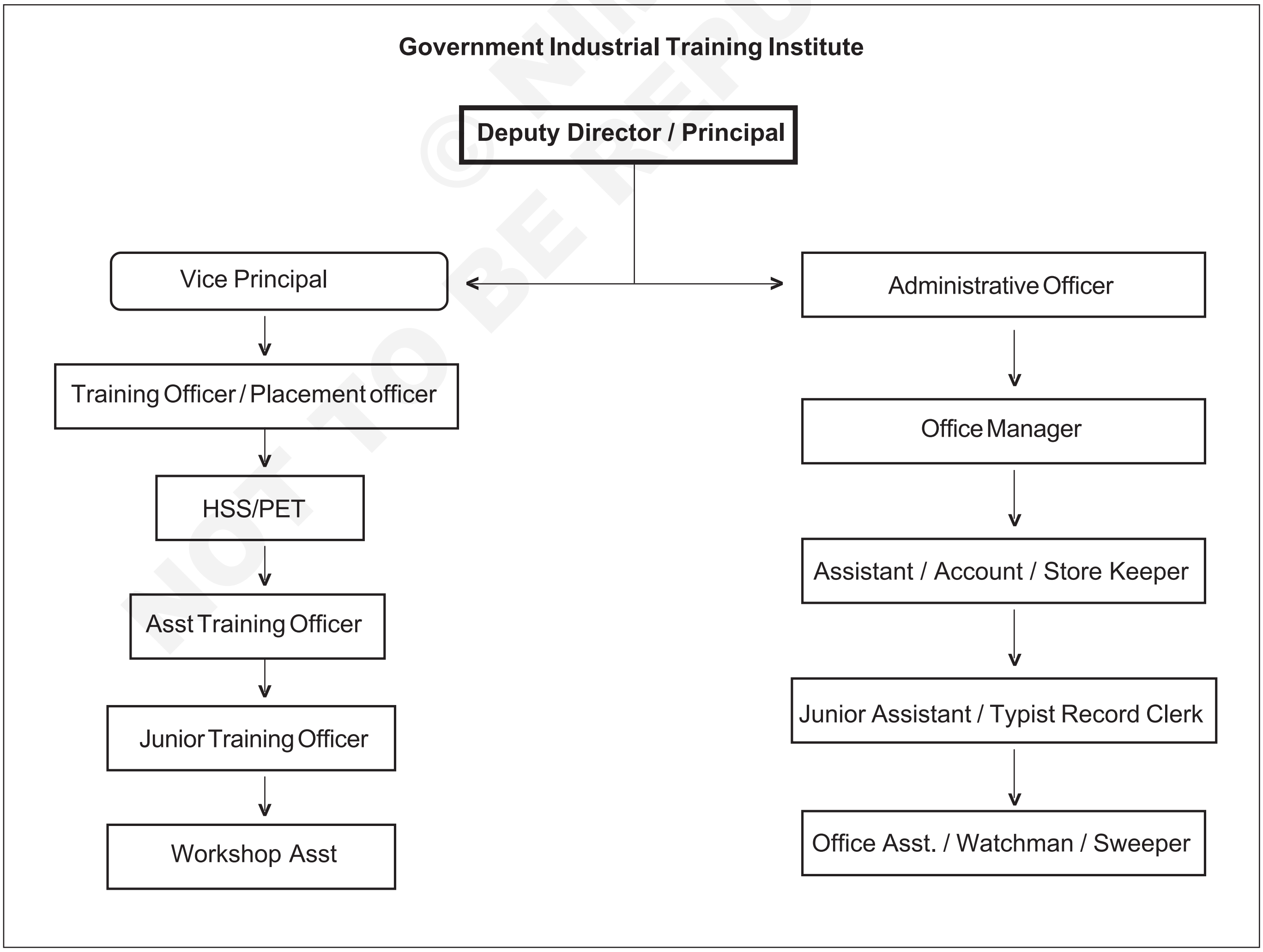
The objective of an ITI is to ensuing a steady flow of skilled workers and to reduce unemployment among the educated youth by training & equipping for suitable industrial employment and as well as for self employment.

The institute imparts training in engineering and non engineering two years/ one year trade courses approval by the Government of India in consultation with the National Council for Vocational Training, New Delhi.

Structural of ITI

The structural of industrial training institute is shown in the following chart 1. It may vary state to sate It explain the information /order flow from higher superior officials to the ground level officials. The working hours may differs state to state. The trade master is the overall in-charge for the particular trade .the trainee has to report to trade master.

In every ITI there is a store and the incharge of the store is storekeeper for inward and outward movement of tool, equipment and consumable. The instructor will indent the training requirement and used for the training purposes



Infrastructure available in ITI's

To provide 100% practical training to the trainees, tools ,equipments, machineries and class room facilities are available in ITI's. Continuous learning process/ programs are initiates and conducted in regular intervals as per the instructions given by the DGT.

The following facilities are available in ITI's

- Hostel facilities
- Libraries
- Soft skills lab/ computer labs
- High end classrooms available/smart class.
- Store
- Sports
- Wifi enabled campus.
- Industrial visit's/ Industrialist guest lecture
- Internship training on the job training
- Apprentice programs
- Campus interview and etc

CTS Admission Process

Online counseling is conducted Statewide Selection is made on merit basis duly following rules of reservation. The candidates exercise the option of choosing the ITI and trade of their choice.

Students between the age of 14 - 40 are admitted in Industrial Training Institutes Admission is made during the month of August every year.

Craftsman Training Scheme Exam System

Trade Test is conducted on All India basis and the question papers are issued to all Trade Testing Centres by the NCVT. Passed-out candidates are issued with National Trade Certificate (NTC) under the seal and authority of NCVT by DGT, New Delhi

Job area after completion of training

This highlights the employability aspect on 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 indifferent industries in india and Abroad.

After successful completion of training in any one of the engineering trade one can seek 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 is own factory / ancillary unit or design products manufacture and became an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

Skill competition

India skill competition is organized by national skill development corporation., India skill competition the country's biggest skill competition is designed to demonstrate the highest standards of skilling and offers a platform to young people to show their talent at national level and international levels.

- All India Skill Competition for Craftsmen scheme at national level was introduced to foster a healthy competition among the trainees of ITIs.
- The competition is now held every year in 15 trades viz. Instrument Mechanic, Electronic Mechanic, Welder, Fitter, Turner, Machinist, Mechanic Motor Vehicle, Foundry man, Electrician, Cutting & Sewing, Computer Operator & Programming Assistant, Draughtsman (Civil), Draughtsman (Mechanical), Mechanic Diesel and Mechanic Refrigeration & Air- Conditioning.
- The best trainee of each of the above trades at the State level competition competes at the All India Skill Competition.

Awards

The best Craftsmen in each of the above 15 trades at the All India level are awarded merit certificates and a cash prize of Rs. 50,000/- each. ITIs whose trainee stands first in the competition at the All India Skill Competition is awarded a merit certificate and is declared as best ITI.

Approach on soft skills

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

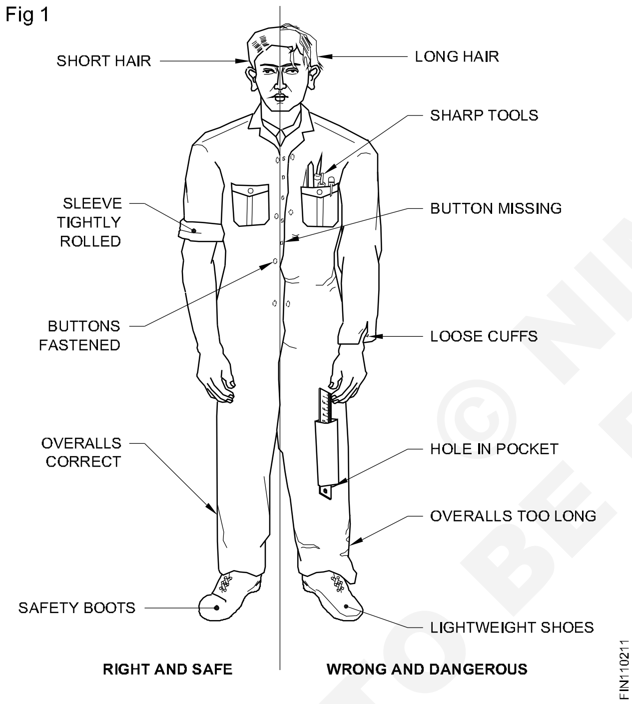
More and more business are considering soft skills as an important job criteria. Soft skills are used in personal and professional life. Hard skills / technical skills do not matter without soft skills.

Safety and general precautions in 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 a 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 crack practical jokes while on work.

Use the appropriate 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 workpiece is securely mounted
- the feed of machinery is in the neutral
- the work area is clear & neat.

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 methodological 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 workpiece 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 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 make people to varying degrees. The same can also be defined as an ability to interact communicate positively & productively with others. Sometimes called "character skills".

More and more business are considering soft skills as important job criteria. Soft skills are used in personal and professional life. Hard skills/technical skills do not matter 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 area completion of training: This highlights the employability aspect on 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 trade 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 is own factory/ancillary unit or design products manufacture and became an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

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

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

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.

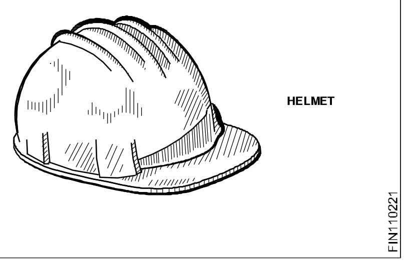
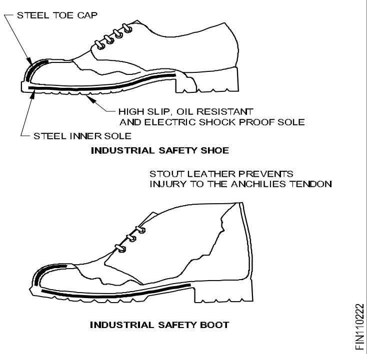
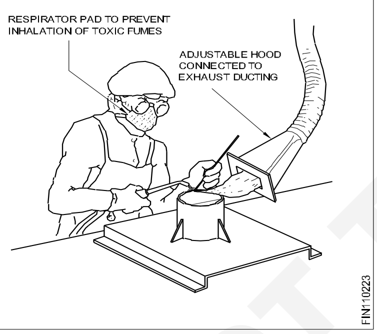
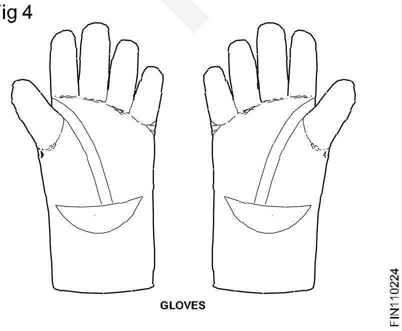
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

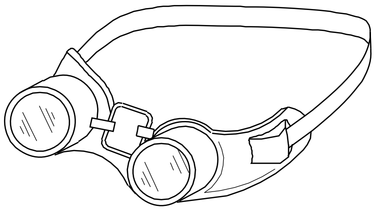
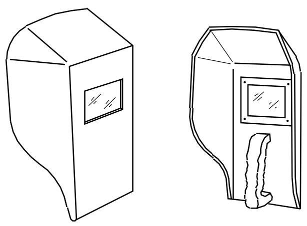
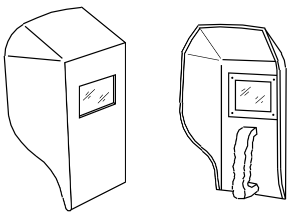
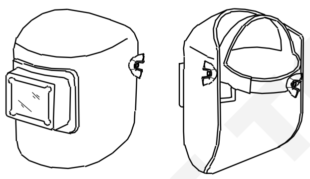
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

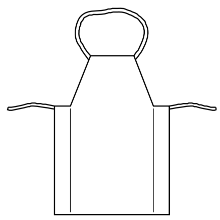
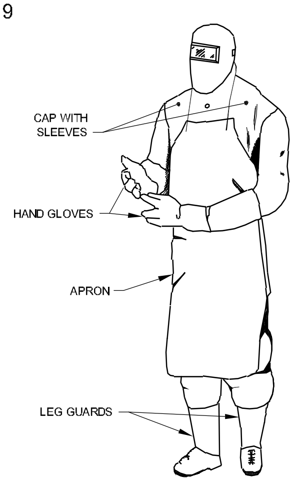
Table 1

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

Personal protective equipments and their uses and hazards are listed in Table 2

Types of protection	Hazards	PPE to be used
Head protection (Fig 1) Fig 1 	1. Falling objects 2. Striking against objects 3. Spatter	Helmets
Foot protection (Fig 2) Fig 2 	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots
Nose (Fig 3) Fig 3 	1. Dust particles 2. Fumes/gases/ vapours	Nose mask
Hand Protecion (Fig 4) Fig 4 	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves

Types of protection	Hazards	PPE to be used
Eye protection (Fig 5 & Fig6) Fig 5  FIN110225 Fig 6  HAND SCREEN FIN110226	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible	Goggles Face shield radiation Hand shield Head shield
Face protection (Fig 6 &Fig 7) Fig 6  HAND SCREEN FIN110226 Fig 7  WELDING HELMET FIN110227	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 (Fig 7)  Ear muffs  Ear plug	1. High noise level	Ear plug Ear muff

Types of protection	Hazards	PPE to be used
Body protection (Fig 8, & Fig 9) Fig 8  APRON FIN110228 Fig 9  LEG GUARDS FIN110229	1. Hot particles	Leather aprons

Quality of PPE's

PPE must meet the following criteria with regard to its quality-provide absolute full pretection 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.

Selection of PPE's requires certain conditions

- Nature and severity of the hazard
- Type of contaminant, its concentration and loacation 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.

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.

First-aid

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

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.

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.

Important guideline for first aiders

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.

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)

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.

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.

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

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.

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.- If you are trained.

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.

- Shock (Cardiogenic, Neurogenic)
- Head injury (Concussion, Compression)
- Asphyxia (obstruction to air passage)
- Extreme of body temperature (Heat, Cold)
- Cardiac arrest (Heart attack)
- Stroke (Cerebro-vascular accident)
- Blood loss (Haemorrhage)
- Dehydration (Diarrohea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or very high)
- Over dose of alcohol, drugs
- Poisoning (Gas, Pesticides, Bites)
- Epileptic fits (Fits)
- Hysteria (Emotional, Psychological)

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

First aid

- 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.
- 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.

DO NOT

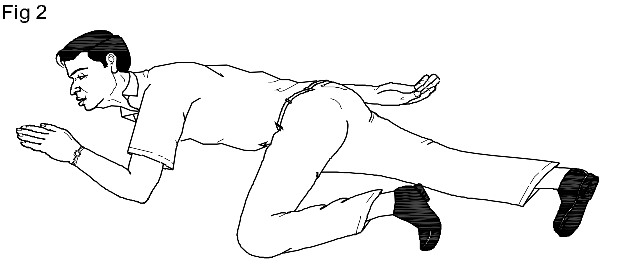
- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

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 dishevelled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?

Fig 2



- **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.

Shock: 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.

Operation of electrical mains

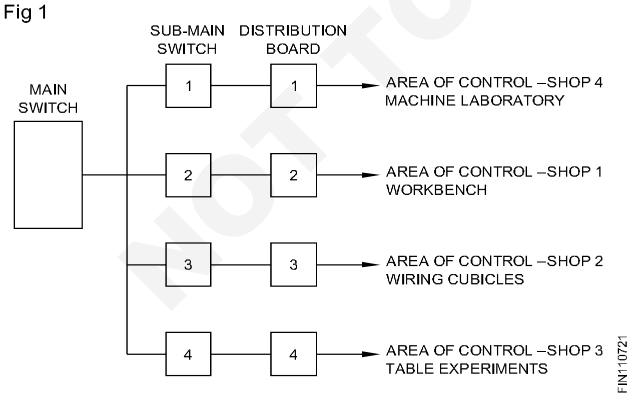
Objectives : At the end of this lesson you shall be able to
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON & 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 submain 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.

Fig 2

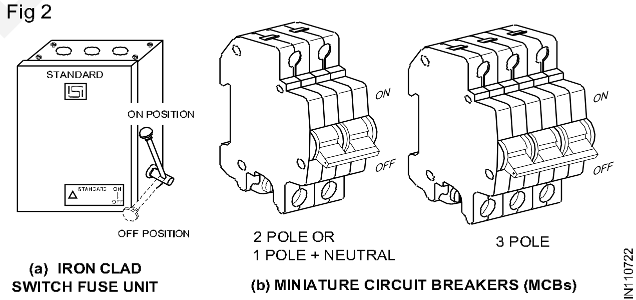
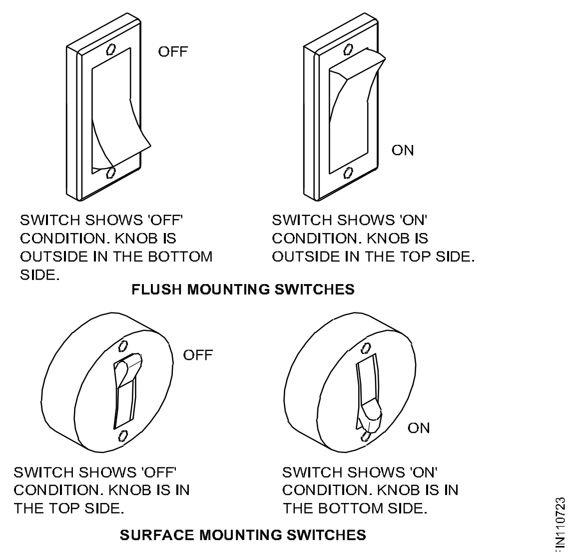


Fig 3



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)

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.

Electrical safety

Objectives : At the end of this lesson you shall be able to
- **explain the necessary 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 electricaian. Here a 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 wih 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 standardisation.
- 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 good 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 firm 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.
- 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 after inserting insulating porcelain tubes.
- Connections in the electrical apparatus should be tight. Lossely 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.

Disposal of waste material

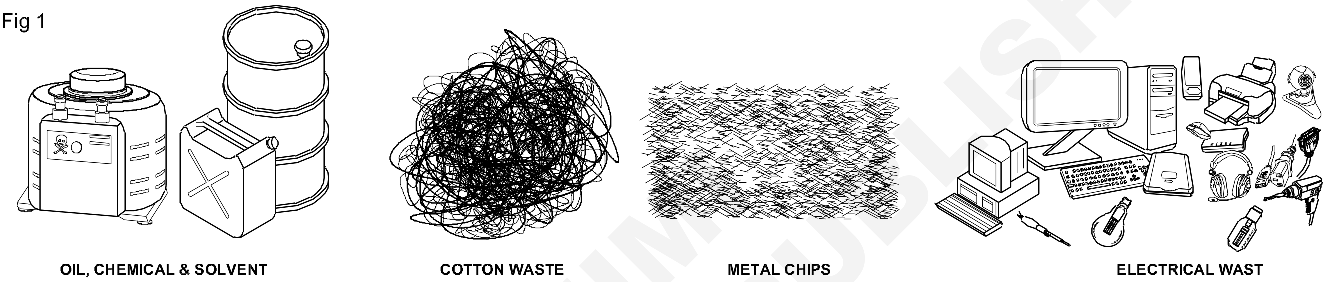
Objectives: At the end of this lesson you shall be able to
- **state what is waste material**
- **list the waste materials in a work shop**
- **explain the methods of disposal of waste material.**
- **state advantage of disposal of waste material.**
- **state colour code for bins for waste segregation.**

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)

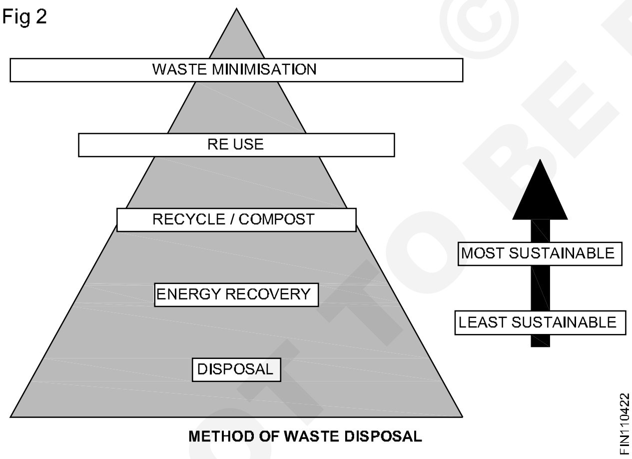
- Cotton waste
- Metal chips of different material.
- Oily waste such as lubricating oil, coolant etc.
- Other waste such electrical, glass etc.

Fig 1



Methods of waste disposal (Fig 2)

Fig 2



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.

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.

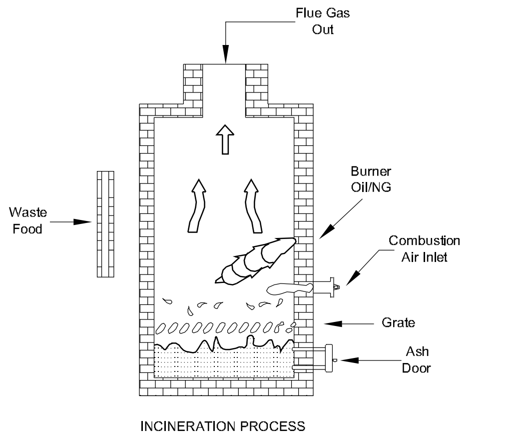
Burning the waste material: If you cannot recycle or if there are no proper places for setting up landfills, you can burn the waste matter generated in your household. Controlled burning of waste at high temperatures to produce steam and ash is a preferred waste disposal technique.

Advantage of waste disposal:

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

Incineration (Fig 3)

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 reduced 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 space need, 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
- **describe occupational safety and its importance at work place to prevent unsafe act and conditions in work-related activities**
- **brief the Environmental guidelines, legislations & regulations in India, framed to protect workplace health and safety.**
- **list the Occupational safety and health Tips.**

Occupational safety, and health

Occupational safety, and health means actions or working conditions which are safe from any cause resulting in danger to life, physique, mentality or health arising out of or related to working environment. OSH includes the laws, standards and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

The goal of Occupational safety and health

The goal of Occupational safety and health program is to foster a safe and healthy occupational environment. OSH also protects all the general public who may be affected by the occupational environment.

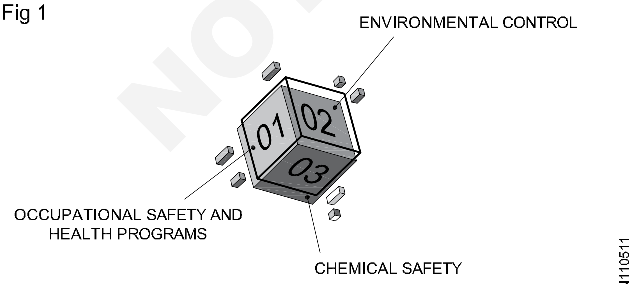
Environmental safety

Environmental safety is defined by the guidance, policies, and practices enforced in order to ensure that the surrounding environment is free from hazards that will warrant the safety and well-being of workers and employees, residents near industrial operations, as well as the prevention of accidental environmental damage

The surrounding areas include industrial facilities, work areas, and laboratories. Environmental safety is a crucial issue for any industrial activity as negligence and non-compliance heighten the risk resulting in injuries, illnesses, and accidental environmental releases.

Environmental safety is usually divided into three subcategories: (fig1) Occupational safety and Health Programs, Environmental Control, and Chemical Safety. (Fig 1)

Fig 1



ENVIRONMENTAL SAFETY SEGMENTS

In order to protect the workers against work related sickness, disease and injury. The International labour organization(ILO) came up with an official order on OSH.

Similarly government of India is enacted the following acts

- The legislation for labour welfare, known as the Factories Act 1948, was enacted with the prime objective of protecting workmen employed in factories against industrial and occupational hazards. There are number of Acts enacted by the government of India and amended from time to time; among them the following are the most important ones in this regard:
- Factories Act, 1948,
- Mines Act, 1952,
- Dock workers (Safety, Health and welfare) Act, 1986,
- Building and other Construction workers (Regulation of Employment and conditions of service) Act, 1996,
- Plantation Labour Act, 1951,
- Contract Labour (Regulation and Abolition) Act, 1970
- The Child labour (Prohibition and Regulation) Act, 1986, etc.

Constitutional provisions form the basis of workplace safety and health laws in India by imposing a duty on the State governments to implement policies that promote the safety and health of workers at workplaces. In addition, safety and health statutes for regulating occupational safety and health (OSH) of persons at work exist in different sectors, namely manufacturing, mining, ports, and construction sector.

The health and safety at work Act,1974 states employers are responsible for protecting the safety of their employees at work by preventing potential dangers in the workplace. It places general duties on employers to ensure the health, safety and welfare of all persons while at work.

Legislation is a directive proposed by a legislative body while a regulation is a specific requirement within legislation. Legislation is broader and more general while regulation is specific and details how legislation is enforced.

The difference between legislation and regulation is that legislation is the act of process of making certain laws while regulation is maintaining the law or set of rules that govern the people. It is a government-driven or ministerial order having the force of law.

The ILO's primary goal is to promote opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity.In 2003 the ILO adopted a global strategy to improve preventive standards on occupational safety and health to provide essential tools for governments, employers, and workers to establish safe practices and health culture for providing maximum safety at work.

The four important aims of health and safety legislation is to

i secure the safety, health and welfare of employees and other people at work;

ii protect the public from the safety and health risks of business activities;

iii amend statutes relating to safety aspects of substances, equipment and environment;

iv eliminate workplace risks at the source.

Occupational safety and health Tips:

- Be aware of your surroundings.
- Maintain a correct posture.
- Take break regularly.
- Use Equipment properly.
- Locate Emergency Exits.
- Report Unsafe conditions.
- Practice Effective Housekeeping.
- Make use of mechanical aids.
- Wear the correct Safety equipment.
- Reduce workplace stress.

Safety signs

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

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.

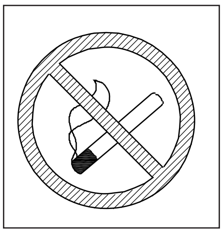
Safety signs fall into four separate categories. These can be recognised by their shape and colour. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

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)

Prohibition signs

Fig 1



SHAPE	**Circular.**
COLOUR	**Red border and cross bar. Black symbol on white background**
MEANING	**Shows it must not be done.**
Example	**No smoking**

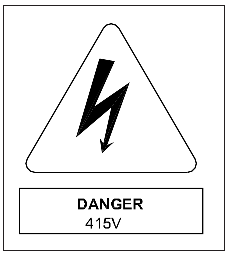
Mandatory signs

Fig 2

SHAPE	**Circular.**
COLOUR	**White symbol on blue background**
MEANING	**Shows what must be done**
Example	**Wear hand protection**

Warning signs

Fig 3



SHAPE	**Triangular**
COLOUR	**Yellow background with black border and symbol.**
MEANING	**Warns of hazard or danger.**
Example	**Caution, risk of electric shock.**

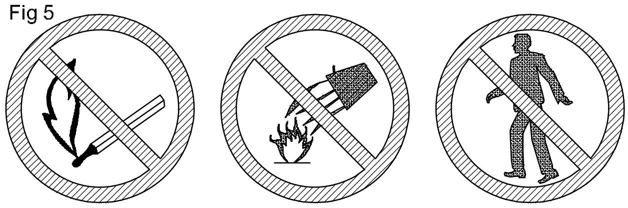
Information signs

Fig 4

SHAPE	**Square of oblong.**
COLOUR	**White symbols on green background.**
MEANING	**Indicates or gives information of safety provision.**
Example	**First aid point.**

Prohibition signs

Fig 5



SMOKING AND NAKED FLAMES PROHIBITED | DO NOT EXTINGUISH WITH WATER | PEDESTRIANS PROHIBITED

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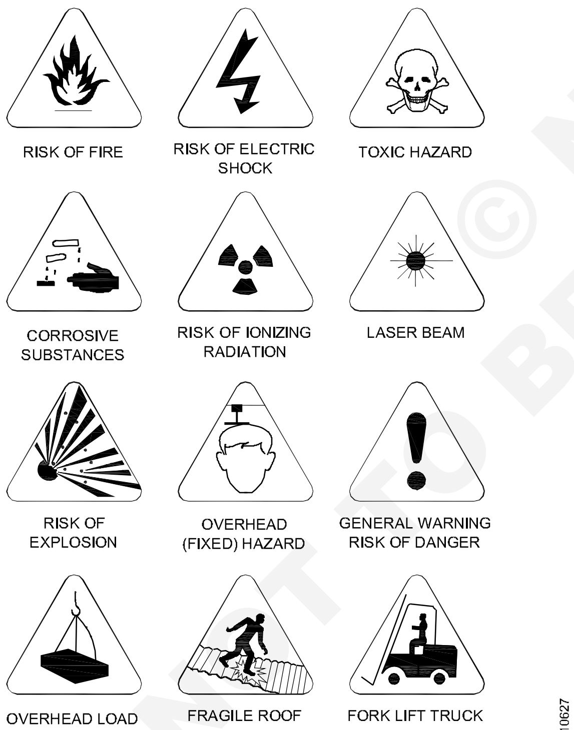
Mandatory signs

Fig 6

MANDATORY SIGNS

Warning signs

Fig 7



WARNING SIGNS

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 you 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?

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

Objectives: At the end of this lesson you shall be able to
- **respond incase of power failure, system failure and fire**
- **report an emergency.**

Power failure, System failure & Fire

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 1 Assassin bug

2 Lightening bug

3 Brain bug

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

3 Fire

When fire alarm sounds in your buildings

- Evacuate to outside immediately.
- Never go back
- Make way for fire fighters and their trucks to come
- Never use an elevator
- Do not panic

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 prevail 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 passer by would like to get involved to assist the victims. Hence first aid managements is often very difficult to attend to the injured persons. 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 helps 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 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.

Importance of housekeeping

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

Housekeeping

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

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of Machines :** Reduce accidents to keep machines cleaned well
- **Prevention of Leakage and spillage:** Use splash guards in machines and collecting tray
- **Disposal of Scrap-** Empty scrap, wastage, sward from respective containers regularly
- **Tools Storage-** Use special racks, holders for respective tools
- **Storage Spaces:** Identify storage areas for respective items. Do not leave any material in gangway
- **Piling Methods-** Do not overload platform, floor and keep material at safe height.
- **Material handling:** Use forklifts, converyors 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 improvement of the manufacturing process.

- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety results 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"

Introduction to 5S concept and its application

Objectives: - At the end of this lesson you shall be able to
- **stat what is 5S**
- **state the general benefits of implementing 5S**
- **explain the terms in 5S and its concept of implementation.**

Introduction

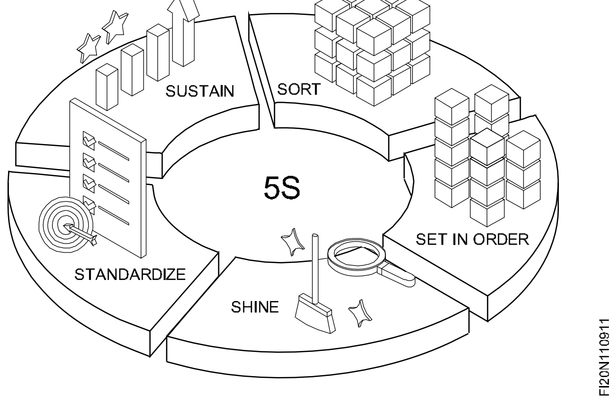
5S is a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating waste, improving flow and reducing process unreasonableness. There are five steps in the system, each starting with the letter S:

1 Sort 2 Set in order 3 Shine
4 Standardize 5 Sustain

The Steps of 5S (Fig 1)

5S was created in Japan, and the original "S" terms were in Japanese, so English translations for each of the five steps may vary. The basic ideas and the connections between them are easy to understand, though.

Fig 1

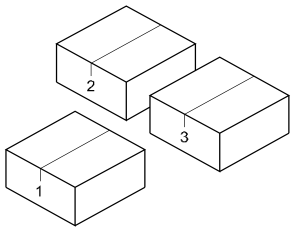


Step Name	Japanese term	Explanation
1	Sort Seiri (tidiness)	Remove unnecessary items from each area
2	Set In Order	Seiton (orderliness) Organize and identify storage for efficient use
3	Shine Seiso (cleanliness)	Clean and inspect each area regularly
4	Standardize	Seiketsu (standardization) Incorporate 5S into standard operating procedures
5	Sustain Shitsuke (discipline)	Assign responsibility, track progress, and continue the cycle

Step 1 Sort

The first step in the 5S process is Sort, or "seiri," which translates to "tidiness." The goal of the Sort step is to eliminate clutter and clear up space by removing things that don't belong in the area. (Fig 2)

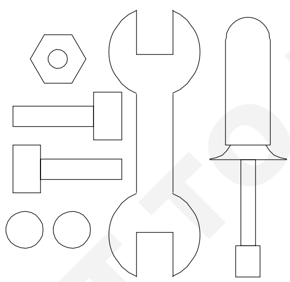
Fig 2



Step 2: Set In Order

The second step, Set in Order, was originally called "seiton," which translates to "orderliness." A variety of names have been used in English: "Systematic Organization," "Straightening Out," and "Simplify," for example. No matter what it's called, the goal of this step is to organize the work area. Each item should be easy to find, use, and return: a place for everything, and everything in its place. (Fig 3)

Fig 3



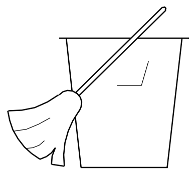
Implementation steps of Set in order

- Draw up a map, and then implement it
- Physically arrange the workplace first, and then map it out
- Map as you go, testing ideas and writing down what works well

Step 3: Shine

The third step of 5S is Shine, or "seiso," which means "cleanliness." While the first and second steps cleared up space and arranged the area for efficiency, this step attacks the dirt and grime that inevitably builds up underneath the clutter, and works to keep it from coming back.(Fig 4)

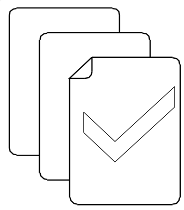
Fig 4



Step 4: Standardize

The fourth step is Standardize, or "seiketsu," which simply means standardization. By writing down what is being done, where, and by whom, you can incorporate the new practices into normal work procedure. This paves the way for long-term change.(Fig 5)

Fig 5



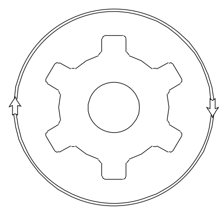
Tools for Standardizing

- 5S checklists
- Job cycle charts
- Procedure labels and signs

Step 5: Sustain

The fifth step of a 5S program is Sustain, or "shitsuke," which literally means "discipline." The idea here is continuing commitment. It's important to follow through on the decisions that you've made and continually return to the earlier steps of 5S, in an ongoing cycle. (Fig 6)

Fig 6



Sustaining a 5S program can mean different things in different work places, but there are some elements that are common in successful programs.

- Management support
- Department tours
- Updated training
- Progress audits
- Performance evaluations

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

Objectives: At the end of this lesson you shall be able to
- **state what is hot working**
- **brief confined space work**
- **use of 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 Wrong lifting techniques can result in injury.

A load need not necessarily be very heavy to cause injury The wrong way of lifing 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.

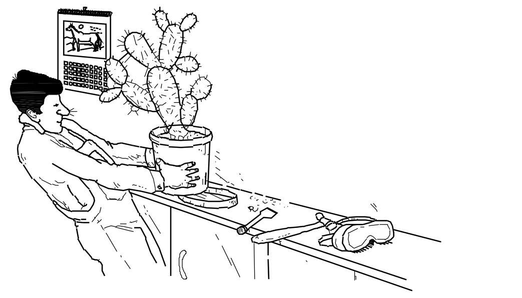
Type of injury and how to prevent them?

Cuts and abrasions

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

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

Fig 1



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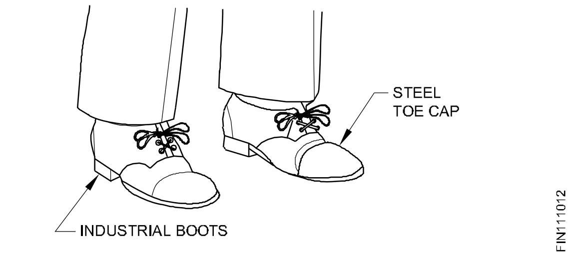
Leather hand gloves will usually be suffcient for protection, but the load should be checked to make sure of this, since large or heavy loads may involve body contact as well.

Crushing of feet or hands

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

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

Fig 2



Strain to muscles and joints

Strain to muscles and joints may be result of:

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

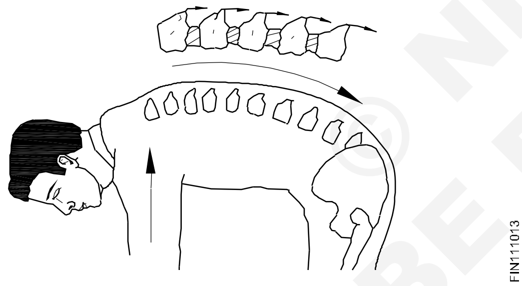
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

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 yourself 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 farther 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 to lifting and handling heavy loads.

What makes an object difficult to lift and carry?

- Weight is not the only factor which makes it difficult to lift and carry.
- The size and shape can make an object awkward to handle.
- Loads high require the arms to be extended in front of the body, place more strain on the back and stomach.
- The absence of hand holds or natural handling points can make it difficult to raise and carry the object.

Correct manual lifting techniques

- Approach the load squarely, facing the direction of travel
- 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.
- Ensure that a safe firm hand grip is obtained. Before the weight is taken, the back should be straightened and held as near the vertical position as possible. (Fig4)

Fig 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.
- 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

- To complete the lift, raise the upper part of the body to the vertical position. When a load is near 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

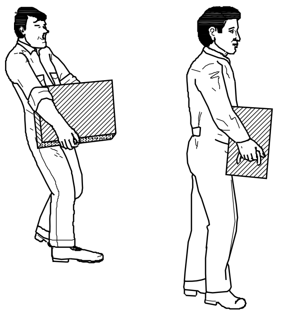
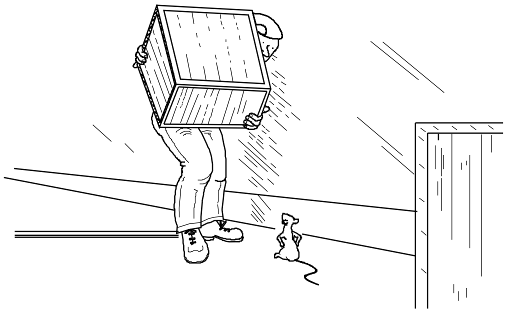


Fig 7



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

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
- **name 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 equipments are moved in industry using any of the following methods.

Crane and slings

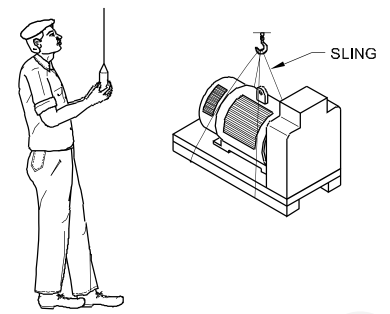
Winches

Machine moving platforms

Layers and rollers

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

Fig 1



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

Damaged slings must not be used.

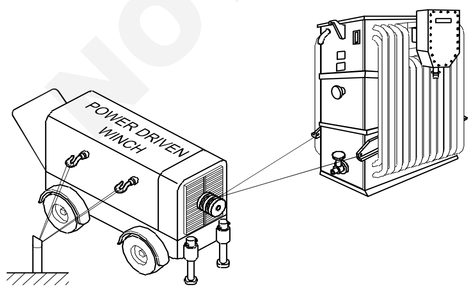
Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 1)

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)

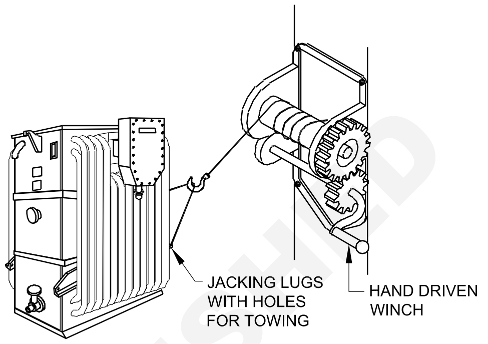
Fig 2



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.

Fig 3



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 lugs 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. Practice how to use the brakes.

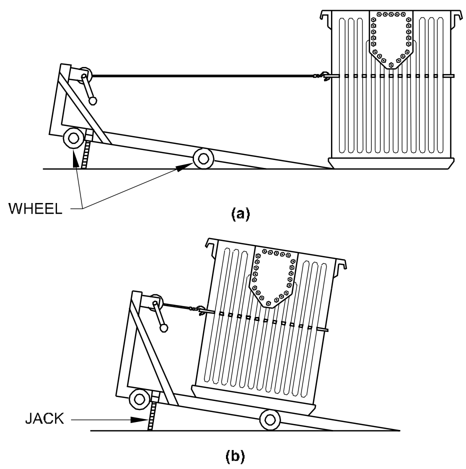
Keep hands and fingers well away from the gear wheels.

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.

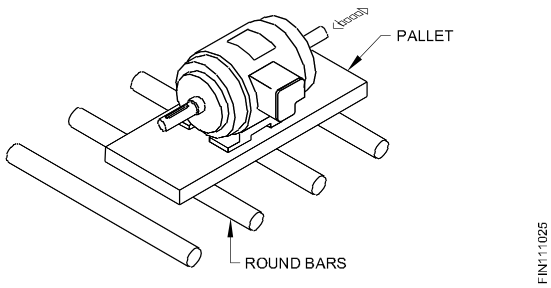
For unloading follow the procedure in the reverse order.

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



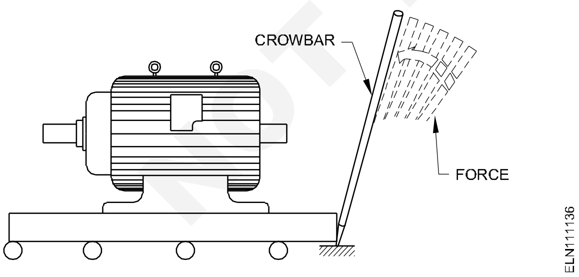
Ensure the bars (rollers) are long enough to project at each side of the load, for ease of handling.

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

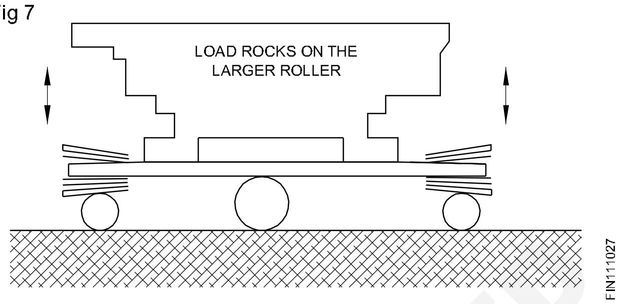
> **When a load is on rollers, only shallow slopes can be negotiated.**
>
> **Hold the load in check all the time if it is on the slope.**
>
> **Use a winch with an effective brake for this operation.**

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

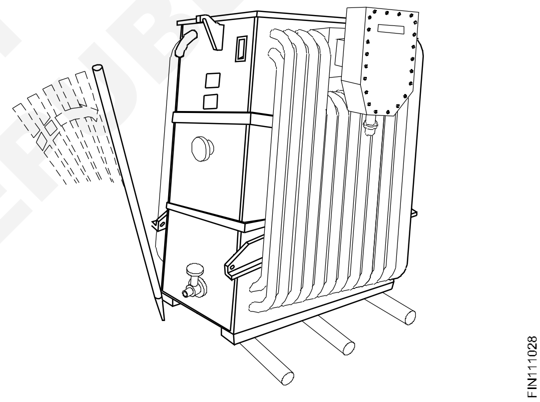


For heavier loads

Stop the load on the roller at the beginning of the corner.

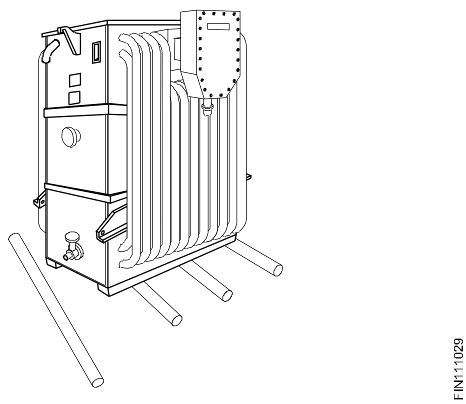
Twist the load round on the rollers by pushing the sides with crowbars until the load is just over the ends of the rollers. (Fig 8)

Fig 8



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

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.

Safety consideration

Moving heavy loads with crowbars or jacks

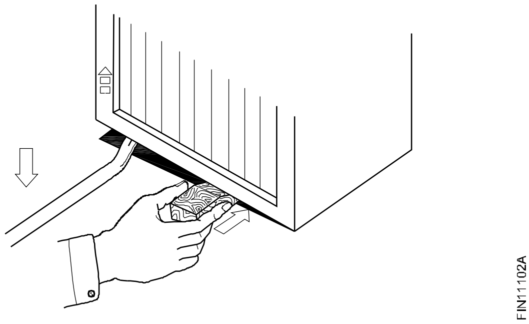
Make sure your hands are clear of the load before lowering it on to the packing or rollers.

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.

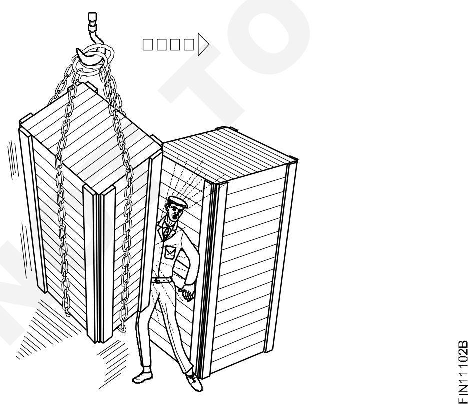
Before starting to lift a load, if you cannot see an assistant on the far side of the load, verify that he is ready to lift the load and ensure that his hands are clear of the slings.

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



Minimise such movement by locationg 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

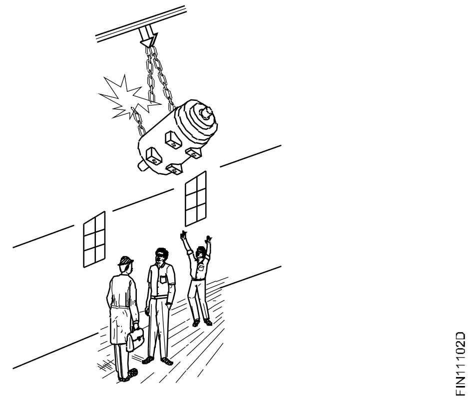
Stand clear off the load and move it steadily.

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)

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.

Measurement, lines standard, end standard and steel rule

Objectives: At the end of this lesson you shall be able to
- **name the base unit of length measurement as per the international system of units of measurement (SI)**
- **state the multiples of a metre and their values.**

Measurement: It is an action of measuring something, quantifying in standard units. The standard length under International (British) system is inches/feet, yards, miles, whereas in Metric unit it is millimeter, centimeter, meter & kilometer. Length determines the distance between two points or the amount space between two points expressed in standard unit.

Line & End standard: Linear measurement is basically a Metrological science of precise and accurate measurement. Measurements are classified as linear measurement, angular measurement and form measurements. All these are carried out as per standards established and maintained at the highest level of standardisation.

As per the System International (SI) system of measurements the standard unit for length measurement is meter. The meter (m) is defined as the length of the path travelled by light in vacuum during the time interval of 1/299 792 458 of a second, each artifact meter is calibrated against the proto type for use as National Standard.

Length measurement are grouped as Line Standard and end Standard. When the length being measured in expressed as the distance between two lines, this is known as Line Standard. Line standards are not as accurate as end standards & can’t be used for close tolerance measurement.

End standard is standard of length in the form of a metal bar (cylindrical) or block (ship gauge) or feeler gauge, Limit gauges, whose end faces are the standard distance apart.

All measurements measured along a line through a graduated scale instruments such as Vernier caliper, Micrometer etc., comes under Line standard measurements.

All measurements done with the help of gauge block set (slip gauges) or cylindrical bar, measuring wise, etc, are covered under the End standard measurements. Limit gauges line Go and No Go snap gauges, plug gauges etc also comes under End standard.

When we measure an object, we are actually comparing it with a known standard of measurement.

The base unit of length as per SI is the metre.

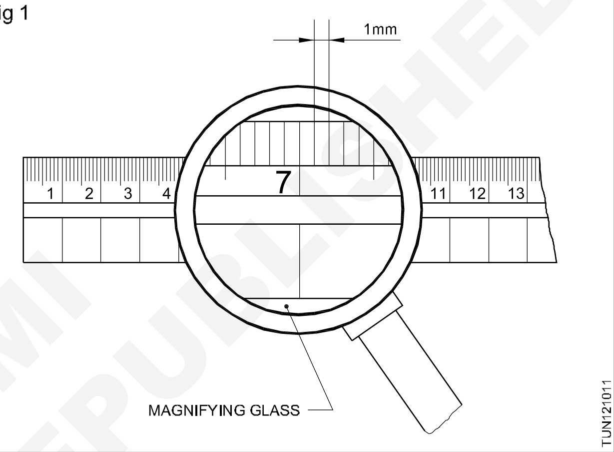
Length - SI units and multiples.

Base unit : The base unit of length as per the systems international is the metre. The table given below lists some multiples of a metre.

1 Metre (m)	= 1000 mm
1 Centimetre (cm)	= 10 mm
1 Millimetre (mm)	= 1000µm
1 Micrometre (µm)	= 0.001 mm

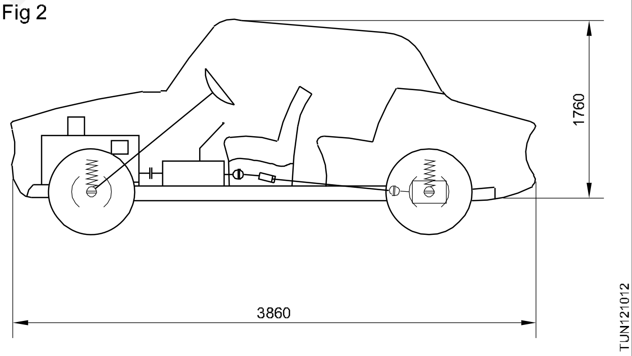
Measurement in engineering practice: Usually, in engineering practice, the preferred unit of length measurement is the millimetre. (Fig 1)

Fig 1



Both large and small dimensions are stated in millimetres. (Fig 2)

Fig 2



The british system of length measurement : An alternative system of length measurement is the british system. In this system, the base unit is the imperial standard yard. Most countries, including great britain itself, have, however, in the last few years, switched over to SI units.

12 Inch = 1 Feet

3 Feet = 1 Yard

Line standards and end standards

Line standards: In the line standard the unit of length is defined as the distance between the centres of engraved lines e.g. steel rule.

End standards: When the length being measured is expressed as the distance between two surfaces, e.g. slip gauges.

Difference between line standards and end standards

The differences between line standards and end standards are given as follows:

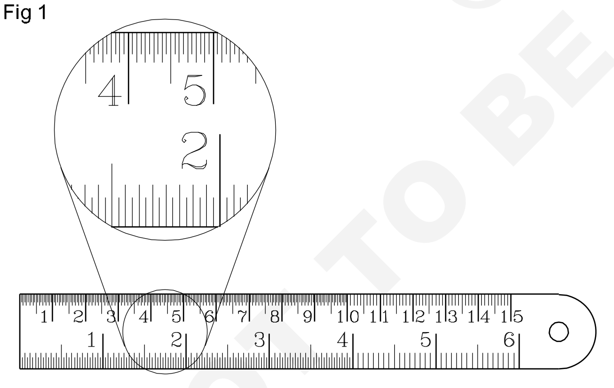
Sl. No	Line standard	End standard
1	Line standards do not provide high accuracy.	End standards more suited to accuracy requirement of high order.
2	They are quick and easy to use over a wide range.	They are time consuming in use, and prove only one dimension at a time.
3	They are not subjected to wear although significiant wear on leading and leads to under-sizing.	They are subjected to wear on their measuring faces.
4	They are subjected to the parallax effect, a source of both positive and negative reading errors.	They are not subjected to parallax effects as their use depends on 'feel'.

Steel rule - Different types

Objectives: At the end of this lesson you shall be able to
- **state the purpose of steel rule**
- **state the types of steel rule**
- **state the precautions to be followed while using a 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. These rules are available in length 150mm. 300mm and 600mm. the reading accuracy of steel rule is 0.5mm and 1/64 inch.

For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 2)

Steel rule in English measure, they can also be furnished with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 3)

Fig 2

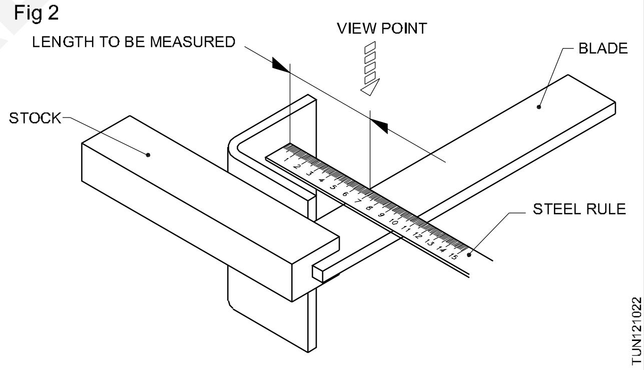
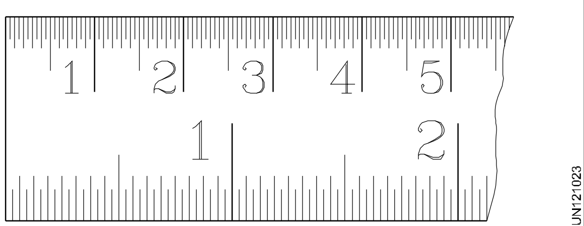


Fig 3



Other types of rule

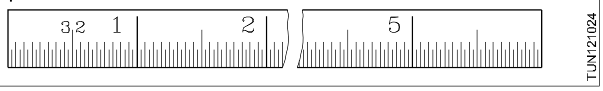
– Narrow steel rules

– Short steel rules

– Full flexible steel rule with tapered end

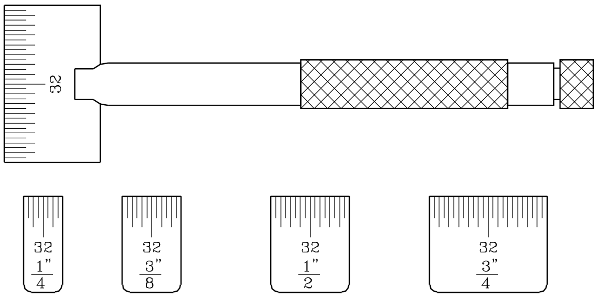
Narrow steel rule : Narrow steel rule are used to measure the depth of key-ways and depth of smaller dia, blind holes and other jobs, where the ordinary steel rule cannot reach. Width approximately 5mm thickness 2mm. (Fig 4)

Fig 4



Short steel rule (Fig 5) : This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers and tool and die work.

Fig 5



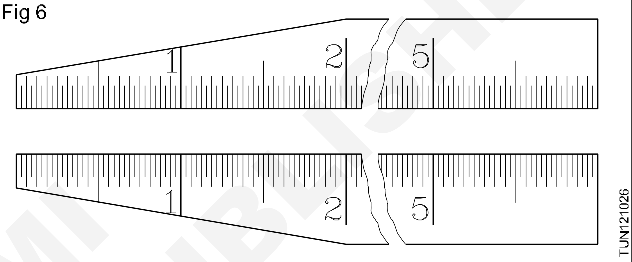
The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. five rule lengths are provided 1/4", 3/8", 1/2", 3/4" and 1" and each rule is graduated in 32nds on one side and 64ths on the reverse side.

Steel rule with tapered end : This rule is a favorite with all mechanics since its tapered end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 6)

For maintaining the accuracy of a steel rule, it is important to see to it that its edges and surfaces are protected from damage and rust.

Do not place a steel rule with other cutting tools. Apply a thin layer of oil when not in use.

Fig 6



Selection of metals

Objectives: At the end of this lesson you shall be able to
- **state the different methods of identifying ferrous metals and alloys**
- **state how non-ferrous metals and alloys are identified**
- **state the corrosion, scaling, rusting.**

One has to handle different types of metals in his work. A knowledge about how to recognise and differentiate the commonly used metals will help in many ways.

Ferrous metals and alloys can be identified by

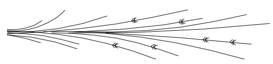
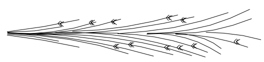
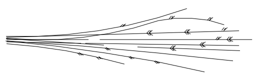
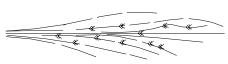
- their appearance (colour, texture etc)
- their weight (light or heavy)
- the sound
- cold hammering
- the spark test (grinding).

Note

The above characteristics of different ferrous metals and alloys are given in Table 1. Apart from the above tests, steel bars are also identified by the code colours painted on them.

Different colours are marked, based on the different composition of materials and grade. Colour charts are available to determine the different metals.

Table 1

Ferrous metals & alloys	**Appearance**	**Density/ weight**	**Sound (Drop a ø 15 bar 25 cm long, on to the ground)**	**Cold hamme -ring**	**Spark test**	
Low carbon steel	Smooth scale with blue/ black sheen/ silver grey	7.85 medium	Medium metallic sound	Flattens easily	Stream of yellow white sparks varying in length, slightly 'fiery'.	
Medium carbon steel	Smooth scale black sheen steel	Weight 7.85 medium	Higher note than that of low carbon	Fairly difficult to flattern	Yellow sparks shorter than those of low carbon steel, finer and more feathery.	
High carbon steel	Rougher scale black	Weight 7.85 medium	Good ringing sound	Difficult to flattern	Sparkless bright, starting near grinding wheel and more feathery with secondary branching.	
High speed steel	Roughness scale black with reddish tint	Weight 9 comparitivily to heavy	Lower ringing more like low carbon steel	Very difficult flattern tends crack easily.	Faint red streak ending in fork.	

Most non-ferrous metals and alloys can be identified by their colour. (Table 2)

Table 2

Metal/Alloy	Colour
Copper	Distinctive red colour
Aluminium	Dull white
Lead	Bluish-grey colour
Tin	Silvery white, with a slightly yellowish tinge
Brass (Alloy) (free cutting)	Distinctive yellow colour
Bronze (alloy)	Colour between copper and brass

Rusting

Rusting is the process in which iron turns into iron oxide. It happens when iron comes into contact with water and oxygen. The process is a type of corrosion that occurs easily when natural conditions.

Rusting is the conversion related to iron and iron-based alloys. Non-ferrous metals corrode but do not rust. (Fig 1)

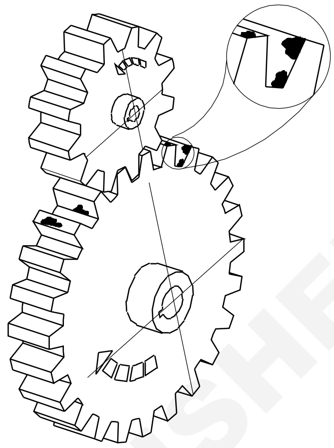
Fig 1

Corrosion

The slow and continuous eating away of metallic components by chemical or electro-chemical action is known as corrosion. Corrosion affects the service conditions and accuracy of the components. It is very essential to understand the causes for corrosion and to know the metals that resist corrosion.

Conversion is the deterioration of materials by chemical interaction with their environments. The term corrosion is some times also applied to the degradation of plastics, concrete and wood, but generally refers to metals. (Fig 2)

Fig 2



Scaling

Scale is hard mineral coatings and corrosion deposits made up of solids and sediments that collect on or it distribution system.

Scaling which is the deposition of mineral solids on the interior surfaces of water lines and containers. (Fig 3)

Fig 3

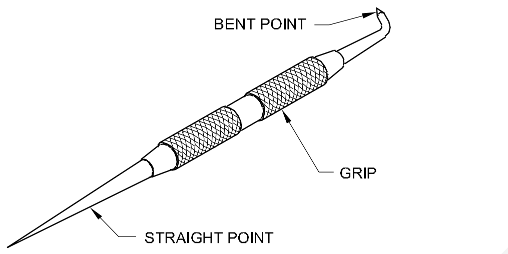
Scribers

Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of 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 lapped frequently for maintaining its sharpness.

Scribers are available in different shapes and sizes. The most commonly used one is the plain scriber. (Fig 1)

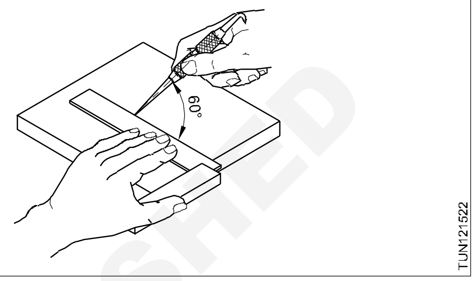
Fig 1



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 2



Place a cork on the point when not in use to prevent accidents.

Prick punch : The angle of the prick punch is 30°. The 30° point punch is used for making light punch marks needed to position dividers. (Fig 5c)

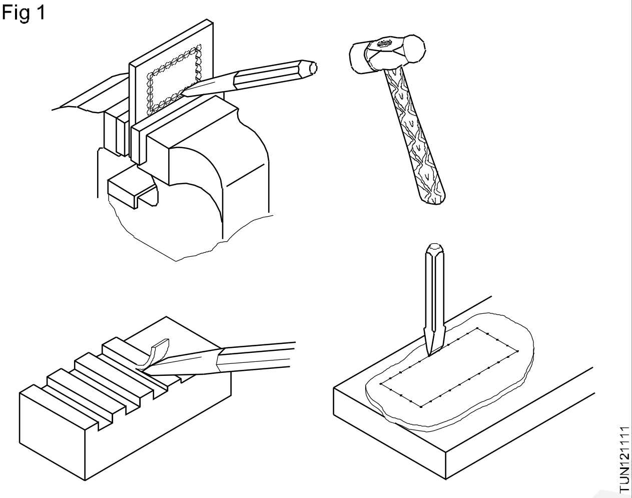
The witness marks should not be too close to one another.

Chisel - Materials, types and uses

Objectives: At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **name the parts of a cold chisel**
- **state the different types of chisels**
- **follow the safety measures.**

The cold chisel is a hand cutting tool used for chipping and cutting off operations. (Fig 1)

Fig 1

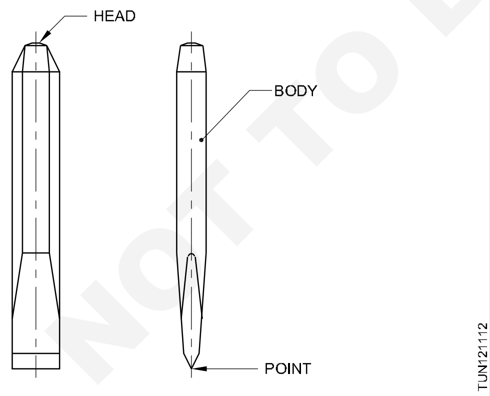


Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

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.

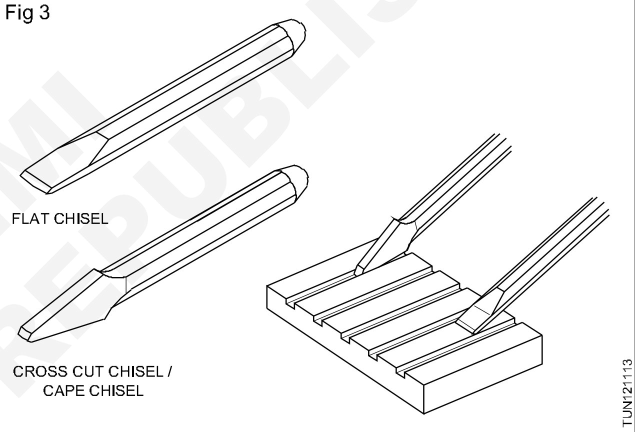
Common types of chisels : There are five common types of chisels.

- Flat chisel
- Cross-cut chisel
- Half-round nose chisel
- Diamond point chisel
- Web chisel

Flat chisels (Fig 3) : They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

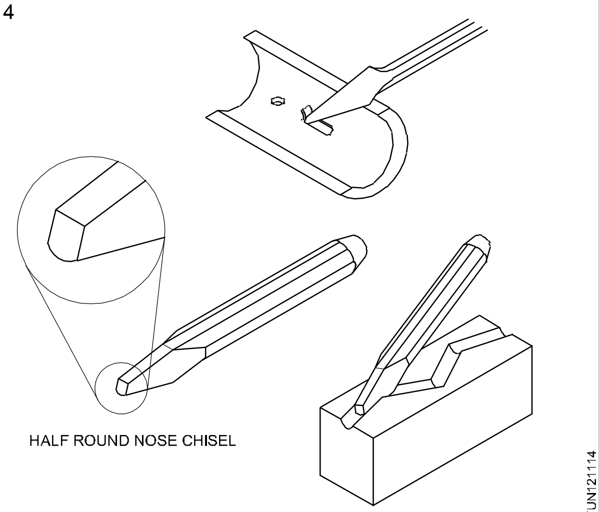
Cross-cut or cape chisels (Fig 3) : These are used for cutting keyways, grooves and slots.

Fig 3



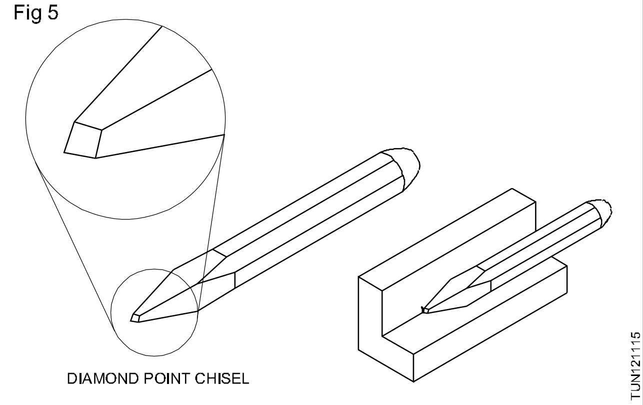
Half-round nose chisels (Fig 4) : They are used for cutting curved grooves (oil grooves).

Fig 4



Diamond point chisels (Fig 5): These are used for squaring materials at the corners, joints.

Fig 5



Web chisels/punching chisels (Fig 6) : These chisels are used for separating metals after chain drilling.

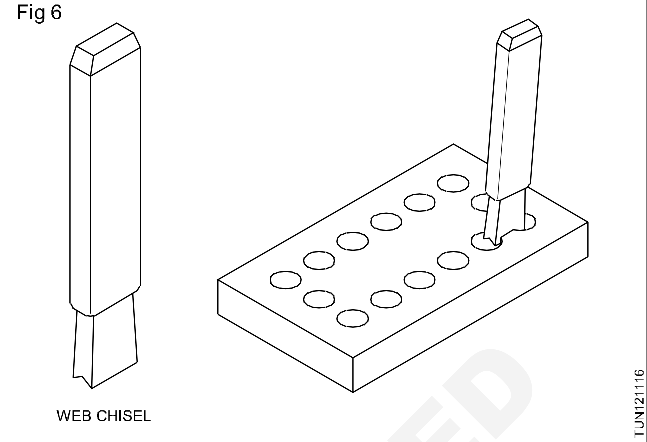
Chisels are specified according to their

– length	– width of the cutting edge
– type	– cross-section of the body

The length of chisels ranges from 100 mm to 200 mm.

The width of the cutting edge varies according to the type of chisels.

Fig 6



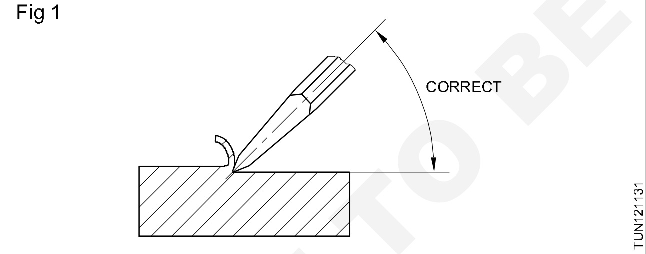
Angles of chisels

Objectives: At the end of this lesson you shall be able to
- **determine the point angles of chisels for different materials**
- **state the effect of rake and clearance angles.**

Point angle and materials: The correct point/cutting angle of a chisel depends on the material to be chipped. Sharp angles are given for soft materials and wide angles for hard materials.

The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 1)

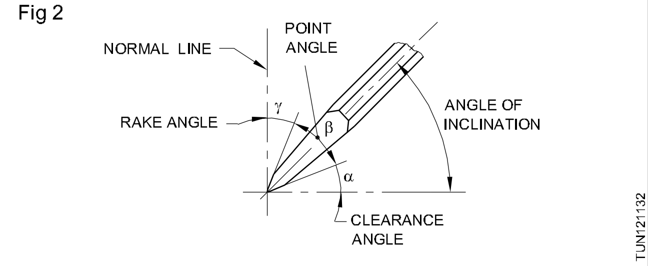
Fig 1



Rake angle : Rake angle is the angle between the top face of the cutting point and normal (90°) to the work surface at the cutting edge. (Fig 2)

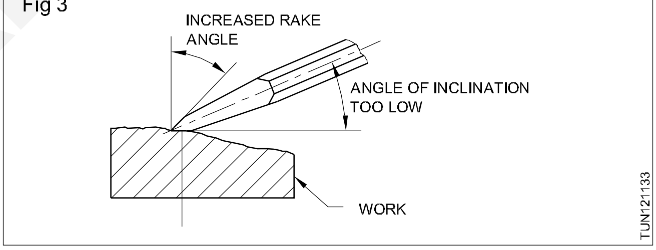
Clearance angle : Clearance angle is the angle between the bottom face of the point and the tangent to the work surface originating at the cutting edge. (Fig 2)

Fig 2



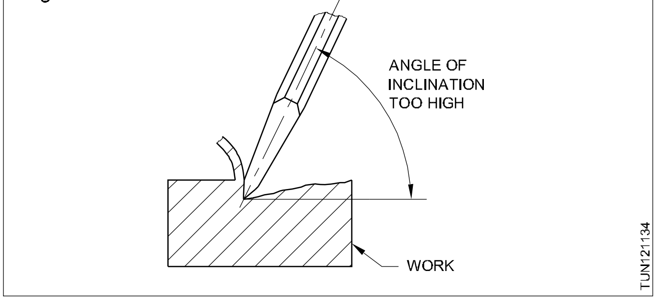
If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)

Fig 3



If the clearance angle is too great, the rake angle reduces. The cutting edge digs in and the cut will become deeper and deeper. (Fig 4) The correct point angle and angle of inclination for different materials for chipping is given in Table 1.

Fig 4



Crowning : A slight curvature is ground called "Crowning" to the cutting edge of the chisel, to prevent digging or corners, which leads to breakage of chisel point. "Crowning" allows the chisel to move freely along a straight line while chipping.

The point angle of cutting tool for the machining of different material is shown in table 1

Table 1

Material to be cut	Point angle	Angle of 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°

Hammer

Objectives: At the end of this lesson you shall be able to
- **state the uses of an engineer's hammer**
- **name the parts of an engineer's hammer**
- **name the types of engineer's hammers**
- **specify the engineer's hammer.**

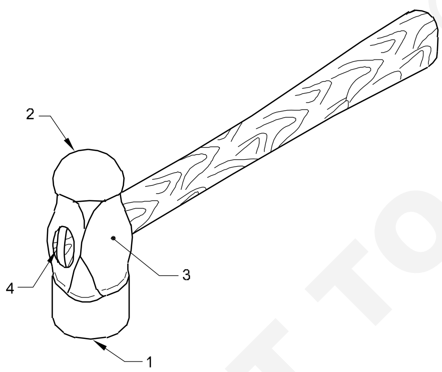
An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging and riveting.

Major parts of a hammer : The major parts of a hammer are the head and the handle.

The head is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer head (Fig 1) are the face (1), pein (2), cheek (3) and the eyehole (4).

Fig 1



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 :

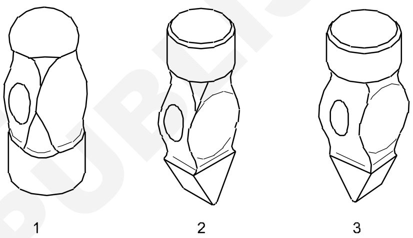
- ball pein - cross-pein - straight pein (Fig 2)

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-is left soft.

Fig 2



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

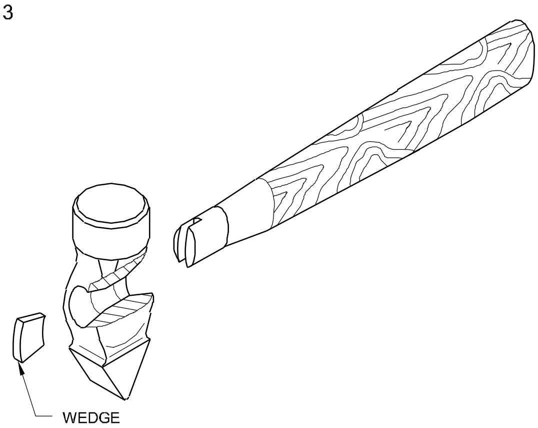
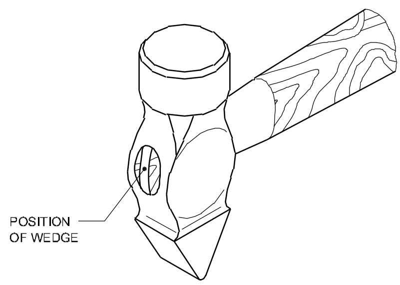
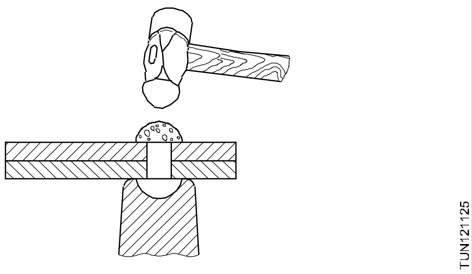


Fig 4



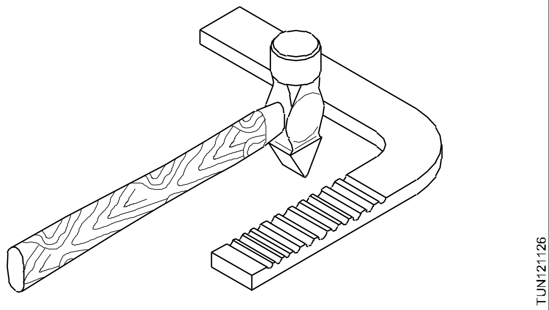
Application of hammer pein : The ball pein is used for riveting. (Fig 5)

Fig 5



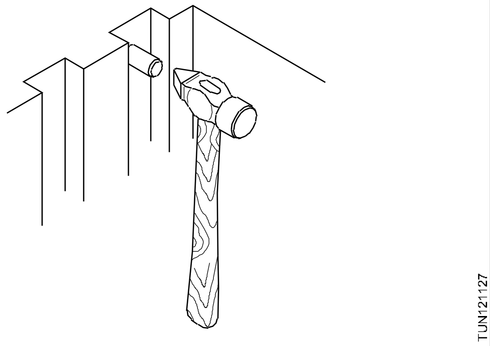
The cross-pein is used for spreading the metal in one direction. (Fig 6)

Fig 6



The straight pein is used at the corners. (Fig 7)

Fig 7



Specification: An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750gms.

The weight of an engineer's hammer used for marking purposes is 250 gms.

The ball pein hammers are used for general work in machine/ fitting shop.

Before using a hammer:

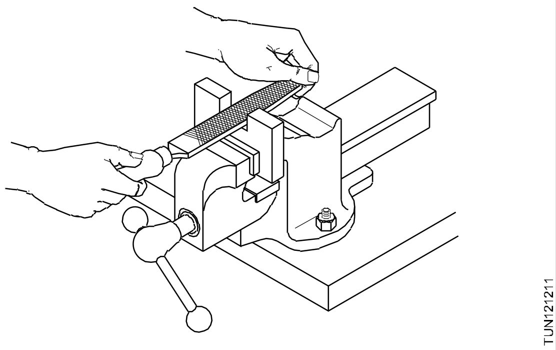
- make sure the handle is properly fitted.
- select a hammer with the correct weight suitable for the job.
- check the hammer head and handle whether any crack is there.
- ensure that the face of the hammer is free from oil or grease.

Files - Different type, uses, grade, shape

Objectives: At the end of this lesson you shall be able to
- **name the parts of a file**
- **name and state the uses of each grade of file**
- **state the specification of a file.**

Filing is a method of removing excess material from a workpiece by using a file. (Fig 1)

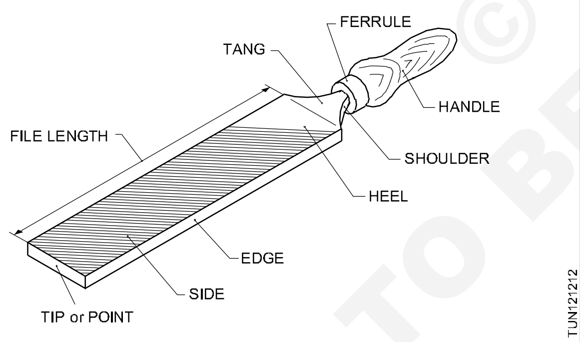
Fig 1



Files are available in many shapes and sizes. They are made of high carbon or high grade cast steel. The teeth portion of the file (body) alone is hardened and tempered.

Parts of a file (Fig 2): The illustration above will help you in learning the parts of a file.

Fig 2



Files are specified according to their (1) length (2) grade (3) cut and (4) shape.

Eg. File flat 300 mm bastard double cut.

The length of a file is the distance from the tip 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 (Fig 3A) and fins-burrs on forged components.

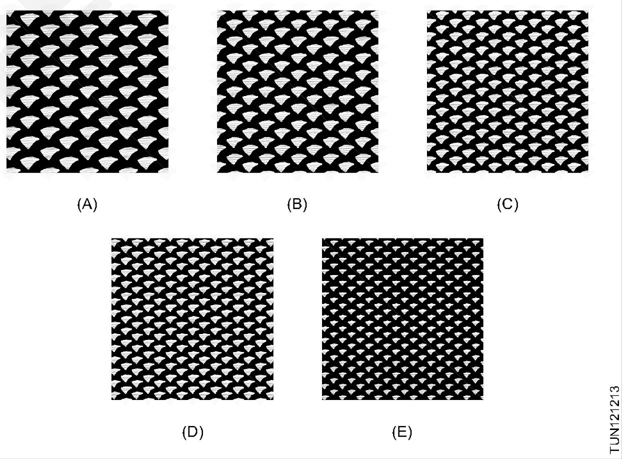
A bastard file is used in cases where a heavy reduction of material is required. (Fig 3B)

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. (Fig 3C)

A smooth file is used to remove small quantities of material and to give a good finish. (Fig 3D)

A dead smooth file is used to bring the material to accurate size with a high degree of finish. (Fig 3E)

Fig 3



Flat file & hand file

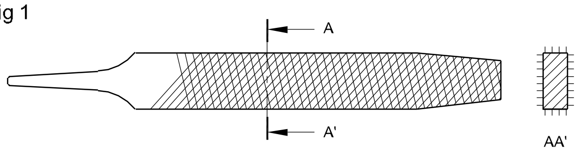
Objectives: At the end of this lesson you shall be able to
- **state the features of flat and hand files**
- **state the application of flat and hand files**
- **list different cuts and their uses.**

Files are made in different shapes so as to able to file and finish components to different shapes.

The shape of files is usually specified by their cross section. The files useful for this exercise are flat files and hand files.

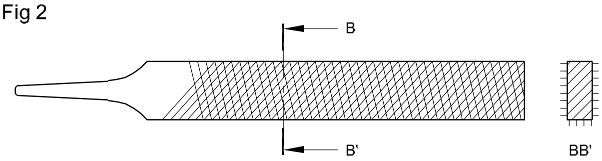
Flat files (Fig 1)**:** These files are of rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towards the point. The faces are double cut and the edges single cut. These files are used for general purposes work. They are useful for filing and finishing external and internal surfaces.

Fig 1



Hand files (Fig 2)**:** These files are similar to the flat files in their cross-section. The edges along the width are parallel throughout the length. The faces are double cut. One edge is a single cut whereas the other is a safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces already finished.

Fig 2



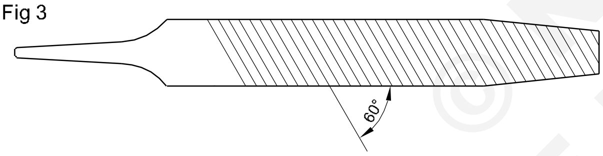
The most used grades of files are bastard, second cut, smooth and dead smooth. These are the grades recommended by the Bureau of Indian Standards. (BIS)

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The uses of the different cuts of files are as follows.

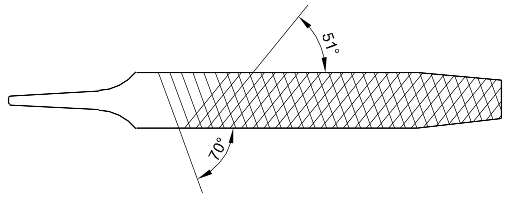
Single cut files are useful for filing soft metals like brass, aluminium, bronze and copper and also used for deburring the job on lathe. (Fig 3)

Fig 3



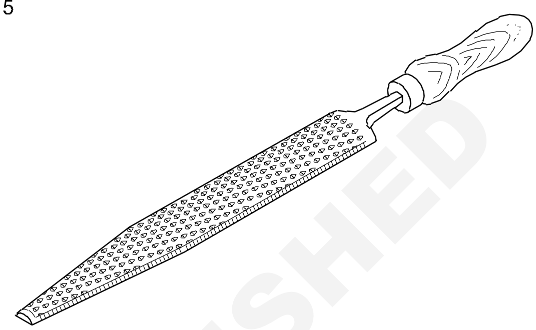
Double cut files remove material faster than the single cut files. (Fig 4)

Fig 4



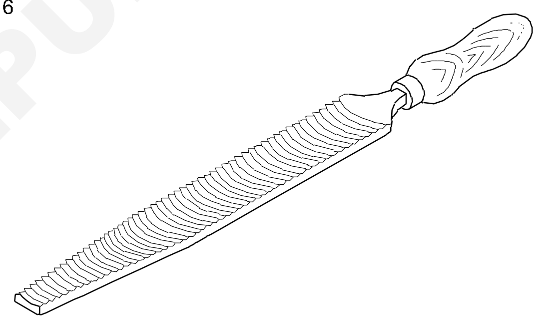
Rasp cut files are useful for filing wood, leather and other soft materials and are available only in half round shape. (Fig 5)

Fig 5



Curved cut files have deeper cutting action and are useful for filing soft materials like aluminium, tin, copper and plastic. (Fig 6)

Fig 6



Bench vice

Objectives: At the end of this lesson you shall be able to
- **name the parts and uses of a bench vice**
- **specify the size of a bench vice**
- **state the uses of vice clamps.**

Bench vice

Vices are used for holding 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)

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.

Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a file.

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 aluminium over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may be damaged.

Fig 1

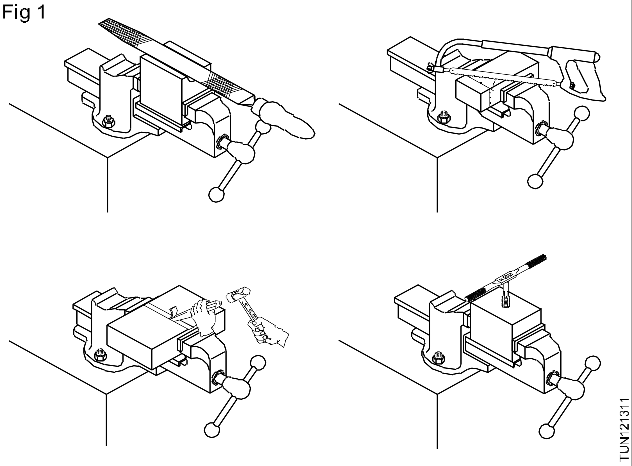


Fig 2

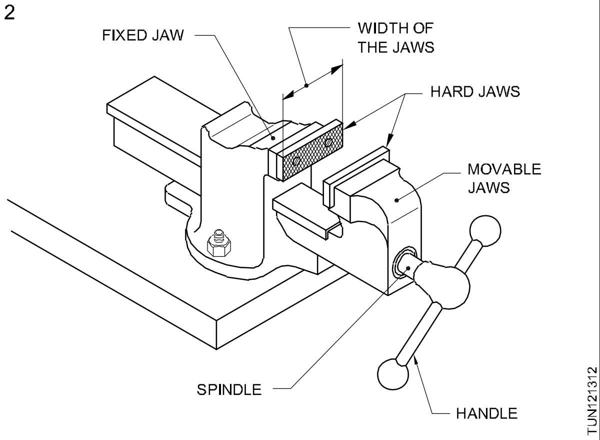
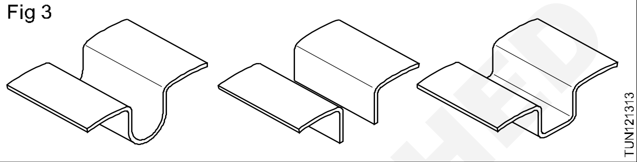


Fig 3

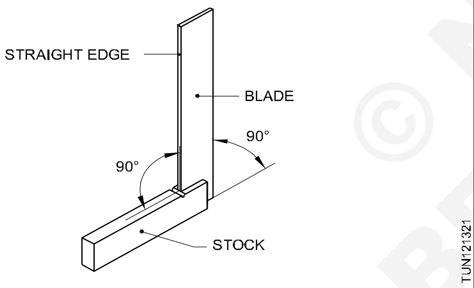


Try square

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.

Fig 1



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°.

Try squares are made of hardened steel.

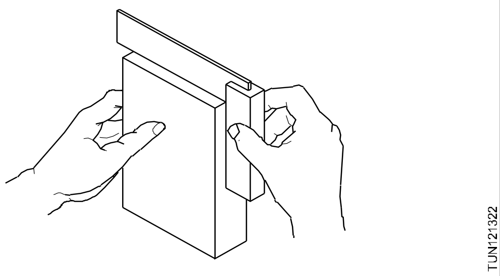
Try squares are specified according to the length of the blade i.e. 100mm, 150mm 200mm.

Uses

The try-square is used to:

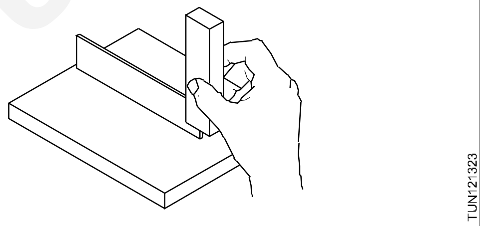
– check the squareness (Fig 2)

Fig 2



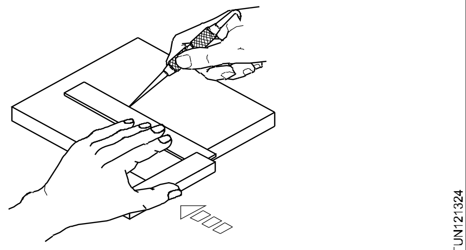
– check the flatness (Fig 3)

Fig 3



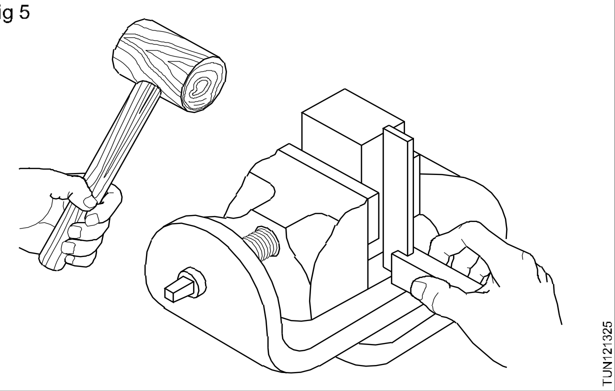
– mark lines at 90° to the edges of workpieces (Fig 4)

Fig 4



– set workpieces at right angles. (Fig 5)

Fig 5



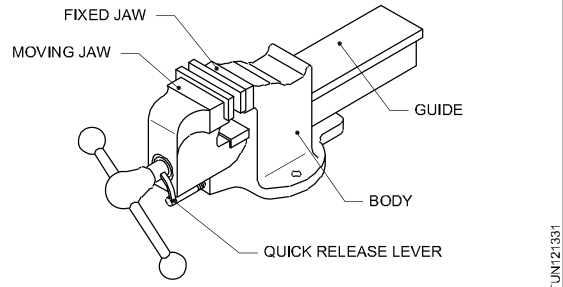
Types of vices

At the end of this lesson you shall be able to
- **state the construction and advantages of a quick releasing vice**
- **state the uses of pipe vice, toolmakers vice, hand vice and pin vice.**

There are different types of vices used for holding work-pieces. They are quick releasing vice, pipe vice, hand vice, pin vice and toolmaker's vice.

Quick releasing vice (Fig 1)

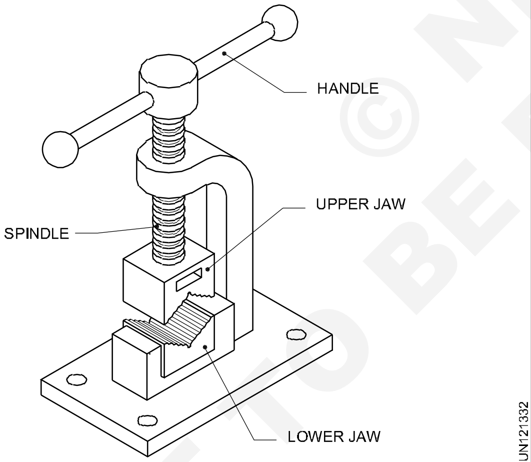
Fig 1



A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.

Pipe Vice (Fig 2)

Fig 2



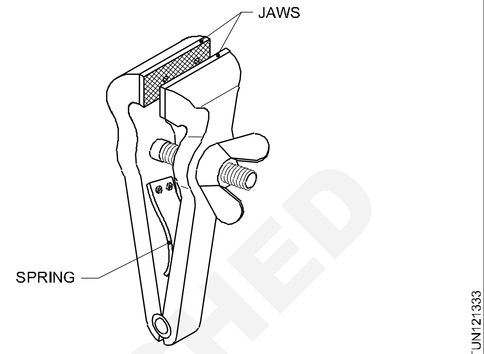
A pipe vice is used for holding round sections of metal, tubes and pipes. In this vice, the screw is vertical and movable. The jaw works vertically.

The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Figure 2.

Hand Vice (Fig 3)

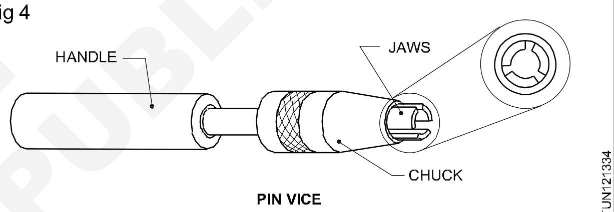
Hand vice are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Fig 3



Pin Vice (Fig 4)

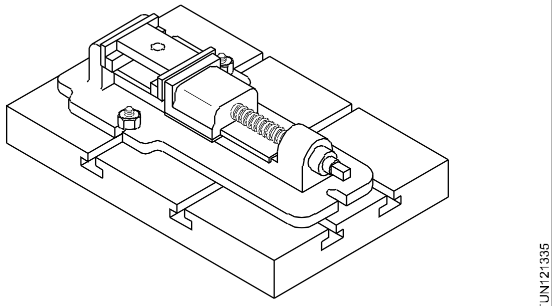
Fig 4



The pin vice is used for holding small diameter jobs. It consists of a handle and a small collect chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

Toolmarker's Vice (Fig 5)

Fig 5



The toolmarker's vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of high quality alloy steel. Toolmarker's vice is accurately machined.

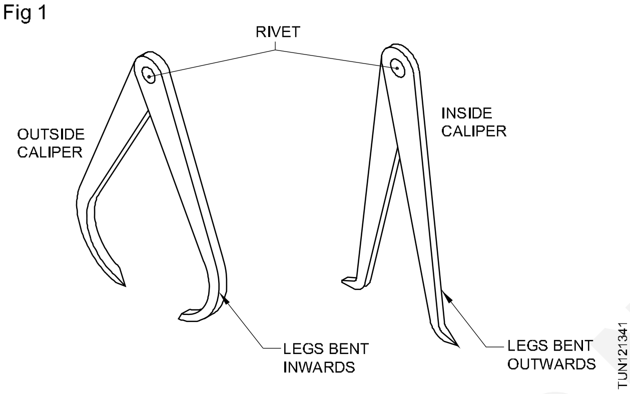
Calipers

Objectives: At the end of this lesson you shall be able to
- **name the parts of the calipers**
- **mention the capacities of the calipers**
- **differentiate between the various types of calipers and their applications.**

The most common devices used for measuring the outside and inside diameter of an object are the outside calipers and inside calipers. these devices cannot read the sizes themselves but measurements taken by them can be read by transfering the sizes on to a steel rule or other precision measuring instruments. There are two types of calipers namely, firm joint calipers and spring calipers.

Firm joint calipers (Fig 1)

Fig 1



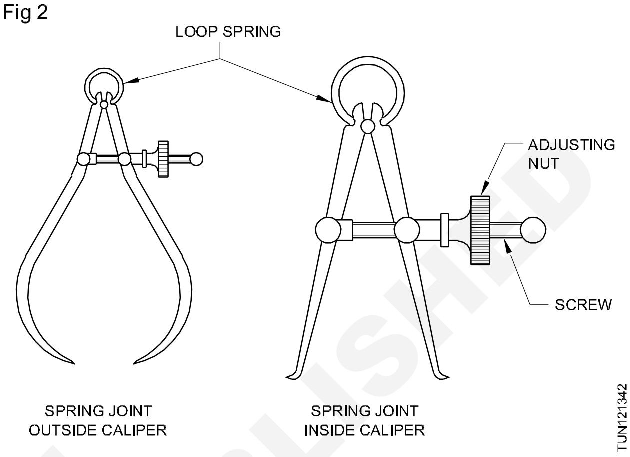
Firm joint calipers consist of two legs that are fixed together with a rivet or screw and nut. The capacity of the caliper is decided, based on the maximum opening dimension between the two legs. For example, 150mm capacity caliper is able to measure the maximum size or 150mm.

Firm joint calipers can be set very quickly for various measurements but there are chances of getting the set dimension disturbed, thereby causing errors in their use.

Spring calipers (Fig 2)

Spring calipers take more time in setting the dimensions but eliminate the possible errors arising out of the set being disturbed while using.

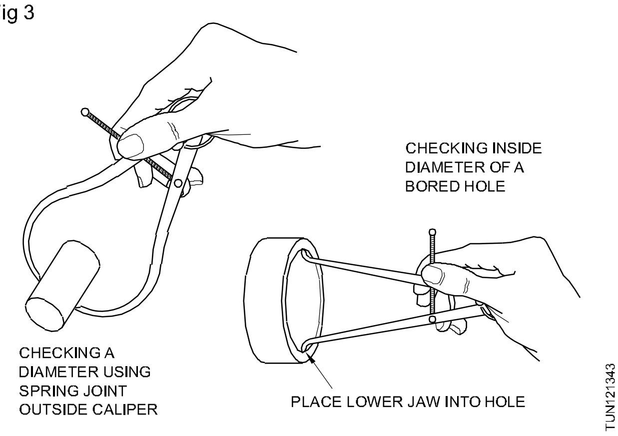
Fig 2



An inside caliper has its legs bent outwards and outside caliper has its legs bent inwards. Inside caliper are used for measuring the external dimensions and outside calipers are used for measuring the internal dimensions.

These calipers are also used for checking the external and internal dimensions as well as the parallelism of external and internal surfaces. (Fig 3)

Fig 3



'V' - Blocks

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of 'V' blocks**
- **list the types of 'V' blocks and state their uses**
- **specify 'V' blocks as per the standards recommended by B.I.S.**

Constructional features

'V' blocks are devices used for marking and setting up work on machines. The features of a common type of 'V' blocks are as given in Fig 1.

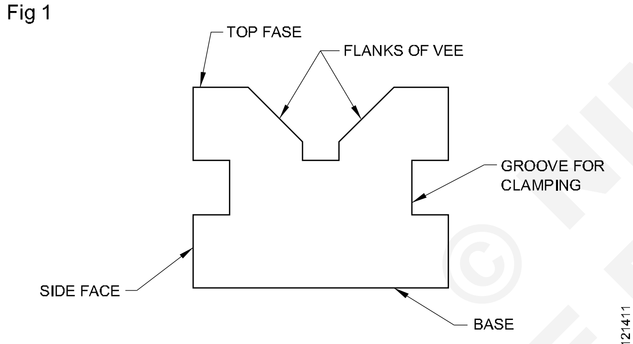
The included angle of the general purpose 'V' is 90°. 'V' blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

'V' blocks of different types are available. As per B.I.S. they are:

- single level, single groove 'V' block (Fig 1)

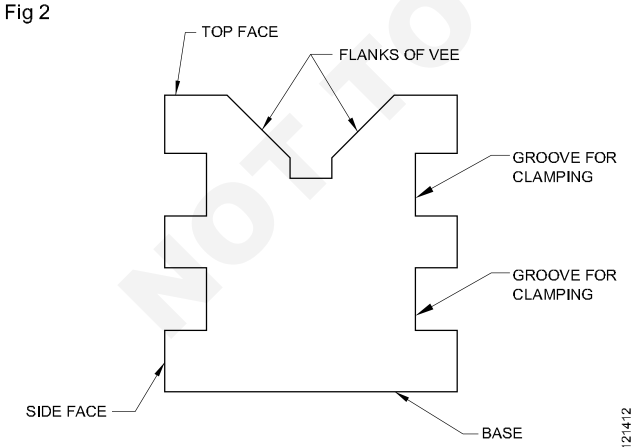
Fig 1



SINGLE LEVEL SINGLE GROOVE 'V' BLOCK

- single level, double groove 'V' block (Fig 2)

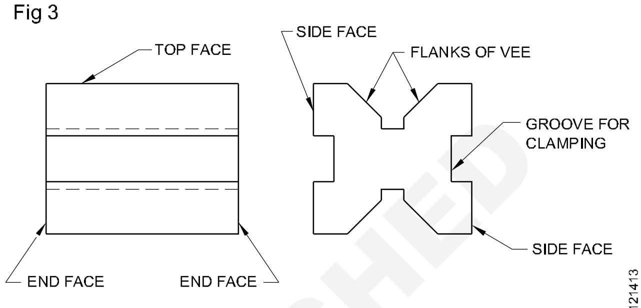
Fig 2



SINGLE LEVEL DOUBLE GROOVE BLOCK

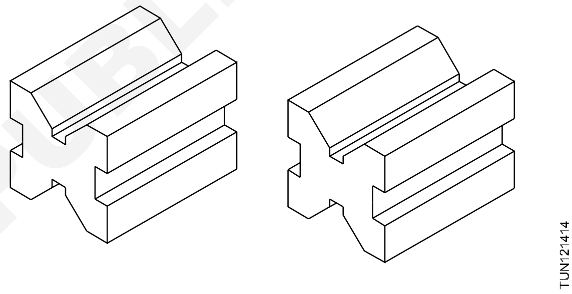
- double level, single groove 'V' Block (Fig 3)
- matched pair 'V' block. (Fig 4)

Fig 3



DOUBLE LEVEL SINGLE GROOVE 'V' BLOCK

Fig 4



Single level, single groove 'V' block (Fig 1)

This type has only one 'V' groove and has single square slots cut on both the sides.

This slot on both the sides, accommodates the work-holding clamps.

Single level, double groove 'V' block (Fig 2)

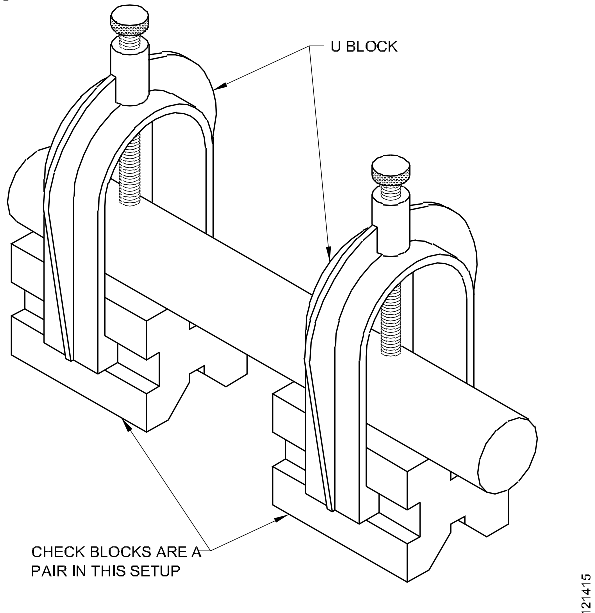
In this case, the 'V' block will have two slots on both sides. This permits for positioning the clamps depending on the diameter of the jobs.

Matched pair 'V' block (Figs 4 and 5)

These blocks are available in pairs which have the same size and same grade of accuracy. They are identified by the number or the letter given by the manufacturer. These sets of blocks are used for supporting long shafts parallel to the marking off or machine tables.

'V' blocks are made in pairs of exactly the same size and shape. They are ground parallel and square on all their sides, and have the 'Vee' groove cut in the centre, symmetrical to the centre line.

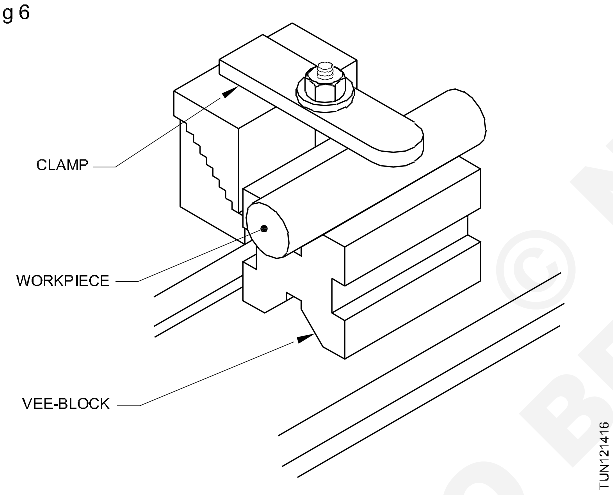
Fig 5



'V' BLOCKS SUPPORTING A SHAFT FOR MARKING OUT AND DRILLING

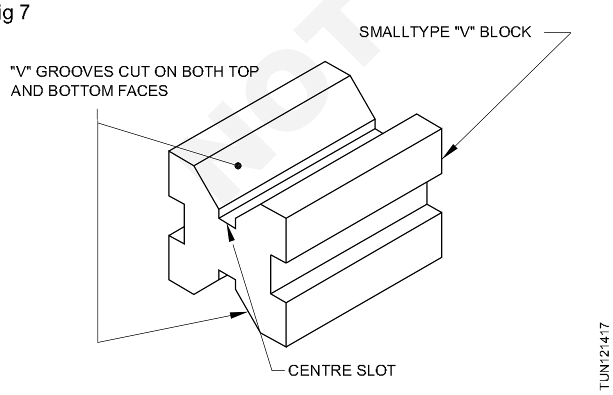
'V' blocks are used to support and clamp round workpieces. (Fig 6)

Fig 6



Smaller type 'V' blocks have the 'V' grooves cut both on the top and bottom faces. (Fig 7)

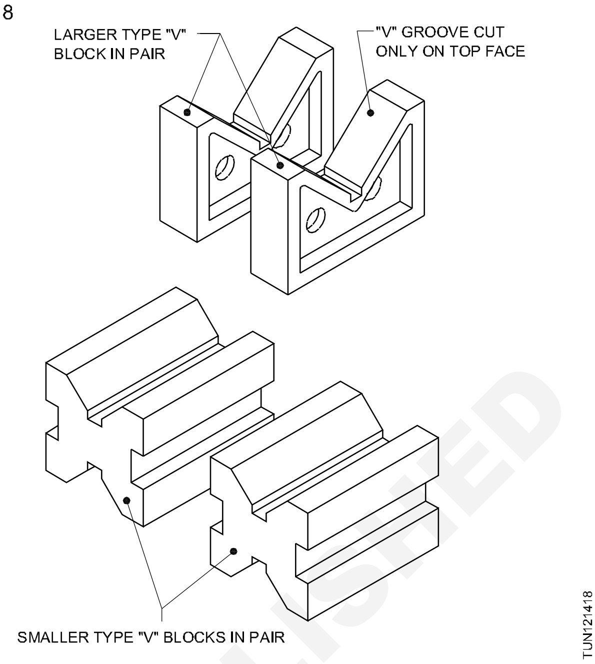
Fig 7



The narrow slots at the apex of the 'V' grooves provide clearance for the drill during drilling operations, and also provide space for chips to flow away during the machining operations.

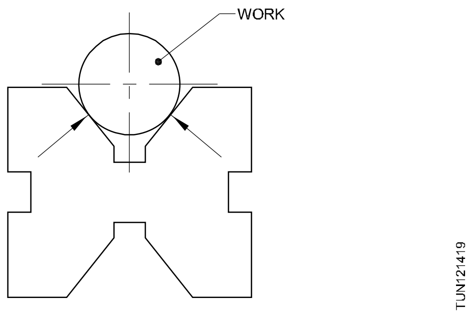
Small sizes of 'V' blocks are made of hardened steel, and larger sizes are made of cast iron. The larger sizes do not have slots on the side faces. (Fig 8)

Fig 8



When selecting a 'V' Block to support a round workpiece, the size of the 'V' block selected should be such that the workpiece touches the flanks of the 'V' groove at about the centre. (Fig 9)

Fig 9



Designation

'V' blocks are designated by the nominal size (length), the minimum and maximum diameters of the workpiece capable of being clamped and the grade and the number of the corresponding B.I.S. standard.

In the case of matched pairs it should be indicated by the letter 'M'.

For 'V' blocks with clamps it should be indicated as 'with clamps'.

Example

1 A 50 mm long (nominal size) 'V' block capable of clamping workpieces between 5 to 40 mm in diameter and Grade A will be designated as - 'V' block 50/5-40 A - B.I.S. 2949.

2 In the case of a matched pair, it will be designated as 'V' block M50/5-40 A B.I.S. 2949.

3 For ‘V’ blocks supplied with clamps, the designation will be ‘V’ block with clamp 50/5-40 A B.I.S.2949.

Grades and materials

‘V’ blocks are available in Grade ‘A’ and Grade ‘B’.

Grade A

A grade ‘V’ blocks are more accurate and are available only up to 100 mm length. These are made of high quality steel.

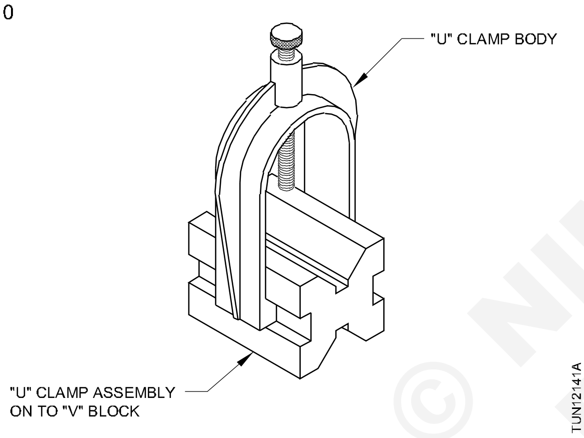
Grade B

B grade ‘V’ blocks are not as accurate as A grade ‘V’ blocks and these are useful for general machine shop work. These ‘V’ blocks are available up to 300 mm length. Grade B ‘V’ blocks are made of closely grained cast iron.

Clamping devices for ‘V’ blocks

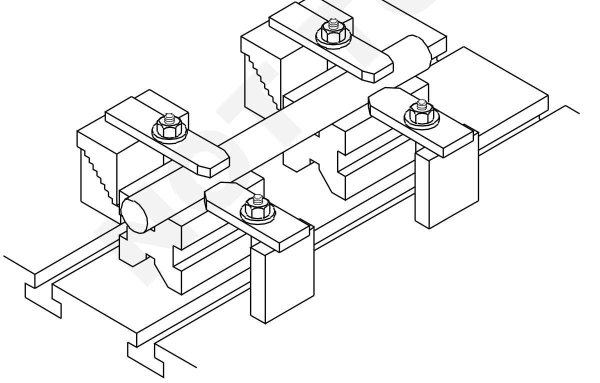
For holding cylindrical jobs firmly on V blocks, U clamps are provided (Fig 10)

Fig 10



Because ‘V’ blocks are supplied in pairs of the same size and shape, it is possible to support long workpieces so that they are parallel to the surface upon which the blocks rest, such as on a machine, worktable or a surface table. (Fig 11)

Fig 11



When round workpieces have to be clamped parallel to the edge of a machine worktable, one or two ‘V’ blocks are first set up parallel on the worktable, using clamps and setting blocks. (Fig 12)

Then a second clamp or pair of clamps is used to clamp the workpiece in the ‘V’ block(s). (Fig 13)

Fig 12

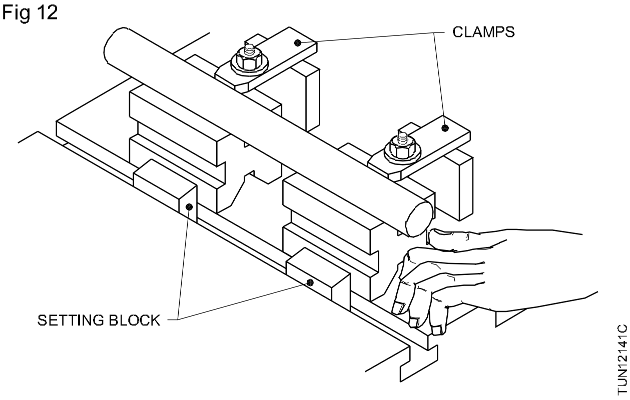
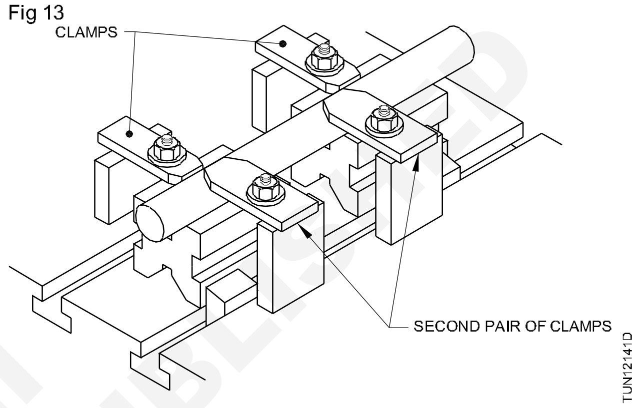
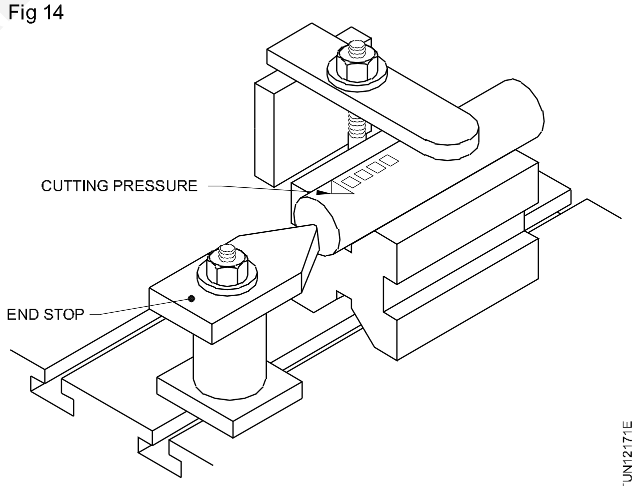


Fig 13



When machining operations are likely to push the workpiece out of position, an end stop can be used to prevent movement of the workpiece. The end stop is clamped to the machine work table as shown in Fig 14.

Fig 14



‘V’ blocks Grade ‘A’ will have a hardness of 650 to 700 HV (60 to 63 HRC)

‘V’ blocks Grade ‘B’ will have a hardness of 180 to 220 HB. ‘V’ blocks of both grades should be suitably stabilized.

Grade ‘B’ ‘V’ blocks are made from suitable quality closely grained cast iron.

In B.I.S. standard (IS: 2949-1974) a table is provided to indicate the dimensions of the ‘V’ blocks, together with the maximum and minimum diameters of the workpiece that can be accommodated on the ‘V’block.

Straight edges

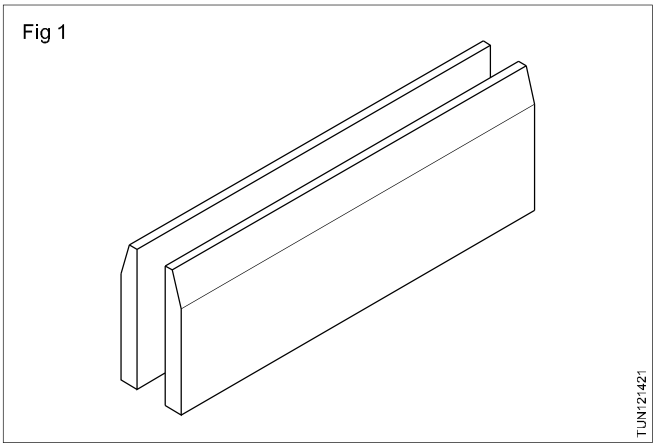
Objectives: At the end of this lesson you shall be able to
- **name the different types of straight edges**
- **state the features and uses of each type of straight edge**
- **state the different methods of testing straightness.**

For testing straightness and to use a guide for marking long straight lines, straight edges made of steel or cast iron are used.

Steel straight edges

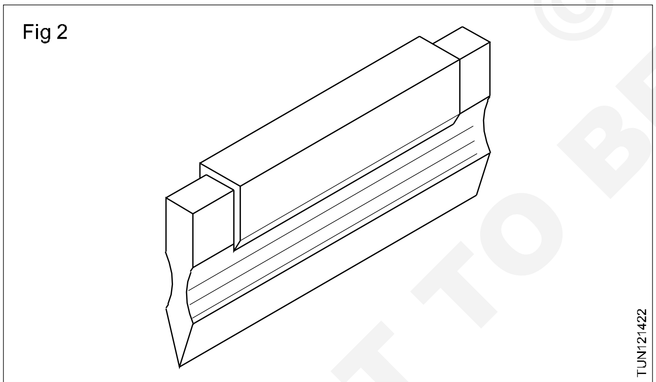
These are usually available up to 2 metres in length and may be rectangular in cross-section or have one edge bevelled. (Fig 1)

Fig 1



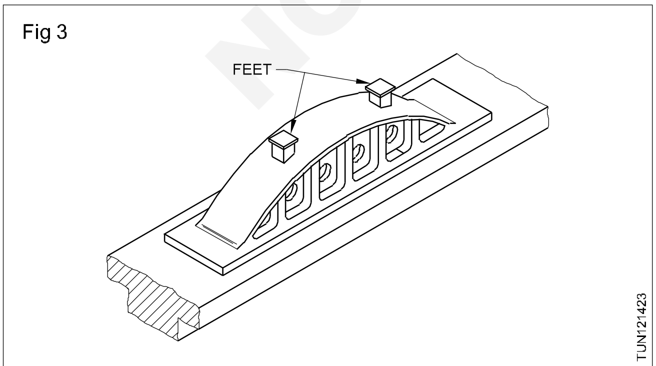
Toolmaker's steel straight edges are available in smaller lengths with bevelled edge. Some of these straight edges will have an acute angle of 60° for checking internal angles. (Fig 2)

Fig 2



Cast iron straight edges (Fig 3)

Fig 3



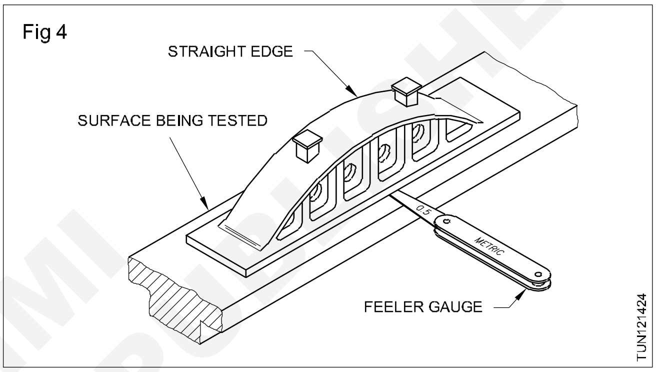
These are made from close-grained, grey, cast iron and can be considered as narrow surface plates. They are available up to 3 metres length and are used for testing machine tool slideways. Cast iron straight edges have ribs, and bow-shaped tops to prevent distortion. These straight edges are provided with feet to prevent distortion under their own weight.

Use of straight edges

Checking with feeler gauges

In certain situations when the gap between the surface and the straight edge is more, a feeler gauge can be used (Fig 4) to determine the extent of deviation.

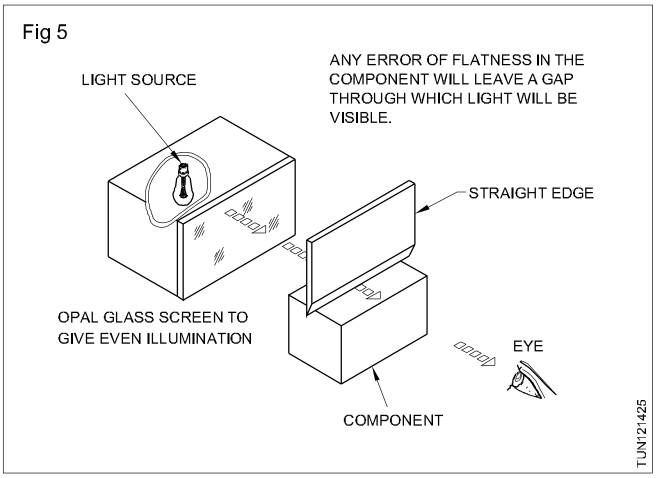
Fig 4



Use of light box

Where precision straight edges (toolmaker's) are used, a light box which can provide uniform illumination will be of advantage. Through the gap between the straight edge and the component a strip of light will be visible. (Fig 5) By practice the quality of surface can be determined by the amount of light passing through the non-contact surfaces.

Fig 5



From practice it is said that if the gap is more than 0.002 mm, white light will be seen, and if it is less than 0.002 mm, it will be tinted light.

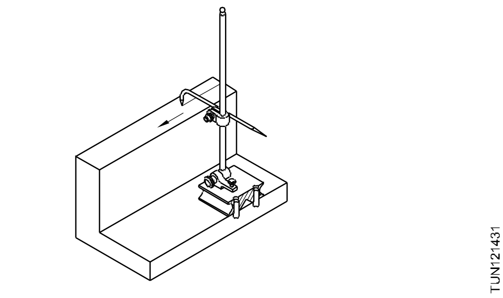
To make this judgement about the amount of deviation, one needs a great deal of practice. The same is applicable in the case of a try-square.

Surface gauges (or) Scribing block

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of surface gauges**
- **name the types of surface gauges**
- **state the uses of surface gauges**
- **state the advantages of universal surface gauges.**

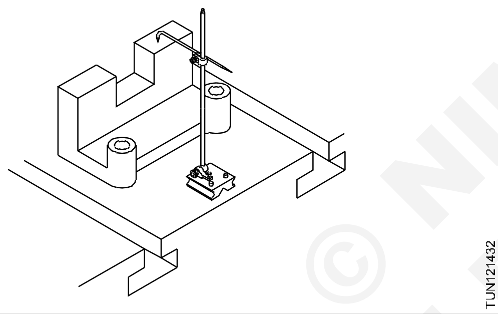
The surface gauge is one of the most common marking tools used for scribing lines parallel to a datum surface. (Fig 1)

Fig 1



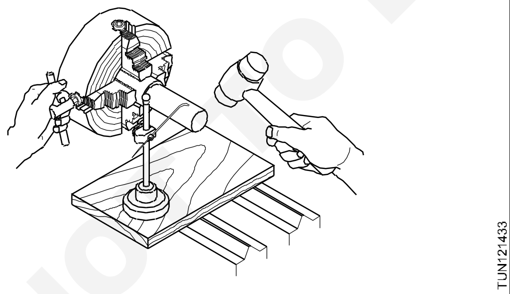
Setting jobs on machines parallel to a datum surface. (Fig 2)

Fig 2



Checking the height and parallelism of jobs, setting jobs concentric to the machine spindle. (Fig 3)

Fig 3



Types of surface gauges

Surface gauges/ scribing blocks are of two types, fixed and universal.

Surface gauge - fixed type (Fig 4)

The fixed type of surface gauge consists of a heavy flat base and a spindle fixed upright, to which a scriber is attached with a snug and a clamp nut.

Universal surface gauge (Fig 5)

This has the following additional features.

The spindle can be set to any position.

Fine adjustments can be made quickly.

Can also be used on cylindrical surfaces.

Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 6)

Fig 4

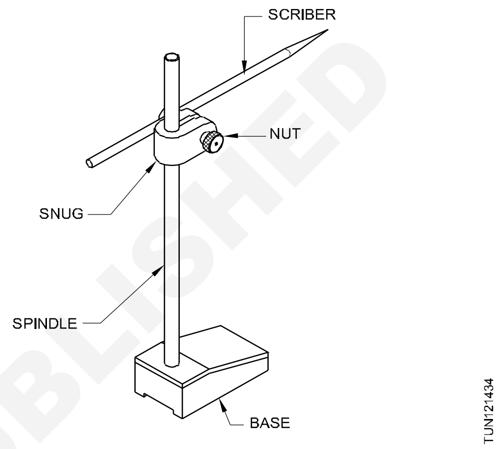


Fig 5

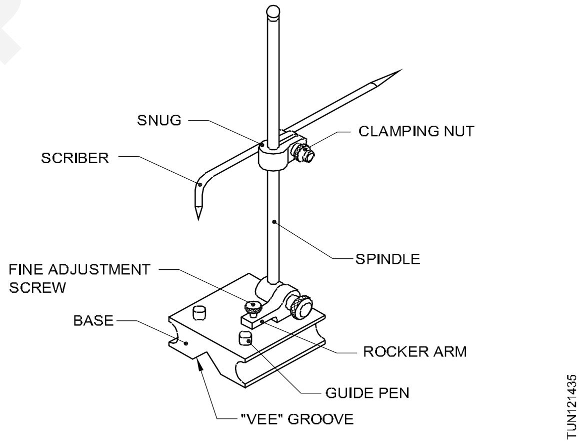
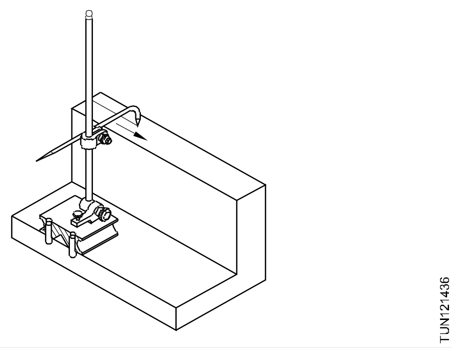


Fig 6



Parts and functions of a universal surface gauge

Base

The base is made of steel or cast iron with a V groove at the bottom. The 'V' groove helps to seat on circular work. The guide-pins, fitted in the base are helpful for scribing lines from any datum edge.

Rocker arm

The rocker arm is attached to the base along with a spring and a fine adjustment screw. This is used for fine adjustments.

Spindle

the spindle is attached to the rocker arm.

Scriber

The scriber can be clamped in any position on the spindle with the help of a snug and a clamping nut.

Hacksaw frame

Objectives: At the end of this lesson you shall be able to
- **name the different types of hacksaw frames**
- **identify parts of hacksaw frame.**

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-tuber-250-300 or 8" - 12"

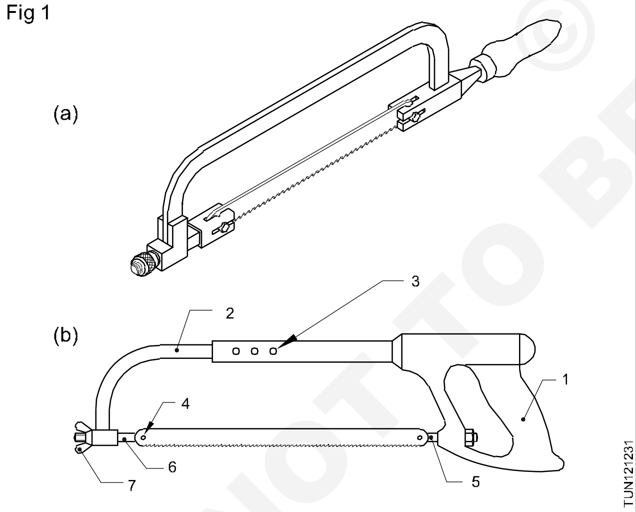
Types of hacksaw frames

Solid frame (Fig 1a) : Only a blade of a particular standard length can be fitted to this frame. e.g. 300mm or 250mm.

Adjustable frame (flat type) : Different standard lengths of blades can be fitted to this frame i.e. 250mm and 300mm.

Adjustable frame (tubular type) (Fig 1b) : This is the most commonly used type. It gives a better grip and control.

Fig 1



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

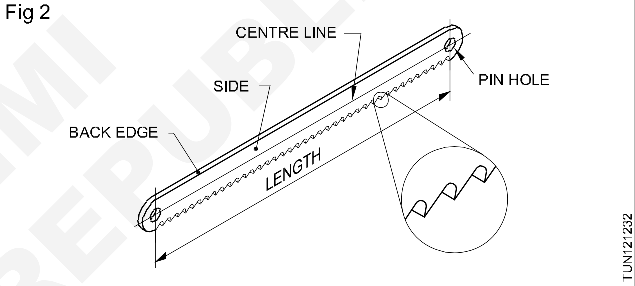
Hacksaw Blade

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 300 mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)

1	Back edge	2	Side
3	Centre line	4	Pin holes

Fig 2



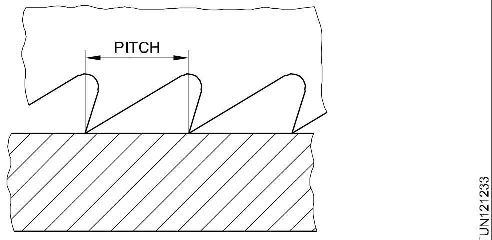
Type of hacksaw blades

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.

Fig 3



Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

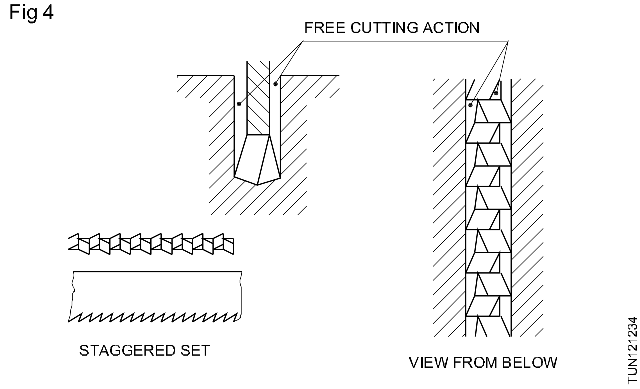
Example

300 x 1.8 mm, pitches 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.

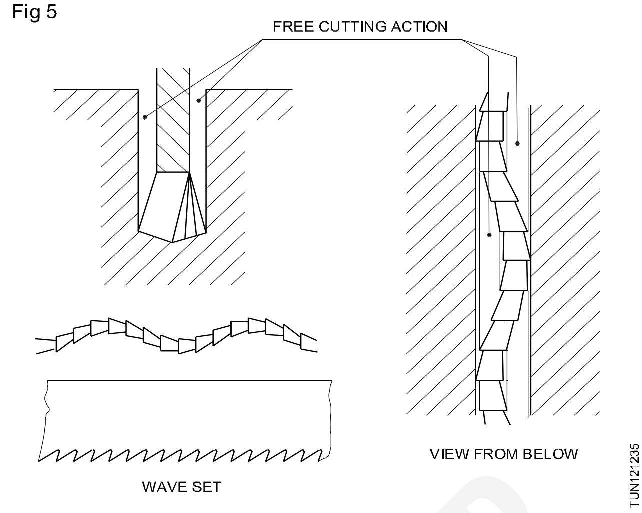
Staggered set (Fig 4)**:** Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

Fig 4



Wave set (Figs 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

Fig 5



Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

Types of marking punches

Objectives: At the end of this lesson you shall be able to
- **name the different punches used 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 up 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)

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 1

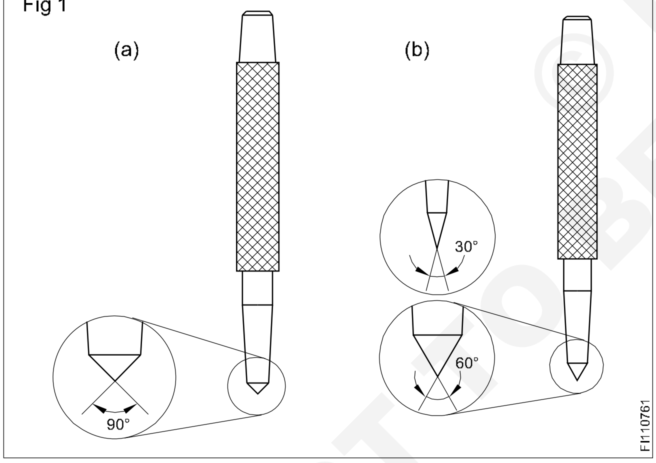
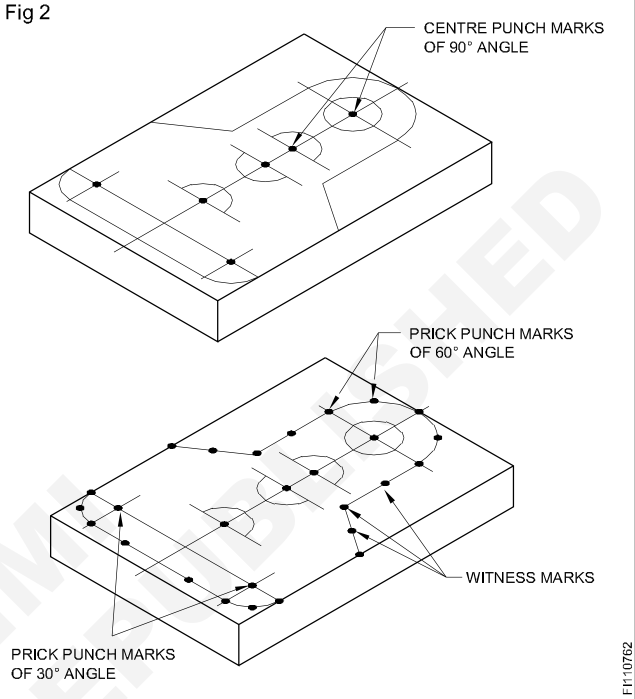


Fig 2



Drill machines - Types and parts

Objectives: At the end of this lesson you shall be able to
- **name the various types of drilling machine**
- **name the parts of the bench and pillar type drilling machines**
- **compare the features of the bench and pillar type drilling machines.**

The principal 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.)

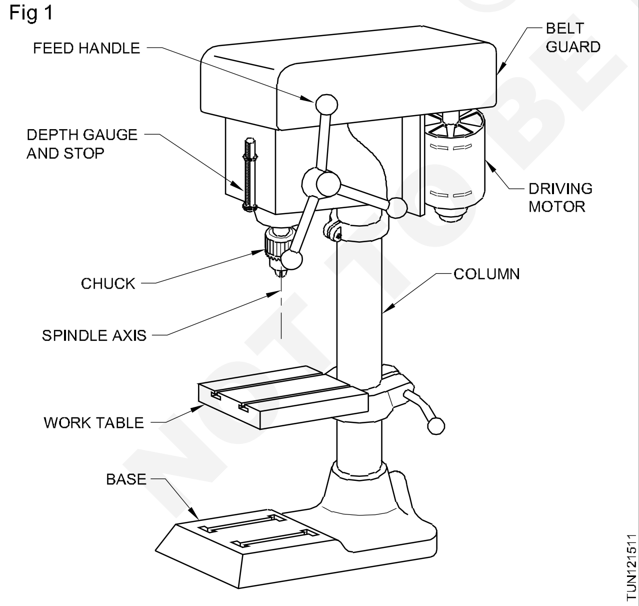
The sensitive bench drilling machine (Fig 1)

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 arrangement not shown in Fig 1)

Fig 1



Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (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. They are also used for light duty work. Pillar drilling machines are available in different sizes.

Fig 2

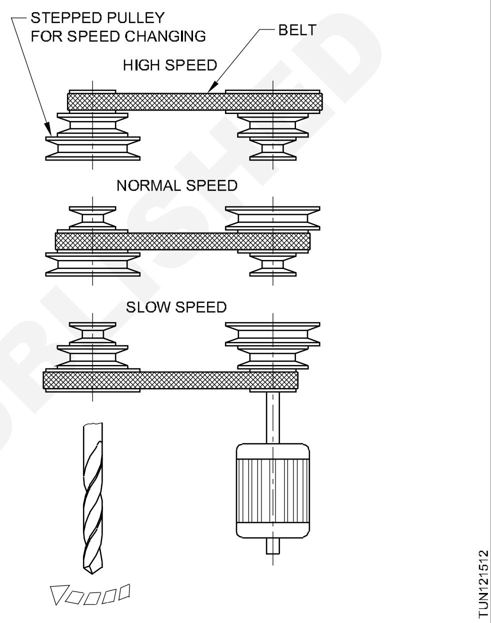
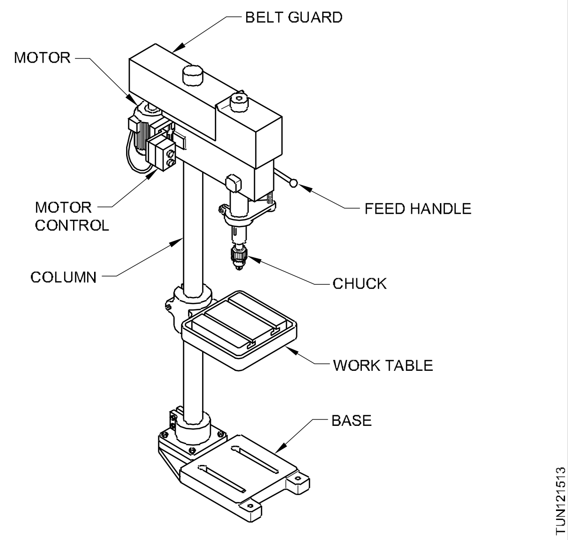


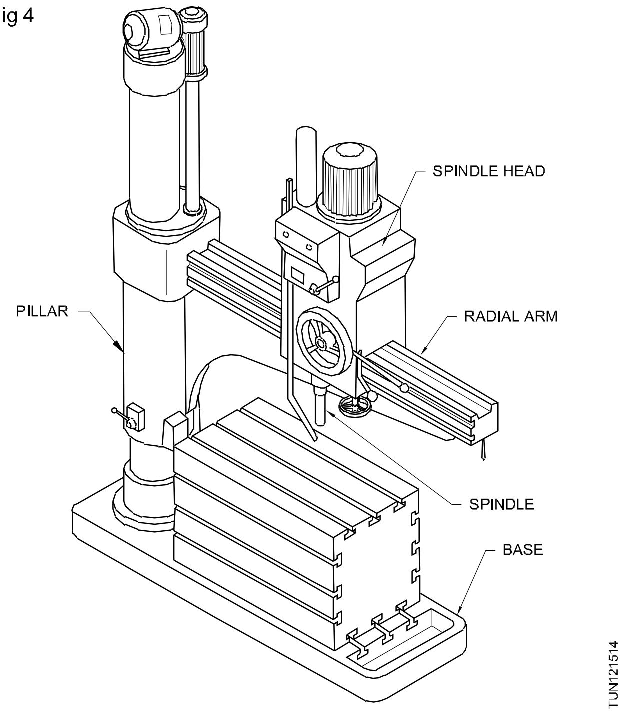
Fig 3



The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Radial drilling machines (Fig 4)

Fig 4



These are used to drill :

- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

Features

The radial drilling machine has a radial arm on which the spindle head is mounted.

The spindle head can be moved along the radial arm and can be locked in any position.

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

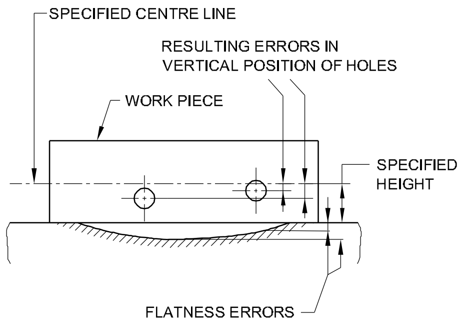
The variable-speed gearbox provides a large range of r.p.m.

Surface plate - its necessity

Objectives: At the end of this lesson you shall be able to
- **state the necessity of surface plate**
- **classify a surface plate**
- **specify a surface plate**

When accurate dimensional features are to be marked, it is essential to have a datum plane with a perfectly flat surface. Marking using datum surfaces which are not perfectly flat will result in dimensional inaccuracies. (Fig 1) The most widely used datum surfaces in machine shop work are the surface plates and marking tables.

Fig 1



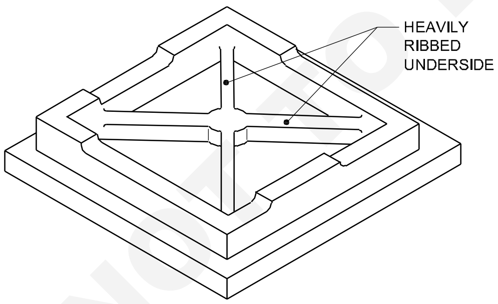
EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

Materials and construction

Surface plates are generally made of good quality cast iron which are stress-relieved to prevent distortion.

The work-surface is machined and scraped. The underside is heavily ribbed to provide rigidity. (Fig 2)

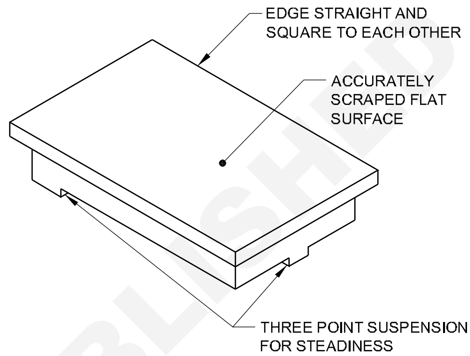
Fig 2



CAST IRON SURFACE PLATE

For the purpose of steadiness and convenience in levelling, a three point suspension is given. (Fig 3)

Fig 3



Smaller surface plates are placed on benches while the larger surface plates are placed on stands.

Other materials used

Granite is also used for manufacturing surface plates. Granite is a dense and stable material. Surface plates made of granite retain their accuracy, even if the surface is scratched. Burrs are not formed on these surfaces.

Classification and uses

Surface plates used for machine shop work are available in three grades - Grades 1, 2 and 3. The grade 1 surface plate is more acceptable than the other two grades.

Specifications

Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

Cast iron surface plate 2000 x 1000 Gr1. I.S. 2285.

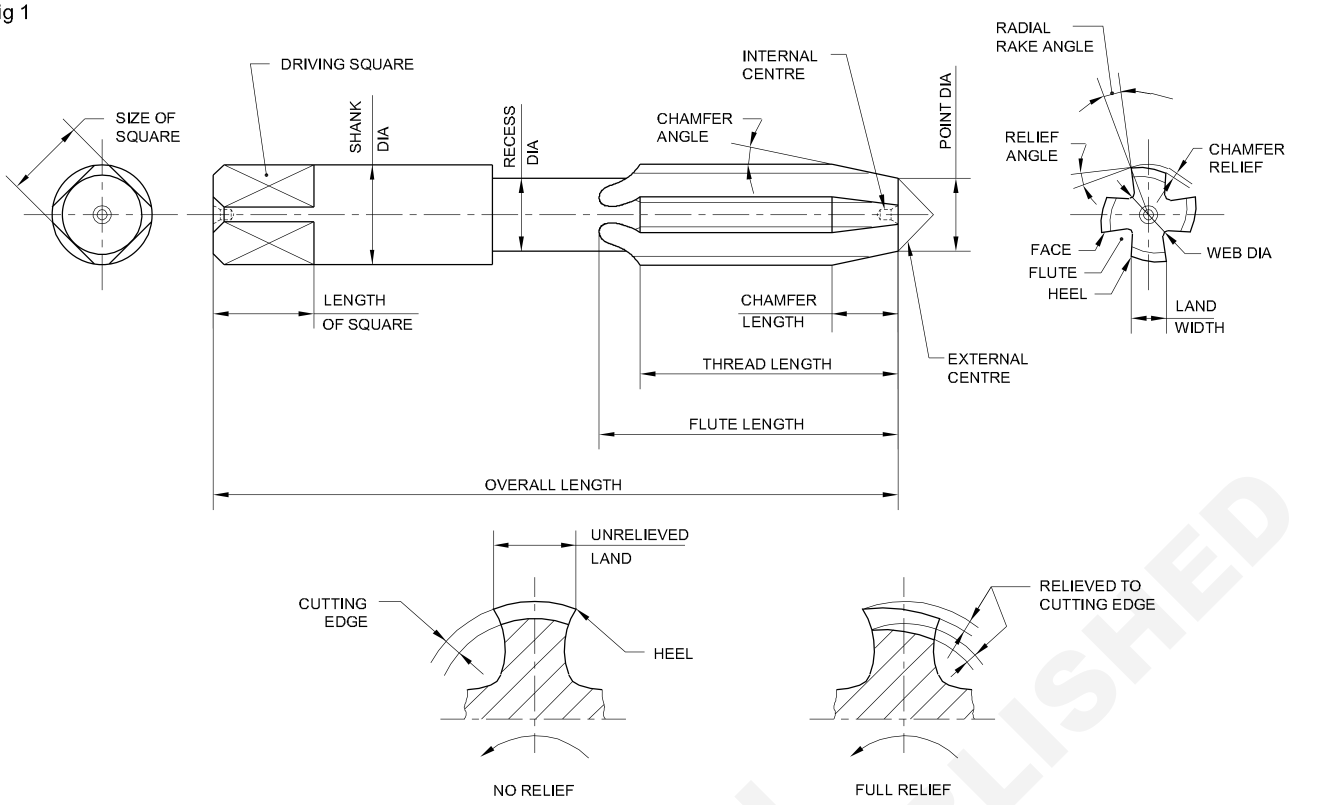
Tap - Types, Die & die stock, care while taping

Objectives: At the end of this lesson you shall be able to
- **state the use of hand taps and its feature**
- **distinguish between the different taps in a set**
- **name the different types of tap wrenches and its uses**
- **calculate in the drill size for tapping.**

Use of hand taps: Hand taps are used for internal threading of components.

Features (Fig 1): They are made from high carbon steel or high speed steel, hardened and ground.

Fig 1



The threads are cut on the periphery and are accurately finished.

To form the cutting edges, flutes are cut across the thread.

The end of the shank of the tap is made of square shape for the purpose of holding and turning the taps.

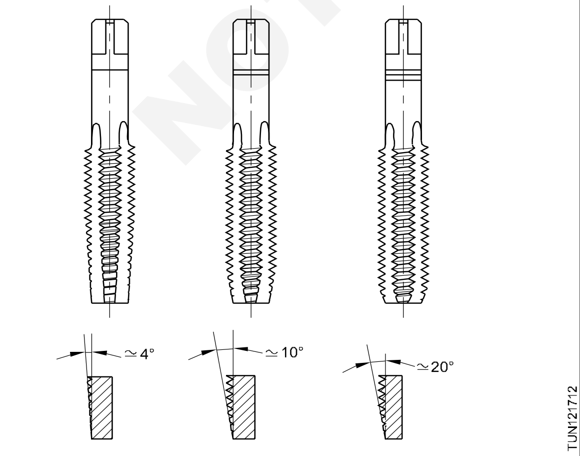
The end of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps, the thread standard, the pitch of the thread, the dia. of the tapping hole are usually marked on the shank.

Marking on the shank are also made to indicate the type of tap i.e. first, second and plug.

Types of taps in a set: Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

Fig 2



These are:

– first tap or taper tap

– second tap or intermediate tap

– plug or bottoming tap

These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

For identifying the type of taps quickly - the taps are either numbered 1,2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two and the bottoming tap has three rings. (Fig 2)

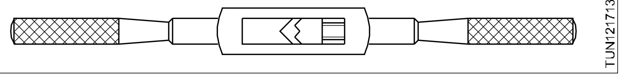
Tap wrenches: Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types, such as double-ended adjustable wrench, T-handle tap wrench, solid type tap wrench etc.

Double-ended adjustable tap wrench or bar type tap wrench (Fig 3)**:** This is the most commonly used type of tap wrench. It is available in various sizes - 175, 250, 350 mm long. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap.

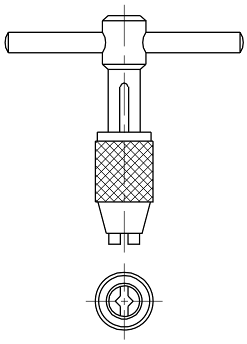
It is important to select the correct size of wrench.

Fig 3



T-handle tap wrench (Fig 4)**:** These are small, adjustable chucks with two jaws and a handle to turn the wrench.

Fig 4

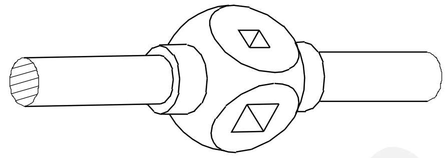


This tap wrench is useful to work in restricted places, and is turned with one hand only. Most suitable for smaller sizes of taps.

Solid type tap wrench (Fig 5)**:** These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 5

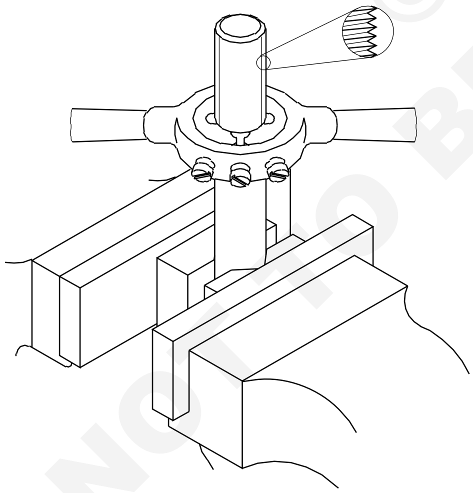


Die and die stock

Objectives: At the end of this lesson you shall be able to
- **list the different types of dies**
- **state the features of each type of die**
- **state the uses of each type of die**
- **name the type of the stock for each type of die**
- **determine the diameter of blank size for external thread cutting.**

Threading dies are used to cut external threads on cylindrical workpieces. (Fig 1)

Fig 1



Types of dies: The following are the different types of dies.

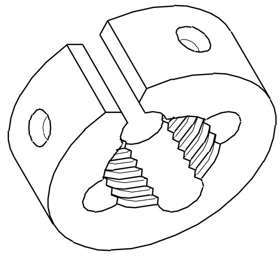
– Circular split die (Button die)

– Half die

– Adjustable screw plate die.

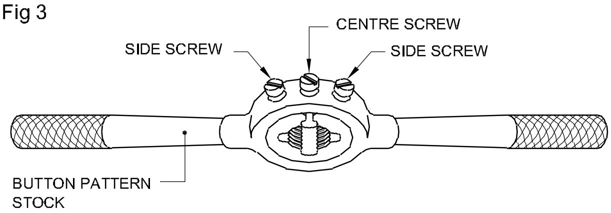
Circular split die/button die (Fig 2): This has a slot cut to permit slight variation in size.

Fig 2



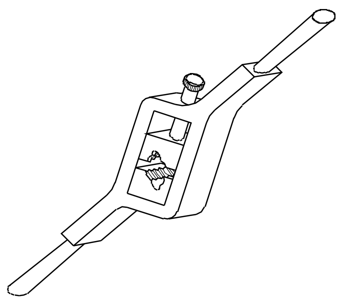
When held in the die stock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 3) For adjusting the depth of cut, the centre screw is advanced and locked in the groove. This type of die is called the button die.

Fig 3



Half die (Fig 4): Half dies are stronger in construction.

Fig 4



Adjustments can be made easily to increase or decrease the depth of cut.

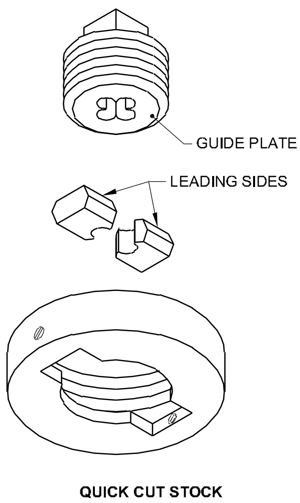
These dies are available in matching pairs and should be used together.

By adjusting the screw of the die, the die pieces can be brought close together or can be moved apart.

They need a special die-holder.

Adjustable screw plate die (Fig 5)

Fig 5



This is another type of a two-piece die similar to the half die.

This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

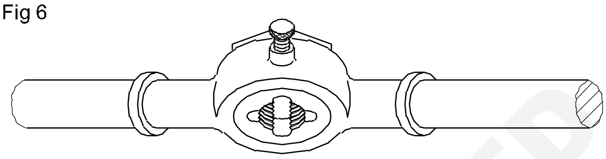
When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

The die pieces can be adjusted, using the adjusting screws on the collar.

The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped. Both pieces should have the same serial numbers.

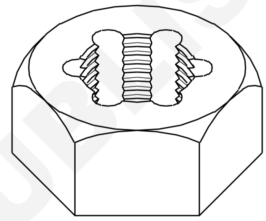
This type of die stock is called quick cut die stock. (Fig 6)

Fig 6



Die nut (Solid die) (Fig 7): The die nut is used for chasing or reconditioning the damaged threads.

Fig 7



Die nuts are not to be used for cutting new threads

The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Determining the diameter of blank size for external thread cutting

Why should the blank size be less?

It has been observed from practice that the threaded diameters of steel blanks show a slight increase in diameter. Such increase in the diameter will make the assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced equal to 0.1 x pitch of the thread before commencing the threading.

Calculation involved in finding out drill size (metric and inch)

Objectives: At the end of this lesson you shall be able to
- **state what is tap drill size**
- **choose the tap drill size for metric and BSW thread from the tables**
- **calculate the tap drill size for metric ISO threads.**

Calculation involved in finding out drill size (metric and inch)

What is tap drill size?

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap drill sizes for different threads

ISO metric thread

Tap drill size for M10 x 1.5 thread

Minor diameter	= Major diameter - (2 x depth)
Depth of thread	= 0.6134 x pitch of a screw
2 depth of thread	= 0.6134 x 2 x pitch
	= 1.226 x 1.5 mm
	= 1.839 mm
Minor dia.	= 10 mm - 1.839 mm
	= 8.161 mm or 8.2 mm.

This tap drill will produce 100% thread because this is equal to the minor diameter of the tap. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread. Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size	= major diameter minus pitch
	= 10 mm - 1.5 mm
	= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

BSW inch (1") threads formula 1" = 8 T.P.I

Tap drill size =

$$\text{Major diameter} - \frac{1 \text{ inch}}{\text{No.of threads per inch}}$$

$$= 1'' - \frac{1}{8}'' = \frac{8-1}{8}'' = \frac{7}{8}''$$

$$= \frac{7}{8}''$$

Compare this with the table of drill sizes for unified inch threads.

What will be the tap size for the following threads?

a M20

b BSW 3/8

Refer to the chart for determining the pitches of the thread.

Table for tap drill size

Nominal diameter M.M	ISO Metric (60°)		B.S.W. (55°)		Tap drill sizes
	Pitch	Tap drill sizes	Nominal diameter (inch)	Threads per inch (mm)	
3	0.5	2.50	1/8	40	2.5
4	0.7	3.30	5/32	32	3.2
5	0.8	4.20	3/16	24	4.0
6	1.0	5.00	1/4	20	5.0
8	1.25	6.80	5/16	18	6.5
10	1.50	8.50	3/8	16	8.0
12	1.75	10.20	1/2	12	10.5
14	2.00	12.00	9/16	12	12.5
16	2.00	14.00	5/8	11	14.00
18	2.50	15.50	3/4	10	16.00
20	2.50	17.50	13/16	10	18.00
22	2.50	19.50	7/8	9	19.5
24	3.00	21.00	1	8	22.2

Tap extractor

Objectives: At the end of this lesson you shall be able to
- **name the different methods of removing broken taps.**

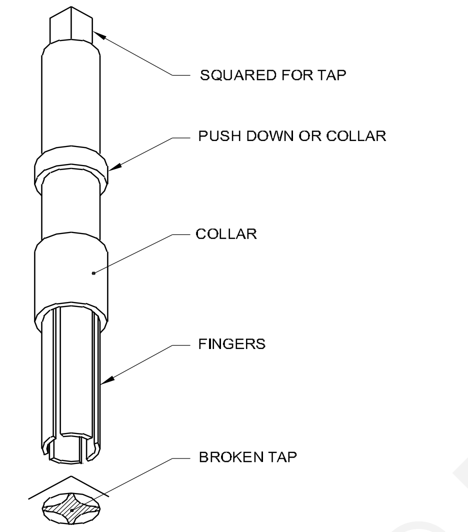
A tap broken above the surface of the workpiece can be removed using gripping tools like pliers.

Taps broken below the surface pose a problem for removing. Any one of the several methods given below can be used.

Use of tap extractor (Fig 1)

This is a very delicate tool and needs very careful handling.

Fig 1

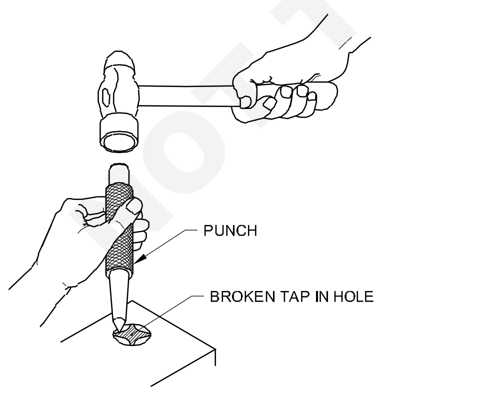


This extractor has fingers which can be inserted on the flutes of the broken tap. The sliding collar is then brought to the surface of the work and the extractor turned anticlockwise to take out the broken tap.

A light blow on the broken tap with a punch will help to relieve the tap if it is jammed inside the hole.

Use of punch (Fig 2)

Fig 2

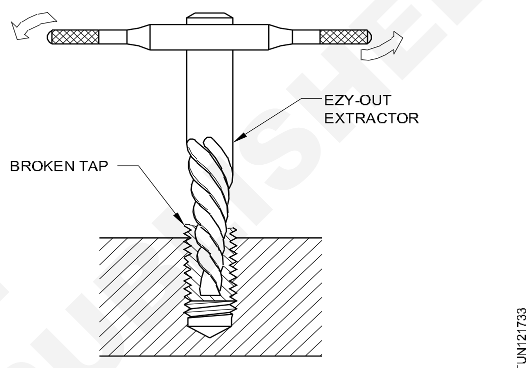


In this method the point of the punch is placed in the flute of the broken tap in an inclination and struck with a hammer. The positioning of the punch should be such that the broken tap is rotated anticlockwise when struck.

Annealing and drilling the tap

This is a method adopted when other methods fail. In this process the broken tap is heated by flame or by other methods for annealing. A hole is then drilled on the annealed tap. The remaining piece can be removed either by using a drift or using an EZY-OUT (extractor). This method is not suitable for workpieces with low melting temperatures such as aluminium, copper etc.(Fig 3)

Fig 3



Use of arc welding

This is a suitable method when a small tap is broken at the bottom of materials like copper, aluminium etc. In this method the electrode is brought in contact with the broken tap and stuck so that it is attached with the broken tap. The tap may be removed by rotating the electrode.

Use of nitric acid

In this method nitric acid diluted in a proportion of about one part acid to five parts of water is injected inside. The action of the acid loosens the tap and then it is removed with an extractor or with a nose plier. The workpiece should be thoroughly cleaned for preventing further action of the acid.

While diluting acid mix acid to water

Use of spark erosion

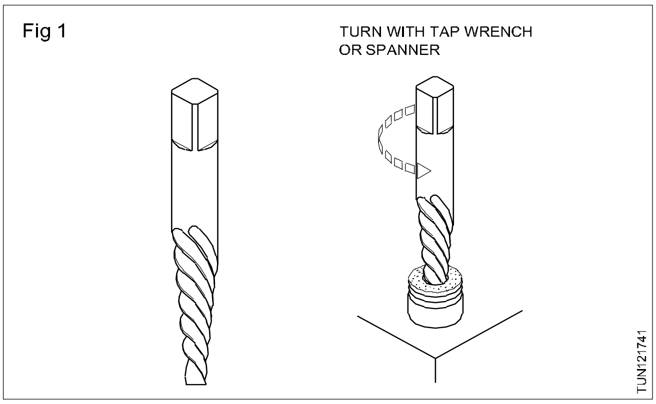
For salvaging certain precision components damaged due to breakage of taps, spark erosion can be used. In this process, the metal (broken tap) is removed by means of repetitive spark discharges. The electrical discharge occurs between an electrode and the electro-conductive workpiece (tap) and the minute particles are eroded both from the electrode and the workpiece. In many cases it may not be necessary to remove the broken tap completely. (After a small portion has been eroded, a screwdriver or punch can be used to remove the remaining portion of the tap.) The shape of the electrode also need not be round. It can be square or in the form of a slot on the workpiece for assisting the tools for rotating the broken tap.

Methods of removing broken studs

Objectives: At the end of this lesson you shall be able to
- **name the different methods used for removing broken studs**
- **state the situations in which each of the above methods is applied.**

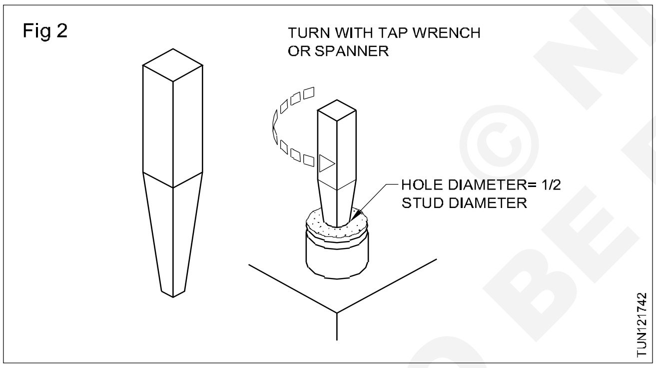
When studs or screws are broken the following methods are used for removing them.

Screw extractor (Fig 1)



Screw extractors are available in different sizes. Depending on the size of the broken stud a hole is first drilled. A screw extractor is then inserted into the hole and turned anticlockwise until it is tight. Turning further will loosen the stud.

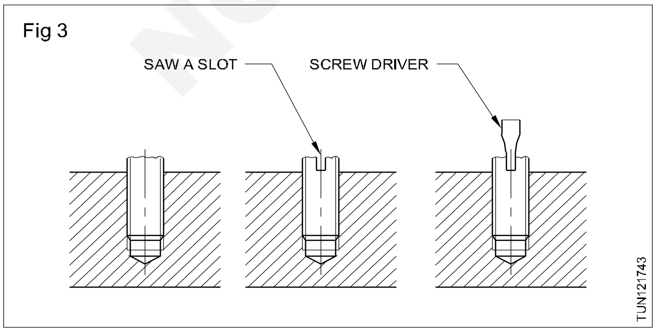
Tapered square drift (Fig 2)



First a hole approximately to half the diameter and to about half the length of the broken stud may be drilled. A tapered drift with a square head is then driven into the hole.

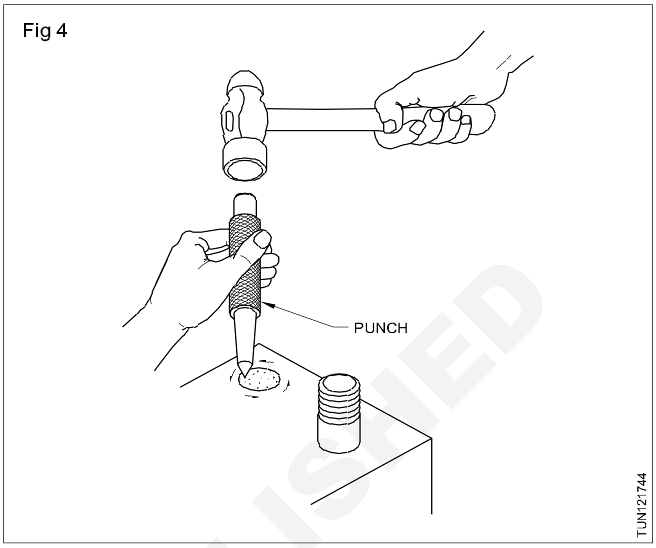
Use a tap wrench or spanner and rotate the drift for unscrewing the stud.

Using a screwdriver (Fig 3)



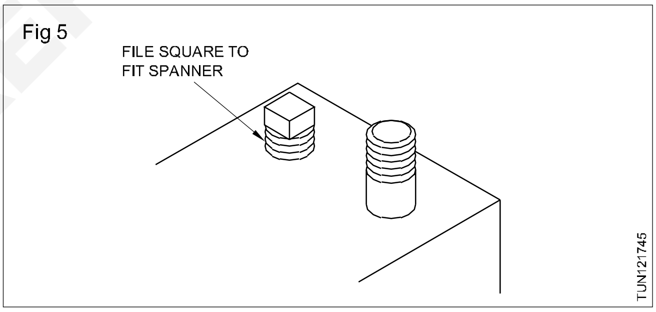
If there is sufficient projection of the broken stud, cut a slot with a saw and unscrew it with a screwdriver. This method is suitable only for small diameter studs.

Punch and hammer (Fig 4)



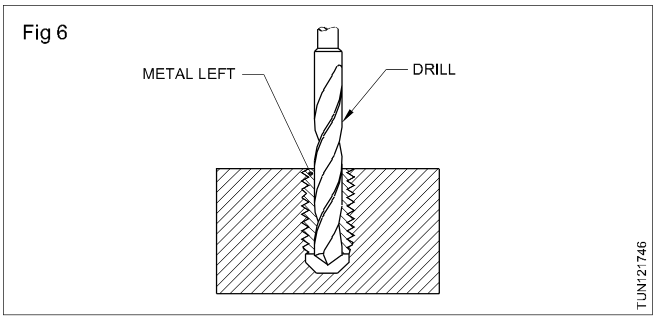
If the breakage of the stud is near the surface, sometimes it can be removed by using a punch. The punch is used to direct blows at different points to loosen the stud. Be sure the punch is used in the direction of unscrewing.

Using spanner (Fig 5)



Large diameter studs which are broken above the surface can be removed by shaping a square head and then removing by a spanner.

By drilling (Fig 6)



Broken studs which are very stubborn can be drilled through. The remaining metal can be removed using a tap or a scriber point.

Sometimes it may be necessary to remove the stud completely by drilling and re-threading for oversize stud.

Lathe - parts and lubrication points

Objectives: At the end of this lesson you shall be able to
- **name the main parts of a lathe**
- **state the safety precautions to be observed when working on a lathe.**

Turning and centre lathe

Turning is a machining process to bring the raw material to the required shape and size by metal removal. This is done by feeding a cutting tool against the direction of rotation of the work.

The machine tool on which turning is carried out is known as a lathe.

Constructional features of a lathe

A lathe should have provision :

- to hold the cutting tool, and feed it against the direction of rotation
- to have parts, fixed and sliding, to get a relative movement of the cutting tool with respect to the rotation of the work
- to have accessories and attachments for performing different operations.

The following are the main parts of a lathe. (Fig 1 & 2)

Headstock

Tailstock

Carriage

Cross-slide

Compound slide

Bed

Quick change gearbox

Legs

Feed shaft

Lead screw

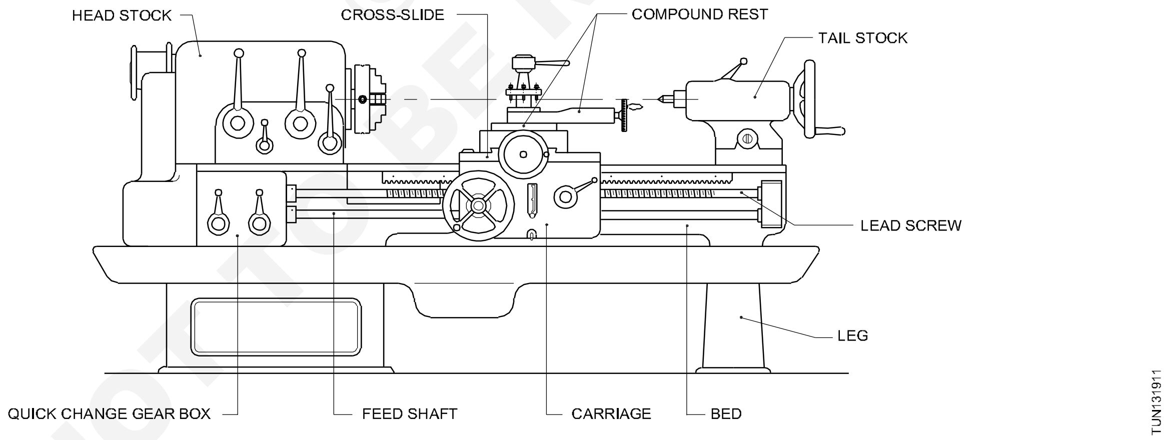
Safety precautions

Before working

Ensure that the electrical power supply is as needed for the machine.

Ensure that the safety guards are in proper condition. Ensure that the work area is clean and tidy.

Fig 1



Ensure that the meshing gears are in proper mesh, and the power feed levers are in neutral.

Ensure that the automatic lubricating system is functioning.

During working

Shift the levers to change the speeds and feeds only when the rotating parts are fully stationary.

Wear an apron (not too loose) with the sleeves of the shirt folded.

Avoid wearing rings and watches when working. Wear shoes to avoid injury to your feet.

Remove the chips by a hook, and use a brush to clear them.

After working

Clean the machine with a brush and wipe with cotton waste.

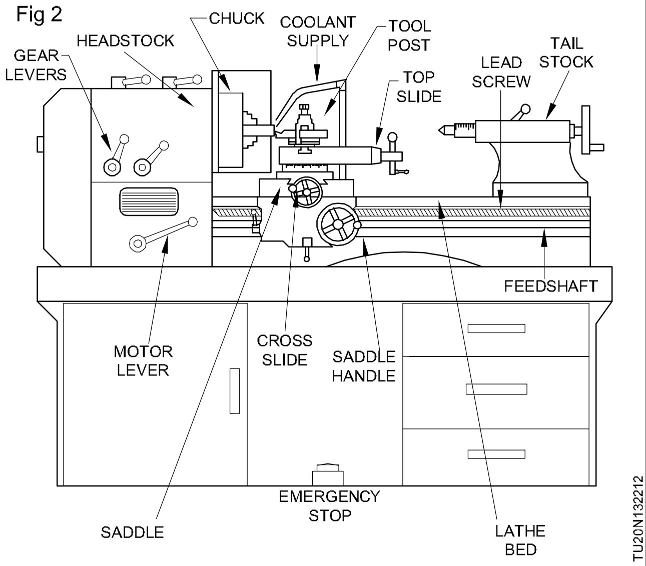
Oil the bed-ways and the lubricating points.

Clean the precision instruments and hand them over to the instructor for safe keeping.

Clean the cutting tools and place them in their respective places.

Clean the area surrounding the lathe by wiping the spilt oil and coolant, and remove the swarf.

Fig 2



Various Lubrication Points

1 Place a few drops of oil on the rocker shaft bearing and cams every time the lathe is in use.

2 Countershaft roller bearing - Fill both grease cups with automotive cup grease every two weeks. Give the grease cup caps a turn or so every time the lathe is used.

3 Place a few drops of oil on the rocker shaft lever bearings and lever fulcrum bearing every time lathe is used.

4 Motor bearings - sleeve type motors have two oil cups which should be filled once a week with S.A.E. No. 10. Motor oil or equivalent. Ball bearing motors have a sealed in - type bearing-every six months the small headless screw in these bearings should be removed and a moderate quantity of automotive cup grease forced around the bearing.

5 Left and right headstock bearings - oil with No.10 motor oil or equivalent every time the lathe is used.

6 Spindle pulley - every time the lathe is used in backgear, remove the small screw in the bottom of the second step of the idler pulley and oil freely with No. 10 motor oil or equivalent. Replace screw.

7 Back gear spindle - every time the back gears are used, remove the small screw in the centre of the back gear spindle and oil freely with No.10 motor oil or equivalent. Replace screw.

8 Back gears and change gears - A small amount of keystone No.122 heavy outer gear lubricant or equivalent applied to the gear teeth will aid in obtaining smoother, more quiet operation. Be sure to remove all oil in the gear teeth before applying this lubricant or it will not adhere.

9 Change gear bearings - put a few drops No.10 motor oil or equivalent on the change gear bearings each time the lathe is used.

10 Lead screw stub bearing and reversing gears - put a few drops of No. 10 motor oil or equivalent in the three oil holes on the top of the reversing gear box every time the lathe is used.

11 Carriage traverse gear case - every time the lathe is in use, put a few drops of No. 10 motor oil in oil hole on top of gear case on back of carriage apron.

12 Carriage hand wheel bearing - put a few drops of No.10 motor oil or equivalent in the ball spring oil hole every time the lathe is used.

13 Cross feed gear bearing - put a few drops of oil in the ball spring oil hole every time lathe is used.

14 Half-nut lever bearing-put a few drops of No.10 motor oil or equivalent in the ball spring oil hole every time the lathe is used.

15 Thread dial-once a week put a few drops of No.10 motor oil or equivalent around the rim of the top of the thread dial.

16 Wipers (front and back) - saturate the felts in the four wipers, located on the carriage with oil every time the lathe is used.

17 Cross slide screw - Put a few drops of No.10 motor oil or equivalent in the oil hole above the front cross slide screw bearing after removing the small screw. Replace the screw. This should be done every time the lathe is used. Clean the cross slide screw regularly with a small stiff brush. Oil the screw threads by running the compound rest back and forth.

18 Cross feed gears - put a few drops of oil in the oil hole above the cross feed screw after removing the small screw. Replace the screw. This should be done every time the lathe is used.

19 Cross slide ways - clean regularly and apply a liberal quantity of No. 10 motor oil or equivalent to the ways whenever the lathe is used.

20 Compound slide screw - every time the lathe is used put a few drops of No.10 motor oil or equivalent in the oil hole on top of the compound rest and above the compound screw bearing.

21 Compound slide ways - clean regularly and apply a liberal quantity of No.10 motor oil or equivalent to the ways whenever the lathe is used.

22 Lead screw - about once a month clean the lead screw threads with kerosene and a small stiff brush and apply a small amount of No.10 motor oil or equivalent.

23 Rack (on bed, under front way) - about once a month apply a small amount of cup grease to the rack after cleaning with kerosene and a small stiff brush.

24 Lead screw bearing (right end of lathe) - put a few drops of No.10 motor oil or equivalent in the oil hole on top of the bearing every time the lathe is used.

25 Place a few drops of oil between the handwheel and screw bearing when ever using lathe.

26 Tailstock center lubricant - fill the small cup on the tailstock with a mixture of white lead and oil and apply to the tailstock center whenever turning between centres. If white lead is not available, use a liberal amount of cup grease on the center.

27 Tailstock ram - keep the outside surface of the tailstock ram well oiled.

28 Lathe bed ways - keep the bed ways oiled at all times with No.10 motor oil or equivalent and free from chips. Wipe off the ways before using and cover with fresh oil. Always leave a generous film of oil on the ways when the lathe is not in use. The lathe should be completely covered when not in use. During all grinding operations cover bed ways with canvas or carboard.

Keep all the lathe bearing surfaces perfectly clean. Dirt is the natural enemy of accurate lathe work.

Machine tool & development of lathe

Objectives: At the end of this lesson you shall be able to
- **distinguish between machine and machine tool**
- **brief the history of lathe.**

Machine

Machine is a device that performs related operation to produce desired product. It can be stitching of a cloth with a sewing machine, producing a component in forging press, are it can be mass production using a CNC machine tool.

A machine tool is defined as a power driven machine, capable of holding/ supporting the work and tool, at the same time, directing/guiding the cutting tool or job or both to perform various metal cutting operations to produce various shape and size.

Fundamentals of machine tools

A machine tool is a device that utilizes electric energy for shaping and sizing a product by removing excess material in the form of chips, with the help of cutting tool.

Machine tools are used for producing components at a rapid rate. Optimum productivity from machine tool calls for a fairly high degree of skill. Properly carried out operations are capable of producing a large number of components at a fairly rapid rate.

Machine tools and machines are two different things. Machine tools when taken as a group can produce a machine tool, which is not true of machines.

Lathe, milling machine, shaping machine, slotter etc., are all machine tools.

Every metal working machine cannot be called a machine tool merely because it removes material. Forging hammers, drawing dies, extruders, rolling machine etc., are not machine tools.

Functions of machine tools

1 To hold and support the workpiece to be machined.

2 To hold and support the cutting tool.

3 To provide requisite motion to the workpiece tool or both.

4 To regulate the cutting speed and feed of the tool and workpiece.

5 To hold various attachments for different operations. Jobs and tools are held in properly designed devices on a machine tool. Different machine tools are provided with different holding devices.

In a workshop, a machine tool is generally used for producing different shapes and for finishing the surfaces.

Classification of machine tools

1 According to the type of the surface generated.

  i Cylindrical work machine tools - Lathes, capstan, turret etc.,

  ii Flat surface machine tools - milling m/c, shapping m/c, planning m/c etc.,

2 Classification based on the purpose of the m/c tool.

  i Single - purpose

  ii Multi purpose

  iii Special purpose

  iv Transfer machine

  v Numerically controlled

3 Classification based upon the size of chip

  i Machine tools using cutting tools - lathe, milling, planner, slotter etc.,

  ii Machine tools using abrasives - honing, lapping etc.,

Machine tool performance criteria

While designing a machine tool the following factors need consideration.

1 It should be safe and easy to operate.

2 It should be accurate.

3 It should have good production capacity.

4 The operational cost should be low.

5 Controls should be located at convenient points.

6 Blanks should be such that they can be loaded and clamped easily.

Factors in machining operations

The operations of removing metal by means of a cutting tool using some sort of machine tool in order to obtain a desired shape is called machining.

It includes number of operations such as turning boring, shaping, milling etc.,

The selection of a machine tool for a particular operation depends upon many factor such as

1 The shape and size of the product required.

2 The quantity of material to be removed.

3 The type of operation to be performed.

4 The number of components required.

5 The type of material to be handled.

6 the degree of accuracy required.

The - longitudinal axis tool holding equipment

Fig 1

Lathe introduction

Lathe is a machine widely used for wood works and machining of metal parts. Lathe is a machine which turns the work piece against a cutting tool. The lathe is used for facing, turning, knurling, taper cutting, threading, gear cutting and many other metal and wood works.

History of lathe

Lathe is a very ancient tool and its first use dates back to 1300 BC in Egypt. Lathe was also known and used in Syria and Greece. Ancient romans came to know about this machine and they further developed this machine. During the medieval period, the use of this machine had spread to most parts of Europe and it was during the industrial revolution when this machine gained popularity with its use in all the industries. After the development of electronics, automated lathes have been developed.

Evolution of lathe

The first lathe was a simple lathe which is now referred to as two person lathe. One person would turn the wood work piece using rope and the other person would shape the work piece using a sharp tool. This design was improved by ancient romans who added a turning bow which eased the wood work. Later a pedal (as in manual sewing machines) was used for rotating the work piece. This type of lathe is called “spring pole” lathe which was used till the early decades of the 20th century. In 1772, a horse-powered boring machine was installed which was used for making cannons. During the industrial revolution, steam engines and water wheels were attached to the lathe to turn the work piece at higher speed which made the work faster and easier. After 1950, many new designs were made improved the precision of work.

Lathes are classified depending upon their application and functionality.

Light duty lathe - These machine find their application in automobile, electronic, electrical industries and are manufactured from quality tested raw materials.

Medium duty lathe - These machines are powerful than the light duty lathes and can work on bigger work pieces and have more strength than the light duty lathes.

Heavy duty lathe - these machines are manufactured from high test grades of materials like iron and steel. They are designed for high precision heavy duty operations.

All geared lathe - In all geared lathe, all the rotating components of the machines are driven by the same source at different speeds by using gears to perform various operations.

Imported lathe - Imported lathes are high quality lathes used for high precision operations.

Depending upon the modes of operation, the lathes can be classified as

Manual lathe - In these lathes, the tool handling is done manually and so the precision of work also depends upon the skill of the person handling the machine.

CNC lathe - CNC lathes are completely automated lathes. We just have to feed the instructions into the computer and the lathe will perform the operations according to the data fed to the computer.

Classification of lathe, lathe specification

Objectives: At the end of this lesson you shall be able to
- **state the different types of lathes and their uses**
- **state the method of specifying a centre lathe.**

Types of lathe

1 Speed lathe
   a) Wood working
   b) Centering
   c) Polishing
   d) Spinning

2 Engine lathe (or) centre lathe
   a) Belt drive
   b) Individual motor drive
   c) Gear head lathe

3 Bench lathe

4 Tool room lathe

5 Capstan and turret lathe

6 Special purpose
   a) Wheel lathe
   b) Gap bed lathe
   c) T-lathe
   d) Duplicating lathe

7 Automatic lathe

8 CNC machine

Speed lathe

- The speed lathe has been so named because of very high speed head stock spindle.
- It consists of head stock, tailstock and tool post mounted on adjustable slide.
- Tool is fed into the work by hand control.
- It has no gear box lead screw and carriage.
- Different speeds are obtained by cone pulley (1200-3600rpm)
- Wood working, spinning, polishing, centering operations can be performed.

Engine lathe (or) centre lathe

- The term engine is because of that early lathes were driven by steam engine.
- It consists of basic parts like bed, head-stock and tail stock but head-stock is more robust and has additional drive mechanism for multiple speeds.
- Engine lathe can feed cutting tool both in cross and longitudinal directions with the help of carriage, feed rod, and leadscrew.
- Belt drive lathe gets power from an over head line shaft equipped with speed cone and one or more back gears.
- Individual motor driven lathe gets power from individual motor.
- A geared head lathe gets its power from constant speed motor and all speed changes are obtained by shifting various gears located in the headstock.

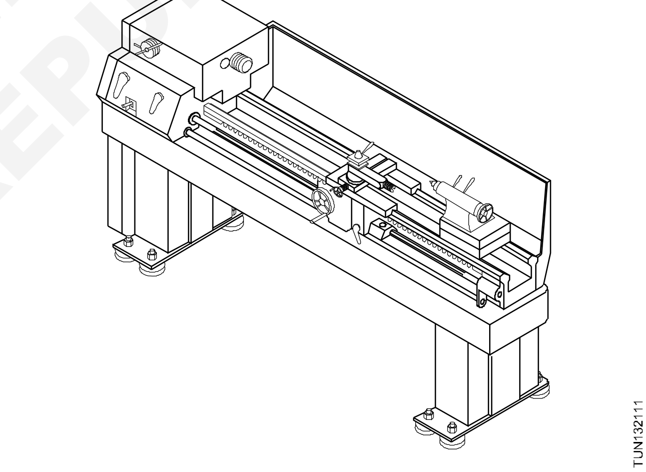
Bench lathe

- It is mounted on bench and has the same features like engine lathe.

Tool room lathe (Fig 1)

- It has the same features like engine lathe and has very low to high speed up to 2500rpm.

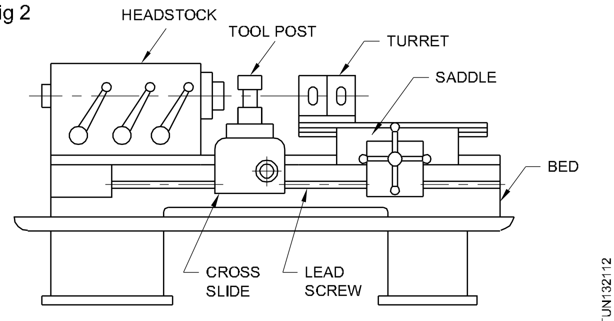
Fig 1

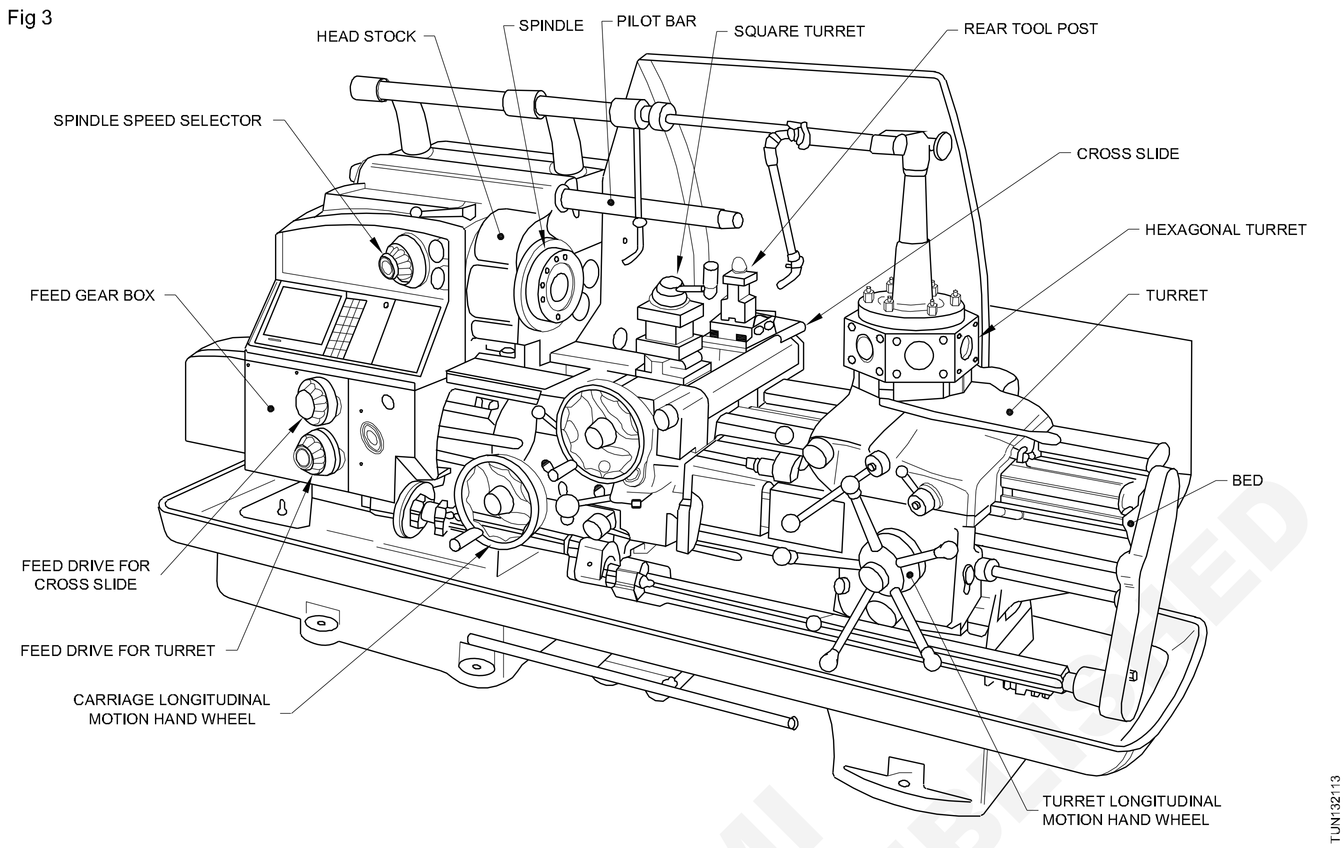


- It has taper turning attachment, draw in collet attachment, thread chasing dial, relieving attachment, steady and follower rest, pump for coolant.
- Used for precision work on tools, dies, gauges.

Capstan and turret lathe (Fig 2 & 3)

Fig 2





- These are developed from engine lathe, used for production work.
- Tailstock of an engine lathe is replaced by hexagonal turret where number of tools can be mounted.
- Number of identical parts can be produced in minimum time.

Special purpose lathe

- These are used for special purposes.
- Wheel lathe is used for finishing the journal and turning the thread on locomotive wheels.
- The gap bed lathe can accommodate the jobs having extra diameter.
- T-lathe is intended for machining the rotors for jet engines, axis of bed is right angles to the axis of head stock spindle.
- Duplicating lathe is used for duplicating the shape of given template using mechanical or hydraulic system.

Special purpose lathe

- These are high speed, heavy duty, mass production lathes with complete automatic control.
- Once the tools are set and machine is started it performs automatically all the operations to finish at a time.
- Change of tools, speeds and feeds can be done automatically, operator can run 5 to 6 machines at a time.

CNC machine

- Complex shapes machined easily.
- High production rate.
- Accuracy and repeatability is achieved.
- Less operation skill and involvement.
- Reduced space.

Centre lathe specification

Objective: At the end of this lesson you shall be able to
- **specify the size of a lathe.**

The size of a lathe is generally specified by the following means:

a) Swing or maximum diameter that can be rotated over the bed ways.

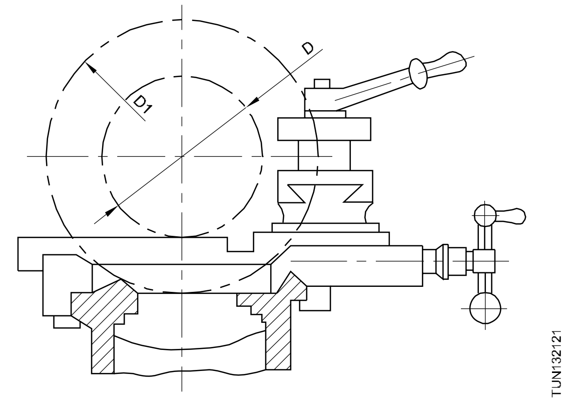
b Maximum length of the job that can be held between head stock and tailstock centres.

c Bed length, which may include head stock length also,

d Maximum diameter of the bar that can pass through spindle or collect chuck of capstan lathe.

Fig 1 illustrates the elements involved in specifications of a lathe. the following data also contributes to specify a common lathe machine.

Fig 1



- Maximum swing over bed.
- Maximum swing over carriage.
- Height of centers over bed.
- Maximum distance between centers.
- Length of bed.
- Width of bed.
- Morse taper of center
- Diameter of hole through spindle.
- Face plate diameter.
- Capacity of tool post.
- Number of spindle speeds
- Lead screw diameter and number of threads per inch or pitch in mm.
- Capacity of electrical motor.
- Pitch range of metric and inch threads etc.

Lathe bed function and construction

Objectives: At the end of this lesson you shall be able to
- **state the functions of a lathe bed**
- **list the different types of bed - ways**
- **state the reasons for manufacturing a lathe bed out of cast iron.**

Functions of a lathe bed

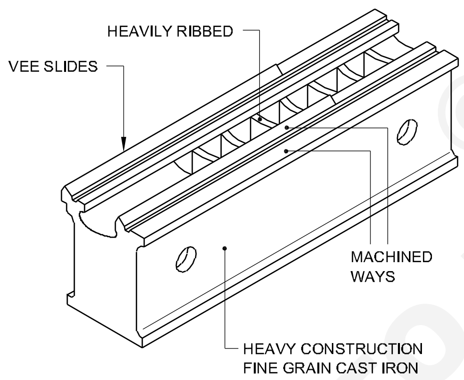
The two functions of a lathe bed are :

- to locate the fixed units in accurate relationship to each other
- to provide slideways upon which the operating units can be moved.

Constructional features of *a* lathe bed (Fig 1)

In the majority of cases, the bed generally, a single iron casting. In larger machines, the bed may be in two or more sections, accurately assembled together. Web bracings are often employed to increase the rigidity. For absorbing shock and vibration, the bed should be of considerable weight. Bed castings are usually rough machined and then allowed to 'age' naturally before finish machining to remove distortions.

Fig 1



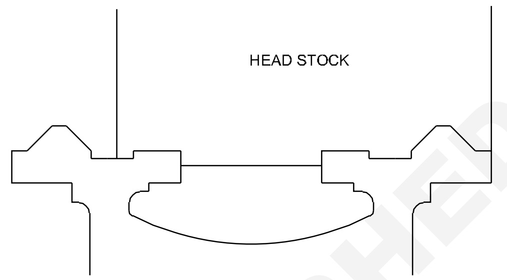
A swarf or a combined swarf and a coolant tray are provided on the lathes. This may be an integral part with the lathe bed. This increases the rigidity of the bed.

The bed generally rests on cast iron or welded sheet metal legs of box section. This provides the necessary working height for the lathe. Very often the electrical switch gear unit and the coolant pump assembly are housed in the box section legs at the headstock end.

Bed-ways (Fig 2)

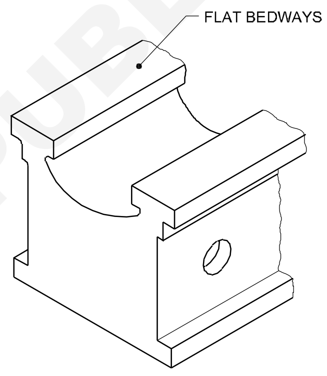
The surfaces of the bed in contact with the sliding units of the lathe are known as bed-ways or guideways or guide shoars. The beds are classified according to the shape of the ways. They are:

Fig 2



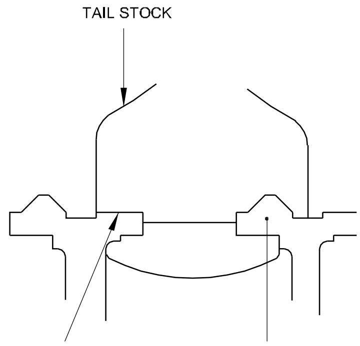
Flat bed-ways (Fig 3)

Fig 3



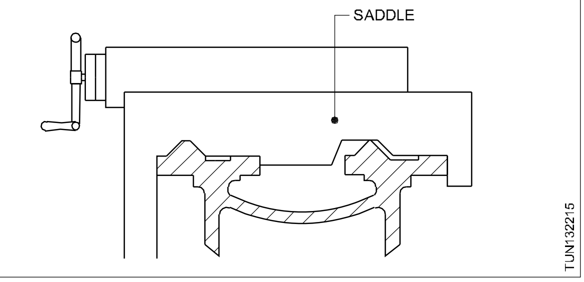
'V' bed (Fig 4)

Fig 4



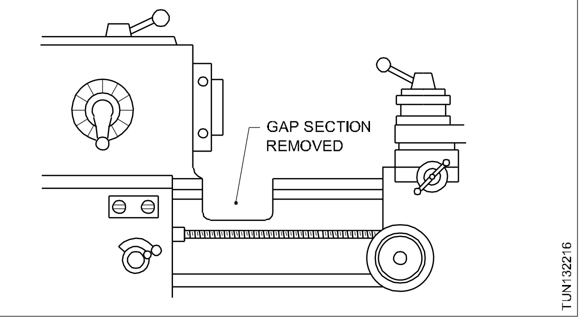
Combination bed (Fig 5)

Fig 5



Gap bed (Fig 6)

Fig 6



Normally the bed is positioned at several centimeters from the headstock, and the bed is reduced at this point. This enables for the swing of larger diameters of work.

A few lathes have at this point a detachable section of the bed which can be fitted when desired to enable the saddle to operate close to the headstock without over hanging the gap. (Fig 6)

In the case of flat bed shears, the machined bases of saddle and tailstock rest and they are guided by their machined edges. The inverted V ways support and guide the sliding units.

The bed-ways are fine-finished by grinding. Some lathes have their bed-ways hand- scraped. Some have their bed-ways hardened and ground. The wear resisting qualities of bearing surfaces are improved by employing chilled iron castings.

The beds are mostly made of close-grained grey cast iron.

The advantages are :

- easily available and costs comparatively less
- under load, cast iron will not bend but break
- in its molten state its fluidity is more so that it can occupy intricate parts of the mould
- carbon is in free state which has self-lubricating property
- grey cast iron is easily machinable
- can withstand more compressive load
- resists vibration.

Different parts of lathe, tailstock

Objectives: At the end of this lesson you shall be able to
- **name the parts of a tailstock**
- **state the purposes of a tailstock**
- **state the functioning of a tailstock.**

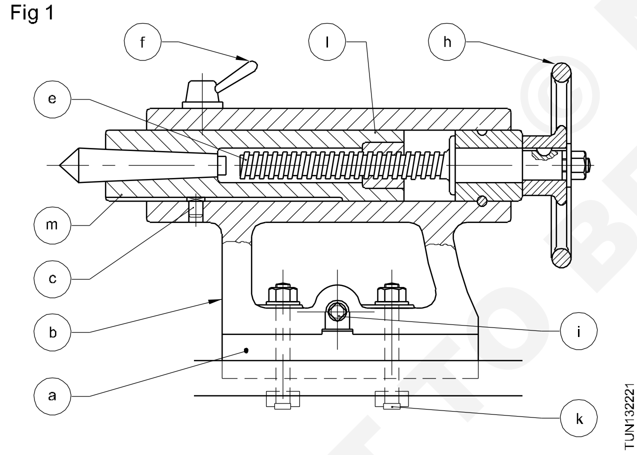
Tailstock

It is *a* sliding unit on the bed-ways of the lathe bed. It is situated on the right hand side of the lathe. It is made in two parts, namely the 'base' and the 'body'. The base bottom is machined accurately and has 'V'grooves corresponding to the bed-ways. It can be slided over the bed and clamped in any position on the bed by means of the clamping unit. The body of the tailstock is assembled to the base and has a corresponding longitudinal movement as to that of the base, along the bed. It has a limited transverse movement as well, with respect to the base. Graduations are marked on the rear end of the base and a zero line is marked on the body.

When both zero lines coincide the axis of the tailstock is in line with the axis of the headstock.

The body and base are made of cast iron. The parts of a tailstock are: (Fig 1)

Fig 1



- base (a)
- body (b)
- spindle (barrel) (c)
- spindle-locking lever (f)
- operating screw rod (e)
- operating nut (l)
- tailstock hand wheel (h)
- key(m)
- clamping unit (k)
- set over screw (i).

Functioning of tailstock

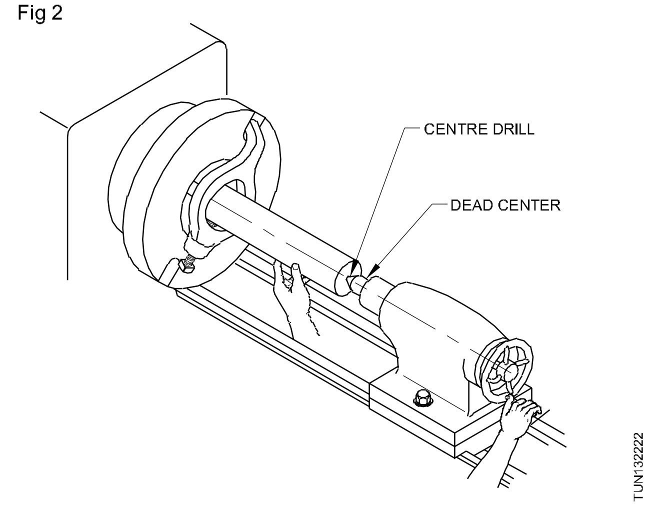
By rotating the hand wheel the screw rod is operated. This causes the barrel, which carries the nut, to move forward and backward according to the direction of rotation. The key, which fits in the keyway milled at the bottom of the barrel, prevents the barrel from rotation. The thread in the screw rod is mostly of left hand square thread to have forward movement for anticlockwise rotation of the hand wheel. The barrel may be locked in any required position. The hollow end of the barrel at the front is provided with a Morse taper to accommodate the cutting tools with the taper shank. Graduations may be marked on the barrel to indicate the movement of the barrel. The screw rod is made of alloy steel and the operating nut is made of bronze. With the help of the adjusting screws, the body can be moved over the base laterally and the amount of movement may be read approximately referring to the graduations marked.

Purpose of the tailstock

To accommodate the dead centre to support a lengthy work for carrying out lathe operations.

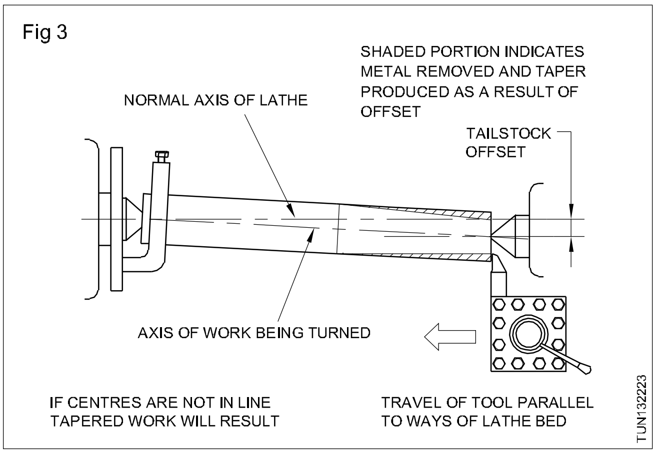
To hold cutting tools like drills, reamers, drill chucks which are provided with taper shank. (Fig 2)

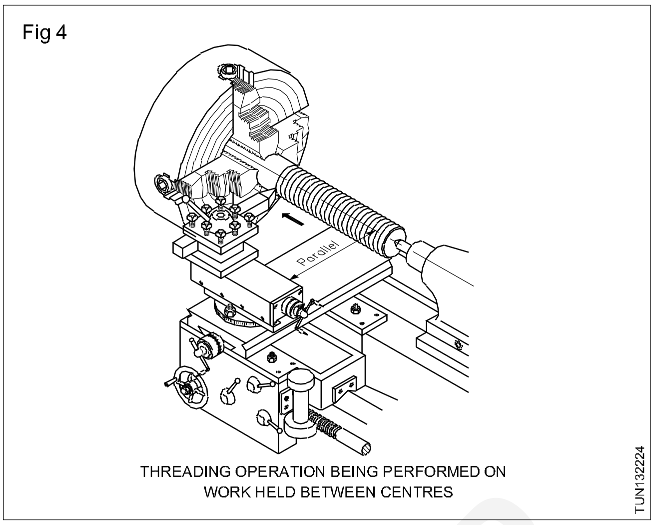
Fig 2



To turn the external taper by offsetting the body of the tailstock with respect to the base. (Fig 3)

To perform external operations on the shaft held between centres. (Fig 4)



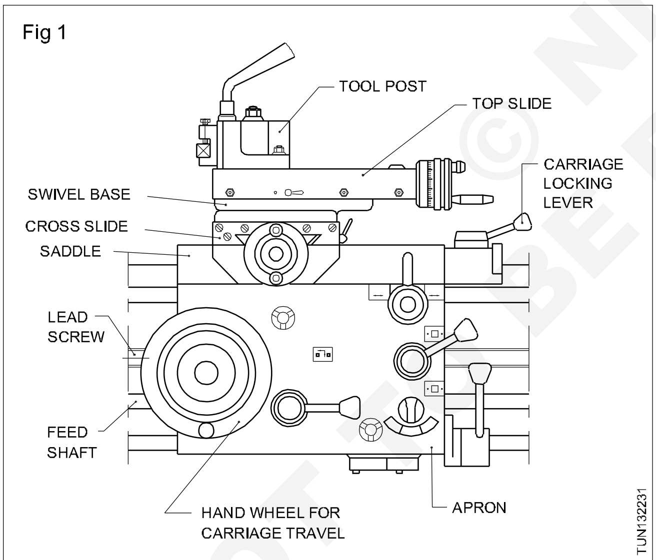


The carriage

Objectives : At the end of this lesson you shall be able to
- **state the purpose of a carriage**
- **list out the parts of a carriage**
- **state the functioning of the carriage.**

Purpose of a carriage

The carriage is the part of the lathe which slides over the bed-ways between the headstock and the tail stock. (Fig 1)



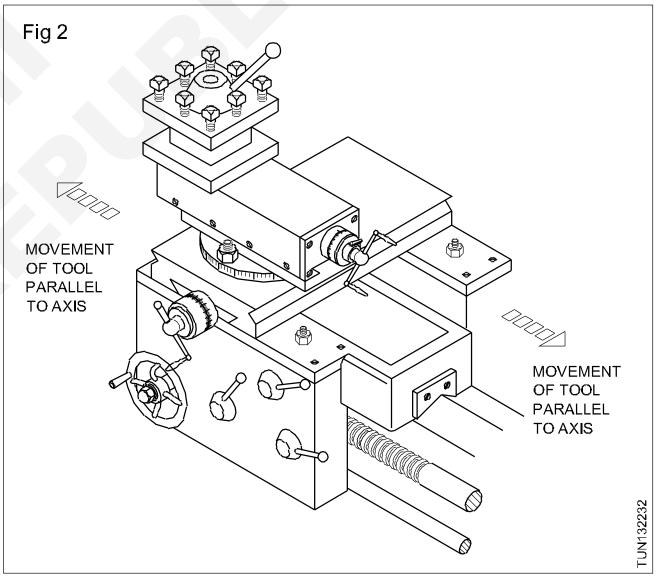
It provides various movements for the cutting tool manually as well as by power feed.

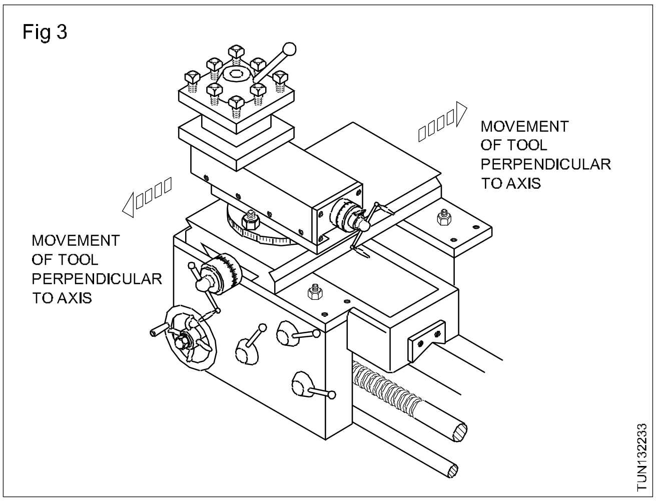
The carriage can be locked on the bed at any desired position by tightening the carriage lock-screw.

The tool is provided with the following three movements by the carriage.

Longitudinal feed - with the help of the carriage movement (parallel to the axis of work). (Fig 2)

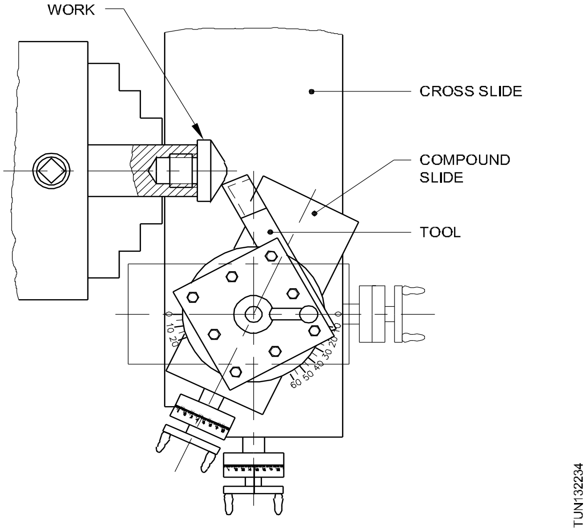
Cross-feed - with the help of the cross-slide movement (perpendicular to the axis of the work). (Fig 3)





Angular feed - with the help of the compound slide movement positioned at an angle to the axis of the work. (Fig 4)

Fig 4



The carriage consists of the following parts. (Fig 5)

Saddle

Cross-slide

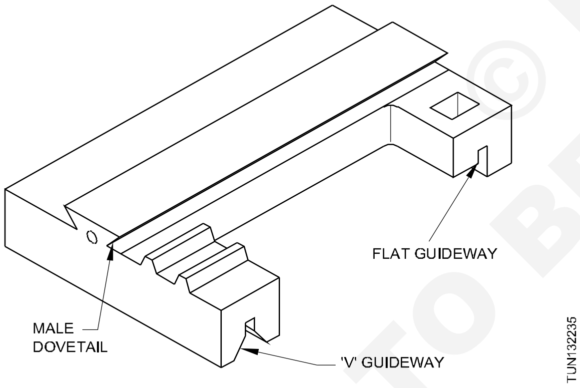
Compound rest swivel and top slide.

Tool post

Apron

The saddle (Fig 5)

Fig 5



It is 'H' shaped casting and has 'V' guide grooves and flat grooves machined at the bottom face corresponding to the lathe bed-ways for mounting the saddle on the lathe bed and for sliding over the bed by the operation of the hand wheel.

The cross-slide (Fig 6 & 7)

The bottom of the cross-slide has got a dovetail groove machined, which corresponds to the external dovetail machined on the saddle. The cross-slide is assembled to the saddle with the help of a tapered jib. The adjustment of the jib facilitates the required fit for the movement of the cross-slide on the saddle. The cross-slide functions perpendicular to the lathe axis either by hand feed or by automatic feed.

A left hand square or acme thread screw-rod fitted with a hand wheel helps in the manual movement of the cross-

Fig 6

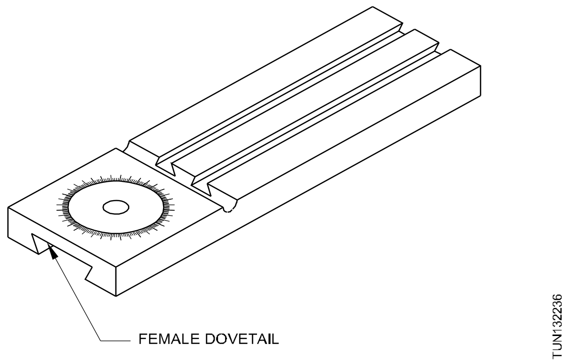
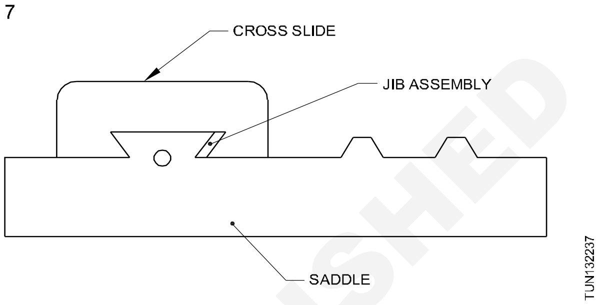


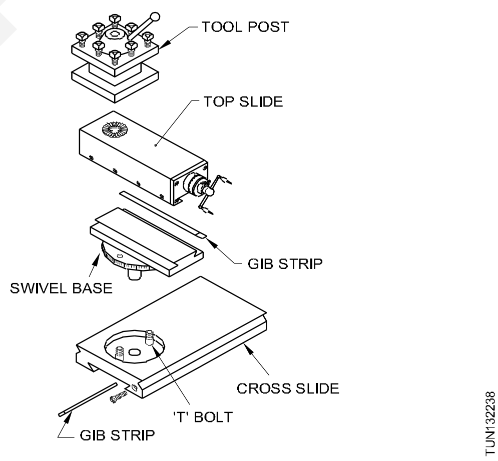
Fig 7



slide. The automatic feeding is achieved through gearing. A graduated collar mounted on the screw-rod along with the hand wheel helps to set the fine, movements of the cross slide.

The compound rest (Fig 8)

Fig 8



It is of two parts.

- The swivel base
- The top slide

The swivel base is assembled to the top of the cross-slide and may be clamped at any required position between 0° to 360° by tightening the T' bolts. The head of the bolts moves in the T slot groove on the top of the cross-slide. The swivel base is provided with a dovetail on its top surface and the top slide has *a* corresponding dovetail groove. The assembly of the top slide to the swivel base is done by a tapered jib which can be adjusted to control the top slide movement. The sliding of the top slide on the swivel base is accomplished by the help of a screw-rod fitted with a hand wheel and a graduated collar. Only manual operation is possible for the top slide. The top slide assists in feeding the tool to the work.

Tool posts - Types and tool setting

Objectives : At the end of this lesson you shall be able to
- **identify and name the different types of tool posts**
- **state the constructional features of each types of tool post**
- **indicate the application of each type or tool post.**

Tool post

The tool post holds the tool or tools meant for the operation to be performed on the work.

The tool post is assembled to the top slide.

The three types of tool posts most commonly found lathes are listed here.

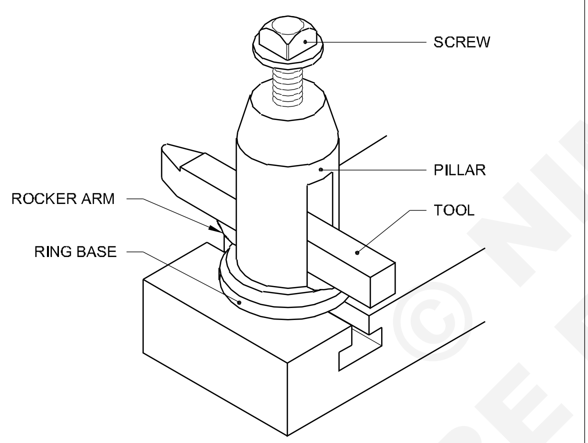
American type tool post or single way tool post

Indexing type of tool post or square tool post.

Quick change tool post.

Single way tool post (Fig 1)

Fig 1



AMERICAN PILLAR TYPE TOOL POST

It consists of a circular tool post body with a slot, for accommodating the tool or tool-holder. A ring base, a rocker arm, and a tool clamping screw complete the assembly of this type of tool post. The tool is positioned on the rocker arm and clamped. The centre height of the tool tip can be adjusted with the help of the rocker arm and the ring base. Only one tool can be fixed in this type of tool post. The rigidity of the tool is less as it is clamped with only one bolt.

Indexing type tool post (Fig 2)

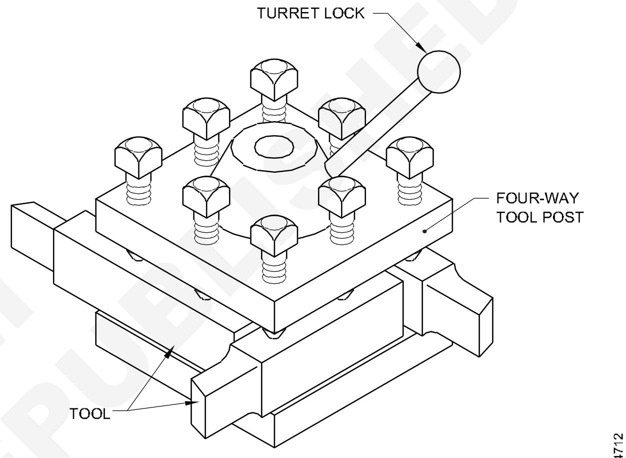
It is also called a square tool post or a four-way tool post. Four tools can be fixed in this type of tool posts and any one can be brought to the operating position and the square head is clamped with the help of the locking lever. By loosening the locking lever the next tool can be indexed and brought to the operating position. The indexing may be manual or automatic.

The advantages are each tool is secured in the tool post by more than one bolt and so rigidity is more.

frequent changing of the tool for different operations need not be done as four tools can be clamped simultaneously.

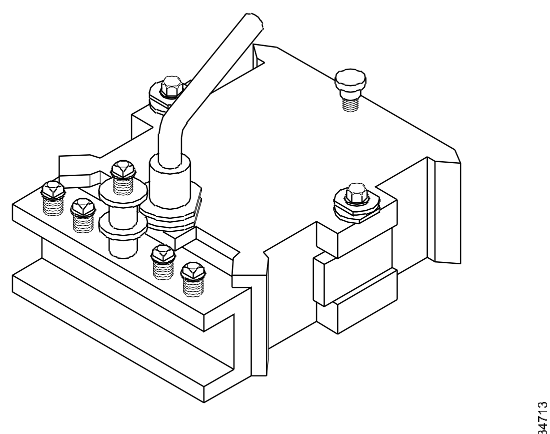
The disadvantage is that skill is required to set the tools and it takes more time to set to the centre height.

Fig 2



INDEXING TYPE TOOL POST

Fig 3



QUICK CHANGE TOOL POST

Quick change tool post/universal tool post (Fig 3)

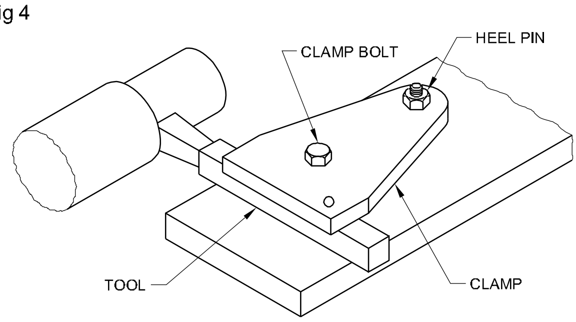
Modern lathes are provided with this type of tool posts. Instead of changing the tools, the tool holder is changed in which the tool is fixed. This is expensive and requires a number of tool holders. But it has the advantage of ease with which it can be set to the centre height and has the best rigidity for the tool.

British type tool post (Fig 4)

This type of tool post is found mostly on British lathes. This also has provision for only one tool to be clamped for performing the operation. This is more rigid when compared to the pillar-type tool post, as the tool is held in position by the flat clamp. This requires greater skill in clamping as the adjustment of the heel pin is needed to give a grip on the full width of the tool.

Packing strips may be needed to be placed for adjusting the tool centre height.

Fig 4



BRITISH (CLAMP) TYPE TOOL POST

Tool setting

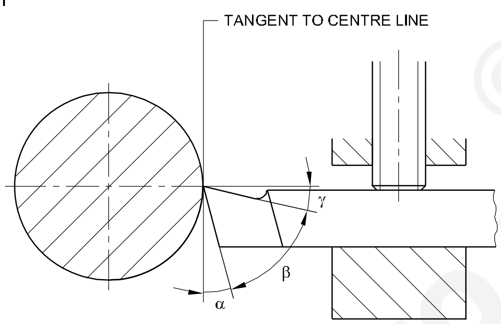
Objective : This shall help you to
- **set the tool in the tool post for performing the operation.**

For optimum cutting, the effective rake angle and clearance angle of the clamped tool must be equal to the ground angles of the tool. This requires clamping of the tool to have its axis perpendicular to the lathe axis, with the tool tip at the workpiece centre. (Fig 1)

It is difficult to determine the effective angles of the tool when it is not set to the centre height.

The tool nose can be set to the work centre by means of a tool-holder with adjustable height. (Fig 1)

Fig 1



The tool nose can be set to the exact centre height by placing the tool in the tool post on the shims or packing strips. These packing strips should be preferably a little less in width than the width of the tool but should never be more. The length of these strips should be according to the shank length and the tool seating face of the tool post. (Fig 2)

The procedure to follow is given below: Clean the tool post seating face, and place the shims on the seating face.

Use a minimum number of shims for height adjustment.

Shims must be flushed with the edge of the seating face.

Place the tool in the tool post on the shims, with the rear butting against the wall of the seating face. (Fig 3)

Fig 2

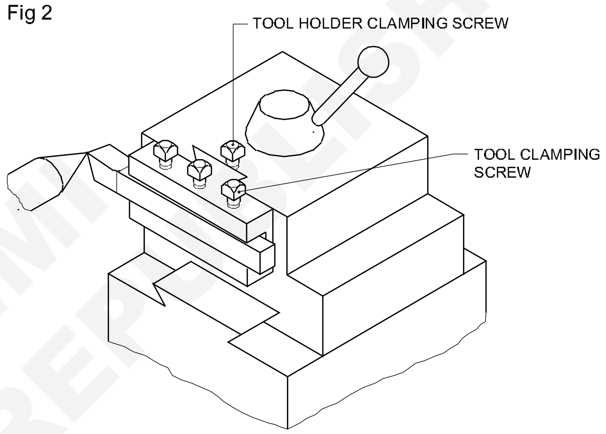
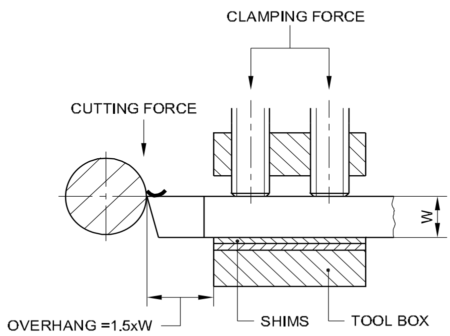


Fig 3



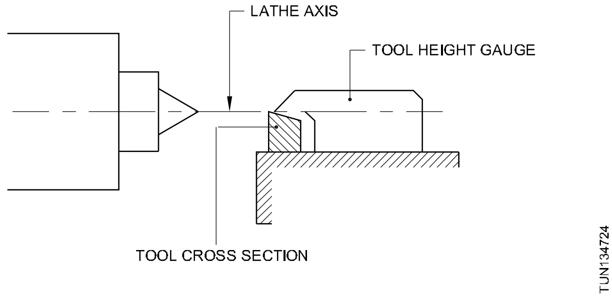
The unsupported length of the overhanging end of the turning tool should be kept to a minimum. As a rule, the overhanging length of tool is equal to the tool shank width x 1.5.

Tighten the tool with the centre screw of the tool post.

Check the centre height with a height setting gauge. (Fig 4)

Remove or add shims and check the height when the tool is tightened by the centre screw.

Fig 4



Tighten the other two tool-holding screws alternately applying the same amount of pressure.

When both the screws have a full gripping pressure, tighten the centre screw fully.

Check once again with a tool height setting gauge.

The gauge should be made according to the size of the machine. If a gauge is not available, use a surface gauge and set the pointer tip to the dead centre height fixed in the tailstock. Use this as the height to which the tool is to be set.

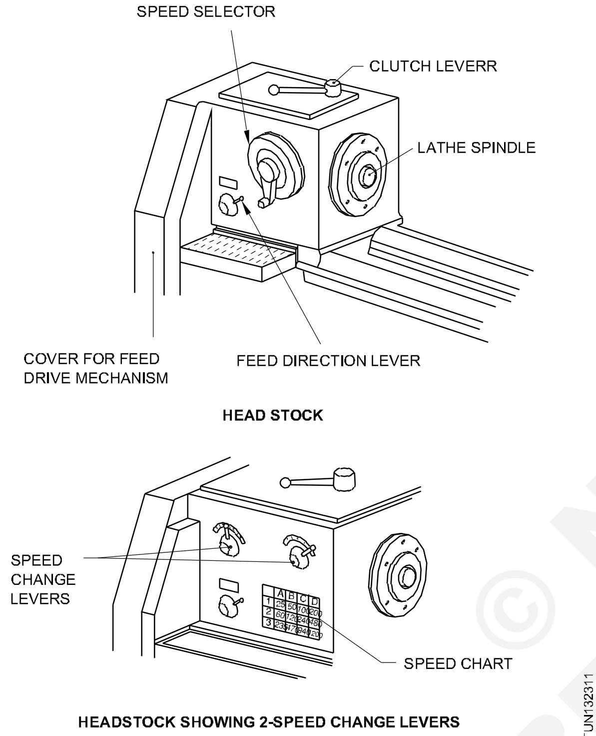
Type of Lathe drive - Merits and de-merits

Objectives: At the end of this lesson you shall be able to
- **state the functions of the headstock**
- **differentiate between cone pulley headstock and all geared headstock.**

Headstock

It is a fixed unit of lathe on the left hand side. (Fig 1)

Fig 1



HEAD STOCK

HEADSTOCK SHOWING 2-SPEED CHANGE LEVERS

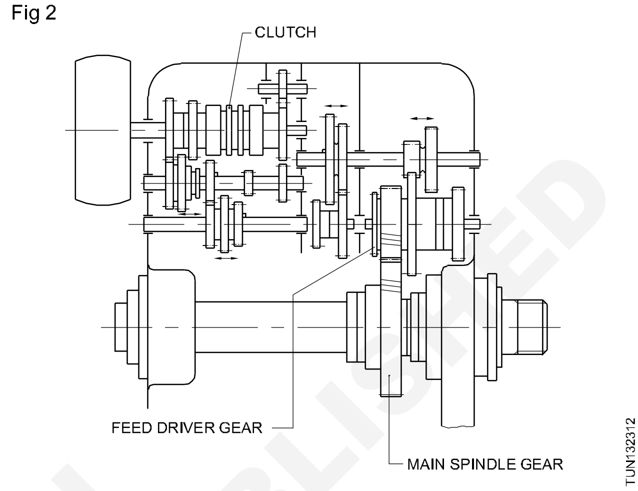
Its main functions are to :

- provide a means to assemble work-holding devices
- transmit the drive from the main motor to the work to make it revolve
- accommodate shafts with fixed and sliding gears for providing a wide range of work speeds
- have shift levers to slide gears to bring in mesh for different speeds
- have a means for lubricating the gears, shafts and bearings.

Constructional features of all-geared headstock (Fig 2)

It is a box-section alloy iron casting having a top cover which can be removed, if needed. It has internal webs for stiffening and taking shaft bearings. It has an input shaft which is connected by means of 'V' belts to the main motor, and runs at constant speed. It is equipped with clutches and a brake.

Fig 2

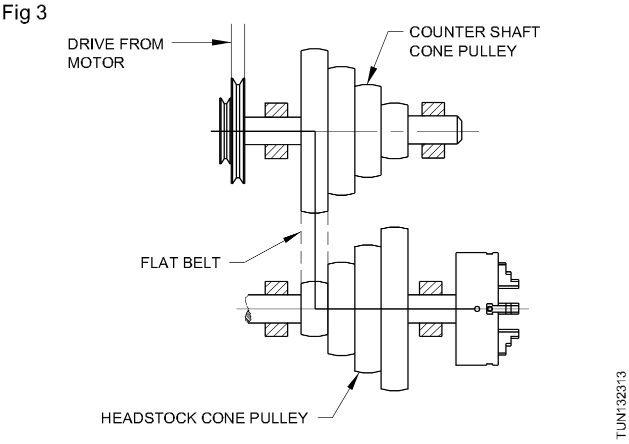


There may be two or more intermediate shafts on which sliding gears are mounted. The main spindle is the last driven shaft in the headstock assembly. The nose of the spindle is outside the headstock casting and is designed to accommodate the work-holding devices.

The levers operating the forks of the sliding gears are situated outside in the front of the headstock casting. A sight glass is provided on the top to indicate the functioning of the automatic lubricating system and side of sight glass is provided oil length of the machine.

Cone pulley headstock (Fig 3)

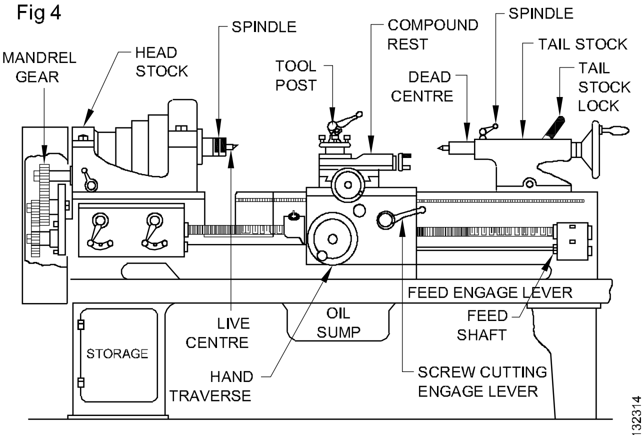
Fig 3



It has a stepped cone pulley mounted on the main spindle and is free to revolve. It is connected by means of a flat belt to a similar cone pulley, the steps arranged in a reversing order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bush bearings in the headstock casting and a gear wheel called 'bull gear' keyed to it. A pinion is coupled to the cone pulley. The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and the pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a lever. The back gear unit is engaged to have reduced spindle speeds. (Fig 4)

Fig 4



CONE PULLEY HEAD STOCK LATHE

A three-stepped cone pulley headstock provides three direct ranges of speeds through the belt connection, and with the back gear in engagement, three further ranges of reduced speeds.

Advantages

Easy for maintenance.

Can take up heavy load.

Less noise during functioning.

During overloads, the belt slips off, and hence, no major damage to the lathe is caused.

Positive drive when the back gear is in engagement.

Disadvantages

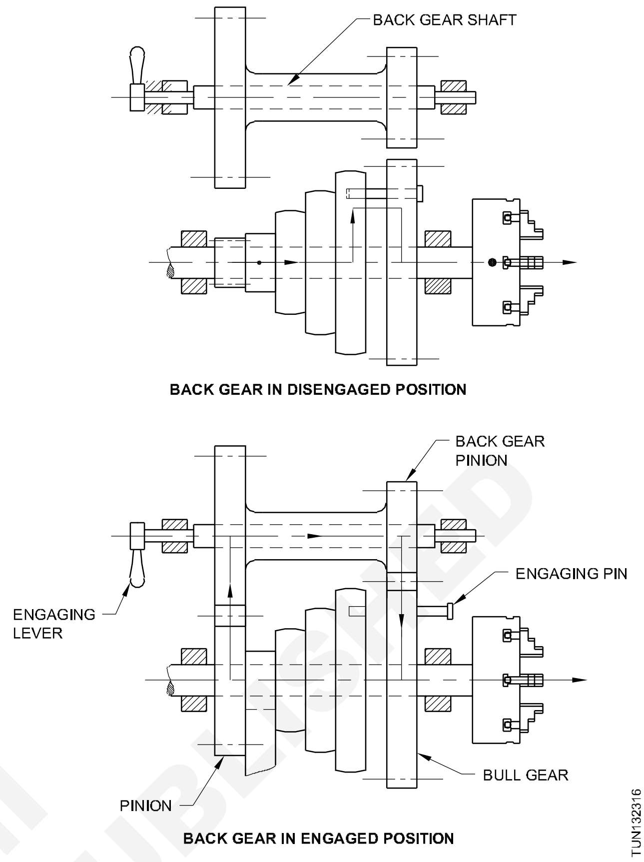
Number of spindle speeds limited to the number of steps in the cone pulley.

Takes time to change spindle speeds.

Needs adjustments of bush bearings.

Back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the pull gear and the pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a ever. The back gear unit is engaged to have reduced spindle speeds. (Fig 5)

Fig 5



If three stepped cone pulley headstock provides three direct ranges of speeds through the belt connection and with the back gear in engagement, three further ranges of reduced speeds.

Advantages

Easy for maintenance.

Can take up heavy load.

Less noise during functioning.

During overloads, the belt slips off, and hence, no major damage to the lathe is caused.

Positive drive when the back gear is in engagement.

Disadvantages

Number of spindle speeds limited to the number of steps in the cone pulley.

Takes time to change spindle speeds.

Needs adjustments of bush bearings.

Difference between individual drive vs group drive. (Fig 6)

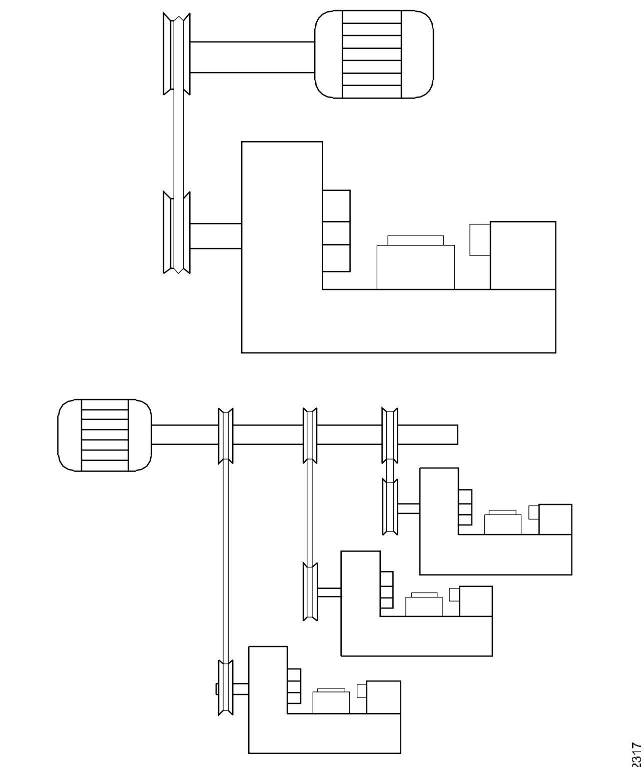


Fig 6

INDIVIDUAL DRIVE VS GROUP DRIVE

Difference between individual drive vs group drive

	Individual drive	**Group drive**
Initial cost	Low	High
Speed	More variation possible	Wider variation possible
Running cost	One	More than one
One time of breakdown	Only one machine get affected	All machine connected to group drive get affected
More likely used	For job production	For mass production
Efficiency	High	Less
Power required	Less	More

Back gear and its use

Objectives: At the end of this lesson you shall be able to
- **state the construction details of back gear assembly**
- **state the function and purpose of back gear.**

Back gear

As its name implies “back gear” is a gear mounted at the back of the head stock. It is used to reduce the speed.

Necessity of back gear

For machining a heavy job, taking a rough cut we need more power at a reduced speed of the spindle. The back gear arrangement provides this low speed with higher power.

The spindle is mounted on the bush bearings in the headstock casting and a gear wheel called 'bull gear' keyed to it. A pinion is coupled to the cone pulley. The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and the pinion on the cone pulley. The axis of the back gear eccentric shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a lever. The back gear unit is engaged to have reduced spindle speeds. (Fig 1 & 2)

A three-stepped cone pulley headstock provides three direct ranges of speeds through the belt connection, and with the back gear in engagement, three further ranges of reduced speeds.

Uses of Back gear

- It enables to rotate the chuck at very low speed.
- It provides increased turning power.
- It is highly suitable for turning large diameter castings.
- It reduces the rpm but increases the torque.
- Even the largest face-plate mounted job can be turned successfully.

Fig 1

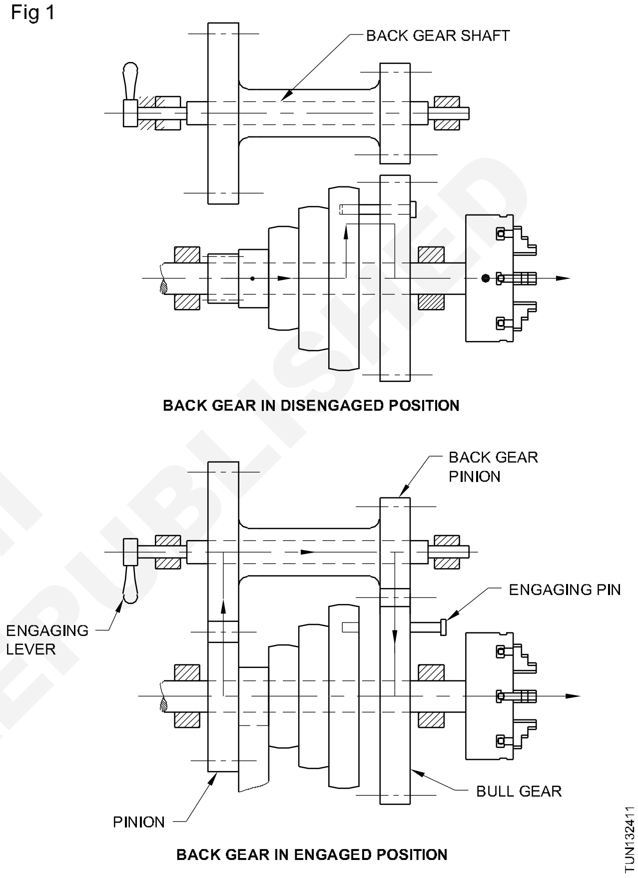
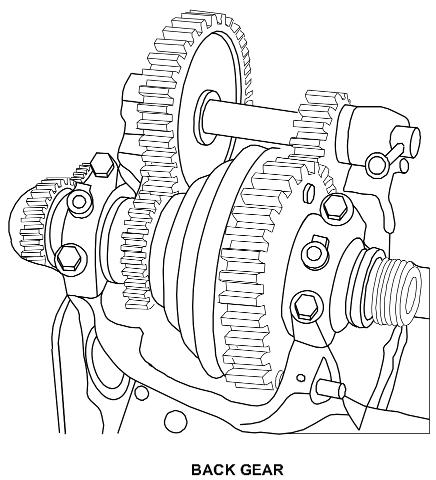


Fig 2



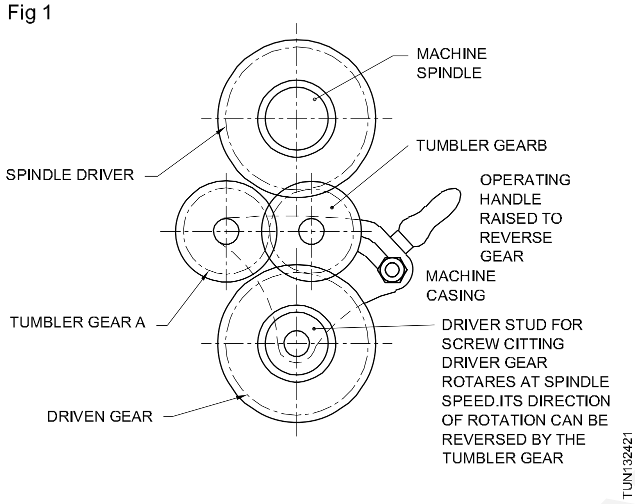
Tumbler gear

Objectives: At the end of this lesson you shall be able to
- **state the purpose of the tumbler gear mechanism**
- **state the construction details of the tumbler gear mechanism.**

Tumbler gear mechanism (Fig 1)

The tumbler gear mechanism is used for changing the direction of rotation of the lead screw and feed shaft. It is normally situated between the spindle drive and the feed gear box. It consists of 3 gears arranged in a simple gear train, mounted on a bracket. The bracket can be shifted into 3 positions.

Fig 1



- For forward rotation of the lead screw and feed shaft.
- For neutral position (no rotation of lead screw and feed shaft).
- For the reverse rotation of the lead screw and feed shaft.

In practice, the first driver gear of a screw cutting train is not fitted directly to the lathe spindle but is mounted on a driver stud which rotates at the same speed as the spindle.

The driving gear on the spindle drives the fixed stud gear, and, since they have the same speed, they must be of the same size. Tumbler gear A is always in mesh with the driven gear and in mesh with the fellow tumbler gear B. In the figure, the drive is direct through the tumbler gear A, and tumbler gear B is idle.

If the tumbler bracket is moved upwards, tumbler gear A rolls around the driven gear until it is out of mesh with the driver gear, and tumbler gear B moves into mesh with the driver, reversing the direction of the driven gear. Thus the two trains available are:

Forward: Driver —>A—>Driven

Reverse: Driver —>B—>A—>Driven.

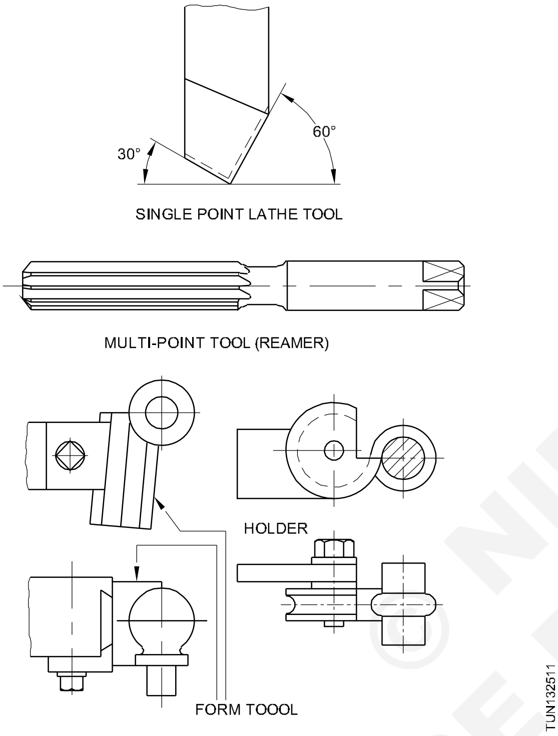
In yet another position of the tumbler bracket, tumbler gears A or B do not mesh with the driver gear and no drive is transmitted to the driven gear. No feed movement or thread cutting is possible.

Lathe cutting tools

Objectives : At the end of this lesson you shall be able to
- **classify lathe cutting tools**
- **list the types of lathe cutting tools**
- **state the features of each type.**

Cutting tool classification (Fig 1)

Fig 1



Cutting tools are classified as:

- single point cutting tools
- multi-point cutting tools
- form tools.

Single point cutting tools

Single point cutting tools have one' cutting edge which performs the cutting action. Most of the lathe cutting tools are single point cutting tools.

Single point cutting tools used on lathes may be grouped into:

- side cutting tools
- end cutting tools.(Fig 2)

Side cutting tools

Side cutting edge tools have their cutting edges formed on the side of the cutting tool, and are used on lathes for most of the operations. They are again classified as right hand tools and left hand tools. (Fig 3) A right hand tool operates from the tailstock end towards headstock and a left hand tool operates from the headstock end towards the tailstock. The cutting edge is formed accordingly.

Fig 2

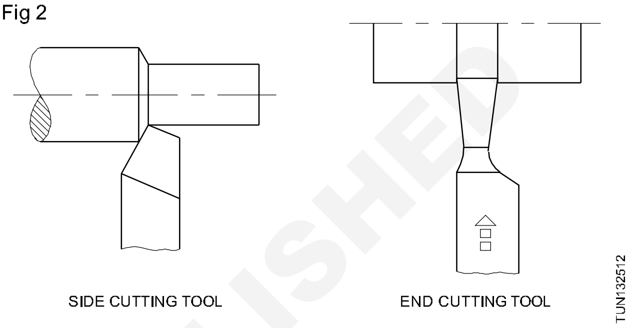
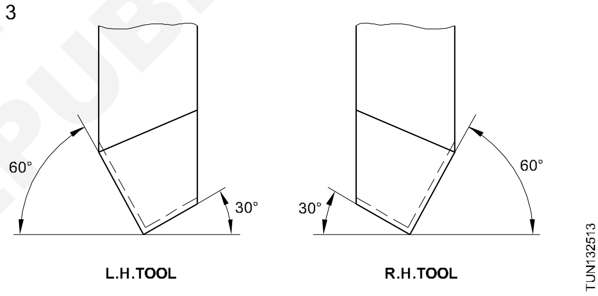


Fig 3



End cutting tools

End cutting tools have their cutting edge at the front end of the tools and are used on lathes for plunge cut operations.

Multi-point cutting tools

These tools have more than one cutting edge, and they remove metal from the work simultaneously by the action of all the cutting edges. The application of the multi-point cutting tools on the lathe is mostly done by holding the tool in the tailstock and feeding it to the work.

Form tools (Fig 4)

These tools reproduce on the work the form and shape of the cutting edge to which they are ground. The form tools perform the operations on the work by a plunging action, and are fixed on the tool post square to the axis of the work and fed by a cross-slide. They may have their cutting edges formed on square or rectangular section tool blanks acting radially. The form tools may be circular form tools and tangential form tools. They may require special holders to which they can be fixed, and the holders are clamped on the tool posts for operation.

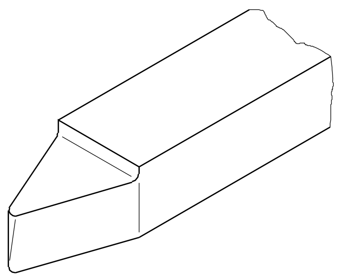
Lathe cutting tool types

The tools used on lathes are classified as :

- solid type tools
- brazed type tools
- inserted bits with holders
- throw-away type tools.

solid bits of square, rectangular and round cross sections. Most of the lathe cutting tools are of solid type, and high carbon steel and high speed steel tools are used. The length and cross-section of the tool depend upon the capacity of the machine, the type of tool post and the nature of the operation.

Fig 4



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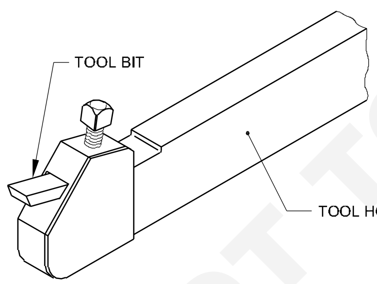
Inserted bits with holders (Fig 5)

Solid high speed steel tools are costly, hence they are sometimes used as inserted bits. These bits are small in sizes and inserted in the holes shaped according to the cross-section of the bit to be inserted. These holders are held and clamped in the tool posts to carry out the operations.

The disadvantage in these types of tools is that the rigidity of the tool is poor in the slot.

Fig 5



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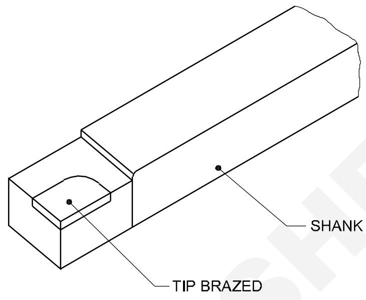
Brazed tools (Fig 6)

These tools are made of two different metals. The cutting portions of these tools are good cutting tool materials, and the body of the tools does not possess any cutting ability and is tough. Tungsten carbide tools are mostly of the brazed type. Tungsten carbide bits of square, rectangular and triangular shape with proportionately less thickness are brazed to the tips of the shank metal.

The tips of the shank metal pieces have machined top surface according to the shape of the bit to accommodate the carbide bits. These tools are economical and give better rigidity to the tools than the inserted bits clamped in the tool-holders. This is applicable to high speed steel brazed tools also.

Fig 6



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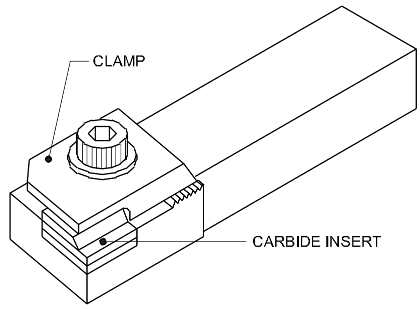
Throw-away type tools (Fig 7)

Carbide-brazed tools, when blunt or broken, need grinding which is time absorbing and expensive. Hence they are used as throw-away inserts in mass production. Special tool-holders are needed, and the carbide bits of rectangular, square or triangular shapes are clamped in the seating faces machined in these types of special holders.

The seating faces are machined such that the rake and clearances needed for the cutting bits are automatically achieved when the bits are clamped. As these tools are to be operated at very high cutting speeds, the capacity of the machine must also be high and the rigidity of the machine must be good as well.

Fig 7



HOLDER FOR THROW-AWAY CARBIDE INSERTS

TUN132517

Types and specifications of carbide tools

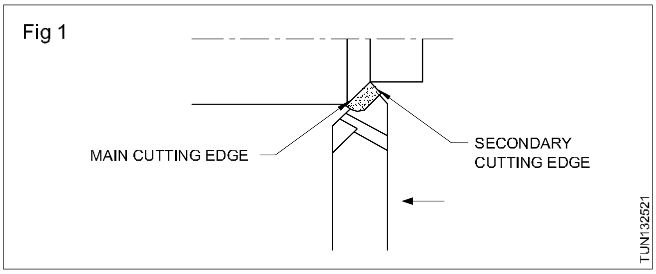
Objectives : At the end of this lesson you shall be able to
- **identify the different types of carbide tools**
- **state the specifications of carbide tools.**

Cemented carbide tools are available as brazed tipped tools and throw away tips held in specially designed tool holders.

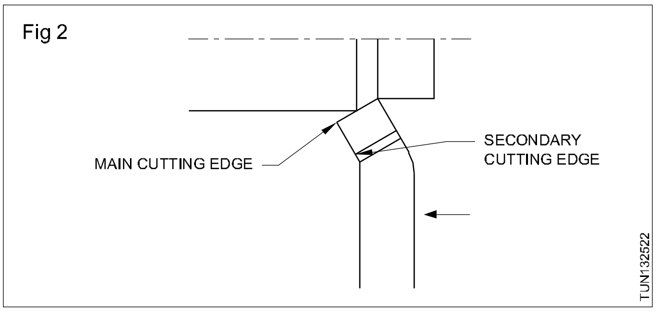
Standard shapes of carbide-tipped turning and facing tools are shown in the Figs. Carbide tipped cut off and boring tools are also available. these tools are resharpened as needed using special silicon carbide and diamond wheels.

Standard terms for carbide tools as specified in ISO

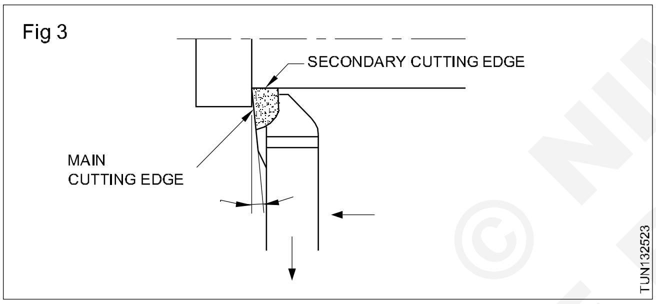
ISO 1 straight turning tool (Fig 1)



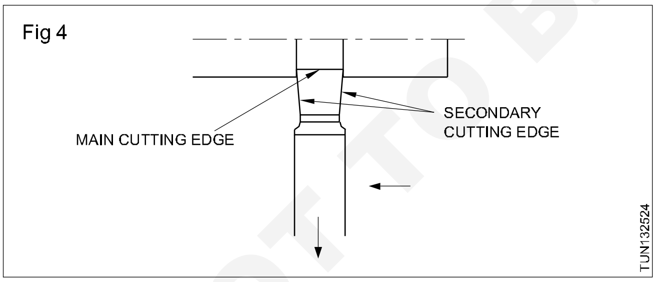
ISO 2 Cranked turning tool (Fig 2)



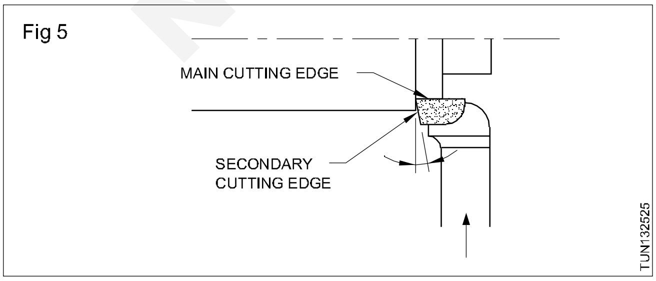
ISO 3 Offset facing tool (Fig 3)



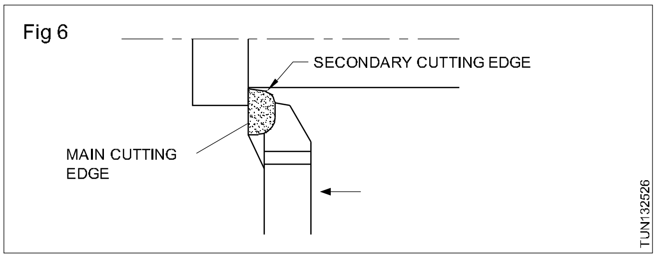
ISO 4 Wide nose square turning tool (Fig 4)



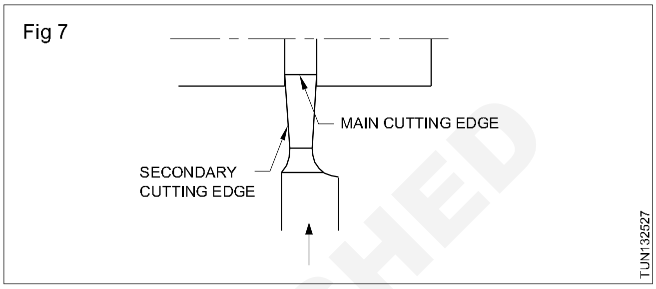
ISO 5 Offset turning and facing tool (Fig 5)



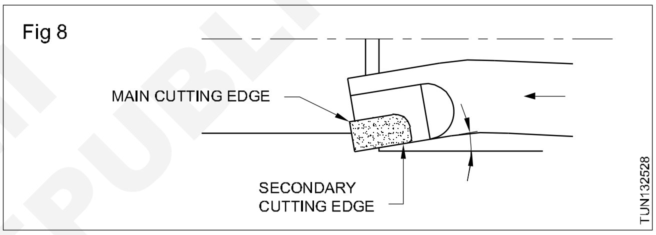
ISO 6 Offset side cutting tool (Offset knife tool) (Fig 6)



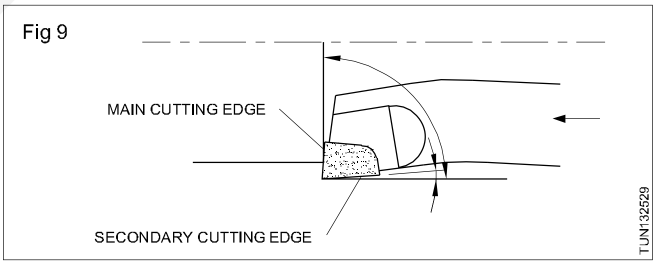
ISO 7 Recessing tool (parting tool) (Fig 7)



ISO 8 Boring tool (Fig 8)



ISO 9 Corner boring tool (finishing) (Fig 9)



The carbide tools are specified according to

1 the operations (rough and finish)

2 right hand or left hand

3 material being turned and machining conditions. Refer to Fig 1 to 9.

Kinds of lathe cutting tools

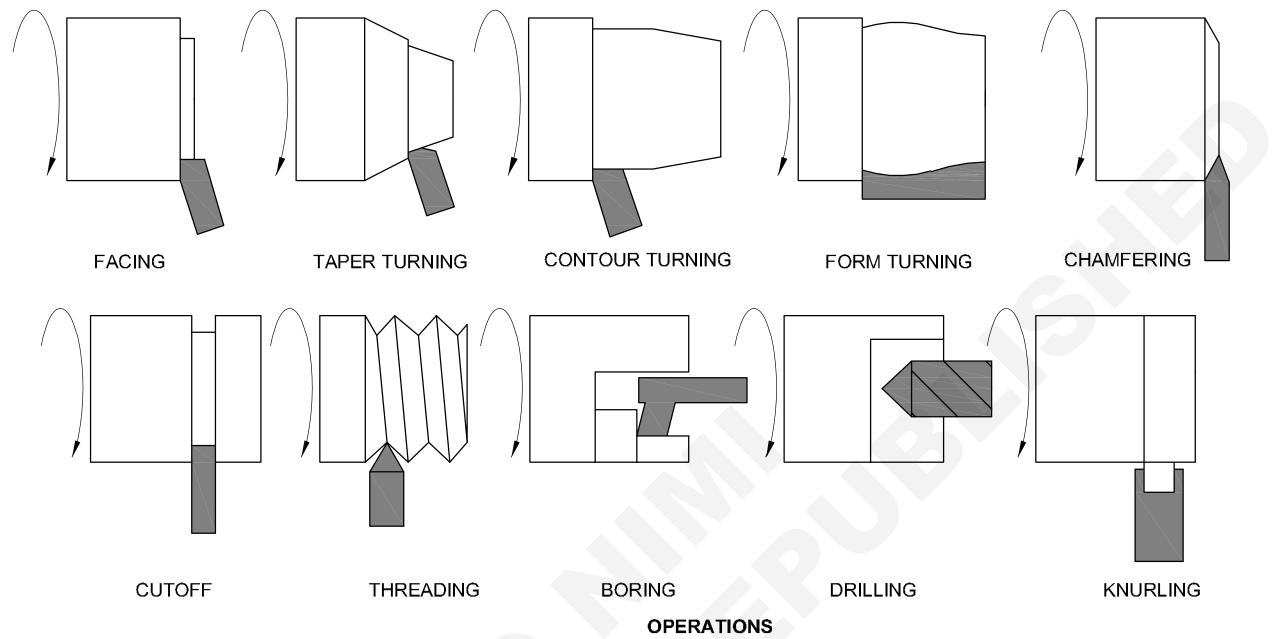
The different types of lathe cutting tools are distinguished by the shape of the cutting edge and the operations which they have to perform. Some of the lathe cutting tools are listed here.

- Facing tool
- Knife edge tool

- Roughing tool
- Round nose finishing tool
- Broad nose finishing tool
- Chamfering tool
- Undercutting tool
- External threading tool
- Parting off tool
- Boring tool
- Internal recessing tool
- Internal threading tool

The tools and their application are illustrated in the Fig 10.

Fig 10



Angle of lathe cutting tools

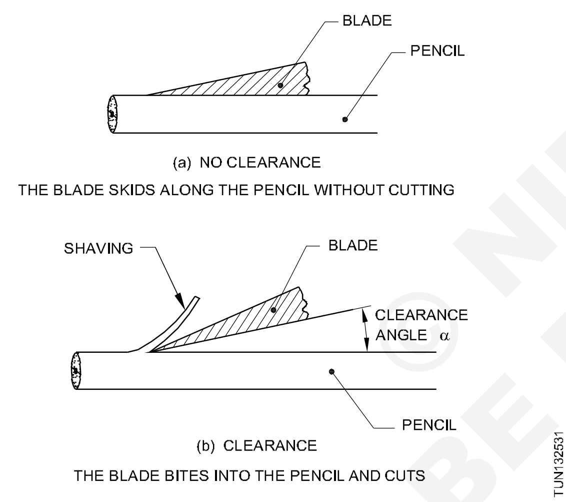
Objectives : At the end of this lesson you shall be able to
- **state the necessity of providing angles and clearances on cutting tools**
- **name the angles of a lathe cutting tool**
- **state the characteristics of a rake angle**
- **state the characteristics of a clearance angle**
- **refer to a chart to determine the recommended rake and clearance angles for turning different metals.**

Need to provide angles and clearances

The cutting action of a lathe tool during turning is the wedging action. The wedge-shaped cutting edge has to penetrate into the work and remove the metal. This necessitates the grinding of the solid tool bit to have the wedge formation for the cutting edge.

When we sharpen a pencil with a pen knife by trial and error, we find that the knife must penetrate into the wood at a definite angle, if success is to be achieved. (Fig 1)

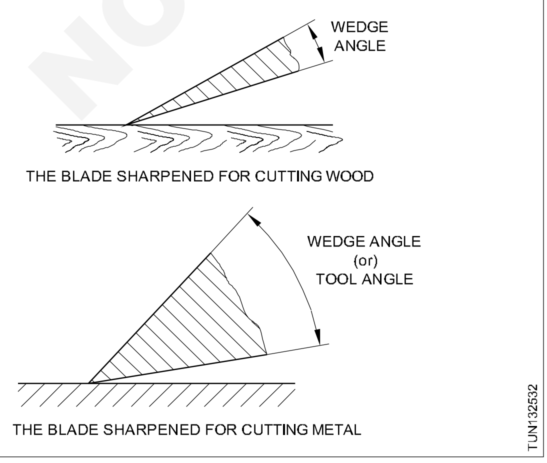
Fig 1



If, in the place of a wooden pencil, a piece of soft metal, such as brass is cut, it will be found that the cutting edge of the blade soon becomes blunt, and the cutting edge has crumbled. For the blade to cut brass successfully,

the cutting edge must be ground to a less acute angle to give greater strength as can be seen in Fig 2.

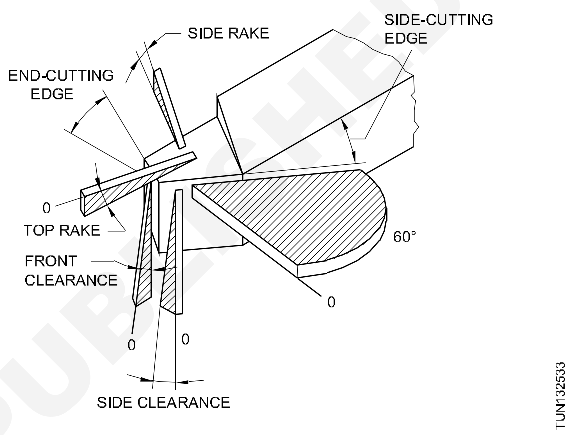
Fig 2



The angle shown in Fig 1 is known as a clearance angle and that shown in Fig 2 is a wedge angle.

Angles ground on a lathe cutting tool (Fig 3)

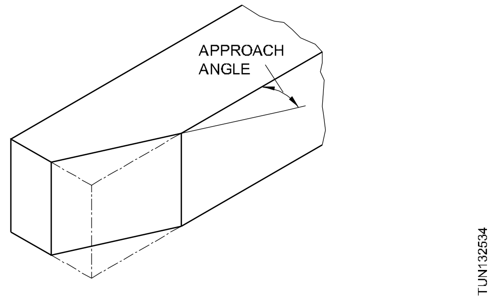
Fig 3



Side cutting edge angle

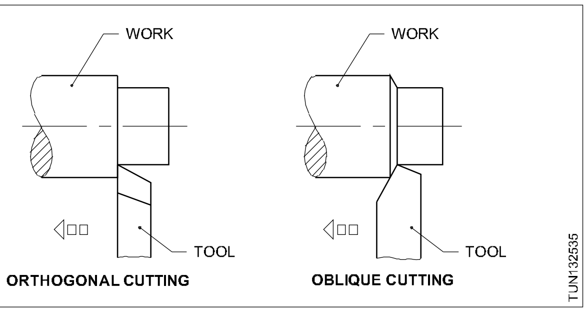
(Approach angle) (Fig 4)

Fig 4



This is ground on the side of the cutting tool. The cutting will be oblique. The angle ground may range from 25°to 40° but as a standard a 30° angle is normally provided. The oblique cutting has certain advantages over an orthogonal cutting, in which the cutting edge is straight. More depth of cut is given in the case of oblique cutting since when the tool is fed to the work, the contact surface of the tool gradually increases as the tool advances, whereas, in the case of orthogonal cutting, the length of the cutting edge for the given depth fully contacts the work from the beginning itself, which gives a sudden maximum load on the tool face. The area, over which heat is distributed, is more in oblique cutting. (Fig 5)

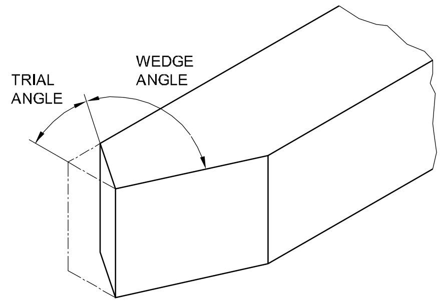
Fig 5



End-cutting edge angle (Trial angle) (Fig 6)

The end-cutting edge angle is ground at 30° to a line perpendicular to the axis of the tool, as illustrated in Fig 3. The side-cutting edge angle and the end-cutting edge angle, when ground, form a nose (wedge) angle of 90° for the tool.

Fig 6



Top or back rake angle (Fig 7)

The rake angle ground on a tool controls the geometry of chip formation for any given material. It controls the mechanics of the cutting action of the tool. The top or back rake angle of the tool is ground on the top of the tool, and it is a slope formed between the front of the cutting edge and the top face.

Resistive top rake angle (Fig 7A)

If the slope is from the front towards the back of the tool, it is known as a positive top rake angle. When turning soft materials which form curly chips and good surface finish. Cutting tool life is very short.

Negative top rake angle (Fig 7B)

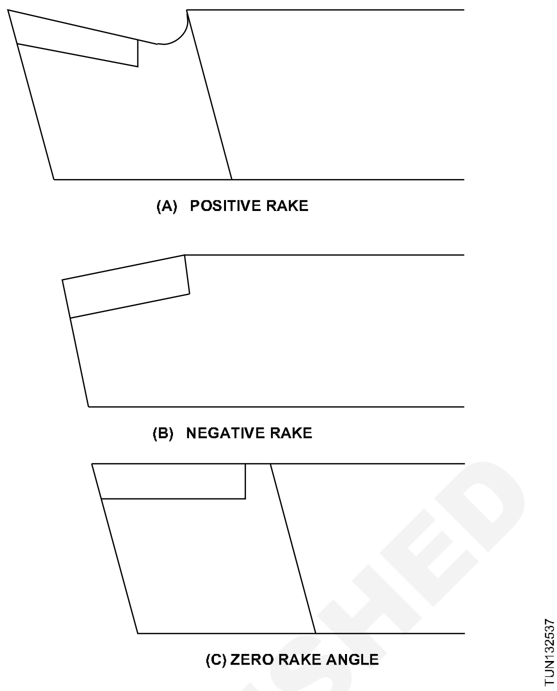
If the slope is from the back of the tool towards the front of the cutting edge, it is known as the negative top rake angle. When turning the hard brittle metals with carbide tools it is usual practice to give a negative top rake.

Negative top rake tools have more strong than positive top rake angle tools. Tool life is too long. Chip should be broken and rough surface finish.

Zero top rake angle (Fig 7C)

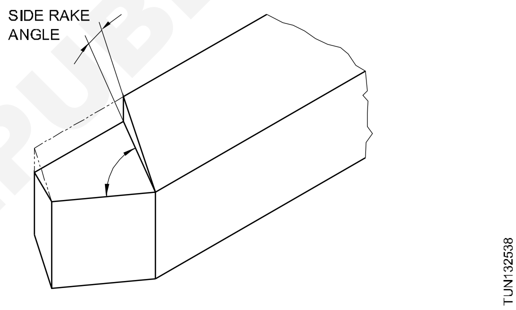
If the cutting edge is straight line is called zero top rake angle when turning soft, ductile materials i.e. aluminium, brass, copper.

Fig 7



Side rake angle (Fig 8)

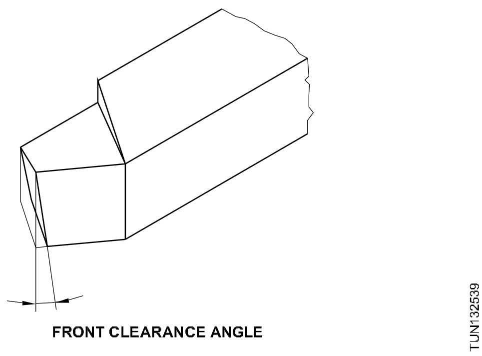
Fig 8



The side rake angle is the slope between the side of the cutting edge to the top face of the tool widthwise. The slope is from the cutting edge to the rear side of the tool. It varies from 0° to 20° according to the material to be machined. The top and side rakes, ground on a tool, control the chip flow and this results in a true rake angle which is the direction in which the chip that shears from the work passes.

Front clearance angle (Fig 9)

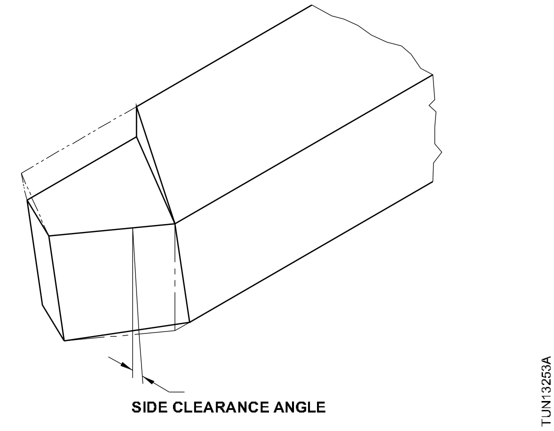
Fig 9



This angle is the slope between the front of the cutting edge to a line perpendicular to the axis of the tool drawn downwards. The slope is from the top to the bottom of the tool, and permits only the cutting edge to contact the work, and avoids any rubbing action. If the clearance ground is more, it will weaken the cutting edge.

Side clearance angle (Fig 10)

Fig 10

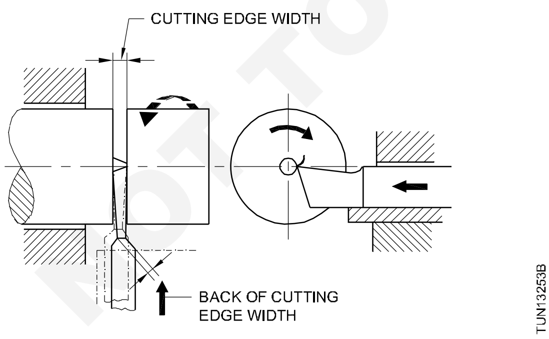


The side clearance angle is the slope formed between the side cutting edge of the tool with a line perpendicular to the tool axis drawn downwards at the side cutting edge of the tool. The slope is from the top of the side cutting edge to the bottom face. This is also ground to prevent the tool from rubbing with the work, and allows only the cutting edge to contact the work during turning. The side clearance angle needs to be increased when the feed rate is increased.

When grinding the rake and clearance angles, it is better to refer to the standard chart provided with the recommended values, and then grind. However, actual operation will indicate the performance of the tool and if any modification is needed for the angles ground on the tool.

Side relief angle (Fig 11)

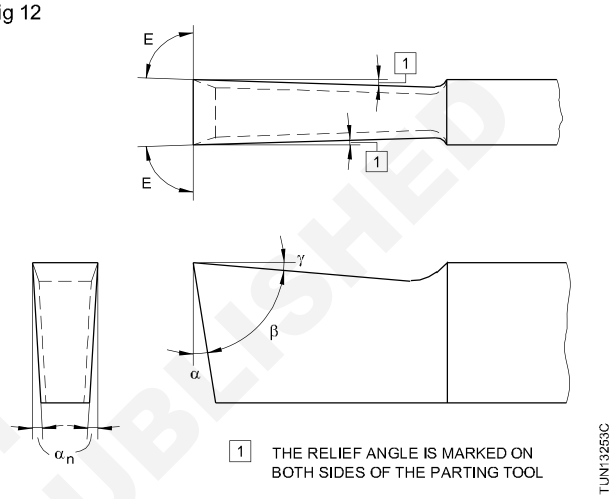
Fig 11



This angle is ground on the parting and the undercutting tools on both sides. This will provide the width of the cutting edge slightly broader than the back of the cutting edge.

This permits clearance between the sides of the tool and the groove walls formed by the plunging action of the tool, thereby, preventing the tool from getting jammed in the groove and causing breakage. The relief is kept as minimum as possible. Too much of relief will weaken the tool cutting edge, and also permit the chips to clog in the gap, causing the tool in both cases to break. Side relief is also provided sometimes to the main cutting edge of the facing tools, permitting only the cutting point performing the operation, when the tool axis is set perpendicular to the lathe axis. The side relief angle normally does not exceed 2°. (Fig 12)

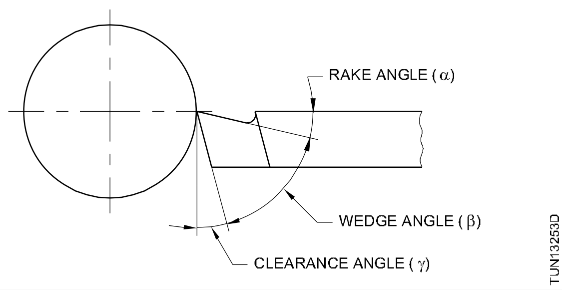
Fig 12



Relationship between rake, clearance and wedge angles (Fig 13)

The rake angle (∝), clearance angle (γ) and the wedge angle (β) have close relationship for efficiency in cutting. Excessive rake angle reduces the wedge angle, which helps in good penetration and it is particularly useful for cutting soft metals. A decreased wedge angle weakens the tool strength. Therefore, for cutting hard metals, the rake angle is zero or negative. The clearance angle is generally fixed depending on the geometry of the surface being cut.

Fig 13



Properties of good cutting tool materials

Objectives: At the end of this lesson you shall be able to
- **state the qualities of good cutting tool material**
- **distinguish between the characteristics of cold hardness, red hardness and toughness**
- **state the factors to be noted when selecting a tool material.**

Tool materials

Metal cutting tool materials perform the function of cutting. These materials must be stronger and harder than the material to be cut. They must be sufficiently tough to resist shock loads that result during cutting operations. They must have good resistance to abrasion and a reasonable tool life.

The three most important basic qualities that any cutting tool material should possess are:

- cold hardness
- red hardness
- toughness.

Cold hardness

It is the amount of hardness possessed by a material at normal temperature. Hardness is the property possessed by a materially which it can cut other metals, and has the ability to scratch on other metals.

When hardness increases, brittleness also increases, and a material which is having too much of cold hardness is not suitable for the manufacture of cutting tools.

Red hardness

It is the ability of a tool material to retain most of its cold hardness even at very high temperature. During machining due to friction between tool and work, tool and chip, heat is generated, and the tool loses its hardness, and its efficiency to cut diminishes. If a tool maintains its cutting efficiency even when the temperature during cutting increases, then that metal possesses the property of red hardness.

Toughness

The property possessed by a material to resist sudden load that results during metal cutting is termed as toughness. This will avoid the breakage of the cutting edge.

Points to be noted when selecting a tool material

- Condition and form of material to be machined.
- Material to be machined.
- Condition of the machine tool available.
- The total quantity of production and the rate of production involved.
- The dimensional accuracy required and the quality of surface finish.
- The amount of coolant applied and the method of application.
- The skill of the operator.

Different tool materials

Objectives : At the end of this lesson you shall be able to
- **classify the tool materials**
- **list the tool materials under each group**
- **state the merits and demerits of each tool material.**

Classification of tool material

The tool materials may be classified into three categories, namely:

- ferrous tool materials
- non-ferrous tool materials
- non-metallic tool materials.

Ferrous tool materials

Ferrous tool materials have iron as their chief constituent.

High carbon steel (tool steel) and high speed steel belong to this group.

Non-ferrous tool materials

Non-ferrous tool materials do not have iron, and they are casted by alloying elements like tungsten, vanadium, molybdenum etc. Stellate belongs to this group.

Carbides which are also of non ferrous tool material are manufactured by powder metallurgy technique. Carbon and tungsten are the chief alloying elements in this process.

Non - Metallic tool materials

Non-metallic tool materials are made out of non-metals. Ceramics and diamonds belong to this category.

Merits and demerits of each cutting tool materials

High carbon steel is the first tool material introduced for manufacturing cutting tools. It has poor red hardness property, and it loses its cutting efficiency very quickly. By adding alloying elements like tungsten, chromium and vanadium to high carbon steel, high speed steel tool material is produced. Its red hardness property is more than high carbon steel. It is used as solid tools, brazed tools and as inserted bits. It is costlier than high carbon steel.

Carbide cutting tools can retain their hardness at very high temperatures, and their cutting efficiency is higher than that of high speed steel. Due to its brittleness and cost, carbide cannot be used as a solid tool. It is used as brazed tool bit and throw-away tool bit.

Combination drill

Objectives : At the end of this lesson you shall be able to
- **state what is centre drilling**
- **state the purpose of centre drilling**
- **state the defects in centre drilling**
- **indicate the causes for the defects**
- **state the remedies to avoid the defects.**

Centre drilling (Fig 1)

It is an operation of drilling and countersinking a hole on the face of the work, and on the axis of the work. It is done by a cutting tool known as centre or combination drill held in a drill chuck. The drill chuck is mounted in a tailstock spindle and the feeding on the drill to work is done by rotating the tailstock hand wheel. The spindle speed for the work rotation is calculated, taking into consideration the plain drilling diameter and the recommended cutting speed for the drilling. (Fig 2)

Fig 1

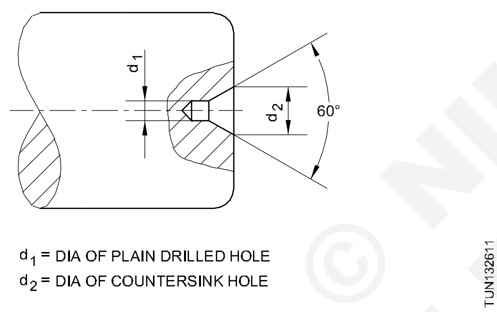
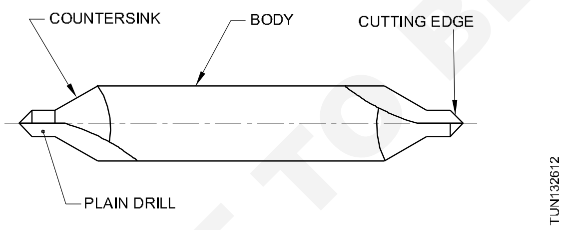


Fig 2

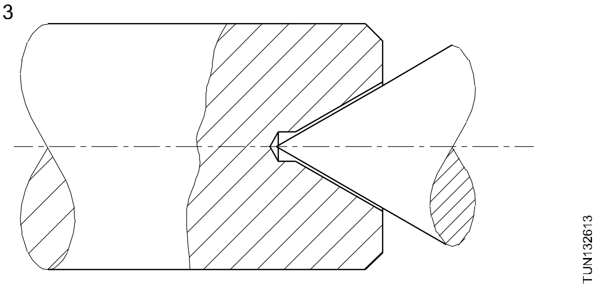


Defects in centre drilled holes

The two major defects in centre drilling are:

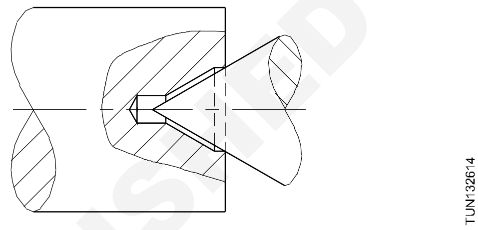
- insufficient depth of plain drilled portion (Fig 3)

Fig 3



- centre drilling-done too deep. (Fig 4)

Fig 4



The first defect results in making the tip of the centre to contact the work surface, and the conical portion of the centre does not have any contact with the bearing surface of the centre drilled hole. Undue friction and overheating will be noticed which will damage the tip of the centre. Sometimes breakage is also possible and the broken part of the centre may get welded to the centre hole. By feeding the centre drill up to 3/4th of the 60° countersink, this defect is avoided.

when the centre arm feeding is too much, a plain drilled portion by the body of the centre drill will be formed at the nose of the bearing surface of the centre hole, and the area of contact between the bearing surface and the work-supporting centre will be the only point of contact, as illustrated in Fig 4. This will not provide proper support to the work and any operation if carried out, may result in dimensional inaccuracy, chatter and poor surface finish.

To rectify this defect, face the work, if the length of the work permits, and feed the centre drill to the recommended length.

Centre drills

It is made of high speed steel and is cylindrical in shape. At both the ends, it has a plain drill and countersink *as* its integral part. It is hardened and ground. It is available in standard sizes.

Classification as per Indian Standard

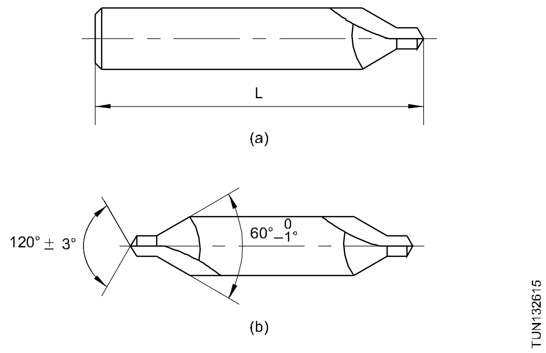
Indian Standard classifies centre drills into three types. They are Type A, Type B and Type R.

The difference lies in the formation of the countersink by each type.

Uses and specifications

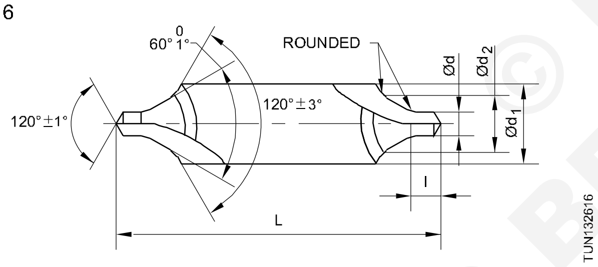
Type 'A' centre drill is used to produce centre holes with plain drilled portion and countersink. It is designated as Centre Drill A. 1.6 x 4.0 IS : 6708 which means that the centre drill is of Type 'A' with the plain drill portion having a diameter .of 1.6 mm and a shank diameter 4 mm. (Fig 5a and b)

Fig 5



Type 'B' centre drill is used to produce a centre hole with a plain drilled portion and a countersink, and has a further conical portion to form additional countersinking to protect the centre hole. The countersinking for providing the bearing surface for centres has an angle of 60° and the countersinking surface has an angle of 120°. This type is designated as Centre Drill B1.6 x6.3 IS: 6709 which means that the pilot diameter is 1.6 mm and shank diameter is 6.3 mm (Fig 6)

Fig 6



The third type, 'R' is designated as Centre Drill R 1.6 x 4.0 IS : 6710. This also has provision to provide a protected centre hole. This has an enlarged radius, machined along with the countersinking portion. (IS : 6710) (Fig 7)

Fig 7

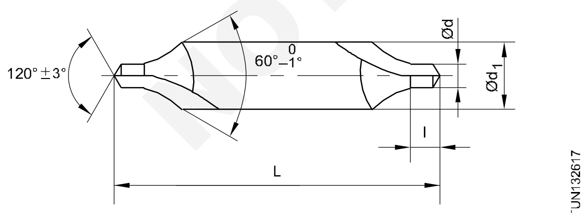


CHART OF COMBINATION DRILL

TABLE 1

d	d_1
K_{12}	h_g
(0.5)	3.15
(0.63)	3.15
(0.8)	3.15
1.0	3.15
(1.25)	3.15
1.6	4.0
2.0	5.0
2.5	6.3
3.15	8.0
4.0	10.0
(5.0)	12.5
6.3	16.0
(8.0)	20.0
10.0	25.0

TABLE 2

d	d_1	d_2
K_{12}	h_g	K_{12}
1.0	4.0	2.12
(1.25)	5.0	2.65
1.6	6.3	3.35
2.0	8.0	4.25
2.5	10.0	5.30
3.15	11.2	6.70
4.0	14.0	8.50
(5.0)	18.0	10.60
6.3	20.0	13.20
(8.0)	25.0	17.00
10.0	31.5	21.20.

TABLE 3

d	d_1
K_{12}	h_g
1.0	3.15
(1.25)	3.15
1.6	4.0
2.0	5.0
2.5	6.3
3.15	8.0
4.0	10.0
(5.0)	12.5
6.3	16.0
(8.0)	20.0
10.0	25.0

Data for centre Holes : Types A, B and R
(Dimensions in mm)

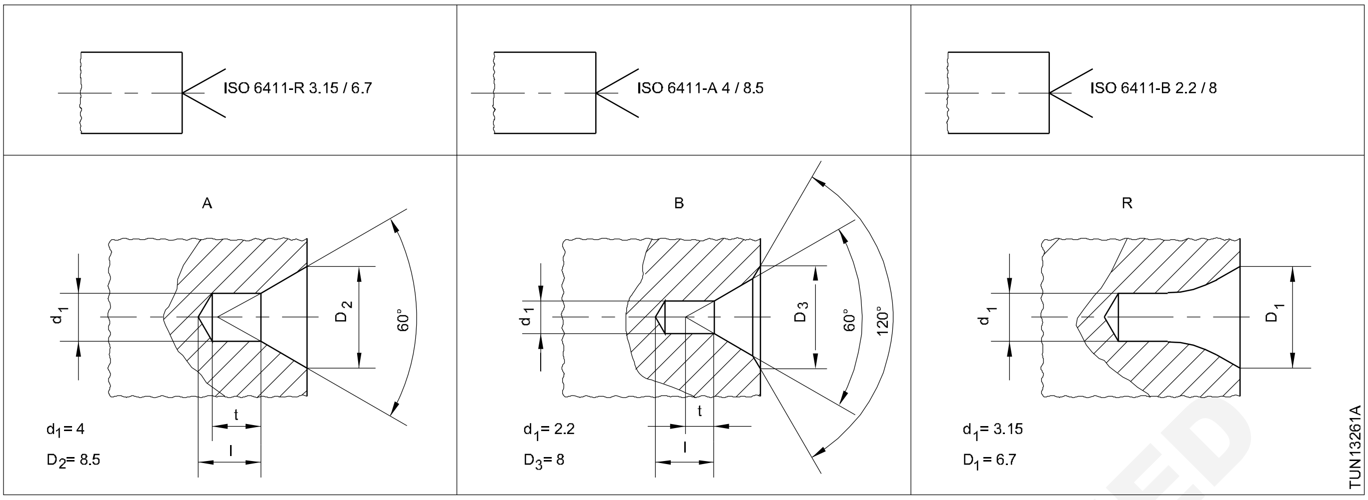
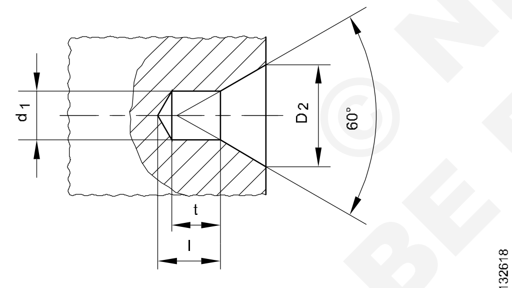


Figure 6 is an additional class of centre hole formed. The end of the bearing surface has a protective countersinking of its convex radius.

The protective countersinking and convex radius are provided to safeguard the bearing surface of the centre holes from getting damaged. (Fig 8 & Fig 9)

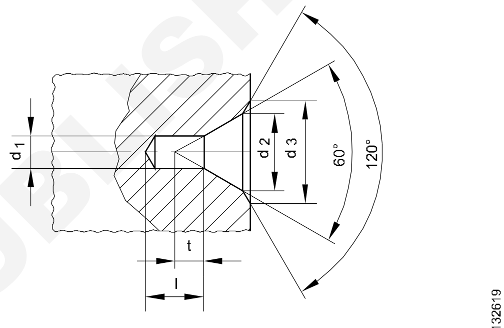
Any damage caused to the bearing surface will not allow the work to run true.

Fig 8



WITHOUT PROTECTIVE CHAMFER AND WITH STRAIGHT RUNNING SURFACES

Fig 9



WITH CONICAL PROTECTIVE CHAMFER AND STRAIGHT RUNNING SURFACES

Drill chuck

Objectives : At the end of this lesson you shall be able to
- **state what is a drill chuck**
- **list out the various types of drill chucks**
- **name the parts of a 3 jaw drill chuck**
- **state the constructional features and functioning of the 3 jaw drill chuck.**

Drill chuck

A drill chuck is a holding device, used to hold straight shank drill bits up to 13 mm diameter. It can be fitted in the tapered bores of the lathe tailstock spindle and in the drilling machine spindle.

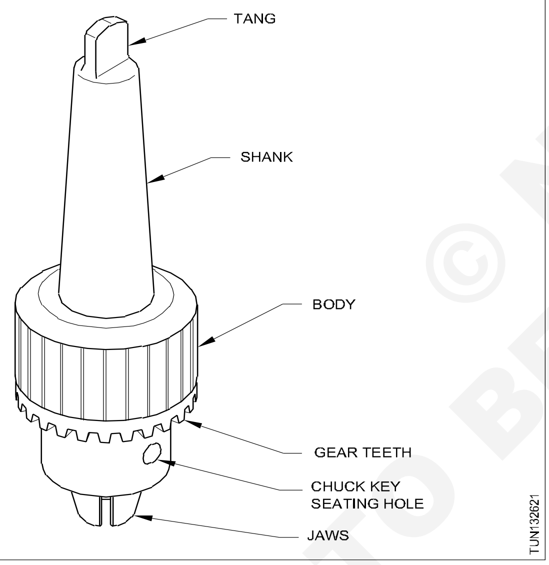
Types of drill chucks

Various types of drill chucks are available according to the construction and utility. The three commonly used drill chucks are:

- 3 jaw drill chuck (Fig 1)
- 2 jaw drill chuck
- quick releasing drill chuck.

Parts of a 3 jaw drill chuck (Fig 2)

Fig 1



The figure shows the different parts of a 3 jaw drill chuck. They are :

1 Sleeve
2 Jaws
3 Tang
4 Shank
5 Arbor hole in chuck body (the arobor assembled in the hole)
6 Chuck key
7 Taper to fit the arbor hole in the chuck body
8 Chuck key slot

Constructional features and functioning of a 3 jaw drill chuck (Fig 3)

The figure shows the sectional view of a 3 jaw drill chuck. The drill bit is gripped by the jaws (6). These jaws can expand grid contract while moving in the slot of the body (2). The jaws have teeth which are in mesh with threads of the inside surface of the ring (4). The chuck key (5) has a pinion' which meshes with the bevel teeth of sleeve (3). When the chuck key is rotated, the sleeve rotates along with the ring which drives the jaw up and down, according to the direction of rotation. The taper shank (1) serves to mount the chuck into the tailstock spindle.

Fig 2

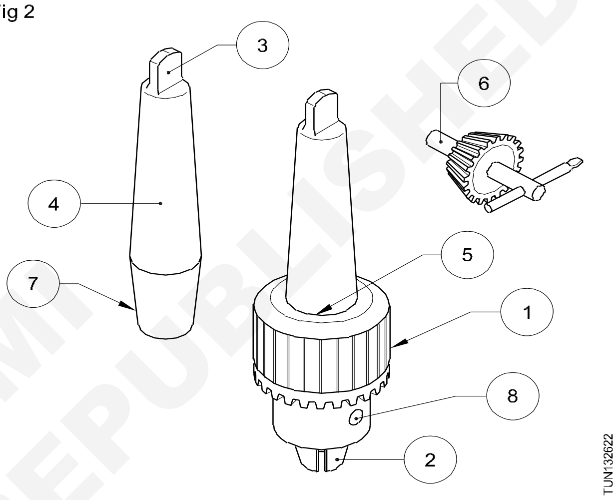
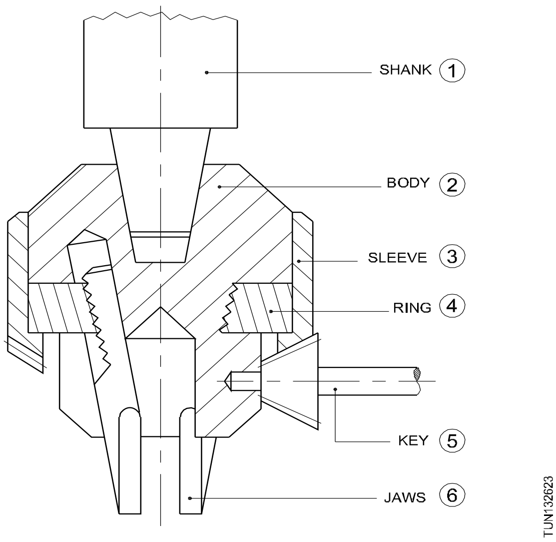


Fig 3



Uses of drill chucks

- It is very useful for drilling operations.
- It can hold varity of drill sizes.
- It is very easy to clamp and remove the drill.
- It can be used in all type of drilling machine.
- It is very useful specifically useful for portable drilling machines widely used by plumbers, electricians, etc,.

Lathe accessories

Objectives : At the end of this lesson you shall be able to
- **identify and name the accessories used on a centre lathe.**
- **identify the accessories used for in-between centre work.**
- **name the types of lathe carriers.**
- **state the uses of each type of lathe carriers.**

The lathe accessories are machined, independent units supplied with the lathe. The accessories are essential for the full utilization of the lathe. The accessories can be grouped into:

- Work-holding accessories
- Work-supporting accessories.

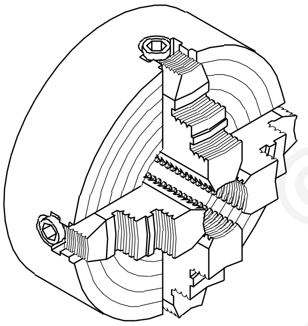
Work-holding accessories

The work can be directly mounted on these accessories and held.

The accessories are :

- Four jaw independent chuck (Fig 1)

Fig 1



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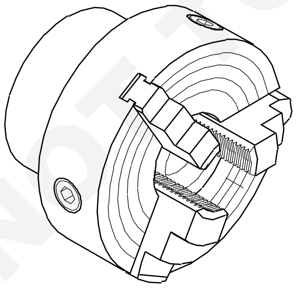
- Three jaw self-centering chuck (Fig 2)

Fig 2



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- Face plates (Fig 3)
- Lathe mandrels. (Fig 4)

Fig 3

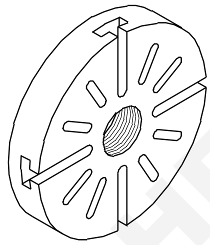

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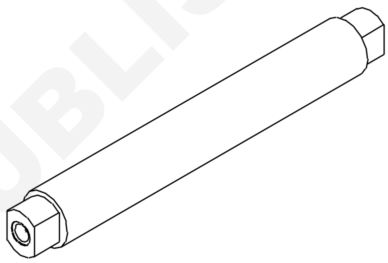
Fig 4



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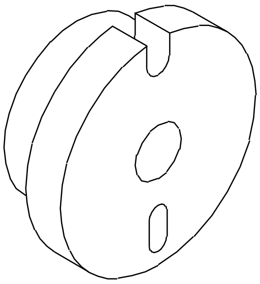
These accessories do not hold the work themselves. They support the work. The following are the work sup-porting accessories.

- Catch plate (Fig 5)

Fig 5



CATCH PLATE

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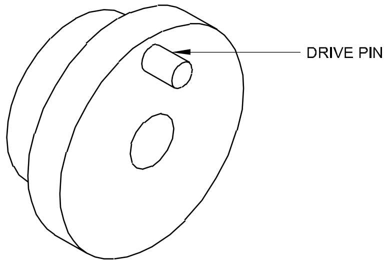
- Driving plate (Fig 6)

Fig 6



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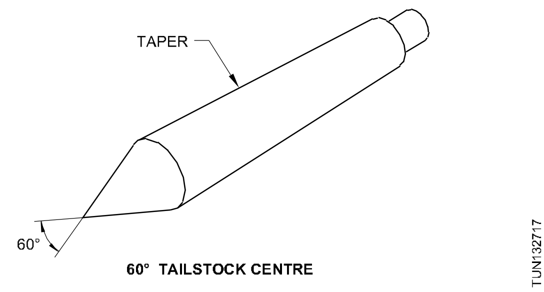
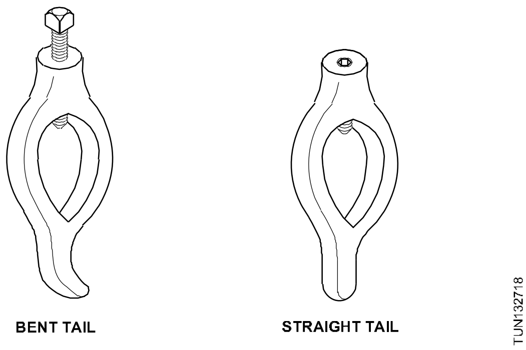
- Lathe centres (Fig 7)

Fig 7



- Lathe carriers (Fig 8)

Fig 8



- Lathe fixed steady (Fig 9)
- Lathe travelling steady (Fig 10)

Fig 9

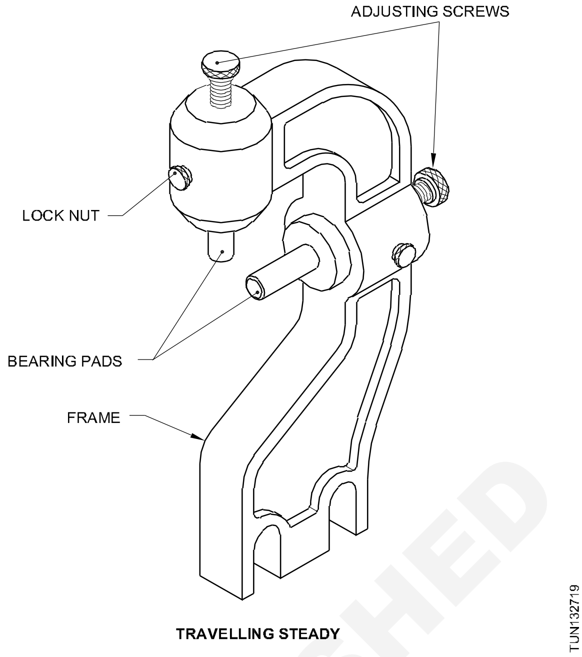
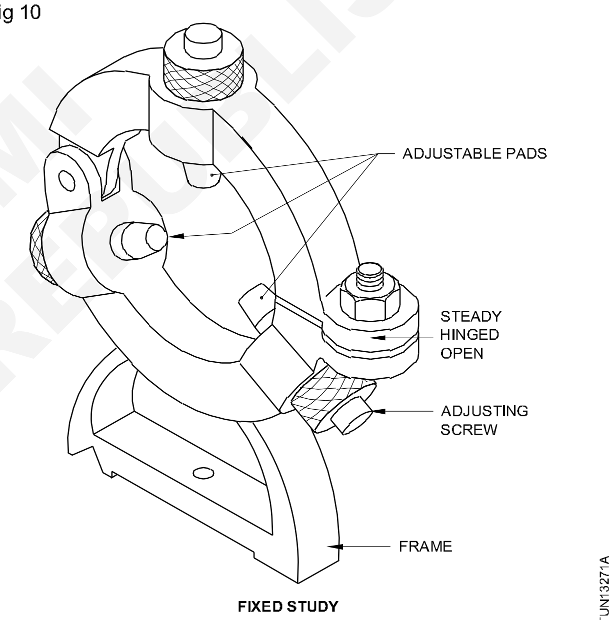


Fig 10



3 Jaw chuck

Objectives : At the end of this lesson you shall be able to
- **name the parts of a 3 jaw chuck**
- **state the constructional features of a 3 jaw chuck**
- **distinguish between a 3 jaw chuck and a four jaw chuck**
- **state the merits and demerits of the 4 jaw chuck over a 3 jaw chuck**
- **specify a chuck.**

The 3 jaw chuck (Fig 1)

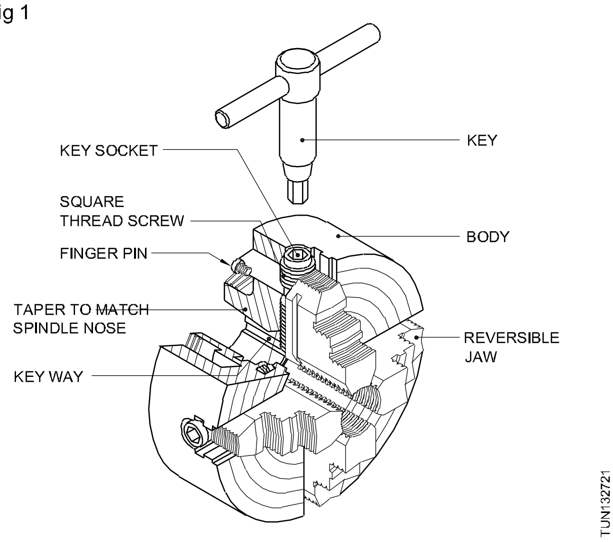
The 3 jaw chuck is also known as self-centering chuck. The majority of the chucks have two sets of jaws for holding internal and external diameters. Only perfectly round work, or work with equally spaced flats, divisible by three, should be held in a 3 jaw chuck.

The construction of a 3 jaw chuck shows that the scroll not only clamps a component in place but also locates the component. This is fundamentally a bad practice, since any wear in the scroll and / or the jaws impairs the accuracy of location. Further, there is no means of adjustment possible to compensate for this wear.

The jaws of this type of chuck are not reversible, and separate internal and external jaws have to be used.

Parts of a 3 jaw chuck (Fig 1)

Fig 1



- Back plate
- Body
- Jaws
- Crown wheel
- Pinion

Back plate

The back plate is fastened at the back of the body by means of allen screws. It is made out of cast iron. Its bore is tapered to suit the taper of the spindle nose. It has a key-way which will fit into the key provided on the spindle nose. There is a step in the front on which the thread is cut. The threaded collar, which is mounted on the spindle, locks the chuck by means of the thread, and locates by means of the taper and the key.

Body

The body is made out of cast steel, and the face is hardened. The body has three openings - 120° apart to assemble the jaws and operate them. Three pinions are fixed on the periphery of the body to operate the jaws by means of a chuck key. The body is hollow in cross-section. The crown wheel is housed inside the body.

Jaws

The jaws are made out of high carbon steel, hardened and tempered, which slide on the openings of the body. Generally there are two sets of jaws, viz. external jaws and internal jaws. External jaws are used for holding solid works. Internal jaws are used for holding hollow works. The steps on the jaws increase the clamping range. The back side of the jaws are cut out of scroll thread. Each jaw is numbered in a sequential manner, which will help in fixing the jaws in the corresponding numbered slots.

Crown wheel

The crown wheel is made out of alloy steel, hardened and tempered. On one side of the crown wheel a scroll thread is cut to operate the jaws and the other side is tapered on which bevel gear teeth are cut to mesh the pinion. When the pinion is rotated by means of the chuck key, the crown wheel rotates, thus causing the jaws to move inward or outward depending upon the rotation.

Pinion

The pinion is made out of high carbon steel, hardened and tempered. It is fitted on the periphery of the body. On the top of the pinion, a square slot is provided to accommodate the chuck key. It has a tapered portion on which the bevel gear teeth are cut, which match with the crown wheel.

Comparison Between a 3 Jaw Chuck and 4 Jaw Chuck

3 Jaw Chuck	4 Jaw Chuck
Only cylindrical or equally spaced flat - Divisible by three type work can be held	A wide range of regular and irregular shaped work can be held
Internal and external jaws are available	Jaw are reversible for external and internal
Setting up of work is easy	Setting up of work is difficult
Less gripping power	More gripping power
Depth of cut is comparatively less	More depth of cut can be given
Heavier jobs cannot be turned	Heavier jobs can be turned
Workpieces cannot be set for eccentric turning	Workpieces can be set for eccentric turning
Concentric circles are not provided on the face	Concentric circles are provided
Accuracy decreases as chuck gets worn out	There is no loss of accuracy as the chuck gets

Merits of a 4 jaw chuck

A wide range of regular and irregular shapes can be held.

Work can be set to run concentrically or eccentrically at will.

Has considerable gripping power; hence, heavy cuts can be given.

The jaws are reversible for internal and external work.

Work can be readily performed on the end face of the job.

There is no loss of accuracy as the chuck gets worn out.

De-merits of a 4 jaw chuck

Workpieces must be individually set.

The gripping power is so great that a fine work can be easily damaged during setting.

Merits of a 3 jaw chuck

Work can be set quickly and trued easily.

A wide range of cylindrical and hexagonal work can be held.

Internal and external jaws are available.

De-merits of a 3 jaw chuck

Accuracy decreases as chuck gets worn out.

Run out cannot be corrected.

Only round and hexagonal components can be held.

When accurate setting or concentricity with an existing diameter is required, a self-centering chuck is not used.

Specification of a chuck

To specify a chuck, it is essential to provide details of the:

- type of chuck
- capacity of the chuck
- diameter of the body
- width of the body
- the method of mounting to the spindle nose.

Examples

3 jaw self-centering chuck

Gripping capacity 450 mm

Diameter of the body 500 mm

Width of the body 125 mm

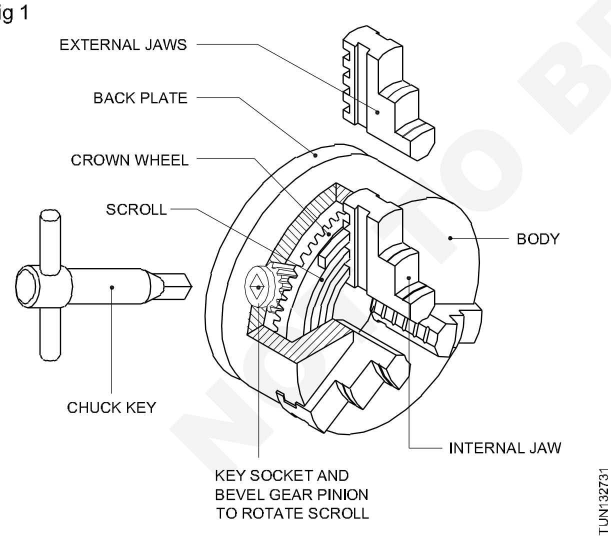
Tapered or threaded method of mounting

4 Jaw chuck

Objectives : At the end of this lesson you shall be able to
- **name the parts of a 4 jaw chuck**
- **state the constructional features of a 4 jaw chuck.**

4 jaw chuck (Fig 1)

Fig 1



The four jaw chuck is also called as independent chuck, since each jaw can be adjusted independently; work can be trued to within 0.001" or 0.02 mm accuracy.

This type of chuck is much more heavily constructed than the self-centering chuck, and has much greater holding power. Each jaw is moved independently by a square thread screw, and is reversible.

The independent 4 jaw chuck has four jaws, each working independently of the others in its own slot in the chuck body and actuated by its own separate square thread screw. By suitable adjustment of the jaws, a workpiece can be set to run either true or eccentric as required. 'T' slots are provided on the face of the chuck to accommodate 'T' bolts for clamping irregular works or for assembling balance weights.

To set the job for the second time it can be trued with the

help of a dial test indicator. The check on the workpiece should be carried out near the chuck and repeated as far from it as the workpiece permits, to ensure that the work is not held in the chuck at an angle to the axis of rotation.

The independent adjustment also provides the facility of deliberately setting the work off-centre to produce an eccentric workpiece.

Figure 1 shows a setting of an independent 4 jaw chuck for turning on eccentric crankpin.

The parts of a 4 jaw chuck are:

- back plate
- body
- jaws
- screw shaft

Back plate

The back plate is fastened to the back of the body by means of Allen screws. It is made out of cast iron/steel. Its bore is tapered to suit the taper of the spindle nose. It has a keyway which fits into the key provided on the spindle nose. There is a step in front on which the thread is cut. A threaded collar which is mounted on the spindle locks the chuck by means of the thread, and locates by means of the taper and key. Some chucks do not have back plates.

Body

The body is made out of cast iron/cast steel and the face is flame-hardened. It has four openings at 90° apart to assemble the jaws and operate them. Four screw shafts are fixed on the periphery of the body by means of finger pins. The screw is rotated by means of a chuck key. The body, hollow in the cross-section, has equi-spaced circular rings provided on the face, which are marked by numerical numbers. Number 1 starts in the middle and increases towards the periphery.

Jaws

Jaws are made out of high carbon steel. hardened and tempered, which slide on the openings of the body. These jaws are reversible for holding hollow work.

The back side of the jaws are square-threaded which will help in fixing the jaws with the operating screws.

Screw shaft

Screw shaft is made out of high carbon steel, hardened, tempered and ground. The top portion of the screw shaft is provided with a square slot to accommodate the chuck key. On the body portion, a left hand square thread is cut. In the middle of the screw shaft, a narrow step is made and held by means of finger pins. The finger pins permit the screws to rotate but not to advance.

Chucks other than 3 Jaw and 4 Jaw types and their uses

Objectives : At the end of this lesson you shall be able to
- **list the name of the chucks other than the 3 jaw and 4 jaw types**
- **state their constructional features**
- **state the uses of each of these chucks.**

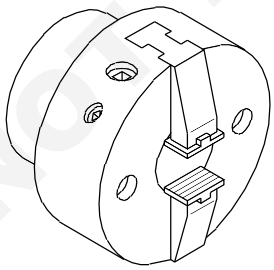
Apart from the four jaw independent chucks and self-centering chucks, other types of chucks are also used on a centre lathe. The choice depends upon the component, the nature of the operation, the number of components to be machined.

Some of the other types of chucks are:

- two jaw concentric chuck
- combination chuck
- collect chuck
- magnetic chuck
- hydraulic chuck or air operated chuck.

Two jaw concentric chuck (Fig 1)

Fig 1



TWO JAW CONCENTRIC CHUCK

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The constructional features of this chuck are similar to those of 3 jaw and 4 jaw chucks.

Each jaw is an adjustable jaw which can be operated independently. In addition to this feature, both jaws may be operated concentric to the centre. Irregular shaped works can be held. The jaws may be specially machined to hold a particular type of job.

Combination chuck

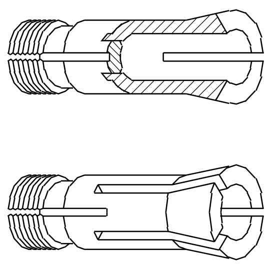
The combination chuck is normally a four jaw chuck in which the jaws may be adjusted either independently as done in a 4 jaw chuck, or together, as done in a 3 jaw universal chuck.

This kind of chuck is used in places where duplicate workpieces are to be machined. One piece is accurately set as done in a 4 jaw chuck, and the subsequent jobs are held by operating the centering arrangement.

Collet chuck (Fig 2)

A collet is a hardened steel sleeve having slits cut partly along its length. It is held by a draw-bar which can be drawn in or out in the lathe spindle. The collet is guided in the collet sleeve, and held with the nose cap. It is possible to change the collet for different cross-sections depending on the cross-section of the raw material.

Fig 2



SPLIT COLLET

TUN132742

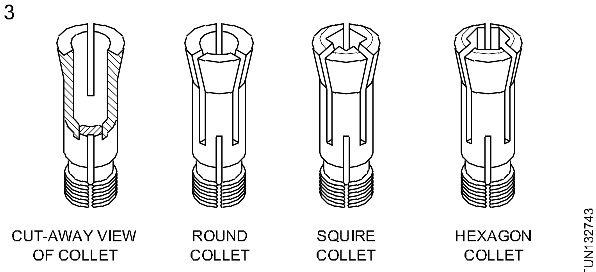
There are three most commonly used types of collet chucks.

- Push-out chucks
- Draw-in chucks

- Dead length bar chucks

The operation of these chucks may be manual, pneumatic, hydraulic or electrical. They are mainly used to hold round, square, hexagonal or cast profile bars. (Fig 3)

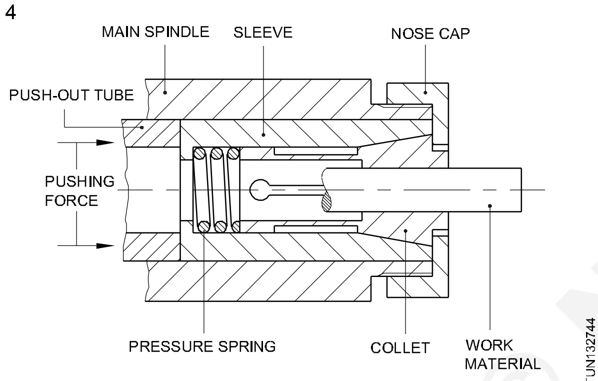
Fig 3



Push-out chucks (Fig 4)

the collet closes on the workpiece in a forward direction and consequently an end-wise movement of the work results. The cutting pressure tends to reduce the grip of the collet on the workpiece.

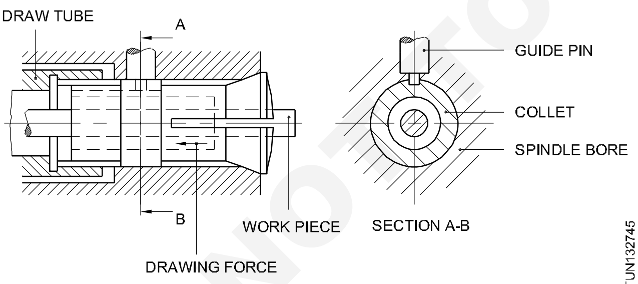
Fig 4



Draw-in chuck (Fig 5)

The collet closes on the workpiece in a backward direction and movement of the work. Take special care to avoid increases the grip of the collet on the workpiece.

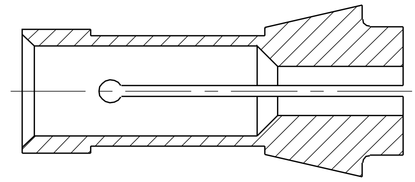
Fig 5



Dead length bar chucks (Fig 6)

These chucks are widely used in modern machines as they provide an accurate end-wise location of the workpiece. The chuck does not move end-wise during gripping or closing operation. These chucks are made to hold round, hexagonal or square bars, and when they are not gripping, they maintain contact with the core thus preventing sward and chips collecting between the collet and the core

Fig 6



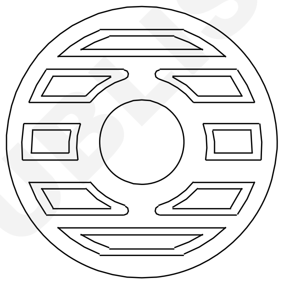
SPRING COLLET USED IN DEAD LENGTH BAR CHUCK

The disadvantage with these chucks is that each collet cannot be made to grip bars which vary by more than about 0.08 mm without adjustment.

Magnetic chuck (Figs 7a & 7b)

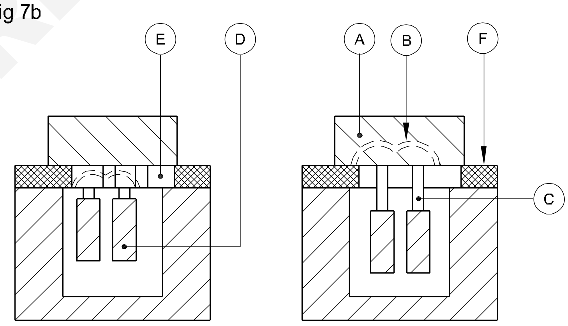
This chuck is designed to hold the job by means of magnetic force. The face of the chuck may be magnetized by inserting a key in the chuck and turning it to 180°. The amount of magnetic force may be controlled by reducing the angle of the key. The truing is done with a light magnetic force, and then the job is held firmly by using the full magnetic force.

Fig 7a



MAGNETIC CHUCK

Fig 7b



INSIDE DETAILS OF MAGNETIC CHUCK

A WORKPIECE
B MAGNETIC FIELD
C CONNECTION
D MAGNETS
E KEEPERS
F FACE PLATE

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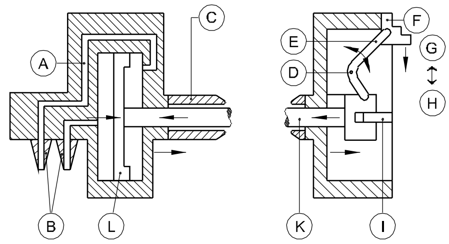
Hydraulic chuck or air-operated chuck (Fig 8)

These chucks are mainly used for getting a very effective grip over the job. This mechanism consists of a hydraulic or an air cylinder which is mounted at the rear end of the headstock spindle, rotating along with it. In the case of a hydraulically operated chuck the fluid pressure is transmitted to the cylinder by operating the valves. This mechanism may be operated manually or by power. The movement of the piston is transmitted to the jaws by means of connecting rods and links which enable them to provide a grip on the job.

Fig 8



Uses of a two jaw concentric chuck

It is mainly employed to hold an irregularly shaped job. As the chuck is designed with two jaws, it can be used as a turning fixture.

Uses of a combination chuck

This chuck may be used both as a universal 3 jaw chuck and as a 4 jaw independent chuck. This chuck is very useful where duplicate workpieces are involved in the turning.

Uses of a collet chuck

It is mainly used for holding jobs within a comparatively small diameter. The main advantage of collets lies in their ability to centre work automatically and maintain accuracy for long periods. It also facilitates to hold the bar work.

Uses of a magnetic chuck

This type of a chuck is mainly used for holding thin jobs which cannot be held in an ordinary chuck. These are suitable for works where a light cut can be taken on the job.

Uses of hydraulic or air-operated chuck

These chucks are mainly used in mass production because of their speedy and effective gripping capacity.

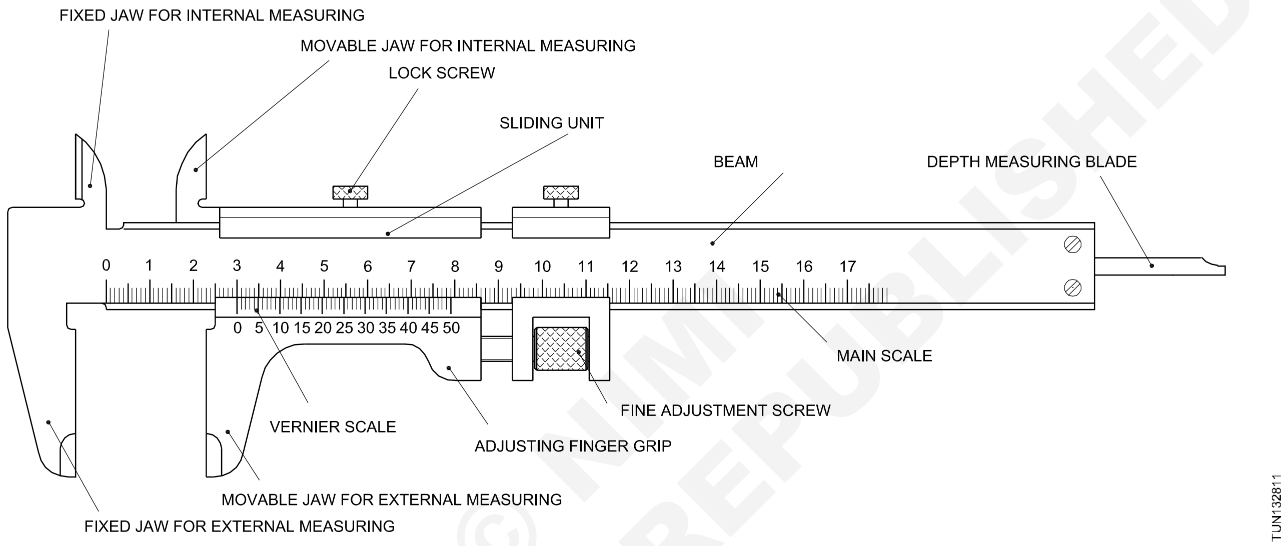
Vernier caliper - Its construction, principle, graduation

Objectives : At the end of this lesson you shall be able to
- **list out the parts of a vernier caliper**
- **state the constructional features of the vernier caliper**
- **state its functional features**
- **read a measurement.**

One of the precision instruments having the principle of vernier applied to it is the vernier caliper. It is known as a vernier caliper because of its application to take outside, inside and depth measurements. Its accuracy is 0.02 mm.

Vernier principle: The vernier principle state that two different scales are constructed on a single known legth of line and the difference between then is taken for the measurement. (Fig 1)

Fig 1



Parts of a vernier caliper

A universal vernier caliper consists of a:

- Beam
- Fixed jaw for external measurements
- Movable jaw for external measurements
- Movable jaw for internal measurements
- Blade for depth measurement
- Main scale
- Vernier scale
- Fine adjustment screw
- Set of locking screws.

All parts are made out nickel-chromium steel or invested heat-treated and ground. They are machined to a high accuracy. They are stabilized to avoid distortion due to temperature variations.

Constructional features

The beam is the main part and the main scale graduations are marked on it. The markings are in millimeters and every tenth line is drawn a little longer and brighter than the other graduations and numbered as 1,2,3 ….

To the left of the beam the fixed jaws for external and internal measurements are fixed as integral parts., The vernier unit slides over the beam.

At the bottom face of the beam a keyway-like groove is machined for its full length, permitting the blade to slide in the groove.

At the bottom right hand end, a unit is fixed serving as a support for the blade when it slides in the groove.

The vernier unit has got the vernier graduations marked on it. The movable jaws for both external and internal measurements are integral with this.

The fixed and movable jaws are knife-edged to have better accuracy during measurement. When the fixed and movable jaws are made to contact each other, the zero of the vernier scale coincides with the zero of the main scale.

At this position in the blade will be in line with the right hand edge of the beam.

When the vernier scale unit slides over the beam, the movable jaws of both the measurements as well as the blade advance to make the reading.

To slide the vernier unit, the thumb lever is pressed and pulled or pushed according to the direction of movement of the vernier unit.

Sizes

Vernier calipers are available in sizes of 150 mm, 200 mm, 900 mm and 1200 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Graduations and reading of vernier calipers

Objectives: At the end of this lesson you shall be able to
- **determine the least count of vernier calipers**
- **state how graduations are made on vernier calipers with 0.02mm least count**
- **read vernier caliper measurements.**

Vernier calipers

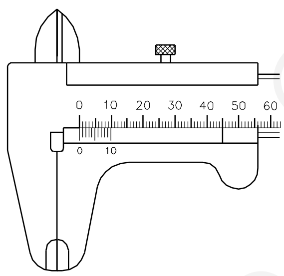
Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the size of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and vernier scale divisions.

Determining least count of vernier calipers

In the vernier caliper shown in Fig 1, the main scale divisions (9mm) are divided into 10 equal parts in the vernier scale.

Fig 1



i.e.	One main scale division (MSD)	=	1 mm
	One vernier scale division? (VSD)	=	9/10 mm
	Least count is 1 mm - 9/10 mm	=	1/10 mm
	The difference between one MSD and one VSD	=	0.1 mm

Example

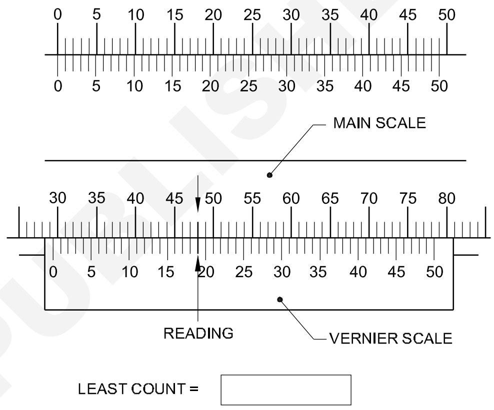
Calculate the least count of the vernier given in Fig 2.

Reading vernier measurements

Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide).

The figure above shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Fig 2



i.e One main scale division (MSD) = 1mm

One Vernier scale division? (VSD) = 49/50 mm

Least count = 1 MSD - 1 VSD

= 1mm - 49/50

= 50 - 49/50 = 1/50 = 0.02 mm

Example for vernier caliper (Fig 3)

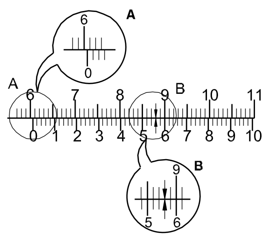
Main scale reading 60 mm.

The vernier division coinciding with the main scale is the 28th division. Value = 28 x 0.02

= 0.56 mm

Reading = 60+0.56 = 60.56mm

Fig 3



Classroom Exercise

In figures 3, 4, 5, 6 and 7, 49 main scale divisions are divided into 50 equal parts on the vernier scale. Value of-one M.S.D. is 1 mm.

Fig 4

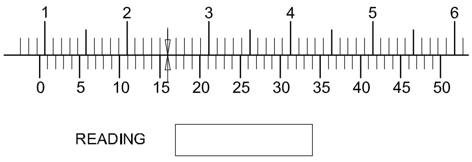


Fig 5

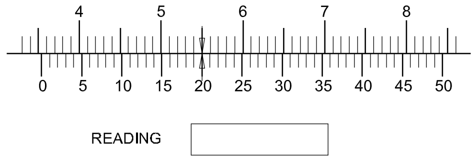


Fig 6

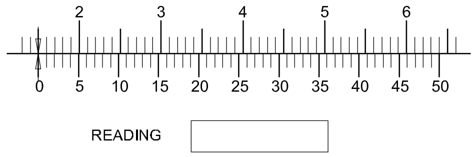
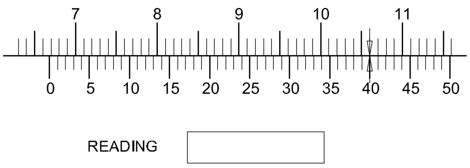


Fig 7



TUN132824

1 Calculate the least count.

2 Record the reading of each, figure in the space pro-vided.

Disadvantages

Accuracy of reading depends on the skill of the operator.

Loses its accuracy by constant usage as slackness in the sliding unit develops.

Cannot be used to measure components having devia-tions less than ± 0.02 mm.

Possibility of parallax error during noting down the coinciding line may cause the reading of the measurement to be wrong.

To read a measurement

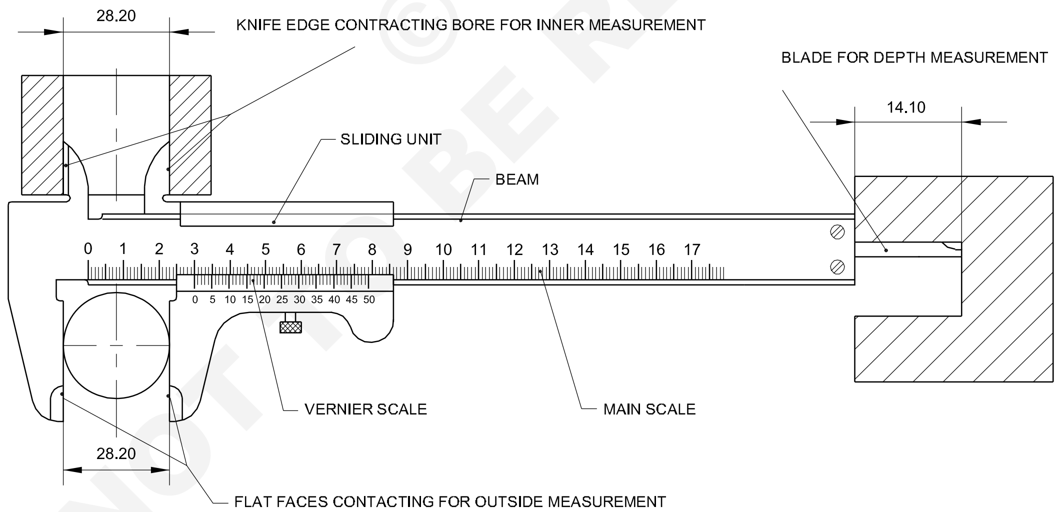
Note the number of graduations on the main scale passed by the zero of the vernier. This gives the full mm.

Note which of the vernier scale division coincides with any one line on the main scale.

Multiply this number with the least count.

Add the multiplied value to the main scale reading.

Fig 8



TUN132828

Digital vernier caliper

Objectives: At the end of this lesson you shall be able to
- **state the uses of digital caliper**
- **name the parts of a digital caliper**
- **brief the zero setting of a digital caliper.**

The digital caliper (sometime incorrectly called the digital vernier caliper) is a precision instrument than can be used to measure internal and external distance accurately to 0.01mm, The digital vernier caliper is shown in Fig 1. The distance or the measurements are read from LED drawing. The parts of digital calipers are similar to the ordinary vernier caliper except the digital display and few other parts. The parts are indicated in Fig 1.

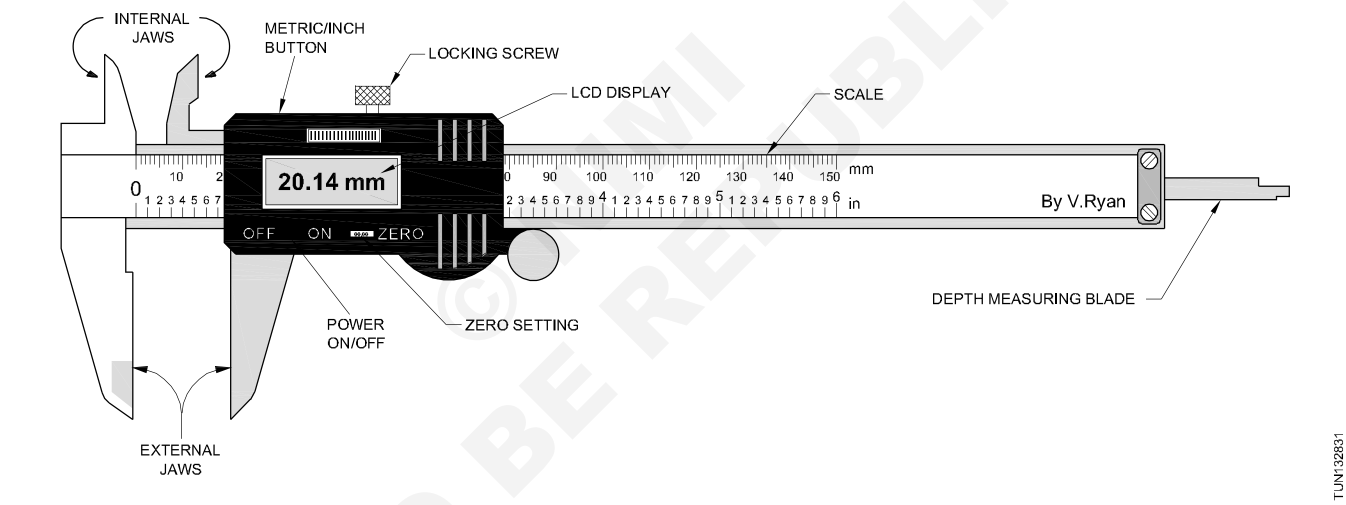
Earlier versions of the type of measuring instrument had to read by looking carefully at the inch or metric scale and there was a need for very good eye sight in order to read the small sliding scale. Manually operated vernier caliper are remain popular because they are much cheaper than the digital version.

The digital caliper requires a small battery whereas the manual version does not need any power source.The digital calipers are easier to use as the measurement is clearly display and also, by pressing inch/mm button the distance can be read as metric or inch.

The display is turned on with the ON/OFF button. before measuring, the zero setting to be done, by bringing the external jaws together until they touch each other and then press the zero button. Now the digital caliper is ready to use.

Always set zero position when turning on the display for the first time.

Fig 1



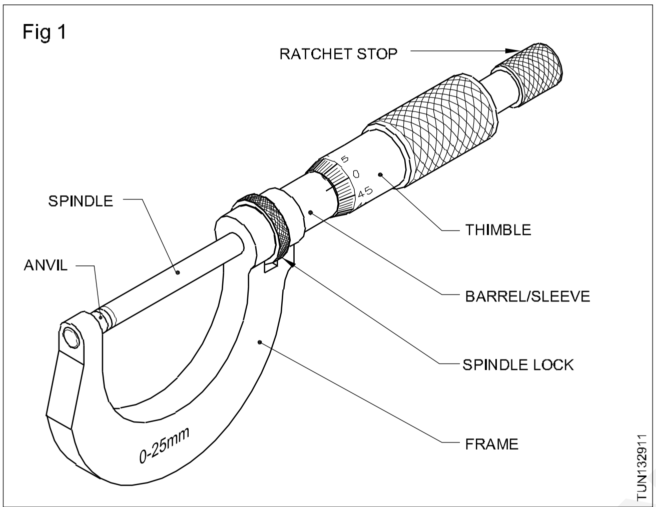
Outside Micrometers, parts, principle

Objectives : At the end of this lesson you shall be able to
- **list the parts of an outside micrometer**
- **state the functions of the main parts of an outside micrometer.**

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

Fig 1



The parts of a micrometer are listed here.

Frame

The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve

The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble

On the bevelled surface of the thimble also, the graduation is marked. The spindle is attached to this.

Spindle

One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil

The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

Spindle lock nut

The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop

The ratchet stop ensures a uniform pressure between the measuring surfaces.

Graduations of metric outside micrometer

Objectives : At the end of this lesson you shall be able to
- **state the principle of a micrometer**
- **determine the least count of an outside micrometer.**

Working principle

The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

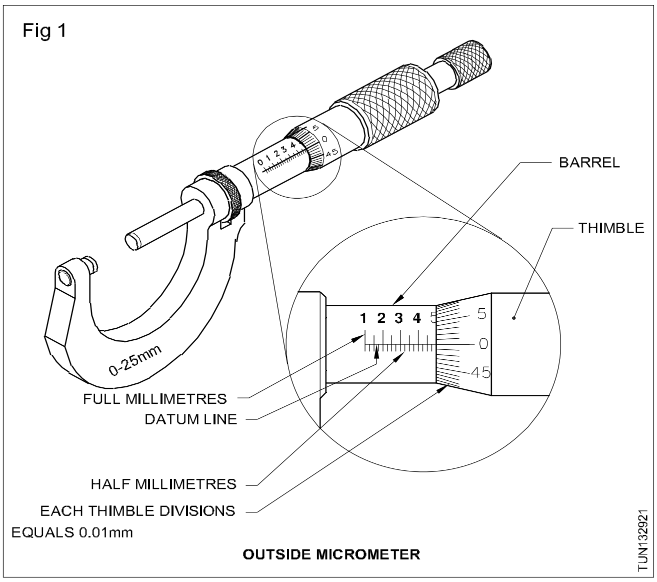
Graduations (Fig 1)

In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres (i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

Fig 1



The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 .... 45-50 in a clockwise direction.

The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

Movement of one division of the thimble = 0.5 x 1/50

= 0.01 mm

Accuracy or least count of a metric outside micrometer is 0.01mm.

Reading dimensions with an outside micrometers

Objectives: At the end of this lesson you shall be able to
- **select the required range of a micrometer**
- **read micrometer measurements.**

Ranges of outside micrometer

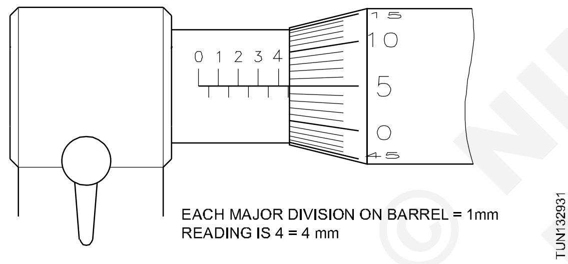
Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 1)

Method of reading

Read on the barrel scale the number of whole millimeters that are completely visible from the bevel edge of the thimble. It reads 4 mm. (Fig 1)

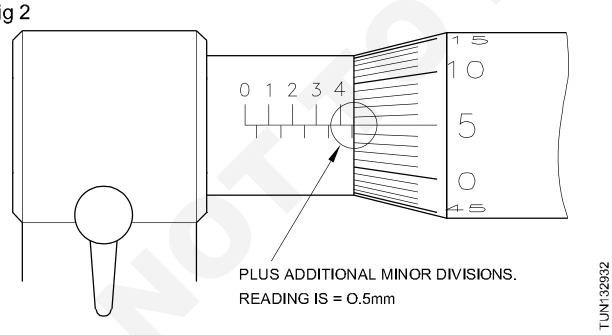
Fig 1



Add to this any half millimeters that are completely visible from the bevel edge of the thimble.

The figure reads 1/2 = 0.5 mm.(Fig 2)

Fig 2



Add the thimble reading to the two earlier readings.

The figure shows the 5th division of the thimble is coinciding with the index line of the sleeve. Therefore the reading of the thimble is 5x0.01 mm = 0.05 mm. (Fig 3)

The total reading of the micrometer.

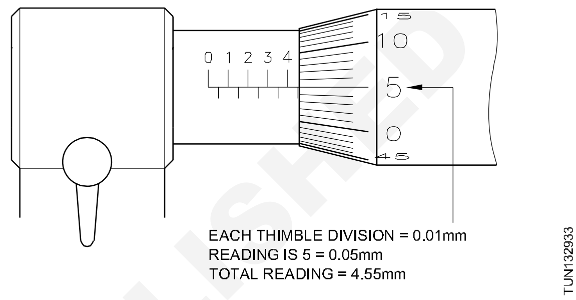
a 4.00 mm

b 0.50 mm

c 0.05 mm

Total reading 4.55 mm (Fig 3)

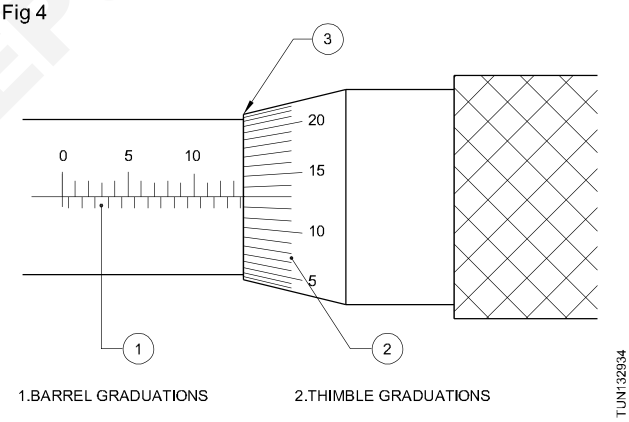
Fig 3



Reading micrometer measurements

How to read a measurement with an outside micrometer? (Fig 4)

Fig 4



First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

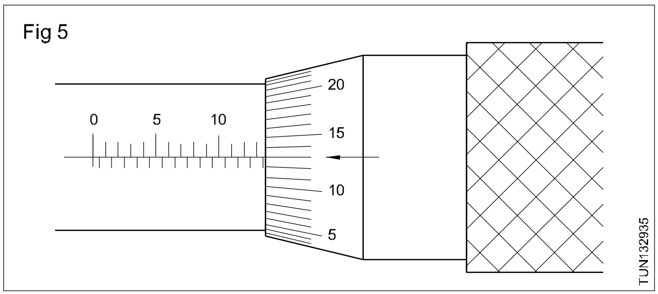
Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm
+ 00.50 mm

13.50 mm

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 5)



Multiply this value with 0.01 mm (least count).

13 x 0.01 mm = 0.13 mm.

Add

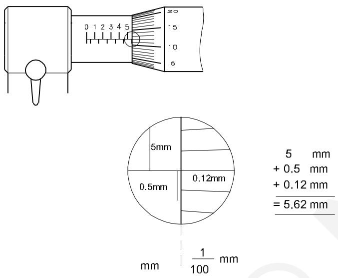
Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

The micrometer reading is 63.63 mm.

Some examples of metric micrometer readings and their solution

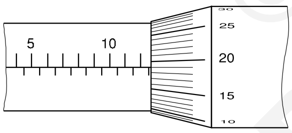
i
5.00 mm
0.50 mm
0.12 mm

Total 5.62 mm



iii
12.00 mm
0.50 mm
0.19 mm

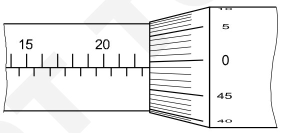
Total 12.69 mm



12.69mm

iiii
22.00 mm
0.50 mm
0.49 mm

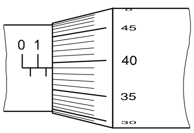
Total 22.99 mm



23.99mm

iv
1.00 mm
0.50 mm
0.39 mm

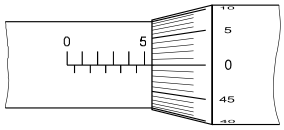
Total 1.89 mm



1.89mm

v
5.00
0.50 mm
0.00 mm

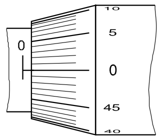
Total 5.50 mm



5.50 mm

vi
0.00 mm
0.50 mm
0.00 mm

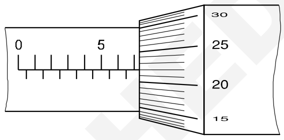
Total 0.50 mm



0.50 mm

vii
7.00 mm
0.00 mm
0.22 mm

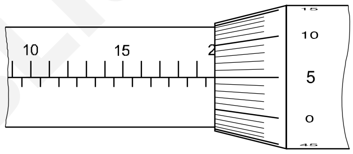
Total 7.22 mm



7.22 mm

viii
19.00 mm
0.50 mm
0.05 mm

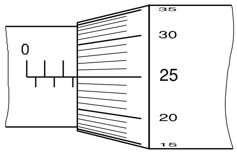
Total 19.55 mm



19.55 mm

ix
2.00 mm
0.50 mm
0.25 mm

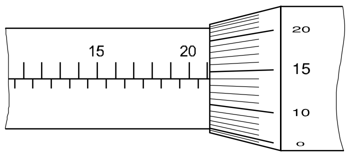
Total 2.75 mm



2.75 mm

x
21.00 mm
0.00 mm
0.14 mm

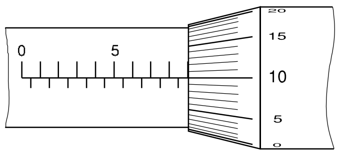
Total 21.14 mm



21.14 mm

xi
9.00 mm
0.00 mm
0.10 mm

Total 9.10 mm



9.10 mm

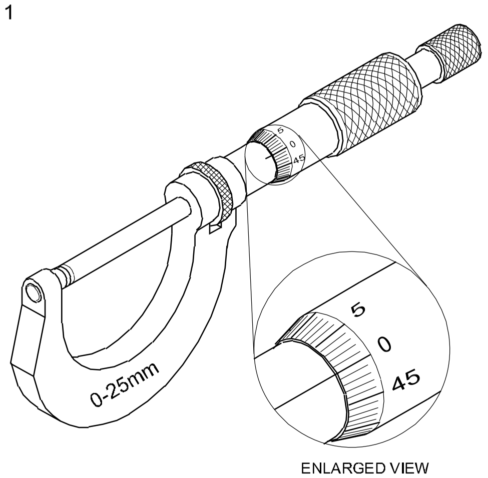
Error in micrometer

Objective: This shall help you to
- **check outside micrometer for '0' error.**

No zero error

When the measuring faces are in contact if the zero of the thimble should be coincide with the datum line No zero error (Fig 1).

Fig 1



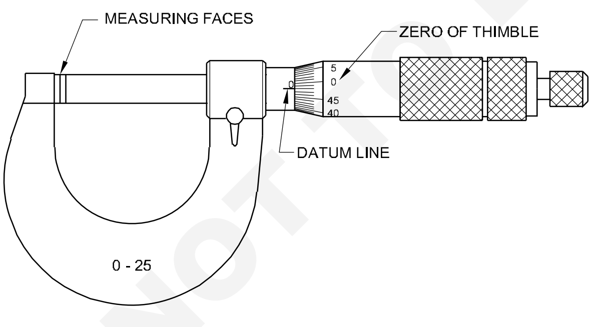
Zero error

When the measuring faces are in contact, (Fig 2) if the zero of the thimble do not coincide with the datum line (the zero of the thimble will be above or below the datum line) the micrometer is said to be with zero error. There are two types of zero error.

a) Positive error

b) Negative error

Fig 2

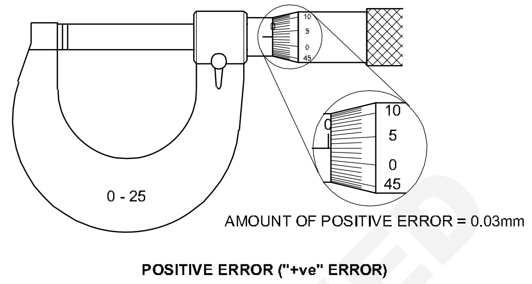


All micrometers should be checked for its zero error and the error should be noted if any before using it on checking dimensions.

Clean measuring faces with clean cloth before checking for zero error.

Positive error: When the anvil and spindle faces are in contact in case of a 0-25 mm micrometer or 0-1 micrometer and with a test piece in between the measuring faces in case of a higher range micrometer. If the zero of the thimble rest below the datum line of the sleeve the error is called as "Positive". (Fig 3)

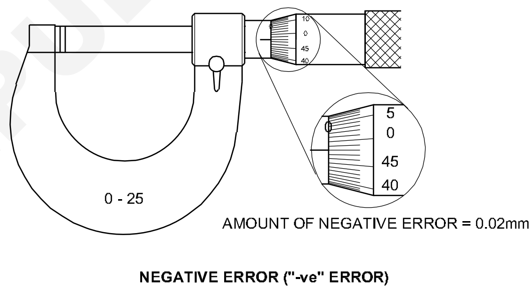
Fig 3



To get the correct reading the amount of error should be subtracted from the reading dimension.

Negative error: When the anvil and spindle faces are in contact, if the zero of the thimble passes above the datum line of the sleeve, the error is called as "Negative". (Fig 4)

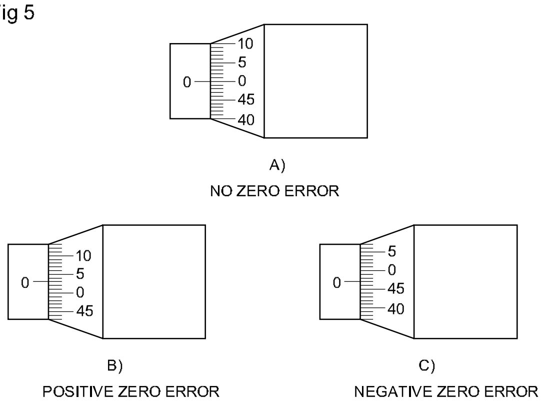
Fig 4



To get the correct reading the amount of negative error should be added to the reading dimension.

Caution: When you come across with micrometer having "zero error", inform your instructor and get it corrected by him. Do not try yourself to correct at this stage.

Fig 5



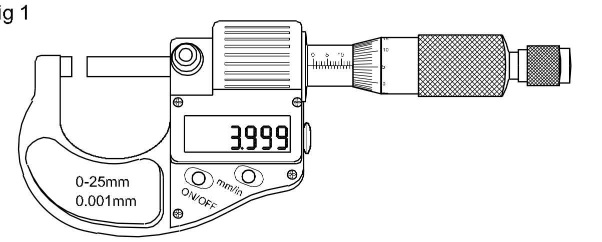
Digital micrometers

Objectives: At the end of this lesson you shall be able to
- **state the uses of digital micrometer**
- **list the parts of digital micrometer**
- **read the reading from LED display and thimble and barrel**
- **brief the maintenance, maintenance of digital micrometers.**

Digital micrometers is one of the simplest and most widely used measuring equipment in any manufacturing industry. Its simplicity and the versatile nature make Digital micrometers so popular. Different kinds of Digital micrometers available in the market.

Feature of digital micrometers (Fig 1)

Fig 1



FEATURE OF DIGITAL MICROMETERS

- LCD displays measuring data and makes direct read out with resolution of 0.001mm.
- Origin setting mm/inch conversion, switch for absolute and incremental measurement.
- Carbide tipped measuring faces.
- Ratchet ensures invariable measurement and accurate repeatable reading

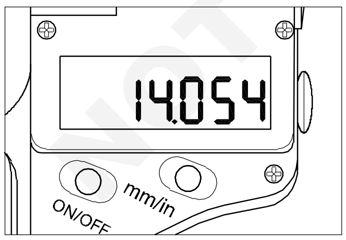
Accuracy of digital micrometers

Digital micrometers provide 10 times more precision and accuracy : 0.00005 inches or 0.001mm resolution, with 0.0001 inches or 0.001mm accuracy.

Reading of the digital micrometer

The digital micrometers are provided with high precision reading with LCD display. The reading is 14.054 mm as shown in Fig 2.

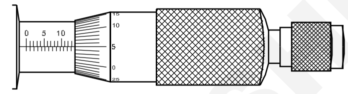
Fig 2



READING OF THE DIGITAL MICROMETERS

Reading also by reading the marks on the sleeve and the thimble. Usually, the reading from the large LCD display for the digital micrometer because the digital reading is more accurate. The reading on the sleeve and the thimble is just for reference. Read the markings on the sleeve and the thimble, firstly, read the point which the thimble stops at it on the right of the sleeve (It is 14mm here, because each line above the centre long line represents 1mm while each line below the centre long line represent 0.5mm) (Fig 3)

Fig 3



Secondly, read the markings on the thimble, It is between 5 and 6, So you need to estimate the reading. (It is 0.055mm for each line here represents 0.001mm). At last, add all the reading up : 14mm + 0.055 mm = 14.055mm. So the total reading is 14.055mm.

Maintenance of a digital micrometers

Never apply voltage (e.g. engraving with an electric pen) on any part of the Digital Micrometers for fear of damaging the circuit.

Press the ON/OFF button to shut the power when the Digital micrometers stands idle; take out the battery if it stands idle for a long time.

As for the battery, abnormal display (digit flashing or even no display) shows a flat battery. Thus you should push the battery cover as the arrow directing and then replace with a new one. Please note that the positive side must face out If the battery bought from market doesn't work well (the power may wear down because of the long-term storage or the battery's automatic discharge and etc.) Please do not hesitate to contact the supplier.

Flashing display shows dead battery. If this is the case please replace the battery at once. No displace shows poor contact of a battery or short circuit of both poles of the battery. Please check and adjust pole flakes and battery insulator cover. In case water enters the battery cover, open the cover immediately and blow the inside of the battery cover at a temperature of no more than 40^{0}C till it gets dry.

Cutting speed and feed & depth of cut, recommended speed

Objectives : At the end of this lesson you shall be able to
- **distinguish between cutting speed and feed**
- **read and select the recommended cutting speed for different materials from the chart**
- **point out the factors governing the cutting speed**
- **state the factors governing feed.**

Cutting speed (Fig 1)

The speed at which the cutting edge passes over the material, which is expressed in metres per minute is called the cutting speed. When a work of a diameter 'D' is turned in one revolution the length of portion of the work in contact with the tool is π x D. When the work is making 'n' rev/min, the length of the work in contact with the tool is π x D x n. This is converted into metres and is expressed in a formula form as

$$V = \frac{\pi DN}{1000}$$

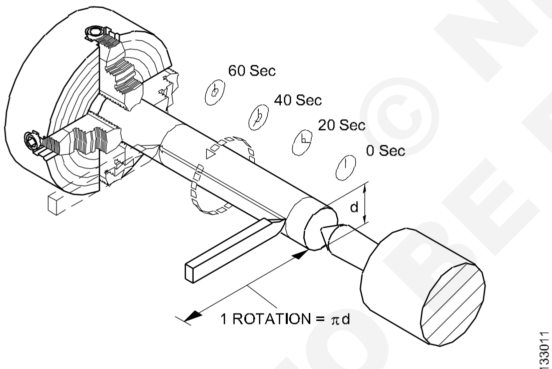
Where V = cutting speed in metre/min

π = 3.14

D = diameter of the work in mm.

N = r.p.m.

Fig 1



CUTTING SPEED FOR TURNING OPERATION

When more material is to be removed in lesser time, a higher cutting speed is needed. This makes the spindle to run faster but the life of the tool will be reduced due to more heat being developed. Recommended cutting speeds are given in a chart form which provides normal tool life under normal working conditions. As far as possible the recommended cutting speeds are to be chosen and the spindle speed calculated before performing the operation. (Fig 2)

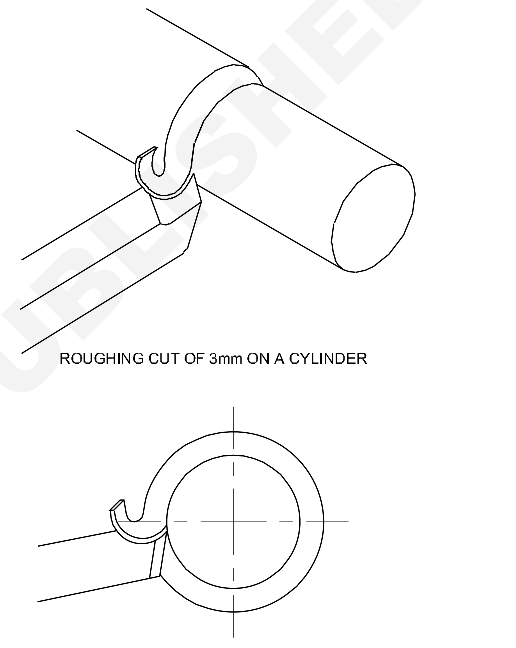
Example

Find out the rpm of the spindle for a 50 mm bar to cut at 25 m/min.

$$V = \frac{\pi DN}{1000} \quad N = \frac{1000V}{\pi D}$$

$$\frac{1000 \times 25}{3.14 \times 50} = \frac{500}{3.14} = 159 \text{ r.p.m}$$

Fig 2



DEPTH OF CUT

Factors governing the cutting speed

Finish required

Depth of cut

Tool geometry

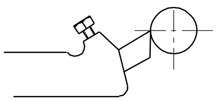
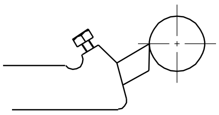
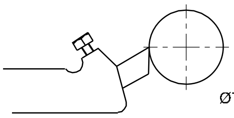
Properties and rigidity of the cutting tool and its mounting

Properties of the workpiece material

Rigidity of the workpiece

Type of cutting fluid used & Rigidity of machine tool

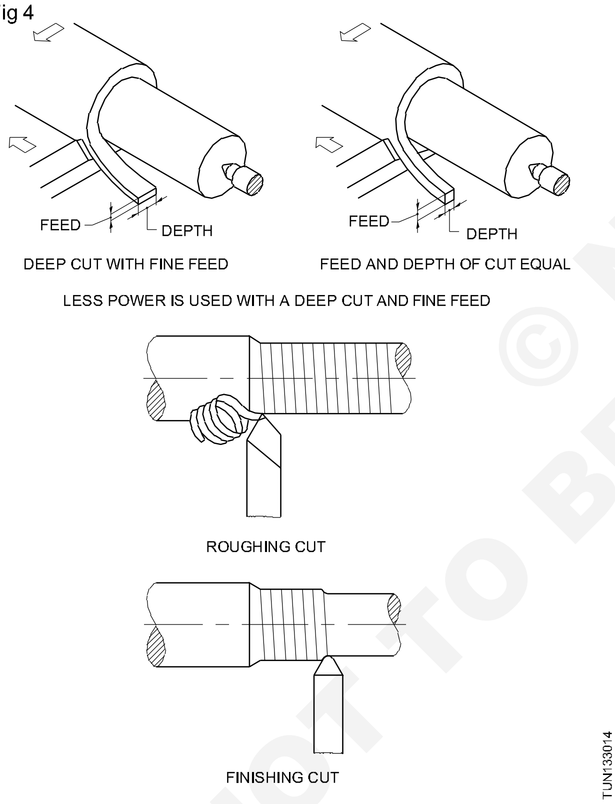
Relationship of r.p.m to the cutting speed on different diameter

Cutting speed 120m/min	Length of metal passing cutting tool in one revolution	Calculated r.p.m of spindle
 Ø25 mm	.... 78.5 mm	1528
 Ø50 mm	.... 157.0 mm	764
 Ø75 mm	.... 235.5 mm	509.5

Feed (Fig 3)

The feed of the tool is the distance it moves along the work for each revolution of the work, and it is expressed in mm/rev.

Fig 4



Factors governing feed

Tool geometry

Surface finish required on the work

Rigidity of the tool

Coolant used.

Depth of cut (Fig 3)

It is defined as the perpendicular distance measured between the machined surface (d) and the unmachined surface (D) expressed in mm.

$$\text{Depth of cut} = \frac{D - d}{2}$$

Rate of metal removal

The volume of metal removal is the volume of chip that is removed from the work in one minute, and is found by multiplying the cutting speed, feed rate and the depth of cut.

The recommended cutting speed and feed for different metals are given in the table. It can be observed that soft materials has a very high cutting speed and hard metal has a lesser cutting speed. The feed for hard material is generally very low compare to the feed given for soft material.

Cutting speeds and feeds for H.S.S. tools are given in Table 1

Table 1

Material being turned	Feed	Cutting speed
Aluminium	0.2 - 1.00	70 - 100
Brass (alpha) - ductile	0.2 - 1.00	50 - 80
Brass (free cutting)	0.2 - 1.5	70 - 100
Bronze (phosphor)	0.2 - 1.00	35 - 70
Cast iron (grey)	0.15 - 0.7	25 - 40
Copper	0.2 - 1.00	35 - 70
Steel (mild)	0.2 - 1.00	35 - 50
Steel (medium-carbon)	0.15 - 0.7	30 - 35
Steel (alloy high tensile)	0.08 - 0.3	5 - 10
Thermosetting plastics	0.2 - 1.00	35 - 50

Note

For super HSS tools the feeds would remain the same, but cutting speeds could be increased by 15% to 20%

A lower speed range is suitable for heavy, rough cuts.

A higher speed range is suitable for light, finishing cuts.

The feed is selected to suit the finish required and the rate of metal removal.

When carbide tools are used, 3 to 4 times higher cutting speed than that of the H.S.S. tools may be chosen.

Calculation involving cutting speed, feeds

Objectives : At the end of this lesson you shall be able to
- **determine the spindle speed for turning jobs of different materials of different diameters with different tool materials**
- **determine the turning time with the given data.**

The selection of the spindle speed is one of the factors which decides the efficiency of cutting. It depends on the size of the job, material of the job and material of the cutting tool. The formula to determine cutting speed is.

$$= \frac{\pi \times D \times N}{1000} \text{ metre/min. where D is in mm.}$$

$$N = \frac{CS \times 1000}{\pi \times D}$$

To determine the spindle speed (N)

Example 1

Calculate the spindle speed to turn a MS rod of ø40 mm. Using HSS tool data in the above problem, since the material is mild steel and tool is HSS, the recommended cutting speed from the chart is 30m/min.

ø = 40 mm

$$N = \frac{CS \times 1000}{\pi \times D}$$

$$= \frac{30 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{30 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{30 \times 25 \times 7}{22}$$

= 238.6 r.p.m.

The spindle speed should be set nearest to the calculated r.p.m., on the lower side.

Example 2

Determine the spindle speed to be set for a hard cast iron round rod of ø 40 mm using a HSS tool.

Data: The cutting speed for hard cast iron from the chart is 15 m/min.

ø = 40 mm

$$N = \frac{CS \times 1000}{\pi \times D}$$

$$= \frac{15 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{15 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{15 \times 25 \times 7}{22}$$

= 119.3 r.p.m.

The spindle speed should be set nearest to the calculated r.p.m., on the lower side.

Example 3

Calculate the spindle speed to turn a ø40 mm MS rod using a cemented carbide tool.

Data: The cutting speed recommended for-turning mild steel using a carbide tool is 92 mtr/minute.

ø of job = 40 mm

$$N = \frac{CS \times 1000}{\pi \times D}$$

$$= \frac{92 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{92 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{92 \times 25 \times 7}{22}$$

= 731.8 r.p.m.

The spindle speed should be set to the nearest calculate r.p.m.

Turning time calculation

The time factor is very important to decide the manufacturing of the component as well as to fix the incentives to the operator. If the spindle speed, feed and length of the cut are known, the time can be determined for a given cut.If the feed is 'f' and length of cut is 'l', then the total number if revolutions the job has to make for a cut is l/f. If N is the rpm, the time required for a cut is found by

$$\text{Time to turn} = \frac{\text{Length of cut} \times \text{No.of cuts}}{\text{Feed} \times \text{r.p.m}}$$

$$T = \frac{l \times n}{f \times N}$$

where 'n' is the number of cuts and 'N' is the r.p.m.

Example 1

A mild steel of ø 40 mm and 100 mm length has to be turned to ø 30 mm in one cut for full length using a HSS tool with a feed rate of 0.2 mm/rev. Determine the turning time.

$$\text{Turning time} = \frac{l \times n}{f \times N}$$

The r.p.m. for the above is calculatedHand found out as 238.6 r.p.m.

l = 100mm

f = 0.2 mm

n = 1

N = 238.6 r.p.m.

$$\text{Time} = \frac{100 \times 1}{0.2 \times 238.6}$$

$$= \frac{100 \times 10}{2 \times 238.6}$$

$$= \frac{500}{238.6}$$

= 2.09 minutes

2 minute 5.4 seconds.

Cutting speed and RPM

Objectives : At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and r.p.m.**
- **determine r.p.m. spindle speed**
- **select r.p.m. for drill sizes from tables.**

For a drill to give satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the r.p.m., at which a drill has to be driven, is determined.

Calculating r.p.m.

$$v = \frac{n \times d \times \pi}{1000} \text{ m/min}$$

Materials being drilled for HSS	Cutting speed(m/min)
Aluminium	70-100
Brass	35-50
Bronze(phosphor)	20-35
Cast iron (grey)	25-40
Copper	35-45
Steel (medium carbon /mild steel)	20-30
Steel (alloy, high tensile)	5-8
Thermosetting plastic (low speed due to abrasive properties)	20-30

$$n = \frac{v \times 1000}{d \times \pi} \text{ r.p.m.}$$

n - r.p.m.

v - Cutting speed in m/min.

d - diameter of the drill in mm

π = 3.14

Example

Calculate the r.p.m. for a high speed steel drill Ø 24 mm to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ r.p.m.}$$

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed is 300 r.p.m.

The r.p.m. will differ according to the diameter of drills. The cutting speed being the same, larger diameter drills will have lesser r.p.m. and smaller diameter drills will have higher r.p.m.

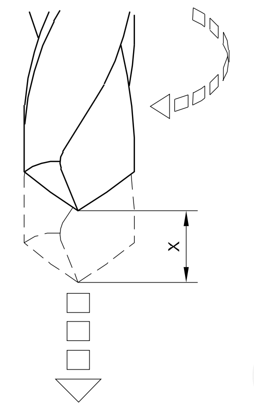
The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

Objectives : At the end of this lesson you shall be able to
- **state what is meant by feed**
- **state the factors that contribute to an efficient feed rate.**

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)

Fig 1



Feed is expressed in hundredths of a millimetre.

Example - 0.040mm.

The rate of feed is dependent upon a number of factors.

- Finish required
- Type of drill (drill material)
- Material to be drilled

Factors like rigidity of the machine, holding of workpiece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.

Table 1

Drill diameter	Rate of feed
(mm) H.S.S.	(mm/rev)
1.0 - 2.5	0.040-0.060
2.6 - 4.5	0.050-0.100
4.6 - 6.0	0.075-0.150
6.1 - 9.0	0.100-0.200
9.1 -12.0	0.150-0.250
12.1 -15.1	0.200-0.300
15.1 -18.0	0.230-0.330
18.1 -21.0	0.260-0.360
21.1 -25.0	0.280-0.380

Types of micrometer

Objectives : At the end of this lesson you shall be able to
- **name the different types of micrometers other than regular micrometers**
- **state the specific use of each micrometer.**

In addition to regular micrometers, there are several other types of micrometers, with the same fundamental principle, but specifically designed to meet the various special applications, such as external, internal, depth measurement etc.

Types of micrometers other than regular

Screw thread micrometer

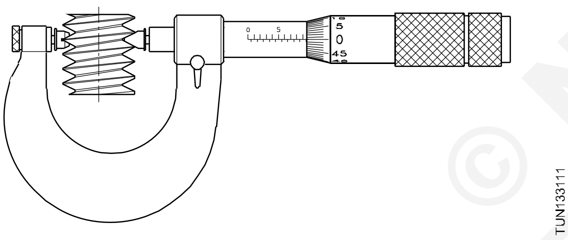
Tube micrometer	Digital micrometer
Depth micrometer	Flange micrometer
Ball micrometer	Stick micrometer

External micrometer with interchangeable anvils

Keyway depth micrometer

Screw thread micrometer (Fig 1)

Fig 1



A screw thread micrometer is similar to an outside micrometer except that the spindle is pointed to fit between 60° V threads, and the anvil is shaped to fit over 60° V thread. It is used to measure the pitch diameter of the thread. Screw thread micrometers are available in many sizes depending on the pitch of the thread to be measured.

Tube micrometer (Fig 2)

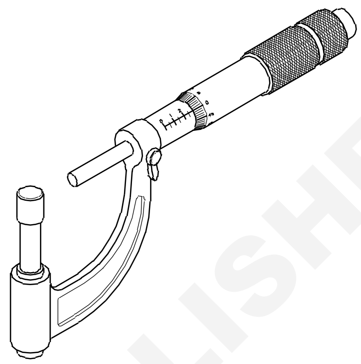
A tube micrometer is specially designed to measure the thickness of the material of piping, tubing and and other parts of similar shapes.

Digital micrometer

This type of micrometer has got a dial on the frame of the micrometer and an illuminated screen below it. The dial pointer has an internal connection with the micrometer screw for measuring. The graduations on the sleeve and thimble are the same as on a regular micrometer. This micrometer is used to measure the dimensions similar to those measured by the outside micrometers, and the reading can be noted. (Fig 3)

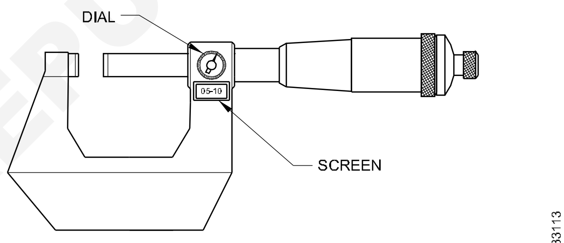
The advantage of this micrometer is, the readings are seen on the screen or the dial directly, without any diffi-culty. We need not look on the sleeve or the thimble scale coincidence. This avoids errors in reading and saves time. A layman can also read the measurement directly.

Fig 2



TUBE MICROMETER

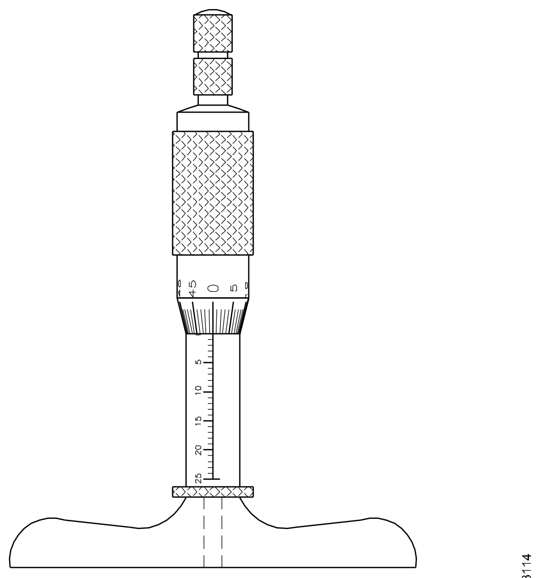
Fig 3



DIGITAL MICROMETER

Depth micrometer (Fig 4)

Fig 4

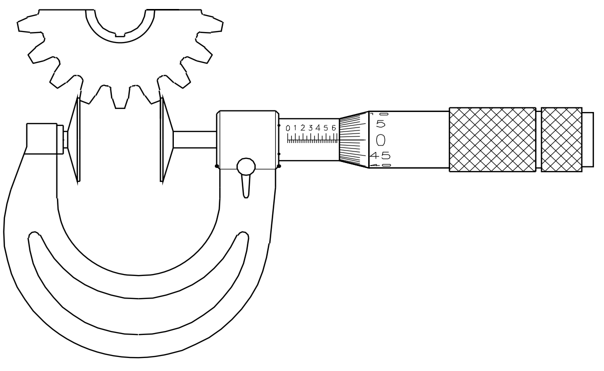


DEPTH MICROMETER

A depth micrometer is designed to measure accurately the depth of grooves, bores, counterbores, recesses and holes. The graduations are read in the same manner as is done in the case of regular micrometers. Larger ranges of depth can be measured by inserting an extension rod through the top of the micrometer. The graduations are in the reversed direction to those of an o/s micrometer.

Flange micrometer (Fig 5)

Fig 5



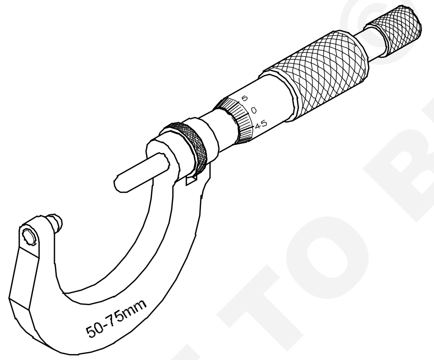
FLANGE MICROMETER

TUN133115

A flange micrometer is similar to a regular micrometer and is equipped with two flanges in the place of the anvil and spindle. This is used to measure chordal thickness of the gear teeth and the thickness of the fins of an engine and the collar thickness of the job.

Ball micrometer (Fig 6)

Fig 6



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In this form of micrometer, hemispherical balls are fitted at the anvil and spindle. Measurement is similar to that in a regular micrometer. It is used to measure a sphere where the point of contact comes in between.

Stick micrometer

Stick micrometers are designed for the measurement of longer internal lengths.

This comprises of:

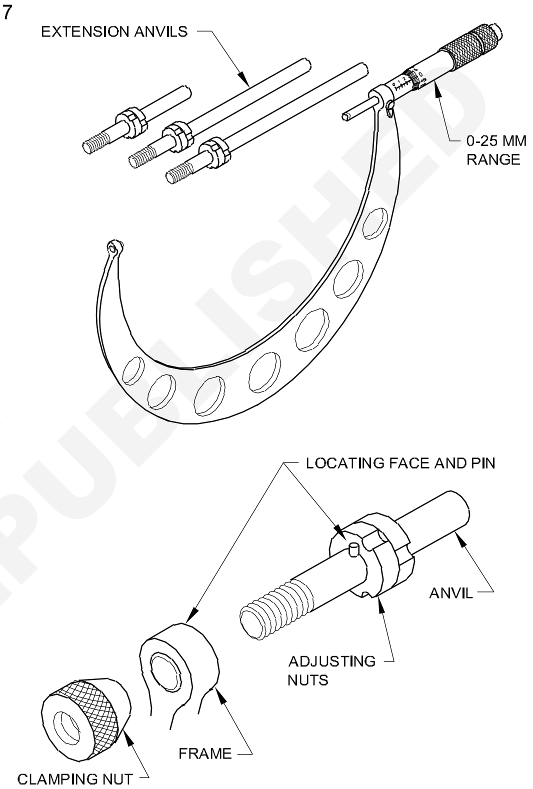
- a 150 mm or 300 mm micrometer unit, fitted with a micrometer of 25 mm range and having rounded terminal faces
- a series of extension rods, which together with the micrometer unit, permits a continuous range of measurement up to the maximum length required.

Secured joints are used for joining the end piece, extension rod and the measuring unit. The screw unit generally has threads of 0.5 mm pitch. The extension rod is generally hollow and has a minimum external diameter of 14 mm.

In this type of micrometer, there should be sufficient play between the external and internal threads of the joint to permit the abutment forces of the various parts of the micrometer to butt together solidly.

External micrometer with interchangeable anvils (Fig 7)

Fig 7



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It is nothing but an external micrometer. The advantage in this micrometer is the range of the micrometer can be increased by merely changing the different anvils.

A set of replaceable anvils is supplied in a box and the size of the anvil is marked on each anvil. Depending upon the size of the job, the anvil size can be changed, and reading can be taken. Thus it is an economy micrometer, i.e. in one micrometer itself, long ranges can be accommodated. To fix the anvils to the frame, a guide is provided and locked by a nut.

Keyway depth micrometer

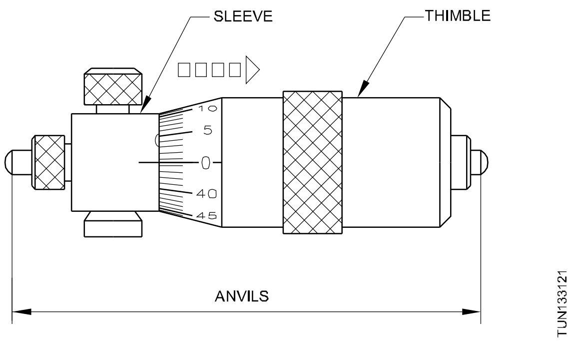
It is similar to a depth micrometer except that the frame has 120° inclined butting surfaces to rest on the circumference on a cylindrical job. It is used for measuring depth of keyways on a cylindrical shaft. While measuring the depth of the keyway, first take the measurement on a cylindrical job opposite to the keyway; then take the measurement of the keyway depth, subtract the initial measurement from the final measurement to know the exact depth of the keyway.

Inside micrometer - metric

Objectives : At the end of this lesson you shall be able to
- **name the parts of an inside micrometer**
- **determine the reading of the bore or hole**
- **determine the reading with a spacing collar & extension rods**
- **determine the distance between internal parallel surfaces.**

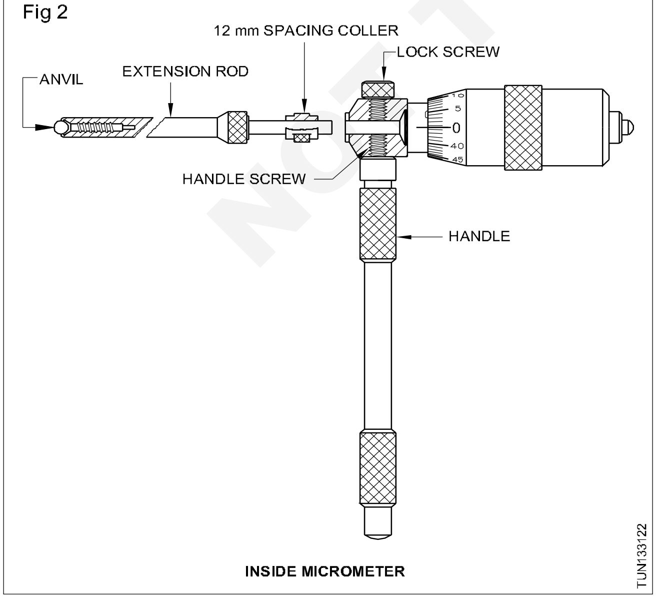
The inside micrometer is similar to an ordinary outside micrometer but without the 'U' frame. (Fig 1) The measurement is taken over the contact points. As the thimble opens or closes, the contact points get opened or closed. The inside micrometer consists of a sleeve, thimble, anvils, a spacing collar and extension rods. It is also equipped with a handle to measure deep bores. The least count of the instrument is also 0.01 mm

Fig 1



The inside micrometer is equipped with a 12mm spacing collar and 4 extension rods for measuring holes of ranges. 50-75mm, 75-100 mm, 100-125mm and 125-150mm. The sleeve is marked with the main scale and the thimble with the thimble scale. The barrel has a limited adjustment of 13mm. when the inside micrometer is closed (when zero of thimble coincides with the zero of the barrel), it is capable of reading the minimum dimension of 25mm. In addition to this, it is possible to read up to 38mm with the thimble opening to the extreme right. In order to read further higher ranges, a standard spacing collar of 12mm width is to be added. This facilitates the micrometer to read a minimum range of 50mm (Fig 2).

Fig 2



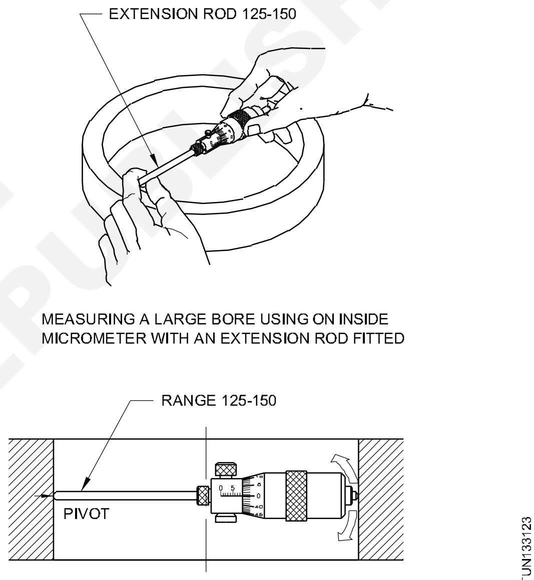
INSIDE MICROMETER

Similarly, each extension rod has to be used without the collar for measuring a minimum range up to 13mm variation and with the collar for a maximum range of measurements. a clamping screw is also provided to clamp the extension rod firmly.

Determining the size of a bore or hole

Fig 3 shows an inside micrometer with a spacing collar and extension rod of 125-150mm range. The size of the bore is 125mm + 12mm + barrel reading + thimble reading which is equal to 125 + 12 + 1.5 + 0.00 = 138.50mm.

Fig 3

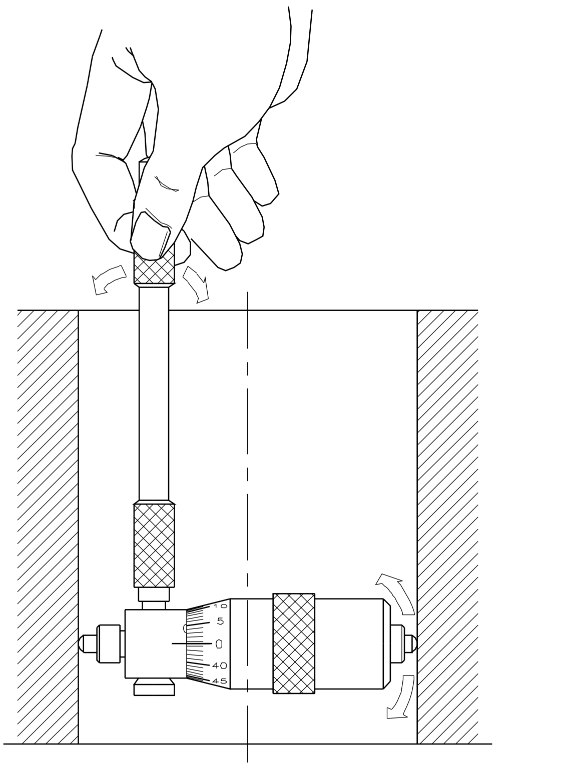


MEASURING A LARGE BORE USING ON INSIDE MICROMETER WITH AN EXTENSION ROD FITTED

Determining the distance between internal parallel surfaces

While checking parallelism between two surfaces of a deep bore, a handle must be used along with the inside micrometer. The figure shows the inside micrometer with a handle. In order to ascertain the parallelism., a minimum of two readings has to be taken, i.e. one at the top surface of the bore. If there is no difference in the two readings, we may take it for granted that the surfaces are perfectly parallel. Any variation in the reading shows the bore has an error between the two surfaces. (Fig 4)

Fig 4



USING AN EXTENDED HANDLE WHEN MEASURING THE BORE OF A SLEEVE BEARING

Three-point internal micrometer

Objectives : At the end of this lesson you shall be able to
- **state the uses of a three-point internal micrometer**
- **identify the parts of a three-point micrometer**
- **state the features of a three-point micrometer.**

Three point internal micrometer

A three-point internal micrometer is used for a direct measurement of an internal diameter accurately and efficiently. It is also used to measure the diameter of a deep hole, the end of a blind hole, internal recess etc.

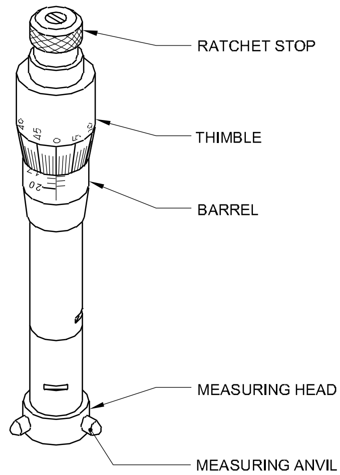
The instrument is checked for its zero error with a master ring gauge.

The three-point internal micrometer (Fig 1) is useful for :

- measuring the diameters of through and blind holes
- checking cylindricity and roundness of bores.

The commonly used three-point internal micrometers have a least count of .005mm

Fig 1



Parts

- The measuring head (consisting of three measuring anvils)
- Ratchet stop
- Thimble
- Barrel

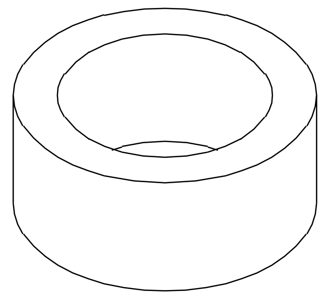
This micrometer has a cone spindle which advances when the thimble is rotated clockwise. The movement of the cone spindle makes the measuring anvils to move forward and backward uniformly. The three measuring anvils facilitate self-alignment of the instrument within the bore.

Three-point internal micrometers are available in sets. Each set consists of 3 or 4 micrometers. The measuring range of each of them will be 10mm.

The ratchet stop permits uniform pressure between the anvils and the work surfaces being measured.

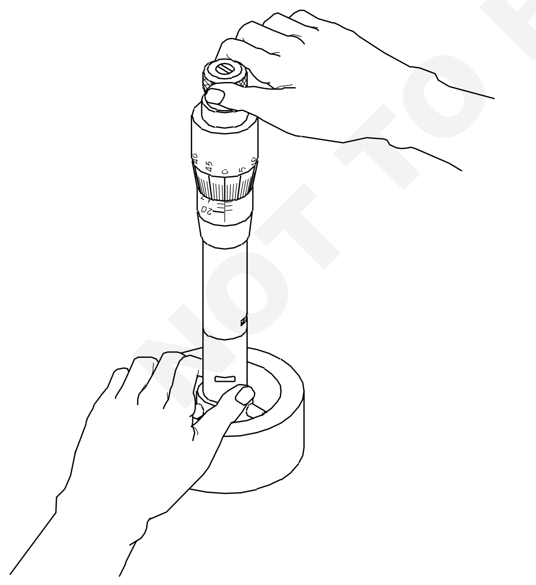
These micrometers are provided with one or more zero setting rings. (Fig 2)

Fig 2



Before taking measurement, the zero setting has to be checked using the setting ring. (Fig 3)

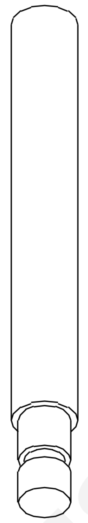
Fig 3



The position of the anvil can be reset by loosening the barrel using a screw driver provided for this purpose.

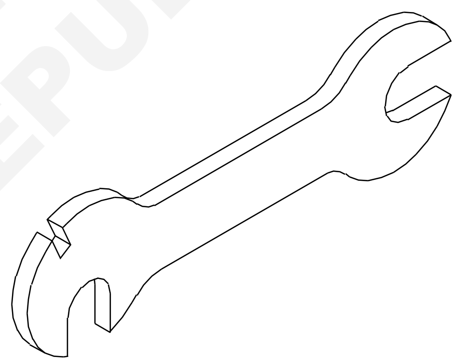
Depending on the depth of the bore the length of the micrometer can be varied using the extension rod. (Fig 4)

Fig 4



A set of spanners is provided for assembling and disassembling the extension rod. (Fig 5)

Fig 5



The instruments are available in various sizes and forms for measuring different sizes.

They are also available in analogue or digital readouts.

Sources of measuring errors

Objectives : At the end of this lesson you shall be able to
- **state what is meant by measuring errors**
- **name the different types of measuring errors**
- **identify each of the measuring errors.**

Measuring errors occur each time when we measure a workpiece. We must, therefore, always allow for a certain inaccuracy when we measure a workpiece. The degree of this inaccuracy depends on the skill of the person measuring it and the inaccuracy of the measuring instrument.

Measuring errors can be grouped as follows.

- Systematic errors
- Random errors
- Geometrical errors
- Contact errors
- Gauge and instrument errors
- Elastic deformation
- Parallel errors
- Observation errors
- Cosine errors
- Temperature errors

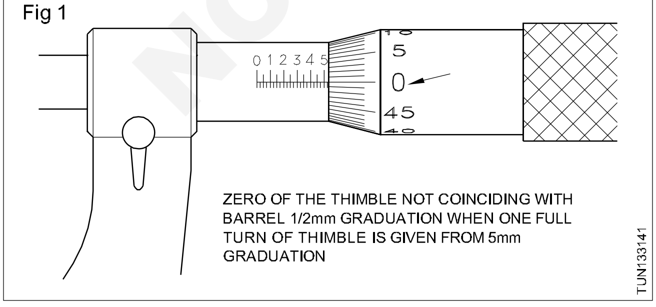
Systematic errors

Measuring errors which are due to the measuring instrument are known as systematic errors. The systematic errors can be subdivided into:

- known systematic errors
- unknown systematic errors.

The known systematic errors are those which always influence the measuring result to the same extent and in the same direction (+ or -); for example, a subdividing error for a scale as shown here. The value to be read off here can then be corrected. (Fig 1)

Fig 1



The unknown systematic errors give different values in different directions (+ and -) in different measurements. An example of this type of error is errors due to friction changes in the measuring instrument.

The result of all the unknown systematic errors is referred to as the degree of inaccuracy of the measuring device.

Random or accidental errors

Random errors are caused by external conditions, such as differences in temperature, air humidity, dirt and vibrations and also the human factor such as viewing errors and fatigue.

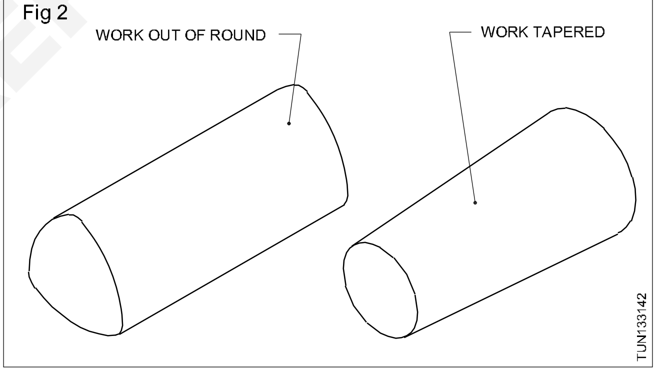
Geometric errors

Geometric errors can be subdivided into:

- macro-geometrical errors
- micro-geometrical errors.

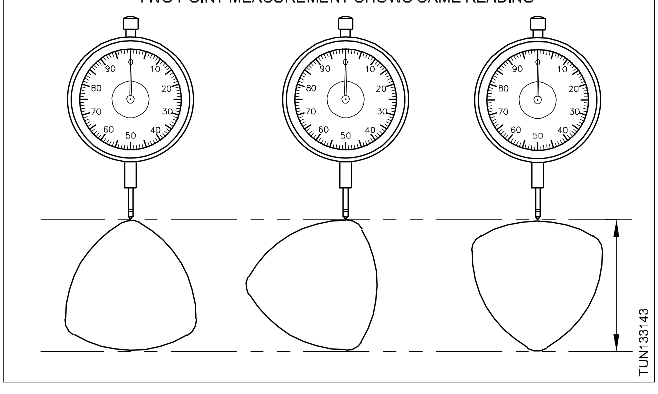
Macro-geometrical errors occur when the workpiece measured does not correspond to the theoretical form indicated in the drawing. For example, when a cylinder is tapered or out of round as shown in Fig 2, it results in a macro-geometrical error.

Fig 2



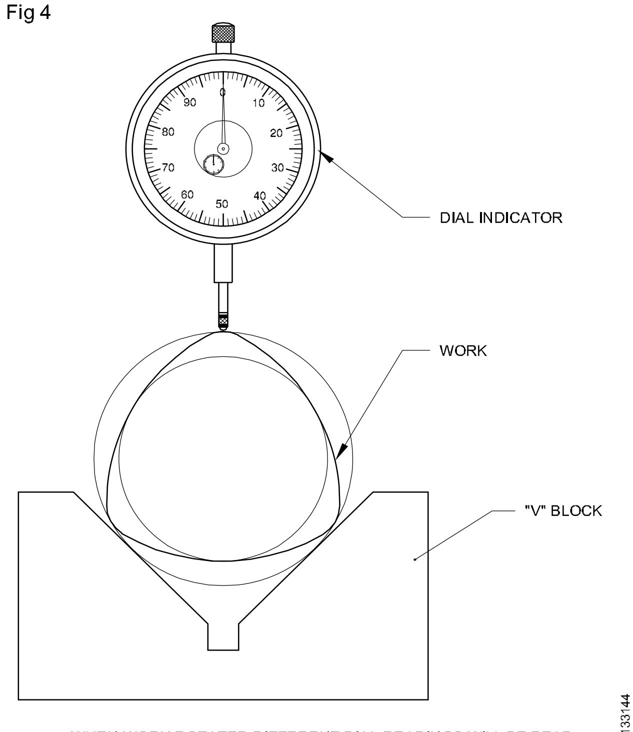
This type of error cannot be detected with the two point measurement as shown in Fig 3.

Fig 3



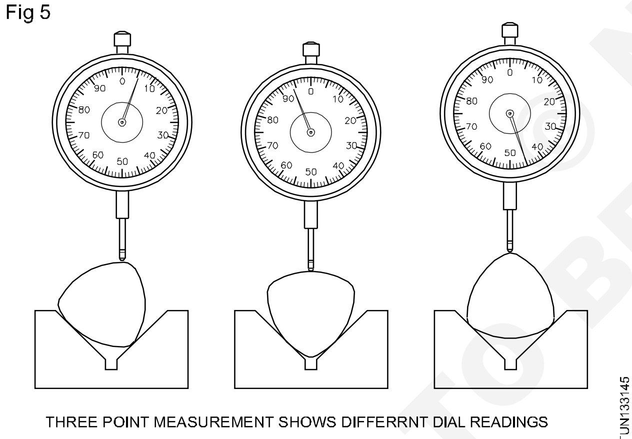
By placing the shaft on a 'V' block (three point measurement), this defect can be immediately noticed. (Figs 4 and 5)

Fig 4



WHEN WORK ROTATED DIFFERENT DIAL READINGS WILL BE READ

Fig 5



THREE POINT MEASUREMENT SHOWS DIFFERRNT DIAL READINGS

This error can also occur when measuring holes.

Micro-geometrical errors are due to surface roughness. In the case of a surface with considerable profile depth, the measuring tip could drop down in a profile recess, thereby giving a faulty reading.(Fig 6)

Contact errors: Impurities between the measuring tip and the workpiece being measured can often cause measuring errors. In order to eliminate the contact errors (considered quite serious), always keep the measuring instruments clean.

Gauge and instrument errors: In the case of the vernier caliper, the measurement is parallel but not in line with the scale. (See the distance 's' on the illustration). A play between the movable jaw and the main scale can, in this case, produce an error which could have a considerable effect on the result. (Fig 7)

Fig 6

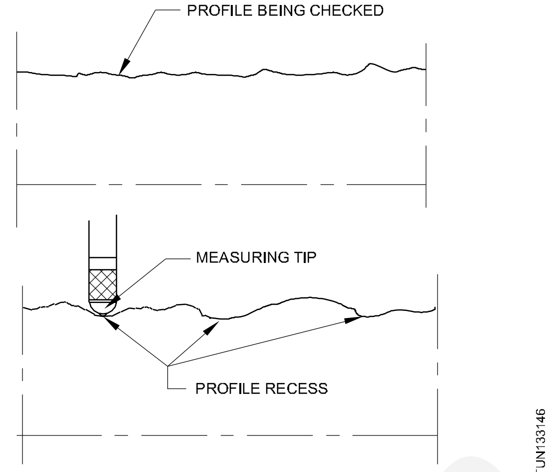
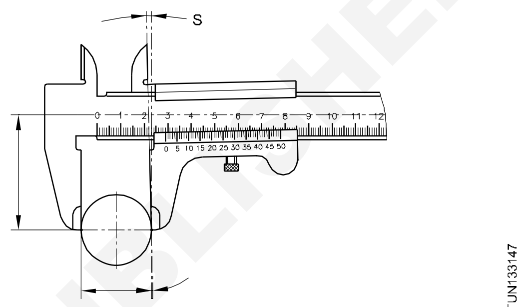
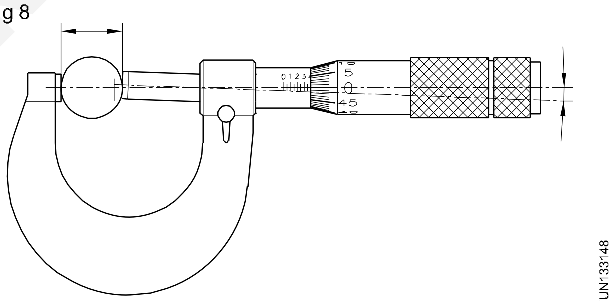


Fig 7



In the case of a micrometer an angular error is negligible but a parallel error will occur. Other errors that come under this heading are errors due to changes in friction, and backlash in measuring instruments. (Fig 8)

Fig 8

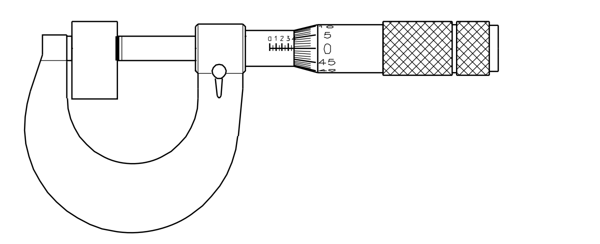


Elastic deformation: In order to keep the elastic deformation within reasonable limits, the indicator stands, measuring clamps and measuring fixtures must be robustly constructed. By using a small and constant measuring force, this error can also be brought to a minimum. Eg. the ratchet drive provided in micrometers.

Parallel errors (Fig 9)

If measurement is being carried out between two flat measuring surfaces, these must be parallel to each other. If the measuring workpiece surfaces are not parallel to each other, parallel errors will result. By using a spherical measuring tip against a flat surface to be measured, parallel errors can be avoided.

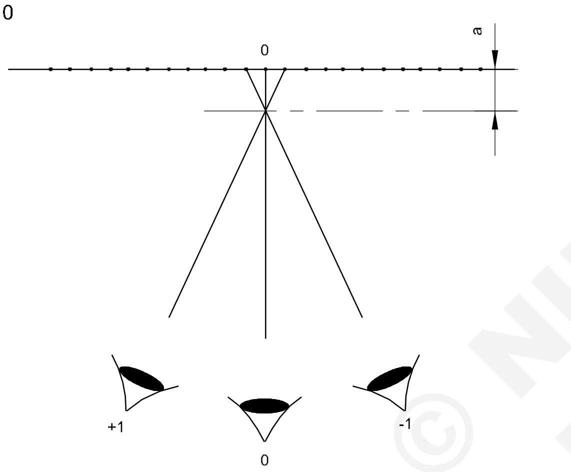
Fig 9



Observation errors (Fig 10)

Parallax errors occur in connection with the reading of scales and instruments with dial indicators. The error depends on the fact that the pointer has a certain distance 'a' from the scale. If viewed at from one side instead of from straight ahead as you should do, the pointer appears to show a larger or smaller reading.

Fig 10

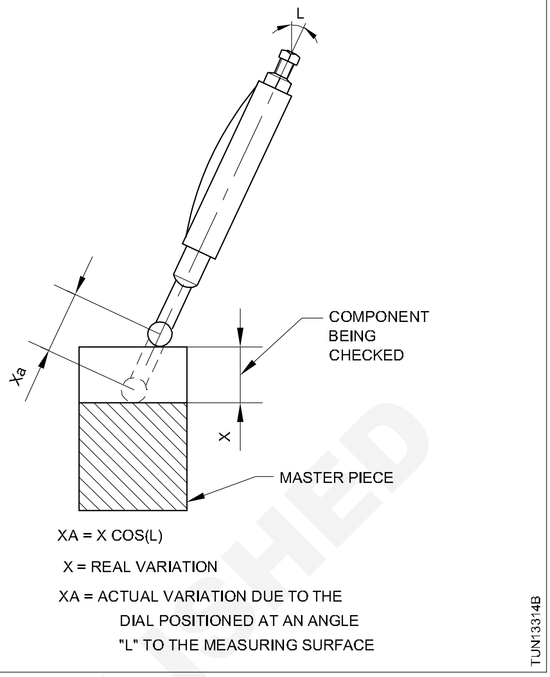


Temperature errors

The change in temperature can cause major measuring errors. For this reason 20°C has been set as the reference temperature for measurements.

Cosine errors (Fig 11)

Fig 11



A cosine error occurs when the plunger/lever of the measuring instrument is not parallel with the workpiece being measured.

It may be noted that the movement of the dial indicator hand depends on the movement of the plunger or lever.

An inclination of the plunger, as shown in the figure, would need additional movement of the plunger for a distance. X is the deviation of the component perpendicular to the surface of the work, and naturally the dial indicator will show a reading of Xa. (Xa is the plunger movement.)

Drills - different parts, types and sizes

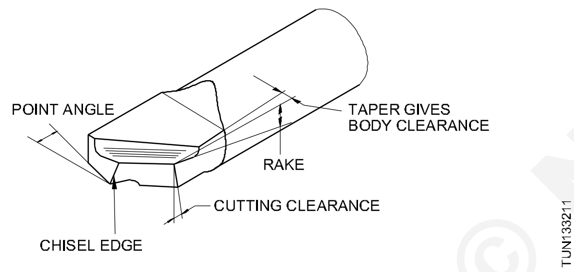
Objectives : At the end of this lesson you shall be able to
- **state what is drilling**
- **state the necessity of drilling**
- **list the types of drills used**
- **name the parts of a twist drill**
- **list the defects in a drilled hole**
- **state the causes and the remedies for the defects.**

Drilling: Drilling is the production of cylindrical holes of definite diameters in workpieces by using a multi-point cutting tool called a 'drill'. It is the first operation done internally for any further operation.

Types of drills and their specific uses

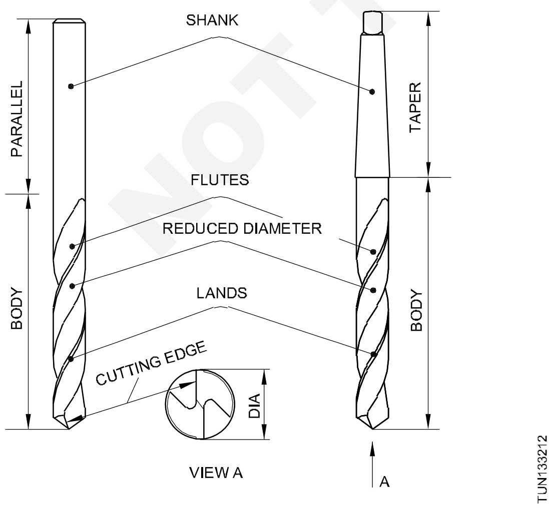
Flat drill (Fig 1): The earliest form of drill was the flat drill which is easy to operate, besides being inexpensive to produce. But it is difficult to hold during operation, and the chip removal is poor. Its operating efficiency is very low.

Fig 1



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 flutes 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 2)

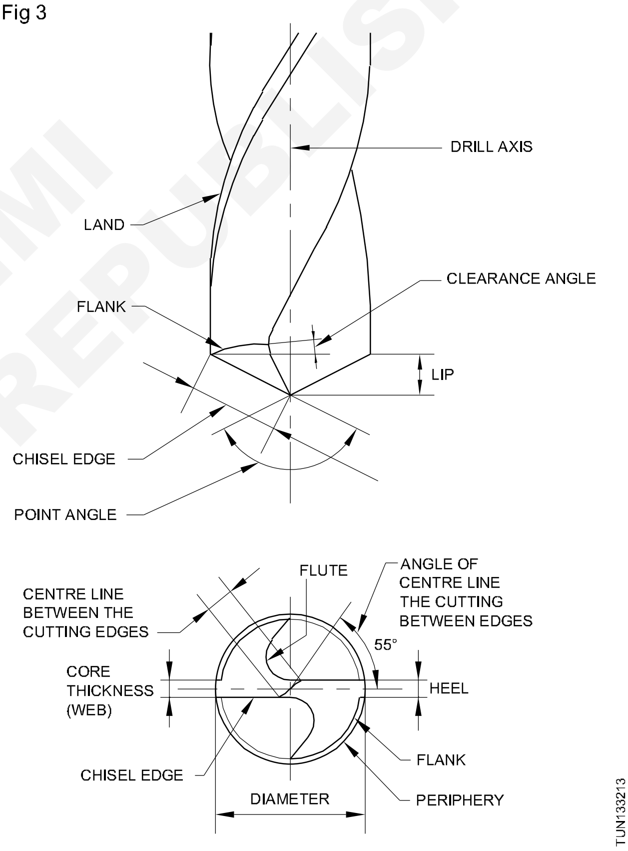
Fig 2



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 coolant to the cutting edge during drilling. (Fig 3)

Fig 3

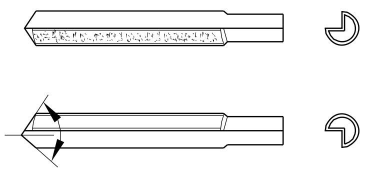


The portions left between the flutes are called 'lands'. The size of a drill is determined and governed by the diameter over the lands.

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°.

Deep hole drills: Deep hole drilling is done by using a type of drill known as 'D' bit. (Fig 4)

Fig 4



DEEP HOLE DRILL

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Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of 27 1/2°. They are used on mild steel and cast iron. (Fig 5a)

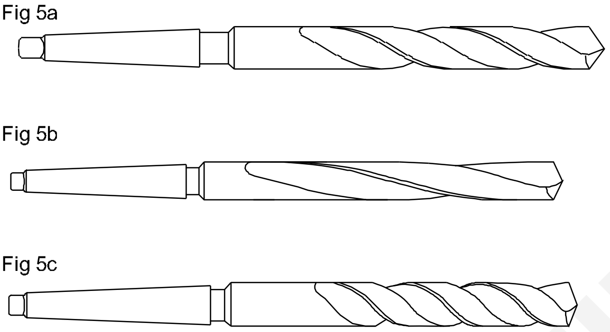
A slow helix drill is used on materials like brass, gun-metal, phosphor-bronze and plastics. (Fig 5b)

A quick helix drill is used for copper, aluminium and other soft metals. (Fig 5c)

Fig 5a

Fig 5b

Fig 5c



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> **Quick helix drill should never be used on brass as it will 'dig in' and the workpiece may be thrown from the machine table.**

Parallel shank drills can be held only in drill chucks. Taper shank twist drills are mounted directly in the tailstock barrel or fitted to a sleeve and mounted. The tang in the taper shank twist drill provides a positive drive. When inserting a taper shank twist drill in a socket or sleeve, tap the sleeve with a hide mallet. To remove the drill from the socket, a drift is used.

Factors governing drilling operations

The three factors governing drilling operations are:

- cutting speed
- feed pressure
- cooling method.

Cutting speed for drilling

The cutting speed for drilling is the peripheral speed of the drill, and it is stated in metres per minute. The cutting speed depends upon the machinability of the work material. When the cutting speed for drilling a material is determined, the revolutions for which the lathe has to be set during drilling is calculated by the formula.

$$V = \frac{\pi \times D \times N}{1000}$$

Feed

The rate at which the drill advances into the material for each revolution of the drill is known as the feed rate and it is expressed in mm/rev. The feed rate selection also depends upon the machinability of the metal being drilled:

Boring tools, counter sinking

Objectives : At the end of this lesson you shall be able to
- **identify and name the different types of boaring tools**
- **list out the advantages of the different boring tools.**

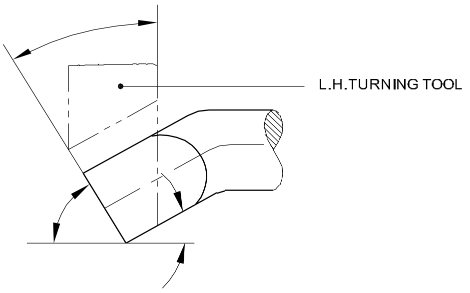
Boring is the process of enlarging and truing an existing drilled or core hole with a single point cutting tool.

Necessity of boring a hole

- To enlarge a drilled hole larger than the drill size as drills are available in standard sizes only.
- To obtain concentricity of the hole.
- To maintain accuracy of the hole.
- To obtain better surface finish.
- To remove the error formed by drilling, and to facilitate the reaming operation.

Boring tools and holders: Boring is an internal operation performed on the drilled or cored holes. The cutting edge of a boring tool is ground similar to the left hand plain turning tool. But the operation being performed is from right to left. (Fig 1)

Fig 1



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Parts of a rough boring tool (Figs 1,2 & 3)

Types of boring tools

The following are the different types of boring tools.

- Solid forged tools
- Boring bars with bits

Fig 2

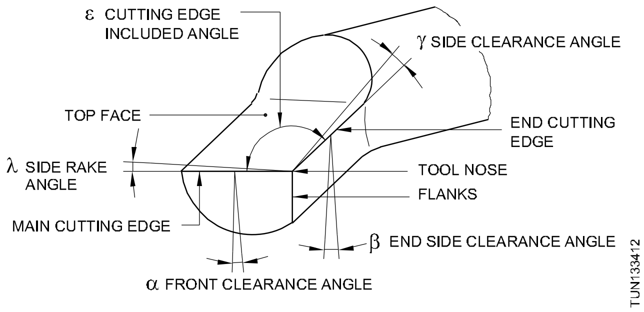
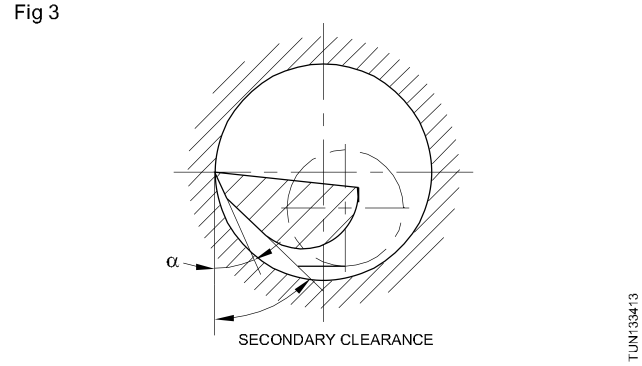
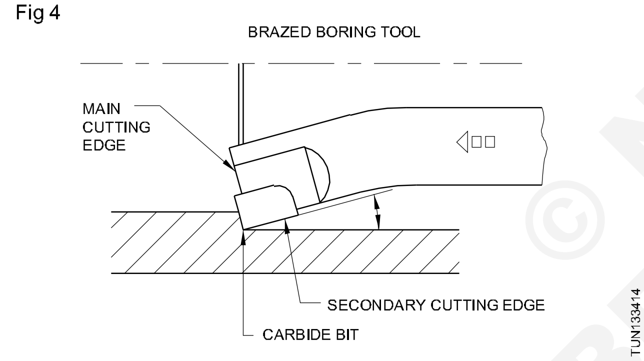


Fig 3



- Brazed tools (Fig.4)

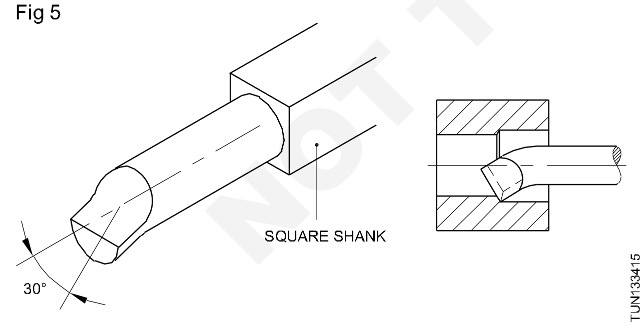
Fig 4



- Throw-away bits inserted in special holders.

Solid forged tools (Fig 5)

Fig 5

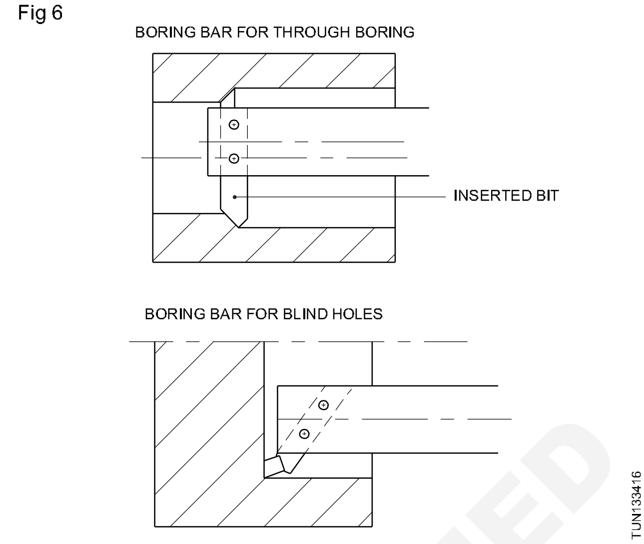


The solid forged boring tool is generally made of high speed steel, with the end forged and ground to resemble a left hand turning tool. They are light duty tools and are used on small diameter holes. They are held in special tool holders which are mounted in the tool post.

Occasionally tungsten carbide or high speed steel tips are brazed to low carbon bars, for economy.

Boring bars with inserted bit (Fig 6)

Fig 6



The boring bar tool-holder is mounted in the tool post and is used for heavier cuts than those for the forged boring tool.

The square tool bits are set at angles of 30°, 45° or 90° in the broached holes in the bar.

The boring bars may be plain type or end cap type. The cutting tool of the plain type is held in position by a set screw. The cutting tool of the end-cap type is held in position by the wedging action of a hardened plug.

The round or square section tool bits may be inserted in boring bars, the size depending on the diameter of the bar.

The tool bit may be square to the axis of the bar for plain boring or at an angle for facing shoulder, or threading up to a shoulder.

The bar is held in a split or ‘V’ block holder.

The advantages of different boring tools

Solid boring tools

Available with square and round shank.

Enables to mount on the tool post easily.

Re-grinding is easy.

As the tool is integral, alignment is easy.

Can be easily forged to the required shape and angle.

Boring bars and inserted bits

Used for heavy duty boring operation.

Used for deep boring operation.

Tool insert changing is faster, thereby re-sharpening time is insert.

Cost is less because the boring bar is made out of low carbon steel.

Boring tools can be set square to the axis of the boring bar or at an angle very quickly.

Counter sinking

Objectives: At the end of this lesson you shall be able to
- **state what is countersinking**
- **list the purpose of countersinking**
- **state the angles of countersinking for the different applications**
- **name the different types of countersinks**
- **distinguish between Type A and Type B countersink holes.**

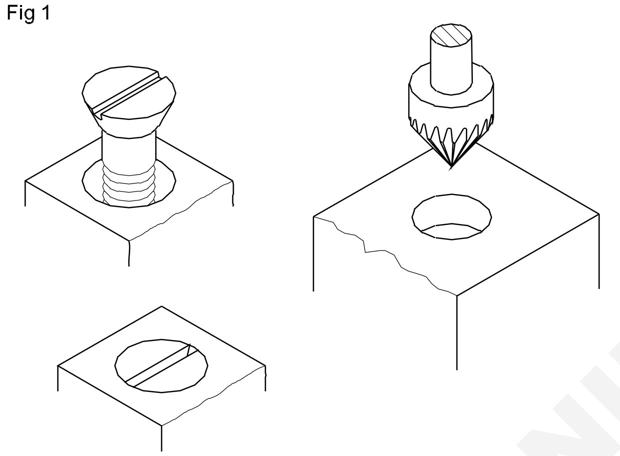
What is countersinking?

Countersinking is an operation of beveling the end of a drilled hole. The tool used is called a countersink.

Countersinking is carried out for the following purposes,

to provide a recess for the head of a countersink screw, so that it is flush with the surface after fixing. (Fig 1)

Fig 1



to deburr a hole after drilling

for accommodating countersink rivet heads

to chamfer the ends of holes for thread cutting and other machining processes.

Angles for countersinking: Countersinks are available in different angles for different uses.

75° countersink riveting

80° countersink self tapping screws

90° countersink head screws and deburring

120° chamfering ends of holes to be threaded or other machine processes.

Countersinks

Countersinks of different types are available.

The commonly used countersinks have multiple cutting edges and are available in taper shank and straight shank. (Fig 2)

For countersinking small diameter holes special counter-sinks with two or one flute are available. This will reduce the vibration while cutting.

Countersinks with pilot (Fig 3)

For precision countersinking, needed for machine tool assembling and after machining process, countersinks with pilots are used.

Fig 2

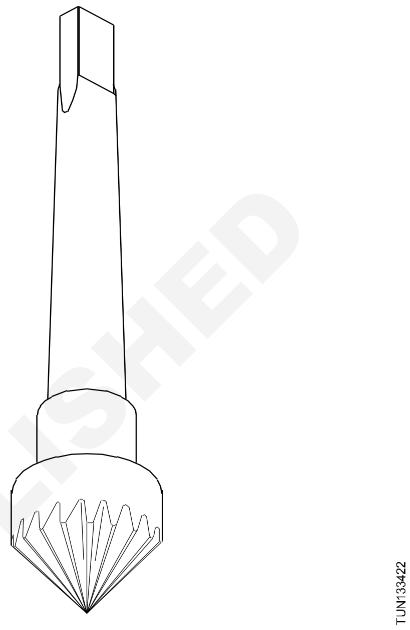
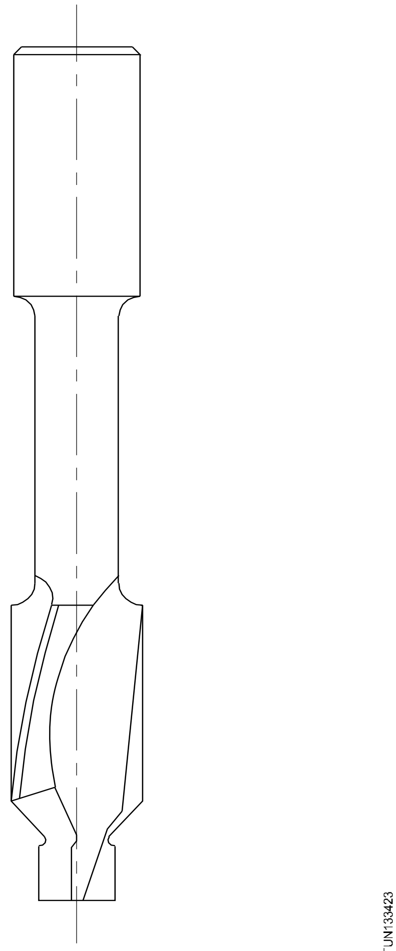


Fig 3



They are particularly useful for heavy duty work.

The pilot is provided at the end for guiding the countersink concentric to the hole.

Countersinks with pilots are available with interchange able and solid pilots.

Countersink hole sizes: The countersink holes according to Indian Standard IS 3406 (Part 1) 1986 are of four types: Type A, Type B, Type C and Type E.

Type A is suitable for slotted countersink head screws, cross recessed and slotted raised countersink head screws.

These screws are available in two grades i.e. medium and fine.

Type 'B' countersink holes are suitable for countersink head screws with hexagon socket.

Type 'C' countersink holes are suitable for slotted raised countersink (oval) head tapping screws and for slotted countersink (flat) head tapping screws.

Type 'E' countersinks are used for slotted countersink bolts used for steel structures.

Methods of Representing countersink holes in drawings: Countersink hole sizes are identified by code designation or using dimension.

Designation : A countersink Type C for screw size 2 shall be designated as - Countersink C 2 - IS : 3406.

Use of dimension

The dimension of the countersink can be expressed by diameter of the countersink and the depth of the countersink. (Figs 4 & 5)

Fig 4

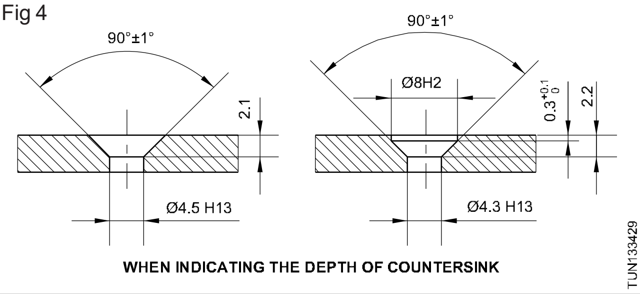
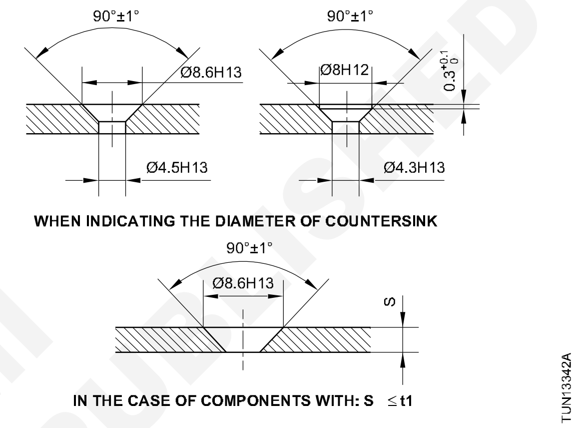


Fig 5

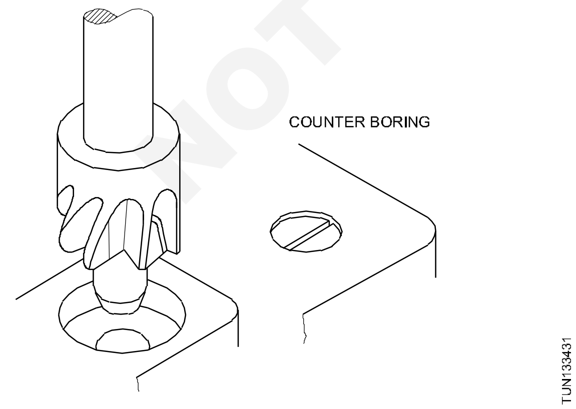


Counterboring and spot facing

Objectives: At the end of this lesson you shall be able to
- **differentiate counterboring and spot facing**
- **state the types of counterbores and their uses**
- **determine the correct counterbore sizes for different holes.**

Counterboring: Counterboring is an operation of enlarging a hole to a even depth to house heads of socket heads or cap screws with the help of a counterbore tool. (Fig 1)

Fig 1



Counterbore (Tool): The tool used for counterboring is called a counterbore. (Fig 2). Counterbores will have two or more cutting edges.

At the cutting end, a pilot is provided to guide the tool concentric to the previously drilled hole. The pilot also helps to avoid chattering while counterboring. (Fig 3)

Counterbores are available with solid pilots or with interchangeable pilots. The interchangeable pilot provides flexibility of counterboring on different diameters of holes.

Spot facing: Spot facing is a machining operation for producing a flat seat for bolt head, washer or nut at the opening of a drilled hole. The tool is called a spot facer or a spot facing tool. Spot facing is similar to counterboring, except that it is can be used for spot facing as well. (Fig 4)

Fig 2

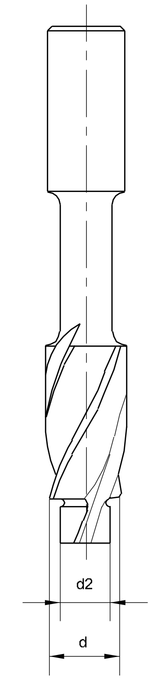


Fig 3

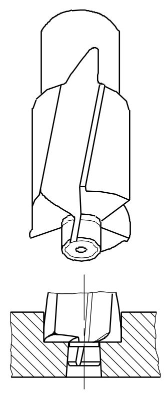
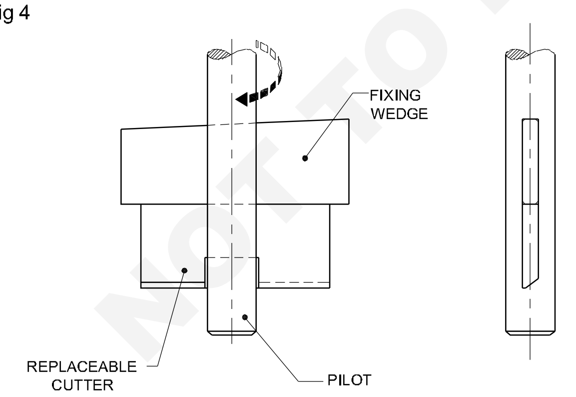
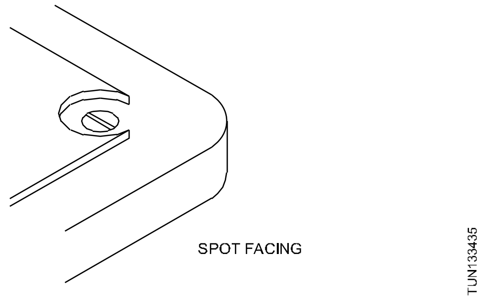


Fig 4



Spot facing is also done by fly cutters by end-cutting action. The cutter blade is inserted in the slot of the holder, which can be mounted on to the spindle. (Fig 5)

Fig 5



Counterbore sizes and specification

Counterbore sizes are standardised for each diameter of screws as per BIS.

There are two main types of counterbores. Type H and Type K.

The type H counterbores are used for assemblies with slotted cheese head, slotted pan head and cross recessed pan head screws. The type K counterbores are used in assemblies with hexagonal socket head cap-screws.

For fitting different types of washers the counterbore standards are different in Type H and Type K.

The clearance hole d1 are of two different grades i.e. medium (m) and fine (f) and are finished to H13 and H12 dimensions.

The table given below is a portion from I S 3406 (Part 2) 1986. This gives dimensions for Type H and Type K counterbores.

Counterbore and Clearance Hole Sizes for Different Sizes of Screws.

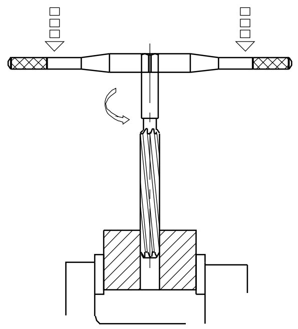
Reamers types and uses

Objectives : At the end of this lesson you shall be able to
- **state the use of reamers**
- **state the advantages of reaming**
- **distinguish between hand and machine reaming**
- **name the elements of a reamer and state their functions.**

What is a reamer?

A reamer is a multi-point cutting tool used for enlarging by finishing previously drilled holes to accurate sizes.(Fig 1)

Fig 1



Advantages of 'reaming'

Reaming produces

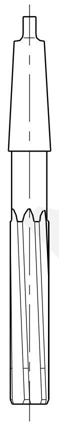
- high quality surface finish
- dimensional accuracy to close limits.

Also small holes which cannot be finished by other processes can be finished.

Classification of reamers

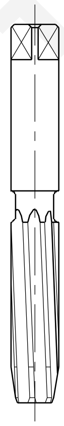
Reamers are classified as hand reamers and machine reamers. (Figs 2 and 3)

Fig 2



MACHINE REAMER

Fig 3



HAND REAMER

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Reaming by using hand reamers is done manually for which great skill is needed.

Machine reamers are fitted on spindles of machine tools and rotated for reaming.

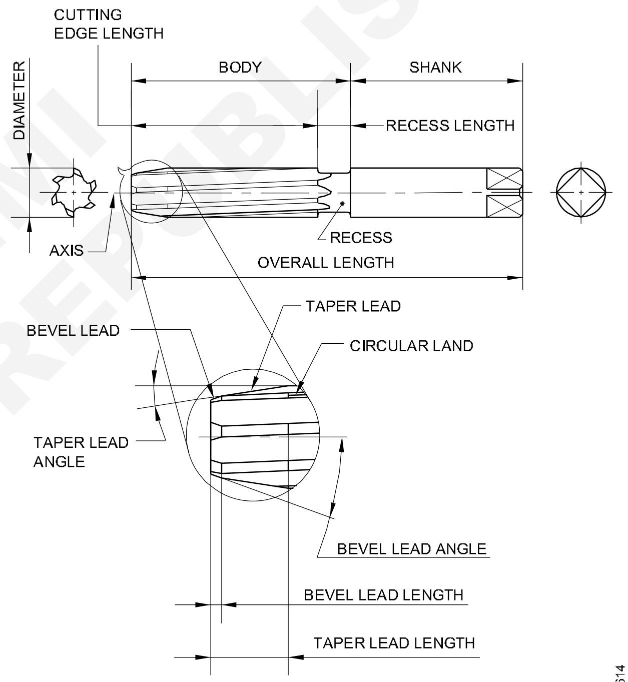
Machine reamers are provided with morse taper shanks for holding on machine spindles.

Hand reamers have straight shanks with 'square' at the end, for holding with tap wrenches. (Figs 2 & 3)

Parts of a hand reamer

The parts of a hand reamer are listed hereunder. Refer to Fig 4.

Fig 4



Axis

The longitudinal centre line of the reamer.

Body

The portion of the reamer extending from the entering end of the reamer to the commencement.

Recess

The portion of the body which is reduced in diameter below the cutting edges, pilot or guide diameters.

Shank

The portion of the reamer which is held and driven. It can be parallel or tapered.

Circular land

The cylindrically ground surface adjacent to the cutting edge on the leading edge of the land.

Bevel lead

The bevel lead cutting portion at the entering end of the reamer cutting its way into the hold. It is not provided with a circular land.

Taper lead

The tapered cutting portion at the entering end to facilitate cutting and finishing of the hole. It is not provided with a circular land.

Bevel lead angle

The angle formed by the cutting edges of the bevel lead and the reamer axis.

Taper lead angle

The angle formed by the cutting edges of the taper and the reamer axis.

Terms relating to cutting geometry flutes

The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips, and to allow the cutting fluid to reach the cutting edges. (Fig 5)

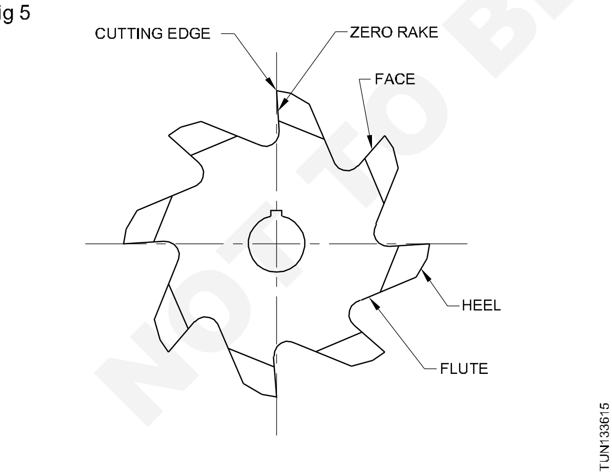
Heel

The edge formed by the intersection of the surface left by the provision of a secondary clearance and the flute. (Fig 5)

Cutting edge

The edge formed by the intersection of the face and the circular land or the surface left by the provision of primary clearance. (Fig 5)

Fig 5



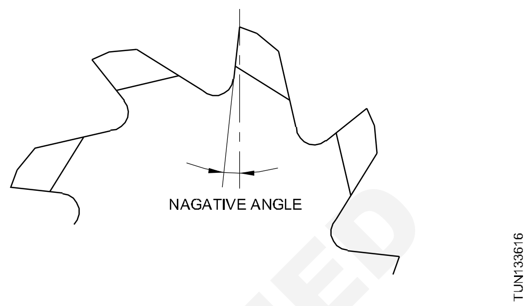
Face

The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work. (Fig 5)

Rake angles

The angles in a diametric plane formed by the face and a radial line from the cutting edge. (Fig 6)

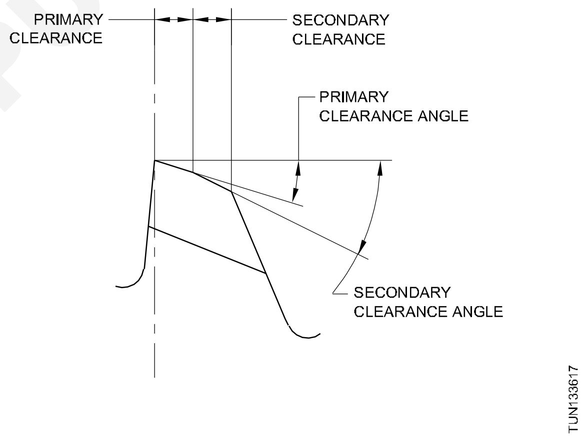
Fig 6



Clearance angle

The angles formed by the primary or secondary clearances and the tangent to the periphery of the reamer at the cutting edge. They are called primary clearance angle and secondary clearance angle respectively. (Fig 7)

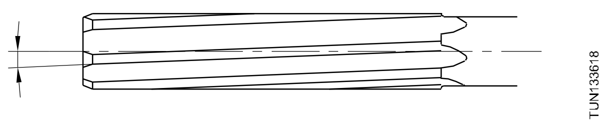
Fig 7



Helix angle

The angle between the edge and the reamer axis. (Fig 8)

Fig 8

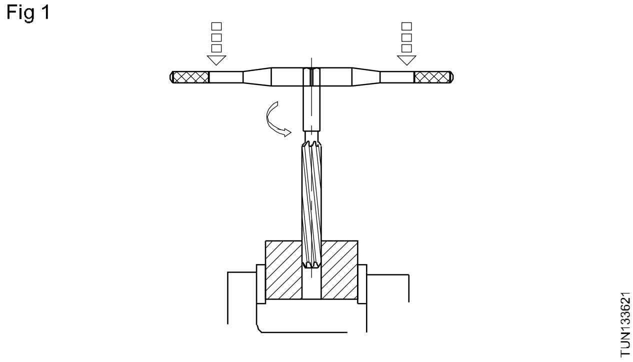


Hand reamers

Objectives : At the end of this lesson you shall be able to
- **state the general features of hand reamers**
- **identify the types of hand reamers**
- **distinguish between the uses of straight fluted and helical fluted reamers**
- **name the materials from which reamers are made and specify reamers.**

General features of hand reamers (Fig 1)

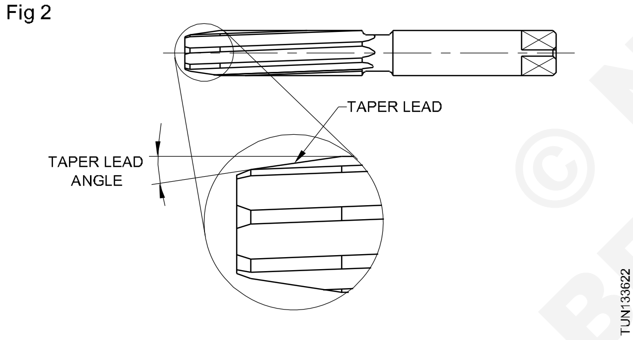
Fig 1



Hand reamers are used to ream holes manually using tap wrenches.

These reamers have a long taper lead.(Fig 2) This allows to start the reamer straight and in alignment with the hole being reamed.

Fig 2

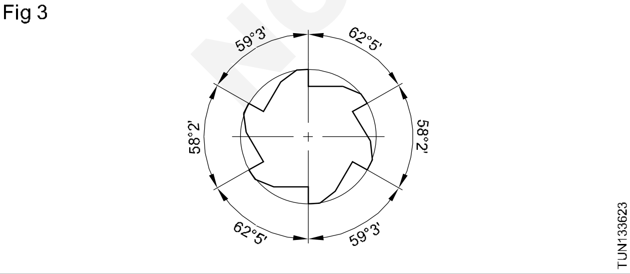


Most hand reamers are for right hand cutting.

Helical fluted hand reamers have left hand helix. The left hand helix will produce smooth cutting action and finish.

Most reamers, machine or hand, have uneven spacing of teeth. This feature of reamers helps to reduce chattering while reaming. (Fig 3)

Fig 3



Types, features and functions

Hand reamers with different features are available for meeting different reaming conditions. The commonly used types are listed here under.

Parallel hand reamer with parallel shank (Fig 4)

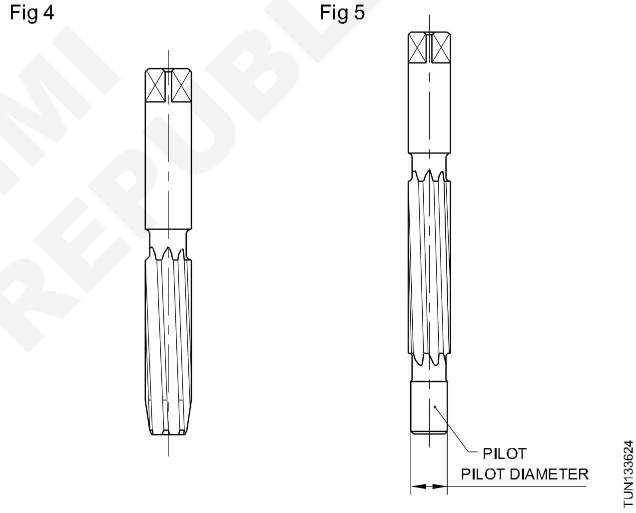
A reamer which has virtually parallel cutting edges with taper and bevel lead. The body of the reamer is integral with a shank. The shank has the nominal diameter of the cutting edges. One end of the shank is square shaped for tuning it with a tap wrench. Parallel reamers are available with straight and helical flutes. This is the commonly used hand reamer for reaming holes with parallel sides.

Reamers commonly used in workshop produce H8 holes.

Hand reamer with pilot (Fig 5)

For this type of reamer, a portion of the body is cylindrically ground to form a pilot at the entering end. The pilot keeps the reamer concentric with the hole being reamed.(Fig 3)

Fig 4 Fig 5



Socket reamer with parallel shank (Figs 6 and 7)

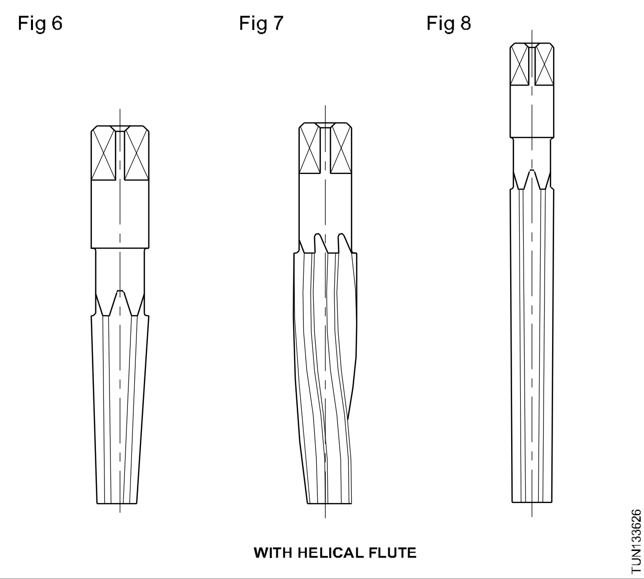
This reamer has tapered cutting edges to suit metric morse tapers. The shank is integral with the body, and is square shaped for driving. The flutes are either straight or helical. The socket reamer is used for reaming internal morse tapered holes.

Taper pin hand reamer (Fig 8)

This reamer has tapered cutting edges for reaming taper holes to suit taper pins. A taper pin reamer is made with a taper pin of 1 in 50. These reamers are available with straight or helical flutes.

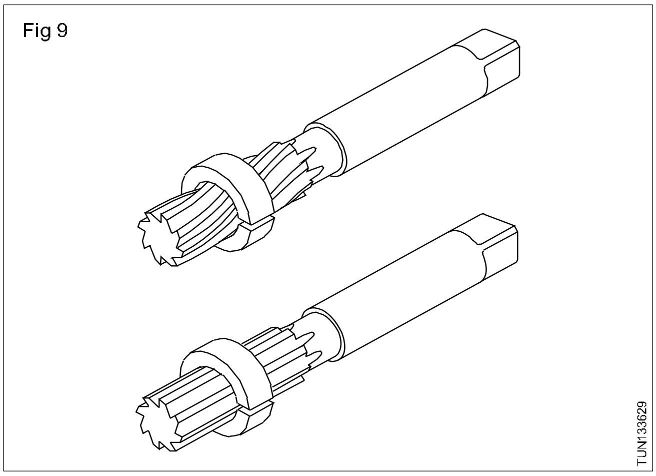
Use of straight and helical fluted reamers (Fig 9)

Straight fluted reamers are useful for general reaming work. Helical fluted reamers are particularly suitable for reaming holes with keyway grooves or special lines cut into them. The helical flutes will bridge the gap and reduce binding and chattering.



Material of hand reamers

When the reamers are made as a one-piece construction, high speed steel is used. When they are made as two-piece construction then the cutting portion is made of high speed steel while the shank portion is made of carbon steel. They are butt-welded together before manufacturing.



Specifications of a reamer

To specify a reamer the following data is to be given.

- Type
- Flute
- Shank end
- Size

Example

Hand reamer, straight flute, parallel shank of Ø 20 mm.

Drill size for reaming

Objectives : At the end of this lesson you shall be able to
- **determine the hole size for reaming.**

For reaming with a hand or a machine reamer, the hole drilled should be smaller than the reamer size.

The drilled hole should have sufficient metal for finishing with the reamer. Excessive metal will impose a strain on the cutting edge of the reamer and damage it.

Calculating drill size for reamer

A method generally practised in workshop is by applying the following formula.

Drill size = Reamed size – (Undersize + Oversize)

Finished size

Finished size is the diameter of the reamer.

Undersize

Undersize is the recommended reduction in size for different ranges of drill diameter. (See Table 1)

TABLE 1

Undersizes for reaming

Diameter of ready reamed hole (mm)	Undersize of rough bored hole (mm)
under 5	0.1.....0.2
5......20	0.2.....0.3
21....50	0.3.....0.5
over 50	0.5.....1

Oversize

It is generally considered that a twist drill will make a hole larger than its diameter. The oversize for calculation purposes is taken as 0.05 mm - for all diameters of drills. For light metals the undersize will be chosen 50% larger.

Example

A hole is to be reamed on mild steel with a 10 mm reamer. What will be the diameter of the drill for drilling the hole before reaming?

Drill size = Reamed size – (Undersize + Oversize)

(Reamed size)	=	10 mm
Undersize as per table	=	0.2 mm
Oversize	=	0.05 mm
Drill size	=	10 mm – 0.25 mm
	=	9.75 mm

Determine the drill hole sizes for the following reamers:

i 15 mm

ii 4 mm

iii 40 mm

iv 19 mm.

Answer

i ________________________________

ii ________________________________

iii ________________________________

iv ________________________________

Note

> **If the reamed hole is undersize, the cause is that the reamer is worn out.**

Always inspect the condition of the reamer before commencing reaming.

For obtaining good surface finish

> **Use a coolant while reaming. Remove metal chips from the reamer frequently. Advance the reamer slowly into the work.**

Defects in reaming - Causes and remedies

Reamed hole undersize

If a worn out reamer is used, it may result in the reamed hole being undersize. Do not use such reamers.

Always inspect the condition of the reamer before using.

Surface finish rough

The causes may be any one of the following or a combination thereof.

- Incorrect application
- Swarf accumulated in reamer flutes
- Inadequate flow of coolant
- Feed rate too fast

While reaming apply a steady and slow feed-rate.

Ensure a copious supply of the coolant.

Do not turn the reamer in the reverse direction.

Letter and number drills

Objectives: At the end of this lesson you shall be able to
- **state the range of drill sizes in number and letter drill series**
- **determine the number and letter drills for given diameters referring to the chart**
- **state the core drill.**

Generally drills are manufactured to standard sizes in the metric system. These drills are available in specified steps. The drills, which are not covered under the above category, are manufactured in number and letter drills. These drills are used where odd sizes of holes are to be drilled.

Letter drills

The letter drill series consists of drill sizes from 'A' to 'Z'. The letter 'A' drill is the smallest with 5.944 mm diameter, and the letter 'Z' is the largest, with a 10.490 mm diameter. (Table 1)

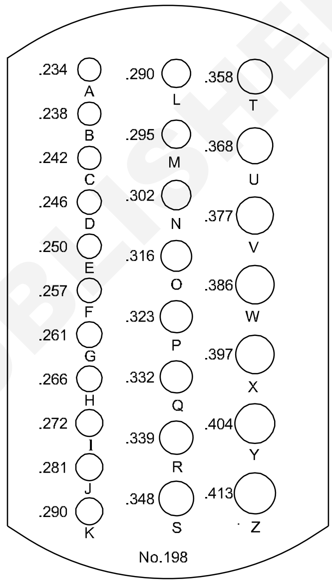
TABLE 1

Letter drill sizes

Letter	Diameter	
	Inches	mm
A	.234	5.944
B	.238	6.045
C	.242	6.147
D	.246	6.248
E	.250	6.35
F	.257	6.528
G	.261	6.629
H	.266	6.756
I	.272	6.909
J	.277	7.036
K	.281	7.137
L	.290	7.366
M	.295	7.493
N	.302	7.671
O	.316	8.026
P	.323	8.204
Q	.332	8.433
R	.339	8.611
S	.348	8.839
T	.358	9.093
U	.368	9.347
V	.377	9.576
W	.386	9.804
X	.397	10.084
Y	.404	10.262
Z	.413	10.490

In the number drill and the letter drill series, the correct diameter of the drill is gauged with the help of the respective drill gauges. A drill gauge is a rectangular or square shaped metal piece containing a number of different diameter holes. The size of the hole is stamped against each hole. (Fig 1)

Fig 1



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Number drills

The number drill series consists of drills numbered from 1 to 80. The No.1 drill is the largest, with 5.791 mm diameter, and the No.80 drill is the smallest, with 0.35 mm diameter. (Table 2) There is no uniform variation in the drill diameters from number to number. To find the correct diameter of a number drill, refer to a drill Size Chart or a Handbook. Number drill series are also known as 'wire gauge' series.

TABLE 2

Number drill sizes

No.	Diameter	
	Inches	mm
1	.228	5.791
2	.221	5.613
3	.213	5.410
4	.209	5.309
5	.2055	5.220
6	.204	5.182

Number drill sizes (contd)

No.	Diameter	
	Inches	mm
7	.201	5.105
8	.199	5.055
9	.196	4.978
10	.1935	4.915
11	.191	4.851
12	.189	4.801
13	.185	4.699
14	.182	4.623
15	.180	4.572
16	.177	4.496
17	.173	4.394
18	.1695	4.305
19	.166	4.216
20	.161	4.089
21	.159	4.039
22	.157	3.988
23	.154	3.912
24	.152	3.861
25	.1495	3.797
26	.147	3.734
27	.144	3.658
28	.1405	3.569
29	.136	3.454
30	.1285	3.264
31	.120	3.048
32	.116	2.946
33	.113	2.870
34	.111	2.819
35	.110	2.794
36	.1065	2.705
37	.104	2.642
38	.1015	2.578
39	.0995	2.527
40	.098	2.489
41	.096	2.438
42	.0935	2.375
43	.089	2.261
44	.086	2.184

Number drill sizes (contd)

No	Diameter	
	Inches	mm
45	.082	2.083
46	.081	2.057
47	.0785	1.994
48	.076	1.930
49	.073	1.854
50	.070	1.778
51	.067	1.702
52	.0635	1.613
53	.0595	1.511
54	.055	1.395
55	.052	1.321
56	.0465	1.181
57	.043	1.092
58	.042	1.067
59	0.41	1.041
60	.040	1.016
61	0.0390	1.00
62	0.0380	0.98
63	0.0370	0.95
64	0.0360	0.92
65	0.0350	0.90
66	0.033	0.85
67	0.032	0.82
68	0.031	0.79
69	0.0292	0.75
70	0.0280	0.70
71	0.0260	0.65
72	0.0240	0.65
73	0.0240	0.60
74	0.0225	0.58
75	0.0210	0.52
76	0.0200	0.50
77	0.0180	0.45
78	0.0160	0.40
79	0.0145	0.38
80	0.0135	0.35

Core drill

A core drill is a specifically designed to remove a cylinder of material, much like a hole saw. The material left inside the drill bit is referred to as the core. The earliest core drills were those used by the ancient egyptians, invented in 3000 BC. core drills are used for many applications, either where the core needs to be preserved, or where drilling can be done more rapidly since much less material needs to be removed than with a standard bit. This is the reason that diamond-tipped core drills are commonly used in construction to create holes for pipes, manholes and other large-diameter penetrations in concrete or stone. Core drills are used frequently in mineral exploration where the coring may be several hundred to several thousand feet in length. The core samples are recovered and examined by geologists for mineral percentage and stratigraphic contact points. This gives exploration companies the information necessary to begin or abandon mining operations in a particular area. Before the start of world war two, Brenner Newsom, a California mining engineer, invented a core drill that could take out large diameter cores up to 16 feet in length for mining shafts. This type of core drill is longer in use as modern drill technology allows standard drilling to accomplish the same at a much cheaper cost.

Fig 2

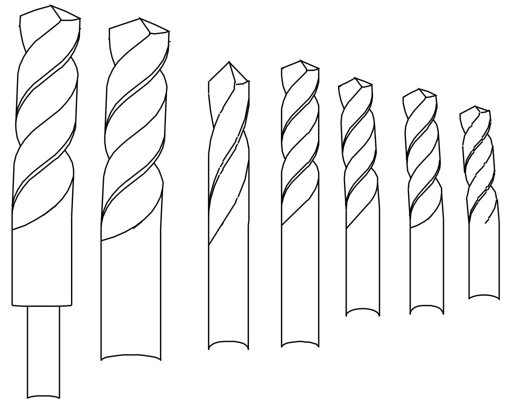

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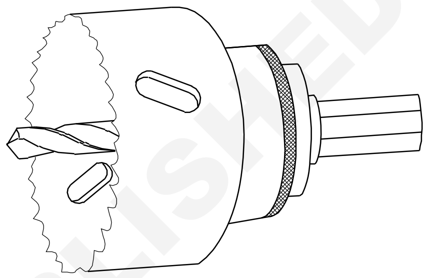
Fig 3



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Drill cutting angle, cutting speed

Objectives : At the end of this lesson you shall be able to
- **state what is drilling**
- **state the necessity of drilling**
- **name the types of drills used**
- **name the parts of a twist drill**
- **list out the defects in a drilled hole**
- **state the causes and the remedies for the defects.**

Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

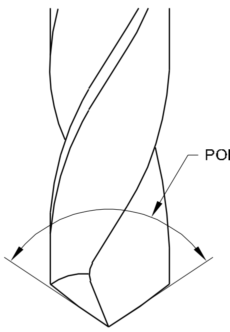
Angles

There are different angles for different purposes. They are listed below.

Point angle, Helix angle, Rake angle, Clearance angle and Chisel edge angle.

Point angle/Cutting angle (Fig 1)

Fig 1



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The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips). The angle varies according to the hardness of the material to be drilled.

Helix angle (Figs 2, 3 and 4)

Fig 2

Fig 3

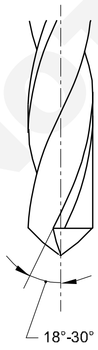
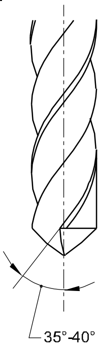


Fig 4



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Twist drills are made with different helix angles/The helix angle determines the rake angle at the cutting edge of the twist drill.

Fig 5

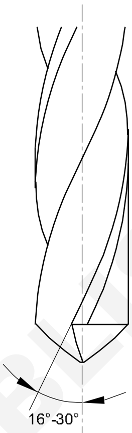

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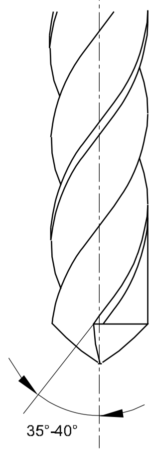
Fig 6



TUN133316

The helix angles vary according to the material being drilled. According to Indian Standard, three types of drills are used for drilling various materials.

Type N = for normal low carbon steel.

Type H = for hard and tenacious materials.

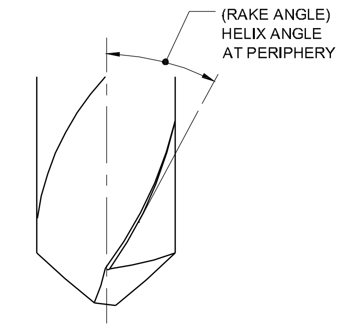
Type S = for soft and tough materials.

The type of drill used for general purpose drilling work type N.

Rake angle (Fig 7)

Rake angle is the angle of flute (Helix angle).

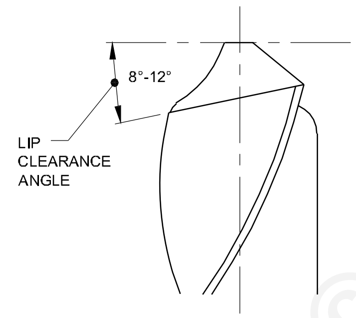
Fig 7



Clearance angle (Fig 8)

Clearance angle is to prevent the friction of the land behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak, if it is too small, the drill will not cut.

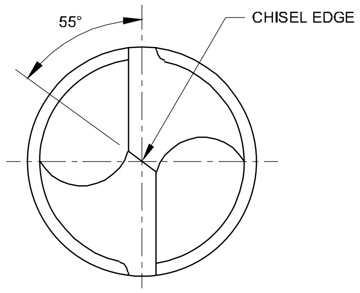
Fig 8



Chisel edge angle/Web angle (Fig 9)

This is the angle between the chisel edge and the cutting lip.

Fig 9



Designation of drills

Twist drills are designated by the

- diameter
- tool type
- material

Example

A twist drill of 9.50 mm dia., of tool type 'H' for right hand cutting and made from HSS is designated as

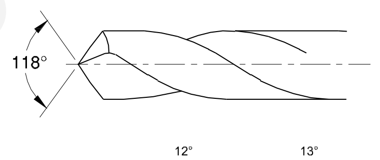
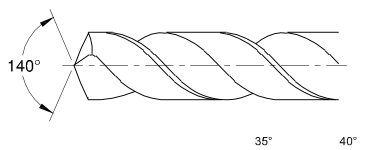
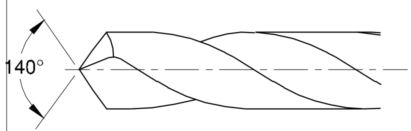
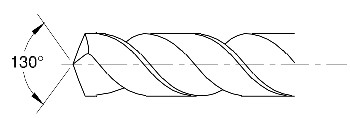
Twist drill 9.50 - H - IS5101 - HS

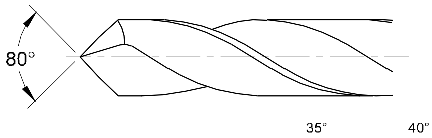
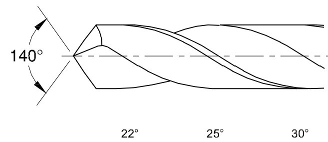
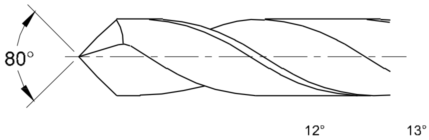
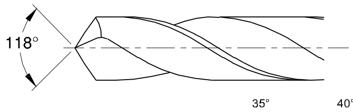
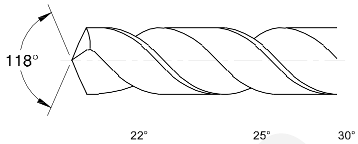
- **Diameter of drill** (9.50)
- **IS NO.** (IS5101)
- **Tool type** (H)
- **Material** (HS)

NOTE: If the tool is not indicated in the designation, it should be taken as Type 'N' tool.

Drills for different materials

Recommeded drills

Material to be drilled	Point angle Helix angle d=3.2.5 5-10 10	Material to be drilled	Point angle Helix d=3.5 mm 5 mm
Steel and cast steel up to 70 kgf/mm^2 strength Gray cast iron Malleable cast iron Brass German silver, nickel	 118° ; 12° 13° 13°	Copper (up to 30 mm drill diameter) Al - alloy, forming Curly chips Celluloid	 140° ; 35° 40°
Brass, Cuzn 40	 140° ; 12° 13°	Austenitic steels Magnesium alloys	 130° ; 22° 25° 30°

Steel, and cast steel 70... 120 Kgf/mm² 	Moulded steels (with thickness S>d) 
Stainless steel Copper (drill diameter more than 30 mm) Al-alloy, forming short borken chips 	Moulded plastics, with thickness s>d Laminated plastics Hard rubber (ebonite) Marble, state, coal  Zinc alloys 

Drill grinding

Any one of the following indicates the sign that the drill needs re-sharpening.

- A need for high feed pressure to make the drill to cut and advance.
- Chattering or screaming of the drill when pressure is applied.

It is recommended that a drill grinding jig is to be used for re-sharpening purposes as it is almost impossible to grind the drills to the correct angles by off-hand grinding. But for general purpose drilling, off- hand grinding may also be done, taking care to avoid the following faults.

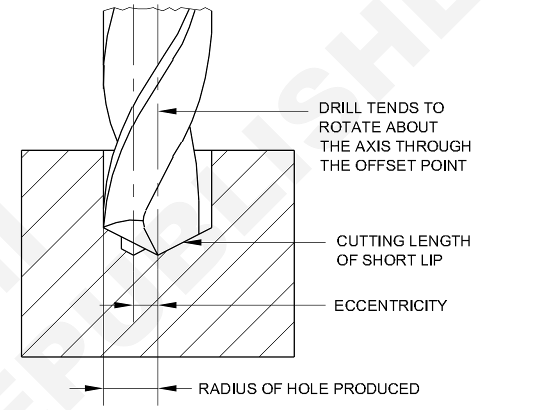
Grinding faults

Faulty grinding is indicated by the following.

The two cutting edges are of unequal length. This fault causes two cuttings of unequal thickness, or one cutting being ejected and an oversize hole results. (Figs 6 and 7)

Excessive clearance angle ground. This fault will cause the cutting edges to chip off and break. This in turn, will cause the drill to dig into the workpiece. (Fig 8)

Fig 6



ACTION OF DRILL GROUND WITH CUTTING EDGES OF UNEQUAL LENGTH

Fig 8

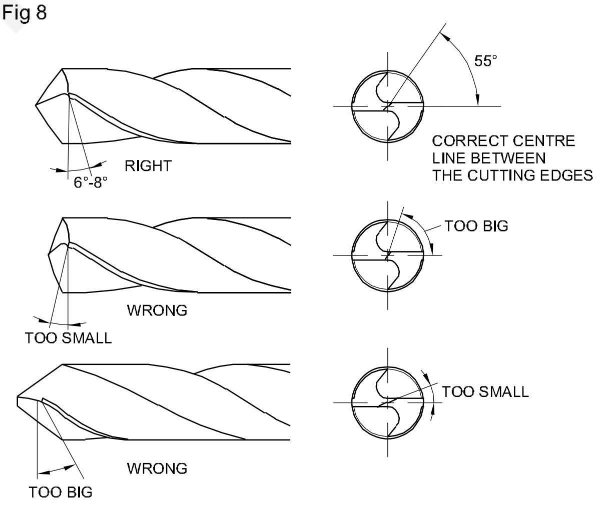
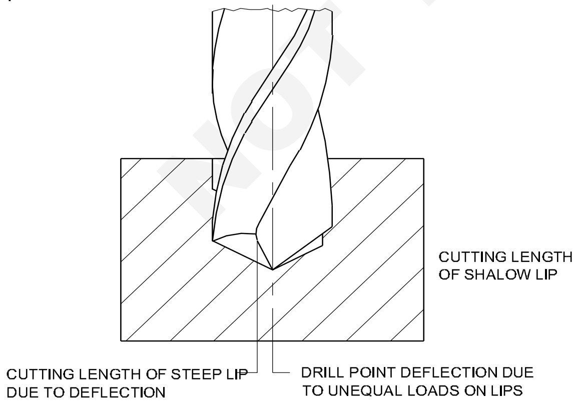


Fig 7



ACTION OF DRILL GROUND WITH CUTTING EDGES EQUAL BUT UNEQUAL ANGLE

Insufficient clearance angles. The drill rubs rather than cuts. When a drill gets badly worn out, it cuts poorly and the three signs of a badly worn out drill are :

blunt cutting edges' at the point of the drill

- too much feeding pressure to make the drill to cut
- work and drill getting heated up.

It is essential to provide a bigger point angle of the drill for drilling hard metals.

Recommended helix point angles for drilling different : Work materials Pilot hole drilling

(For guidance only)

Material of the workpiece	Helix angle angle	Point angle
Steel, alloyed and unalloyed cast steel, cast iron, malleable iron	28°	118°
White cast iron	28°	150°
Brass, bronze	15°	118° to 140°
Bakellite	40°	118° to 140°

For producing large size holes by drilling, it is always advantageous to drill with smaller drills and finally use the drill of the required size. This operation is known as pilot drilling.

The steps to finish a required size of a drilled hole are shown in Fig 9.

Cutting fluids for drilling

The use of an appropriate cutting fluid will always give a better surface finish; it permits the use of a higher cutting speed, and extends the tool life.

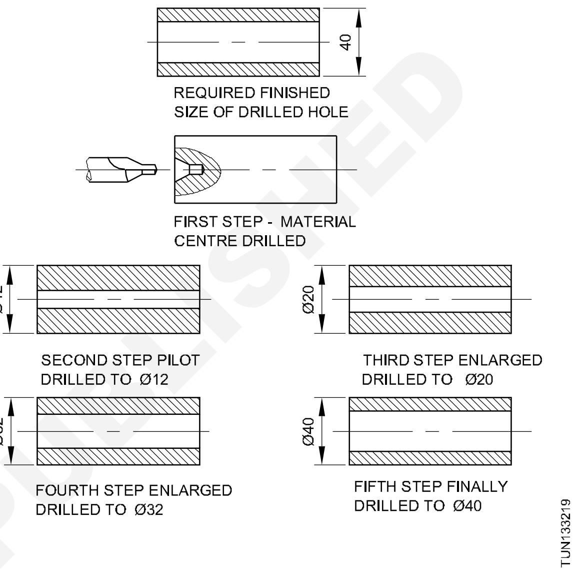
The cutting fluids generally used for drilling operation are the same that are used for other lathe operations.

Soluble oil is the most commonly used cutting fluid.

Recommended cutting fluids for drilling different metals

- Aluminium and its alloys - dry or kerosene.
- Copper - soluble oil.
- Brass - dry or soluble oil.
- Cast iron- dry or cooled with compressed air.
- Chilled cast iron - soluble oil.
- Mild steel - soluble oil, sulphurised oil.
- Alloy steels - soluble oil, sulphurised oil.

Fig 9



Lubricant and coolant - types its necessity, system of lubrication, selection of coolant, handling & care

Objectives : At the end of this lesson you shall be able to
- **state what is cutting fluid**
- **state the function of cutting fluids & their advantages**
- **state the properties of a good cutting fluid**
- **list the different types of cutting fluids**
- **select appropriate cutting fluids for different materials.**

Cutting fluids and compounds are the substances used for efficient cutting while cutting operations take place.

Functions

The functions of cutting fluids are:

- to cool the tool as well as the workpiece
- to reduce the friction between the chip and the tool face by lubricating
- to prevent the chip from getting welded to the tool cutting edge
- to flush away the chips
- to prevent corrosion of the work and the machine.

Advantages

As the cutting fluid cools the tool, the tool will retain its hardness for a longer period; so the tool life is more.

Because of the lubricating function, the friction is reduced and the heat generated is less. A higher cutting speed can be selected.

As the coolant avoids the welding action of the chip to the tool-cutting edge, the built up edge is not formed. The tool is kept sharp and a good surface finish is obtained.

As the chips are flushed away the cutting zone will be neat.

The machine or job will not get rusted because the coolant prevents corrosion.

Properties of a good cutting fluid

A good cutting fluid should be sufficiently viscous.

At cutting temperature, the coolant should not catch fire.

It should have a low evaporation rate.

It should not corrode the workpiece or machine.

It must be stable and should not foam or fume.

It should not create any skin problems to the operator.

Should not give off bad smell or cause itching etc. which are likely to irritate the operator, thus reducing his efficiency.

Should be transparent.

Types of cutting fluids

The following are the common cutting fluids.

- Straight mineral oil
- Chemical solution (synthetic fluids)
- Compounded or blended oil
- Fatty oils
- Soluble oil (Emulsified oil-suds)

Straight mineral oil

Straight mineral oils are the coolants which can be used undiluted. Use of straight mineral oil as a coolants has the following disadvantages.

It gives off a cloud of smoke.

It has little effect as a cutting fluid.

Hence straight mineral oils are poor coolants. But kerosene which is a straight mineral oil is widely used as a coolant for machining aluminium and its alloys.

Chemical solution (Synthetic oil)

These consist of carefully chosen chemicals in dilute solution with water. They possess a good flushing and a good cooling action, and are non-corrosive and non-clogging. Hence they are widely used for grinding and sawing. They do not cause infection and skin trouble. They are artificially coloured.

Compounded or blended oil

These oils are used in automatic lathes. These oils are much cheaper and have more fluidity than fatty oil.

Fatty oil

Lard oil and vegetable oil are fatty oils. They are used on heavy duty machines with less cutting speed. They are also used on bench-works for cutting threads by taps and dies.

Soluble oil (Emulsified oil)

Water is the cheapest coolant but it is not suitable because it causes rust to ferrous metals. An oil called soluble oil is added to water which gets a non-corrosive effect with water in the ratio of about 1:20. It dissolves in water giving a white milky solution. Soluble oil is an oil blend mixed with an emulsifier.

Other ingredients are mixed with the oil to give better protection against corrosion, and help in the prevention of skin irritations.

Soluble oil is generally used as a cutting fluid for centre lathes, drilling, milling and sawing.

Soft soap and caustic soda serve as emulsifying agents.

A chart showing coolants for different metals is given below.

Recommended Cutting Fluids for Various Metals and Different Operations

Material	Drilling	Reaming	Threading	Turning	Milling
Aluminium	Soluble oil Kerosene Kerosene and lard oil	Soluble oil Kerosene Mineral oil	Soluble oil Kerosene Lard oil	Soluble oil	Soluble oil Lard oil Mineral oil Dry
Brass	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Cast Iron	Dry Air jet	Dry Soluble oil	Dry Sulphurized oil	Dry Soluble oil	Dry Soluble oil
Copper	Dry Soluble oil	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral
General purpose steel	Soluble oil Sulphurized oil Lard oil Mineral lard oil	soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Lathe mandrels - different types and their uses

Objectives : At the end of this lesson you shall be able to
- **define a mandrel**
- **state the constructional features of a solid mandrel**
- **identify and name the different types of mandrels**
- **enumerate the uses of different mandrels.**

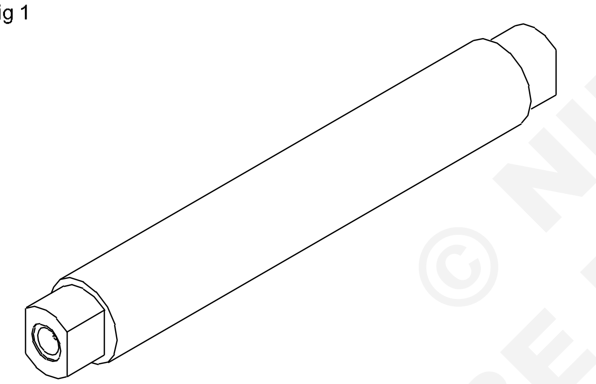
Types of mandrels and their uses

Sometimes it is necessary to machine the outer surfaces of cylindrical works accurately in relation to a hole concentric that has been previously bored in the centre of the work. In such cases the work is mounted on a device known as a mandrel.

Mandrel (Fig 1)

Lathe mandrels are devices used to hold the job for machining on lathes. They are mainly used for machining outside diameters with reference to bores which have been duly finished by either reaming or boring on a lathe.

Fig 1

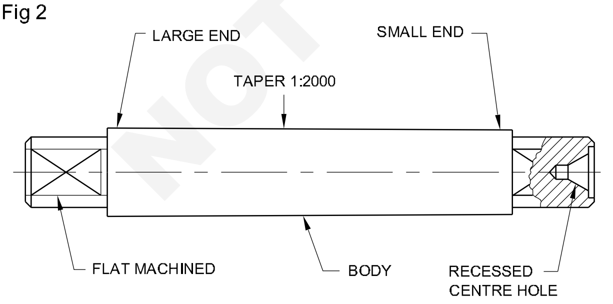


MANDREL

Constructional features of a solid mandrel (Fig 2)

The standard solid mandrel is generally made of tool steel which has been hardened and ground to a specific size and is ground with a taper of 1:2000.

Fig 2



DETAILS OF THE STANDARD SOLID MANDREL

It is pressed or driven into a bored or reamed hole in a workpiece so that it can be mounted on a lathe. The ends of the mandrel are machined smaller than the body and and are provided with a flat for the clamping screw of the lathe carrier. This preserves accuracy and prevents damage to the mandrel when the lathe carrier is clamped on.

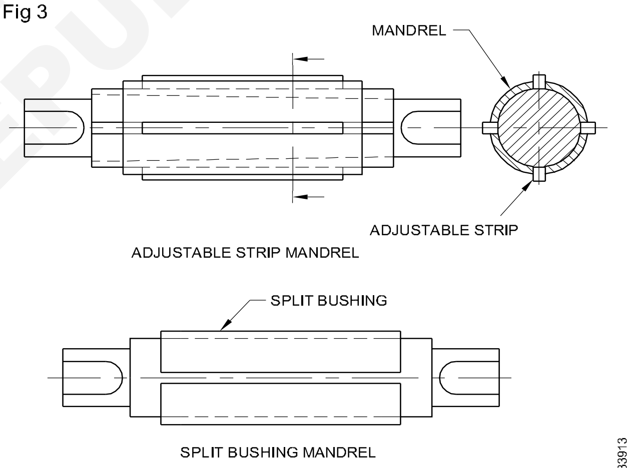
The centres made in these mandrels are 'B' type i.e. protected centres. In such centres the working portion is deep and does not get damaged while handling.

Types of mandrels

- Expansion mandrel
- Gang mandrel
- Stepped mandrel
- Screw or threaded mandrel
- Taper shank mandrel
- Cone mandrel

Expansion mandrel (Fig 3)

Fig 3



EXPANSION MANDRELS

The two most common types of expansion mandrels are:

- split bushing mandrel
- adjustable strip mandrel.

Split bushing mandrel

A split bushing mandrel consists of a solid tapered mandrel, and a split bushing, which expands when forced on to the mandrel. The range of application of each solid mandrel is greatly increased by fitting any number of different sized bushings. As a result only a few mandrels are required.

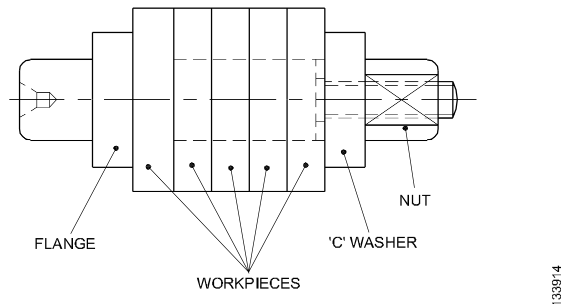
Adjustable strip mandrel

The adjustable strip mandrel consists of a cylindrical body with four tapered grooves cut along its length, and a sleeve, which is slotted to correspond with the tapered grooves. Four strips are fitted in the slots.

When the body is driven in the strips are forced out by the tapering grooves and expanded radially. Sets of different sized strips greatly increase the range of each mandrel. This type of mandrel is not suitable for thin walled work, since the force applied by the strips may distort the workpiece.

Gang mandrel (Fig 4)

Fig 4



GANG MANDREL

A gang mandrel consists of a parallel body with a flange at one end and a threaded portion at the other end. The internal diameters of workpieces are larger than the mandrel body diameters by not more than 0.025 mm. A number of pieces can be mounted and held securely when the nut is tightened against the 'U' washer. The nut should not be over-tightened, otherwise inaccuracies will result.

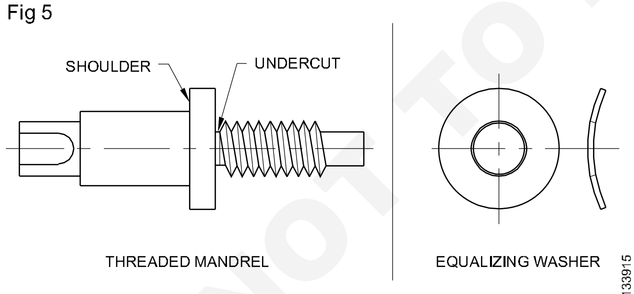
A gang mandrel is especially useful when machining operations have to be performed on a number of thin pieces which might easily be distorted, if held by any other method.

Stepped mandrel

The stepped mandrel is manufactured in order to reduce the number of mandrels. It differs from the plain mandrel in the fact that a number of steps are provided on it. Its use saves time in holding various bored works.

Screw or threaded mandrel (Fig 5)

Fig 5



THREADED MANDREL

A threaded mandrel is used when it is necessary to hold and machine workpieces having a threaded hole.

This mandrel has a threaded portion which corresponds to the internal thread of the work to be machined. An undercut at the shoulders ensures the work to fit snugly (tightly) against the flat shoulder.

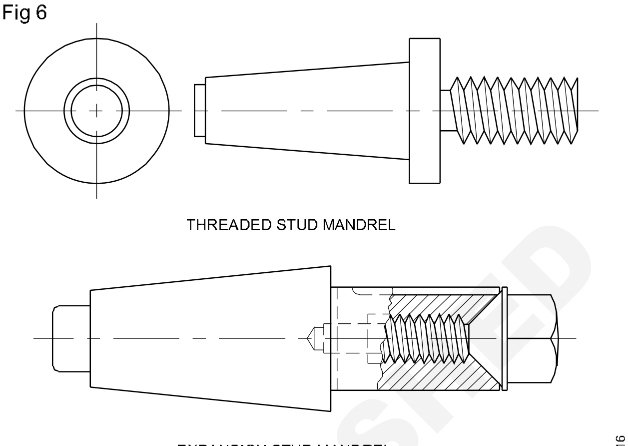
Taper shank mandrel (Fig 6)

Taper shank mandrels are not used between lathe centres. They are fitted to the internal taper of the headstock spindle. The extending portion can be machined to suit the workpiece to be turned. Taper shank mandrels are generally used to hold small workpieces.

Two common types of taper shank mandrels are:

- expansion stud mandrel
- threaded stud mandrel.

Fig 6



TAPER SHANK MANDRELS

Expansion stud mandrel

The expansion stud mandrel is slotted and has an internal thread. When a tapered screw is tightened, the outside diameter of the stud expands against the inside of the workpiece. This type of mandrel is useful when machining a number of similar parts whose internal diameters vary slightly.

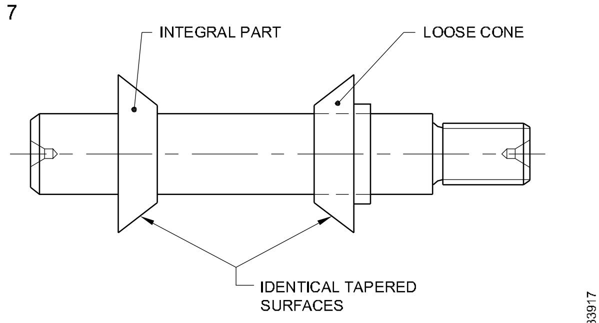
Threaded stud mandrel

The threaded stud mandrel has a projecting portion which is threaded to suit the internal thread of the work to be machined. This type of mandrel is useful for holding workpieces which have blind holes.

Cone mandrel (Fig 7)

A cone mandrel is a solid mandrel. It has a portion taper turned with a steep taper and integral with the body. One end of the mandrel is threaded. A loose cone slides over the plain turned portion of the body of the mandrel. It has the same steep taper as that of the tapered integral part. A job of large bore, can be held between these two tapers and tightly secured by means of nut, washer and spacing collars.

Fig 7



CONE MANDREL

Concept of interchangeability, limits & fits

Objectives : At the end of this lesson you shall be able to
- **state what is mass production and interchangeable manufacture**
- **state the necessity of the limits system**
- **name the different standard systems of limits and fits accepted and adopted internationally.**

Mass production

When identical components are manufactured in large quantities it is stated that they are mass produced. These identical components should fulfil:

- dimensional accuracy
- degree of surface finish
- interchangeability.
- Standardization

Mass production has the advantage of interchangeable manufacture of components machined by different operators on different machine tools under different environments that can be assembled without any rectification with their mating parts. This avoids selective assembly which is time consuming.

Necessity of limit system

It is practically impossible to machine components to an exact size, due to the varying skills of the operators, the condition of the machine tools, the quality of the cutting tools and the accuracy of the precision instrument used. Hence some permissible deviations to the exact size are accepted and given, and the operator is expected to produce the components within the limits, which, even though not necessarily equal to the exact size, will not affect the functioning of the components. This necessitates the introduction of the limit system.

Internationally accepted systems of limits and fits

- British Standard System of Limits and Fits (B.S.).
- International Standard Organization System of Limits and Fits. (I.S.O.)
- Bureau of Indian Standard System of Limits and Fits (B.I.S.)

Apart from the above most commonly used limit systems, various countries follow their own standards to manufacture components for some of their industries.

Advantages of the limit system

- Interchangeability is assured.
- Not necessary to employ highly skilled operators.
- Not necessary to use conventional measuring instruments.
- Time for the manufacture of components will be comparatively less.

Limits, Fits and Tolerance

The B.I.S. standard system of limits and fits is followed by the industries in our country as the standard. It is adopted from the I.S.O. and B.S. standards with modifications to suit our conditions and requirements. For the purpose of B.I.S. standard, the following definitions and symbols are followed.

Size

It is a number expressed in a particular unit in the measurement of length.

Basic size

It is the size based on which the dimensional deviations are given. (Fig 1)

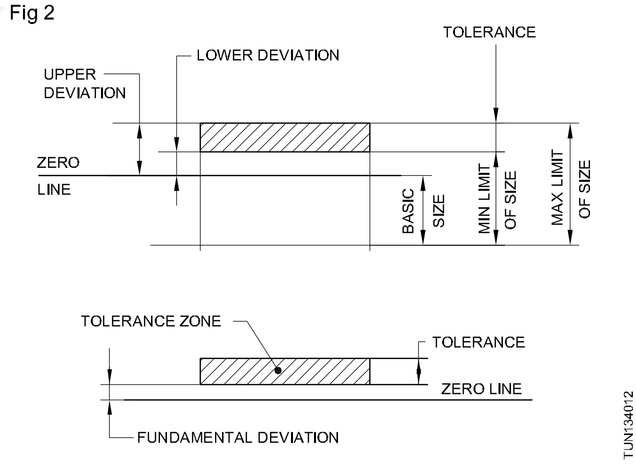
Maximum limit of size

It is the greater of the two limit sizes..(Fig 2) (Table 1)

Minimum limit of size

it is the smaller of the two limits of size. (Fig 2).(Table 1)

Fig 2



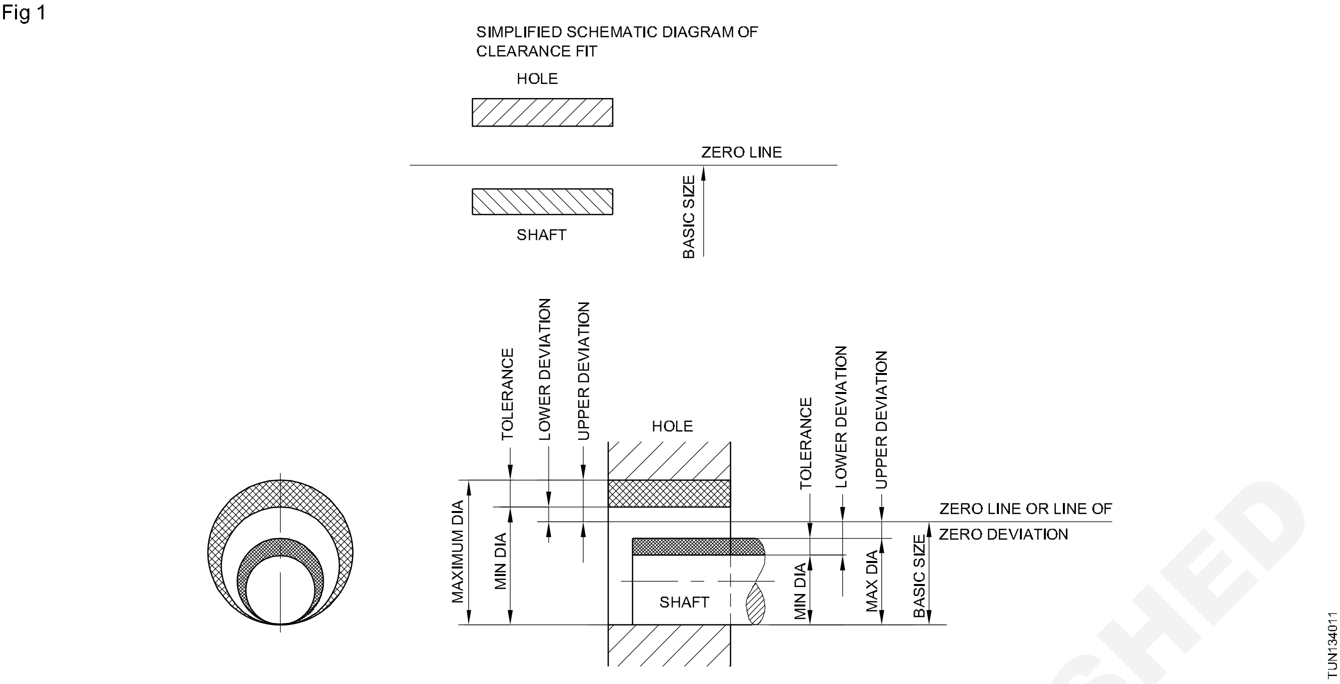
Actual size

It is the size of the component by actual measurement after it is manufactured, it should lie between the two limits of size if the component is to be accepted.

Limits of size

These are the extreme permissible sizes within which the operator is expected to make the component. (Fig 2) (Maximum and minimum limits)

Fig 1



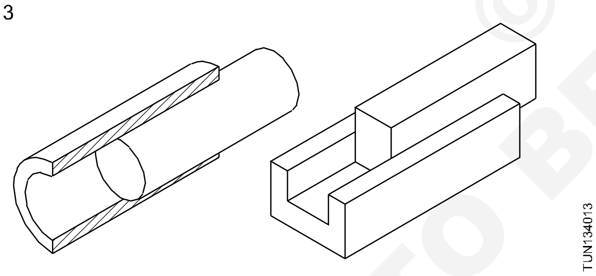
Hole

In the BIS system of limits & fits, all internal features of a component including those which are not cylindrical are designated as 'hole'. (Fig 3)

Shaft

In the BIS system of limits & fits, all external features of a component including those which are not cylindrical are designated as 'shaft'. (Fig 3)

Fig 3



Deviation

It is the algebraic difference between a size, to its corresponding basic size. It may be positive, negative or zero. (Fig 2)

Upper deviation

It is the algebraic difference between the maximum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Upper deviation is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

TABLE 1 (Examples)

Sl. No.	Size of Components	Upper Deviation	Lower Deviation	Max-Limit of Size	Min-Limit of Size
1	$20.00^{+0.008}_{-0.005}$	**+0.008**	**- 0.005**	**20.008**	**19.995**
2	$20.00^{+0.028}_{+0.007}$	**+0.028**	**+0.007**	**20.028**	**20.007**
3	$20.00^{-0.012}_{-0.021}$	**-0.012**	**-0.021**	**19.988**	**19.979**

Actual deviation

It is the algebraic difference between the actual size and its corresponding basic size. (Fig 2)

Tolerance

It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign. (Fig 2)

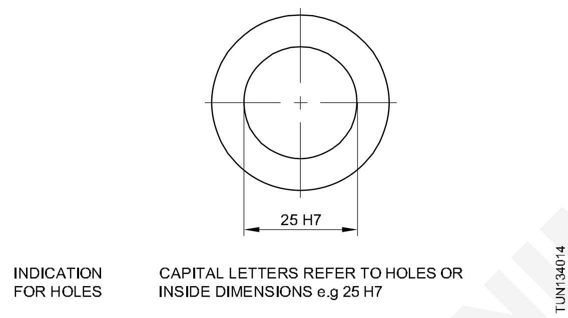
Zero line

In graphical representation of the above terms, the zero line represents the basic size. This line is also called as the line of zero deviation. (Figs 1 and 2).

Fundamental deviation

There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts), i.e for holes - ABCD....Z excluding I,L,O,Q & W. (Fig 4)

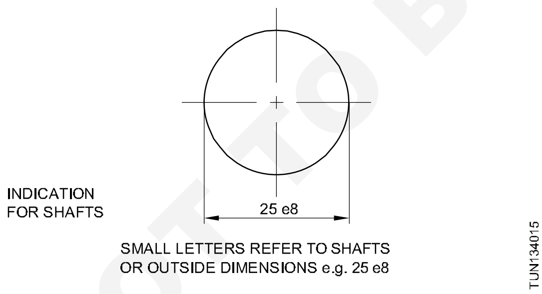
Fig 4



In addition to the above, four sets of letters JS, ZA, ZB & ZC are included. For fine mechanisms CD, EF and FG are added. (Ref.IS:919 Part II -1979)

For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

Fig 5



The position of tolerance zone with respect to the zero line is shown in Figs 6 and 7.

Fundamental tolerance

This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades of tolerances represented by number symbols, both for hole and shaft, denoted as IT01, IT0, IT1....to IT16. (Fig 8) A high number gives a large tolerance zone.

> **The grade of tolerance refers to the accuracy of manufacture.**

Fig 6

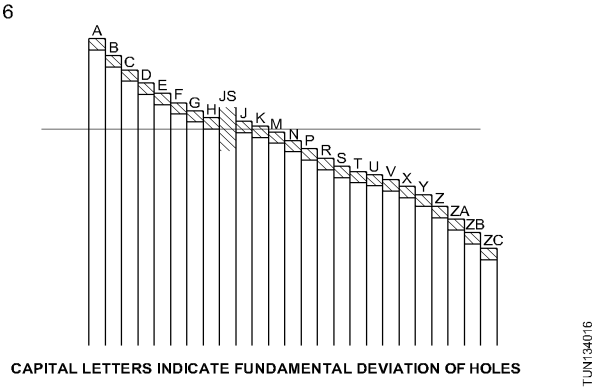


Fig 7

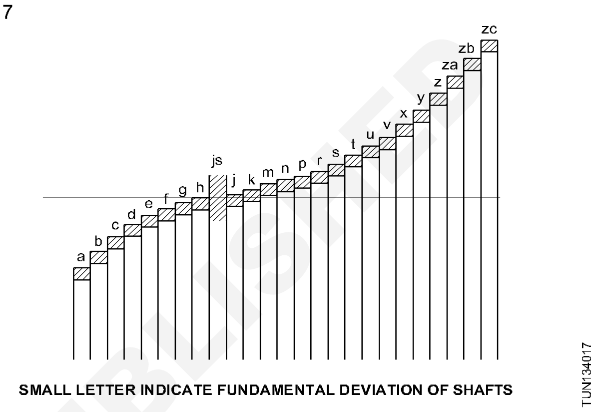
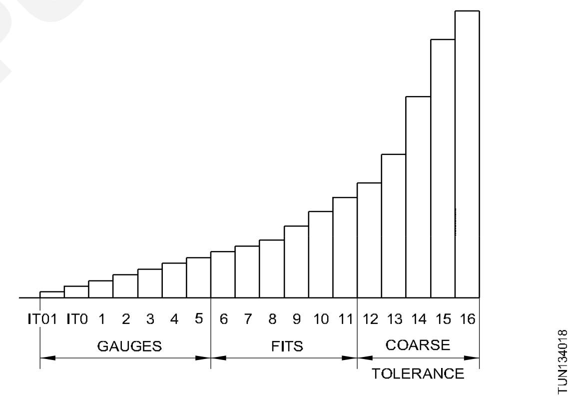


Fig 8



In a standard chart, the upper and lower deviations for each combination of fundamental deviation and fundamental tolerance are indicated for sizes ranging up to 500 mm. (Refer to IS 919)

Toleranced size

This includes the basic size, the fundamental deviation and the grade of tolerance.

Example

25 H7 - toleranced size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 9)

25 e8 - is the toleranced size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol 'e' and the grade of tolerance is represented by the number 8. (Fig 10)

Fig 9

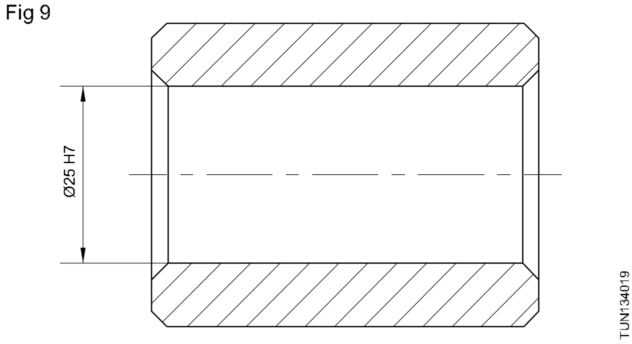
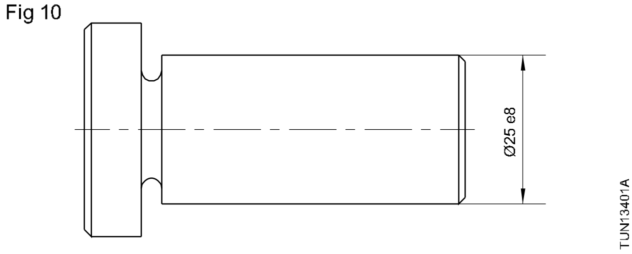


Fig 10



A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

Example

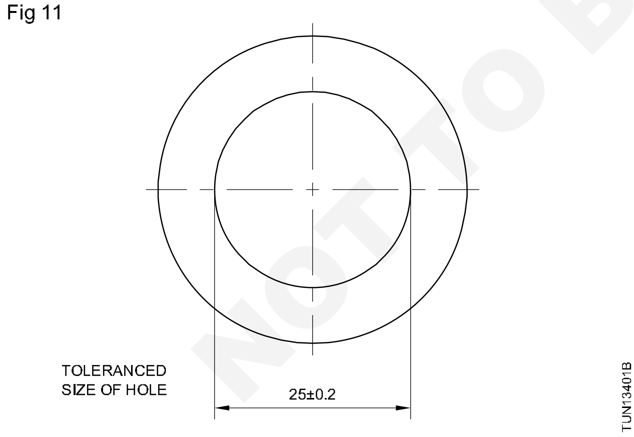
In figure 13, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

The deviation is mostly given on the drawing with the dimensions.

In the example 25 ± 0.2, ± 0.2 is the deviation of the hole of 25 mm, diameter. (Fig 11) This means that the hole is of acceptable size if its dimension is between.

Fig 11



25 + 0.2 = 25.2 mm

or 25 - 0.2 = 24.8 mm.

25.2 mm is known as the maximum limit. (Fig 12)

24.8 mm is known as the minimum limit. (Fig 13)

The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm (Fig 14)

Fig 12 Fig 13

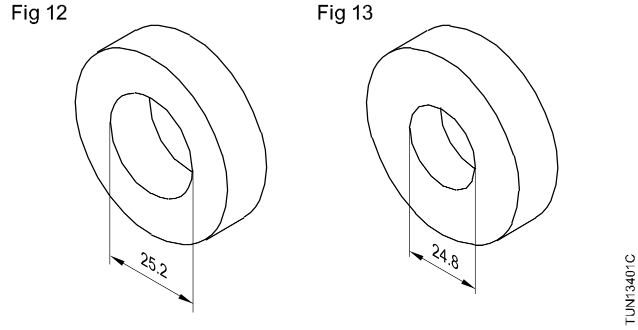
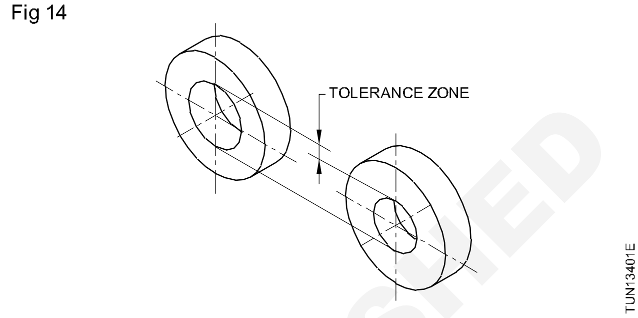
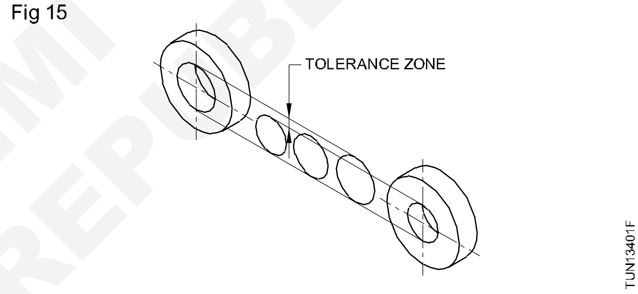


Fig 14



All dimensions of the hole within the tolerance zone are of acceptable size as in Fig 15.

Fig 15

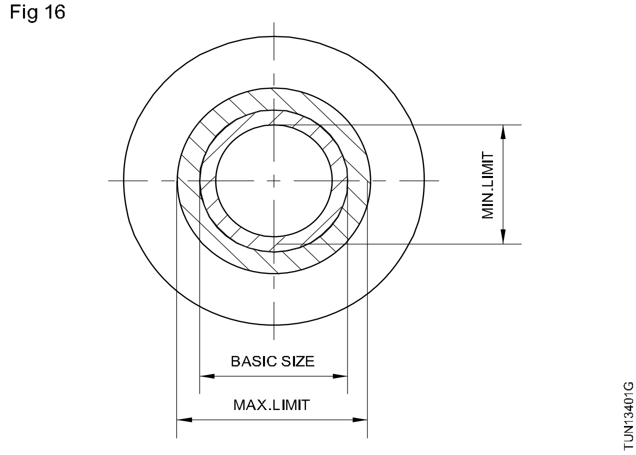


As per IS 919, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Unilateral & bilateral system

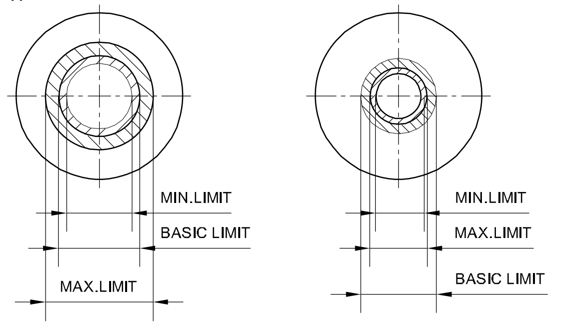
When the deviations given for a particular combination of the symbols are positive and negative so as to give the maximum limit more than the basic size and the minimum limit less than the basic size, then we call it bilateral tolerancing. (Fig 16) If the deviations have only positive

Fig 16



or negative values and have both the maximum limit and minimum limit more than the basic size or less than the basic size respectively, then it is called unilateral tolerancing. (Fig 17)

Fig 17



Fits and their classification as per the Indian standard IS : 919

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional differences before assembly.

Expression of a fit

A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft,) followed by the symbol for the hole, and by the symbol for the shaft.

Example

30 H7/g6 or 30 H7 - g6 or 30 H7/g6

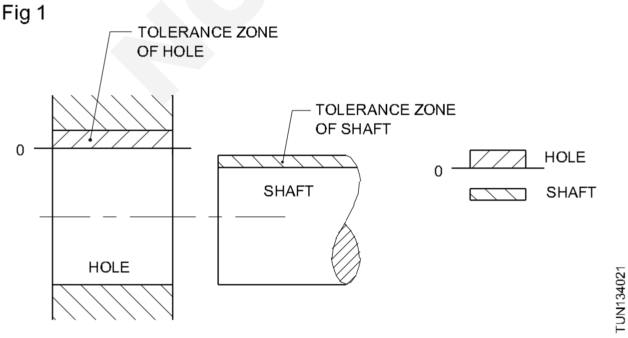
Clearance

In a fit the clearance is the different between the size of the hole and the size of the shaft which is always positive.

Clearance fit

It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

Fig 1



Example 20 H7/g6

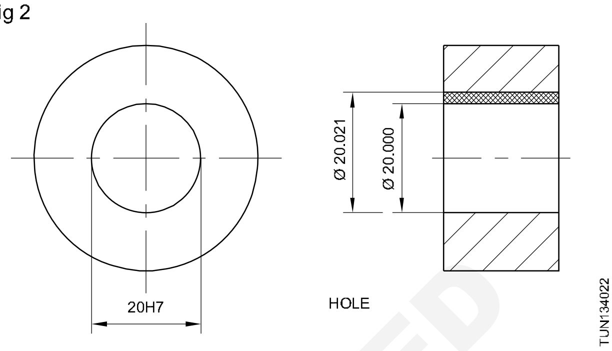
With the fit given, we can find the deviations from the chart.

For a hole 20 H7 we find in the table + 21.

These numbers indicate the deviations in microns. (1 micrometre = 0.001 mm)

The limits of the hole are 20 + 0.021 = 20.021 mm and 20.000 + 0 = 20.000mm. (Fig 2)

Fig 2

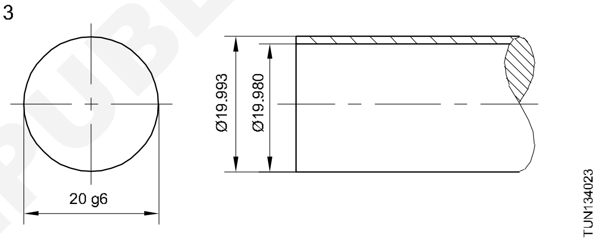


For a shaft 20 g6 we find in the table - 7

- 20.

So the limits of the shaft are 20-0.007 =19.993 mm and 20 - 0.020 =19.980mm.(Fig 3)

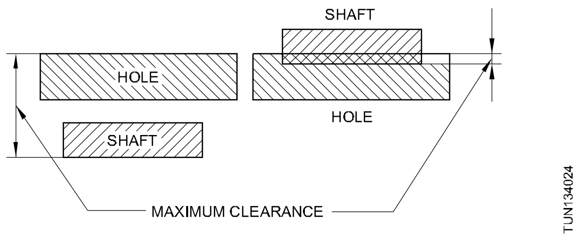
Fig 3



Maximum clearance

In a. clearance fit or transition fit, it is the difference between the maximum hole and minimum shaft. (Fig 4)

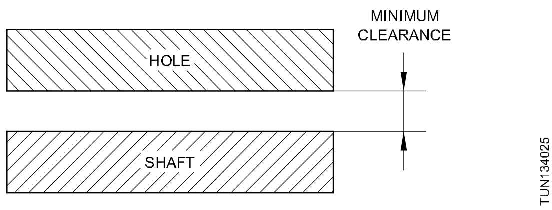
Fig 4



Minimum Clearance

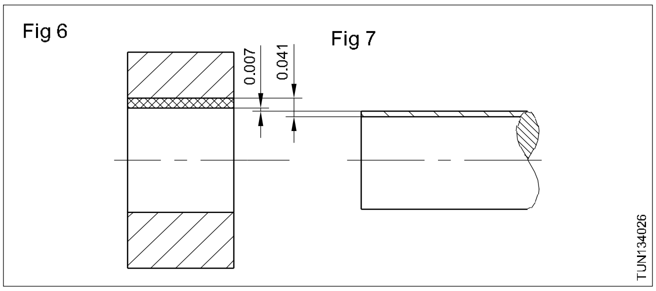
In a clearance fit, it is the difference between the minimum hole and the maximum shaft. (Fig 5)

Fig 5



The minimum clearance is 20.000 -19.993 = 0.007mm. (Fig 6)

The maximum clearance is 20.021 -19.980 = 0.041 mm. (Fig 7)



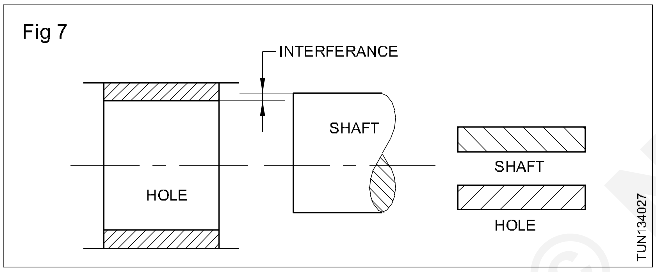
There is always a clearance between the hole and the shaft. This is the clearance fit.

Interference

It is the difference between the size of the hole and the shaft before assembly, and this is negative. In this case, the shaft is always larger than the hole size.

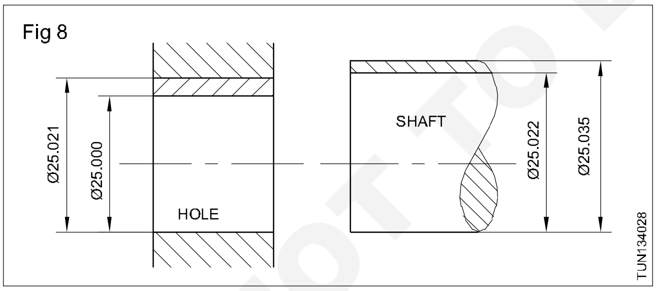
Interference Fit

It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 8)



Example Fit 25H7/p6 (Fig 9)

The limits of hole are 25.000 and 25.021 mm and the limits of the shaft 25.022 and 25.035 mm. The shaft is always bigger than the hole. This is an interference fit.

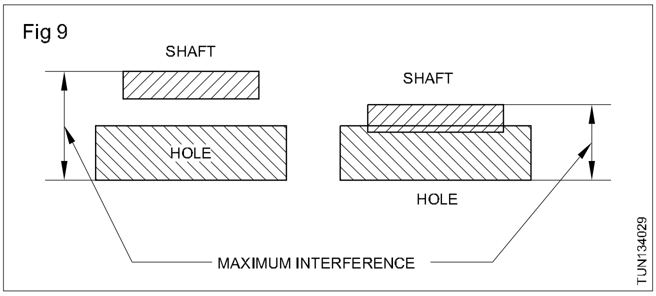


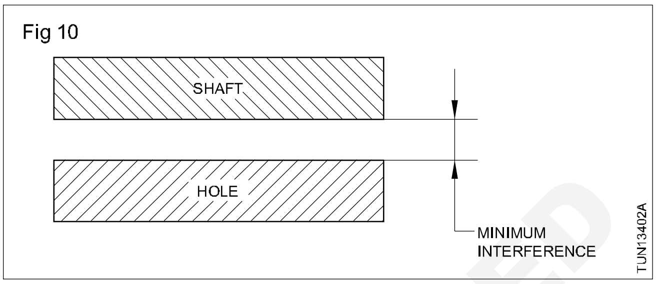
Maximum interference

In an interference fit or transition fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 10)

Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 11)





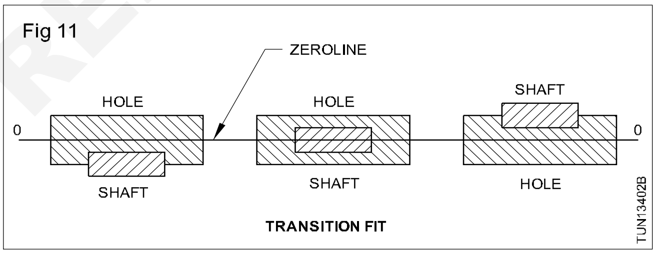
In the example shown in figure 9

The maximum interference is = 25.035 - 25.000
= 0.035

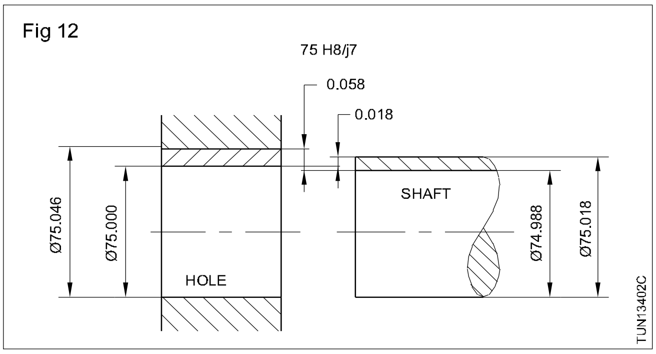
The minimum interference is = 25.022 - 25.021
= 0.001

Transition fit

It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 12)



Example Fit 75 H8/j7 (Fig 13)



The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 75.018 and 74.988 mm.

Maximum Clearance = 75.046 - 74.988 = 0.058 mm.

If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference. This is a transition fit because it can result in a clearance fit or an interference fit.

Symbols for holes, shaft, hole basis & shaft basis system, representation of tolerance in drawings

Objectives : At the end of this lesson you shall be able to
- **learn the symbols for hole & shaft**
- **understand Hole Basis system & its importance Shaft Basis system**
- **read the tolerance limits shown in the drawing**
- **identify the tolerance limits from the symbols shown in the drawing.**

Introduction

In the Engineering manufacturing process, it is difficult to produce components to the exact size, as indicated in the drawing. Particularly in mass production there is bound to be certain variations in dimensions between each component. Such variations do occur due to machine inaccuracy, lack of skill of the operator, method adopted etc., Hence certain variations, over the specified sizes (Normal size) in the drawing has to be allowed in practice. These permitted variations are called tolerance.

In Engineering assemblies, tolerance has to be provided for both male (shaft) and female (hole) parts. The permissible tolerance are based on the exact applications and is given IS:919 standard in the form of tables. The permissible tolerance varies with the size of the part for each grade. Higher the size of component, higher the tolerance permitted. The above standard gives tolerance for each grade from 0 to 500 mm nominal size.

Symbols for Holes/Shafts

The tolerance has two limits, the upper limit and lower limit. The upper limit is represented as Es/Is indicating Ecart Superior and the lower limites represented Ei/e. Ecart Inferior.

These tolerances are applicable separately for Shafts and Holes. To distinguish the permissible tolerance for shaft and hole, the Indian standards IS:919 given the symbols as detailed below.

Shafts (external features of a component) e

Holes (Internal features of a component) E

eg. ø 25g represents dia 25 shaft of h grade

ø 50H rerpesents HOle 50 of H grade

There are 25 grades of tolerance (fundamental deviations) form A grade to Z grade Holes and also tolerances of a to z grade shafts are indicated in the Standard.

The table for tolerance for shafts for all grades for sizes 0 to 6500 mm (nominal size) is given separately, so also for the Holes. In order to find the tolerance limits, select the horizontal row pertaining to the size of component and vertical column (the grade & upper limit/lower limit)

NSDC founded in 2008, with HQ ND was set a Public, Private partnership Co. in order to create and fund vocational training instructions & create support system for skill development.

Intersecting gives the two limits of tolerance for the components.

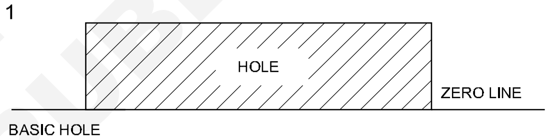
Hole Basis/shaft Basis system

Hole basis system

In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different class of fits, then it is known as the hole basis system.

The fundamental deviation symbol 'H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole 'H' is zero. It is known as "basic hole'. (Fig 1)

Fig 1

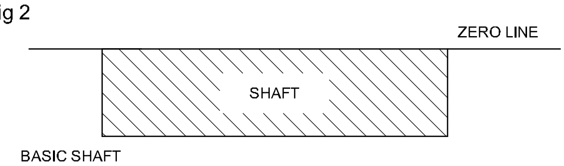


TUN134111

Shaft basis system

In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol 'h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft "h" is zero. It is known as basic shaft'. (Fig 2)

Fig 2

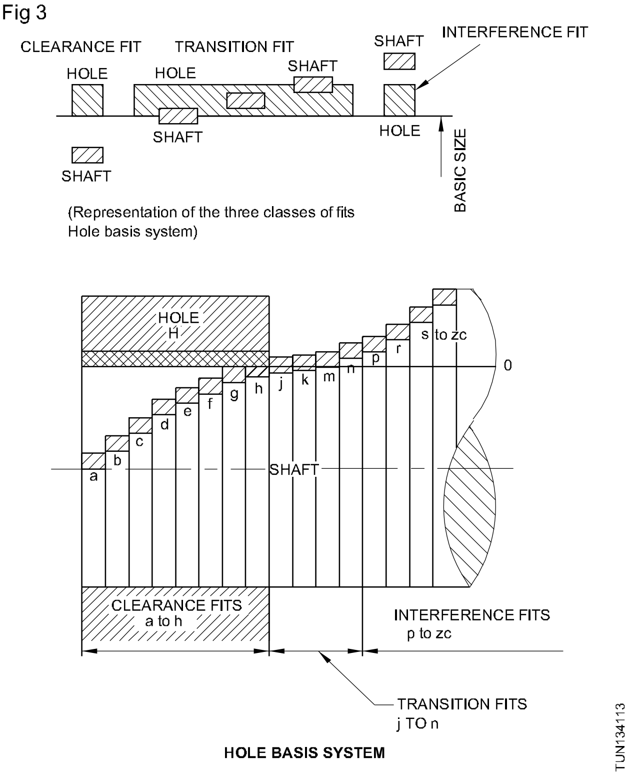


TUN134112

The hole basis system is followed mostly. This is be-cause, depending upon the class of fit, it will be always easier to alter the size of the shaft because it is external, but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard toolings.

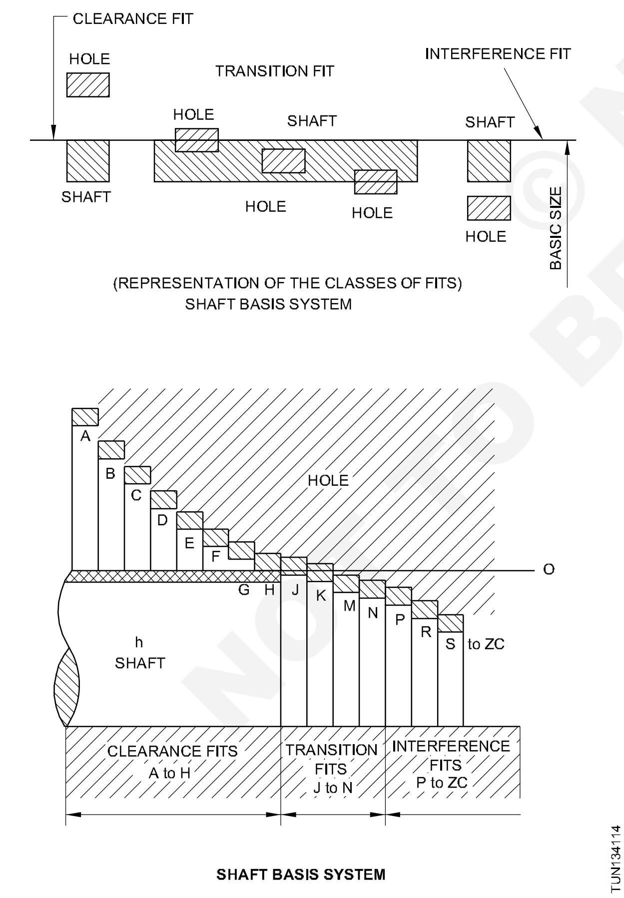
The three classes of fits, both under hole basis and shaft basis, are illustrated in Fig 3 & 4.

Fig 3



HOLE BASIS SYSTEM

Fig 4

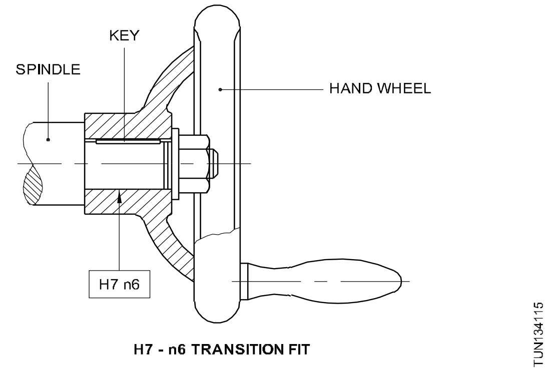


SHAFT BASIS SYSTEM

Hole basis tolerance applications

The hand wheel is fitted to the end of the spindle and held in place by a self-locking nut and washer. (Fig 5)

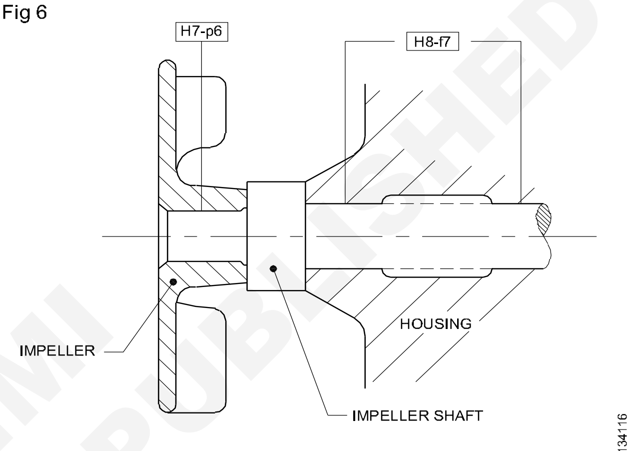
Fig 5



H7 - n6 TRANSITION FIT

A light alloy pump impeller is shown pressed on to steel shaft which runs on two bearings. (Fig 6)

Fig 6



H7 - p6 INTERFERENCE FIT H7 - f7 CLEARANCE FIT

The main bore is shown produced to an H7 limit and it is used to provide support and location for the free end of the boring bar, not directly but through the medium of a pilot bush. Such a bush is made of brass or phosphor bronze. The outside diameter of the busih is made to g6 limits to provide for a close running location fit, and the bore to H8 limits to fit on an j7 bar end to give a normal running fit. Such a machining operation would take place at a slow speed. The fit of the blade tool in its bar slot can be treated in the same way. (Fig 7)

Fig 7

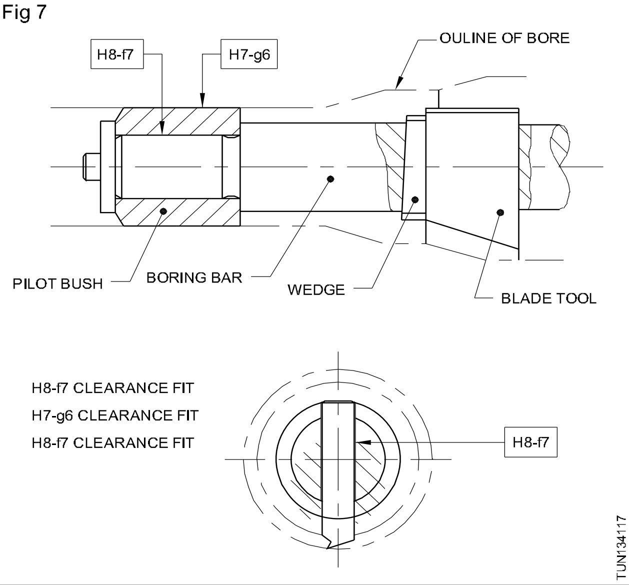
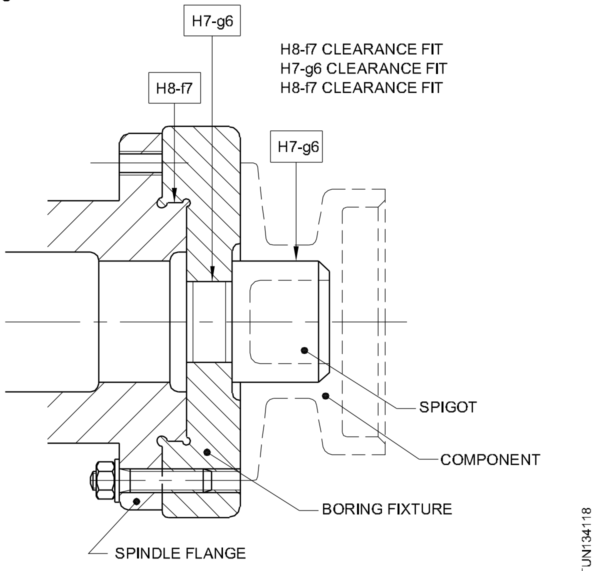


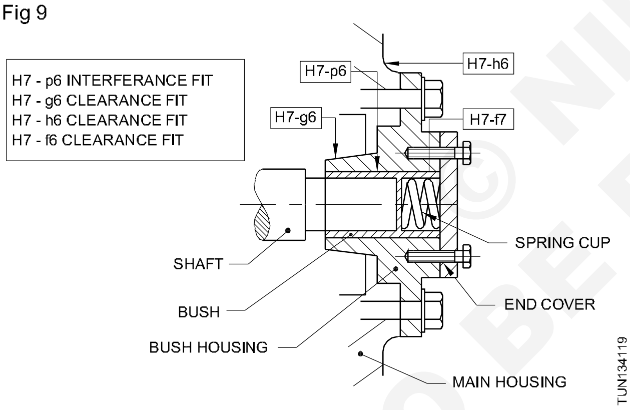
Figure 8 illustrates a flanged spindle nose of a turret lathe with a boring fixture attached. For simplicity in this example, the clamps holding the component to the fixture have been omitted.

Fig 8



The detail shows the end mounting of the crank shaft of a reciprocating type of compressor. (Fig 9)

Fig 9



This (Fig 10) details a sectional view of a part of a gearbox in which the upper gears rotate with the drive shaft.

This (Fig 11) illustrates a diagram of a bevel gear driven camshaft, which is supported in two bearing bushes housed in brackets attached to a machine bed.

Fig 10

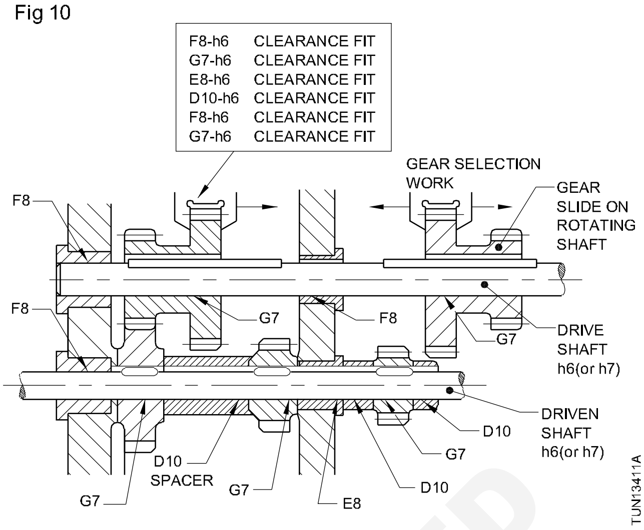
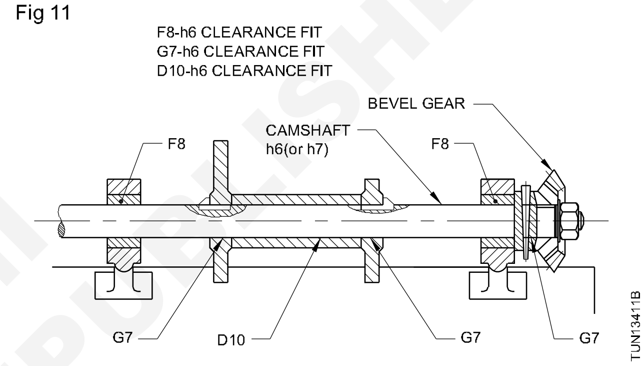
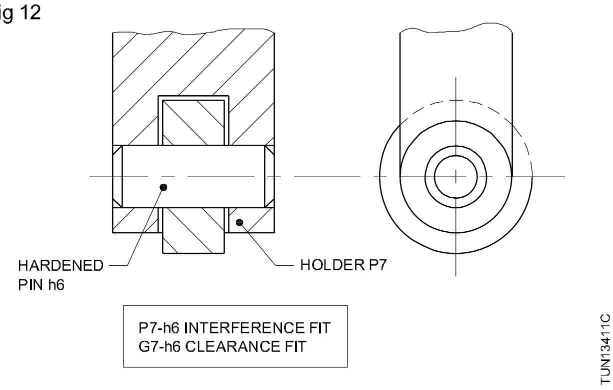


Fig 11



This (Fig 12) shows a hardened steel roller fitted into a soft steel holder. The roller must be free to rotate on the hardened steel pin which does not itself rotate.

Fig 12



Further classification of fits their applications and service conditions

Fit designation	Classification	Typical applications and service conditions
Clearance H11 - c11	Extra loose running it	Where large clearance is required and where dirty conditions or corrosion are problems. Ex. Agricultural and steel mill pulleys.
Clearance H9 - d10	Loose running fit	Large bearings or pulley and parts requiring ease of assembly.
Clearance H9 - e9	Easy running fit	For smaller applications where a fairly large clearance can be permitted, and where there is more than one bearing on a shaft : Ex. Camshafts, selection shafts in gearboxes, rocker shafts.
Clearance H8 - f7	Normal running fit	Generally used in medium and light engineering for easily produced quality fits as required on gearbox shaft bearings, gears on fixed shafts, guide bushes.
Clearance H7 - g6	Close running fit or location	Although called a running fit, the very small clearance makes it unsuitable for continuous running and should be used only for intermittent or light loadings. May be used for spigot locators.
Clearance H7 - h6	Precision slide fit	Although there is zero fundamental deviation, in practice there is very small clearance enabling this fit to be used on non-running combinations, such as, precision sliding and jig location fits.
Transition H7 - k6	Push or easy keying fit	For location fits, not requiring frequent removal or where vibration of the part is to be prevented.
Transition H7 - n6	Tight keying fit	Care needed in this selection as a transition fit. Some combinations may, in practice, give an interference fit.
Interference H7 - p6	Light drive fit	This is a true interference fit, providing a press fit for ferrous parts which are not to be damaged or overstrained in any subsequent dismantling.
Interference H7 - s6	Heavy drive fit	For ferrous parts requiring permanent or semi-permanent assembly. (Light and heavy drive fits are frequently used for the assembly of non-ferrous parts such as bearing sleeves and bushes, the actual type of fit, depending upon the size of bush and its function.)

Representation of tolerance in drawings: (Fig 13 & 14)

The tolerance permissible as per drawing as shown in capital for Holes and small letters for shaft as shown below.

The drawing will only indicate the grade the value of tolerance has to be obtained from IS: Table.

Fig 13

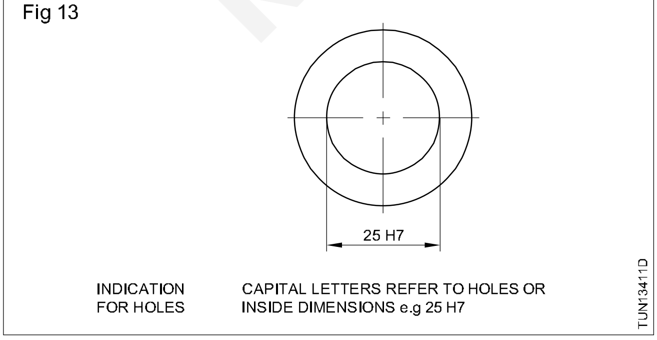


Fig 14

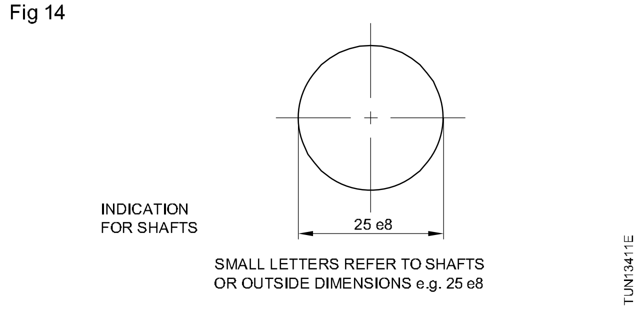


TABLE FOR TOLERANCE ZONES & LIMITS (DIMENSIONS IN μ m)

B11	A11			s6	r6	p6	n6	k6	js6	h6	h7	h9	h11	g6	f7	e8	d9	c11	b11	a11	S7	R7	P7	N7	K7	JS7	H7	H8	H9	H11	G7	F8	E9	D10	C11
	From		1	+20	+16	+12	+10	+6	+3	0	0	0	0	-2	-6	-14	-20	-60	-140	-270	-14	-10	-6	-4	0	+5	+10	+14	+25	+60	+12	+20	+39	+60	+120
+200																			+330																
+140	up to + 270		3	+14	+10	+6	+4	0	-3	-6	-10	-25	-60	-8	-16	-28	-45	-120	-200	-330	-24	-20	-16	-14	-10	-5	0	0	0	0	+2	+6	+14	+20	+60
	Over		3	+27	+23	+20	+16	+9	+4	0	0	0	0	-4	-10	-20	-30	-70	-140	-270	-15	-11	-8	-4	+3	+6	+12	+18	+30	+75	+16	+28	+50	+78	+145
+215	+345		up to		6	+19	+15	+12	+8	+1	-4	-8	-12	-30	-75	-12	-22	-28	-60	-145	-215	-345	-27	-23	-20	-16	-9	-6	0	0	0	0	+4	+10	+20
+30	+70	+140	+270																																
	Over		6	+32	+28	+24	+19	+10	+4.5	0	0	0	0	-5	-13	-25	-40	-80	-150	-280	-17	-13	-9	-4	+5	+7.5	+15	+22	+36	+90	+20	+35	+61	+98	+170
+240	+370																																		
	up to		10	+23	+19	+15	+10	+1	-4.5	-9	-15	-36	-90	-14	-28	-47	-76	-170	-240	-370	-32	-28	-24	-19	-10	-7.5	0	0	0	0	+5	+13	+25	+40	+80
+150	+280																																		
	Over		10																																
	up to		14	+39	+34	+29	+23	+12	+5.5	0	0	0	0	-6	-16	-32	-50	-95	-150	-290	-21	-16	-11	-5	+6	+9	+18	+27	+43	+110	+24	+43	+75	+120	+205
+260	+400																																		
	Over		14	+28	+23	+18	+12	+1	-5.5	-11	-18	-43	-110	-17	-34	-59	-93	-205	-260	-400	-39	-34	-29	-23	-12	-9	0	0	0	0	+7	+16	+32	+50	+95
+150	+290																																		
	up to		18																																
	Over		18																																
	up to		24	+48	+41	+35	+28	+15	+6.5	0	0	0	0	-7	-20	-40	-65	-110	-160	-300	-27	-20	-14	-7	+6	+10.5	+21	+33	+52	+130	+28	+53	+92	+149	+240
+290	+430																																		
	Over		24	+35	+28	+22	+15	+2	-6.5	-13	-21	-52	-130	-20	-41	-73	-117	-240	-290	-430	-48	-41	-35	-28	-15	-10.5	0	0	0	0	+7	+20	+40	+65	+110
+160	+300																																		
	up to		30																																
	Over		30															-120	-170	-310															+280
+330	+470																																		
	up to		40	+59	+50	+42	+33	+18	+8	0	0	0	0	-9	-25	-50	-80	-280	-330	-470	-34	-25	-17	-8	+7	+12.5	+25	+39	+62	+160	+34	+64	+112	+180	+120
+170	+310	N																																	
O	Over		40	+43	+34	+26	+17	+2	-8	-16	-25	-62	-160	-25	-50	-89	-142	-130	-180	-320	-59	-50	-42	-33	-18	-12.5	0	0	0	0	+9	+25	+50	+80	+290
+340	+480	M	up to		50															-290	-340	-480													
	+130	+180	+320	I																															
N	Over		50	+72	+60													-140	-190	-340	-42	-30													+330
+380	+530																																		
A	up to		65	+53	+41	+51	+39	+21	+9.5	0	0	0	0	-10	-30	-60	-100	-330	-380	-530	-72	-60	-21	-9	+9	+15	+30	+46	+74	+190	+40	+76	+134	+220	+140
+190	+340																																		
L																																			
	Over		65	+78	+62	+32	+20	+2	-9.5	-19	-30	-74	-190	-29	-60	-106	-174	-150	-200	-360	-48	-32	-51	-39	-21	-15	0	0	0	0	+10	+30	+60	+100	+340
+390	+550																																		
S	up to		80	+59	+43													-340	-390	-550	-78	-62													+150
+200	+360																																		
I																																			
Z	Over		80	+93	+73													-170	-220	-380	-58	-38													+390
+440	+600																																		
E	up to		100	+71	+51	+59	+45	+25	+11	0	0	0	0	-12	-36	-72	-120	-390	-440	-600	-93	-73	-24	-10	+10	+17.5	+35	+54	+87	+220	+47	+90	+159	+260	+170
+220	+380																																		
R	Over		100	+101	+76	+37	+23	+3	-11	-22	-35	-87	-220	-34	-71	-126	-207	-180	-240	-410	-66	-41	-59	-45	-25	-17.5	0	0	0	0	+12	+36	+72	+120	+400
+460	+630	A	up to		120	+79	+54													-400	-460	-630	-101	-76											
	+180	+240	+410																																
N																																			
G	Over		120	+117	+88													-200	-260	-460	-77	-48													+450
+510	+710																																		
E	up to		140	+92	+63													-450	-510	-710	-117	-88													+200
+260	+460																																		
mm	Over		140	+125	+90	+68	+52	+28	+12.5	0	0	0	0	-14	-43	-85	-145	-210	-280	-520	-85	-50	-28	-12	+12	+20	+40	+63	+100	+250	+54	+106	+185	+305	+460
+530	+770																																		
	up to		160	+100	+65	+43	+27	+3	-12.5	-25	-40	-100	-250	-39	-83	-148	-245	-460	-530	-770	-125	-90	-68	-52	-28	-20	0	0	0	0	+14	+43	+85	+145	+210
+280	+520																																		
	Over		160	+133	+93													-230	-310	-580	-93	-53													+480
+560	+830																																		
	up to		180	+108	+68													-480	-560	-830	-133	-93													+230
+310	+580																																		
	Over		180	+151	+106													-240	-340	-660	-105	-60													+530

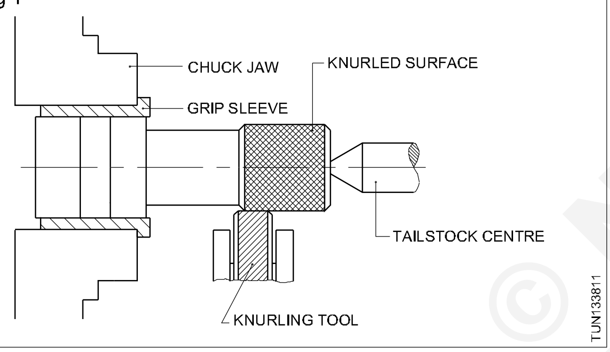
Knurling, meaning, necessity, types, grades & cutting speed for knurling

Objectives : At the end of this lesson you shall be able to
- **define knurling operation**
- **state the purpose of knurling**
- **list out the different types of knurls and knurling patterns**
- **list out the grades of knurls**
- **distinguish between the various types of knurling tool-holders.**

Knurling (Fig 1)

It is the operation of producing straight lined, diamond shaped pattern or cross lined pattern on a cylindrical external surface by pressing a tool called knurling tool. Knurling is not a cutting operation but it is a forming operation. Knurling is done at a slow spindle speed (1/3 times the turning speed). Soluble oil is to be used as coolant mostly and, sometimes straight cutting oil may be used to get better finish.

Fig 1



Purpose of knurling

The purpose of knurling is to provide:

- a good grip and make for positive handling.
- good appearance
- for raising the diameter to a small range for assembly to get a press fit.

Types of knurls and knurling patterns

The following are the different types of knurling patterns.

Diamond knurling, Straight knurling, Cross knurling, Concave knurling and Convex knurling.

Diamond knurling (Fig 2)

It is a knurling of diamond shaped pattern. It is done by using a set of rolls. One roller has got right hand helical teeth and the other has left hand helical teeth.

Straight knurling (Fig 3)

It is a knurling of straight lined pattern. This is done by using either a single roller or a double roller with straight teeth.

Fig 2

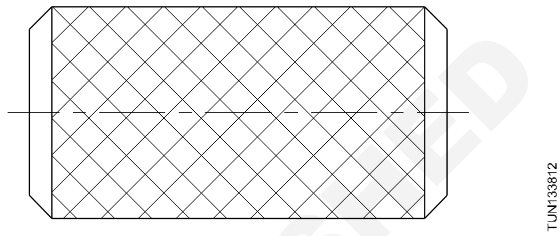
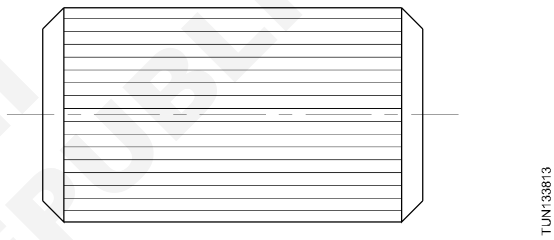


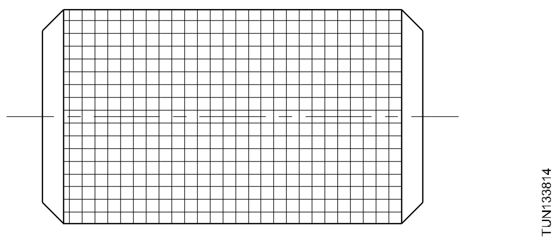
Fig 3



Cross knurling (Fig 4)

It is a knurling having a square shaped pattern. It is done by a set of rollers, one having straight teeth the other having teeth at right angles to the axis of knurl.

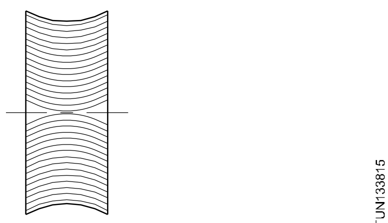
Fig 4



Concave knurling (Fig 5)

This is done by a convex knurl on a concave surface. This is done only by plunging the tool. The tool should not be moved longitudinally. The length of the knurling is limited to the width of the roller.

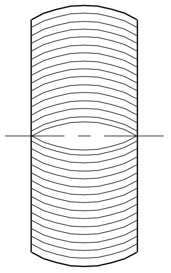
Fig 5



Convex knurling (Fig 6)

This is done by using a concave knurl on a convex surface. This is also done by plunging the tool.

Fig 6



Grades of knurling (Fig 7)

Knurling can be done in three grades.

Coarse knurling, Medium knurling and Fine knurling

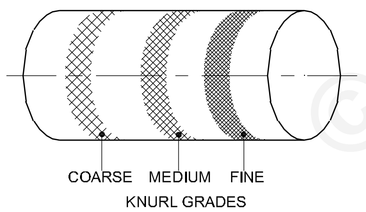
Coarse knurling is done by using coarse pitched knurls of 1.75 mm pitch. (14 TPI)

Medium knurling is done by using medium pitched knurls of 1.25 mm pitch. (21 TPI)

Fine knurling is done by using fine pitched knurls of 0.75 mm pitch. (33 TPI)

Types of knurling tool-holders

Fig 7



The different types of knurling tool-holders are:

- single roller knurling tool-holders (parallel knurling tool-holders)
- knuckle joint type knurling tool-holders
- revolving type knurling tool-holders (universal knurling tool-holders).

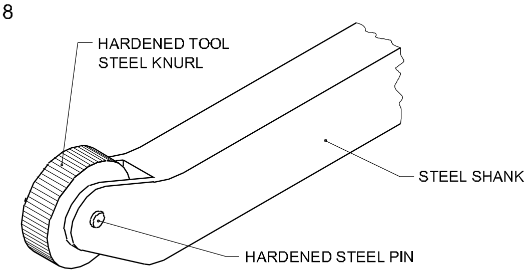
A knurling tool-holder has a heat-treated steel shank and hardened tool steel knurls. The knurls rotate freely on hardened steel pins.

Single roller knurling tool-holder (Fig 8)

It has only one single roller which produces a straight lined pattern.

Knuckle joint type knurling tool-holders (Fig 9)

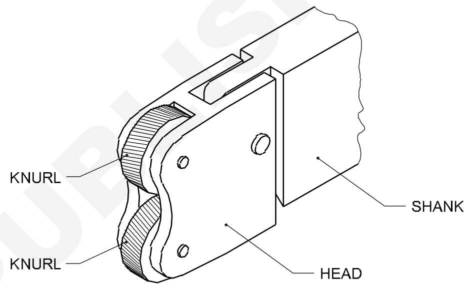
Fig 8



This tool holder has a set of two rollers of the same knurling pitch. The rollers may be of straight teeth or helical teeth. It is self-centering.

Revolving head knurling tool (Fig 10)

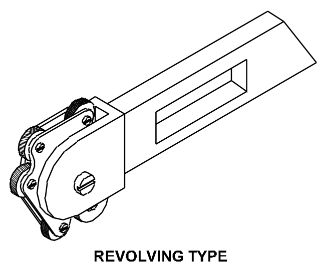
Fig 9



This tool-holder is also called a universal knurling tool-holder. It is fitted with 3 pairs of rollers having coarse, medium and fine pitches. These are mounted on a revolving head which pivots on a hardened steel pin. It is also self-centering.

Knurling - Speed and Feed

Fig 10



Differences between different types of knurling tool-holders are given in Table -1

Table -1

Single roller	**Knuckle joint**	**Revolving type**
Only one roller is used.	A pair of rollers are used.	Three pairs of rollers are used.
Only one pattern of knurling can be produced with this type of knurling tool-holder.	Cross or diamond knurling pattern can be produced.	Knurling patterns of different pitches can be produced.
It is not self-centering.	It is self-centering.	It is self-centering.

The tables shown be used as a guide for determining the amount of end-feed or in-feed per revolution of the work. The rate of the feed for diamond pattern knurling is slower than that for straight or diagonal knurling.

Straight or Diagonal

End - FEED KNURLING

Approximate

FEED per REVOLUTION

Straight or Diagonal

T.P.I	**Alum Brass**	**Mild Steel**	**Alloy Steel**
12	.008”	.006”	.004”
16 - 20	.010”	.008”	.005”
25 - 35	.013”	.010”	.007”
40 - 80	.017”	.012”	.009”

IN - FEED KNURLING

Approximate

REVOLUTION

T.P.I	**Alum Bras**	**Mild Steel**	**Alloy Steel**
12	12	15	25
16-20	10	13	22
25-35	8	11	20
40-80	6	9	18

Driving plate and face plate

Objectives : At the end of this lesson you shall be able to
- **name the parts of a driving plate**
- **distinguish between the different driving plates**
- **state the uses of the different driving plates**
- **name the parts of a face plate**
- **distinguish between different face plates.**
- **list out the accessories used along with the face plates.**

Driving plates

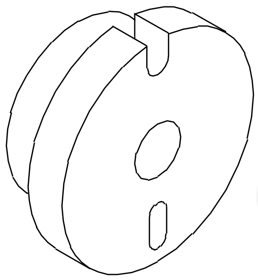
When turning a work in between the centres, the driving plate is used for transmitting the drive to the work.

They are grouped as catch plates and driving plates and safety driving plates.

Catch plate

It is designed with a 'u' slot and an elliptical slot to accommodate the bent tail of the lathe carrier. (Fig 1)

Fig 1

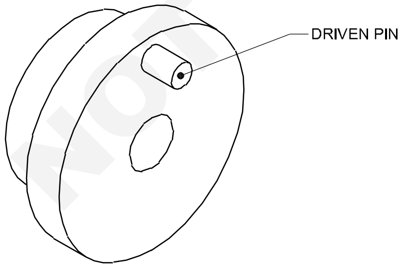


CATCH PLATE

Driving plate

It is designed with a projected pin which locates the straight tail of the lathe carrier. (Fig 2)

Fig 2

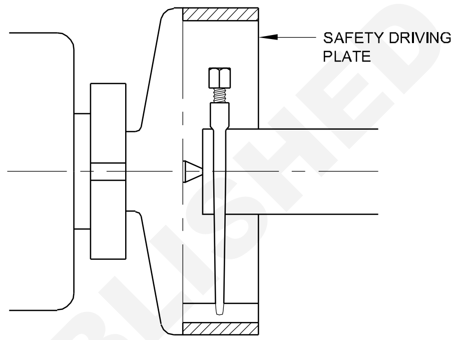


DRIVE PLATE

Safety driving plate

It is similar in construction to a driving plate but equipped with a cover to protect the operator from any injuries. (Fig 3)

Fig 3



The safety driving plates are made of cast steel and are machined to have their face perfectly at right angles to the bore. They are provided with a stepped collar at the back. The bore is designed to suit the spindle nose to which the plate has to be mounted.

The driving plate with a straight tail carrier provides a positive drive for the workpiece.

A catch plate with a bent tail carrier uses a minimum clamping length of the workpiece for clamping purposes.

A safety driving plate prevents likely injuries to the operator.

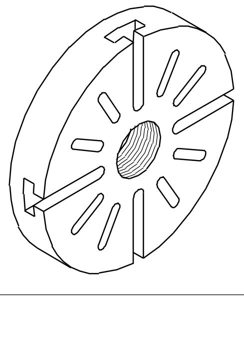
Face plates

They are similar in shape to the lathe catch plates but are larger in diameter.

The different types of face plates are:

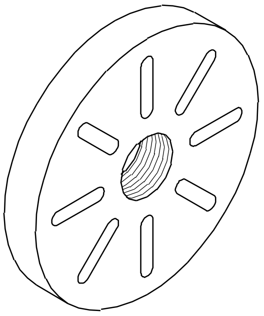
- face plates with elongated slots and 'T' slots (Fig 4)

Fig 4



- face plates with only elongated radial slots (Fig 5)

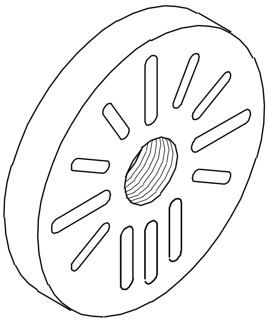
Fig 5



TUN134215

- face plates with elongated radial slots and additional parallel slots (Fig 6)

Fig 6



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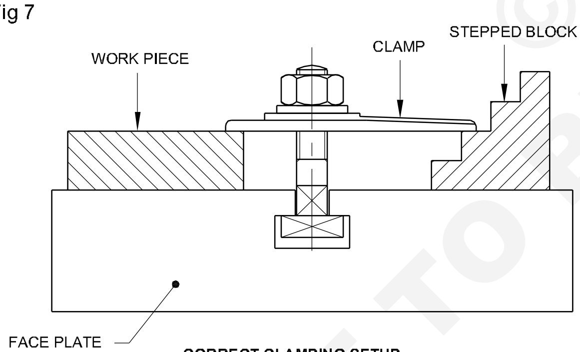
Face plates are used along with the following accessories when in use. The accessories are listed here.

- Clamps,'T' bolts and stepped block (Fig 7)

Fig 7



CORRECT CLAMPING SETUP

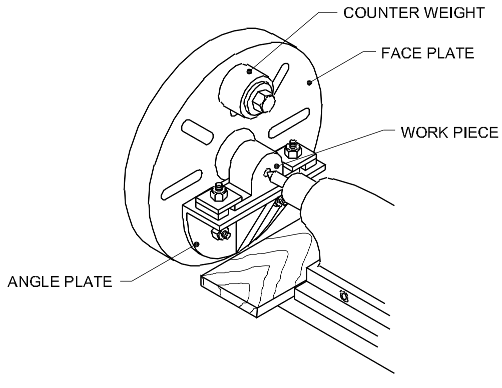
TUN134217

- Angle plate and counterweight (Fig 8)
- Parallels (Fig 9)

Uses

Large, flat, irregular shaped workpieces, castings, jigs and fixtures may be firmly clamped to a face plate for various turning operations .

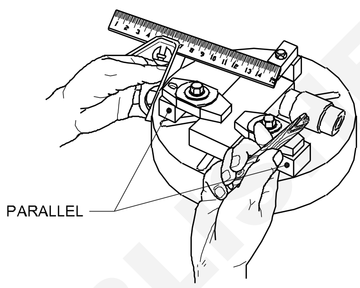
Fig 8



WORK HELD BY AN ANGLE PLATE

TUN134218

Fig 9



LOCATING WORK ON A FACE PLATE

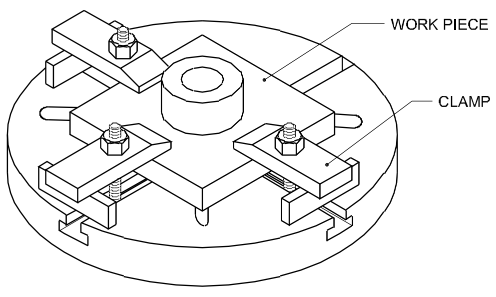
TUN134219

The work can be mounted on a face plate while the face plate is on the lathe spindle or on the workbench. If the workpiece is heavy or irregular to hold, the workpiece is mounted while the face plate is on the workbench. Before mounting the face plate set up to the spindle, it is advantageous to locate the workpiece on the face plate and centre the workpiece with reference to the centre punch mark or hole approximately on the face plate. This makes it easier to true the work after the face plate is mounted on to the spindle.

The position of the bolts and clamps is very important, if a workpiece is to be clamped effectively.

If a number of duplicate pieces are to be machined, the face plate itself can be set up as a fixture, using parallel strips and stop blocks.

Fig 10



WORK CLAMPED DIRECTLY TO FACE PLATE

TUN13421A

Fixed, travelling steadies, transfer caliper & its construction, uses

Objectives : At the end of this lesson you shall be able to
- **state what is a steady rest**
- **identify and name the various types of steady rests**
- **distinguish between a fixed steady rest and a follower steady rest**
- **state the uses of a steady rest**
- **identify the cat head and its use.**

A steady rest is a lathe accessory used to give extra support for a long slender workpiece in addition to the centre support during turning.

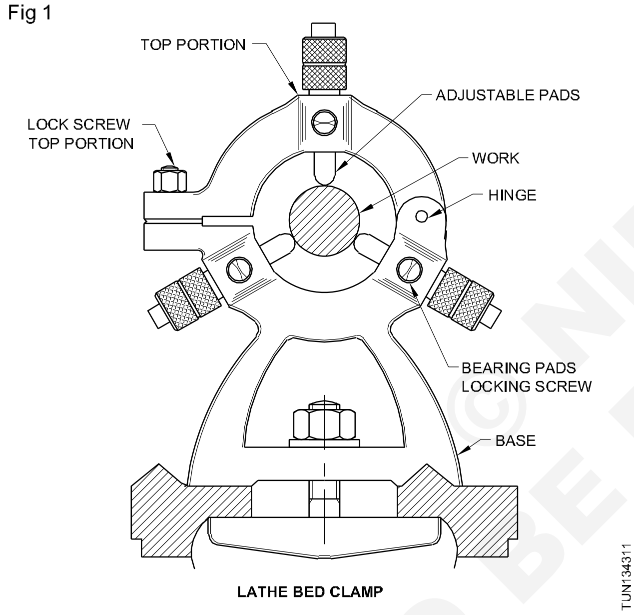
The most common types of steady rests are :

- Fixed steady rest.
- Followed steady rest (travelling steady)

Fixed steady rest (Fig 1)

The figure shows the parts of a fixed steady rest.

Fig 1



A fixed steady rest is fixed to the lathe bed and it is stationary. It gives support at one fixed place only.

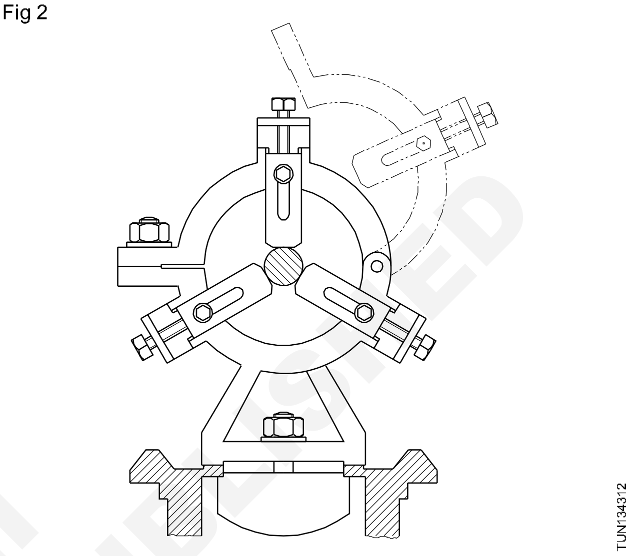
It consists of a frame containing three adjustable pads.

The base of the frame is machined to suit the inside ways of the lathe bed. The top portion is hinged at the back to permit the top to be lifted or assembled to the bottom half for allowing the work to be mounted or removed. A fixed steady can be clamped at any desired position on the lathe bed by the base clamping screw. (Fig 2)

The three adjustable pads can be moved radially in or out by means of adjusting screws. The three pads are adjusted on a trued cylindrical face of the workpiece.

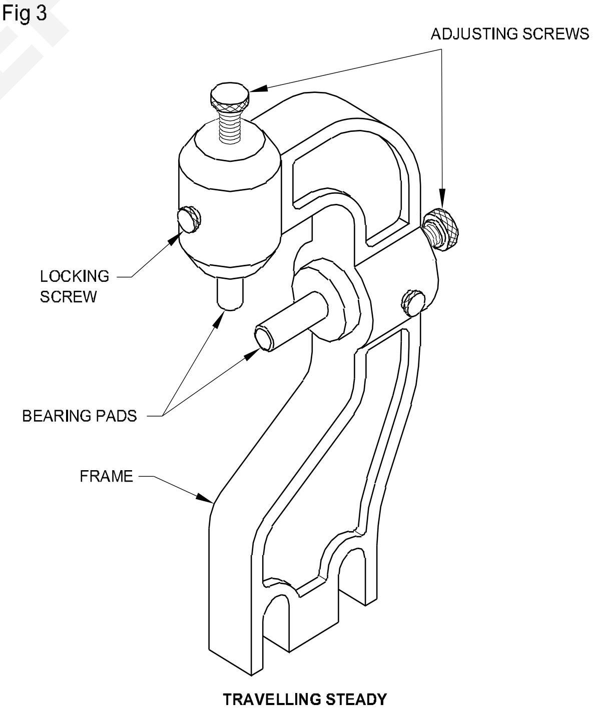
A follower steady is fixed to the saddle of the lathe. As it follows the tool, it gives support where cutting actually takes place. In the follower steady, the support is continuous to the entire length of cutting.

Fig 2



Follower steady rest (Fig 3)

Fig 3

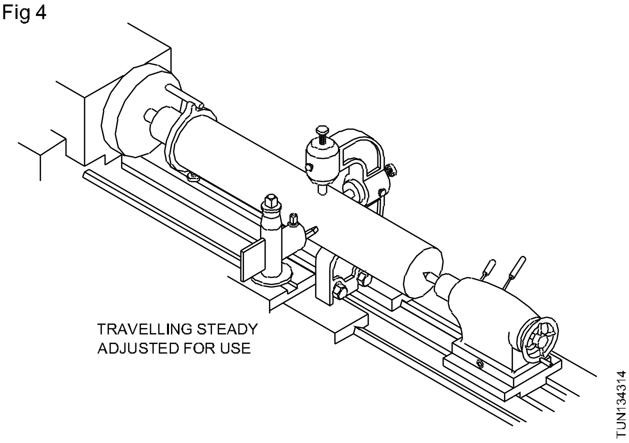


The follower steady rest has usually two pads. One pad is located opposite to the cutting tool and the other pad bears the top of the workpiece to prevent it from springing up. The figure shows a travelling steady rest in action. (Fig 4)

Cat head

If the job shape is not round or where we cannot turn a true cylindrical surface on the job, it is not possible to support the job, by a fixed steady rest. For those types of jobs, a device called cat head is fixed on the workpiece.

Fig 4



The cat head is a type of bush, its external surface is round. Fig 5 shows a cat head. The middle portion is cylindrical and free to rotate. The two ends have the adjusting screws for holding and centering the work. After centering the work the fixed steady is positioned, and pads are adjusted to hold the cat head's centre portion. When the lathe is running the work revolves along with the ends of the cat head whereas the centre portion is stationary. (Fig 6) Another type of cat head, shown in Fig 7, is a single piece and it rotates along with the job.

Fig 5

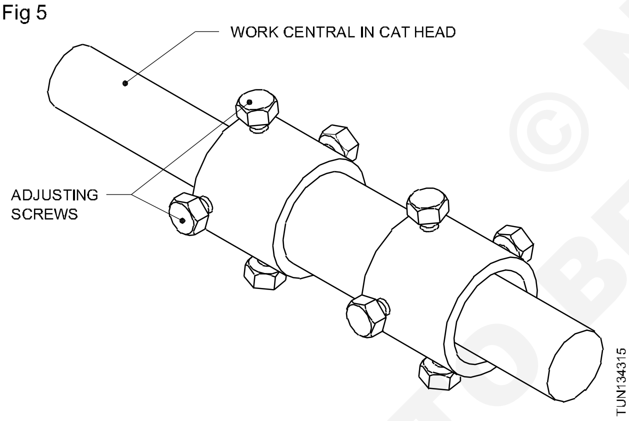
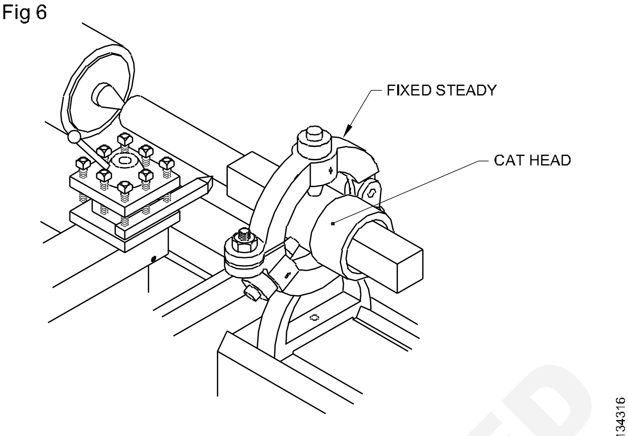
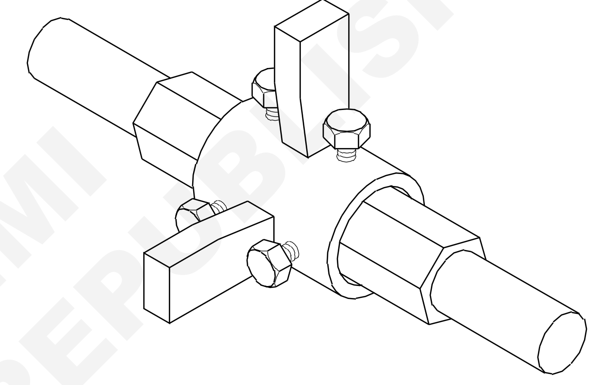


Fig 6



USING CAT HEAD AND FIXED STEADY REST

Fig 7

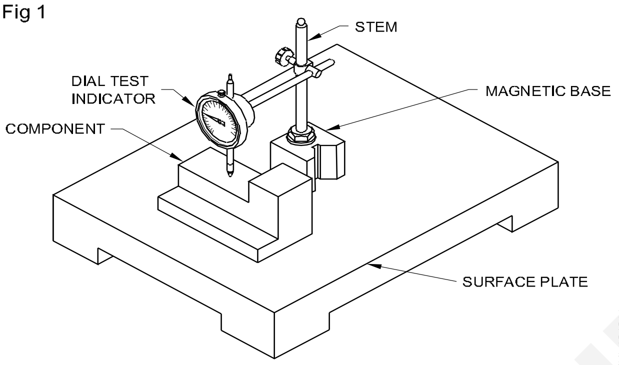


Magnetic stand dial indicator its uses and care

Objectives : At the end of this lesson you shall be able to
- **state the working principle of a dial test indicator**
- **identify the parts of a dial test indicator**
- **state the important features of a dial test indicator**
- **state the functions of a dial test indicator**
- **identify different types of stands.**

What are dial test indicators: Dial test indicators are fine precision type of instruments used for comparing and determining the variation in the sizes of components. (Fig 1)

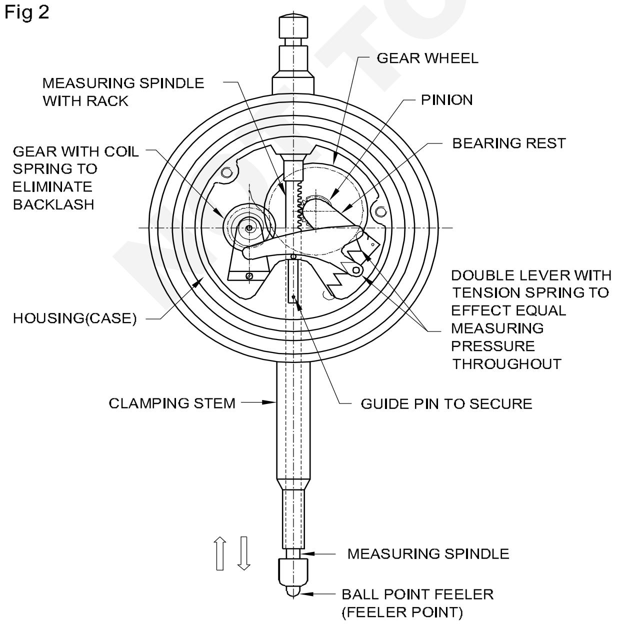
Fig 1



These instruments cannot give the direct reading of the sizes like micrometers and vernier calipers. A dial test indicator magnifies small variations in sizes by means of a pointer on a graduated dial. This direct reading of the deviations gives an accurate picture of the conditions of the parts being tested.

Principle of working: The principle of a dial test indicator is the magnification of a small movement of the plunger by converting it into rotary motion of a pointer on a circular scale. (Fig 2)

Fig 2



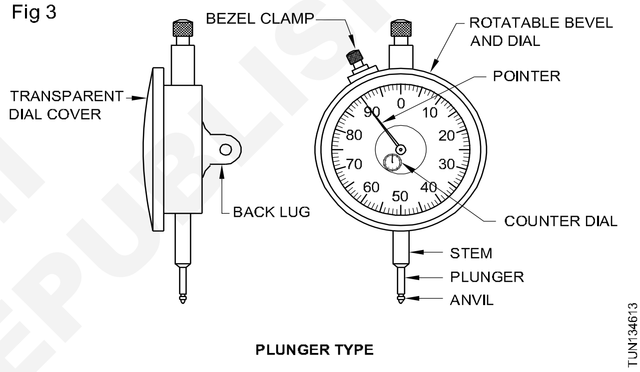
For converting linear motion of the plunger into rotary motion of the pointer, a rack and pinion mechanism is used.

Types

Two types of dial test indicators are in use according to the method of magnification.

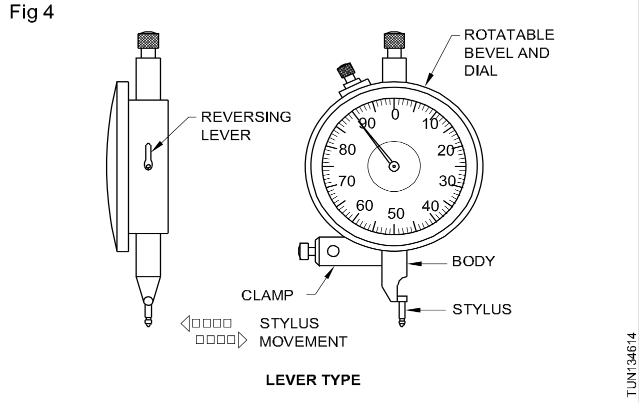
- Plunger type (Fig 3)

Fig 3



- Lever type (Fig 4)

Fig 4

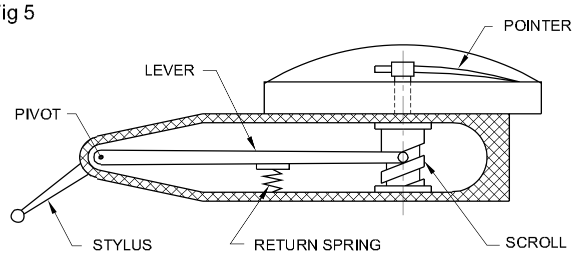


Important features of a dial test indicator: An important feature of the dial test indicator is that the scale can be rotated by a ring bezel, enabling it to be readily set to zero.

Many dial test indicators read plus in a clockwise direction from zero and minus in a counter clockwise direction to give plus and minus indications.

The lever type dial test indicator: In the case of this type of dial test indicators the magnification of the movement is obtained by a mechanism of lever and scroll. (Fig 5)

Fig 5

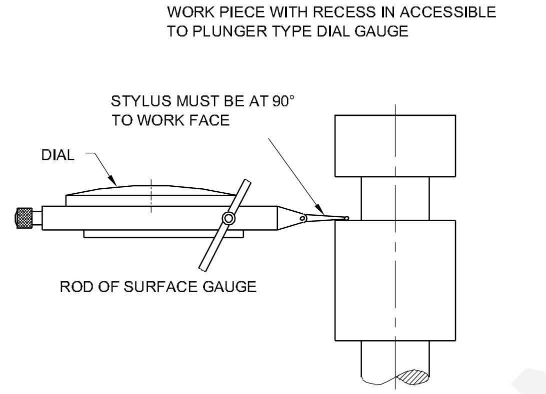


MECHANISM OF THE LEVER TYPE DIAL GAUGE

It has a stylus with a ball type contact operating in the horizontal plane.

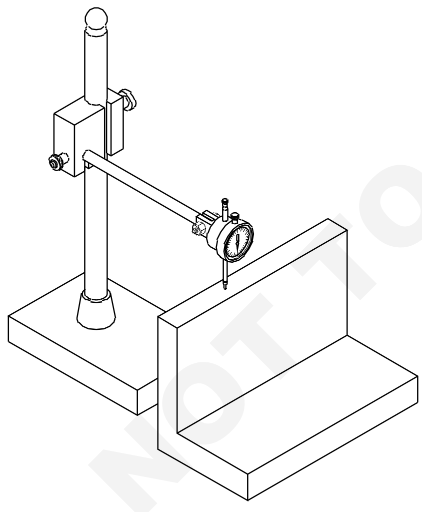
This can be conveniently mounted on a surface gauge stand and can be used in places where the plunger type dial test indicator application is difficult. (Fig 6)

Fig 6



Uses (Figs 7 to 11)

Fig 7

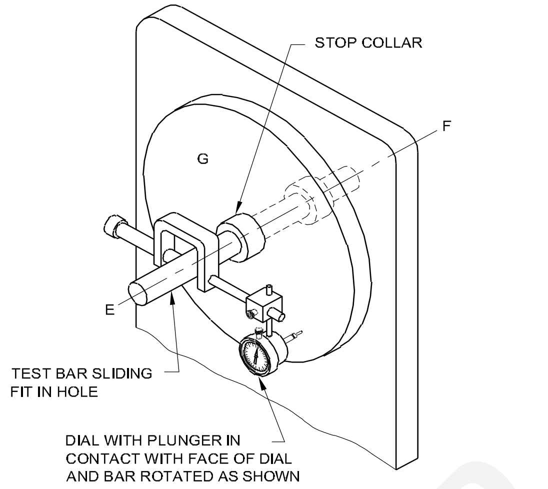


CHECKING FOR PARALLELISM

- To compare the dimensions of a workpiece against a known standard.
- To check plane surfaces for parallelism and flatness.
- To check parallelism of shafts and bars.
- To check concentricity of holes and shafts.

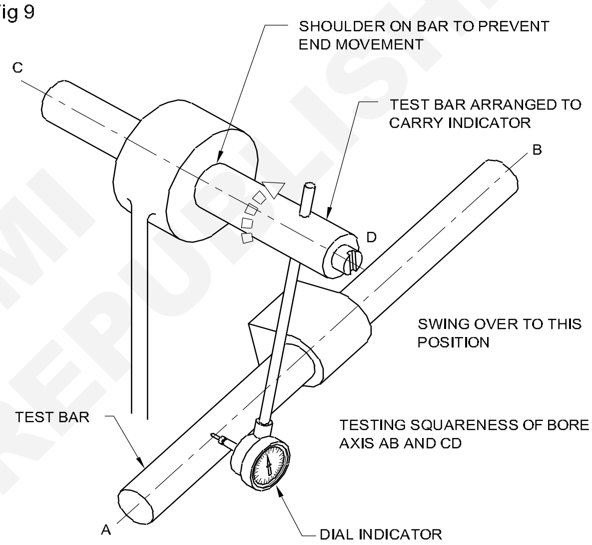
Stands: Dial test indicators are used in conjunction with stands for holding them so that the stand itself may be placed on the datum surface or machine tools.

Fig 8



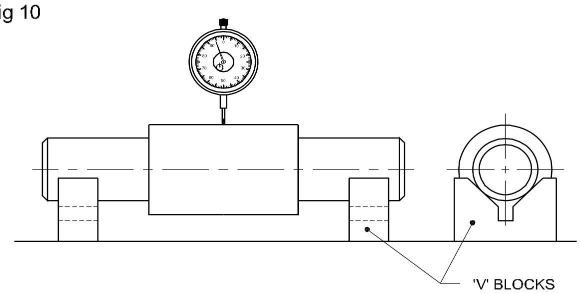
TESTING SQUARENESS OF FACE G
WITH AXIS EF OF CENTRE HOLE

Fig 9

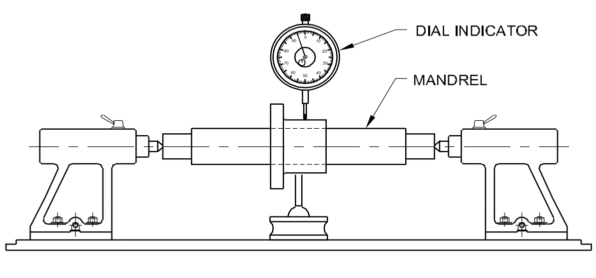


TEST SQUARENESS OF BORE AXIS USING TEST BAR

Fig 10

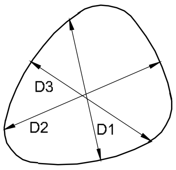


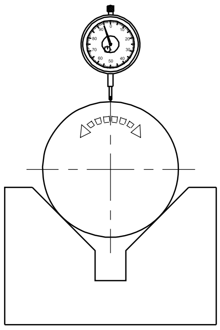
CONCENTRICITY TEST ON ENLARGED PORTION OF SHAFT



TESTING BUSH FOR CONCENTRICITY

Fig 11

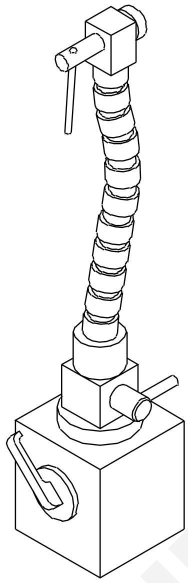




TEST FOR ROUNDNESS WITH VEE BLOCKS AND CLOCK INDICATOR

TUN13461B

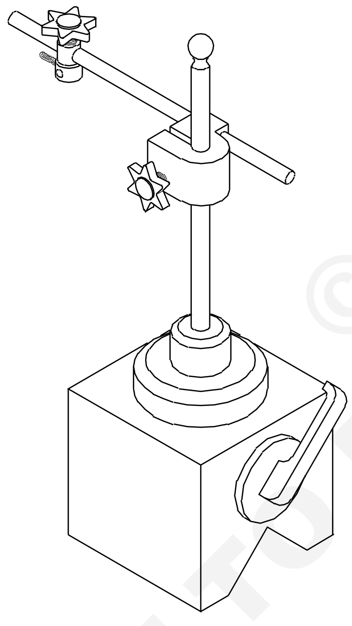
Fig 13



MAGNETIC STAND WITH FLEXIBLE POST

TUN13461D

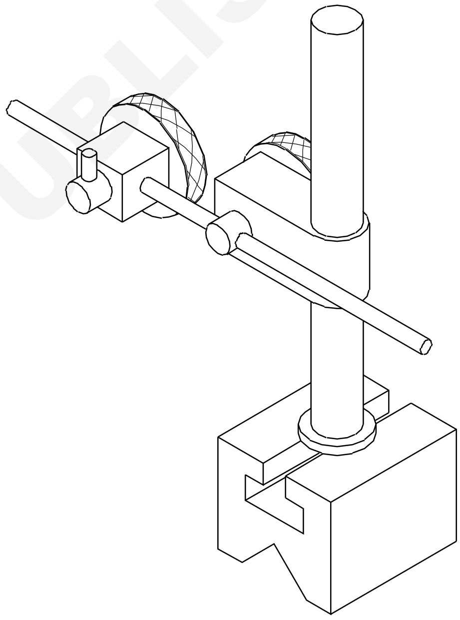
Fig 12



MAGNETIC STAND UNIVERSAL CLAMP

TUN13461C

Fig 14



GENERAL PURPOSE HOLDER WITH CAST IRON BASE

TUN13481E

Transfer Caliper

Objectives : At the end of this lesson you shall be able to
- **Identify the parts of an transfer caliper**
- **State the function of the transfer caliper**
- **Read transfer caliper measurement.**

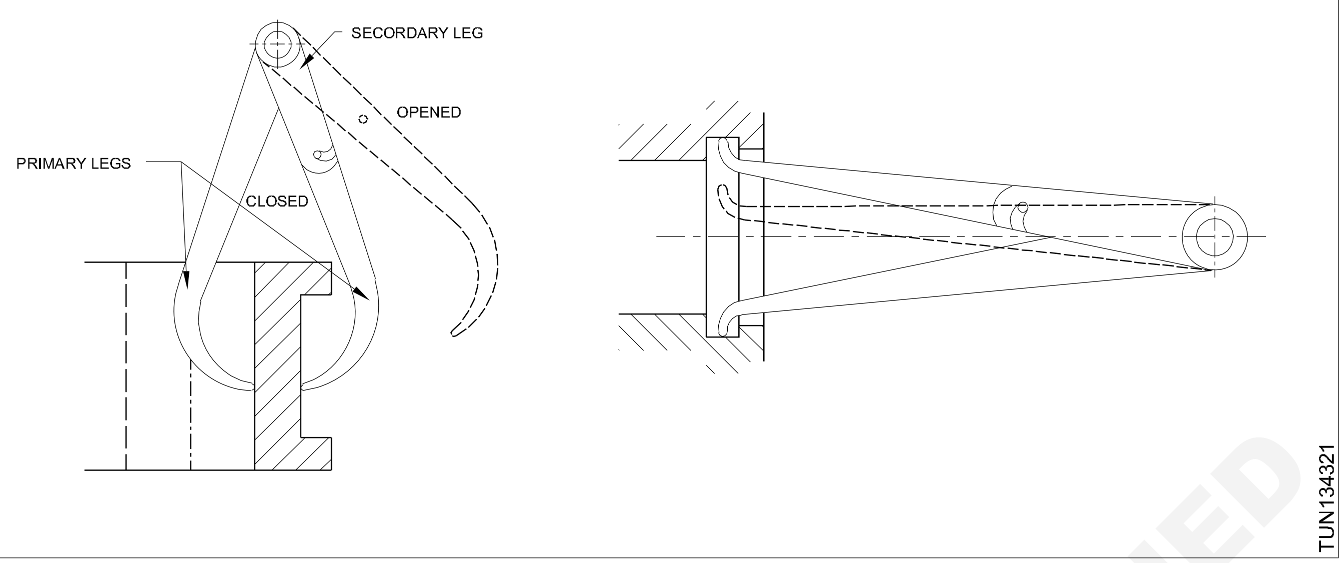
Transfer Caliper: This type of caliper (outside or inside) used where caliper cannot be access directly due steps, projections, grooves etc.

The construction is similar to ordinary (Pivoted or with Thumb nut) firm joint caliper with additional secondary leg at the top of one of the primary legs with or without lock met facility.

In this type the primary legs are made to touch the surface to be measured and then the secondary leg brought to position till the pin in primary leg coincides through the slot. New the position of secondary leg unchanged and primary leg with stopper pin in relieved of from measured surface.

Once caliper taken out, the primary leg which was relieved in to the position to secondary leg position. Then the dimension measure with the help of measuring instrument.

Fig 1



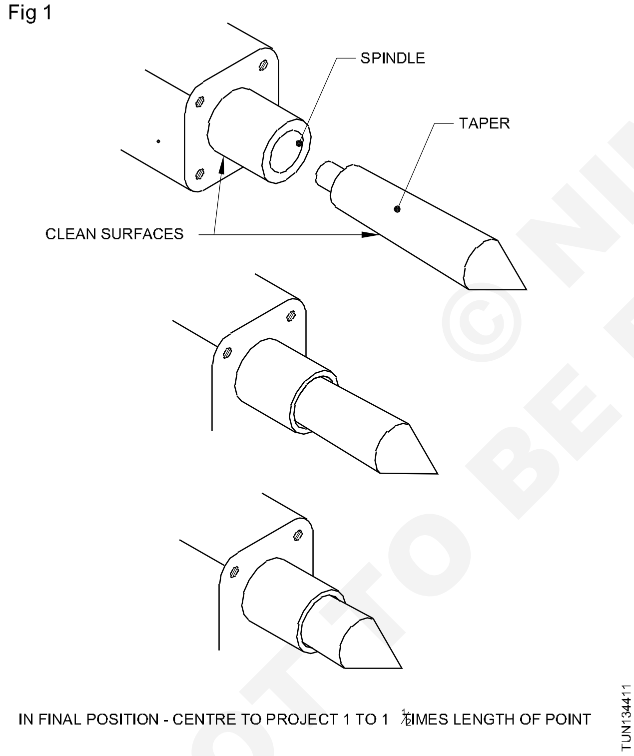
Lathe centre and types & their uses

Objectives : At the end of this lesson you shall be able to
- **state what is a lathe centre**
- **distinguish between a live centre and a dead centre**
- **state the purpose of lathe centres**
- **identify and name the different types of centres**
- **indicate the specific uses of each type of centre.**

Lathe centre

It is a lathe accessory. It is used to support a lengthy work to carry out lathe operations. When a work is held in a chuck, the centre is assembled to the tailstock, and it supports the overhanging end of the work. The work is to be provided with a centre drilled hole on the face of the overhanging end. When the job is held in between centres to carry out the operation, it functions together with a driving plate and a suitable lathe carrier.

Fig 1



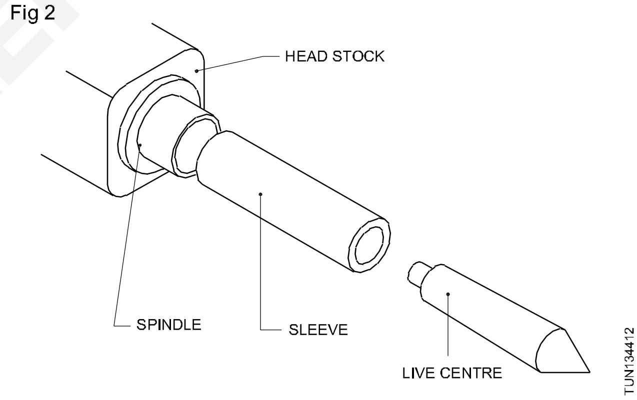
The centre, which is accommodated in the main spindle sleeve, is known as a 'live centre' and the centre fixed in the tailstock spindle is known as a dead centre. In construction, both centres are identical, made as one unit that consists of a conical point of 60° included angle, a body provided with a Morse taper shank and a tang.

The dead centre is made out of high carbon steel, hardened and around whereas the live centre need not have its conical tip hardened as it revolves with the work. A good lubricant should be used for the dead centre.

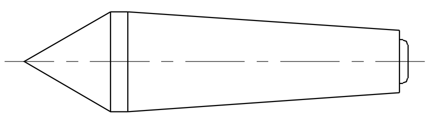
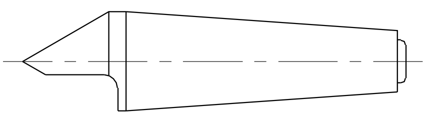
Types of centres and their uses

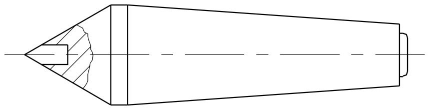
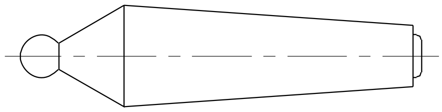
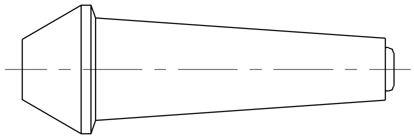
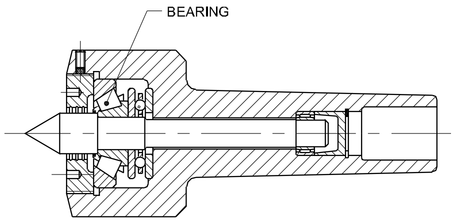
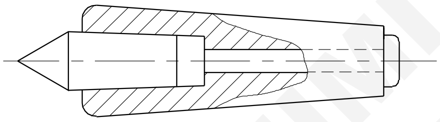
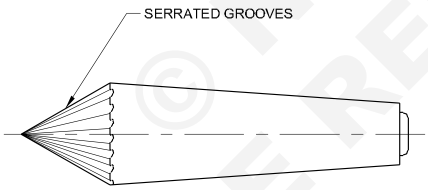
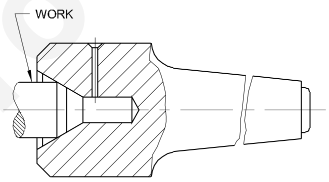
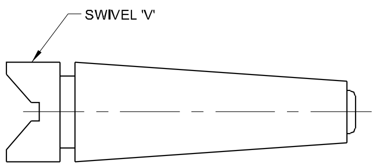
The following table gives the names of the most widely used types of lathe centres, their illustrations and their specific uses. (Fig 2)

Fig 2



Various Types of Lathe Centres

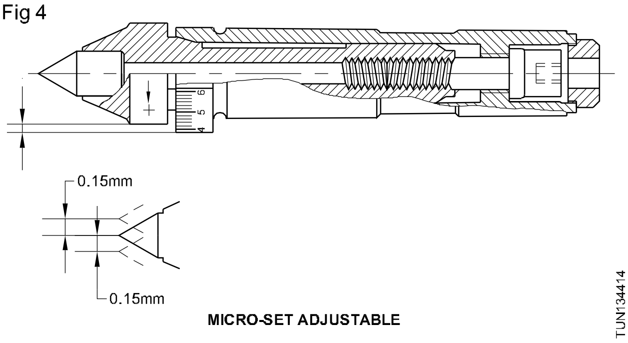
1	Ordinary centre-common type		Used for general purpose.
2	Half centre		Though it is termed as half centre, little less than half is relieved at the tip portion. eved at the tip portion. Used while facing the job without disturbing the setting.

3	Tipped centre		A carbide or a hard alloy tip is brazed into an ordinary steel shank. The hard tip is wear- resistant.
4	Ball centre		Minimum wear and strain. Particularly suitable for taper turning.
5	Pipe centre		Used for supporting pipes, shells and hollow end jobs.
6	Revolving centre		Frictionless. Used for supporting heavy jobs and jobs revolving with high speeds. A high-speed steel inserted centre is supported by two bearings housed in a body. It is also called the revolving dead centre.
7	Insert-type centre		Economical. Only the small high-speed steel insert is replaced.
8	Self-driving live centre		Usually mounted on the head-stock spindle. Used while machining the entire length of the job in one setting. Grooves cut around the circumference of the centre point provide for good gripping of the job and for getting the drive. This centre can be used for only soft jobs and not for hardened jobs.
9	Female centre		This centre is used to support the end of the job where no countersink hole is permitted.
10	Swivel 'V' centre		This centre is used to support a job in the `V' portion and to drill holes across the round job by using a drill bit in the head-stock spindle.

A micro-set adjustable centre fitted into the tailstock spindle provides a fast and accurate method of aligning lathe centres. (Fig 3)

Some of these centres contain an eccentric, others contain a dovetail slide which permits slight adjustment of the centre itself to correct alignment.

Fig 4



MICRO-SET ADJUSTABLE

Lathe carrier - Function, types of carrier and uses

Objectives : At the end of this lesson you shall be able to
- **name the types of lathe carrier**
- **state the use of each type of lathe carriers.**

The purpose a lathe carrier is mainly to hold the work and provide rotation by transfering the power from the spindle using special attachment.

Accessories used for in-between centre work

The accessories used during turning work held in between centres are as follows.

Live centre, Dead centre, Catch plate, Driving plate, Lathe spindle sleeve and Lathe carriers.

Lathe carriers

They are also called lathe dogs. They are used to drive the work during turning between centres. The work is clamped firmly in the lathe carrier. It consists of a cast iron or forged steel body and a clamping screw. It is designed with a straight or bent tail. It is available in a set of 10, capable of accommodating work of a wide range of diameters. The tails of the carriers are meant to locate and drive the workpiece for turning. (Fig 1) To protect the finished surface from damages, a soft metal packing piece is used under the clamping screw.

Types of Lathe carriers

The following are the four types of lathe carriers.

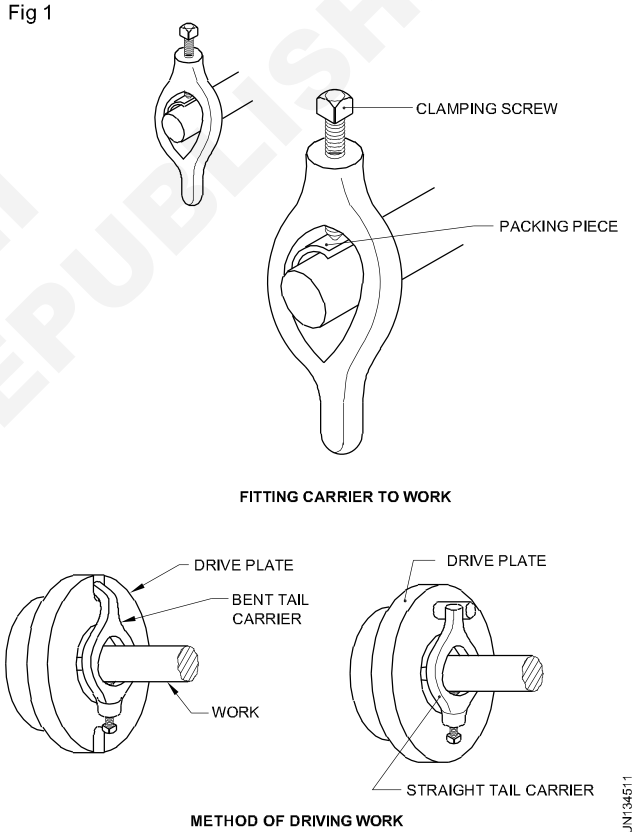
Straight tail carrier, Bent tail carrier, Clamp type carrier and Safety clamp type carrier.

A straight tailed carrier locates against the driving pin of the driving plate and provides a positive drive for the workpiece. (Fig 2)

A bent tailed lathe carrier engages into a ‘u’ slot of the catch plate and drives the workpiece. (Fig 3).

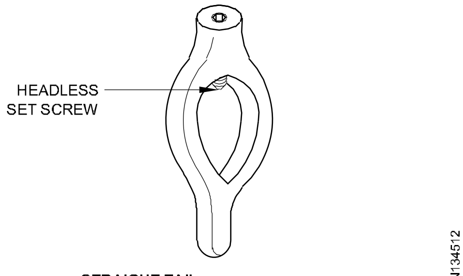
The clamp type lathe carrier is designed with a clamping plate and adjustable screws. It holds a wide range of diameters of work because it is provided with a ‘V’ groove and adjustable bolts and nuts. This carrier may be used to hold square and rectangular sectioned rods also. They are also useful to hold small diameter jobs because of the provision of the ‘V’ groove. (Fig 4)

Fig 1



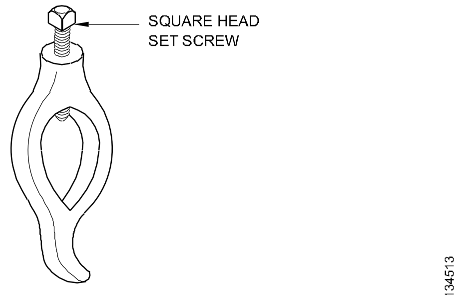
METHOD OF DRIVING WORK

Fig 2



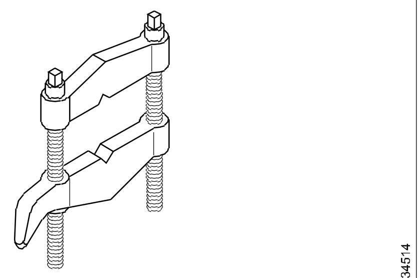
STRAIGHT TAIL

Fig 3



BENT TAIL

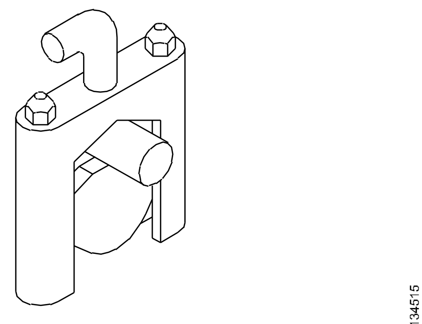
Fig 4



CLAMP TYPE

Safety clamp lathe carriers are designedwith safety - top and bottom clamping plates. These plates provide a positive grip of the work during turning. (Fig 5)

Fig 5



SAFETY CLAMP

Uses of Carrier

- Hold component/workpiece and held between centres to carry out turning operation.
- It can also be used for tapper turning and threading.

Different methods of expressing tapers

Objectives : At the end of this lesson you shall be able to
- **define a taper**
- **state the uses of a taper**
- **identify the elements of a taper**
- **express the taper and its conversion**
- **classify the tapers**
- **state the different Standard tapers and their uses.**

Definition of a taper

Taper is a gradual increase or decrease in the diameter along the length of the job.

Uses of a taper

Tapers are used for:

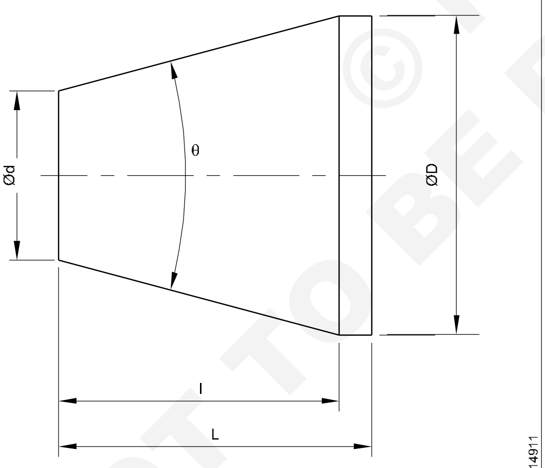
- easy assembly and disassembly of parts
- giving self-alignments in the assembled parts
- Transmitting the drive in the assembled parts.

Elements of a taper (Fig 1)

Big diameter (D)

Small diameter (d)

Fig 1



SYMBOLS USED FOR CALCULATING TAPERS

Length of the taper (l)

Angle of taper (θ)

Total length of the job (L)

Different methods of expressing tapers

Tapers can be expressed by

- giving the big dia. small dia. and the length of the taper (Fig 2)
- giving the included angle of the taper in degrees (Fig 3)

Fig 2

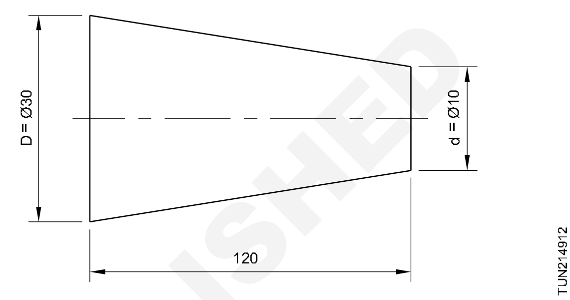
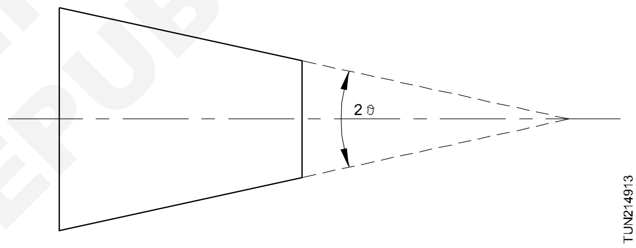
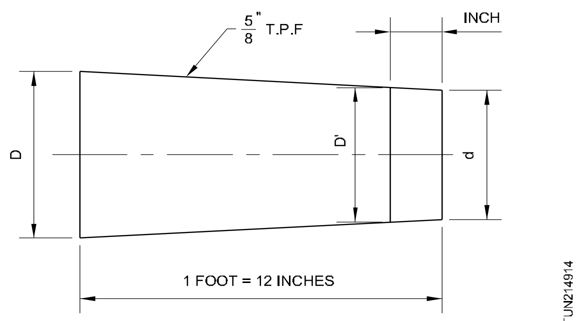


Fig 3



- giving the taper per foot, (Ex: 5/8" TPF means in a 12" (one foot) taper length , the difference between big & small diameter is 5/8") (Fig 4)

Fig 4



- giving the taper in ratio (This is also termed as conicity and it is indicated as K) (Ex: Ratio 1:20 means, for a taper length of 20 units, the difference in diameter is 1 unit.) (Fig 5)
- mentioning by standard taper MT3. (Fig 6)

Conversion

The relationship between the elements of a taper are:

$$\text{Tan}\,\theta = \frac{D - d}{2L}$$

Fig 5

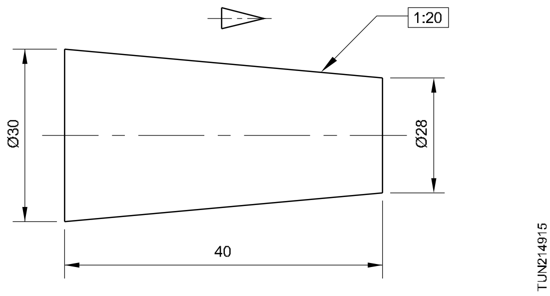
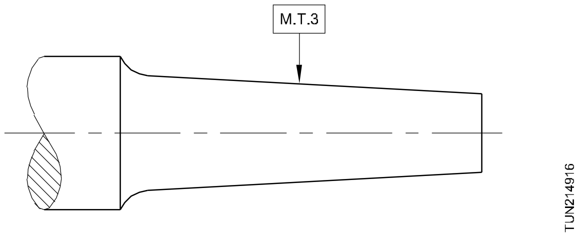


Fig 6



$$\tan\theta = \frac{TPF}{24}$$

$$\tan\theta = \frac{ratio}{2}$$

Classification of tapers

Tapers are classified into the following:

- Self-holding tapers (Figs 7 & 7a)

Self-holding tapers have a low taper angle, limited to a maximum of 10°. They will not have any locking devices for holding the components assembled.

Examples

Taper shank of drills, reamers and sleeves.

Fig 7

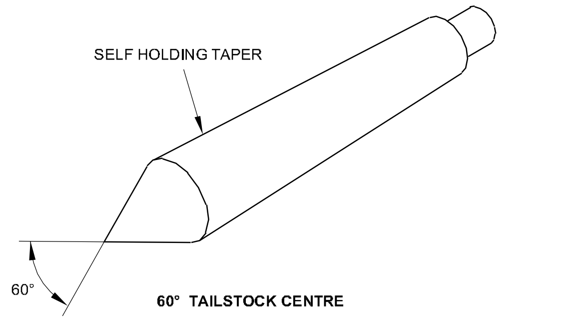
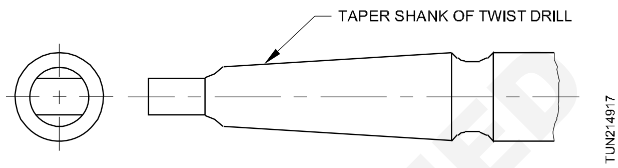
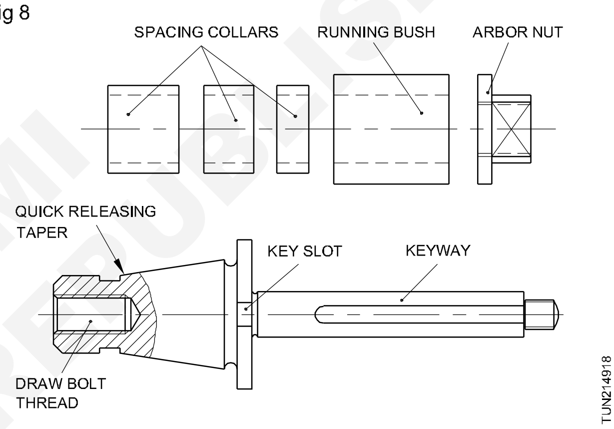


Fig 7a



- Quick releasing tapers (Fig 8)

Fig 8



Quick releasing tapers have higher taper angles and they require locking devices for holding.

Example

Arbor of a milling machine.

Different Standard tapers and their uses

Objectives: At the end of this lesson you shall be able to
- **name the standard tapers in use in engineering**
- **state the specialty of each standard taper**
- **list out their specific applications in engineering.**

The different standard tapers and their uses

The following are the common standard tapers in use.
Morse taper (MT)

Brown & Sharpe taper (BS)

Jarno taper (JT)

Metric taper

Pin taper

Morse taper

It is the most commonly used standard taper in the industry. It is a self-holding taper. This taper is usually used in bores of spindle noses of lathes and drilling machines, shanks of drills, reamers, centres, etc. The Morse taper is denoted by the letters MT. They are available from MT0 to MT7. The numbers MT0 to MT4 are commonly used on taper shanks of twist drills, reamers and lathe centres. The included angle of Morse taper is approximately 3° and the taper per foot is 5/8". A chart showing the angles and TPF of different Morse taper numbers in detail may be referred to for specific use.

Brown and Sharpe taper

Both quick-releasing and self-holding tapers are available in Brown and Sharpe tapers. The taper used in the arbors of milling machines is the quick-releasing Brown and Sharpe taper having a taper of 3 1/2" T.P.F.

Brown and Sharpe self-holding tapers are available from BS1 to BS18. The taper per foot is 1/2" except BS 10. BS10 has a taper of 0.5161" taper per foot.

Jarno taper

Jarno tapers are also used on the external taper of the lathe spindle nose where chuck or face plate is mounted. They are available from No.I to No.20. The amount of taper per foot is 0.6". The dimensions of this taper will be found as follows.

Jarno taper is mostly used in die-sinking machines.

Metric taper

It is available as both self-holding and quick-releasing tapers. A self-holding metric taper has an included angle of 2° 51' 51". The commonly used self-holding metric tapers are expressed in numbers, and they are 4, 6, 80, 100, 120,160 and 200. These numbers indicate the highest diameter of the taper shank up to which the gauge or mating part is to match.

Quick-releasing metric tapers are used as the external

$$\text{Big diameter} = \frac{\text{Number}}{8}$$

$$\text{Small diameter} = \frac{\text{Number}}{10}$$

$$\text{Length of taper} = \frac{\text{Number}}{2}$$

tapers of lathe spindle noses. Metric tapers are expressed by numbers which represent the big diameter of the taper in millimetres. The equivalent quick (self) releasing taper in metric also has a taper of 7/24 and the available sizes are 30, 40, 45, 50.

A 7/24 taper of No.30 will have a maximum diameter of 31.75 mm at the larger end and No.60 will have 107.950 mm. All other sizes fall within this range.

Standard pin taper

It is used in taper pins. It is a self-holding taper. It is available both in Metric and British systems. The amount of taper is 1:50 in the Metric system and 1:48 (1/4" TPF) in the British system.

A taper pin is used to assemble parts which must be held and positioned for accurate, quick and easy assembly. It also permits to transmit the drive.

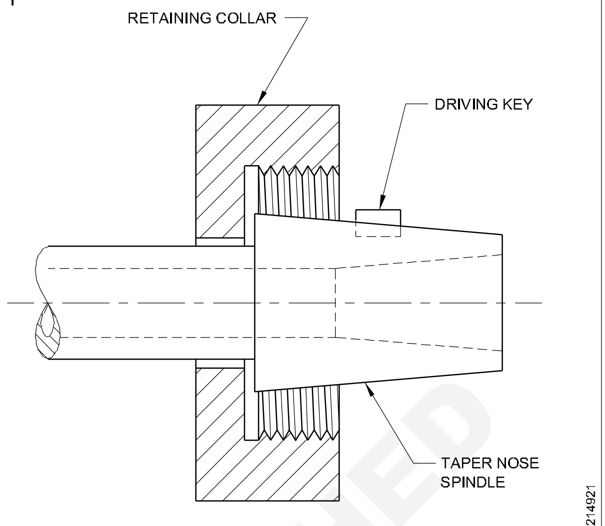
Uses of standard tapers

Tapers are used for:

- self-alignment/location of components in an assembly
- assembling and dismantling parts easily
- transmitting drive through assembly.

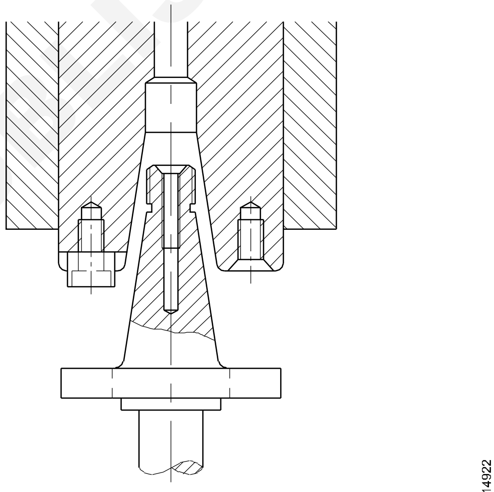
Tapers have a variety of applications in engineering assembly work.(Figs 1,2 & 3)

Fig 1



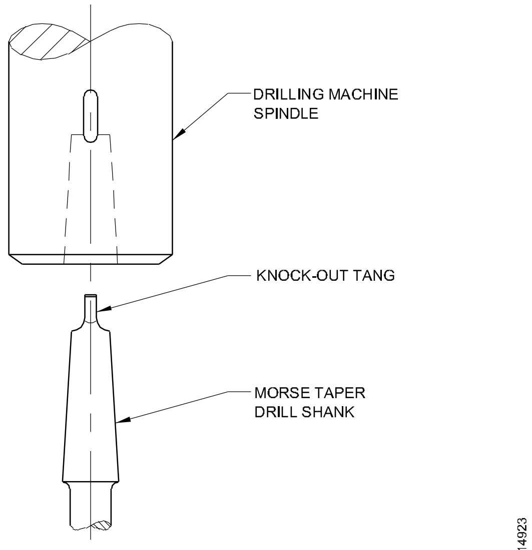
LATHE-TAPER NOSE SPINDLE

Fig 2



MILLING MACHINE SPINDLE

Fig 3



DRILLING MACHINE SPINDLE AND DRILL WITH TAPER SHANK

Tapers used in other assembly work

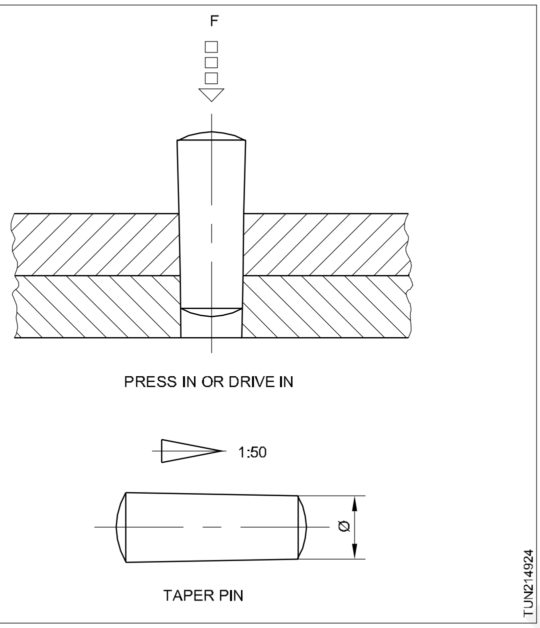
A variety of tapers are used in engineering assembly work. The most common ones are:

- pin taper
- key and keyway taper.

Pin taper

This is the taper used for taper pins used in assembly. (Fig 4)

Fig 4



The taper is 1:50.

The diameter of taper pins is specified by the small diameter.

Taper pins help in assembling and dismantling of components without disturbing the location.

Key and keyway tapers

This taper is 1:100. This taper is used on keys and keyways. (Figs 5 & 6)

For further information about the tapers used for special application refer to: IS:3458-1981

Fig 5

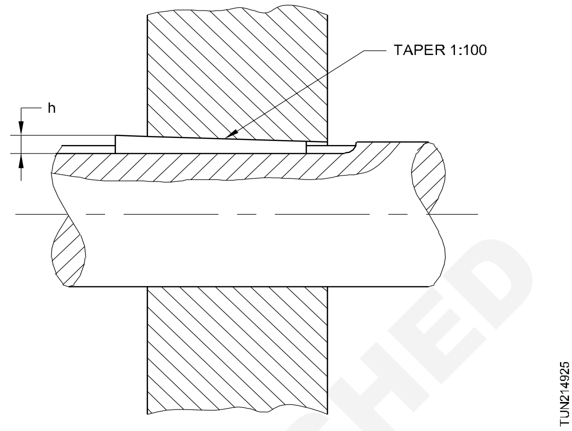
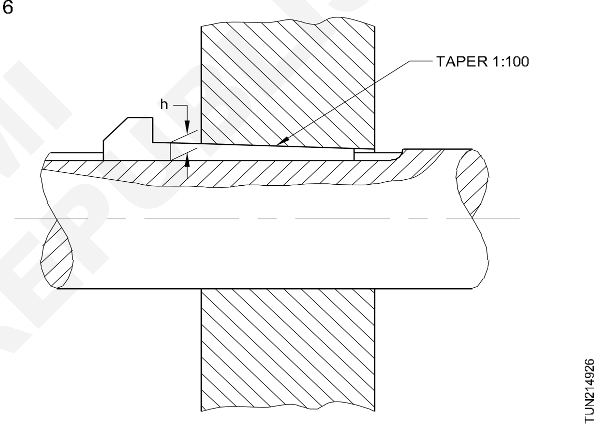


Fig 6



Methods of turning taper on Lathe and important dimensions of taper

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

- **point out the taper turning methods on a lathe**
- **state the features of each method**
- **list out the important dimension of taper.**

Methods of turning taper on a lathe

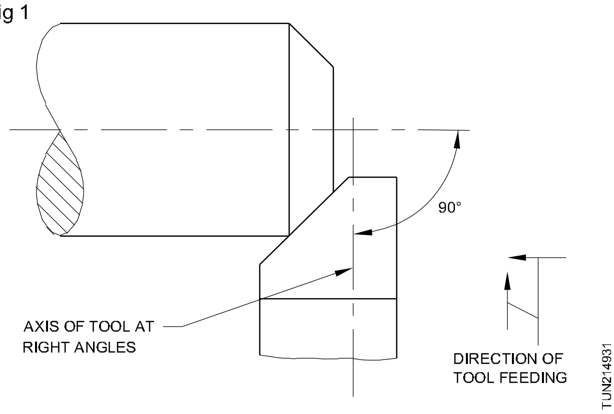
The different methods of taper turning on a lathe are:

- form tool method
- swivelling compound slide method
- tailstock offset method
- taper turning attachment method.

Form tool method (Fig 1)

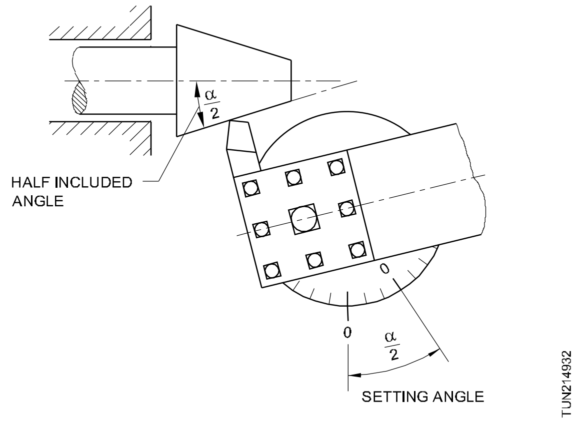
This method is used in mass production for producing a small length of taper where accuracy is not the criterion. The form tool should be set at right angles to the axis of the work. The carriage should be locked while turning taper by this method.

Fig 1



Swivelling Compound slide method (Fig 2)

Fig 2



In this method the top slide of the compound rest is swivelled to half the included angle of the taper, and the taper is turned.

The amount of taper for setting the angle is found by the formula

$$\tan\frac{\alpha}{2} = \frac{D - d}{2 \times l}$$

where

D= larger taper diameter

d= smaller taper diameter

l = length of taper

$\frac{\alpha}{2}$ = 1/2 included angle in degrees.

Advantages

Both internal and external taper can be produced.

Steep taper can be produced.

Easy setting of the compound slide.

Disadvantages

Only hand feed can be given.

Threads on taper portion cannot be produced.

Taper length is limited to the movement of the top slide.

- Fig.3 shows the settings of a top slide for turning different taper angles.

Tailstock offset method (Fig 4)

In this method the job is held at an angle and the tool moves parallel to the axis. The body of the tailstock is shifted on its base to an amount corresponding to the angle of taper.

The taper can be turned between centres only and this method is not suitable for producing steep tapers. The amount of offset is found by the formula:

$$\text{Offset} = \frac{(D - d) \times L}{2l}$$

Fig 3

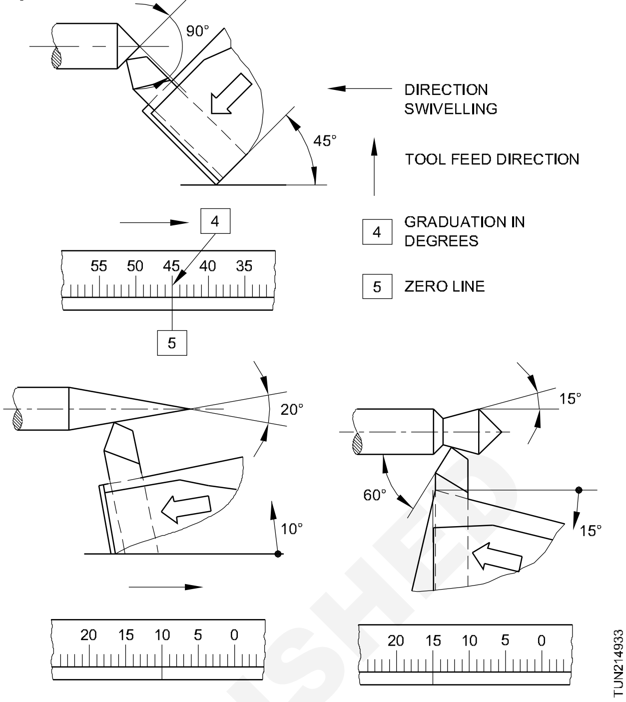
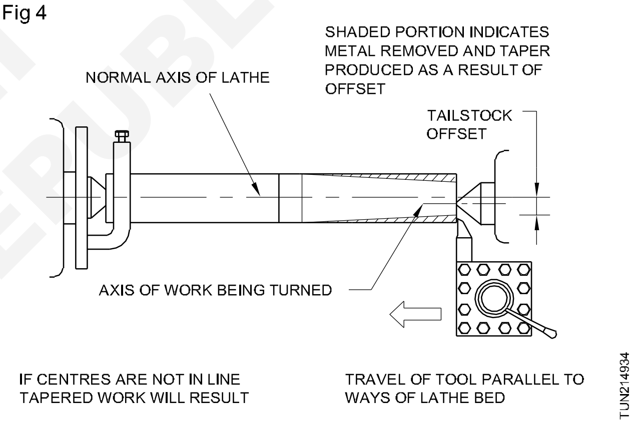


Fig 4



where

D = big dia. of taper

d = small dia. of taper

l = taper length

L = total length of job.

Advantages

- Power feed can be given.
- Good surface finish can be obtained.
- Maximum length of the taper can be produced.
- External thread on taper portion can be produced.
- Duplicate tapers can be produced.

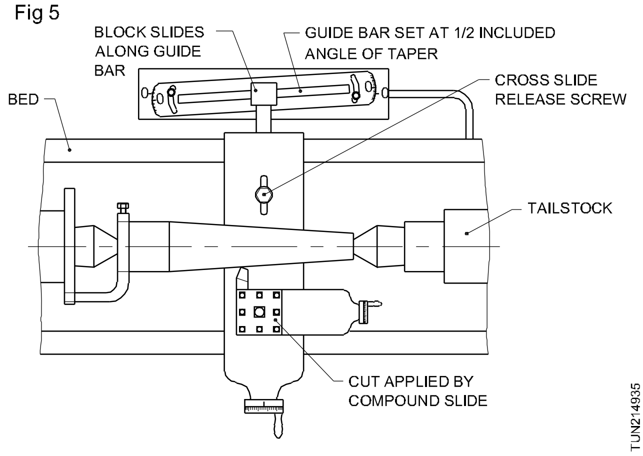
Disadvantages

- Only external taper can be turned.
- Accurate setting of the offset is difficult.
- Taper turning is possible when work is held between centres only.

- Damages the centre drilled holes of the work.
- The alignment of the lathe centres will be disturbed.
- Steep tapers cannot be turned.

Taper turning by attachment (Fig 5)

Fig 5



This attachment is provided on a few modern lathes. Here the job is held parallel to the axis and the tool moves at an angle. The movement of the tool is guided by the attachment.

Advantages

- Both internal and external tapers can be produced.
- Threads on both internal and external taper portions can be cut.
- Power feed can be given.
- Lengthy taper can be produced.
- Good surface finish is obtained.
- The alignment of the lathe centres is not disturbed.
- It is most suitable for producing duplicate tapers because the change in length of the job does not affect the taper.
- The job can be held either in chuck or in between centres.

Disadvantage

- Only limited taper angles can be turned.

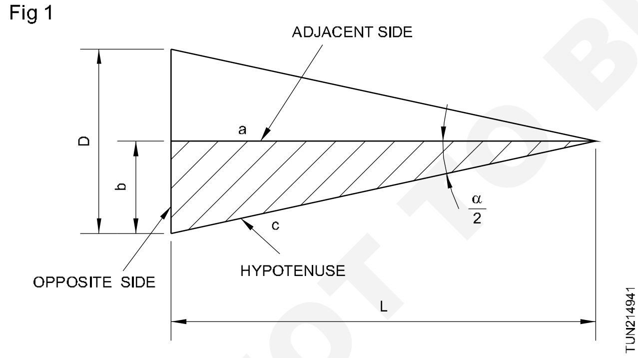
Calculation of the compound slide swivel angle

Objectives: At the end of this lesson you shall be able to
- **derive a formula to determine the swivel angle**
- **solve problems involving taper calculation**
- **refer to tables and determine the value of the angle for the arrived result**
- **determine the depth of cut to reduce the taper length.**

Derivation of the formula

For convenience a tapered job whose small diameter is zero is taken (Fig 1) to illustrate as to how the formula can be derived.

Fig 1

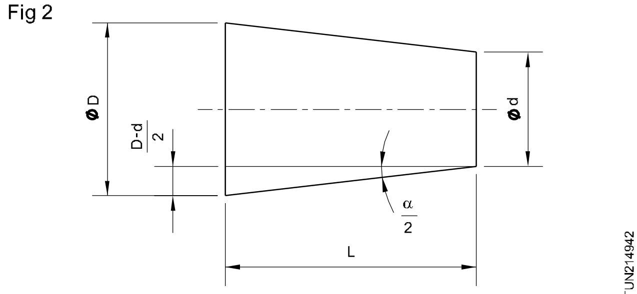


The taper is divided into two right angled triangles by the centre line. By referring to the shaded right angled triangle in figure 1, the side (b) shown against the half included angle of taper a/2, is termed as the opposite side. The side (a) is termed as the adjacent side and side (c) is termed as the hypotenuse. There is a relationship between the sides of the triangle and the angle a/2. They can be expressed as ratios. The ratio of the sides (b) and (a) is a constant value for a given angle a/2. This ratio b/a does not change for a given value of a/2. This means that if 'b' increases or decreases there will be a proportionate increase or decrease of side 'a' making the ratio b/a constant. This ratio between the opposite side to the adjacent side of an angle in a right angled triangle is referred to as the tangent value of the angle.

The equation for the tangent $\alpha/2$ is, therefore, Tan $\alpha/2$ = b/a. Since this value is the same for a particular angle, the tangent values for all angles are put together into tables under the heading 'Natural Tangents'. Therefore, they need no longer be calculated individually, but can be taken from the tables.

Referring to Fig 2, which has a small diameter also, the shaded triangle D–d refers to 'b' of the formula and l refers to 'a' of the formula.

Fig 2



D = 30 mm d = 22 mm & l = 40 mm

Now the formula becomes

$$\text{Tan}\ \frac{\alpha}{2} = \frac{\frac{D-d}{2}}{l} = \frac{D-d}{2 \times l}$$

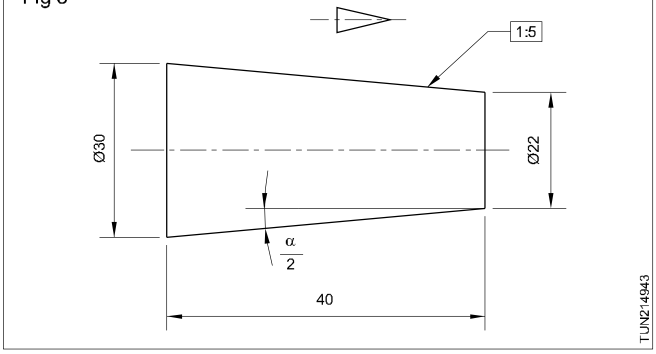
For example, referring to Fig.3 we have

$$\text{Tangent } \alpha/2 = \frac{D - d}{2l} = \frac{30 - 22}{80}$$

$$= \frac{8}{80} = \frac{1}{10} = 0.1$$

Referring to the logarithm tables of Natural Tangents we find that the angle whose tangent value is 0.1, is 5° - 45‘, and this is the top slide swivelling angle to turn the tapered job of Fig 3.

Fig 3



Taper expressed as a ratio to determine the swivel angle

The general formula is

$$\text{Tan} \frac{\alpha}{2} = \frac{D - d}{2l}$$

This can be rewritten as

$$\text{Tan} \frac{\alpha}{2} = \frac{D - d}{l} \times \frac{1}{2}$$

This $\frac{D - d}{l}$ is the taper ratio

Hence the formula becomes

$$\text{Tan of half the included angle} = \frac{\text{Taper ratio}}{2}$$

Example

The taper ratio is given as 1:5.

To determine the compound slide swivel angle (Fig 3), the Taper ratio=1:5= 1/5

$$\text{Tan} \frac{\alpha}{2} = \frac{1/5}{2} = \frac{1}{10} = 0.1$$

$$\frac{\alpha}{2} = 5^{o}45^{'}$$

The compound slide swivel angle is 5°45’.

Taper per foot is given to determine the compound slide swiveling angle.

Example

(Given 5/8” TPF)

This means that the difference in diameter (D-d) is 5/8” for a taper length of 1 foot or 12”.

$$\text{Tan } \alpha/2 = \frac{D - d}{2l}$$

Here D-d=5/8” and l=12”

$$\text{Tan } \alpha/2 = \frac{\frac{5''}{8}}{2x12} = \frac{5}{8x24} = 0.0260$$

$$\alpha/2 = 1^{o}26^{'}$$

The formula is Tan of half included

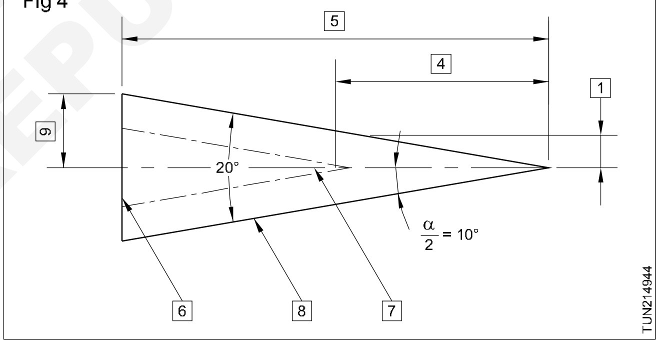
$$= \frac{\text{Taperperfoot}}{24}$$

Remember that it is the half included angle of the taper to which the top slide is to be swivelled.

To determine the depth of cut to be given to get a definite change in length of the taper, the taper angle remaining the same. (Fig. 4)

Referring to Fig.4, [9] is the radius at the bigger end, (also the diference in diameter divided by 2, since the small diameter of the taper is zero), [5] is the length of the taper,

Fig 4



[4] is the change in the taper length, [1] is the depth of cut to be given to get the change in taper length.

[6] Opposite side to $\alpha/2$

[7] Adjacent side

[8] Hypotenuse

Then [1] = [4] x tan $\alpha/2$

Example

The taper length [5] of Fig 4 with an included angle of 20° is to be shortened by 2 mm. What should be the depth of cut?

l = [4] x tan $\alpha/2$

[1]=2mm x tan 20°/2

=2mm x tan 10°

=2 x 0.1763

=0.3526mm

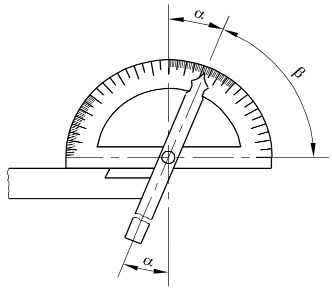
Hence a depth of cut of 0.35 mm is to be given in order to reduce the taper length by 2 mm, the taper included angle remaining the same 20°.

Bevel protractor and Vernier bevel protractor

Objectives: At the end of this lesson you shall be able to
- **identify the parts of a universal bevel protractor**
- **state the functions of each part**
- **list the uses of a vernier bevel protractor.**

Bevel protractor (Fig 1) : The bevel protractor is a direct angular measuring instrument, and has graduation marked from 0° to 180°. This instrument can measure angles within an accuracy of ±1°.

Fig 1



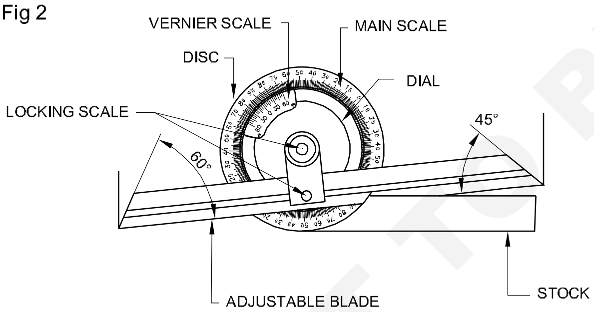
BEVEL PROTRACTOR
TUN215011

The vernier bevel protractor is a precision instrument meant for measuring angles precisely to an accuracy of 5 minutes. (5')

Parts of a Vernier Bevel Protractor

The following are the parts of a vernier bevel protractor. (Fig 2)

Fig 2



TUN215012

Stock

This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the surface from which the inclination is measured.

Disc

The disk is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

Dial

It is pivoted to the disc and can be rotated through 360°. The vernier scale of the instrument is attached to the dial. The dial is locked to the disc while reading the measurement.

Blade

This is the other contacting surface of the instrument that contacts the work during measurement, preferably the inclined surfaces. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

Locking screws

Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial.

All parts are made of good quality alloy steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

Uses of a vernier bevel protractor

The vernier bevel protractor is used to measure acute angles, i.e. less than 90° (Fig 3), obtuse angles i.e more than 90° (Fig 4) for setting work-holding devices to angles on machine tools, work tables etc. (Figs 5 & 6)

Fig 3

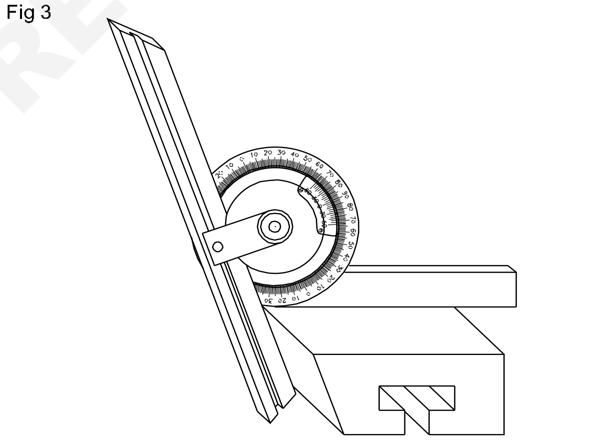

TUN215013

Fig 4

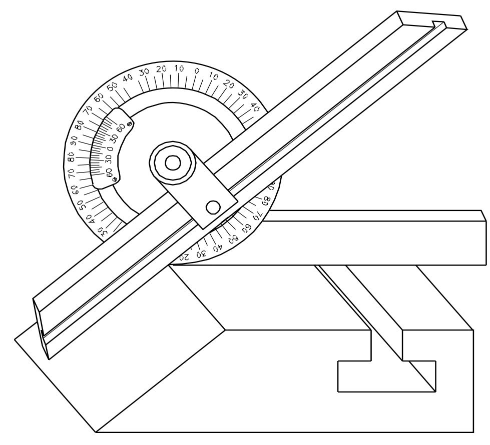

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Fig 5

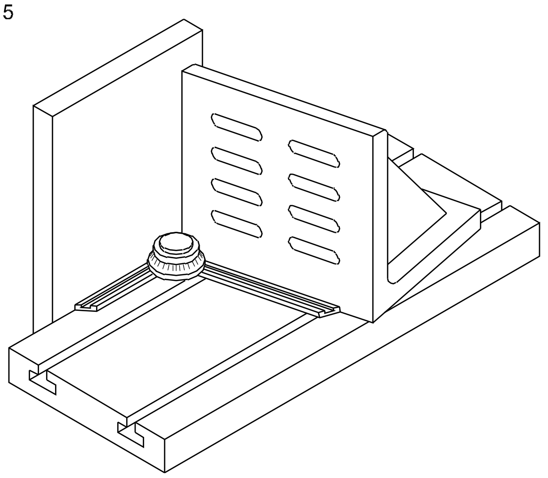
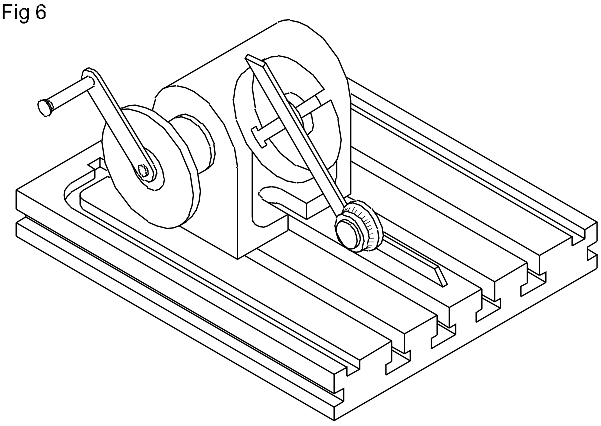


Fig 6



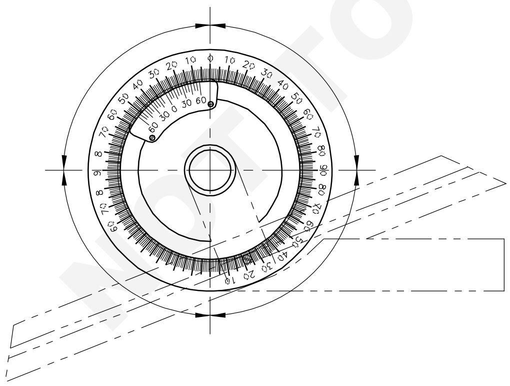
Graduations on vernier bevel protractor

Objectives: At the end of this lesson you shall be able to
- **state the main scale graduations on the disc**
- **state the vernier scale graduations on the dial**
- **determine the least count of the vernier bevel protractor.**

The main scale graduations

For purposes of taking angular measurements, the full circumference of the disc is quadrants in degrees.The 360° are equally divided and marked in four quardrants, from 0 degree to 90 degrees, 90 degrees to 0 degree, 0 to 90 degrees and 90 degrees to 0 degrees. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the disc are known as the main scale divisions. On the dial, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of 0 also. (Fig 1)

Fig 1



One vernier scale division (VSD) (Fig 2)

$$= \frac{23^o}{12} = 1\frac{11^o}{12} = 1^o55'$$

The least count of the vernier bevel protractor

When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 1)

Hence, the least count is

2 MSD – 1 VSD

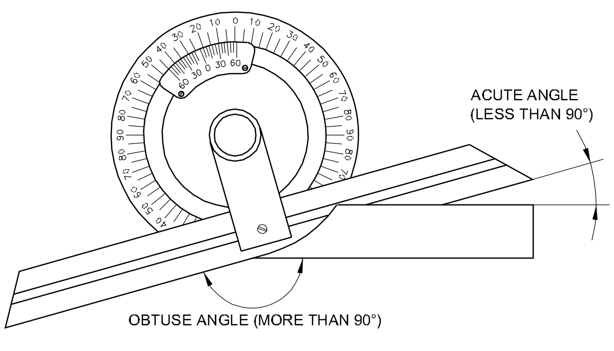
$$\text{i.e. the least count} = 2^o - 1\frac{11^o}{12}, 2 - 1^o55'$$

$$= \frac{1^o}{12}$$

$$= 5'$$

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the dial assist to achieve this. (Fig 2)

Fig 2

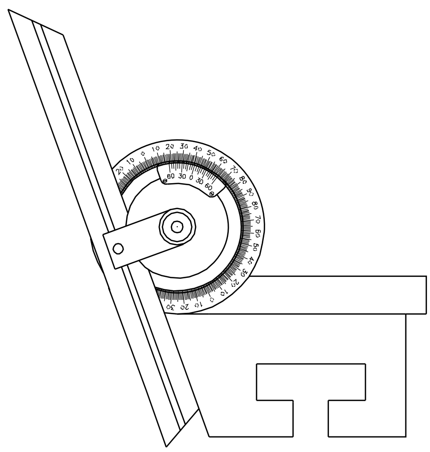


Reading of vernier bevel protractor

Objectives: At the end of this lesson you shall be able to
- **read a vernier bevel protractor for acute angle setting**
- **read a vernier bevel protractor for obtuse angle setting.**

For reading acute angle set up (Fig 1)

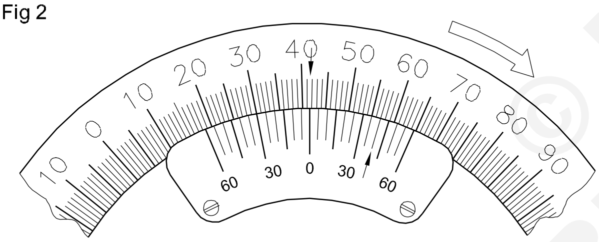
Fig 1



First read the number of whole degrees between zero of the main scale and zero of the vernier scale. (Fig 1)

Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)

Fig 2



To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example: 8 x 5' = 40'

Sum up both readings to get the measurements. = 41° 40'

> **If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.**
>
> **If you read the main scale in a clockwise direction, read the vernier scale also in a clockwise direction from zero.**

For obtuse angle set up (Fig 3)

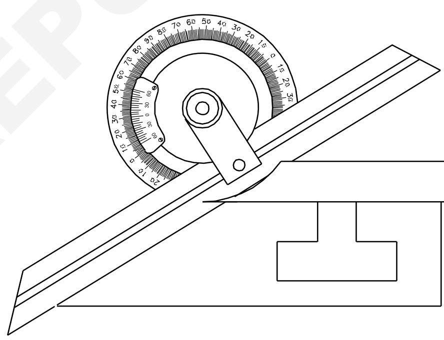
The vernier scale reading is taken on the left side as indicated by the arrow. The reading value is subtracted from 180° to get the obtuse angle value.

Reading 22° 30'

Measurement

180° — 22° 30'=157° 30'

Fig 3



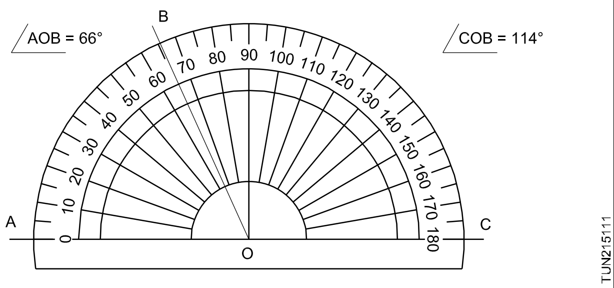
Method of taper angle measurement

Objectives: At the end of this lesson you shall be able to
- **state the units and fractional units of angles**
- **express degrees, minutes and seconds using symbols.**

The unit of an angle

For angular measurements a complete circle is divided into 360 equal parts. Each division is called a degree. (A half circle will have 180°) (Fig 1)

Fig 1



Subdivisions of an angle

For more precise angular measurements, one degree is further divided into 60 equal parts. This division is one MINUTE ('). The minute is used to represent a fractional part of a degree and is written as 30° 15'. One minute is further divided into smaller units known as seconds ("). There are 60 seconds in a minute.

An angular measurement written in degrees, minutes and seconds would read as 30° 15' 20".

Examples for angular divisions

1	complete circle	360°
1/2	circle	180°
1/4	of a circle (right angle)	90°

Subdivisions	1 degree or 1°	= 60 mts or	60'
	1 min or 1'	= 60 secs or	60"

Measuring angles with vernier bevel protractor

Objective: At the end of this lesson you shall be able to
- **state the methods of measuring angles with a vernier bevel protractor.**

A vernier bevel protractor setting depends on the type of the angle to be measured. It can be set in different ways for measuring and checking angles. (Figs 1 to 6)

Before measuring, check that the measuring surfaces (the blade and the stock of the protractor) are not damaged.

Clean the measuring faces of the protractor and the workpiece. Use a soft clean cloth.

While measuring, loosen the vernier scale locking screw.

Loosen the blade locking screw, adjust the blade to suit the workpiece, tighten the blade screw and place the protractor on the work-surface.

Adjust the protractor so that the inner surface of the blade and the base are in contact with the workpiece.

Make sure that the protractor is perpendicular to the surface being measured.

The protractor must be adjusted so that the blade and base are in full contact with the surfaces being measured. (There should not be any gap between the blade, base and the workpiece surfaces).

Lock the vernier locking nut and carefully remove the vernier bevel protractor.

Take the reading.

> **When you have finished measuring, clean the protractor using a soft cloth and put it in its case.**
>
> **Do not leave the protractor in any place from where it could fall, or be otherwise damaged.**

Fig 1

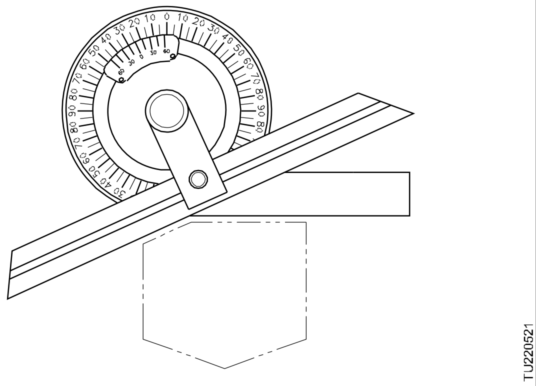


Fig 2

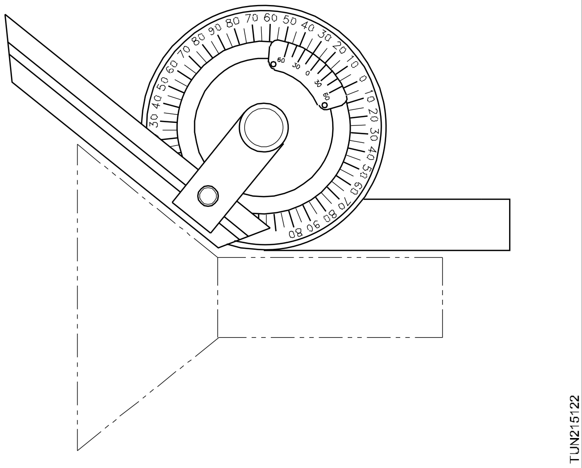


Fig 3

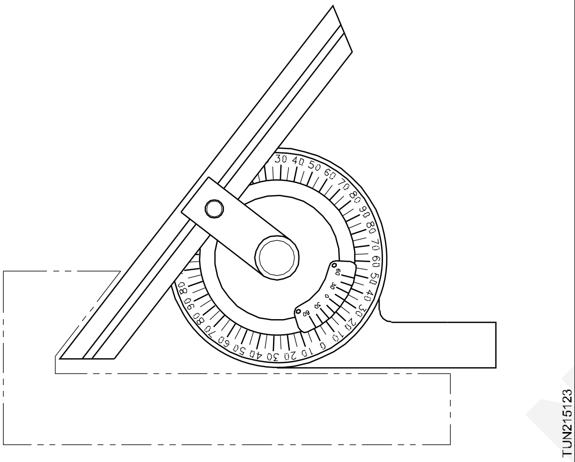


Fig 4

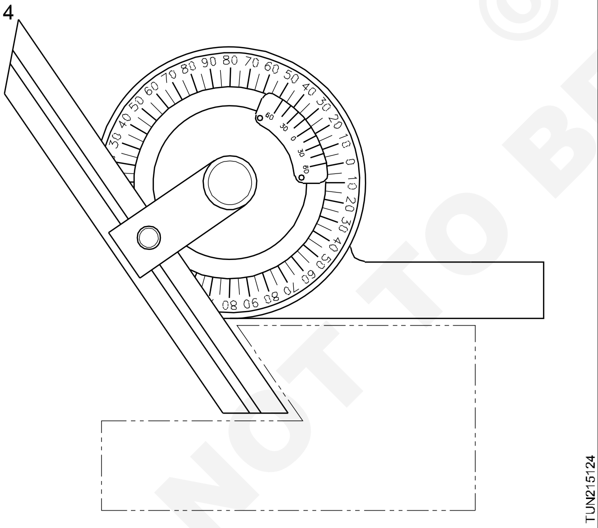


Fig 5

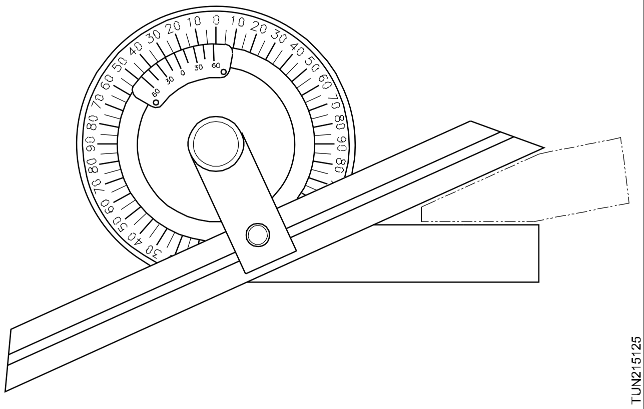


Fig 6

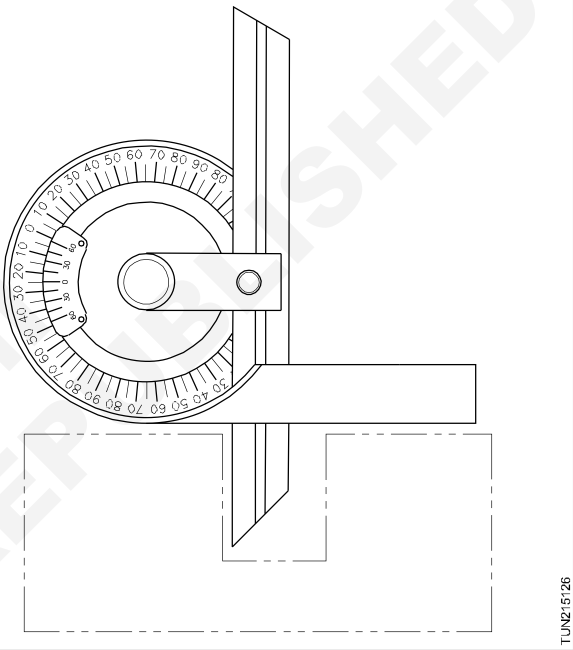
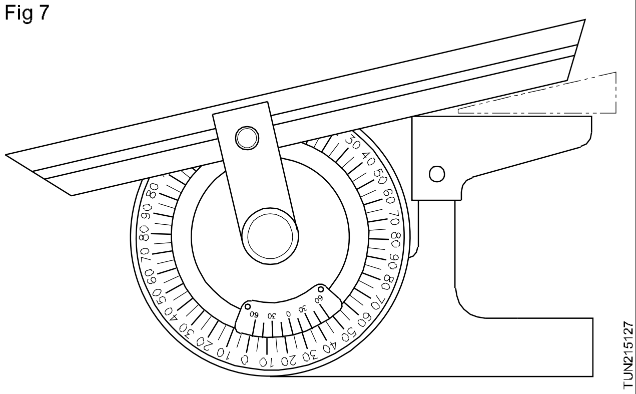


Fig 7



Measuring angle of tapered (external) components

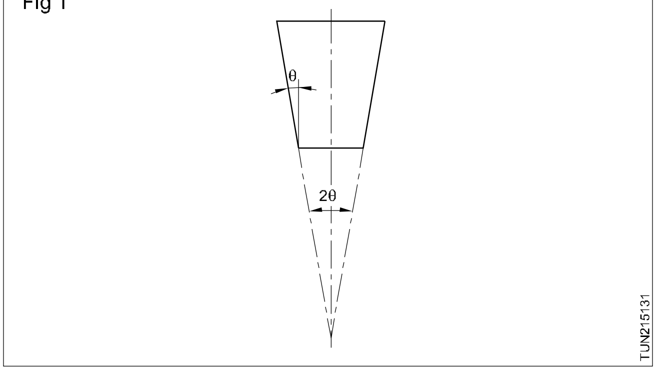
Objectives: At the end of this lesson you shall be able to

- **name the features of a taper which can be measured using precision rollers and slip gauges**
- **state the formula for measuring the angle of the taper**
- **calculate the angle of the taper.**

A method used for checking the dimensions of the tapered components is by using precision rollers or balls along with the slip gauges. Using this method the following elements of the tapers can be checked.

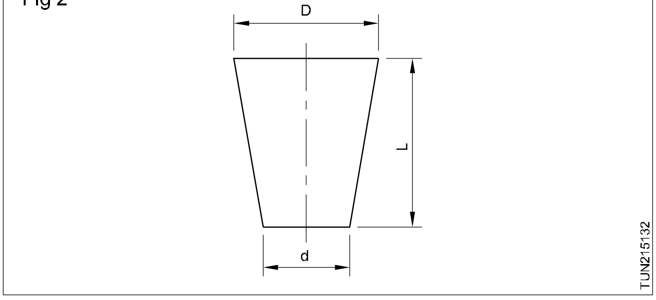
- Angle of the taper (Fig 1)

Fig 1



- Small end diameter (Fig 2)
- Large end diameter (Fig 2)

Fig 2

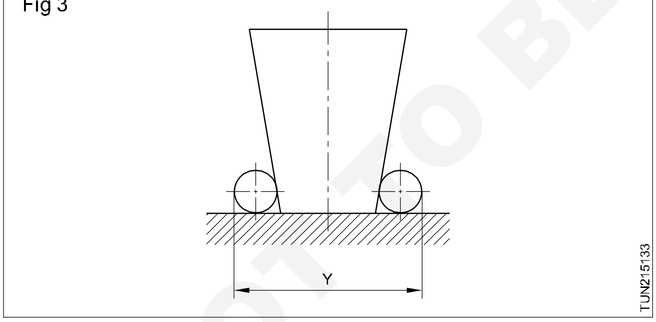


Checking the angle of the taper

For determining this angle two measurements are taken. i.e. X and Y.

The measurement Y is taken by placing the component against a datum surface like the surface plate or the marking table. Two precision rollers are then placed at the smaller end resting on the datum surface and contacting the workpiece. (Fig 3)

Fig 3



Measurement 'X' is taken by lifting and placing the rollers on both sides with the help of two sets of slip packs having the same size.

The measurement is then taken with a micrometer over the rollers. (Fig 4)

For computing the taper angle the following trigonometrical ratio is applied. (Fig 5a)

$$\text{Tan}\,\theta = \frac{BC}{AB} = \frac{a}{c}$$

From the two measurements taken and the height of the slip packs the ratio is established by subtracting the measurement 'Y' from 'X' and dividing it by two. This corresponds to the distance AB. (Fig 5b)

The length AC corresponds to the size of the slip pack used on one side.

$$AB = \frac{x - y}{2}$$

Then the tangent of the taper angle is

$$\text{Tan}\theta = \frac{AB}{AC} = \frac{\frac{x-y}{2}}{H} = \frac{x-y}{2H}$$

Where X is the measurement over the rollers placed on the slip gauge height, Y is the measurement over the rollers at the smaller end and H is the slip gauge height.

The included angle of the taper will be double the above angle.

Fig 4

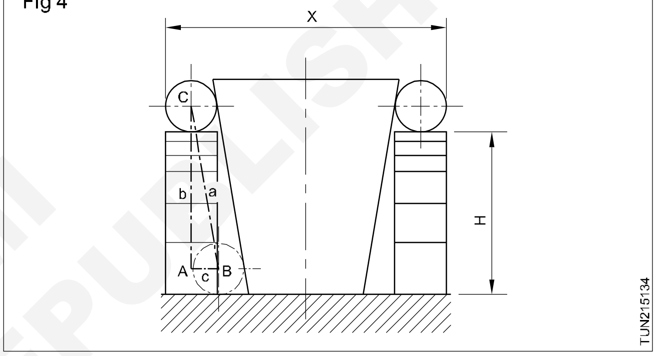
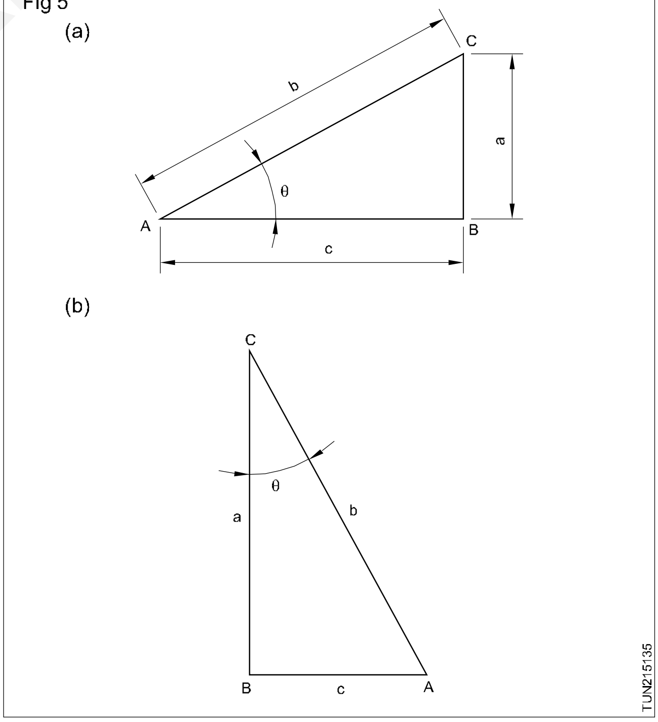


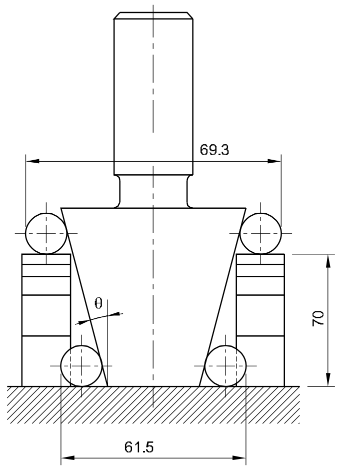
Fig 5



Example

Calculate the included angle of the tapered component shown in Fig 6.

Fig 6



TUN215136

The measurement

X = 69.3 MM

X = 69.3 MM

Y = 61.5 MM

Height = 70 MM

TANθ = (69.3)–(61.5)/2X70

= 7.8/2X70

$$= \frac{3.9}{70} = \frac{0.39}{7} = 0.0557$$

Referring to the log table under Natural Tangents we find θ = 3° 11'.

HENCE INCLUDED ANGLE OF THE TAPER

2θ = 3° 11'X 2 = 6° 22'

2θ = 6° 22'.

Determining diameters of tapered components

Objectives: At the end of this lesson you shall be able to
- **calculate the small diameter of a tapered component**
- **calculate the large diameter of a tapered component.**

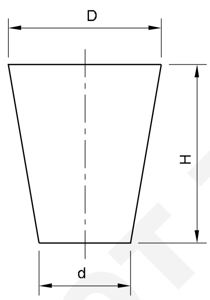
Diameters at any position of tapered components can be determined when the angle of taper is known.

For inspection of tapered components for dimensional quality the following diameters are measured.

Small end diameter d (Fig 1)

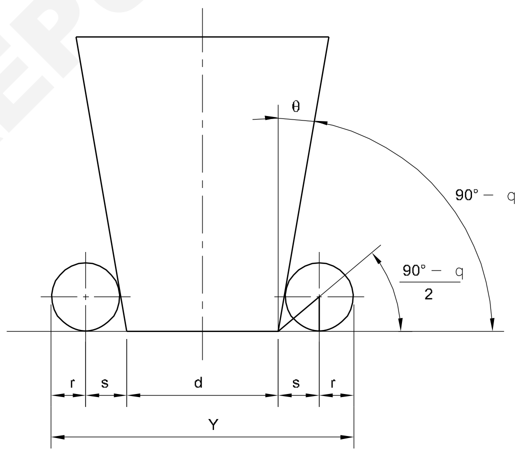
Large end diameter D (Fig 1)

Fig 1



TUN215141

Fig 2



TUN215142

Determining small end diameter (Fig 2)

The small diameter 'd' is = Y – 2 (S + r).

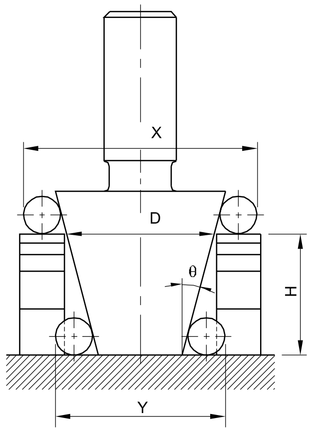
Y - is the diameter over the two precision rollers.

r - is the radius of the roller.

S - is the distance from the centre of the roller to the end of the component.

Calculating S (Fig 3)

Fig 3



TUN215143

$$Tan\left\{\frac{90-\theta}{2}\right\} = \frac{r}{s}$$

$$s = \frac{r}{Tan\left\{\frac{90-\theta}{2}\right\}}$$

$$d = Y - 2\left[\frac{r}{Tan\left\{\frac{90-\theta}{2}\right\}} + r\right]$$

$$= Y - 2r\left[Cot\left\{\frac{90-\theta}{2}\right\} + 1\right]$$

Example

θ = 3° 11"

Y = 61.5 mm

r = (radius of roller) 6 mm

$$\text{Then } d = 61.5\text{-}12\left[Cot\left\{\frac{90 - 3^{o}11'}{2}\right\}\right] + 1$$

= 61.5 – 12 (1.0570 + 1)

= 61.5 – 12 x 2.0570

= 61.5 – 24.6840 = 36.3160 mm

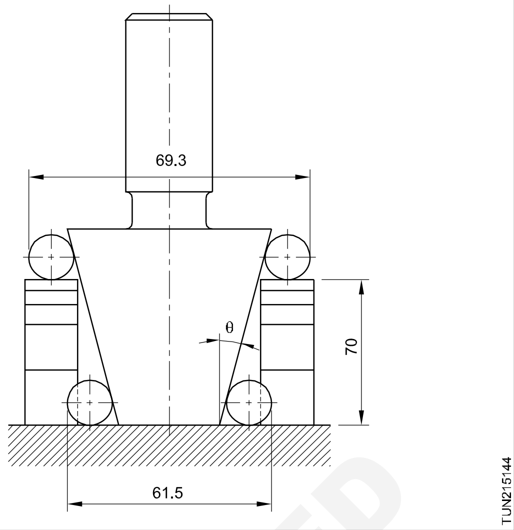
Determining the large diameter of taper at any desired heigh (H for example)

The formula is derived by taking into consideration the measurement over the rollers placed at a known height 'H', the diameter of the roller and the angle of taper. The diameter 'D' at larger end at height 'H'.

= X – 2 (s + r)

Example (Fig 4)

Fig 4



θ = 3° 11'

X = 69.3 mm

H = 70 mm

r = (radius of the roller) 6 mm

Then the diameter of the taper at height H from the small end. = 69.3 – 12 (1+1.0570)

= 69.3 – 24.6840 = 44.6160 mm

The length of the taper can be directly measured by using a vernier height gauge. Then the largest diameter of the taper is determined by computing the known values.

If 'M' is the maximum diameter of the taper, 'T' is the minimum diameter of the taper and L is the tapered length

then $M = T + 2L \times Tan\ \theta$.

Sine bar - Types - Uses

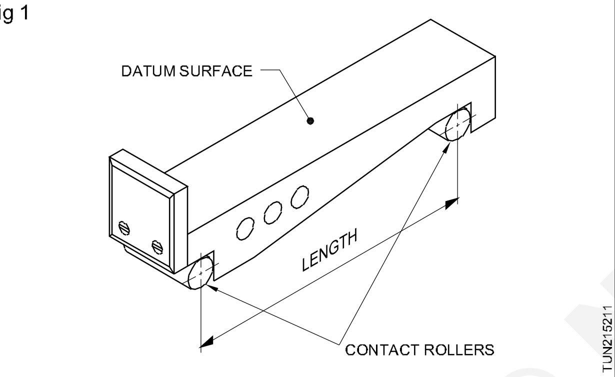
Objectives: At the end of this lesson you shall be able to
- **state the different uses of a sine bar**
- **state the features of a sine bar**
- **specify the sizes of a sine bar**
- **state the principle of a sine bar.**

A sine bar is a precision instrument meant for setting work to machine angular surfaces, to determine the angles of tapered jobs by calculation.

Features

The sine bar is a rectangular bar made of stabilized chromium steel. (Fig 1)

Fig 1



The surfaces are accurately finished by grinding and lapping.

Two precision rollers of the same diameters are mounted on either end of the bar. The centre line of the rollers is parallel to the top face of the sine bar.

There are holes drilled across the bar. This helps in reducing the weight, and also facilitates clamping the sine bar to the angle plates, with bolts and nuts.

The length of the sine bar is the distance between the centres of the rollers. The commonly available sizes are 100 mm, 200 mm, 250 mm and 500 mm. A sine bar is specified by its length.

Uses

Sine bars are used when high degree of accuracy is needed during

- the checking of parallelism (Fig 2)
- the marking out (Fig 3)
- the setting up of components for machining angular surfaces. (Fig 4)

The principle of a sine bar

The principle of a sine bar is based on the trigonometrical function of sine of an angle.

Fig 2

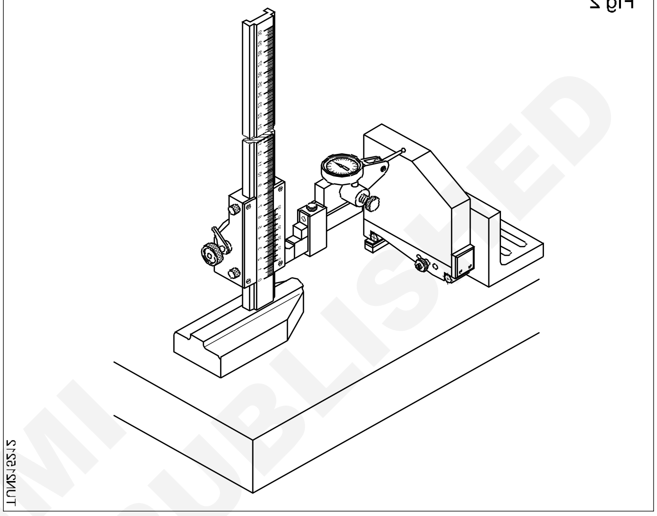
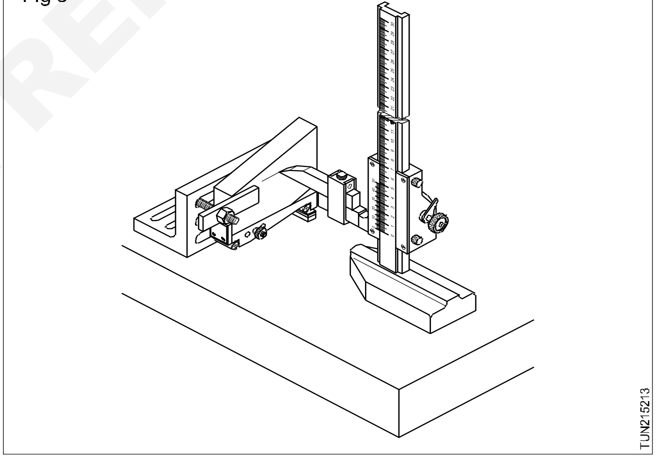


Fig 3



In a right angled triangle the function known as sine of an angle is the relationship existing between the hypotenuse and the side opposite to the angle. (Fig 5)

It may be noted that for setting the sine bar to different angles, slip gauges are used.

A surface plate or marking table provides the datum surface for the set up.

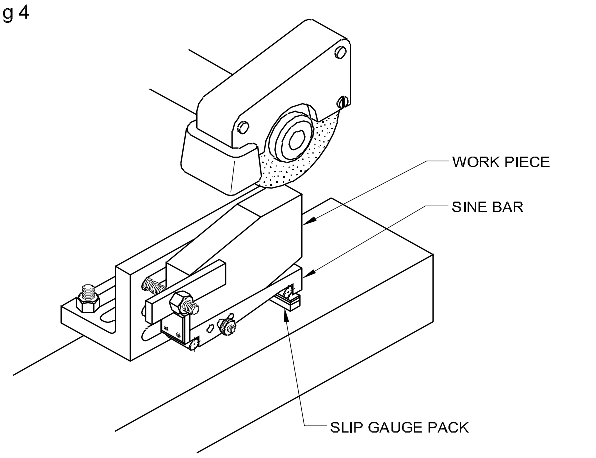
The sine bar, the slip gauges and the datum surface upon which they are set form the sides of a right angle triangle. (Fig 6)

The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite to the angle θ (a).

Sine of the angle $\theta = \dfrac{\text{Opposite side}}{\text{Hypotenuse}}$

$$\text{Sine } \theta = \frac{a}{c}$$

Fig 4



ANGULAR SURFACE OF THE WORKPIECE SET FOR FURTHER MACHINING (GRINDING)

Fig 5

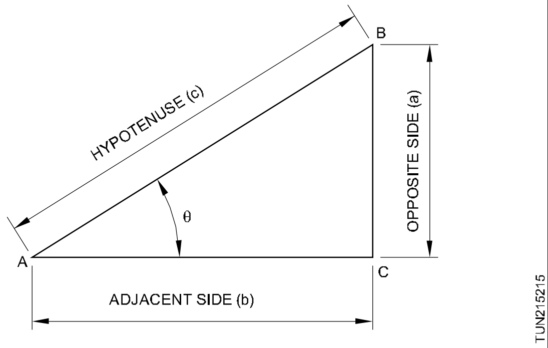
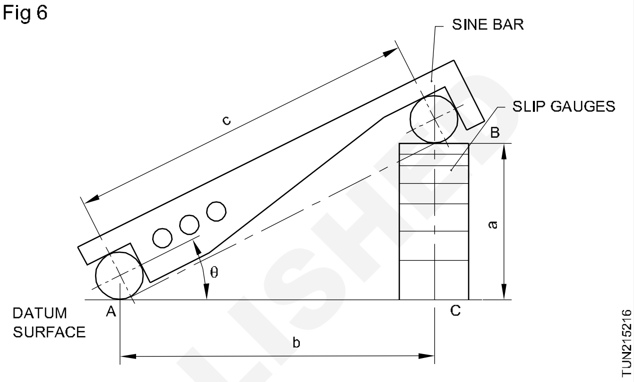


Fig 6



Determining taper angle using sine bar and slip gauges

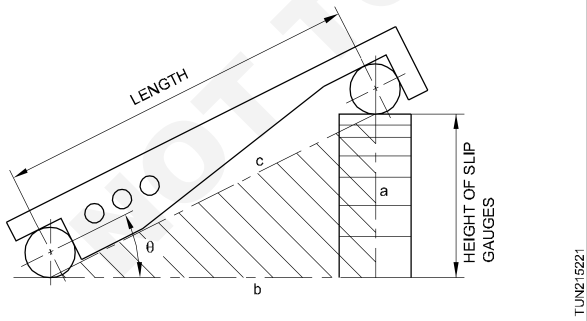
Objectives: At the end of this lesson you shall be able to

- **check the correctness of the known angle of the work**
- **calculate the height of slip gauges to build up the height for a given angle.**

A sine bar provides a simple means of checking angles to a high degree of accuracy.

The use of a sine bar is based on the trigonometrical function. The sine bar forms the hypotenuse of that triangle and the slip gauge height forms the opposite side of the angle. (Fig1)

Fig 1

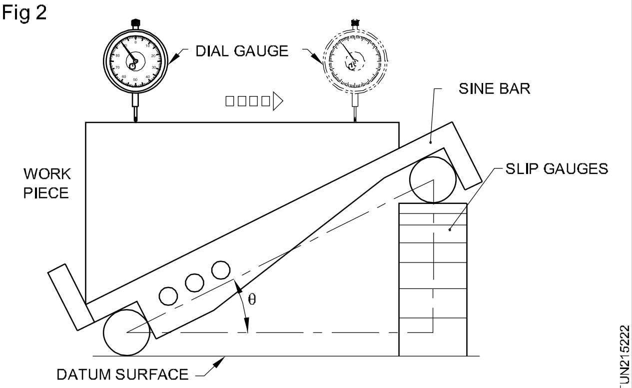


Checking the correctness of a known angle

For this purpose first choose the correct slip gauge combination for the angle to be checked.

The component to be checked should be mounted on the sine bar after placing the selected slip gauges under one roller, with the other roller resting on the datum surface. (Fig 2)

Fig 2



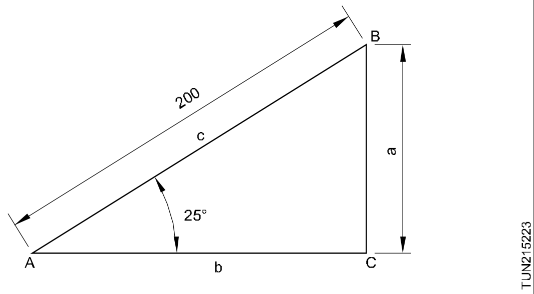
A dial test indicator is mounted on a suitable stand or vernier height gauge. (Fig 2) The dial test indicator is then set in first position as shown in the figure, and the dial is set to zero. Move the dial indicator to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads the same reading at both ends. The actual angle can then be calculated and the deviation, if any, will be the error.

Method of calculating the slip gauge height

Example

To determine the height of slip gauges for an angle of 25° using a sine bar of 200 mm long. (Fig 3)

Fig 3



$$\text{Sine } \theta = \frac{a}{c}$$

θ = 25°

a = C sine q

= 200 x 0.4226

= 84.52 mm.

The height of the slip gauge required is 84.52 mm.

Note

The value of Sine θ can be seen from mathematical tables. (Natural Sine)

Use always accurate tables while working with sine bars.

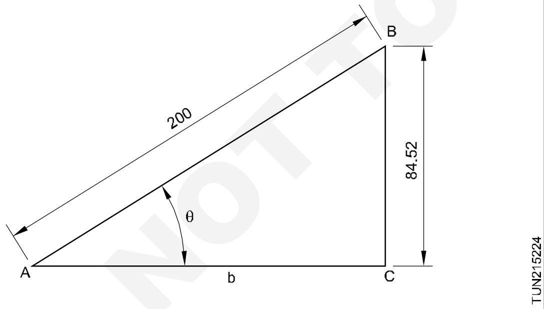
Tables are also available with ready worked out sine bar constants for standard lengths of sine bars.

Calculating the angle of tapered components

The height of the slip gauge used is 84.52 mm. The length of the sine bar used is 200 mm.

What will be the angle of the component? (Fig 4)

Fig 4



$$\text{Sine}\theta = \frac{a}{c} = \frac{84.52}{200}$$

Sin θ = 0.4226

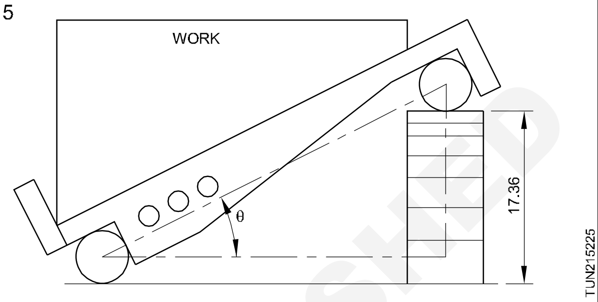
The value of sine of the angle is 0.4226.

\ the angle = 25°.

Examples

1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Fig 5



$$\text{Sine}\theta = \frac{a}{c} = \frac{17.36}{100}$$

= 0.1736

Θ = 10°

2 Calculate the height of the slip gauge pack required to raise a 100 mm sine bar to an angle of 3°35'.

$$\text{Sine}\theta = \frac{a}{c}$$

$$\text{Sine } 3^o.35' = \frac{a}{100\text{mm}}$$

A = 100 MM X SIN 3°.35'

= 100 X 0.0624 MM

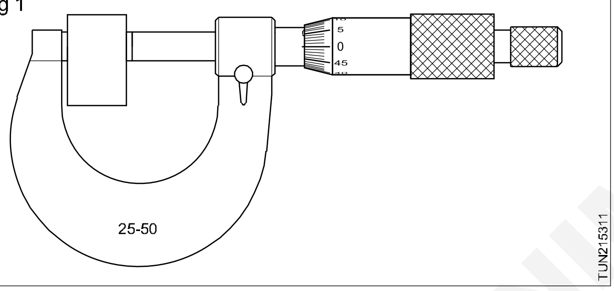
Height of the slip gauge = 6.24 mm

Slip Gauges, types uses and selection

Objectives : At the end of this lesson you shall be able to
- **state the features of slip gauges**
- **state the different grades of slip gauges and their uses**
- **state the number of slips in standard sets**
- **state the care and maintenance to be followed in the case of slip gauges.**

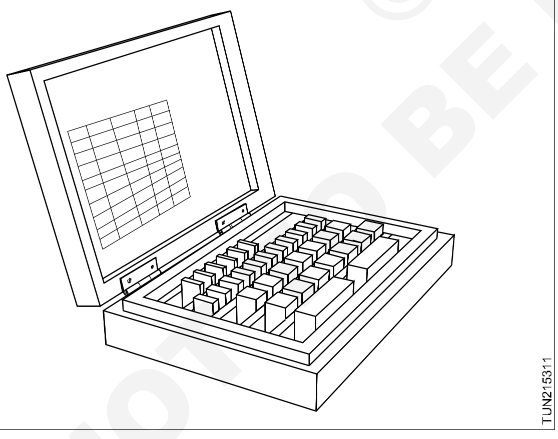
Slip gauges or gauge blocks are used as standards for precision length measurement. (Fig 1) These gauges are made in sets and consist of a number of hardened blocks made of high grade steel with low thermal expansion. They are hardened throughout, and further heat treated for stabilization. The two opposite measuring faces of each block are lapped flat and parallel to a definite size within extremely close tolerances.

Fig 1



These slip gauges are available in various sets with different numbers. (Fig2) (Ref.Table 1)

Fig 2



A particular size can be built up by wringing individual slip gauges together. (Figs 3 & 4)

Fig 3

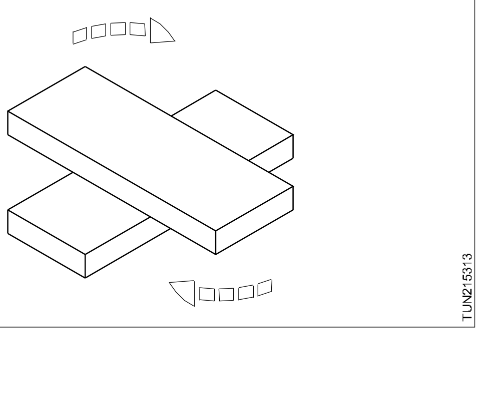
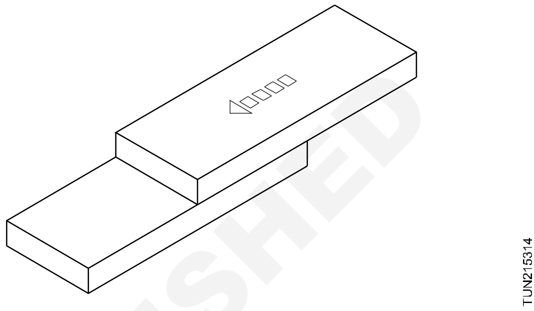


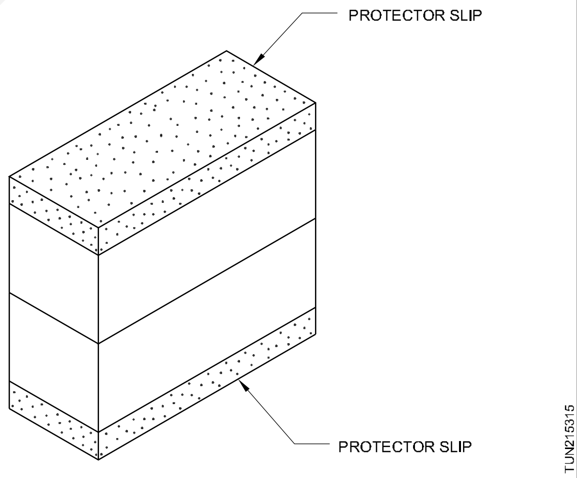
Fig 4



Wringing is the act of joining the slip gauges together while building up to sizes.

Some sets of slip gauges also contain protector slips of some standard thickness made from higher wear-resistant steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage. (Fig 5)

Fig 5



B.I.S. recommendations

Four grades of slip gauges are recommended by B.I.S. (IS 2984). They are:

Grade 00 Reference

Grade 0 Calibration

Grade i Inspection

Grade ii Workshop

GRADES

Grade of accuracy

It is a reference grade for reference standard and to calibrate the calibration grade slip gauges.

Grade o accuracy

It is a calibration grade used to calibrate the inspection grade slip gauges.

Grade i accuracy

It is an inspection grade used to calibrate workshop grade slip gauges and measuring instruments.

Grade ii accuracy

It is a workshop grade used for general workshop applications.

Care and Maintenance

Points to be remembered while using slip gauges

Use as minimum a number of blocks as possible while building up for a particular dimension.

While building the slip gauges, start wringing with the largest slip gauges and finish with the smallest.

While holding the slip gauges do not touch the lapped surfaces.

If available use protector slips on exposed faces.

After use clean the slips with carbon tetrachloride and apply petroleum jelly for protecting against rust.

Before use remove the petroleum jelly with carbon tetrachloride. Use chamois leather to wipe the surfaces.

TABLE 1

Different sets of slip gauges.

Set of 112 pieces

Range (mm)	Steps (mm)	No.of pieces
Special piece 1.0005	-	1
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25.0 to 100.0	25	4
Total pieces		112

Set of 103 pieces

Range (mm)	Steps (mm)	No.of pieces
1st series 1.005	-	1
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25 to 100	25.0	4
Total pieces		103

Set of 78 pieces

Range (mm)	Steps (mm)	No.of pieces
1.0025	-	1
1.005	-	1
1.0075	-	1
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10.0 to 50.0	10.0	5
75.0 & 100.0	-	2
Total pieces		78

Set of 47 pieces

Range (mm)	Steps (mm)	No.of pieces
1st series 1.005	-	1
2nd series 1.01 to 1.09	0.01	9
3rd series 1.1 to 1.9	0.1	9
4th series 1.0 to 24.0	1.0	24
5th series 25.0 to 100.0	25.0	4
Total pieces		47

Set of 87 pieces

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 9.5	0.5	19
4th series 10.0 to 100.0	10.0	10
Total pieces		87

Set of 45 pieces

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.09	0.01	9
3rd series 1.1 to 1.09	0.1	9
4th series 1.0 to 9.0	1.0	9
5th series 10.0 to 90.0	10.0	9
Total pieces		45

Set of 32 pieces

Range (mm)	Steps (mm)	No.of pieces
1.005	-	1
1st series 1.01 to 1.09	0.01	9
2nd series 1.1 to 1.9	0.1	9
3rd series 1 to 9.0	1.0	9
4th series 10.0 to 30.0 60.0	10.0 1	3
Total pieces		32

Set of 86 pieces

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 9.5	0.5	19
4th series 10.0 to 90.0	10.0	9
Total pieces		86

Even though there are a number of sets of slip gauges available, the popularly recommended ones are:

1) Set No.45 (Normal set)

2) Set No.86 (Special set).

Selection and determination of slip gauges for different sizes

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

- **select slip gauges for different sizes.**

For determining a particular size, in most cases a number of slip gauges are to be selected and staked one over the other by wringing the slip gauges.

While selecting the slip gauges for a particular size using available set of slip gauges:

- first consider the last digit of the size to be built up
- then consider the last digit or the last two digits of the subsequent value and continue to select pieces until the required size is available.

Example

Building up a size of 44.8725 mm with the help of 112 piece set. (Table 1)

Set of 112 pieces

Range (mm)	Steps (mm)	No.of pieces
1.0005	-	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25.0 to 100.0	25.0	4
Total pieces		112

TABLE 1

	Procedure	Slip pack	Calculation
a)	First write the required dimension.		44.8725
b)	Select the slip gauge having 4th decimal place.	1.0005 Subtract	1.0005 43.8720
c)	Select a slip gauge from the 1st series that has the same last figure.	1.002 Subtract	1.002 42.87
d)	Select a slip gauge from the 2nd series that has the same last figure and that .0 will leave or 0.5 as last fig.	1.37 Subtract	1.37 41.5
e)	Select a slip gauge from the 3rd series that will leave the nearest 4th series slip (41.5 25 = 16.5).	16.5 Subtract	16.5 25.00
f)	Select a slip gauge that eliminates the final figure.	25.0 Subtract 44.8725	25.00 0.00

Basic process of soldering, welding and brazing

Objectives : At the end of this lesson you shall be able to
- **state the process of soldering**
- **state the method of application of soldering iron**
- **state the different types of solder and their application.**

There are different methods of joining metallic sheets. Soldering is one of them.

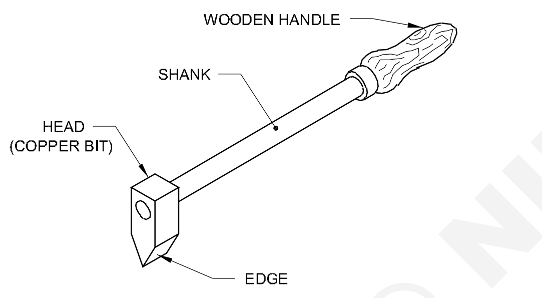
Soldering is the process by which metallic materials are joined with the help of another liquefied metal (solder).

The melting point of the solder is lower than that of the materials being joined.

The solder wets the base material without melting it.

Soldering iron (Fig 1): The soldering iron is used to melt the solder and heat the metal that are to be joined together.

Fig 1



SOLDERING IRON (HATCHET TYPE)

The soldering iron has the following parts,

- Head (copper bit)
- Shank
- Wooden handle
- Edge

Shape of head: The head of the iron is made of forged copper. This is because copper has a good heat conductivity and has a strong affinity for the solder so that the solder melts easily and sticks to the bit.

A Hatchet type soldering as in (Fig 1) has shank fitted at 60° to the head. The soldering edge is 'V' shaped.

The soldering iron is used to melt the solder and heat metal that are joined together.

Soldering iron are normally made of copper or copper alloys. So they are also called as copper bits.

Copper is the preferred material for soldering bit because

- It is a very good conductor of head
- It has affinity for tin lead alloy
- It is easy to maintain in serviceable condition
- It can be easily forged to the required shape

Soldering method: There are different methods of joining metallic sheets. Soldering is one of them.

Soldering is the process by which metals are joined with the help of another alloy called solder without heating the base metal to be joined. The melting point of the solder is lower than that of the materials being joined.

The molten solder wets the base material which helps in binding the base metal to form a joint.

Soldering should not be done on joints subjected to heat and vibration and where more strength is required.

Soldering can be classified as soft soldering and hard soldering. Hand soldering is further divided as (a) brazing (b) silver brazing. The process of joining metals using tin and lead as a soldering alloy which melts below 450° is known as soft soldering.

The process of joining metals using copper, zinc and tin alloy as filler material in which the base metal is heated above 450° C below 850°C is called hard soldering (brazing).

Silver brazing is similar to brazing except that the filler material used is a silver-copper alloy and the flux used is also different.

Solders: Pure metals or alloys are used for solders.

Solders are applied in the form of wires, sticks, ingots, rods, threads, tapes, formed sections, powder and pastes. (Fig 4)

Types of solders

There are two types of solders.

- Soft solder
- Hard solder

One distinguishes between soft solders whose melting points are below 450° C and hard solders whose melting points lie above 450° C.

Soft solders: These are alloys of the metals- tin, lead, antinomy, copper, cadmium and zinc and are used for soldering heavy (thick) and light metals.

Hard solders: These are alloys of copper, tin, silver, zinc, cadmium and phosphorus, and are used for soldering heavy metals.

Flux

Objectives: At the end of this lesson you shall be able to
- **state the criteria for the selection of fluxes**
- **distinguish between corrosive and non-corrosive fluxes**
- **name the different types of flux and their application.**

Fluxes are non-metalic materials which are used at the time of soldering.

Functions of flux

- Flux removes oxides from the soldering surface.
- It prevents corrosion.
- It helps molten solder to flow easily in the required place.
- It promotes the wet surface.
- It localize the heat in molten fool

Selection of flux

The following criteria are important for selecting a flux.

- Working temperature of the solder
- Soldering process
- Materials to be joined.

Classes of flux

Flux can be classified into corrosive flux, and non-corrosive flux.

Corrosive flux in acid form and should be washed immediately after the soldering operation is completed.

Non-corrosive flux is in the form of lump, powder, paste or liquid.

Different types of fluxes

Hydrochloric acid

Concentrated hydrochloric acid is a liquid which fumes when it comes into contact with air. After mixing with water, 2 or 3 times the quantity of the acid, it is used as dilute hydrochloric acid.

Hydrochloric acid combines with zinc forming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc, iron or galvanised sheets.

Zinc chloride

It is mainly used for soldering copper sheets, brass sheets and tin plates.

As it is extremely corrosive, the flux must be perfectly washed off after soldering.

Ammonium chloride

This is in the form of powder or lump. It evaporates when heated.

Ammonium chloride, dissolved in water, is used as a flux for soldering steel.

A solution of a mixture of hydrogen chloride, zinc chloride and ammonium chloride is used as a flux for stainless steel sheets.

Resin

As resin is not very effective for removing oxidation coating, and, as it is not highly corrosive, it is used as flux for copper and brass. Resin melts at about 80° to 100°C.

Paste

This is a mixture of zinc chloride, resin, glycerin and others and is available as a paste.

Basic process of Welding

Objective: At the end of this lesson you shall be able to
- **define welding process.**

Welding: Welding is a process of joining similar metals by application of heat with or without application of pressure and addition of filler materials.

Welding Porcess: According to the sources of heat, welding process can be broadly classified as:

- electric welding proces (heat source is electricity)
- gas welding processes (heat source is gas flame)
- other welding processes (heat source is neither electricity nor gas).

Electic welding processes can be classified as:

- electric arc welding
- electric resistance welding
- laser welding
- electron beam welding

Electric arc welding can be further classified as:

- metallic arc welding
- carbon arc welding

- atomic hydrogen arc welding
- inert gas arc welding
- CO_2 gas arc welding
- submerged arc welding
- electro-slag welding
- plasma arc welding.

Electric resistance welding can be further classified as:

- spot welding
- seam welding
- butt welding
- flash butt welding
- projection welding.

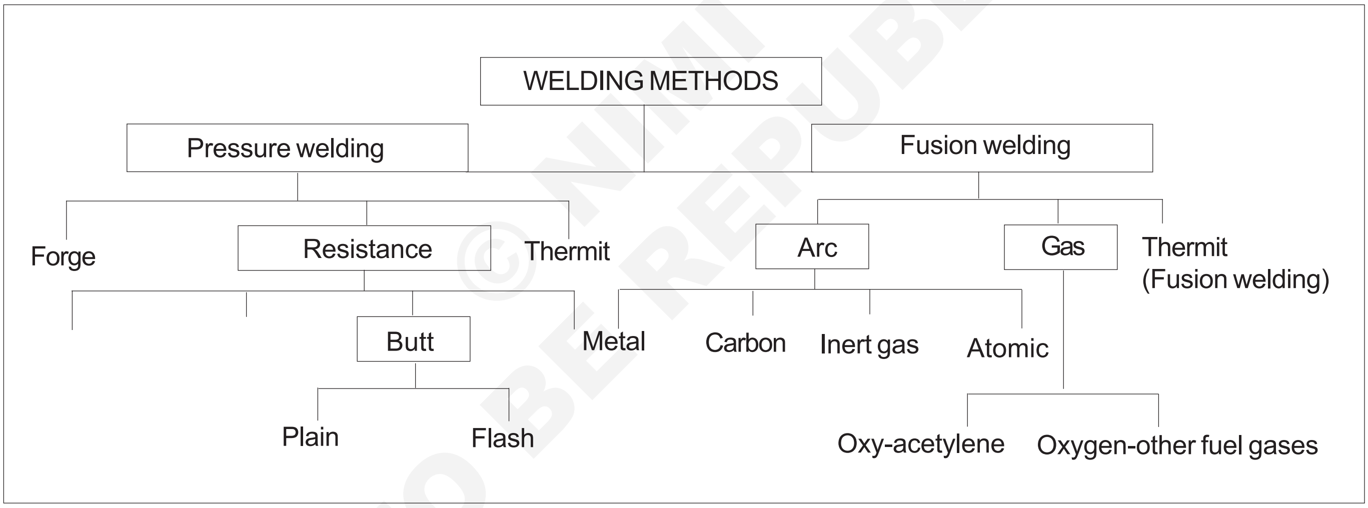
Gas welding process can be classified as:

- oxy-acetylene gas welding
- oxy-hydrogen gas welding
- oxy-coal gas welding
- oxy-liquefied petroleum gas welding
- air acetylene gas welding.

The other welding processes are:

- thermit welding
- forge welding
- friction welding
- ultrasonic welding
- explosive welding
- cold pressure welding
- plastic welding.

Chart showing welding methods.



Welding rods

Welding rods also known as filler rods provides extra metal to the weld. The extra metal is obtained by melting the end of a rod or piece of wire known as either a filler rod or welding rod. In many instances the composition of the rod is the same as that of the material being welded.

Edge preparation: To obtain sound welds, good edge preparation is beveling the edges and carefully cleaning the faces to be welded from dust, sand, grit, oil and grease.

Different edge preparation which are used for butt welding are shown at Fig 1, namely single V, single J single V etc.,

Welded joints

Weld joint is classified based on the relative position of the two metal pieces being joined, determines the type of joint. There are five basic type of joints that are used in welding namely butt, lap, corner, edge & T-joints. (Fig 2)

1. Butt joint
2. Lap joint
3. T-joint
4. Corner joint
5. Edge joint

Gas Welding

It is by melting the edges or surfaces to be joined by gas flame and allowing the molten metal to flow together, thus forming a solid continuous joint after cooling. This process suitable for joining metal thickness of 2mm to 25 mm in one pass.

Fig 1

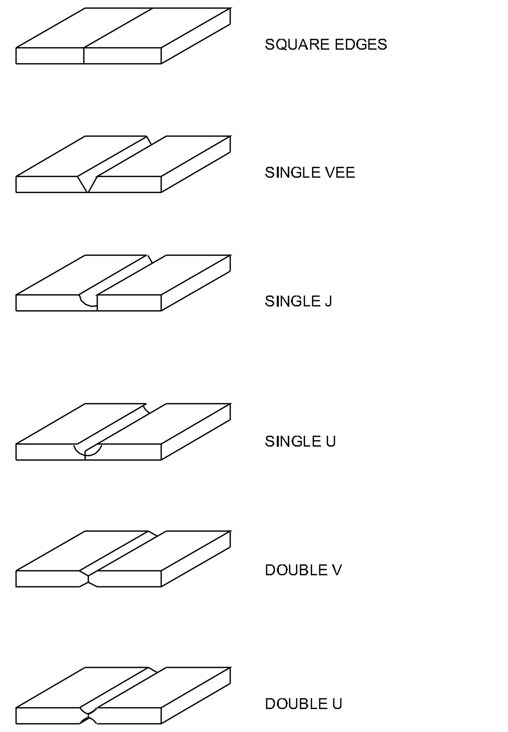
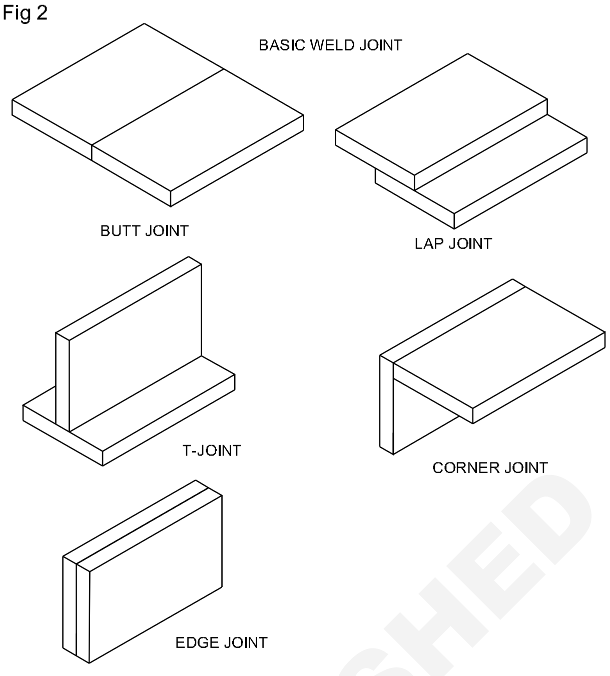


Fig 2



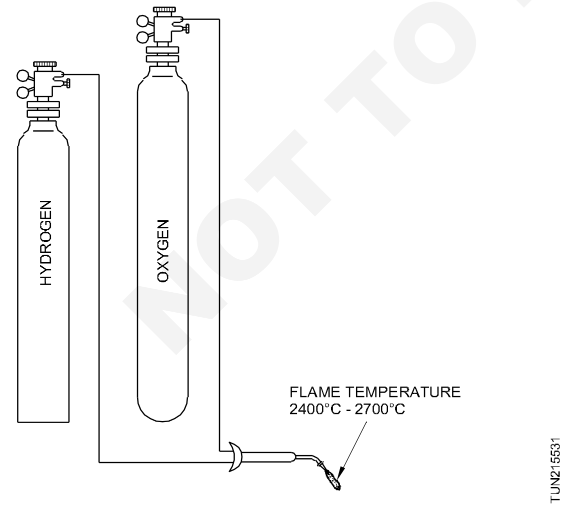
Systems of oxy-acetylene

Objectives : At the end of this lesson you shall be able to
- **distinguish between high pressure and low pressure acetylene plants**
- **distinguish the features of low pressure and high pressure blowpipes.**

Oxy-acetylene plants can be either high pressure or low pressure.

A high pressure plant utilizes acetylene under high pressure, upto 1 kg/cm^2. (Fig 1)

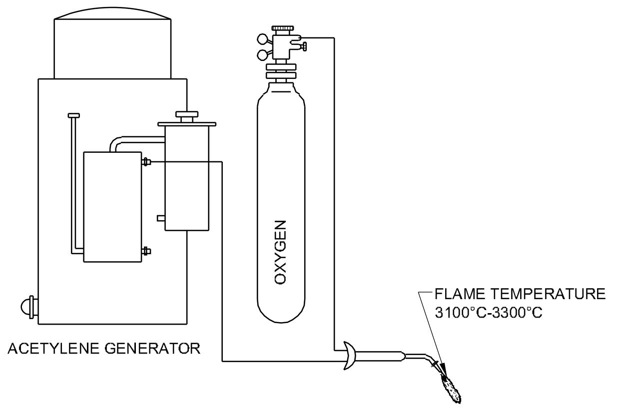
Fig 1



Dissolved acetylene (acetylene in cylinder) is a commonly used source.

A low pressure plant utilizes acetylene under low pressure (0.017 kg/cm^2) produced by an acetylene generator only. (Fig 2)

Fig 2



Gases used in gas welding

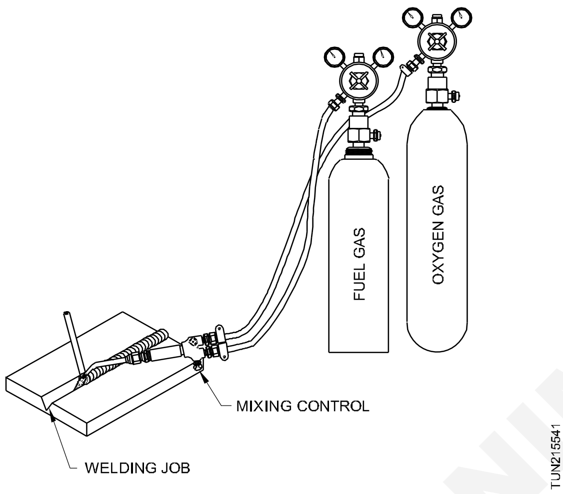
Objectives: At the end of this lesson you shall be able to
- **name the different types of gases used in gas welding**
- **state the different types of gas flame combinations**
- **state the temperatures and uses of the different gas flame combinations.**

In the different gas welding processes, the welding heat is obtained from the combustion of the fuel gases.

All the fuel gases require oxygen to support combustion.

As a result of the combustion of the fuel gases and oxygen, a flame is obtained. This is used to heat the metals for welding. (Fig 1)

Fig 1



Fuel gases used in welding

The following are the gases used as fuel for welding.
- Acetylene gas
- Hydrogen gas
- Coal gas
- Liquid petroleum gas (LPG)

Supporter of combustion gas

All gases burn with the help of oxygen. Hence it is known as the supporter of combustion.

Different gas flame combinations

Oxygen + Acetylene = Oxy-acetylene gas flame

Oxygen + Hydrogen = Oxy-hydrogen gas flame

Oxygen + Coal = Oxy-coal gas flame

Oxygen + LPG = Oxy-LP gas flame

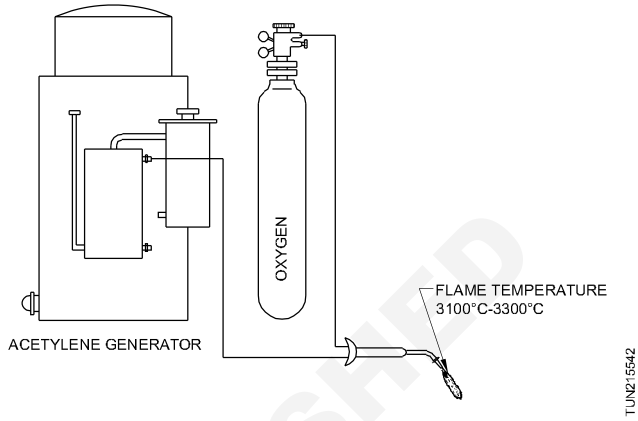
Temperature and uses of gas flame combinations

Oxy-acetylene gas flame (Fig 2)

Flame temperature : 3100° C to 3300° C

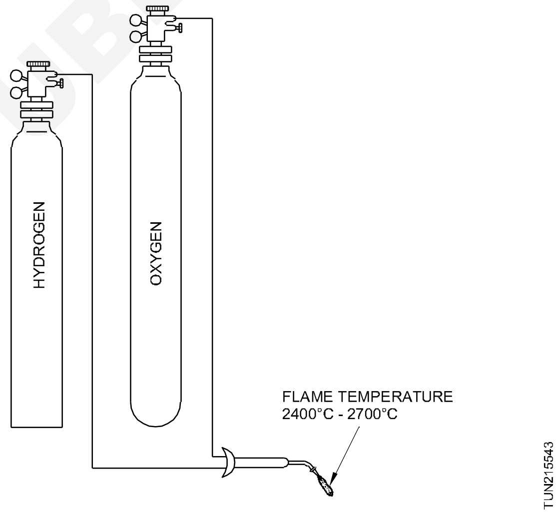
The oxy-acetylene gas flame is used for welding all ferrous and non-ferrous metals and their alloys, gas cutting, gouging, steel brazing, bronze welding, metal spraying and powder spraying, operations.

Fig 2



Oxy-hydrogen gas flame (Fig 3)

Fig 3



Flame temperature : 2400°C to 2700°C

This type of flame is used only for brazing, silver soldering and underwater gas cutting of steel.

Oxy-liquid petroleum gas flame (Fig 4)

Flame temperature : 2700°C to 2800°C

This flame has carbon and moisture effect.

It is only used for gas cutting of steel, and for heating purposes.

Oxy-coal gas flame (Fig 5)

Flame temperature : 1800°C to 2200°C

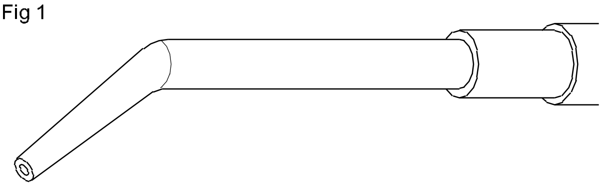
This flame has carbon effect in the flame and is highly suitable used for silver soldering and brazing.

Welding Nozzles - sizes and selection

Objectives : At the end of this lesson you shall be able to
- **identify the different sizes of nozzles**
- **select the correct nozzle for the job**
- **select the correct gas pressure for the nozzles.**

The welding nozzle is a part of the welding blowpipe (made of copper with a small orifice) fitted at the end where the flame is ignited. (Fig 1)

Fig 1



Nozzle sizes

The size of the nozzle is determined by the diameter of its orifice.

Smaller orifice nozzles make a smaller flame useful for welding thin metals, whereas larger hole nozzles make a larger flame useful for welding thick metals, where more heat is required.

The common nozzle sizes are

1,2,3,4,5,7,10,13,18,25,35,45, 55,70 and 90.

The selection of a nozzle is determined by the

- Thickness of the metal to be welded
- Mass of the metal to be welded
- Kind of the metal to be welded.
- The gas pressure required for the flame. You may observe from the table that the nozzle size number increases with increased thickness of jobs to be welded.

Selection of gas pressure for nozzles

Smaller size nozzles require less pressure whereas the larger size nozzles require more pressure (Table 1)

Selection of Nozzle

Table 1

Plate thick-ness (mm)	Nozzle size	Oxygen Acetylene pressure (kg/cm)
0.8	1	
1.2	2	
1.6	3	0.15
2.4	5	
3.2	7	
4.0	10	
5.0	13	0.20
6.5	18	
8.2	25	
10.0	35	
13.0	45	
19.0	55	
25.0	70	0.40
Over 25.0	90	0.45

Safety precautions in handling gas welding plant

Objective : At the end of this lesson you shall be able to
- **state the general safety precautions in handling gas welding plants.**

To be accident-free, one must know the safety rules first and then practice them strictly as we all know that ''Accident starts when Safety ends''.

Ignorance of rules is no excuse!

In gas welding, the welder must follow the safety precautions in handling gas welding plants and flame-setting to keep himself and others safe.

Safety precautions are always based on good common sense.

The following precautions are to be observed, to keep a gas welder accident-free.

General safety

Do not use lubricants (oil or grease) in any part or assembly of a gas welding plant. It may cause explosion.

Keep all flammable material away from the welding area. Always wear goggles with filter lens during gas welding.

Always wear fire resistant clothes, asbestos gloves and apron.

> **Never wear nylon, greasy and torn clothes while welding.**

Whenever a leakage is noticed rectify it immediately to avoid fire hazards.

Even a small leakage can cause serious accidents.

Always keep fire-fighting equipment handy and in working condition to put out fires.

Keep the work area free from any form of fire.

Safety gas cylinders: Do not roll gas cylinders or use them as rollers.

Use a trolley to the carry the cylinders.

Close the cylinder valves when not in use or empty.

Keep full cylinders separate and empty cylinders separate.

Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders QUICKLY in the case of a back-fire or flash-back.

Always use the cylinders in an upright position for easy handling and safety.

Always crack the cylinder valves to clean the valve sockets before attaching regulators.

Safety for rubber hose pipes: Inspect the rubber hose pipes periodically and replace the damaged ones.

Do not use odd bits of hose pipes / tubes.

Do not replace the hose pipes for acetylene with the ones used for oxygen.

Always use black hose pipes for oxygen and maroon for acetylene.

Safety for regulators: Prevent hammer blows to the gas cylinders and ensure that water, dust and oil do not settle on the cylinders.

Note right hand threaded connection for oxygen and left hand threaded connection for acetylene.

Safety for blowpipes: When a blowpipe is not in use put out the flame and place the blowpipe in a safe place.

When flame snaps out and backfires, quickly shut both the blowpipe valves (oxygen first) and dip in water.

While igniting the flame, point the blowpipe nozzle in a safe direction. (Fig 6)

While extinguishing the flame, shut off the acetylene valve first and then the oxygen valve to avoid a backfire.

Safety precautions during arc welding

Objective: At the end of this lesson you shall be able to
- **state the precautions necessary in arc-welding.**

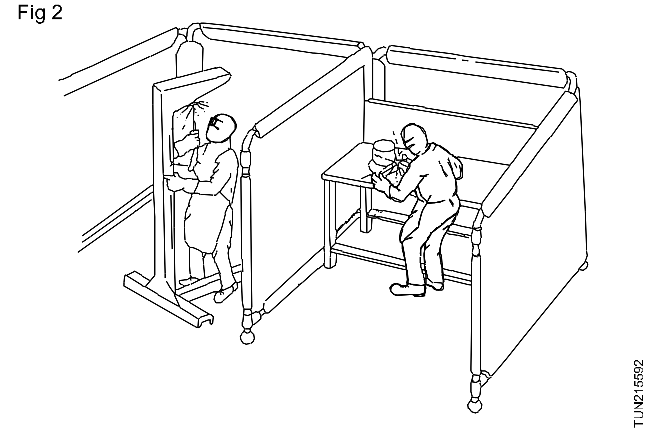
Safety precautions

- Never stand on a damp or wet place while arc-welding.
- Always wear all the safety apparels (gloves, apron, sleeves, shoes). (Fig 1)

Fig 1

- Use welding and a chipping screen during welding and chipping respectively, for the protection of the eyes and the face.
- Switch off the machine when not in use.
- Keep the clothes free from oil and grease.
- Use tongs while handling hot metals.
- Do not carry matches or petrol lighters in your pocket during arc-welding.
- Protect the outsiders from radiation and reflection of rays, by using portable screens or welding booths. (Fig 2)

Fig 2



- Keep the welding area free from moisture and flammable material.
- Do not try to rectify electrical faults yourself; call an electrician.
- Do not throw the electrode stubs on the floor. Put them in a container.
- Use exhaust fans to remove the arc-welding smoke and fumes.

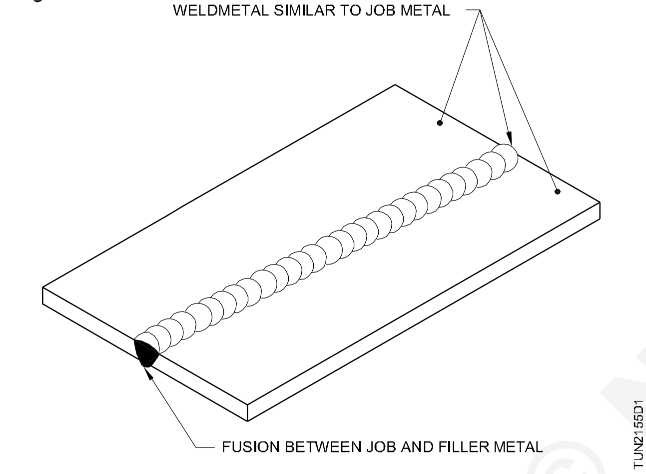
Keep the welding area always clean removing unused metal, scrap etc, to avoid getting hurt.

Braze welding

Objective: At the end of this lesson you shall be able to
- **distinguish between fusion welding and braze welding.**

Fusion welding (Fig 1): A metal joining process wherein a permanent joint is made by melting and fusing the joining edges by a welding process is known as fusion welding.

Fig 1

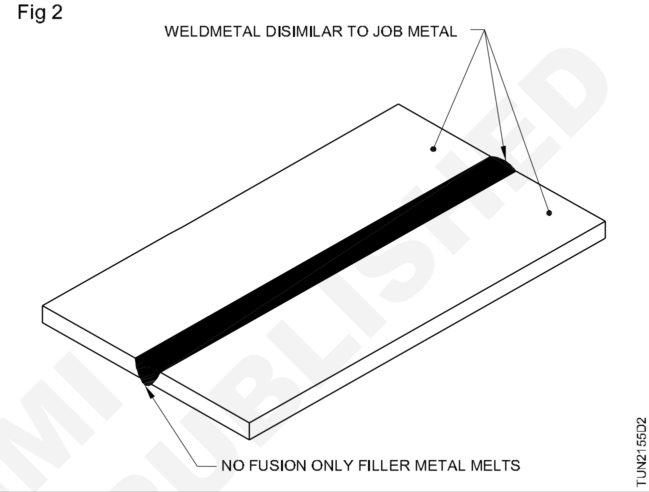


Braze welding (Fig 2): Braze welding is a welding process in which a filler metal, having a melting point above 840°F (450° C) and below that of the base metal, is used. Unlike brazing, in braze welding, the filler metal is not distributed in the joint by capillary action.

Brazing: Brazing is a metal joining process which is done at a temperature of above 450°C as compared to soldering which is done at below 450°C

So brazing is a process in which the following steps are followed.

Fig 2



- Clean the area of the joint thoroughly by wire brushing, emerging and by chemical solutions for removing oil, grease, paints etc.
- Fit the joints tightly using proper clamping, (Maximum gap permitted between the two joining surfaces is only 0.08mm)
- Apply the flux in paste form (for brazing iron and steel a mixture of 75% borax powder with 25% boric acid (liquid form) to form a paste is used). Usually the brazing flux contains chlorides, fluorides, borax, borates, fluoroborates, boric acid, wetting agents and water. So suitable flux combination is selected based on metal being used.

Filler rods and fluxes for braze welding

Objectives : At the end of this lesson you shall be able to
- **state the different types of filler rods required for braze welding**
- **state the functions and types of fluxes required for braze welding.**

Filler rods for braze welding: There are many types of braze-welding rods.

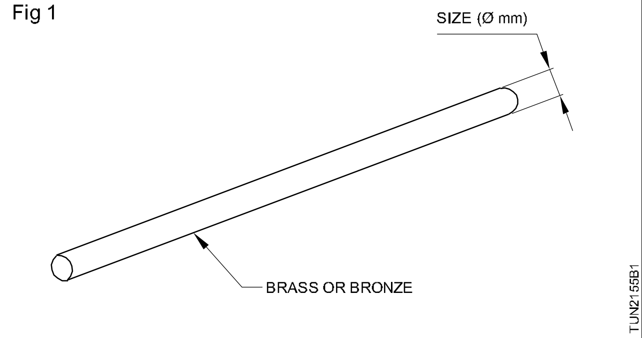
The most common rod used for ferrous metals is a copper-zinc alloy with the addition of a small percentage of silicon, manganese, nickel and tin. (Fig 1)

Types & application (Conforming to IS: 1278-1972)

Brass filler rods - Type S-C6

For use in the braze welding of copper and mild steel and for the fusion welding of materials of the same or a closely similar composition (oxidising flame).

Fig 1



Manganese bronze (high tensile brass) - Type S-C8

For use in the braze welding of copper, cast iron and malleable iron, and for the fusion welding of materials of the same or a closely similar composition (oxidising flame).

Medium nickel bronze - Type S-C9

For use in the braze welding of mild steel, cast iron and malleable iron. (oxidising flame)

Fluxes for braze welding

The purpose of the flux is to

- Chemically clean the joint.
- Remove impurities from the weld
- Allow the molten filler metal to flow and spread more easily into the joint surface.

For braze welding using the above filler rods, an oxydising flame is used.

For brazing with brass and bronze filler rods different fluxes are commercially available under different brand names. Borax may also be used as a flux.

Melting points of common metals

Objective: At the end of this lesson you shall be able to
- **determine the melting points of the common metals used in welding.**

Melting point: The temperature at which a solid metal changes to a liquid is known as its melting point.

Melting points of some common metals are given in Table 1.

Table 1

MELTING POINTS OF COMMON METALS	
Metal	**Melting Point**
	(°C)
Tin	232
Lead	327
Zinc	419
Aluminium	659
Bronze	882-915
Brass	850-982
Silver	960

Melting points of some common metals are given in Table 1.

Metal	Melting Point (°C)
Copper	1083
Cast iron	1150
Monel metal	1342
High carbon steel	1371
Medium carbon steel	1426
Stainless steel	1426
Nickel	1449
Low carbon steel	1510
Wrought iron	1593
Tungsten	3410

Methods of cleaning (For Brazing)

Objectives : At the end of this lesson you shall be able to
- **state the mechanical cleaning methods**
- **state the chemical cleaning methods.**

Necessity for cleaning: Plates or sheets are often coated with rust, paint, oil, grease, scale etc. During brazing, they are trapped in the joint and cause defective brazed joints.

Mechanical cleaning: The joining edges/surfaces may be cleaned by

- Wire brushing (Fig 1)
- Sand blasting
- Filing
- Machining
- Grinding (Fig 2)
- Cleaning with steel wool.

Fig 1

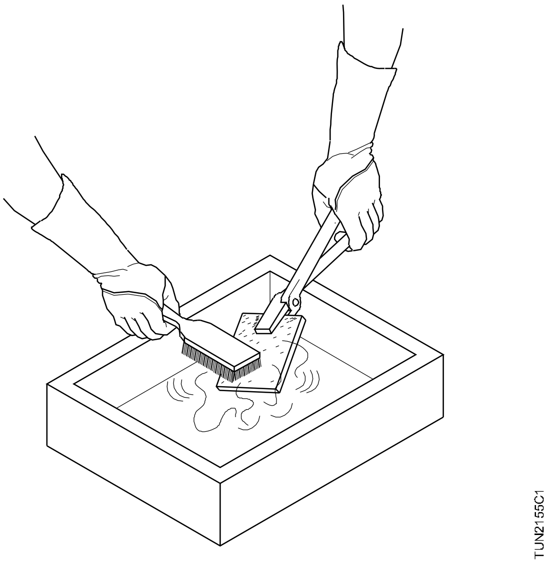
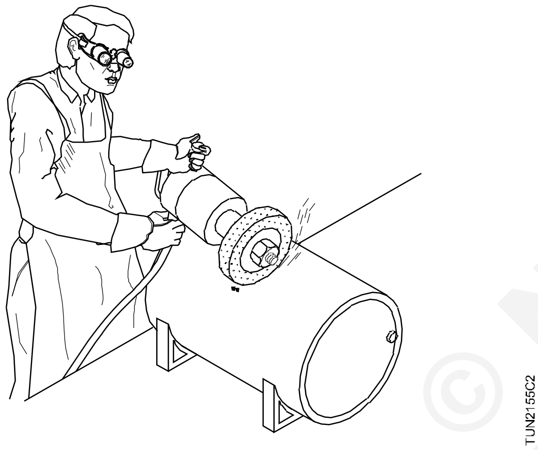


Fig 2



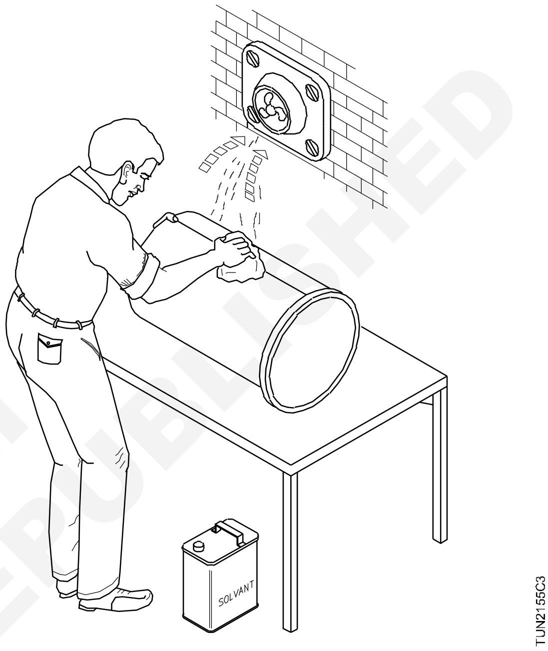
Chemical cleaning: The joining edges/surfaces can also be cleaned chemically to remove oil, grease, dirt, rust etc.

Ferrous metal surfaces are washed with solvents such as kerosene, diesel and petrol. (Fig 3)

For cleaning copper and its alloys, use a solution consisting of 0.2 kg. sodium orthosilicate, 0.2 kg. sodium resinate and 3.8 litres of water at 51.7° to 82.2°c.

Dipping the plates in the solution or applying the solution at the joint will produce a clean surface required for brazing.

Fig 3



Vernier height gauge, function and description

Objectives: At the end of this lesson you shall be able to
- **name the parts of a vernier height gauge**
- **state the constructional features of a vernier height gauge**
- **state the functional features of a vernier height gauge**
- **list the various applications of the vernier height gauge in engineering.**

Parts of a vernier height gauge (Fig 1)

A Beam

B Base

C Main slide

D Jaw

E Jaw clamp

F Vernier scale

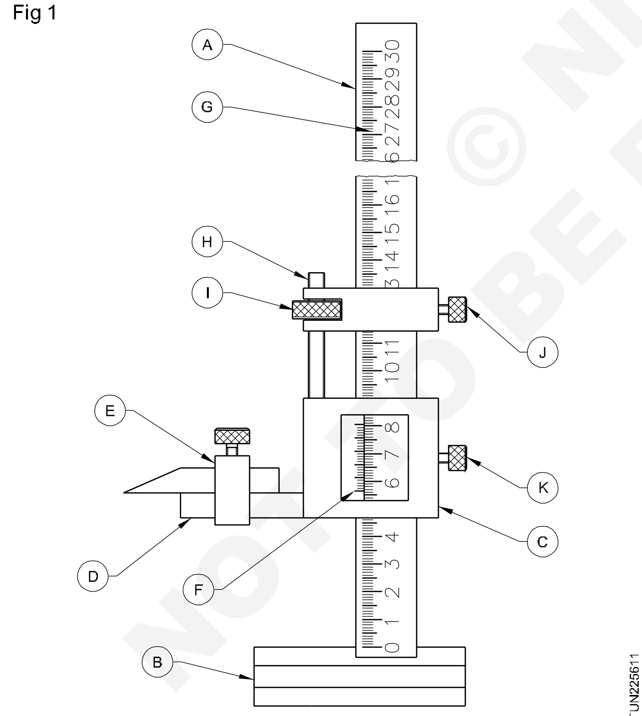
G Main scale

H Fine adjusting slide

I Fine adjusting nut

J&K Locking screws

Fig 1



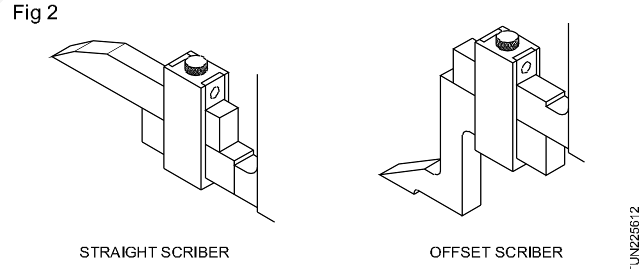
Constructional features of a vernier height gauge

The construction of a vernier height gauge is similar to that of the vernier caliper except that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.

It consists of an upright steel beam fastened to a steel base. The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the fine adjusting slide. The movable jaw is most widely used with the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose. The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the lock screws. The vernier height gauges are available, in ranges of capacities reading from zero to 1000 mm.

Fig 2



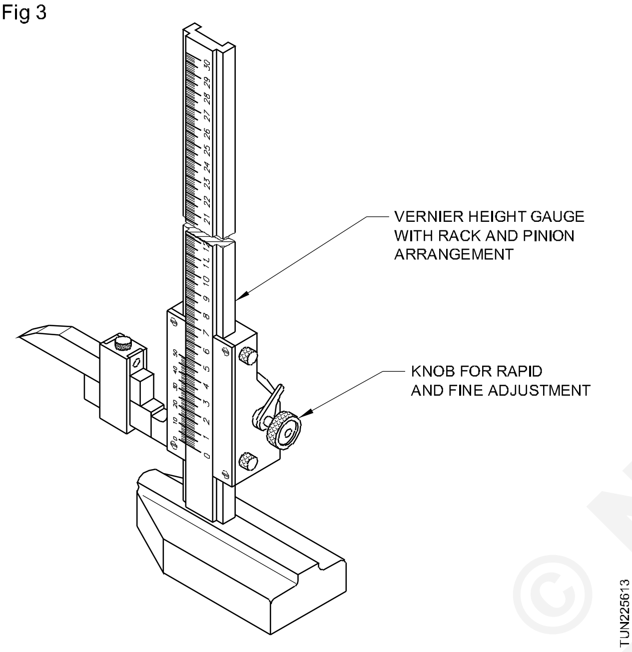
Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the fine adjusting slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

The fine adjusting slide has to be locked in position, for an approximate height as required. To get an exact mark able height, the fine adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading. Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

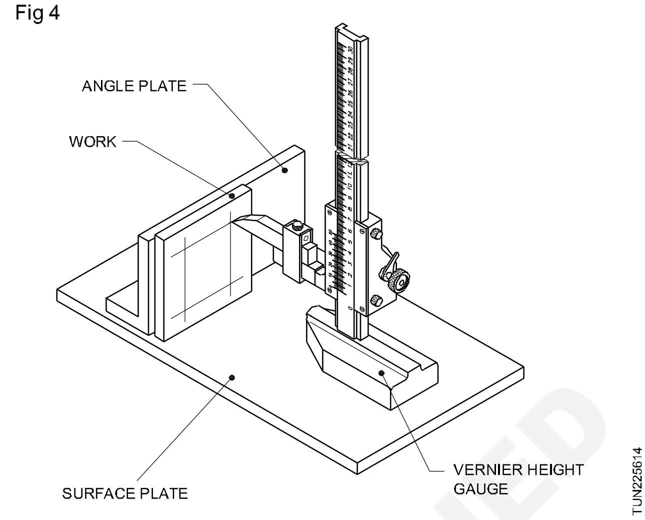
Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.

Fig 3



Application of vernier gauge in Engg: The vernier height gauge is mainly used for layout work,(Fig 4)

Fig 4



It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scriber.

Templates its function and construction

Objectives: At the end of this lesson you shall be able to
- **state the uses of templates**
- **define template.**

Templates: Templates are used in the sheet metal and plate fabrication industries. For example

1 To avoid repetitive measuring and marking the same dimension, where many identical parts are required.

2 To avoid unnecessary wastage of material and from information given on drawing, it is almost impossible to anticipate exactly where to begin in order that the complete layout can be economically accommodated.

3 To act as a guide for cutting processes.

4 As a simple means of checking bend angles and contours.

Information given on templates

Written on templates may be as follows:

1 Job or contract number
2 Size and thickness of plate
3 Quantity required
4 Bending or folding instructions
5 Drilling requirement
6 Cutting instructions
7 Assembly reference mark.

Templates as a means of checking is shown in Fig 4,5,6,7,8,9.

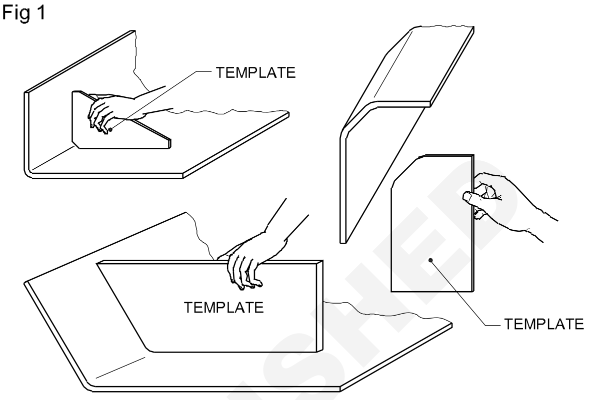
Templates for setting out sheet metal fabrications: For economy reasons, many patterns are made for marking out the sheet metal prior to cutting and forming operations. Fig 6,7,8 show a smoke cowl. Here a template is required to check and to mark out the contours of the intersection joint lines for the parts A,B & C whose developed sizes are marked out in the flat with the appropriate datum lines.

Fig 9 shows a square to round transformer is an isometric view of the sheet metal trans forming piece which is used to connect a circular duct to a square duct of equal area of cross section. In this example the dia of the round duct is 860 mm and length of one side of the square duct is 762 mm and the distance between the two ducts is 458 mm and sheet thickness is 1.2 mm.

Fig 10 shows a scale development pattern on which are marked the full size dimensions. This type of drawings are supplied by the drawing office for marking out purposes. Allowances for the seams and the joints must be added to the layout.

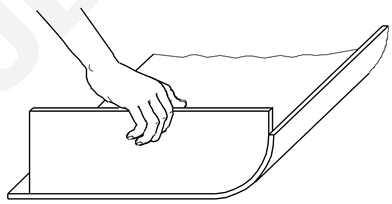
Fig 11 shows a simple sheet metal template may be used to check the form turning job

Fig 1



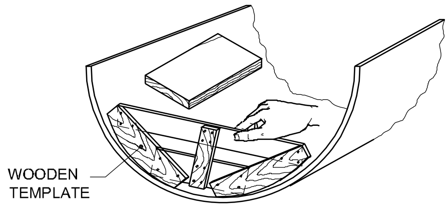
CHECKING ANGLES WITH A TEMPLATE

Fig 1



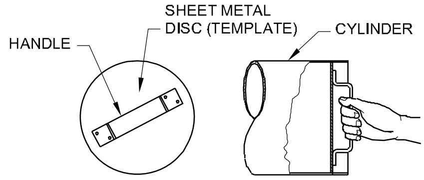
CHECKING THE CONTOUR OF A RADIUSED CORNER

Fig 3



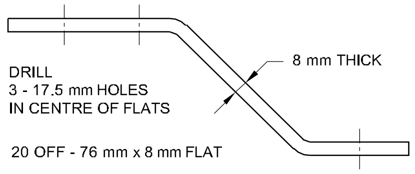
CHECKING THE CONTOUR OF A ROLLED PLATE

Fig 4



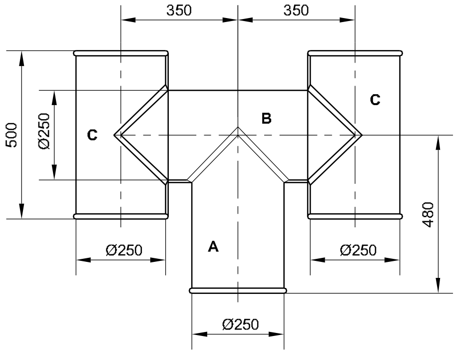
TEMPLATE USED FOR CHECKING CONTOUR OF CYLINDRICAL WORK SUCH AS DUCTWORK.

Fig 5



THE USE OF TEMPLATES AS A MEANS OF CHECKING

Fig 6



CHIMNEY SMOKE COWL

Fig 7

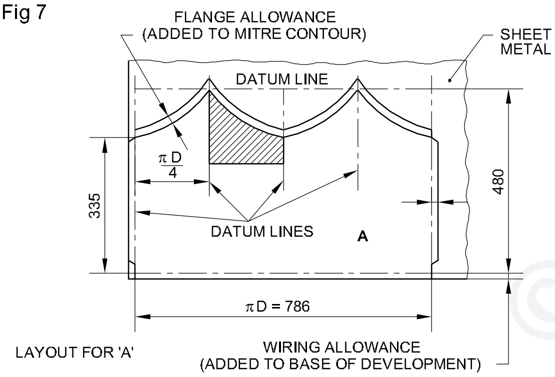
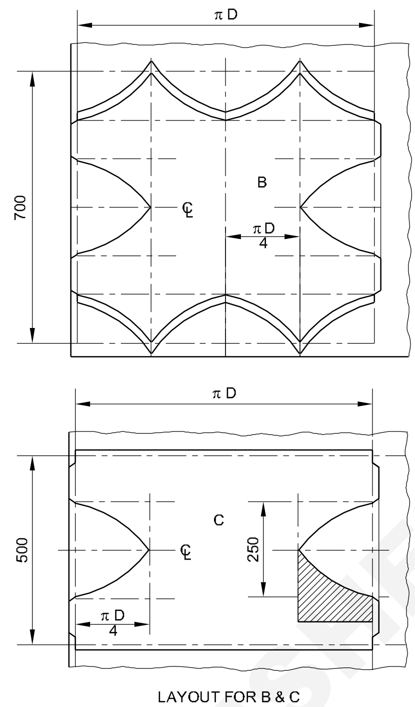
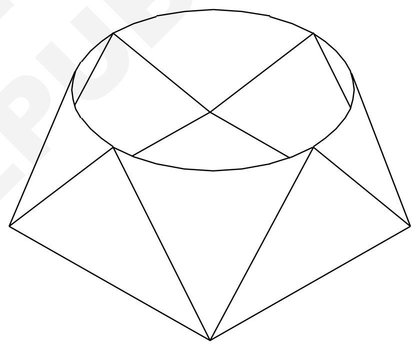


Fig 8



AN EXAMPLE OF THE USE OF TEMPLATES

Fig 9

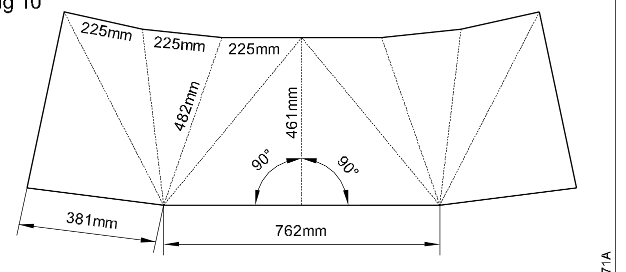


THE COMPLETE TRANSFORMER

Difference between gauges & Template:

Gauge	Template
• It is made from tool steel and has more thickness	It is thin sheet and low cost material
• More accurate	Less accurate
• Not used in heated jobs	Normally used in heated job
• It is used for greater accuracy	Rough and less accuracy jobs.
• Treated with heat treatment	To make simple and low cost material and grinding.

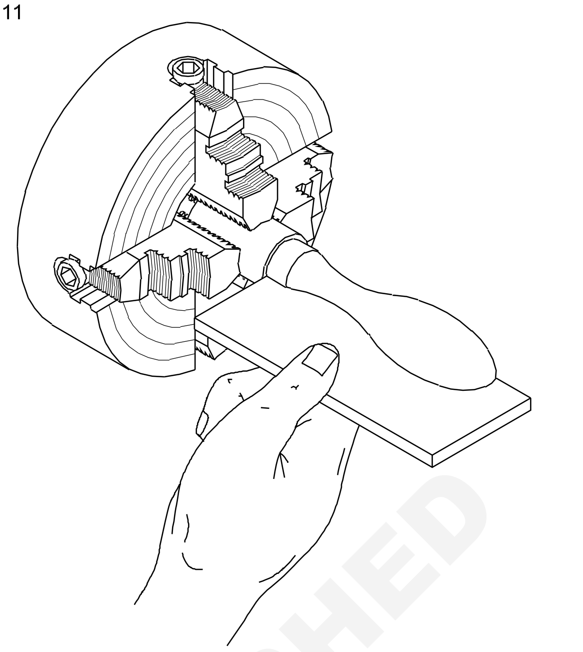
Fig 10



PATTERN OR HALF-TEMPLATE WITHOUT JOINT ALLOWANCES

SQUARE TO ROUND TRANSFORMER

Fig 11



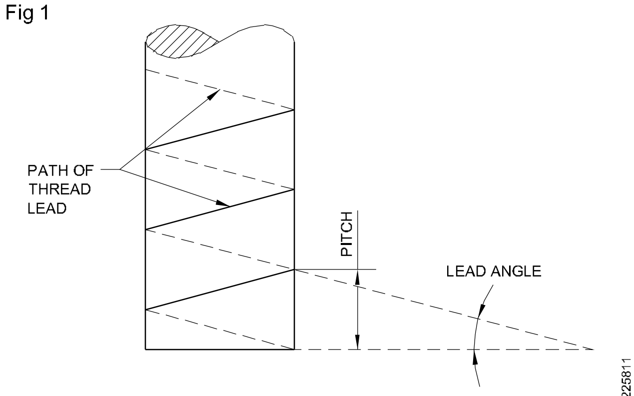
Screw thread - definition, purpose & its elements

Objectives : At the end of this lesson you shall be able to
- **define thread**
- **state the purpose of threads**
- **identify the parts of a thread (terminology).**

Definition

Thread is a ridge of uniform cross-section which follows the path of a helix around the cylinder or cone, either externally or internally. (Fig 1)

Fig 1



THREAD LEAD

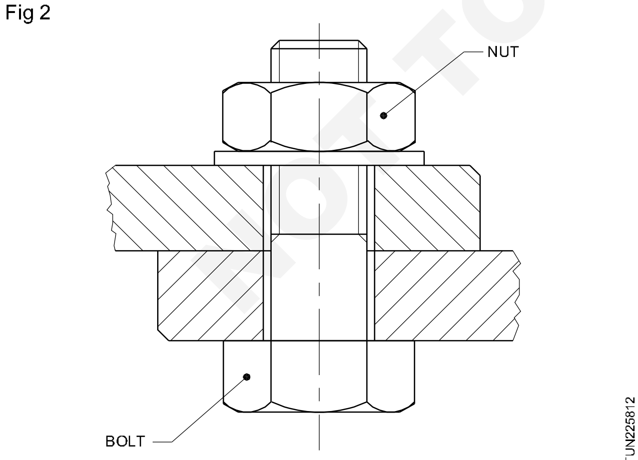
Helix is a type of curve generated by a point which is moving at a uniform speed around the cylinder or cone, and at the same time, moves at a uniform speed parallel to the axis. (Fig 1)

Purpose of thread

Threads are used for the following purposes.

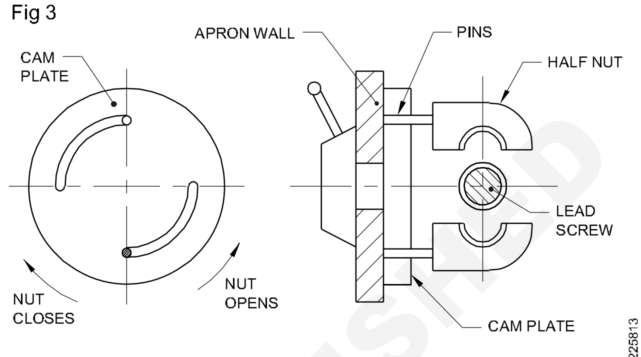
- For fastening purposes *Ex.* Bolts & nuts. (Fig 2)

Fig 2



- Transmission of motion *Ex.* Half nut with lead screw (Fig.3)
- Used in precision measuring instruments. *Ex.* Micrometer spindle.

Fig 3



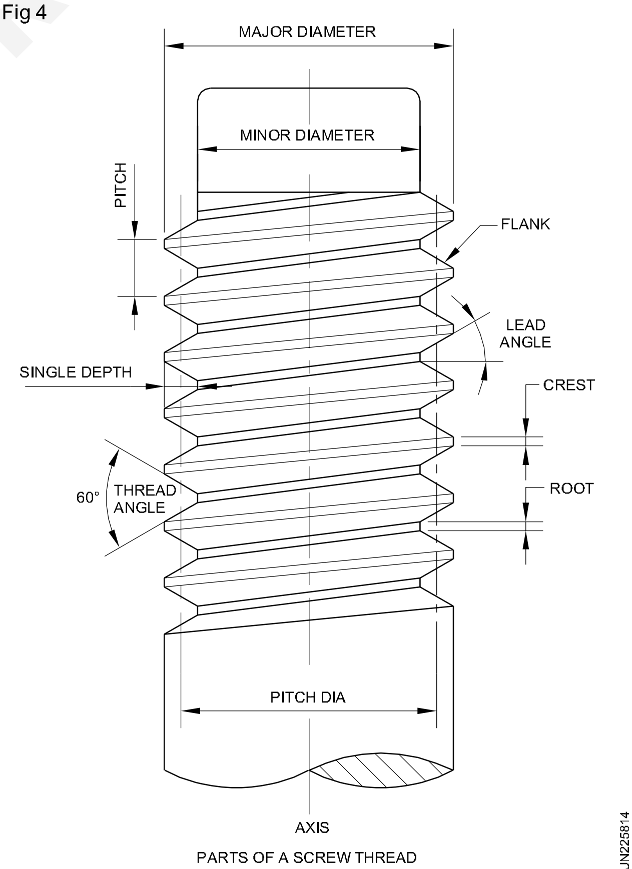
LEAD SCREW HALF NUT MECHANISM

- Load lifting purposes *Ex.*Screw-jack
- Elevating arm of radial drilling machines.

Elements of threads (Fig 4)

Elements of threads means naming the parts and other terms systematically. The parts of a thread are identified as follows. (Fig 4)

Fig 4



PARTS OF A SCREW THREAD

Major diameter
Minor diameter
Pitch diameter
Pitch of the thread
Crest
Root
Flank of the thread
Thread angle
Depth of thread
Lead angle (helix angle)
Lead
Hand
Clearance

Major diameter

It is the largest diameter over which a thread is cut in the case of an external thread, and in the case of an internal thread, it is the largest diameter resulting after cutting the thread. (Fig 4)

Minor diameter

It is the smallest diameter formed after an external thread is cut, and in the case of internal thread, it is the diameter over which the thread is cut.

Pitch diameter

It is the diameter of an imaginary cylinder which passes through the thread such that the width of the space is equal to the width of the thread. It is equal to the major diameter minus one depth.

Pitch of thread

It is the horizontal distance from a point on one thread to the corresponding point on the adjacent thread measured parallel to the axis.

Crest

It is the top surface joining the flanks of the same thread.

Root

The bottom surface joining the flanks of the adjacent threads is called the root.

Flank

It is the surface connecting the crest and the root.

Thread angle

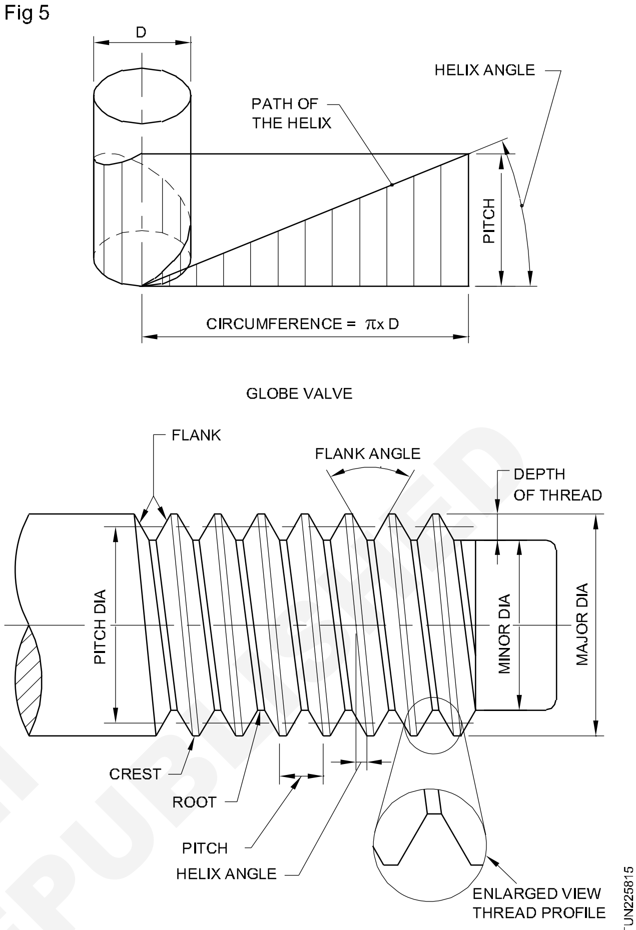
It is the included angle between two flanks of the thread.

Depth of thread

It is the perpendicular distance between the crest and the root of the thread.

Helix angle (Fig 5)

Fig 5



It is the angle which the helix makes with a line drawn perpendicular to the axis. It is calculated by the formula

$$\tan \alpha = \frac{\text{lead}}{\text{pitchdia}}$$

where α = helix angle in degrees,

pitch dia = pitch diameter of the thread.

Hand of thread

The hand of the thread is the direction in which the thread is turned to advance. If the direction is clockwise it is right hand thread, and if the direction is anticlockwise, it is left hand thread.

Start of the thread

When there is only one helix formation on a work, the start of the thread is known as single start. If there are more than one helix, then the thread is known as a multi-start thread. The starting points of the threads in the case of multi-start threads are equally spaced on the face of the work, and may be determined by a careful look at the face to know the number of starts.

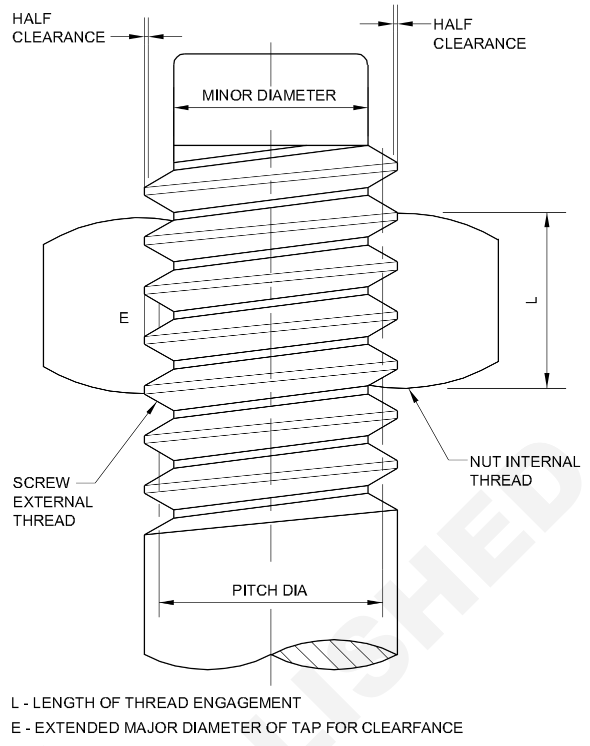
Threads of any form can be cut having multi-starts, depending upon their applications. The helix angle of a multi-start thread of a definite pitch is greater than that of a single start thread of the same pitch cut on the same diameter. Multi-start threads may be left hand or right hand threads according to the need. The term 'lead' is always used in conjunction with multi-start threads which will be equal to the pitch of the thread multiplied by the number of starts.

Multi-start threads are cut on parts to have faster transmission of motion with the diameter of the work, the pitch of the thread being kept to the minimum.

Clearance

It is a space left between the mating of external and internal threads to facilitate easy rotation of the threaded parts. (Fig.6)

Fig 6



FIT OF NUT AND BOLT

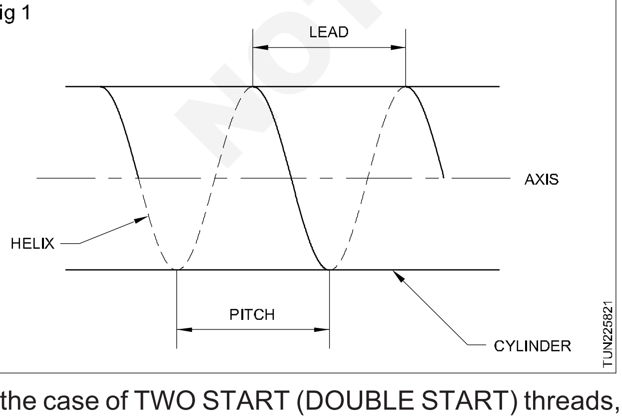
Multi-start, right hand and left hand threads

Objectives: At the end of this lesson you shall be able to
- **distinguish between the features of single start and multi-start threads**
- **give examples of a multi-start thread's applications**
- **distinguish between the features of right hand and left hand threads**
- **give examples on the application of right hand and left hand threads**
- **identify right hand and left hand threads.**

Threads are formed on screws in a helix. Helix is the path of a point travelling around an imaginary cylinder such that its axial and circumferential velocities maintain a constant ratio.

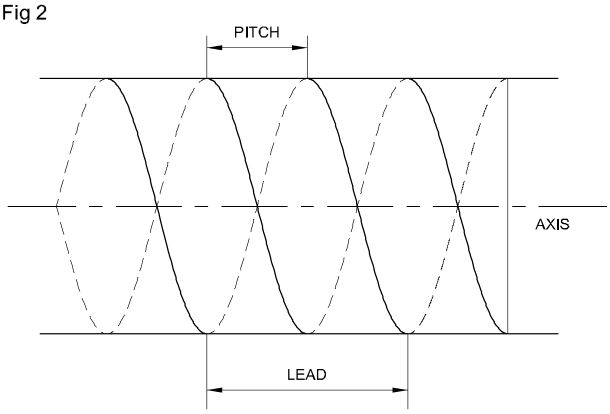
When a single helix is making a screw, it is called a SINGLE START thread. In a single start thread the LEAD and PITCH are the same. (Fig 1)

Fig 1



In the case of TWO START (DOUBLE START) threads, one thread is found within the other exactly in the middle (Fig.2). This enables the lead of the helix increased without increasing the pitch.

Fig 2



Lead = Pitch x Number of starts

A screw-thread may have any number of starts. The general term for such threads other than single start is MULTI- START. Application of multi-start threads can be found in fly presses, pen caps etc. A multi-start thread makes it possible to keep the depth of thread less, and provides a rapid axial movement of the screws.

Left-Hand thread and Right-Hand thread

Screw handedness refers to the direction that a screw's thread wraps around its shaft. "Right-handed" thread run clockwise, and "left-handed" thread run counter clockwise.

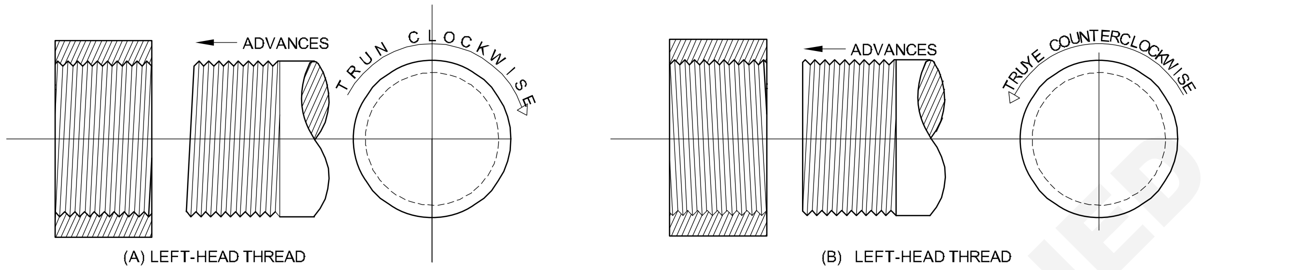
Some applications that benefit from the use of right and left handed fasteners include:

Automotive: Some tires bolts are reverse threaded to keep torque from loosening them

Heating and plumbing: Pipes are often with both right and left handed threads to provide an extra layer of defense from leakage

Safety: Gas supply valves use left handed threads to differentiate them from the valves that control oxygen. (Fig 3)

Fig 3



RIGHT HAND AND LEFT HAND TREAD

Combination set

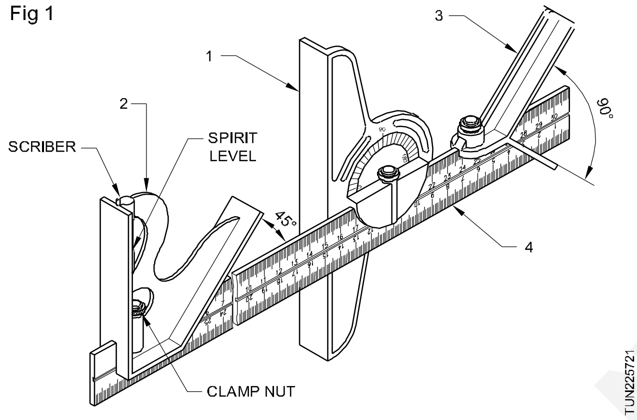
Objectives : At the end of this lesson you shall be able to
- **identify the parts of a combination set**
- **state the uses of each attachment in a combination set.**

Combination sets can be used for different types of work, like layout work, measurement and checking of angles.

The combination set (Fig 1) has a

- protractor head (1)
- square head (2)
- centre head, and (3)
- rule. (4)

Fig 1



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 workpieces on the machines and measure the depth of slots. (Figs 2,3 & 4)

Fig 2

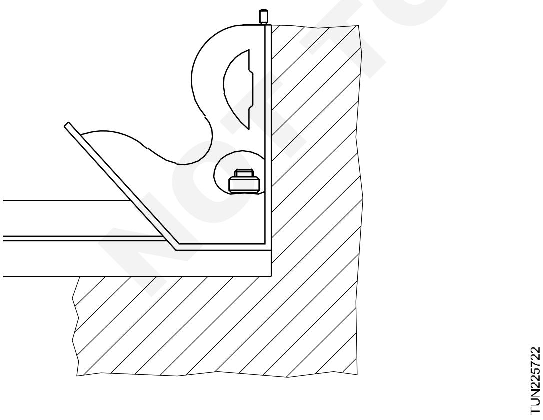


Fig 3

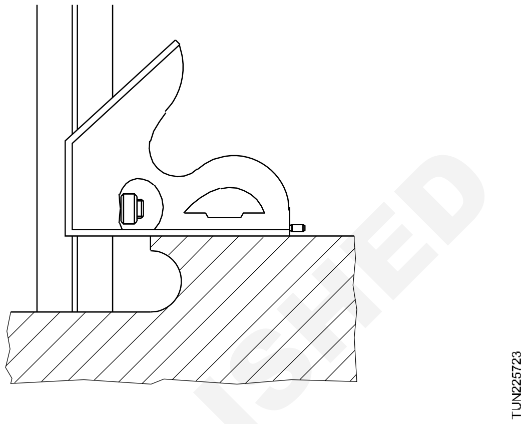
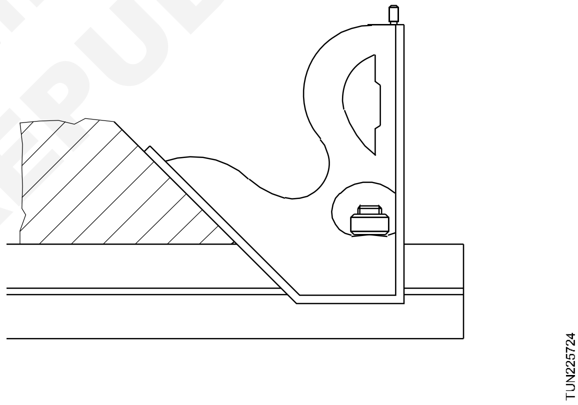


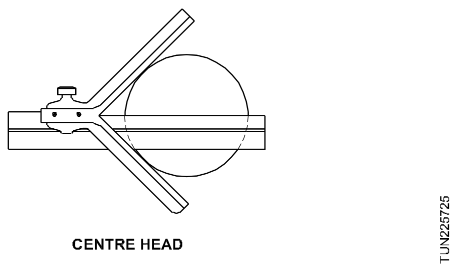
Fig 4



Centre head

This along with the rule is used for locating the centre of cylindrical jobs. (Fig 5)

Fig 5



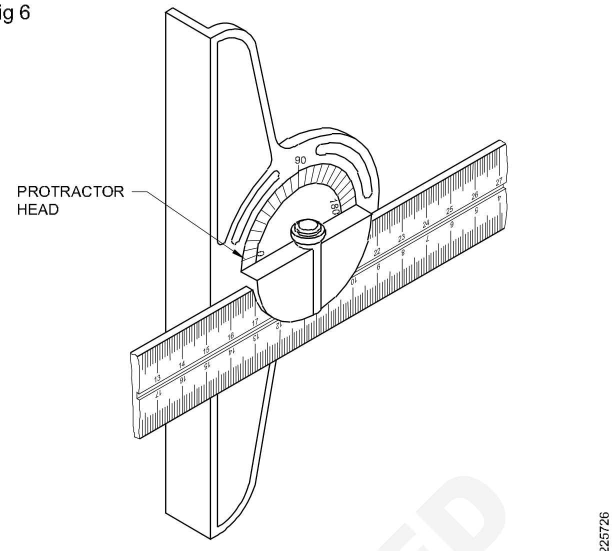
For ensuring accurate results, the combination set should be cleaned well after use and should not be mixed with cutting tools, either while using or storing.

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 6



PROTRACTOR HEAD

Fundamentals of thread cutting on lathe

Objectives : At the end of this lesson you shall be able to
- **state the principle of thread cutting on lathe**
- **identify the parts involved in the thread cutting mechanism and state their functions**
- **State the method of setting tool, depth of cut and feeding method.**

Screw threads

Principle of thread cutting: The principle of thread cutting is to produces a uniform helical groove on a cylindrical or conical surface by rotating the job at a constant speed, and moving the tool longitudinally at a rate equal to the pitch of the thread per revolution of the job, with required tool feed.

The cutting tool moves with the lathe carriage by the engagement of a half nut of the lead screw. The shape of the thread profile on the work will be the same as that of the tool ground. The direction of rotation of the lead screw determines the hand of thread being cut.

Parts involved in thread cutting (Fig 1)

Fig 1

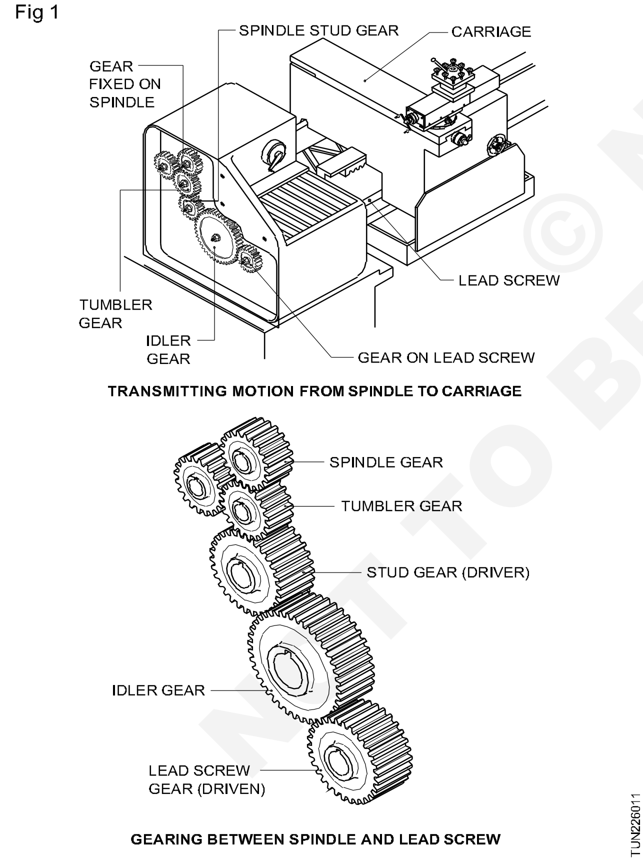
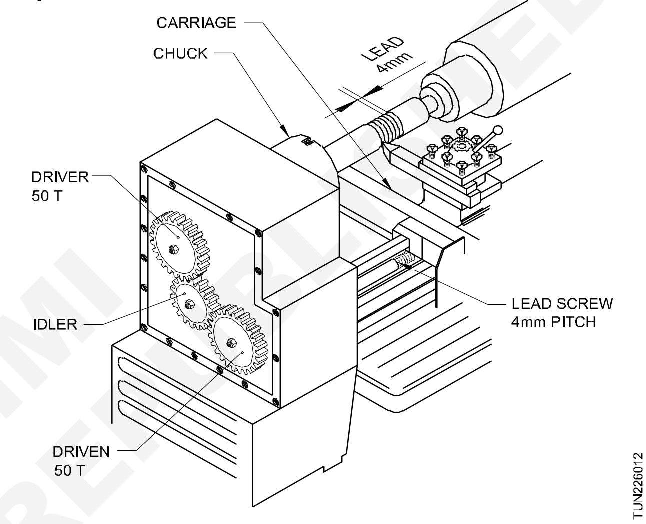


Figure illustrates how the drive is transmitted from the spindle to the lead screw through the change gear arrangement. From the lead screw the motion is transmitted to the carriage by engaging the half nut with the lead screw.

We have to cut a 4 mm pitch (lead) thread on a job in a lathe having a lead screw of 4 mm pitch. When the job rotates once, the lead screw should make one revolution to move the tool by 4 mm. Hence, if the stud gear (driver) has 50 teeth, the lead screw should be fixed with a gear of 50 teeth (driven) to get the same number of revolutions as the spindle. (Fig 2)

Fig 2



If we have to cut 2 mm pitch threads instead of 4 mm in the same lathe, then the job makes one rotation and the lead screw should rotate 1/2 revolution so that the lead screw rotation is slower. Therefore, the driven wheel (lead screw gear) should be of 100 teeth if the driver (stud gear) has 50 teeth.

If we have to cut a 8 mm pitch thread on the job, the tool should move 8 mm per revolution of the job. The lead screw should rotate 2 revolutions when the job makes one rotation, making the L.S to run twice the speed of the spindle. So the driven wheel (lead screw gear) should be of 25 teeth if the driver wheel has 50 teeth.

Thread cutting on lathe: After the changes gear set up on lathe next step to do lathe is to turn the blank to required size and then setting the V-tool. The excess material is turned to the required thread to be cut to major diameter size and chamfered. The thread cutting tool is set in line with lathe axis and perpendicular with help of thread tool gauge as shown in fig.

The depth of cut given in two ways:

1. Advancing the tool perpendicular to the lathe axis, usually it varies from 0.05 to 0.2 mm depth
2. Advanced at an angle, by setting the compound rest at half of the thread angle, if it is metric 30° the methods shown in figure.

Different types of screw threads-forms, elements and applications

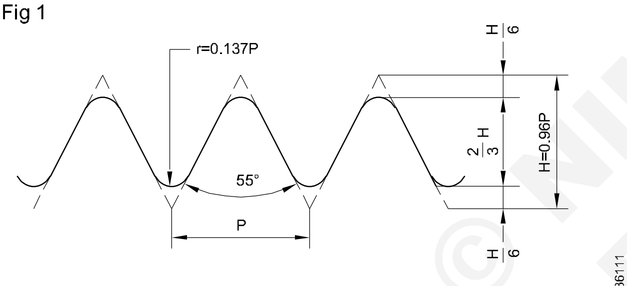
Objectives: At the end of this lesson your shall be able to
- **name different types of screw threads**
- **name the different form of screw threads**
- **illustrate their forms and elements**
- **describe their applications.**

The different types of V threads are

- BSW Thread: British Standard Whitworth Thread
- BSF Thread: British Standard Fine Thread
- BSP Thread: British Standard Pipe Thread
- B.A. Thread: British Association Thread
- I.S.O. Metric thread: International Standard Organisation metric thread
- American National or sellers 'thread

BIS Metric thread: Bureau of Indian Standard metric thread.

Fig 1



WHITWORTH THREAD (BSW)

BSW thread (Fig 1): it has an included angle of 55° and depth of the thread is 0.6403xP. The crest and root are rounded off to a definite radius. The figure shows the relationship between the pitch and the other elements of the thread.

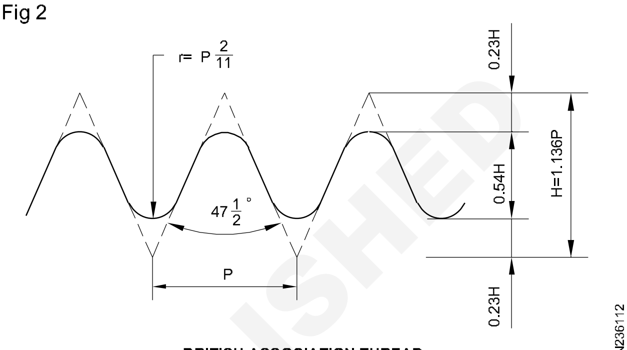
BSW thread is represented in a drawing by giving the major diameter. For example: 1/2" BSW, 1/4" BSW. The table indicates the standard number of TPI for different diameters. BSW thread is used for general purpose fastening threads.

BSF thread: This thread is similar to BSW thread except the number of TPI for a particular diameter. The number of threads per inch is more than that for the BSW thread for a particular diameter. For example, 1" BSW has 8 TPI and 1" BSF has 10 TPI. The table indicates the standard number of TPI for different dia. of BSF threads. It is used in automobile industries.

BSP thread: This thread is recommended for pipe and pipe fittigs. The table shows the pitch for different diameters. it is also similar to BSW thread. The thread is cut externally with a small taper for the threaded length. This avoids the leakage in the assembly and provides for further adjustment when slackness is felt.

BA Thread (Fig 2)

Fig 2

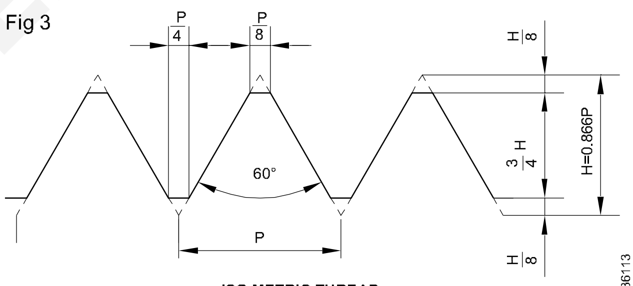


BRITISH ASSOCIATION THREAD

This thread has an included angle of 47 1/2°. Depth and other elements are as shown in the figure. It is used in small screws of electrical appliances, watch screws, screws of scientific apparatus.

Unified thread (Fig 3)

Fig 3



ISO METRIC THREAD,
UNIFIED INCH SERIES THREAD

For both the metric and inch series, ISO has developed this thread. Its angle is 60°. The crest and root are flat and the other dimensions are as shown in the figure. This thread is used for general fastening purposes.

This thread of metric standard is represented in a drawing by the letter 'M' followed by the major diameter for the coarse series.

EX: M14, M12, etc.

For the fine series, the letter 'M' is followed by the major diameter and pitch.

EX: M14 x 1.5

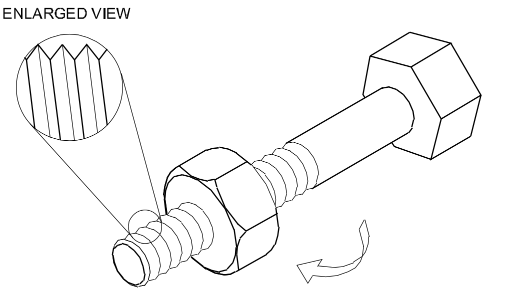
M24 x 2

Screw thread applications

In mechanical assemblies and in transfer of power these thread applications play a vital role. In milling machine worm& thread helps in indexing the job. The square thread is generally used for transferring power like screw jack, and lead screw of a thread in thread cutting.

External threads and internal threads are assembled together for different engineering uses. (Fig 1)

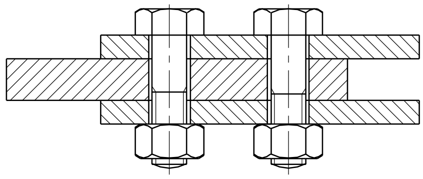
Fig 1



Uses of Screw Threads

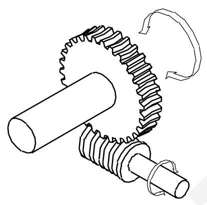
Screw threads are used as fasteners to hold together and dismantle components when needed (Fig 2)

Fig 2



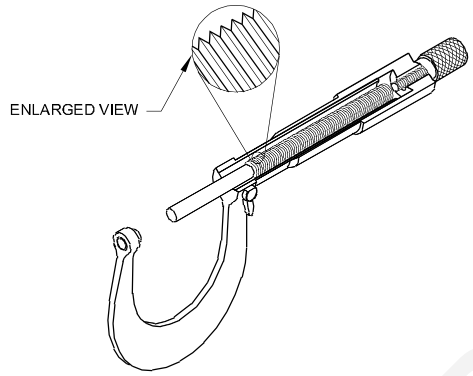
To transmit motion on machines from one unit to another (Fig 3)

Fig 3



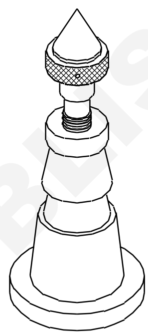
To make accurate measurements (Fig 4)

Fig 4



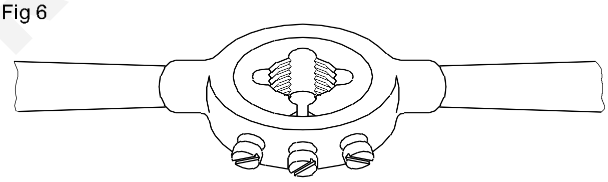
To apply pressure (Fig 5)

Fig 5



to make adjustments. (Fig 6)

Fig 6



Forms of screw threads

Basic forms of screw threads

Screw threads of different forms are available for meeting the various requirements. The basic forms of screw threads are

vee threads

square threads

trapezoidal threads.

Vee threads (Fig 1)

These threads are of a 'V' shape. Vee threads of different types are available. Vee thread is the most commonly used form of screw threads, and is used for domestic and industrial applications like bolts, nuts and spindles for micrometers etc.

Square and trapezoidal threads: Square and trapezoidal threads have more cross-sectional area than 'V' threads. They are more suitable to transmit motion or power than 'V' threads. They are not used for fastening purposes.

Square thread: In this thread the flanks are perpendicular to the axis of the thread. The relationship between the pitch and the other elements is shown in Fig 1.

Square threads are used for transmitting motion or power. Eg. screw jack, vice handles, cross-slide and compound slide, activating screwed shafts.

Fig 1

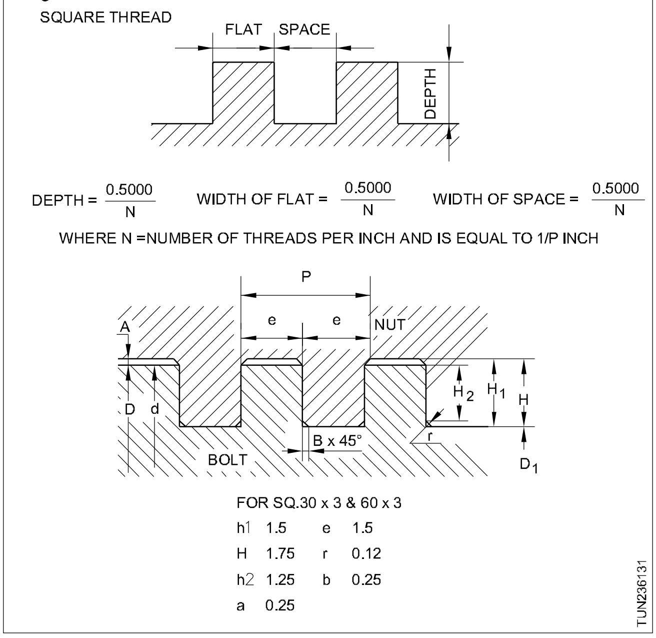
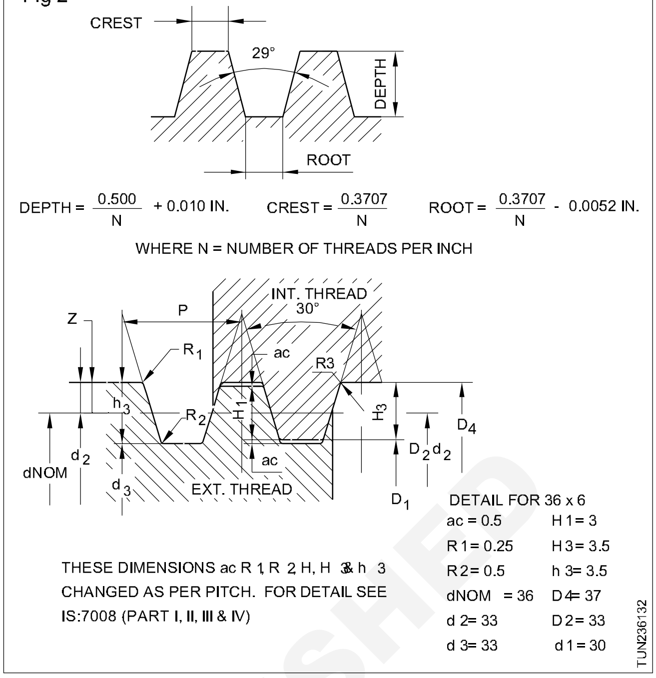
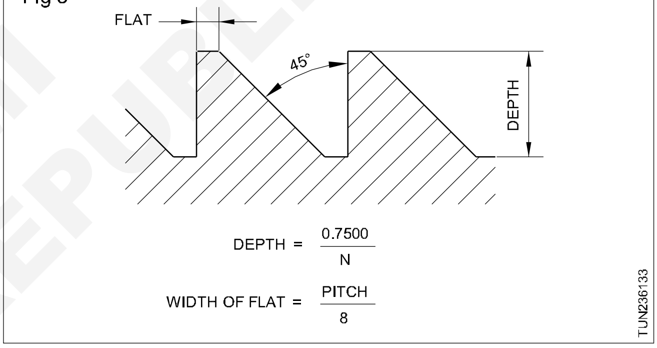


Fig 2



Modified square thread: Modified square threads are similar to ordinary square threads except for the depth of the thread. The depth of thread is less than half pitch of the thread. The depth varies according to the application. The crest of the thread is chamfered at both ends to 45° to avoid the formation of burrs. These threads are used where quick motion is required.

Fig 3



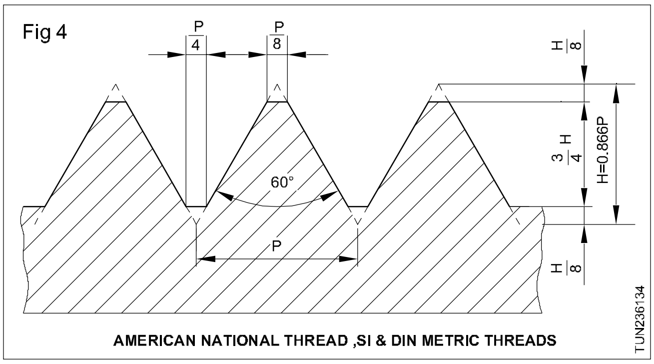
Trapezoidal threads: These threads have a profile which is neither square nor 'V' thread form and have a form of trapezoid. They are used to transmit motion or power. The different forms of trapezoidal threads are:

- acme thread
- buttress thread
- saw-tooth thread
- worm thread.

Acme thread (Fig 2): This thread is a modification of the square thread. It has an included angle of 29°. It is preferred for many jobs because it is fairly easy to machine.

Acme threads are used in lathe lead screws. This form of thread enables the easy engagement of the half nut. The metric acme thread has an included angle of 30°. The relationship between the pitch and the various elements is shown in the figure.

Fig 4



Buttress thread (Fig 3): In buttress thread one flank is perpendicular to the axis of the thread and the other flank is at 45°. These threads are used on the parts where pressure acts at one flank of the thread during transmission. Figure 3 shows the various elements of a buttress thread. These threads are used in power press, carpentry vices, gun breeches, ratchets etc.

American National Thread (Fig 4): These threads are also called as seller's threads. It was more commonly used prior to the introduction of the ISO unified thread.

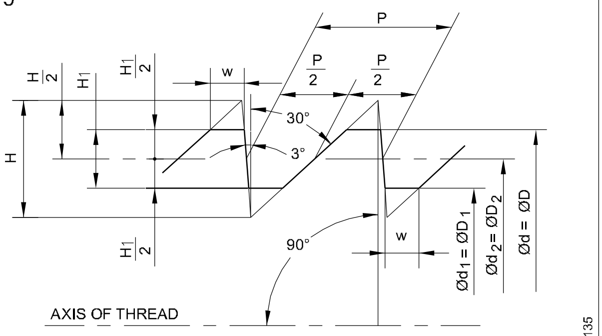
Saw-tooth thread: This is a modified form of buttress thread. In this thread, the flank taking the load is inclined at an angle of 3°, whereas the other flank is inclined at 30°.

The basic profile of the thread illustrates this phenomenon. (Fig 5) The proportionate values of the dimensions with respect to the pitch.

Worm thread: This is similar to acme thread in shape but the depth of thread is more than that of acme thread. This thread is cut on the worm shaft which engages with the worm wheel. Fig 6 shows the elements of a worm thread.

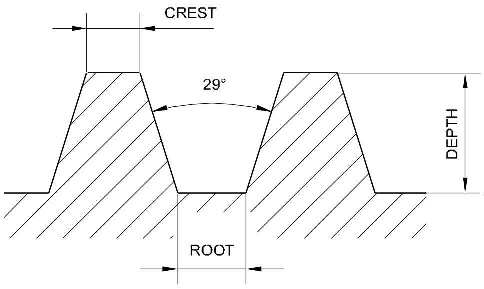
The worm wheel and worm shaft are used in places where motion is to be transmitted between shafts at right angles. It also gives a high rate of speed reduction.

Fig 5



BASIC PROFILE FOR SAW TOOTH THREADS

Fig 6



$\text{DEPTH} = \frac{0.6866}{N}$ $\quad \text{ROOT} = \frac{0.310}{N}$

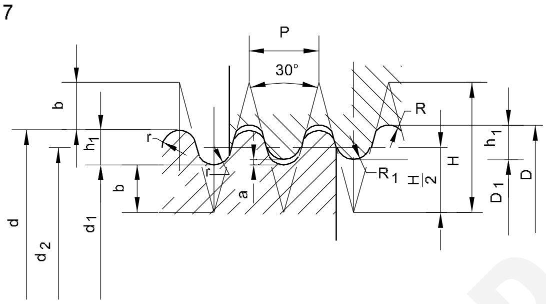
$\text{CREST} = \frac{0.335}{N}$

WORM THREAD

TUN236136

Knuckle threads: The shape of the knuckle thread is not trapezoidal but it has a rounded shape. It has limited application. The figure shows the form of knuckle thread. It is not sensitive against damage as it is rounded. It is used for valve spindles, railway carriage couplings, hose connections etc. (Fig 7).

Fig 7



BASIC PROFILE OF KNUCKLE THREAD

$b = 0.68301.P$
$h_1 = 0.5P$
$a = 0.05P$

DESIGNATION:- A KNUCKLE THREAD OF DIAMETER 60 mm & PITCH 4.233mm SHALL BE DESIGNATED AS k60x4.233 IS:4695

TUN236137

Drive train - change gear formula & calculation

Objectives : At the end of this lesson you shall be able to
- **state what is a change gear train**
- **identify and name the different types of change gear trains**
- **distinguish between a simple gear train and a compound gear train.**

Change gear train: Change gear train is a train of gears serving the purpose of connecting the fixed stud gear to the quick change gearbox. The lathe is generally supplied with a set of gears which can be utilized to have a different ratio of motion between the spindle and the lead screw during thread cutting. The gears which are utilized for this purpose comprise the change gear train.

The change gear train consists of driver and driven gears and idler gears.

Simple gear train: A simple gear train is a change gear train having only one driver and one driven wheel. Between the driver and the driven wheel, there may be an idler gear which does not affect the gear ratio. Its purpose is just to link the driver and the driven gears, as well as to get the desired direction to the driven wheel.

Fig 1 shows an arrangement of a simple gear train.

Fig 1

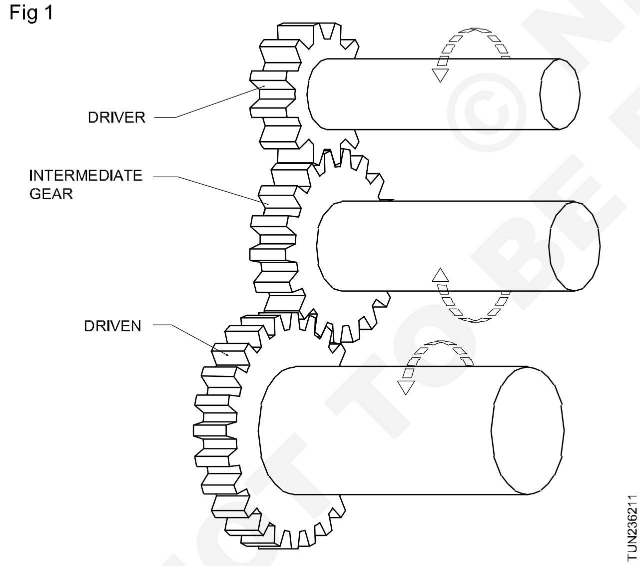


Fig 2 shows mountings of the driver and driven gears in a lathe.

The driver gear and the driven gear are changed according to the pitch of the thread to be cut on the job.

Compound gear train: Sometimes, for the required ratio of motion between the spindle and the lead screw, it is not possible to obtain one driver and one driven wheel. The ratio is split up and then the change gears are obtained from the available set of gears which will result in having more than one driver and one driven wheel. Such a change gear train is called a compound gear train.

Fig 2

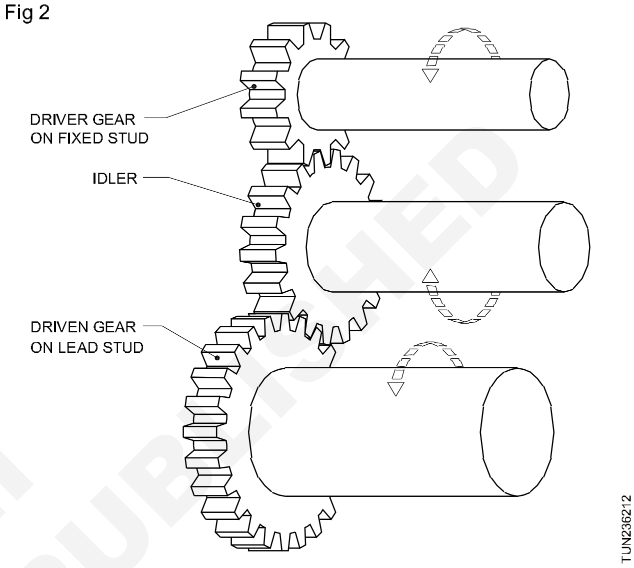


Fig 3

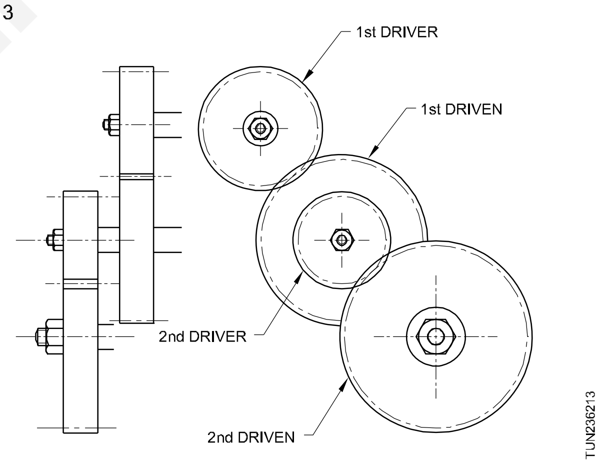


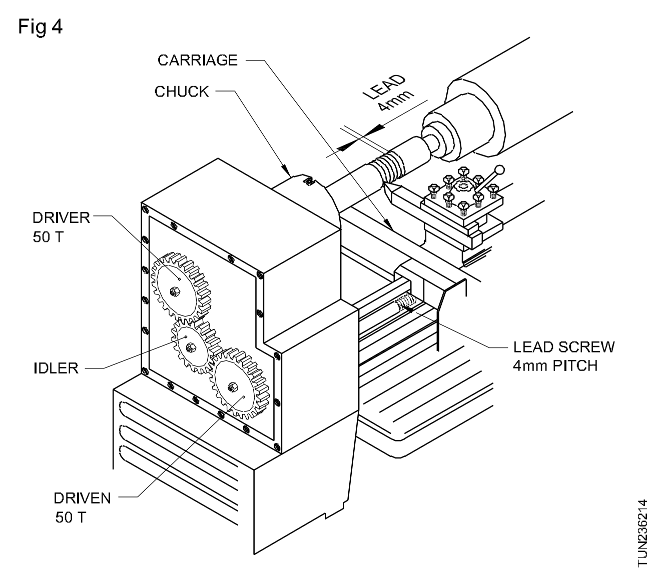
Fig 3 shows the arrangement of a compound gear train.

Derivation of the formula for change gears

Examples

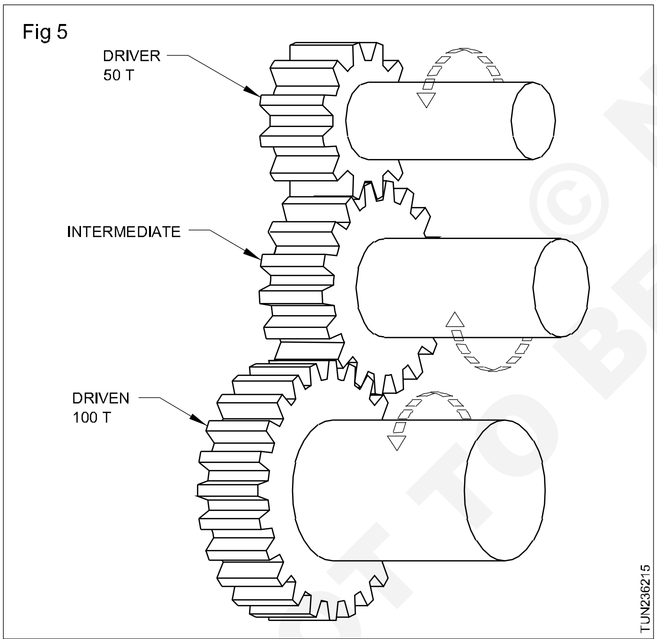
Case 1

We have to cut a 4 mm pitch (lead) thread on a job in a lathe having a lead screw of 4 mm pitch. When the job rotates once, the lead screw should make one revolution to move the tool by 4 mm. Hence, if the stud gear (driver) has 50 teeth, the lead screw should be fixed with a gear of 50 teeth (driven) to get the same number of revolutions as the spindle. (Fig 4)



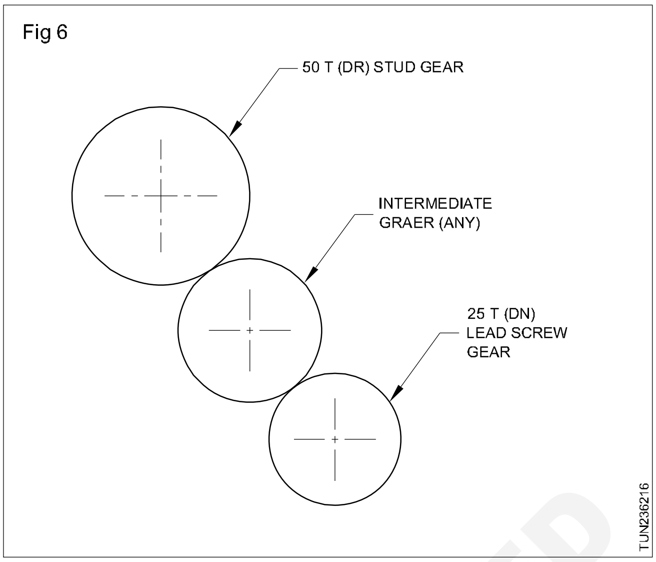
Case 2

If we have to cut 2 mm pitch threads instead of 4 mm in the same lathe, then the job makes one rotation and the lead screw should rotate 1/2 revolution so that the lead screw rotation is slower. Therefore, the driven wheel (lead screw gear) should be of 100 teeth if the driver (stud gear) has 50 teeth.(Fig 5)



Case 3

If we have to cut a 8 mm pitch thread on the job, the tool should move 8 mm per revolution of the job. The lead screw should rotate 2 revolutions when the job makes one rotation, making the L.S to run twice the speed of the spindle. So the driven wheel (lead screw gear) should be of 25 teeth if the driver wheel has 50 teeth. (Fig 6)



Let us compare the above three examples.

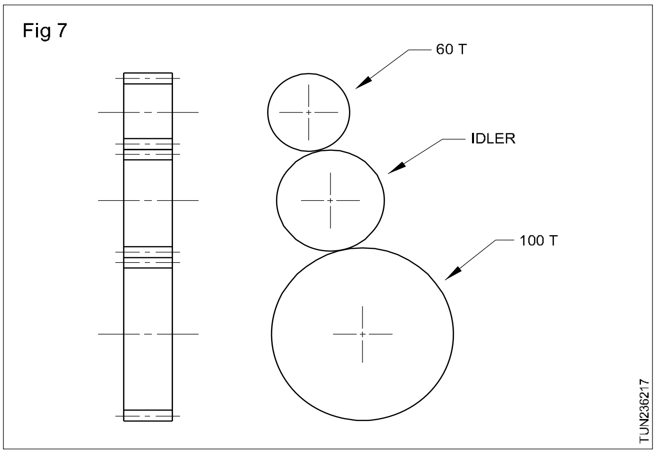
	I	II	III
Pitch(Lead)of job	4	2	8
Pitch(Lead) of L.S	4	4	4
Driver	50	50	50
Driven	50	100	25

Stating the above in the form of a formula

$$\text{the gear ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of Lead Screw}}$$

Solved examples

1 Find the change gears required to cut a 3 mm pitch on a job in a lathe having a lead screw of 6 mm pitch. (Fig.7)



$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of L/S}} = \frac{3}{6}$$

$$= \frac{3}{6} \times \frac{20}{20} = \frac{60}{120}$$

Driver 60 teeth

Driven 120 teeth.

2 Find the change gears to cut a 2.5 mm pitch in a lathe having a lead screw of 5 mm pitch.

$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of Lead Screw}}$$

$$= \frac{2.5}{5}$$

$$= \frac{2.5 \times 20}{5 \times 20}$$

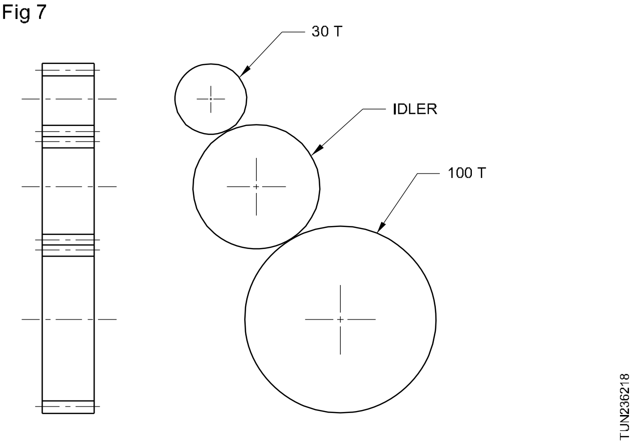
$$= \frac{50.0}{100} = \frac{50}{100}$$

Driver 50 teeth

Driven 100 teeth.

3 Calculate the gears required to cut a 1.5 mm pitch in a lathe having a lead screw of 5 mm pitch. (Fig 8)

Fig 7



$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of Lead screw}}$$

$$= \frac{1.5}{5} = \frac{3}{5 \times 2} = \frac{3 \times 10}{10 \times 10} = \frac{30}{100}$$

Driver 30 teeth

Driven 100 teeth.

Different methods of forming threads

Objectives : At the end of this lesson you shall be able to
- **state the different methods of forming threads**
- **distinguish the procedure of forming threads by different methods.**

The different methods of forming threads depend on many factors.

Type and number of components required

Type accuracy of thread and its surface finish

Availability of machine tools

Skill of the operator, etc.

The different methods of forming threads are:

by hand tools like tapes and dies

by using a single point cutting tool on the table

by using a multi-point cutting tool called chasers

by using a coventry die-head and collapsible taps in production lathes

by thread rolling

by thread milling

by thread grinding

by thread casting (die - casting or moulding).

Using taps and dies (Fig 1 & 2)

Fig 1

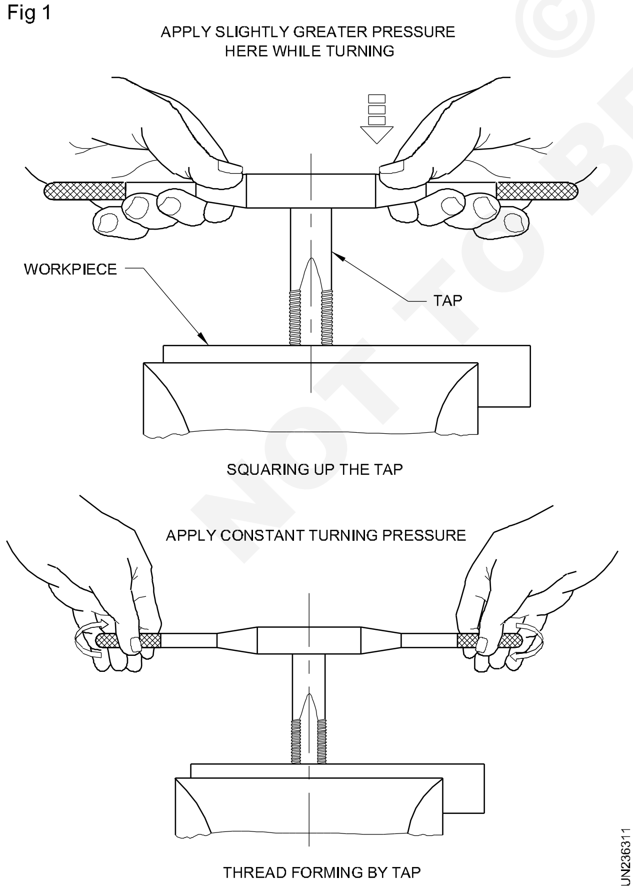
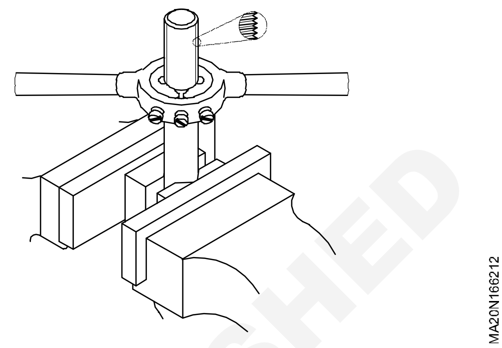


Fig 2

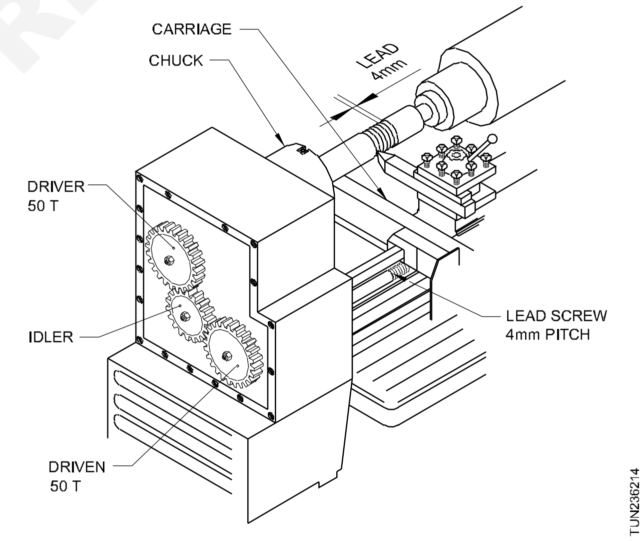


Taps and dies are commonly used for general purpose bolts and nuts. Taps are used to produce internal threads. Dies are used to produce external threads.

Taps and dies can be used only for products standard 'V' threads for both coarse and fine pitches. Machine taps are also available for cutting threads.

Using single point cutting tools on lathe (Fig 3)

Fig 3



Both internal and external right hand and left hand threads can be cut by this method. Any form of thread to a required pitch can be cut or produced by using the corresponding tools. Accuracy of the thread depends on the skill of the operator.

Using chasers (Fig 4)

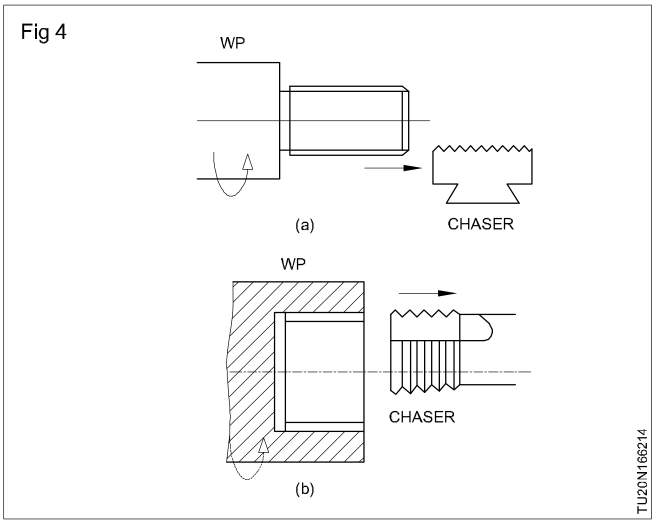


Fig 4

Chasers are multi-point cutting tools to produce external 'V' threads. There are different types of chasers, each one having its own special characteristics.

Usually, hand chasers are used to finish the thread, and machine chasers for producing the threads. Machine chasers are used in conjunction with the die-heads.

Using coventry die-heads and collapsible taps (Fig 5)

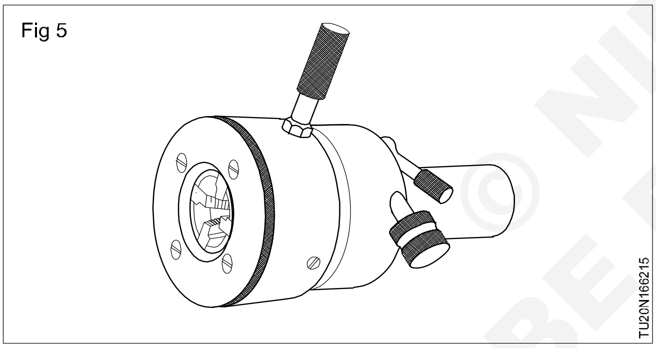


Fig 5

They are used in mass production to produce threads on capstan, turret lathes and automats. A highly skilled operator is not essential for cutting threads but for setting, skilled setters are required. This method is limited to producing 'V' threads.

Collapsible taps are used with floating holders for producing internal threads.

Thread rolling (Fig 6)

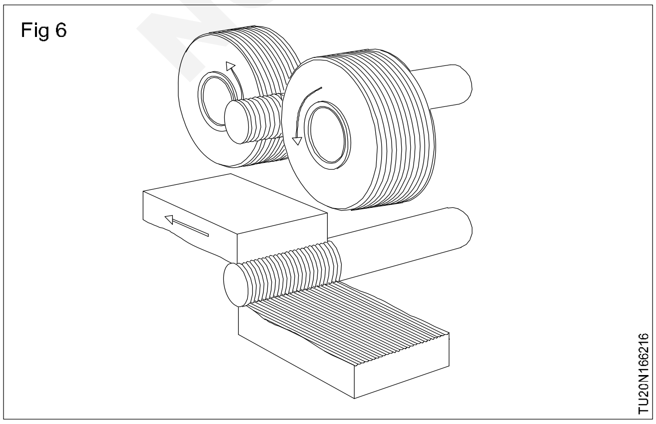


Fig 6

It is used in mass, production. In this method, the thread is not cut and chips will not be produced. Thread is produced by rolling. Rolling is a process of cold forging resulting in a plastic deformation. The job is turned to pitch diameter before rolling. The rollers may be flat or disc type. Threads produced by rolling have better strength and good finish.

Thread milling (Fig 7)

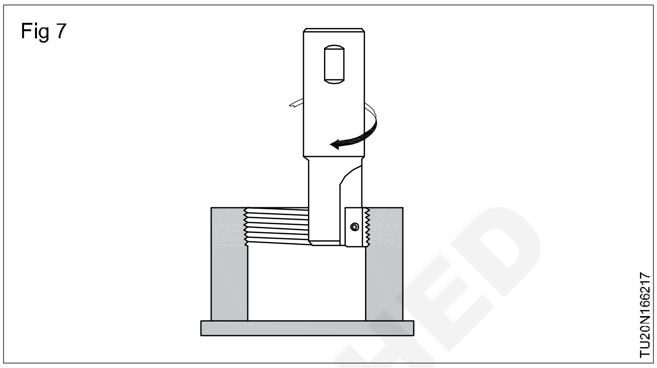


Fig 7

Threads are produced by thread milling cutters. The operation is performed on a special thread milling machine to produce accurate threads in small or large quantities. In this operation there are three driving motions, that is, for cutter, work, and longitudinal movement of the cutter. The thread is completed in one cut by setting the cutter to the full depth of thread and then feeding it along the entire length of the workpiece. Internal thread milling can also be performed to produce accurate internal threads.

Thread grinding (Fig 8)

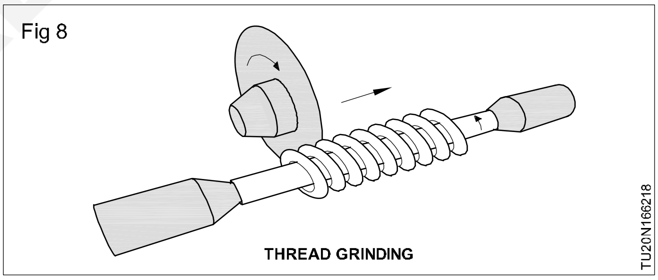


Fig 8

Special grinding machines are required for thread grinding. Both the external threads and internal threads can be ground.

There are two main types of thread grinding i.e single rib and multiple rib.

Single rib grinding involves the use of a narrow grinding wheel which is shaped to the required form of thread.

Multiple-rib grinding is done with a grinding wheel with many grooves on its face. This type of wheel grinds many threads at one time.

Thread casting

Threads can be produced by casting for crude threads. It is produced either by die casting or moulding. Threads on non-metals are produced by this method.

Calculation involved in finding core dia, gear train

Objectives : At the end of this lesson you shall be able to
- **describe change gear calculation**
- **calculate change gear calculation for simle and compound gear train.**

Calculation for change gears

To calculate change gear to cut thread to required pitch, it is to know ration of driving and driven gear to be fixed. for example if the lathe lead screw pitch is 12mm and the thread to be cut 3mm pitch, the spindle must rotate 4 times the speed of lead screw

Therefore $\frac{\text{Spindle turn}}{\text{Lead screw turn}} = \frac{4}{1}$

for which we must have

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{1}{4} = \frac{\text{Lead screw turn}}{\text{Spindle turn}}$$

$$= \frac{\text{Pitch of the thread to be cut}}{\text{Pitch of the lead screw}}$$

(for British standard screws $\frac{\text{TPI on lead screw}}{\text{TPI on work}}$)

The gear fixed on spindle shaft drive called driver.

Example: The pitch of lead screw is 6mm pitch of the thread to be cut is 2mm. find change gears. for simple gear train.

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{\text{pitch of the work}}{\text{pitch of the lead screw}} \quad \frac{2}{6} = \frac{2\text{x}20}{2\text{x}60} = \frac{40}{120}$$

The driver gear will have 40T and driven gear will have 120T

Example: The pitch of the leadscrew is 12mm and thread to be cut 1.5mm find change gear for compound gear train.

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{\text{Pitch of the work}}{\text{Pitch of the lead screw}} = \frac{1.5}{12}$$

$$= \frac{1.5\text{x}2}{12\text{x}2} \quad \frac{63}{48} \quad \frac{63}{14} \quad \frac{1}{12}$$

Change wheel calculations for fractional pitch threads

Objectives : At the end of this lesson you shall be able to
- **calculate change wheels for cutting fractional pitch threads (BritishSystem)**
- **calculate change wheels for cutting decimal fractional pitch threads (BritishSystem)**
- **calculate change wheels for fractional pitch threads by continued fraction method.**

It is necessary to calculate the ratio of change gears to cut fractional leads for worms, hobs etc. on a centre lathe at times.

To obtain a formula; suppose it is required to cut a lead of 1/4" on a lathe which has a lead of 1/2". If one to one ratio were used between the driver and the driven gears, the carriage would move 1/2" per revolution of the lathe spindle. Therefore, to cut a lead of 1/4" the ratio of the driver and driven gears must be as

$$\frac{1}{4}\frac{1}{2}$$

That is $\frac{1/4}{1/2}$ or $\frac{1}{2} \equiv \frac{\text{Driver}}{\text{Driven}}$

Expressed as a formula:-

$$\frac{DR}{DN} \equiv \text{ratio of change gears} \equiv \frac{\text{Lead screw to be cut}}{\text{Lead of lead screw}}$$

or alternatively:-

$$\frac{\text{lead of screw to be cut}}{1} \text{x} \frac{1}{\text{lead of screw}} = \frac{\text{Driver}}{\text{Driven}}$$

lead of screw to be cut x

No.of threads / inch of lead screw $= \frac{\text{Driver}}{\text{Driven}}$

Example

Calculate the change gears necessary to cut a thread of 7/16" lead on a lathe with a lead screw of 4 threads per inch.

lead of screw to be cut x

$$\text{No.of threads / inch of lead screw} = \frac{\text{Driver}}{\text{Driven}}$$

$$= \frac{7}{16} \times 4 = \frac{28}{16} = \frac{7}{4}$$

$$= \frac{7}{4} \times \frac{10}{10} = \frac{70}{40} = \frac{\text{Driver}}{\text{Driven}}$$

If the lead to be cut is a whole number and a vulgar fraction, change it to an improper fraction and apply the above formula.

Example

Calculate the change gears required to cut an oil groove having 8 turns in 11 inches on a lathe with a lead screw of 4 threads per inch.

Pitch of the groove x

$$\text{No.of threads / inch of lead screw} = \frac{\text{Driver}}{\text{Driven}}$$

$$\text{Pitch of groove} = \frac{\text{travel or given number of turns}}{\text{number of turns}}$$

$$= \frac{11}{8}\text{inches}$$

$$\text{Gear ratio} = \frac{\frac{11}{8}}{\frac{1}{4}}$$

$$= \frac{11}{8} 4 = \frac{44}{8} = \frac{4 \times 11}{2 \times 4} = \frac{4}{2} = \frac{11}{4}$$

$$\text{First fraction} = \frac{4}{2} \times \frac{15}{15} = \frac{60}{30}$$

$$\text{2nd fraction} = \frac{11}{4} \times \frac{10}{10} = \frac{110}{40}$$

$$\text{Thus } \frac{DR}{DN} = \frac{60}{30} \times \frac{110}{40} \text{ (Fig 1)}$$

Example

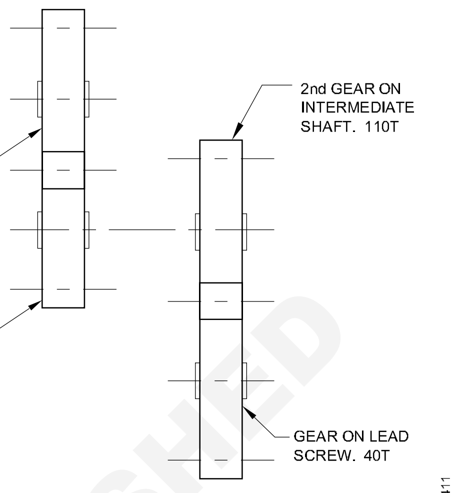
Calculate the change gears to cut a worm of 0.35 inches lead on a lathe with a lead screw having 4 threads per inch. lead to be cut x no.of threads/inch of lead screw

$$= \frac{DR}{DN} = 0.35 \times 4$$

$$= \frac{35}{100} \times \frac{4}{1} = \frac{7}{5} \times \frac{10}{10} = \frac{70}{50} = \frac{\text{driver}}{\text{driven}}$$

When the lead occurs as a decimal, it may be necessary to use the method of continued fractions to obtain a suitable approximation of the change gear ratio, for which the change gears may be selected from the available set of gears.

Fig 1



GEAR TRAIN ARRANGEMENT

Example

Calculate the change gears required to cut a worm of 0.55 inches lead on a lathe, with a lead screw of 6 threads per inch.

$$\text{lead to be cut x no.of threads/inch of lead screw} = \frac{DR}{DN}$$

$$= 0.55 \times 6$$

$$= \frac{55}{100} \times \frac{6}{1}$$

$$\text{1st fraction} = \frac{55}{100}$$

$$\text{2nd fraction} = \frac{6}{1} \times \frac{20}{20} = \frac{120}{20}$$

$$\frac{\text{driver}}{\text{driven}} = \frac{55}{100} \times \frac{120}{20}$$

Example

Calculate the change gears required to cut a worm of 0.95 inches lead on a lathe with a lead screw of 6 threads per inch.

$$\text{lead to be cut x no.of threads/inch of lead screw} = \frac{DR}{DN}$$

$$= 0.95 \times 6$$

$$= \frac{95}{100} \times \frac{(6 \times 20)}{(1 \times 20)} = \frac{95}{100} \times \frac{120}{20}$$

$$\frac{\text{driver}}{\text{driven}} = \frac{95}{100} \times \frac{120}{20}$$

Example

Calculate the change gears to cut 2BA threads (0.81mm pitch) on a lathe which has a lead screw of 1/4 inch - pitch by the continued fraction method.

This could be cut exactly if the 1/5 ratio were combined with a 81T driver and a 127T driven change gears.

If special gears are not available we have to obtain the nearest fraction by the continued fraction method. For this nearest fraction gears may be selected from the available set of gears.

$$\text{Ratio : } \frac{\text{driver}}{\text{driven}} = \frac{0.81}{1/4 \times 25.4} = \frac{0.81}{6.35}$$

$$\frac{\text{driver}}{\text{driven}} = \frac{81}{635} \times \frac{1 \times 81}{5 \times 127}$$

Determining the convergents by the continued fraction method.

```
81)   635 (7
      567
      ----
      68 ) 81   (1
           68
           ----
         13 ) 68  (5
              65
              ----
             3) 13  (4
                12
                ----
                 1) 3 (3
```

		7	1	5	4	3
1	0	1	1	6	25	81
0	1	7	8	47	196	635
		7	1	5	4	3

$$\text{The convergents are : } \frac{1}{7}; \frac{1}{8}; \frac{6}{47}; \frac{25}{196}; \frac{81}{635}$$

$$\text{The 4th convergent : } \frac{25}{196} \text{ may be written } \frac{5}{14} \times \frac{5}{14}$$

$$\frac{\text{driver}}{\text{driven}} = \frac{25}{70} \times \frac{25}{70}$$

and this could be obtained with duplicate 25 T and 70 T gears, a circumstance not unlikely, provided two similar lathes are available.

The actual pitch obtained from this driver and driven gears is:

an error of 0.00005mm, which is equivalent to a total pitch error of about 0.0016mm (0.00006 in) over a 1 in. length of the thread. This is well within the permissible limits of accuracy of an ordinary commercial lead screw.

Thread chasing dial - Function, construction and use

Objectives : At the end of this lesson you shall be able to
- **state the necessity of a thread chasing dial**
- **state the constructional details of a British thread chasing dial**
- **state the functional features of a British thread chasing dial.**

Thread chasing dial

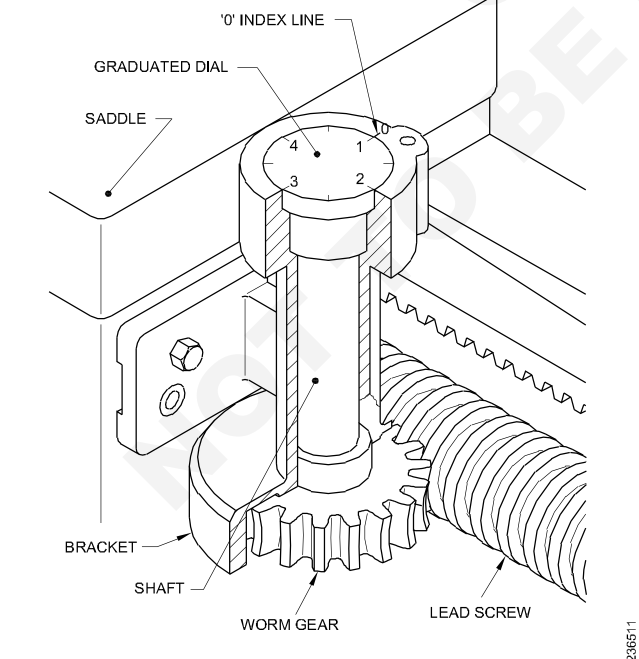
To catch the thread quickly and to save manual labour, use of a chasing dial is very common during thread cutting by a single point cutting tool. A thread chasing dial is an accessory.

Constructional details (Fig 1)

The figure shows constructional details of a British thread chasing dial. It consists of a vertical shaft with a worm wheel made out of brass or bronze, attached to the shaft at the bottom. On the top, it has a graduated dial. The shaft is carried on a bracket in bearing (bush) which is fixed to the carriage. The worm wheel can be brought into an engaged or disengaged position with the lead screw as needed. When the lead screw rotates it drives the worm wheel which causes the dial to rotate. The movement of the dial is with reference to the fixed mark ('O' index line).

The face of the dial is usually graduated into eight (8) divisions, having 4 numbered main divisions and 4 unnumbered subdivisions in between.

Fig 1



THREAD CHASING DIAL MECHANISM

The number of teeth on the worm gear is the product of the number of threads per inch on the lead screw and the number of numbered divisions on the dial.

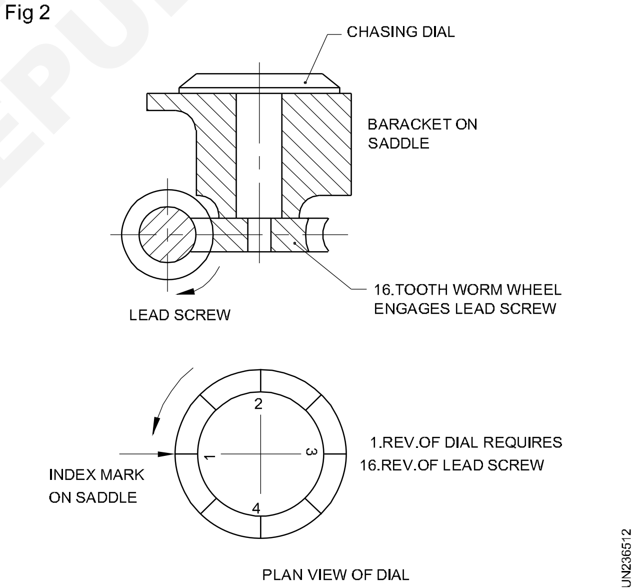
Each numbered division represents 1 inch travel of the carriage.

Let the worm wheel have 16 teeth, and the lead screw 4 TPI. The number of numbered graduations and unnumbered graduations are 4 each.

The half nut can be engaged 16 times for one revolution of the graduated dial. The movement of the carriage for one complete revolution of the dial is 4". (Fig 2) Since the dial is having totally 8 graduations marked, each graduation represents 1/2" travel of the carriage.

The chart given here shows the positions at which the half nut is to be engaged when cutting different threads per inch, when a British thread chasing dial with the above data is fitted to the lathe.

Fig 2



THREAD CHASING DIAL CHART

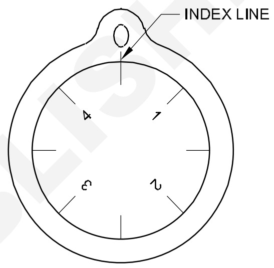
Threads per inch to be cut	Dial graduation at which the half nut can be engaged to catch the thread	Reading on the dial illustrated
Threads which are a multiple of the number of threads per inch of the lead screw.	Engage at any position the half nut meshes.	Use of dial unnecessary.

Example T.P.I. to be cut - 8

$$\frac{DR}{DN} \quad \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} \quad \frac{4}{8} \quad \frac{1}{2}$$

The predetermined travel of 1/4" is represented by the dial position in the exact middle between any numbered division and adjacent un-numbered division. The half nut engagement can be done at any position at which it can be engaged (ie. 16 positions).

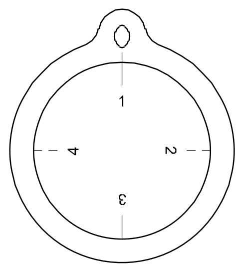
Referring to the dial is not necessary.

Even number of threads	Engage at any graduation on the dial. 8 positions	1 1 1/2 2 2 1/2 3 3 1/2 4 4 1/2	

Example T.P.I. to be cut - 6

$$\frac{DR}{DN} \quad \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} \quad \frac{4}{6} \quad \frac{2}{3}$$

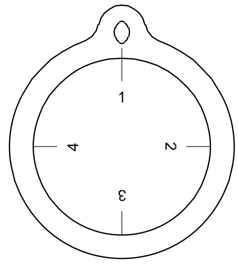
The predetermined travel of 1/2" is represented by dial movement from any numbered division to the next adjacent unnumbered division. The half nut can be engaged when any numbered or unnumbered graduation coincides with the zero line (8 positions).

Odd number of threads	Engage at any main division. 4 positions	1 2 3 4	

Example T.P.I. to be cut - 5

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{5} = \frac{4}{5} \qquad \text{Predeterminedtravel} = 4 \times \frac{1''}{1} = 1''$$

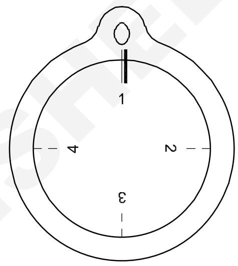
The predetermined travel of 1" is represented by the dial movement from any numbered division to the next numbered division or from any unnumbered division to the next unnumbered division. Therefore, if the first cut is taken when a numbered division of the dial coincides with zero, then the half nut engagement for successive cuts can be done when any numbered division coincides with the zero mark. If the first cut is taken when an unnumbered division coincides with the zero, then the half nut for successive cuts, is engaged when any unnumbered division coincides with the zero. (4 positions)

Half fractional number of threads	Engage at every other main division. 2 positions	1 & 3 or 2 & 4	

Example T.P.I. to be cut - 3 1/2

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{3\ 1/2} = \frac{8}{7}$$

The half nut can be engaged only at opposite numbered or unnumbered graduations (2 positions).

Quarter fractional number of threads ——	Engage at the same main division. 1 position	1 or 2 or 3 or 4	

Example T.P.I. to be cut - 2 3/4

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{2\ 3/4} = \frac{16}{11}$$

$$\text{Predetermined travel} = 16 \times \frac{1"}{4} = 4"$$

The half nut can be engaged to catch the thread only when the same numbered or unnumbered graduated line, at which the first cut is taken, coincides with the zero line (1 position only).

Example T.P.I. to be cut - 1 3/8

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{1\ 3/8} = \frac{32}{11}$$

$$\text{Predetermined travel} = 32 \times \frac{1"}{4} = 8"$$

The half nut engaged for the first cut should remain at the engaged position till thread cutting is completed and the machine is reversed as it takes a long time to cover the predetermined travel arrived at by calculation.

Metric thread chasing dial

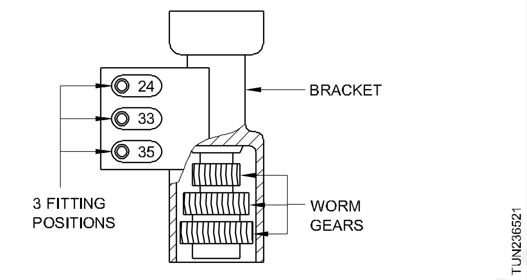
Objectives : At the end of this lesson you shall be able to
- **state the constructional details of a metric thread chasing dial**
- **state the functional features of a metric thread chasing dial.**

Construction of a metric thread chasing dial (Fig 1)

The construction of a metric thread chasing dial is similar to that of a British chasing dial. The shaft carries a set of worm/spur wheel of different numbers of teeth which vary according to the type of the lathe. But there is always more than one worm/spur wheel. The dial graduation of the metric chasing dial also differs from that of the British thread chasing dial.

Fig 1 shows the construction of a metric thread chasing dial.

Fig 1



For cutting metric threads, using a metric thread chasing dial, the product of the pitch of the lead screw and the number of teeth on the worm wheel must be an exact multiple of the pitch of the thread to be cut. Accordingly the corresponding worm wheel has to be engaged with the lead screw.

For instance, if the lead screw thread has a 4 mm pitch and the number of teeth on the worm wheel is 15, then the product is 4 x 15 = 60.

Therefore, the following pitches can be cut which exactly divide the product.

ie. 1,1.25,1.5, 2, 2.5, 3, 3.75, 4, 5, 6, 7.5, 10, 12, 15, 20, 30 and 60.

The figure shows the metric thread chasing dial of an HMT lathe and the chart indicates the worm wheel and graduated dial plate to be chosen for cutting threads of different pitches. (Fig 2)

The following are worked out examples, showing the selection of the dial and worm wheel for a given pitch in the above HMT lathe.

Example 1

TO CUT 0.625 mm PITCH

$$\text{Gear ratio} = \frac{DR}{DN} = \frac{\text{Pitch to be cut}}{\text{Pitch of lead screw}}$$

$$= \frac{0.625}{6} = \frac{5/8}{6}$$

$$= \frac{1}{8} \times \frac{5}{6} = \frac{5}{48}$$

The thread will be in unison, if the lead screw makes 5 revolutions when the job makes 48 revolutions predetermined travel.

P.D.T. = 5 x Pitch of lead screw

= 5 x 6 = 30 mm.

The product of the number of teeth on the worm wheel and the pitch of the lead screw

= 35 x 6 = 210.

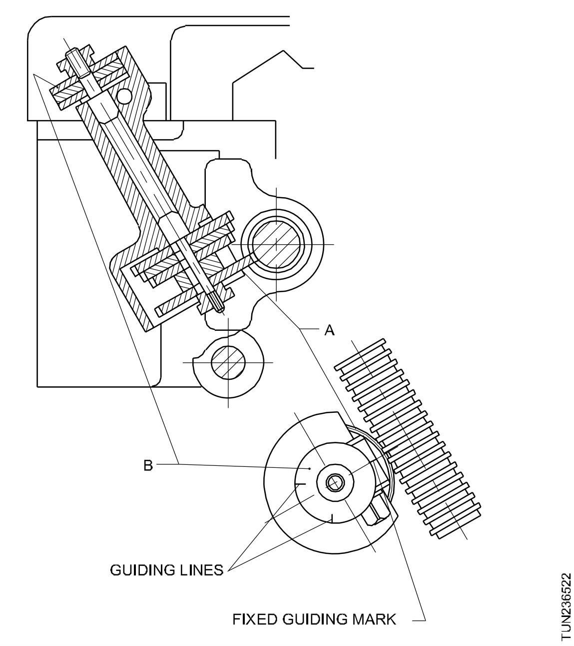
A dial with 7 graduations marked is to be selected since

$$\frac{210}{PDT} = \frac{210}{30} = 7.$$

So to cut a 0.625 mm pitch, the half nut is engaged for any of the 7 graduations coinciding with the zero line.

Example 2

Fig 2



LEAD SCREW 6 mm PITCH					
Threads in m/m	**Driving pinion A**	**No. of lines on Disc B**	**Threads in m/m**	**Driving pinion A**	**No. of lines on Disc B**
.5			3.25	39	3
.625	35	7	3.5	35	5
.75			4	36	18
.875	35	5	4.5	36	12
1			5	35	7
1.125	36	12	5.5	33	3
1.25	35	7	6		
1.375	33	3	6.5	39	3
1.5			7	35	5
1.625	39	3	8	36	9
1.75	35	5	9	36	12
2			10	35	7
2.25	36	12	11	33	3
2.5	35	7	12	36	18
2.75	33	3	13	39	3
3			14	35	5

TO CUT A 4.5 mm PITCH

$$\text{Gear ratio} = \frac{DR}{DN} = \frac{\text{Pitch to be cut}}{\text{Pitch of lead screw}}$$

$$= \frac{4.5}{6} \text{ or } \frac{9/2}{6} = \frac{9}{2 \times 6} = \frac{9}{12} = \frac{3}{4}$$

P.D.T. = 3 x Pitch of lead screw

= 3 x 6 = 18 mm.

The product of the number of teeth on the worm wheel and the pitch of the lead screw= 36 x 6 = 216

A dial with 12 graduations marked is selected since

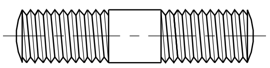
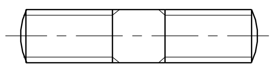
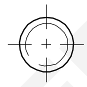
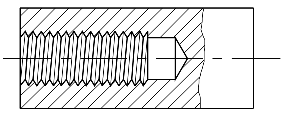
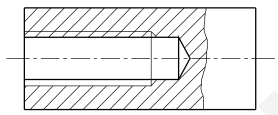
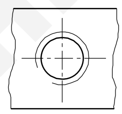
$$\frac{216}{PDT} = \frac{216}{18} = 12.$$

So to cut a 4.5 mm pitch, the half nut is engaged for any of the 12 graduations coinciding with the zero line.

Conventional chart for different profile of metric, BA, whit worth and pipe thread

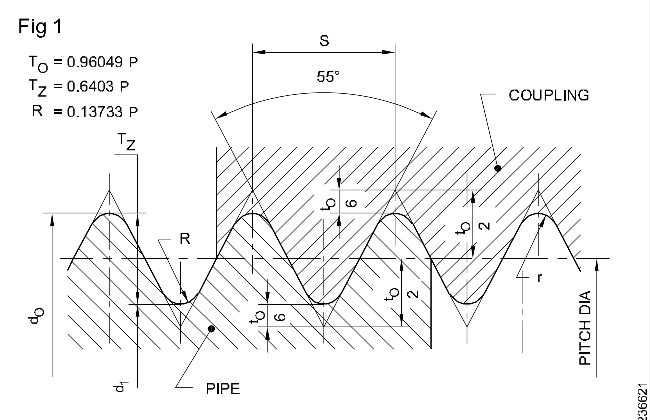
Objectives : At the end of this lesson you shall be able to
- **describe the symbol for internal and external threads**
- **read the chart to find, pitch, core diameter and depth etc.**

Conventional representation of threads

Title	Actual Projection/Section	Convention	Symbol
External Threads			
Internal Threads			

OD	Imperial MM	TPI	Pitch MM	Pitch Imperial Impe-rial	Core in MM	Core Dia Male imperial	Thread Dia Male MM	Thread Depth Female Imperial	Thread Depth female MM	Thread Depth MM	Hex Depth Flats MM	Head A/ MM	Tapping Depth Imperial	MM Size	Imperial
1	0.0394	102	0.0098	0.25	0.0274	0.693	0.0060	0.153	0.0053	0.135			0.0290	0.75	69
1.1	0.0433	102	0.0098	0.25	0.0312	0.793	0.0060	0.153	0.0053	0.135			0.0335	0.85	65
1.2	0.0472	002	0.0098	0.25	0.0351	0.893	0.0060	0.153	0.0053	0.135			0.0374	0.95	62
1.4	0.0551	85	0.0118	0.30	0.0407	1.032	0.0072	0.184	0.0064	0.612			0.0433	1.10	57
1.6	0.0630	73	0.0138	0.35	0.0460	1.171	0.0085	0.215	0.0074	0.189	3.2		0.0492	1.25	3/64
1.8	0.0709	73	0.0138	0.35	0.0539	1.371	0.0085	0.215	0.0074	0.189			0.0570	1.45	54
2	0.0787	64	0.0157	0.40	0.0595	1.510	0.0096	0.245	0.0085	0.217	4.00	1.5	0.0630	1.60	1/16
2.2	0.0866	56	0.0177	0.45	0.0648	1.648	0.0109	0.276	0.0096	0.244			0.689	1.75	51
2.3	0.0906	56	0.0177	0.45	0.0688	1.750	0.0109	0.276	0.0096	0.244			0.0730	1.85	49
2.5	0.0984	56	0.0177	0.45	0.0766	1.950	0.0109	0.276	0.0096	0.244			0.0810	2.05	46
2.6	0.1024	56	0.0177	0.45	0.0832	2.05	0.0109	0.276	0.0096	0.244	5.00		0.0870	2.20	44
3	0.1181	50.8	0.0197	0.50	0.0967	2.387	0.0121	0.307	0.0107	0.271	5.50	2.13	0.0984	2.50	40
3.5	0.1378	42.3	0.0236	0.60	0.1088	2.767	0.0145	0.368	0.0128	0.325			0.1142	2.90	33
4	0.1575	36.3	0.0276	0.70	0.1237	3.141	0.0169	0.429	0.0149	0.379	7.00	2.93	0.1300	3.30	30
4.5	0.1772	33.9	0.0295	0.75	0.141	3.580	0.0181	0.460	0.0160	0.406			0.1500	3.80	24
5	0.1968	31.8	0.0315	0.80	0.1582	4.019	0.0193	0.491	0.0170	0.433	8.00	3.65	0.1650	4.20	19
5.5	0.2165	28.2	0.0354	0.90	0.1705	4.331	0.0230	0.584	0.0205	0.520			0.1770	4.50	16
6	0.2362	25.4	0.0394	1.00	0.1880	4.773	0.0241	0.613	0.0213	0.541	10.00	4.15	0.1970	5.00	9
7	0.2756	25.4	0.0394	1.00	0.2274	5.773	0.0241	0.163	0.0213	0.541	11.00		0.2362	6.00	B
8	0.3150	20.3	0.0492	1.25	0.2668	6.466	0.0301	0.767	0.0267	0.677	13.00	5.65	0.2720	6.90	I
9	0.3543	20.3	0.0492	1.25	0.2939	7.466	0.0302	0.767	0.0267	0.677	13.00		0.3071	7.80	N
10	0.3937	16.9	0.0590	1.50	0.3213	8.160	0.0362	0.920	0.320	0.812	17.00	7.18	0.3346	8.50	Q
11	0.4331	16.9	0.0590	1.75	0.3878	9.852	0.0423	1.074	0.0373	0.947	19.00	8.18	0.4015	10.20	Y
12	0.4724	14.5	0.0689	1.75	0.3878	9.852	0.0423	1.074	0.0373	.947	19.00	8.18	0.4015	10.20	Y

OD	Imperial MM	TPI	Pitch Imperial MM	Pitch in Imperial	Core Dia MM	Core Dia Male imperial	Thread Depth Male MM	Thread Depth Female Imperial	Thread Depth female MM	Thread Depth MM	Hex A/ Flats MM	Head Depth MM	Tapping Size Imperial	MM	Imperial
14	0.5512	12.7	0.0787	2.00	0.4546	11.546	0.0483	1.227	0.0426	1.083	22.00		0.4724	12.0	15/3
16	0.6299	12.7	0.0787	2.00	0.5333	13.546	0.0483	1.227	0.0426	1.083	24.00	10.18	0.551	14.00	35/64
18	0.7087	10.2	0.0984	2.50	0.5879	14.932	0.0604	1.534	0.0533	1.353	27.00		0.6102	15.50	39/64
20	0.7874	10.2	0.0984	2.50	0.6666	16.932	0.0604	1.534	0.0533	1.353	30.00	13.22	0.6889	17.50	11/16
22	0.8661	10.2	0.0984	2.50	0.7453	18.932	0.0604	1.534	0.0533	1.353	32.00		0.7677	19.50	49/64
24	0.945	8.5	0.1181	3.00	0.8002	20.320	0.0724	1.840	0.0640	1.624	36.00	15.22	0.8267	21.00	53/64
26	1.024	8.5	0.1181	3.00	0.8792	22.32	0.0724	1.840	0.0640	1.624			0.9055	23.00	29/32
27	1.063	8.5	0.1181	3.00	0.9182	23.320	0.0724	1.840	0.0640	1.624	41.00		0.9448	24.00	15/16
28	1.102	8.5	0.1181	3.00	0.9572	24.320	0.0724	1.840	0.0640	1.624			0.9920	25.2	63/64
30	1.181	7.3	0.1378	3.50	1.0120	25.706	0.0845	2.147	0.0781	1.894	46.00	19.26	1.0430	26.50	1-3/64
32	1.299	7.3	0.1378	3.50	1.1300	28.706	0.0845	2.147	0.0781	1.894	50.00		1.1614	29.50	1-5/32
33	1.299	7.3	0.1378	3.50	1.1300	28.706	0.0845	2.147	0.0781	1.894	50.00		1.1614	29.50	1-5/32
34	1.339	7.3	0.1378	3.50	1.1700	29.71	0.0845	2.147	0.0781	1.894			1.210	30.70	1-13/64
36	1.417	6.4	0.1575	4.00	1.2238	31.093	0.0966	2.454	0.0852	2.165	55.00	23.26	1.260	32.00	1-1/4
38	1.496	6.4	0.1575	4.00	1.3028	33.092	0.0966	2.454	0.0852	2.165			1.377	35.00	1-11/32
39	1.535	6.4	0.1575	4.00	1.3418	34.093	0.0966	2.454	0.0852	2.165	60.00		1.377	35.00	1-3/8
40	1.575	6.4	0.1575	4.00	1.3818	35.100	0.0966	2.454	0.0852	2.165			1.4252	36.20	1-29/64
42	1.654	5.6	0.1772	4.50	1.4366	36.480	0.1087	2.760	0.959	2.436			1.4252	36.20	1-15/32
44	1.732	5.6	0.1772	4.50	1.5146	38.48	0.1087	2.760	0.959	2.436			1.551	39.4	1-35/64
45	1.772	5.6	0.1772	4.50	1.5546	39.480	0.1087	2.760	0.0959	2.436			1.594	40.50	1-19/32
46	1.811	5.6	0.1772	4.50	1.5936	40.48	0.1087	2.760	0.0959	2.435			1.653	42.00	1-21/32
48	1.890	5.1	0.1968	5.00	1.6486	41.866	0.1207	3.067	0.1065	2.706			1.692	43.00	1-23/32
50	1.969	5.1	0.1968	5.00	1.7276	43.870	0.1207	3.067	0.1065	2.706			1.772	45.00	1-25/32
52	2.047	5.1	0.1968	5.00	1.8056	45.866	0.1207	3.067	1.1065	2.706			1.850	47.00	1-55/64
56	2.205	4.6	0.2165	5.50	1.9394	49.252	0.1328	3.374	0.1172	2.0977			1.988	50.50	2-5/32
60	2.362	4.6	0.2165	5.50	2.0964	53.252	0.1328	3.374	0.1172	2.977			2.283	58.00	2-9/32
64	2.677	4.2	0.2362	6.00	2.3872	60.638	0.1449	3.681	0.1279	3.248			2.283	58.00	2-9/32
68	2.677	4.2	0.2362	6.00	2.3872	60.638	0.1449	3.681	0.1279	3.248			2.441	62.00	2-19/32
72	2.835	4.2	0.2362	6.00	2.5452	64.64	0.1449	3.681	0.1279	3.248			2.598	66.00	2-19/32
76	2.992	4.2	0.2362	6.00	2.7022	68.640	0.1449	3.681	0.1279	3.248			2.756	70.00	2-3/4
80	3.150	4.2	0.2362	6.00	2.8602	72.64	0.1449	3.681	0.1279	3.248			2.933	79.00	3-7/64
85	3.346	4.2	0.2362	6.00	3.0562	77.640	0.1449	3.681	0.1279	3.248			3.110	79.00	3-5/16
90	3.543	4.2	0.2362	6.00	3.2532	82.64	0.1449	3.681	0.1279	3.248			3.504	84.00	3-1/2
95	3.740	4.2	0.2362	6.00	3.4502	87.64	0.1449	3.681	0.1279	3.248			3.504	89.00	3-1/2
100	3.937	4.2	0.2362	6.00	3.6472	92.64	0.1449	3.681	0.1279	3.248			3.700	94.00	3-1/2

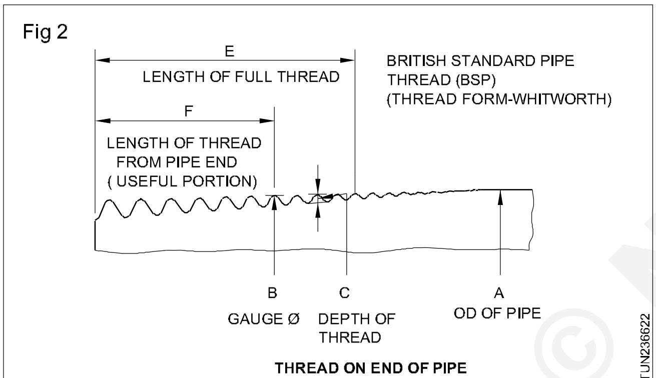


PROFILE OF STRAIGHT PIPE THREAD (BSP)

Pipe thread

The Standard table given here helps to identify the diameter of the pipes from 1/8" to 10", and corresponding outer diameter of pipes, depth of threads and threads per inch.

The table also has reference to Fig 2.



THREAD ON END OF PIPE

Standard Table

Size = Bore dia. of pipe	A	B	C	Threads per inch	E
in	in	in	in		in
1/8	15/32	0.383	0.0230		3/8
1/4	17/32	0.518	0.0335	19	7/16
3/8	11/16	0.656	0.0335	19	1/2
1/2	27/32	0.825	0.0455	14	5/8
3/4	1 1/16	1.041	0.0455	14	3/4
1	1 11/32	1.309	0.0580	11	7/8
1 1/4	1 11/16	1.650	0.0580	11	1
1 1/2	1 29/32	1.882	0.0580	11	1
2	2 3/8	2.347	0.0580	11	1 1/8
2 1/2	3	2.960	0.0580	11	1 1/4
3	3 1/2	3.460	0.0580	11	1 3/8
3 1/2	4	3.950	0.0580	11	1 1/2
4	4 1/2	4.450	0.0580	11	1 5/8
4 1/2	5	4.950	0.0580	11	1 5/8
5	5 1/2	5.450	0.0580	11	1 3/4
6	6 1/2	6.450	0.0580	11	2
7	7 1/2	7.450	0.0640	10	2 1/8
8	8 1/2	8.450	0.0640	10	2 1/4
9	9 1/2	9.450	0.0640	10	2 1/4
10	10 1/2	10.450	0.0640	10	2 3/8

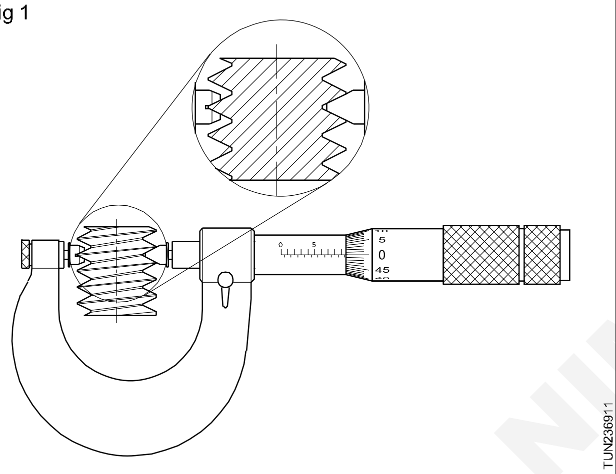
Screw thread micrometer and its uses

Objectives : At the end of this lesson you shall be able to
- **state the features of a screw thread micrometer**
- **state the features of the three-wire system of measurement with the help of tables**
- **select the best wire with the help of tables for using in the three-wire method.**

The screw thread micrometer

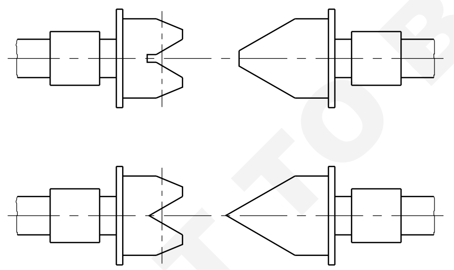
This micrometer (Fig 1) is used to measure the effective diameter of the screw threads. This is very similar to the ordinary micrometer in construction but has facilities to change the anvils.

Fig 1



The anvils are replaceable and are changed according to the profile and pitch of the different systems of threads. (Figs 2 & 3)

Fig 2



INTERCHANGEABLE ANVILS

The three-wire method

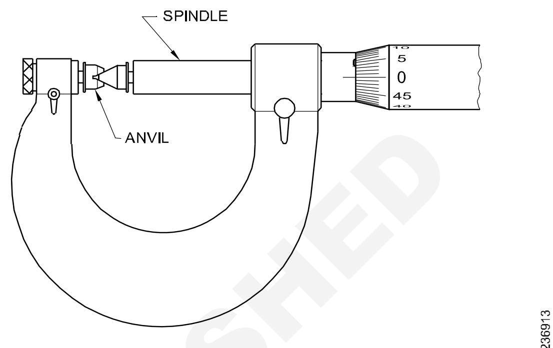
This method uses three wires of the same diameter for checking the effective diameter and the flank form. The wires are finished with a high degree of accuracy.

The size of the wires used depends on the pitch of the thread to be measured.

For measuring the effective diameter the three wires suitable for the thread pitch are placed between the threads. (Fig 4)

The measuring wires are fitted in wire-holders which are supplied in pairs. One holder has provisions to fix one wire and the other for two wires. (Fig 5)

Fig 3



SPINDLE AND ANVIL OF MICROMETER AT ZERO SETTING

Fig 4

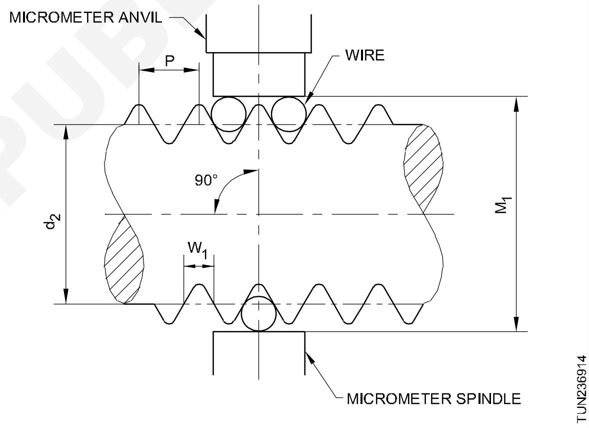
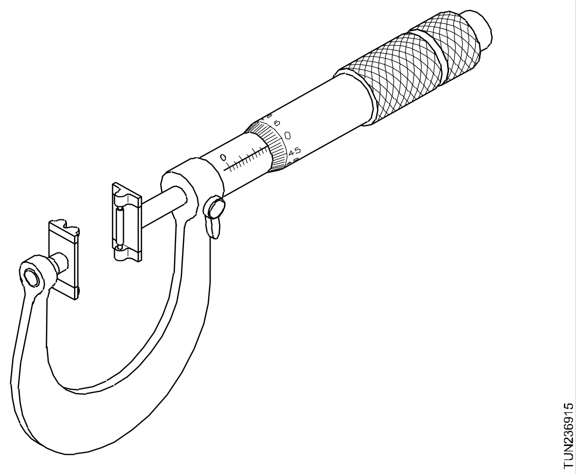
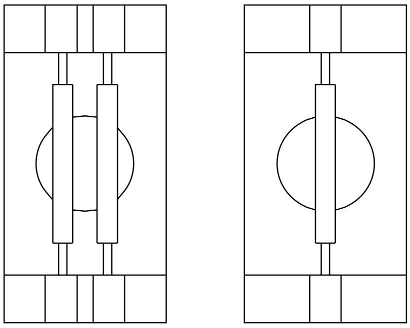


Fig 5



While measuring the screw thread, the holder with one wire is placed on the spindle of the micrometer and the other holder with two wires is fixed on the fixed anvil. (Fig.6)

Fig 6



TUN236916

TABLE 1

Measurement with measuring wires. Metric threads with coarse pitch (M)

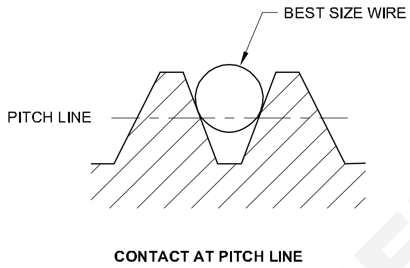
Thread designation	Pitch P mm	Basic measurement d_2 mm	Measuring wire dia. mean W_1 mm	Dimension over wire M_1 mm
M 1	0.25	0.838	0.15	1.072
M 1.2	0.25	1.038	0.15	1.272
M 1.4	0.3	1.205	0.17	1.456
M 1.6	0.35	1.373	0.2	1.671
M 1.8	0.35	1.573	0.2	1.870
M 2	0.4	1.740	0.22	2.055
M 2.2	0.45	1.908	0.25	2.270
M 2.5	0.45	2.208	0.25	2.569
M 3	0.5	2.675	0.3	3.143
M 3.5	0.6	3.110	0.35	3.642
M 4	0.7	3.545	0.4	4.140
M 4.5	0.75	4.013	0.45	4.715
M 5	0.8	4.480	0.45	5.139
M 6	1	5.350	0.6	6.285
M 8	1.25	7.188	0.7	8.207
M 10	1.5	9.026	0.85	10.279
M 12	1.75	10.863	1.0	12.350
M 14	2	12.701	1.15	14.421
M 16	2	14.701	1.15	16.420
M 18	2.5	16.376	1.45	18.564
M 20	2.5	18.376	1.45	20.563
M 22	2.5	20.376	1.45	22.563
M 24	3	22.051	1.75	24.706
M 27	3	25.051	1.75	27.705
M 30	3.5	27.727	2.05	30.848

Selection of 'best wire' (Fig 7)

The best wire is the one which, when placed in the thread groove, will make contact at the nearest to the effective diameter. The selection of the wire is based on the type of thread and pitch to be measured.

The selection of the wire can be calculated and determined but readymade charts are available from which the selection can be made.

Fig 7



TUN236917

TABLE 2

Measurement with measuring wires. Metric threads with fine pitch (M)

Thread designation	Basic measurement d_2 mm	Measuring wire dia. mean W_1 mm	Dimension over wire M_1 mm
M 1 x 0.2	0.870	0.12	1.057
M 1.2 x 0.2	1.070	0.12	1.257
M 1.6 x 0.2	1.470	0.12	1.557
M 2 x 0.25	1.838	0.15	2.072
M 2.5 x 0.35	2.273	0.2	2.570
M 3 x 0.35	2.773	0.2	3.070
M 4 x 0.5	3.675	0.3	4.142
M 5 x 0.5	4.675	0.3	5.142
M 6 x 0.75	5.513	0.45	6.214
M 8 x 1	7.350	0.6	8.285
M 10 x 1.25	9.188	0.7	10.207
M 12 x 1.25	11.188	0.7	12.206
M 14 x 1.5	13.026	0.85	14.278
M 16 x 1.5	13.026	0.85	14.278
M 18 x 1.5	17.026	0.85	18.277
M 20 x 1.5	19.026	0.85	20.277
M 22 x 1.5	21.026	0.85	22.277
M 24 x 2	22.701	1.15	24.420
M 27 x 2	25.701	1.15	27.420
M 30 x 2	28.701	1.15	30.419

TABLE 3

Measurement with measuring wires. Unified fine threads (UNF)

Thread designation	Pitch mm	Basic measurement d_2 mm	Measuring wire dia. mean W_1 mm	Dimension over wire M_1 mm
Nr 0-80 UNC	0.317	1.318	0.2	1.644
Nr 0-72 UNC	0.353	6.25	0.2	1.920
Nr 2-64 UNF	0.397	1.927	0.25	2.334
Nr 3-56 UNF	0.454	2.220	0.25	2.578
Nr 4-48 UNF	0.529	2.501	0.3	2.944
Nr 5-44 UNF	0.577	2.800	0.35	3.351
Nr 6-40 UNF	0.635	3.093	0.35	3.594
Nr 8-36 UNF	0.706	3.708	0.4	4.298
Nr10-32 UNF	0.794	4.310	0.45	4.974
Nr 12-28 UNF	0.907	4.897	0.5	5.612
1/4"-28 UNF	0.907	5.761	0.5	6.477
5/16"-28 UNF	1.058	7.249	0.6	8.134
3/8"-24 UNF	1.058	8.837	0.6	9.721
1/2"-20 UNF	1.27	11.875	0.7	12.876
5/8"-18 UNF	1.411	14.958	0.85	16.287
3/4"-16 UNF	1.588	18.019	0.9	19.345
7/8"-14 UNF	1.814	21.046	1.0	22.476
1" -12 UNF	2.117	24.026	1.3	26.094

TABLE 4

Measurement with measuring wires. Unified coarse threads (UNC)

Thread designation	Pitch mm	Basic measurement d_2 mm	Measuring wire dia. mean W_1 mm	Dimensionover wire M_1 mm
Nr 1-64 UNC	0.397	1.596	0.22	1.913
Nr 2-56 UNC	0.454	2.25		2.249
Nr 3-48 UNC	0.529	2.171	0.3	2.614
Nr 4-40 UNC	0.635	2.433	0.35	2.935
Nr 5-40 UNC	0.635	2.763	0.35	2.265
Nr 6-32 UNC	0.794	2.990	0.45	3.654
Nr 8-32 UNC	0.794	3.650	0.45	4.314
Nr 10-24 UNC	1.058	4.139	0.6	5.026
Nr 12-24 UNC	1.058	4.799	0.6	5.685
1/4"-20 UNC	1.27	5.524	0.7	6.527
5/16"-18UNC	1.411	7.021	0.85	8.352
3/8"-16 UNC	1.587	8.494	0.9	9.822
1/2"-13 UNC	1.954	11.430	1.15	13.191
5/8"-11 UNC	2.309	14.376	1.3	16.279
3/4"-11 UNC	2.540	17.399	1.45	19.552
7/8"-9 UNC	2.822	20.391	1.6	22.750
1" -8 UNC	3.175	23.338	1.8	25.991
1 1/4"-7 UNC	3.629	29.393	2.05	32.403
1 1/2"-6 UNC	4.233	35.349	2.4	38.885
1 3/4"-5 UNC	5.08	41.151	3	45.755
2"–4 1/2 UNC	5.644	47.135	3.5	52.751

Calculation involving gear ratio metric thread cutting on inch lead screw lathe and vice versa

Objectives : At the end of this lesson you shall be able to
- **state the formula of the gear ratio for cutting metric thread on a British lathe**
- **state the formula of the gear ratio for cutting British thread on a metric lathe**
- **solve the problems involving cutting metric thread on British lathe and vice versa.**

Gear ratio for cutting metric thread on British lathe

The formula of the gear ratio for cutting metric thread on a metric lathe is

$$\frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead to be cut on the job}}{\text{Lead of lead screw}}$$

Now, for cutting metric thread on a British lathe, the lead of the work to be cut in mm is converted to inches by multiplying with the constant 5/127.

Because 25.4 mm = l"

1 mm = 1/25.4"

= 10/254

= 5/127"

Therefore,

Gear ratio

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in mm on job} \times 1 \times 5}{\text{Lead of L.S.} \times 127}$$

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in mm} \times \text{T.P.I. on L.S.} \times 5}{127}$$

A translating gear of 127 teeth is provided for cutting metric thread on a British lathe. This gear wheel is used as the driven wheel. The worked out example illustrates this statement.

Gear ratio for cutting British thread on metric lathe

The general formula for cutting British thread on a British lathe is

$$\frac{DR}{DN} = \frac{\text{Lead to be cut on job}}{\text{Lead of lead screw}}$$

Now for cutting British thread on a metric lathe the lead of the screw in mm is converted into inches by multiplying with a constant of 5/127.

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in inch on job}}{\text{lead of lead screw in mm} \times \frac{5}{127}}$$

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in inch on job} \times 1 \times 127}{\text{Lead of lead screw in mm} \times 5}$$

$$\frac{DR}{DN} = \frac{1}{\text{T.P.I. to be cut}} \times \frac{1}{\text{Lead of lead screw}} \times \frac{127}{5}$$

As a practice, it is advisable to have a larger wheel as a driven gear as far as possible. But in this case the 127 teeth wheel has to be used as a DRIVER only.

Gear ratio for cutting metric thread on British lathe using 63 teeth as driver wheel.

Instead of taking the constant $\frac{5}{127}$

$\frac{63}{1600}$ is taken because 1 metre = 39.37".

1 metre = 39.375" (approx.)

$1000 \text{ mm} = 39.375" = 39\frac{3"}{8}$

$1 \text{ mm} = \frac{315}{1000 \times 8}$

$= \frac{63}{1600}$

Gear ratio

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in mm} \times \text{TPI on LS} \times 63}{1600}$$

Gear ratio for cutting British thread on metric lathe using the 63 teeth wheel as the driven wheel:

$$\frac{DR}{DN} = \frac{1}{\text{T.P.I. to be cut}} \times \frac{1}{\text{Lead of lead screw in mm}} \times \frac{1600}{63}$$

Lathe constant

Lathe constant is the number of threads per inch that can be cut when the change gear ratio is 1 and the ratio between the main spindle gear and the fixed stud gear is also 1.

On some machines the ratio of the spindle gear to the fixed stud gear is more than 1 in which case the lathe constant is equal to:

$$\frac{\text{spindle gear} \times \text{T.P.I on lead screw}}{\text{fixed stud gear}}$$

When lathe constant is given

(Gear ratio for cutting thread) $\frac{DR}{DN} = \frac{\text{Lathe constant}}{\text{T.P.I. to be cut}}$

Find the gears required to cut 4.5 mm pitch in a lathe having a lead screw of 6 T.P.I. Gears available from 20 to 120 teeth by 5 teeth range with a conversion gear of 127 teeth.

DATA

Lead of work = 4.5 mm

T.P.I of L/s = 6 T.P.I

Lead of L/s = $\frac{1}{\text{T.P.I.}}$

Lead of L/s = $\frac{1}{6}$

Gear ratio = $\frac{DR}{DN} = \frac{5}{127} \times \frac{\text{Lead of work}}{\text{Lead of lead screw}}$

$= \frac{5}{127} \times \frac{4.5}{1/6}$

$= \frac{5 \times 6 \times 4.5}{127 \times 1}$

Now it is not possible to have a change gear train with a simple gear train. So a compound gear train is used,

i.e. $\frac{30}{127} \times \frac{4.5}{1}$

$\frac{30}{127} \times \frac{45}{10}$

$\frac{45 \times (30 \times 2)}{127 \times (10 \times 2)} = \frac{45}{127} \times \frac{60}{20}$

45 T & 60 T are drivers.

127 T & 20 T are driven.

Problems involving cutting metric threads on British lathe and vice versa

Find the gears required to cut a 3 mm pitch in a lathe having a lead screw of 6 T.P.I. Gears available from 20 to 120 teeth by 5 teeth with a special gear of 127 teeth.

DATA

Lead of work = 3 mm

T.P.I on L/s = 6 T.P.I

Lead of L/s = $\frac{1}{6}$

Gear ratio $= \frac{DR}{DN} = \frac{5 \times \text{Lead of work}}{127 \times \text{Lead of lead screw}}$

$= \frac{5}{127} \times \frac{3}{1/6}$

$= \frac{5}{127} \times \frac{3 \times 6}{1}$

$= \frac{90}{127}$

90 teeth gear is driver.

127 teeth gear is driven.

Problems involving cutting British threads on metric lathe

Find the gears required to cut 6 T.P.I on job in a lathe having a lead screw of 6 mm pitch.

Gears available from-20 T to 120 by 5 teeth range with a special gear of 127 teeth.

DATA

Lead of work = 1/6"

Lead of L/s = 6 mm

Gear ratio $= \frac{DR}{DN} = \frac{127}{5} \times \frac{\text{Lead of work}}{\text{Lead of L/s.}}$

$= \frac{127}{5} \times \frac{1/6}{6}$

$= \frac{127}{5} \times \frac{1}{6 \times 6}$

$= \frac{127}{30} \times \frac{1}{6}$

$= \frac{127}{30} \times \frac{(1 \times 20)}{(6 \times 20)}$

$= \frac{127}{30} \times \frac{20}{120}$

127 T & 20 T are driver gears.

30 T & 120 T are driven gears.

Tool Life negative top rake

Objectives: At the end of this lesson you shall be able to
- **state the relationship between cutting speed and tool life**
- **explain tool life index equation**
- **determine the maximum cutting speed for a given tool life.**

Relationship between cutting speed and tool life

Duration of correct cutting to the anticipated surface finish between grinding is termed as tool life. In metal cutting, increase in cutting speed increases power requirement. Therefore, the mechanical energy is converted into heat energy at the cutting edge. Much of the heat is absorbed by the cutting tool with corresponding increase in temperature, resulting in softening of the cutting tool, which is the reason for inefficient cutting action. The effect of this reduction in tool life is largely present in high carbon steels. Hence, they have to be operated at lower cutting speeds.

Cutting materials such as high speed steel, metallic carbides and oxides can operate at much higher temperatures without reduction in hardness.

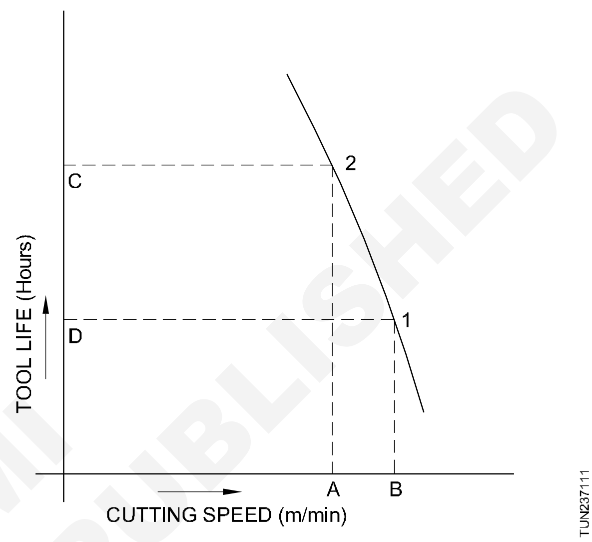
Fig 1 shows graphically the relationship between cutting speed and tool life curve in logarithmic form. A small increase in cutting speed from A to B causes large reduction in tool life from C to D, while small reduction in cutting speed causes a large increase in tool life.

Thus when the machine gearbox does not give the required cutting speed, it is better to use the next lower speed rather than the higher speed.

Tool life index

The relationship between tool life and cutting speed can be represented by the following equation for most practical purposes.

Fig 1



$Vt^n = C$

where V = cutting speed in m/min.

t = tool life in minutes

n and C are constants for a given set of conditions.

The value of n lies between 0.1 to 0.2 and typical values are given in the following table.

Table

Tool life index

Material and conditions	Tool material	n
3 1/2% nickel steel	Cemented carbide	0.2
3 1/2% nickel steel (roughing)	Highspeed steel	0.14
3 1/2% nickel steel (finishing)	Highspeed steel	0.125
High carbon, high chromium die steel	Cemented carbide	0.15
High carbon steel	Highspeed steel	0.2
Medium carbon steel	High-peed steel	0.15
Mild steel	Highspeed steel	0.125
Cast iron	Cemented carbide	0.1

The following example is shown to determine the maximum cutting speed for a given tool LIFE.

Example

The life of a lathe tool is 8 hours when operating at a cutting speed of 40 m/min. Given that $Vt^n = C$, find the highest cutting speed that will give a tool life of 16 hours. The value of n is 0.125.

(i) Determine the value of Log C from initial conditions.

$C = Vt_1^n$ where

$V = 40$ m/min.

$t^1 = 480$ min.

$n = 0.125$

$\text{Log } C = \text{Log } V + n \text{ Log } t1$

$= \log 40 + (0.125 \text{ Log} 480)$

$= 1.6021 + (0.125 \times 2.681)$

$= 1.6021 + 0.3351$

$= 1.9372$

(ii) Determine Vmax for revised conditions

$$V_{max} = \frac{C}{t_2^n}$$

Where $t_2 = 960$ min.

$\text{Log } V_{max} = \text{Log } C - n \text{ Log } t_2$

$= 1.9372 - (0.125 \times \log 960)$

$= 1.9372 - (0.125 \times 2.9823)$

$= 1.9372 - 0.3728$

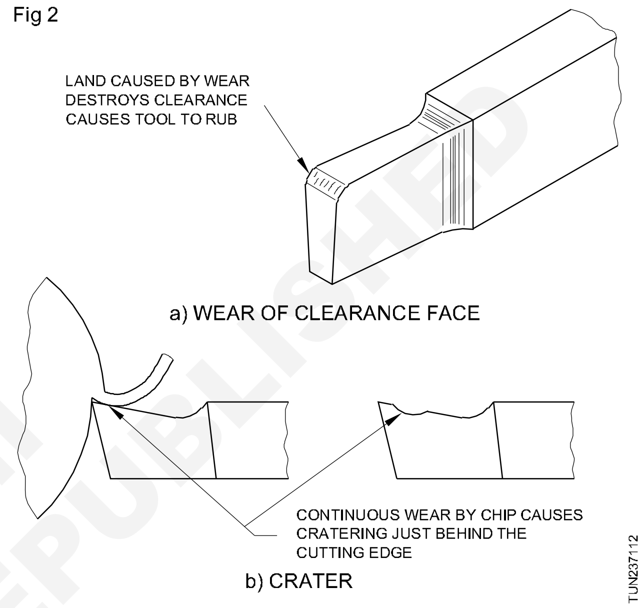
$= 1.5644$

Vmax = 36.68 m/min.

From the calculations, tool life is doubled by reduction of cutting speed by 8.3 percent, or reduction of tool life can be calculated for an increase of 8.3 percent in cutting speed. Hence, it is always important to select a lower cutting speed, rather than a higher cutting speed, if the machine controls do not give optimum value.

Tool life calculations are useful in achieving optimum operating conditions of cutting tools. Modern cutting tool materials are singularly resistant to softening under the heat of normal cutting and usually fail in two ways as shown in Fig 2.

Fig 2



a) Wear of clearance face

b) Crater of rake face

The above conditions can be corrected only by regrinding immediately for effective metal cutting.

Calculation involving tool thickness, core dia, depth of cut of square thread

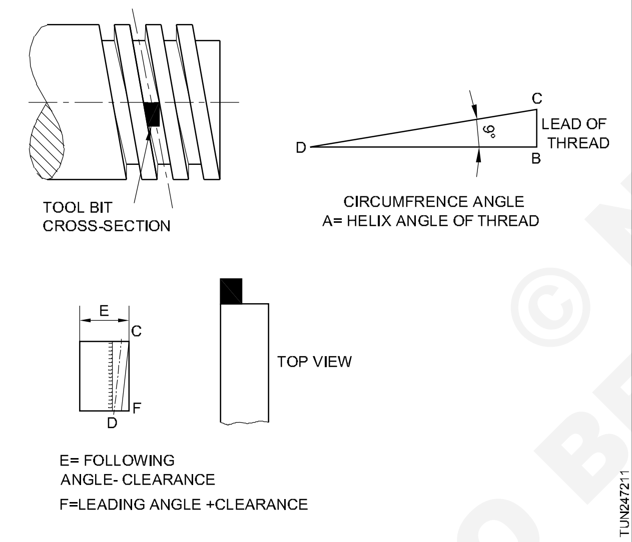
Objectives : At the end of this lesson you shall be able to
- **calculate the heleix angles of square tool**
- **brief the clearance angle in square threading tool**
- **read a standard thread chart.**

Square threads were often found in vice screws, jacks, and other devices where maximum power transmission was required. Because of the difficulty of cutting this thread with taps and dies, it is being replaced by Acme thread. With care, square threads can be readily cut on a lathe.

The shape of a square threading tool

The square threading tool looks like a short cutting - off tool. It differs from it in that both sides of the square threading tool must be ground at an angle to conform to the helix angle of the thread (Fig.1)

Fig 1



The helix angle of a thread, and therefore the angle of the square threading tool, depends on two factors:

1 The helix angle changes for each different lead on a given diameter. The greater the lead of the thread, the greater will be the helix angle.

2 The helix angle changes for each different diameter of thread for a given lead. The larger the diameter, the smaller will be the helix angle.

The helix angle of either the leading or following side of a square thread can be represented by a right-angle triangle (Fig. 1). The side opposite equals the lead of the thread, and the side adjacent equals the circumference of either the major or minor diameter of the thread. The angle between the hypotenuse and the side adjacent represent the helix angle of the thread.

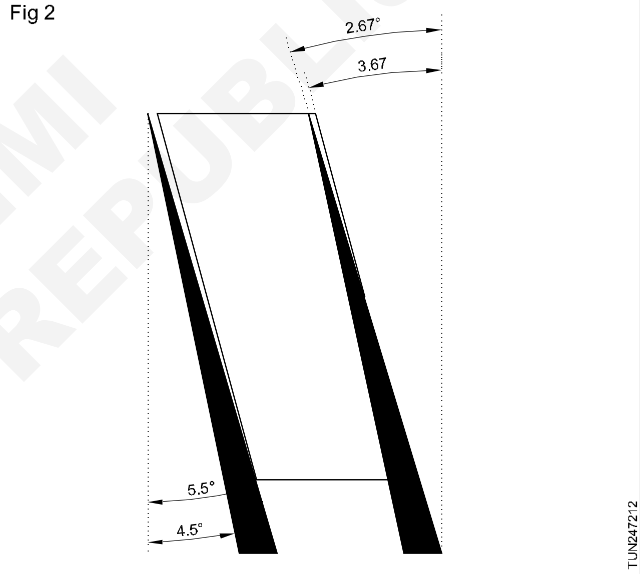
To calculate the helix angles of the leading and following sides of a square thread

$$\text{Tan loading angle} = \frac{\text{lead of thread}}{\text{circumference of minor diameter}}$$

$$\text{Tan following angle} = \frac{\text{lead of thread}}{\text{circumference of major diameter}}$$

Clearance

Fig 2



If a square tool bit is ground to the same helix angles as the leading and following sides of the thread, it would have no clearance and the sides would rub. To prevent the tool the tool from rubbing, it must be provided with approximately 1° clearance on each side, making it thinner at the bottom (Fig. 2). For the leading side of the tool, add 1° to the calculated helix angle. On the following side, subtract 1° from the calculated angle.

Example

To find the leading and following angles of a threading tool to cut a 11/4 in - square thread.

Solution

To cut a square thread

- Grind a threading tool to the proper leading and following angles. The width of the tool should be approximately 0.002 in. (0.05mm) wider than the thread groove. This will allow the completed screw to fit the nut readily. Depending on the size of the thread, it may be wise to grind two tools; a roughing tool 0.015in. (0.38mm) undersize, and a finishing tool 0.002 in. (0.05mm) oversize.

Lead = 0.250 in

$$\text{single depth} = \frac{0.500}{4}$$

= 0.125 in

Double depth = 2x0.125

= 0.250 in

Minor diameter = 1.250 − 0.250

= 1.000 in

$$\text{Tan leading angle} = \frac{\text{lead}}{\text{minor dia. circumference}}$$

$$= \frac{0.250}{1.000 \times \pi}$$

$$= \frac{0.250}{3.1416} = 0.0795 \text{ in.}$$

$\therefore$ the angle of the thread = $4^{\circ}33'$

The toolbit angle = $4^{\circ}33'$ plus 1° clearance

= $5^{\circ}33'$

$$\text{Tan following angle} = \frac{\text{lead}}{\text{major dia. circumference}}$$

$$= \frac{0.250}{1.250\pi} = \frac{0.250}{3.927} = 0.0636 \text{ in}$$

$\therefore$ the angle of the thread = $3^{\circ}38'$

The toolbit angle = $3^{\circ}38'$ - 1° clearance

= $2^{\circ}38'$

- Align the lathe centers and mount the work.
- Set the quick change gearbox for the required number of tpi.
- Set the compound rest at 30° to the right. This will provide side movement if it becomes necessary to reset the cutting tool.
- Set the threading tool square tool square with the work and on center.
- Cut the right - hand end of the work to the minor diameter for approximately 1/16 in. (1.58mm) long. This will indicate when the thread is cut to the full depth.
- If the work permits, cut a recess at the end of the thread to the minor diameter. This will provide room for the cutting tool to "run out" at the end of the thread.
- Calculate the single depth of the thread as

$$\frac{(0.500)}{N}$$

- Start the lathe and just touch the tool to the work diameter.
- Set the cross feed graduated collar to zero (0)
- Set a 0.003 - in. (0.08mm) depth of cut with the cross feed screw and take a trial cut.
- Check the thread with a thread pitch gage.
- Apply cutting fluid and cut the thread to depth, moving the crossfeed in from 0.002 to 0.010 in. (0.05 to 0.25mm) for each cut. The depth of the cut will depend on the thread size and the nature of the workpiece.

Since the thread sides are square, all cuts must be set using the crossfeed screw.

Standard threads

Standards of threads describe pitch core diameter and major diameter. The standard threads can be cut in standard machine tools with standard cutters and designer can use them for calculation of sizes and ensure interchangeability. We will see in illustrated examples how the standards are used by designer. Presently we describe Indian standard IS 4694-1968 for square threads in which a thread is identified by its nominal diameter which is also the major diameter. According to standard the major diameter of nut is 0.5 mm greater then major diameter of the screw which will provide a clearance of 0.25 mm between the outer surface of screw and inner surface of nut thread. The basic dimensions of square threads are described in Table 1.

Table 1 : Basic Dimensions of Square Thread, (mm)

Pitch, p		5		
Core Dia. d1	17	19	24	23
Major Dia. d	22	24	29	28
Pitch, p		6		
Core dia. d1	24	26	28	30
Major dia. d	30	32	34	36
Pitch p 7				
Core dia. d1	31	33	35	37
Major dia. d	38	40	42	44
Pitch, p		8		
Core dia. d1	38	40	42	44
Major dia. d	46	48	50	56
Pitch, p		9		
Core dia. d1,	46	49	51	53
Major dia. d	55	58	60	62
Pitch, p		10		
Core dia. d1	55 58	60 62	65 68	70 72
Major dia. d	65 68	70 72	75 78	80 82

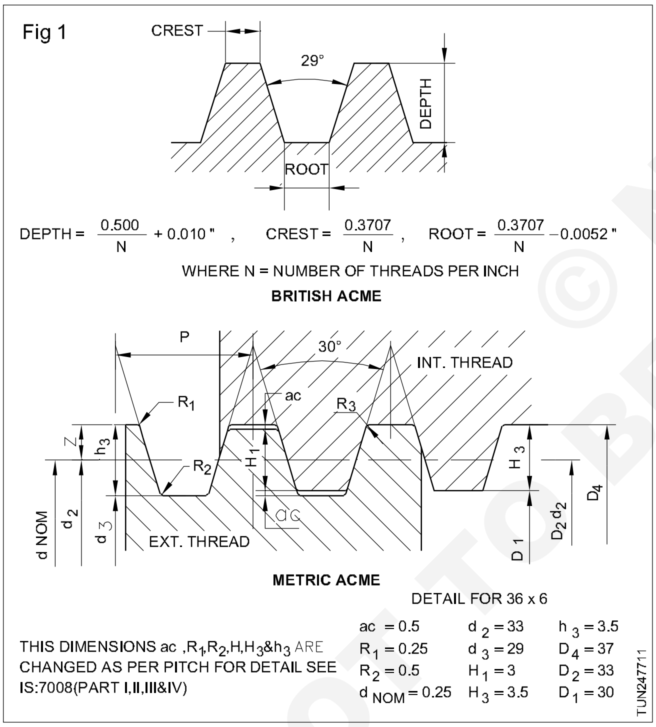
Calculation involves - depth, core dia, Pitch proportion etc of ACME thread & Buttress thread

Objectives : At the end of this lesson you shall be able to
- **claculation of ACME thread angle**
- **brief the clearance angle in threading tool**
- **read a standard thread chart.**

ACME Thread

This thread is a modification of the square thread. It has an included angle of 29°. It is preferred for many jobs because it is fairly easy to machine. Acme threads are used in lathe lead screws. This form of thread enables the easy engagement of the half nut. The metric acme thread has an included angle of 30°. The relationship between the pitch and the various elements is shown in the figure.

Acme thread (Fig 1)



Detail For 36X6

This dimensions ac, R1, R2, H, H3 & h3 are changed as per pitch for detail see I.S 7008 (Part I,II, III pic)

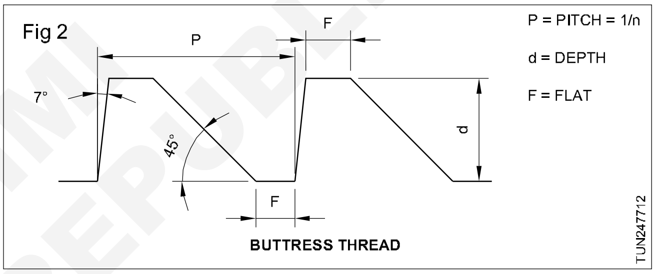
ac = 0.5 d_2 = 33 h_3 = 3.5

R_1 = 0.25 d_3 = 29 D_4 = 37

R_2 = 0.5 H_1 = 3 D_2 = 33

dNom = 0.25 H_3 = 3.5 D_1 = 30

Buttress thread (Fig 2)



The flanks have different angles. One of the flanks have an angle of 7º with respect to a line perpendicular to the axis. This flank can take heavy loads and is called the “pressure flank” of the thread. The other flank has an angle of 45º.

They are used where great pressures are to be applied in one direction only.

They are not used for translation motions.

Threads of buttress form

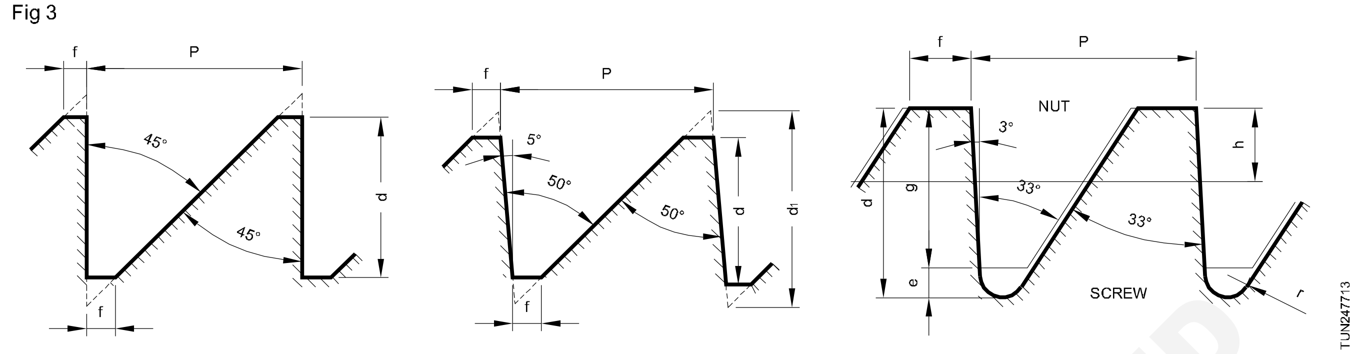
The buttress form of thread has certain advantages in applications involving exceptionally high stresses along the thread axis in one direction only. The contacting flank of the thread, which takes the thrust, is referred to as the pressure flank and is so nearly perpendicular to the thread axis that the radial component of the thrust is reduced to a minimum. Because of the small radial thrust, this form of thread is particularly applicable where tubular members are screwed together, as in the case of breech mechanisms of larger guns and airplane propeller hubs.

Fig. 1a shows a common form. The front or load-resisting face is perpendicular to the axis of the screw and the thread angle is 45 degrees. According to one rule, the pitch P=2 x screw diameter ÷ 15. The thread depth d may equal 3/4 x pitch, making the flat f=1/8 x pitch. Sometimes depth d is reduced to 2/3 x pitch, making f=1/6 x pitch.

The load - resisting side or flank may be inclined an amount ranging usually from 1 to 5 degrees to avoid cutter interference in milling the thread. With an angle of 5 degrees and an included thread angle of 50 degrees, if the width of the flat at both crest and root equals 1/8 x pitch, then the thread depth equals 0.69 x pitch or 3/4 d_1.

The saw - tooth form of thread illustrated by Fig. 1c is known in Germany as the "Sagengewinde" and in Italy as the "Fillettatura a dente di Sega. "Pitches are standardized from 2 millimeters up to 48 millimeters in the german and Italian specifications. The front face inclines 3 degrees from the perpendicular and the included angle is 33 degrees.

Fig 3



The thread depth d for the screw =0.86777 x pitch P. The thread depth g for the nut=0.75 x pitch. Dimension h=0.341 x P. The width of flat at the crest of the thread on the screw =0.26384 x pitch. Radius r at the root = 0.12427 x pitch. The clearance space e=0.11777 x pitch.

British Standard Buttress Threads BS 1657:1950 - Specificiations for buttress threads in this standard are similar to those in the American Standard except: 1) A basic depth of thread of 0.4p is used instead of 0.6p; 2) Sizes below 1 inch are not included; 3) Tolerances on

Table 1 Dimensions of basic profile

All dimensions in millimeters

Pitch P	H	H/2	H1	w
	1.587 8 P	0.793 9	0.75 P	0.263 84 P
(1)	(2)	(3)	(4)	(5)
2	3.175 6	1.587 8	1.50	0.527 68
3	4.763 4	2.381 7	2.25	0.791 52
4	6.351 2	3.175 6	3.00	1.055 36
5	7.939 0	3.969 5	3.75	1.319 20
6	9.526 8	4.763 4	4.50	1.583 04
7	11.114 6	5.557 3	5.25	1.846 880
8	12.7024	6.351 2	6.00	2.110 72
9	14.290 2	7.145 1	6.75	2.374 56
10	15.878 0	7.939 0	7.50	2.638 40
12	19.053 6	9.526 8	9.00	3.166 08
14	22.229 2	11.114 6	10.50	3.693 76
16	26.404 8	12.702 4	12.00	4.221 44
18	28.580 4	14.290 2	13.50	4.749 12
20	31.756 0	15.878 0	15.00	5.276 80
22	34.931 6	17.465 8	16.50	5.804 48
24	38.107 2	19.053 6	18.00	6.332 16
28	44.458 4	22.229 2	21.00	7.387 52
32	50.809 6	25.404 8	24.00	8.442 88
36	57.160 8	28.580 4	27.00	9.498 24
40	63.512 0	31.756 0	30.00	10.553 60
44	69.863 2	34.931 6	33.00	11.608 96

major and minor diameters are the some as the pitch diameter tolerances, whereas in the American Standard separate tolerances are provided; how ever, provision is made for smaller major and minor diameter tolerances when crest surfaces of screws or nuts are used as datum surfaces, or when the resulting reduction in depth of engagement must be limited; and 4) Certain combinations of large diameters with fine pitches are provided that are not encouraged in the American Standard.

Lowenherz or lowenherz thread

The lowenherz thread is intended for the fine screws of instruments and is based on the metric system. The lowenherz thread has flats at the top and bottom the same as the U.S. standard buttress form, but the angle is 53 degrees 8 minutes. The depth equals 0.75 x the pitch, and the width of the flats at the top and bottom is equal to 0.125 x the pitch. The screw thread used for measuring instruments, optical apparatus, etc., especially in Germany.

The minor diameter clearance and the clearance between the non-stressed thread flank and the fundamental deviations of the pitch diameter of the stressed thread flank are related to these basic sizes.

Nominal profiles

The nominal profiles to which the deviations and tolerances are related have specified clearances on the minor diameter and between the non-load bearing thread flanks, relative to the basic profile.

The numerical threads data associated with the nominal profile is given in Table 2.

Table 2 Basic numerical threads data for nominal profile

All dimensions in millimeters

Pitch P	a_e 0.117 77 P	a $0.1\sqrt{P}$	e 0.263 84 P- $0.1\sqrt{P}$	h3 0.867 77 P	R 0.124 27
(1)	(2)	(3)	(4)	(5)	(6)
2	0.236	0.141 4	0.386	1.736	0.249
3	0.353	0.173 2	0.618	2.603	0.373
4	0.471	0.2	0.855	3.471	0.497
5	0.589	0.223 6	1.096	4.339	0.621
6	0.707	0.244 9	1.338	5.207	0.746
7	0.824	0.264 6	1.582	6.074	0.870
8	0.942	0.282 8	1.828	6.942	0.994
9	1.060	0.3	2.075	7.810	1.118
10	1.178	0.316 2	2.322	8.678	1.243
12	1.413	0.346 4	2.820	10.413	1.491
14	1.649	0.374 2	3.320	12.149	1.740
16	1.884	0.4	3.821	13.884	1.988
18	2.120	0.424 3	4.325	15.620	2.237
20	2.355	0.447 2	4.830	17.355	2.485
22	2.591	0.469 0	5.335	19.091	2.734
24	2.826	0.489 9	5.842	20.826	2.982
28	3.298	0.529 2	6.858	24.298	3.480
32	3.769	0.565 7	7.877	27.769	3.977
36	4.240	0.6	8.898	31.240	4.474
40	4.711	0.632 5	9.921	34.711	4.971
44	5.182	0.663 3	10.946	38.182	5.468

Profiles of threads with clearance on the flank

The formulae associated with the dimensions indicated in Fig. 2 and Fig. 3 are given below:

H_1=0.75P

h_3=H_1+a_c=0.867 77 P

$a = 0.1\sqrt{P}$ (axial play)

a_c=0.117 77P

$w = 0.263\ 84\ P$

$e = 0.263\ 84\,P - 0.1\sqrt{P} = w - a$

$R = 0.124\ 27P$

$D_1 = d - 2H1 = d - 1.5P$

$d_3 = d - 2h3$

$d_2 = d - 0.75P$

$d_1 = d - 0.75P + 3.175\ 8a$

The profiles for external and internal threads with clearance on the non-load bearing flank on the minor diameter but with no clearance between the load bearing flanks or on the major diameter (nominal size) is indicated in Fig.2.

The profile for external and internal threads with clearances on the minor diameter and on the flank (standard nut system) but with no clearance on the major diameter is indicated in Fig. 3.

$S = 0.314\ \ 9\ A_o$

Where

A_o=fundamental deviation (upper deviation) for external thread on the pitch diameter.

Profile for multiple -start threads

The profile for multiple start threads is given in Fig. 4.

P_h=lead (axial advance at one turn), and

P=pitch (axial distance between two neighboring flanks being in the same direction).

Multiple start (n-start) threads have the same profile as single start threads with lead P_h=pitch P. For the pitch P of multiple start threads, only the values permitted for the lead P (which is equal to pitch P) of single start threads may be selected. However, the multiple of the pitch P of multiple start threads need not correspond to the value permitted for single start threads.

Fig 4

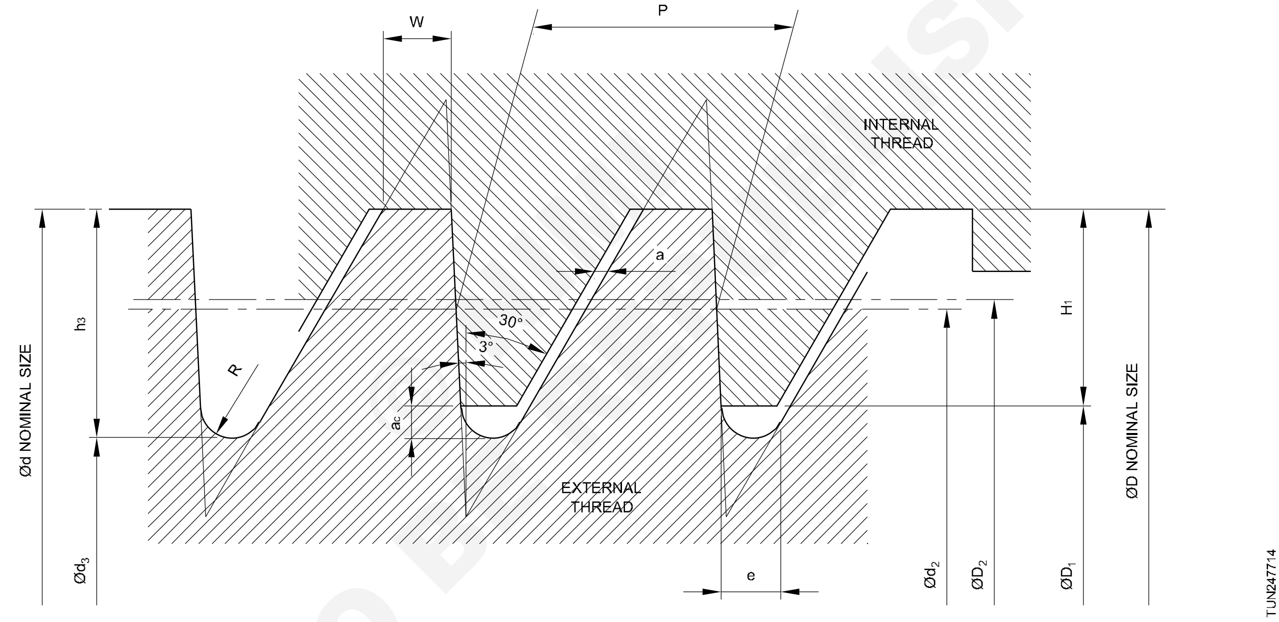


Fig 5

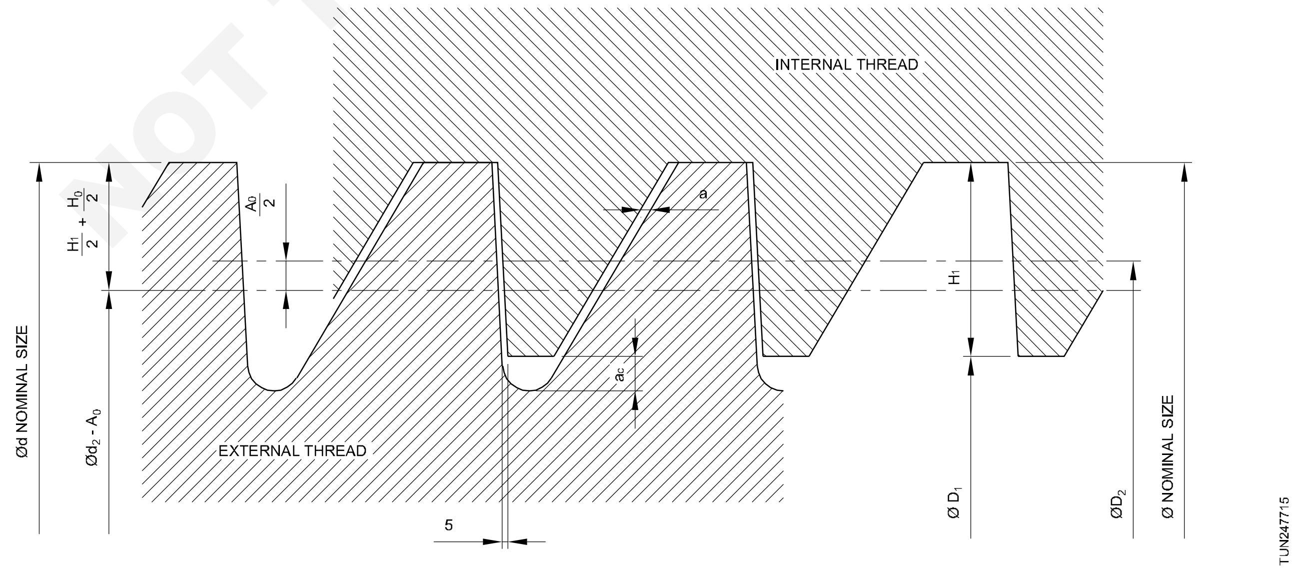
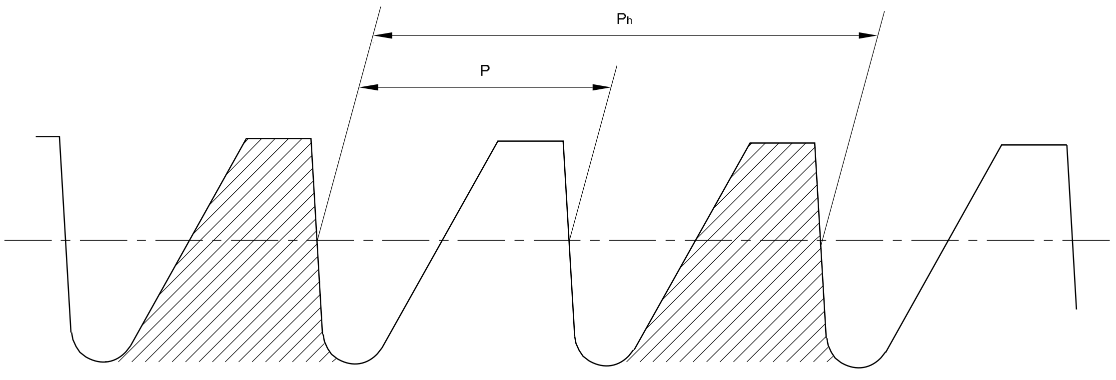


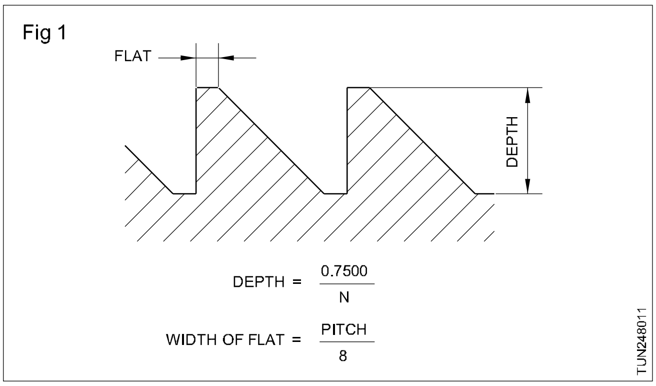
Fig 6



Buttress thread cutting (male & female) & tool grinding

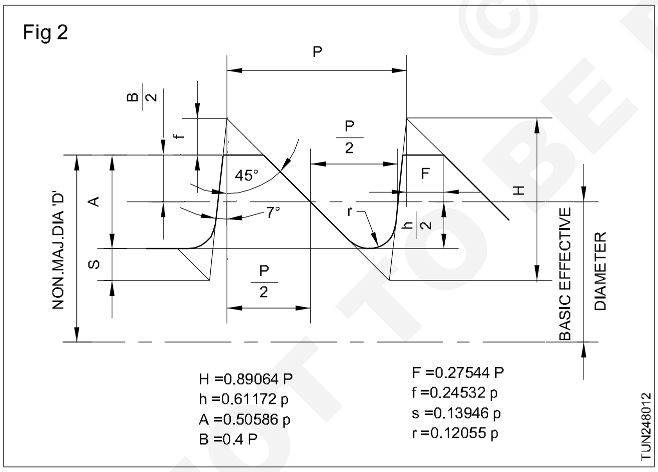
Objectives : At the end of this lesson you shall be able to
- **grind buttress threading tool**
- **list the advantages of butters thread**
- **brief the thread proportion.**

Buttress thread (Fig 1)



In buttress thread one flank is perpendicular to the axis of the thread and the other flank is at 45°. These threads are used on the parts where pressure acts at one flank of the thread during transmission. Figure 1 shows the various elements of a buttress thread. These threads are used in power press, carpentry vices, gun breeches, ratchets etc.

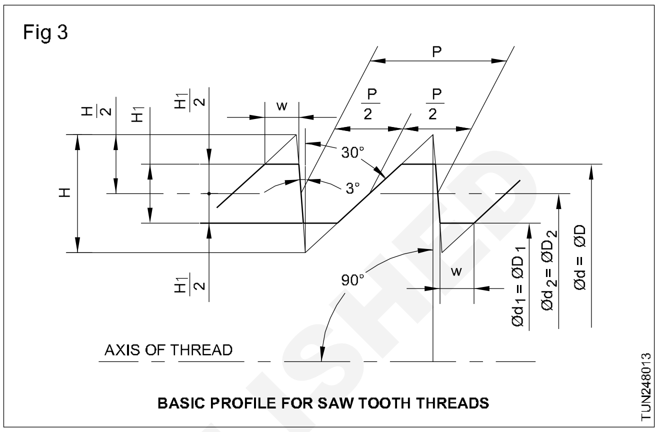
Buttress thread as per B.I.S. (Fig 2)

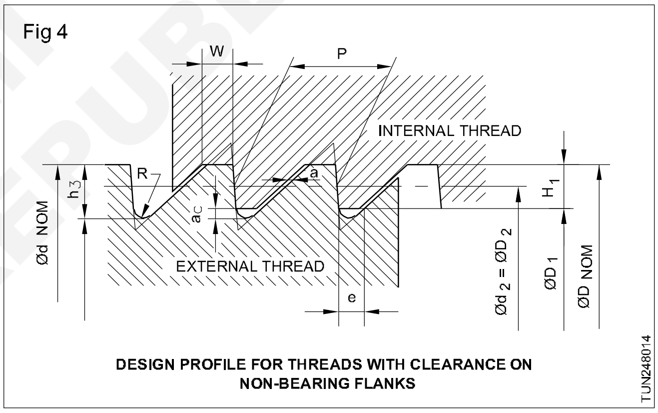


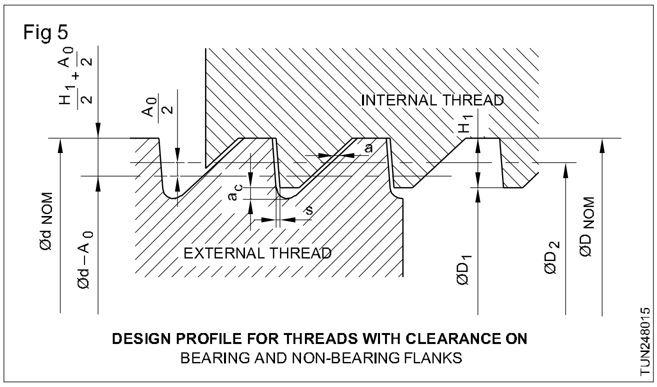
This is a modified form of the buttress thread. Figure 2 shows the various elements of the buttress thread. The bearing flank is inclined by 7° as per B.I.S. and the other flank has a 45° inclination.

Saw-tooth thread as per B.I.S. 4696

This is a modified form of buttress thread. In this thread, the flank taking the load is inclined at an angle of 3°, whereas the other flank is inclined at 30°. The basic profile of the thread illustrates this phenomenon. (Fig 3) The proportionate values of the dimensions with respect to the pitch are shown in Figs 4 and 5.







The equations associated with the dimensions indicated in the two figures (Figs 5 and 6) are given below.

H_1 = 0.75 P

$h_3 = H_1 + a_c$ = 0.867 77 P

a = 0.1 Ö P (axial play)

a_c = 0.117 77 P

W = 0.263 84 P

e = 0.263 84 P - 0.1 Ö P = W - a

$R = 0.124\ 27\ P$

$D_1 = d - 2\ H_1 = d - 1.5\ P$

$d_3 = d - 2\ h_3$

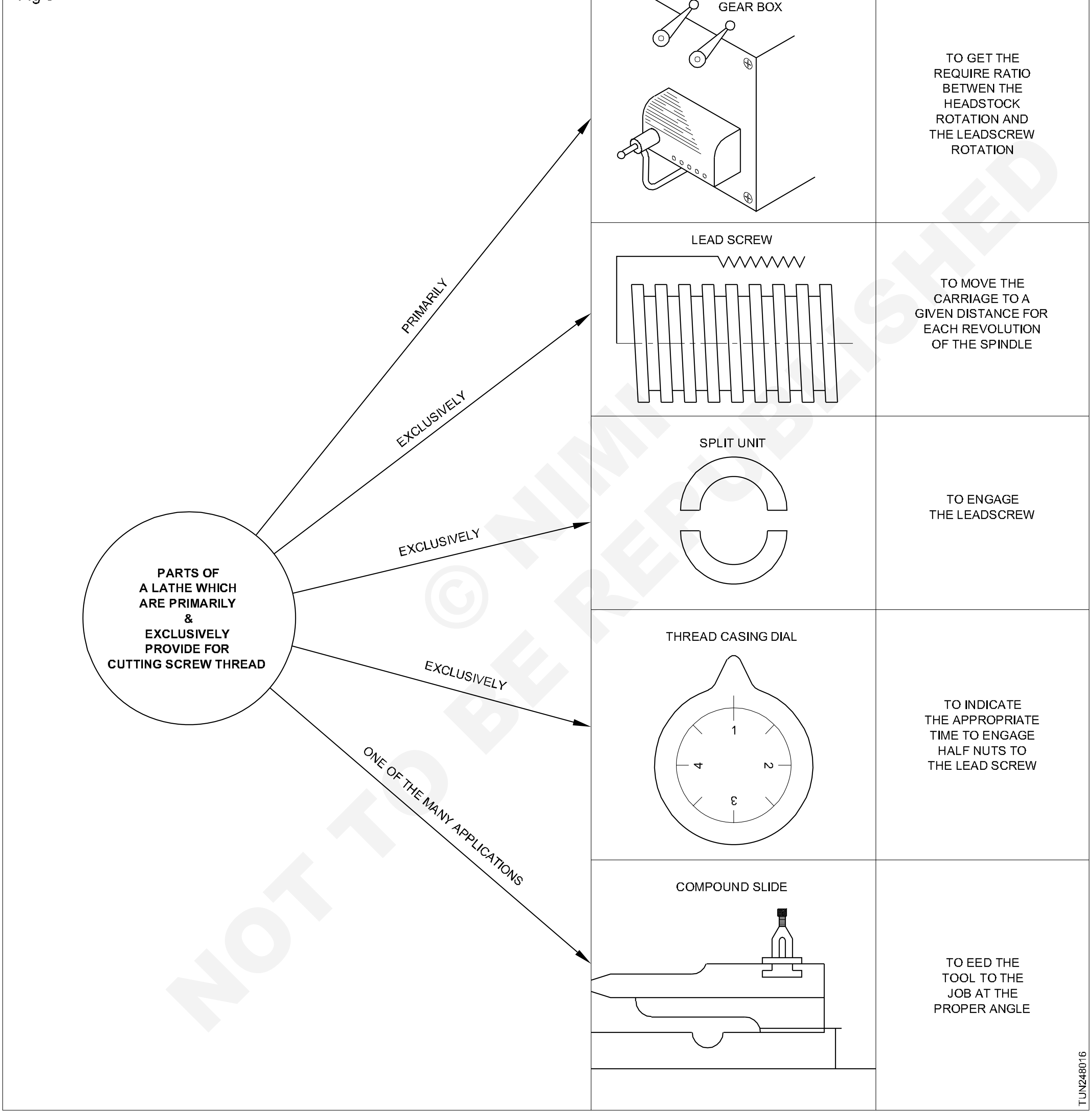
$d_2 = D_2 = d - 0.75\ P$

$S = 0.314\ 99\ A_o$, where A_o = basic deviation (= upper deviation) for external thread in the pitch diameter.

Diagram of CNC machine indicating thread cutting sequences

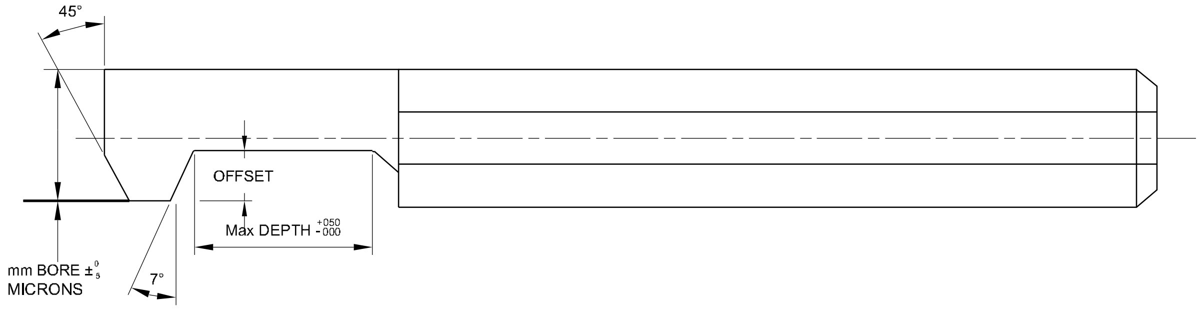
The sequence of thread cutting in CNC is explained in below

Fig 6



Internal Threading

Fig 1



BUTTRESS THREADING TOOL (FEMALE)

Buttress internal thread cutting is more demanding their external threading, due to threaded need to evacuate chips effectively. Chip evacuations especially in blind hole, os helped by used left hand tools for R.H. thread and vice versa (pull - threading) boring bar section has a strong influence on the quality of internal threading. Three types of bar can be used for internal threading.

Boring type	Max. overhang
Steel	2-3 x dW
Steel dampered	5 x dW
Carbide	5-7 x dW

dW = Borind bare dia

External threading can be produced in number of ways. The spindle can rotate clock wose or anticlock wise, with the tool fed towards or away from the chuck. The thread turning tool can be used in normal or upside down position (The later heaps in removal of clips). The internal and external thread cutting are indicated in the following sketches.

Important elements in tool grinding is the provision of flank clearance and radial clearance for precise and accurate threading.

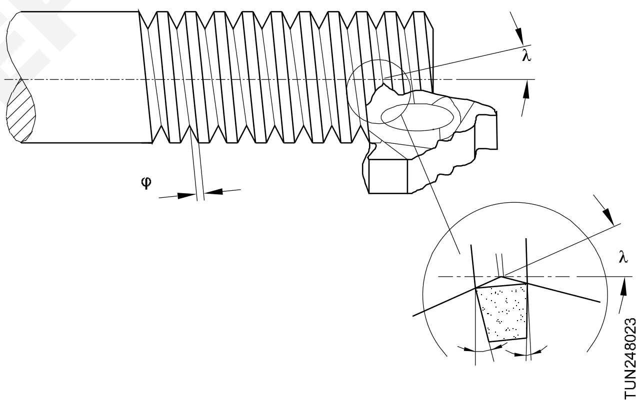
Flank clearance

The cutting edge clearance between the sides of the inserts and thread flank a figure indicating side clearance and flank clearance is shown in the sketch.

Butters thread is designed to handle externally high axial thread in one direction. The lead bearing thread face is perpendicular to screw axis.

Buttress thread often used in the construction of artillery particularly with screw type breech block. They are also used in vices and in the form of pipe thread in oil fixed tubing. This thread gives a tight hydraulic seal.

Fig 3



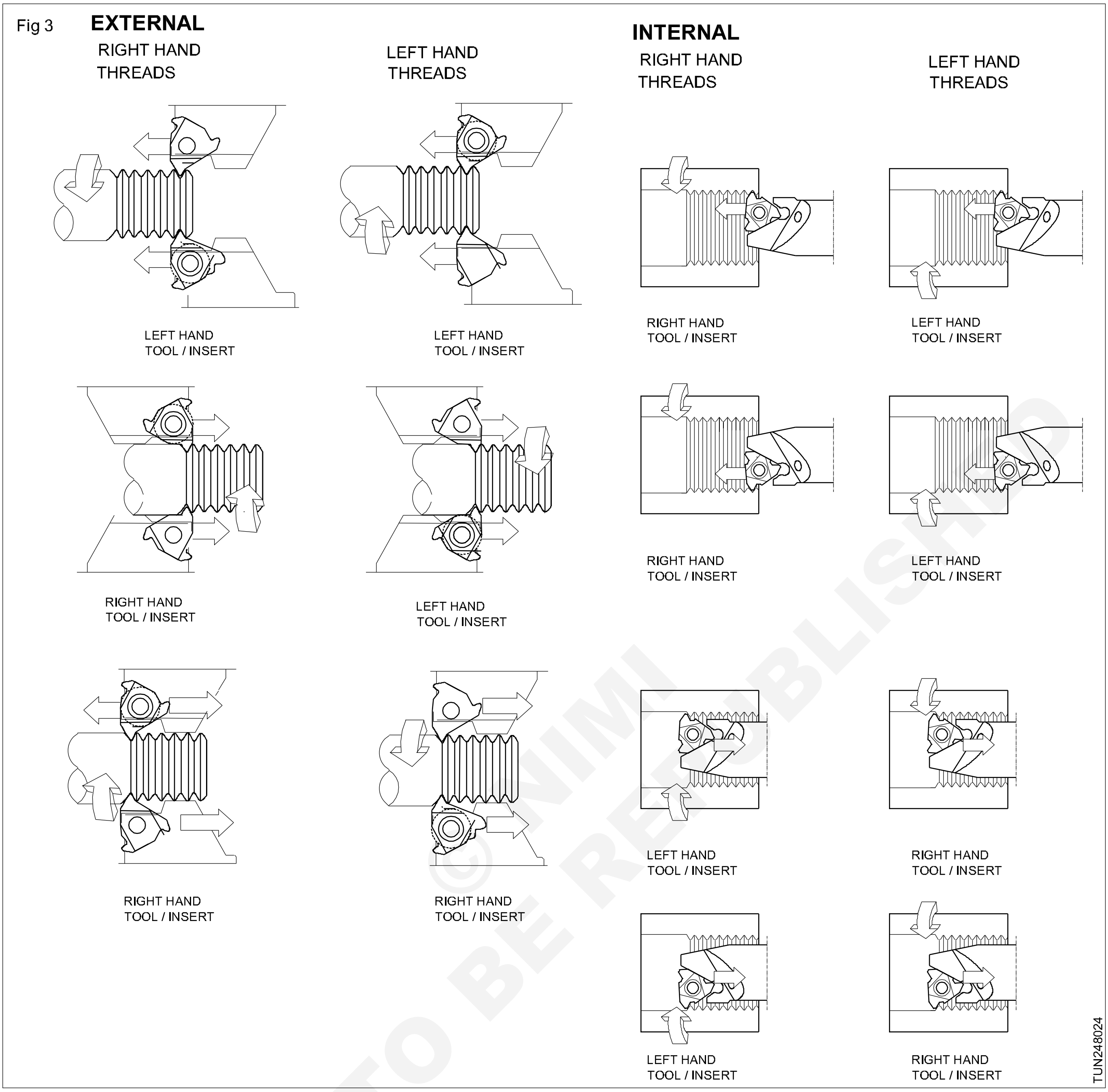


Fig 3
EXTERNAL
RIGHT HAND THREADS
LEFT HAND THREADS
INTERNAL
RIGHT HAND THREADS
LEFT HAND THREADS
LEFT HAND TOOL / INSERT
LEFT HAND TOOL / INSERT
RIGHT HAND TOOL / INSERT
LEFT HAND TOOL / INSERT
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Lubrication-function, types, source & method of lubrication

Objectives : At the end of this lesson you shall be able to
- **state the purpose of using lubricants**
- **state the properties of lubricants**
- **state the qualities of a good lubricant**

With the movement of two mating parts of the machine, heat is generated. it is not controlled the temperature may rise resulting in total damage of the mating parts. Therefore a film of cooling medium, with high viscosity is applied between the mating parts which is known as a lubricant.

A 'lubricant' is a substance having an oily property available

in the form of fluid. semi-fluid, semi-fluid, or solid state it is

the lifeblood of the machine, keeping the vital parts in perfect condition and prolonging the life of the machine. It saves the machine and its parts from corrosion, wear and tear, and it minimises friction.

Purposes of using lubricants

- Reduces friction.
- Prevents wear.
- Prevents adhesion.
- Aids in distributing.
- Cools the moving elements.
- Prevents correction.
- Improves machine efficiency.

Properties of lubricants

Viscosity

It is the fluidity of an oil by which it can withstand high pressure or load without squeezing out from the bearing surface.

Oiliness

Oiliness refers to a combination of wet ability, surface tension and slipperiness. (The capacity of the oil to beave an oily skin on the metal).

Flash point

It is the temperature at which the vapour is given off from the oil (it decomposes under pressure soon).

Fire point

Its is the temperature at which the oil catches fire and continues to be in flame.

Pour point

The temperature at which the lubricant is able to flow when poured.

Emulsification and de-emulsibility

Emulsification indicates the tendency of an oil to mix intimately with water to form a more or less stable emulsion. De-emulsibility indicates the readiness with which subsequent separation will occur.

Types of lubricant

Objectives : At the end of this lesson you shall be able to
- **state base of lubricant**
- **state sources of lubricant.**

Sources of lubricant:

Paraffin base has high lubricating oil content with high pour point with high viscosity index.

Asphalt base: this has a low lub-oil content with a low pour point and low viscosity index.

It is therefore important to subject lubricating oils refined from paraffin and asphalt base to various treatment to improve their properties suitable for blending produce wide range of lub-oils.

Mineral oils:

This is gotten by refining or through distillation of crude oil. (Paraffin or asphalt base). It most important property is viscosity and must have it is the lowest value for satisfactory under all conditions especially in load seed and temperature differences.

Synthetic oils:

Silicons possess the properties of synthetic oils. They are useful where. viscosity is almost independent of temperature. Example is gas turbine machine which is usually very expensive.

Grease:

Greases are semisolid lubricant which has high viscosity with filler and metallic soap. The filler enable grease to with stand shock and heavy loads. The soap include metal base like calcium, sodium with fatty or vegetables oil fillers, lead, zine, graphite or molybdenum disulphide

Grease properties is seen as it act as a real lubricant useful is accessing difficult areas or parts and large clearance it has a continuous lubricating ability.

Vegetable and Animal oils:

Fallow, whale, cod-liver, castor and olives oils belongs to this family but they are unsuitable at usual operating conditions especially temperature. They are used in grease and as additives to mineral oils to give improved boundary lubrication.

Solids:

Graphite, tale molybdenum disulphide are good source of the king of lubricant. They are difficult to apply may be suspended in a fluid when being used and are useful for high operating temperature.

Water:

They are used in steel, rubber or steel plastic bearings e.g. water.

Lubricated stern bearing with rubber bearing surfaces or impregnated plastic resin compounds.

Gases:

Gases like air and Co2 are used when liquids are not allowed. It has very low viscosity and more suitable for hydrostatic lubrication.

Classification of lubricants

Objectives : At the end of this lesson you shall be able to
- **state solid lubricants and their application**
- **state liquid and semi-liquid lubricants and their application**
- **state the classification of lubricants as per Indian Oil Corporation.**

Lubricants are classified in many ways. According to their state, lubricants are classified as:

- solid lubricants
- semi-solid or semi-liquid lubricants
- liquid lubricants.

Solid lubricants

These are useful in reducing friction where an oil film cannot be maintained because of pressure and temperature. Graphite, molybdenum disulphide, tale, wax, soap-stone, mica and French chalk are solid lubricants.

Semi-liquid or semi-solid lubricants

Greases are semi-liquid lubricants of higher viscosity than oil. Greases are employed where slow speed of heavy pressure exists. Another type of application is for high temperature components, which would not retain liquid lubricants.

Liquid lubricants

According to the nature of their origin, liquid lubricants are classified into:

- mineral oil
- animal oil
- synthetic oil.

According to the product line of Indian Oil Corporation the lubricants are classified as:

- automotive lubricating oils
- automotive special oils
- rail-road oils
- industrial lubrication oils
- metal working oils
- industrial special oils
- industrial greases
- mineral oils.

For industrial purposes the commonly used lubricants for machine tools are:

- turbine oils
- circulation and hydraulic oils (R & O Type)
- circulating and hydraulic oils (anti-wear type)
- circulating oil (anti-wear type)
- special purpose hydraulic oil (anti-wear type)
- fire-resistant hydraulic fluid
- spindle oil
- machinery oils
- textile oils
- gear oils
- straight mineral oils
- morgan bearing oils
- compressor oils.

In each type, there are different grades of viscosity and flash point. According to the suitability, lubricants are selected using the catalogue.

Example 1

Spindle oils are graded according to their viscosity and flash point.

Servospin - 2

Servospin - 5

Servospin - 12

Servospin - 22

Servospin oils are low viscosity lubricants containing anti-wear, anti-oxidant, anti-rust and anti-foam additives. These oils are recommended for lubrication of textile and machine tool spindle bearings, timing gear, positives displacement blowers, and for tracer mechanism and hydraulic system of certain high precision machine tools.

Example 2

Gear oils are graded according to their viscosity and flash point.

Servomesh - 68

Servomesh - 150

Servomesh - 257

Servomesh - 320

Servomesh - 460

Servomesh - 680

Servomesh oils are industrial gear oils blended with lead and sulphur compounds. These oils provide resistance to deposit formation, protect metal components against rust and corrosion, separate easily from water and are non-corrosive to ferrous and non-ferrous metals.

These oils are used for plain and anti-friction bearings subjected to shock and heavy loads, and should be used in system where the operating temperature does not exceed 90° C. These oils are not recommended for use in food processing units.

Servomest A-90 is a litumenous product which contains sulphur-lead type and anti-wear additive. It is specially suitable for lubrication of heavily leaded low-speed open gears.

Servomesh - SP 68

Servomesh - SP 150

Servomesh - SP 220

Servomesh - SP 257

Servomesh - SP 320

Servomesh - SP 460

Servomesh - SP 680

Servomesh SP oils are extreme pressure type industrial gear oils, which contain sulphur-phosporous compounds and have better thermal stability and higher oxidation resistance compared to conventional lead-napthenate gear oils.

These oils have good de-emulsibilty, now foaming tendency and provide rust and corrosion protection to metal surfaces. These oils are recommended for all heavy duty enclosed gear drives with circulation or splash lubrication system operating under heavy or shock load conditions up to a temperature of 110° C.

Lubricating System

Objective : At the end of this lesson you shall be able to
- **state the methods of applying a lubricant.**

There are 3 systems of lubrication.

- Gravity feed system
- Force feed system
- Splash feed system

Gravity feed

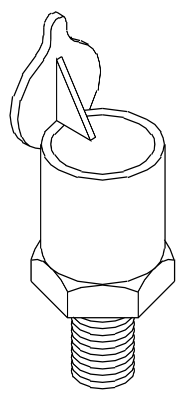
The gravity feed principle is employed in oil holes, oil cups and wick feed lubricators provided on the machines. (Fig 1 & 2)

Force Feed/Pressure Feed

Oil, grease gun and grease cups

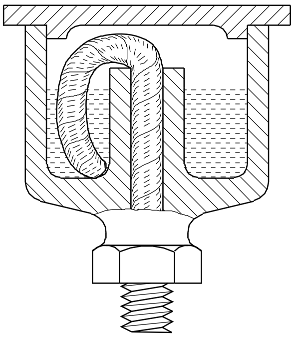
The oil hole or grease point leading to each bearing is fitted with a nipple, and by pressing the nose of the gun against this, the lubricant is forced to the bearing. Greases are also force fed using grease cup. (Fig 3)

Fig 1



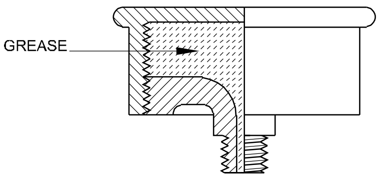
OIL CUP

Fig 2



WICK FEED

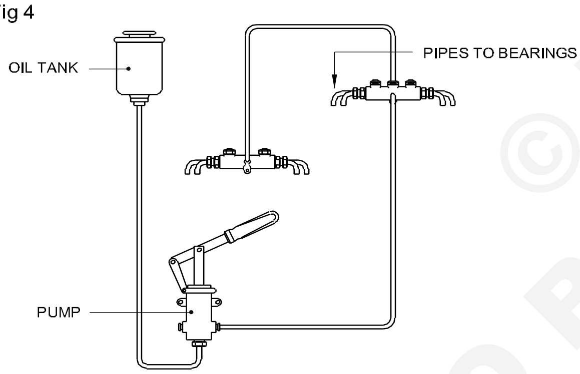
Fig 3



MANUAL SCREW DOWN GREASER

Oil is also pressure fed by hand pump and a charge of oil is delivered to each bearing at intervals once or twice a day by operating a lever provided with some machines. (Fig 4) This is also known as shot lubricator.

Fig 4



HAND PRESSURE FEED (ONE SHOT)

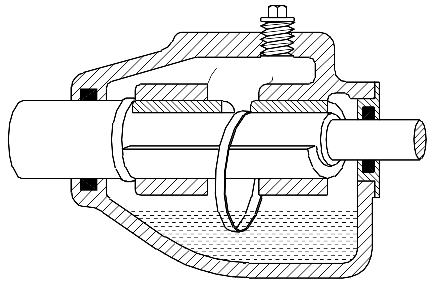
Oil pump method

In this method an oil pump driven by the machine delivers oil to the bearings continuously, and the oil afterwards drains from the bearings to a sump from which it is drawn by the pump again for lubrication.

Splash lubrication

In this method a ring oiler is attached to the shaft and it dips into the oil and a stream of lubricant continuously splashes around the parts, as the shaft rotates. The rotation of the shaft causes the ring to turn and the oil adhering to it is brought up and fed into the bearing, and the oil is then led back into the reservoir. (Fig 5) This is as known as ring oiling.

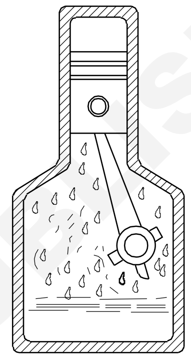
Fig 5



RING OILING

In other systems one of the rotating elements comes in contact with that of the oil level and splash the whole system with lubricating oil while working. (Fig 6) Such systems can be found in the headstock of a lathe machine and oil engine cylinder.

Fig 6



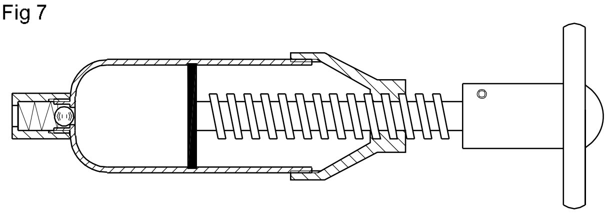
SPLASH-LUBRICATING SYSTEM

Types of grease guns

The following types of grease guns are used for lubricating machines.

- ‘T’ handle pressure gun (Fig 7)

Fig 7



T-HANDLE PRESSURE GUN

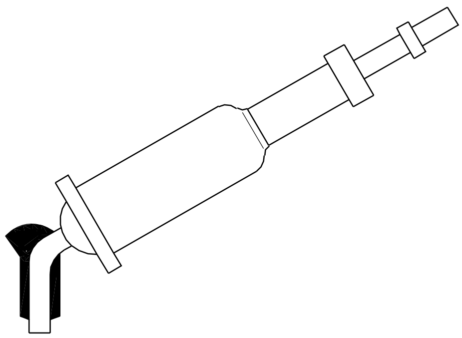
- Automatic and hydraulic type pressure gun (Fig 8)
- Lever-type pressure gun (Fig 9)

Lubrication to exposed slideways

The moving parts experience some kind of resistance even when the surface of the parts seems to be very smooth.

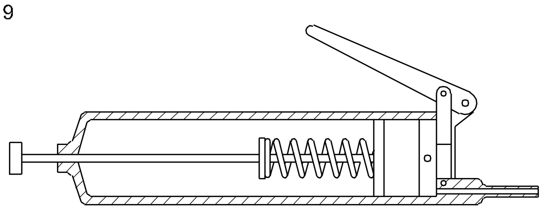
The resistance is caused by irregularities which cannot be detected by the naked eyes.

Fig 8



AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

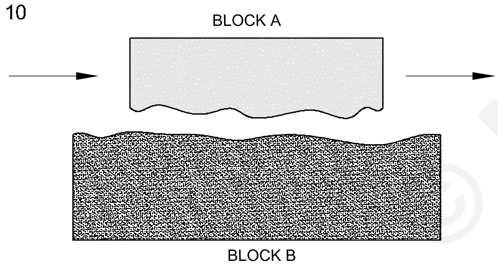
Fig 9



PRESSURE GREASE GUN

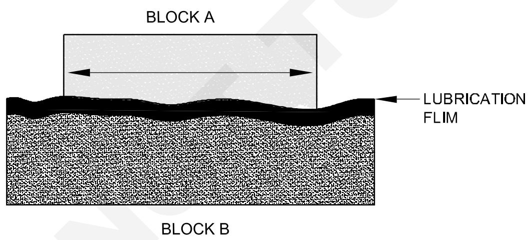
Without a lubricant the irregularities grip each other as shown in the diagram. (Fig 10)

Fig 10



With a lubricant the gap between the irregularities fills up and a film of lubricant is formed in between the mating components which eases the movement. (Fig 11)

Fig 11



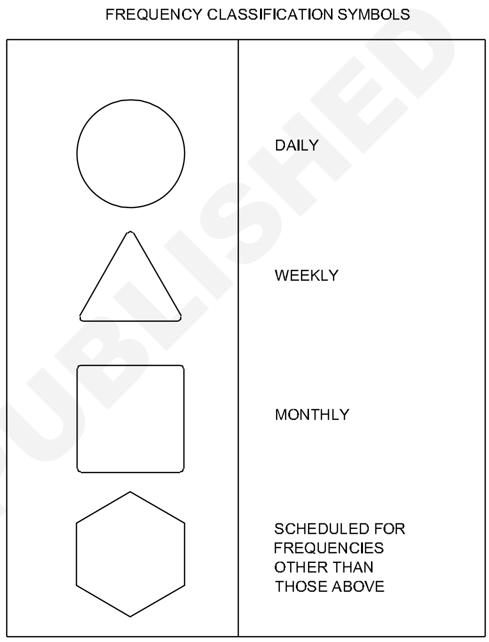
Hints for lubricating machines

- identify the oiling and greasing points
- select the right lubricants and lubricating devices
- apply the lubricants.

The manufacturer's manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer's manual.

These places are indicated in the maintenance manuals with symbols as shown in Fig 12.

Fig 12



The best guarantee for good maintenance is to follow the manufacturer's directives for the use of lubricants and greases. Refer to the Indian Oil Corporation chart for guidance. The commonly used oils in the workshop is given in Annexure I.

The lubricant containers should be clearly labelled. The label must indicate the type of oil or grease and the code number and other details. Oil containers must be kept in the horizontal position while the grease container should be in the vertical position.

Industrial lubrication oils

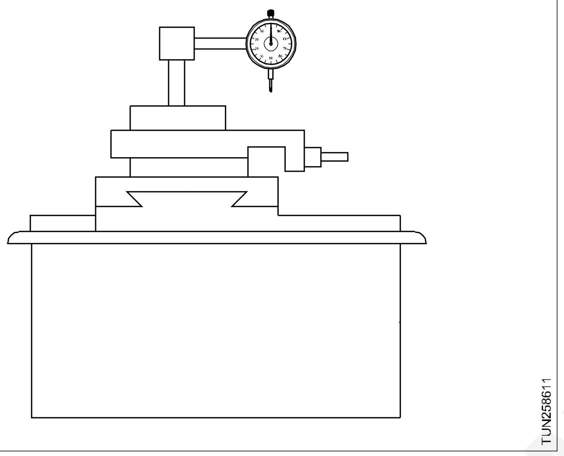
Product	Kinematic viscosity Cst at 40°C	VI	Flash point COC°C	Description/Application
General Purpose Machinery Oils Lubrex 57 Lubrex 68	 54.60 64.72	 - -	 160 160	Lubrex oils are low viscosity index straight mineral lubricants having good inherent oxidation stability; they protect machine elements from excessive wear and provide economical lubrication. These oils are recommended for lubrication of bearings, open gears, lightly loaded slides and guideways of machine tools.
Flushing Oil Lubrex Flush 22	 19.22	 -	 150	Lubrex Flush 22 is a light coloured, low viscosity, straight mineral oil specially developed for slushing of automotive and industrial equipment. The characteristics of Lubrex Flush 22 make it possible to easily clean all inacessible internal surfaces of various equipments.
Circulating and Hydraulics Oils (Anti-wear Type) Servosystem 32 Servosystem 57 Servosystem 68 Servosystem 81 Servosystem 100 Servosystem 150	 29.33 55.60 64.72 78-86 95-105 145-155	 95 95 95 90 90 90	 196 210 210 210 210 230	Servosystem oils are blended from highly refined base stocks and carefully selected anti-oxidant, anti-wear, anti-rust and anti-foam additives. These oils have long service life, and are recommended for hydaulic systems and a wid of circulation systems of industrial and automotive equipment. These oils are also used for compressor crank case lubrication, but are not recommended for lubrication of turbines and equipment having silver coated components.
Spindle Oils Servospin 2 Servospin 5 Servospin 12	 2.0-2.4 4.5-5.0 11-14	 - - 90	 70 70 144	Servospin oils are low viscosity lubricants containing anti-wear, anti-oxidant, anti-rust and anti-foam additives. These oils are recommended for lubrication of textile and machine tool spindle bearings, timing gears, positive displacement blowers, and for tracer mechanism and hydraulic systems of certain high precision machine tools.
Machinery Oils Servoline 32 Servoline 46 Servoline 68	 29.33 42.50 64.-72	 - - -	 152 164 176	Servoline oils provide good oiliness for general lubrication even under boundary lubrication conditions, protect parts gaingst rust and corrosion and maintain thin film strength and anti-rust additives. Servoline oils are general purpose lubricants for all loss lubrication systems of textile mills, paper mills, machine tools.
Gear Oils Servomesh 68 Servomesh 150 Servomesh 257	 64-72 145-155 250-280	 90 90 90	 204 204 232	Servomesh oils are industrial gear oils blended with lead and sulphur compounds. These oils provide resistance to desposit formation, protect metal components against rust and corrosion, separate easily from water and are non-corrosive to ferrous and non-ferrous metals. Servomesh oils are recommended for lubrication of industrial gears, plain and anti-friction bearings subjected to shock and heavy loads and should be used in systems were operating temperature does not exceed

Dial Test indicator use for parallelism and concentricity

Objectives: At the end of this lesson you shall be able to
- **checking will movement of fail stock & alignment of the spindle**
- **test the coil stock sleeve movement relative to the carriage giving**
- **parallelism of bed and carriage movement.**

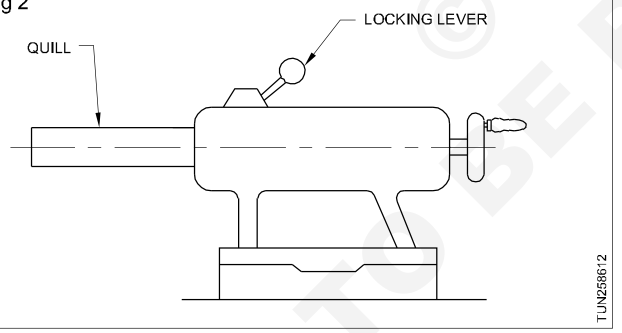
Fix the dial gauge on the carriage. (Fig 1)

Fig 1



Project the quill of the tailstock to the maximum extent possible and lock it. (Fig 2) Check the quill in the vertical and horizontal positions by a dial test indicator.

Fig 2



Clamp the quill during each measurement. If it is not clamped it will affect the measurement.

Place the dial plunger to contact over the free end of the quill in the vertical plane. (Fig 3)

Ensure that the dial is set at the topmost point of the quill.

Set the dial at the zero position. (Fig 4)

Move the carriage slowly towards the entire length of the quill. (Fig 5)

Note the dial reading at the extreme end of the quill.

Verify the deflection of the dial reading and compare the value with the test chart supplied. (IS: 6040)

For checking in the horizontal plane, set the dial horizontally and repeat the above procedure. (Fig 6)

Fig 3

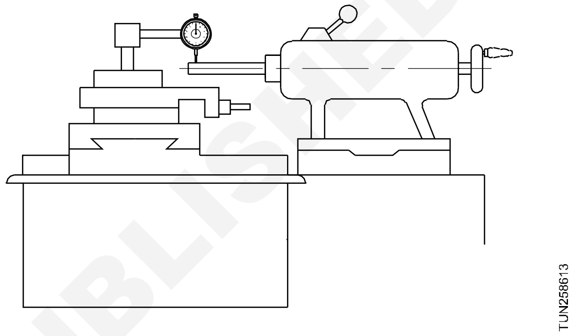


Fig 4

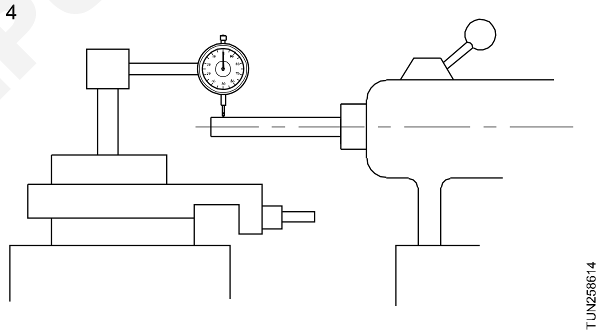
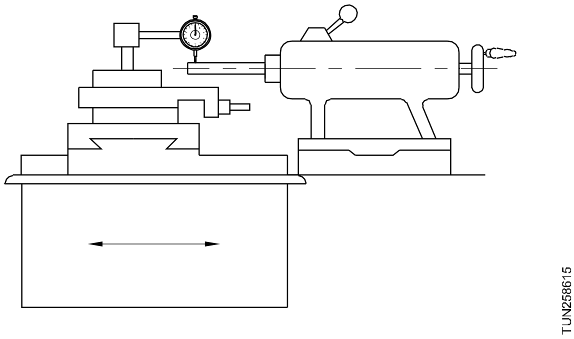


Fig 5



Fix the test mandrel into the tailstock spindle. Repeat the same procedure to test the accuracy of the tailstock spindle bore in the vertical and horizontal positions as shown in the figure.

Insert a hollow test mandrel (300 to 500 mm long) in between the centres. (Fig 6)

Ensure that the spindle bearing is at its working temperature.

Fix the dial gauge on the saddle, the plunger touching a position of the mandrel and set it to zero.(Fig 7)

Fig 6

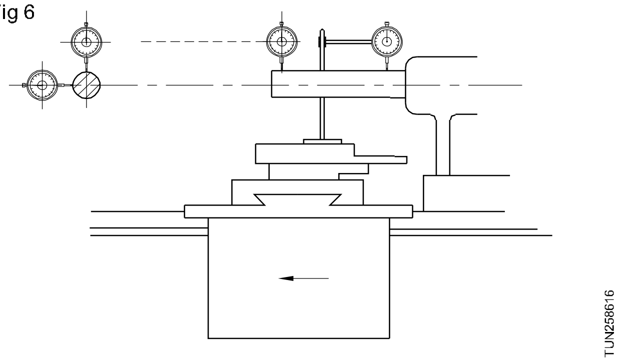
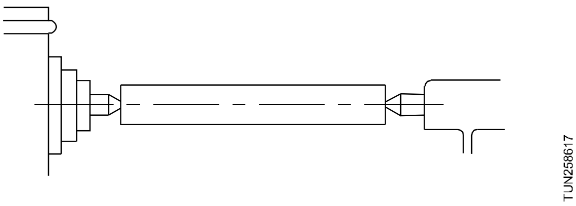


Fig 7

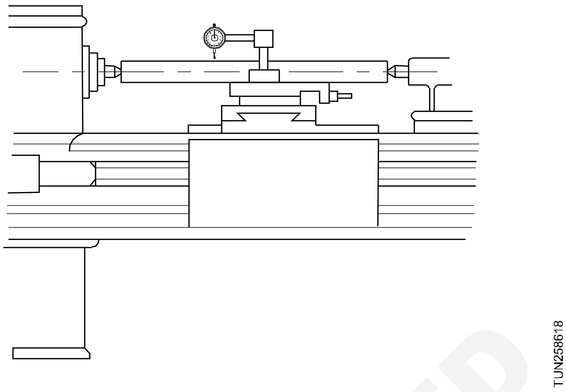


Move the carriage from one end to the other end of the mandrel to check the mandrel is in correct alignment in the horizontal position.

Rest the dial plunger at right angles (radially) to the surfaces to be tested.

Set the dial plunger at the top of the mandrel and move the saddle along the bed slowly to the entire length of the mandrel. (Fig 8)

Fig 8

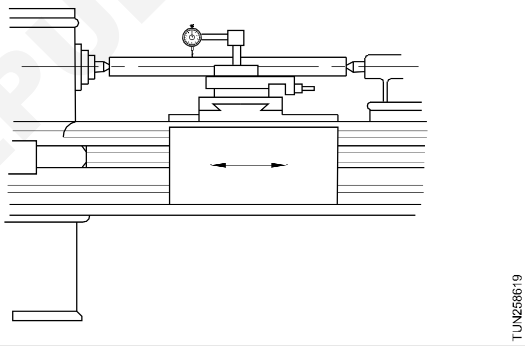


Observe the reading of the dial as the saddle moves along the beds and note for variation, if any.

The tailstock centre must be higher than the spindle centre within the permissible limit.

Verify the deflection of the dial gauge reading and compare the value with the test chart. (IS: 6040)

Fig 9



Checking the true running of a spindle

Objective: This shall help you to

- **test the true running of a lathe spindle with a test mandrel.**

Locate the taper shank of the test mandrel in the spindle taper.

Hold a dial gauge, stationary in the carriage, its plunger contacting the mandrel near its free end (Fig 1) and set it to '0' position.

Rest the dial gauge plunger at right angles (radially) to the surface to be tested.

Rotate the spindle along with the mandrel slowly by hand.

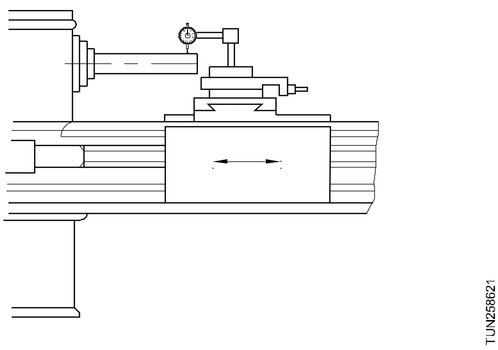
Observe and note the reading of the dial gauge.

Move the dial gauge near the spindle nose. Rotate the spindle along with the mandrel slowly by hand and note the reading.

Take readings of the dial gauge while the spindle is slowly rotated. Verify the deflection of the dial reading and compare the value with the test chart. (IS: 6040)

Adjustment of the spirit level with the plane surface

Fig 1



Grinding wheel - abrasive, grit, grade and bond

Objectives: At the end of this lesson you shall be able to
- **name the two abrasives used to manufacture grinding wheels**
- **identify and name the bonds used during the manufacture of grinding wheels**
- **state the cutting action of an abrasive wheel**
- **specify a grinding wheel as per B.I.S.**
- **state the factors which affect the selection of abrasive wheels.**

Satisfactory results can be obtained only by having the right type of abrasive wheel rotating at the correct speed for the kind of work that is to be ground.

Abrasive wheels are made from manufactured abrasive grains, held together by a suitable binding material called the bond.

The two abrasives used in the manufacture of grinding wheels are:

- aluminium oxide
- silicon carbide.

The aluminium oxide grinding wheels are suitable for grinding high tensile, tough materials, and all types of steels.

The silicon carbide grinding wheels are used to grind hard materials, such as, stone or ceramics, non-ferrous metals and other non-ferrous materials.

The type of the abrasive is clearly marked on an abrasive wheel by the manufacturer.

The bond

Abrasive particles in a grinding wheel are held together by a material called the bond.

The bond may be:

- vitrified
- silicate
- organic.

Vitrified bonds produce strong rigid grinding wheels that are not affected by water, acid or normal temperature changes. Most of the abrasive wheels are produced with vitrified bonds.

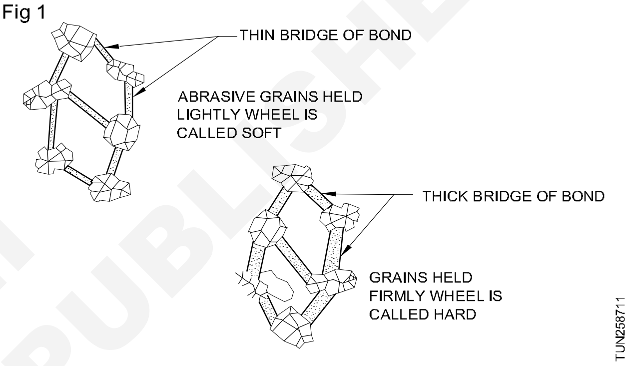
A silicate bond produces a wheel with a milder cutting action than a vitrified bonded wheel. Large diameter wheels have a silicate bond.

The organic bonds may be made of:

- resinoid
- bakelite
- rubber
- shellac.

The organic bonded wheels have a safe higher operating speed. They are better able to withstand rough usage. They are used on portable grinders and for rough foundry work. Thin cut-off wheels are made with an organic bond. (Fig 1)

Fig 1



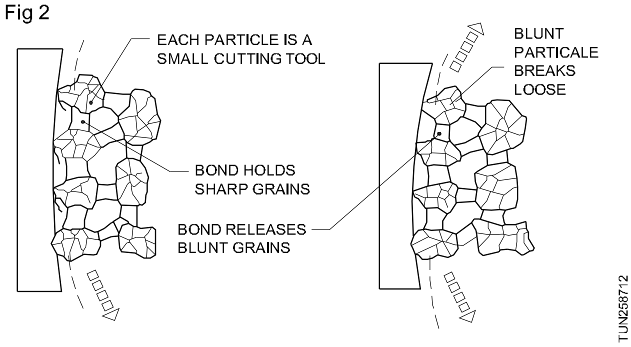
Degree of bond

The bond holds the abrasive particles together and supports them while they cut. The degree of bond determines whether the abrasive grains are held lightly or firmly.

A wheel is said to be 'soft' only when a thin bridge of bond holds the abrasive grains together so that the grains break away. A wheel is said to be 'hard' when a thick bridge of bond holds the grains firmly.

> **It is the amount or grade of bond that determines the 'hardness' or 'softness' of an abrasive wheel.**

Fig 2



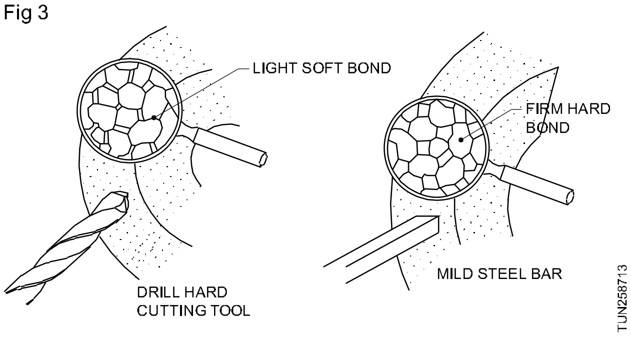
Cutting action of an abrasive wheel

The cutting action of a grinding wheel depends to a large extent on the grade of bond of the wheel. The principle is that the individual abrasive grains are small cutting tools.

The bond must be such that it must hold the grinding particles together when they are sharp, and must release them when they become blunt so that new sharp grains take their place to continue the cutting. This continuous process is known as the cutting action of the wheel. (Fig 2)

Use 'soft' light bond wheels to grind hard materials, and 'hard' firm bond wheels to grind soft materials. (Fig 3)

Fig 3



Abrasive wheel specification

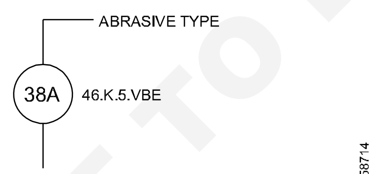
A standard marking system is used to specify and identify grinding wheels.

The following is the sequence of arrangement.

- Abrasive type
- Structure
- Grain size
- Bond type
- Grade of bond

Abrasive type (Fig 4)

Fig 4



ALUMINIUM OXIDE FOR GRINDING HSS CUTTING TOOLS

Letters are used to identify each of the two types of abrasives.

They are:

- 'A' for aluminium oxide
- 'C' for silicon carbide.

The manufacturer may use a number in front of this letter to designate a particular variation of each type.

Examples

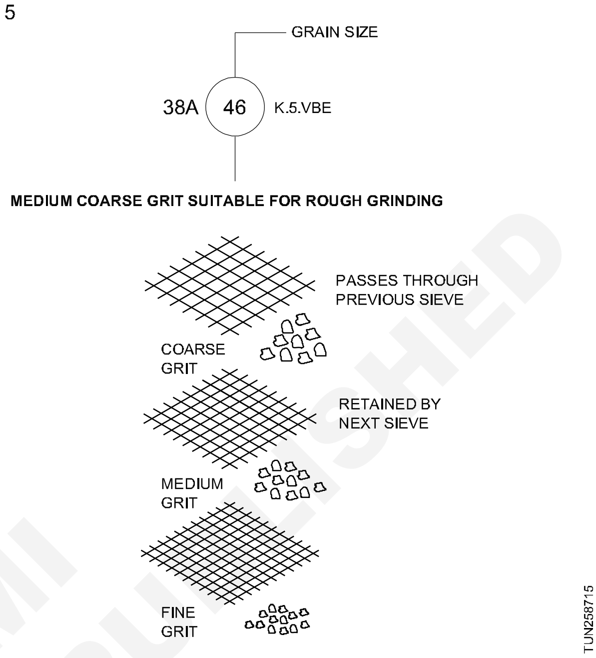
38 A is an aluminium oxide abrasive designed for grinding high speed steel cutting tools.

39C is a silicon carbide abrasive designed for grinding cemented carbide tools.

Grain size (Fig 5)

Grain or grit size is the actual size of the abrasive grain. The abrasive particles are graded by passing through sieves of various sizes. They are indicated by a number ranging from 10 (coarse) up to 600 (very fine). Generally a fine grit wheel gives a smooth surface and is used for finishing work.

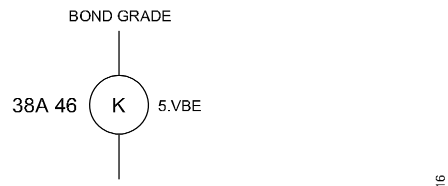
Fig 5



Grade of bond (Fig 6)

The grade or amount of bond in an abrasive wheel is indicated by a letter of the alphabet. The grades range from 'A' indicating a light or 'soft' bond to 'Z' indicating a firm or 'hard' bond. The grade of bond selected for a particular job would be one that produces the most satisfactory cutting action from the wheel.

Fig 6



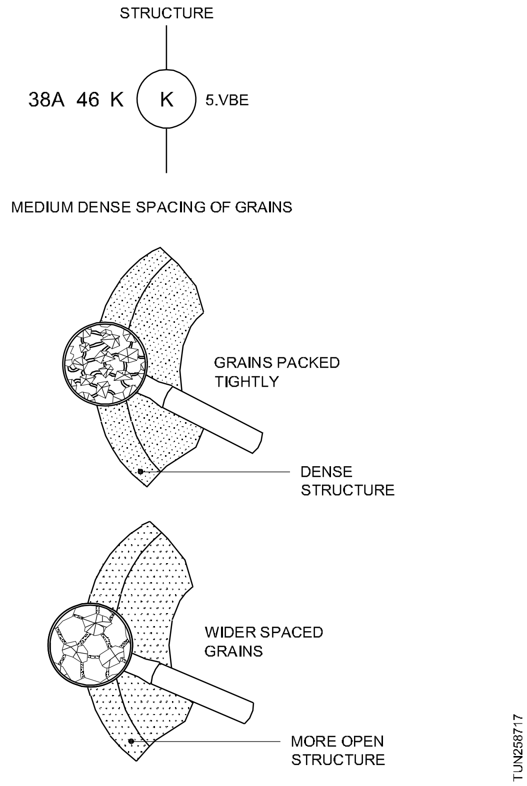
MEDIUM SOFT BOND TO ALLOW BLUNT PARTICLES TO BREAK OUT READLY (SOFT WHEEL)

Structure

The structure of an abrasive wheel is the spacing of the abrasive grains. An abrasive wheel can be manufactured with the abrasive grains tightly packed together or widely spaced. This structure is indicated by a number from 1 to 12. The higher numbers indicate a progressively more open structure.

The structure number need not be shown on the wheel markings. (Fig 7)

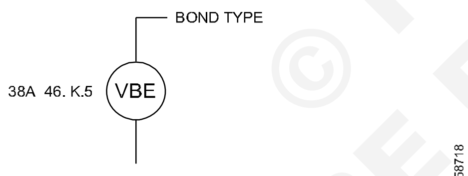
Fig 7



Bond type

A letter is used to indicate the type of material or the process used for the bond of the wheel. (Fig 8)

Fig 8



VITRIFIED TYPE OF BOND WITH A BOND VARIATION

V Vitrified

S Silicate

B Resinoid

R Rubber

E Shellac

O Oxychloride

Wheel marking

An abrasive wheel suitable for the rough grinding of a steel casting would be marked

A 16 P.5 V BE.

The expansion of the separate components would be:

A Aluminium oxide abrasive

16 Coarse grain size

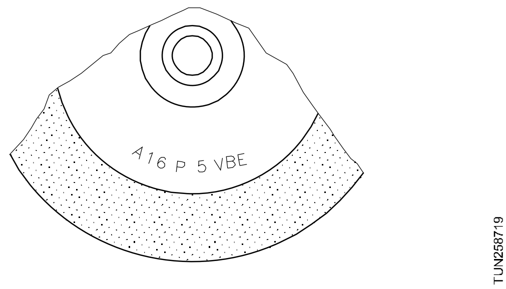
P Medium to hard grade of bond

5 Medium to dense structure

V Vitrified bond

BE Manufacturer's particular bond characteristic. (Fig 9)

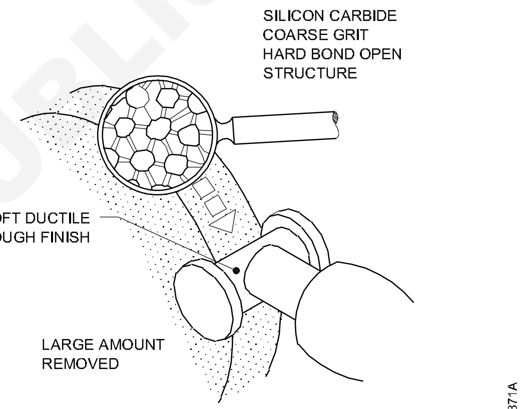
Fig 9



Factors for selecting an abrasive wheel for a particular job

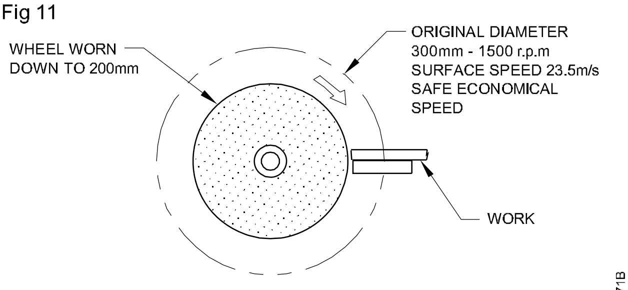
- The kind of material to be ground. (Fig 10)
- The amount of material to be removed. (Fig 10)
- The surface finish required.
- The type and condition of the machine.
- The wheel speed.(Fig 11)

Fig 10



DRESSING A BRASS CASTING

Fig 11



1500R.P.M - SURFACE SPEED NOW 15.7m/s
SPEED TOO SLOW WHEEL WEARS RAPIDLY

Defects in grinding wheel

Objectives: At the end of this lesson you shall be able to
• state the problems which may arise relating to the surface of the wheel
• identify each one of the problems and state the effects.

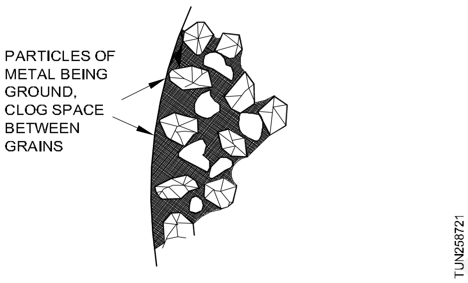
The problems which may arise relating to the surface of the grinding wheels by grinding are:

- loading
- glazing
- grooving
- out-of-round.

Loading

Small particles of the material being ground become embedded in the space between the grains of the wheel. The surface of the wheel becomes clogged or loaded. This reduces the cutting efficiency of the wheel. (Fig 1)

Fig 1



A loaded wheel can be easily recognized, and the first indications will be:

- a rapid reduction of the cutting action of the wheel
- normal pressure of the work against the wheel has little effect
- the volume of sparks produced by the wheel is reduced.

An increased pressure of the work against the wheel results in:

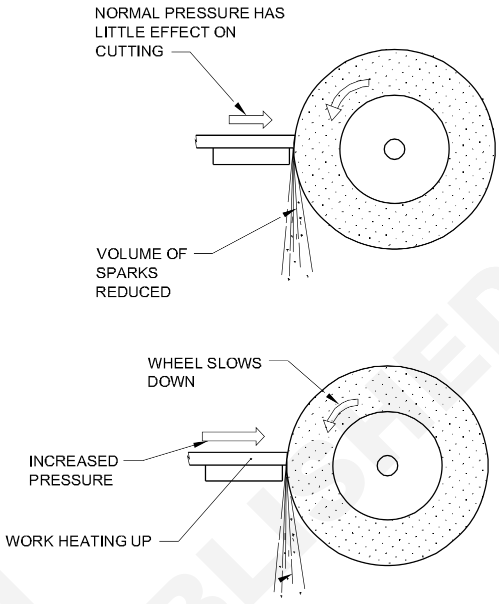
- the work heating up
- a slowing down of the wheel, particularly on the smaller machines. (Fig 2)

When these symptoms become apparent stop grinding and switch off the machine.

When the wheel has stopped rotating by itself, look at the wheel face. See whether the surface is dotted and streaked with metallic particles. Often these particles will have built up on the surface, and will protrude above the wheel face. This accounts for the sudden loss of cutting action of the wheel. (Fig 3)

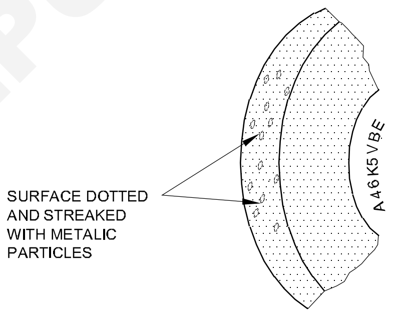
> **'Loading' is the result of using the wrong type of wheel for the material being ground.**
>
> **Refer to the manufacturer's reference handbook which gives the recommendations for wheel selection.**

Fig 2



EFFECTS OF LOADING

Fig 3



LOADED WHEEL

Glazing

Glazing is caused by grinding hard materials on a wheel that has too hard a grade of bond. The abrasive particles become dull owing to cutting the hard material. The bond is too firm to allow them to break out. The wheel loses its cutting efficiency. The symptoms of a glazed wheel are very similar to those of a loaded wheel. The inspection of the wheel face shows a smooth glassy appearance.

Glazing may be prevented by selecting a wheel with a softer grade of bond.

The manufacturer's handbook may be referred to for wheel selection for the job in hand. (Fig 4)

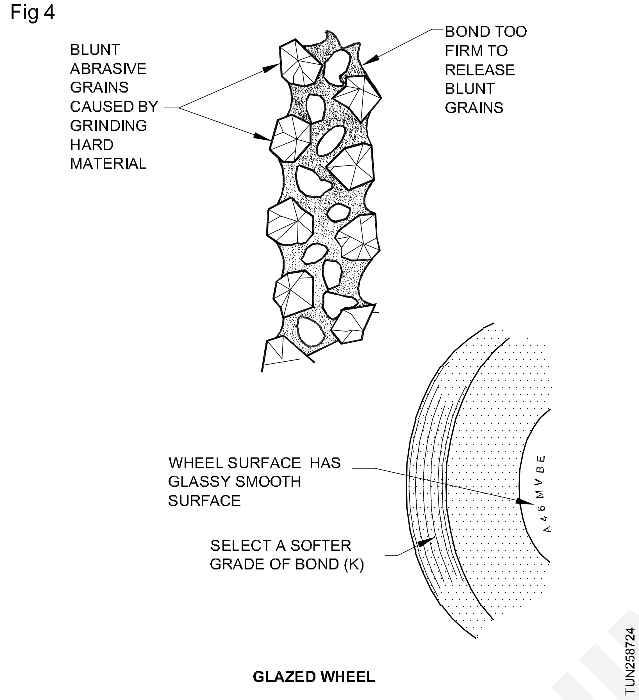
Grooving

Grooves are formed on the surface of the wheel by the wearing away of the wheel by the pressure that is being applied in one position.

Grooving may be prevented by moving the work across the full face of the wheel.

Avoid grinding on the outside edges of the wheel; otherwise, it results in rapid wear and causes a curved surface on the wheel. (Fig 5)

Fig 4



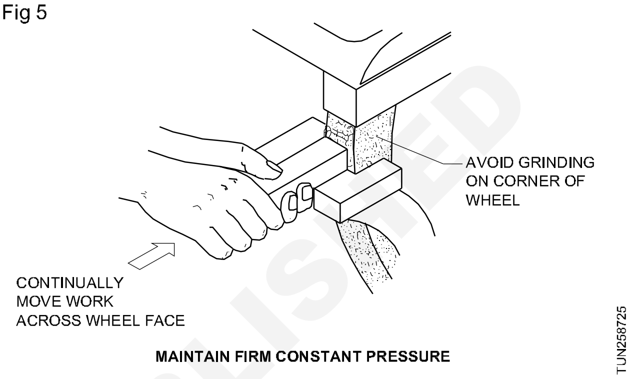
GLAZED WHEEL

Out-of-round

Uneven application, bumping or vibration of the work against the wheel will cause the wheel to wear out-of-round. It will lead to an out of balance condition. Applying even pressure and having the work well supported by the work-rest will help in preventing the wheel from becoming out-of-round.

Never attempt to perform heavy, rough grinding on a small bench grinder set-up for the sharpening of cutting tools.

Fig 5



MAINTAIN FIRM CONSTANT PRESSURE