GENERAL MACHINIST

PAPER - II

WORKSHOP ENGINEERING

VOCATIONAL EDUCATION

HIGHER SECONDARY - FIRST YEAR

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GENERAL MACHINIST

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PAPER - II
WORKSHOP ENGINEERING

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1. WORKSHOP ENGINEERING – SAFETY PRECAUTIONS

1.1 Introduction

In this era of technological revolution, modern machineries and industries show dramatic development. New techniques lead to new machines. In order to cater to the needs of our daily life, new machines are developed and find places in our house, office, commercial plazas, industry etc., Machines became a part of our life. We can see our daily life begins and ends with machines - from water-heater, grinder, refrigerator etc, Giant machines in the factories also fit the bill.

In order to satisfy the rising demands of the mankind, such machines are manufactured in large number. Machinists involve themselves in the process of mass production and avert any shortfall in the demand. Special trainings need to be given to machinists to make them aware of modern manufacturing techniques and special skill developing abilities.

A machine tool is a machine which is used in manufacturing process. An industry or a factory may have many machine tools such as lathes, drilling machines, shaping machines, milling machines and grinding machines. It may also have several types of hand tools and cutting tools involved in the production process.

Industries can be classified as small scale industry, medium scale industry and large scale industry according to the range of investments and production. All such industries need specially skilled machinists in achieving their target in production.

1.2 Machinist

A machinist can be defined as a person who has a complete knowledge of operating various machine tools and handling different hand tools. In the process of doing so, he makes components or machine parts of required size and shape from various materials.

1.2.1. Duties of a machinist

1. A machinist should have a complete and thorough knowledge of operating different machine tools.

2. He should know how to handle various hand tools and instruments.

3. He should have a complete knowledge of reading production drawings. He should understand the various notes given in the drawing and different symbols marked on the drawing. He will then analyse about the size and shape of the component or assembly, the material(s) used for manufacturing them and the method of production.

4. He should operate the machine tools in a proper manner providing periodical maintenance.

5. He should be able to provide appropriate cutting speed, feed and depth of cut according to the rigidity of the machine, nature of the material used for manufacturing and the type of cutting tool used.

6. He should provide wholesome support to the overall development of the industry he works in.

1.2.2. The role of a machinist in the growth of a country

1. The industrial growth depends solely on the capacity of qualitative and quantitative production. A machinist should keep this in mind and dedicate himself in achieving this.

2. A machinist performs his duties to meet his own ends. If the economical status of a worker or a machinist is better, the overall economical growth of the industry and the country are bound to be better.

3. The growth of industry increases the employment opportunities.

4. Any commodity when produced in lesser numbers, costs high. Increased production reduces the cost of the item. Reduced costs increase the number of consumers. Increased number of consumers is the index of growth of a country on real terms.

So, it is evident that the growth of industry or a workshop depends on the efficient and skilled machinists.

1.3. Accidents

Accidents can be called as an undesired event which takes place suddenly causing damages to human lives and materialistic loss. Accidents occur everywhere in factories, workplace, on roads and at home. The main reasons of accidents can be attributed to lack of carefulness and not correcting some minor faults or deficiencies.

1.3.1. Causes for accidents

In industries, accidents can be averted by placing proper attention on the activities that take place there. Some important causes for accidents are

1. Not possessing adequate experience in the task to be done
2. Showing sense of urgency in the work
3. Desire of making quick time money
4. Working with poor health
5. Lack of adequate rest or sleep
6. Improper handling of hand tools
7. Inadequate facilities in the workplace
8. Improper environment
9. Wearing improper attire
10. Incorrect holding of work pieces and tools in machines
11. Lack of focus, indolence
12. Unnecessary conversations and lack of attention on the work

1.4. Safety

Safety can be defined as an attitude to keep away damages or accidents from happening in a workshop by strictly following the precautions and conducting the activities in a careful manner.

The advent of new gadgets and machines are welcome to cater our needs. But at the same time, they bring dangers and potential of accidents along with them. Accidents take place at a regular basis in industries. Every human life is essential and invaluable. In order to prevent the loss of human lives, safety should be enforced at all costs. Safety is an attitude and working safely is a state of mind. A machinist should accept that safe working habits are important in keeping himself and others working alongside him away from accidents.

Safety in a workshop can be categorized under four headings. They are

1. General workshop safety precautions
2. Safety precautions regarding hand tools
3. Safety precautions regarding machine tools
4. Safety regarding operators

1.4.1. General Workshop safety precautions

1. The layout of machines in the workshop should be suitably done considering proper lighting and ventilation.

2. First- aid box containing proper medicine and instruments should be kept always ready in a workshop.

3. Inflammable materials should be kept in safe places with proper precautions.

4. Round and cylindrical objects, sharp articles and tools should not be found in pathways for it may cause injuries to the workers.

5. Oil and grease should not be found spilled inside the workshop.

6. Hot objects should be kept separately wherein messages like “HOT”, “DO NOT TOUCH” are displayed.

1.4.2 Safety precautions regarding hand tools

1. Files, hammers and screw drivers with proper handles alone should be put into use.

2. When hammers, chisels and punches are put into use, care should be taken that any oil, grease or metal chips present on their heads are cleaned completely.

3. Measuring instruments should be handled properly to increase their durability.

4. After use, measuring instruments should be kept safely in their respective covers.

5. Sharp tools and accessories should be kept in their covers or boxes safely.

6. The hand tools should be used for the specific purpose for which they are intended. They should not be substituted for some other tools, when proper tools are not available.

7. Hand tools should not be placed near machine tool when their usage is not necessary.

8. Marking and measuring should not be done on rotating and moving parts.

9. Tools having cutting edges like files, chisels and scarpers should not be grouped with other hand tools when storing.

10. Tools like file, try square and hacksaw frames should not be used as an hammer or a screw driver.

11. Hacksaw blades should not be given undue tightening when fitted on hacksaw frames.

12. The hand tools should not be placed on electrical equipments.

1.4.3. Safety precautions regarding machine tools

1. Proper packing pieces should be used while lifting or shifting machine tools.

2. Operators should work on machines which they are familiar with. When they choose to work on unfamiliar machines, accidents may take place.

3. The amount of parameters like feed, cutting speed and depth of cut should be selected according to the strength and rigidity of the machine tools.

4. Sharp tools should not be placed on machine tools.

5. Sudden failures and defects in the machines should not be corrected or attended by the operator himself. Proper technicians should be called for repair works.

6. The machines should be stopped immediately if any abnormal sound comes from them.

7. Placards showing the message “THE MACHINE IS OUT OF ORDER” should be placed near the machines which are breakdown or under repair.

8. The operator should not change the speed or lubricate when the machine is still functioning.

9. While erecting new machine tools, their weight, efficiency and speed are assessed and foundation bolts of sufficient strength should be installed.

10. The machine tools should be maintained properly. It should be monitored regularly for scheduled maintenance and periodical lubrication.

1.4.4 Safety precautions regarding operators

1. Operators should wear tight clothings. They should avoid wearing loose dresses.

2. Operator should not wear ties and bows while working.

3. The dress code of the operator does not allow him to wear small towel or clothes around his neck or on shoulders.

4. Operator should wear only leather footwear.

5. While performing operations like grinding, welding and chiseling, the operator should wear safety goggles.

6. Metal chips should not be cleaned with bare hands but with proper brushes.

7. Safety plates and equipments should be installed before the machine is set on for operation.

8. The operator should wear gloves while handling hot and sharp articles.

9. The operator should resist himself from changing the speed, marking or lubricating on functioning machines.

10. The operator should seek the help of others while handling heavy and fragile materials.

11. Strict code of discipline should be followed in the workshop. Running, playing and chatting with others are to be avoided in the workshop.

12. The operator should not rest his body on the machines at any time, when working on them.

13. The operator should prefer working on machines which are familiar to him.

14. The operator should not touch unsafe and un -insulated electrical wires.

1.5 First aid

So far, we have discussed about various factors to enforce safety and avoid accidents. At some times, the focus on safety may be missing due to some reason or other. In such circumstances, accidents may happen causing liabilities to the industry as well as to the operator.

Accidents may happen at anytime in a workshop. The affected or injured person should be provided with immediate medical attention before he is taken to a hospital. This treatment which is given on the spot is known as first aid.

Every factory or a workshop should be equipped with a doctor or a first aid assistant. Apart from this, all the operators should be given proper training in first aid. These measures will avoid heavy losses of lives.

Every workshop should have a first aid box always ready with proper medicine and instruments.

1.5.1 Materials to be found in a first aid box

1. Tincture iodine
2. Tincture Benzene
3. Dettol
4. Burnol
5. Boric powder
6. Meshed cloth
7. Cotton
8. Plaster
9. Small scissors
10. Knife
11. Small stirrer
12. Small wooden strips
13. Basin for washing eyes
14. Broad based beaker for mixing medicine

A wheel chair and a stretcher are also necessary for transferring the injured or affected person to a hospital.

QUESTIONS

I. A. Choose the correct option

1. The person who manufactures different parts is
   a. Supervisor b. Machinist c. Manager d. Foreman

2. First aid is
   a. a manufacturing process b. safety regarding operators
   c. immediate treatment given at the spot of accidents
   d. breakdown of machines

I. B. Answer the following questions in one or two words

1. How are industries classified ?
2. Mention any two duties of a machinist.

II. Answer the following questions in one or two sentences

1. Who is a machinist?
2. What is an accident?
3. What is safety?
4. What is known as first aid?
5. What are the medicines found in a first aid box?

III. Answer the following question in about a page.

1. What are the duties of a machinist?
2. Discuss the role of a machinist in the growth of a country?
3. What are the main causes for accidents?
4. List out the safety precautions regarding hand tools?
5. What are the safety precautions regarding machine tools?
6. What are the safety precautions regarding operators?

2. HAND TOOLS

2.1. Introduction

Different types of tools are used in fabricating various components of a machine or a machine tool. Tools are also useful in assembling or dissembling machine elements. Some other tools are used to measure dimensions, marking sizes and dimensions and cutting off undesired portions of materials. All these tools are known as hand tools. These hand tools serve as the nerve centre of workshops. Hand tools are very much necessary even in a modern workshop which has very accurate and precise machines.

Some of the hand tools are

1. Vise	2. File
3. Hacksaw frame	4. Try square
5. Scriber	6. Punch
7. Hammer	8. Surface plate
9. V block	10. Angle plate
11. Surface gauge	12. Parallel clamp
13. C Clamp	14. Spanner and wrench
15. Bearing puller	16. Tap set
17. Die and die holder	18. Scraper

The above tools can be broadly classified under following categories

1. Measuring tools
2. Marking tools
3. Cutting tools
4. Assembling and dismantling tools

2.2 Vise

Vise is generally used to hold workpieces when operations like drilling, filing, chiseling and hacksaw cutting are performed on them. Vise is a essential hand tool in a workshop. A workshop is complete only when it has different types of vises. There are several types of vises used according to the type of work to be performed, the shape & size of the work and the method of holding.

The types of vises are

1. Bench vise
2. Hand vise
3. Leg vise
4. Pipe vise
5. Pin vise
6. Tool maker's vise
7. Machine vise
8. Swivel vise
9. Universal vise

2.2.1. Bench vise

Bench vise is a tool which finds application in all workshops. It is useful in holding workpieces while doing works like filing, chiseling and hacksaw cutting. It is mounted on a bench by means of bolts and nuts. There are two jaws in a vise and they are 1. Fixed jaw and 2. movable jaw. Jaw plates are screwed on the faces of these two jaws. The gripping surfaces of the jaw plates are knurled for proper gripping of the work. The body of the vise is made of cast iron, and the jaws are made of tool steel. The handle is made of mild steel.

There is a screw arrangement to make the movable jaw move upto a desired point. When the handle is rotated, the screw which passes through a nut in the fixed jaw makes the movable jaw move. The movement is suitably adjusted according to the size of the work to be held. The size of the vise is specified by the maximum distance between the fixed and movable jaw.

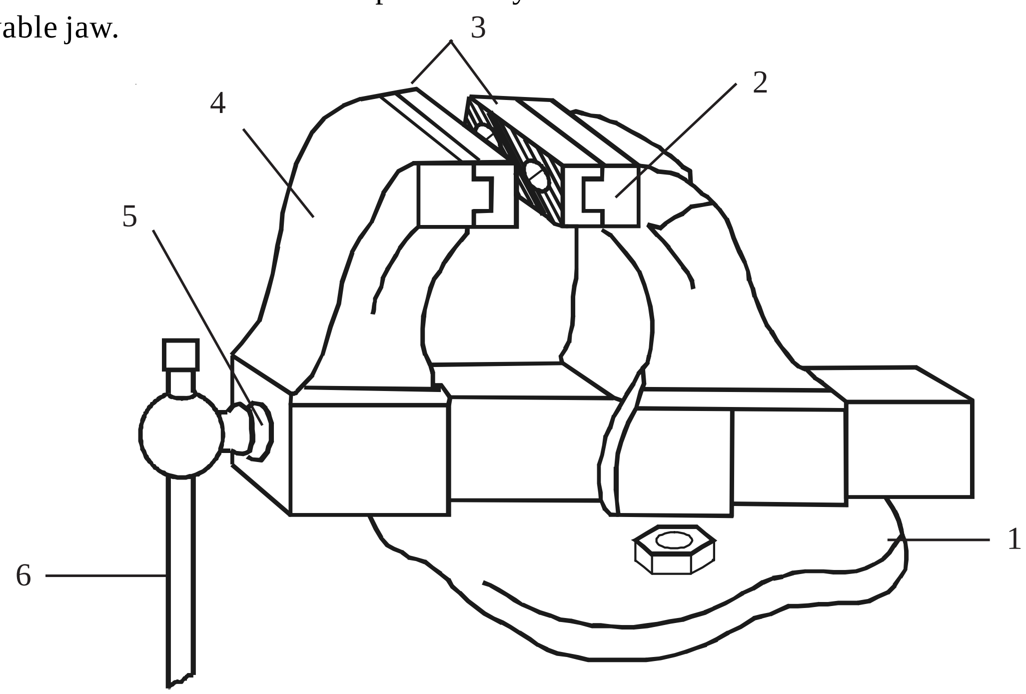


Fig 2.1. Bench vise

1. Base, 2. Fixed jaw, 3. Jaw plates, 4. Movable jaw, 5. Screw, 6. Handle

2.2.2. Hand vise

Small objects like screws, rivets, keys and drills are held with the help of a hand vise. When the force which needs to be applied is more, hand vises are fitted on benches.

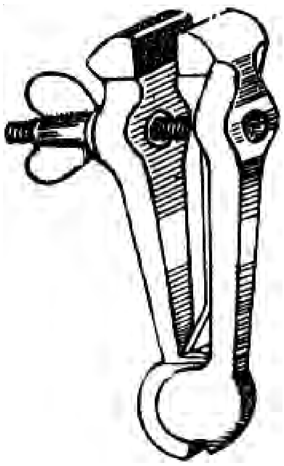


Fig 2.2 Hand vise

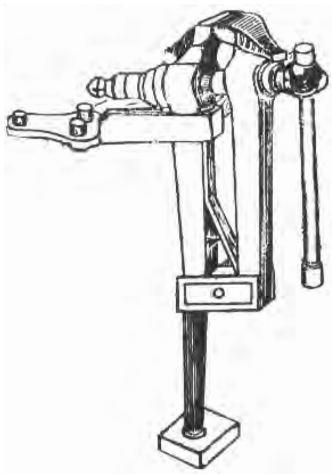


Fig 2.3 Leg vise

2.2.3. Leg vise

Leg vises are generally used in a blacksmith's shop or in a foundry. They are useful in holding work pieces when doing works like striking, chiseling and cutting. The body of the leg vise is made of Nought iron and so it holds on to sudden and heavy blows made on it.

2.2.4. Pipe vise

Pipe vise consists of a base and a column fitted on it. A 'V' shaped jaw is fitted on the base. The column is provided with another 'V' shaped movable jaw. Work is done on pipes or round rods fitted between these two jaws.

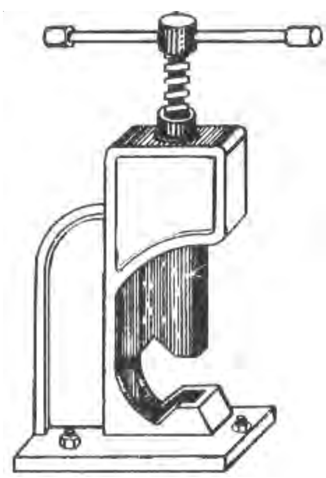


Fig 2.4 Pipe vise

2.2.5. Pin vise

The pin vise has three jaws which open or close by equal amount on turning a sleeve surrounding the jaws. This movement enables the vise to hold small round objects. Strings and wires of small diameters can be held with a pin vise.

The other types of vises are used in big workshops and machine shops.

Fig 2.5 Pin vise

2.2.6. Maintenance of vise

1. Vises should be maintained properly. Care should be taken that the screw of the vise is free from dirt or metal burrs.

2. The screw of the vise should be lubricated with grease for proper sliding of the movable jaws.

3. The top of the vise should not be used as an anvil.

2.3. Clamps

2.3.1. Parallel clamp

Parallel clamp can also be known as tool makers clamp. Two iron frames are connected to a screw. It is useful in holding small parts made of non ferrous metals.

2.3.2. C – Clamp

It resembles the English alphabet 'C' and hence named so. It consists of a frame in the shape of the letter 'C', a screw and an handle. It is made of low carbon steel. One side of the frame is flat and the other end is bored and threaded. The screw which has a flat end passes through the threaded hole in the frame. The other side of the screw has an handle attached to it. The work is held between the flat ends of the frame and the screw.

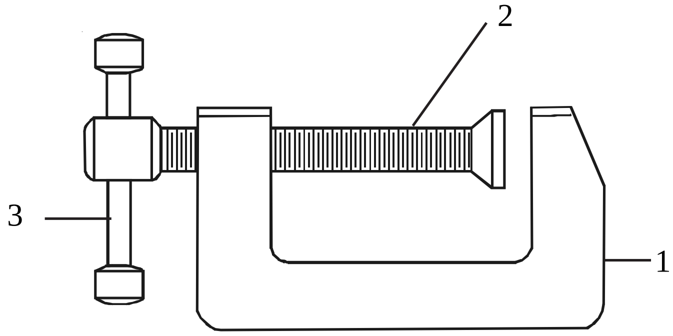


Fig 2.6 'C' clamp
1. Frame
2. Screw 3. Handle

2.4. Files

A file is a hardened steel tool having slanted and parallel rows of cutting edges or teeth on its surfaces. It is used to cut, smooth or fit metal parts. It is also used on wooden and plastic parts. It cuts all materials except hardened steel. Small quantities of unrequired metal can be removed with files. Metal burrs leftout after chiseling and hacksaw cutting are removed with the help of files. It is also used to sharpen the cutting edges of sharp tools like saws.

The tang is a pointed part which fits into the handle. The point is the end opposite to the tang. The heel is next to the tang. The face of the file has a slanting rows of cutting edges.

Files are classified according to the following factors.

1. Effective length
2. Sectional form
3. Cut of teeth
4. Grade

2.4.1. Length

The length of the file is its size. It is measured from the point to the heel excluding tang. Generally files are available in sizes ranging from 100mm to 200 mm. Files upto the length of 500 mm are also available to be used for heavy duty work.

2.4.2. Sectional form

The shape of the file is its cross section. Files are made in different forms of shape. Most commen types of forms are

1. Hand file
2. Flat file
3. Square file
4. Round file
5. Half round file
6. Triangular file
7. Knife edge file

Hand file

It is similar to a flat file but its only difference is that it has uniform width. It is useful in filing internal square edges.

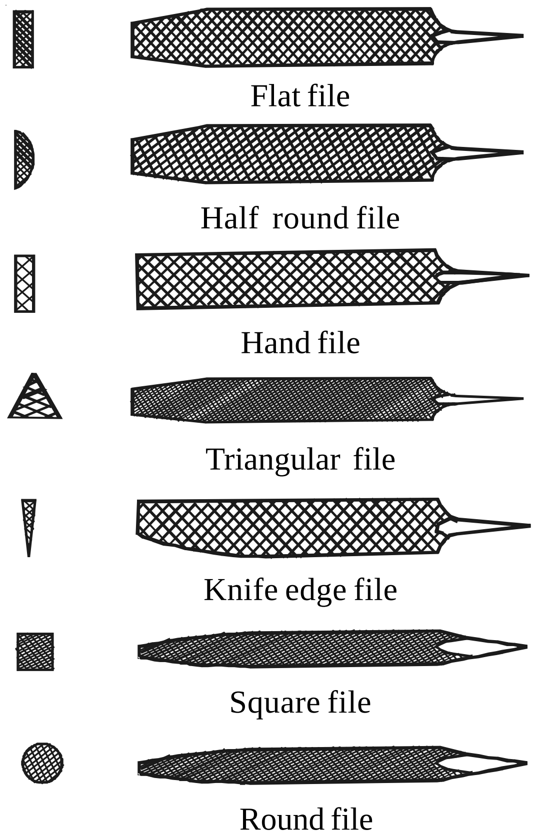


Fig 2.7 Types of files

Flat file

It is rectangular in cross section and is the most common form of file. It is always double cut on the faces and single cut on the edges. It is tapered in width towards point. It is used for general work and can be adopted for speed work.

Square file

It is square in cross section. It is tapered towards the point. It has double cut teeth on all the four faces. It is used for filing square corners, enlarging square and rectangular openings.

Round file

Round file is circular in cross section. The diameter of the file is uniform for about two thirds of its length. From there it is tapered towards point. It carries single cut teeth all around its surface. It is used for filing curved surfaces and enlarging round holes.

Half round file

The cross section of a half round file is not a half circle but around 1/3 rd of the circle. The width of the file is tapered towards point. It may have single cut teeth on the curved surface and double cut teeth on the flat surface. It is used to file concave and convex surfaces as well as other curved surfaces.

Triangular file

It is also called as three square file and its cross section is a triangle. Each side is inclined at 60^0 to its adjacent side. It is tapered towards point and has single cut or double cut teeth on all its sides. It is used for filing grooves and sharp corners of edges more than 60^0.

Knife edge file

The cross section of this file is tapered and looks like that of a knife. It carries double cut teeth on both its faces and single cut teeth on the edge. It is used to file sharp corners and edges of keyways.

Maintenance of files

During filing, the metallic burns coming out of the filed parts occupies the clearance spaces between the teeth. It prevents efficient cutting. These burns should be removed with brushes having thin metallic wires.

2.4.3. Cut of teeth

Cut of teeth of a file refers to the type of teeth on the faces. Files can be classified according to cut of teeth as

1. Single cut file
2. Double cut file
3. Rasp cut file

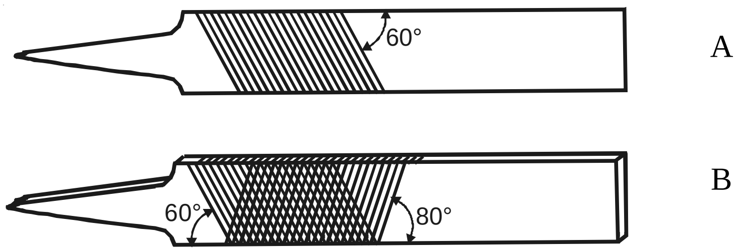


Fig 2.8 Single cut and Double cut file
A. Single cut B. Double cut

Single cut file

In single cut file, the teeth are cut in parallel rows on the faces normally inclined at an angle of 60^0 with the centre line of the face.

Double cut file

In double cut file, there are two sets of teeth one similar to those of a single cut file and another set running diagonally across the first set at an angle of about 80^0 from the other side. Harder materials are cut with double cut files.

Rasp cut file

The cross section of this file is half round. The teeth of the file are triangular in shape and project from the face surfaces. Rasp cut files are used to file soft materials like wood, plastic and hard rubbers.

2.4.4. Grade

The grade of a file refers to the coarseness or the spacing between the rows of the teeth. It is designated by the number of rows of teeth per inch.

There are five types of files according to its grade. They are

1. Rough file (R) – 20 to 25 teeth / inch
2. Bastard file (B) – 25 to 30 teeth / inch
3. Second cut file (SC) – 35 to 40 teeth / inch
4. Smooth file (S) – 40 to 60 teeth / inch
5. Deed smooth file (DS) – 80 to 100 teeth / inch

2.5. Hacksaw frame

Hacksaw frame consists of a frame, a wooden handle, prongs, tightening screw and a wing nut. It is used for sawing all metals except hardened steel. Tightening screw with the help of a wing nut is used to stretch the blade as desired.

There are two types of hacksaw namely

1. Standard or solid hacksaw
2. Adjustable hacksaw

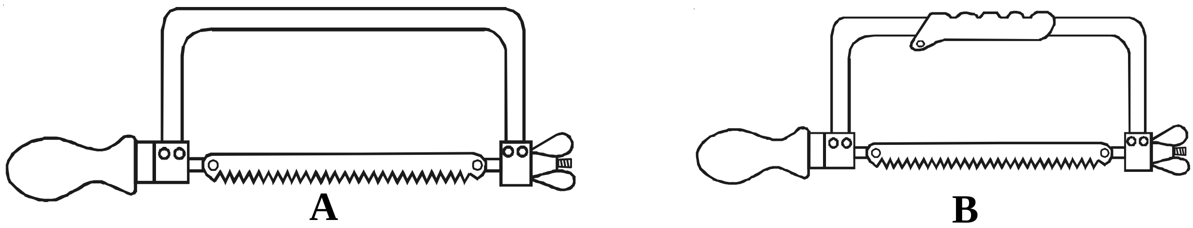


Fig 2.9 Types of hacksaw frames
A. Solid type B. Adjustable type

Standard hacksaw

In this type, the distance between the prongs cannot be altered. So it is suitable for a particular length of hacksaw blades only.

Adjustable hacksaw

In this type, the distance between the prongs can be adjusted to hold hacksaw blades of different lengths say from 200 mm to 300 mm.

2.5.1. Hacksaw blades

Hacksaw blades are made of high carbon steel, Tungston steel, low alloy steel or high speed steel. They are then hardenered and tempered. They are made as thin sheet with cutting edges present on one side or on both sides. The size of the blade is specified by the distance between the holes on either sides along the length.

According to the distance between two successive teeth on the blade (pitch), they are classified as coarse, medium, and fine pitch blades. Soft materials like plastics are cut by coarse pitch blades. Medium pitch blades are employed to cut tool steel, hard light alloys, thick sections and tubes. Materials of small thickness are cut accurately by fine pitch blades.

2.5.2. Reasons for the breakage of hacksaw blades

1. The cutting action may not be of uniform speed and thrust
2. Improper fitting of blades (undue tightness or looseness)
3. Putting into use new blades in old cuts
4. Not selecting blades of suitable pitch
5. Poor workmanship

2.5.3. Reasons for the blunting of hacksaw blades

1. The material being cut is harder than the blades
2. Improper selection of blades
3. Application of high thrust and speed
4. Applying thrust during return stroke also
5. Not applying a coolant

2.6. Scraper

Scrapers are used for shaving off or parting off thin slices or flakes of metal to make a fine, smooth surface. The material used for making scrapers is a good quality forged steel and the cutting edge is very hard. Scraping is a process of obtaining a true flat surface which is superior in quality than that can be produced by machining are filing. The top of the surface plate is coated with a thin film of Prussian blue. The surface to be scraped is laid on the surface plate and moved back and forth. The high spots on the work will be marked with Prussian blue. The high spots are scraped down by giving the scraper a small circular motion. There are three different types of scrapers according to its shape. They are

1. Flat scraper
2. Half-round scraper
3. Triangular scraper

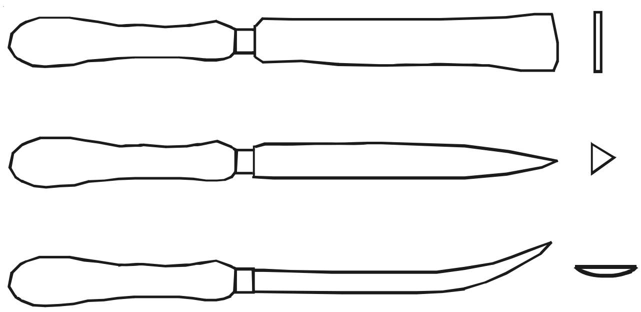


Fig 2.10 Scrapers

Flat scraper :

The flat scraper is the most common type and has the cutting edge at the end. It is used to produce a perfect flat surface. It is available in different lengths ranging from 200 to 250 mm.

Half-round scraper

The shape of half-round scraper is like a half-round file. They are used to scrape round or curved surfaces.

Triangular scraper

The triangular scraper has three cutting edges. Its is used to scrape round or curved surfaces and to finish sharp corners free from burrs.

Maintenance of scrapers

1. The cutting edges of the scraper should always be kept sharp.
2. It should be kept in a special case or wrapped in a piece of cloth when not in use.
3. It should be used for no other purposes other than scraping.

2.7. Marking tools

In addition to the measuring instruments, some tools are used to make marking on the workpieces and to scribe lines on them. They are known as marking tools.

Scribing is a very important action in making a component. Lines are to be drawn on the workpiece according to the design. These lines are drawn with reference the contours of the work preferably at right angles or with reference to a certain datum line. The position of these edges or the position of the datum line may be determined from the drawing which is necessary for each job.

Effects of poor marking

1. Waste of job material
2. Wastage of time
3. Leads to loss because of the production of inaccurate products
4. Consequent transporting expenditure
5. Earning bad name in the industry

Guidelines for good marking

1. Drawing should be correctly understood
2. Marking tools should be kept ready
3. Proper marking tools should be used
4. Scribed lines are checked for correctness before punching
5. Selection of punches should be done properly

Types of marking tools

1. Steel rule
2. Jenny caliper
3. Divider
4. Trammel
5. Punches
6. Try square
7. Scriber
8. Surface plate
9. Marking table
10. Surface gauge
11. V – block
12. Angle plate

2.7.1 Steel rule

Steel rule is used generally for measuring all kinds of objects. It is also adapted for marking and scribing straight lines. It is made of thin steel sheet and hence named so.

2.7.2 Jenny caliper

Jenny caliper has two legs – one straight and sharp and the other slightly bent at the bottom. The top of the legs are connected by a rivet or a spring. It is made of mild steel and case hardened. It is also called as odd leg caliper and hermoprodite. There are two types of jenny calipers namely fixed point odd leg caliper and adjustable point odd leg caliper. Jenny calipers are used to find the centre of the round rod and to draw parallel lines at regular intervals on workpieces

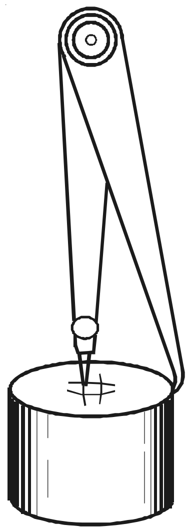


Fig 2.11 Jenny caliper

2.7.3 Divider

Divider has got two legs having sharpened ends. The two legs are connected at the top by a rivet or by a spring.

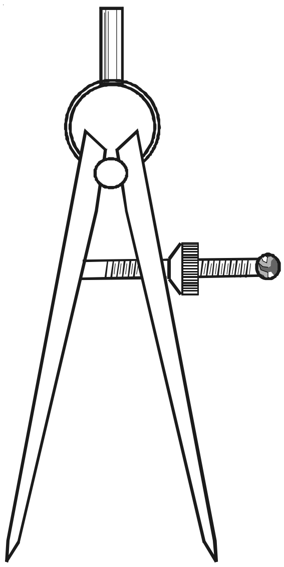


Fig 2.12 Divider

It is made of high carbon steel and hardened.

Uses of divider

1. To scribe arcs and parallel lines on workpieces
2. To divide straight lines and curved lines into equal parts
3. To find and check the centre of a round rod
4. To mark correct dimensions taken from the steel rule on workpieces

2.7.4 Trammel

Trammel can be used as a divider and as well as an inside and outside caliper. It consists of a solid beam known as trammel bar into which two trams are attached. These trams have a chuck attached to each of them which will hold pointed edges to be used as the tools mentioned above. The position of the trams can be locked at a desired point.

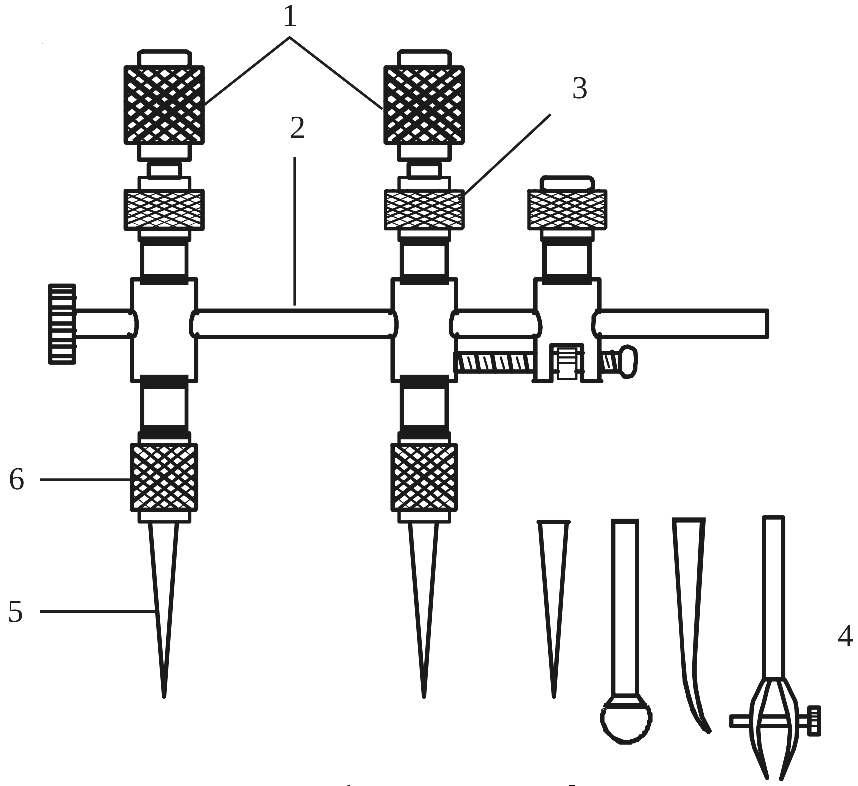


Fig 2.13 Trammel

1. Clamping screws 2. Horizontal beam 3. Tram
4. Types of legs 5. Driver leg 6. Chuck

2.7.5 Punches

Punches are used to make permanent marks on the lines already scribed on the workpieces. The punch marks make the line appear clearly. Punches are also used to make marks on exact locations on the workpieces where drilling is to be performed.

Punches are made of steel alloys. The punching ends are ground to a required angle. The body of the punch is knurled to provide gripness.

Types of punches

1. Prick punch
2. Dot punch
3. Centre punch
4. Hollow punch
5. Bell punch
6. Pin punch

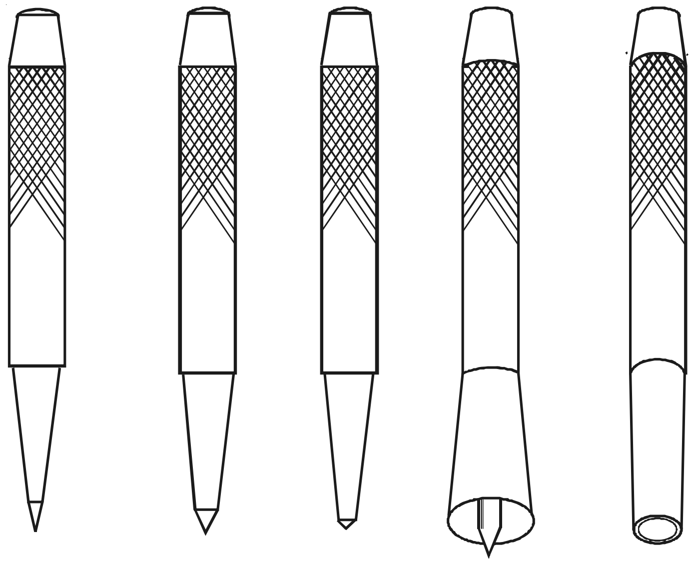


Fig 2.14 Types of punches

A. Prick punch B. Dot punch C. Centre punch

D. Bell punch E. Hollow punch

Prick punch

Prick punches are used in some precision works and on softer materials. The end of the punch carry an angle of 30 degrees.

Dot punch

Dot punches are used to make marks on the workpieces and to make scribed lines appear clearly. The end of the dot punch is ground to have an angle of 60 degrees. Punch marks are made at regular intervals on the lines (interval may be 6mm for straight lines and 3mm for curved lines).

Centre punch

The angle of the centre punch is 90 degrees. It is used to make marks on locations where drilling operation is going to be performed. The marks made by the punches will allow the drill to get seated and rotated at the exact location.

Hollow punch

The end of the hollow punch is concave inside. It is used to make holes on sheet materials like leather, rubber and cardboard sheets.

Bell punch

It is useful in marking centres on the faces of round rods.

Pin punch

Pin punch is used to make small holes on thin sheet materials. It is also used to insert or remove small pins into or out of holes.

2.7.6 Try square

Try square is used to check the perpendicularity of surfaces (both external and internal) It is also useful in scribing parallel lines perpendicular to a particular surface and to check flatness of surfaces.

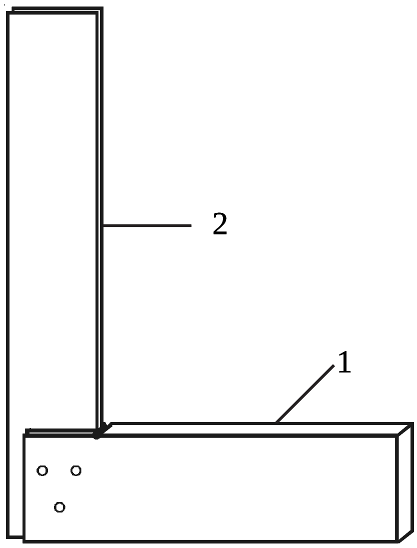


Fig 2.15 Try square
1. Stock, 2. Blade

Try square consists of two parts namely stock and blade. Stock is made of cast iron or cast steel and blade is made of high carbon steel or stainless steel. All sides of the stock are machined accurately and perpendicular to the adjacent sides. The blade is rivetted to the stock such that both of them are absolutely perpendicular to each other. There will be an undercut on the stock nearer to the bottom of the blade. It will accomodate burrs on the workpiece if any. The blade of the try square may be graduated.

Try square should be maintained properly. The blade of the try square should not be used as a screw driver and stock as hammer. It should be oiled properly for avoiding rust formation on its surfaces

2.7.7 Scriber

A scriber is used to scribe lines on the workpieces. It is made of high carbon steel which is hardened and tempered. The end of the scriber is ground sharp to have an angle of 12^0 to 15^0. The body of the scriber is knurled to provide gripness. It is available in different lengths - 150mm, 200mm & 250mm.

There are different types of scribers available. They are :

1. Straight ended scriber
2. Bent ended scriber
3. Adjustable scriber
4. Offset scriber
5. Knife-edge scriber

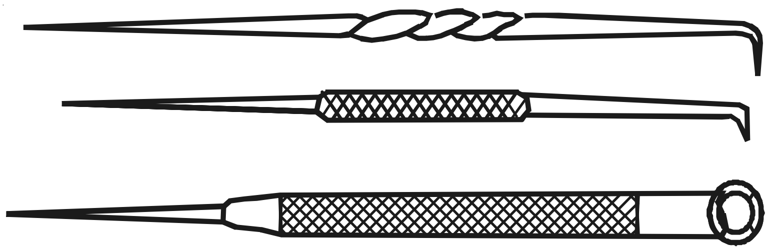


Fig 2.16 Scibers

2.7.8 Surface plate

The flatness of a surface of a work can be tested with the help of a surface plate. It is also used for marking-out work.

Fig 2.17 Surface plate

Surface plates are made of grey cast iron. The top surface of the surface plate is very accurately machined and scraped for further accuracy. It should be mounted on a bench or on a special stand at an height of about 800mm. They are made in two grades of accuracy - A grade & Bgrade. A grade suface plates are with 0.005mm flatness and B grade with 0.2mm flatness. It is available in sizes of 150 x 100mm and 1000 x 750mm.

Care of surface plate :

1. The surface plate should be covered when not in use.
2. The top surface should be kept free from rust and dirt.
3. It should be wiped with a clean cloth and smeared with grease or oil after use.
4. Parts having burrs on them should not be rubbed on the top surface of the plate.

2.7.9 Marking table

Marking table accommodates surface plates to be mounted on it. It helps in marking and inspection. It is made of mild steel and the top is made of cast iron. It is available in sizes of 900 x 900 x 825 mm.

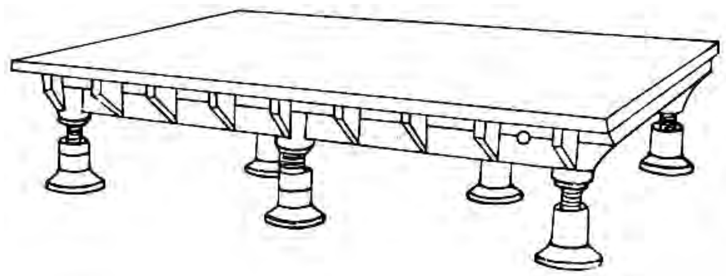


Fig 2.18 Marking table

2.7.10 Surface gauge

Surface gauge is also a marking tool. It can also be called as marking block. This instrument is used to scribe straight lines on work surfaces and it can also be used to check the correctness of surface level. In combination with a dial indicator, it is used to lineup cutting tool or workpieces for inspection.

The base of the surface gauge is accurately machined and a pillar stands vertically on it. A scriber is attached to the pillar by means of a clip. The scriber can be positioned practically in any position.

There are two types of surface gauges namely

1. Vertical pillar surface gauge
2. Universal surface gauge

Vertical pillar surface gauge

This is a simple form of surface gauge in which a pillar is fitted into a heavy base vertically. A scriber is attached to the pillar by means of a clip. It is adjusted by means of a knurled nut. It is not suitable for precision work.

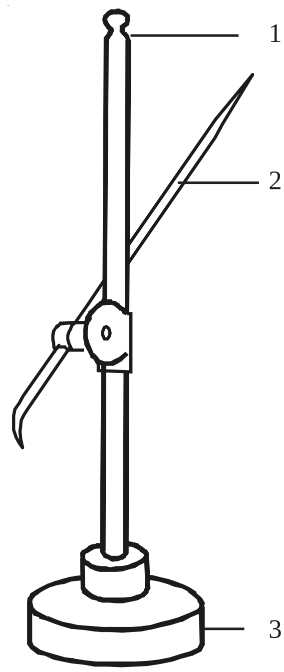
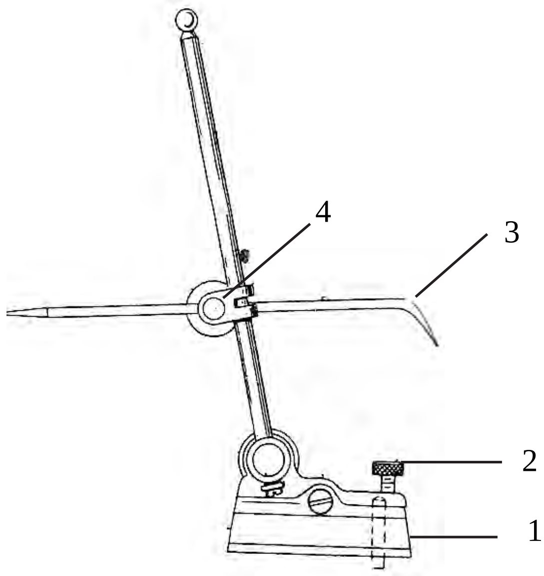


Fig 2.19 Vertical pillar Surface gauges

1. Base 2. Scriber 3. Pillar



Before setting the instrument for scribing and checking, the surface plate, the angle plate and the work are cleaned neatly. For measuring purposes, the steel rule of the combination set is selected. Angle plate is placed on the surface plate. The steel rule and the work are placed closely on one side of the angle plate. The tip of the sciber is set and adjusted by sliding the clip suitably. The required straight line may be drawn by moving the surface gauge along the work upon the surface plate.

Fig 2.20 Universal Surface gauges
1. Base 2. Adjusting screw 3. Scriber 4. Clip

Universal surface gauge :

It has a base having ‘V’ groove, a spindle and a scriber. The scriber is adjusted by means of a knurled nut. The advantage in comparison with pillar type is that fine adjustments can be made by means of an adjusting screw. Pins provided on the base can be pushed down to act as a guide against the top of the surface plate. ‘V’ groove on the base enable it to be placed on round rods.

Uses of surface gauges

1. To find centres of round rods and square rods
2. To set workpieces aligned to the axis of the lathe while held by chucks
3. Can be used as a vernier height gauge to draw horizontal lines on workpieces
4. To check parallelism of opposite sides on machined parts
5. The scriber of the surface gauge is replaced by a dial indicator and used for alignment of machine tools.

2.7.11 V- block

V’ blocks have a ‘V’ shaped groove and rectangle grooves on it. The angle of the V groove is either 90^0 or 120^0.The face of the ‘V’ block is square or rectangular in section. It is used to hold cylindrical workpieces when these workpieces are be machined in a drilling machine, shaping machine and milling machine. It is also used to hold round rods when some markings are to be done on it.

The usual sizes of a V block are 50 mm to 250 mm in length and 50 mm to 100 mm in width and height.

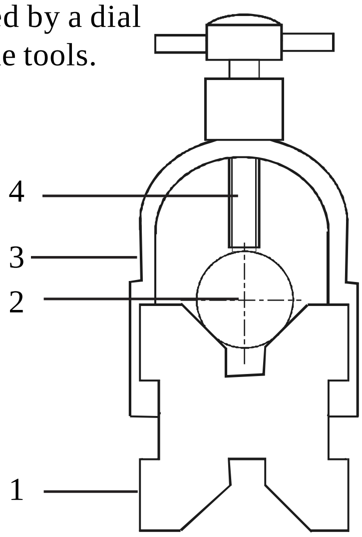


Fig 2.21 ‘V’ block
1. V block 2. Cylindrical work
3. U Clamp 4. Screw

2.7.12 Angle plate

It resembles the English alphabet 'L'. It has got two sides absolutely perpendicular to each other.Usually it is made of cast iron. The sides of the angle plate has got slots and holes on it. It is used to hold workpieces on machine tools like lathe, drilling machine and milling machine. It is also used to check the perpendicularity of surfaes either internally or externally. It is also used for marking on workpieces when used along with other marking tools like surface gauge. It is specified by its length, width and height.

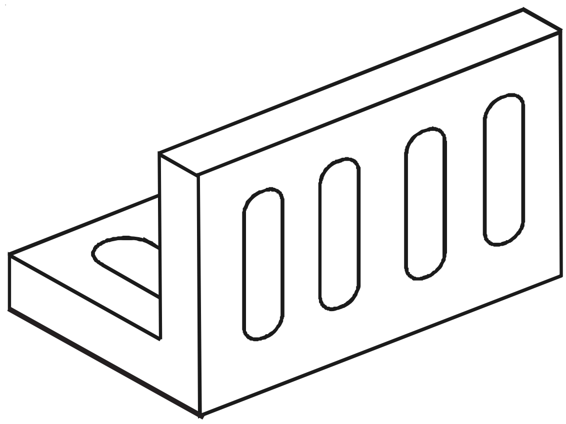


Fig 2.22 Angle plate

2.8 Hammer

Hammer is a striking tool. It is used to strike metal parts to straighten or bend them and bring them to the required shape. It is also used to drive nails and rivets. It finds place in a blacksmith's shop also.

The types of hammers are

1. Hand hammer
2. Sledge hammer
3. Claw hammer
4. Soft hammer

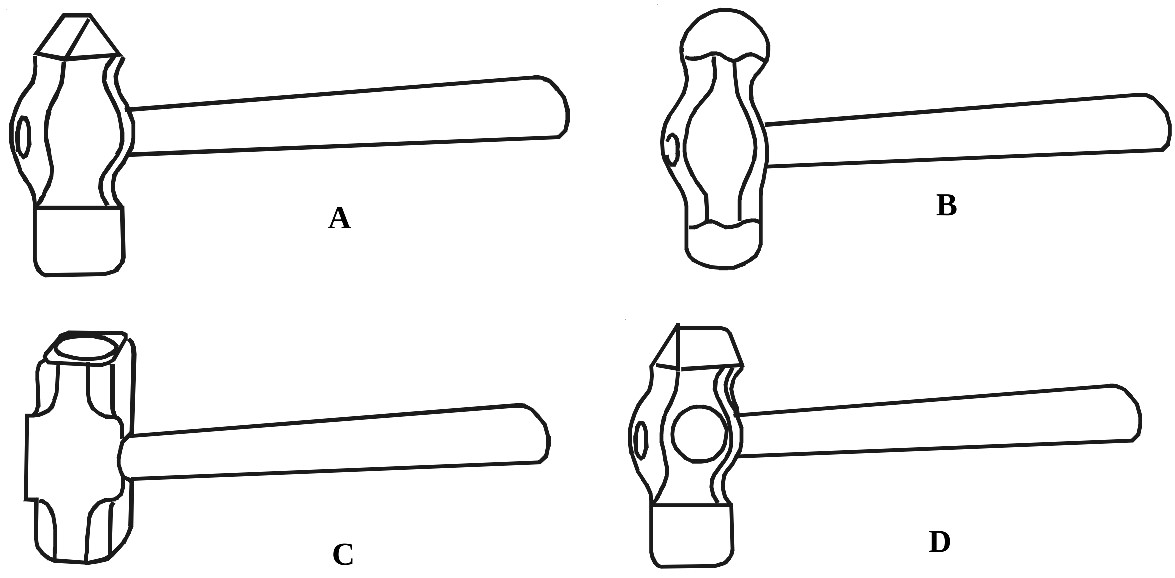


Fig 2.23 Types of hammers

A - Cross peen hammer B - Ball peen hammer

C - Sledge hammer D - Straight peen hammer

Hand hammers are of different types and they are

1. Ball peen hammer
2. Cross peen hammer
3. Straight peen hammer
4. Double face hammer

2.8.1 Hand hammers

They are made of cast steel or carbon steel. The peen and the face are hardened. The body of the hammer has a through slot. An handle made of wood is inserted into the slot with suitable wedges.

2.8.2 Sledge hammer

Sledge hammers are generally used in blacksmith's shop. They are useful in bending and straightening cylindrical and square rods. It is very similar in shape to a double face hammer but of larger size. As the weight of sledge hammer is very high, it is used on heavier workpieces.

2.8.3 Claw hammer

Claw hammer is special type of hammer. The face of the claw hammer is cylindrical in shape and the peen is slightly bent towards the handle. The peen has a central opening which facilitates in the removal of nails.

2.8.4 Soft hammer

Soft hammers are used for gentle blows on metal parts. It is adapted where the blow marks are not desired. It is also used on softer materials. It is made of materials like wood, plastic, brass and aluminium. It is also known as mallet.

2.9 Spanners and wrenches

These tools are generally used to drive in or drive out bolts and nuts into or out from sleeves or collars. There are different types of spanners according to shape and utility. Their sizes correspond to the sizes of the bolts and nuts on which they are used.

2.9.1 Double ended spanner

It is made of high carbon steel and mostly made by forging method. Slots are provided on both the ends of the spanner. These slots are inclined at about 30^0. There may be some slipping when operating with this spanner.

Fig 2.24 Double ended spanner

2.9.2 Box spanner

Box spanner looks like a sleeve. It is designed to be used on nuts requiring great leverge. There won't be any sliping during handling. It is made in a variety of shapes such as square, hexagon and octagon.

2.9.3 Ring spanner

It is designed with 12 notches or points inside a closed end. The points of a nut may be gripped by any one of the 12 notches of the spanner which permits the turning of a nut where only a short pull of the spanner is possible.

Fig 2.25 Ring spanner

2.9.4 Adjustable spanner

Adjustable spanneror wrench has a movable jaw which makes it adjustable to various sizes of nuts. When using this wrench, the jaws should be pointed in the direction of the force applied.

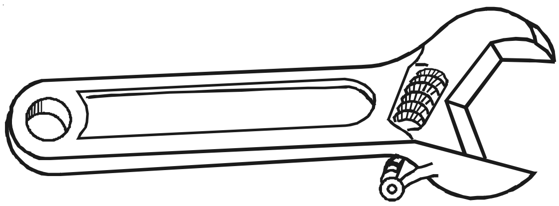


Fig 2.26 Adjustable spanner

2.9.5 Allen key

It is made of square or hexagon shaped stock to fit the holes in the heads of safety set screws or socket head screws. They are available in differet sizes.

2.9.6. Screw driver

A screw driver is a hand tool that is designed to turn screws. The blade is made of steel, attached to one end of which is a wooden or plastic handle. The other end is flattened to fit in to the slots in the heads of screw or bolts. Screw drivers are made in many sizes.

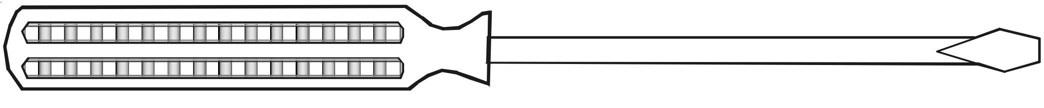


Fig 2.27 Screw driver

2.9.7. Philips Screw driver

A Philips screw driver is specialy designed to fit the heads of Philips screws. It differs from other screw drivers in that the end of the blade is fluted instead of being flat. It is made in several sizes.

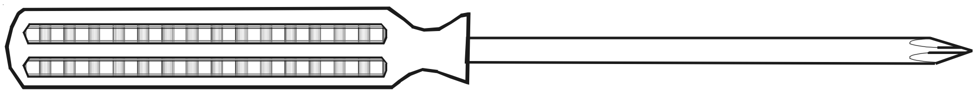


Fig 2.28 Philips screw driver

2.9.8. Pliers

Pliers are made in many styles and are used to perform as many different operations. They are used for holding and gripping small articles in situatuins where it may be inconvenient or unsafe to use hands.It is not a good practice to use pliers in place of a wrench.

Side cutting pliers

Side - cutting pliers are made with cutting blades on one side of the jaws. They are used mostly for gripping and cutting wires.

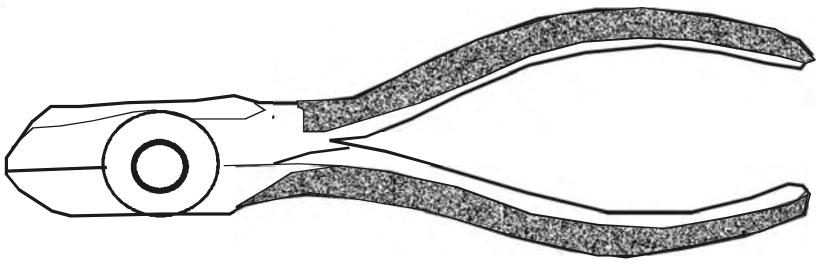


Fig 2.29 Side cutting pliers

Nose pliers

Nose pliers are made with a thin nose or jaws.This tool can be used for placing and removing small items in narrow spaces. It is also preferred for electrical and radio repair work.

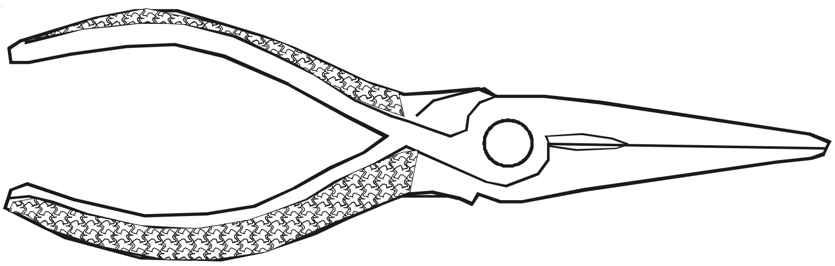


Fig 2.30 Nose pliers

2.10 Bearing puller

This is a device to remove the bearing from the shaft. It works in the principle of bench - vice. The legs of the puller is widened to hold the bearing and the bottom of the screws of the puller should touch the face of the shaft, then turned clockwise as shown in the figure. Due to the movement of the screw rod of the puller the bearing is easily pulled out from the shaft. Arbor press is used to fix the bearing in the shafts.

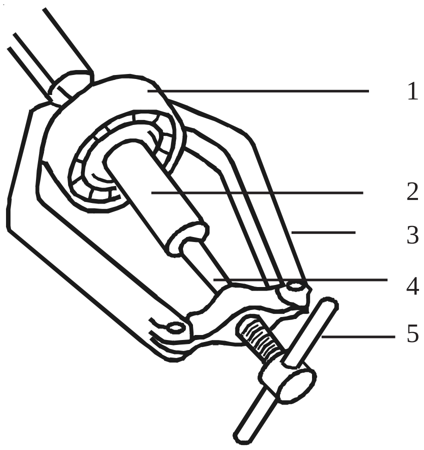


Fig 2.31 Bearing puller

1. Bearing 2. Shaft 3. Leg 4. Screw 5. Handle

2.11 Tap

A tap is a screw like tool which has threads like a bolt and three or four flutes cut across the thread. It is used to cut threads on inside of a hole as in a nut. The tap is used along with the wrench which holds the tap with it. The cutting edges are formed by the flutes on the thread. The lower end of the tap is somewhat tapered so that it can dig into the walls of the hole. The top of the tap has a square shank which helps it to be held by the wrench. Taps are made of either high speed steel or high carbon steel and hardened and tempered.

Taps are made in sets of three -
1. Taper tap
2. Second tap
3. Bottoming tap

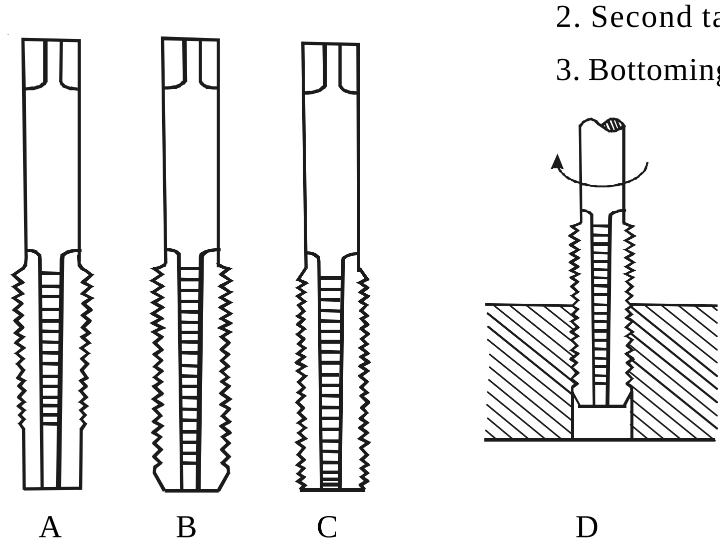


Fig 2.32 Tap set

A. Taper tap B. Second tap
C. Bottoming tap
D. Tapping operation

Taper tap

The taper tap has about six threads tapered. It allows the tap to dig into the hole easily to form threads gradually as the tap is turned into the hole. The wrench holding the tap is moved clockwise and anti - clockwise while tapping. Oil is applied into the hole as the tap is screwed.

Second tap

It is tapered back from the edge about three or four threads. This is used after the taper tap has been used to cut the thread as far as possible.

Bottoming tap

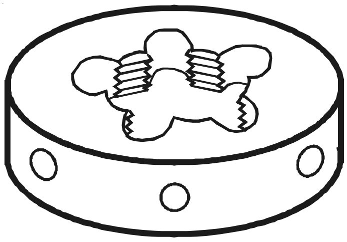
It has threads for the whole of its length. It is used to finish the work prepared by the other two taps.

Hints to be observed while tapping :

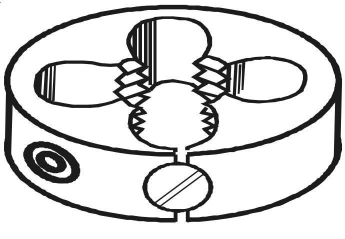
1. Taps should be used in order i.e from taper tap to bottoming tap through the second tap.
2. It should be ensured whether the tap enters into the hole properly.
3. Burrs are removed by turning the tap back and forth.
4. High pressure should not be applied on the taps.
5. Proper wrenches should be used to operate the taps.
6. Cooling agents should be used while tapping.

2.12 Dies

Dies are used to cut threads on a round bar of metal, such as the threads on bolt. It is a round or square block of hardened steel with a hole containing threads and flutes which form cutting edges.



A



B

Fig 2.33 Dies

A. Solid die B. Adhustable die

There are mainly two types of dies in common use

1. Solid die 2. Adjustable die

Solid die

A solid die is one which has fixed dimension and cannot be adjusted for larger or smaller diameter. Adjustable means that it can be set to cut on larger or smaller diameter.

Adjustable die

A circular adjustable split die shown in the figure is very common. The die is split through one side and a slight adjustment is made by means of the set - screw . If this screw is tightened up the die is opened up slightly, whilst unscrewing will cause the die to spring in. Another common type is the two - piece rectungular die. In this type the dies are fitted into a special stock and they are closed by means of the adjusting screw. The size of the die is specified by the outer diameter of the thread to be made.

The tool for holding and turning the threading die is called a die - stock.

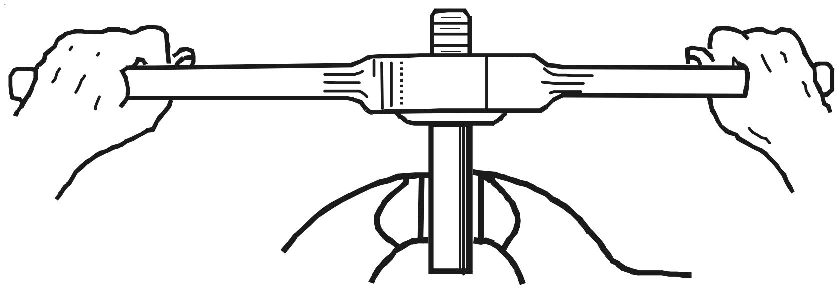


Fig 2.34 Threading by a die

1. Work 2. Die stock 3. Vise

QUESTIONS

I. A. Choose the correct option

1. The vise with ‘V’ shaped jaws is
   a. leg vise b. hand vise c. pipe vise d. pin vise
2. Convex and concave surfaces can be filed with a
   a. flat file b. square file c. triangular file d. half round file
3. Grade of a file with 40 to 60 teeth per inch is
   a. rough file b. second cut file c. smooth file d. dead smooth file
4. An hammer made of wood, plastic or rubber is known as
   a. hard hammer b. soft hammer
   c. straight hammer d.double face hammer
5. The tool used to hold and cut sheets and wires is a
   a. screw driver b. pliers c. allen key d. ring spanner
6. Centre of a round rod can be found with a
   a. steel rule b. jenny caliper c. trammel d. punch
7. Punch with an angle of $30^0$is known as
   a. centre punch b. dot punch c. pin punch d. prick punch
8. The tool used for finding centre of a work held in a lathe is
   a. Marking table b. universal surface gauge c. V block d. angle plate

I. B. Answer the following questions in one or two words

1. Name two types of vises.
2. State the use of a round file.
3. What are the two types of hacksaw frames?
4. What is the use of an adjustable spanner?
5. What is the use of a divider?
6. What is the use of a scriber?
7. Mention the use of angle plate.

II. Answer the following questions in one or two sentences

1. What is a vise?
2. What is a C - Clamp?
3. Name four types of files.
4. What are the types of hammer?
5. What is a nose plier?
6. What is a scraper?
7. What is a tap?
8. What is a die?
9. What is a centre punch?
10. What is an angle plate?

III. Answer the following questions in about a page.

1. What are the reasons for the breakage and blunting of hacksaw blades?
2. Explain the process of tapping with a diagram.
3. Draw and explain the construction and uses of a jenny caliper.
4. Explain the construction of try square with a diagram.
5. Explain a pillar type surface gauge with a diagram.

IV. Answer the following questions in detail.

1. Explain the types of files with suitable diagrams.
2. Draw and explain a bearing puller.

3. MEASURING INSTRUMENTS

3.1 Introduction

Measuring instruments are useful in checking the sizes and grades of an object. The grade of a product depends upon its shape, correct size and the quality of the surface finish. To measure these features, different types of measuring instruments are used.

Some of the instruments are used to measure the sizes to a high degree of accuracy. Some other instruments are useful in checking whether the sizes of the products are within the desired limits. We can compare the actual sizes of the products with correct sizes with the help of some instruments.

3.2 Different categories of measuring instruments

1. Linear measuring instruments
   eg. - Steel rule, vernier calipers, depth gauge
2. Angular measuring instruments
   eg. - Bevel protractor, sine bar, combination set
3. Plane surface measurements
   eg. - Surface plate, dial indicator

3.2.1. Types of measuring Instruments

a. Standard measuring instruments
   Standard measuring instruments include steel rule etc.

b. Adjustable measuring instruments
   These instruments include calipers, vernier caliper, micrometer, dial test indicator, vernier height guage, bevel protractor etc.

3.2.2 Methods of measuring

1. Direct method - with instruments like steel rule, micrometer, vernier calipers, vernier height gauge, bevel protractor,dial indicator etc.,

2. Indirect method - with instruments like calipers, divider, surface gauge, sine bar etc.,

3. Inspection method - with gauges

3.2.3. Grades of measuring instruments

a. Precision measuring instruments

b. Semi – precision measuring instruments

c. Non- precision measuring instruments

3.3. Linear measuring instruments

There are several measuring instruments available to measure linear dimensions with different accuracies. The accuracy of an instrument depends upon the least count of the particular device. The least count of steel rule in 0.5 mm whereas dimensions to an accuracy of 0.01 mm can be measured with micrometers. With some instruments, reading of dimensions can be done directly as in the case of steel rule, micrometer, vernier caliper etc., In some other instruments like calipers, readings have to be arrived with reference to some other instruments like steel rule. Some linear measuring instruments are explained in this section.

3.3.1. Steel rule

It is one of the most useful tools in a workshop for taking linear measurements and scribing straight lines. It is usually made of materials like hardened steel, stainless steel and spring steel.

Lline graduations are etched or engraved at intervals of fractions of a standard unit of length. Measurements are marked both in English and Metric scales. In English scale, the markings are in inches whereas they are in millimetres in Metric scale. The accuracy of the steel rule is 0.5 mm in Metric scale and 1/64'' in English scale.

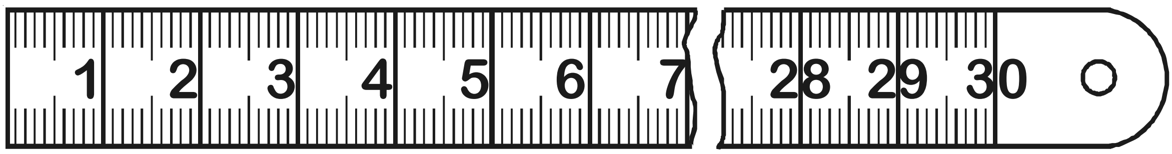


Fig 3.1 Steel rule

Steel rules are available in different lengths, breadths and thickness. Steel rules are in lengths of 100, 300, 500, and 1000mm. The width and thickness of the rules vary with their length. For example- For a rule of 500mm length, the width wiil be 18 to 22 mm and the thickness will be 0.4 to 0.6 mm.

There are different types of steel rules and they are:

1. Standard rule
2. Flexible rule
3. Narrow rule
4. Hook rule
5. Folding rule
6. Steel tape
7. Spring rule

Standard rule:

Standard rules have standardised measurements marked on it and are accepted the World over. They are useful in measuring, scribing llines and checking measurements. They are available in lengths of 150mm to 300 mm (6 to 12 inches).

Flexible rule:

This type of steel rule is flexible in nature and so it is useful in taking measurements on irregular and cylindrical sufaces.

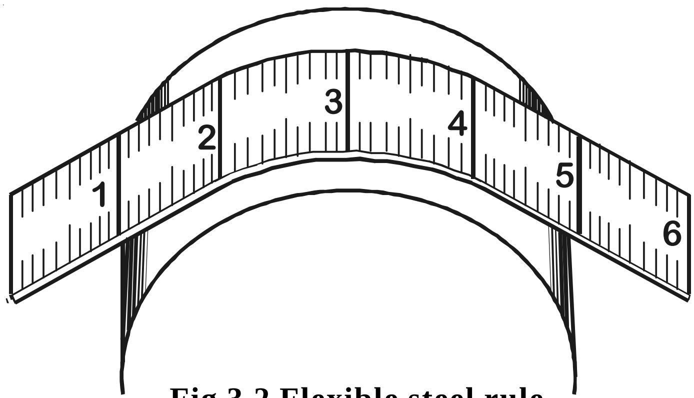


Fig 3.2 Flexible steel rule

Narrow rule:

The width of this type of rule is small. So it is used for measuring depths of narrow holes, lengths and widths of narrow slots. Measurements of any one of the scales - either Metric or English may be marked on them.

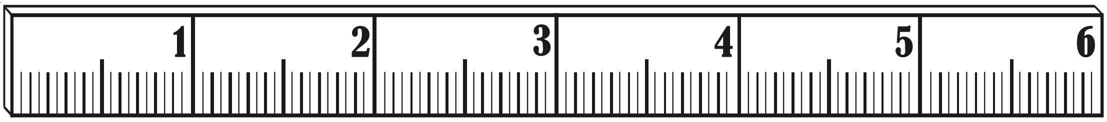


Fig 3.3 Narrow rule

Hook rule:

It has a hook attached to one of its ends. Hook rules are used to measure from broken or bevelled ends. It is also useful in measuring narrow and deep slots. When measurements are to be taken from the centre of chamfered centre holes of gears, hook rules are utilised.

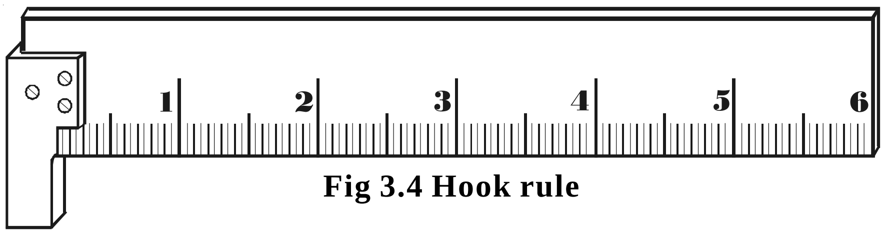


Fig 3.4 Hook rule

Folding rule

Folding rules are designed to be able to be folded or unfolded according to the need.

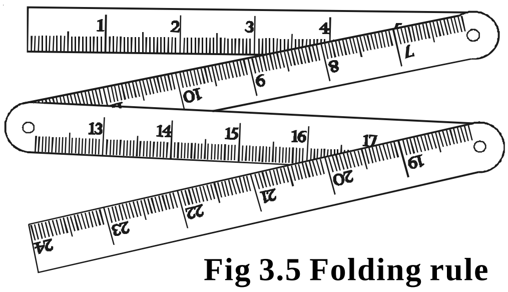


Fig 3.5 Folding rule

Steel tape

The steel tapes are made of thin steel sheet. They are available in different lengths of 1m, 3m and 5m. The tape is wound inside a closed case and can be pulled out when necessary to the required length.

Spring steel rule

These types of rules are useful where castings are made. Metallic components will expand at the influence of heat and shrink on cooling. Moulds are made considering this fact. Rules used in this context are known as spring rules.

Miantenance of steel rules

1. It should not be used on rough surfaces.
2. It should not be used as a wedge or as a screw-driver.
3. Heavy objects should not be placed on it.

3.3.2 Calipers

Calipers are used to measure diameters of round rods and to measure the internal and external dimensions of square or rectangular objects. Measurements can not be taken directly as in a steel rule but along with steel rule.

According to construction, there are two diffrent types of calipers. They are:

1. Solid joint calipers
2. Spring calipers

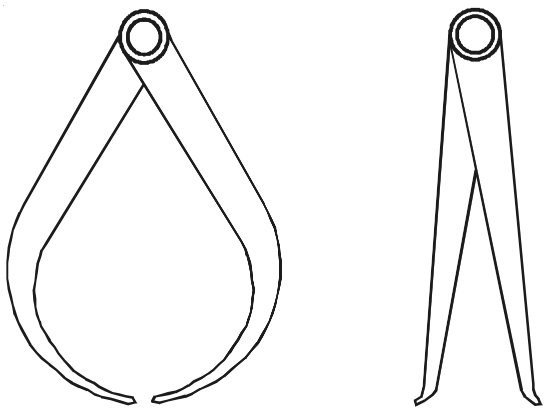


Fig 3.6 Calipers
A. Outside caliper B. Inside caliper

Solid joint calipers

The legs of this type of calipers will be connected by rivets at the top. It is slightly difficult to adjust the distance between the two legs of the solid joint calipers. It can be handled by a skilled operator only. *Different types of solid joint calipers are shown in Fig. 3.6ii*

Spring caliper

The top portions of the legs of this type of caliper are connected by a spring. There is a screw and a nut to adjust the distance between the legs. The nut is rotated in suitable direction to open or close the distance between the legs.

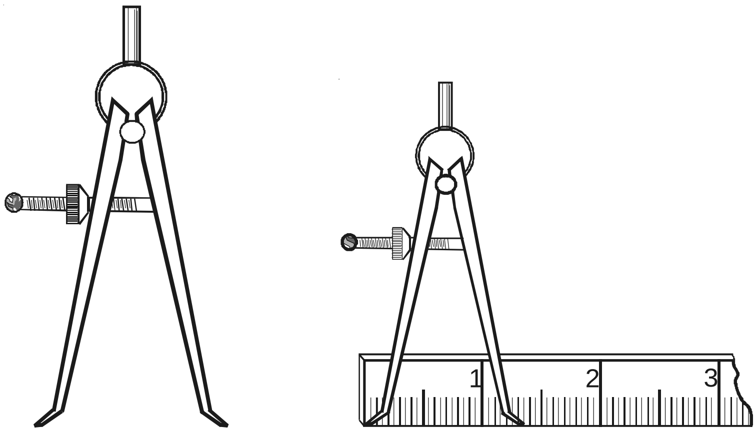


Fig 3.7
Method of measuring with inside caliper

Types of calipers

1. Inside caliper
2. Outside caliper
3. Jenny caliper

Inside caliper

This type of caliper is used to measure the internal dimensions of holes and slots.

Outside caliper

This type of caliper is used to measure external dimensions like length and breadth of various objects and diameters of round rods etc.,

Jenny caliper:

Jenny calipers are used to find the centres of round rods and to draw parallel lines at regular intervals on workpieces. One of the legs of this type of caliper is straight and the other is bent. It can also be called as odd leg caliper or hermoprodite.

Maintenance of calipers

1. It should not be used on hot and rotating parts.
2. It should be kept on flat surfaces.
3. Heavy objects should not be placed on it.

3.3.3. Vernier caliper

Vernier caliper is a precision measuring instrument. The least count of vernier caliper is usually 0.02 mm. Vernier caliper was developed by a French scientist known as Pere Vernier in the year 1830 and the instrument is called after his name.

Vernier calipers are useful in measuring outer dimensions, inner dimensions and depths of holes and slots. Graduation in millimeters are marked on a scale known as main scale. A fixed jaw is attached to the mainscale. There is another jaw known as movable jaw attached with a vernier head. It is also graduated and this scale in known as vernier scale. A screw is attached to the movable jaw to lock the movable jaw afer sliding it to the required distance. The inner sides of both the jaws are parallel.

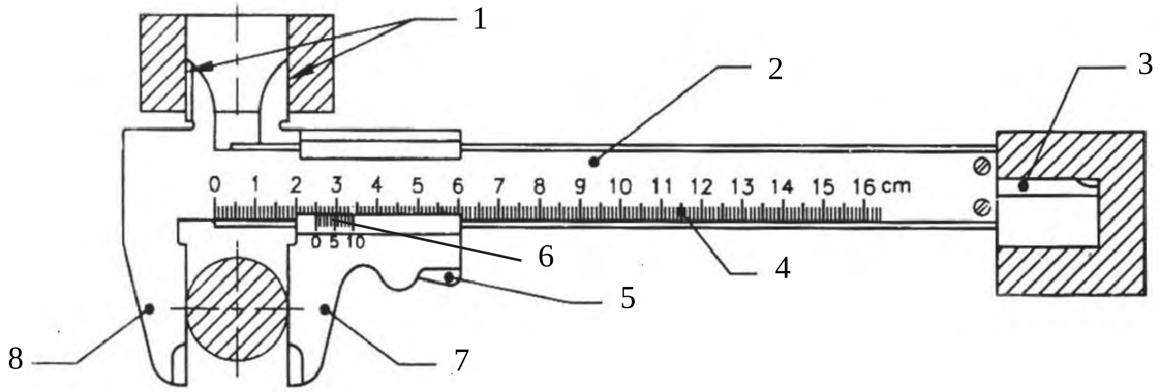


Fig 3.8 Vernier caliper

1. Jaws for measuring inner dimensions 2. Main scale 3. Narrow plate for measuring deprh 4. Main scale graduations 5. Locking screw 6. Vernier scale 7. Movable jaw 8. Fixed jaw

The object to be measured is held between the fixed jaw and the movable jaw and the movable jaw is adjusted to have contact on the side of the object. Fine adjustment screw is then adjusted for accurate contact and correct measurement. The reading on both the main scale and the vernier scale are then noted.

A narrow slot is provided on the back of the main scale to accommodate a narrow plate. This plate is made to move along with the vernier scale to measure depths of holes and slots. Two separate jaws are provided on the top side for measuring inner dimensions.

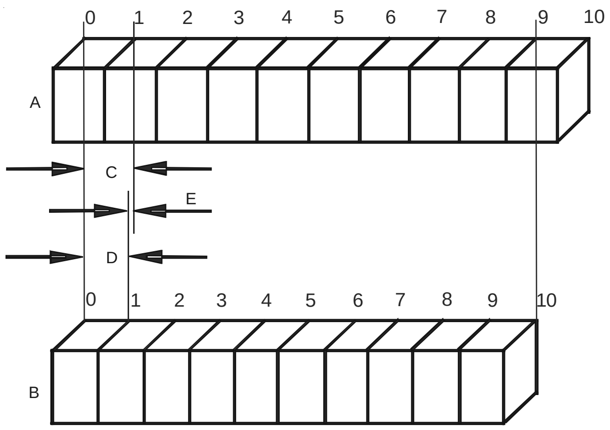


Fig 3.9 Visualisation of least count

A. Main scale dividions B. Vernier scale dividions C. One main scale dividions D. One vernier scale dividions E. Least count

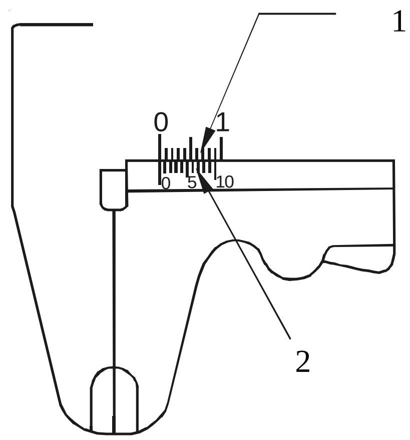


Fig 3.10 Main scale and vernier scale

1. Main scale division
2. Vernier scale division

Method of measuring:

One division of the main scale is 1mm. The vernier scale has 10 divisions which is equal to 9 mm.

10 vernier division = 9 mm
1 vernier division = 9 / 10 mm
= 0.9 mm

Least count of a vernier caliper is the difference between one main scale division and one vernier scale division.

= 1.00 - 0.9
= 0.01 mm

In some other types of vernier calipers, one main scale division is 0.5mm and the vernier scale has 25 divisons.

25 vernier divisios = 12mm
1 vernier division = 12 / 25 mm
= 0.48 mm

Least count of a vernier caliper is the difference between one main scale division and one vernier scale division.

= 0.5 - 0.48
= 0.02 mm

$$\text{Reading} = \left.\begin{matrix}\text{No. of main scale}\\ \text{divisions}\end{matrix}\right\} + \left(\begin{matrix}\text{Least}\\ \text{count}\end{matrix}\right) \text{X} \begin{matrix}\text{No. of vernier}\\ \text{divisions}\end{matrix}$$

3.3.4 Vernier height gauge

Vernier height gauge is used to measure the height of objects and for precision layout work. Measurements are made by placing the instrument on the surface plate. Measurements can be done to an accuracy of 0.02mm.

The base of the height gauge is made of steel. A graduated beam is mounted vertically on the base. It is graduated in millimeters. A movable jaw called slider is fitted on the graduated beam. It can be adjusted up and down to enable it measure objects of diffrent heights. A scriber is attached to the slider for layout purposes. The slider has a graduated scale called vernier scale. There is a fine adjustment screw fitted on the slider which is useful in adjusting the jaw accurately. A clamping screw is fitted on the slider to lock the jaw at the required position.

To take measurement , the instrument and the object are placed on the surface plate. The measuring jaw is placed on the top of the object and fine adjustment is made with the screw meant for it. The jaw is locked in this particular position with the help of slider clamping screw. The main scale division and the vernier scale division are taken note of.

Reading = No. of main scale divisions + (Least count) X No. of vernier divisions

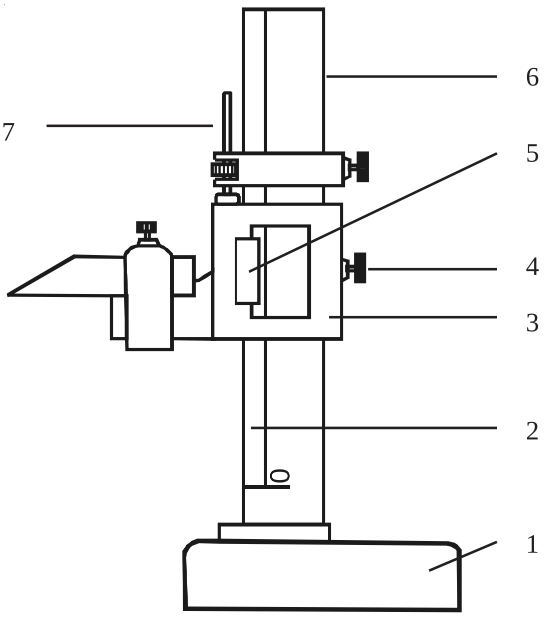


Fig 3.11 Vernier height gauge

1. Base
2. Main scale
3. Slider
4. Clamping screw
5. Vernier scale
6. Graduated beam
7. Scriber

3.3.5. Micrometer

Micrometer is an instrument to measure length, width and thickness of small and medium sized objects to an accuracy of 0.01mm in Metric scale and 0.001inches in English scale. The working principle of this instrument is based on a screw. It is also known as screw gauge.

The frame is 'U' shaped and it is made of cast steel or light alloys. The anvil is hardened and is attached to one end of the frame. The graduated barrel is attached to the other end of the frame. It has the dactum line and fixed graduations. The spindle is attached to the thimble and the rotation of the thimble will make the spindle to move forward or backward. The spindle does the actual measuring and has threads of 0.5mm pitch.

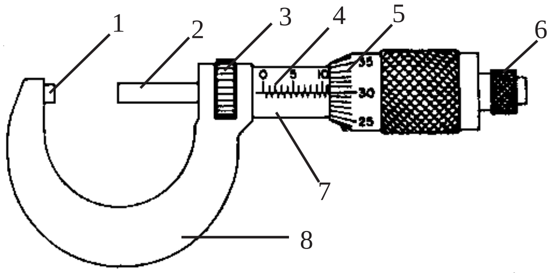


Fig 3.12 Micrometer

1. Anvil 2. Spindle 3. Locking nut 4. Main scale division 5. Thimble 6. Ratchat 7. Barred 8. Frame

Thimble is a tubular cover attached to the spindle. The bevelled edge of the thimble is divided into 50 equal divisions and every fifth division is numbered. Ratchet is a small extension of the thimble. It slips when the pressure on the screw reaches a certain amount. This produces uniform readings.

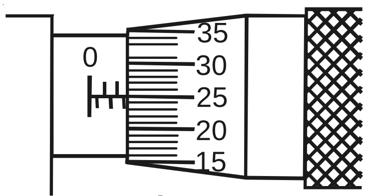
Method of measuring

One division of the main scale (barrel) is equal to 0.5mm. The micrometer screw is of 0.5mm pitch while the thimble is divided into 50 equal divisions. So one full revolution of the thimble will make the spindle to move forward or backward by a distance of 0.5mm.

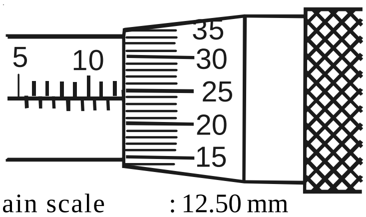
50 thimble divisions = 0.5mm
1 thimble division = 0.5 / 50 mm
= 0.01 mm

This measurement is called the least count of the instrument. The part to be measured is held between the end of the spindle and the anvil. The reading on the main scale and the thimble divisions are taken and the reading is

Reading = No. of main scale divisions } + (Least count) X No. of thimble divisions ± Zero error

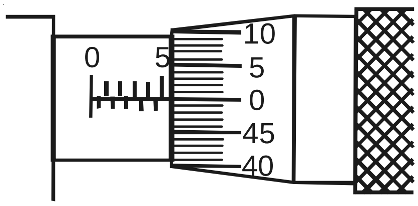


Main scale : 2.50 mm
Thimble scale : 0.25 mm
: 2.75 mm

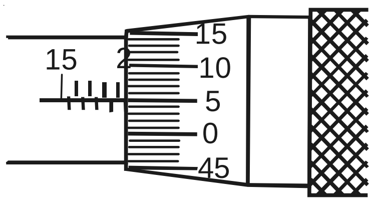


Main scale : 12.50 mm
Thimble scale : 00.24 mm
: 12.74 mm

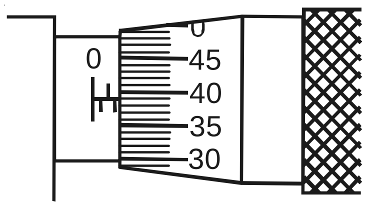
Fig 3.13 Different reading of micrometer



Main scale : 5.50 mm
Thimble scale : 0.00 mm
: 5.50 mm



Main scale : 19.50 mm
Thimble scale : 00.05 mm
: 19.55 mm



Main scale : 1.50 mm
Thimble scale : 0.39 mm
: 1.89 mm

British micrometer

The screw used in a British micrometer has 40 T.P.I. It is understood that the pitch value is 1/40". The thimble has 25 equal divisions on it. When the thimble is rotated for one full revolution, the spindle moves a distance of 1/40". When the thimble is rotated for one of its own divisions, the spindle moves a distance of 1/40" X 1/25 = 1/1000" = 0.001". This is the least count of British micrometer.

Errors in a micrometer

When the micrometer is closed, the end of the spindle and the anvil come into contact. The zero of the thimble should coincide with the datum line on the barrel. If these two do not coincide, some error is said to be in the micrometer. This error is known as zero error and it should be corrected. There are two types of errors found in a micrometer.

They are

1. Positive error
2. Negative error

Positive error

When the micrometer is closed, if the zero of the thimble is found below the datum line, the error is said to be positive. The amount of error should be deducted from the reading. The number of thimble divisions between the zero of the thimble and the datum line is the reading necessary for calculating the amount of error.

Positive error = thimble divisions as obtained above x least count

The error calculated as above should be corrected whenever measurements are taken using the instrument.

$$\left.\begin{matrix}\text{Reading}\\ \text{after correction}\end{matrix}\right\} = \left.\begin{matrix}\text{No. of main scale}\\ \text{divisions}\end{matrix}\right\} + \left(\begin{matrix}\text{Least}\\ \text{count}\end{matrix}\right) \text{X} \begin{matrix}\text{No. of thimble}\\ \text{divisions}\end{matrix} - \begin{matrix}\text{positive}\\ \text{error}\end{matrix}$$

Negative error

When the micrometer is closed, if the zero of the thimble is found above the datum line, the error is said to be negative. The amount of error should be added to the reading. The number of thimble divisions between the zero of the thimble and the datum line is the reading necessary for calculating the amount of error.

Negative error = thimble divisions as obtained above x least count

The error calculated as above should be corrected whenever measurements are taken using the instrument.

$$\left.\begin{matrix}\text{Reading}\\ \text{after correction}\end{matrix}\right\} = \left.\begin{matrix}\text{No. of main scale}\\ \text{divisions}\end{matrix}\right\} + \left(\begin{matrix}\text{Least}\\ \text{count}\end{matrix}\right) \text{X} \begin{matrix}\text{No. of thimble}\\ \text{divisions}\end{matrix} + \begin{matrix}\text{Negative}\\ \text{error}\end{matrix}$$

3.3.6 Inside micrometer

The inside micrometer is useful in taking internal measurements to an accuracy of 0.01 mm and 0.001". The principle of inside micrometer is very similar to that of the external micrometer. Holes with diameters over 50 mm are measured with inside miocrometer.

The inside micrometer has the following parts - measuring unit, extension rod and an handle. The distance between the measuring faces wiil vary from 50 to 63 mm when the thimble is rotated. Extension rods may be attached to the unit for measuring holes with diameter over 63 mm. Extension rods are available in the following sizes - 13 mm, 25mm, 50 mm, 100 mm, 150 mm, 200 mm and 600 mm.

The pitch value of the inside micrometer is 0.5 mm. The main scale on the barrel is graduated for 13mm. The circumference of the thimble is divided into 50m equal divisions. One full revolution of the thimble will make the measuring end to move a distance of 0.5 mm. One division of the thimble is equivalent to a measurement of 0.01 mm.

3.3.7 Depth micrometer

Depth micrometer is useful in measuring the depth of holes, slots and keyways. The method of measuring is very similar to that of an external micrometer.The accuracy of this instrument is 0.01 mm. There should be proper seating for the instrument head to measure accurately. The depth micrometer consists of an head, spindle, barrel, thimble, locking ring and a ratchet stop. Head is the part of the instrument which is placed on top of the hole. The bottom of the head is perfectly flat to ensure correct seating of the instrument. The spindle does the actual measuring. The amount of protrusion of the spindle from the bottom of the head is the actual measurement. The barrel has got the datum line and fixed graduations which are numbered. The thimble is connected with the spindle at its outer end and moves with the spindle. The locking ring is used to lock the instrument at the desired setting.

The depth micrometer is provided with three interchangeable spindles with measuring ranges of 25 to 50 mm, 50 to 75 mm, and 75 to 100 mm.

3.3.8 Differences between a vernier caliper and a micrometer

VERNIER CALIPER	MICROMETER
1. Available in various accuracies	1. Accuracy is mostly 0.01mm or 0.001’’
2. External, internal and depth measurements can be measured with a single instrument of vernier caliper.	2. External, internal and depth measurements should be taken with different types of micrometers.
3. The measuring range is more (can measure upto 200mm)	3. The measuring range is less (can measure upto 25mm only at the most.)
4. Measuring is done with sliding arrangement	4. It has thread arrangement for measuring
5. Measuring is done quickly.	5. Slow measuring process
6. Contact area is more.	6. Less contact area .

3.3.9 Vernier micrometer

Vernier micrometer is an instrument in which a vernier scale is attached to the conventional external micrometer. It is used in the same manneras that of an ordinary micrometer. Measurements are taken using three scales namely - main scale (on the barrel), thimble scale and vernier scale. The vernier scale has 10 spaces running parallel to the dactum line on the barrel. These 10 divisions are equal to 9 divisions of the thimble.

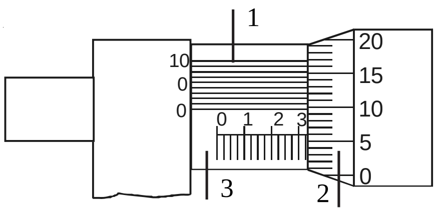


Fig 3.14 Vernier Micrometer
1. Vernier scale 2. Thimble division
3. Barrel (Main scale)

3.4. Angular measuring instruments

Like linear measuring instruments, angular measuring instruments are available in different accuracies. Combination set, vernier bevel protractor and sine bar have different accuracies.

3.4.1 Combination set

Combination set consists of a blade (steel rule), a square head, a protractor head and a centre head. The rule is made of tempered steel with a groove cut along the lentgh on which all the other parts may slide. Each part is provided with a knurled nut for locking it into position.

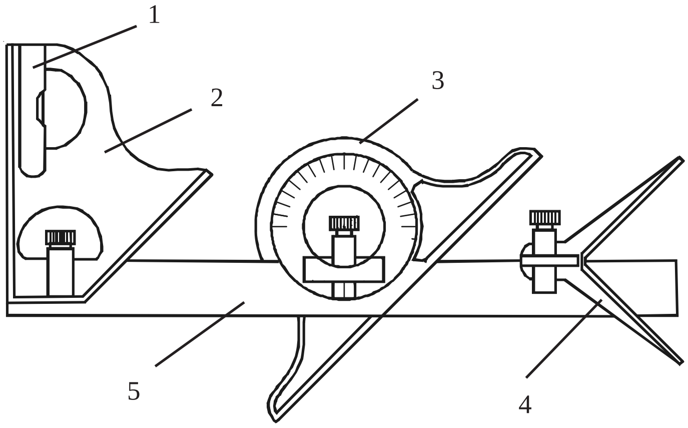


Fig 3.15 Combination set

1. Sprit level 2. Square head 3. Protractor head 4. Centre head 5. Steel rule

Steel rule

Steel rule is graduated on both the ends. The size of a combination set is specified by the length of the steel rule.

Square head

It is a small part which has one of its sides at 90^0 and other side at 45^0 to the base surface. It has got a spirit level which can be used to check the levels of surfaces (horizontality). Square head can be used to scribe and check angle. When used along with steel rule, it serves as depth gauge. It is useful in checking the perpendicularity of surface internally.

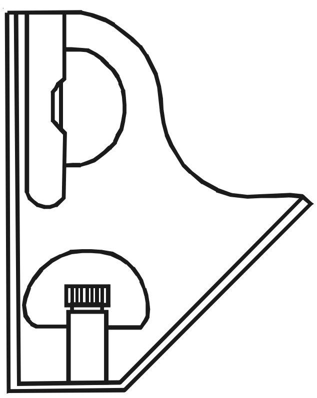


Fig 3.16 Square head

Centre head

It has two legs at right angles to each other. So it is 'V' shaped with an angle of 90^0.When it is attached to steel rule, the angle is bisected. This construction helps in finding the centre of round rods. It is also useful in checking perpendicularity of surfaces externally.

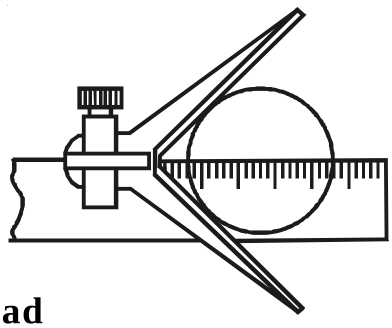


Fig 3.17 Square head

Protractor head

It has a protractor attached to a frame. Angular graduations are marked on the protractor from 0^0 to 180^0. There is a '0' mark on the frame. When the '0' on the frame coincides with '0' of the protractor it is understood that the line is horizontal. When used along with steel rule, straight lines can be scribed on the workpieces at a requried angle to the external surface. It is also useful in checking the levels of angular surfaces. As a spirit level is attached to the protractor it is easy to operate it.

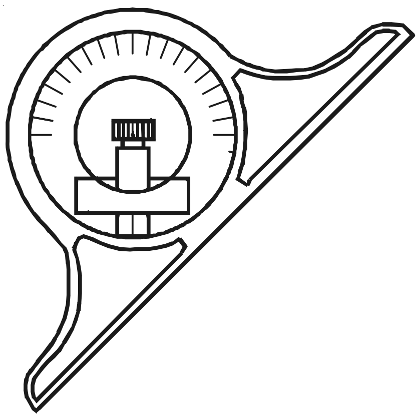


Fig 3.18 Protractor head

3.4.2 Vernier bevel protractor

Bevel protractor is an instrument used for measuring and testing angles. It is adopted where angles are to be laid out or measured within the limits of 5 min.

The bevel protractor consists of a stock integal with a disc which is fitted with a pivot at the centre. On this point, the graduated dial is allowed to rotate when clamping nut is released. Another clamp clamps the blade rigidly to the dial. The blade can be moved lengthwise or replaced by another blade of differrent length. A vernier scale is fitted to the disc to take vernier readings and for accurate measurements. To set the instrument, it is necessary to release the clamping nut and turned to the required position.

The dial is graduated in degrees over an arc of 180 degrees reading from each end of the arc. The vernier scale has 12 divisions which is equal to 23^0 in the main scale.

12 vernier divisions = 23^0

‘ = 23 X 60 min

1 vernier division = $\frac{23 \times 60}{12}$

= 115 Min

One vernier division is 5 minutes short of 2 degrees. The instrument can be utilised to measure angles to the accuracy of 5 minutes.

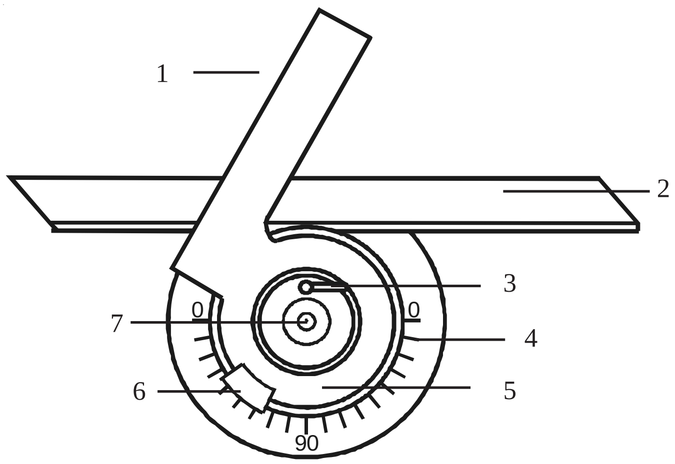


Fig 3.19 Vernier bevel protractor

1. Stock 2. Movable blade, 3. Clamp of blade 4. Main Scale 5. Disc 6. Vernier Scale 7. Locking screw

In order to take reading from the bevel protractor, the reading on the main scale is directly taken to the number of whole degrees between ‘0’ of the main scale and ‘0’ of the vernier scale. The number of spaces from ‘0’ of the vernier scale to a line which coincides with a line on the main scale is also taken note of. This number is multiplied by ‘5’ to be added as a reading in minutes.

Fig 3.20 Reading with vernior bevel protractor

3.4.3 Sine bar

Sine bar is used to measure angles accurately. Measurements of angles using bevel protractor is direct whereas sine bar makes indirect mesurements. Sine bar is used in conjuction with slip guages for setting of angles and of tapers from a horizontal surface. The accuracy attained with this instrument is very high.

Sine bar consists of an accurately lapped steel bar which is stepped at its ends with a roller secured into each step by a screw. The screw holds the roller in contact with both faces of the step. A sine bar is specified by the distannce between the centres of two rollers (100 mm or 250 mm)

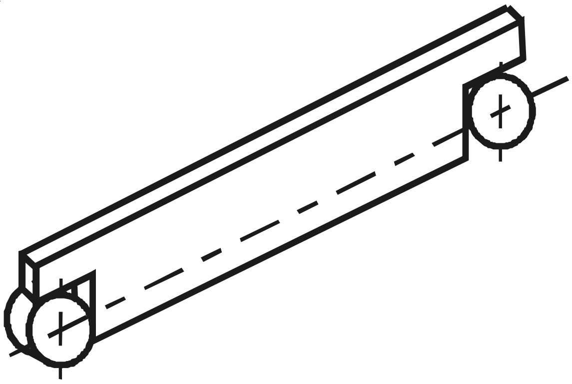


Fig 3.21 Sine bar

For accurate measurements, the following points are important

1. The rollers of must be of same diameter.

2. The distance between their centres must be absolutely correct.

3. The line joining the centre of the rollers must be absolutely parallel with the bottom and top surfaces of the bar.

H	=	100mm
Sin A	=	a / H
< A	=	Sin-1 (a / 100)

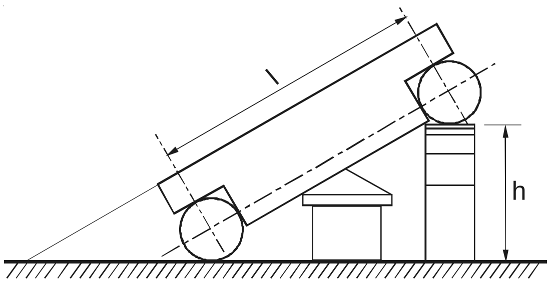


Fig 3.22 Measuring with Sine bar

Where 'a' is the difference in total heights of slip gauges at both ends of the sine bar. The corresponding angle can be obtained from trignometre tables.

3.5 Gauges

Gauges are the tools which are used to check the size, shape and relative positions of various parts. They are not provided with graduated parts. They are manufactured for a particular size. Different gauges are designed for different sizes and shapes. They are made of alloy steel, heat treated and ground accurately to the required size.

3.5.1 Advantages of gauges

1. The measurements are checked quickly and easily.
2. The cost of gauges is less when compared with precision measuring instruments.
3. A semi-skilled operator can handle gauges.
4. No supervision is required.
5. The production is increased.

3.5.2 Grades of gauges

Gauges are made of alloy steel preferrably high speed steel. They are hardened and tempered and made in three different grades.

1. Workshop gauge
2. Inspection gauge
3. Master gauge

Workshop gauge

This grade of gauges are used in workshops to check the dimensional accuracy of the products manufactured in the shop. The accuracy of workshop gauge is 0.025mm or 0.0001".

Inspection gauge

Inspection gauges are designed to be handled by skilled operators for inspection purposes. It is made with an accuracy of 0.0001" or 0.0025mm.

Master gauge

Master gauges are useful in checking the workshop gauges and inspection gauges. It is also used to check very accurate tools and are made with an accuracy of 0.00001" or 0.00025mm.

3.5.3 Classification of gauges

Gauges can be classified as standard gauges and limit gauges.

Standard gauges

They are made to the nominal size of the part to be tested.

Limit gauges

Limit gauges are made to the limit sizes of the work to be measured. One of the sides or ends of the gauge is made to the maximum permissible size and the other side or end is made to the minimum permissible size. The use of a limit gauge is to decided if the actual dimensions of the part are within the specified limits.

3.5.4 Types of gauges

Gauges are classified according to accuracy, shape and the elements to be checked. Some of them are mentioned below.

1. Plug gauge
2. Ring gauge
3. Taper gauge
4. Snap gauge
5. Thread gauge
6. Screw pitch gauge
7. Template gauge
8. Radius and fillet gauge
9. Wire gauge
10. Plate gauge
11. Feeler gauge
12. Telescopic gauge
13. Slip gauge

Plug guage

Plug gauges are used for checking the bores of many different shapes and sizes. There are plug gauges dor straight cylindrical holes, tapered holes and splined holes.

Stanndard plug gauges are used to check the nominal size of a cylindrical hole. The progressive limit plug gauges has got 'go' end and ' no go 'end on the same side of the gauge. It is used to check the limits of sizes. The double ended limit plug gauges are used to test the limit of sizes. At one end it has a plug of minimum limit size - 'go' end at the other end a plug of maximum limits sizes 'no go' end.

Fig 3.23 Plug gauge

A - Double ended plug gauge B - Progressive plug gauge

Ring gauges

Ring gauges are used to test external diameters. They allow shafts to be checked more accurately since they embrace whole of their surfaces. Ring gauges are expensive to manufacture and therrefore find limitted usage.

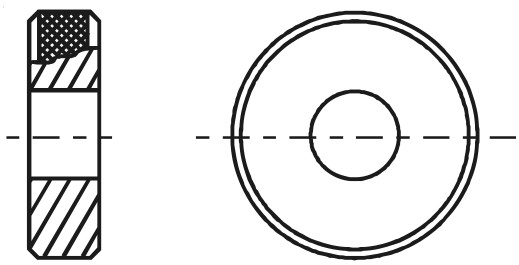


Fig 3.24 Ring gauge

Taper gauge

The best method of testing taper is to use taper gauges. They are also used to gauge the diameter of taper at some point. The gauges are made in both the plug and ring style.

The taper diameter is checked by noting how far the gauge enters the tapered hoe. A mark is made at some point on the gauge to show the right diameter for the large end of the taper.

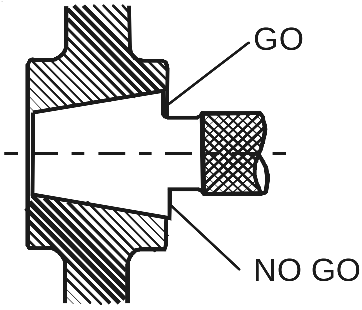


Fig 3.25 Taper plug gauge

Snap gauges

Snap gauges are used for checking external dimensions. There are different types of snap gauges namely

1) Caliper snap gauge

2) Adjustable snap gauge

3)Double ended solid snap gauge

Caliper gauge

The caliper gauge with ‘go’ and ‘no go’ end is used for medium sizes.

Adjustable snap gauge

Adjustable snap gauges are used for larger sizes. This is made with two fixed anvils and two adjustable anvis. One set of anvils is for the ‘go’ end and the another set of anvils is for ‘no go’ end. These gauges have two recesses to receive the adjustable anvils with screws. The anvils are set for a specified sizes with adjustable range of 3 to 8 mm.

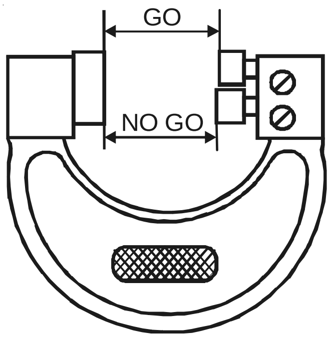


Fig 3.26 Adjustable snap gauge

Double ended solid snap gauge

Double ended solid snap gauges are used for smaller sizes.

Thread gauges

Threads (pitch diameter of threads) are checked with thread gauges. For checking internal threads, plug threads gauges are used, while for checking external threads (Screws and bolts) ring gauges are used.

Screw pitch gauge

Screw pitch gauges are useful in picking out a required screw and for checking pitch of screw threads. They consist of a number of flat blades which are cut out to a given pitch and pivoted in a holder. Each blade is stamped with the pitch or number of threads.

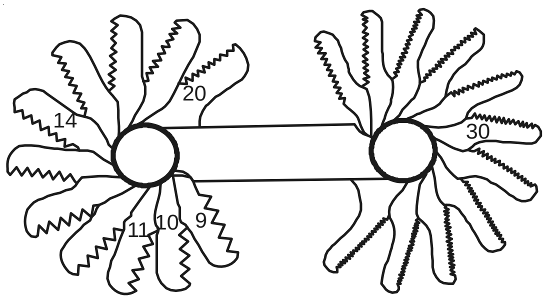


Fig 3.27 Screw pitch gauge

Template gauges

Template gauges are made from sheet steel. A template profile gauge may contain two outlines that represent the limits within which a profile must lie.

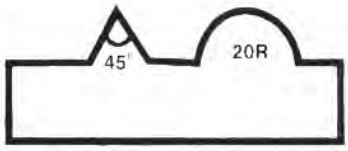


Fig 3.28 Template

Radius gauge

The function of a radius gauge is to check the radii of curvature of convex surfaces over a range of 10 to 25 mm. The gauges are made in sets of thin plates curved to different radii at the ends. Each set consists of 16 convex and 16 concave blades.

Fillet gauge

The function of these gauges is to check the radii for curvature of concave surfaces

Plate and wire gauges

The thickness of sheet metal is checked by means of plate gauges and wire diameters by means of wire gauges. The plate gauge is used to check the thickness of plates from 0.23 to 3 mm and the wire gauge is used to check the wire diameters from 0.1 to 10 mm.

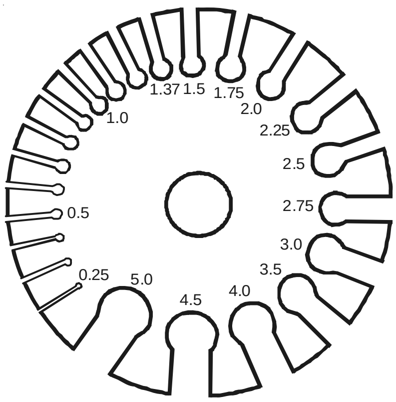


Fig 3.29 Plate and wire gauge

Feeler gauges

Feeler gauges are useful in checking small gaps between mating surfaces. They are made as precision machined blades with different thickness. The thickness ranges from 0.03 to 1.0 mm. All the blades are placed in a holder and have indications of their thickness marked on them.

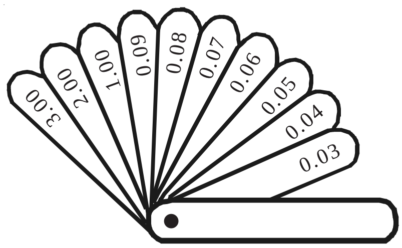


Fig 3.30 Feeler gauge

Telescopic gauge

Telescopic gauge is used for measuring inner dimensions of holes and slots. It consists of a handle and two plungers. The two plungers are telescopic into each other with spring tension. The plungers are compressed and inserted into the hole or slot. It is allowed to expand and touch the opposite surfaces. The plungers are locked in position and taken out to know the measurement. The measurement can be done with a micrometer.

Slip gauge

Slip gauges are also known as gauge blocks. They are made of high speed steel and alloy steel. They are made as rectangular hardened blocks machined accurately and finished to a very high accuracy.

They are made in different sizes as blocks and arranged in a case exclusively meant for that. They are used for verifying measuring tools such as micrometers and comparators. Slip gauges are made both in Metric method (mm) and in English method (inches). After use, the blocks should be placed back safely in the case.

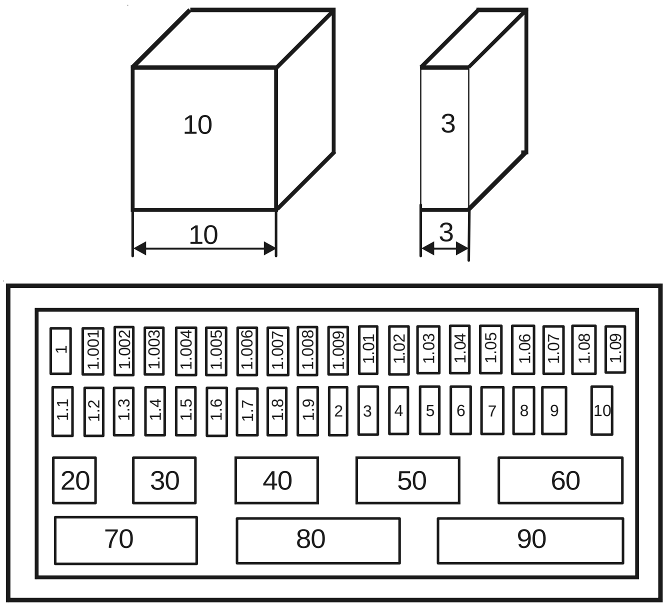


Fig 3.31 Slip gauge

3.7 Differences between gauges and templates

Gauges	Templates
1. Mostly made of high speed steel	1. Made of thin steel sheets
2. Accuracy is very high	2. They are not very accurate
3. Costly	3. The cost is less
4. Used to cheek sizes and shapes	4. Used only to cheek the shape of particular object
5. Not used on hot articles	5. Can be used on all parts

QUESTIONS

I. A. Choose the correct option

1. ________ is a direct measuring instrument
   a. Caliper b. Gauge c. Vernier caliper d. Divider

2. Surface gauge is a
   a. direct measuring instrument b. indirect measuring instrument
   c. inspecting instrument d. plane surface measuring instrument

3. Measurements on cylindrical surfaces are done with
   a. narrow rule b. hook rule c. folding rule d. flexible rule

4. The length and outside diameter of an object can be measured with
   a. jenny caliper b. combination set
   c. vernier height gauge d. outside caliper

5. The least count of a vernier is
   a. 0.01mm b. 0.02 mm c. 0.001 mm d. 0.1mm

6. Zero errors are generally found in
   a. micrometer b. combination set c. sine bar d. vernier caliper

7. Angular measurements are done to an accuracy of 5 minutes with
   a. Sine bar b. vernier bevel protractor
   c. combination set d. inside micrometer

I.B. Answer the following questions in one or two words

1. Give an example for inspecting instrument.
2. Mention one use of jenny caliper.
3. What is the accuracy of a master gauge?
4. What is the use of feeler gauge?
5. Mention the use of a telescopic gauge.

II. Answer the following questions in one or two sentences

1. What are the different categories of measuring instruments?
2. What is a steel rule?
3. What is a caliper?
4. What are the types of calipers?
5. What is a micrometer?
6. What is sine bar?
7. What is the use of vernier bevel protractor?
8. What are gauges?
9. What is a depth gauge?
10. The reading obtained in a micrometer with a positive error of 0.08mm is 25mm. Find the reading after correction.
11. The reading obtained in a micrometer with a negative error of 0.07mm in 20mm. Find the reading after correction.

III. Answer the following questions in about a page

1. Explain different methods of measuring.
2. Explain the types of steel rule.
3. Explain the errors found in a micrometer.
4. List different types of gauges.
5. Explain plate gauge with a diagram.
6. Draw and explain a screw pitch gauge.
7. Explain a template.
8. Explain – Ring gauge and plug gauge
9. Differentiate a template from a gauge.

IV. Answer the following questions in detail

1. Draw and explain a vernier caliper.
2. Explain a vernier height gauge with a diagram.
3. Draw a neat diagram of a micrometer and explain how measurements are taken using it.
4. Differentiate a vernier caliper from a micrometer.
5. Draw and explain a sine bar.
6. Explain slip gauges with a diagram.

4 ENGINEERING MATERIALS

4.1 Introduction

A material can be defined as the one which occupies space. It may be a solid, a liquid or a gas. We need materials of different kinds for food, clothing, housing, medicine, energy, telecommunication, transportation etc. The materials are either natural or artificial. The natural materials in need include air, water, oil, minerals, cereals, metals, wood, rubber etc., The artificial materials are made from primary materials which occur naturally. The latest trend is to make or synthesize special materials for specific applications. The synthetic materials include vitamins, medicines, textiles, petrol, fuels, refrigerants, textiles, dyes, soaps, detergents, chemicals, paper, glass, polymers like plastics, cement, steel, non ferrous alloys etc. Though we need the materials found in the list for our daily life, only a few of them are useful in engineering industry.

4.2 Engineering materials

Engineering is all about making or constructing something. New technologies pave way for the engineers in various fields to design, develop and manufacture several machines, fabrication vehicles, and electronic gadgates and build structures. We find by observing the products, that all of them are made of materials with specific characteristics. With the evolution of new materials, the technology gets further boost by developing more efficient products.

For example, it is everybody's knowledge that very little current is consumed when a computer executes its operation. But this current is converted as heat which has to be conducted by some packing material. The complex situation in this aspect is the speed of execution needs to be multifold and the size of the computer should be reduced. This will take the heat generated into greater heights. If a computer of said capacity should become a reality, a proper packing material is needed. Nowadays very compact size computers are available with the advent of new matrix composite materials which conducts away the high quantum of heat. In deciding the characteristics of various materials, the structure is an important factor.

4.3 Structure of materials

When we work with various materials in our daily life not all of them have similar characters or properties. Some of them are soft and some other hard. Some material withstands high temperatures but others do not withstand. We observe some metals are shaped into different shapes whereas it is not possible for some other metals.

Water is stored in metal jars. But acids are stored in glass bottles only and not in metal jars. The differences in the structure of various materials are the reason for their different characters and properties. So, it becomes necessary to know about the structures and their influence upon the general properties of different materials.

4.3.1 Structure of metals

When molten metals attain solid shapes, the atoms are arranged in a specific position to form a shape known as crystals. The centers of atoms in a crystal are connected by lines to form a three dimensional geometrical shape known as **lattice.** The smallest basic shape representing the relative position of atoms is known as a unit cell. Many unit cells make a crystal when they are arranged in a proper order. The unit cells of majority of the metals are of cubic and hexagonal shape.

The common crystal lattice structures are

1. Simple cubic crystal
2. Body centered cubic crystal
3. Face centered cubic crystal
4. Hexagonal closely packed crystal

Simple cubic crystal (SCC)

In this structure, the atoms are present at the corners of the cube only.

Body centered cubic crystal (BCC)

The unit cell of this structure consists of atoms present at each corner of a cube and another atom at the centre of the cube. Metals like Iron, Sodium ,Vanadium and Molybdenum belong to this category. An important character of BCC metals is that their tendency to deform plastically.

Face centered cubic crystal (FCC)

Atoms are present on all the corners of the cube. In this structure, apart from this one atom each is present on all the faces of the cube. Examples of FCC structure are Copper, Gold, Nickel, Aluminium and their alloys. FCC metals are ductile and have high electrical conductivity.

Hexagonal closely packed crystal (HCP)

The unit cell of HCP crystal is hexagonal in shape. Atoms are present on all the corners of the hexagonal prism, one atom each at the centre of both top and bottom faces and three atoms in a mid plane. Zinc, Cadmium, Cobalt and Titanium are some examples of HCP crystal structure. They are very ductile and can easily be deformed.

There are some materials which don't have their atoms arranges in a lattice and they are known as amorphous. Rubber, thermostat plastics and metallic glasses are amorphous. The atomic structures of materials are identified by X-ray diffraction technique.

4.4 Properties of materials

Now, we know different types of internal structure are responsible for the varied behavior of different materials. These behavior or properties are classified as

Physical properties

Mechanical properties

Chemical properties

Electrical properties

Thermal properties

Density, melting point and specific heat of a material are known as its physical properties. Properties such as oxidation, corrosion and solubility are classified as chemical properties. Electrical properties of a material are resistivity, conductivity and dielectric strength. Thermal conductivity and thermal expansion are known as thermal properties.

Mechanical properties of a material

Mechanical properties of a material are defined as the behavior of a material when external mechanical forces are applied on them. These behaviors are very essential during designing and manufacturing processes. They are

1. Strain
2. Stress
3. Strength
4. Hardness
5. Toughness
6. Stiffness
7. Elasticity
8. Ductility
9. Malleability
10. Resilience

External mechanical forces can act on an object in different ways. If the load is acting on the object as two equal and opposite forces to pull it, the object tends to elongate and the load is known as **tensile load**.

The load is **compressive** when two equal and opposite forces act on object to push or compress it. The object will tend to shorten on compressive load.

When an object is subjected to two equal and opposite forces acting on the cross section of the object to make it shear, the load is known as **shear load**.

Strain

When an external force acts upon an object, it deforms the object and brings about changes in its dimensions. Strain can be defined as the ratio of change in dimension to the original dimension of the object on which the forces act. As it is the ratio between dimensions equal unit, strain has no unit.

Stress

When an object is subjected to external forces, some resisting forces are set-up within the object. Stress in an object can be defined as the force that resists the deformation caused by external forces per unit area. It is expressed in Newton/m^2. When an object is subjected to tensile load, it is under tension. The stress developed within the body is known as tensile stress. When compression forces act upon an object, it is under compression. The stress developed to resist compression is called compressive stress. Shear stress is a force developed within an object to resist shear force which tends to shear in cross section.

Strength

When an object is subjected to external forces, the ability of the material of the object to withstand such forces is known as strength.

A material has different strengths to withstand different forces. The ability of the material to withstand stretching is its tensile strength. Objects which are designed to carry heavy loads should have high tensile strength.

Compressive strength of a material is its ability to withstand compression. Concrete and bricks have high compression strength.

The ability of a material to resist shearing forces is called shear strength. Bolts, screws, rivets and welded joints should have higher shear strength as they are subjected to shear forces to fracture them across their cross section.

Hardness

Hardness of a material is defined as its strength to oppose penetration or indentation, wear, tear and scratching. Hardness is a property considered primary when selecting materials for producing cutting tools and machine tool structures. Diamond is the hardest material. High carbon steel and high speed steels have higher hardness.

Toughness

Toughness is the ability of a material to withstand sudden external forces. It is the amount of energy absorbed by the material before it develops fracture. Materials which do not withstand sudden forces are called brittle. Milling cutters and gears are subjected to sudden impacts. Tough materials like alloy steels are used for manufacturing such components.

Stiffness

Stiffness of a material is its ability to resist deformation. It is also referred as Youngs's modules of electricity.

Young's modulus of elasticity = Stress/Strain

Elasticity

The ability of a material to regain its original size and shape on removal of the applied forces is known as elasticity. It is the ratio of strain and stress.

Elasticity = Strain/Stress

Ductility

Ductility is defined as the ability of a material to sustain plastic deformation before breaking. Ductile materials undergo considerable permanent deformation before breaking. Gold and Copper are highly ductile. Ductile materials are easily bent or formed to required shapes.

Malleability

Malleability of a material is the ability to get deformed under compression. A malleable material can be flattened into thin sheets without breaking. Ductility is a tensile property whereas malleability is a compressive property. Not all malleable materials are ductile. Lead is malleable but not ductile. But it can be said all ductile materials are malleable. Apart from Lead, Tin, Copper, Aluminuim and Silver are malleable.

Resilience

The ability of a material to absorb energy when elastically deformed and to give it off when unloaded is known as resilience.

4.5 Classification of materials

The variety and number of engineering materials are growing at a faster rate. A proper material for manufacturing a particular component has to be selected considering various properties of the material. Materials intended for engineering purposes are broadly classified as

1. Metals
2. Ceramics
3. Polymers
4. Composites

4.5.1 Metals

The main characters of metals are their luster, high thermal and electrical conductivity, strength, ability to be easily shaped and moderate to higher strength and density. But they are less corrosion resistant and their properties change vastly at higher temperatures.

Metals are extracted from their ores and purified. But pure metals don't have all the properties to be used as engineering materials. In order to get the desired properties and to use them in industry, two or more metals are combined and the resultant material is known as alloy.

Alloys are classified as ferrous alloys and non-ferrous alloys.

Ferrous alloys have iron as their main constituent.

I. Iron alloys

- a. Pig iron (95% Iron, rest-Carbon, Sulphur, Silicon, Phosphorus)
- b. Cast iron (Iron, 2-4.5% - Carbon, 3.5%-Silicon)
  - i. White cast iron
  - ii. Grey cast iron
  - iii. Malleable cast iron
  - iv. Alloy cast iron
- c. Wrought iron

II. Steel

- a. Carbon steel
  - i. Low carbon steel or mild steel
  - ii. Medium carbon steel
  - iii. High carbon steel
- b. Alloy steels (Metals alloyed with steel include Nickel, Chromium, Cobalt, Manganese, Tungsten, Molybdenum and Vanadium)

Non – Ferrous alloys

Non- Ferrous alloys have elements other than Iron as their main constituent. Non-ferrous alloys include alloys of Aluminium, Copper, Tin, Zinc, Lead.

4.5.2 Ceramics

Ceramics are otherwise known as a non metallic, inorganic material. The general characteristics of ceramics are

1. Hardness
2. Very high strength even at high temperatures
3. Resistant to oxidation and corrosion
4. Good thermal and electrical insulation
5. Wear resistant
6. Highly brittle

They are made from powdered materials by fabrication through the application of heat. They include oxides, silicates, borides, nitrides and carbides.

The application of ceramics

Constructional products	-	Brick, sewage pipes, roof tiles & wall tiles
White ware	-	Dinnerware, electrical porcelain
Refractory	-	Bricks and monolithic products used in different industries
Glasses	-	Flat glasses for windows, container vessels, pressed and blown Glass.
Abrasives	-	Natural (diamond) Synthetic (Silicon Carbide & Aluminium Oxide) - used for grinding , polishing & lapping
Cement	-	Buildings, bridges & dams.
Electrical	-	Insulators, capacitors, magnets & super conductors.

4.5.3 Polymers

A polymer has a repeating structure based on Carbon. The repeated structure gives a chain like molecules bonded together to form solids.

The main characteristics of polymers are

1. Easy to fabricate
2. Resist corrosion of all forms
3. Good electrical insulation
4. Lighter and less dense than metals and ceramics
5. Low strength
6. High toughness
7. Poor resistance to higher temperature.

Important industrial polymers are plastics and rubber. Plastics are a large group of synthetic materials manufactured by forming or by moulding methods. Plastics can be broadly divided into two classes namely

Thermo plastic polymers   Thermosetting polymers

Thermo plastic polymers include polystyrene, polyvinylchloride (PVC), polyethylene and polypropylene. They melt on heating and can be processed by a number of moulding and extrusion methods. Thermosetting polymers cannot be melted.

Rubber is a natural polymer and a variety of rubbers are known as elastomers.

Here are some selected polymers and their applications:

Nylon

It is a thermoplastic polymer and has high tensile strength. Nylon is used in textile industry to manufacture clothes, bags and ropes. They are also useful in manufacturing gears, pulleys, belts, electrical cables etc. In domestic front, sieves, brushes, mosquito nets and cutlery are manufactured with nylon.

PVC (Poly vinyl chloride)

It is used to manufacture frames for doors and windows, furniture, bottles, lids, pipes and plumbing fittings. In automobile field, door panels, arm rests and dash boards are made with PVC. In medical field, I.V bottles and respiratory masks are made with PVC.

Polycarbonates

Their very high strength, scratch and corrosion resisting character and ability to withstand high temperature make them find applications in making eye lenses, spectacles, helmets, bullet-proof jackets, windows of aeroplane and space vehicles.

Teflon

Teflon finds applications in non-stick cookware and electric irons.

4.5.4 Composites

A composite can be defined as a combination of two or more distinct materials to form a new material. The new material will have properties that cannot be achieved by any one of the constituent material. But they will retain their original properties. A wide range of engineering materials are composites.

Composites generally have two phases namely matrix phase and reinforcing phase. The matrix material and the reinforcing material may be a metal, a ceramic or a polymer. Generally the matrix material is ductile and tough and reinforcing materials are strong and have low densities.

Common classifications of composites are

1. Reinforced plastics
2. Metal-matrix composites
3. Ceramic-matrix composites
4. Concrete
5. Sandwich structure

4.6. Common engineering materials

An engineering material which satisfies all the requirements of the produce has to be found out in order to obtain the complete advantage of the technology. A good material needs to satisfy functional requirements, fabrication requirements and economic requirements. Some of the common engineering materials are listed below

1. Cast iron
2. Steel
3. Aluminium
4. Copper
5. Lead
6. Zinc
7. Tin
8. Chromium

All these metals and their alloys

4.6.1. Cast iron

The different types of cast iron are alloys of Iron, Carbon and other elements like Silicon, Manganese, Phosphorus and Sulphur. The amount of Carbon present in cast iron ranges from 2% to 4.5%

Characteristics of cast iron

1. Hard and brittle
2. Cannot be forged, magnetized or tempered
3. High compressive strength
4. Low tensile strength
5. Melting point about 1100^0c
6. Better machinability (Grey cast iron)
7. Higher absorption of vibrations and deflections
8. Wear resistant

Because of these characters, cast iron is useful in manufacturing machine beds, columns, frames and housings, pipes and cylinders of automobile engines.

Alloy cast iron is obtained by alloying cast iron with other metallic elements like Nickel, Chromium, Cobalt, Copper, Tungsten, Molybdenum and Vanadium. Cast iron is brittle and cannot withstand shocks. Besides, it has a low tensile strength. By alloying the above metals with cast iron, these shortcomings can be improved greatly.

4.6.2 Steel

Both Cast iron and Steel are alloys of Iron and Carbon. If the Carbon content goes beyond 2%, it is present in free state in the alloy and the alloy is known as cast iron. When the content of carbon is within 2%, carbon is found in the combined state only.

There are two distinct categories of steel

1. Carbon steels
2. Alloy steels

Carbon steels

Carbon steels are further classified on the basis of percentage of carbon as

1. Low carbon steel
2. Medium carbon steel
3. High carbon steel

Low carbon steel

It contains 0.05% to 0.3% of Carbon. It is soft, ductile and has low tensile strength but is tough. Screws, nuts, bolts, boiler plates, structural sections, chains are made with low carbon steels. It is also known as mild steel.

Medium carbon steel

0.3% to 0.6% Carbon is present in medium carbon steels. It has high tensile strength and high machinability. It is less ductile when compared with low carbon steel. It is used to manufacture products like agricultural tools, wheel axles, wires, ropes, hammers, springs dies and crankshafts.

High carbon steel

The amount of carbon present in high carbon steel ranges from 0.6% to 1.7%. It is very hard and has high tensile strength and high wear resistance. But the ductility is very low. High carbon steel is used to make wrenches, chisels, punches, files, drills and carpentry tools.

Alloy steel

Steels having one or more elements other than Iron and Carbon are termed as alloy steels. According to American Iron & Steel Institute, the other elements present in the alloy steel also influence the properties of steel. The alloying elements with steel are Chromium, Nickel, Manganese, Silicon, Vanadium, Molybdenum, Tungsten, Phosphorous, Copper, Titanium, Cobalt, and Aluminium.

The presence of various elements makes up different types of steel. They are utilized for some specific purposes only. Some important alloy steels are

1. Stainless steel
2. Tool steel
3. Special alloy steel

Stainless steel:

Stainless steel is obtained by adding 4% to 6% of Chromium and 4% to 8% of Nickel with low carbon steel. Along with these elements, 0.8% of Silicon and 0.5% of Molybdenum are also added. A little further quantity of Chromium is added to reduce the possibility of rusting.

Tool steel:

Different types of tools used in various machine tools and majority of hand tools are made with tool steel. Though there are different types of tool steels available, High Speed Steel (HSS) is very important.

High speed steel is used in making drills, single point cutting tools and milling cutters. Because of the presence of HSS, the tools can be used for high speed machining. Tungsten HSS, Molybdenum HSS, Cobalt HSS and Vanadium HSS are different types of HSS. Of all these steels, Tungsten HSS is most widely used in making cutting tools. It contains 18% of Tungsten, 4% of Chromium 1% of Vanadium and 0.7% of Carbon. It has high wear resistance and high heat resistance.

4.6.3 Non-ferrous metals

A metal other than Iron is known as non-ferrous metal. The melting points of these metals are low when compared with that of Iron. Non-ferrous metals include Aluminium, Copper, Tin, Lead, Zinc, Nickel, Chromium, Gold etc., These metals can be mixed in desired proportions to obtain various alloys like brass, bronze and bell metal.

Aluminium and its alloys

Aluminium is bluish-white or light grey in colour. It is light weight, ductile, malleable, highly corrosion resistant and good electrical and thermal conductor. Initially, it was extracted from Aluminium Chloride. Generally it is extracted from its main ore bauxite by electrolysis method. As pure Aluminium is soft, some other elements are added to make it stronger. These alloys can be moulded, forged and turned on lathes. The melting point is 658^0 C. Utensils and reflectors are some of its main applications. Duralumin and Y – alloy are some important alloys of Aluminium.

Lead and its alloys

Lead is probably the heaviest common metal. It is grey in colour. It is soft, ductile and non-corrosive. It is extracted from the ore of Galena. It has a low melting point of 327^0 C.

Copper and its alloys

Copper can be distinguished from other metals with its reddish-brown colour. It is generally extracted from an ore called pyrites. The impurities are filtered in various stages to obtain pure Copper. It is soft, ductile, and malleable and conducts heat & electricity. The melting point of Copper is 1083^0 C. It is used in making electrical wires, pressure vessels and utensils. Brass and Bronze are important alloys of Copper.

Tin

It is white in colour, soft, ductile and malleable. Because of its non-corrosive property, it is used for coating on Copper and other steel parts. The melting point of Tin is 232^0 C.

Zinc

It is a white coloured metal. Zinc sulphite and Zinc carbonate are its ores. It is purified in several stages to obtain its pure form. The melting point of Zinc is 419^0 C. Zinc is used for coating a protective layer on Iron and Steel parts. This process of coating is known as Galvanizing.

Chromium:

It is a grey coloured metal. The melting point of Chromium is 2930^0 C. It is used as an additive to steel to form alloy steels.

QUESTIONS

I. A. Choose the correct option

1. Oxidation is a
   a. physical property   b. electrical property
   c. thermal property   d. chemical property

2. The property of changing the shape of a metal part is a
   a. thermal property   b. electrical property
   c. physical property   d. chemical property

3. Metal with 18% of Tungsten, 4% of Chromium 1% of Vanadium and 0.7% of Carbon is
   a. High Speed Steel   b. Carbon steel
   c. Bronze   d. Tungsten HSS

B. Answer the following questions in one or two words

1. State two major divisions of metals.
2. Mention any two types of Cast Iron.
3. What are the two types of Steel?
4. Mention any two types of alloy steels.
5. Expand – HSS.
6. What do you mean by 'ceramics'?

II. Answer the following questions in one or two sentences

1. What are the important properties of metals?
2. What is hardness?
3. What is ductility?
4. What is the use of Zinc?

III. Answer the following questions in about a page

1. Explain the mechanical properties of a material.

5. HEAT TREATMENT

5.1 Introduction

Every metal has its unique characteristics and properties. The properties of these metals can be altered to suit our needs by heating them in their solid state and then cooling them. Heat treatment is a process which includes heating a metal or an alloy to a particular temperature, soaking the metal at the temperature for a particular period of time and cooling the metal at a particular rate to attain certain desired qualities.

When steel is heated, changes are found in their internal structure. The amount of Carbon changes because of the heat. The structure and the properties are subjected to changes during cooling process after heating.

The amount of change in internal structure of Steel will vary according to the amount of heat it is subjected to, the method and the speed of cooling.

5.2 Objectives of heat treatment

A metal or an alloy may be heat-treated to accomplish one or more of the following purposes.

1. To restructure the physical properties like hardness, ductility and toughness of the metal.
2. To improve the characters of wear resistance, corrosion resistance and heat resistance
3. To soften the metal for machining
4. To harden the outer surface of the metals
5. To alter the grain size of metals
6. To create homogenous internal structure
7. To relieve internal stress of the metal that is developed while going through machining processes
8. To make changes in electrical and magnetic properties
9. To improve machinability.

While heating metals, their internal structure starts to transform at a particular temperature. This temperature is known as **Lower critical temperature** of the metal. On further heating, the whole internal structure is transformed at a particular temperature. This temperature is called **Upper critical temperature**.

5.3 Methods of heat treatment

1. Annealing
2. Normalising
3. Hardening
4. Tempering
5. Case - hardening
    a) Carburising
    b) Nitriding
    c) Cyaniding
    d) Induction hardening
    e) Flame hardening

5.4 Annealing

Annealing consists of

1. Heating the steel slightly above the critical temperature
2. Holding it as this temperature for a considerable period of time
3. Slowly cooling it

The annealing temperature is 30^0 C to 50^0 C above the higher critical temperature. Generally, oil fired furnace, gas fired furnace or sintering (electrical) furnaces are used for heating. The temperatures are monitored by barometers. The holding at the annealing temperature is 3 to 4 minutes for each millimeter of section of the largest piece being heated. The metal is slowly cooled by burying in a conducting material such as sand, lime or ashes.

The critical temperature of the metal varies with the amount of carbon present in it.

The purpose of annealing are

1. Soften the steel
2. Improve machinability
3. Increase or restore ductility and toughness
4. Relieve internal stresses
5. Refine grain size
6. Prepare steel for subsequent heat treatment
7. Make structural homogeneity

5.5 Normalising

The process of normalising consists of heating the metal to temperatures within the normalising range (Usually 40^0 C to 50^0 C above higher critical temperature) and holding it at the temperature for a short time (about 15 min) and cooling in air.

Normalising is done usually on forged, rolled and cast parts. The internal structure of these parts will be in total disarray after the said processes. Normalizing is done to correct these defects.

The purposes of normalising are

1. To eliminate coarse grained structure
2. To remove internal stresses
3. To improve mechanical properties of steel
4. To create homogenous internal structure
5. To increase the strength

5.6. Hardening

The process of hardening consists of heating the steel to a temperature above critical point (from 750^0C to 850^0C), holding it at the temperature for a considerable period of time and rapidly cooling it by quenching it in water, oil or salt bath.

The purposes of hardening are

1. To develop hardness
2. To resist wear and enable it to cut other metals
3. To improve strength, elasticity, toughness and ductility

5.7 Tempering

It is observed that the hardened steel is very hard and brittle. This structure is not suitable for engineering work. So hardening should always be followed by tempering.

The process of tempering involves reheating the steel after hardening to temperatures below lower critical temperature, holding it for a considerable time and slow cooling.

The purposes of tempering

1. To decrease the brittleness of hardened steel
2. To stabilise the structure of metal
3. To reduce some of the hardness produced during hardening
4. To increase the toughness of steel
5. To improve ductility

5.8 Case hardening

At times it is necessary that only the outer skin of a part should be hard and wear resistant. The inner core may be soft and tough. The case hardening process involves a chemical change in the outer surface of the work and so differs from other methods of heat treatment. Its is a process of forming a high carbon surface on a low carbon steel part and the objective is to produce a part with tough, ductile core and a hard outer surface.
The different processes of case hardening are

1) Carburising
2) Nitriding
3) Cyaniding
4) Induction hardening
5) Flame hardening

5.8.1 Carburising

The process of carburising involves heating iron or steel to red heat (from 900^{0}C to950^{0}C)in contact with some carbonaceous materials such as wood (or) leather, charcoal, crushed bones with compounds such as carbonates of barium, calcium or sodium. Iron at temperatures close to its critical temperature has an affinity of carbon. The carbon enters the metal to form an outer surface of high carbon steel.

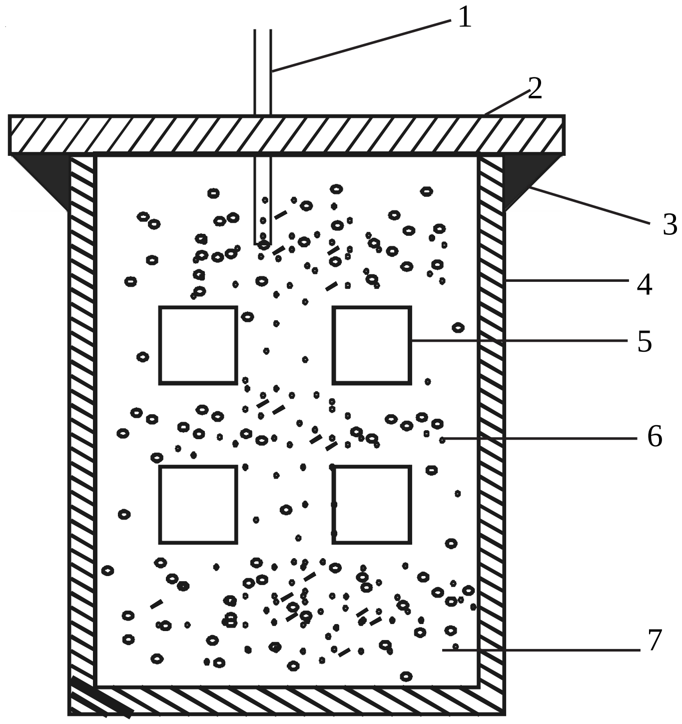


Fig 5.1 Carburising

1. Test bar
2. Lid
3. Fireclay
4. Steel case
5. Metal parts
6. Carburising powder
7. Rammed powder

Disadvantages of carburizing are

1. Not suitable for mass production
2. Time involved is more (for packing, heating, cooling and unpacking)
3. The amount of hardening cannot be controlled easily

5.8.2 Cyaniding

Cyaniding is the process of producing hard surfaces on low carbon or medium carbon steel by immersing steel in molten salt bath containing cyanide at 800^0 to 900^0 C for about 15 minutes and then quenching the steel in water or oil. The hardness produced by this treatment is due to the presence of compounds of Nitrogen and Carbon in the surface layer. A bath containing 1/3 (one third) each of Sodium chloride, Sodium carbonate and Sodium cyanide is used for cyaniding treatment. The surface is hardened to a thickness of 0.125mm.

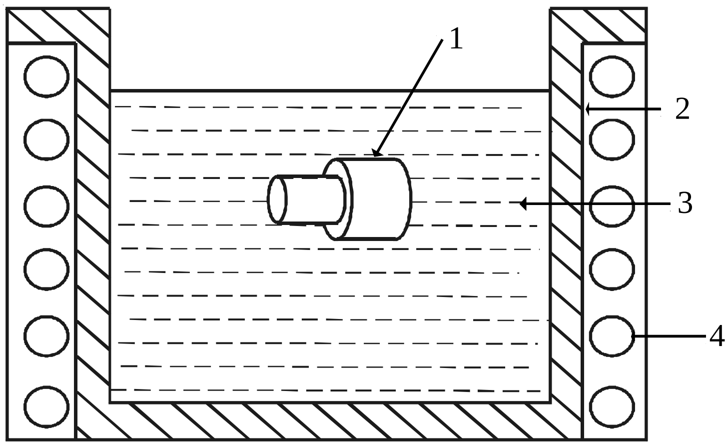


Fig 5.2 Cyaniding

1. Metal part 2. Container 3. Salt bath 4. Heating coil

Advantages of Cyaniding

1. It is a rapid process
2. The exterior will have high lustre
3. Uniform hardening
4. The ductility is increased

5.8.3 Nitriding

Nitriding is the process of producing hard surface layer on alloy steels only. Nitriding consists of heating the steel in the atmosphere of Ammonia gas at temperatures of 500^0 C to 600^0 C. The ammonia is dissociated as Nitrogen and Hydrogen and the Nitrogen combined with elements in the steel to form nitrides. These nitrides give extreme hardness to the surface.

Advantages of Nitriding

1. The obtained hardness is very high
2. Wear resistance and corrosion resistance is increased
3. No scaling because of rapid cooling
4. Suitable even for complicated structures

5.8.4 Induction hardening

It is a method of hardening the outer surface of the parts by heating them with a high frequency current. It can be done very quickly. It has proved satisfactory for many surface hardening operations required in crankshafts, camshafts, axle shafts and similar surfaces. It can be differentiated from other case hardening processes in the sense that the analysis of the surface steel is not changed. It is accomplished by very rapid heating and quenching of the surface.

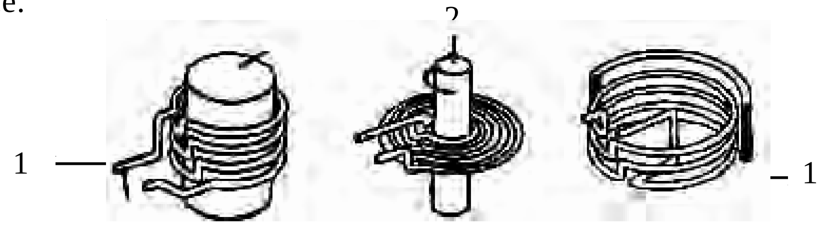


Fig 5.3 Induction hardening
1. Heating coil 2. Metal part

Advantages

1. The process is very quick
2. High rate of change of properties
3. The exterior surface can be made of high quality
4. The internal hardening can be controlled

Disadvantages :

1. The cost of the equipment is very high
2. Low carbon steel can not be hardened
3. Maintenance cost of the equipment is more

5.8.5 Flame hardening

Flame hardening is a process of hardening the steel by heating it with the flame of an oxy-acetylene torch. The flame is directed to the desired part without heating the other parts. The part to be hardened is fitted on the rotating shaft of a motor and the flame is directed to the part. After heating, the part is subjected to rapid quenching in water.

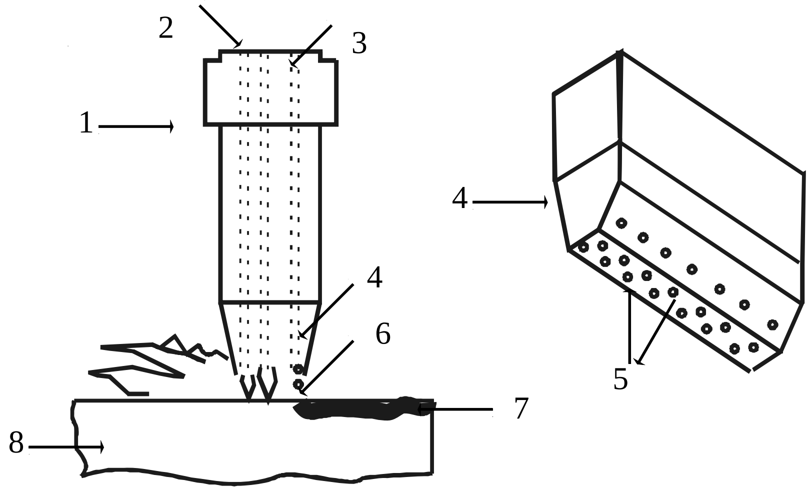


Fig 5.4 Flame hardening
1. Direction of torch movement
2. Oxy acctylene inlet
3. Water inlet
4. Water nozzle
5. Flame nozzle
6. Quenching by awater
7. Hardend portion of the part
8. Metal part

Advantages

1. It is simple and cost effective
2. It is possible to harden a part which is too large or inconvenient to be placed in a furnace
3. The time required for heating is less than in a furnace

5.9 Quenching

Quenching is done as a cooling process after the metal is heated and soaked in the same temperature for a certain period of time. It is done with water, oil or high pressure air.

The materials used for quenching are

1. Sodium solution
2. Cool water
3. Salt baths
4. Grades of oil
5. Air

5.10 Heat treatment furnaces

Some common types of heat treatment furnaces are mentioned below

1. Sintering furnace
2. Gas fired furnace
3. Oil fired furnace
4. Salt bath furnace

5.10.1 Sintering furnace

It is also known as electrical furnace. There are three layers in this type of furnace. The parts to be heated are arranged in a tray and sent into the furnace by means of conveyors.

The amount of heat inside the furnace is controlled by thermocouples and resistors. The temperature required for the heating process is set in this instrument. The parts are kept in the same temperature for a required time in the soaking zone. Afterwards the parts are cooled by a proper method to complete the hardening process. There are separate control devices to operate the conveyors at different speeds.

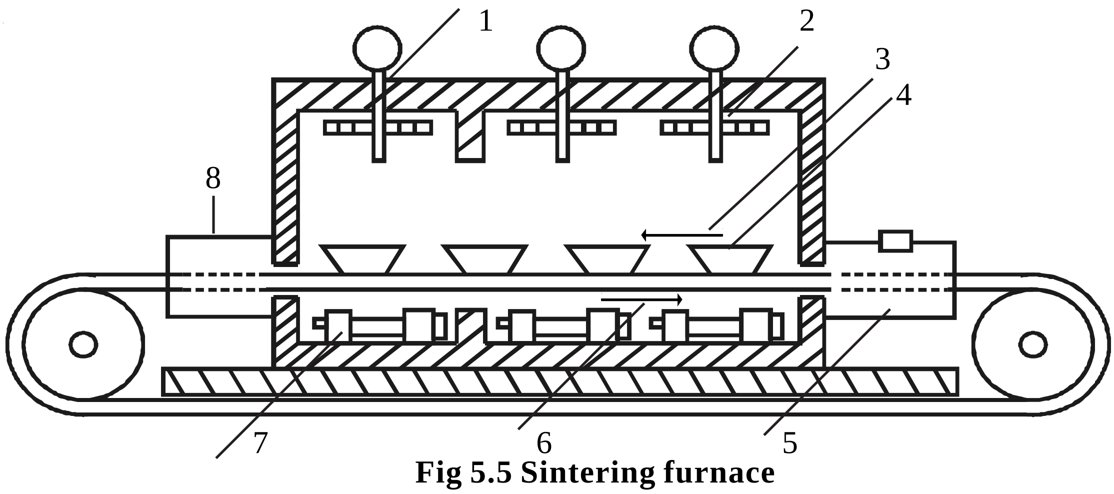


Fig 5.5 Sintering furnace

1. Thermo couple 2. Resistors 3. Gas 4. Workpiece 5. Quaking zone 6. Divection of belt movement 7. Resistors 8. Heating zone

QUESTIONS

I.A Choose the correct option

1. The method of heat treatment done to increase the wear resistance quality is
   a. annealing b. hardening c. tempering d. normalising

2. ……………………. is a method of case-hardening
   a. Tempering b. Annealing c. Nitriding d. Hardening

3. The media used for rapid quenching is
   a. Cyaniding b. Tempering c. Sodium salt bath d. Oil

4. The furnace with three layers is
   a. Gas fired furnace b. Salt bath furnace
   c. Sintering furnace d. Oil fired furnace

I. B Answer the following questions in one or two words

1. What change can be obtained by heat treating steels and alloys?
2. Mention one case-hardening process.

II. Answer the following questions in one or two sentences

1. Define ‘Heat treatment’.
2. What are the methods of heat treatment?
3. What is lower critical temperature and upper critical temperature?
4. What is annealing?
5. What are the types of furnaces?
6. What is quenching?

III. Answer the following questions in about a paragraph

1. What is case-hardening? Mention the case-hardening methods.
2. Explain “ Hardening”.
3. Carburising, Cyaniding – Explain
4. Nitriding, Induction hardening – Explain.
5. Normalising, Tempering – Explain.

IV. Answer the following questions in detail.

1. Explain the objectives of heat treatment.
2. Draw and explain - Sintering furnace
3. Induction hardening, flame hardening – Explain with diagrams

6. JIGS AND FIXTURES

6.1 Introduction

Jigs and fixtures are used to hold the workpieces firmly, locate the work and to guide the tool accurately. They are useful where large quantities of identical workpieces are to be manufactured with accurate measurement and precise quality. They replace the conventional work holding devices and are meant exclusively for a particular pattern of work. The processes of marking dimensions, and setting of workpieces are totally eliminated.

6.2 Advantages of jigs and fixtures

1. The production is increased as jigs and fixtures are adapted for quantity production of identical workpieces.

2. The cost of production is minimised.

3. The total machining time is reduced as it is not necessary to make marking on every individual workpiece.

4. The mounting time for the workpiece is considerably reduced.

5. The work is located accurately and so the accuracy of the product is more.

6. As the size and tolerance on dimensions are within specified limits, there is scope for interchangeability.

7. The cost incurred on quality control becomes less.

8. Machining can be performed even by a semi-skilled operator.

9. Machining can be performed at a quick rate by providing more cutting speed, feed and depth of cut.

10. As the machining process is safer, accidents are avoided.

6.3 Jigs

Jigs are special devices used to hold the workpieces and to guide and control the tools used in the machining process. Steel sleeves attached to the jig will guide the tool. The jigs are easy to handle as they are of very less weight. Jigs are classified according to the type of operation performed on the work.

6.4 Fixtures

Fixtures are devices which hold and locate the work during inspection or in a production process. It does not guide the tool. Vise, V block, angle plate, step block and T bolts can be seen as simple fixtures. Fixtures can hold irregular and unsymmetrical workpieces also.

6.5 Differences between a jig and a fixture

Jigs	Fixtures
1. A jig holds and locales the work as well as guides the tool.	1. A fixture holds and locates the work but does not guide the tool.
2. Jigs are made lighter for quick handling.	2. Fixtures are generally heavier.
3. Clamping with the table is mostly unnecessary	3. Fixtures are bolted rigidly on the machine table.
4. Jigs are used for drilling, reaming and tapping operations	4. Fixtures are used in milling, grinding, planing and turning operations

6.6 Elements of jigs and fixtures

The main aim of a jig or fixture is to hold the work properly in a particular position relative to the position of the tool. This aim is met by special provisions built within a jig or fixture. The basic elements of a jig or a fixture are

1. Body or frame
2. Locating elements
3. Clamping elements
4. Tool guiding elements
5. Indexing elements

6.6.1 Body or frame

This is an important part of jigs and fixtures. It gives support to the other elements of the jig. Projecting lugs are provided on the bottom of the jig body to attach it to the table of the machine. Holes are drilled in the base of the fixture body to clamp it to the machine table.

6.6.2 Locating elements

The locating elements are responsible for proper positioning and supporting of the work inside a jig of fixture. They ensure that the relative positions of the tool and the work is not disturbed due to clamping or cutting forces of the tool. They should resist bending, shearing and twisting of the parts supported by jigs or fixtures. Correct location of the work influences the accuracy of the finished product. Stop pins, rest buttons, jack pins, V block parallels are some locating elements.

6.6.3 Clamping elements

The clamping elements ensure stable position of the work located in a jig or a fixture. The work gets loose in a fixture because of either cutting forces or of the work's own weight. So, adequate number of clamping devices of proper type should be provided in a jig or fixture for its effective operation. The clamping devices should also ensure easy clamping and as well as easy releasing of the work after machining processes. Some common clamping devices are: Edge clamp, Strap clamp, Screw clamp, Latch clamp and Hinge clamp.

6.6.4 Tool guiding elements

Tool guiding elements are useful in mounting the tool with respect to the location of the work and guiding the tool during machining process. For example, the accuracy of drilling operation will depend on the tool guide that guides the drill. This guiding element known as sleeve or bush will be subjected to wear and tear because of the rotating tool. So the bushes should be made of wear resisting materials.

6.6.5. Indexing elements

Indexing elements are useful only when it is required to machine at different positions on a work. They rotate the work through a required angle and hold it firmly in correct position for the next part of the machining. This may be compared to the indexing head mechanism in a milling machine.

6.7 Location

Location helps to provide the required relationship between the workpiece and the jig or fixture. Correct location ensures high accuracy in the finished products. Jigs and fixtures are designed to restrict all possible movements of workpiece.

6.7.1. Principle of location

The rectangular block is free to move along the three axes. The body can also rotate about the axes and thus the total degree of freedom of a body along which it can move is six. In order to locate the block correctly within a jig, all these six movements must be restrained by arranging suitable locating points and then clamping the block in position.

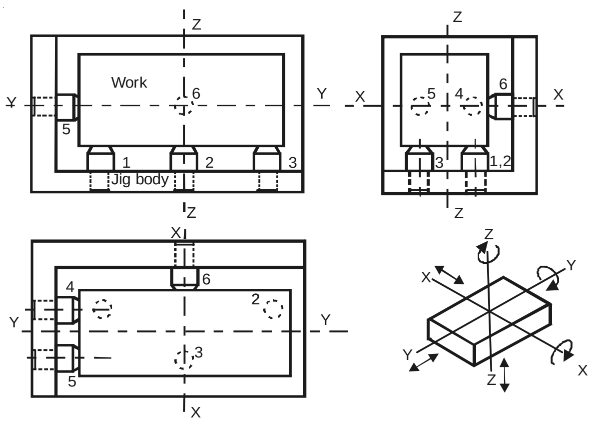


Fig. 6.1 3-2-1 Location

6.7.2 Six point location (3 - 2 - 1 location)

This is also called six points location of a rectangular block. It is assumed that the block shown in the figure is made to rest on several points on the jig body. The bottom of the block is supported against three points, the rear face of the block bears against two points and the side of the block rests against a single point, all projections from the jig body. It will be now clear that the downward movement of the block is restrained by three supporting points, which have the capability of supporting even a rough casting. The movements along other axis are restrained by the double and the single points respectively.

The rotary movements of the block about the three axes are also restrained by the bottom, back and side pins. The axes points thus serve to locate a block correctly while restraining all its movements. The locating points for an uneven object can be determined by different arrangements, but the guiding principle remains the same.

6.8 Types of jigs

1. Plate jig
2. Angle plate jig
3. Channel jig
4. Box jig
5. Diameter jig
6. Leaf jig
7. Vise jig
8. Ring jig
9. Indexing jig
10. Jig bushing

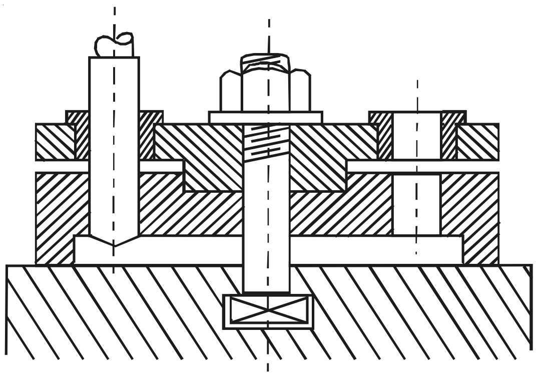


Fig. 6.2 Drill jig

Plate jig

Plate jigs are used when many numbers of holes are to be drilled on a workpiece. A plate having the required number of bushings fitted on it is held over the work. The plate and the work are held together by bolts. Holes at the required locations are then made by feeding the drills into the bushings.

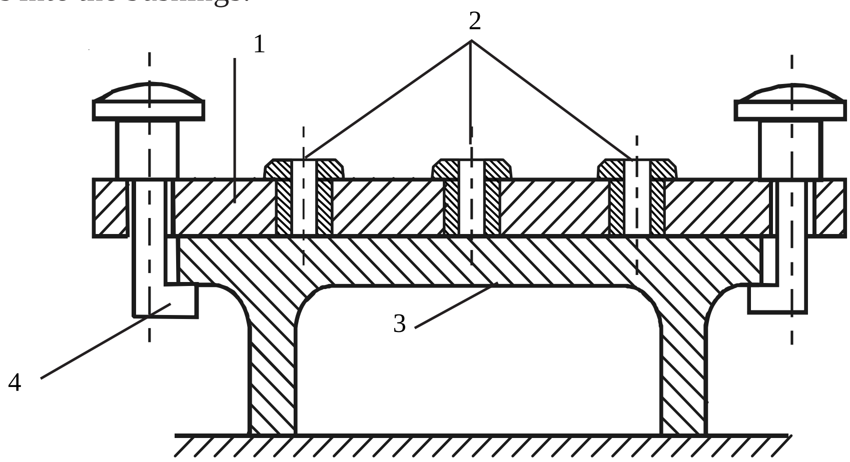


Fig. 6.3 Plate jig

1. Plate 2. Drill bushes 3. Work 4. Bolt

Channel jig

A channel jig is made of a channel section. The work is mounted in the channel and held firmly. It has clamping devices and the usual bushings at the required locations. Holes at the required locations are then made by feeding the drills into the bushings.

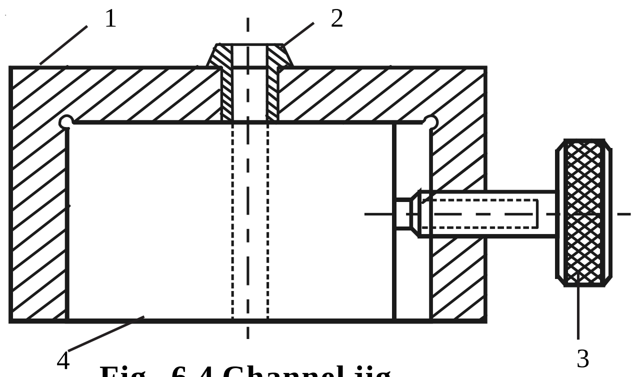


Fig. 6.4 Channel jig

1. Channel 2. Bush 3. Threaded knob 4. Work

Angle plate jig

It resembles an angle plate. One side of the jig is fitted on the machine table. On top of the other side, a plate with required drill bushes is attached to guide the drills. The work is held and clamped on the vertical side of the angle plate by means of a stud bolt. It is used for drilling holes in pulleys and gears.

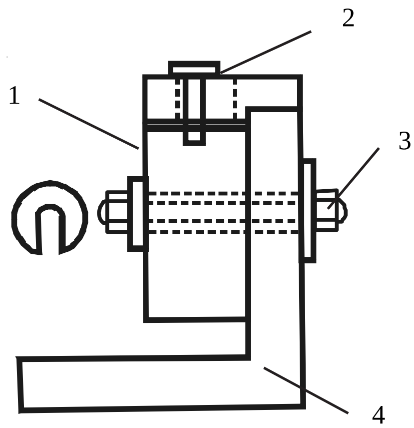


Fig. 6.5 Angle plate jig

1. Work 2. Bush 3. Stud bold 4. Angle plate

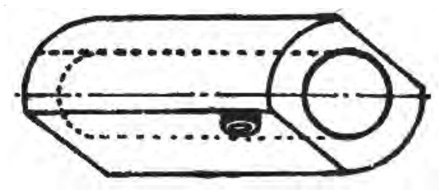


Fig. 6.6 Diameter jig

Diameter jig

This type of jig is used to drill holes on cylindrical pieces of work.

Box jig

It looks like closed box. The work is completely enclosed inside the jig. The top of the box is present with drill bushings at the required locations. Holes are then made by feeding the drills into the bushings.

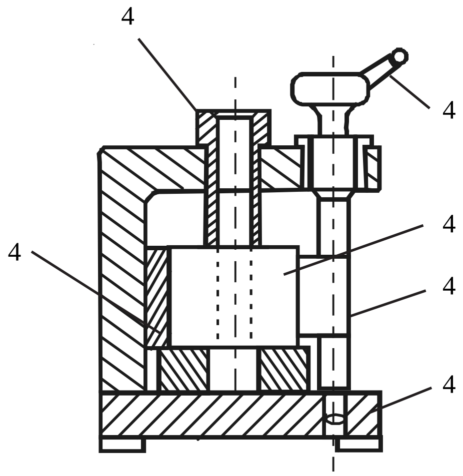


Fig. 6.7 Box jig

1. Pad 2. Bush 3. Handle 4. Work 5. Cam 6. Base

6.9 Types of fixtures

There are different types of fixtures used on the machine tables of different machine tools. Some important fixtures are listed below

1. Milling fixture with vise jaws
2. Plain milling fixture
3. Milling fixture with keyways
4. Spring milling fixtures

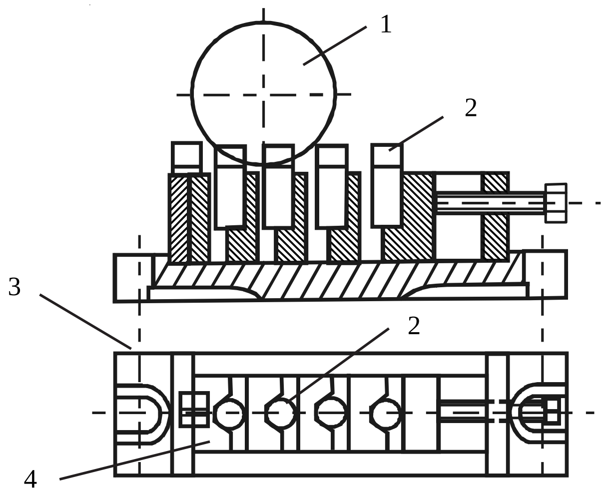


Fig. 6.8 Plain milling fixture

1. Slot milling cutter 2. Work pieces 3. Base 4. V - block

Plain milling fixture

The example shown in the diagram is useful in machining slots on the top of cylindrical workpieces. The diagram shows four V blocks holding four cylindrical pieces by straps. A setting block present in the fixture sets the path for the cutter's feed movement. The table is moved vertically for the depth of cut to finish the operation.

6.10 Points to be considered for designing a jig or a fixture

1. A thorough study of the workpiece is necessary. Details such as accuracy, weight, number of pieces to be machined, the type of material and the type of operation are to be considered.

2. The type, capacity and accuracy of the machine tool are to be taken note of.

3. Methods of mounting workpieces, loading and unloading methods, clamping methods, locating methods, the recess between the work and the jig, tool setting and guiding methods are to be considered.

4. Fool proofing arrangements for proper loading of work and swarf (chips) removal arrangement

5. Safety

QUESTIONS

I.A Choose the correct option

1. The jig meant to hold cylindrical workpieces
   a. Box jig   b. Diameter jig   c. Channel jig   d. Angle jig

2. The fixture meant to hold cylindrical workpieces
   a. Milling fixture with vise jaws   b. Plain milling fixture
   c. Milling fixture with keyways   d. Spring milling fixtures

I. B Answer the following questions in one or two words

1. Are the tools guided in jigs?
2. Name any two clamps used in a jig.

II. Answer the following questions in one or two sentences

1. What is a jig?
2. What is a fixture?
3. What do you mean by location?
4. What are the types of jigs?
5. What are the types of fixtures?

III. Answer the following questions in about a paragraph

1. What are the differences between jig and fixtures?
2. Explain ‘Plate jig’ with a diagram.
3. Explain ‘Channel jig’ with a diagram.
4. Draw and explain Ring jig and Box jig.

IV. Answer the following questions in detail.

1. List out the advantages of jigs and fixtures.
2. Explain various elements in a jig.
3. Explain 3-2-1 location with a diagram.

7. STANDARDISATION

7.1 Introduction

In order to manufacture a machine, we require thousands of small components. For this, various materials are used. Several parts are machined in various machines. In engineering, these materials and components are classified according to their qualities. This should be followed and the components should be manufactured accordingly. The aim of all modern manufacturing is to produce parts of absolute accuracy. The accuracy of the product depends upon the precision of the parts & accessories of the machine and keenness of the cutting tools used in the machine tool. But it is not always possible to keep exact measurements in mass production. If sufficient time is given, any operator would work and maintain the sizes within a close degree of accuracy. Still there would be some size variations. Some standards regarding a few parts are set by competent organizations by allowing size variations within restricted limits.

For example, bolts, nuts, threads, keys, studs, washers, tapers, gears, bearings and different sizes of plates and wires are available in standard sizes very easily. The production is also increased by reducing the cost. Then only the components are easily available and sold everywhere. Trading from one country to other is also increased.

7.2 Standardization

If any component is broken or to be changed due to wear and tear, it can be easily replaced by a new component by purchasing it from the market. These parts are manufactured by following the quality, the accuracy of size and other standards strictly prescribed by the following organizations like ISO and BIS. This is called standardization.

7.3 Interchangeability

In making mating parts in mass production, it is not always possible to maintain the dimensional accuracy of the parts. There are some variations in dimensions in few of the many number of products. If the variations of sizes are within certain limits, all parts of equivalent sizes will be fit for operating in machines and mechanisms. Certain deviations are allowed to ensure interchangeability of mating parts.

7.3.1 Advantages of interchangeability

1. As the parts are manufactured within desired limits, all parts of equivalent sizes will fit for operation.

2. The rate of production is increased in shorter period of time. The cost is reduced.
3. As standard parts are available easily, the time taken for replacement is very limited.
4. The rate of waste in mass production becomes less.

7.4 Basic terminology in interchangeable system

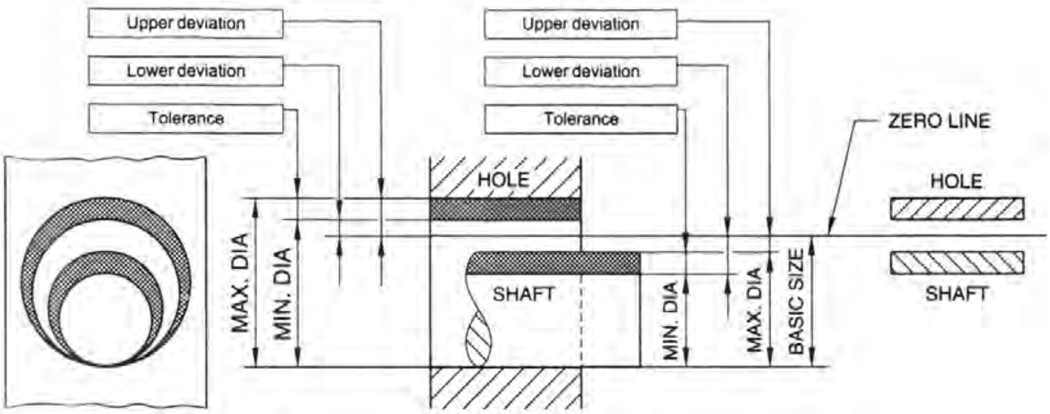


Fig 7.1 Interchangeable system

7.4.1 Shaft

The shaft indicates the outer diameter of a cylindrical profile.

7.4.2 Hole

The hole indicates the inner diameter of a cylindrical hole of a part.

7.4.3 Basic Size

Basic size of a dimension is the size in relation to which all limits of variation are determined. This is fixed up by designer considering its functional aspects without indicating any tolerance.

7.4.4 Actual size

The actual size of a component is its measured size. The actual size of a finished part will always deviate from the basic size or nominal size. But the difference between the basic size and actual size must not exceed a certain limit.

7.4.5 Limits of sizes

Limits of a size are two extreme permissible sizes between which the actual size is contained. The maximum limit of a size is the largest permissible size while the smallest permissible size is known as minimum limit of a size.

7.4.6 Deviation

The algebraic difference between the actual size and its corresponding basic size is called deviation.

Upper deviation

It is the algebraic difference between the maximum limit of a size and its corresponding basic size.

Lower deviation

It is the algebraic difference between the minimum limit of a size and its corresponding basic size.

7.4.7 Zero line

The zero line is the line of zero deviation and it represents the basic size. When the zero line is drawn horizontally positive deviations are shown above it and the negative deviations are shown below it. The sign + is added with positive deviations and the sign – is added with negative deviations.

7.4.8 Tolerance

Tolerance on a dimension is the difference between the maximum limit of size and minimum limit of size. It is the variation in size tolerated to cover reasonable imperfections in workmanship and varies with different grades of work.

However, tolerance is equal to the algebraic difference between the upper and the lower deviations.

There are two basic ways of specifying to tolerance

1) Unilateral tolerance

2) Bilateral tolerance

Unilateral tolerance

Unilateral tolerance is used where it is important for the dimension to vary in only one direction. Parts manufactured will fall close to the desired dimension but can vary in only one direction. An example is a drilled hole. As the drill is made close to the basic hole size, it is not possible to drill hole under size.

Example

Basic size is 40.00

Maximum limit is 40.02 (+0.02) and Minimum limit is 40.00(-0.00)

Here the tolerance is 0.02 and it is covered in the positive side only.

or

Basic size is 40.00

Maximum limit is 40.00 (+0.00) and Minimum limit is 39.98(-0.02)

Here the tolerance is 0.02 and it is covered in the negative side only.

Bilateral tolerance

Bilateral tolerance is used where the parts may vary in either direction from the basic size. If the tolerance is divided some being allowed on either side of the zero line (basic size), the system is called bilateral. It is not necessary that the variation should be equal.

Basic size is 40.00

Maximum limit is 40.04 (+0.04) and Minimum limit is 39.98(-0.02)

Here the tolerance is 0.06 and it is covered on both sides of the zero

7.5 Fits

The relation between two parts where one is inserted into the other with a certain degree of tightness or looseness is known as fit.

Types of fits

Depending upon actual limits of the hole and the shaft, fits can be divided into three classes

1. Clearance fit
2. Interference fit
3. Transition fit

7.5.1 Clearance fit

In a clearance fit, there is a positive difference between the largest possible shaft and the smallest possible hole. In this type of fit, the minimum clearance is always greater than zero. Such fits give loose joining and there will be some amount of freedom between the shaft and the hole. Bush bearings and channel bearings are fitted with clearance fit.

7.5.2 Interference fit

In an interference fit, there is a negative allowance between the largest hole and the smallest shaft, the shaft being larger than the hole. Ball bearings require interfere fits.

There are three grades of interference fits namely

1. Shrink fit
2. Heavy driving fit
3. Light driving fit

The parts with holes are heated to expand. In this condition, the shaft is inserted into the hole and the joint is rapidly cooled to have a strong fit. This is known as shrink fit.

In heavy driving fit, a good amount of force is given to drive the shaft into the hole.

Light diving fit involves a light force employed to drive the shaft into the hole.

7.5.3 Transition fit

They cover cases between first two classes of fits. The use of transition fit does not guarantee either interference or a clearance. Any pair of parts mating with transition fit may fit with interference while another pair with same fit may have a clearance fit. There are four different grades of transition fits and they are

1. Force fit
2. Tight fit
3. Wringing fit
4. Push fit

7.6 Hole basis and shaft basis

In a general limit system, it is necessary to decide on what basis the limits are to be found to give the desired fit. There are two distinct systems for varying the sizes of parts known as: hole basis and shaft basis.

7.6.1 Hole basis

A limit system is said to be on a hole basis when the hole is the constant member and different fits are obtained by varying the size of the shaft. In this hole system the high and low limits are constant for all fits of the same accuracy grade and for the same basic size.

7.6.2 Shaft basis

A limit system is said to be on a shaft basis when the shaft is the constant member and different fits are obtained by varying the size of the hole. In this shaft system the high and low limits are constant for all fits of the same accuracy grade and for the same basic size.

7.7 Limit systems

It is very important to keep limits and fits within desired limits. It has to be standardised to be able to produce components with interchangeability. There are several organizations Worldwide to ensure standardisation. They are

1. International Organization of Standards (ISO)
2. Newall system
3. Indian Standard Institution (ISI)

7.7.1 International Organization of Standards (ISO)

This system, setout in BS 4005: 1969, allows for 27 types of fits and 18 grades of tolerance covering a size range of 0 to 3150 mm. In this system, the 27 possible holes are designated by capital letters A, B, C,...... etc. and the shafts by lower case letters a, b, c...... etc. The 18 grades of tolerance are designated by numerals T01, T0, T1, T2...... T16.

For specifying a particular hole or shaft, it is to be written as the letter followed by the numeral. For example **H7** for a hole and **f7** for a shaft.

7.7.2 Newall system

This system is a bilateral hole basis system. It provides two classes of tolerance (A and B) for holes to accommodate two grades of workmanship. Class A is for extremely accurate work and grade B for general engineering work. This system gives shaft limits for the following classes of fit.

7.7.3 Indian Standards

This system of limits and fits recommended in IS: 919-1963 comprises 18 grades of fundamental tolerances or grades of accuracy of manufacturing with designations IT 01, IT 0, IT1,.....IT16.

It also recommends 25 types of fundamental deviations indicated by letter symbols for both holes and shafts (Capital letters of A to ZC for holes and small letters of a to zc for shafts)

In order to indicate a particular fit, the basic size common for both the hole and the shaft is noted followed by tolerance and deviation.

Example : **50 H8g7**

QUESTIONS

I.A Choose the correct option

1. The system that enables parts of equivalent sizes with dimensional variation within certain limits to be fit for operating is
   a. Limits   b. Unilateral tolerance
   c. Deviation   d. Interchangeability

2. If the size of the shaft is smaller than the hole size, the system of fits is
   a. Interference fit   b. Clearance fit   c. Driving fit   d. Push fit

3. The fit which involves the shaft being driven into the hole with light force
   a. Light driving fit   b. Heavy driving fit
   c. Shrink fit   d. Tight fit

4. The algebraic difference between the actual size and its corresponding basic size is called
   a. Maximum limit   b. Deviation
   c. Tolerance   d. Minimum limit

I. B Answer the following questions in one or two words

1. Define ‘Shaft’ in terms of interchangeable system.
2. What are the two basic ways of specifying tolerance?

II. Answer the following questions in one or two sentences

1. Define ‘Interchangeability’.
2. What do you mean by limits of size?
3. What is fit?
4. What is ‘Basic size’?
5. Write short notes on the types of deviations.
6. What are the different limit systems?

III. Answer the following questions in about a paragraph

1. What is tolerance? Explain.
2. Explain the limit systems.

IV. Answer the following questions in detail

1. Explain the terms used in interchangeability.
2. Explain the different types of fits.

8. TRANSMISSION OF POWER

8.1 Introduction

A source of power is always needed in workshop processes particularly in cutting and forming of metals. Electricty as a means of conveying power to machinery is widely adopted. The electrical energy is converted into rotational energy by means of an electric motor and the machine converts the input of rotational energy into various forms necessary for doing the job.

When power is transmitted by gears and chain, there is no slip in velocity ratio. It is called positive drive. When power is transmitted by a belt drive, there is always a possibility of some slipping between the belt and the faces of the pulleys. So the character of motion transmitted is non-positive.

8.2 Methods of transmitting power

1. Belt drive
2. Gear drive
3. Chain drive
4. Clutch drive
5. Rope drive
6. Friction drive

8.3 Belt drive

Belt drive is one of the common methods of transmitting motion and power from one shaft to another by means of a thin inextensible band running over two pulleys. In a belt drive arrangement, the shaft which transmits the rotational power is known as the driving shaft. The pulleys mounted on the driving shaft is known as driver or driving pulley. The shaft which receives the rotational power is known as driven shaft and the pulley mounted on it is known as follower or driven pulley. The transmission of power becomes possible because of the grip between the pulley and the belt. Belt drive is generally used in mills and factories. When the distance between the connected shafts is not great, belt drive to used.

8.3.1 Types of belt drive

Generally power is transmitted by belt drives in two types

1. Open belt drive
2. Crossed belt drive

Open belt drive

In this type of belt drive the belt is not crossed. The belt connects the top portions of the pulleys directly. The grip between the belt and the pulley is minimum. The driver and the follower rotate in the same direction. The portion of the belt joining the pulleys on the upper side is called slack side. The portion of the belt joining the pulley on the lower side is called the tight side.

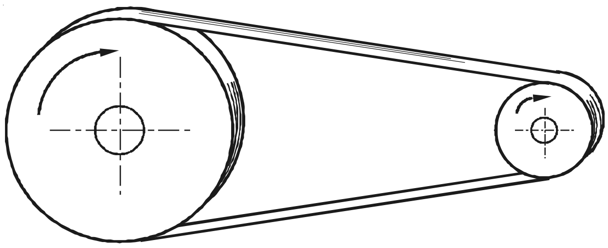


Fig. 8.1 Open belt drive

Crossed belt drive

In this type of belt drive, the belt is crossed between the pulleys. The belt connects the top portion of the driver with the lower portion of follower. The grip between the belt and pulley is greater because of the crossed nature of the belt. The pulleys connected by the cross belt arrangements rotate in the opposite directions. If the driver rotates in clockwise direction, the follower will rotate in the anticlockwise direction.

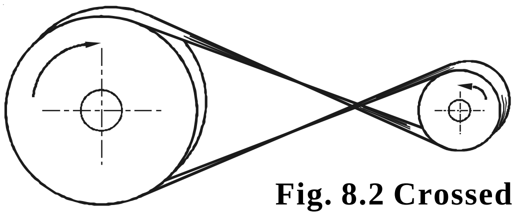


Fig. 8.2 Crossed belt drive

8.3.2 Types of belt

Belt is usually made from leather, rubber and canvas thread in a moulded form . The two ends of a belt are connected by hooks and pins. Generally two forms of belts are used

1. Flat belt
2. V – belt

The cross section of a flat belt is in the form of a rectangle. The thickness of a flat belt varies from 0.75 mm to 5 mm. The efficiency of this form of belt is approximately 98%. It is used on pulleys having flat faces.

V belt has a cross section of trapezoidal form. The thickness of the V-belt ranges from 8 mm to 19 mm. The efficiency various from 70 % to 98 %. This form of belt is used on pulleys having V grooves.

8.3.3 Velocity ratio of a belt drive

Velocity ratio of a belt drive is the ratio of number of revolutions of follower to the number of revolutions of driver in a particular time.

If D1 and D2 are the diameter of driver and follower and N1 and N2 are the number of revolutions per minute of the driver and the follower

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2}$$

Though the theoretical value of velocity ratio is calculated as above, it differs from it because of the thickness of the belt and belt slip. These factors should also be taken into account in calculating the actual velocity ratio.

The speed of the shaft or the pulley is expressed in RPM (Revolutions Per Minute). If we want to increase the speed of the follower with respect to the driver, the pulley on the driven shaft should be smaller in size (diameter) than the pulley on the driving shaft. If we want to decrease the speed of the follower, the pulley on the driven shaft should be larger in size.

$$D1N1 = D2N2$$

8.3.4. Solved Examples

Example -1

Pulleys of diameters 200 cm and 50 cm are connected by a belt drive. Find the velocity ratio.

Solution

Consider N1 as the speed of the driving pulley

N2 as the speed of the driven pulley

D1 as the diameter of the driving pulley = 200 cm

D2 as the diameter of the driven pulley = 50 cm

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2} = \frac{200}{50} = 4$$

Example -2

Two pulleys of diameters of 600 mm and 200 mm are connected by means of a open belt drive. If the smaller pulley rotates at a speed of 400 r.p.m. in clockwise direction, find the speed and direction of rotation of the larger pulley.

Solution

Consider D1 = 600 mm ; D2 = 200 mm ; N1 = 400 r.p.m. ; N2 = ?

$$D1N1 = D2N2$$

$$N2 = \frac{D1N1}{D2} = \frac{600 \text{ X } 400}{200} = 1200 \text{ r.p.m}$$

The larger pulley will rotate at the speed of 1200 r.p.m. in clock wise direction.

Example -3

Two shafts are connected by a belt drive. On one of the shafts, a pulley of 100 mm diameter is fitted and it rotates at a speed of 1500 rpm in anticlockwise direction. What should be the diameter of the driven pulley if it is to rotate at a speed of 750 rpm in clock wise direction? What should be the type of belt drive?

Consider D1 = 100mm ; N1 = 1500rpm ; N2 = 750 rpm; D2 =?

$$D1N1 = D2N2$$

$$D2 = \frac{D1N1}{N2} = \frac{100 \text{ X } 1500}{750} = 200 \text{ mm}$$

The diameter of the pulley is 200mm and the belt should be cross driven.

8.3.5 Belt slip

When power is transmitted through belt drive, the follower of the drive will not rotate at the estimated speed. It will rotate at a lower speed only. The main reason for this defect is slackness of the belt.

Belt slip is the difference between the distance covered by a point on the pulley and the distance covered by a point on the belt per minute. Belt slip is always expressed in percentage.

$$\text{Belt Slip} = \frac{\text{Estimated speed - Actual speed}}{\text{Estimated speed}} \times 100$$

If D1 and D2 are the diameters of the pulleys and N1 and N2 are their speed in rpm and S is the amount of belt slip in percentage,

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2} \times \frac{(100 - S)}{100}$$

Example - 4

A driving pulley of diameter 60cm rotates at a speed of 200rpm. The driven pulley of diameter 40cm connected by a belt drive rotates at speed of 291rpm. Find the percentage of belt slip.

D1 = 60 cm D2 = 40cm

N1 = 200rpm N2 (Actual)= 291rpm

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2}$$

$$\frac{N2}{200} = \frac{60}{40} \quad N2 = \frac{60}{40} \times 200 = 300 \text{ rpm}$$

The estimated speed of the driven pulley is 300rpm. But it rotates at 291rpm.

$$\text{Belt Slip} = \frac{\text{Estimated speed - Actual speed}}{\text{Estimated speed}} \times 100$$

$$= \frac{(300-291)}{300} \times 100 = \frac{9}{300} \times 100 = 3\ \%$$

8.4 Gears

Gears are used to transmit power between rotating parts to operate various machines. The power transmission is achieved without any slip. It is also advantageous in the sense that higher velocity ratio can be achieved in limited space. Only parallel shafts are connected by belt drive whereas non-parallel and perpendicular shafts are connected by means of gears to transmit power.

8.4.1 Forms of gears

There are different forms of gears namely

1. Spur gear
2. Helical gear
3. Bevel gear
4. Rack and pinion gear
5. Worm and Worm gear

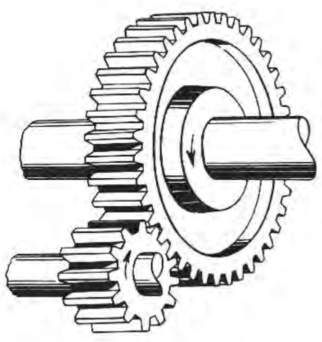


Fig. 8.3 Spur gear

Spur gear

Spur gears have their teeth elements parallel to the rotating shafts. These gears are used to transmit power between parallel shafts. A small sized gear is called pinion.

Helical gears

If the teeth elements are twisted or helical, they are known as helical gears. These gears may be used for connecting shafts that are at an angle in the same plane or in different planes. They are smooth acting because there will always be more than one tooth in contact. Depending upon helix, the helical gears are classified as right hand type or left hand type.

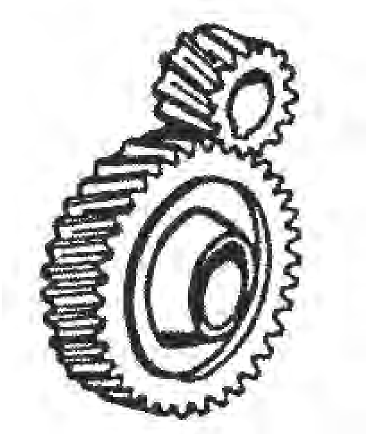


Fig. 8.4 Helical gear

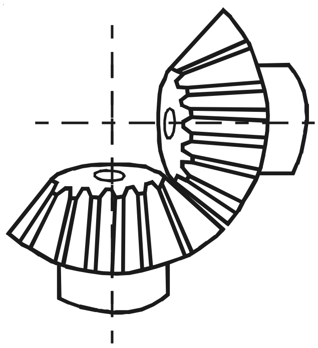


Fig. 8.5 Bevel gear

Bevel gears

The power is transmitted between two shafts which are at right angles through bevel gears. It is in the shape of a truncated cone having all the teeth elements on the conical surface. When the connected shafts are right angles and the bevel gears have same number of teeth, the gears are known as miter gears.

Rack and pinion gears

This type of gear is used to convert rotary motion into linear motion or vice versa. The rack gears are straight and flat and have no curvature. This mechanism is used in lathe and drilling machine.

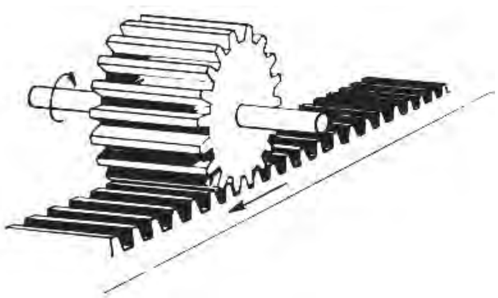


Fig. 8.6 Rack and pinion gear

Worm and worm gear

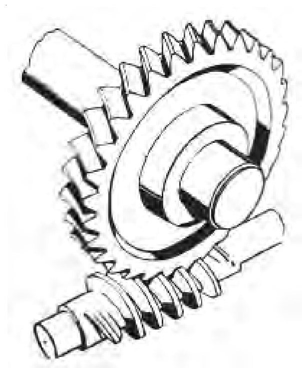


Fig. 8.7 Worm and worm gears

Worm and worm gear are used to transmit power between two perpendicular shafts. Worm may be single threaded or multi threaded. The worm gear resembles a spur gear. In this gearing the worm will always be the driver. This gearing is used where a large speed reduction is desired. It is useful in indexing head, lifts, rotary table and in the apron of lathe.

8.4.2 Gear drive

It is possible to drive shafts that are parallel or intersecting by the use of gearing arrangement. Gear drive is used where moderate to large amount of power is to be transmitted at constant velocity ratio. If the driving gear rotates in the clockwise direction, the follower will rotate in the anti-clockwise direction. The velocity ratio of a gear drive depends on the number of teeth present on the driving gear and the driven gear or the pitch diameter of the driving and driven gears.

8.4.3 Velocity ratio of gear drive

Velocity ratio of a gear drive is the ratio of number of revolutions of driven shaft or driven gear to the number of revolutions of driving shaft or driving gear in a particular time.

If N1 and N2 are the number of revolutions of driver and follower and T1 and T2 are the number of teeth on the driving gear and the driven gear.

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{T1}{T2}$$

Example

If a gear having 24 teeth rotates at a speed of 450 rpm. in clock-wise direction, what will be speed and direction of rotation of a gear having 36 teeth which is in mesh with the first one ?

T1 = 24 teeth N1 = 450rpm T2 = 36 teeth

$$\text{Velocity ratio} = \frac{T1}{T2} = \frac{N2}{N1}$$

$$\text{Velocity ratio} = \frac{24}{36} = \frac{N2}{450}$$

$$N2 \times 36 = 450 \times 24$$
$$N2 = (450 \times 24) / 36 = 300 \text{ rpm}$$

The second gear will rotate at 300 rpm in anti-clockwise direction

8.4.4 Simple gear train

If a gear train is arranged by keeping only one gear on a shaft, it is called simple gear train. The net velocity ratio of the gear drive is determined by the number of teeth present on the first and the last gears of the drive. To get higher velocity ratio simple gear train is not suitable. The intermediate gears of the drive are used only to fill the gap between the driving shaft and the driven shaft. It is also useful in changing the direction of rotation of the follower with respect to the driver.

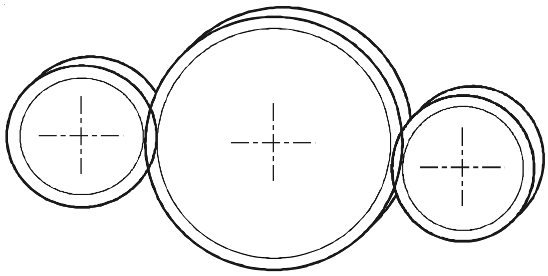


Fig. 8.8 Simple gear train

Example

Gears A,B,C and D are connected by a simple gear train. The number of teeth on them are 80,50,60 and 40. If the gear D rotates at a speed of 320rpm in clock-wise direction, what will be the speed of the gear A ?

TA = 80teeth ; TB = 50teeth ; TC = 60teeth ; TD = 40teeth ;

ND = 320rpm.

Velocity ratio = NA ÷ ND = TD ÷ TA

$$\text{Velocity ratio} = \frac{NA}{ND} = \frac{TD}{TA}$$

$$NA = (TD \div TA) \times ND$$

$$= (40 \div 80) \times 320$$

$$= 160 \text{ rpm}$$

8.4.5 Compound gear train

If the gear drive is arranged by keeping more than one gear on a shaft, it is called compound gear train. The net velocity ratio of the gear drive is influenced by the intermediate gears also. So it is possible with a compound gear train to attain a higher velocity ratio in limited space. The direction of rotation of the follower with respect to the driver is determined by a number of intermediate gears on separate shafts.

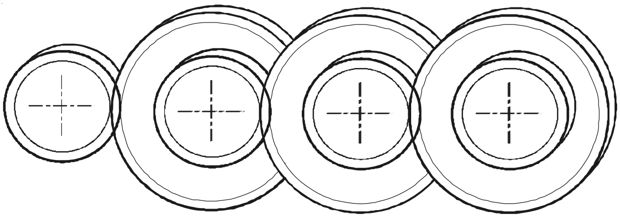


Fig. 8.9 Compound gear train

Example

A compound gear train is arranged in which the driving shaft A rotates shaft C through intermediate shaft B. The gear on shaft A has 30 teeth which rotates at 1200 r.p.m. in clock wise direction. It meshes with a gear of 90 teeth on shaft B. This shaft has another gear with 40 teeth which meshes with a gear on shaft C. What is the speed and direction of rotation of the gear on shaft C which has 60 teeth?

TA = 30 teeth ; TB1 = 90 teeth ; TB2 = 40 teeth ; TC = 60 teeth

NA = 1200 ; NB1 = ? NB2 = ? NC = ?

$$\text{Velocity ratio} = \frac{NA}{NB1} = \frac{TB1}{TA}$$

$$NB1 = \frac{TA \times NA}{TB1} = \frac{30 \times 1200}{90} = \frac{36000}{90} = 400 \text{ r.p.m.}$$

NB2 = NB1 = 400 r.p.m.

$$NC = \frac{TB2 \times NB2}{TC} = \frac{40 \times 400}{60} = \frac{16000}{60} = 266.66 \text{ r.p.m.}$$

The driven shaft will rotate at 266.6 rpm in clockwise direction.

QUESTIONS

I. A. Choose the correct option

1. Power is transmitted between shafts at moderate distance by
   a. belt drive b. gear drive c. chain drive d. friction drive

2. The diameter of the driving pulley is 200cm. The velocity ratio of the drive is 4. The diameter of the driven pulley is
   a. 100cm b. 25cm c. 40 cm d. 50cm

3. Velocity ratio of a gear drive is
   a. N1D1 = N2D2 b. NT-NA/NTX100 c. T1/T2 = N2/N1 d. r.p.m.

B. Answer the following questions in one or two words.

1. Expand r.p.m.
2. What are the types of belt drive?
3. Mention any two forms of gears.
4. What is a idle gear?

II. Answer the following questions in one or two sentences

1. What are methods by which power can be transmitted?
2. What is belt slip?
3. What are the types of gear train?
4. What is rack and pinion?

III. Answer the following questions in about a page

1. Explain power transmission by a belt drive.
2. Explain velocity ratio.
3. Draw a simple gear train and explain.
4. Draw a compound gear and explain.

IV. Answer the following questions in detail

1. Explain open belt drive with a diagram.
2. Crossed belt drive – draw and explain.

9. HYDRAULICS

9.1 Introduction

The volume of a liquid can not be changed by applying pressure. This quality of liquids forms the base of study of Hydraulics. Hydraulics in general means the study of water but industrial hydraulics involves the projects based on different types of oils. In modern metal working plants, hydraulic pressure is being used to operate practically every type of machine tool. So the hydraulic liquid is the working medium used in hydraulic circuits. This is due to the simplicity of the method of applying power and to the smoothness of operation that can be obtained.

9.2 Properties of fluids

The following are the important properties of fluids

1. Density
2. Pressure
3. Specific weight
4. Specific volume
5. Relative density
6. Compressibility
7. Viscosity

9.2.1 Density

Density of a fluid can be defined as the mass per unit volume.

Density = Mass / Volume

The unit of density is Kg/m^3

9.2.2 Pressure

The force acting on a unit area of a plane is the pressure of the liquid.

Pressure = Force / Area

The unit of pressure is Newton / m^2 (N/m^2) or Pascal.

The pressure at a point in a static liquid depends upon the depth and the density of the liquid. The pressure increases with the depth.

9.2.3 Specific weight

Specific weight of a fluid can be defined as the weight per unit volume.

Specific weight = weight / volume

The unit of specific weight is N/m^3

9.2.4 Specific volume

Specific volume of a fluid can be defined as the volume per unit mass.

Specific volume = volume / mass

The unit of specific volume is m^3/Kg.

It can be seen as the reciprocal of density.

9.2.5 Relative density

Relative density of a liquid can be defined as the ratio of the density of the liquid and the density of water.

Relative density of the liquid = Density of the liquid / Density of water

Since it is the ratio between the densities of two liquids, this quantity has no unit.

9.2.6 Compressibility

Compressibility of a liquid can be defined as the property of changing its volume under the influence of pressure. However, the change in volume of a liquid under pressure is very small and liquids are generally incompressible fluids.

9.2.6 Viscosity

Viscosity can be defined as the resisting quality of the liquid against its flow. If the temperature increases, the viscosity of a liquid decreases.

9.3 Hydraulic system

An Hydraulic system is one in which the power is transmitted from one place to another through the medium of an incompressible fluid called oil. Various actions in industries take place with hydraulic systems by utilising hydraulic power.

9.3.1 Pneumatic system

If the medium of oil is replaced by compressed air, the system is called pneumatic system. In modern machineries, various actions of machine tools and automatic machines take place using hydraulic or pneumatic systems.

9.4 Characteristics of hydraulic liquids

1. The main requisite of the hydraulic liquid is to transmit energy.
2. It should be lubricating
3. It should have an easy flow
4. The liquid should not easily be changed in to a solid or a gas.
5. It should not be inflammable.
6. It should be easily available at low cost.
7. It should not easily be oxidized.
8. It should be non – corrosive.
9. The viscosity index of the oil should be high.

Oil having all the above characteristics is very rare. Suitable oils are prepared by mixing various chemicals for this purpose. Oils having different hydraulic properties are available in market.

9.5 Advantages of hydraulic drive over mechanical drive

1. The heat generated during power transmission in the bearings and the moving parts are carried away by the oil itself. So the system does not require any cooling arrangements.

2. Highly efficient and makes minimum noise.

3. It is more compact and eliminates the complicated linkages like gears, cams and levers.

4. It does not require any lubricating as the result of wear and tear because the moving parts are very less compared to a mechanical drive.

5. The hydraulic system components are connected by pipelines. Hence it provides flexibility in locating the components at any desired place.

6. By varying the quantity of oil flow by means of a valve, any amount of speeds can easily be obtained.

7. The oil used in the system provides cushioning effect for the shock loads and so the life of the components is increased.

8. Very large forces can easily be obtained and force multiplication is also possible with minimum loss of energy.

9. Whenever the hydraulic system is overloaded, the pressure is immediately relieved. So the system components are protected against breakages and over strains.

10. The hydraulic oil is incompressible. Hence the system is very sensitive far instantaneous operations. So back lashes experienced in mechanical system will not exist in hydraulic system.

11. The system requires very simple maintenance care.

12. The system provides quick return motion of components with simple arrangements. So the idle time of machining operations is reduced.

13. The hydraulic system provides very high degree of dependability.

14. It is advisable to have hydraulic devices where there are chances for electrical accidents.

15. As the cutting action is smooth and steady, the tools last longer.

16. The hydraulic energy can be transformed into different types of work which require rotational, linear, continuous and intermittent movements. These movements can be had at constant speed or at variable speeds.

9.5.1 Disadvantages of hydraulic drive

1. There is always a possibility of leakage of oil. This will attract dust and the shop will present an ugly outlook.

2. The hydraulic system should be maintained with maximum care. The failure to do so will lead to the breakdown of the system.

3. The pressure of the oil passing through the circuit is very high. Accidents will take place if any break of circuit takes place.

4. The leakage of the oil will lead to fire accidents at times.

9.5.2 Advantages of pneumatic drive

1. Air is available in large quantities at free of cost.

2. Pneumatic drive does not hamper the environment.

3. Pneumatic circuits are simple to establish and they are cheaper.

9.5.3 Disadvantages of pneumatic drive

1. Pneumatic drive involves air under very high pressure and so it may cause failures because of sudden change of pressure.

2. Heat is generated in machine elements

9.6 Hydraulic pipelines

The pipelines used in hydraulic circuits should be strong and the inner surface of the pipes should be smooth. It should be of sufficient diameter and be able to withstand shock loads.

9.6.1 Materials used in making hydraulic pipelines

1. Steel 2. Plastic 3. Rubber

9.7 Hydraulic safety devices

When hydraulic equipments are in operation, the pressure of the liquid will not remain constant. The change of pressure may be a uniform increase or uniform decrease. The changes may also be sudden. But at the same time the pressure of the circuit should not exceed a predetermined value. If the pressure goes beyond the desired limit, it will cause damage to the circuit and make it inactive. So, proper safety devices should be added to the circuit.

Hydraulic fuse, pressure relief valve, shock absorber, and accumulator are some of the safety devices used in a hydraulic circuit.

9.7.1 Hydraulic fuse

Hydraulic fuse is a thin sheet placed inside a chamber. It will withstand only the optimum pressure of the circuit. When the pressure exceeds the desired limits the sheet tears and the oil is made to flow back to the reservoir. In this case, a new valve has to be put in the place of a damaged one.

9.7.2 Pressure relief valve

Pressure relief valve is a device used to control the pressure in the hydraulic circuit at a desired limit to protect the circuit. Pressure relief valve is directly connected to the hydraulic circuit. It has got a globe like valve attached to a spring. The tension of the spring can be altered according to the need with the help of a screw. The globe like valve prevents the oil to pass through the bypass entry due to the pressure exerted by the spring. If the pressure in the circuit exceeds the desired limit, the valve opens to allow the oil to pass through the bye pass back to the reservoir. By this, the pressure of the circuit is brought back to the desired limit.

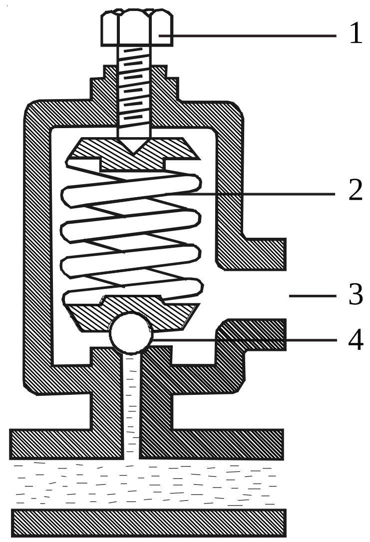


Fig 9.1 Pressure relief valve
1. Screw 2. Spring 3. Bye pass 4. Value

9.7.3 Hydraulic accumulator

The accumulator is used to preserve a good amount of hydraulic liquid in itself and to provide the flow of oil when necessary. Though it cannot be classified as a safety device, it can be utilized as a shock absorber. When the flow of oil in the circuit is required to be minimum the surplus oil is preserved in the accumulator. When additional amount of oil is needed, the accumulator provides the same to the circuit.

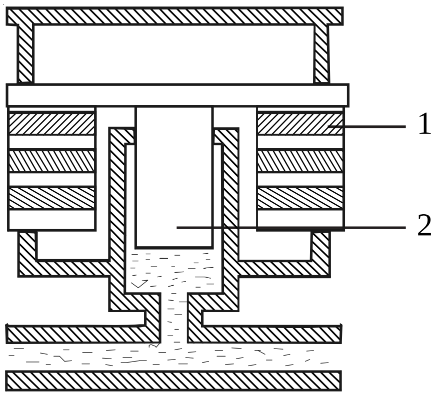


Fig 9.2 Hydraulic accumulator
1. Weight 2. Ram

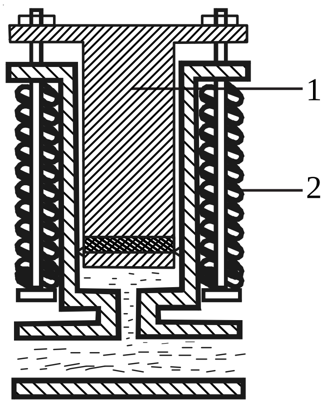


Fig 9.3 Hydraulic shock absorber
1. Ram 2. Spring

9.7.4 Hydraulic shock absorber

Pressure in a hydraulic circuit will experience a sudden surge, fall or shock due to opening and closing of valves and the change of volume of the liquid in the circuit. If the same is allowed to happen continuously, the circuit will get damaged. To adjust such pressure fluctuations and absorb the shocks, shock absorbers are connected to the circuit as shown in the diagram. It prevents the circuits from being damaged.

9.7.5 Emergency cut-off valve

When the pressure of the hydraulic liquid in the circuit goes beyond controllable limits and when, the motor, which is used to operate the hydraulic pump, consumes excessive electric current, the emergency cut off valve comes into operation to switch off the motor.

The emergency cut off valve is positioned between the hydraulic pump and the primary control valve. If the pressure relief valve in the circuit fails to function, the pressure in the circuit goes beyond limits. It will make the pipelines of the circuits to break. So it is necessary that the emergency cut off valve is positioned between the hydraulic pump and the primary control valve to switch off the motor of the hydraulic pump.

9.8 Basic hydraulic circuit

The hydraulic liquid is pumped by a hydraulic pump through the filter from the reservoir. The pressure of the liquid can be known with the help of a pressure gauge. If the pressure in the circuit is above the desirable value, a pressure relief valve connected to the circuit releases the excessive pressure. The high-pressure liquid reaches the four-way plunger valve (selector valve) through the inlet. The diagram shows the plunger in neutral position. In this position the inlet P is disconnected from the outlets A and B. So the pumped oil goes back to the reservoir.

If the plunger in the selector valve is pushed to the left position the inlet P and outlet A are connected and so are B and drain E. The high-pressure liquid pushes the piston in the forward direction. The oil present on the right side of the piston reaches the reservoir through B and E.

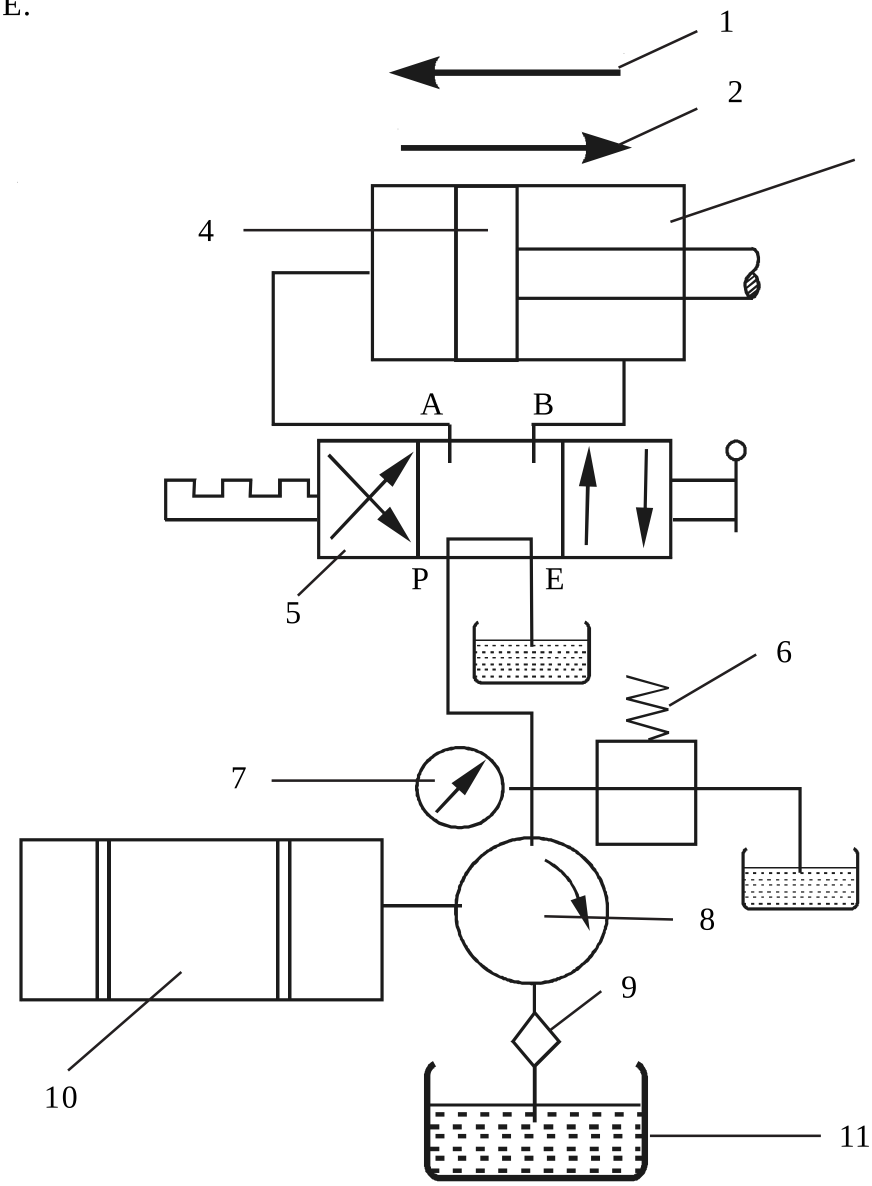


Fig 9.4 Basic hydraulic circuit

1.Forward stroke 2. Return stroke 3. Cylinder 4. Piston 5. Direction control valve 6. Pressure relief valve 7. Pressure gauge 8. Pump 9. Filter 10. Motor 11. Reservoir

If the position of the plunger is altered to the right side P and B & A and E are connected. High-pressure oil passes through B to push the piston in the opposite direction. The oil present on the other side of the piston reaches the reservoir through A and E.

QUESTIONS

I. A. Choose the correct option

1. Mass per unit volume is

   a. density b. pressure c. specific volume d. viscocity

2. The unit of pressure is

   a. m^2 b. N/m^2 c. m^3 d. None of the above

B. Answer the following questions in one or two words

1. State two characters of hydraulic liquids.
2. Mention an advantage of pneumatic circuits.
3. Mention any one material used to make hydraulic pipeline.

II. Answer the following questions in one or two sentences

1. What is hydraulics?
2. What is hydraulic fuse?
3. What is pressure relief valve?
4. What is a hydraulic shock absorber?
5. What do you mean by an hydraulic system?
6. Mention four hydraulic safety devices.

III. Answer the following questions in about a page

1. Mention various characters of hydraulic liquids.
2. Draw and explain a hydraulic accumulator.
3. Hydraulic shock absorber – Draw and explain.

IV. Answer the following questions in detail

1. Draw and explain the functioning of a pressure relief valve.
2. What are the advantages and disadvantages of hydraulic drive?
3. Draw and explain a basic hydraulic circuit.

10. ELECTRICITY

10.1 Introduction

Matters are in three states – solids, liquids and gases. All these matters are made up of minute particles known as molecules. Several atoms make up a molecule. According to electronic theory, atoms are made of positively charged particles known as protons, negatively charged particles known as electrons and uncharged particles - neutrons. Electricity is - energy made available by the flow of electric charges (electrons & protons) through a conductor.

In this modern era, this power of electricity moves and operates the world- to operate all the machines and every movements that take place in it.

10.2 Voltage, Current and Resistance

10.2.1 Voltage

The force or pressure between opposite potentials of charged atoms are called voltage or potential difference (PD). In the case of D.C., it is the potential difference between the positive and negative terminals. In A.C., it is the potential difference between the phase and neutral terminals. The unit of voltage is Volt and V denoted by the letter ‘V’.

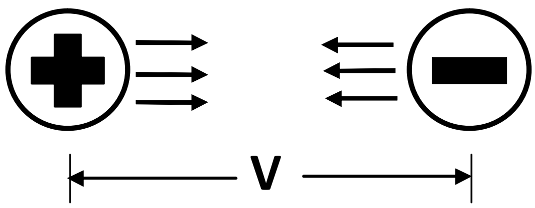


Fig 10.1 Voltage

Volt :

A volt is the amount of potential difference required to pass one Ampere of current through a conductor with a resistance of one Ohm.

10.2.2 Current

The flow of electrons across the cross section of a conductor is known as Current. The unit of current is Ampere and is denoted by the letter ‘A’.

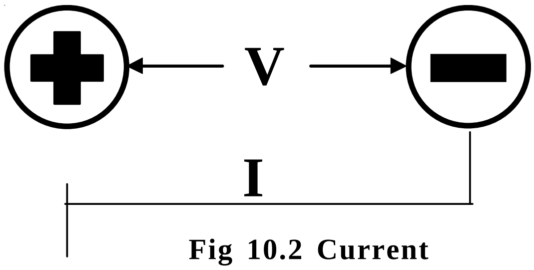


Fig 10.2 Current

Ampere

It is the amount of current passing through the cross section of a conductor if one Coulomb of electricity is allowed to pas through the conductor.

I = **Q** / t Ampere

Where I – Current in Amperes

Q – Electricity in Coulombs

t – time

10.2.3 Resistance

The property of a material to oppose the flow of electrons through it is known as Resistance. The unit of resistance is Ohm and is denoted by the letter 'R'.

R, Resistance = *l* L /A

Where

l - the specific resistivity in ohm- meter

L - length of material in meter

A - area of the material in m^2

Also the resistance is depends on the temperature of co-efficient of the material.

10.3 Ohm's law

The current passing through a conductor under constant temperature is directly proportional to the potential difference across the conductor and indirectly proportional to the resistance of the conductor.

I = V / R ; R = V / I ; V= IR

Where I - Current

V - Voltage

R - Resistance

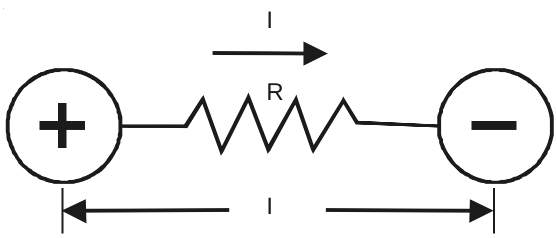


Fig 10.3 Ohm's Law

10.4 Electric circuit

It is a complete closed path which allows electricity to pass from a source through the conductors.

10.4.1 Series circuit

When a circuit is made up of two or more resistances connected in series, it is known as series circuit.

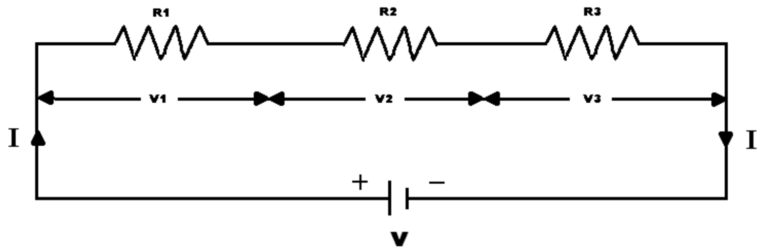


Fig 10.4 Series circuit

$V = V_1 + V_2 + V_3$ $\quad$ $R = R_1 + R_2 + R_3$ $\quad$ I = Same for all elements.

10.4.2 Parallel circuit

When two or more resistances are connected parallel to each other with same starting and end points, the circuit is known as parallel circuit.

$V = V_1 = V_2 = V_3$

$I = I_1 + I_2 + I_3$

$R = 1/R_1 + 1/R_2 + 1/R_3$

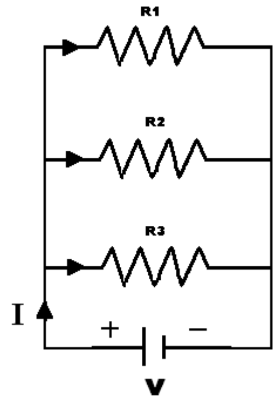


Fig 10.5 Parallel circuit

Example 1

Calculate the total resistance of a circuit with three resistances connected in series with the source of 36 V with reference to Fig 10.6

R_1 = *4 Ohms ;* R_2 = *8 Ohms ;* R_3 = *12 Ohms*

$R = R_1 + R_2 + R_3$

= 4 + 8 + 12

= 24 Ohms

I = V/R

= 36/24 = 1.5 A

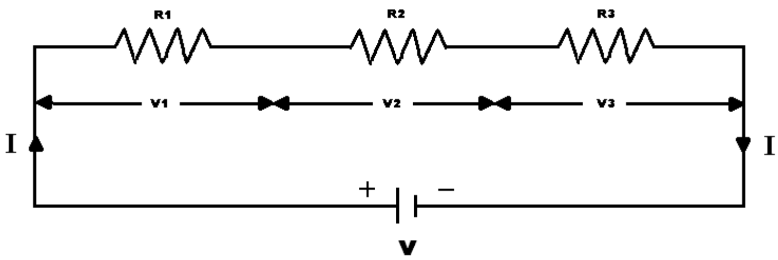


Fig 10.6

Example 2

Calculate the total resistance of the circuit connected with three resistances in parallel as in fig with the source of 36V. Also calculate the current passing through each resistances with reference to Fig 10.7

R_1 = 4 Ohms ; R_2 = 6 Ohms ; R_3 = 12 Ohms

$1/R = 1/R_1 + 1/R_2 + 1/R_3$

$= 1/4 + 1/6 + 1/12$

$= 1/2$

$R = 2$ Ohms

$I_1 = V/R_1 = 36/4 = 9A$

$I_2 = V/R_2 = 36/6 = 6A$

$I_3 = V/R_3 = 36/12 = 3A$

$I = I\text{-}_1 + I_2 + I_3$

$= 9+6+3 = 18A$

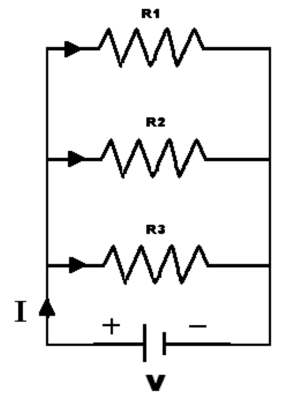


Fig 10.7

Example 3

Calculate the effective resistance of the following combination of resistances connected in series and parallel between point A and C with reference to Fig 10.8

V= 60V; R_1= 3 Ohm; R_2= 6 Ohm; R_3= 18 Ohm

R between AB (parallel)

$1/R_{AB} = 1/R_1 + 1/R_2$

$= 1/3 + 1/6$

R_{AB} = 2 ohm

R between AC (series)

$R_{AC} = R_{AB} + R_3$

= 2+18

= 20 ohm

Total circuit current

I = V/R = 60/20 = 3A

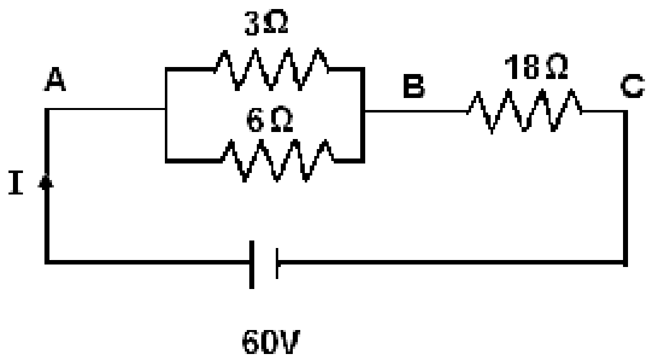


Fig 10.8

10.5 Kirchhoff's laws

Kirchhoff's laws are used in determining the equivalent resistance of a complex network and the current flowing in various conductors. There are two laws namely

1. First law or Current law
2. Second law or Voltage law

10.5.1 First law or Current law

The algebraic sum of the currents at any junction of a network is zero. In other words, the sum of the currents flowing towards a point is equal to the total current flowing away from it.

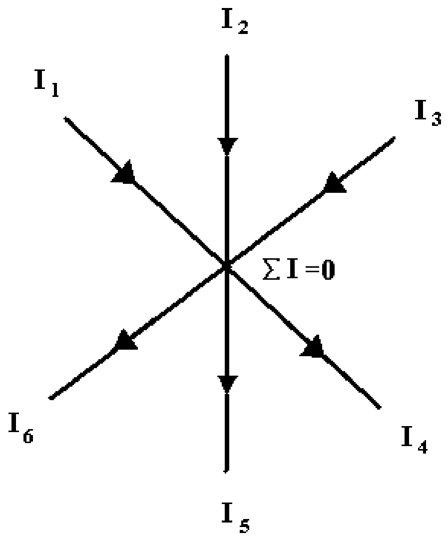


Fig 10.9 Kirchhoff's First Law

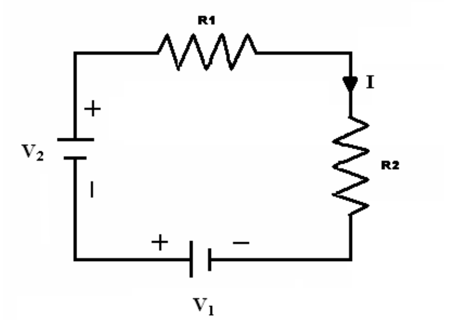
(At a junction, the incoming currents are equal to the out going currents)

$$I_1 + I_2 + I_3 = I_4 + I_5 + I_6$$

$$I_1 + I_2 + I_3 - I_4 - I_5 - I_6 = 0$$

10.5.2 Second law or Voltage law

In any closed electric circuit, the algebraic sum of potential drops is equal to the sum of impressed e.m.fs.



$$V_1 + V_2 = I R_1 + I R_2$$

$$V_1 + V_2 - IR_1 - I R_2 = 0$$

Fig 10.10 Kirchhoff's Second Law

10.6 Power and energy

10.6.1 Power

Power is the rate of doing work.

P= W/t

where P – power

W – work done

t – time

Power in an electric circuit is

P = V x I

V – voltage

I - current

The unit of power is Watt.

10.6.2 Energy

Energy may be defined as the capacity to do work. It is the power utilized for a particular time.

Electric energy = electric power x time

The unit of energy is Watthours. It may also be expressed in KiloWatthour.

One unit of energy is 1 KiloWatthour.

1 H.P = 735.5 Watts

10.7 Magnetism

Magnet is a substance having a property of attracting things made of Iron and its alloys. The magnet has two poles. When a magnet is suspended, it comes to rest by pointing North and South directions. The end pointing towards North is called North pole and the other end pointing South is known as South pole. The attraction takes place between opposite poles and the like poles repel.

10.7.1 Electromagnetism

Electromagnet is a device consisting of a laminated core and a coil which produces appreciable magnetic flux only when an electric current flows through the coil. The science which deals with the relation between electricity and magnetism is known as electromagnetism.

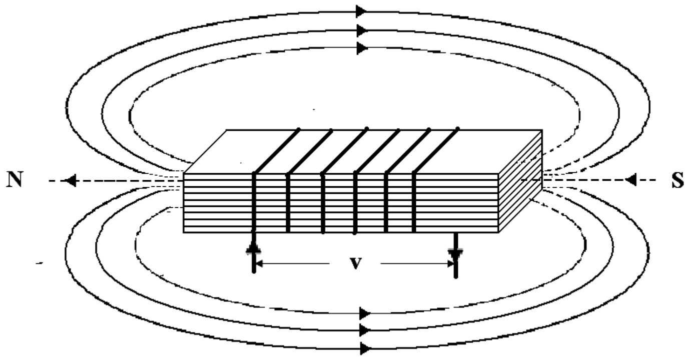


Fig 10.11 Electromagnetism

10.7.2 Magneto-Motive Force

It is the difference of magnetic potential which maintains a magnetic flux in a magnetic circuit. The unit of MMF is Gilbert. In M.K.S. System the unit is Ampere Turns (AT).

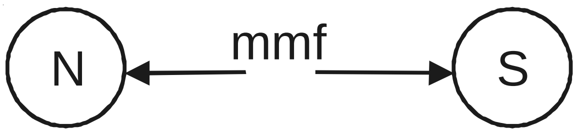


Fig 10.12 Magneto-motive force

10.7.3 Magnetic Flux

Magnetic flux is a group of lines of force crossing the space of a magnetic field. It is denoted by ϕ.

The unit of Magnetic flux is Weber in M.K.S. system and Maxwell in C.G.S. system.

10.7.4 Flux Density

Flux density is the number of lines of magnetic flux per unit area. It is denoted by the letter 'B'.

10.7.5 Magnetic Intensity

Within the magnetic field, the intensity at any point will be measured by the source felt by the N pole of one Weber placed at that point. It is denoted by H.

10.7.6 Permeability

It is the ratio of the magnetic flux produced by a given magnetic force of the material to the magnetic flux which would be produced by the same magnetic force in a perfect vacuum. There are two types of permeability namely

1. Absolute permeability
2. Relative permeability

10.7.7 Reluctance

It is the opposition offered by a magnetic path to the presence of a magnetic flux. The unit of reluctance is AT/wb.

10.8 Electromagnetic induction

A current is induced in a conductor when it is cut by a magnetic flux. It is known as electromagnetic induction. The current so induced is known as electro motive force (e.m.f). The e.m.f induced in the conductor depends upon the strength of the magnetic flux and the speed at which the conductor cuts the flux.

10.8.1 Faraday's laws of electromagnetic induction

First Law

Whenever any conductor is made to rotate in a magnetic field and hence cut the magnetic lines of force or the flux, an electro motive force (e.m.f.) will be induced in that conductor.

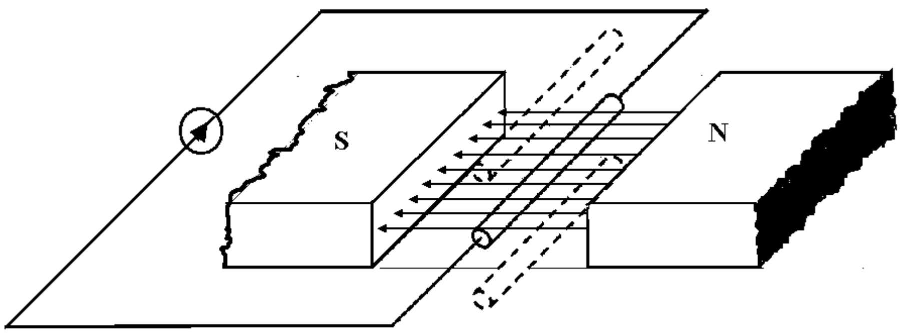


Fig 10.13 Faraday's Laws

Second Law

The magnitude of the induced e.m.f. is directly proportional to the rate of change of flux linked with the conductor.

If the conductor AB has N number of turns and the flux linked with the conductor changes from $\phi_1$wb to $\phi_2$wb in 't' secconds,

the initial linked flux = $N\phi_1$ and

the final linked flux = $N\phi_2$

Induced e.m.f = $N\phi_1 - N\phi_2$ / t wb / sec

10.8.2 Direction of e.m.f

The relation between the directions of the motion of conductor, the induced e.m.f and the magnetic flux can be explained by Flemming's right hand and left hand rules.

Flemming's right hand rule

If we spread the thumb, forefinger and the middle finger of the right hand mutually at right angles to each other and the thumb is placed in the direction of motion of the conductors and the fore finger in the direction of the magnetic flux, then the middle finger indicates the direction of induced e.m.f.

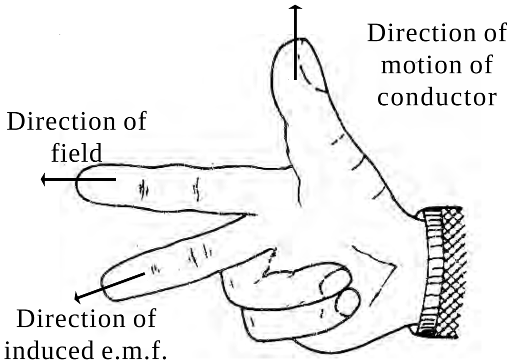


Fig 10.14 Flemming's Right hand Rule

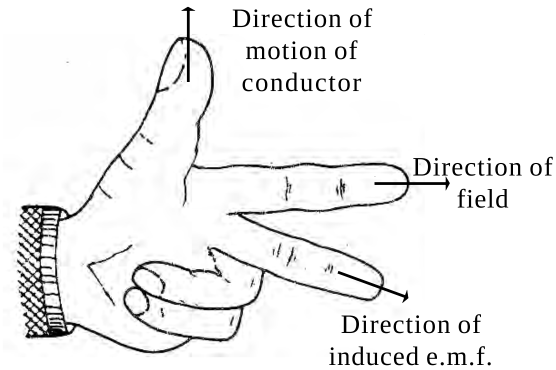


Fig 10.15 Flemming's Left hand Rule

Flemming's left hand rule (for electric motors)

If we spread the thumb, forefinger and the middle finger of the left hand mutually at right angles to each other and the fore finger is placed in the direction of the magnetic flux and the middle finger in the direction of induced e.m.f., then the thumb indicates the direction of motion of the conductors.

10.9 D C and A C fundamentals

10.9.1 D C fundamentals

D.C. means direct current and it is available from positive terminal (anode) and negative terminal (cathode). Current flows as electrons from negative potential to positive potential. D.C is generally produced by chemical processes as in batteries. D.C generators are used for generation of high capacity.

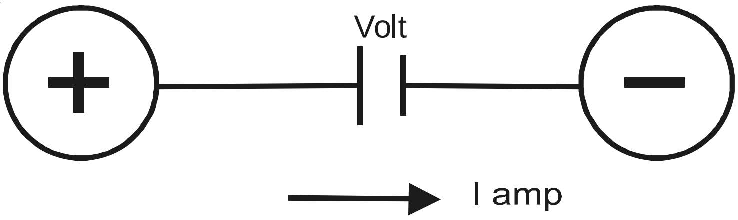


Fig 10.16 D.C current

10.9.2 AC fundamentals

A.C means alternating current. The magnitude and the direction of the current and the voltage alternates continuously.

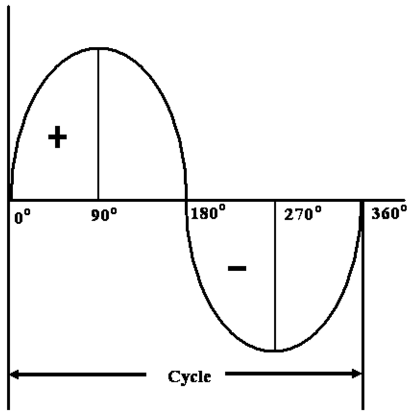


Fig 10.17 A.C current

10.9.3 Cycle

A full change in value and direction of alternating quantity is known as a cycle. The time taken for one cycle is known as period.

10.9.4 Frequency

The number of cycles per second of alternating quantity is known as frequency. It is expressed in cycles per second. Its unit is Hertz (Hz). In India, the standard value of AC system is 50 Hz.

10.10 AC 3 Phase system

The 3 phase AC system can be achieved by the rotation of 3 coils of conductors placed in a magnetic field at 120 ° apart. This system can be operated as delta(three wire) or star(four wire) connection.

Line Voltage (V_L) :

The voltage between any two phases of the system is known as Line Voltage.

$$V_L = V_{RY} = V_{YB} = V_{RB}$$

Line Current (I_L):

The current flowing between any two phases of the windings is called as Line Current.

$$I_L = I_R = I_Y = I_B$$

Phase Voltage (V_P) :

The voltage between any one of the phases and the neutral terminal is known as Phase Voltage.

Phase Current (I_P) :

The current flowing through any one of phase winding is called as Phase Current.

10.10.1 Delta System

$V_L = V_P = V_{RY} = V_{YB} = V_{RB}$

$I_P = I_R = I_Y = I_B$

And $I_P = I_L \sqrt{3}$

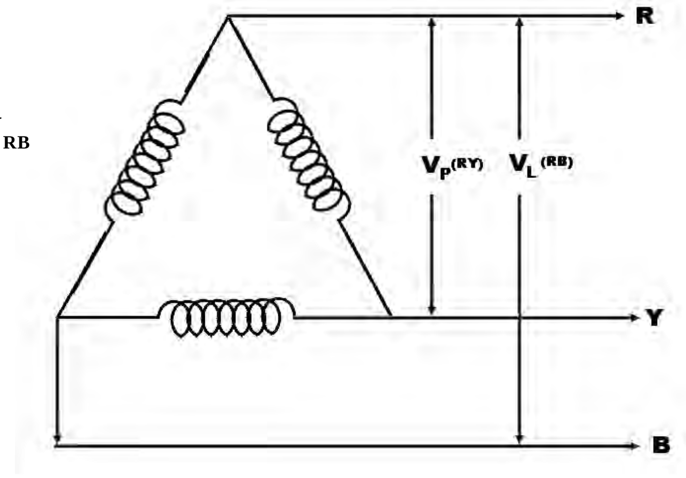
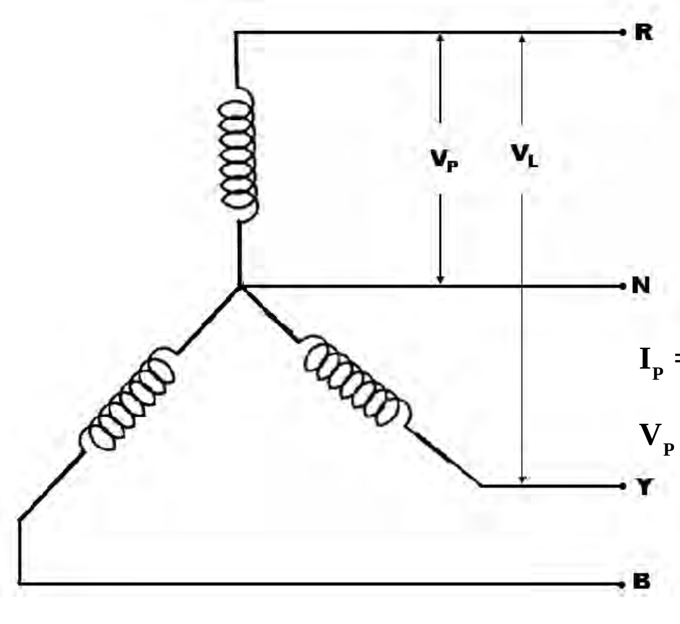


Fig 10.18 Three phase Delta system

10.10.2 Star System



$I_P = I_L = I_R = I_Y = I_B$

$V_P = V_L \sqrt{3}$ ($V_{RN} = V_{YN} = V_{BN} = V_P$)

Fig 10.18 Three phase Star system

10.10.3 Comparison of Star and Delta systems

Delta	Star
$V_L = V_P$	$V_P = V_L \sqrt{3}$
$I_P = I_L \sqrt{3}$	$I_L = I_P$

10.11 Differences between DC and AC systems

DC SYSTEM

1. 

2. The voltage increases from " 0" to higher potential
3. It is direct current system
4. There is no frequency
5. The current will be spent only when connected to load
6. It is only one voltage system
7. It has the polarity system

AC SYSTEM

1. 

2. It has instantaneous potential refered to Vm and instant of phase angle with RMS
3. It is the alternating current system
4. It has the frequency in the system
5. It has the reactive load with resistance ,inductance and capacitance (RLC load)
6. It has multiple phase system with three phase star , three phase delta and single phase system
7. There is no polarity in the system

QUESTIONS

I. A. Choose the correct option

1. The unit of current is
   a. Volt b. Watt c. Ampere d. Ohm

2. The unit of voltage is
   a. Watt b. Weber c. Volt d. Gilbert

3. The unit of resistance is
   a. Meter b. Ohm c. Watthour d. Coulomb

4. The unit of power is

a. Volt   b. Ampere   c. Watt   d. Ohm

5. The frequency of A.C current is

a. 50 c/s   b. Volt   c. Coulomb   d. Meter

I. B. Answer the following questions in one or two words

1. What type of circuit has equal current in all its elememnts?
2. What type of circuit has equal voltage in all its elememnts?
3. How is Kirchhoff's first law otherwise known as?
4. How is Kirchhoff's second law otherwise known as?
5. 1 HP = ...
6. Expand - mmf.
7. Expand - emf.
8. How is D.C current generally generated?
9. Mention the two methods of connection in A.C three phase supply.
10. Differentiate 'Star' and 'Delta'.

II. Answer the following questions in one or two sentences

1. What is electric current?
2. What do you mean by Resistance?
3. State Ohm's law.
4. What is Flux density?
5. What is Permeability?
6. State Faraday's first law.
7. State Faraday's second law.

III. Answer the following questions in about a page

1. Series circuit, Parallel circuit – Explain.
2. Explain Kirchhoff's laws with illustrations.
3. Explain Flemming's laws with illustrations.
4. Explain Star and Delta connections with circuit diagrams.
5. Compare D.C with A.C.

11. INDUSTRIAL MANAGEMENT

11.1 Introduction

Over the period of years, industry has shown tremendous growth. The growth of industry has created a sense of competition and became complex. In order to overcome the challenges of modern business, new concepts and techniques of management became inevitable. The system of modern management should be scientific and at the same time it should be humanistic.

In this chapter, we will discuss a very few important aspects of industrial management.

11.2 Plant engineering

A factory or a plant is a place where all raw materials are collected and the end products are manufactured. Capital can be referred to the raw material, the man power and the machineries required.

Plant engineering is a discipline of study about shaping, establishing and enhancing the utility power of the above factors of men, machine and materials.

11.2.1 Plant location

Plant location is an important exercise of selecting a suitable site and area for establishing a new plant or for expanding a existing plant. This is very essential as it decides the operational and capital cost of the product.

11.2.2 Important factors to be considered in selecting a plant location

1. The plant should be located as near as possible to the place where the raw materials are available. This will reduce the cost involved in transportation of the raw material.

2. The location should be conveniently connected by highways and railways.

3. The availability of adequate labour is a important factor.

4. The topography of geography, area of available land, shape of the site and drainage facitlities should be suitable to the needs of the plant. The location should not be prone to floods and earthquakes.

5. Sufficient quantity of quality water should be available near the plant location. It will be useful for drinking and sanitary purpose.

6. Electrical power of adequate strength and necessary fuel should be available at the plant location.

7. The atmosphere of the plant should provide adequate lighting and ventilation facilities.

8. Location of a plant should be selected to avail maximum tax concessions, loan facilities and low power tariff.

9. Proper housing facilities for the employees, presence of hospitals, educational institutions, markets and recreational facilities should also be considered while selecting locations.

10. Presence of related industries near the location is preferable.

11.2.3 Plant Layout

The physical arrangements of buildings, machinery, equipments, workplaces and other facilities for the manufacturing process is known as plant layout. A good plant layout makes the process of production more efficient by providing easier movement of men and materials with minimum handling.

11.2.4 Advantages of a good plant layout

1. Handling of materials and transportation becomes minimum

2. The rate of production increases because of effective use of man and machines

3. Workers feel comfortable with less movement inside the plant

4. The available space is economically and efficiently used

5. Investments on equipments becomes minimum

6. Simple, easy and effective supervision is possible

11.3 Work Study

Work study is a technique to increase the productivity. It is used to find out the reasons for shortfall in the efficiency of the human work and set guidelines for improvement. By increasing production, the cost is reduced and the product reaches more people. Work study aims on the above objective.

Work study is a combination of two techniques namely (i) Method study and (ii) Work measurement.

11.3.1 Method study

Method study is a systematic recording and critical analysis of the method of doing a work. It also proposes a new method of doing the same work in a easy and effective manner to reduce costs.

11.3.2 Work Measurement

Work measurement is a technique to find out the time taken for a qualified worker to finish a specified work at a particular level of performance.

11.3.3 Production and productivity

Production can be defined as a process of manufacturing the required end product from the available raw materials.

Productivity can be defined as a ratio between the output in quantum of wealth and the input of resources of production

$$\text{Productivity} = \frac{\text{Production output}}{\text{input of resources.}}$$

11.3.4 Productivity based on different resources

a. Productivity of land

Let us assume an agriculturist spends Rs. 5000.00 to plant casuarina saplings in his land of 1 acre and earns yields worth Rs. 10000.00

$$\text{Productivity} = \frac{\text{Production output}}{\text{input of resources.}} = \frac{10000}{5000} \times 100 = 200\%$$

We consider another case where the same agriculturist spends Rs. 1000 more for better saplings and better methods of cultivation in the same area and earns yields worth Rs. 15000.00

$$\text{Productivity} = \frac{\text{Production output}}{\text{input of resources.}} = \frac{15000}{6000} \times 100 = 250\%$$

In this case the productivity is increased by 50%

b. Productivity of men

We consider a case of a machinist who works on a milling machine and makes 40 gears a day. By improved methods of work, the same machinist is able to machine 50 gears in a day. The increase in productivity can be calculated as

$$\frac{50 - 40}{40} \times 100 = 25\%$$

Increase in productivity = 25%

c. Productivity of machine

Let us consider a case where an operator works on a drilling machine for 8 hours to make drills on 100 identical workpieces. With the same machine, the operator is able to make drills on 140 workpieces by using jigs and drills with high cutting speeds.

$$\text{The increase in productivity} = \frac{140-100}{100} \times 100 = 40\%$$

11.3.5 Means of increasing productivity

Some important means of increasing the productivity are given below

1. By improving the working conditions
2. By improving the process involved in production
3. By reducing the non- productivity time by work measurement
4. By providing suitable incentives to the workers
5. By proposing better plant maintenance programmes
6. Old and worn out machines should be corrected to make them function as before
7. Men (Workers), Machine and materials should be maintained at the required quantum
8. By providing the operators with new and proper training
9. Layout of the plant and equipments should be improved

11.4 Production Planning and Control (PPC)

Production planning is a process of scheming the production procedures to get the finished products of required quality from the raw mqterials within a prescribed time frame economically.

Production control is a process of making specific arrangements to carry out the procedures outlined by production planning. It should also oversee corrective measures in case of failures in the production process.

11.4.1. Functions of PPC

1. Preplanning : It involves the decisions of the preparatory functions in the production process.

2. Route plan : It is the plan of arranging various activities that take place from the stage of raw material to the finished product.

3. Scheduling : Scheduling is the preparation of a time table to show the time of starting and the time of completing of operations involved in production of each component.

4. Despatching : It is the process of ordering different departments to carry out production process as per the route plan and scheduling.

5. Controlling : It is the process of getting reports from all departments regarding production and taking correcting actions (if necessary).

11.4.2 Importance of PPC

No action will take place in a plant on its own. A worker cannot go on with production process without specific instructions. This important task of arranging specific instructions to the workers to carry out specific tasks at specific time frame with specific materials at specific quantity and quality on specific machines. It is the main duty of the Department of PPC. It is not exaggeration if it is said that PPC is the nerve centre of an industry. PPC ensures the name and reputation of an industry in the society.

11.5 Quality Control

The quality of a product is the fitness of the product regarding its intended purpose. In production process, it is not always possible to maintain the quality for all the number of products. The quality may vary with each piece of the product. It depends on the machine on which it is produced, the tools used, the methods holding tools and workpieces etc., This variation in quality is unavoidable. However, the variations should be within desired limits.

By ensuring quality control, we can look forward to quality productions in future. It can be said that the quality control cannot do anything with the past production. So the action plan deviced to control the quality of the product before the production process is known as quality control.

11.6 Management

With the industrial growth in the twentieth century, new machines, mechanism and production methods have evolved. The field of production has shown a remarkable development. Increased production led to competitions in business. Competition and confusion were the results of new methods of trade. The bosses of the industries were not able to face the competitions and resolve problems arising out of it. In order to resolve these issues, a new set up in governing was found necessary. Separate personal have been appointed to supervise and control the activities of the industries. They are known as managers.

Management can be defined as a system of extracting work from men with full satisfaction of the employer, employee and the common man. It is a process of achieving the objectives of an organisation by directing and controlling the various activities of the involved manpower.

11.6.1 Frederick W. Taylor

Frederick W. Taylor is regarded as the father of 'Scientific management movement.' He laid foundation for modern scientific management between 1880 and 1890. He started his career as a labourer in the Midvale steel company, U.S.A. in the year 1878. He held different positions in the company and later became the Chief Engineer in 1884. He was instrumental in developing new principles of management and wrote a book titled 'The principles of scientific management'

According to F.W. Taylor, scientific management involves the following procedures,

1. Observation
2. Measurement
3. Experimental comparison
4. Formulation of procedure

11.6.2 Henri Fayol

Henri Fayol was a French industrialist. He was a graduate in Mining engineering. He joined as an Engineer in a coal mining company in the year 1860. Later, he became the Managing Director of the company. He retrieved the company from near bankruptcy to set it as a leading coal mining company in France.

Based on his hard work and a successful managing experience, he wrote a book titled "General and Industrial Management". It contained his general management principles. He categorized all the activities of industrial undertakings into six groups. They are

1. Technical activities (Production related)
2. Financial activities (Capital related)
3. Commercial activities (buying material and selling products)
4. Security activities (Protection of properties)
5. Accounting activities (Statistics and stock taking)
6. Managerial activities (plan and control)

11.7 Organisation

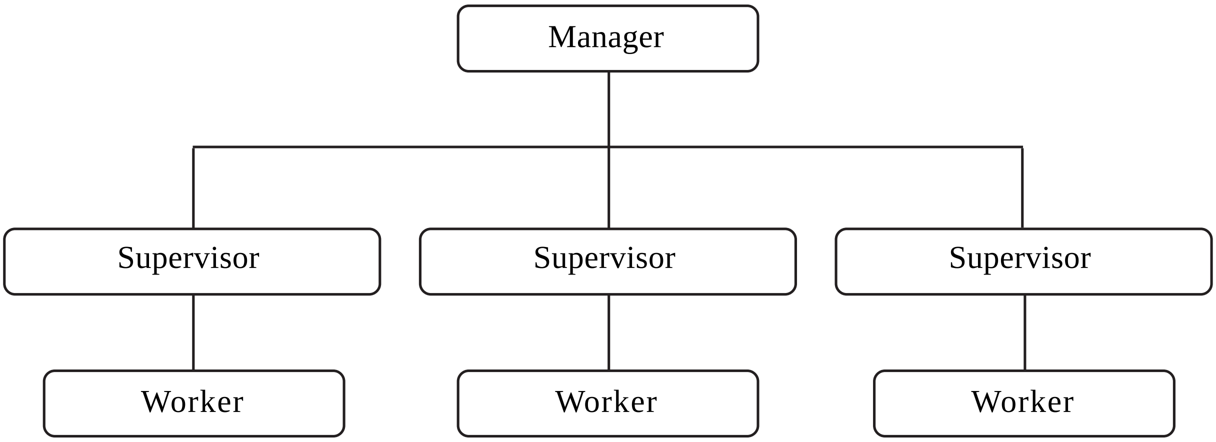
The process of organizing in a industry involves the identification and establishment of its objectives and coordination of the capital, raw material, machines and people to reach out the set objectives. The institution which involves in the process is known as an organisation.

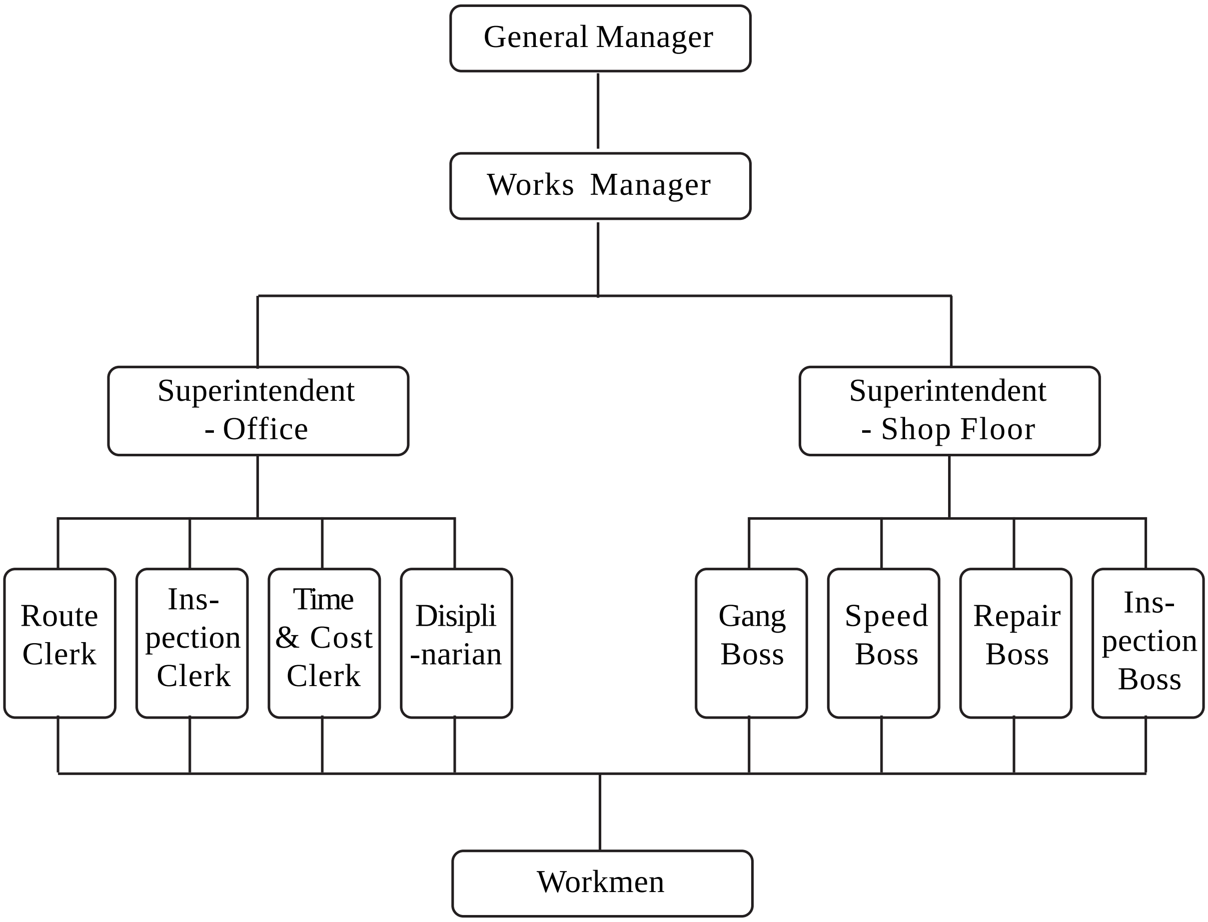
11.7.1 Types of organisation

1. Line Organisation
2. Taylor's functional organisation
3. Line and staff organisation
4. Line and functional staff organisation
5. Committee organisation

11.7.2. Organisation chart

Organisation chart is a graphical representation of various steps of organisational structure.





QUESTIONS

I. A. Choose the correct option

1. Work study is
   a. a technique of increasing production b. method of plant layout
   c. method study d. work measurement

2. Production planning is
   a. Productivity of men b. Productivity of machine
   c. Scheming of productivity procedures d. Quality control

3. Father of 'Scientific management movement' is
   a. Henri Fayol b. Vernier c. F.W. Taylor d. James Nasmith

I. B. Answer the following questions in one or two words

1. What is method study?
2. Mention any one method of increasing productivity.
3. Mention any one type of organisation.
4. Who is a manager?

II. Answer the following questions in one or two sentences

1. What is plant engineering?
2. What is plant location?
3. Define – Work study.
4. What is management?
5. What is an organisation?

III. Answer the following questions in about a page

1. Production, Planning and Control – Explain.
2. Explain 'Quality control'.
3. List out the types of organisation.
4. What are the advantages of a good plant location.

IV. Answer the following questions in detail

1. What are the factors to be considered in selecting a plant location?
2. Explain the methods of increasing productivity.
3. Draw a sample organisation chart.

12. COST ESTIMATION

12.1 Introduction

Cost estimation can be defined as the estimation of expenditure incurred for the entire manufacturing process in producing an object.

Cost estimation should be done by taking into account the following points.

1. Cost of the raw material

   It is calculated by considering the size of the work and the expected wastage of the material during production.

2. Wages paid to the workers
3. Machining charges
4. Cost for making accessories like jigs and fixtures
5. Administrative expenditure
6. Profit

12.2 Cost of the material

The cost of the raw material includes the price of the material required, taxes, labour paid for loading and unloading, and transportation charges.

Miscellaneous expenditures like the cost of the soap, oil, blades, cotton waste, grease and chalkpieces should also be included in this head. These items add up as indirect cost of the material.

Raw materials are of two types

1. Standard raw material purchased according to the size
2. Cast material

12.3 Machining charges

A part or component is obtained only after it is subjected to several operations performed on different machine tools. The machining charges are calculated by considering the duration of machining on each of these machine tools involved in manufacturing the particular component. The machining charges differ for different type of machine tools.

Following is the table prepared approximately for calculating the machining charges. The charges mentioned may vary according to the capacity and the accuracy of the machine tool.

Machine	Duration	Rate per hour
Drilling machine	1 hour	Rs. 100.00
Lathe	1 hour	Rs. 150.00
Shaping machine	1 hour	Rs. 200.00
Milling machine	1 hour	Rs. 250.00
Grinding machine	1 hour	Rs. 300.00

12.4 Wages paid to the workers

This includes the amount of wages paid to the workers employed for operating the machine tools and the expenditure for miscellaneous operations performed on the workpieces. Charges for hacksaw cutting, marking and indexing, polishing, fitting and assembling are counted under this head.

12.5 Cost for making accessories like jigs and fixtures

If the production process involves the usage of jigs and fixtures, the cost incurred for manufacturing or purchasing the same should be taken into account.

12.6 Administrative expenditure

It can also be called as overhead charges. It includes

1. Depreciation (Wear and tear on machine tools and other tools)
2. Repairs and maintenance of the machine tools
3. Expenditure on fuels and electricity
4. Rent and maintenance for the building of the manufacturing unit
5. Salary paid to the administrative staff
6. Salary paid to the supervisors, storekeepers and watchman
7. Expenditure on advertising, travel and postage.
8. Welfare of the workers, contribution to the employee's fund
9. Interest on capital

The overhead charges may vary from a factory to factory. It may range from 130% to 300%.

12.7 Profit and tax

Profit is calculated 10% of all the expenditure mentioned above. Sales tax and packing charges should also be included in this account.

Example

100 No's of spur gears are required with the following specifications.

No. of teeth	=	60
Module	=	3
Width of the gear	=	30mm
Diameter of the stock	=	40mm

Find out the total cost of estimation and the cost of a single gear if the cost of the cast material is Rs.35 per Kg and the approximate weight of a gear is 1Kg.

I. Cost of the raw material

As the gears are to be cast, the cast material should be ordered.

Weight of a single gear	=	1Kg
Weight of 100 gears	=	100 Kg
Cost of 1Kg of Cast material	=	Rs. 35
Cost of 100Kg of material	=	100x35
	=	Rs. 3500
Loading and unloading charges	=	Rs.50
Transportation (Freight)	=	Rs. 50
Cost of the raw material	=	3500 + 50 + 50
	=	Rs. 3600

II. Machining charges

Name of the Machine	Operation	Total time for 100 gears		Rate per hour	Total
		In minutes	In hours		
Lathe	24 minutes are required for turning both the sides of the cast gear blank (for 1 gear)	2400	40	150	6000
Slotting Machine	24 minutes are required for slotting (for 1 gear)	2400	40	200	8000
Milling Machine	48 minutes are required for milling (for 1 gear)	4800	80	250	20,000
Total machining charges			160		34,000

III. Wages paid to the workers

Total machining time = 160 Hours

Working hours (8 Hours per day) 160 / 8

= 20

Labour(Rs.200 per day) = 20 x 200

= 4000

IV. Overhead charges

= Rs. 500

V. Profit

Profit	=	(Cost of raw material + Machining charges + Wages + Overhead charges) x 10%
	=	(3600 + 34000 + 4000 + 500) x 10%
	=	42100 x 10%
	=	4210
Cost of 100 gears	=	42100 + 4210
	=	Rs. 46310
Cost of a single gear	=	46310 / 100
	=	463.10

QUESTIONS

I. A. Choose the correct option

1. The expenditure on the maintenance of the machine tools is
   a. Administrative expenditure b. Salary to the staff
   C. Cost of raw materials d. Tax

I.B. Answer the following questions in one or two words

1. What is the name of the expenditure incurred for making work holding devices?

II. Answer the following questions in one or two sentences

1. What is cost estimation?
2. What do you mean by the wages paid to the workers?

III. Answer the following questions in about a page

1. What are the important factors to be considered in cost estimation ?
2. Administrative expenditure – Explain.
3. Explain ‘Cost of raw materials’.

IV. Answer the following questions in detail

1. Explain ‘machining charges’.

MODEL QUESTION PAPER

GENERAL MACHINIST PAPER - II

WORKSHOP ENGINEERING

Time : 3 hours Marks : 200

PART - I

A. Choose the correct answer **30 x 1 =30**

1. The person who manufactures different parts is
   a. Supervisor b. Machinist c. Manager d. Foreman

2. First aid is
   a. a manufacturing process b. safety regarding operators
   c. immediate treatment given at the spot of accidents
   d. breakdown of machines

3. The vise with 'V' shaped jaws is
   a. Leg vise b. Hand vise c. Pipe vise d. Pin vise

4. The tool used to hold and cut sheets and wires is a
   a. screw driver b. pliers c. allen key d. ring spanner

5. Centre of a round rod can be found with a
   a. steel rule b. jenny caliper c. trammel d. punch

6. _______ is a direct measuring instrument
   a. Caliper b. Gauge c. Vernier caliper d. Divider

7. Measurements on cylindrical surfaces are done with
   a. narrow rule b. hook rule c. folding rule d. flexible rule

8. The property of changing the shape of a metal part is a
   a. thermal property b. electrical property
   c. physical property d. chemical property

9. The method of heat treatment done to increase the wear resistance quality is
   a. Annealing b. Hardening c. Tempering d. Normalising

10. The media used for rapid quenching is
    a. Cyaniding b. Tempering c. Sodium salt bath d. Oil

11. The system that enables parts of equivalent sizes with dimensional variation within certain limits to be fit for operating is
    a. Limits b. Unilateral tolerance
    c. Deviation d. Interchangeability

12. If the size of the saft is smaller than the hole size, the system of is

a. Interference fit   b. Clearance fit   c. Driving fit   d. Push fit

13. The fit which involves the shaft being driven into the hole with light force

a. Light driving fit   b. Heavy driving fit
c. Shrink fit   d. Tight fit

14. Power is transmitted between shafts at moderate distance by

a. belt drive   b. gear drive   c. chain drive   d. friction drive

15. The unit of pressure is

a. m^2 b. N/m^2 c. m^3 d. None of the above

B. Answer the following questions in one or two words

16. Mention the use of a round file.
17. What is the use of adjustable spanner?
18. What is rhe use of a scriber?
19. Mention one use of a jenny caliper.
20. Mention one use of a feeler gauge.
21. Expand HSS.
22. Are the tools guided in jigs?
23. Expand RPM.
24. What is the use of bevel gears?
25. Mention one use of a pneumatic circuit.
26. How is Kirchhoff's first rule otherwise known as?
27. Mention any one material used to make hydraulic pipeline.
28. Mention the unit of electric current.
29. What is the unit of Resistance?
30. Who is the father of 'Scientific management movement?

PART - II

Answer any ten questions in one or two sentences   10 x 4 = 40

31. What is 'First aid'?
32. Mention any four types of files.
33. What is a centre punch?
34. What is a caliper?
35. What are gauges?
36. What is annealing?
37. Define - Hardness.
38. What is a jig?
39. What is basic size?
40. What are the methods poer transmission?

41. What is a pressure relief valve?
42. What is current?
43. What is resistance?
44. What is management?
45. What is cost estimation?

PART - III

Answer the following questions in about a page **5 x 10 = 50**

46. What are the safety precautions regarding an operator?
47. State the reasons for the breaking and blunting of hacksaw blades.
48. Draw and explain a jenny caliper.
49. Explain different methods of measuring.
50. Ring gauge, Plug gauge - Explain.
51. Explain the process of Hardening.
52. Draw and explain - Series circuit and Parallel circuit.

PART - IV

Answer the following questions in detail **4 x 20 = 80**

53. Explain a bearing puller with a diagram.

(or)

Vernier caliper - Draw and explain.

54. Explain the differences between gauges and templates.

(or)

Explain sintering furnace with a diagram.

55. Explain 3 - 2 - 1 location with a diagram.

(or)

Explain the interchangeable system

56. Draw a basic hydraulic circuit and explain.

(or)

What are the important factors to be considered in selecting a plant location?

QUESTION PAPER BLUE PRINT

Sl. No.	CHAPTER	Questions allotment				Remarks
		Part - A	Part - B	Part - C	Part - D	
		1 mark	4 marks	10 marks	20 marks	
1.	Workshop Engineering & Safety Precautions	2	1	1 O	-	
2.	Hand Tools	6	2	2	1	
3.	Measuring Instruments	4	2	2	2	
4.	Engineering Materials	2	1	-	-	
5.	Heat Treatment	2	1	1 B	1	
6.	Jigs and Fixtures	1	1	1 B	1	
7.	Standardisation	3	1	-	1	
8.	Transmission of Power	3	1	1 O	-	
9.	Hydraulics	3	1	1 A	1	
10.	Electricity	3	2	1 A	-	
11.	Industrial Management	1	1	-	1	
12.	Cost Estimation	&	1	&	&	
	Total questions	30	15	10	8	

Note : Any one of the O, A & B marked questions