E-CONTENTS

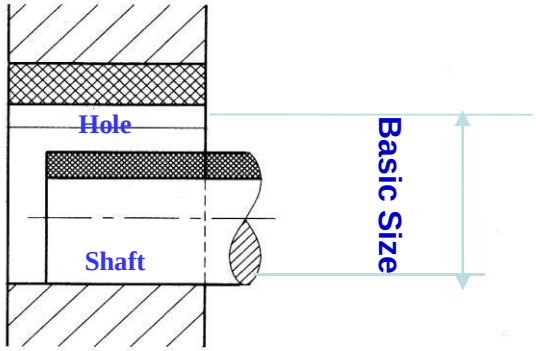
OF

Plant Maintenance & Material Handling

Limit, Fit, Tolerance

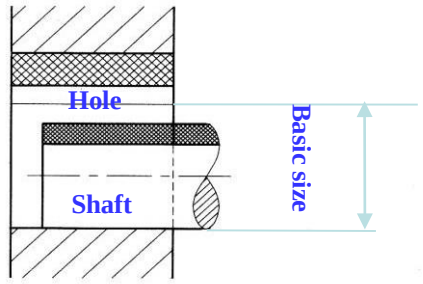
LIMITS, FITS & TOLERANCE

- **Terminology:- The terms related to limit system as per BIS are as below;**



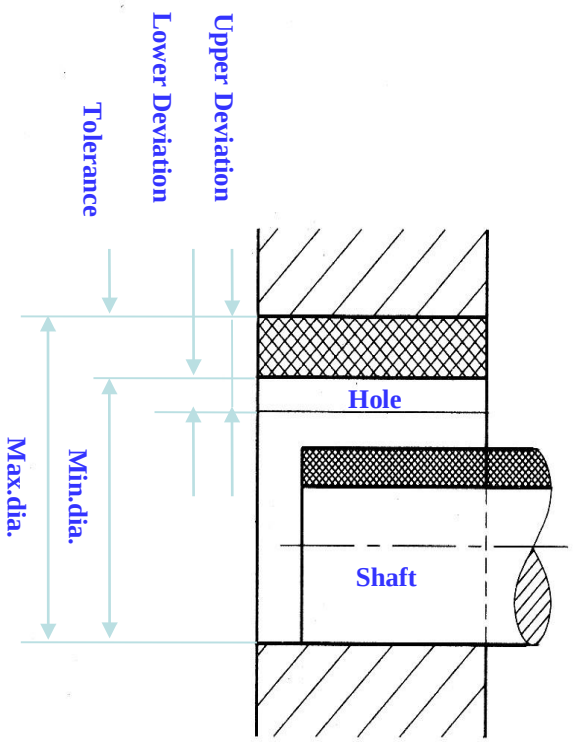
- **Size:- It is a number expressed in a particular unit in the measurement of length.**
- **Basic Size:- It is the size based on which the dimensional deviations are given.**
- **Actual Size:- It is the size of the component by actual measurement after it is manufactured. It should lie between the two limits of size.**

❖ **Limits of size:-** These are the extreme permissible sizes within which the operator is expected to make the component. Maximum limit of size is the greater of the two limit size, whereas the Minimum limit of size is the smaller of the two limit size.



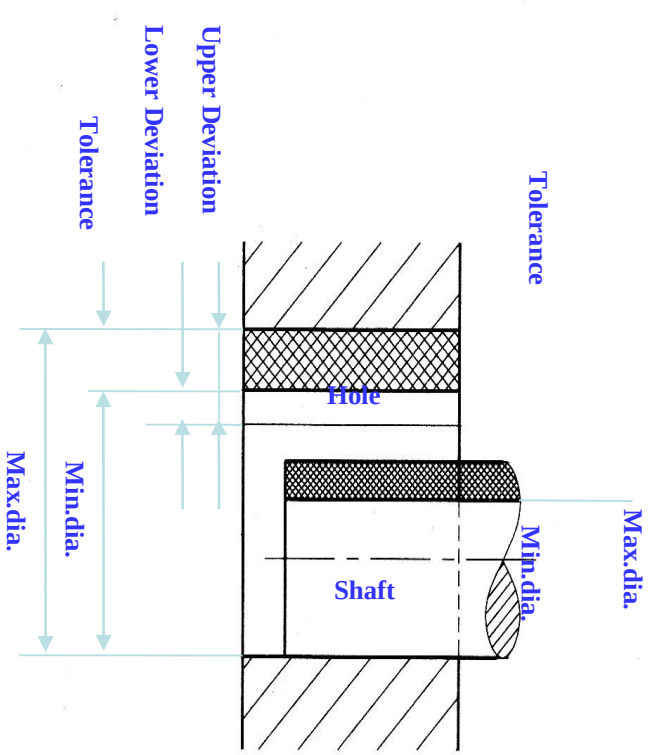
❖ **Hole:-** In the B.I.S. system of limits and fits, all internal features of a component including those which are not cylindrical are designated as ‘Hole’.

❖ **Shaft:-** In the B.I.S. system of limits and fits, all external features of a component including those which are not cylindrical are designated as ‘Shaft’.

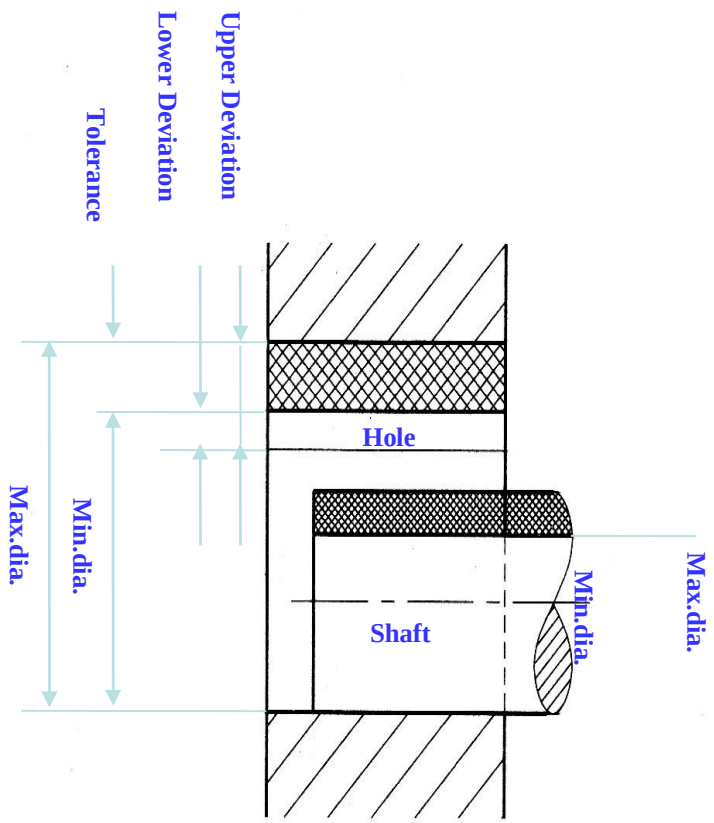


❖ **Tolerance:-** It is the difference between maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign.

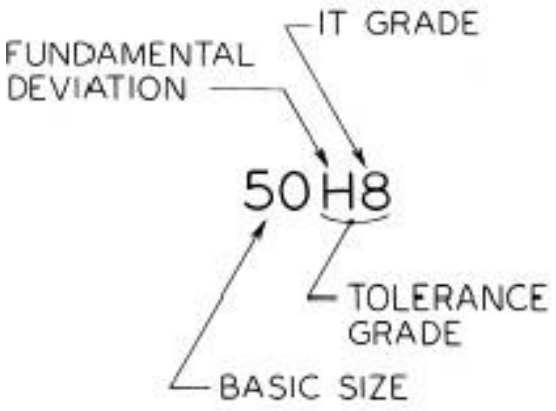
❖ **Zero line:-** In graphical representation of the above terms, the zero line represents the basic size. This line is also called as the line of zero deviation.



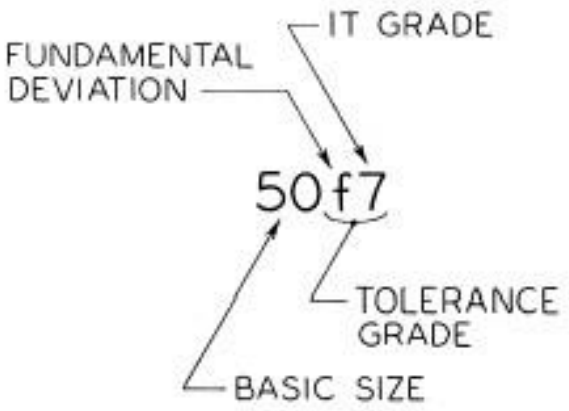
- **Fundamental deviation:-** There are 25 fundamental deviations in the B.I.S. system represented by letter, symbols (Capital letters for Holes and small letters for Shaft)



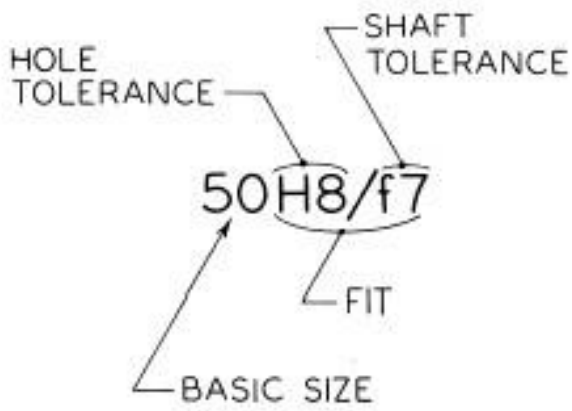
❖ **Fundamental Tolerance:-** This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades represented by number symbols, both for hole and shaft denoted as IT01, IT0, IT1, IT2.....IT16. A high number



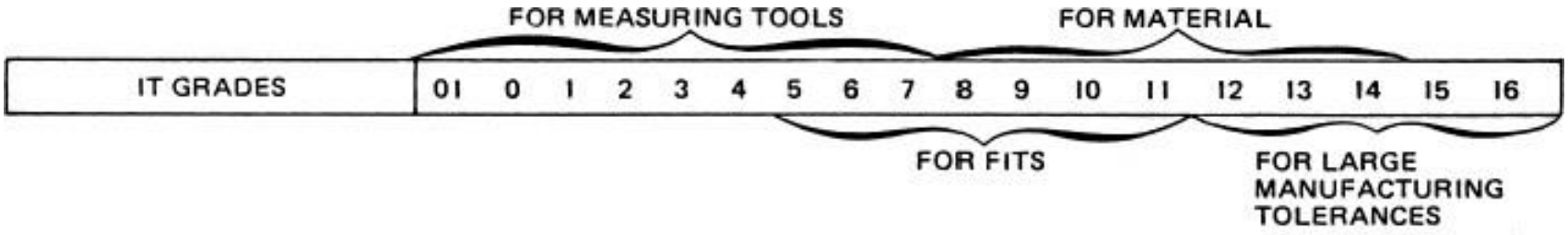
(a) HOLE



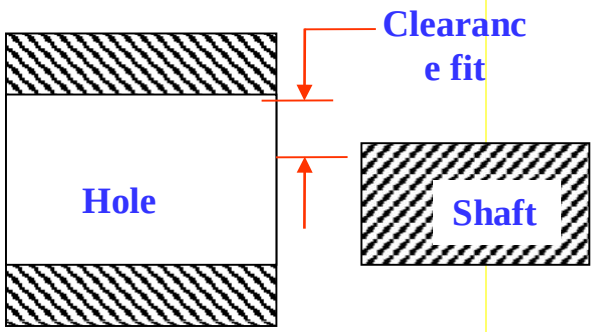
(b) SHAFT



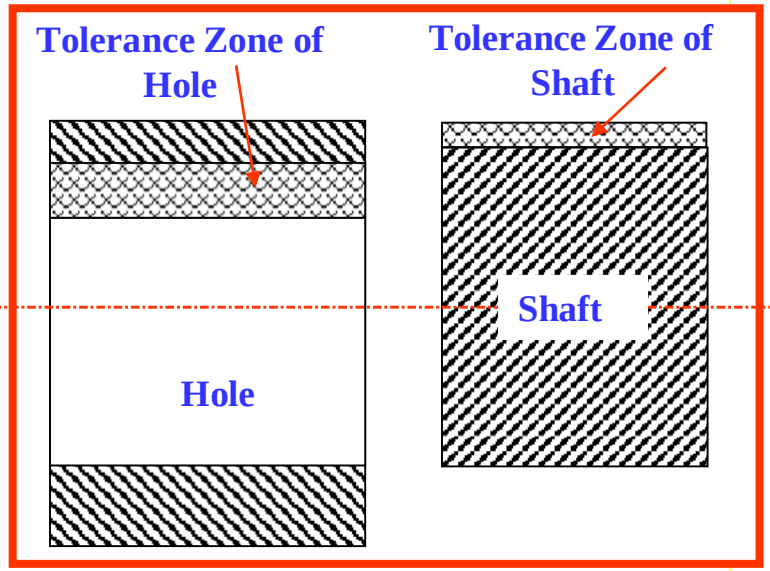
(c) FIT



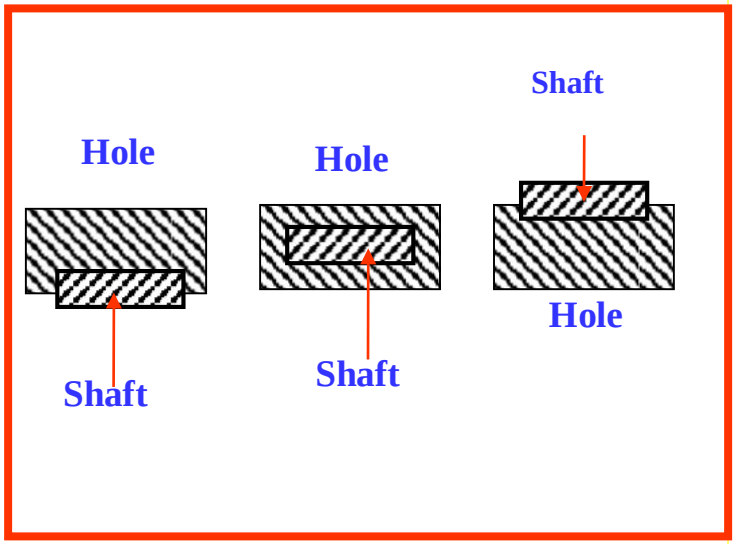
❖ **FIT:-** It is the relationship that exists between two mating parts, a hole and shaft with respect to their dimensional difference before assembly. Three types of fit are given hereunder;



❖ Clearance fit:- It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. Maximum clearance is the difference between the maximum hole and minimum shaft. Minimum clearance is the difference between the minimum hole and maximum shaft.



- **Interference fit:- It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. Maximum interference is the algebraic difference between the minimum hole and maximum shaft. Minimum interference is the algebraic difference between the maximum hole and minimum shaft.**



❖ **Transition fit:- It is a fit which may sometimes provides clearance and sometimes interference. When this class of fit is represented graphically, the tolerance zone of the hole and shaft will overlap each other.**

Mass Production :- Mass production means production of a unit, component or part in large numbers.

Advantages:- 1.Time for the manufacture of components is reduced

2.The cost of pieces is reduced.

3. Spare parts can be quickly made available.

Disadvantages:-1. Special purpose machines are necessary.

2.Jigs and Fixtures are needed.

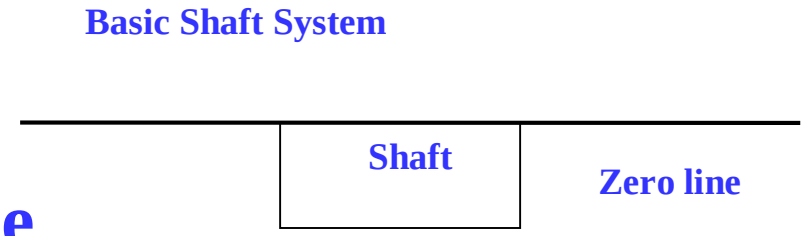
3. Gauges are to be used instead of conventional precision instruments.

4. Initial expenditure will be very high.

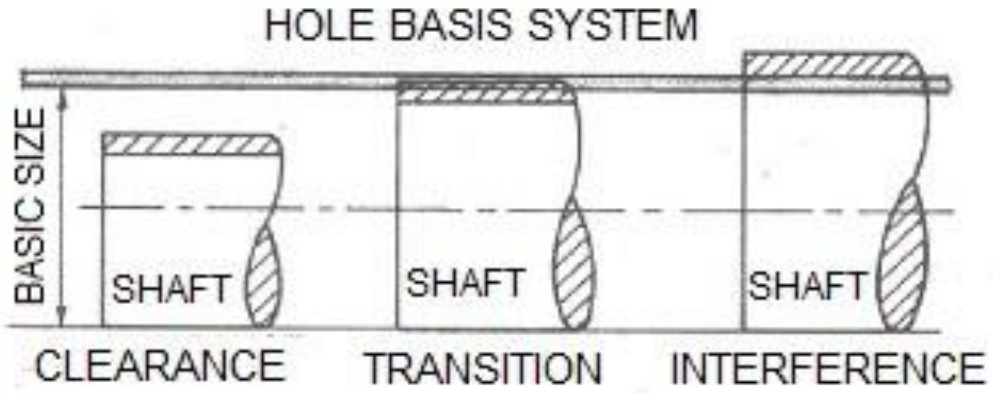
- **Interchangeability:-** When components are mass produced, unless they are interchangeable, the purpose of mass production is not fulfilled. By interchangeability, we mean that identical components, manufactured by different personnel under different environments, can be assembled and replaced without any further rectification during the assembly stage, without affecting the functioning of the component when assembled.

- **Hole Basis System:-** Where the size of the hole is kept constant and the size of the shaft is varied to get the different class of fits, then it is known as the hole basis system.

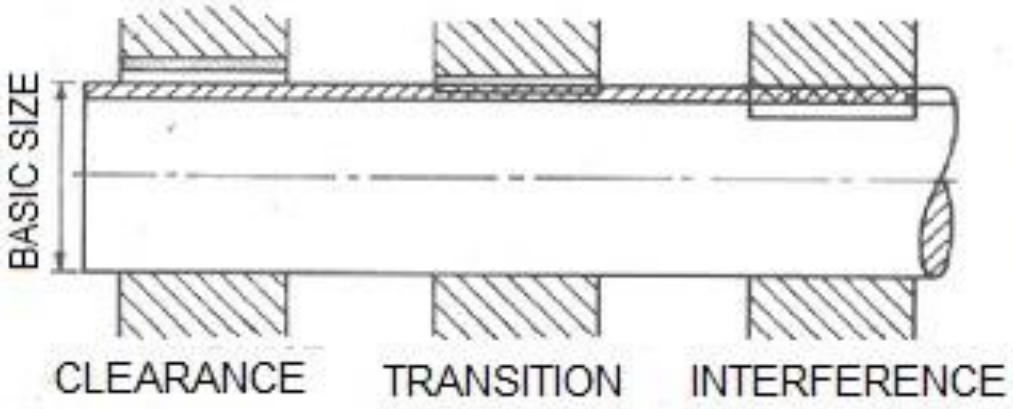
- **Shaft Basis System:-** Where the size of the shaft is kept constant and the variations given to the hole to get the different class of fits, then it is known as the shaft basis system.



HOLE AND SHAFT BASIS SYSTEM



HOLE BASED SYSTEM
Size of hole is kept constant,
shaft size is varied
to get different fits.



SHAFT BASED SYSTEM
Size of shaft is kept constant,
hole size is varied
to get different fits.

Plant Layout and its Types

Layout?

“Plant layout ideally involves allocation of space and arrangement of equipment in such a manner that overall operating costs are minimized”.

Objectives of Layout

Efficient utilization of available floor space

To ensure that work proceeds from one point to another point without any delay

Provide enough production capacity.

Reduce material handling costs

Reduce hazards to personnel

Utilize labor efficiently

Increase employee moral.

OBJECTIVES OF LAYOUT….CONT..

Reduce accidents
Provide for volume and product flexibility
Provide ease of supervision and control
Provide for employee safety and health
Allow ease of maintenance
Allow high machine or equipment utilization
Improve productivity

Types of Layout

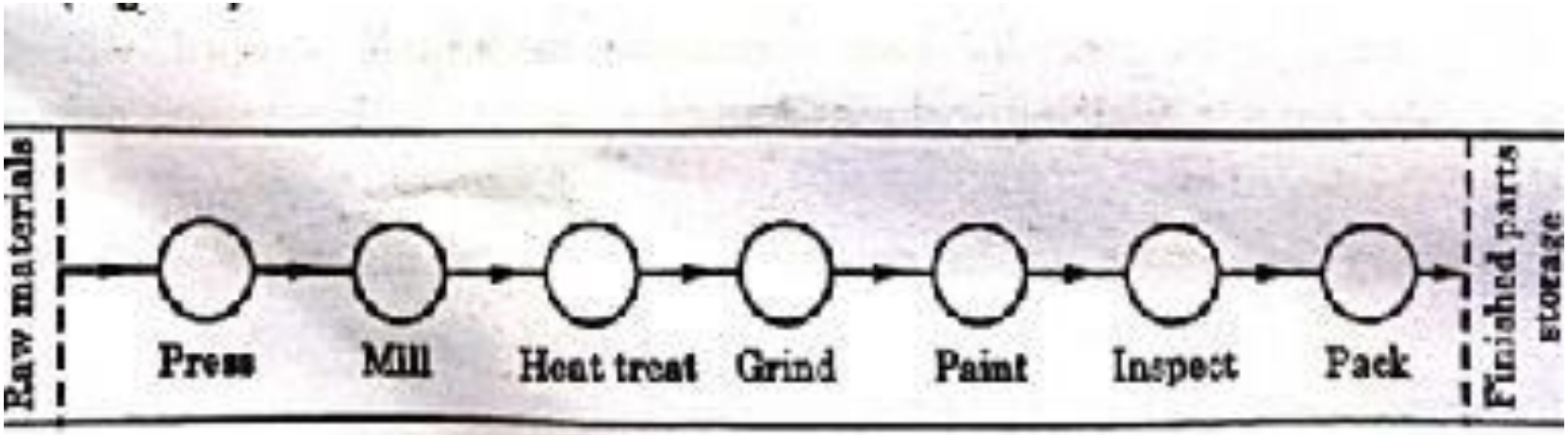
1. Product Layout
2. Process Layout
3. Group Technology layout
4. Fixed position layout
5. Combined layout

- Product layout

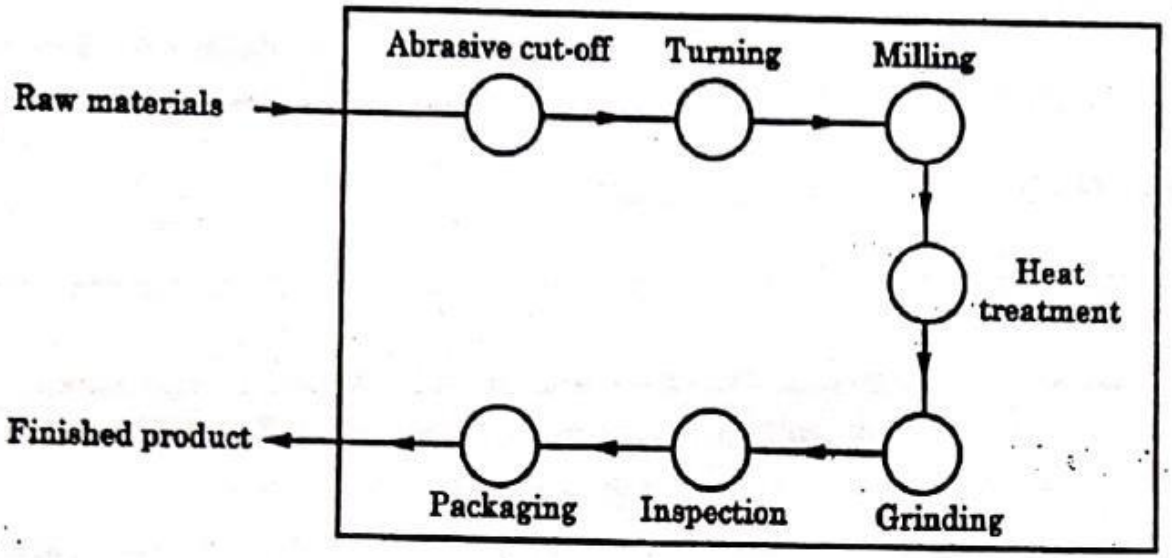
Product Layout

- Also called flow line layout, line layout.
- In this machines, equipment and work centers are arranged in straight or curved line in order they are used.

Block diagram of product layout



(a)


Abrasive cut-off
Turning
Milling
Raw materials
Heat
treatment
Finished product
Packaging
Inspection
Grinding

(*b*)

Advantages of Product layout

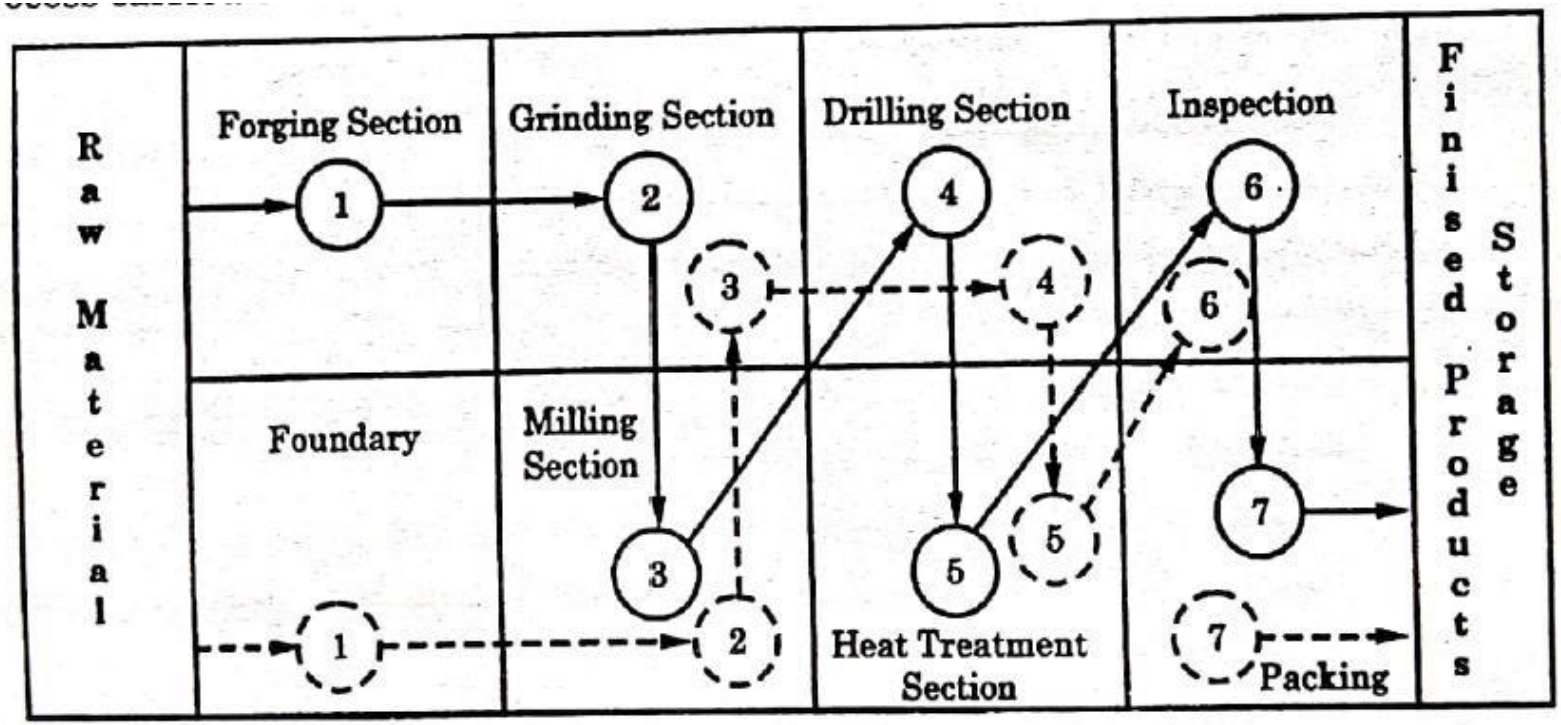
- Higher Productivity
- Minimum material handling.
- Reduced total production time.
- Reduced delays.
- Less work in progress.
- Better utilization of machines and workers.
- Simple design.

Disadvantages of Product Layout

- Break down in single machine line leads to shut down of the whole production line.
- High capital investment.

Process Layout

- Also known as functional layout.
- Used where low volume of production is needed.
- Machines are operated as per nature or type of operations.


Raw Material
Forging Section
Grinding Section
Drilling Section
Inspection
Finised products Storage
Foundary
Milling Section
Heat Treatment Section
Packing
1
2
3
4
5
6
7

Advantages of Process layout

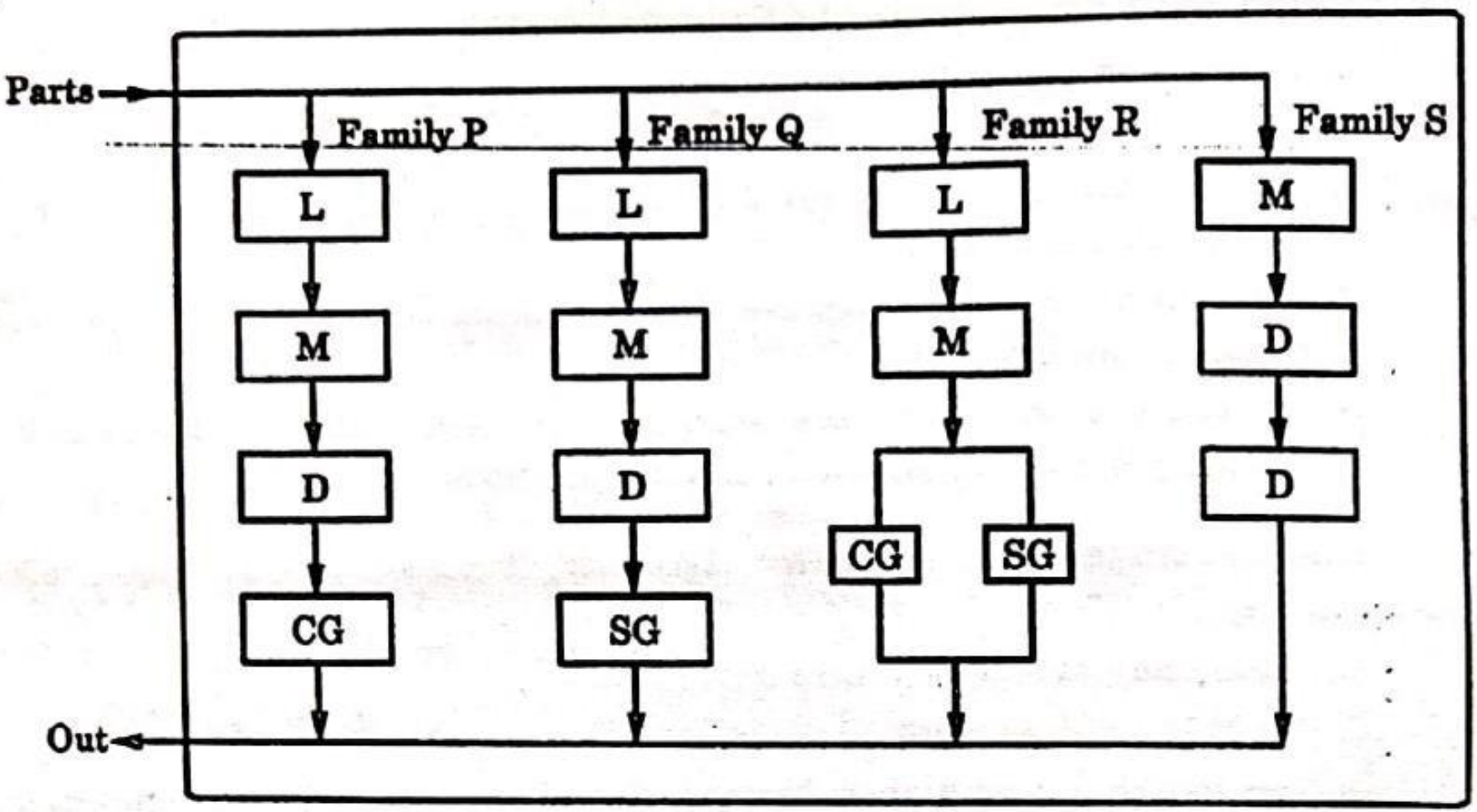
- Lower initial investment in machinery because of less duplication of equipment.
- Ease in maintenance.
- Greater flexibility of production.
- Better utilization of high production equipment.
- Better control.

Disadvantages of Process Layout

- Occupies more floor space
- Higher accident rates.
- Handling cost is higher
- Longer production cycles.
- Inspection is costlier.

Group Technology Layout

- It is element of flexibility in manufacturing system as regards to variation in batch sizes and sequences of operations.
- Families of products are created by analysis.
- Then hybrid of process and product layout is created.



L : Lathe; M = Milling Maching ; D = Drilling Machine
CG : Cylindrical Grinder ; SG = Surface Grinder

Fixed Position Layout

- Used for products which are very massive.
- Work is not moved.

ADVANTAGES:

- Capital investment in plant layout is minimum.
- Higher flexibility.
- Effective used of skilled worker.

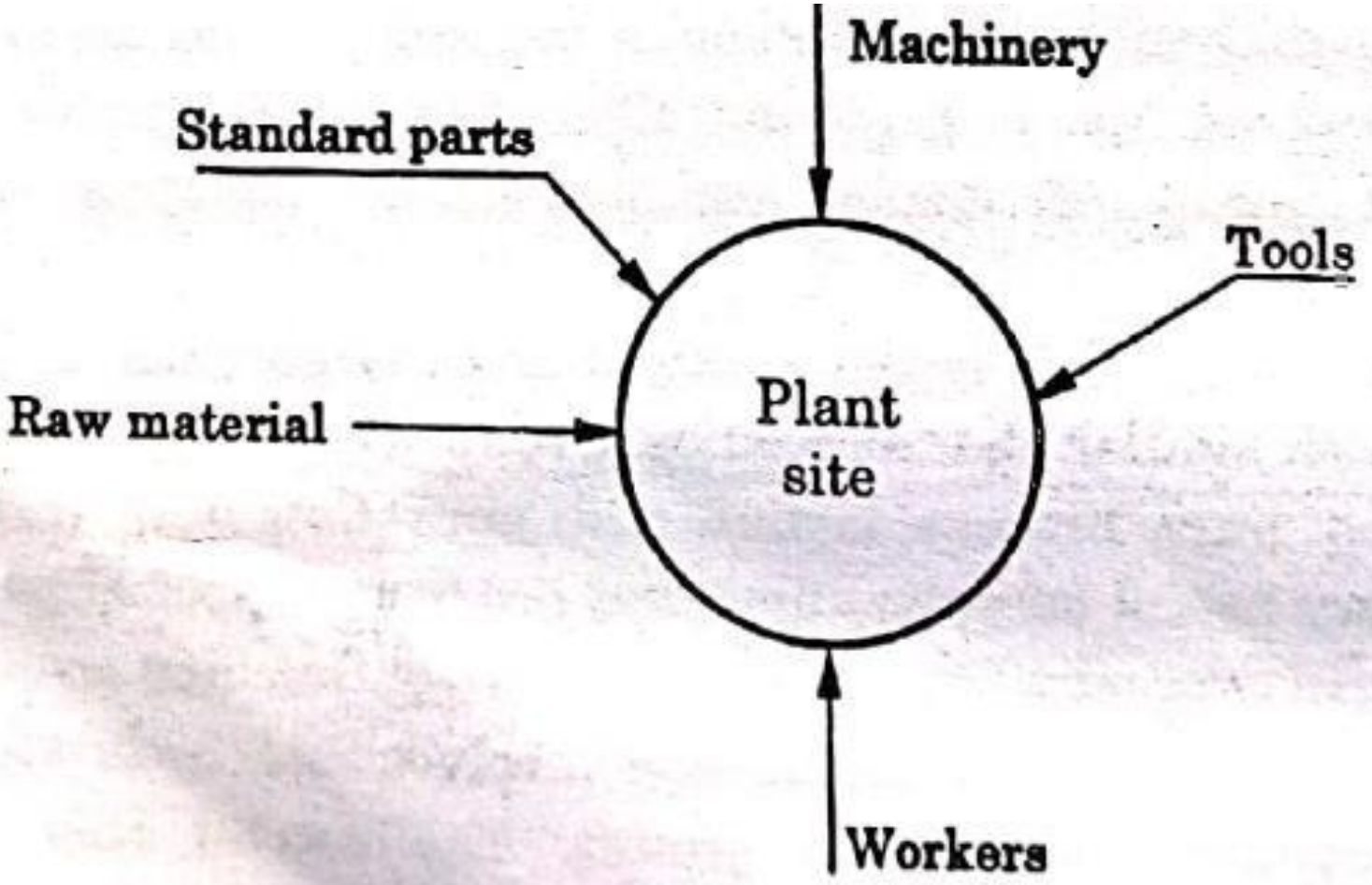


Fig. 2.4: Fixed-position Layout

Disadvantages of Fixed Position Layout

- Can be used for limited quantity of jobs.
- Very costly, complicated jigs and fixtures are required.
- Highly skilled workers required.
- Not applicable for mass production.

Combined layout

- The combined layout incorporates the benefits of process and product layout.
- Production shops may be process layout, while the assembly is accomplished online.

Foundations

- The lowest artificially built part of a structure which transmits the load of the structure to the soil lying under-neath is called foundation.

Types of foundations

- Accordingly to type of machine
    1. foundation for reciprocating machines.
    2. foundation for centrifugal type machines.
    3. foundation for Impact type machines.

- Type of foundations according to material used.
  1) Concrete
  2) Brick
  3) Stone.
  4) Reinforced Concrete foundation.
  5) Structural Steel

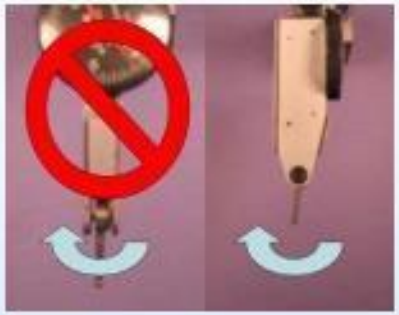
  - According to Structure:

  1) Block pedestal type foundation
  2) Box type foundation
  3) Wall type foundation
  4) Framed type.

Dial Indicators - Mill

1. Location / Types

- Dial Indicators are located on the top of the Metrology Cabinet
- Spindle Indicators are located in dial indicator drawer



2. Using Indicators

- Used to accurately measure small distances
- Probe swings in an arc around its hinge point
- Damaged if force is applied perpendicular to this arc

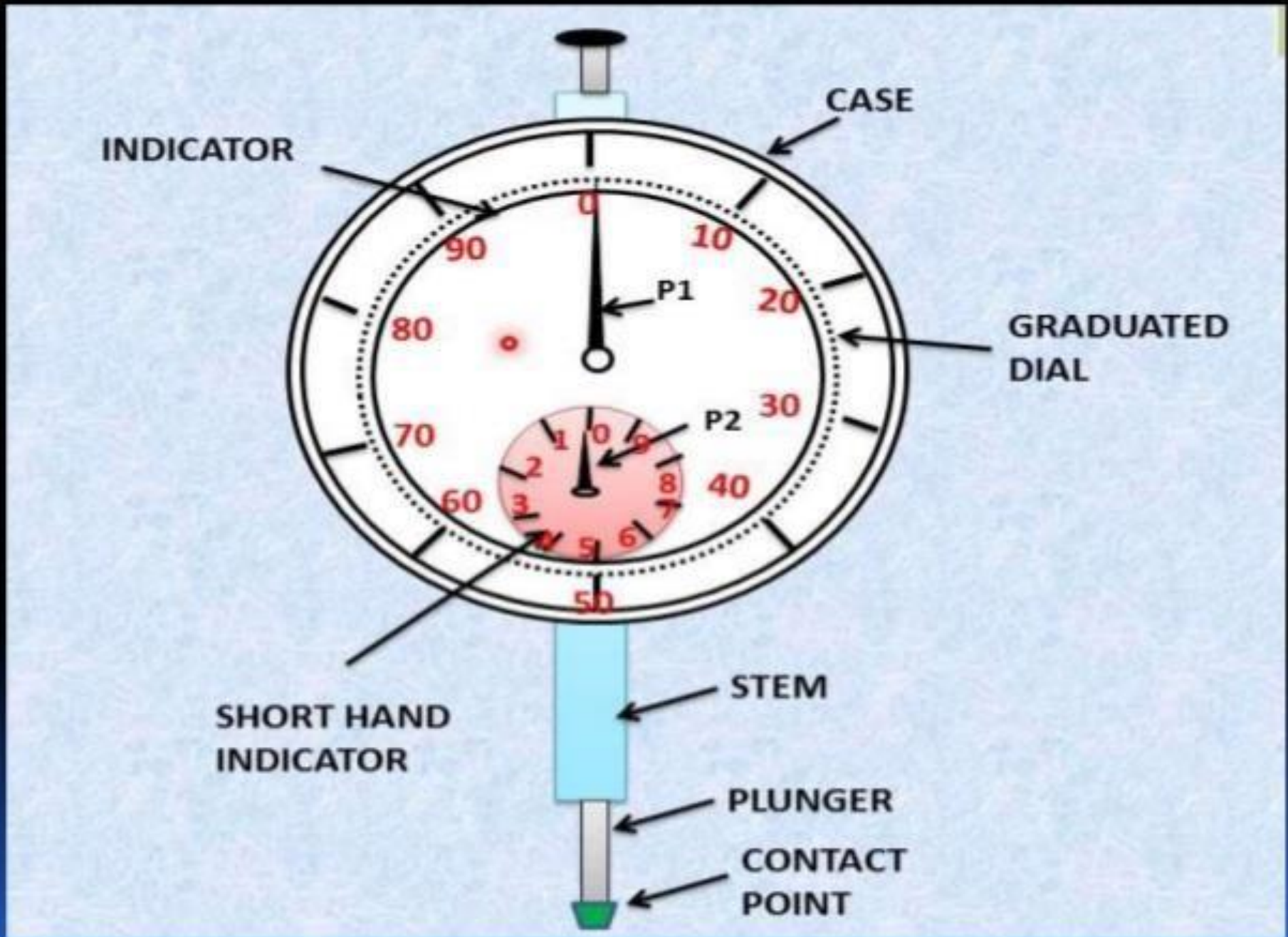
3. Checking Flatness

- Attach Magnetic Indicator to the bottom of the spindle
- Using the table axis touch the indicator to the surface to be measured
- Adjust the gage to read zero
- Use the table to sweep the indicator across the surface
- Measure the change in flatness (gage reads ½ thousandths)
- Return indicator to cabinet

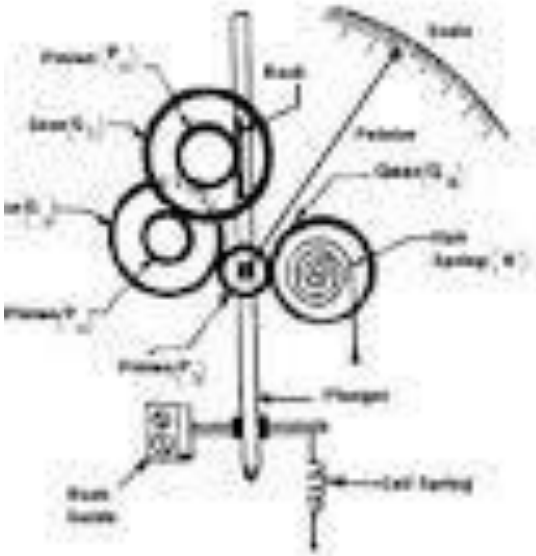
4. Finding the Center of a Hole

- Clamp spindle indicator to bottom of the spindle
- Position the indicator so there is contact all the way around the hole
- Align the y-axis by sweeping the indicator to both sides (180 degrees apart) y direction and splitting the difference by moving the table
- Repeat for the x-axis
- The spindle is centered when the hole holds the same reading on all 4 sides.

Last updated June 1, 2007

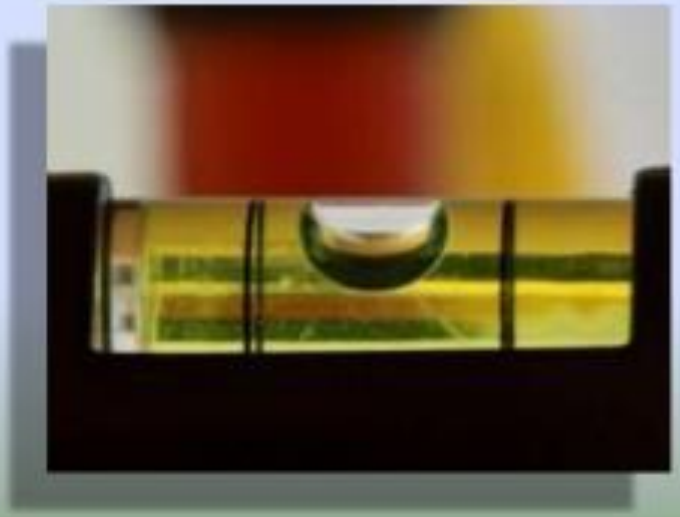

CASE
INDICATOR
GRADUATED
DIAL
P1
P2
STEM
SHORT HAND
INDICATOR
PLUNGER
CONTACT
POINT
0
10
20
30
40
50
60
70
80
90

1. Dial Indicator



Spirit Level

- A **Spirit Level is used for ascertaining If the table is properly level**.
- The **Table is leveled by placing the level on the board in two positions at right angles** and getting the bubble central in both positions.

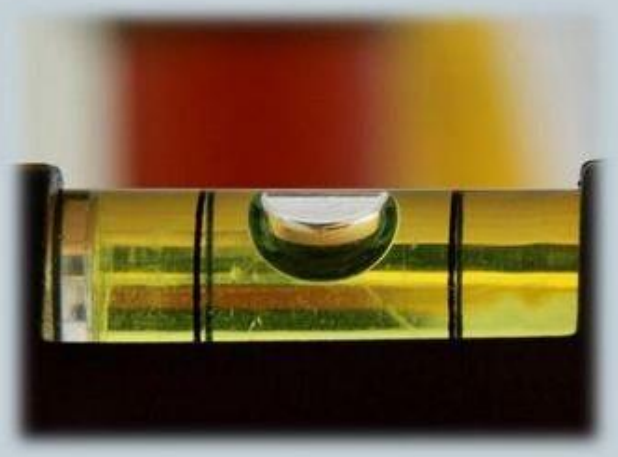


Spirit Level

- tool used for testing vertical and horizontal surfaces

SPIRIT LEVEL

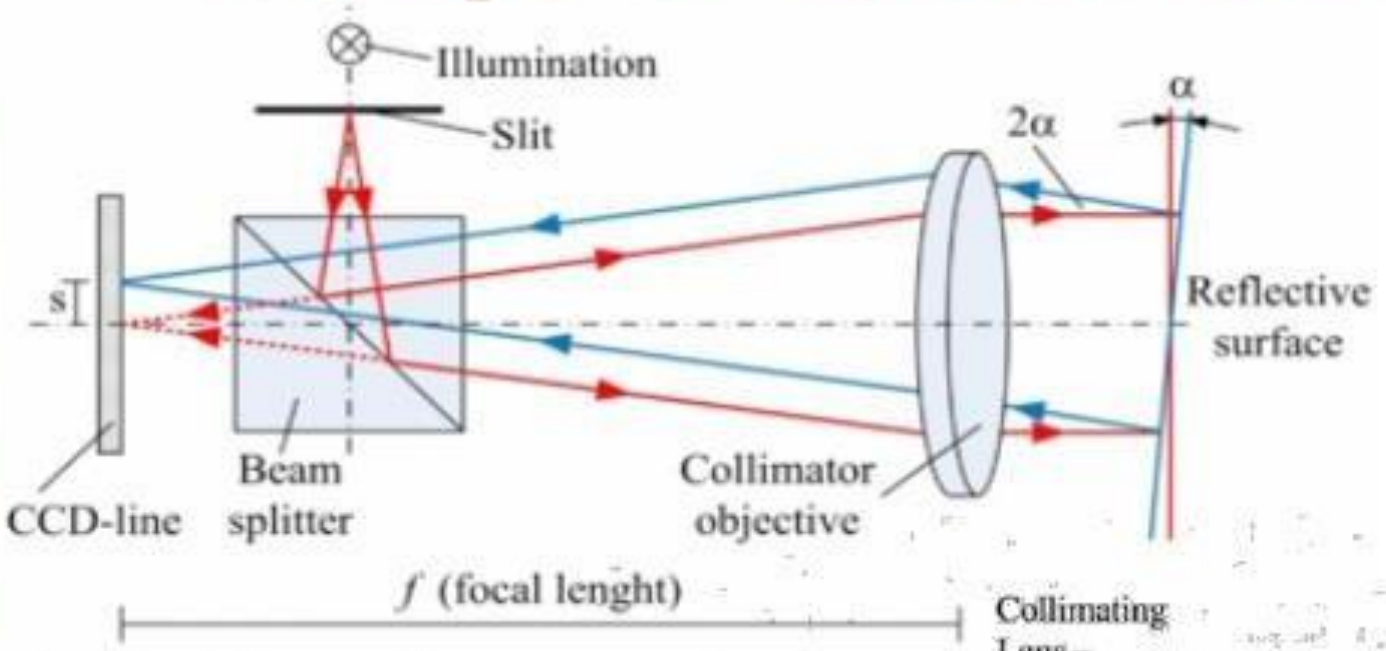
- A Spirit Level is used for ascertaining If the table is properly level.
- The Table is leveled by placing the level on the board in two positions at right angles and getting the bubble central in both positions.



Straight Edge

- A **straightedge** is a tool with an edge free from curves, or straight, used for transcribing straight lines, or checking the straightness of lines. If it has equally spaced markings along its length it is usually called a ruler.
- Straightedges are used in the automotive service and machining industry to check the flatness of machined mating surfaces.
- True straightness can in some cases be checked by using a laser line level as an optical straightedge: it can illuminate an accurately straight line on a flat surface such as the edge of a plank or shelf.

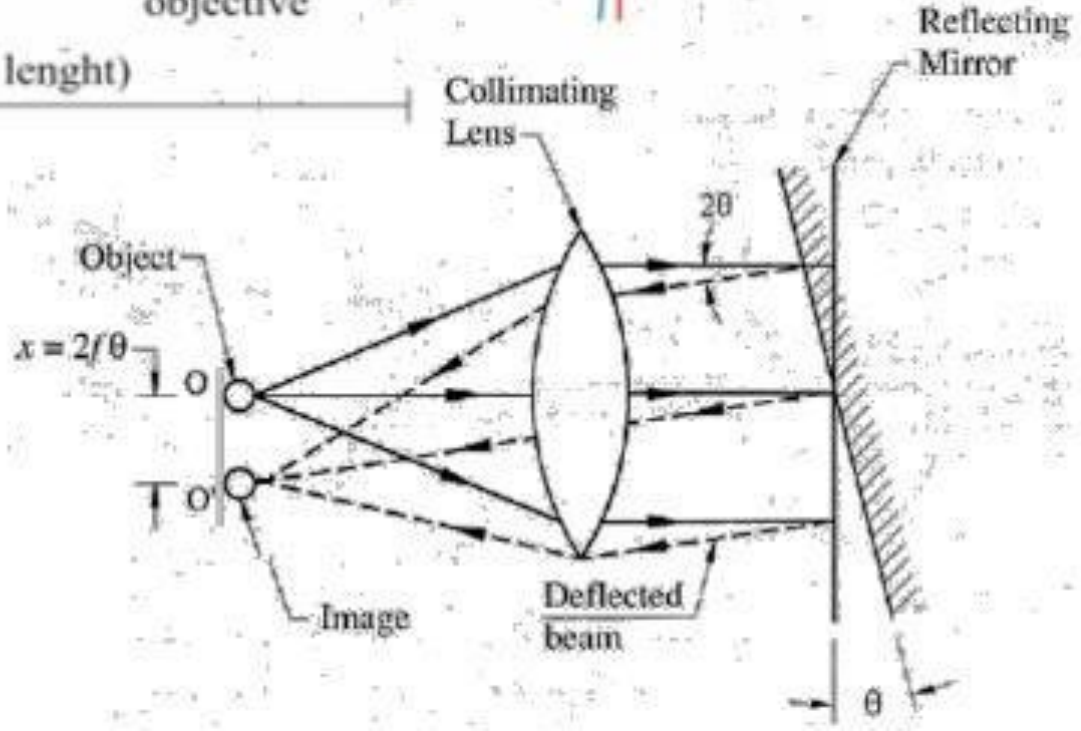
Principle of AutoCollimator



The two main principles used in an autocollimator are

(a) the projection and the refraction of a parallel beam of light by a lens, and

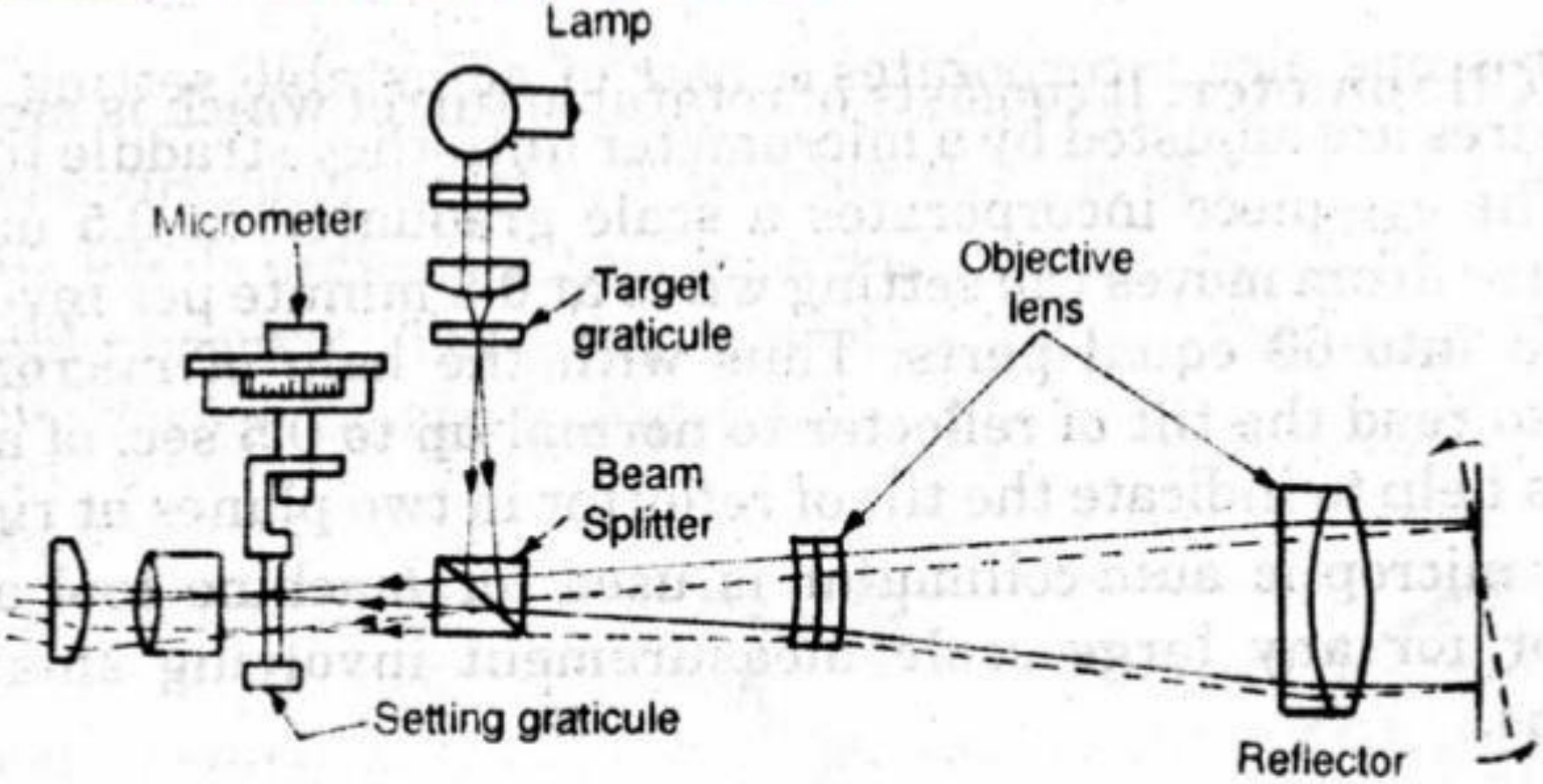
(b) the change in direction of a reflected angle on a plane reflecting surface with change in angle of incidence.



DEFINITION

- Auto-collimator is an optical instrument used for the measurement of small angular differences.
- For small angular measurements it provides a very sensitive and accurate approach.
- It is essentially an infinity telescope and a collimator combined into one instrument.

AutoCollimator



Optical return path reflector square

Optical return path reflector tilted

Line diagram of an injected graticule autocollimator

AutoCollimator

Applications:

1. Checking of an internal right angle.
2. Comparative measurement using master angles.
3. Measuring straightness and flatness of the surfaces.
4. Assessment of squareness and parallelism of component.
5. For machine tool adjustment setting.

3.2 RECALIBRATION OF MEASURING INSTRUMENTS

Generally the measuring instruments are worn-out after repetition of use. Hence, they start giving errors in measurements. Then, they need recalibration.

The activity which is performed to check, maintain and regain the accuracy level of the measuring instruments after a fixed interval of use is termed as recalibration.

The main objectives of recalibration are as follow:

1. To maintain the accuracy.
2. If there is any error, then make again the instrument error free.

3.2.1 Procedure for Recalibration of Vernier Calipers, Micrometers

Check before Recalibration:

1. Check scale ends are worn round or unsquare before using.
2. Damages of Jaws.
3. Digits printed on the measuring parts.
4. Looseness/play in faces.
5. Error in scale.
6. Chips or dirt present at the Jaws/anvil etc.

Recalibration:

1. Remove the calipers magnetism effect by placing a rag on a demagnetizer and run calipers over it.
2. Wash or clean the Jaws properly.

Testing Methods of machines

- Geometrical test or alignment test.
- Performance test or practical test.
- Testing under load.
- Idle-run test.
- Vibration resistance test.
- Noise resistance test.

Geometrical test or Alignment Test

This test consists of checking the relationship between various elements.

- Straightness of guide ways and slide ways
- Flatness of machine tables and slide ways.
- Parallelism of slide ways.
- True running and alignment of shafts and spindles.
- Pitch error of lead screw.
- Pitch error of gears.
- Eccentricity, out of roundness etc.

Performance test or Practical test

- It is for checking the accuracy of work done on machine.

Testing under load

- Testing under load is carried out tot find out the performance of machine under load. This testing is very important as it reveals the actual operation of machine.

Idle run test

- Carried out on no load.

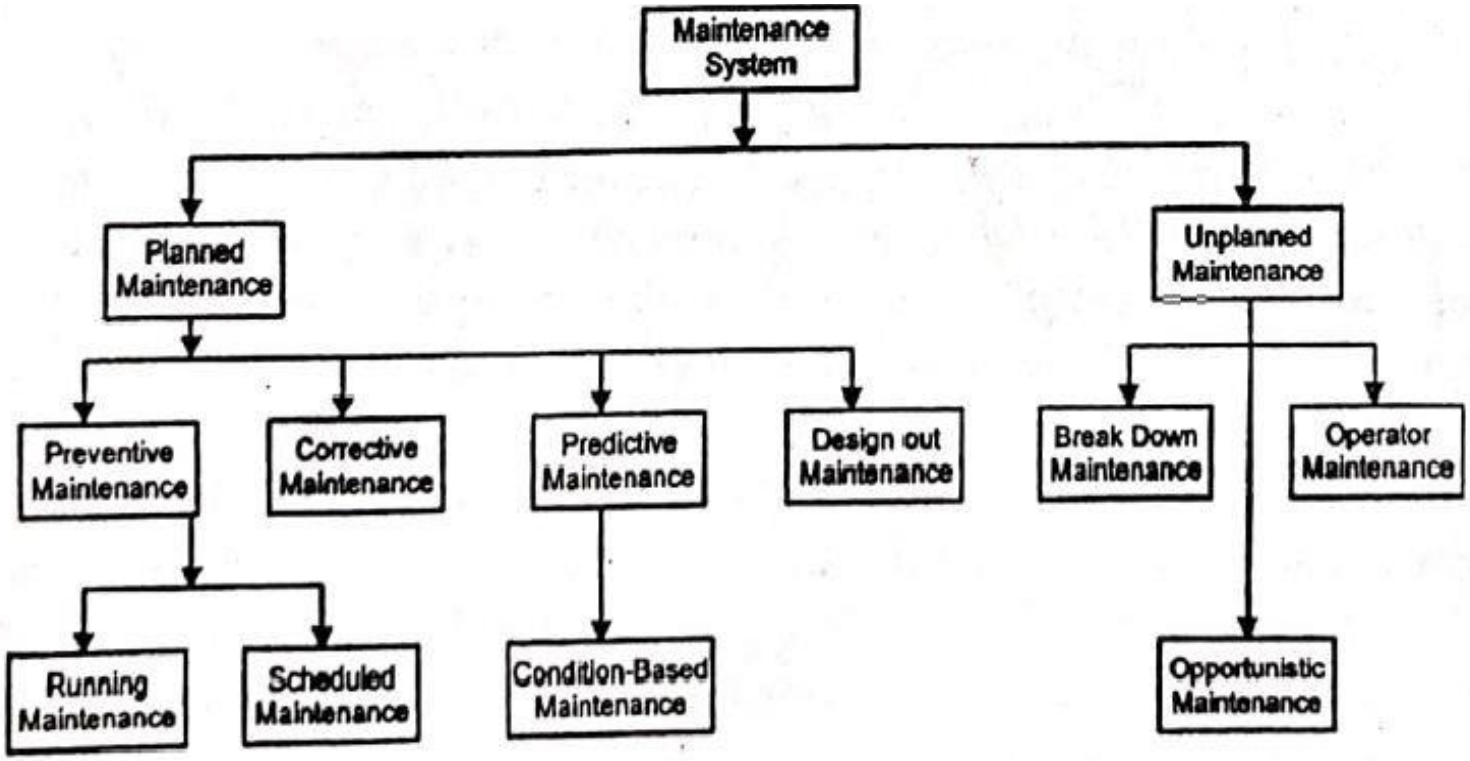
Vibration resistance test

- The objective of vibration resistance test is to develop such methods which reduce the vibrations in the machines. This test is carried out on definite test samples.

Unit 5
Maintenance

Definition of Maintenance

- It is a combination of various actions to be performed to keep fit an item for its proper functioning.
- Combination of actions carried out to replace, repair, service or modify the components or some identifiable grouping of components in a manufacturing plant so that it will continue to operate at a specified availability for a specified time.


Maintenance System
Planned Maintenance
Unplanned Maintenance
Preventive Maintenance
Corrective Maintenance
Predictive Maintenance
Design out Maintenance
Break Down Maintenance
Operator Maintenance
Running Maintenance
Scheduled Maintenance
Condition-Based Maintenance
Opportunistic Maintenance

4.12 COMPUTERISATION OF MAINTENANCE

Huge volume of data is absolutely no problem for modern computers. The large numbers of manual performas can be eliminated and total data can be stored centrally and safely taking a small space in a computer. The total data can also be duplicated easily and stored separately on Floppies/CD's or spare hard disc so that in case the data in computer gets accidently erased or affected by virus, it can again be copied easily. Retrieving any part of data does not take any time. Computerisation, again, is the only answer for problems like shortage of any manpower, duplication of work by various agencies and inter-department and intra-department communication etc. Integrated Computerised system can be developed so that data or informations can be shared by different departments regularly (by on-line or off-line systems) for decisions making. However, initial feeding of data to the computer system is time consuming and may become monotonous for repetitive jobs which is taken care in suitable software by press of a button.

4.13 MACHINE HISTORY CARD

The history of machine starts right from its purchase. After purchasing the machine, all the procedures of installation, operation and testing are carried out. *A document is prepared to record all the above which is called machine history card.* The following informations are recorded in the machine history card:

1. Name of machine.
2. Bed number of machine.
3. Source of supply.
4. Place of installation of machine.
5. Date of installation of machine.
6. Cost of machine.
7. Expected life span of machine in years.
8. Specifications of machine.
9. Date of last inspection.

4.14 PURPOSES AND ADVANTAGES OF MACHINE HISTORY CARD

The followings are the purposes and advantages of machine history card:

1. All the informations relating to machine right from its purchase till its installation can be known.
2. Current condition of machine can be known and then it becomes easy to take necessary action.
3. The production capacity of the machine can be evaluated.
4. Repairing/complete overhauling of machine becomes easy.
5. The decision of replacement/upgradation of machine can be taken.
6. The decision to purchase machines of new technology can be taken.
7. The decision to use old machines or to declare them unserviceable can be taken.
8. The decision to replace obsolete machine can be taken.

4.15 PREVENTIVE MAINTENANCE SCHEDULES

Annual maintenance schedules are prepared for maintaining equipments under preventive maintenance schedules (PM-schedules). Preventive maintenance schedules are prepared on specified performas on the basis of important data. The important data which is collected is as follows:

1. Name of machine/equipment.
2. Model/Make of machine/equipment.
3. Index of repair complexity.
4. Serial of repair cycle.
5. Time period between two constructive maintenance stages of repair (on the basis of shift).
6. Location of oil tank in machine/ equipment.
7. Grade of lubricant to be used in machine/equipment.
8. Quantity of lubricant.
9. Time interval for replacing the lubricant (on the basis of shift).

4.17 MEAN TIME BETWEEN FAILURES (MTBF)

MTBF is referred to as the average time of satisfactory operation of the system. Larger the MTBF, higher is the reliability of the system. It is applicable to repairable systems and is expressed in hours e.g. If an item fails 8 times over a period of 40,000 hours of operation the MTBF would be 500 hrs. During the operating period, the failure rate is fairly constant MTBF is the reciprocal of the constant failure rate or the ratio of test time to number of failures.

4.18 MEAN TIME TO FAILURE (MTTF)

This is applicable to non-repair systems. The mean time to failure is expressed as the average time an item is expected to function before failure. If we have the life test information on 'n' items with failure times t_1, t_2.....t_n, then the mean time to failure is defined as

$$\text{MTTF} = \frac{1}{n}\sum_{i=1}^{n} ti$$

4.21 SPARE PARTS MANAGEMENT

Production machines and other equipments worth crores of rupees remain idle for want of spares, while on the other hand huge stores lying which perhaps may not be used at all. This emphasize the need for paying more attention on management of spares. Improvements in capacity utilisation, cost reduction, and reliability can be achieved by better spare parts management. Studies have indicated that 40% of the tool working capital tied in spares inventory and out of this about 25% is obsolete in terms of value.

4.22 OBJECTIVES OF SPARE PARTS MANAGEMENT

The objective of spare parts management is to:

1. Provide right quality of parts
2. Provide parts at right time
3. Provide parts in right quantity
4. Provide parts at right cost.

4.23 SPARE PART

A spare part can be defined as *part identical to the part of a machine which needs replacement due to wear and tear during the operating life of equipment.*

4.24 SPARE PARTS PLANNING

The main aim of spare parts planning is to obtain optimum results *i.e.* maximum availability with minimum total cost. Spare parts requirement and its purchase must be planned in a systematic way based on the factors described here, so that inventory is not blocked more than that desired to meet the required service level.

4.27 CLASSIFICATION OF SPARES

Spare parts are generally classified as:

1. Maintenance spares
2. Rotable spares
3. Insurance spares
4. Overhauling spares

1. **Maintenance Spares:** The maintenance spares are those which are consumed regularly like belt, bearing, oil seals etc.
2. **Rotable Spares:** Costly parts like, engine, pump and motors etc. are not usually scrapped. When become defective then they are changed in the equipment and removed one is overhauled and kept as reserve for replacement in future. This rotation process gives the name as rotable spares.
3. **Insurance Spares:** These spares are generally vital parts, which are normally not required to be changed as it has life equal or more than that of the equipment/machine itself. But to cater for emergency failures, one standby is required to be kept.
4. **Overhauling Spares:** These spares are required to carry out regular overhauls of the equipment, in order to given a new lease of life to it.

4.28 PROCUREMENT OF SPARES

Following are the main parameters of purchasing:

1. **Right Time:** The procurement action should be taken at such time so that part is reached before it is actually required. The time can be decided after considering the total lead time.
2. **Right Price:** Price should be lowest acceptable for a fixed quality.
3. **Right Quantity:** This should be decided by using the concept of Economic Order Quantity. It may vary for each category of spares such as maintenance, insurance, overhaul or rotable spares.
4. **Right Source:** While deciding a source for obtaining the spare parts, important factors to be considered are, timely supply, reliability, service facilities, price etc. The source may be out of the following main sources :
   (*a*) Authorised dealer's of manufacturer of original equipment.
   (*b*) Local dealer holding genuine spare parts.
   (c) By manufacturing or reconditioning in own workshop.

Unit 5

Repairing

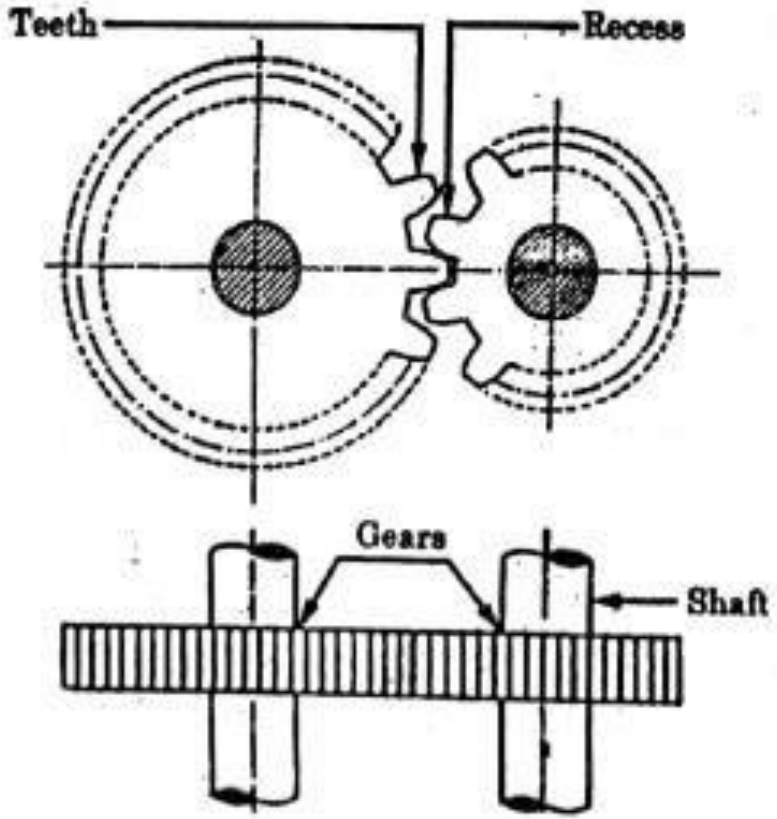
5.1 COMMON PARTS WHICH ARE PRONE TO FAILURE, THEIR REASONS OF FAILURE AND REMEDIAL MEASURES

Every equipment / machine has number of parts and every part has a particular life. After completion of its life generally it fails down. But, by proper maintenance or remedial measures the life of parts can be enhanced. Here, we are taken only few parts which frequently fails down and these are as follows:

1. Gears
2. Seals, Packing and Gaskets
3. Bearings
4. Keys
5. Chains
6. Clutches
7. Machine spindles etc.

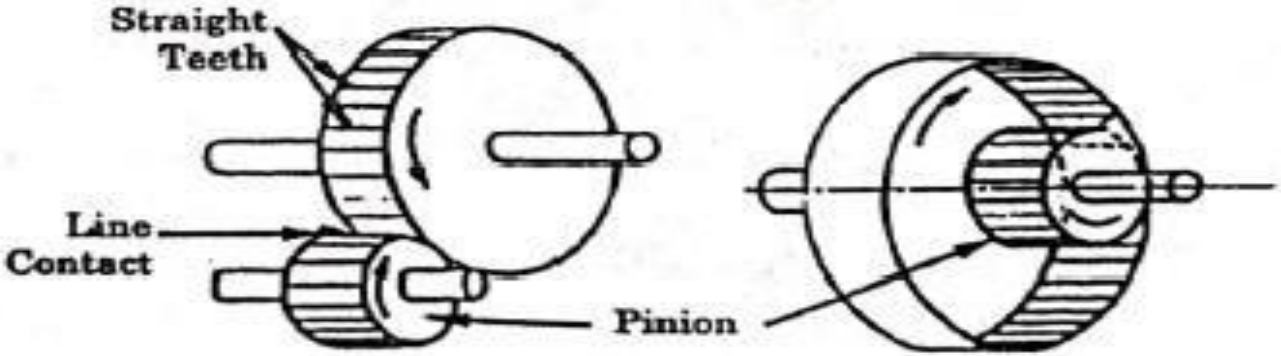
5.1.1 Gears

A gear may be defined as a *toothed element which is used for transmitting rotary motion from one shaft to another.*



The gears can be classified as:

1. **According to the Position of axes of the shafts**
   - (*i*) Parallel
   - (*ii*) Intersecting
   - (*iii*) Non-parallel and non-intersecting
2. **According to the Peripheral Velocity of the gears**
   - (*i*) Low velocity gears
   - (*ii*) Medium Velocity gears
   - (*iii*) High velocity gears
3. **According to the position of teeth on the wheel**
   - (*i*) Straight
   - (*ii*) Inclined
   - (*iii*) Curved
4. **According to type of gearing**
   - (*i*) External gear
   - (*ii*) Internal gear
   - (*iii*) Rack and Pinion



External Gear (a)

Internal Gear (b)

Causes of Failures of Gears:

The causes of failures of gears are given below:

1. If the meshing of two gears are not proper.
2. If the material used for gears is not useful.
3. If the gear ratio is not proper.
4. If gears are weak to take sufficient load.
5. If the teeths of gears worn out.
6. Present of, dirts burres present on the surface of teeth.
7. If the error is present in the pitch of gears.
8. Due to absence of lubrication.
9. If mounting of gears on the shafts is not proper.

Remedial Measures of Gears:

1. Use proper lubricants for lubrication.
2. Clean the surfaces of gears.
3. Select the proper materials for gears.
4. Use the right size of gears.

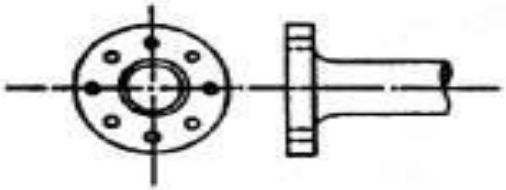
Seal, Packing and Gaskets

Seal is used to stop or minimise leakages of fluids. Packing and gaskets are also used for the same purpose. The Packings are used in the case of dynamic clearance while the gaskets are used to seal the static clearance. A few of the wide applications of packings or gaskets may here be mentioned.

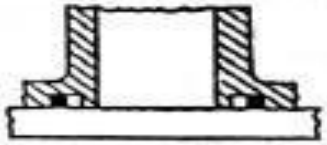
1. Piston ring in steam engines.
2. Gasket below the cylinder head of an I.C. engine etc.
3. Gland packing on reciprocating shaft of pumps.

The seals, may be classified, considering their nature of performance, on the basic shape of the surface (cylindrical, spherical etc) or on the type of motion (rotary, reciprocating etc). However a typical classification is given here:

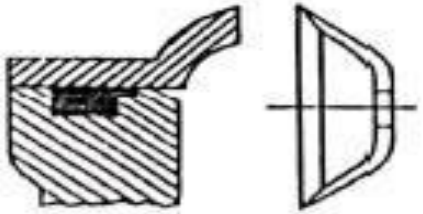
1. Static Seal (Gasket)
2. Dynamic Seal
3. Labyrinth Seals



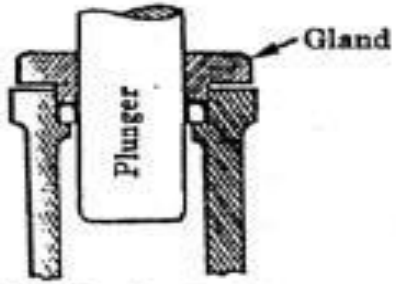
(*a*) Hand Cut Gasket



(*b*) O-ring Gasket



(*c*) Cut Gasket



(*d*) U-leather Packing

Causes of Failure:

Following are the causes of failure of seals, packing and gaskets.

1. Due to wear of seals.
2. Due to age of seals, packing or gaskets.
3. Due to over heating.
4. If the material is not proper.
5. If the fitting of gaskets are not proper.
6. If the thickness of seal, gaskets is less.
7. If not use at the suitable place.
8. Due to lack of lubrication.

Remedial Measures of Seal, Packing and Gaskets:

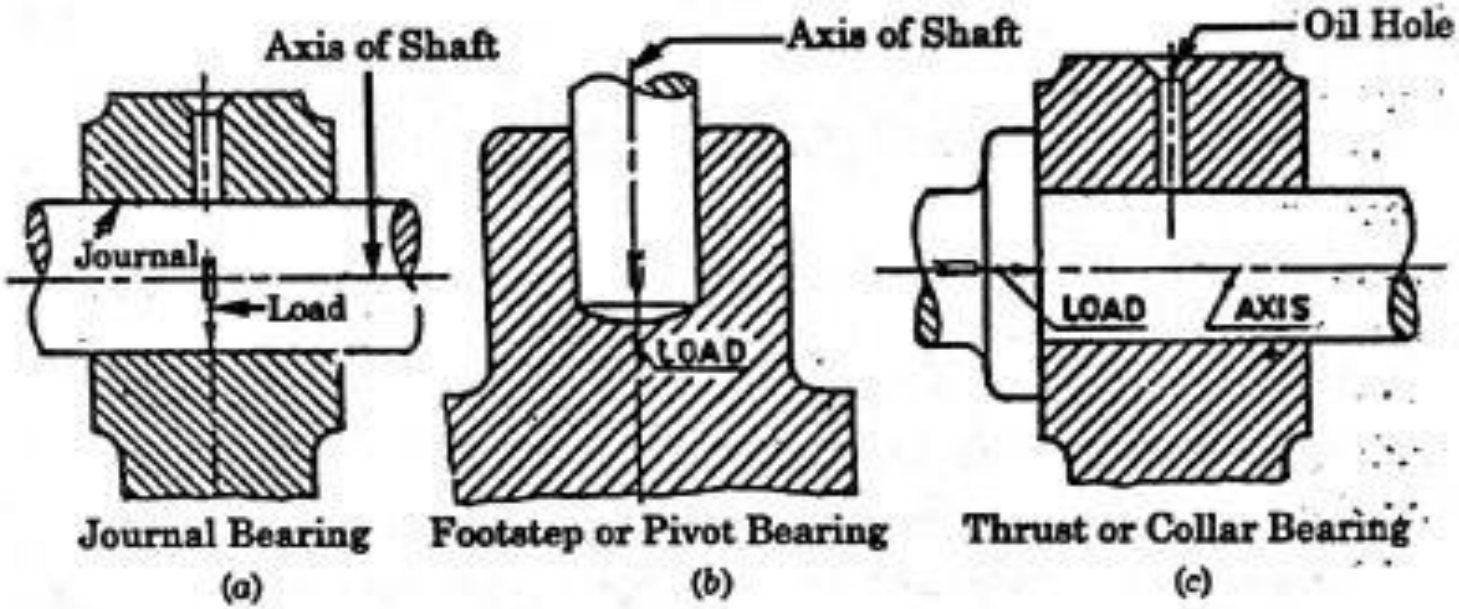
1. Avoid overheating and overload.
2. Material used should be of high quality.
3. Fit the seals or gaskets properly.
4. If feel the gasket is worn out, replace it.
5. Provide lubrication properly.
6. Use seal, gasket according to their use.

5.1.3 Bearings

Rotating shafts are supported on bearings. If a long shaft is supported only at two ends, it will deflect at its center due to its own weight. Hence, to have a long shaft straight and its running smooth, the shaft it supported at suitable intervals by

Bearings

1. **Journal Bearing:** In this type of bearing, the supporting pressure is perpendicular to the axis of shafts, fig. 5.4 (*a*).
2. **Pivot or Footstep Bearing:** In this type of bearing the bearing pressure is parallel to the axis of shaft or vertically upwards, Fig 5.4 (*b*). The end of shaft reset within the bearing body.
3. **Thrust or Collar Bearing:** In this type of bearing the bearing pressure is parallel to shaft axis and has end thrust. Shaft extends through and beyond bearing. Fig. 5.4(*c*).



Causes of Failure of Bearings:

1. Dirt is one of the main factor for bearing failure. It causes rupture and removal of lining while rubbing.
2. If the running time exceeds the alloy's capability, the bearing fail due to fatigue.
3. Due to hot shot phenomenon. This may be caused due to insufficient oil flow, dirt in the used oil or misalignment.
4. Due to fretting. Fretting occurs due to load concentration.
5. Due to overheating. Tight fit is responsible for overheating of bearings.
6. If lubrication between the bearing and shaft is not proper.

Remedial Measures of Bearings:

1. Clean the inner surface of bearing.
2. Grinding and Polishing the journal surfaces if necessary.
3. Maintenance of oil film thickness at desired level.
4. Do not run the shaft in the bearing for a very long time.
5. Temperature at the contact surface should not be allowed to rise more than the specified level.
6. Mating faces of the bearing assemble should be cleaned and made burr-free while installation.
7. Care should be taken during mounting specially regarding fit selection.
8. Provide proper lubrication to avoid lubrication.

Keys

Causes of Failure of Keys:

The main causes are as follows:

1. Due to overload.
2. Due to improper filling of key in keyways and key seat.
3. Due to improper material of key.
4. If the procedure of fitting of key is not proper.
5. If buns are present either on keys surface or on hub surface.
6. In case taper key, if the taper is not right.
7. If the size of key chosen is not proper.

Remedial Measures of Keys:

1. Choose the right size of keys.
2. Check physically the material of key, if there are some cracks present, Replace it before use.
3. Before using key, smooth down the outer surfaces of keys.
4. Select the right type of key according to use.
5. Use Proper method for fitting or disassemble the key.
6. Provide proper coating on the key surfaces to avoid corrosion.
7. Avoid overloading.
8. Replace the key when it looks like to be failed (According to preventive maintenance).

Chains

Causes of Chain Drive Failure:

The following are the main causes of chain drive failure:

1. If speed is more than 15 m/sec. Because chain drives is successful up to 15 m/sec.
2. If there is lack of lubrication.
3. If the links after chain are loose.
4. If the shafts are not parallel on which sprockets are mounted.
5. If the distance between sprockets and bearing is large.
6. If the chain is too much tight.

Remedial Measures of Chain Drive:

The following are the remedial actions for the successful working of chain drives:

1. Speed should not be increased more than 15 m/sec.
2. Proper lubrication of chain to restrict wear of bushes and pins.
3. Inspect the chain periodically by pulling it radially away from the larger sprocket.
4. Replace the worn out sprocket.
5. New chains should not be installed over a worn out sprocket.
6. Loose the chain, if it is too much tight.
7. Worn-out sprocket may sometimes be used refitting it in a reverse manner, if the wear is not too high.
8. Mount the sprocket near to the bearings.
9. Check and maintain the parallalism of the shafts on which sprockets are mounted.
10. Check the alignment about one mouth after the installation and then at a regular intervals of six months.

Clutches

Causes of failure of Friction Clutches:

1. Due to excessive wear of plates.
2. If cam surfaces are worn out.
3. In case of cone clutch, due to wear of cones.
4. Due to not proper lubrication.
5. If the size of coupling is small, in case of cone clutch.
6. Due to not proper use of discs.
7. If the flywheel is not mounted properly on the shaft.
8. Due to wear of sliding bush.
9. If the oil has creeped on to the roller surfaces in case of cylindrical friction clutch.
10. Due to not proper disengagement of driver and driven shaft.

Remedial Measures of Friction Clutches:

1. Clean the disks and friction lining properly.
2. Replace the worn out plates.
3. If the oil has creeped on to the roller surfaces then it is rectified by washing the clutch with kerosene.
4. If distortion of disks are too much they are to be replaced.
5. Check the condition of lubrication film.
6. For minor distortion grinding of plate may be done without disturbing the hardened surface layer (with in 0.24 mm). Deposition of weld and subsequent filing may also be done.

Belts

Causes of Belt Drive Failure: The main causes of best drive failures are:

1. If groove surfaces are worn-out in case of V-belt.
2. If belts are worn-out.
3. If speed is too much high.
4. If joints of belts are not proper.
5. If the selection of size of the belt is not right.
6. If the surface of belts is not clean.
7. If shafts on which pulleys are mounted are not aligned.
8. Improper lubrication of belts.
9. Improper mounting of belt in grooves in case of V-belt.
10. If the belt is not homogenous material wise.
11. If the belt is loose or too much tight.

Repair and Maintenance of Belts:

1. Replace worn out belts.
2. Preserve the belts from conditions injurious to rubber. These should not be operated close to radiators, furnaces, steam pipes or inside un-ventilated guards, where these may become over heated.
3. Check the drive for alignment.
4. Never use idler on the top side of a vee-belt.
5. Keep the belt grooves clean and in good condition.
6. New and old belts should not run together.
7. Slippage if any in the drive, should be checked periodically to ensure the transmission of rated load.
8. Extra load more than rated load on the belt should be avoided.
9. Check the end joints of belt properly and repair also if necessary.
10. Choose the right procedure for installation of belt.
11. The belt drive may be made covered from the top and sides.

Coupling

Causes of Coupling Failure: Following are the main causes of coupling failure.

1. Due to defective materials used during construction.
2. Improper tolerance may also be the cause of failure.
3. Due to improper selection of coupling.
4. Due to improper alignment of shafts.
5. If the rotating speed is high.
6. Failure may also be caused due to improper lubrication.
7. If the distance between the shaft ends is very long.

Repair and Maintenance of Coupling:

1. Check physically the material of coupling.
2. Provide proper lubrication film.
3. Choose proper selection of coupling.
4. There should be not excessive looseness between the coupling hub and shaft.
5. Ambient conditions should be right.
6. The speed of rotating shafts should not be too high.

Threaded Fastener

Causes of failure of Threaded fasteners:

Some of the main causes of failure of threaded fasteners are:

1. Improper sizes of nuts and bolts.
2. Due to rust.
3. Due to different types of threads used for nuts and bolts.
4. Due to over-tightness.
5. If the threads of nuts and bolts are of different starts (single start, double start or multi-start).
6. If dust particles are present on the surfaces of nuts and bolts.
7. Due to high vibrations of machines/equipment.
8. Improper lubrication may also cause failure of fasteners.

Repair and Maintenance of Fasteners:

1. Provide proper lubrication film.
2. Clean the surfaces of the nuts and bolts.
3. Check the threads of nuts and bolts before wounding.
4. Use nuts and bolts with proper tightening.
5. Use spanners or wrench for opening of nuts of bolts.
6. Threads of nuts can be repaired by drilling and tapping operation.
7. Do proper coating over the surfaces to avoid corrosion.

Engines

2. **Small Repair – (S):**
   - (i) Dismental some minor units of the engine.
   - (ii) Clean all the dimental parts.
   - (iii) Prepare the list of defects.
   - (iv) Tighten all the loose nuts and bolts.
   - (v) Repair or replace the worn-out parts.
   - (vi) Check the lubrication oil and replace if necessary.
   - (vii) Clean the fins in case of air cooled or water jacket in case of water cooled engine.
   - (viii) Repair the leakages.
   - (ix) Replace the gaskets.
   - (x) Replace the worn-out beairngs.
3. **Medium Repair – (M):**
   - (i) Disassemble all the major units of engine.
   - (ii) Wash the each parts of dismental unit.
   - (iii) Repair or replace the piston.
   - (iv) Replace the piston rings.
   - (v) Replace the engine oil.
   - (vi) Repair the inner surface of the cylinder head.
   - (vii) Tighten all the fasteners and replace the damaged one.
   - (viii) Polish all the unmachined surfaces.
   - (ix) Replace the damaged bearings.
4. **Complete Overhaul – (C):**
   - (i) Dismental all the parts of the engine.
   - (ii) Clean and wash all the parts of the engine.
   - (iii) Replace all the worn-out parts.
   - (iv) Check the condition of lubrication oil and replace it if necessary.
   - (v) Replace the connected rod if necessary.
   - (vi) Replace or repair crank pin or gudgeon pin.
   - (vii) Replace the piston rings.
   - (viii) Replace the valve timing gears and bearings.
   - (ix) Assembled all the parts.
   - (x) Check the performance of engine.

Boiler Repairs & Maintenance

(ii) Check the pressure gauges.
(iii) Check the working of water level indicator.
(iv) Check all the mountings and accessories properly.
(v) Check the working of feed pump.
(vi) Inspect the tubes and shell properly.
(vii) Check all the fasteners and replace if they worn-out or damaged.
(viii) Check the blockage of chimney.
(ix) Clean the combustion chamber.
(x) Prepare the list of defects.

2. **Small Repair – (S)**
(i) Dismental 2 to 3 units of boiler.
(ii) Clean all the parts of units.
(iii) Replace the old or damaged nuts and bolts.
(iv) Check the leakage in all in coming and outlet pipes.
(v) Wash and clean all the tubes thoroughly.
(vi) Check the quality of fuel used, if fuel not combustible, replace it.
(vii) Clean all the mountings and accessories.
(viii) Prepare the list of defects properly, so that they can be remedify in next stage.

3. **Medium Repair – (M):**
(i) Dismental all the major units of boiler.
(ii) Clean properly all the dismental parts with air and water blow.
(iii) Tighten all the loose fasteners.
(iv) Repair the sensitive mountings.
(v) Check the working of all the mounting and accessories according to the boiler act.
(vi) Replace all the damaged tubes.
(vii) Repair the shell if there is any type of leakage.
(ix) Paint all the unmachined surfaces.

4. **Complete Overhauling – (C)**
(i) Dismental all the parts of the boiler.
(ii) Wash all the parts throughly.
(iii) Replace all the damaged tubes.