Total productive maintenance

Objectives: At the end of this lesson you shall be able to
- **explain the concept of TPM**
- **state advantages of TPM**
- **explain the concept of OEE**
- **describe the components of OEE and their effects.**

Total Productive Maintenance(TPM) concepts

TPM aims to maximize overall equipment effectiveness. Establishes a complete system of productive maintenance for the machines/equipments entire lifespan is implemented by various departments. [Engineering, Operations, Maintenance, Quality and Administration]

TPM can be considered as the medical science of machines.

TPM involves every single employee, from top management to all the operators on the shop floor. TPM raises and implements productive maintenance based on autonomous small group activities.

TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipments.

The goal of TPM is to an extent increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity.

Downtime for maintenance is scheduled as a part of the manufacturing day. In some cases as an integral part of the production process.

The goal of TPM is to stop the emergency and unscheduled maintenance.

Form different teams to reduce defects and self maintenance.

Advantages of TPM

- Avoids wastage in quickly changing economic environment.
- Produces goods without reducing product quality.
- Reduces maintenance cost.
- Produces a low batch quantity at the earliest possible time.
- Ensures the non defective goods to the customers.
- Reduce customers complaints.
- Reduce accidents.
- Follow pollution control measures.
- Favourable change in the attitude of the operator.

Overall equipment effectiveness (OEE)

Overall equipment effectiveness (OEE) is a concept utilized in a lean manufacturing implementation. OEE is described as one such performance measurement tool that measures different types of production loses and indicate areas of process development. The OEE concept normally measures the effectiveness of a machine center or process line, but can be utilized in non-manufacturing operation also.

The high level formula for the lean manfacturing OEE is

OEE = Availability x Productivity x Quality

Availability

The availability is part of the above equation measures the percentage of time the machine/equipment of operation was running compared to the available time. For example if the machine was available to run 20 hours but was only run for 15, then the availability is 75 percent 15/20. The five hours when the machine didn't run would be set up time, breakdown or other downtime. The 4 hours the company did not plan to run the machine is rarely used in the calculation.

Performance

The performace part of the equation measures the running speed of the operation compared to its maximum capability often called the rated sppe. For example, if a machine produced 80 pieces per hour while running, but the capability of the machine is 100, then the performance is 80% (80/100). The concept can be used multiple ways depending on the capability number. For example, the machine might be capable of producing 100 pieces per hour with the perfect part, but only 85 on that particular order. When the capability of 100 is used for the calculation, the result is more a measure of facility OEE.

Quality

The third portion of the equation measures the number of good parts produced compared to the total number of parts made. For example if 100 parts are made and 95 of them are good, the quality is 95% (95/100).

Combining the above example into the OEE equation the OEE is

OEE = 75% x 80% x 95% = 57%

Autonomous Maintenance

Autonomous Maintenance put simply is the restoration and preventionof accelerated deterioration and has a major positive effect on OEE. It is a step by step improvement process, rather than production teams taking on maintenance tasks.

- Understanding the equipment functions and safety risks.

The seven steps of Autonomous Maintenance

1 Initial cleaning (Initial inspection & registration)	- Detect problem of the lives and restore the original state. - Start managing the line autonomously (5s, Minor stops, quality) autonomously - Create & perform temporary "cleaning/lubrication produces"
2 Source of contamination & Hard-to-reach areas	Solve "sources of contamination" and hard to reach clear (Cleaning, Inspection lubrication)
3 Standard of cleaning & lubrication	Develop tentaive standards for cleaning lubrication and inspection.
4 General Inspection	Provide training on their equipments, products and materials, inspection skills and other Am skills.
5 Autonomous Inspection	Develop a routine maintenance standard by operations.
6 Standadize autonomous maintenance operation	Standadize routine operation related to work place management such as quality inspection of products, life cycle of jigs, tools, set up operation and safety
7 Autonomous management	Autonomous team working.

Routine maintenance

Objectives: At the end of this lesson you shall be able to
- **state the need for routine maintenance**
- **describe the functions of routine maintenance**
- **state the advantages of routine maintenance.**

Routine Maintenance

- In order to get trouble free service from productive equipment.
- Following activities is necessary to carry out.
  - i Lubrication
  - ii Periodic inspection
  - iii Adjustments of various parts
  - iv Cleaning

All the above maintenance operations are carried out while the machine is running or during pre-planned shutdowns.

This type of maintenance may prevent breakdown of equipment.

Routine maintenance should not interfere with production schedules.

Planned preventive maintenance (PPM), more commonly referred to as simply planned maintenance (PM) or scheduled maintenance, is any variety of scheduled maintenance to an object or item of equipment. Specifically, planned maintenance is a scheduled service visit carried out by a competent and suitable agent, to ensure that an item of equipment is operating correctly and to therefore avoid any unscheduled breakdown and downtime.

Along with condition based maintenance planned maintenance comprises preventive maintenance, in which the maintenance event is preplanned, and all future maintenance is preprogrammed. Planned maintenance is created for every item separately according to manufacturers recommendation or legislation. Plans can be date-based, based on equipment running hours, or on the distance travelled by the vehicle. A good example of planned maintenance program is car maintenance, where time and distance determine fluid change requirements. A good example of condition based maintenance is the oil pressure warning light that provides notification that you should stop the vehicle because engine lubrication has stopped and failure will occur.

Planned maintenance has some advantages over condition-based maintenance (CBM), such as:

- Easier planning of maintenance and ordering spares.
- Costs are distributed more evenly.
- No initial costs for instruments used for supervision of equipment.

Disadvantages are:

- Less reliable than equipment with fault reporting associated with CBM.
- More expensive due to more frequent parts change.
- Requires training investment and on going labour costs.

Parts that have scheduled maintenance at fixed intervals, usually due to wear out or a fixed shelf life, are sometimes known as time-change interval or TCI items.

Maintenance schedule

Objective: At the end of this lesson you shall be able to
- **describe the normal procedure followed in machine tool maintenance in shop floor.**

Any kind of action or activity there should be some procedure and sequence likewise maintenance also has some normal procedure to execute the maintenance activity without any confusion. If maintenance is not followed any procedure there will be time loss and the machine and equipment could not be ready in time. The procedure guides the maintenance people how to start, execute, where to inpect and how to complete the maintenance in time. The maintenance is carried out with the following procedure.

- Initial cleanup
- Identification of fault
- Dismantling
- Inspection
- Identification of cause for defect
- Inspection and replacement/ Repair of spares
- Reassembling
- Trial run
- Inspection with standards
- Maintaining records

Initial cleanup

Main machine, connected accessories, lubrication system, panels and adjacent parts are to be cleaned first.

Identification of fault

The fault of the machine is to be identified by visual inspection and getting information from the complaint and justified the same.

Dismantling

The fault area is dismantled with the referring to the manual and all the spares are kept seperate in a tray and preserved safely.

Inspection

All the dismantled parts such as gear, bearing, shaft, key, etc. are cleaned and inspected for any damages. Any damages/breakage is recorded in the maintenance checklist.

Identification of cause for defect

The defect in spare parts thoroughly examined and analysed the causes for damage and the same has to be rectified.

Inspection and replacement/ repair of spares

The damaged or broken spares are procured from stores/ repaired and the same is inspected to the standards.

Reassembling

The next course of action is assembling the parts in reverse manner of dismantling order.

Trial run

After completion of assembling the machine is to run first manually and all the lubrication, electrical connection to be given. Finally the machine should run on is trial run for some time and observed for any unusual sound from the machine.

Inspection with standards

The machine is finally checked/inspected for geometry accuracy safety hazards etc., according to the manufacturer standard any other recommended standard as required by the nature of maintenance work carried.

Maintaining records

All the activities related to fault attended, spares changed, etc. to be recorded in the inspection report/maintenance record, machine history cards suitably for future reference.

Retrieval data from machine manuals:

Information Retrieval (IR) in computing and information science is the process of information system resources that are relevant to an information need from a collection of those resources. Automated Information retrieval systems are used to reduce what has been called information overload.

"Classification tasks that are well suited to machine learning" in many cases, tasks that untill recently had to be accomplished manually install. Learning algorithms use examples, attributes and values, which information retrieval systems can supply in abundance.

Preventive maintenance

Objectives: At the end of this lesson you shall be able to
- **state the need for preventive maintenance**
- **describe the functions of the P M department**
- **state the advantages of P M**
- **state the advantages of maintenance records and periodic inspection of machines.**

Need for Preventive maintenance

The machine tools are of high precision, and are sensitive and expensive.

They must be handled and maintained carefully in order to give good and long service.

The basic function of the maintenance department is the upkeep of the machines and equipment in good operating condition.

Earlier the maintenance of the equipment used to receive attention only when the equipment suffered some set-back or breakdown as a result of some minor/major fault. Such breakdowns not only brought a serious production hold-up but also used to upset the production flow of the industry where the other equipment also had to stand idle. This resulted in a more cautious approach to the maintenance of the equipment and this brought up the more scientific way of tackling the maintenance problem, through preventive maintenance. (P M)

Preventive maintenance

Preventive maintenance consists of a few engineering activities which help to maintain the machine tools in good working order.

The basic activities of preventive maintenance are the:

- Periodic inspection of machines and equipment to uncover conditions leading to production breakdowns or harmful depreciation
- Upkeep of machines and equipment to avoid such conditions or to adjust, repair or replace them while they are still in the initial stages.

Advantages of preventive maintenance system

- Less down time in production.
- Improves quantity and quality of product.
- Standby equipment is not needed which saves capital investment.
- Lower unit cost of manufacture.
- Reduces major and repetitive repairs of machines.
- P.M. helps in prolonging the life of the machines and reduction in un-expected breakdowns.

Functions of preventive maintenance department

- Periodic inspection of machines and equipment as per the 'Check- lists'. (Annexure I)
- Lubrication of machines and equipment as per the manufacturer's instruction manuals.
- Servicing and overhauling of machine and equipment as per the P M schedule.
- Keeping basic records of each machine and equipment. (Annexure II)
- Analysis of inspection reports and systematic review of reports of machines and equipment.

Periodic inspection of machines and equipment as per the check-list

The check-list items for the inspector about all the points to be checked on individual machines. While preparing the check-list of the machine, make sure that no machine part or item that is omitted needs attention. The inspection of machine tools like lathe and drilling machine includes the following.

- Driving system and feeding system
- Lubricating and coolant system
- Slides and wedges and gibs
- Belts, bearings, clutch, brake and operating controls
- Guideways, lead screws and their mating parts

After inspection of each machine, the inspector has to make out the list of parts which need repairs or spares for replacement.

Frequency of inspection

The frequency of inspection depends on the age, kind of machine and its operating conditions. Frequent inspection of machines and equipment may be expensive and frequency with long intervals may result in more breakdowns. A good balance is needed to bring optimum savings.

Lubrication of machines and equipment

The length of time a machine will retain its accuracy and give satisfactory service depends on the lubrication and care it receives. It is essential that lubrication of machines should be carried out systematically at regular intervals as recommended in the service manual supplied by the machine manufacturer.

The manufacturer's manual contains all the necessary details like grade of oil, grease, oiling and greasing points and also indicates the time intervals of lubrication.

Maintenance records (Annexure III)

Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyses Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyses the cause of a fault and rectification.

Maintenance records analysis

Systematic review and regular analysis of the equipment records will help to:

- Re-design the weak part which gives repetitive trouble
- Substitute with better material for high cost items
- Minimise frequent breakdowns
- Reduce the cost of production.

Preventive Maintenance Programme

Name of the Machine :

Location of the machine :

Machine Number :

Model No. & Make :

Annexure I

CHECK-LIST FOR MACHINE INSPECTION

Inspect the following items and tick in the appropriate column and list the remedial measures for the defective items.

Items to be checked	Good working/satisfactory	Defective	Remedial measures
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all feeds			
Lubrication system			
Coolant system			
Carriage & its travel			
Cross-slide & its movement			
Compound slide & its travel			
Tailstock's parallel movement			
Electrical controls			
Safety guards			

Inspected by

Signature

Name :

Date :

Signature of in-charge

EQUIPMENT RECORD **Annexure II**

History sheet of machinery & equipment

Description of equipment:	
Manufacturers' address:	
Supplier's address:	
Order No. and date:	
Date on which received:	
Date on which installed and placed:	
Date of commissioning:	
Size: Length X Width X Height	
Weight:	
Cost:	
Motor particulars:	Watts: r.p.m: Phase: Volts
Bearings/Spares record:	
Belt specification:	
Lubrication details:	
Major repairs and overhauls carried out with dates.	

Annexure III

MAINTENANCE RECORDS

Sl.No	Name of the machine	Nature of fault rectified	Date	Signature of in-charge

Difference between breakdown maintenance and preventive maintenance

Sl.No.	Breakdown Maintenance	Preventive Maintenance
1	Maintenance is undertaken only after breakdown	Maintenance is undertaken only before breakdown
2	No attempt is made to prevent breakdown	Maintenance is made to prevent breakdown
3	This is unpredictable activity	Predictable activity
4	Maintenance cost less	Cost of maintenance is high
5	Not suitable for equipments like cranes, hoists, pressure vessels	Can be applied to all types of equipments
6	Results in production loss and more "Down time"	Such disadvantages are eliminated

Reactive Maintenance

The oldest maintenance approach is reactive. Equipment is not repaired or replaced until it breaks. In this maintenance equipment fails with little or no warning so this could be down until replacement parts arrive, resulting in income loss. In this maintenance cost and down time increased and also create safety issues. Reactive maintenance can be suitable in some situation such as for non critical and low cost equipment with little or no risk of capital loss or production loss.

Importance of breakdown maintenance and preventive maintenance in productivity

The importance of an effective maintenance program cannot be overlooked because it plays such an important role in the effectiveness of lean manufacturing. As in personal health care insurance, maintenance may be considered the health care of our manufacturing operation, business or service operation. The cost of routine maintenance is very small when its compared to the cost of a major breakdown at which time there is no production.

Purpose of maintenance

The importance use of routine maintenance is to ensure that all equipment required for production is operating at 100% efficiency at all times. Through short daily inspections, cleaning, lubricating and making small adjustment small problems can be detected and corrected before they become major problem that can shutdown a production line. A good maintenance program requires company wide participation and support by everyone ranging from the top executive to the shop floor personel.

Inspection, types of inspection and gadgets for inspection

Objectives: At the end of this lesson you shall be able to
- **retrieval of data from machine manual**
- **state the need of inspection**
- **state the function of inspection**
- **list out the type of inspection**
- **discuss the each type of inspection**
- **list out the gadgets used for inspection.**

Retrieval of data from machine manual

Manual is one of the integral and necessary literary part that the operator has to know before handling and operating the machine. It will be provided by true manufacturer along with the supply of the machine.

Manual furnish all information about the machine like size of the machine, foundation and errection method, safety procedure to be followed, operating procedure and periodical maintenance required.

The machine manual will also provide about the required power supply, safety precaution grade of lubrication oil to be used etc., availability of suitable spare parts and details of dealer/supplier has to be provided in the manual otherwise use of any other parts will not suit and the machine will get damaged.

We have to refer and follow manual if any problem/defects arises during operation of the machine.

The manual will also provide the brand and type of tools that can be used, time period/life of the tools to be replaced based on the usage and periodical inspection to be carried out.

In general manual to provide information right from starting of the machine, operating method of machine and stopping the machine, incase of emergency to stop the machine.

Inspection

Inspection is necessary for any machine/equipment where remarkable risk to health and safety may arise from wrong installation, re-installation or any other circumstances. The purpose of inspection is to find whether machine can be operated, adjusted and maintained safely. The need for inspection and inspection intervals to be determined through risk assessment.

The summary of inspection should be recorded and same should be kept atleast until the next inspection of that machine. Machine/equipment that required inspection should not be used unless the machine has been inspected.

If the machine/equipment obtained from any other source (eg. hired). One should be ensure that physical evidence of last inspection is accompanied with the machine, such as inspection report, some form of tagging, labelling system or colour coding.

Function of Inspection in maintenance

1 Periodic inspection of machines and equipments as per checklist (Annexure 1)

2 Keeping basic records of each machine & equipments.

3 Preparation of list which need for repairs (or) spare for replacements.

4 Analysis of inspection report and systematic review of reports of machines/equipments.

5 Assigning of frequency of inspection.

The following Annexure 1,2 and 3 are the formats used in maintenance inspection.

Annexure I

INSPECTION CHECK-LIST

Name of the machine : Location of the machine :

Machine No :

Model No :

Inspect the following items and tick in the appropriate column and list the measures for the defective items.

Item to be checked	Good working/Satisfactory/Status	Defective	Remedial measures
Availability of machine manual			
Safety guards			
Installation			
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all the feeds			
Lubrication system			
Coolant system			
Sliding part and its travel			
Safety and limit switches			
Electrical controls			
Proper lighting			
Emergency stop			
Alarm specialty			
Condition of work holding devices			
Condition of tool holding devices			
Condition of accessories and attachments			
Chip collection and disposal			

Conclusion of inspection

Recommendations

Inspected by

Signature

Name :

Date :

Signature of incharge

Annexure II

EQUIPMENT RECORD

History sheet of machinery & Equipment

Description of equipment	
Manufacturer's address	
Supplier's address	
Order No. and date	
Date on which received	
Date on which installed and placed	
Date of commissioning	
Size: Length x Width x Height	
Weight	
Cost	
Motor particulars	Watts/H.P./ r.p.m: Phase: Volts:
Bearings/spares/record	
Belt specification	
Lubrication details	
Major repairs and overhauls carried out with dates	

Maintenance - Installation, Maintenance and overhaul of machinery and engineering equipment

Objectives: At the end of this lesson you shall be able to
- **how to install the machinery in the new place**
- **what is the procedure followed installation of new machinery**
- **what are the types of maintenance activities followed in the newly installed machinery**
- **state the procedure for overhauling in a machinery.**

Installation means, it is the stage at which machinery is unpacked, reassembled, realigned connected to essential services and then tested exhaustively to ensure & works at peak operating efficiency when it finally goes into production.

General Procedure of Machine Installation: Installation procedure of a machine involves a series of activities are follows:

a Location and layout

- Once the location is finalized, the work of laying out the foundation plan is to be undertaken.
- Laying out means marking of the foundation plan. It may be done with the help of chalk on a concrete floor and by a string with a number of pegs.
- The general procedure is to indicate the outlines as per specification of the machine.
- The axis lines are to be drawn both longitudinally and crosswise to locate the center of foundation.
- Excavation of soil may be started only when the layout is completed as per the requirement.

b Positioning of machines;

- Equipment may have the weight of a few tons. But it is to be loaded or unloaded, to be moved vertically or horizontally to bring it at the site and to place it on the foundation as well.
- Different types of lifting devices like pulley blocks, chain hoists, and overhead cranes may be used as per the availability and requirement.
- When the load is light, rope pulley blocks are widely used and chain pulley blocks may be useful, but for a very heavy load, electric cranes are generally employed.
- However, the slinging should be done with much care to avoid any impact shock, to avoid formation of any scratches and breakages, etc.

c Foundation;

- The shapes and sizes of the foundation differ according to the type and size of the machines.
- They are also dependent on the property of the subsoil and the dynamic loads of the machine during operation.
- If the weight of the installed machine is not too much or if the dynamic loads are insignificant, the size of the foundation may be finalized on the basis of design considerations.
- But when the dynamic loads predominant, the foundation should also serve the purpose to protect the machine from external vibration and to lower down the frequency of natural vibration by increasing its total mass.

a Ground Condition

o The nature of soil is obviously a vital criterion. For a hard soil or for a normal soil, the construction of a concrete bed does not entangle too many complicacies. It is rather most straightforward to consider the foundation plan supplied by the manufacturer. But, for soft and loose soil, a large surface area with proper depth is needed for the foundation of a machine.

b Vibration Consideration

- To avoid transmission of vibration to adjoining parts of buildings or other foundations, it is necessary to provide a suitable isolation between the equipment foundation and the joining structure.
- Usually a gap is maintained all around the foundation, and is filled by sand to avoid such transmission of vibration. Any vibration isolating material, other than sand, such as rubber, lead sheet, felt etc. may also be used.
- As a rule, the equipment foundation shall not be allowed to serve as support for other structures or for machineries not related to the particular equipment.
- The impact type machines, like stamping press, drop and forging hammer, need special care during foundation. The depth of the foundation becomes very large to make the foundation heavy.

c Foundation Bolts

- To install the machineries, foundation bolts will be specified and supplied by the manufacturers. Some of the foundation bolts become rigid on pouring concrete and some may be removable and adjustable bolts.

Example: Eye foundation bolts, Rag bolt, Lewis bolt, Cotter bolt, Split end bolts

- The machine tool is placed on the foundation with the help of spacers or pads, leveling wedges, etc.

- Foundation plates are also supported similarly, for different machines etc. At this time, a gap (minimum 50 to 70mm) depending on the type of the machine is maintained between the top of the foundation block and the bottom of the machine or base plate.
- The foundation bolts are positioned before positioning the machine and the exact location of the machine is guided by the insertion of the projected foundation-bolt ends through the holes, provided at the machine footings or base plate.
- The bolt-ends should remain sufficiently projected to accommodate the washers and nuts as well.

d Leveling and alignment

- The leveling is performed with leveling wedges, shoes etc. as stated before.
- The horizontal and slight vertical movement of the heavy mass of machine is performed by pipes, rollers.
- Straight edge, spiral level, dial indicator etc., are generally useful instruments to level the machine.
- The leveling is to be checked in the both, longitudinal and transverse direction.
- When leveling is completed, the foundation bolt cavity along with the bolt may be made concreted. Pouring of cement concrete is generally made through the gap provided at the top of the foundation.

e Grouting

- Grouting is a procedure of connecting the machine with the foundation by a concrete mixture of plastic consistency or cement mortar. It is extensively used in installing most of the machines.
- Generally, quick setting cement is used to perform grouting. The top of the foundation block is made roughened, made moistened with water and wooden partitions are placed all around the machine.
- The heights of such wooden boards are kept much higher than the gap between the top or the foundation and the bottom of the machine.
- Quick setting cement is then poured within the boundary with care to eliminate any air gap within it.
- Once started, the pouring should be completed continuously and the machine must be felt undisturbed for a few days after grouting to provide it time to set.

f Fitting of other parts, accessories, piping etc.,

- When the machine is erected, the other accessories may be joined accordingly.
- But, while laying out the foundation plan, the overall requirement should be kept in mind.
- The auxiliary structures e.g. in case of a heavy duty diesel engine foundation, the structures for outer bearing pedestal, water pump blocks etc. should be planned at a time.
- This will minimize the problem of internal fittings.

g Final leveling and test runs

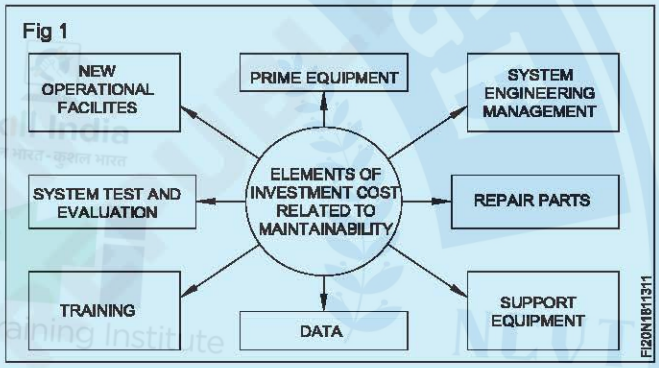
- Accurate leveling can be carried out only when the grouting has set in after a few days.
- The machine is to be made cleaned and leveled then. Such leveling involves minor adjustments.
- Whenever provided, the leveling screws and may be operated to achieve the final level. Everything should now be made ready to carry the test run. The style of testing will differ from machine to machine.
- The accuracy shown in the chart will be re obtained only if the machine is correctly erected and leveled.

Maintenance

Machine maintenance is the work that keeps mechanical assets running with minimal downtime. Machine maintenance can include regularly scheduled service, routine checks, and both scheduled and emergency repairs. It also includes replacement or realignment of parts that are worn, damaged, or misaligned. These Maintenance activities are explained in the following Fig 1.

How we can maintain the heavy machines and extend

Fig 1



their longevity.

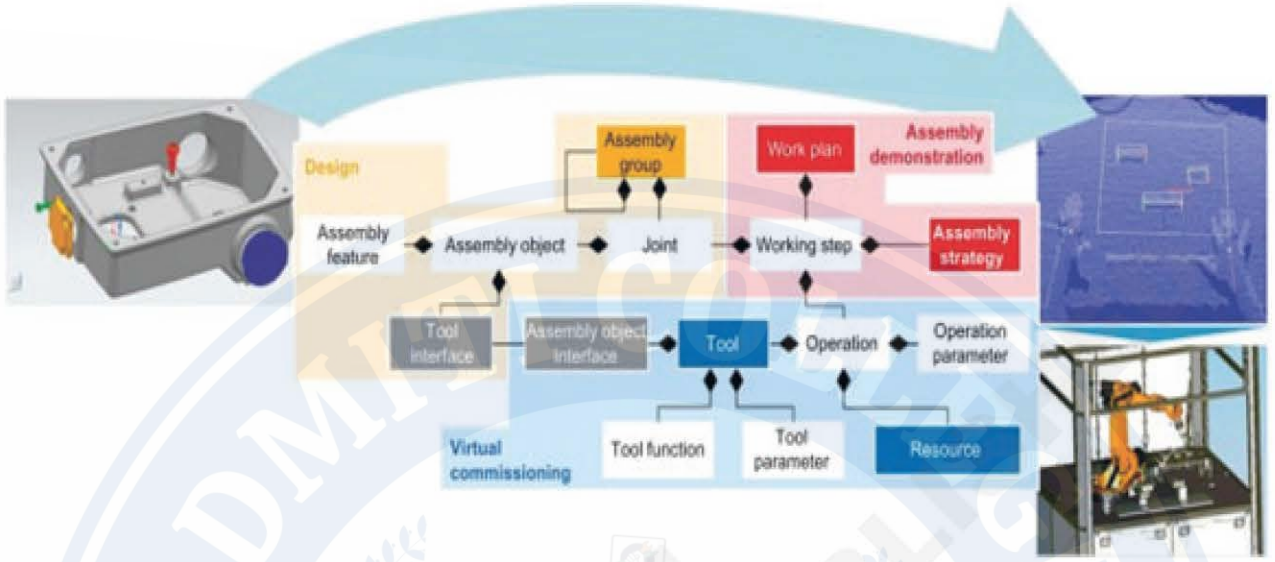
- Clean the Machines Thoroughly and ensure cleaning and lubricating of moving parts
- Check the Machinery for Wear and Tear.
- Ensure all moving parts working properly otherwise replaced.
- Ensure that all bolts and nuts including point machine mounting bolts are tight and split pins are opened properly, during every maintenance visit.
- Check that electrical wire connections inside the cable termination box and inside the machine are tight and the wiring is laced properly.
- Check the rodding connections for tightness and friction free movement. o Lubricate the slide chair plates frequently for smooth working of points.
- Ensure that the rodent entry points in the point machine and CTB etc. if any are properly plugged.
- Lubricate all moving parts with lubricating oil/grease as per manufacture's specifications.
- Avoid Exceeding Performance Specifications; train the operator to short out these problems.

- Document Your Preventive Maintenance and Servicing in Detail.

Over hauling

Overhaul maintenance (OM) is a comprehensive examination and restoration of a system, or a major part thereof, to an acceptable standard of performance. It could involve reconditioning, refitting, rebuilding, or total replacement of subassemblies of the system. The goal of overhauling is to keep the system in serviceable condition (Fig 3). Machinery overhaul is usually performed by companies offering maintenance services.

Fig 2



Overhauling usually involves the following stages:

Inspection: First of all, the machine will be thoroughly inspected. Experienced maintenance crews perform an inspection on the overhauled machine under production conditions. It means, the machine's performance is monitored while the machine is in use. Such a procedure allows allocating any issues and performing the troubleshooting more effectively.

Dismantle: After the initial inspection, the piece of equipment should be taken apart. Disassembly is crucial for further check and the next steps of the overhauling process, such as repair. A skilled maintenance worker is capable of putting the machine down efficiently, indicating which parts of the equipment needs to be replaced or repaired.

Repair: Depending on the issue, the machine is either repaired or certain damaged parts are replaced. This step once again proves how effective overhauling is as opposed to replacing the whole piece of equipment at once. Replacement of parts might take longer than a simple repair, as the spare parts might need to be ordered from a manufacturer.

Reassembly: Following the successful replacement of spare parts, reassembly of the whole mechanism is performed. Being one of the final steps, the reassembly is crucial for the functioning of the equipment. Certain skill is surely needed to perform reassembly, so it's best handled by professionals.

Testing: The final step that concludes the overhauling process. Without testing it is naturally impossible to identify if the performed repair was effective. During testing the retrofit is either proclaimed successful or less frequently the process goes back to the starting point.

Causes for assembly failures and remedies

Objectives: At the end of this lesson you shall be able to
- **state the poor assembly**
- **list out poor service conditions**
- **state the cost of operation.**

Poor assembling: Error in assembly can result due to various reasons such as ambiguous, insufficient or inappropriate assembly procedure, misalignment, poor workmanship. Sometimes, failures are also caused by the inadvertent error performed by the workers during the assembly. For example, failure of nut and stud assembly (used for holding the car wheel) by fatigue can occur owing to lack of information regarding sequence of tightening the nuts and torque to be used for tightening purpose; under such conditions any sort of loosening of nut which is subjected to external load will lead to fatigue failure.

Poor service conditions: Failure of an engineering component can occur due to abnormal service condition experienced by them for which they are not designed. These abnormal service conditions may appear in the form

of exposure of component to excessively high rate of loading, unfavorable oxidative, corrosive, erosive environment at high or low temperature conditions for which it has not been designed. The contribution of any abnormality in Service conditions on the failure can only be established after thorough investigation regarding compatibility of the design manufacturing (such as heat treatment) and material of the failed components with condition experienced by them during the service.

Weight of raw material: Calculate theoretically weight of material, calculate volume of material and multiply with density of material. It gives you exact weight of raw material required.

While calculating weight do not consider final dimension always consider plus size for machining and other operation.

Cost of operation: Decide each operation to be performed on flanges like Drilling, matchinig and boring. While selecting the process do take care of sequence of operation as it matters a lot on costing.

You need to allot time required for particular operation considering all factors of machine. On their basis of price of machine, depreciation and cost of electricity consumed you need to finalise cost of machine running per hour.

Now multiply time required for particular operation and machine running cost/hour

Tools Cost

- **Cost of Labour:** For each piece calculate total working time consumed and calculate total cost need to pay to labour.
- **Accidental/Risk/Rejection cost:** As manufacturing of flange is a manual process, there may be chances of rejection of material, so this cost should be considered.

The simple method is add 1 piece's rate if manufacturing 100 qty in bulk

- Packaging and handling cost: Generally 2% of basic cost
- Profit: Approx 5 to 15% to basic cost
- Admin and depreciation cost

Assembly techniques

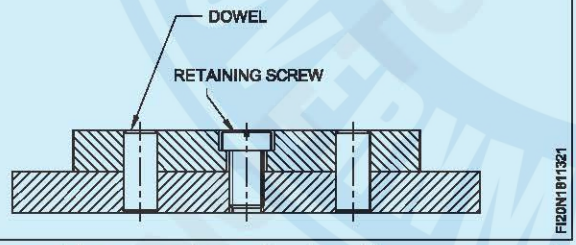
Objectives: At the end of this lesson you shall be able to
- **name the common techniques used for assembling components**
- **distinguish between the application of dowelling, pinning, staking, brazing and use of adhesives for assembling components.**

In machine shop assembly various methods are used for securing components together. A few of the common methods are:

- Dowelling
- Pinning
- Staking
- Brazing/Hard soldering
- Using of adhesives

Dowelling (Fig 1)

Fig 1



This is used for accurate positioning of two or more parts. This allows the parts to be separated and relocated in position. Different types of dowels are used depending on the type of assembly.

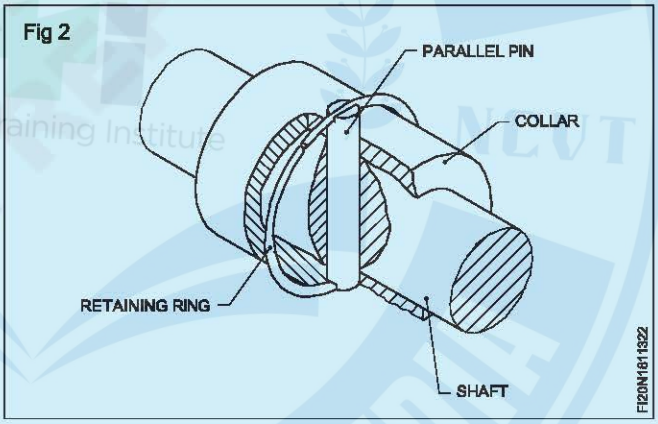
The components dowelled are always fixed with retaining screws in the assembly.

Pinning: This is also a method of locating and securing components together. Pins are of different types.

Parallel pins (Fig 2)

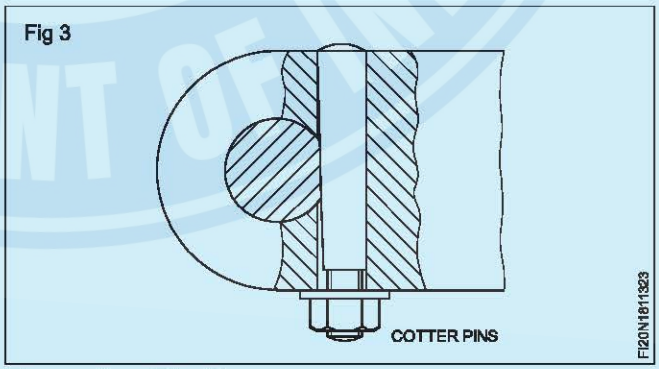
These are fitted like dowels in reamed holes and held in position by a retaining ring.

Fig 2



Cotter pins (Fig 3)

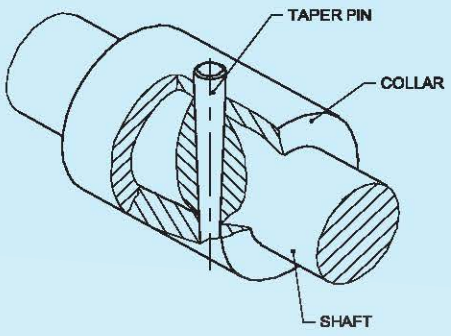
Fig 3



Taper pins (Fig 4)

Taper pins will position parts accurately. The component can be dismantled easily and assembled without any change in location.

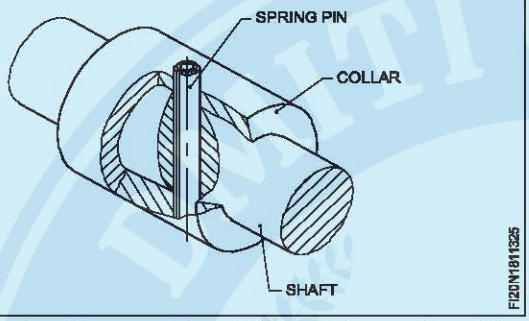
Fig 4



The holes for fitting taper pins are finished using taper pin reamers.

Spring pins (Fig 5)

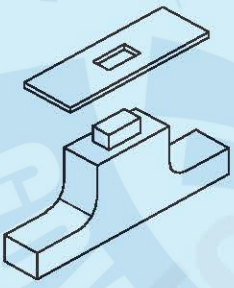
Fig 5



This eliminates the need for drilling and reaming of the assembly together. The spring pin adjusts itself in case of slight misalignment.

Peening (Fig 6)

Fig 6



When parts are to be assembled together this is one method of assembly. Basically this is similar to riveting.

Staking (Figs 7a, b & c)

This is a method of retaining parts in an assembly in which a portion or all of a component is forced to flow on the other component. This increases the efficiency of the fit.

Brazing and hard soldering (Fig 8a & b)

This is a process of joining metals by using layer of non-ferrous metal between the surface to be joined.

The alloy used for brazing is known as spelter (combination of copper and zinc)

Adhesives (Fig 9)

The adhesives commonly used are epoxy adhesives. This adhesive gives a strong bond between materials to be assembled. This is not affected by moderate moisture or heat. It is usually supplied in two containers/tubes. One is resin and the other is the hardener.

Fig 7

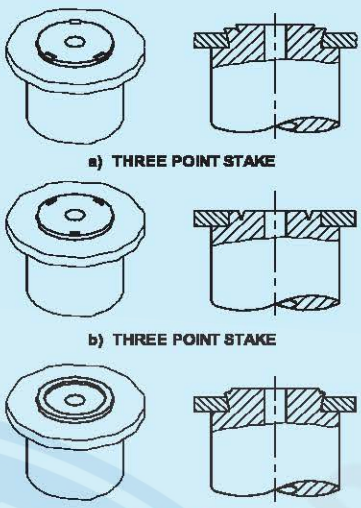


Fig 8

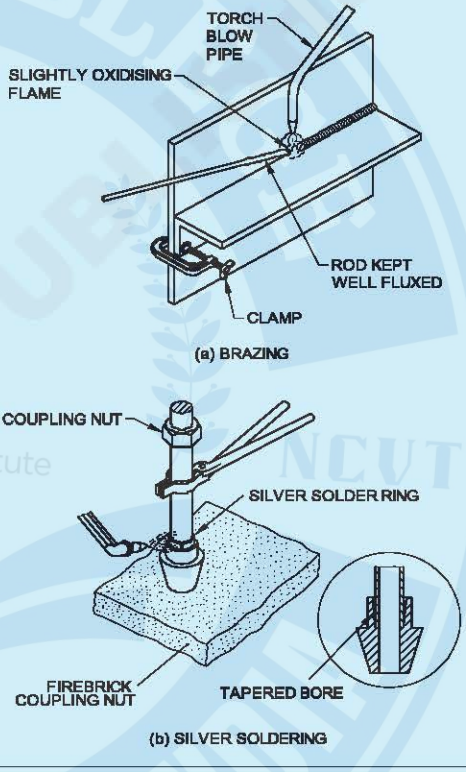
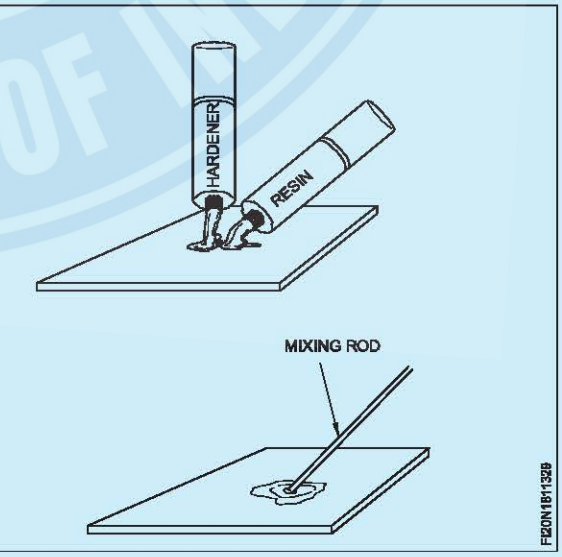


Fig 9



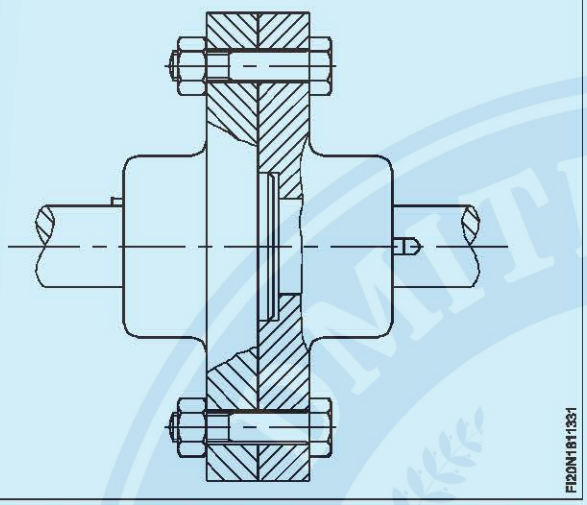
Threaded jointer

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

- **state the situations in which bolts and nuts are used**
- **state the advantages of using bolts and nuts**
- **identify the different types of bolts**
- **state the applications of the different types of bolts**
- **state the situations in which studs are used**
- **state the reason for having different pitches of threads on stud ends.**

Bolts and nuts (Fig 1)

Fig 1



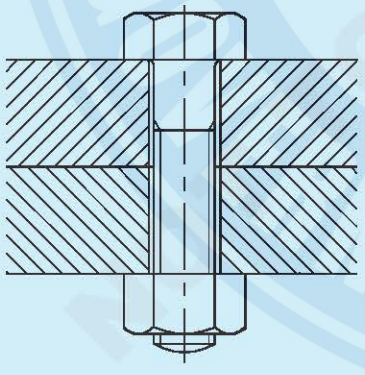
These are generally used to clamp two parts together.

When bolts and nuts are used, if the thread is stripped, a new bolt and nut can be used. But in the case of a screw directly fitted in the component, when threads are damaged, the component may need extensive repair or replacement.

Depending on the type of application, different types of bolts are used.

Bolts with clearance hole (Fig 2)

Fig 2

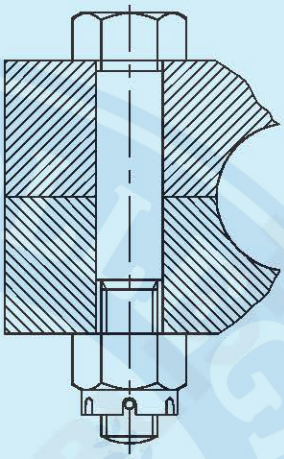


This is the most common type of fastening arrangement using bolts. The size of the hole is slightly larger than the bolt (clearance hole).

Slight misalignment in the matching hole will not affect the assembly.

Body fit bolt (Fig 3)

Fig 3



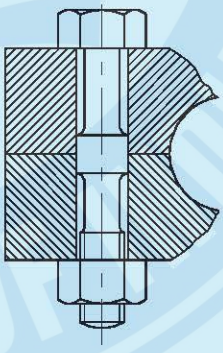
This type of bolt assembly is used when the relative movement between the workpieces has to be prevented.

The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt.

The bolt shank and the hole are accurately machined for achieving perfect mating.

Anti-fatigue bolt (Fig 4)

Fig 4

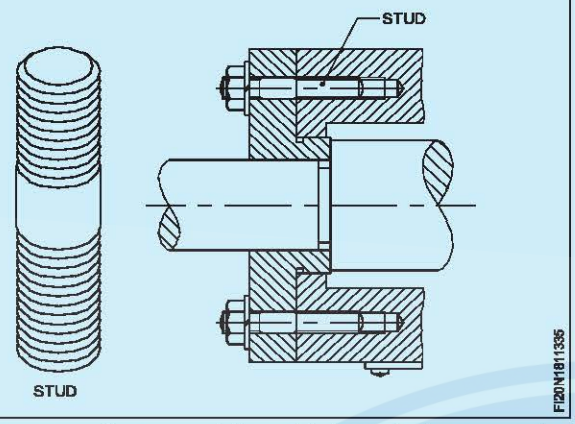


This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connecting rod big ends in engine assembly are examples of this application.

The shank diameter is in contact with the hole in a few places and other portions are relieved to give clearances.

Studs (Fig 5)

Fig 5



Studs are used in assemblies which are to be separated frequently.

When excessively tightened, the variation in the thread pitch allows the fine thread or nut end to strip. This prevents damage to the casting.

Designation of bolts as per B.I.S. specifications: Hexagon head bolts shall be designated by name, thread size, nominal length, property class and number of the Indian Standard.

Example

A hexagon head bolt of size M10, nominal length 60 mm and property class 4.8 shall be designated as:

Hexagon head bolt M10 x 60 - 4.8 - IS:1363 (Part 1).

Explanation about property class

The part of the specification 4.8 indicates the property class (mechanical properties). In this case it is made of steel with minimum tensile strength = 40 kgf/mm^2 and having a ratio of minimum yield stress to minimum tensile strength = 0.8.

Note: Indian standard bolts and screws are made of three product grades - A, B, & C and 'A' being precision and the others of lesser grades of accuracy and finish. While there are many parameters given in the B.I.S specification, the designation need not cover all the aspects and it actually depends on the functional requirement of the bolt or other threaded fasteners.

(For more details on the designation system, refer to IS:1367, Part XVI 1979.)

Cylindrical and taper pins

Objectives: At the end of this lesson you shall be able to
- **state the uses of cylindrical and taper pins**
- **specify cylindrical pins**
- **state the features and uses of different types of cylindrical pins**
- **state the advantages of taper pins**
- **state the features and uses of the different types of taper pins**
- **designate standard taper pins**
- **distinguish the features and uses of the different types of taper pins**
- **state the uses of the different types of grooved pins**
- **state the features and uses of spring pins.**

Cylindrical and taper pins

– Locating hole position for assemblies whenever they are dismantled and assembled (Examples - jigs and fixtures, cover plates, machine tool assembly etc.) (Figs 1a and 1b)

– Assembling components. (Examples - wheels, gears, levers, cranks etc. to shafts) (Figs 2a and 2b)

Cylindrical pins are available with different types of:

- Ends
- Tolerances
- Surface quality

Cylindrical pins are also available in un-hardened and hardened conditions.

Un-hardened cylindrical pins are of three types. (Fig 3)

- Chamfered and rounded end
- Chamfered end
- Square end

Fig 1

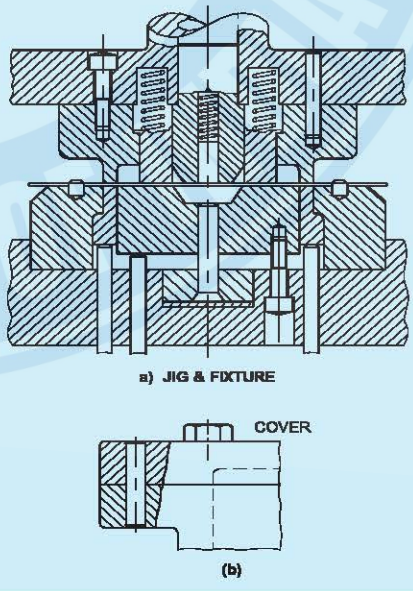


Fig 2

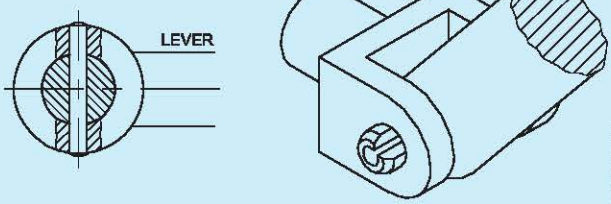
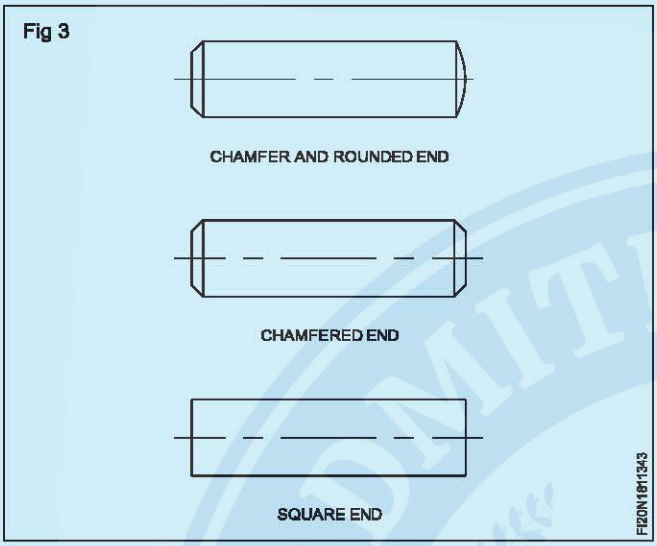


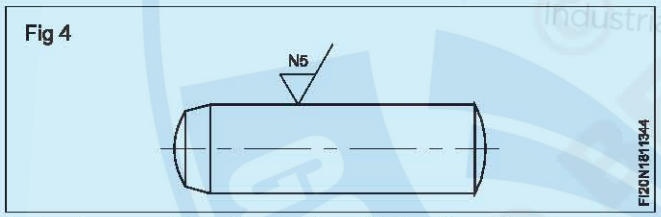
Fig 3



They are useful in general assembly work.

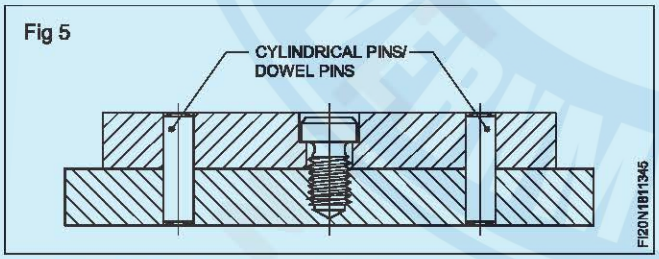
Hardened cylindrical pins are made of high grade steel and are finished by grinding. (Fig 4) These pins can withstand higher shearing force. These pins are used in precision assemblies like jigs and fixtures and other tool making works.

Fig 4



In tool assemblies the parts will be fixed by screws or bolts, (Fig 5) and are located by using cylindrical pins.

Fig 5



Hardened cylindrical pins are available with dimensional tolerance m6.

Un-hardened and hardened cylindrical pins are made to fit in the holes finished by standard reamers.

Cylindrical pins are designated by the name, nominal diameter, tolerance on diameter, nominal length and the number of B.I.S. Standard.

Example: A cylindrical pin of nominal diameter 10 mm, tolerance h8 and nominal length 20 mm shall be designated as-

Cylindrical pin 10h8x20 IS:2393.

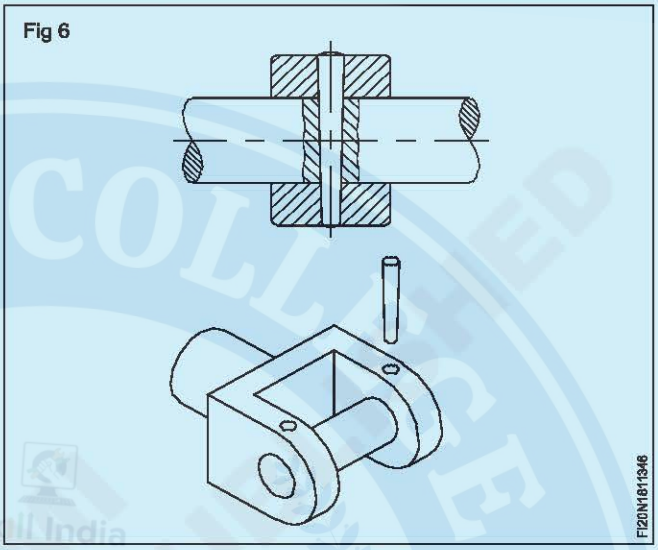
Note: The I.S. number refers to un-hardened cylindrical pins. Cylindrical pins are also referred to as dowel pins.

Taper pins

Taper pins of different types are used in assembly work.

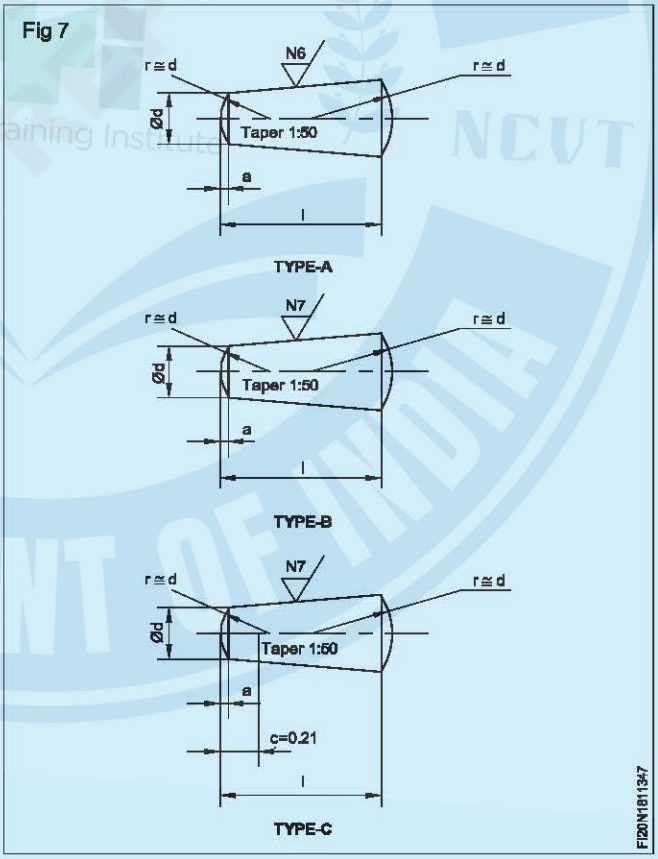
Taper pins allow for frequent dismantling and assembling of components without disturbing the precise nature of location. They are used to transmit small torques. (Fig 6)

Fig 6



Taper pins are of three types. (Fig 7)

Fig 7



Type A - Taper pins with a surface finish of N6.

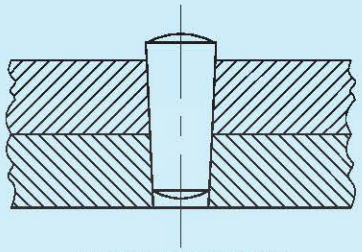
Type B - Taper pins with a surface finish of N7.

Type C - Split taper pins with a surface finish of N7.

All taper pins have a taper of 1:50 and are finished within a dimensional tolerance of h10.

Taper pin types A & B assembly is shown in Fig 8 and type C is shown in Fig 9.

Fig 8



PRESSED OR DRIVEN OUT

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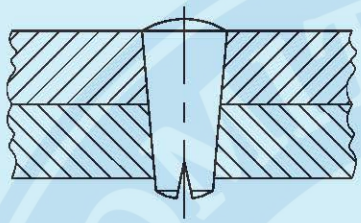
Fig 9



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Split taper pin

In the case of split taper pins the split end can be slightly opened to ensure a more positive locking.

Taper pins are designated by name, type (A, B or C) nominal diameter, nominal length and number of the standard.

Examples

i A taper pin of Type A of nominal diameter 10 mm and nominal length 50 mm shall be designated as - Taper pin A10 x 50 IS:6688.

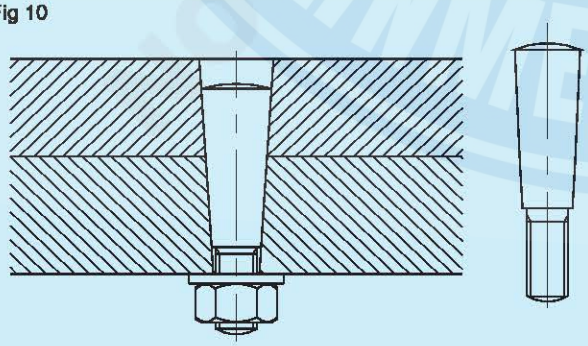
ii A split taper pin of nominal diameter 10 mm and nominal length of 60 mm shall be designated as - Split taper pin C10 x 60 IS: 6688.

The nominal diameter in the case of taper pins is the diameter at the small end of the taper.

Threaded taper pins are available for:

- Locking the pins and preventing loosening due to vibration (Fig 10)

Fig 10



LOCKING

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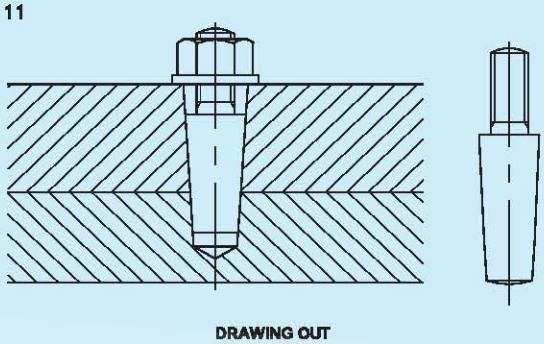
- Assisting in drawing the pins out of the blind holes. (Fig 11)

Fig 11



DRAWING OUT

FI20N181134B

Threaded taper pins with internal threads are also available. (Fig 12)

Fig 12

FI20N181134C

Grooved pins: These pins have three slots rolled on the outer surface. The sides of the grooves/slots bulge out. The holes in which slotted pins are used are not finished by reaming. Grooved pins are available as straight pins (Fig 13a), and tapered pins (Fig 13b). These are used in assemblies which are not dismantled frequently and where high accuracy is not required. (Fig 14)

Fig 13

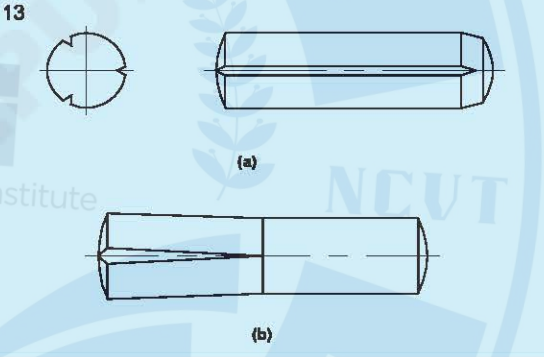


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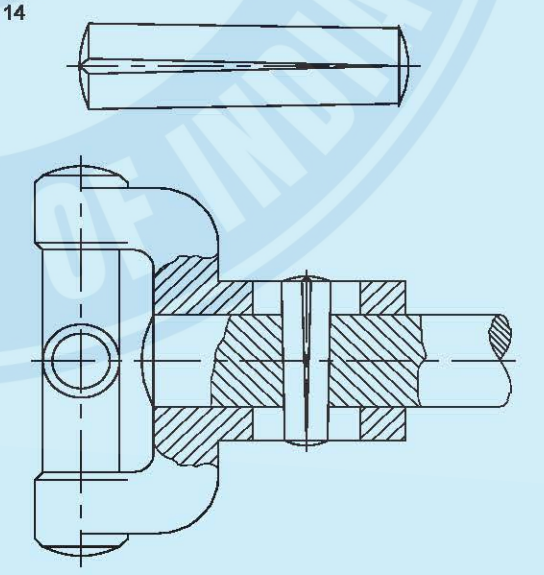
Fig 14



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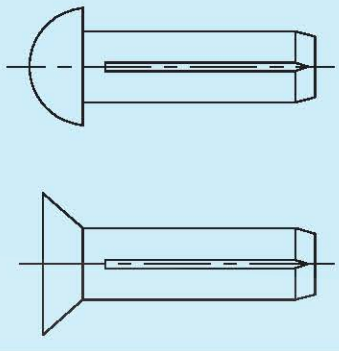
Grooved pins with head are also used in assembly involving small components. (Fig 15)

Fig 15



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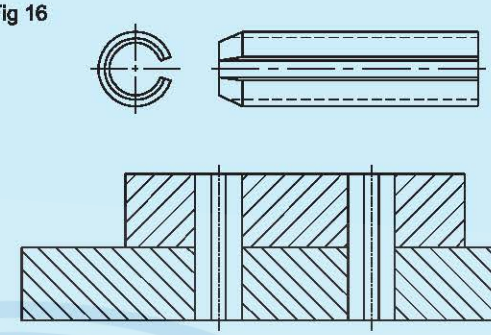
Spring pins (Fig 16)

Spring pins are used for locating assemblies with wide tolerance in the corresponding holes. These pins are manufactured from flat steel bands and rolled to form a cylindrical shape. These springs will stay tight in the fitting hole because of the spring action.

Fig 16



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Seal

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a seal**
- **name the material used for static seal**
- **state the types of static seals and their applications**
- **name the materials used for dynamic seals**
- **state the types of dynamic seals and their applications.**

Purpose

A seal is used to prevent leakage.

It prevents dust, dirt and foreign particles from entering into the system.

Any machining process leaves behind a little imperfection of the surfaces of the mating components. A seal fills up the gap to prevent leakage from the system.

Types

- Static
- Dynamic

Static seal

It is used for sealing the contact areas between the surfaces where there is relative movement, eg. Gasket 'O' ring, bellows, etc.,

Materials used for gaskets

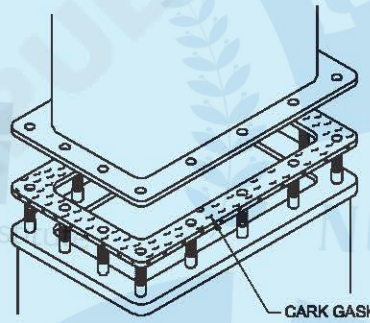
Static seal

- Compressed cork
- Oil-proof paper
- Graphite-impregnated cloth
- Asbestos with copper covering
- PTFE (Poly-tetrafluroethylene)
- Copper
- Steel

Types of static seals

Compressed cork gasket (Fig 1)

Fig 1



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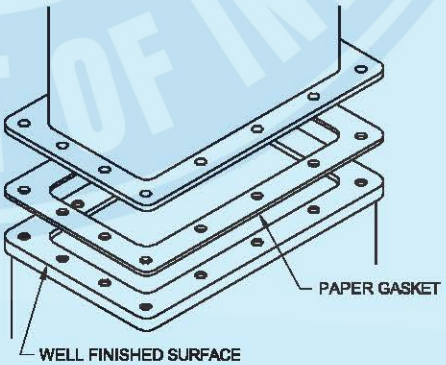
This is used for sealing between mating surfaces which are not having good surface finish. Compressed cork can be obtained in several thicknesses.

Paper (Fig 2)

Fig 2



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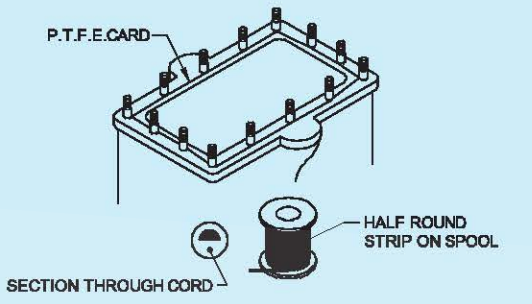
This is used between smooth and accurately finished joint surfaces. It can vary in thickness from thin paper to card and may be grease-proofed.

PTFE cord sealing (Fig 3)

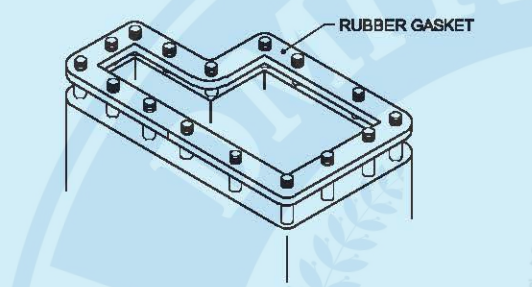
Fig 3



This is suitable for use at very low temperature applications. The material is chemically inert and can be made into soft flexible strips and used to make either flat seals or gland packings.

Rubber gaskets (Fig 4)

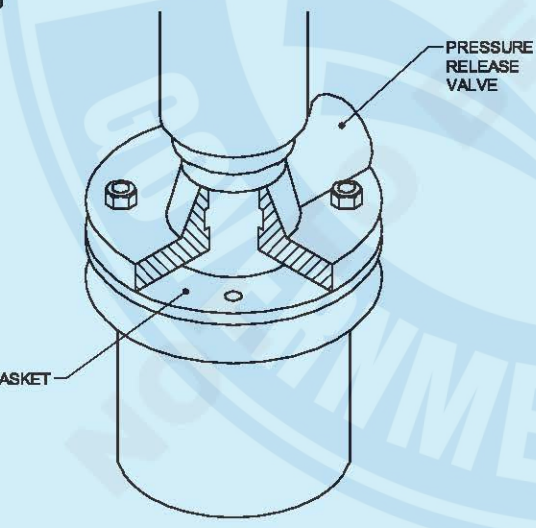
Fig 4



They are the good for sealing flanges of cold water connections. They are not suitable where oil comes in contact.

Graphite impregnated cloth (Fig 5)

Fig 5



This is a suitable material for hot water and steam joints.

Metallic gaskets (Fig 6)

Hard metallic seals made of steel, copper or beryllium are used for high pressure joints found commonly in hydraulic system.

Asbestos covered with copper sheet gasket (Fig 7)

Fig 6

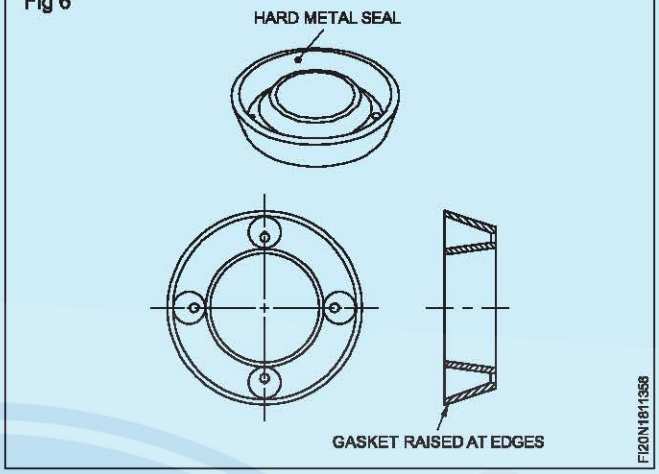
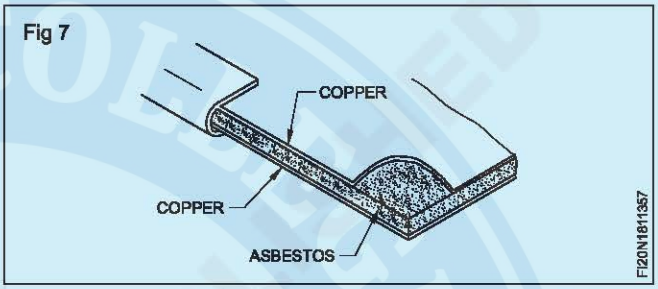


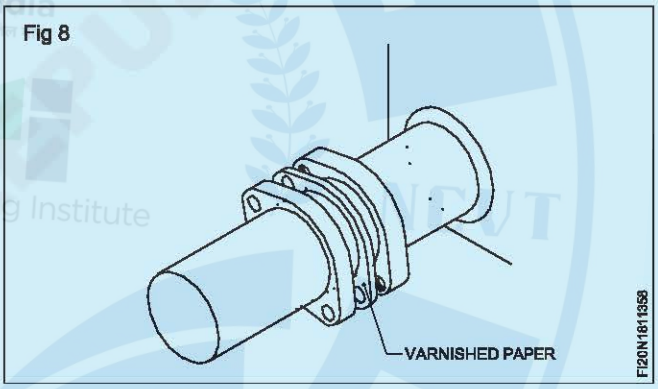
Fig 7



These are suitable for use in high temperature applications.

Varnished paper gasket (Fig 8)

Fig 8



It is suitable for use where liquids would be absorbed into plain paper. The surface of the varnished paper gasket must not be cracked or damaged in any way.

Material used for manufacturing dynamic seal

- Natural rubber
- Nitrile
- Viton
- PTFE plastics
- Flurosilicone
- Butyle
- Neoprene
- Flurocarbon

Table 1 shows the allowable temperature range for different materials.

Table 1

Material	Temp.°C	Material	Temp.°C
Natural rubber	-50 to +80	Flurosilicone	-50 to +100
Nitrile	-30 to +110	Butyle	-40 to +100
Viton	-40 to +180	Neoprene	-40 to +100
PTFE	-85 to +260	Flurocarabon	-20 to +140

Types of dynamic seals

Dynamic seals are required to work under more exacting conditions than static seals because movement lakes place between the surfaces being sealed.

O-ring seal (Figs 9 & 10)

Fig 9

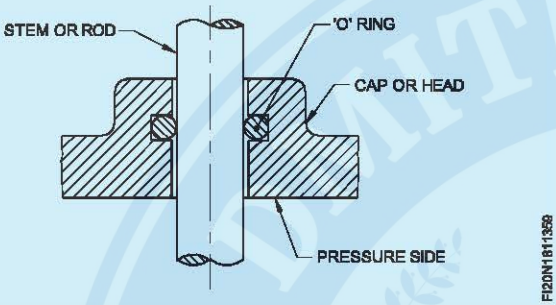
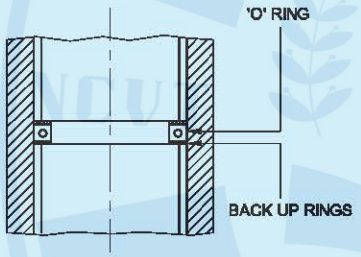


Fig 10



These are the most common types of dynamic seals in use and have many applications. When required to seal against high pressures, they are fitted with back-up rings. There are many similar seals made for special purposes that do not have a circular cross-section.

Radial lip seals

Radial lip seals are used primarily to retain lubricants in equipment with rotating, reciprocating or oscillating shafts. The secondary purpose is to exclude foreign matter.

Non-spring loaded seals

These are used to retain highly viscous materials like grease at shafts less than 600 m/min.

Spring-loaded seals (Fig 11)

They are used to retain low viscosity lubricants such as oils at speeds up to 1000 m/min.

Wiper seal (Fig 12)

These seals are used in rotary and sliding operating conditions and are used to prevent dust or grit entering shaft bearings. The contacting surface of the seal wipes off the particles from the shaft.

Fig 11

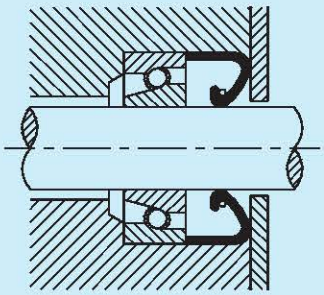
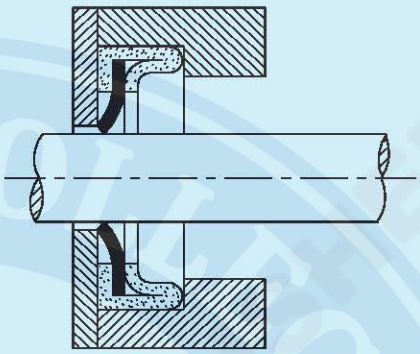
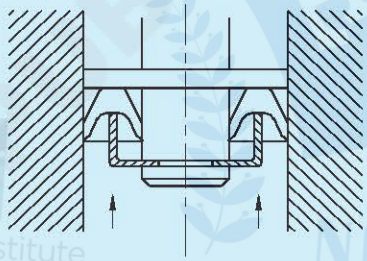


Fig 12



'V' seals (Fig 13)

Fig 13



Fabric reinforced or leather seals are suitable for use against high pressure. These seals are available in various forms.

Flange seal (Fig 14)

Fig 14

'V' type or Chevron seal (Fig 15)

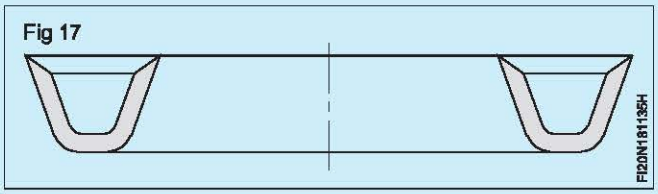
Fig 15

Cup seal (Fig 16)

Fig 16

'U' type seal (Fig 17)

Fig 17

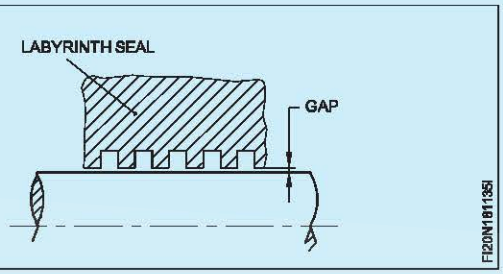


They are often used to form the seal between piston and cylinder assemblies in hydraulic equipment.

Labyrinth seals (Fig 18)

This is a clearance type of seal and it allows some amount of leakage. Labyrinth seals are used primarily to seal gases in compressors and steam turbines. This seal is commonly used in rotary operating conditions. The function of the seal is to provide radial clearance while preventing dust or dirt from entering into the system.

Fig 18



Torqueing

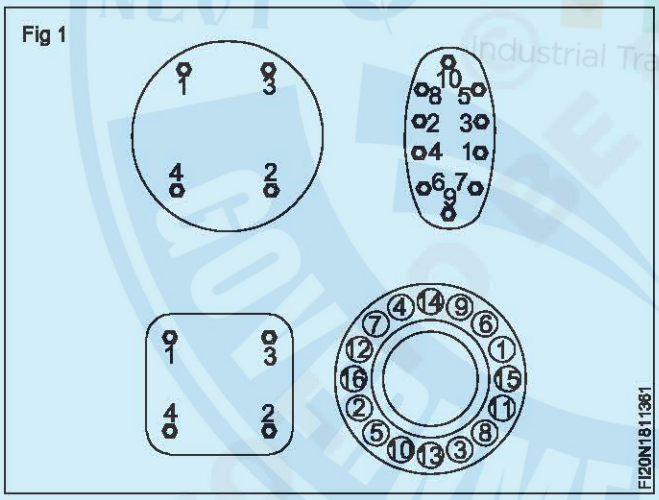
Objectives: At the end of this lesson you shall be able to
- **state torque in assembling**
- **state precautions to be observed during assembling & installation.**

Torqueing: While assembling, threaded fasteners are tightened as per thread manufacturer recommended torque value. If the torque is more than the recommendation, threads may damage on both fasteners and housing and tends to break.

Precautions observed during Assembling and installation

- Tighten the bolts to compress the gasket uniformly. Follow the sequence from side to side around the joint. (Fig 19).

Fig 1



- Use well lubricated fasteners and hardened flat washer.
- All bolts should be tightened in one-third increments, according to proper bolting patterns.
- Make final check pass at the target torque value moving consecutively from bolt to bolt
- Never use liquid or metallic based anti-stick or lubricating compounds on the gaskets. It creates Premature failure.