**BASIC CIVIL AND MECHANICAL ENGINEERING (Common to All branches of Engineering)**

**JNTUA B.Tech. R23 Regulations**


# Prepared by Dr.M.Sivaramakrishnaiah

## SVR Engineering College

## PART B: BASIC MECHANICAL ENGINEERING

**Course Objectives:**

The students after completing the course are expected to

- Get familiarized with the scope and importance of Mechanical Engineering in different sectors and industries.
- Explain different engineering materials and different manufacturing processes.
- Provide an overview of different thermal and mechanical transmission systems and introduce basics of robotics and its applications.

**Course Outcomes:**

On completion of the course, the student should be able to
CO1: Understand the different manufacturing processes.
CO2: Explain the basics of thermal engineering and its applications.
CO3: Describe the working of different mechanical power transmission systems and power plants.
CO4: Describe the basics of robotics and its applications.

**UNIT I Introduction to Mechanical Engineering:** Role of Mechanical Engineering in Industries and Society- Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors.

**Engineering Materials** - Metals-Ferrous and Non-ferrous, Ceramics, Composites, Smart materials.

## I. What is Mechanical Engineering?

Before entering into the Mechanical Engineer role, let us first understand the concept of Mechanical Engineering. Mechanical Engineering is defined as the branch of engineering that deals with the design, development, construction, and operation of mechanical systems and tools. It include machines, tools, and equipment used in various industries, such as transportation, manufacturing, power generation, and medical devices etc.

### 1.1 What role does a Mechanical Engineer play in our society and in Industries?

Mechanical engineers are involved in almost every aspect of human existence and welfare, including machines, cars and other vehicles, aircraft, power plants, automobile parts, and manufacturing plants etc. A Mechanical Engineer plays a significant role in designing, developing, and testing machines as well as thermal devices. It also includes systems that are essential to many aspects of modern society and Industries. They use their knowledge of mechanics, thermodynamics, materials science, and energy to create solutions that improve the quality of life of people.

**Besides, the role of a mechanical engineer in our society is contributed as:**

1.Power Generation: Mechanical engineers design and develop power-generating machines such as internal combustion engines, gas turbines, and steam and wind turbines etc.

2. Heating and Cooling Systems: They design and develop heating, ventilation, refrigeration and air conditioning systems for buildings and other structures.

3.Transportation: Mechanical engineers are involved in designing and developing transportation systems, including cars, trains, airplanes, steamers and boats.

4.Industrial Equipment: They design, develop and maintain industrial equipment such as machine tools, robots, and conveyor systems & belts.

5.Infrastructure: Mechanical engineers play a key role in the design and maintenance of infrastructure, including buildings, bridges, roads, and transportation systems.

Overall, Mechanical Engineers are involved in designing, building, and maintaining the engines, machines, and structures that make modern life possible and comfortable.

They contribute to society by using their skills to improve the safety, security, efficiency, and comfort of the systems and devices that we rely on every day.

**Power Generation**


**Heating and cooling system**

**Industrial Equipment**

Mechanical engineering plays a critical role in manufactured technologies, from cars to airplanes to refrigerators. It enables you to do many daily activities with ease, as it brings helpful technologies to our modern society.

Mechanical englneers work in various industries, building and designing nuclear plants, or automobiles, or railway equipment, or spacecraft. These mechanical engineers are sometimes called nuclear engineers, automotive engineers, railway engineers, and aerospace engineers'

Mechanical engineers also work as consulting practices, government and universities. They may work in classrooms, factories offices, laboratories or testing facilities as teachers, managers, designers or researchers. Some mechanical engineers work in sales and product quality control or equipment maintenance. Many hold managerial positions in their companies. whether working on an oil rig or in corporate headquarters, mechanical engineers are solvlng the technical problems of today and tomorrow

**1.2 Emerging Trends and Technologies in energy sector**

Renewable energy infrastructure development, power generation, storage, and efficiency drive innovations in the sector with numerous emerging companies developing low-cost renewable energy technology.

**a) Renewable:**

Renewable is one of the emerging trends in energy sector. This Renewable energy trend helps to safeguard the environment by emitting Iittle to no harmful pollutants. The fundamental premise of renewable energy is to obtain it from a consistent source in the environment, such as the sun, wind, or geothermal sources. The source is then converted into useful power or fuel.

A variety of technologies that address various facets of generating power and heat from renewable sources is one of the latest technology trends in renewable energy. This involves lowering the cost of building renewable infrastructure and enhancing the efficiency of power generation.

**b) Energy Storage**

Energy storage is one of the effective energy industry emerging trends. Energy storage permits steady pricing by proactively maintaining demand from consumers ln response to shifting energy demands and technological advancements, the energy storage business has evolved, adapted, and innovated during the last century. Energy storage systems offer a diverse set of technological solutions for improving our power supply to build more resilient energy infrastructure and save money for utilities and customers.

The many methods of energy storage can be classified into five categories based on their technology:

Batteries .
Thermal
Mechanical
Pumped hydro
Hydrogen
It has the potential to save consumers money while also improving dependability and resilience, integrating power sources, and reducing environmental impacts.

**c) Blockchains:**

Blockchains or distributed ledgers are emerging technology trends in the energy industry that has drawn significant interest from energy supply firms, start-ups, financial institutions, Governments, technology developers, and the academic community' Block chain technology proposes to combine all energy stakeholders under a single decentralized system. Electricity producers, metering operators, distribution network operators' and traders potentially avail from utilizing smart contracts. These agreements ensure that all energY-related transactions are routed through a safe and immutable network, reducing the risk of losses. Block chain also has the abitity to achieve some degree of equity between energy generators and consumers.

**1.3 Emerging Trends and Technologies in Manufacturing sector**

Al, robots, 3D printing, and the like are all the latest manufacturing trends in manufacturing technology - and have been for some time. 2021 is the year. Manufacturing technology gets even smarter. Robots on the factory floor are growing at warp speed thanks to their declining cost and increasing capabilities.

**1.4 Emerging Trends and Technologies in Automotive sector**

The automotive industry has been experiencing a great deal of change within the past several years. More software is being added to vehicles, along with a greater number of electric and autonomous vehicles are in production and on the road.

Here are the most common automotive trends of 2021. .

A Greater Amount of Al/Machine Learning and Connectivity

An increase ln Electric and Autonomous Vehicles .

Software Security Has Become a Top Concern

Electrification .

Artificial intelligence (Al).

Human-Machine interface.

**1.5 Emerging Trends and Technologies in Aerospace sector**

Aerospace collectively refers to the atmosphere and outer space; it's a diverse industry with a multitude of commercial, industrial, and military applications. Aerospace engineering consists of aeronautics and astronautics and the research, design, production, operation, or maintenance of aircraft and spacecraft involves the work of numerous organizations.

**10 Aerospace Engineering Technology Trends**

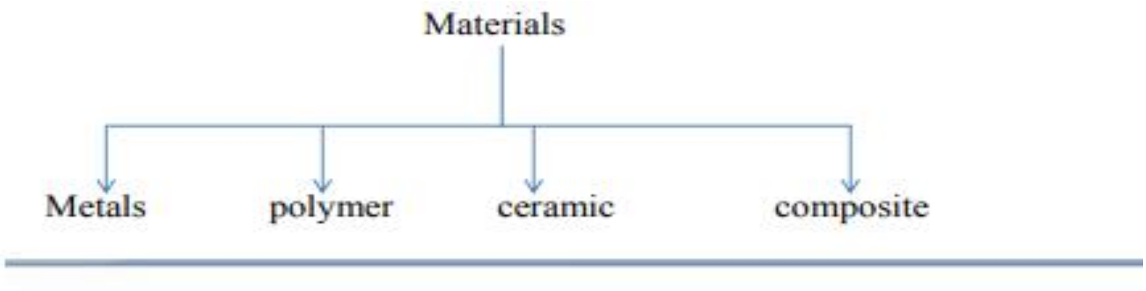
1. Zero-Fuel Aircraft
2. Structural Health Monitoring (SHM)
3. Advanced Materials
4. Smart Automation and Block chain
5. Additive Manufacturing (3D Printing)
5. Supersonic Flights
7. More Resilient and Oynamic A&D Supply Chains
8. Utilizing Internet of Things (loT) to Anticipate Maintenance lssues
9. Artificial intelligence (Al)
1.0. Autonomous Flight Systems.

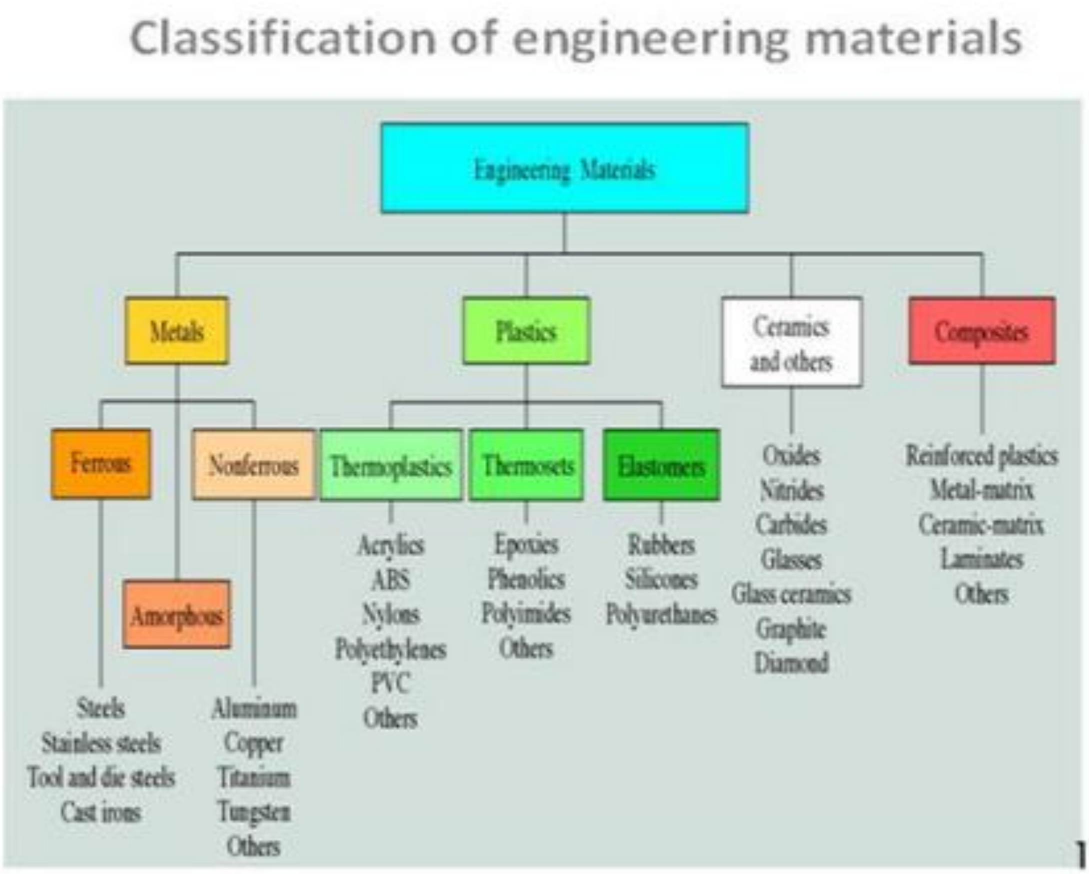
**1.6 What is emerging technologies in the maritime industry?**

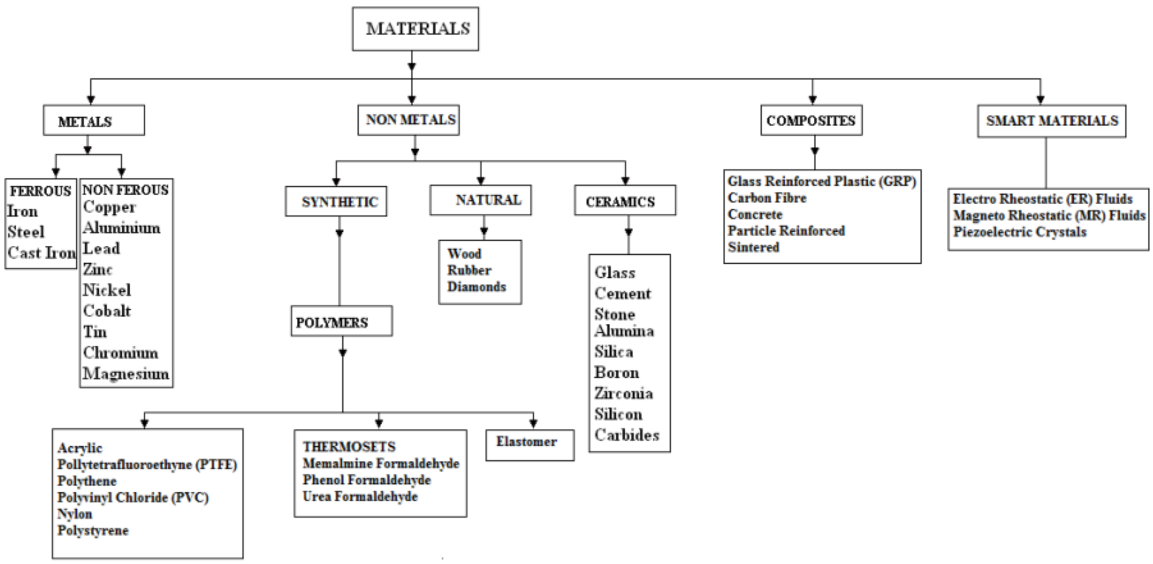
Advances in shipbuilding, propulsion, smart shipping, advanced materials, big data and analytics, robotics, sensors and communications in conjunction with an increasingly skilled

workforce are all having monumental shifts in how the maritime industry are approaching new challenges and opportunities.
The lndian Manufacturing sector currently contributes 16-17% to GDP and gives employment to around l2o/o (201a) of the country's workforce. Various studies have estimated that every job created in manufacturing has a multiplier effect in creating 2-3 jobs in the services sector. Manufacturing, value added (% of GDP) in lndia was reported at 12.96 % in 2020, according to the World Bank collection of development indicators, compiled from officially recognized sources.

**Engineering Materials – Metals-Ferrous and Non-ferrous, Ceramics, Composites, Smart materials**





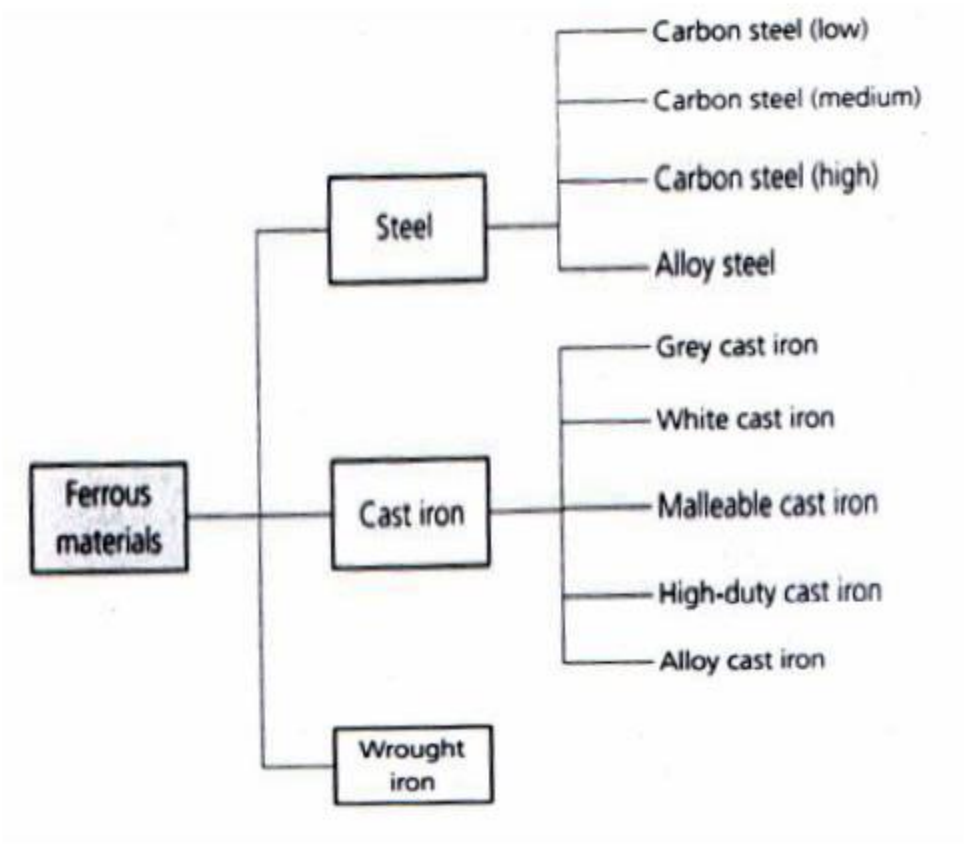

## 1.1 Ferrous metals

These are metals and alloys containing a high proportion of the element iron.

They are the strongest materials available and are used for applications where high strength is required at relatively low cost and where weight is not of primary importance.

As an example of ferrous metals such as : bridge building, the structure of large buildings, railway lines, locomotives and rolling stock and the bodies and highly stressed engine parts of road vehicles.

The ferrous metals themselves can also be classified into "families', and these are shown in figure.



as electrical conductors and, together with sheet zinc and sheet lead, are use as roofing materials. They are mainly used with other metals to improve their• strength. Some widely used non-ferrous metals and alloys are classified as shown in figure.

**Non – ferrous metals**

These materials refer to the remaining metals known to mankind. The pure metals are rarely used as structural materials as they lack mechanical strength.

They are used where their special properties such as corrosion resistance, electrical conductivity and thermal conductivity are required. Copper and aluminum are used as electrical conductors and, together with sheet zinc and sheet lead, are use as roofing materials.

They are mainly used with other metals to improve their strength

**Non – metallic (Natural materials )**

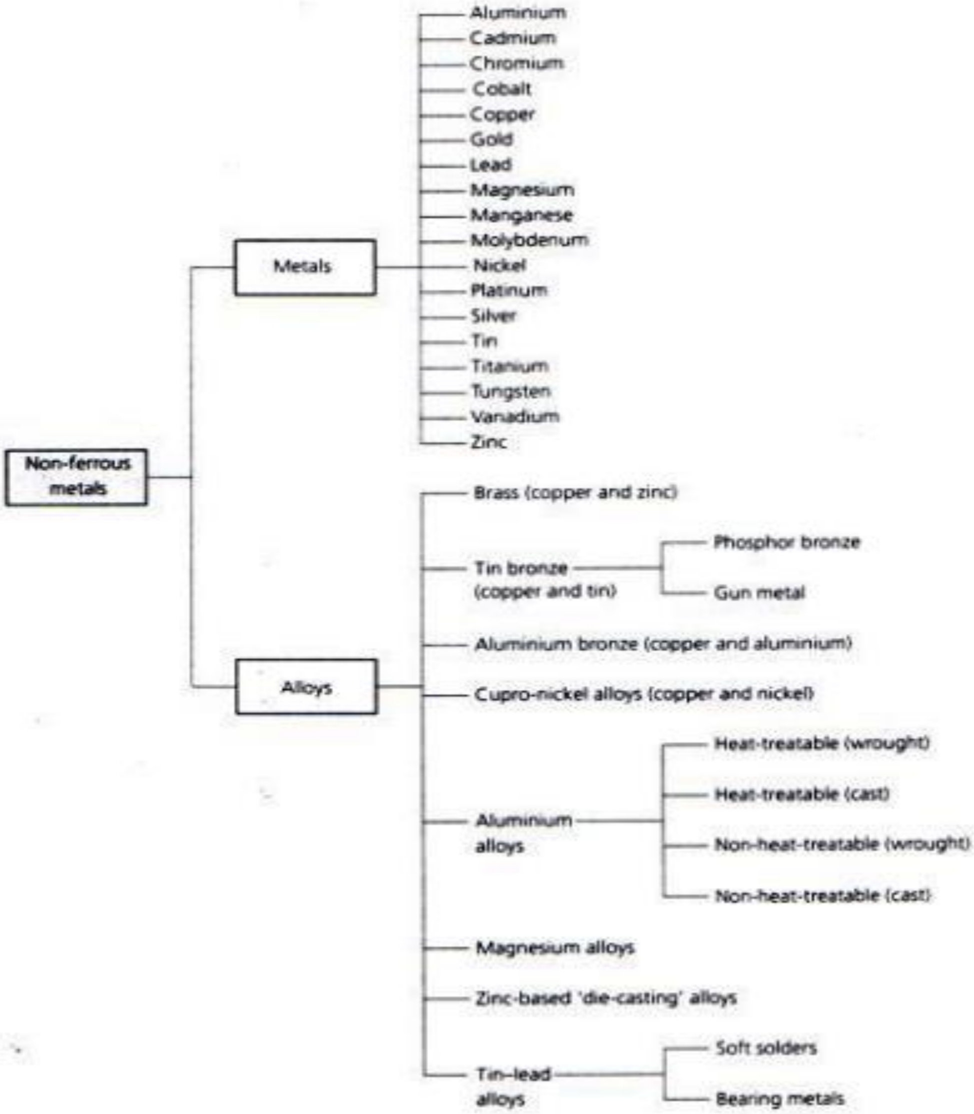
**Ceramic:** These are produced by baking naturally occurring clays at high temperatures after moulding to shape. They are used for high – voltage insulators and high – temperature – resistant cutting tool tips.

## Ceramics

**Ceramics (ceramic materials)** are non-metallic inorganic compounds formed from metallic (Al, Mg, Na, Ti, W) or semi-metallic (Si, B) and non- metallic (O, N, C) elements.

Atoms of the elements are held together in a ceramic structure by one of the following bonding mechanism: Ionic Bonding, Covalent Bonding, Mixed Bonding (Ionic-Covalent).

Most of ceramic materials have a mixed bonding structure with various ratios between Ionic and Covalent components. This ratio is dependent on the difference in the electro negativities of the elements and determines which of the bonding mechanisms is dominating ionic or covalent.




# SMART MATERIALS

- **Smart materials**, also called intelligent or responsive materials .
- Author Rogers, 1988- Defined Smart material are the materials which have the ability to change their physical properties in response to specific stimulus input or environmental changes.
- These stimulus could be pressure, temperature, electric, magnetic filed ,chemical, mechanical stress, radiation etc.

## SOME OF THE SMART MATERIALS TYPES

- Piezo Electric Materials.- Materials that produce a voltage when stress is applied.
- Photovoltaic or Opto electronics materials- Converts Light to electrical current.
- Shape memory materials Induce deformation due to temperature, stress change.
- PH Sensitive polymers- Material which changes in volume when PH of surrounding medium changes.
- Halochromic materials-change their color as a result of changing acidity.
- Temperature response polymers-materials which undergo changes upon temperature.
- Thermo electric materials-convert temperature difference to electricity & Vice versa.
- Di Electric elastomers-produce large strains (up to 500%) under the influence of an electric field.

## FOUR General classification of Smart composites

(1) Structural smart composites;

(2) composites for actuation;

(3) novel functional composites; and

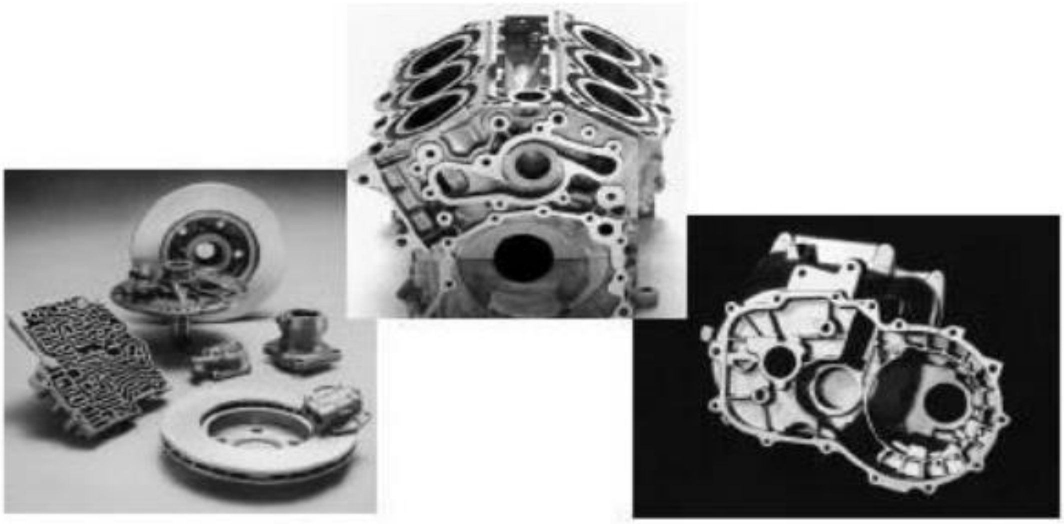
(4) nanocomposites that are enablers of novel functions.

# UNIT-II

**Manufacturing Processes:**
**Casting processes:** Moulding materials and their requirements; Patterns: Types and various pattern materials. Various casting methods, viz., sand casting investment casting, pressure die casting, centrifugal casting, continuous casting, thin roll casting; Mould design; Casting defects and their remedies.

**Steps: -** Making mould cavity - Material is first liquefied by properly heating it in a suitable furnace. - Liquid is poured into a prepared mould cavity - allowed to solidify - product is taken out of the mould cavity, trimmed and made to shape
**We should concentrate on the following for successful casting operation:**

(i)Preparation of moulds of patterns (ii)Melting and pouring of the liquefied metal (iii)Solidification and further cooling to room temperature (iv)Defects and inspection

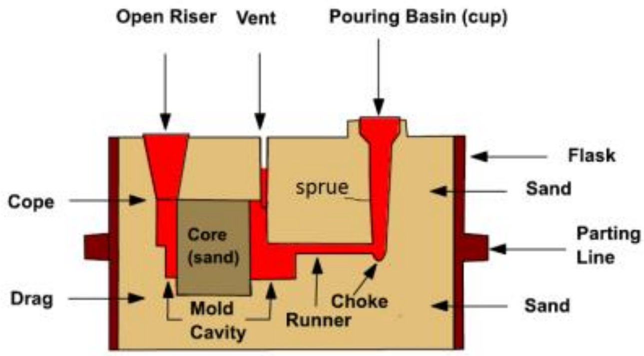


**Advantages** • Molten material can flow into very small sections so that intricate shapes can be made by this process. As a result, many other operations, such as machining, forging, and welding, can be minimized.
• Possible to cast practically any material: ferrous or non-ferrous.
• The necessary tools required for casting moulds are very simple and inexpensive. As a result, for production of a small lot, it is the ideal process.
• There are certain parts (like turbine blades) made from metals and alloys that can only be processed this way. Turbine blades: Fully casting + last machining.
• Size and weight of the product is not a limitation for the casting process.

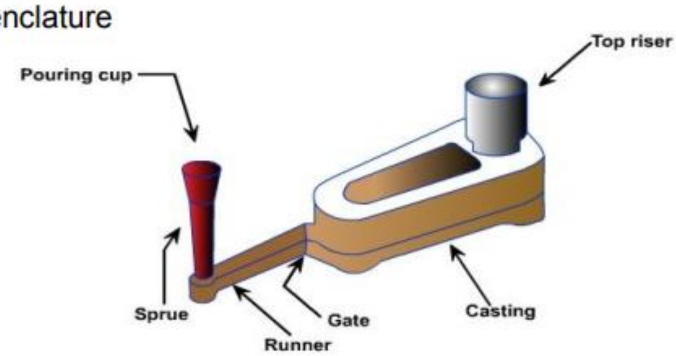
**Limitations**
• Dimensional accuracy and surface finish of the castings made by sand casting processes are a limitation to this technique.
• Many new casting processes have been developed which can take into consideration the aspects of dimensional accuracy and surface finish. Some of these processes are die casting process, investment casting process, vacuum-sealed moulding process, and shell moulding process.

• Metal casting is a labour intensive process
• Automation:

## Typical sand mould

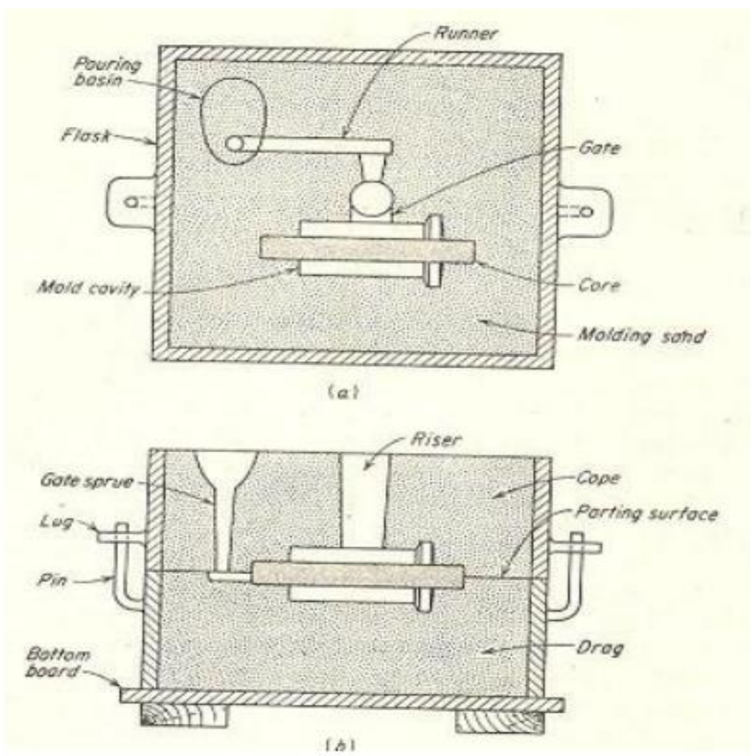



Mould Section and casting nomenclature




NPTEL course on Manufacturing processes – I, Pradeep Kumar et al.

pattern attached with gating and risering system




Mould Section and casting nomenclature, (a) top view, (b) front view

**Flask:** A metal or wood frame, without fixed top or bottom, in which the mould is formed. Depending upon the position of the flask in the moulding structure, it is referred to by various names such as drag – lower moulding flask, cope – upper moulding flask, cheek – intermediate moulding flask used in three piece moulding.

**Pattern:** It is the replica of the final object to be made. The mould cavity is made with the help of pattern.

**Parting line:** This is the dividing line between the two moulding flasks that makes up the mould.

Moulding sand: Sand, which binds strongly without losing its permeability to air or gases. It is a mixture of silica sand, clay, and moisture in appropriate proportions.

**Facing sand:** The small amount of carbonaceous material sprinkled on the inner surface of the mould cavity to give a better surface finish to the castings.

**Core:** A separate part of the mould, made of sand and generally baked, which is used to create openings and various shaped cavities in the castings.

Pouring basin: A small funnel shaped cavity at the top of the mould into which the molten metal is poured.

**Sprue:** The passage through which the molten metal, from the pouring basin, reaches the mould cavity. In many cases it controls the flow of metal into the mould.

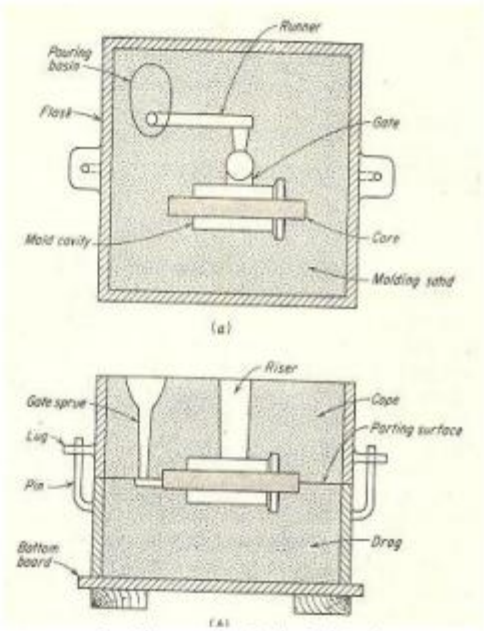
Runner: The channel through which the molten metal is carried from the sprue to the gate.

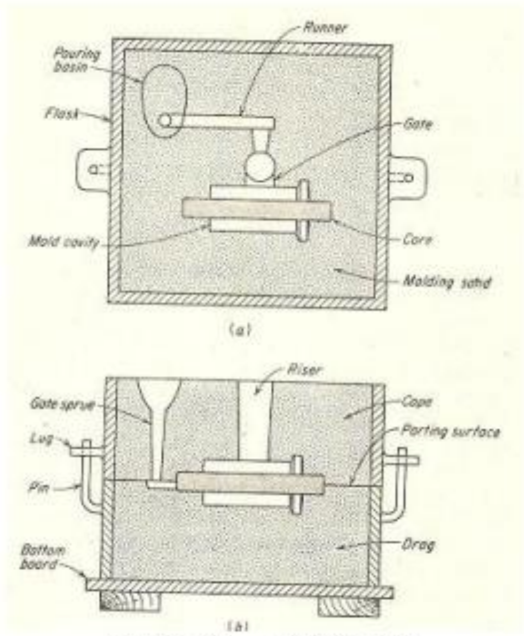
**Gate:** A channel through which the molten metal enters the mould cavity.

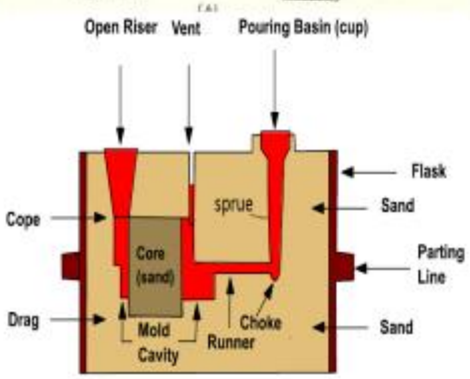
**Chaplets:** Chaplets are used to support the cores inside the mould cavity to take care of its own weight and overcome the metallostatic force.

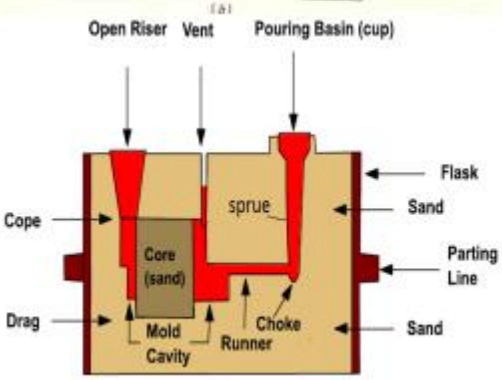
**Riser:** A column of molten metal placed in the mould to feed the castings as it shrinks and solidifies. Also known as “feed head”.

Vent: Small opening in the mould to facilitate escape of air and gases.



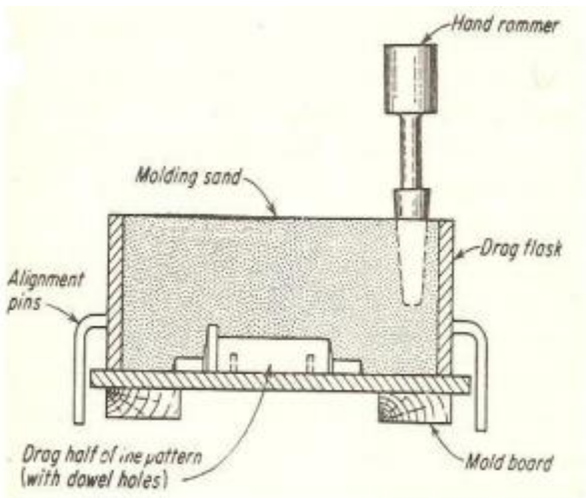




**Making a simple sand mould**

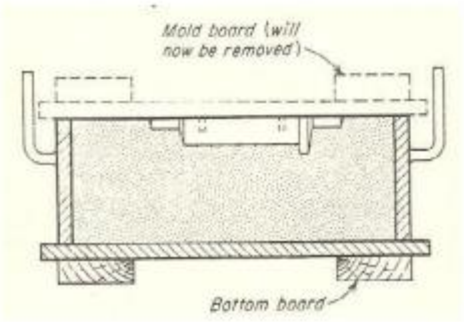
1) The drag flask is placed on the board
2) Dry facing sand is sprinkled over the board
3) Drag half of the pattern is located on the mould board. Dry facing sand will provide a non-sticky layer.
4) Molding sand is then poured in to cover the pattern with the fingers and then the drag is filled completely

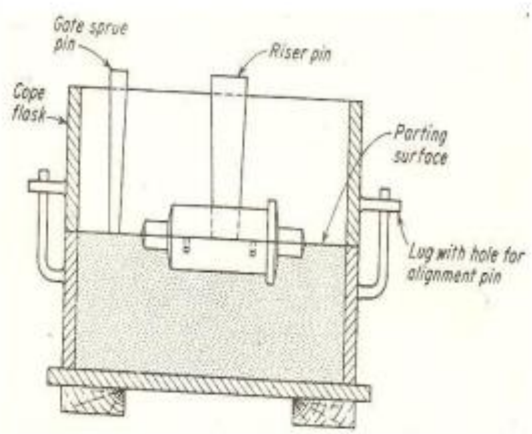



5) Sand is then tightly packed in the drag by means of hand rammers. Peen hammers (used first close to drag pattern) and butt hammers (used for surface ramming) are used.

6) The ramming must be proper i.e. it must neither be too hard or soft. Too soft ramming will generate weak mould and imprint of the pattern will not be good. Too hard ramming will not allow gases/air to escape and hence bubbles are created in casting resulting in defects called ‘blows’. Moreover, the making of runners and gates will be difficult.

7) After the ramming is finished, the excess sand is leveled/removed with a straight bar known as strike rod.



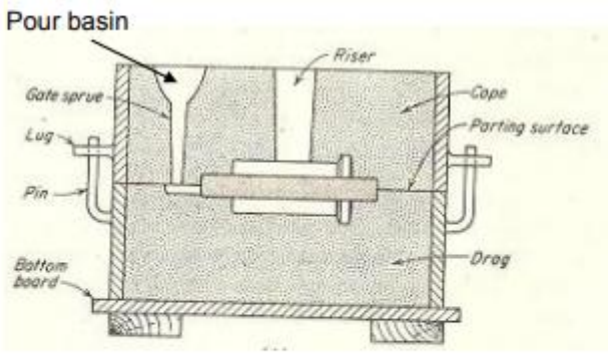

8) Vent holes are made in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during pouring and solidification. Done by vent rod.

9) The finished drag flask is now made upside down exposing the pattern.

10) Cope half of the pattern is then placed on the drag pattern using locating pins. The cope flask is also located with the help of pins. The dry parting sand is sprinkled all over the drag surface and on the pattern.

11) A sprue pin for making the sprue passage is located at some distance from the pattern edge. Riser pin is placed at an appropriate place.

12) Filling, ramming and venting of the cope is done in the same manner.




13) The sprue and riser are removed and a pouring basin is made at the top to pour the liquid metal. 14) Pattern from the cope and drag is removed.

15) Runners and gates are made by cutting the parting surface with a gate cutter. A gate cutter is a piece of sheet metal bent to the desired radius.

16) The core for making a central hole is now placed into the mould cavity in the drag. Rests in core prints.

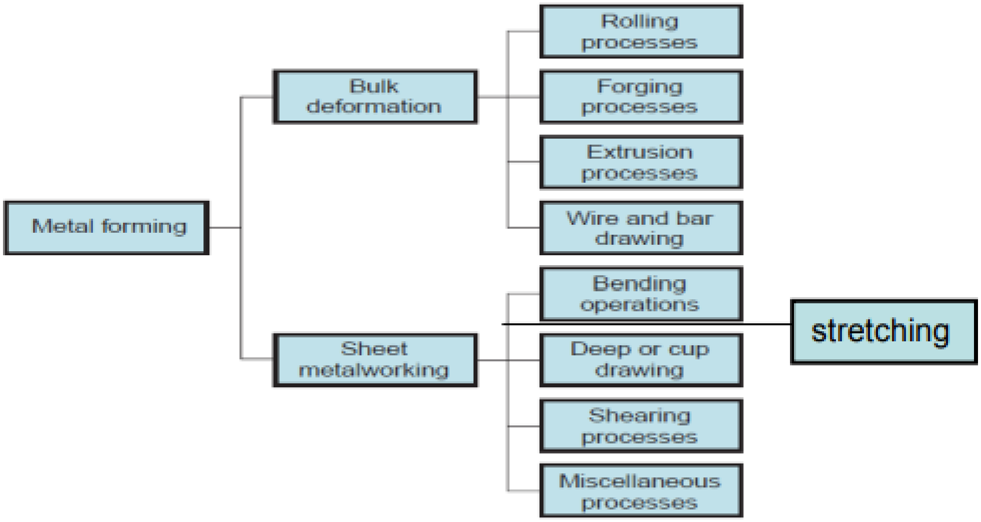
17) Mould is now assembled and ready for pouring.

**Metal forming processes:** Various metal forming techniques and their analysis, viz., forging, rolling, extrusion, wire drawing, sheet metal working, spinning, swaging, thread rolling; Super plastic deformation; Metal forming defects.

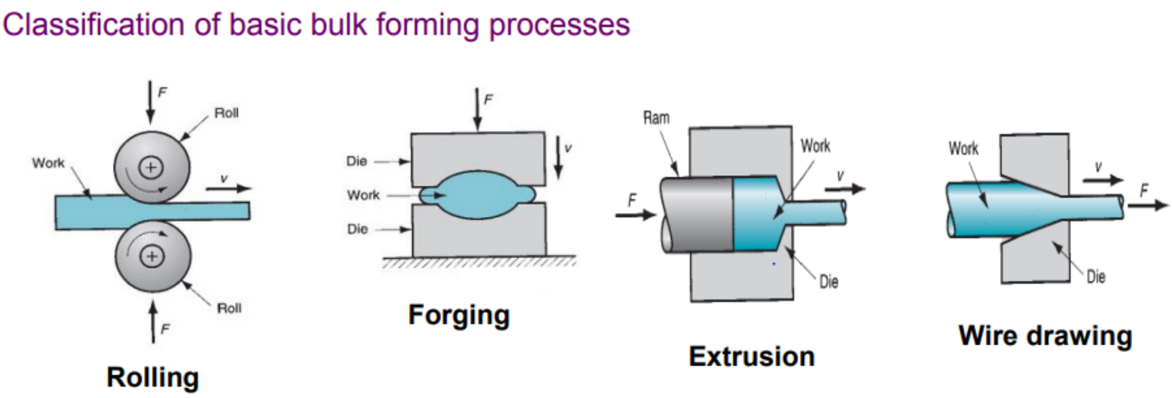
**Metal forming:** Large set of manufacturing processes in which the material is deformed plastically to take the shape of the die geometry. The tools used for such deformation are called die, punch etc. depending on the type of process.

Plastic deformation: Stresses beyond yield strength of the workpiece material is required.

Categories: Bulk metal forming, Sheet metal forming



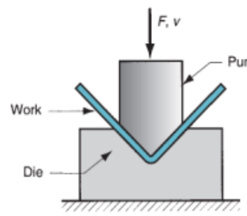

**General classification of metal forming processes**



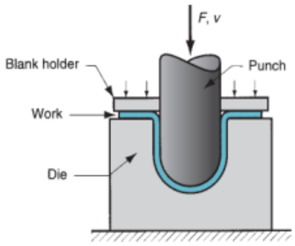

**Rolling:** In this process, the workpiece in the form of slab or plate is compressed between two rotating rolls in the thickness direction, so that the thickness is reduced. The rotating rolls draw the slab into the gap and compresses it. The final product is in the form of sheet.

**Forging:** The workpiece is compressed between two dies containing shaped contours. The die shapes are imparted into the final part.

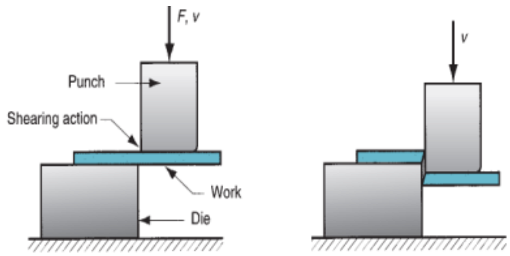
**Extrusion:** In this, the workpiece is compressed or pushed into the die opening to take the shape of the die hole as its cross section. Wire or rod drawing: similar to extrusion, except that the workpiece is pulled through the die opening to take the cross-section.




Bending




Deep drawing




shearing

**Sheet forming:** Sheet metal forming involves forming and cutting operations performed on metal sheets, strips, and coils. The surface area-to-volume ratio of the starting metal is relatively high. Tools include punch, die that are used to deform the sheets.

**Bending:** In this, the sheet material is strained by punch to give a bend shape (angle shape) usually in a straight axis.

**Deep (or cup) drawing:** In this operation, forming of a flat metal sheet into a hollow or concave shape like a cup, is performed by stretching the metal in some regions. A blank-holder is used to clamp the blank on the die, while the punch pushes into the sheet metal. The sheet is drawn into the die hole taking the shape of the cavity.

**Shearing:** This is nothing but cutting of sheets by shearing action.

**Bulk forming processes:**

**Forging:**

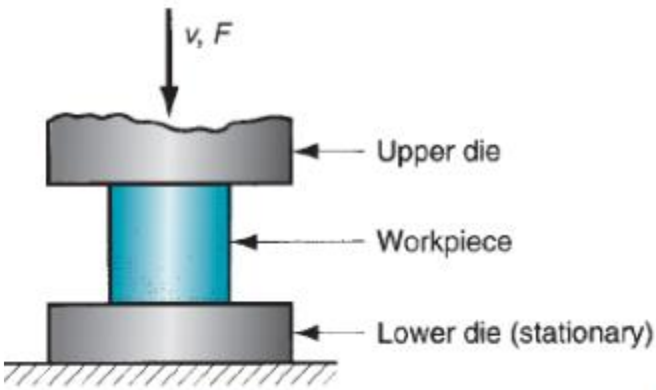
It is a deformation process in which the work piece is compressed between two dies, using either impact load or hydraulic load (or gradual load) to deform it.

• It is used to make a variety of high-strength components for automotive, aerospace, and other applications. The components include engine crankshafts, connecting rods, gears, aircraft structural components, jet engine turbine parts etc.

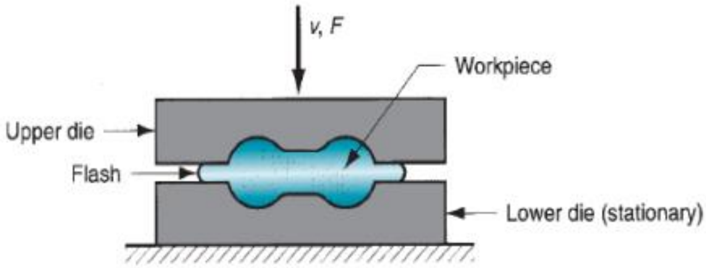
**Category based on temperature :** cold, warm, hot forging

**Category based on presses:** impact load => forging hammer; gradual pressure => forging press

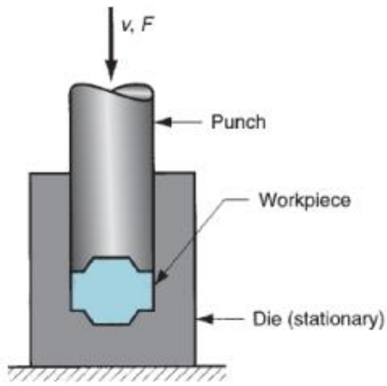
**Category based on type of forming:** Open die forging, impression die forging, flashless forging.




In open die forging, the work piece is compressed between two flat platens or dies, thus allowing the metal to flow without any restriction in the sideward direction relative to the die surfaces.




impression die forging




flashless forging

In impression die forging, the die surfaces contain a shape that is given to the work piece during compression, thus restricting the metal flow significantly. There is some extra deformed material outside the die impression which is called as flash. This will be trimmed off later.

In flashless forging, the work piece is fully restricted within the die and no flash is produced. The amount of initial work piece used must be controlled accurately so that it matches the volume of the die cavity.

**Metal joining processes:** brazing, soldering, welding; Solid state welding methods; resistance welding; arc welding; submerged arc welding; inert gas welding; Welding defects, inspection.

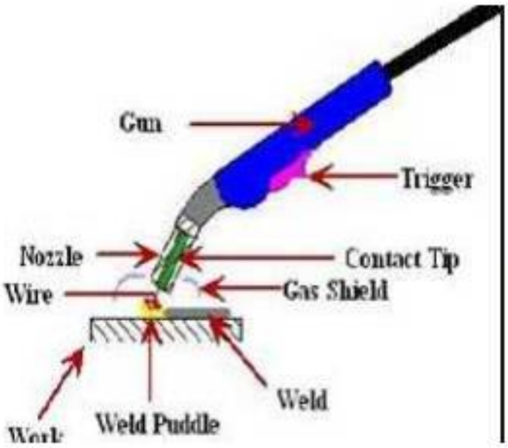
**WELDING**

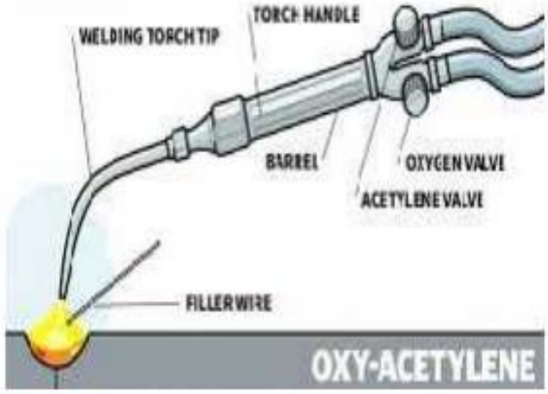
**Welding:** The process of joining similar metals by the application of heat is called "Welding". Welding can be obtained with or without application of pressure and with or without addition of filler metal which is known as 'electrode'.

**Classification of welding process:** 1. Fusion welding 2. Plastic welding. Fusion welding: The metal at the joint is heated to a molten state and then it is allowed to solidify. Pressure is not applied during the process and hence it is called "non pressure welding". Filler material is required for this welding. Plastic welding: The metal parts are heated to a plastic state and are pressed together to make the joint. It is called as "pressure welding". No filler material is required.

TYPES OF WELDING: Thermit welding Fusion welding ---- Arc welding ------ Submerged,Plasma,Automic hydrogen,MIG, Metal, Carbon, Electro slag WELDING.

Gas welding ------ Oxyacetylene, Oxyhydrogen Plastic welding ---- Explosive welding Ultrasonic welding Electric resistance—Butt, Spot, Seam, Projection,Percusion Friction welding Forge welding.




**GAS WELDING:**

1.Oxy – acetylene welding 2) Oxy – hydrogen welding 3) Air – hydrogen Oxy acetylene Welding: The edges of the metal to welded are melted by using a gas flame. No pressure is applied. The flame is produced at the tip of the welding torch. The welding heat is obtained by a mixture of oxygen and combustible gas. The gases are mixed in the required proportion in a welding torch which provides control for the welding flame. The gases used are acetylene, hydrogen, propane and butane. Common gas is oxy acetylene. The flame only melts the metal and additional metal to the weld is supplied by filler rod. A flux is used during welding to prevent oxidation and to remove impurities. Metal 2 mm to 50 mm thick are welded. The temperature of the flame is about 3200 oC. There are two types of oxy acetylene systems, one is High pressure and the other is Low pressure system.

**GAS WELDING EQUIPMENTS:** 1) Gas cylinders: Oxygen in Black colour, Acetylene in maroon colour. 2) Pressure regulators: Each cylinder is fitted with pressure regulator. It is used to control the working pressure of the gases. Oxygen 0.7 to 2.8 kg/cm2 Ace 0.07 to 1.03 kg/cm2

3) Pressure gauges: Each cylinder is fitted with two pressure gauges. One is for cylinder pressure and the other one is working pressure pressure for welding.

4) Hoses: Each cylinder is connected to the torch through two long hoses. It should be flexible, strong, and light. Oxygen is fitted with black colour and Ace in red colour.

5) Welding torch: Oxygen and ace enters the torch through the hose is separate passage. Both the gases are mixed in the mixing chamber of the torch. When it is ignited a flame will be produced at the tip of the torch called nozzle. Two control valves are used to control the quantity of oxygen and ace to adjust the flame.The nozzles are made of copper and available in different sizes depending upon the type of metal to be welded.

6) Goggles: It is used the protect eyes from the flame heat, ultraviolet and infrared rays.

7) Welding gloves: It is used to protect hand from the injury by heat and metal splashes. 8) Spark lighter: It is an igniter to start the burning of the oxy ace gases. 9) Wire brush: It is used to clean the weld joint before and after welding.

**ARC WELDING:** The heat is developed by an electric arc. The arc is produced between and electrode and the work. It is a process of joining two metals by melting their edges by an electric arc. The electrical energy is converted to heat energy. The gap between the electrode and the work is 3mm. The current is passed through the workpiece and the electrode to produce an electric arc. The workpiece is melted by the arc. The electrode is also melted and hence both the workpieces becomes a single piece without applying any external pressure. The temperature of the arc is 5000 to 6000 o C. A transformer or generator is used for supplying the current. The depth to which the metal is melted and deposited is called Depth of fusion. To obtain better depth of fusion the electrode is kept at 70o inclination to vertical.

**COMPARISION OF ARC WELDING AND GAS WELDING:**

| Arc welding | Gas welding |
|---|---|
| Heat is produced by electric arc | Heat is produced by the gas flame |
| The arc temperature is about 4000°C | The flame temperature is about 3200°C |
| Filler rod is used as electrode | Filler rod is introduced separately |
| It is suitable for medium and thick work | It is suitable for thin work |
| Arc weld joints have very high strength | Gas weld joints do not have much |

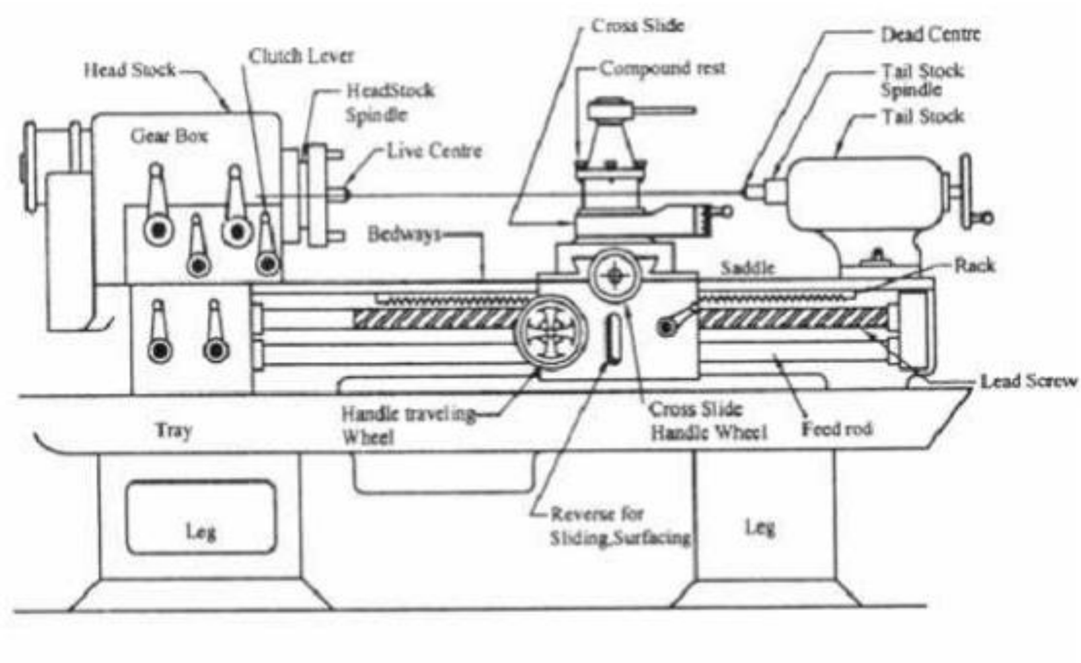
**SOLDERING:** Soldering is a process of joining two metal parts with a third metal. The third metal has a very low melting point. It is known as Solder. It is used as a filler rod. Most of the solders are alloys of tin and lead. They melt at a temp of about 215oC. The work pieces are not melted. Electrically heated soldering irons are available. The two sheets are properly cleaned to remove oil, grease, oxides and dirt. This is done by chemical cleaning, filing, or by emery cloth. Two sheets are positioned. A flux is applied using a brush. The flux prevents oxidation. The flux used is in the formof liquid or paste. The flux used are zinc chloride and hydrochloric acid. The soldering iron is heated to proper temp. It is dipped in the flux and then rubbed on the solder. This is known as tinning of the tip.
Applications: Used in electrical appliances, computers, automobile radiators.

BRAZING: It is the process of joining two similar or dissimilar metals by using a fusible alloy called “spelter”. Spelter is a harder filler rod. Its melting temp is about 600oC. This is below the melting point of the work materials. The most commonly used spelters are copper alloys and silver alloys. For brazing ferrous metals copper alloys made of copper, zinc and tin are used. Silver alloys made of silver and copper are used for any metals.

**Comparisionof Soldering and Brazing:**

| **Soldering** | **Brazing** |
|---|---|
| Filler material is known as solder | Filler material known as spelter |
| Low melting point alloys used | High melting point alloys used |
| Alloys of tin and lead are used | Copper and silver base alloys used |
| Strength of the joint is relatively low | Relatively high strength |
| Fluxes are Zinc chloride and hcl acid | Flux is borax powder |
| Mostly used for elec connections, tins and cans | Joining of dissimilar metals, |

**Machining**




Centre Lathe

Introduction:

Lathe is a machine tool, which is used to remove metal from work piece for required shape and size. This is done by holding the work piece firmly on the machine and turning it against the cutting tool, which will remove metal from the work in the form of chips.

**Center lathe:** This lathe is the most important member of lathe family and most widely used. This lathe is also known as engine lathe. The basic parts of center lathe are bed, headstock, tailstock, and carriages, cross slide, compound rest, tool post and apron.

**Bed:** It is the base of the lathe; the headstock and tailstock are located at either end of the bed and the carriage rests over the lathe bed and slides on it.

**Headstock:** It carries a hollow spindle .A live center can be fitted in to hollow spindle. The live center rotates with the work piece and hence called live center.

**Tailstock:** It is mounted on the bed at right angles end. It is used for supporting the right end of the work piece by means of a dead center. The dead center does not revolve with the work piece and hence called dead center.

**Carriage:** It is supported on the lathe bed ways and can move in a direction parallel to the lathe axis .It carries saddle, cross slide, compound rest, tool post and apron. It is a H- shaped casting fitted over the bed. It moves along the guide way.

**Cross slide:** It carries the compound rest and tool post. It is mounted on the top of the saddle. It may be moved by hand or may be given feed through apron mechanism.

**Compound rest:** It is mounted on the cross –slide .It carries a circular bar called swivel plate, which is graduated on degrees. The upper part is known as the compound slide, and it can be moved by means of the hand wheel.

**Tool post:** The tool post is fitted over the compound rest. the tool is clamped in the tool post.

**Apron:** Lower part of the carriage is termed as the apron. It is attached to the saddle and hangs in front of the bed .It contains gear, clutch and lever for moving the carriage by a hand wheeler power feed.

**Feed mechanism:** The movement of tool relative to the work is termed as feed. A lathe may have three types of feed: longitudinal, cross, and angular feed. The feed mechanisms have different units through which motion id transmitted from the head stock spindle to the carriage. Following are the units: end of bed gearing, feed gear box, feed rod and lead screw, apron mechanism.

**Specification of lathe:** Specifying a lathe should possess the following details: The length of the bed

- The length between centers
- The height of centers from the bed
- The swing diameter of work over bed.
- The swing diameter of work over bed
- The swing diameter of work over carriage
- The maximum bar diameter which will pass through the hole ofϖ head stock spindle.

**Important operations of a lathe:**

**Turning:** The work piece is held in the chuck or between the centers. The turning tool is held parallel to the axis of the lathe spindle and a cylindrical surface is produced. For rough turning, the rate of feed of the tool is fast and the depth of cut is heavy. For rough turning the depth of cut may be from 2 to 5mm.For finishing turning the feed and depth of cut will be small. For this a finish turning tool is used and the depth of cut may be from 0.5 to 1mm.

**Facing:** Facing is the machining of the end face of the work piece to make it flat. The work piece may be held in the chuck as between the centers. A facing too is fed perpendicular to the axis of operation of the work piece. Only the face of the tool is machined in this processes and hence called facing.

**Chamfering:** It is the process of leveling extreme end of the work piece. This is done to protect the end of the work piece from getting damaged. This operation is performed after turning, drilling, boring etc., It is a critical operation to be performed after thread cutting so that the end may pass firstly on the threaded work piece.

**Knurling:** The adjustment screw of a micrometer is not smooth either axis cross or diamond shaped pattern is seen. The process by which such patterns are made is call knurling. It is done to give good gripped surface on the work piece. The teeth may be fine, medium or coarse. Very slow speeds are adapted for knurling.

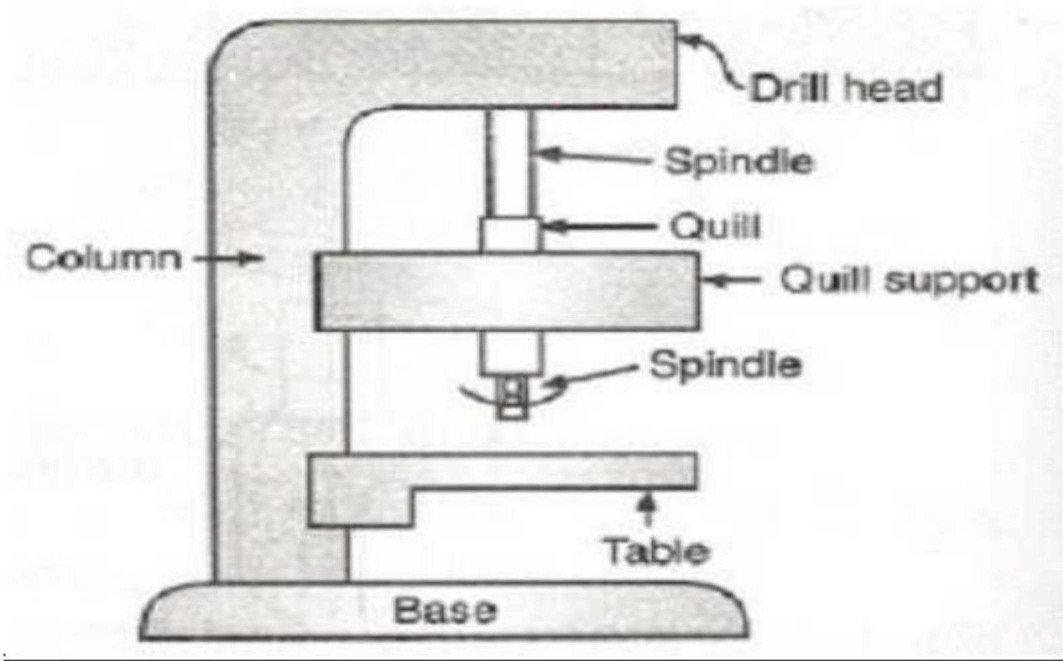
**Reaming:** The operations for finishing a drilled or bored hole for smooth finishing are called as reaming. The tool used is called as reamer. It has multiple cutting edges. The reamer is fitted in the tail stock spindle.

**Drilling:** It is an operation for making a hole on a work piece. For drilling, work piece is held in the chuck on one side where as the other side remains free. The tool for drilling is called drill. The drill is inserted on the tailstock. When the job rotates, the drill bit is inserted in the tailstock by rotating the hand wheel.

**Boring:** It is a process for enlarging a hole produced by drilling. Boring itself cannot produce a hole. The work piece is held in a chuck or face plate. The boring tool is fixed and fed into the job.

**Taper turning:** A large number of components used in engineering have a conical shape or a tapered shape. A taper is defined as the uniform change in diameter measured along its length.

**DRILLING MACHINE**




DRILLING MACHINE

**Introduction:** In a drilling machine holes may be drilled quickly and at a low cost. The hole is generated by the rotating edges of a cutting tool known as the drill, which exerts large force on the work clamped on the table.

Types of drilling machine: 1. Portable
2. Sensitive
3. Upright
4. Radial
5. Gang
6. Multiple spindle
7. Automatic
8. Deep hole

**Principle parts of Radial drilling machine:**
**Base:** The base is a large rectangular casting that it is mounted on its one end vertically it supports radial arm, electrical motor. Which impacts vertical adjustment of the arm by rotating a screw. **Column:** The column is a cylindrical casting, it supports radial arm which may slide up or down on its face. An electric motor is mounted at the top of the column, which impacts vertical adjustments of the arm by rotating a screw passing through a nut to the arm.
**Radial arm:** Radial arm is mounted on the column horizontally over the base; the arm may be swung round the column. In some machines this movement is controlled by a separate motor.
**Drill Head:** Drill Head is mounted on the radial arm and drills spindle is driven. All the mechanism is housed with in a small drill head. The drill head is properly adjusted and clamped on the radial arm.

**Introduction to CNC machines:**

Computer Numeric Control (CNC) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium (computer command module, usually located on the device) as opposed to controlled manually by hand wheels or levers, or mechanically automated by cams alone. Most NC today is computer (or computerized) numerical control (CNC), in which computers play an integral part of the control. In modern CNC systems, end-to-end component design is highly automated using computeraided design (CAD) and computer-aided manufacturing (CAM) programs.

The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine by use of a post processor, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools – drills, saws, etc. – modern machines often combine multiple tools into a single "cell". In other installations, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD design.

**Definition**

Computer Numerical Control (CNC) is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the work piece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off.

**Applications**

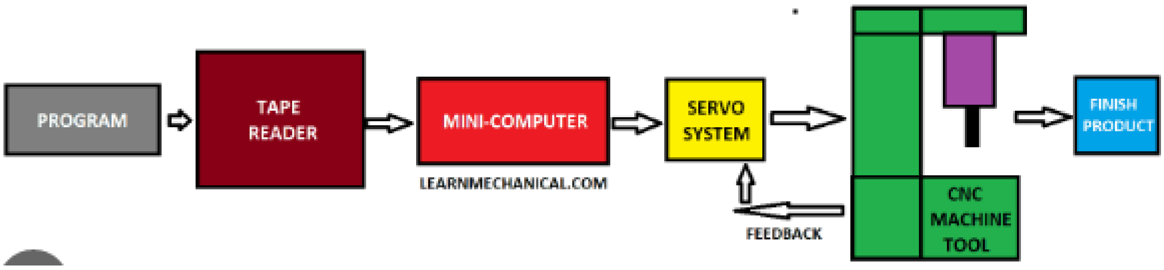
The applications of CNC include both for machine tool as well as non-machine tool areas. In the machine tool category, CNC is widely used for lathe, drill press, milling machine, grinding unit, laser, sheet-metal press working machine, tube bending machine etc. Highly automated machine tools such as turning centre and machining centre which change the cutting tools automatically under CNC control have been developed. In the non-machine tool category, CNC applications include welding machines (arc and resistance), coordinate measuring machine, electronic assembly, tape laying and filament winding machines for composites etc.

**Advantages and Limitations**

The benefits of CNC are (1) high accuracy in manufacturing, (2) short production time, (3) greater manufacturing flexibility, (4) simpler fixturing, (5) contour machining (2 to 5 -axis machining), (6) reduced human error. The drawbacks include high cost, maintenance, and the requirement of skilled part programmer.

ELEMENTS OF A CNC A CNC

system consists of three basic components: Part Program 1 . Part program 2 . Machine Control Unit (MCU) 3 . Machine tool (lathe, drill press, milling machine etc) The part program is a detailed set of commands to be followed by the machine tool. Each command specifies a position in the Cartesian coordinate system (x,y,z) or motion (workpiece travel or cutting tool travel), machining parameters and on/off function. Part programmers should be well versed with machine tools, machining processes, effects of process variables, and limitations of CNC controls. The part program is written manually or by using computer assisted language such as APT (Automated Programming Tool).




# 3D printing

Principle - Stacking two-dimensional layers to form three dimensional objects - Producing 2D layers is relatively simple - Parts usually need to be supported from below

STL file – From CAD, 3D-scan, etc. “Slicing” to multiple layers, toolpath calculated for each Part production using calculated paths.

**Advantages of 3D Printing** – Freedom of design – complexity is free Form optimization, pre-assembly, easy customization..

– No need for tooling No cost from design changes & cheap small volume prod. – No need for inventory On-demand manufacturing, minimal investment,

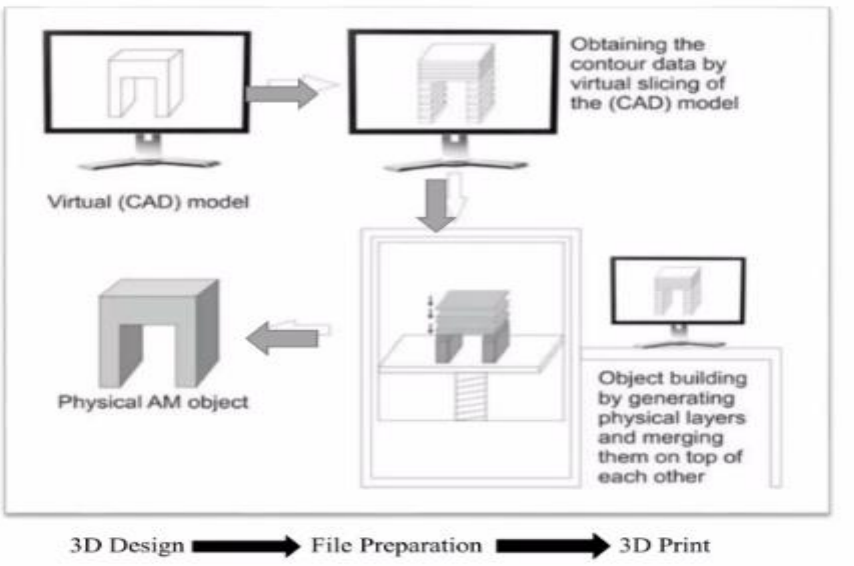
– Fast lead times & responsiveness Quick alteration in design to respond to customer needs

– Localized manufacturing Manufacturing where needed, savings in logistics

– Wide material range

– seamless transitions Innovation potential with new opportunities

– Affordable low volume production Price per piece constant regardless of production size.



- The design should be then converted into an Stl file format ie; StereoLithography format, based on which the 3D printer(s) works.
- This format slices the designed object or part into spatial orientations like x,y,z-axis and each orientations confirms the machine on how to proceed with the process of manufacturing.
- 3D CAD designs can be of any complex dimensions and shapes and wholly could be produced in a 3D printer within less time compared to the conventional methods.
- Thermoplastics are the raw materials commonly used globally were PLA is the prime material used. Other materials like ABS, NYLON, PLA etc.
- 3D printing could be also done using digital files from scanners that scans the object and produce the stl formats.
- The advantage of using a 3D printer is that there will be no wastage of materials used, since its controlled via a computer.
- There is no requirement of any moulding or casting for the production of designed prototype which saves money and time!

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## What Is Steam Boiler?

**Steam boiler** is nothing but a closed vessel combustion chamber which generates steam at a desired pressure by the combustion of fuel to water. Steam is supplied to the ***steam boiler*** in differen field like steam engine,steam turbine,thermal power plant,various heating installation process,different cotton mills,sugar factories etc.

## Working principle of steam boiler

**Working principle of steam boiler** is very very simple. Steam boiler is a cylindrical shape closed vessel which has sufficient capacity to contain water and steam. Generally, water or other fluid is stored in steam boiler to generate steam.This water or fluid is heated by flames or hot gasses which are produced by combustion of fuels and consequently steam is generated in the boiler at different pressure according to boiler's size and it's specification.This steam is now passed through a pipe and supplied into different production unit,power plant etc.This is very basic **working principle of steam boiler**.

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### Component of steam boiler

1. Boiler shell
2. Combustion chamber
3. Grate
4. Furnace
5. Heating surface

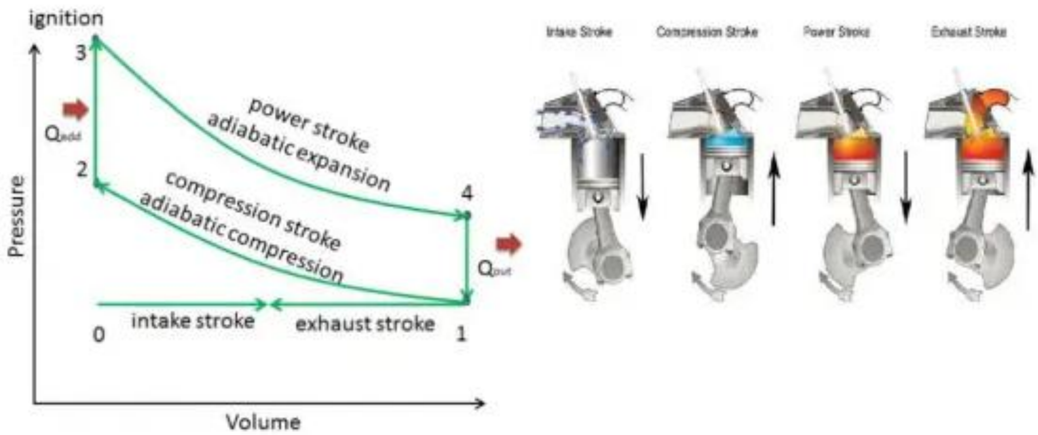
6. Mounting

**7. Boiler accessories**

a) Water level indicator
b) Pressure gauge
c) Safety valve
d) Stop valve
e) Blow off cock
f) Feed check valve
g) Fusing plug

# Otto cycle:

The Otto cycle, also referred to as the spark-ignition cycle, is the fundamental thermodynamic cycle used in petrol engines. It operates on the principle of constant volume combustion and consists of four processes: intake, compression, combustion, and exhaust.




1-2 (Adiabatic process): In this process compression takes place, as the piston moves from BDC to TDC increasing its temperature

2-3 (Isochoric process): In this process, ignition is taking place, combustion happens when the piston is at TDC and pressure increases at a constant volume.

3-4 (Adiabatic process): In this process expansion is taking place, the heat produced due to the combustion pushes the piston down which rotates the crankshaft.

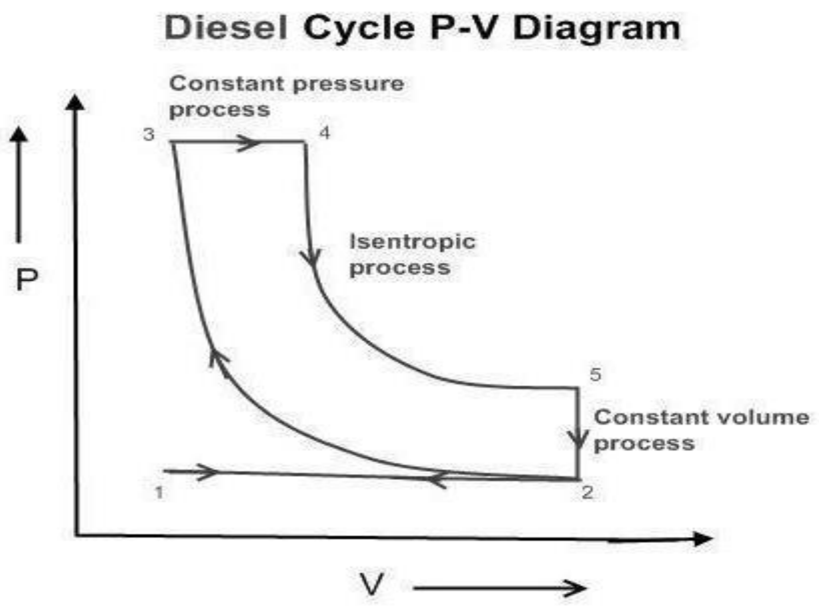
4-1 (Isochoric process): In this process, heat rejection is taking place at constant volume.

The compression ratio of the otto cycle is 8 to 12.

The efficiency of otto cycle is

# Diesel cycle:

The Diesel cycle is a thermodynamic process that is commonly used in diesel engines for internal combustion. It operates on the principle of constant pressure combustion and consists of four distinct processes: intake, compression, combustion, and exhaust.




1-2 In this process suction takes place

2-3 (Adiabatic process) In this process compression takes place. Both the inlet and exhaust valves are closed and the compression takes place which is much higher than that of an otto cycle. This increases the pressure and temperature.

3-4 (Isobaric process) In this process, fuel is added, and combustion occurs due to high temperature, while maintaining a constant pressure because the volume is also increasing.

4-5 (Adiabatic process) In this process expansion takes place, due to combustion the piston moves from TDC to BDC and power is generated.

5-2 (Isochoric process) In this process, heat rejection is taking place at constant volume.

Compression ratio is 14 to 22.

## The Refrigeration and air-condition Cycle:

An air conditioner works using a thermodynamic cycle called the refrigeration cycle. It does this by changing the pressure and state of the refrigerant to absorb or release heat.

The refrigerant (aka coolant) absorbs heat from inside of your home and then pumps it outside.

Most air conditioners are **air-source, split systems**. What this means is that there is one unit inside and one unit outside, which is why it is called a split system.

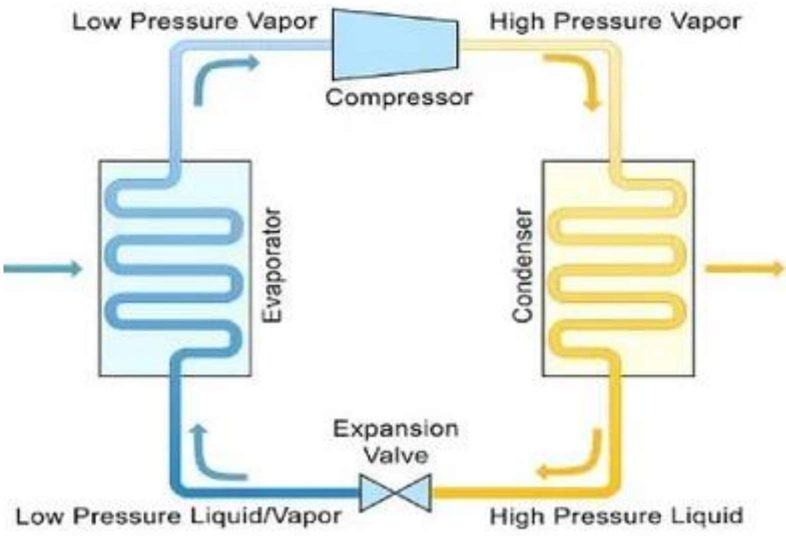
The air-source part refers to the place where the thermal energy is dumped, the outside air. There are other potential places where the heat can be transferred, such as water or ground, known as **water-source**, or **ground-source systems**.

The **inside unit** is normally inside the house somewhere, in the attic, basement, closet or crawl space. The **outside unit** is normally located on the side or back of the building.

Other kinds of air conditioning systems, such as ground-source and water-source, follow the refrigeration cycle, but some of the specifics, such as location and parts may differ.

**Here are the basic parts of the refrigeration cycle (the same process that your refrigerator used to keep food cold):**

- The compressor
- The condenser
- The expansion device
- The evaporator




### The compressor

Compression is the first step in the refrigeration cycle, and a compressor is the piece of equipment that increases the pressure of the working gas. Refrigerant enters the compressor as low-pressure, low-temperature gas, and leaves the compressor as a high-pressure, high-temperature gas.

### The condenser

The condenser, or condenser coil, is one of two types of heat exchangers used in a basic refrigeration loop. This component is supplied with high-temperature high-pressure, aporized refrigerant coming off the compressor. The condenser removes heat from the hot refrigerant vapor gas vapor until it condenses into a saturated liquid state, a.k.a. condensation.

**Expansion device:** create a drop in pressure after the refrigerant leaves the condenser. This pressure drop will cause some of that refrigerant to quickly boil, creating a two-phase mixture.

**Evaparator:** This happens when refrigerant enters the evaporator as a low temperature liquid at low pressure, and a fan forces air across the evaporator's fins, cooling the air by absorbing the heat from the space in question into the refrigerant.

**IC engines**

CONSTRUCTION OF AN IC ENGINE I.C. engine converts the reciprocating motion of piston into rotary motion of the crankshaft by means of a connecting rod. The piston which reciprocating in the cylinder is very close fit in the cylinder. Rings are inserted in the circumferential grooves of the piston to prevent leakage of gases from sides of the piston. Usually a cylinder is bored in a cylinder block and a gasket, made of copper sheet or asbestos is inserted between the cylinder and the cylinder head to avoid ant leakage. The combustion space is provided at the top of the cylinder head where combustion takes place. The connecting rod connects the piston and the crankshaft. The end of the connecting rod connecting the piston is called small end. A pin called gudgeon pin or wrist pin is provided for connecting the piston and the connecting rod at the small end. . The other end of the connecting rod connecting the crank shaft is called big end. When piston is moved up and down, the motion is transmitted to the crank shaft by the connecting rod and the crank shaft makes rotary motion. The crankshaft rotates in main bearings which are fitted the crankcase. A flywheel is provided at one end of the crankshaft for smoothing the uneven torque produced by the engine. There is an oil sump at the bottom of the engine which contains lubricating oil for lubricating different parts of the engine.

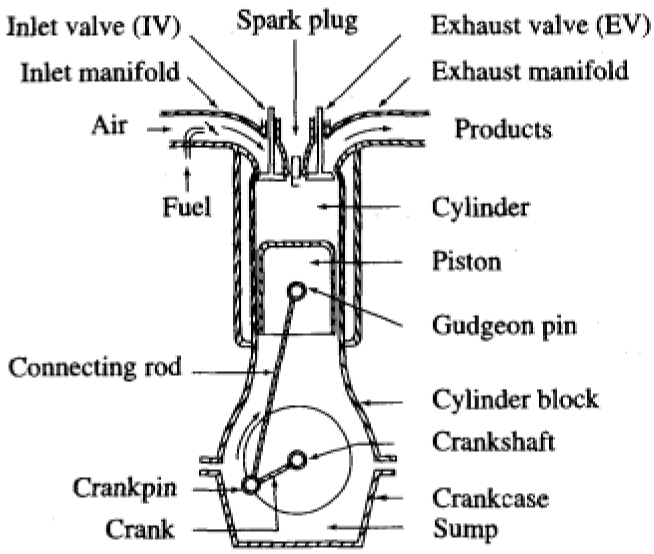



*Fig. 1.2 Cross-section of spark-ignition engine*

**ENGINE COMPONENTS**

Internal combustion engine consists of a number of parts which are given below :

**Top dead centre –**

When the piston is at the top of its stroke, it is said to be at the top dead centre (TDC),

**Bottom dead centre -** when the piston is at the bottom of its stroke, it is said to be at its bottom dead centre (BDC).

i) **Cylinder:** It is a part of the engine which confines the expanding gases and forms the combustion space. It is the basic part of the engine. It provides space in which piston operates to suck the air or air-fuel mixture. The piston compresses the charge and the gas is allowed to expand in the cylinder, transmitting power for useful work. Cylinders are usually made of high grade cast iron.

ii) **Cylinder block:** It is the solid casting body which includes the cylinder and water jackets (cooling fins in the air cooled engines).

iii) **Cylinder head:** It is a detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plugs or injector and valves.

iv) **Cylinder liner or sleeve:** It is a cylindrical lining either wet or dry type which is inserted in the cylinder block in which the piston slides. Liners are classified as : (1) Dry liner and (2) Wet liner. Dry liner makes metal to metal contact with the cylinder block casing. wet liners come in contact with the cooling water, whereas dry liners do not come in contact with the cooling water.

v) **Piston:** It is a cylindrical part closed at one end which maintains a close sliding fit in the engine cylinder. It is connected to the connecting rod by a piston pin. The force of the expanding gases against the closed end of the piston, forces the piston down in the cylinder. This causes the connecting rod to rotate the crankshaft . Cast iron is chosen due to its high compressive strength. Aluminum and its alloys preferred mainly due to it lightness.

vi) Head (Crown) of piston: It is the top of the piston. Skirt: It is that portion of the piston below the piston pin which is designed to adsorb the side movements of the piston. vi) Piston ring: It is a split expansion ring, placed in the groove of the piston. They are usually made of cast iron or pressed steel alloy (Fig.3). The function of the ring are as follows :

vii) **Compression ring** Compression rings are usually plain, single piece and are always placed in the grooves of the piston nearest to the piston head. They prevent leakage of gases from the cylinder and helps increasing compression pressure inside the cylinder. Oil ring: Oil rings are grooved or slotted and are located either in lowest groove above the piston pin or in a groove above the piston skirt. They control the distribution of lubrication oil in the cylinder and the piston. Piston Pin: It is also called wrist pin or gudgeon pin. Piston pin is used to join the connecting rod to the piston.

viii) **Connecting rod:** It is special type of rod, one end of which is attached to the piston and the other end to the crankshaft . It transmits the power of combustion to the crankshaft and makes it rotate continuously. It is usually made of drop forged steel.

ix) **Crankshaft:** It is the main shaft of an engine which converts the reciprocating motion of the piston into rotary motion of the flywheel . Usually the crankshaft is made of drop forged steel or cast steel. The space that supports the crankshaft in the cylinder block is called main journal, whereas the part to which connecting rod is attached is known as crank journal. Crankshaft is provided with counter weights throughout its length to have counter balance of the unit.

**WORKING PRINCIPLE OF I.C. ENGINE/ FOUR STROKE CYCLE ENGINE / TWO STROKE CYCLE ENGINE**

A mixture of fuel with correct amount of air is exploded in an engine cylinder which is closed at one end. As a result of this explosion, heat is released and this heat causes the pressure of the burning gases to increase. This pressure forces a close fitting piston to move down the cylinder. The movement of piston is transmitted to a crankshaft by a connecting rod so that the crankshaft rotates and turns a flywheel connected to it. Power is taken from the rotating crank shaft to do mechanical work. To obtain continuous rotation of the crankshaft the explosion has to be repeated continuously.

Before the explosion to take place, the used gases are expelled from the cylinder, fresh charge of fuel and air are admitted in to the cylinder and the piston moved back to its starting position. The sequences of events taking place in an engine is called the working cycle of the engine. The sequence of events taking place inside the engine are as follows

1. Admission of air or air-fuel mixture inside the engine cylinder ( suction )
2. Compression of the air or air fuel mixture inside the engine (compression)
3. Injection of fuel in compressed air for ignition of the fuel or ignition of air-fuel mixture by an electric spark using a spark plug to produce thermal power inside the cylinder (power )
4. Removal of all the burnt gases from the cylinder to receive fresh charge ( exhaust) Note: Charge means admitting fresh air in to the cylinder in the case of compression ignition engines ( diesel engines ) or admitting a mixture of air and fuel in to the cylinder in the case of spark ignition engines.

**FOUR STROKE CYCLE ENGINE ( DIESEL/ PETROL ENGINE)** In four stroke cycle engines the four events namely suction, compression, power and exhaust take place inside the engine cylinder. The four events are completed in four strokes of the piston (two revolutions of the crank shaft). This engine has got valves for controlling the inlet of charge and outlet of exhaust gases. The opening and closing of the valve is controlled by cams, fitted on camshaft. The camshaft is driven by crankshaft with the help of suitable gears or chains. The camshaft runs at half the speed of the crankshaft. The events taking place in I.C. engine are as follows: 1. Suction stroke 2. Compression stroke 3. Power stroke 4. Exhaust stroke

**Suction stroke**

During suction stroke inlet valve opens and the piston moves downward. Only air or a mixture of air and fuel are drawn inside the cylinder. The exhaust valve remains in closed position during this stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke.

**Compression stroke**

During this stroke the piston moves upward. Both valves are in closed position. The charge taken in the cylinder is compressed by the upward movement of piston. If only air is compressed, as in case of diesel engine, diesel is injected at the end of the compression stroke and ignition of fuel takes place due to high pressure and temperature of the compressed air. If a mixture of air and fuel is compressed in the cylinder, as in case of petrol engine, the mixture is ignited by a spark plug.

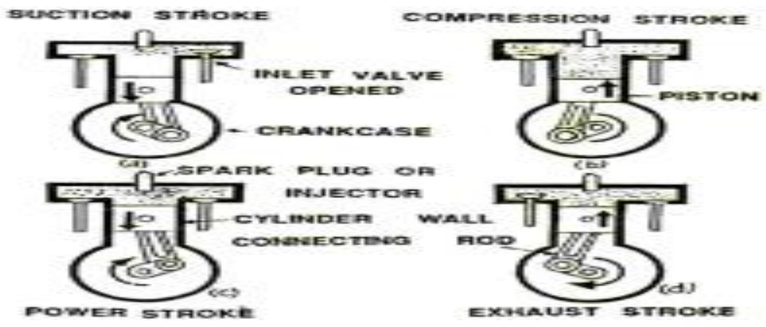
**Power stroke**

After ignition of fuel, tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston downward .The downward movement of the piston at this instant is called power stroke. The connecting rod transmits the power from piston to the crank shaft and crank shaft rotates. Mechanical work can be taped at the rotating crank shaft. Both valves remain closed during power stroke.

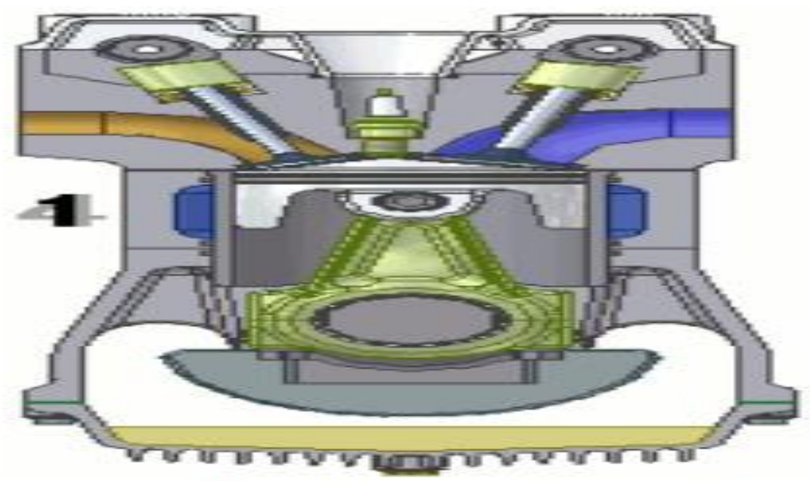
**Exhaust stroke**

During this stroke piston moves upward. Exhaust valve opens and exhaust gases go out through exhaust valves opening. All the burnt gases go out of the engine and the cylinder becomes ready to receive the fresh charge. During this stroke inlet valve remains closed (Fig.1d). Thus it is found that out of four strokes, there is only one power stroke and three idle strokes in four stroke cycle engine.

The power stroke supplies necessary momentum for useful work.



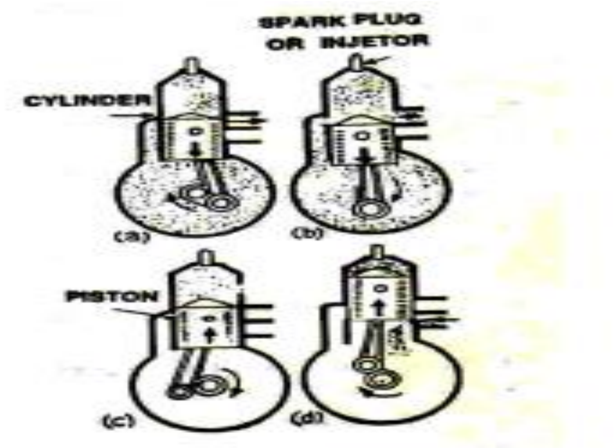

Four stroke cycle engine

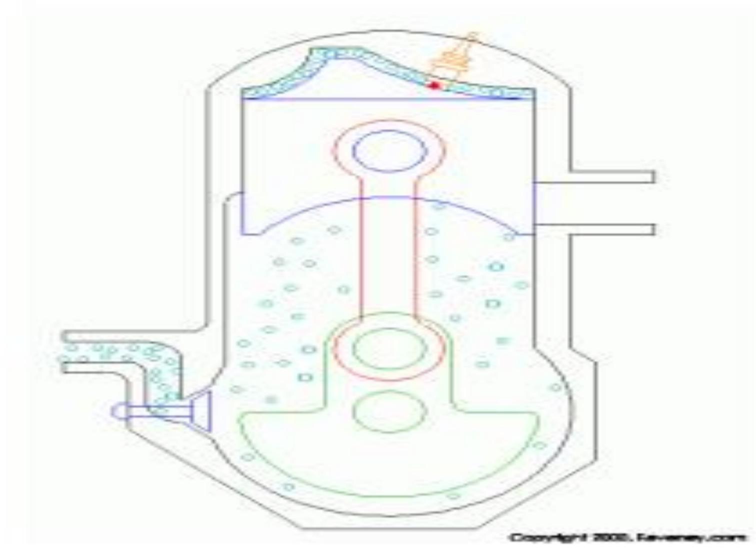


Four stroke cycle engine

**TWO STROKE CYCLE ENGINE (PETROL ENGINE)**

In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder. The crankcase of the engine is air tight in which the crankshaft rotates.



Two stroke cycle

**Upward stroke of the piston (Suction + Compression)**

When the piston moves upward it covers two of the ports, the exhaust port and transfer port, which are normally almost opposite to each other. This traps the charge of air- fuel mixture drawn already in to the cylinder. Further upward movement of the piston compresses the charge and also uncovers the suction port. Now fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited by a spark plug .Thus, during this stroke both suction and compression events are completed.

**Downward stroke (Power + Exhaust)**

Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port. Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases . During the downward stroke of the piston power and exhaust events are completed.

## COMPARISON BETWEEN SI AND CI ENGINES (GENERAL COMPARISON):

| S. NO. | Spark Ignition Engines (SI) | Compression Ignition Engines (CI) |
|---|---|---|
| 1 | It draws air fuel mixture into the cylinder during suction stroke | It draws only air into the cylinder during suction stroke. |
| 2 | Petrol engines operate with low pressure and temperature | Diesel engines operate with high pressure and temperature |
| 3. | Pressure ranges from 6 to 12 bar Temperature ranges from 250°C to 300°C | Pressure ranges from 35 to 40 bar Temperature ranges from 600oC to 700oC |
| 4 | It is fitted with carburettor and spark plugs | It is fitted with fuel injection pump and injectors |
| 5 | The burning of fuel takes place at constant volume | The burning of fuel takes place at constant pressure |
| 6. | Ignition of air fuel mixture takes place by an electric spark produced by spark plug | Ignition of air fuel takes placed by a injection of fuel into the hot compressed air. |
| 7 | Petrol engines are quality governed engines. The speed of petrol engines are controlled by varying the quantity of air fuel mixture. | Diesel engines are quantity governed engines. The speed of diesel engines is controlled by varying quality of air fuel mixture. (rich or weak mixture) |
| 8 | Petrol engines are widely used in automobiles and aeroplanes etc., | Diesel engines are widely used in heavy vehicles, such as buses, lorries, trucks etc., |

## Difference Between 2 Stroke and 4 Stroke Engine

| 2 Stroke | 4 Stroke |
|---|---|
| It can generate one revolution of the crankshaft within one power stroke, i.e.one power stroke per 360 degrees rotation of the crankshaft. | It can generate two revolutions of the crankshaft between one power stroke i.e., one power stroke in every 720 degrees rotation of the crankshaft. |
| Uses port for inlet and outlet of fuel. | Uses valve for inlet and outlet. |
| It requires a lighter flywheel to cause a more balanced force due to one revolution for one power stroke. | It requires heavy flywheel because it gives rise to unbalanced forces due to two revolutions for one power stroke. |
| Cheaper in price as they require less effort in manufacturing and are light by weight. | Hard to manufacture due to the heavy flywheel and valve mechanism and are expensive due to the valve and lubrication mechanism. |
| Generates more torque at a higher rpm. | Generates a higher torque at a lower rpm. |
| The charge is partially burnt and it gets mixed with the burnt gases during inlet. | The charge is fully burnt and doesn't get mixed with the gases inside the cylinder. |
| More power generation. | Less power generation. |
| Produces more heat so it requires greater cooling and lubrication. | Generates less heat. |
| Lower thermal efficiency | Higher thermal efficiency |

## Hybrid Electric Vehicle (HEV):

A Hybrid Electric Vehicle is a type of vehicle that uses a combination of an Internal Combustion (IC) engine and an electric propulsion system. The electric powertrain may enhance fuel efficiency, increase performance, or independently propel the vehicle on pure electric power, depending on the type of hybrid system.

In simple words, an HEV is a vehicle that comprises a conventional fuel engine and an electric powertrain, wherein the electric motor assists the engine to extract more performance, and better fuel economy, depending on the type of the system. We will elaborate on the kinds of HEVs in the following sections of this article.

components of a Hybrid Electric Vehicle

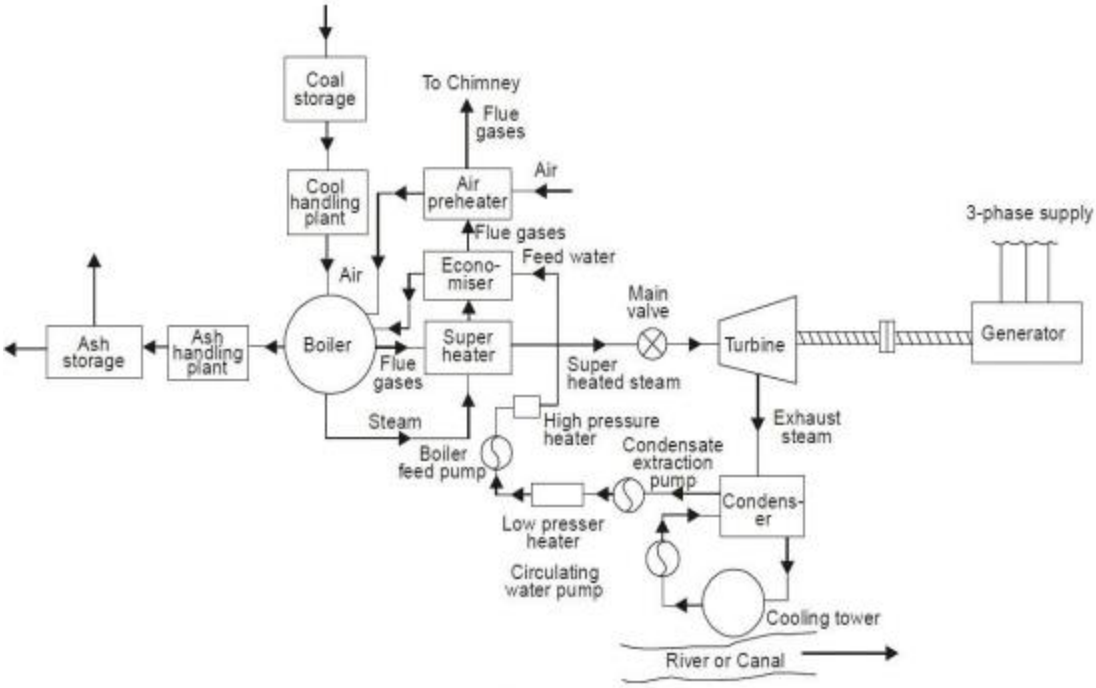
As mentioned before, an HEV combines a conventional engine and electric powertrain. Hence, you can find engine-related and electric powertrain components in an HEV. Below are the key components of a Hybrid Electric Vehicle.

- **Internal combustion engine:** The primary power source of an HEV is a conventional engine. Hence, it is the main component responsible for propelling the vehicle. An HEV cannot run alone on an electric powertrain without an engine.
- **Electric motor:** The secondary power source of an HEV is the electric motor. It assists the engine during initial acceleration to improve performance and fuel economy. It runs on electrical energy stored in the battery pack. It can also charge the battery when the vehicle is braking or coasting via the regenerative braking system.
- **Battery pack:** A battery pack powers the electric motor. Basically, it acts as a fuel tank for the battery, wherein it stores the electrical energy via regenerative braking and the generator driven by the IC engine. The battery pack can also power auxiliary electrical components such as lights.
- **Generator:** It is an essential component found in the series hybrid vehicle. We will touch upon what series hybrid is in the upcoming sections. A generator draws power from the IC engine to power the electric motor and charge the battery pack. In simple words, a generator converts mechanical energy into electrical energy.
- **Transmission:** Typically, hybrid vehicles use conventional transmissions similar to petrol or diesel cars. It transmits the power produced by the IC engine to the drive shaft. The basic working principle of transmission remains the same, even in an HEV. It is one of the crucial components required to propel the vehicle.
- **Fuel tank:** Similar to a conventional car, hybrid electric vehicles also have a fuel tank to store the conventional fuel. With the electric powertrain involved in a hybrid car, the fuel consumption will be comparatively less than a vehicle purely relying on an IC engine.

UNIT-III

# Power plants:

## THERMAL/STEAM POWER PLANT:




**COMPONENTS** • High pressure boiler • Prime mover • Condensers and cooling towers • Coal handling system • Ash and dust handling system • Draught system • Feed water purification plant • Pumping system • Air Pre-heater, Economizer, Super Heater, Feed Heaters.

### High pressure Boiler:

Steam generator is a device or equipment which burns the fuel and facilitates the exchange of heatproduced to the water to generate required quantity and quality of steam. Thus, it is a heat exchanger which has the place for burning of fuel and flow of hot flue gases produced and also has space for storing of water and steam. As steam is produced & stored at high pressure than the atmospheric pressure, steam generator is also a pressure vessel. To handle the hot flue gases and to keep high pressure steam, certain other mountings and accessories are also required for its safe and efficient operation. In this way steam generator is not simply a vessel to boil water but it is a complete unit performing the complete task of producing & handling the high-pressure steam by burning of the fuel and exhausting the flue gases efficiently and safely. Most of the boilers are actually a type of shell & tube type heat exchangers

**COAL DELIVERY** The coal from supply points is delivered by ships or boats to power stations situated near to sea or river whereas coal is supplied by rail or trucks to the power stations which are situated away from sea or river. The transportation of coal by trucks is used if the railway facilities are not available.

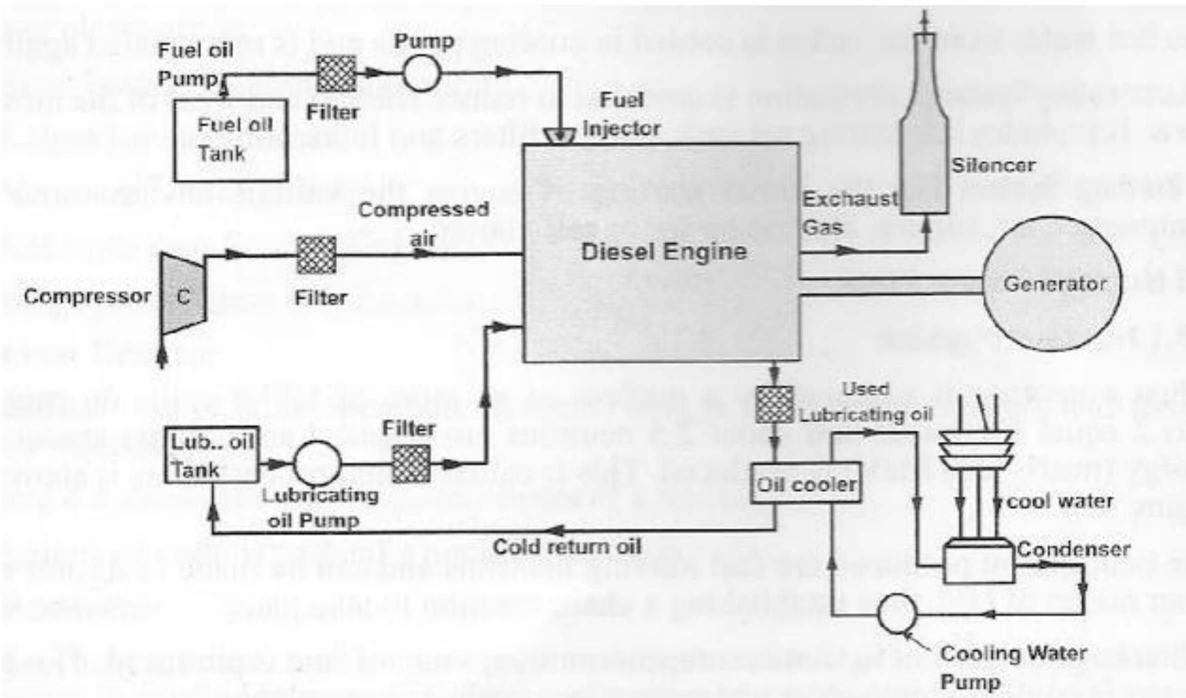
**Super heater:**

WORKING Steam stop valve is opened. The steam (wet or dry) from the evaporator drum is passed through the super heater tubes. First the steam is passed through the radiant super heater and then to the convective super heater. The steam is heated when it passes through these super heaters and converted into superheated steam.This superheated steam is supplied to the turbine through a valve

**Condenser:** Working of condensers In a jet condenser, the steam to be condensed and the cooling water come in direct contact and the temperature of the condensate is the same as that of the cooling water leaving the condenser? For jet condensers the recovery of the condensate for reuse as boiler feed water is not possible. Depending upon the arrangement of the removal of condensate, the jet condensers are subdivided in to the following categories.

**COOLING TOWERS** :A cooling tower is a semi-enclosed device for evaporative cooling of water by contact with air. It is a wooden, steel, concrete structure and corrugated surfaces or troughs or baffles or perforated trays are provided inside the tower for uniform distribution and better atomization of water in the tower. The hot water coming out from the condenser are fed to the tower on the top and allowed to tickle in the form of thin sheets or drops. The air flows from the bottom of the atmosphere after effective cooling. An evaporative cooling tower is a machine of relatively simple conception and operation. The water to be cooled for a chiller, industrial process or refrigeration installation is pumped and distributed through spray nozzles over a fill pack or heat exchange surface through which passes an air current commonly generated buy a fan. A small fraction of this water evaporates and the remainder is cooled thanks to the absorption of latent heat of evaporation by the passing air, and fall under gravity into a basin from there it is pumped back to the heat load source

## DIESEL ENGINE POWER PLANT




A generating station in which diesel engine is used as the prime mover for the generation of electrical energy is known as diesel power station. In a diesel power station, diesel engine is used as the prime mover. The diesel burns inside the engine and the products of this combustion act as the working fluid to produce mechanical energy. The diesel engine drives alternator which converts mechanical energy into electrical energy. As the generation cost is considerable due to high price of diesel, therefore, such power stations are only used to produce small power. Although steam power stations and hydro-electric plants are invariably used to generate bulk power at cheaper costs, yet diesel power stations are finding favour at places where demand of power is less, sufficient quantity of coal and water is not available and the transportation facilities are inadequate. This plants are also standby sets for continuity of supply to important points such as hospitals, radio stations, cinema houses and telephone exchanges.

**Advantages** (a) The design and layout of the plant are quite simple.

(b) It occupies less space as the number and size of the auxiliaries is small.

(c) It can be located at any place.

(d) It can be started quickly and it can pickup load in a short time.

(e) There are no standby losses.

(f) It requires less quantity of water for cooling.

(g) The overall cost is much less than that of steam power station of same capacity.

(h) The thermal efficiency of the plant is higher than that of a steam power station.

(i) It requires less operating staff

**Disadvantages**

(a) The plant has high running charges as the fuel (diesel) used is costly.

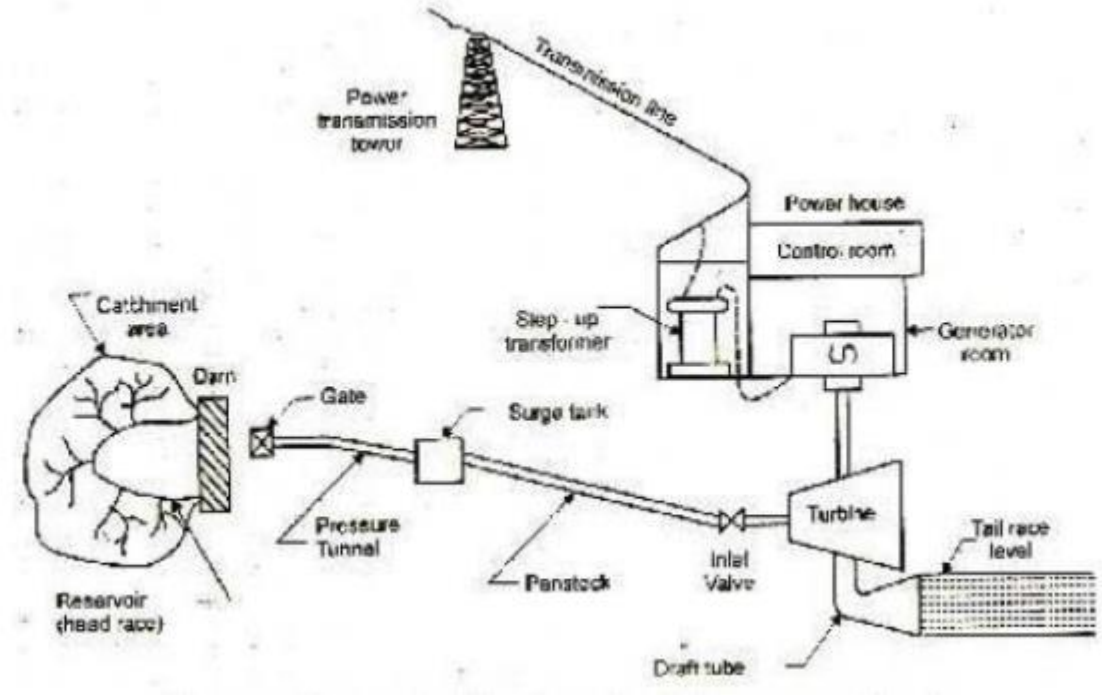
(b) The plant doesn't work satisfactorily under overload conditions for a longer period.

(c) The plant can only generate small power.

(d) The cost of lubrication is generally high. (e) The maintenances charges are generally high

**HYDEL POWER PLANT:**

Water reservoir Continuous availability of water is the basic necessity for a hydro-electric plant. Water collected from catchment area during rainy season is stored in the reservoir. Water surfaces in the storage reservoir us known as head race. Dam The function of a dam is to increase the height of water level behind it which ultimately increases the reservoir capacity. The dam also helps to increase the working heat of the power plant.




**Spillway :**Water after a certain level in the reservoir overflows through spillway without allowing the increase in water level in the reservoir during rainy season.

**Pressure tunnel** :It carries water from the reservoir to surge tank.

**Penstock:** Water from surge tank is taken to the turbine by means of penstocks, made up of reinforced concrete pipes or steel.

**Surge tank :**There is sudden increase of pressure in the penstock due to sudden backflow of water, as load on the turbine is reduced. The sudden rise of pressure in the penstock is known as water hammer. The surge tank is introduced between the dam and the power house to keep in reducing the sudden rise of pressure in the penstock. Otherwise, penstock will be damaged by the water hammer.

**Water turbine** :Water through the penstock enters into the turbine through and inlet valve. Prime movers which are in common use are Pelton turbine, Francis turbine and Kaplan turbine. The potential energy of water entering the turbine is converted into mechanical energy. The mechanical energy available at the turbine shaft is used to run the electric generator. The water is then discharged through the draft tube.

**Draft tube** It is connected to the outlet of the turbine. It allows the turbine to be placed over tail race level.

**Tail race:** Tail race is a water way to lead the water discharged from the turbine to the river. The water held in the tail race is called tail race water level.

**Power house:** The power house accommodates the turbine, generator, and transformer and control room

**NUCLEAR POWER PLANT:**

Basics Atoms consist of nucleus and electrons. The nucleus is composed of protons and neutrons. Protons are positively charged whereas neutrons are electrically neutral. Atoms with nuclei having same number of protons but difference in their masses are called isotopes. They are identical in terms of their chemical properties but differ with respect to nuclear properties.

Natural Uranium consists of $92U^{238}$ (99.282%), $92U^{235}$ (0.712%) and

$92U^{234}$ $92U^{235}$ is used as fuel in nuclear power plants.

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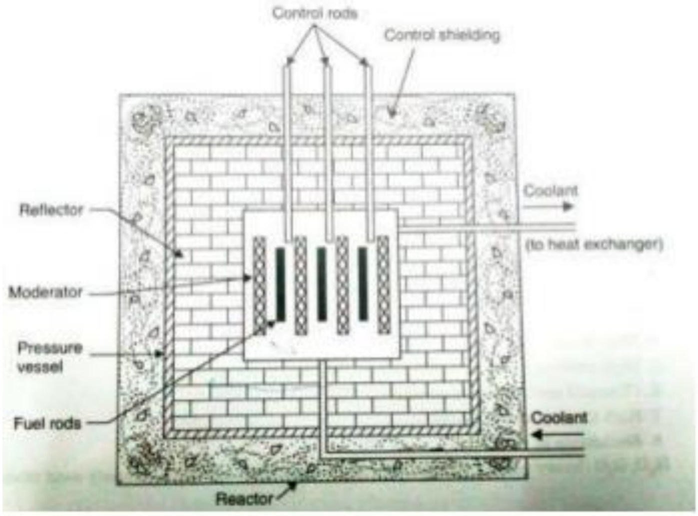
**Energy from Nuclear Reactions:** The sum of masses of protons and neutrons exceeds the mass of the atomic nucleus and this difference is called mass defect Δm. In a nuclear reaction the mass defect is converted into energy known as binding energy according to Einstein’s equation (E=Δm c2). Fissioning one amu of mass results in release of 931 MeV of energy. It has been found that element having higher and lower mass numbers are unstable. Thus the lower mass numbers can be fused or the higher mass numbers can be fissioned to produce more stable elements. This results in two types of nuclear reactions known as fusion and fission. The total energy per fission reaction of U235 is about 200 MeV. Fuel burn-up rate is the amount of energy in MW/days produced by each metric ton of fuel.

**Nuclear Fission** When unstable heavy nuclei are bombarded with high energy neutrons, it splits into several smaller fragments. These fragments, or fission products, are about equal to half the original mass. This process is called Nuclear Fission. Two or three neutrons are also emitted. The sum of the masses of these fragments is less than the original mass. This missing mass (about 0.1 percent of the original mass) has been converted into energy. Fission can occur when a nucleus of a heavy atom captures a neutron, or it can happen spontaneously.

**Nuclear Fusion Fusion :is** the opposite of fission, it is the joining together of two light nuclei to form a heavier one (plus a small fragment). For example if two 2H nuclei (two deuterons) can be made to come together they can form He and a neutron

**NUCLEAR POWER REACTORS** A nuclear reactor produces and controls the release of energy from splitting the atoms of elements such as uranium and plutonium. In a nuclear power reactor, the energy released from continuous fission of the atoms in the fuel as heat is used to make steam. The steam is used to drive the turbines which produce electricity (as in most fossil fuel plants).

**There are several components common to most types of reactors:** Fuel Usually pellets of uranium oxide (UO2) arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core. Moderator This is material which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite.




**Control Rods** These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it. (Secondary shutdown systems involve adding other neutron absorbers, usually in the primary cooling system.)

**Coolant** A liquid or gas circulating through the core so as to transfer the heat from it. In light water reactors the moderator functions also as coolant.

**Pressure Vessel** or **Pressure Tubes** Usually a robust steel vessel containing the reactor core and moderator/coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the moderator.

**Steam Generator** Part of the cooling system where the heat from the reactor is used to make steam for the turbine.

**Reflectors** Some of the neutrons produced during fission will be partly absorbed by the fuel elements, moderator, coolant and other materials. The remaining neutrons will try to escape from the reactor and will be lost. Such losses are minimized by surrounding (lining) the reactor core with a material called a reflector which will reflect the neutrons back to the core. They improve the neutron economy. Economy: Graphite, Beryllium.

**Shielding** During Nuclear fission σ α γ particles and neutrons are also produced. They are harmful to human life. Therefore it is necessary to shield the reactor with thick layers of lead, or concrete to protect both the operating personnel as well as environment from radiation hazards.

# Mechanical Power Transmission:

**BELT, ROPE AND CHANIN DRIVES:**

The belt or ropes are used to transmit power from one shaft by means of pulley which rotates at same speed or different speed. The amount of power transmission depends upon the following factors:

1. Velocity of belts.
2. The tension under which the belt is placed on the pulley.
3. The arc of contact between the belt and the smaller pilley.
4. The conditions under which the belt is used it may be noted:

a. The shafts should be properly in line to insure uniform tension across the belt tension.

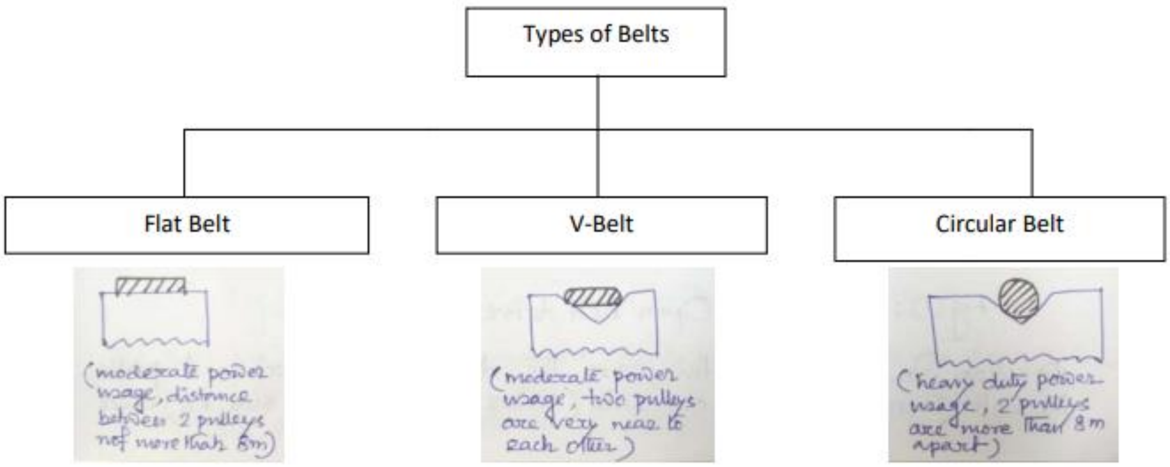
b. The pulley should not be too close together in order that the arc of contact on the smaller pulley may be as large as possible.

c. The pulleys should not be so far apart as to cause the belt to weigh heavily on the shafts, thus increasing the friction load on the bearing.

d. A long belt tends to swing from side to side causing the belt to run out of the pulleys, which in turn develops crooked spot in the belt.

e. The tight side of the belt should be at the bottom, so that whatever sag is present on the loose side will increase the arc on the pulley.

**Selection of Belt Drive:** Followings are the various important factors upon which the selection of a belt drive depends: a) Speed of the driving and driven shafts. b) Speed reduction ratio. c) Power to be transmitted. d) Centre distance between the shafts. e) Positive drive requirements. f) Shafts layout. g) Space available. h) Service conditions.



**Materials used for Belts:**

a. Leather belts
b. Cotton or fabric belts
c. Rubber belts
d. Balata belts (Similar to rubber bets, only balata gum is used in place of rubber. It generally works at a temperature below $40^{o}$ for optimum use.)

**Types of flat belt drives:**

1. **Open belt drive:** The open belt drive as shown in the below fig. is used with shafts arranged parallel and rotating in same direction. In this case, the driven A pulls the belt from one side (lower side RQ) and delivers it to the other side (upper side LM). Thus the tension in the lower side belt will be more than that of the upper side of belt. The lower side due to more tension is known as tight side & the upper side is known as slack side.

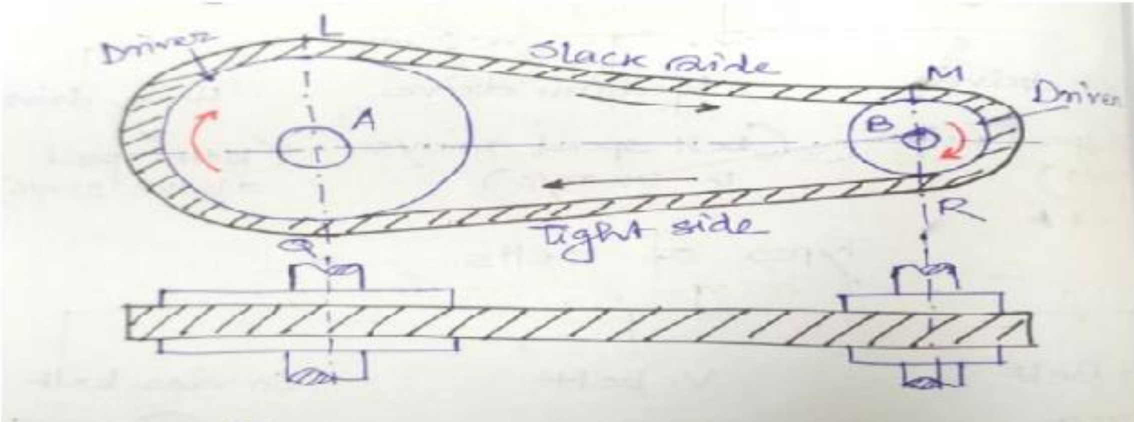
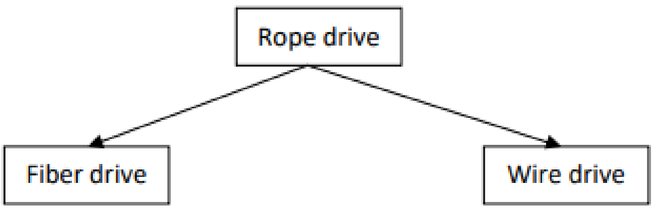



Fig (1): Open belt drive

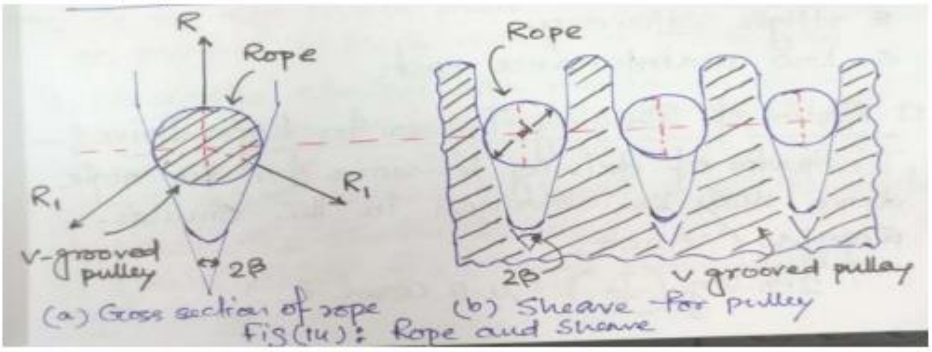
Rope drive: the rope drive widely used where a large amount of power is to be transmitted from one pulley to another, over a considerable distance. One of the main advantages of rope drives is that a number of separate drives may be taken from one driver pulley.




**Advantages of fiber rope drives:**

- They give smooth, steady and quite service.
- They are little effected by the outdoor condition.
- The power may be taken off in any direction and in fractional parts of the whole amount.
- The shaft may be out of strict alignment.
- They give high mechanical efficiency.

**Sheave for fiber ropes:**




The fiber ropes are usually circular is cross section as shown in fig. The sheave for fiber ropes shown in fig. 14(b). the groove angle of the pulley for rope drives is usually 45$^{\circ}$. The groves in the pulleys are made narrow at the bottom and the rope is pinched between the edges of the V-groove on the pulley.

Wire ropes: When a large amount of power is to be transmitted over long distance from one pulley to another (that is if two pulleys are 150m apart) then wire ropes are used. The wire ropes are widely used in elevators, mine hoist, cranes, hauling devices etc.

**Advantages:**

- Lighter in weight
- These offer silent operation
- Can withstand shock load
- More efficiency

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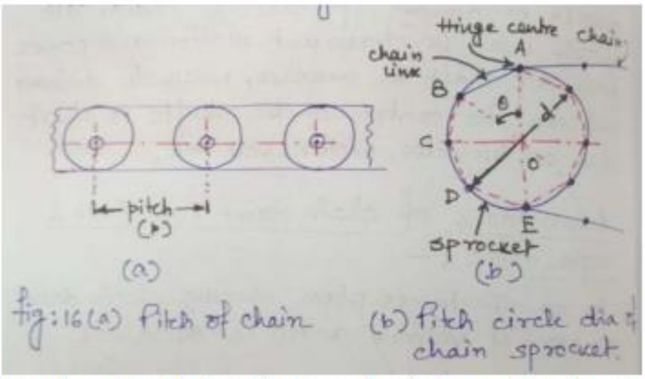
Chain drive terms & definition:

- Pitch of Chain: It is the distance between two consecutive hinge centers of two adjacent links as shown in the fig.16(a)




- Pitch circle diameter: It is the diameter of a circle on which the hinge centers of the chain lie, when the chain is wrapped around a sprocket as shown in fig. 16(b)

The points A,B,C,D,E etc. are the hinge centers of the chain and the circle drawn through these centers is called pitch circle and its dia. is known as pitch circle dia.

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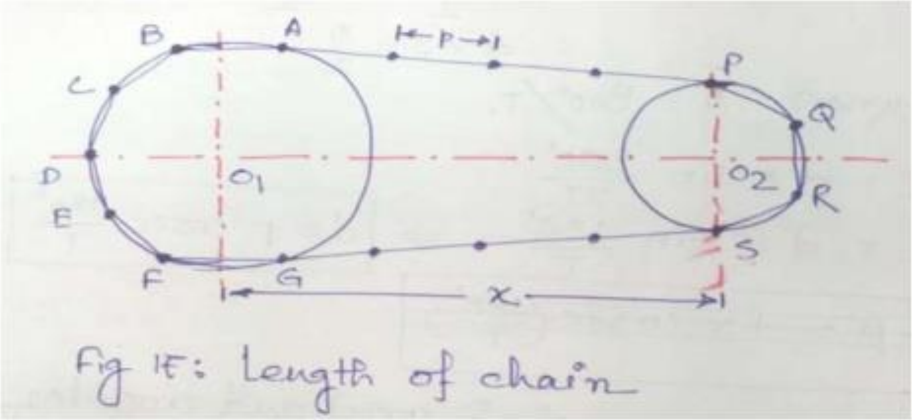
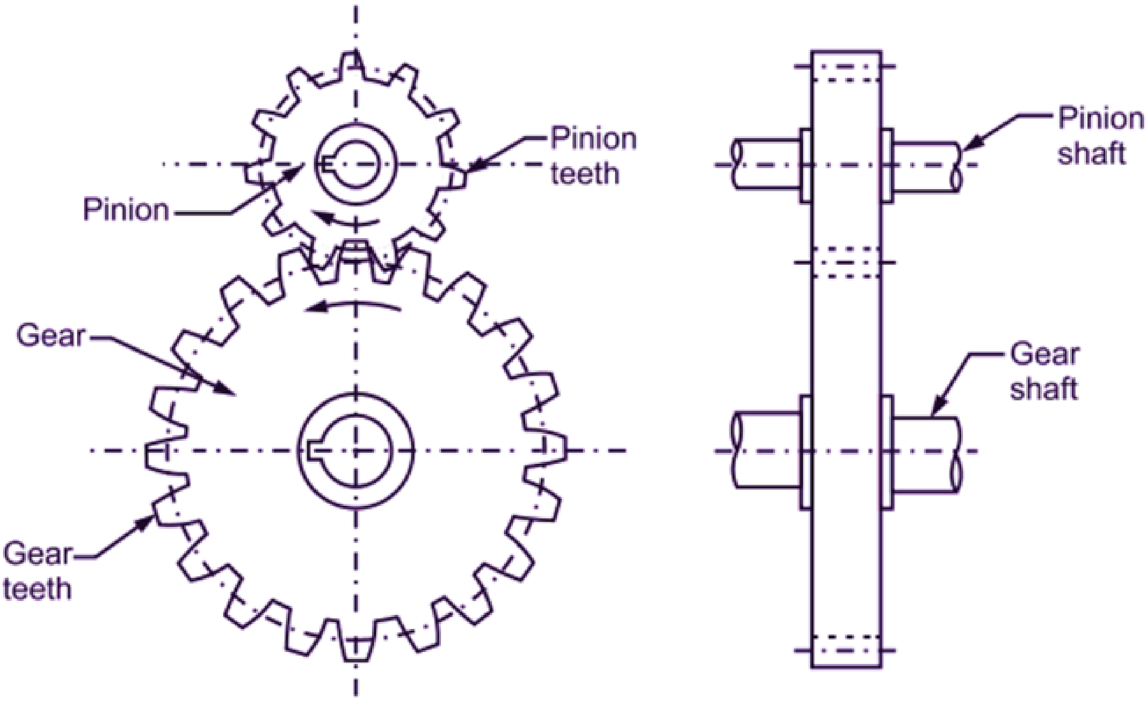
**Length of Chain:** An open chain drive system, connecting two sprockets shown fig.




## Gear drive:

Gear drive is used, when centre to centre distance between driver and driven shafts is very small. Gears are defined as, “toothed wheels, which can transmit power and motion from one shaft to another shaft by means of successive engagement of teeth. ”



It is important to note that, both the gears, which are engaged, always rotate in opposite direction. Gear drive consists of two wheels. The smaller wheel is called as pinion and the larger wheel is called as gear. Refer Fig. 1. In gear drive, slip is absent. Therefore, it gives exact and uniform velocity ratio. Due to this ability of maximum power transmission and exact velocity ratio, gear drive is called as perfect positive drive.

## Advantages of Gear Drive

1. Exact velocity ratio.
2. High efficiency.
3. Compact layout.
4. Ability of transmitting large power.
5. Reliable service.

## Applications of Gear Drive

1. Gear box of vehicle,
2. Machine tools,
3. Dial indicator,
4. Gear mechanism of wrist watches,
5. Differential mechanism of automobile,
6. Cement mixing unit.

# Introduction to Robotics

**Definition for Robot:** The Robot Institute of America (1969) defines robot as a re-programmable, multifunctional manipulator designed to move materials, parts, tools or specialized devices through various programmed motions for the performance of a variety of tasks‖. Asimov's laws of robotics:

1. A robot may not injure a human being or, through inaction, allow a human being to come toharm.
2. A robot must obey the orders given it by human beings except where such orders wouldconflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with theFirst or SecondLaws.

## ROBOT ANATOMY

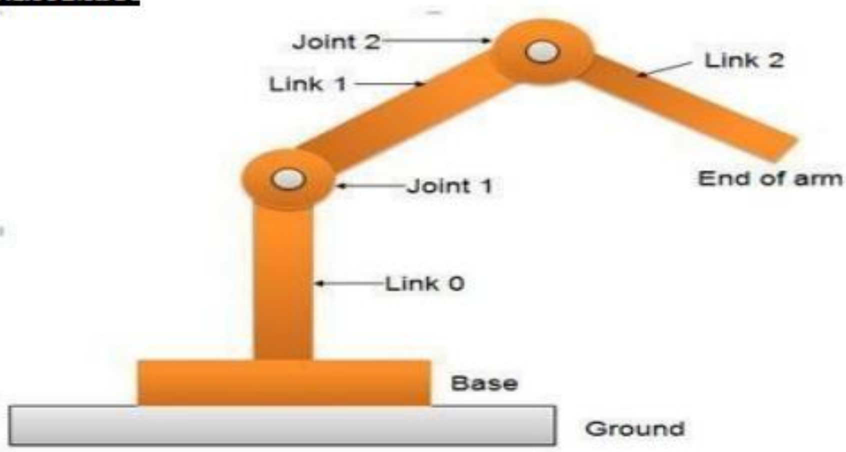



**Fig. 1.1 Joint-link scheme for robot manipulator**

**Joints and Links**:

The manipulator of an industrial robot consists of a series of joints and links. Robot anatomy deals with the study of different joints and links and other aspects of the manipulator's physical construction. A robotic joint provides relative motion between two links of the robot. Each joint, oraxis, provides a certain degree-of-freedom (dof) of motion. In most of the cases, only one degree-of- freedom is associated with each joint. Therefore the robot's complexity can be classified according tothe total number of degrees-of-freedom they possess.

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Each joint is connected to two links, an input link and an output link. Joint provides controlled relative movement between the input link and output link. A robotic link is the rigid component of the robot manipulator. Most of the robots are mounted upon a stationary base, such as the floor. From this base, a joint-link numbering scheme may be recognized as shown in Figure 1.1. The robotic base and its connection to the first joint are termed as link-0. The first joint in the sequence is joint-1. Link-0 is the input link for joint-1, while the output link from joint-1 is link-1 which leads to joint-2. Thus link 1 is,simultaneously, the output link for joint-1 and the input link for joint-2. This joint-link-numbering scheme is further followed for all joints and links in the robotic systems

**Types of joints:**

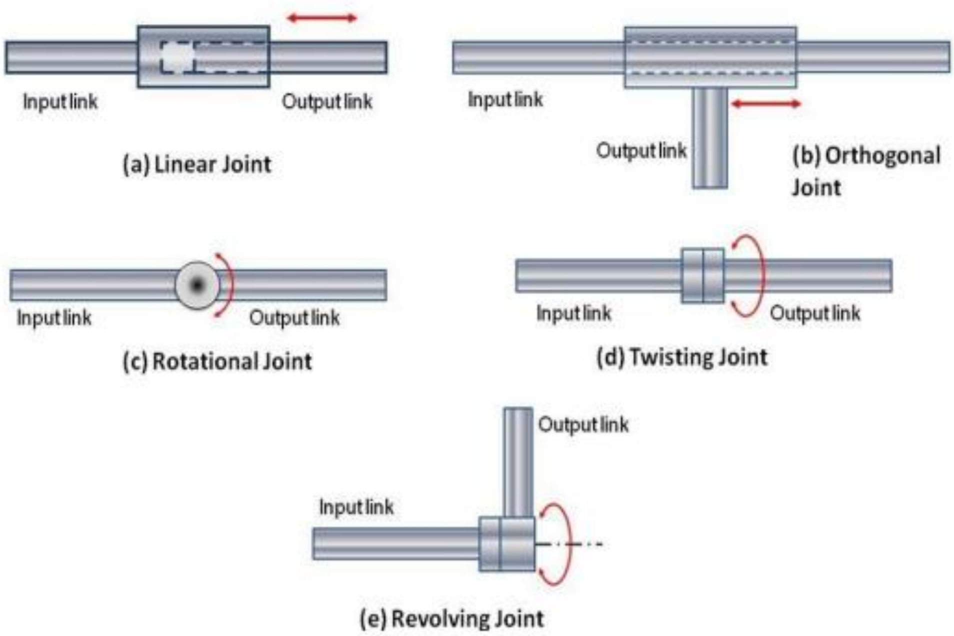
a) Linear joint (type L joint) The relative movement between the input link and the output link is a translational slidingmotion, with the axes of the two links being parallel.

b) Orthogonal joint (type U joint) This is also a translational sliding motion, but the input and output links are perpendicular toeach other during the movement.

c) Rotational joint (type R joint) This type provides rotational relative motion, with the axis of rotation perpendicular to the axesof the input and output links.

d) Twisting joint (type T joint) This joint also involves rotary motion, but the axis or rotation is parallel to the axes of the twolinks.

Nearly all industrial robots have mechanical joints that can be classified into following five types asshown in Figure 1.2.

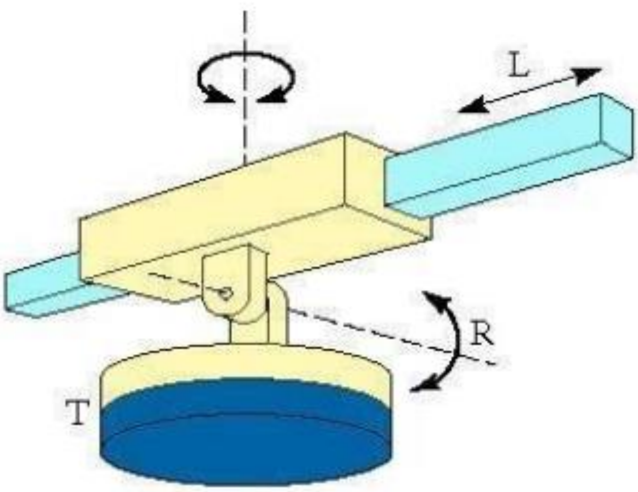



e) Revolving joint (type V-joint, V from the “v” inrevolving) In this type, axis of input link is parallel to the axis of rotation of the joint. However the axis ofthe output link is perpendicular to the axis of rotation.

**Robotic arm configurations:** For body-and-arm configurations, there are many different combinations possible for a three-degree-of-freedom robot manipulator, comprising any of the five joint types. Common body-and-arm configurations are as follows.

1) Polar coordinate arm configuration
2) Cylindrical coordinate arm configuration
3) Cartesian coordinate arm configuration
4) Jointed arm configuration.

### 1) Polar coordinate arm configuration(RRP):

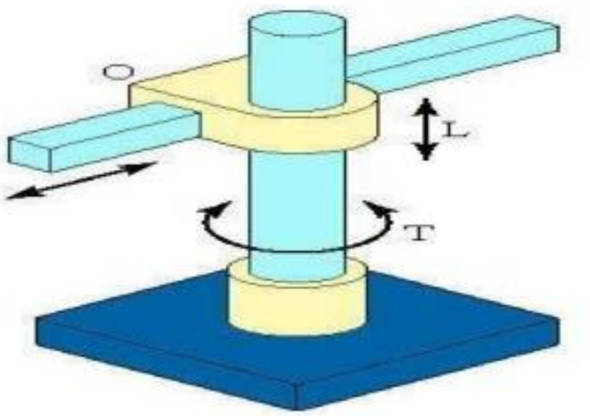


The polar arm configuration is shown It consists of a prismatic joint that can be raised or lowered about a horizontal revolute joint. The two links are mounted on a rotating base. These various joints provide the capability of moving the arm endpoint within a partial spherical space. Therefore it is called as Spherical coordinated configuration. This configuration allows manipulation of objects on the floor.

**Drawbacks:** i. Low mechanical stiffness ii. Complex construction iii. Position accuracy decreases with the increasing radialstroke.

**Applications:** Machining, spray painting Example: Unimate 2000 series, MAKER 110.

## 2) Cylindrical coordinate arm configuration (RPP):



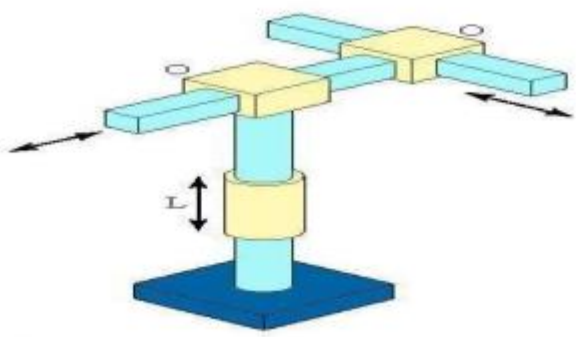

The cylindrical configuration uses two perpendicular prismatic joints and a revolute joint as shown in This configuration uses a vertical column and a slide that can be moved up or downalong the column. The robot arm is attached to the slide, so that it can be moved radially with respect to column. By rotating the column, the robot is capable of achieving a workspace that approximates a cylinder. The cylindrical configuration offers good mechanical stiffness.

**Drawback:** Accuracy decreases as the horizontal stroke increases.

**Applications:** suitable to access narrow horizontal capabilities, hence used for machine loadingoperations.

Example: GMF model M-1A

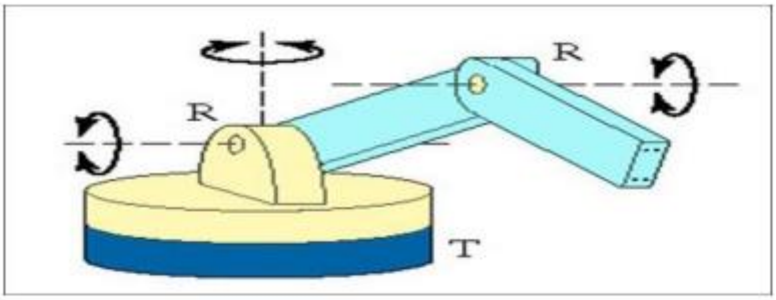
## 3) Cartesian coordinate arm configuration (PPP):




Cartesian coordinate or rectangular coordinate configuration is constructed by three perpendicular slides, giving only linear motions along the three principal axes. It consists of three prismatic joints. The endpoints of the arm are capable of operating in a cuboidal space. Cartesian arm gives high precision and is easy to program.

**Drawbacks:** o limited manipulatability o low dexterity (not able to move quickly and easily) **Applications:** use to lift and move heavy loads. Example: IBM RS-1.

### 4) Jointed arm configuration (RRR) or articulated configuration:




jointed arm configurations are similar to that of human arm. It consists of two straight links, corresponding to human fore arm and upper arm with two rotary joint 11 corresponding to the elbow and shoulder joints. These two are mounted on a vertical rotary table corresponding to human waist joint. The work volume is spherical. This structure is the most dexterous one.

This configuration is very widely used.

**Applications:** Arc welding, Spray coating. Example: SCARA robot (Selective compliance Assembly Robot Arm