BASICS OF MECHANICAL ENGINEERING

UNIT- I

INTRODUCTION TO MECHANICAL ENGINEERING:

Mechanical engineering is a branch of engineering that deals with the design, analysis, manufacturing, and maintenance of mechanical systems. It encompasses a wide range of applications, from machines and engines to heating and cooling systems. Mechanical engineers use principles of physics, mathematics, and material science to create products and systems that serve various industries. They work on everything from designing automotive components to developing energy-efficient HVAC systems, making them essential contributors to technology and industry.

ROLE OF MECHANICAL ENGINEERING IN INDUSTRIES:

Planning : They plan and optimize manufacturing processes to enhance efficiency, reduce production costs, and improve product quality. Mechanical engineers plan for material selection, considering factors like strength, durability, and cost-effectiveness in product manufacturing.

Design : Mechanical engineers are responsible for designing and developing products ranging from consumer goods to industrial machinery. They ensure that these products meet safety, performance, and efficiency standards.

Production : They design manufacturing processes and systems to produce goods efficiently and cost-effectively. This involves selecting materials, creating manufacturing processes, and optimizing production methods

Quality : Mechanical engineers help maintain quality control standards, ensuring that products meet industry and regulatory requirements through inspection and testing.

Safety : Mechanical engineers help plan safety measures and protocols to ensure the well-being of workers and protect against industrial accidents.

Maintenance: Mechanical engineers play a key role in the maintenance and repair of machinery and equipment, minimizing downtime and ensuring safe operations.

Procurement: This role involves determining the cost, quality, and availability of components. The role extends beyond sourcing to evaluating supplier performance and managing relationships. Their work allows for a reliable and timely supply of materials, aiding in project execution.

Service : They may be involved in the development and management of service contracts with external maintenance providers, ensuring that equipment is properly serviced and maintained.

Sales: Mechanical engineers provide technical knowledge and expertise about the products they design. This information is critical for the sales team to effectively communicate the features and benefits of the products to potential customers.

Reasearch and Development: Mechanical engineers often engage in research to innovate and improve existing products and systems, staying at the forefront of technological advancements.

Administration : Mechanical engineers may take on project management roles, overseeing and coordinating complex engineering projects. This administrative function involves scheduling, budgeting, resource allocation, and ensuring project goals are met.

ROLE OF MECHANICAL ENGINEERING IN SOCIETY:

Railways: Mechanical engineers plan and oversee maintenance of railway tracks, bridges, tunnels, and other infrastructure to ensure they are safe and structurally sound. They develop maintenance schedules and inspect railway facilities.

PWD: Mechanical engineers assist in estimating costs associated with infrastructure projects, helping in budgeting and financial planning within PWDs.

Power generation: Mechanical engineers are involved in designing power plants, whether they are fossil fuel-based, nuclear, or renewable energy facilities. They ensure that these plants are efficient, safe, and reliable sources of electricity.

Irrigation: Mechanical engineers design and develop irrigation systems, including pipes, pumps, valves, and distribution networks, ensuring efficient water delivery to crops.

Power supply: Mechanical engineers are involved in the design and construction of power transmission and distribution systems, ensuring energy is efficiently delivered to homes and businesses.

Water supply: Mechanical engineers are involved in designing water treatment plants to ensure the purification of water from natural sources, making it safe for consumption and domestic use.

Public transport: They design and improve vehicles and transportation systems, making travel safer, more efficient, and accessible to a broader range of people.

Aviation: Mechanical engineers develop and oversee various aircraft systems, such as hydraulic, fuel, and environmental control systems, ensuring their reliability and efficiency.

TECHNOLOGIES IN DIFFERENT SECTORS:

1)Energy sector : Mechanical engineers in the energy industry desigs and operate. fasel fuel, hydroelectric, conventional, nuclear, and cogeneration power plants. They are involved in all aspects of the prudattion and conversion of energy from one form to another. Mechanical engineers are also monived in exciting projects such developing alternatives to thermal energy, puwer sysle devices, fuel cells, gas turbines, and innovative uses of cool, wind, and tidal Bow.

2)Manufacturing sector : A majority of the roles in this sector are focused on supply network logistics/operations or manufacturing engineering. The jobs in this sectar are not demarcated in different compartments. The jobs here are a mix of different engineering disciplines

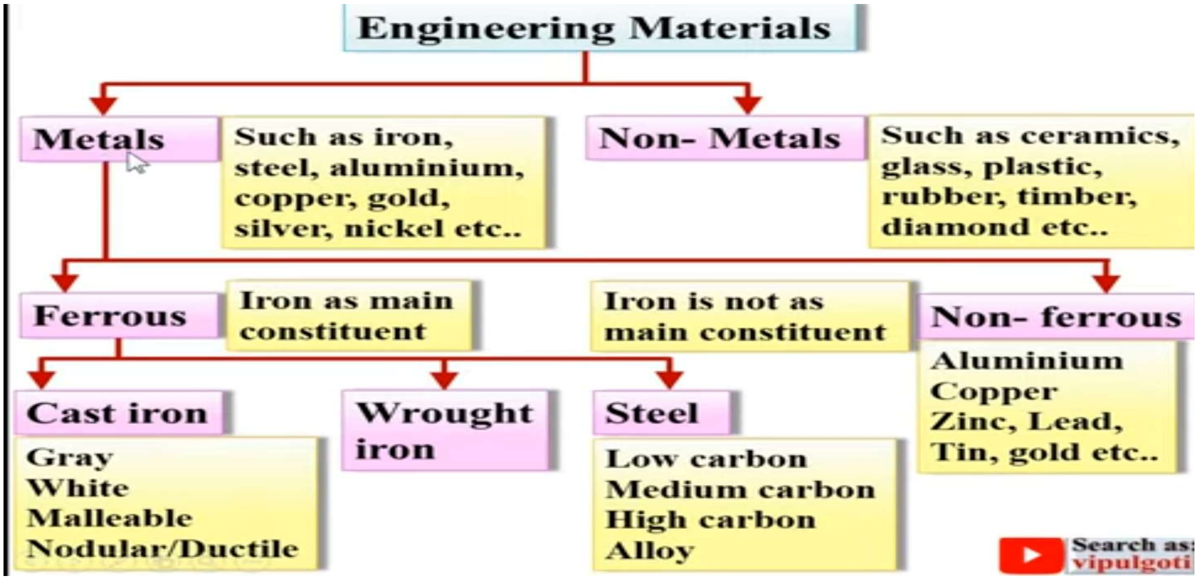
3)Automotive sector: This industry is one of the fastest growing and has therefore opened up numerous jeb opportunities. The role at a mechanical engineer spans the design, manufacturing and maintenance of motor vehicles. With the advancement an technology when breakthrough ideas like diverless cars, pod-based transportation wstems, bullet trains, are being considered. Top companies and automobile hrands ore investing a lat en research and recruiting skilled and passionate mechanical engineers.

4)Aerospace sector: This industry has witnessed lot of innovations and discoveries Flying cars to reusabile satellites, rockets are now not unheard of as technology is progressing so is the demand for newer inventions.

5)Marine sector: Mechanical engineers develop and optimize propulsion systems for ships, such as internal combustion engines, gas turbines, and electric propulsion systems. They focus on efficiency, power output, and environmental considerations.

ENGINEERING MATERIALS:

Engineering materials refer to the substances and compounds used by engineers to design, create, and maintain structures, devices, and systems in various fields of engineering. These materials are selected based on their specific properties and characteristics to meet the requirements of a given application. Engineering materials play a critical role in the design and functionality of a wide range of products and structures.

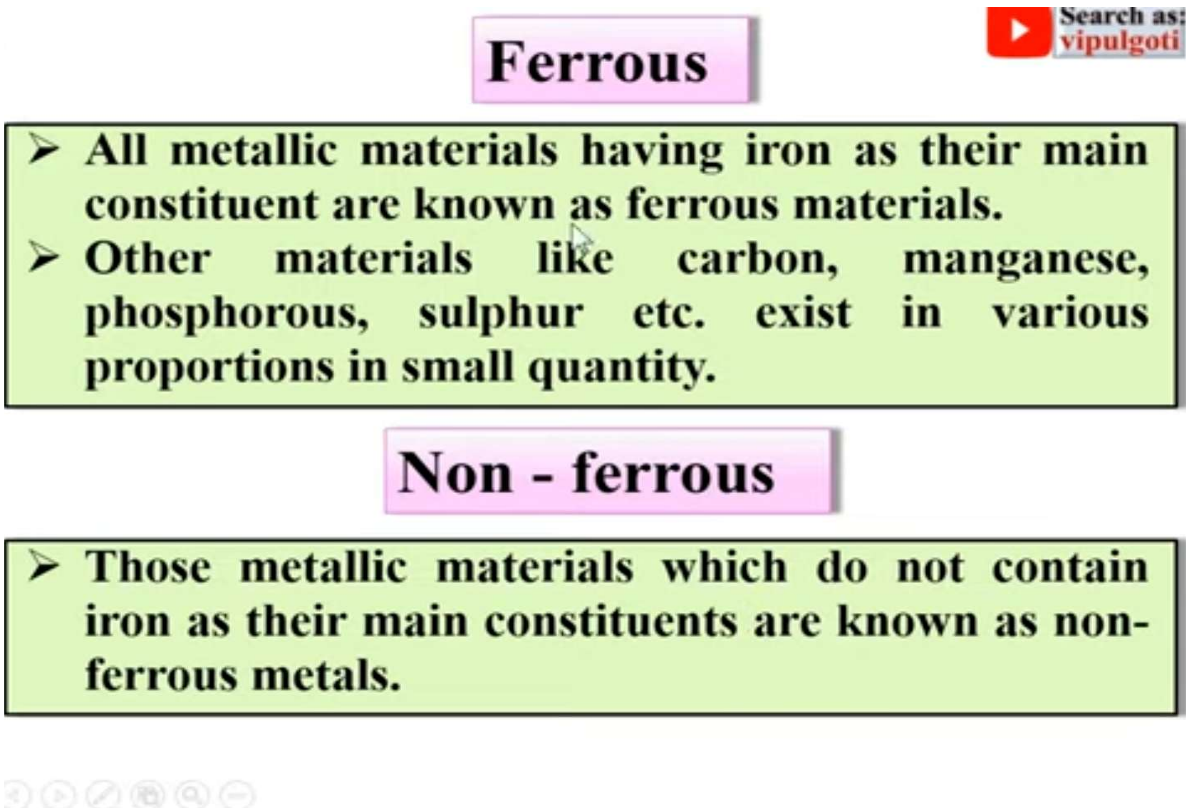


Metals

- They are mostly opaque, hard, heavy, ductile, lustre.
- They are good conductor of heat and electricity.
- Alloys are obtained by mixing or melting two or more metals in order to improve properties of materials.

Non - metals

- They do not contain metal in their composition.
- They are less ductile.
- They are poor conductor of heat and electricity.



Ferrous metals:

In ferrous metals, iron and steel are the most common casting materials.

CAST IRON:

➤ It is obtained by re-melting of pig iron with coke and lime stone in a furnace.

➤ It is mainly an alloy of iron and carbon.

➤ It consists of 2 to 4% carbon and small amount of silicon(Si), phosphorous(P) and sulphur(S). manganese(Mn),

➤ Due to high carbon content it is brittle and has low ductility.

➤ It has good compressive strength but poor tensile and shear strength.

➤ It is used for machine beds, pulleys, brackets, pipe fittings, cylinder block for IC engine etc..

STEEL:

It is a family of iron-based alloys that contain a minimum of approximately 11% chromium, that prevents the iron from rusting & providing heat-resistant properties.It is used to make common household items. It is also used in medical equipment as it's easily sterilized and resistant to corrosion, piping, cutting tools, and food processing equipment.

It is used to make containers for transportation of chemicals & liquids. It's high strength allows thinner containers, saving fuel costs while its corrosion resistance reduces cleaning & maintenance costs.

NON FERROUS METALS:

Non-ferrous metals are metals that do not contain a significant amount of iron. They are typically lighter and more resistant to corrosion than ferrous metals (which contain iron). Common non-ferrous metals include aluminum, copper, lead, zinc, and tin. These metals are used in a wide range of applications, from electrical wiring (copper) to aircraft construction (aluminum) and plumbing (lead-free brass). Their properties make them valuable for various purposes, especially when corrosion resistance or lightweight materials are required.

Aluminum:

Aluminum is a metal with a much lower density than iron, making it a vital material in applications that need strength without weight, such as the aerospace industry. It is corrosion resistant because aluminum, like stainless steel, reacts to oxidization by creating a metal oxide shell that protects it.

Copper:

Copper is one of the best conductors of electricity. It's widely used in electrical wiring, power generation and transmission, and electronics. Copper has natural corrosion resistance, making it suitable for plumbing and roofing materials.

CERAMICS:

Ceramics are a broad class of inorganic, non-metallic materials known for their unique properties and wide range of applications. These materials are formed through the heating and cooling of naturally occurring compounds, often clay or various minerals, and can be found in a multitude of forms, from pottery and tiles to high-tech components in advanced industries.

Key Characteristics of Ceramics:

Brittle: Ceramics are generally hard and brittle materials, which means they can break or fracture easily under stress. Their resistance to compression, however, can be quite high.

High Melting Points: Ceramics often have very high melting points, making them stable at elevated temperatures. This property is valuable in applications where materials must withstand extreme heat.

Non-Conductive: Most ceramics are electrical and thermal insulators, which is why they're used in applications where electrical or thermal conductivity is not desired.

Chemically Inert: Ceramics are typically resistant to chemical reactions, making them suitable for use in corrosive environments.

Diverse Composition: Ceramics can be made from a wide variety of compounds, including oxides, carbides, and nitrides, allowing for a range of properties and applications

COMPOSITE MATERIALS :

Composite materials are a class of materials made by combining two or more distinct components with significantly different physical or chemical properties. These components work together to create a material with enhanced properties that are superior to those of individual constituents. Composites are widely used in various industries due to their strength, lightweight nature, and tailored properties.

Key Characteristics of Composite Materials:

Composition: Composites consist of two main components: the matrix and the reinforcement. The matrix is a binding material that holds the reinforcement together. The reinforcement, which can be fibers, particles, or other forms, provides strength and stiffness to the composite.

Tailored Properties: Composites are designed to have specific properties such as strength, stiffness, lightweight, and resistance to environmental factors. The choice of matrix and reinforcement materials is critical to achieving desired properties.

Enhanced Strength: Composites often exhibit higher strength-to-weight ratios compared to traditional materials like metals or plastics

Lightweight: They are typically lighter than metals, making composites especially valuable in applications where weight reduction is essential, such as aerospace and automotive industries.

Corrosion Resistance: Depending on the materials used, composites can offer excellent resistance to corrosion, making them suitable for marine and chemical environments.

SMART MATERIALS:

Smart materials, also known as responsive materials or intelligent materials, are substances engineered to have properties that can change in response to external stimuli such as temperature, light, pressure, or electrical or magnetic fields. These materials have a wide range of applications in various industries, including aerospace, construction, healthcare, and electronics. Some common examples of smart materials include shape-memory alloys, piezoelectric materials, and self-healing polymers. They are used to create innovative products and systems that can adapt, self-repair, or respond to changing conditions.

There are several types of smart materials, each with its unique properties and applications.

1) Piezoelectric materials: These materials generate an electric charge when subjected to mechanical stress and, conversely, deform when an electric field is applied. They are used in sensors, actuators, and energy harvesting devices.

2) Photovoltaic materials: Photovoltaic materials, which are materials that can directly convert sunlight into electricity, can be considered a subset of smart materials. They are particularly important in the context of renewable energy and are often integrated into smart and adaptive systems for efficient energy generation.

3) Rheological materials: Electrorheological (ER) and Magnetorheological (MR) Fluids: These fluids change their viscosity in response to an electric or magnetic field, respectively. They are used in damping systems and shock absorbers.

4) Magnetosteric materials: Magnetosteric materials, also known as magnetostatic materials, are a subset of smart materials that respond to magnetic fields by changing their shape or mechanical properties. These materials are relatively less common and have specialized applications. Their behavior can be characterized by the magnetomechanical effect, where mechanical stress is induced in response to a magnetic field.

5) shape memory alloys: Shape Memory Alloys (SMAs): SMAs, like Nitinol (nickel-titanium), can "remember" a specific shape and return to that shape when heated or subjected to other stimuli. They find applications in orthodontic wires, robotics, and aerospace.

UNIT- II

MANUFACTURING PROCESS:

Manufacturing processes are a set of methods and techniques used to transform raw materials into finished products. These processes vary depending on the product, materials, and industry, but they generally include steps like design, material selection, shaping, assembly, and quality control. Common manufacturing processes include machining, casting, forging, welding, and additive manufacturing (3D printing). Efficiency, quality, and cost-effectiveness are essential considerations in choosing the right process for a specific product.

Manufacturing processes can be categorized into several types, each suited for different types of products and materials. Here are some common types of manufacturing processes:

1. **Casting:** Involves pouring molten material (such as metal or plastic) into a mold, which then solidifies to form the final shape. Types of casting include sand casting, die casting, and investment casting.

2. **Machining:** Material is removed from a workpiece to achieve the desired shape using cutting tools, such as lathes, milling machines, and drilling machines.

3. **Forming:** Material is reshaped without significant removal, often through processes like forging (using compressive force), rolling, or extrusion (forcing material through a die).

4. **Welding:** Joins two or more pieces of material together by melting them and allowing them to cool and bond. Various methods include arc welding, MIG welding, and TIG welding.

5. **Additive Manufacturing:** Also known as 3D printing, it builds a product layer by layer from a digital design, making it suitable for rapid prototyping and custom manufacturing.

6. **Joining:** Connects two or more parts using methods other than welding, such as fasteners (screws, bolts), adhesives, or rivets.

These are just some of the many manufacturing processes, and each has its advantages and limitations, making them suitable for different applications and industries. The choice of process depends on factors like material, product design, production volume, and cost considerations.

CASTING :

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals.

Casting is a manufacturing process that involves pouring molten material into a mold to create a solid object.

The principle of casting is based on several key steps and principles:

1. **Pattern Creation:** The process begins with the creation of a pattern, which is a replica of the final object to be cast. Patterns can be made from materials like wood, plastic, or metal and must be slightly larger than the desired final product to account for shrinkage during cooling.

2. **Mold Preparation:** A mold is made by packing a material like sand, plaster, or metal around the pattern. The mold is created in two or more halves, and channels, called sprues and runners, are designed to allow the molten material to flow into the mold cavity.

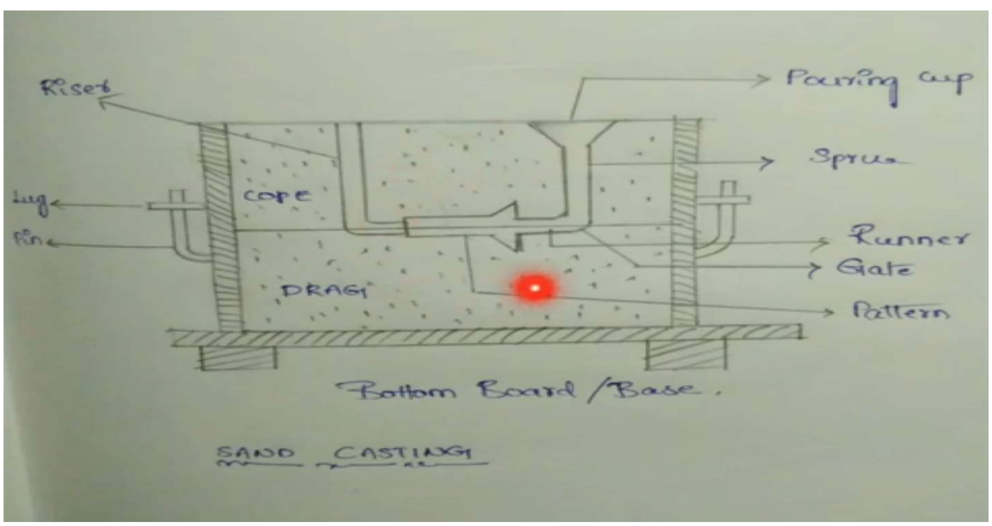
3. **Melting and Pouring:** The material to be cast (commonly metals like aluminum, iron, or steel) is melted in a furnace to a specific temperature. Once molten, it is poured into the mold through the sprues. The molten material takes the shape of the mold cavity.

4. **Solidification:** As the molten material cools and solidifies, it adopts the shape of the mold. This is a critical phase because it determines the final properties and quality of the cast product.

5. **Mold Removal:** After the material has solidified and cooled sufficiently, the mold is removed. This may involve breaking the mold for sand casting or carefully separating mold halves for processes like investment casting.

6. **Finishing:** The cast product often requires finishing processes such as grinding, machining, or sandblasting to remove any excess material or imperfections on the surface.

Casting is a versatile and widely used process, with various methods like sand casting, investment casting, die casting, and more, each tailored to specific materials and applications. The key principle is to create a replica of the desired object by pouring molten material into a mold and allowing it to solidify in that shape.



FORMING:

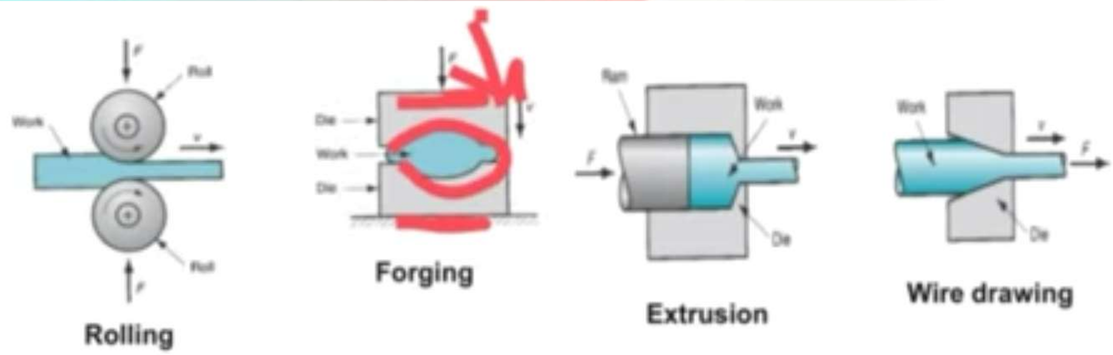
Forming is a category of manufacturing processes that involve changing the shape of a material without removing any significant material. This can be done through the application of force, heat, or a combination of both. Forming processes are used to create complex shapes and structures and are particularly useful for materials like metals, plastics, and ceramics.

Metal forming processes

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



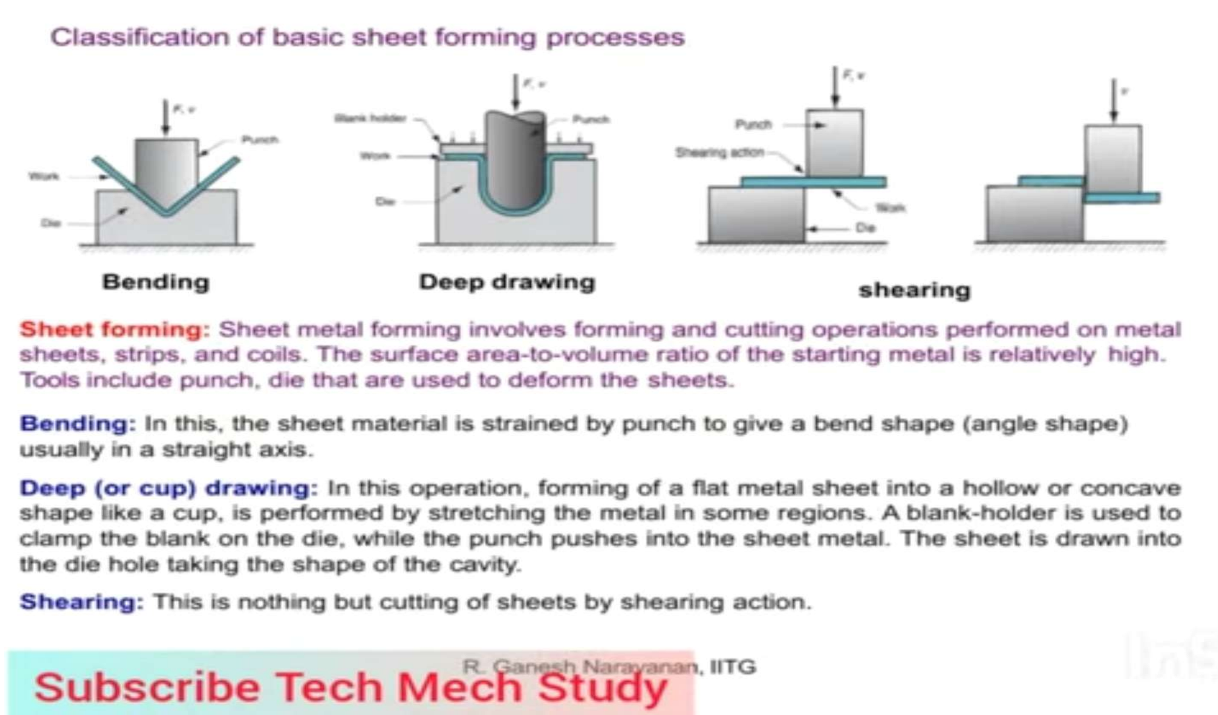
Bulk forming: It is a severe deformation process resulting in massive shape change. The surface area-to-volume of the work is relatively small. Mostly done in hot working conditions.

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 th[illegible] opening to take the cross-section. R. Ganesh Narayanan, IITG



JOINING:

Joining is one of the manufacturing processes by which two or more materials can be permanently or temporarily joined or assembled together with or without the application of external element in order to form a single unit. Now-a-days a large variety of such joining techniques are available to cater the need of assembling a wide variety of materials in various ways for various processing or applications.

In the manufacturing industry, "**permanent joining processes**" refer to methods used to create lasting connections between materials or components. These processes are crucial for building products, structures, and machinery. Here are some common **permanent joining** processes in manufacturing:

Welding: Welding is a widely used process that involves melting the edges of two materials and then allowing them to cool and solidify. This creates a strong, permanent bond. Common welding methods include arc welding, MIG welding, TIG welding, and resistance welding.

Brazing: Brazing involves joining materials using a filler metal that melts at a lower temperature than the base materials. The filler metal is drawn into the joint by capillary action and solidifies, creating a permanent connection.

Soldering: Soldering is similar to brazing but uses even lower-melting-point filler materials. It's often used in electronics and plumbing to create permanent connections between components

Riveting: Riveting involves using rivets to connect materials, typically metal sheets. The rivets are inserted through holes in the materials and are permanently deformed to secure the connection.

Temporary joining processes in manufacturing involve methods that allow for the assembly and disassembly of components without creating a permanent bond. These methods are often used when the components need to be separated or replaced during the product's lifecycle. Here are some common **temporary joining processes** in manufacturing:

Bolting and Fastening: Bolts, nuts, screws, and other fasteners are used to hold components together. They can be easily removed for maintenance or disassembly.

Clamps and Vises: Temporary clamping methods are used to hold components in place for various machining or assembly processes. They can be released when needed.

Snap Fits: Snap fits involve designing components with interlocking features that hold them together without the need for adhesives or fasteners. They can be separated when necessary.

Machining:

Machining is a fundamental process in manufacturing and engineering that involves the use of various tools and machinery to remove material from a workpiece to shape, finish, or create precision components. It is a versatile and precise method of manufacturing parts, and it plays a crucial role in industries such as aerospace, automotive, electronics, and more.

1. Purpose of Machining: Machining is primarily used to achieve the following objectives:Shaping and finishing of parts to exact dimensions and tolerances.Creating intricate and complex geometries that are difficult to achieve through other methods.Improving the surface finish of workpieces.Removing excess material or making adjustments to achieve the desired shape and size.

2. Machining Tools: A variety of cutting tools and machines are used in the machining process, including:

Lathes: Used for cylindrical parts and rotational cutting.

Milling Machines: Ideal for flat and contoured surfaces.

Drilling Machines: For creating holes in workpieces.Grinding Machines: Used for achieving high-precision surface finishes.

CNC (Computer Numerical Control) Machines: Automation and precision enhancement in machining.

3. Cutting Processes: The actual material removal in machining is achieved through cutting processes. Common methods include:

Turning: Rotating a workpiece against a fixed cutting tool.

Milling: Cutting tools rotate and move across the workpiece to remove material.

Drilling: Creating holes in the workpiece using specialized drill bits.

Grinding: Abrasive grains remove material to achieve fine surface finishes.

CNC (Computer Numerical Control):

CNC (Computer Numerical Control) machines are advanced manufacturing tools that have revolutionized various industries, including manufacturing, aerospace, automotive, and more. These machines rely on computerized control systems to precisely and automatically execute a wide range of machining and fabrication tasks.

1. Basic Principle: CNC machines are designed to perform tasks that were traditionally carried out manually by operators, such as cutting, milling, drilling, and shaping materials. They follow a set of programmed instructions to control the movement and operation of cutting tools and other machinery.

2. Components: Key components of a CNC machine include:Computer or Controller: This is the brain of the CNC system, where the program is input and executed.Machine Tool: The physical equipment (e.g., lathe, mill, router) responsible for cutting, shaping, or fabricating the workpiece.Motors and Drives: These components move and position the machine tool precisely.Tooling: Cutting tools or other attachments required for specific operations.Worktable or Workpiece Holder: The platform that holds the workpiece in place during machining.

3. Programming: CNC machines operate based on a set of numerical instructions called G-codes and M-codes. G-codes define tool movements, while M-codes control auxiliary functions like coolant flow. CNC programs can be created manually or generated using Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) software.

4. Precision and Automation: CNC machines offer exceptional precision, repeatability, and the ability to produce complex geometries. They can execute tasks with minimal human intervention, reducing errors and improving efficiency.

3D printing:

3D printing, also known as additive manufacturing, is an innovative and rapidly evolving technology that has revolutionized the way objects and prototypes are designed and produced. It enables the creation of three-dimensional objects by adding material layer by layer, in contrast to traditional subtractive manufacturing methods.

1. Additive Manufacturing: 3D printing is based on the principle of additive manufacturing. Instead of removing material from a solid block (subtractive manufacturing), it adds material layer by layer to build up an object.

2. Key Components: A typical 3D printing system consists of the following key components:3D Printer: The machine responsible for layer-by-layer fabrication of the object.Digital 3D Model: A 3D computer-aided design (CAD) file that serves as the blueprint for the object.Printing Material: Various materials can be used, including plastics, metals, ceramics, and even biocompatible materials.

3. Process: The 3D printing process typically involves the following steps:Design: Create a 3D model of the object using CAD software or 3D scanning.Slicing: A software tool divides the 3D model into numerous thin horizontal layers.Printing: The 3D printer reads the sliced model and deposits material layer by layer to build the object.

Smart manufacturing:

Smart manufacturing, also known as Industry 4.0 or the Industrial Internet of Things (IIoT), represents the convergence of advanced manufacturing techniques with cutting-edge digital technologies to create more efficient, agile, and interconnected industrial processes. This transformation aims to optimize production, reduce waste, enhance quality, and increase responsiveness.

Industrial Internet of Things (IIoT). Deployments involve embedding sensors in manufacturing machines to collect data on their operational status and performance. In the past, that information typically was kept in local databases on individual devices and used only to assess the cause of equipment failures after they occurred.

In addition to the Internet of Things, there are a number of technologies that will help enable smart manufacturing, including:

Artificial intelligence (AI)/machine learning – enables automatic decision-making based on the reams of data that manufacturing companies collect. AI/machine learning can analyze all this data and make intelligent decisions based on the inputted information.

Drones and driverless vehicles – can increase productivity by reducing the number of workers needed to do rote tasks, such as moving vehicles across a facility.

Blockchain – blockchain's benefits, including immutability, traceability and disintermediation, can provide a fast and efficient way to record and store data.

THERMAL ENGINEERING:

BOILERS:

What is Boiler:

The basic principle of a boiler is to convert water into steam with heat energy. This is done by burning fuel in a furnace, which produces hot gasses. These gasses are then passed through a heat exchanger, where they transfer their heat to the water. The water is heated until it reaches its boiling point and vaporizes into steam.

TYPES OF BOILERS

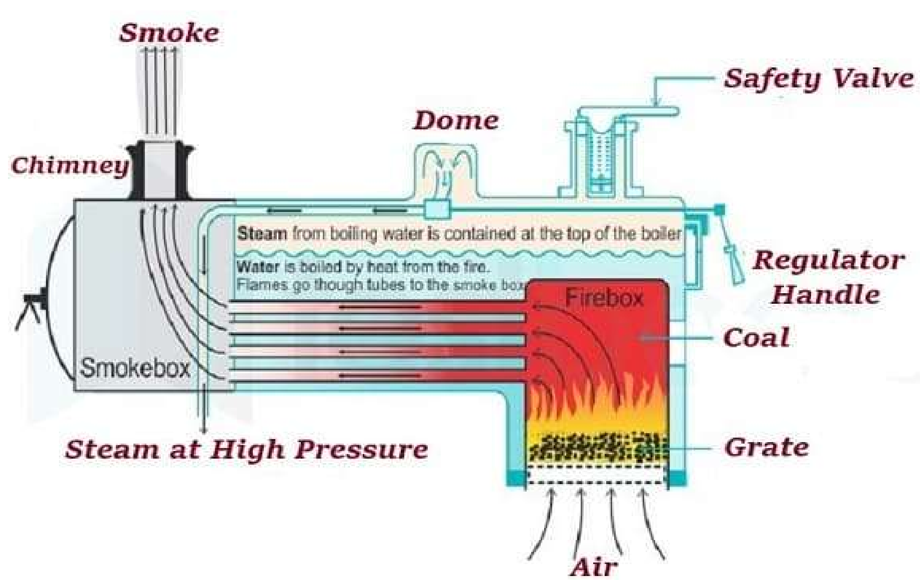
There are two types:

1)Fire tube boilers

2)water tube boilers

1)fire tube boiler

A fire tube boiler is defined as a boiler that consists of a sealed container filled with water and a series of tubes that run through it. The tubes carry hot gases from a fire (usually fueled by coal, oil, or gas) that heat the water and generate steam.



The main components of a fire tube boiler are:

Furnace: The chamber where the fuel is burned to produce hot gases.

Fire tubes: The tubes that carry the hot gases from the furnace to the smokebox.

Smokebox: The chamber where the hot gases are collected and vented out through the chimney.

Steam dome: The upper part of the boiler where the steam is collected and distributed to the outlets.

Superheater: An optional device that further heats the steam to make it dry and superheated.

Grate: The platform where the fuel is placed for burning.

Feedwater inlet: The pipe that supplies water to the boiler.

Steam outlet: The pipe that delivers steam to the desired location.

Working principle of fire tube boiler:-

The operation of a fire tube boiler is simple and straightforward. The fuel is burned in the furnace, creating hot gases that pass through the fire tubes. The heat from the gases transfers to the water surrounding the tubes, raising its temperature and pressure. The steam then rises to the steam dome, where it can be taken out for various purposes. The water is replenished by the feedwater inlet.

The pressure and temperature of the steam depend on the size and design of the boiler, as well as the quality and quantity of the fuel. Generally, fire tube boilers can produce low to medium-pressure steam (up to 17.5 bar) and low to medium capacity (up to 9 metric tons per hour).

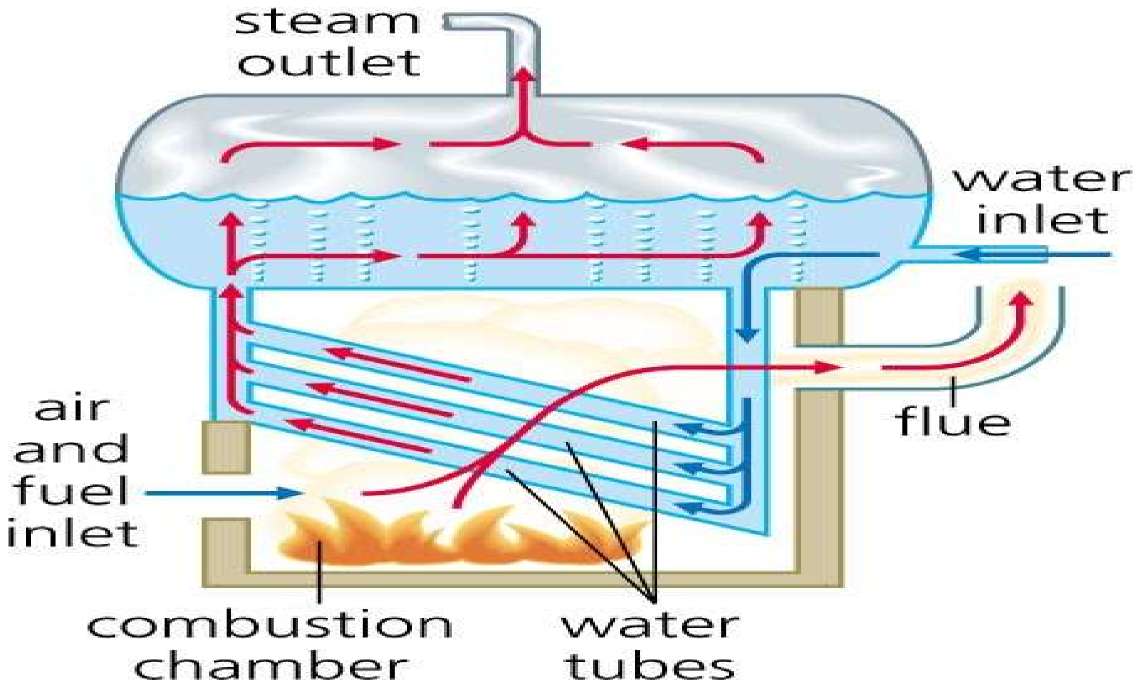
One of the main drawbacks of fire tube boilers is that they have a limited ability to produce high-pressure and high-capacity steam. This is because they have a single large vessel that contains both water and steam, which makes it difficult to control their pressure and temperature. Moreover, fire tube boilers are prone to explosion if their vessel is ruptured due to excessive pressure or damage.

Examples: Cochran Boiler,Cornish Boiler,Locomotive Boiler,Lancashire Boiler,Simple Vertical Boiler,Scotch Marine Boiler.

2)Water tube boiler :

What is a Water Tube Boiler?

A water tube boiler can be defined as a Steam boiler in which the flow of water in the tubes, as well as hot gases, enclose the tubes. Not like fire tube boilers, this boiler attains high-pressures, as well as high-steam capabilities, can be achieved. This is because of condensed tangential pressure on tubes which is known as hoop stress.



Components of Water Tube Boiler

The water tube boiler can be built with boiler shell, burner, mud drum or mud ring, furnace, safety valve, strainer, sight glass, feed check valve, steam stop valve, etc.

Boiler Shell: This shell is the external cylindrical part of a pressure container.

Mud Drum: This is a cylindrical formed space at the base of the water space. The impurities like mud, sediment, and others will be gathered.

Strainer: This is a type of device as a filter to hold solid elements letting a fluid to supply.

Sight Glass: A glass tube is utilized on steam type boilers for giving observable signs of the water level in boilers.

Security Valve: A spring-loaded tap that unlocks when force gets the location of the valve. This can be used for stopping the unnecessary force from the construction of a boiler

Boiler: This is a surrounded space offered for the fuel combustion.

Feed-Test Tap: The high-force water flows via this tap, which releases to the boiler simply and supplies the water to the water type boiler.

Steam-Stop Tap: It controls the steam flow supply at outside.

Burner: This is one type of device for the beginning of air and fuel into a boiler at the preferred velocity. This is the most essential apparatus for the firing of gas or oil.

Working Principle of Water Tube Boiler

The working principle of water tube boiler is thermal siphoning (circulation of natural water). Basically, this type of boiler includes two drums namely steam, lower or mud drum.

The water tube boiler diagram is shown below, and these two drums are associated via two tubes such as downcomer and riser. At first, the water is supplied into the steam type drum with the help of a water pump. Whenever the fuel is burned, then hot gases will be generated that are permitted to supply in the shell part of the boiler. The hot gases which are produced by the fuel will replace heat by the water; the water gets changed into steam. Because, the water temperature increases, the concentration will increase automatically.

Clearly, the concentration of steam will be lesser than the water. Thus in the steam drum, the water, as well as steam, gets divided obviously due to variation in concentration. Here the traveling of steam will be upward because of low concentration as well as water will travel downward because of high concentration

Examples: Babcock and Wilcox boiler,Stirling boiler, yarrow boiler.

Otto Cycle:

The Otto cycle is a thermodynamic process that explains the transformation of gasoline's chemical energy into thermal energy within spark ignition internal combustion engines. It involves a series of pressure, temperature, volume, and heat exchange changes, ultimately converting fuel into motion. This cycle is utilized in both 2-stroke and 4-stroke engine configurations.

Nikolaus August Otto, a German Engineer, involved himself in the study of heat engines and built his first working four-stroke engine in 1876. Coal gas and air mixture were used as working fluid. Wilhelm Maybach joined Otto to revamp the model based on Otto’s theory and made an engine called Otto Engine.

(1) Process 0 - 1: Air at constant pressure is drawn into the piston-cylinder arrangement.The suction Process takes place.

(2) Process 1 - 2: The piston moves from the bottom dead centre (BDC) to the top dead centre (TDC) compressing the fuel and air (charge) in an adiabatic compression. The pressure and temperature increases P1 - P2 and T1- T2. Volume is decreased V1- V2.

(3) Process 2 - 3: The heat is transferred from an external source at a constant volume to the charge while the piston is still at the TDC. The mixture rapidly burns in this process.The pressure and temperature increases P2 - P3 and T2 - T3. Volume remains constant V2 = V3.

(4) Process 3 - 4: When the mixture burns, it expands adiabatically or isentropically. This is called the power stroke.The pressure and temperature decreases P3 - P4 and T3- T4. Volume is increased V3 - V4.

(5) Process 4 - 1: The heat is rejected from the air at constant volume at the end of the cycle. The piston will be at the BDC in this process**.**The pressure and temperature decreases P4 - P1 and T4- T1. Volume remains constant V4 = V1.

Heat supplied during constant volume process

$$Q_s = mC_V(T_3 - T_2)$$

Heat rejected during constant volume process

$$Q_r = mC_V(T_4 - T_1)$$

Net work done = Heat Supplied – Heat Rejected

$$Q_{net} = mC_V(T_3 - T_2) - mC_V(T_4 - T_1)$$

$$\eta_{Otto} = \frac{Output}{Input} = \frac{Net\ Work}{Heat\ Inpout}$$

$$= \frac{Q_{net}}{Q_s} = \frac{mC_V(T_3 - T_2) - mC_V(T_4 - T_1)}{mC_V(T_3 - T_2)}$$

$$= 1 - \frac{mC_V(T_4 - T_1)}{mC_V(T_3 - T_2)}$$

$$= 1 - \frac{(T_4 - T_1)}{(T_3 - T_2)}$$

$$\eta_{Otto} = 1 - \frac{T_1(T_4/T_1 - 1)}{T_2(T_3/T_2 - 1)} \qquad \left(\frac{T_4}{T_1} = \frac{T_3}{T_2}\right)$$

$$\eta_{Otto} = 1 - \frac{T_1}{T_2}$$

$$\boxed{\eta_{Otto} = 1 - \frac{1}{r^{\gamma - 1}}} \qquad \left(\frac{T_2}{T_1} = r^{\gamma - 1}\right)$$

Diesel cycle:

The Diesel cycle is a representation of the combustion process that takes place in a reciprocating internal combustion engine. It is one of the most frequent thermodynamic cycles that can be found in automotive engines. Diesel engines are considered the direct applications of the diesel cycle. Hence, let us understand the cycle in the context of diesel engine

Rudolf Diesel, a German inventor, received a patent for his effective, slow-burning internal combustion engine in the 1890s. Rudolf Diesel's initial cycle idea was a cycle with a constant temperature. In subsequent years, Diesel found that his original cycle was ineffective, and he adopted the constant pressure cycle, also known as the Diesel cycle.

Process 1-2 (reversible adiabatic compression): In the cycle, it is a constant entropy compression process (isentropic). It is equivalent to the intake valve opening and airflow into the piston cylinder arrangement described above.The pressure and temperature increases P1 - P2 and T1- T2. Volume is decreased V1- V2

Process 2-3(Isobaric (or) constant pressure heat addition: The constant pressure heat addition process is also known as the isobaric process. The compressed air reaches a sufficiently high temperature that when fuel is sprayed inside the cylinder, it gets auto-ignited. This auto-ignition leads to the generation of heat.The pressure remains constant P2 = P3 and Temperature increases T2- T3. Volume is increased V2 - V3.

Process 3-4 (reversible adiabatic Expansion): In the Diesel cycle, it is the constant entropy expansion process (isentropic). And in the diesel engine, the expansion of gasses as a result of heat addition will move the piston down. It is the process by which the engine generates the work.The pressure and temperature decreases P3 - P4 and T3- T4. Volume is increased V3- V4.

Process 4-1(Constant volume heat rejection:) The last process in the cycle is the constant volume heat rejection process, also known as the isochoric process. Finally, the outlet valve opens when the work is extracted from the gases.The pressure and temperature decreases P4 - P1 and T4 - T1. Volume remains constant V4 = V1.

Efficiency of Diesel Engine:

Heat supplied $Q_S = mC_P (T_3 - T_2)$

Heat rejceted, $Q_R = m\, C_V (T_4 - T1)$

Net work done, $W_{net} = Q_S - Q_R$

$W_{net} = mC_P (T_3 - T_2) - m\, C_V (T_4 - T1)$

$$\eta_{Diesel} = \frac{Output}{Input} = \frac{Net\ Work}{Heat\ Input}$$

$$= \frac{mC_P (T_3 - T_2) - m\, CV (T_4 - T1)}{mC_P (T_3 - T_2)}$$

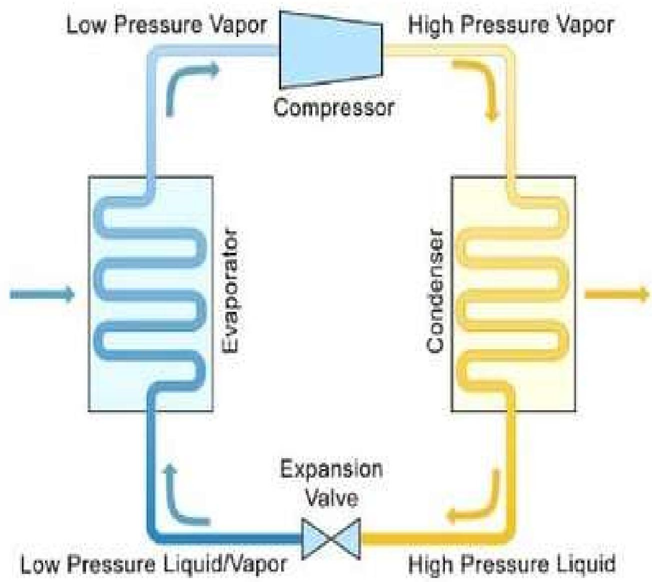
$$= 1 - \frac{mC_V(T_4 - T_1)}{mC_p(T_3 - T_2)} \qquad C_P/C_V = \gamma$$

$$= 1 - \frac{1}{\gamma}\frac{(T_4 - T_1)}{(T_3 - T_2)}$$

$$\boxed{\eta_{Diesel} = 1 - \frac{1}{r^{\gamma - 1}}\frac{1}{\gamma}\left(\frac{\rho^{\gamma} - 1}{\rho - 1}\right)}$$

REFRIGERATION CYCLE:

The refrigeration cycle is a process used in refrigeration and air conditioning systems to transfer heat from a low-temperature area to a high-temperature area. It consists of four main components:



1.Compressor : The vaporized refrigerant is then compressed, which increases its temperature and pressure. This high-pressure, high-temperature vapor is ready to release heat.

2.Condenser : In the condenser, the high-temperature, high-pressure vapor releases heat to the surroundings, causing it to condense into a high-pressure liquid.

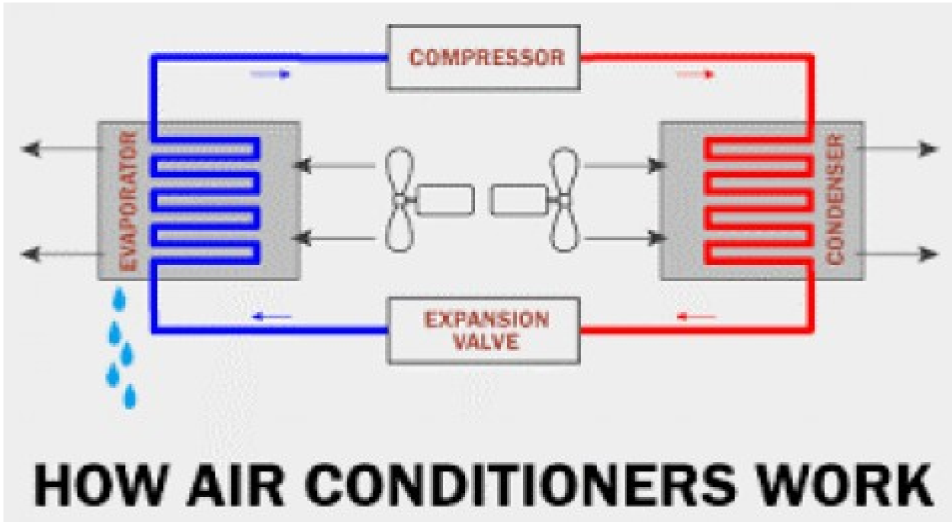
3.Expansion Valve : The high-pressure liquid then passes through an expansion valve or capillary tube, where it undergoes a sudden drop in pressure. This causes it to expand and cool, turning it back into a low-pressure, low-temperature liquid.

4.Evaporator : This is where the refrigerant absorbs heat from the space to be cooled, causing it to evaporate from a low-pressure, low-temperature liquid to a low-pressure, low-temperature vapor.

The cycle then repeats, with the low-pressure liquid returning to the evaporator to absorb more heat. This continuous cycle allows the system to maintain a desired low temperature in the space being cooled.

AIR CONDITIONING CYCLE:

The air conditioning cycle is a specific application of the refrigeration cycle designed to cool and dehumidify indoor air. It shares the same fundamental principles as the refrigeration cycle but is tailored for climate control. Here are the key components and steps in the air conditioning cycle:



1)Compressor: The low-pressure, low-temperature vapor refrigerant is then compressed by the compressor, which raises its temperature and pressure.

2)Condenser Coil : The high-pressure, high-temperature refrigerant vapor is routed to the condenser coil, typically located outside. Here, the refrigerant releases the heat it has absorbed from the indoor air to the outside environment, condensing into a high-pressure liquid.

3)Expansion Valve : The high-pressure liquid refrigerant passes through an expansion valve, reducing its pressure and temperature. This causes it to expand and become a low-pressure, low-temperature liquid, ready to return to the evaporator coil.

4)Evaporator Coil : Warm indoor air is blown over the evaporator coil. The refrigerant inside the coil evaporates, absorbing heat from the indoor air, and in the process, it cools and dehumidifies the air.

The cycle continues, with the now-cooled and dehumidified air blown into the indoor space, while the refrigerant continues to circulate through the system. This process maintains a comfortable indoor temperature and humidity level. Air conditioning systems can also be used for heating when equipped with a heat pump, which reverses the direction of the refrigeration cycle to extract heat from the outside and release it inside.

HEAT ENGINE:

IC ENGINES:

Main components of reciprocating IC engines:

Cylinder: It is the main part of the engine inside which piston reciprocates to and fro. It should have high strength to withstand high pressure above 50 bar and temperature above

2000 ^{o}C. The ordinary engine is made of cast iron and heavy duty engines are made of steel alloys or aluminum alloys. In the multi-cylinder engine, the cylinders are cast in one block known as cylinder block.

Cylinder head: The top end of the cylinder is covered by cylinder head over which inlet and exhaust valve, spark plug or injectors are mounted. A copper or asbestos gasket is provided between the engine cylinder and cylinder head to make an airtight joint.

Piston: Transmit the force exerted by the burning of charge to the connecting rod. Usually made of aluminium alloy which has good heat conducting property and greater strength at higher temperature.

Figure 1 shows the different components of IC engine.

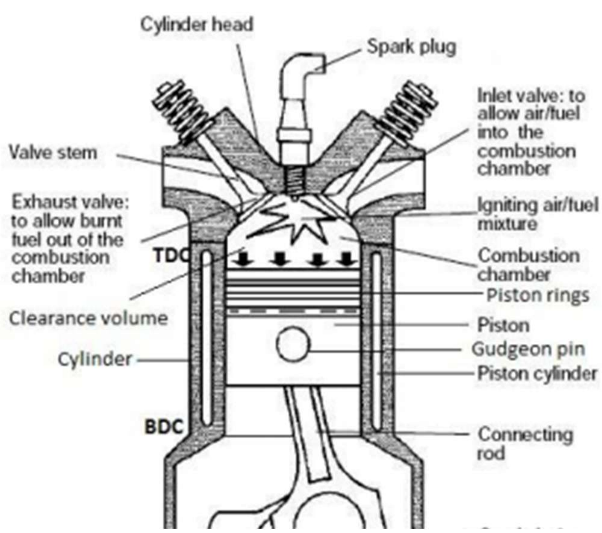


Fig. 1. Different parts of IC engine

Piston rings: These are housed in the circumferential grooves provided on the outer surface of the piston and made of steel alloys which retain elastic properties even at high temperature. 2 types of rings- compression and oil rings. Compression ring is upper ring of the piston which provides air tight seal to prevent leakage of the burnt gases into the lower portion. Oil ring is lower ring which provides effective seal to prevent leakage of the oil into the engine cylinder.

Connecting rod: It converts reciprocating motion of the piston into circular motion of the crank shaft, in the working stroke. The smaller end of the connecting rod is connected with the piston by gudgeon pin and bigger end of the connecting rod is connected with the crank with crank pin. The special steel alloys or aluminium alloys are used for the manufacture of connecting rod.

Crankshaft: It converts the reciprocating motion of the piston into the rotary motion with the help of connecting rod. The special steel alloys are used for the manufacturing of the crankshaft. It consists of eccentric portion called crank.

Crank case: It houses cylinder and crankshaft of the IC engine and also serves as sump for the lubricating oil.

Flywheel: It is big wheel mounted on the crankshaft, whose function is to maintain its speed constant. It is done by storing excess energy during the power stroke, which is returned during other stroke.

Terminology used in IC engine:

1. Cylinder bore (D): The nominal inner diameter of the working cylinder.

2. Piston area (A): The area of circle of diameter equal to the cylinder bore.

3. Stroke (L): The nominal distance through which a working piston moves between two successive reversals of its direction of motion.

4. Dead centre: The position of the working piston and the moving parts which are mechanically connected to it at the moment when the direction of the piston motion is reversed (at either endpoint of the stroke).

(a) Bottom dead centre (BDC): Dead centre when the piston is nearest to the crankshaft.

(b) Top dead centre (TDC): Dead centre when the position is farthest from the crankshaft.

5. Displacement volume or swept volume (Vs): The nominal volume generated by the working piston when travelling from the one dead centre to next one and given as,

$V_s = A \times L$

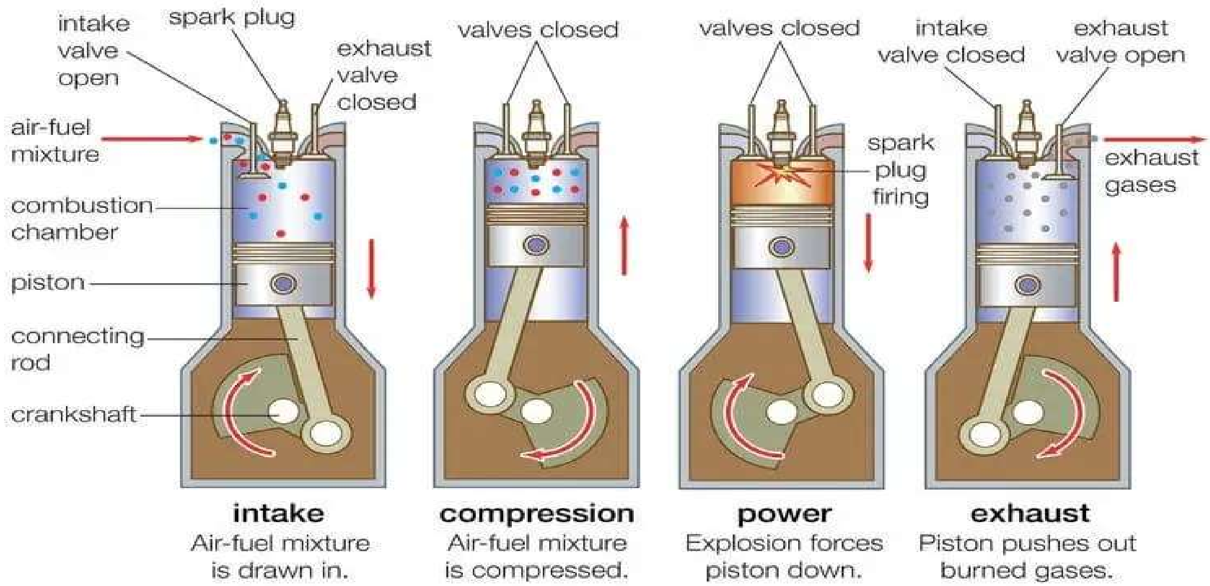
6. Clearance volume (Vc): the nominal volume of the space on the combustion side of the piston at the top dead centre.

7. Cylinder volume (V): Total volume of the cylinder.

$V = V_s + V_c$

8. Compression ratio (r): $r = \frac{Vs}{Vc}$

FOUR STROKE PETROL ENGINE(SI) refers to its use in petrol engines, gas engines, light, oil engine and heavy oil engines in which the mixture of air fuel are drawn in the engine cylinder. Since ignition in these engines is due to a spark, therefore they are also called spark ignition engines. In four stroke cycle engine, cycle is completed in two revolutions of crank shaft or four strokes of the piston. Each stroke consists of 1800 of crankshaft rotation. Therefore, the cycle consists of 7200 of crankshaft rotation



Cycle consists of following four strokes

1) Suction Stroke

2) Compression Stroke

3) Expansion or Power Stroke

4) Exhaust Stroke

SUCTION STROKE: In this Stroke the inlet valve opens and proportionate fuel-air mixture is sucked in the engine cylinder. Thus the piston moves from top dead centre (T.D.C.) to bottom dead centre (B.D.C.). The exhaust valve remains closed through out the stroke.

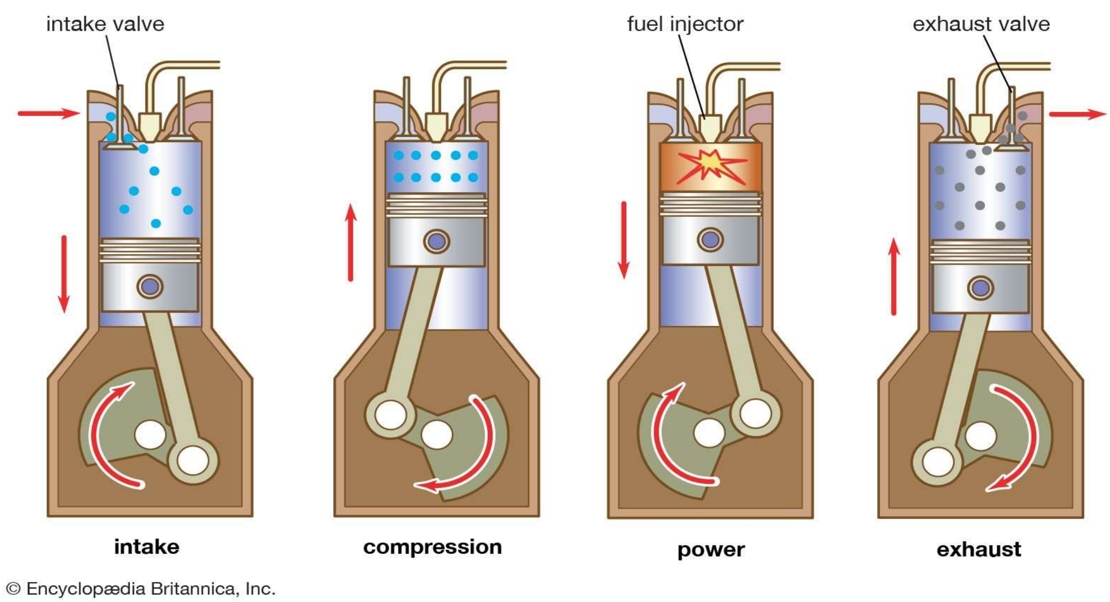
COMPRESSION STROKE: In this stroke both the inlet and exhaust valves remain closed during the stroke. The piston moves towards (T.D.C.) and compresses then closed fuel-air mixture drawn. Just before the end of this stroke the operating. plug initiates a spark which ignites the mixture and combustion takes place at constant pressure.

POWER STROKE OR EXPANSION STROKE: In this stroke both the valves remain closed during the start of this stroke but when the piston just reaches the B.D.C .the exhaust valve opens. When the mixture is ignited by the spark plug the hot gases are produced which drive or throw the piston from T.D.C. to B.D.C. and thus the work is obtained in this stroke.

EXHAUST STROKE: This is the last stroke of the cycle. Here the gases from which the work has been collected become useless after the completion of the expansion stroke and are made to escape through exhaust valve to the atmosphere. This removal of gas is accomplished during this stroke. The piston moves from B.D.C. to T.D.C. and the exhaust gases are driven out of the engine cylinder; this is also called scavenging

FOUR STROKE DIESEL ENGINE (CI):

Compression ignition engine or CI engines an internal combustion engine in which ignition of the fuel takes place with the help of hot compressed air. As the air is compressed, it gets hot and its heat is used for the ignition and burning of the fuel. In this engine the air is sucked during suction stroke and then this air is compressed while compression stroke. At the end of the compression stroke, fuel is injected into the cylinder and it gets ignited from the heat of compressed air and burning process begins. Diesel is used as fuel for the working of this engine. It works on the principle of Diesel Cycle. The compression ratio of this type of engine is usually ranges from 14:1 to 22:1. It is used in heavy duty vehicles like buses, trucks, ships, etc



Cycle consists of following four strokes

1) Suction Stroke

2) Compression Stroke

3) Expansion or Power Stroke

4) Exhaust Stroke

1. Suction Stroke:

In this Stroke the inlet valve opens In this stroke the piston moves from TDC to BDC (i.e downward) and the suction of air takes place through the inlet valve.

2. Compression Stroke:

In this stroke both the inlet and exhaust valves remain closed during the stroke. This stroke compresses the air that is taken into the cylinder in the suction stroke. As the air gets compressed, the temperature of the air increases and reaches upto that level where the combustion of the diesel takes place.

3. Power Stroke:

In this stroke both the valves remain closed during the start of this stroke but when the piston just reaches the B.D.C .the exhaust valve opens. At just before the end of compression stroke, the injector injects the fuel into the cylinder. Due to the heat of the air, the ignition of the fuel begins and combustion takes place. Due to the combustion of the fuel, hot exhaust gases produced that puts a very high thrust force on the piston and it moves downward. The piston rotates the crankshaft with the help of connecting rod. It is called as power stroke because power is produced in this stroke.

4. Exhaust Stroke:

In this stroke the piston moves upward (i.e. BDC to TDC) and pushes the burnt gases out of the engine cylinder through exhaust valve.

Two strokes Spark Ignition (Petrol) Engine.

The principle of a two-stroke spark-ignition engine is shown in the figure. Its two strokes are as follows:

1)Upward Stroke

2)Downward Stroke

Upward Stroke

During the upward stroke, the piston moves upward from the bottom dead center to the top dead center. By compressing the charge air petrol mixture in the combustion chamber of the cylinder. Due to the upward movement of the piston, a partial vacuum is created in the crankcase.And a new charge is drawn into the crankcase through the uncovered inlet port. The exhaust port and transfer port are covered when the piston is at the top dead center position. The compressed charge is ignited in the combustion chamber by a spark given by the spark plug.

Downward Stroke

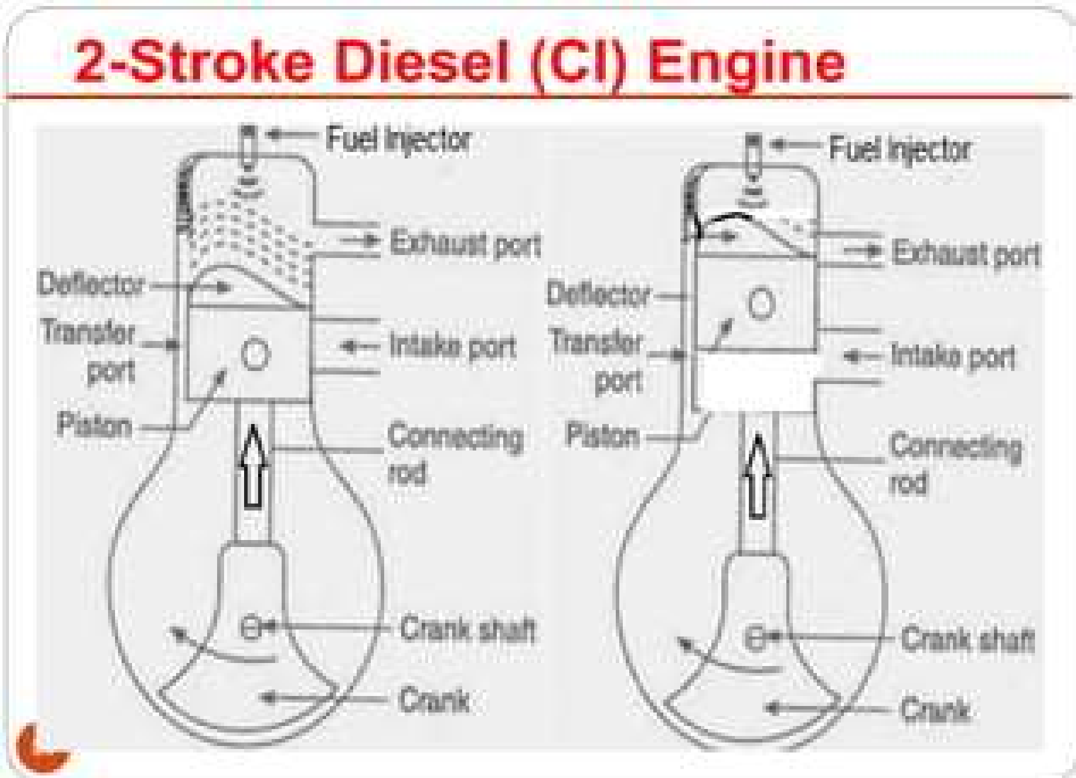
As soon as the charge is ignited the hot gases compress the piston which moves downward, rotating the crankshaft thus doing the useful work. During this stroke, the inlet port is covered by the piston and the new charge is compressed in the crankcase. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. and hence the exhaust starts through the exhaust port.As soon as the transfer port is open, the charge through it is forced into the cylinder. The charge strikes the deflector on the piston crown, rises to the top of the cylinder, and pushes out most of the exhaust gases. The piston is now at the bottom dead center position.

2 STROKE DIESEL(CI) ENGINE:

The principle of a two-stroke Compression-ignition engine is shown in the figure. Its two strokes are as follows:

1)Upward Stroke

2)Downward Stroke



Upward Stroke:

As the piston starts rising from its B.D.C. position, it closes the transfer and the exhaust port. The air which is already there in the cylinder is compressed. At the same time with the upward movement of the piston, vacuum is created in the crank case. As soon as the inlet port is uncovered the fresh air is sucked in the crank case. The charging is continued until the crank case and the space in the cylinder beneath the piston in filled with the air.

Downward Stroke:

Slightly before the completion of the compression stroke a very fine spray of diesel is injected into the compressed air (which is at a very high temperature). The fuel ignites spontaneously.

Pressure is exerted on the crown of the piston due to the combustion of the air and the piston is pushed in the downward direction producing some useful power. The downward movement of the piston will first close the inlet port and then it will compress the air already sucked in the crank case.Just at the end of power stroke, the piston uncovers the exhaust port and the transfer port simultaneously. The expanded gases start escaping through the exhaust port and at the same time the fresh air which is alredy compressed in the crank case, rushes into the cylinder through the transfer port and thus the cycle is repeated again.

Electric vehicles (EV) and Hybrid vehicles (HV)

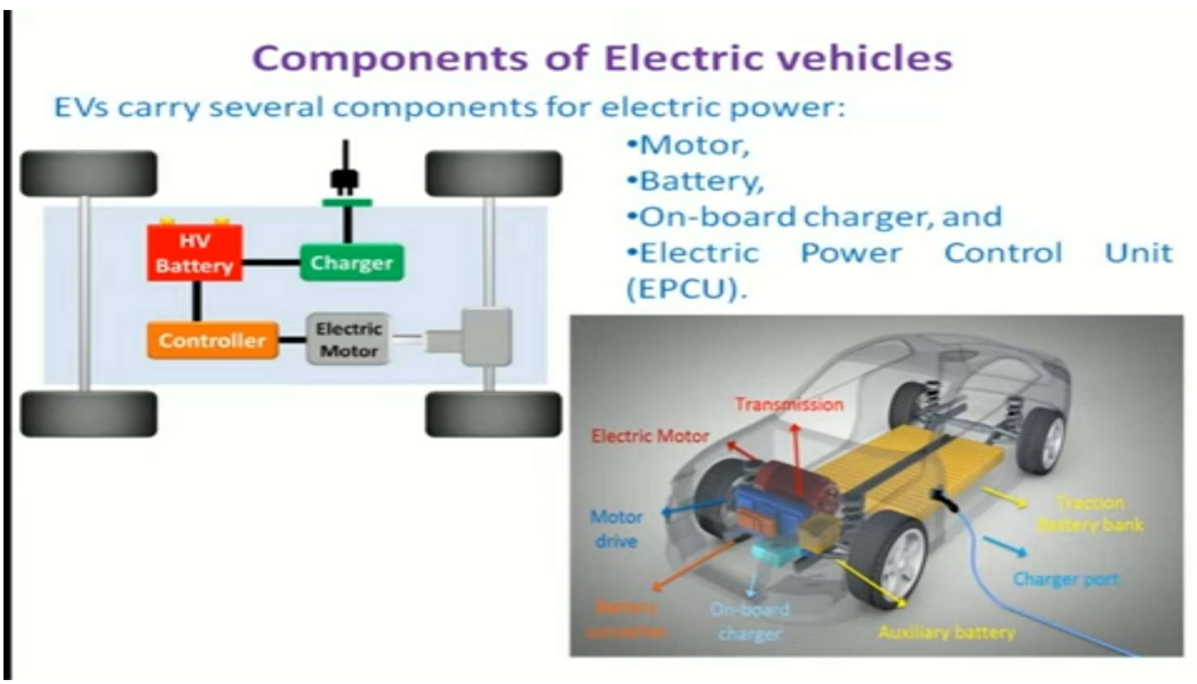
Electric vehicles (EV)

An EV is a shortened acronym for an electric vehicle. EVs are vehicles that are powered by electric motor and battery. Electric vehicles have low running costs as they have less moving parts for maintaining and also very environmentally friendly as they use no fossil fuels (petrol or diesel).

Hybrid vehicles (HV)

Hybrid vehicles are powered by both internal combustion engine and an electric motor, which uses energy stored in batteries. The battery can also power auxiliary loads and reduce engine idling when stopped. Together, these features result in better fuel economy without sacrificing performance. These are also environmentally friendly as they use less or no fossil fuels.

Electric vehicles :



Electric vehicles (EVs) are made up of various components, including:

1. Electric Motor: The electric motor is the heart of an EV. It converts electrical energy from the battery into mechanical energy to drive the vehicle.

2. Battery Pack: The battery pack stores electrical energy in the form of lithium-ion or other types of batteries. This is what powers the electric motor.

3. Charging Port: EVs have a charging port to connect to charging stations or home chargers to replenish the battery's energy.

4. Power Electronics: These components manage the flow of electrical energy from the battery to the electric motor. They include inverters, converters, and other control systems.

5. Transmission: Some EVs have a single-speed transmission because electric motors have a wide range of torque. Others may have multi-speed transmissions for efficiency.

6. Onboard Charger: This device is responsible for converting AC power from the charging station or home charger into DC power to charge the battery.

7. Thermal Management System: To maintain optimal operating temperatures, EVs have cooling and heating systems for the battery, electric motor, and other components.

8. Electric Vehicle Controller:It manages various functions in the vehicle, including power distribution, regenerative braking, and safety systems.

9. Regenerative Braking System: This system recovers energy during braking and converts it back into electrical energy to recharge the battery.

10. High-Voltage Wiring: EVs use high-voltage wiring to efficiently transfer power between components.

11.Energy Management System: It optimizes energy usage and distribution, enhancing efficiency and extending the vehicle's range.

12. Electric Vehicle Battery Management System (BMS): Monitors and manages individual battery cells to maximize their lifespan and performance.

13. Body and Interior: The chassis, frame, and interior components are essential for safety, comfort, and aesthetics.

14. **Electric Vehicle Control Unit (ECU):** It coordinates various systems in the vehicle, ensuring efficient operation.

15. **Wheels and Tires:** Like traditional vehicles, EVs have wheels and tires that are optimized for electric propulsion.

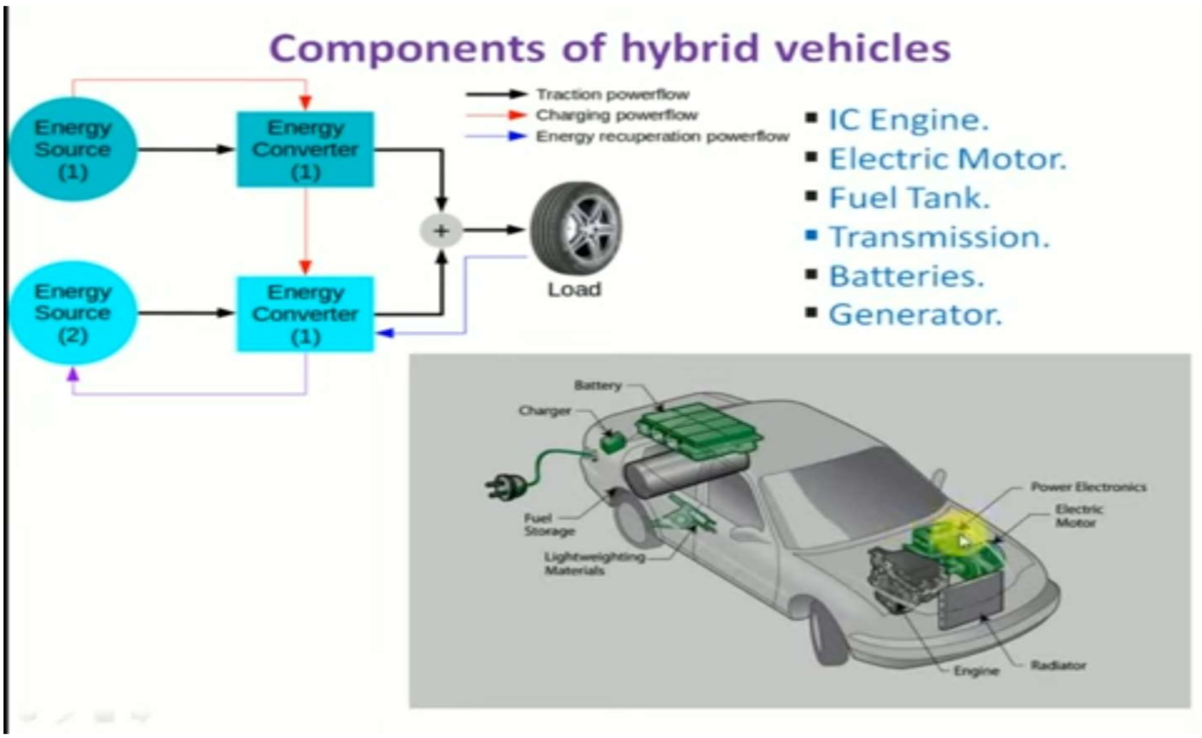
16. **Safety Systems:** This includes airbags, anti-lock braking systems (ABS), and other safety features.

17. **Infotainment System:** The user interface, navigation, and entertainment features.

18. **Exterior Charging Connectors:** The port where you connect the charging cable to the vehicle.

These components work together to make electric vehicles a viable and sustainable mode of transportation. Keep in mind that the specific components and their configurations can vary among different EV models and manufacturers.

HYBRID VEHICLES:



Hybrid vehicles combine an internal combustion engine (usually gasoline) with an electric motor and battery system for improved fuel efficiency and reduced emissions. The components of a hybrid vehicle typically include:

1. **Internal Combustion Engine (ICE):** A gasoline engine that provides power and can charge the battery directly in some hybrid configurations.

2. **Electric Motor:** An electric motor assists the engine in powering the vehicle and can operate independently at low speeds.

3. **Battery Pack:** A smaller battery pack than in pure electric vehicles, used to store and deliver electrical energy to the electric motor.

4. **Transmission:** Many hybrids use a continuously variable transmission (CVT) or an automatic transmission to control power flow between the engine and electric motor.

5. **Hybrid Control Unit (HCU):** Manages the interaction between the engine and electric motor, optimizing performance and efficiency.

6. **Regenerative Braking System:** Captures energy during braking and deceleration to recharge the battery.

7. **Power Split Device:** In a full hybrid (e.g., Toyota Prius), this device divides power from the engine to drive the wheels and to recharge the battery.

8. **Electric Generator (Alternator):** In some hybrids, the engine's mechanical energy is converted into electrical energy to recharge the battery.

9. **Electric Drive (ED) Mode:** Allows the vehicle to operate solely on electric power for short distances.

10. **Hybrid Battery Management System (BMS):** Monitors and controls the state of charge and health of the hybrid battery.

11. **Fuel Tank:** Stores gasoline for the internal combustion engine.

12. **High-Voltage Wiring:** Used to transfer power between components, like the battery and electric motor.

13. **Low-Voltage Electrical System:** Powers conventional vehicle systems, such as lighting, HVAC, and infotainment.

14. **Body and Interior:** Includes the chassis, frame, and interior components for passenger comfort and safety.

15. **Safety Systems:** Such as airbags, ABS, and stability control systems.

16. **Exterior Charging Connectors:** In plug-in hybrid vehicles, there's a port to connect to external power sources for recharging the battery.

17. **Exhaust System:** A modified exhaust system to meet emissions standards and reduce harmful emissions.

18. **Hybrid Cooling System:** For cooling the engine, electric motor, and power electronics.

The combination of these components allows hybrid vehicles to switch between electric and gasoline power, providing improved fuel economy and reduced emissions compared to traditional internal combustion engine vehicles. The exact configuration can vary among different hybrid models and manufacturers.

UNIT- III

POWER PLANT ENGINEERING:

Power plant engineering is a multidisciplinary branch of engineering that focuses on the design, construction, operation, and maintenance of power plants and their associated systems. These power plants are essential for generating electricity, and they play a crucial role in supplying energy to industries, homes, and businesses.

Conventional sources of energy:

Conventional sources of energy refer to the established and widely used means of energy production that have been in use for an extended period. These sources of energy are considered traditional and have historically played a significant role in meeting the world's energy demands. Conventional energy sources typically include fossil fuels like coal, oil, and natural gas, as well as nuclear energy.

Non-conventional sources of energy:

Non-conventional sources of energy, often referred to as renewable or alternative energy sources, are methods of generating power that are newer, more environmentally friendly, and often more sustainable than conventional energy sources. Common non-conventional sources of energy include solar power, wind power, hydropower, geothermal energy, biomass energy, and tidal and wave energy.

various types of power plants:

1)Thermal Power Plants:

2) Diesel power plant:

3)Nuclear Power Plants

4)Hydroelectric Power Plants

5)Wind Farms

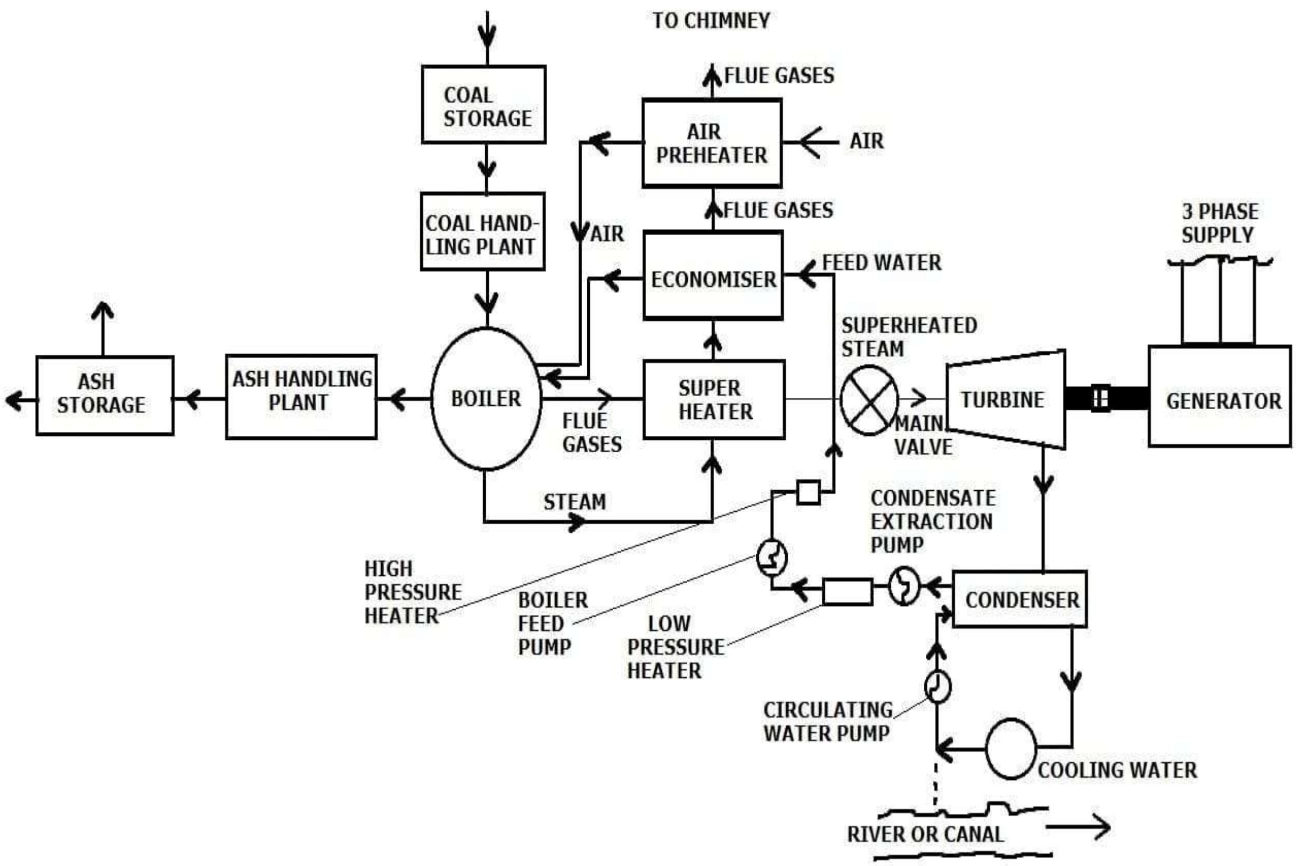
6)Solar Power Plants

7)Geothermal Power Plants

8)Biomass Power Plants

9)Tidal and Wave Power Plants etc..,

THERMAL (STEAM) POWER PLANT:



Layout of thermal plant can be easily understood by dividing the plant components

1)Coal and ash circuit

2)Air and gas circuit.

3)Feed water and steam circuit,

4)Cooling water circuit

Coal and Ash Circuit:

Coal and Ash circuit in a thermal power plant layout mainly takes care of feeding the boiler with coal from the storage for combustion. The ash that is generated during combustion is collected at the back of the boiler and removed to the ash storage by scrap conveyors. The combustion in the Coal and Ash circuit is controlled by regulating the speed and the quality of coal entering the grate and the damper openings.

Air and Gas Circuit:

Air from the atmosphere is directed into the furnace through the air preheated by the action of a forced draught fan or induced draught fan. The dust from the air is removed before it enters the combustion chamber of the thermal power plant layout. The exhaust gases from the combustion heat the air, which goes through a heat exchanger and is finally let off into the environment.

Feed Water and Steam Circuit:

The steam produced in the boiler is supplied to the turbines to generate power. The steam that is expelled by the prime mover in the thermal power plant layout is then condensed in a condenser for re-use in the boiler. The condensed water is forced through a pump into the feed water heaters where it is heated using the steam from different points in the turbine. To make up for the lost steam and water while passing through the various components of the thermal power plant layout, feed water is supplied through external sources. Feed water is purified in a purifying plant to reduce the dissolve salts that could scale the boiler tubes.

Cooling Water Circuit:

The quantity of cooling water required to cool the steam in a thermal power plant layout is significantly high and hence it is supplied from a natural water source like a lake or a river. After passing through screens that remove particles that can plug the condenser tubes in a thermal power plant layout, it is passed through the condenser where the steam is condensed. The water is finally discharged back into the water source after cooling. Cooling water circuit can also be a closed system where the cooled water is sent through cooling towers for re-use in the power plant. The cooling water circulation in the condenser of a thermal power plant layout helps in maintaining a low pressure in the condenser allthroughout.

Working principle of thermal power plant:

Fig-1 shows a schematic arrangement of equipment of a steam power station. Coal received in coal storage yard of power station is transferred in the furnace by coal handling unit. Heat produced due to burning of coal is utilized in converting water contained in boiler drum into steam at suitable pressure and temperature. The steam generated is passed through the super heater.

Superheated steam then flows through the turbine. After doing work in the turbine die pressure of steam is reduced. Steam leaving the turbine passes through the condenser which maintains the low pressure of steam at the exhaust ofturbine.

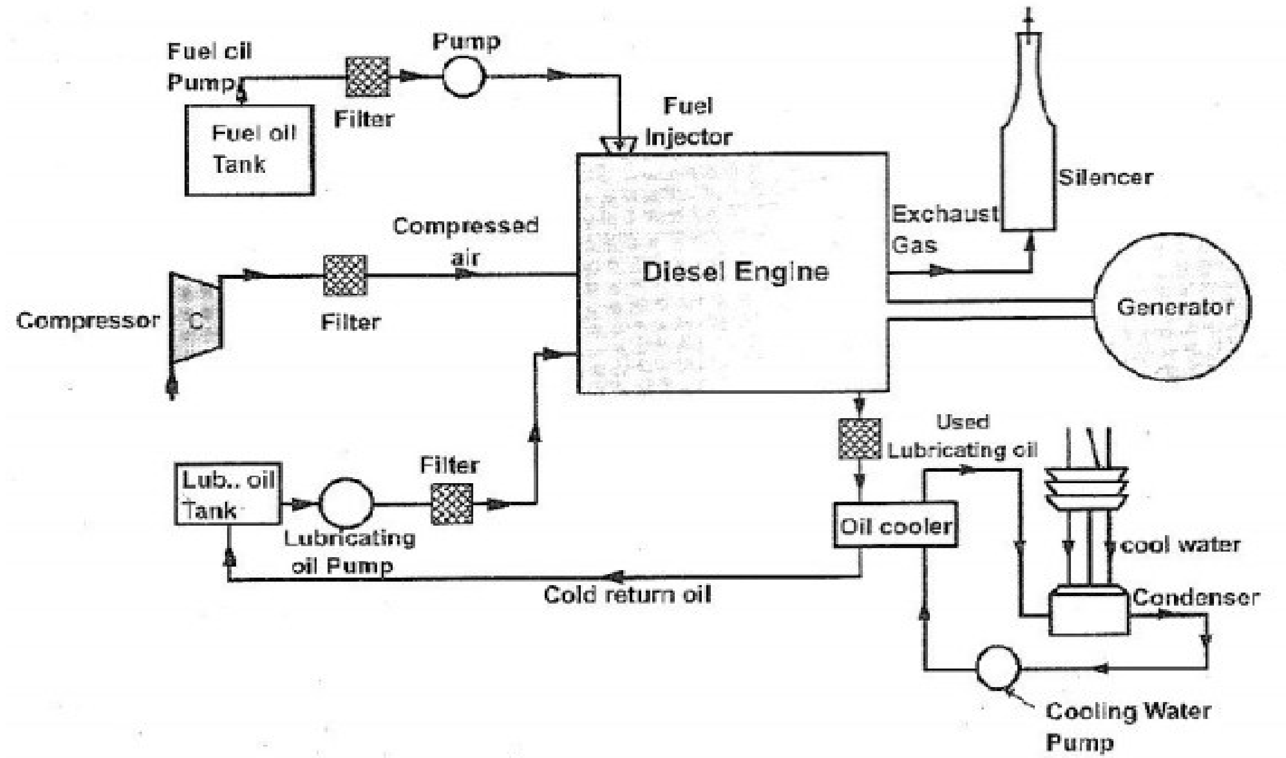
Steam pressure in the condenser depends upon flow rate and temperature of cooling water and on effectiveness of air removal equipment. Water circulating through the condenser may be taken from the various sources such as river, lake or sea. If sufficient quantity of water is not available the hot water coming out of the condenser may be cooled in cooling towers and circulated again through the condenser.

Bled steam taken from the turbine at suitable extraction points is sent to low pressure and high pressure water heaters.

Air taken from the atmosphere is first passed through the air pre-heater, where it is heated by flue gases. The hot air then passes through the furnace.

The flue gases after passing over boiler and super heater tubes, flow through the dust collector and then through economizer, air pre-heater and finally they are exhausted to the atmosphere through the chimney.

DIESEL POWER PLANT:



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Working principle of Diesel power plant:-

A simple diesel power plant is shown in the figure. Diesel engines are generally classified into four strokes and two-stroke engines. Generally, two-stroke engines are used for diesel power plants.

The compressor draws the air from the atmosphere and compresses it. The compressed air is supplied to the engine through the filter for starting, where it is compressed by a piston in a cylinder.

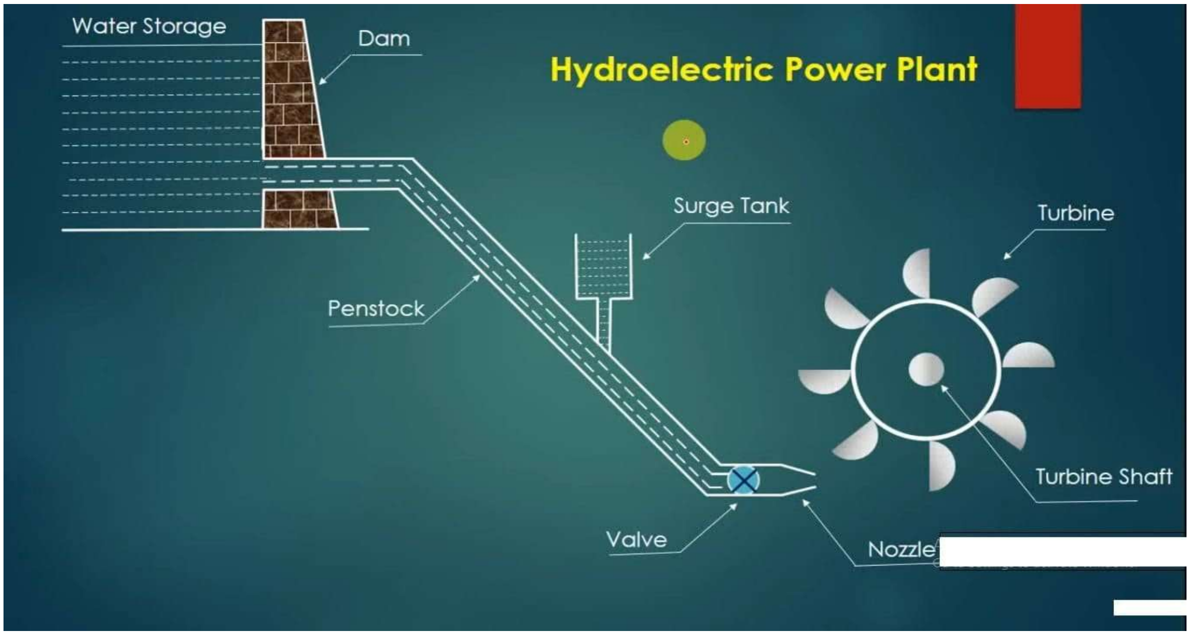
The fuel oil is supplied from the tank through the filter to the fuel injectors. The fuel injector injects the fuel into the cylinder and mixes it with compressed air.The injected fuel gets ignited and combustion takes place. This liberates the huge amount of energy which is utilized to run the generator to produce electric power.

The lubricating oil is supplied from the tank through the filter to engine cylinder. It is used to reduce the friction of moving parts and reduce wear and tear of the engine parts such as cylinder walls and piston. Lubrication oil which gets heated due to the friction of the moving parts is cooled before re-circulation.The cooling water is continuously supplied to cool the engine and lubricating oil is supplied to lubricate the engine parts. The air intake supplies the air

to the engine for subsequent operations.

After the combustion of fuel exhaust gases are formed these exhaust gases are supplied to the silencer to reduce the noise and send to atmosphere through the chimney.

HYDROELECTRIC POWER PLANT:-



Working principle of Hydroelectric Power plant:-

Dam and Reservoir: The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height. The dam forms a large reservoir behind it. The height of water level (called as water head) in the reservoir determines how much of potential energy is stored in it.

Control Gate: Water from the reservoir is allowed to flow through the penstock to the turbine. The amount of water which is to be released in the penstock can be controlled by a control gate. When the control gate is fully opened, maximum amount of water is released through the penstock.

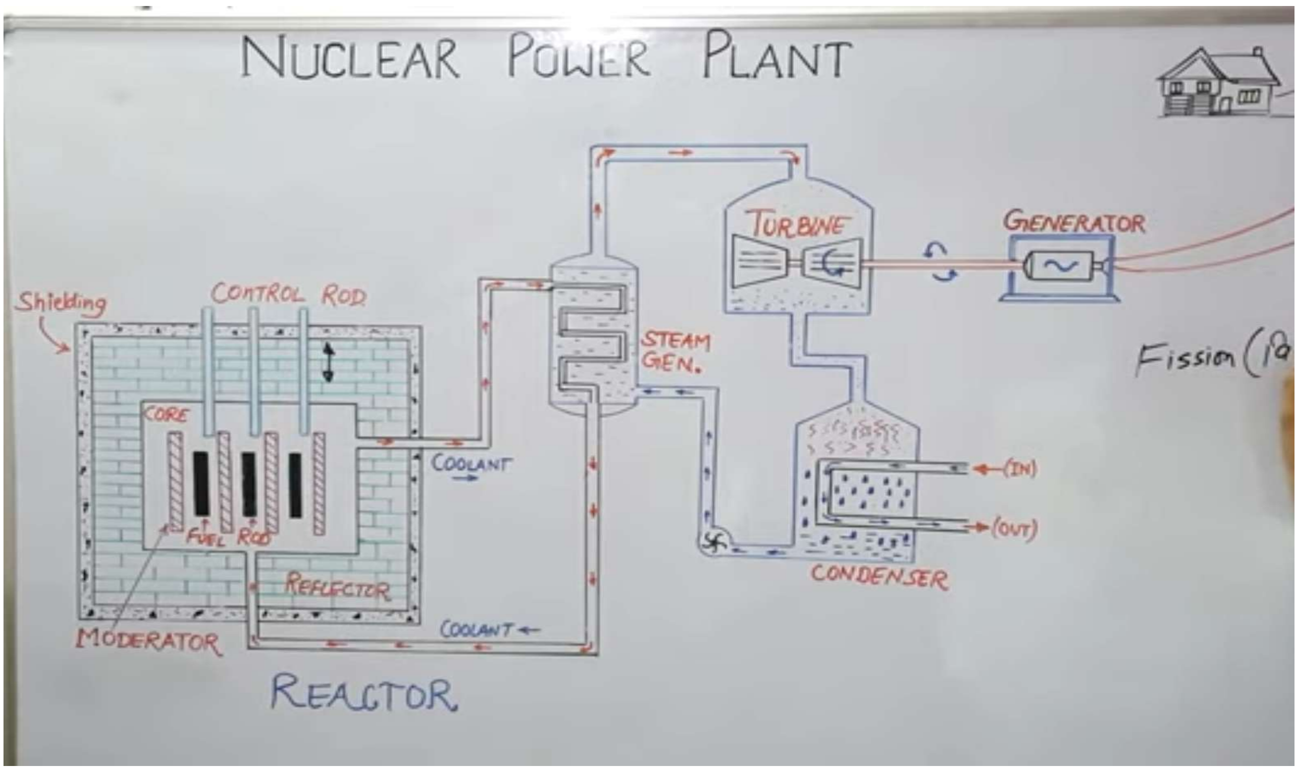
Penstock: A penstock is a huge steel pipe which carries water from the reservoir to the turbine. Potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

Water Turbine: Water from the penstock is taken into the water turbine. The turbine is mechanically coupled to an electric generator. Kinetic energy of the water drives the turbine and consequently the generator gets driven. There are two main types of water turbine; (i) Impulse turbine and (ii) Reaction turbine. Impulse turbines are used for large heads and reaction turbines are used for low and medium heads.

Generator: A generator is mounted in the power house and it is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of a transformer for the transmission purpose.

Surge Tank: Surge tanks are usually provided in high or medium head power plants when considerably long penstock is required. A surge tank is a small reservoir or tank which is open at the top. It is fitted between the reservoir and the power house. The water level in the surge tank rises or falls to reduce the pressure swings in the penstock. When there is sudden reduction in load on the turbine, the governor closes the gates of the turbine to reduce the water flow. This causes pressure to increase abnormally in the penstock. This is prevented by using a surge tank, in which the water level rises to reduce the pressure. On the other hand, the surge tank provides excess water needed when the gates are suddenly opened to meet the increased load demand.

NUCLEAR POWER PLANT:-



Working principle of Nuclear Power plant:-

Nuclear reactor is the main component of nuclear power plant and nuclear fuel is subjected to nuclear fission. Nuclear fission is a process where a heavy nucleus is spitted into two or more smaller nuclei. . A heavy isotope generally uranium-235(U-235) is used as a nuclear fuel in the nuclear reactor because it has the ability to control the chain reaction in the nuclear reactor. Nuclear fission is done by bombarding uranium nuclei with slow moving neutrons. The energy released by the fission of nuclei is called nuclear fission energy or nuclear energy. By the braking of uranium atom, tremendous amount of heat energy and radiation is formed in the reactor and the chain reaction is continuously running until it is controlled by a reactor control chain reaction. A large amount of fission neutrons are removed in this process, only small amount of fission uranium is used to generate the electrical power.

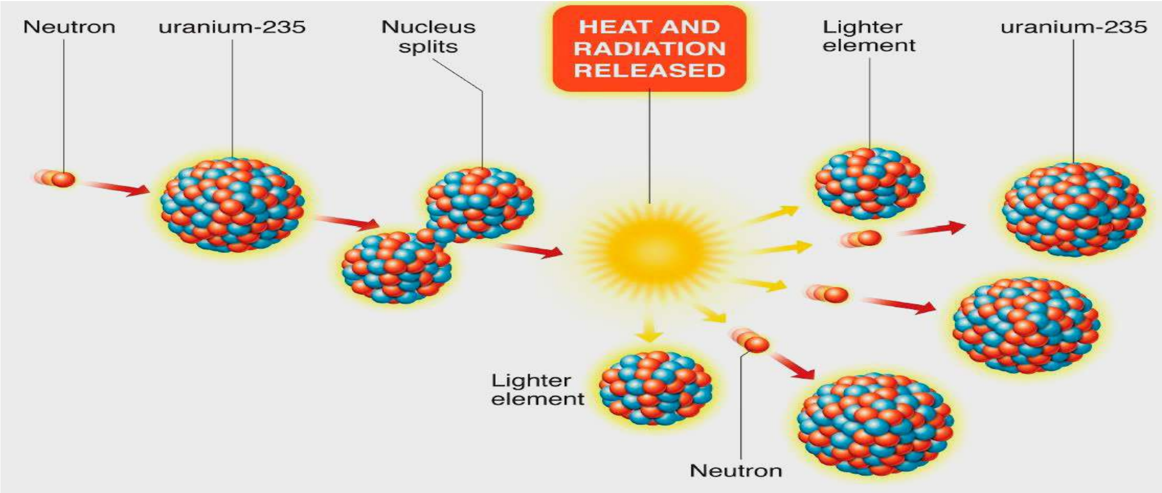
Moderator in the core of the reactor which basically slows down the neutron's speed released from fission with an objective so that they cause more fission. It is generally water, however it might be heavy water or graphite.

Control rods are made up of neutron-absorbing material such as hafnium, cadmium or boron, and are embedded or removed from the core to regulate the rate of reaction, or to stop it.

During nuclear fission, the heat can be generated within the core of the reactor. This heat can be used to warm the water into steam so that turbine blades can be activated. Once the turbine blades activated then they drive the generators to make electricity. In a power plant, a cooling tower is available to cool the steam into the water otherwise they use the water from different resources. Finally, the cooled water can be reused to generate steam.

Defination of Fission :-

Nuclear fission is a reaction in which the nucleus of an atom splits into two or more smaller nuclei. The fission process often produces gamma photons, and releases a very large amount of energy



MECHANICAL POWER TRANSMISSION :-

Mechanical power transmission is the process of transferring mechanical energy from one component to another within a machine or system. It plays a crucial role in various industries and applications, such as manufacturing, transportation, and construction. This energy transfer is essential for the operation of machinery, enabling the conversion of one form of mechanical energy, such as rotary motion, into another, or the transmission of power over distances. Key components involved in mechanical power transmission include gears, belts, chains, shafts, couplings, and bearings. These components work together to transmit power efficiently and control the speed, torque, and direction of motion in mechanical systems.

Types of mechanical power transmission:

1) Belt drives

2)Chain drives

3) Gear drives

4) Rope drive

5) Shaft couplings

6)Power screws (lead screws)

1)Belt drives:-

Belt drives are a common method of mechanical power transmission used to transfer power between two rotating shafts. They consist of a flexible belt, typically made of materials like rubber, leather, or synthetic compounds, that connects a driving pulley (the input) to a driven pulley (the output). Belt drives are widely used in various applications, from industrial machinery to automotive engines and household appliances.

Types of belt:

Flat Belts: Flat belts are simple, flat strips of material, usually made of rubber, leather, fabric, or synthetic materials. They are used for various applications, such as in conveyor systems and some industrial machinery. Flat belts are known for their flexibility and are often used when a simple, cost-effective solution is needed.

V-Belts: V-belts are named for their cross-sectional shape, which resembles the letter "V." They are commonly used in applications where higher torque transmission is required, such as in automotive engines and industrial machinery. V-belts provide excellent traction due to their shape and are available in different sizes and profiles.

Round Belts: Round belts are round cross-sectioned belts made of rubber or other materials. They are used in applications where flexibility and minimal vibration are important, such as in

some printing and paper handling equipment.

TYPES OF BELT DRIVES:

1)Open belt drive

2)Closed or crossed belt drive

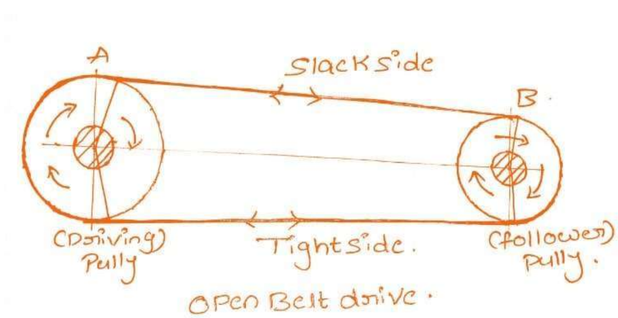
3)Fast and loose cone pulley

4)Stepped cone pulley

5)Jockey pulley drive

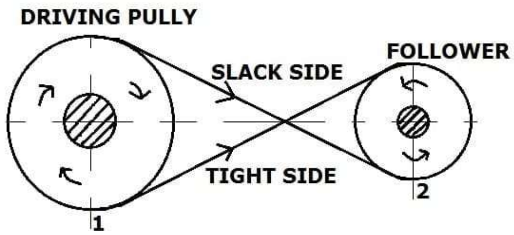
1)Open Belt-Drive

In this, the shafts rotate in the same direction which means the direction of rotation is the same as the driving and driven pulley. The shafts are arranged in a parallel direction. If the shafts are having a more distance between the driver and the driving pulley then there must be the upper side will be the slack side and the below side will be the tight side.



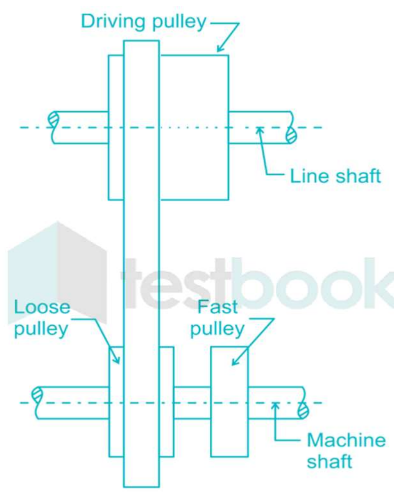
2) Crossed belt drive :

Here in the crossed belt drive the transmitted power is more but there is a problem that it can not run faster. If so then rubbing between belts may wear and tear. In this, the shafts rotate in the opposite direction. At the junction side, it rubs and therefore wears and tears off, and if you don't want to wear and tear then place more distance between the pulley and run at low speed.



3)Fast and loose cone pulley :

As the name indicates fast and loose pulley means there are two pulleys in it. The fast pulley is mounted on a shaft with keyed joint and the loose pulley runs freely on the shaft and it is incapable of transmitting any power. Another term in that is when multiple machines are working from a single power source then in this condition, each machine has provided with this fast and loose cone pulley

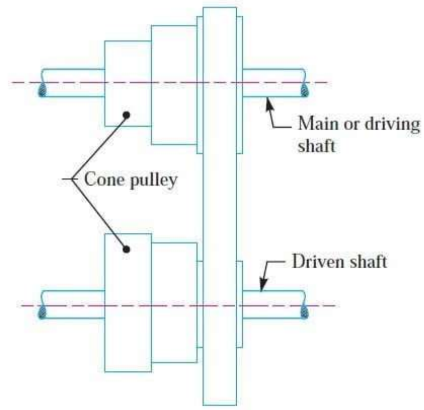


Fast and loose pulley drive

4) Stepped cone pulley :

This is also known as the speed cone. Here in the stepped cone pulley, there are more pulleys attached of different diameters one adjacent to another. Stepped cone pulleys are used where they have to change the gear or speed of the driven shaft change frequently like a machine (Lathe, Milling, and more). The diameter of the driving and driven pulley is such that when we wanted to shift to another pulley the same belt will operate

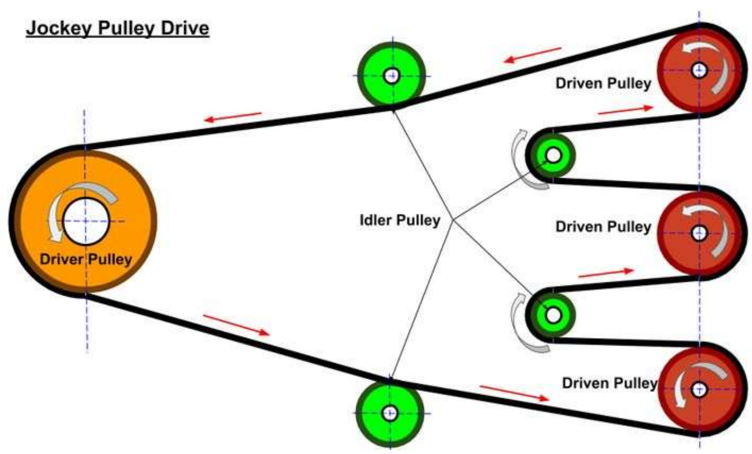
Common applications for this type of drive are lathes and drilling machines. A stepped cone pulley enables to use the same drive motor to obtain different output speeds.



5)Jockey pulley drive :

Jockey pulleys are used in the steering section of the system. A jockey pulley is like an idle pulley and is used for increasing the angle of contact in an open belt drive. Hence increasing the angle of contact steer to the increased power transmission capacity of the drive.

This one pulley is mounted nearer to the smaller pulley and we can say also this is placed on the slack side of the belt. It (jockey or idle pulley) helps to increase the angle of contact of the belt, so that belt tension is increased and also the drive provides a high-velocity ratio.



Applications Of Belt-Drive

1)The belt drive is used in the Mill industry.

2)The belt drive is used in Conveyor.

3)Power transmission in industrial machinery and equipment

4)Automotive applications, in different types of engines and transmissions

5)Agricultural machinery, such as tractors and harvesters

6)Conveyor systems in manufacturing and distribution facilities

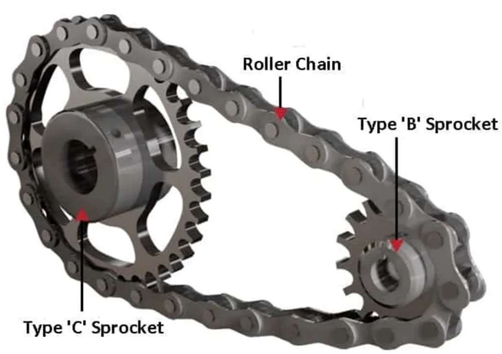
7)HVAC systems in buildings, such as fans and air handling units

8)Exercise equipment, such as treadmills and stationary bikes,Office equipment, such as printers and copiers,Power tools, such as table saws and drill presses.

2) CHAIN DRIVES:-

Chain drives are most commonly used to transmit power between two components that are at a greater distance, but they may also be used for short distances**.**Chain drive is a type of mechanical power transmission system that uses chains to transfer power from one place to another. A conventional chain drive consists of two or more sprockets and the chain itself. The holes in the chain links fit over the sprocket teeth.When the prime mover rotates, the chain wrapped on the shaft's sprocket rotates with it. This applies mechanical force onto the driven shaft, transmitting mechanical power in the process.

One of the main advantages over a belt drive is that a chain drive maintains a constant speed ratio, thanks to its zero slip feature. There is no lag in power transfer and hence, it serves as a timing chain in applications such as internal combustion engines. Having no slippage also ensures high mechanical efficiency. The only losses in a chain drive are due to friction between the chain links and the sprocket.



CHAIN DRIVE

Applications of chain drives:

1)Automotive timing systems.

2)Bicycles for pedal-to-wheel power transfer.

3)Conveyor systems for material handling.

4)Industrial machinery in manufacturing.

5)Agricultural equipment like tractors.

6)Lifting and hoisting in cranes and hoists.

7)Mining equipment for conveyors and rigs**.**

3)GEAR DRIVES:

A gearbox, also known as a gear drive, has three main functions: to increase torque from the driving equipment (motor) to the driven equipment, to reduce the speed generated by the motor, and/or to change the direction of the rotating shafts.

Types of gers:

Spur gear:

Spur gears transmit power through shafts that are parallel. The teeth of the spur gears are parallel to the shaft axis. This causes the gears to produce radial reaction loads on the shaft, but not axial loads. Spur gears tend to be noisier than helical gears because they operate with a single line of contact between teeth. While the teeth are rolling through mesh, they roll off of contact with one tooth and accelerate to contact with the next tooth. This is different than helical gears, which have more than one tooth in contact and transmit torque more smoothly.

Helical gear

Helical gears have teeth that are oriented at an angle to the shaft, unlike spur gears which are parallel. This causes more than one tooth to be in contact during operation and helical gears can carry more load than spur gears. Due to the load sharing between teeth, this arrangement also allows helical gears to operate smoother and quieter than spur gears. Helical gears produce a thrust load during operation which needs to be considered when they are used. Most enclosed gear drives use helical gears.

Bevel Gear

Bevel gears are most commonly used to transmit power between shafts that intersect at a 90 degree angle. They are used in applications where a right angle gear drive is required. Bevel gears are generally more costly and are not able to transmit as much torque, per size, as a parallel shaft arrangement.

Worm Gear

Worm gears transmit power through right angles on non-intersecting shafts. Worm gears produce thrust load and are good for high shock load applications but offer very low efficiency in comparison to the other gears. Due to this low efficiency, they are often used in lower horsepower applications.

Applications of gear drives:

Gears are mechanical devices that are utilised in a wide range of mechanical equipment and systems. There are several types of gears available and used in a variety of household, commercial, and industrial applications, including:

1)Aircrafts

2)Automobiles

3)Clocks

4)Marine systems

5)Material handling equipment

6)Measuring instrumentation

7)Power plants

8)Pumps

4)ROPE DRIVES:

Rope drive is referred to as a simplified form of a belt drive, which is most commonly found having the application of power transmission mechanically. Rope drives are found performing multiple use of circular section ropes instead of the single flats or V-belts. The rope drives are the ones which are widely used where ever there seems to be a large amount of power that needs to be transmitted, from one pulley to another for any particular considerable distance.

It can be noted that the use of belts like flat belts is found to be limited for the purpose of transmission of any medium power considered from one pulley to any another wherever the two pulleys are found not exceeding the distance of minimum 8 m. If there is any large amount of power is found being then it can be transmitted by the flat belt which can result in an excessive belt cross-section

Types of rope drives :

Wire rope:

Wire rope is referred to as that rope which is found having several strands of metal wire twisted into a helix which forms a composite rope, in terms of the pattern which is commonly known to be the laid rope. Larger diameter of wire rope is found consisting of multiple strands of such laid ropes in a pattern which is commonly known as cable laid

Fibre rope:

Fibre ropes are referred to as those ropes which are found being made from fibres of varying length that is also found being dependent on their source. These are the ones which are found being known to be made up of the twisted up rope from the yarns, wherein the twist is responsible for binding the fibres firmly together so that it can hold the friction whenever the yarn is subjected to undergo any kind of strain.

Applications of Rope Drive:

Rope drive is found having various applications which can be used for several purposes like hunting, pulling, carrying purposes, lifting purposes, as well as climbing activities in the ancient era.

INTRODUCTION TO ROBOTICS:

Robotics is a multidisciplinary field that focuses on the design, construction, operation, and use of robots. Robots are autonomous or semi-autonomous machines that can perform tasks in the physical world. They can vary in size and complexity, from small, simple robots used in factories to large, sophisticated ones used in space exploration. Robotics involves aspects of computer science, engineering, mathematics, and physics to create machines that can sense, think, and act in the real world. It has applications in various industries, such as manufacturing, healthcare, agriculture, and even entertainment. Robotics is a rapidly evolving field with the potential to revolutionize many aspects of our lives.

What is joint:

Robotic joints, which are sometimes known as axes, are the moveable parts of a robot that cause relative motion between adjacent links. These links refer to the rigid components that connect the joints to ensure their proper and straightforward operation

Types of Joints:

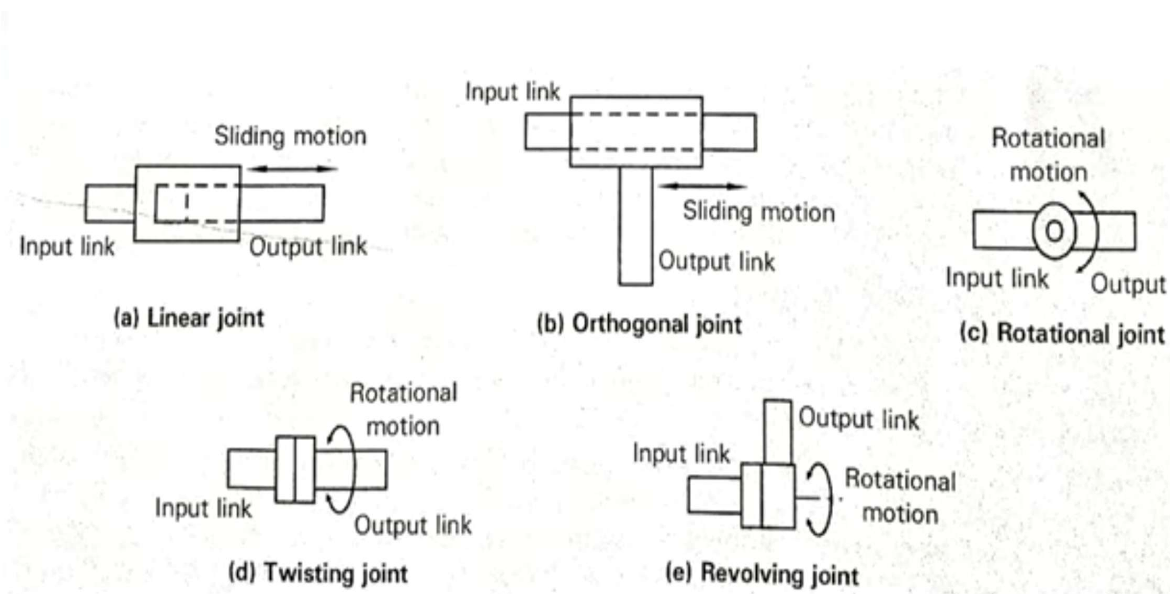
1) Linear joint

2) orthogonal joint

3) Rotational joint

4) Twisting joint

5) Revolving joint



1) Linear joint:

A linear or prismatic joint can move in a translational or sliding movement along a single axis.It is probably the simplest type of joint to imagine and is the easiest to control. Actuating the joint makes it longer or shorter.

2) orthogonal joint:

The orthogonal joints are also popularly referred to as the type O-joints. They feature a relative movement taken by the input link and output link. This kind of motion involved in the Orthogonal joints is a translational sliding motion. However unlike the linear joints arrangement, with the Orthogonal joint, the output link is perpendicular to the input link.

3) Rotational joint:

When it comes to the rotational joints, you'll find the use of rotational relative motions that come in handy for robot manipulators working multiple workspaces. These movements are carried out with the axis of rotation perpendicular to the axes of the input and output links. These rotational joints are also referred to as Type R joints

4)Twisting Joints

This type of joint features rotary motion that also results in some degree of rotation when in use. The movement in these joints is relative to the axis of rotation that is perpendicular o the axes of the input and output links. The twisting joints are also referred to as type T joints.

5)Revolving Joints

In the revolving joints, things are a bit different compared to the others. These joints also feature a rotational movement that comes in handy in different applications. The movement of these joints features motion between the two links. The axis of the input link is designed to be parallel to the axis of rotation of the joint. On the other hand, the axis of the output link is designed to be perpendicular to the axis of rotation of the joint. This type of joint is also referred to as the Type V joint

What is Robotics links :

The links are the rigid members connecting the joints. The joints (also called axes) are the movable components of the robot that cause relative motion between adjacent links.

Types of links:

Rigid Links: These are solid, inflexible components that form the robot's main structure, providing stability and support.

End-Effector: The end-effector, also known as the robot's "hand," is the part of the robot that interacts with the environment. It can have various forms, such as grippers, welding tools, or sensors, depending on the robot's application.

Base Link: The base link is the foundation of the robot, and it typically houses the robot's power source and control systems.

Flexible Links: In some robots, flexible links, made of materials like rubber or plastic, are used to improve safety or adaptability in specific applications**.**

Robotics configuration:

When selecting an industrial robot there are many things which need to be considered, such as: what is its purpose, how fast does it need to move, what precision of movement does it need, will it be a collaborative robot? All of these considerations, and many others, determine the type of industrial robot which is best for a job.

Types of robot configurations:

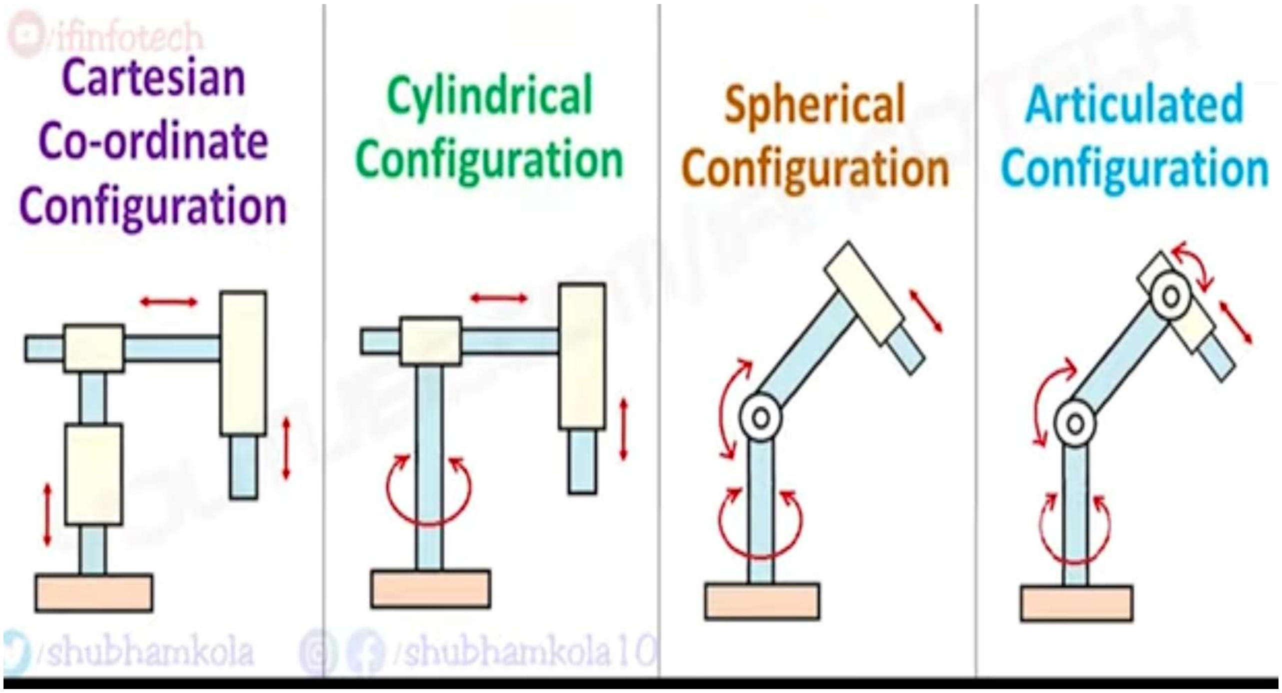
1)Cartesian robot configuration

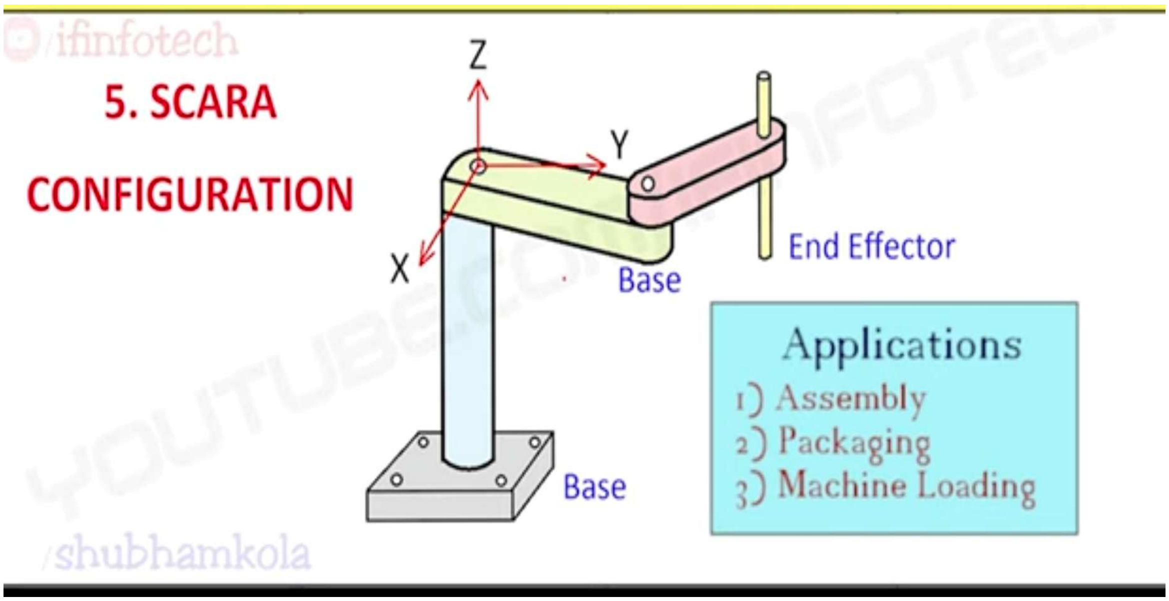
2)Cylindrical robot configuration

3)Spherical robot configuration

4) Selective Compliance Articulated Robot Arm (SCARA) robot configuration

5) Articulate robot configuration





1)Cartesian robot configuration

A Cartesian robot can be defined as an industrial robot whose three principal axes of control are linear and are at right angles to each other.Using their rigid structure, they can carry high payloads. They can perform some functions such as pick and place, loading and unloading, material handling, and so on. Cartesian robots are also called as Gantry robots as their horizontal member supports both the ends.

2)Cylindrical robot configuration

Cylindrical Robots have a rotary joint at the base and a prismatic joint to connect the links. The robots have a cylindrical-shaped work envelop, which is achieved with rotating shaft and an extendable arm that moves in a vertical and sliding motion. Cylindrical Robots are often used in tight workspaces for simple assembly, machine tending, or coating applications due to their compact design.

3)Spherical robot configuration:

Jointed-arm robot- general configuration of a human arm. This consists of a vertical column that swivels about the base using T joint. At the top of the column is a shoulder joint (an R joint), output of an elbow joint (another R joint). Robot is very flexible and suits for different applications. Could be used as working robot (welding, painting, assembly, machining, etc) or servicing robot (loading – unloading of different equipment). For transport applications not the best solution

4) SCARA robot configuration :

SCARA is an acronym that stands for Selective Compliance Assembly Robot Arm or Selective Compliance Articulated Robot Arm. SCARA Robots function on 3-axis (X, Y, and Z), and have a rotary motion as well. SCARA Robots excel in lateral movements and are commonly faster moving and have easier integration than Cartesian Robots. Typically, SCARA robots are used for assembly and palletizing, as well as bio-med application.

5) Articulate robot configuration:

Articulated Robots mechanical movement and configuration closely resembles a human arm. The arm is mounted to a base with a twisting joint. The arm itself can feature anywhere from two rotary joints up to ten rotary joints which act as axes, with each additional joint or axis allowing for a greater degree of motion. Most Articulated Robots utilize four or six-axis. Typical applications for Articulated Robots are assembly, arc welding, material handling, machine tending, and packaging

Applications of Robotics:

Uses of robotics

- Agriculture
- Automobile
- Construction
- Entertainment
- Health care: hospitals, patient-care, surgery , research, etc.
- Household purposes
- Laboratories: science, engineering , etc.
- Manufacturing
- Military: demining, surveillance, attack, etc.
- Mining, excavation and exploration
- Transportation: air, ground, rail, space, etc.
- Utilities: gas, water and electricity
- Warehouses

Uses of Robotics:

Industrial application:

- Material handling
- Material transfer
- Machine loading and unloading
- Spot welding
- Continuous arc welding
- Spray coating
- Assembly
- Inspection

Robots in Hazardous environment

The hazardous environment can be define the place where human can not survive and harmful . Some examples of hazardous environments would be nuclear reactors, outside earth's atmosphere and even behind enemy lines in war.

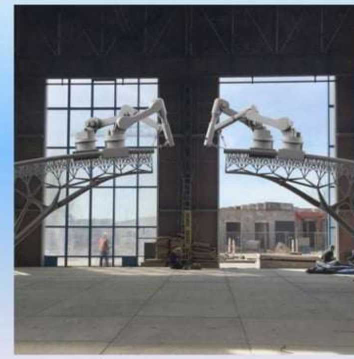
Space Exploration & Research

Military Application

Military robots autonomous robots or remote-controlled mobile robots designed for military applications from transport to search & attack.

Construction application

The construction industry slightly depends on robot. Robots can reduce the breakneck phenomenon such as metal dissolve , piling etc.



Automobiles application

Robotics are Advancing automobile manufacturing to new heights. Robots gives automotive companies a competitive advantage . It mainly use to improve quality and reduce warranty cost.

Medical Robot

A medical robot is a robot used in the medical science. They include, but are not limited to surgical robot .