Part A (Short Answer Questions 5 x 2 = 10 Marks)

1. What are Nanomaterials?
   Nanomaterials are materials possessing, at minimum, one external dimension measuring 1-100nm
2. List any two applications of ceramics
   Common examples are earthenware, porcelain, and brick.
   The earliest ceramics made by humans were pottery objects (pots, vessels, or vases) or figurines made from clay, either by itself or mixed with other materials like silica, hardened and sintered in fire.
3. Write any two boiler mountings
   Water level indicator, spring loaded safety valve, pressure gauge.
4. List out the parts of the I.C. Engine
   Cylinder, Cylinder head, Piston, Piston rings, Gudgeon pin, Connecting rod, Crankshaft, Crank, Engine bearing, Crankcase, Flywheel, Governor
5. List any two applications of robotics
   are used for picking, sorting, packaging

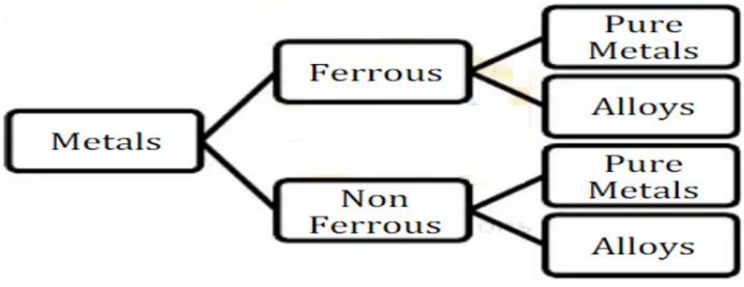
Part B (Long Answer Questions 3 x 10 = 30 Marks)

6. Explain the types and applications of Ferrous & Nonferrous Metals

Ferrous metals: Ferrous metals contain iron. Examples are cast iron, mild steel, medium carbon steel, high carbon steel, stainless steel, and high speed steel.

Non-ferrous metals: Non-ferrous metals do not contain iron. Some common non ferrous metals are aluminium, copper, zinc, tin, brass (copper + zinc), and bronze (copper + tin).

Types of Ferrous metals



Cast iron:

Composition: Alloy of iron and 2-5% carbon, 1-3% silicon and traces of magnesium, sulphur and phosphorus

Properties and characteristics: it is very strong but brittle. Cast iron has relatively low melting point, is wear resistant, possesses good fluidity, has admirable machinability and is resistant to deformation

Application: It is used to manufacture machine frames, columns, beds and plates, housing flywheel, manhole cover, automotive parts such as engine block, cylinder head, gear box case and machine partswhich are not subjected to tension and shocks.

Cast Iron is divided into following types: Grey Cast Iron**,** White Cast Iron**,** Malleable Cast Iron**,** Ductile Cast Iron, Wrought Iron

Mild steel or Low carbon steel
Composition: It has a carbon content of 0.05 to 0.3%. The balance is iron. The most popularly used carbon steel is mild steel.
Properties and characteristics: Tough, ductile and malleable. Good tensile strength, poor resistance to corrosion
Application: General-purpose engineering material like rivets, bolts, keys plain washer boiler plate's shaft, camshafts and gear

Medium carbon steel
Composition: It has a carbon content of 0.3 - 0.6% carbon. The remainder is iron content
Properties and characteristics: Strong, hard and tough, with a high tensile strength, but less ductile than mild steel.
Application: It finds application in transmission shafts, springs, spring washers, crane hooks and handtools etc.

High carbon steel
Composition: It has a carbon content of 0.6 - 1.5%. it has an iron content of 96% to 97%
Properties and characteristics: Even harder than medium carbon steel, and more brittle. Can be heattreated to make it harder and tougher
Application: Cutting tools, hammers, chisels, screw, punches, drills lathe tools, leaf springs and milling cutter

Types of Non -Ferrous metals
Aluminium
Composition: Pure aluminium (an element)
Properties and characteristics: Good strength-to-weight ratio, light, soft, ductile, good conductor of heatand electricity
Application: Kitchen equipment, window frames, general cast components
The alloys of Aluminium are Duralumin and Y-Alloy

Copper
Composition: Pure copper (an element)
Properties and characteristics: Malleable and ductile, good conductor of heat and electricity, good corrosion resistance and light weight.
Application: copper tubes used in refrigerator and air conditioners and radiators due to high thermal conductivity, electrical wires and cables, used to make door knobs. Alloys of copper are Brass and Bronze.

Brass
Composition: Alloy of copper (51% to 81%) and zinc (19% to 49%), small amount of aluminium, tin, manganese and lead give special properties to brass.

Properties and characteristics: Resistant to corrosion, fairly hard, good conductor of heat and electricity
Application: electrical fuses and fittings, brazing solder, musical instruments such as horns, trumpets and bugles etc.,

Bronze
Composition: Alloy of copper and tin
Properties and characteristics: Fairly strong, malleable and ductile when soft
Application: Decorative goods, architectural fittings

7 (a) Explain the role of Mechanical Engineering in Society

Role of Mechanical Engineers in Society

- Mechanical Engineering create and develop mechanical systems for all of humankind Concern with principles of force, energy and motion.
- Eliminates excessive usage of resources by optimizing and improving efficiency.
- To build things that make the world a better living place.
- Reduces human effort and makes work easy.
- Mechanical engineering plays a critical role in manufactured technologies, from cars to airplanes to refrigerators. It enables you to do many daily activities with ease, as it brings helpful technologies to our modern society.

7 (b) Explain the emerging trends and technologies in Automotive and Marine sector

Automotive Industry: The automotive industry includes industries associated with the production, wholesaling, retailing, and maintenance of motor vehicles.

Indian Automobile market is the 3rd Largest automobile market in the world. The automobile market seen a considerable changes in the advance of technology. Electric vehicles are the next alternative to the conventional fossil fueled vehicles. Also, Hybrid vehicles are already in market uses dual fuel technology like electric and gasoline. Automation is another aspect in the automobile industry. Use of mechatronics, internet, AI automobile manufacturers are striving for the better user interface and comfort in automobile experience.

Marine industry: Mechanical engineers in this industry design and build or operate and maintain equipment and marine vessels. These engineers design, install, or maintain engines, shafts, boilers and propellers. They could be a part of the team that enforces regulations for air and sea pollution or be a part of designing futuristic cleaner ships.

Marine engineering is the discipline that deals with matters related to the design, innovation, construction and maintenance of seagoing vessels and navigation equipment. Marine engineers focus primary on the development and production of internal systems of boats, ships, or submarines. They are engaged in designing propulsion systems, auxiliary power machinery and operation equipment. Their technical responsibilities also include working on-board to maintain these systems.

8 (a) Explain about principles of Casting with a neat sketch

The casting process is the manufacturing process in which molten material such as metal is poured into the casting cavity or mold of the desired shape and allowed to harden or solidify within the mold. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.
The mold is usually made of materials like sand, metal, or ceramic. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. Heavy equipment like machine tool beds, ships, propellers, etc. can be cast easily in the required size, rather than fabricating by joining several small pieces.

Basic Terminologies of Casting Process:

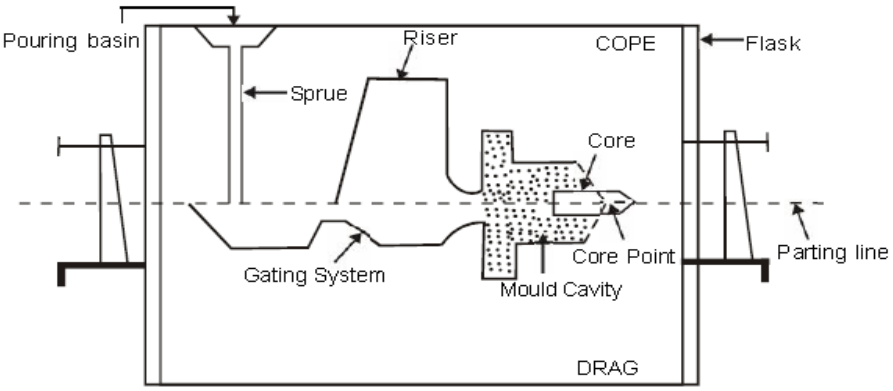
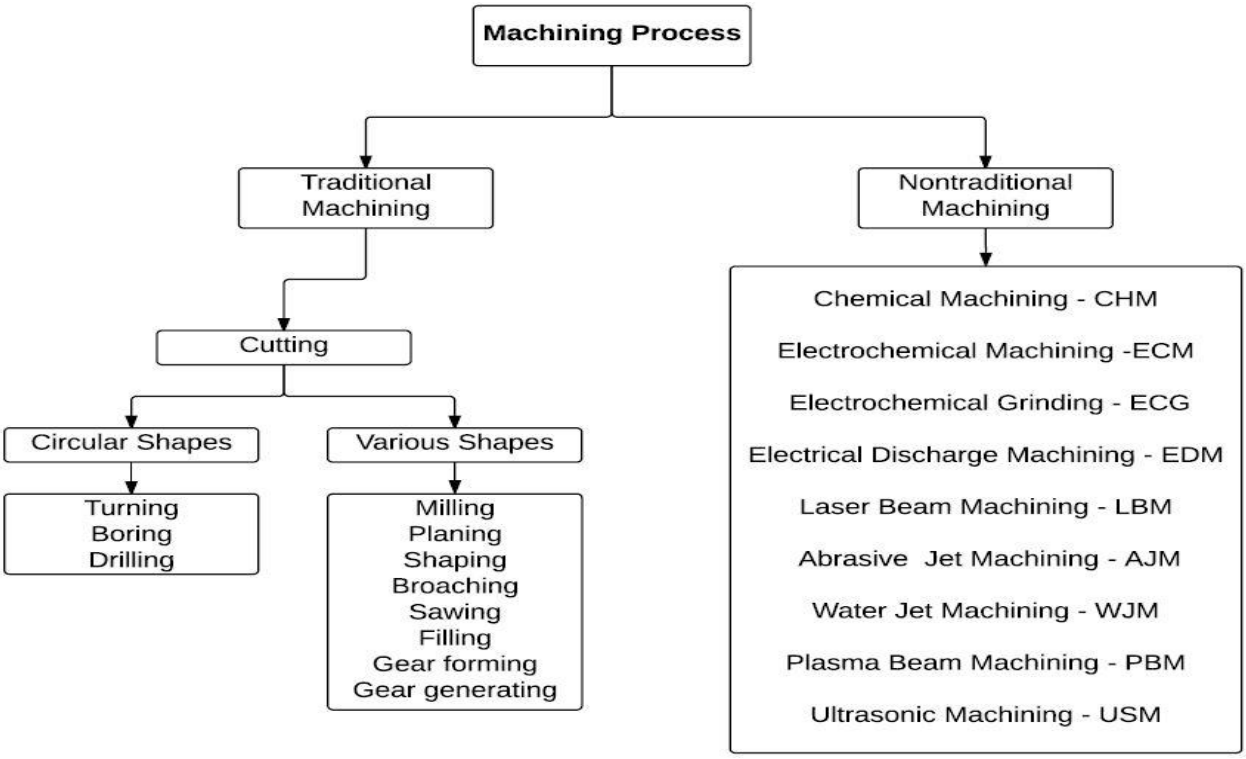


Fig. 1.2 Corss section of a two-part sand mould.

- **Flask:** A metal or wood frame in which mold is formed.
- **Cope:** The upper half of the flask is called cope.
- **Drag:** The lower half of the flask is called drag.
- **Cheek:** Intermediate moulding flask used in three piece moulding.
- **Core:** Core is used to create an internal hollow cavity in the final product.
- **Vents:** These are the places created in the mold to carry off-gases produced when the molten metal comes in contact with the sand.
- **Mold cavity:** This is the hollow space in the mold where the metal part is formed.
- **Riser:** It is the reservoir of molten metal that supplies additional metal in case of any reduction in volume of metal due to solidification.
- **Runner:** It is the passage from where the molten metal can be regulated before reaching the mold cavity.
- **Pouring basin (Cup):** It is the cup or basin from where molten metal is poured in the metal.
- **Pattern:** It is the duplicate of the shape needed to form.
- **Sprue:** The passage through which the molten metal from the pouring basin reaches the mould cavity.
- **Parting Line:** This is the line that separates the cope and drag.
- **Gate** The actual entry point through which molten metal enters mould cavity.

8 (b) Explain about different Machining process with a neat sketch

Machining is a manufacturing process whereby a desired shape or part is achieved by the controlled removal of material from a larger piece of raw material by cutting; most often performed with metal material. These processes are collectively called subtractive manufacturing, which utilizes machine tools.



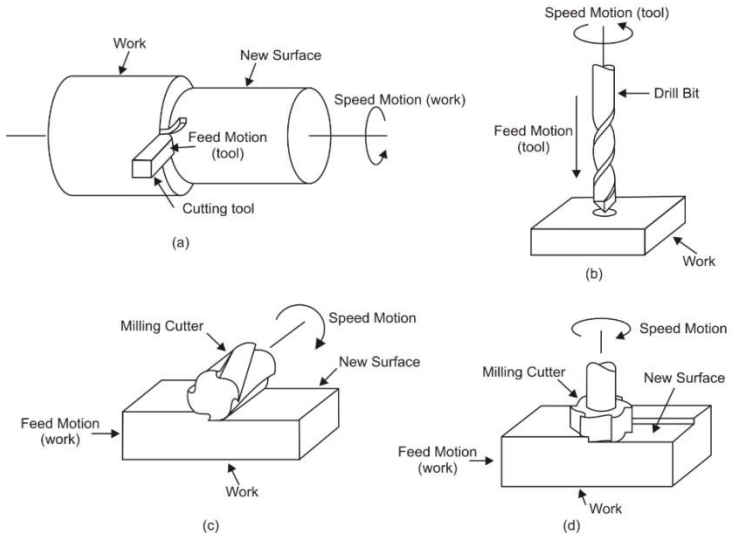
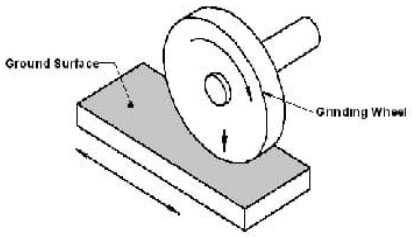


Fig. 1.3 Various machining processes (a) Turning (b) Drilling (c) Horizontal Milling (d) Vertical Milling



(e) Surface Grinding

Traditional Machining

Circular Machining Operations

Turning: Involves rotating a workpiece while a cutting tool removes material to create a cylindrical shape. This is commonly used for creating round parts, such as shafts. Lathes are the principal machine tool used in turning.

Drilling: Involves creating holes in a workpiece using a rotating drill bit. Drilling is a common machining process for creating holes of various sizes. Drilling operations can be performed on a lathe, mill or drill press, or even by hand.

Various Shape Machining

Milling: Uses rotating multi-point cutting tools to remove material from a workpiece's surface. It can produce flat or contoured surfaces and is commonly used in the production of complex parts. Milling machines are the principal machine tool used in milling. Advanced CNC machines may combine lathe and milling operations.

Grinding: Uses an abrasive wheel to remove material and achieve high surface finish and tight tolerances. Grinding is often used for finishing operations.

Non-Traditional Machining

Laser Cutting: Utilizes a laser to cut through materials. It is commonly used for cutting sheet metal and other materials in a precise and efficient manner.

Chemical Machining: Involves the selective removal of material through chemical reactions. This process is less common and is used for specific applications.

9 (a) Explain Otto cycle and Diesel cycle with PV and TS diagram

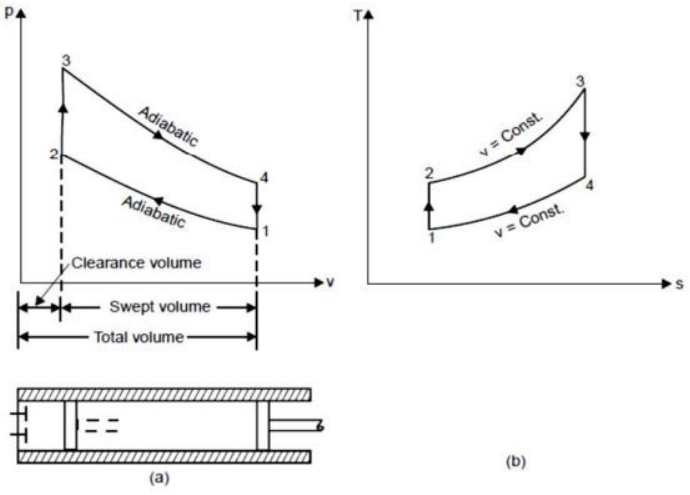
CONSTANT VOLUME OR OTTO CYCLE This cycle is so named as it was conceived by 'Otto'. On this cycle, petrol, gas and many types of oil engines work. It is the standard of comparison for internal combustion engines.

The four processes of this cycle are as follows:

1. Process 1-2: Isentropic (reversible adiabatic) compression
2. Process 2-3: Constant volume (Isochoric) heat addition
3. Process 3-4: Isentropic (reversible adiabatic) Expansion
4. Process 4-1 Constant volume heat rejection.

Application: It is used in all two-stroke and four-stroke petrol engines of motorcycles, cars, and other light-duty vehicles.

$$\eta_{Otto} = 1 - \frac{1}{(r)^{\gamma-1}}$$

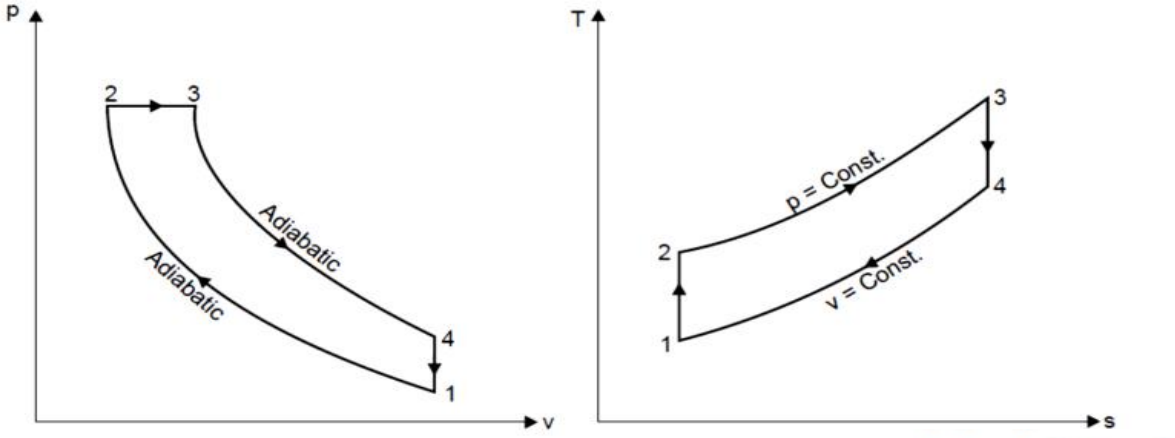


Figs. 1.2. (a) the theoretical p-V diagram (b) the theoretical T-s diagram of Otto Cycle

CONSTANT PRESSURE OR DIESEL CYCLE This cycle was introduced by Dr. R. Diesel in 1897. It differs from Otto cycle in that heat is supplied at constant pressure instead of at constant volume.

The four processes of this cycle are as follows:

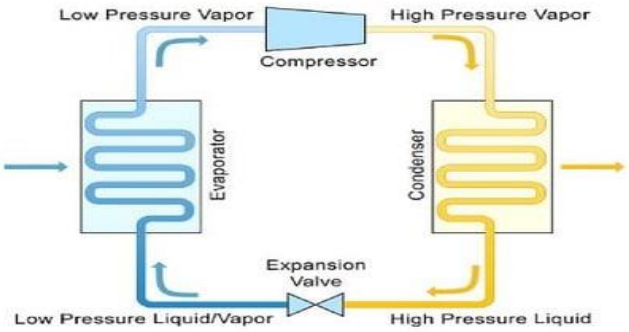
1. Process 1-2: Isentropic (reversible adiabatic) compression
2. Process 2-3: Constant Pressure (Isobaric) heat addition
3. Process 3-4: Isentropic (reversible adiabatic) Expansion
4. Process 4-1 Constant volume heat rejection.



Figs. 1.3. (a) The theoretical p-V diagram (b) The th $\eta_{diesel} = 1 - \frac{1}{\gamma(r)^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\rho-1}\right]$

9 (b) Explain about Refrigeration and air conditioning cycles? Also show the process in p – h and T – S diagrams

The refrigeration cycle, sometimes called a heat pump cycle, is a means of routing heat away from the area you want to cool. This is accomplished by manipulating the pressure of the working refrigerant (air, water, synthetic refrigerants, etc.) through a cycle of compression and expansion



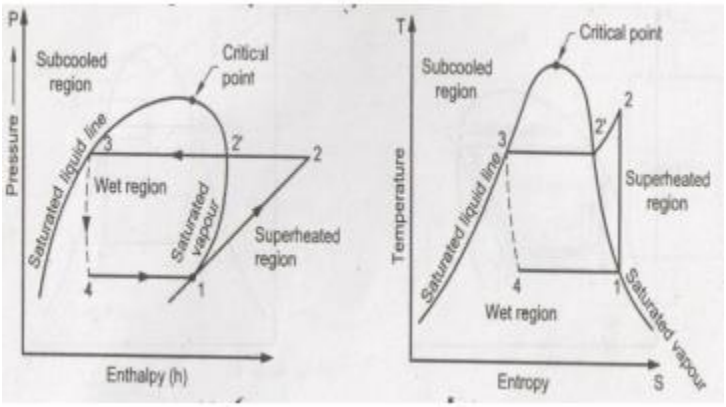
The compressor: Refrigerant enters the compressor as low-pressure, low-temperature gas, and leaves the compressor as a high-pressure, high-temperature gas.

The condenser: This component is supplied with high-temperature high-pressure, vaporized refrigerant coming off the compressor. The condenser removes heat from the hot refrigerant vapor gas vapor until it condenses into a saturated liquid state..

The expansion device: create a drop in pressure after the refrigerant leaves the condenser. Expansion valves are devices used to control the refrigerant flow in a refrigeration system.

They remove pressure from the liquid refrigerant to allow expansion or change of state from a liquid to a vapor in the evaporator. Expansion valves serve two purposes: controlling the amount of refrigerant entering the evaporator and maintaining the pressure difference between the condenser (high-pressure side) and the evaporator (low-pressure side).

The evaporator The Evaporator evaporates the liquid refrigerant in to a vapour and then in to a gas before it gets back to the compressor.



10. Explain the working of Diesel and Nuclear Power Plant with a neat sketch

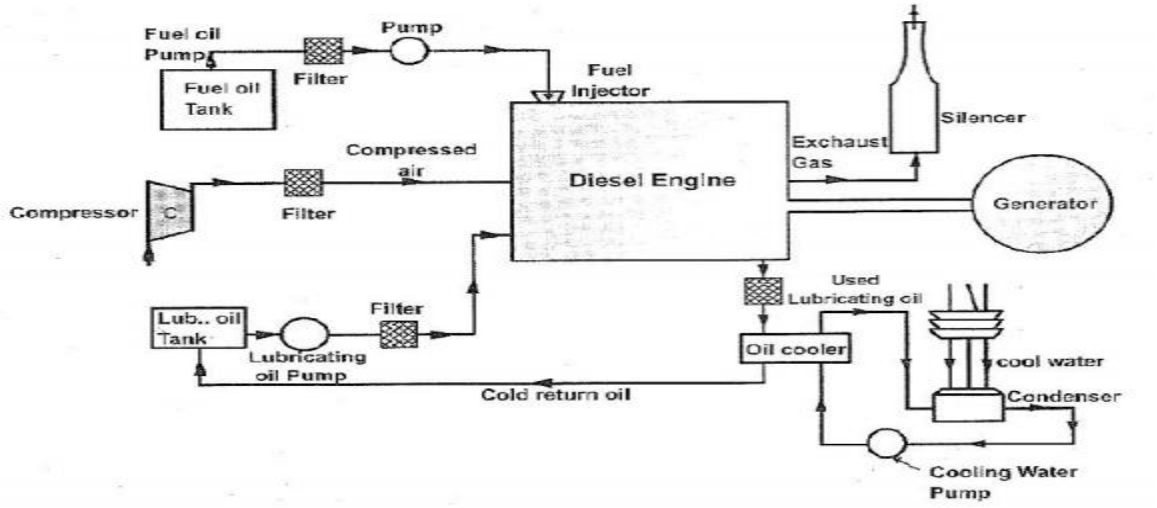
Diesel Power Plant

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.

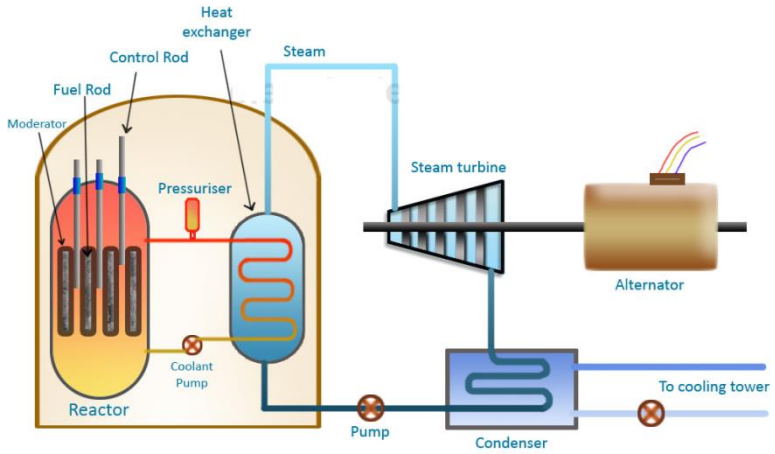
The injected fuel gets ignited and combustion takes place. This liberates the huge amount of energy which is utilized to run the generator to produce electric power.

The 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.



Nuclear Power Plant

Heavy elements such as Uranium (U^{235}) or Thorium (Th^{232}) are subjected to nuclear fission reaction in a nuclear reactor. Due to fission, a large amount of heat energy is produced which is transferred to the reactor coolant. The coolant may be water, gas or a liquid metal. The heated coolant is made to flow through a heat exchanger where water is converted into high-temperature steam. The generated steam is then allowed to drive a steam turbine. The steam, after doing its work, is converted back into the water and recycled to the heat exchanger. The steam turbine is coupled to an alternator which generates electricity. The generated electrical voltage is then stepped up using a transformer for the purpose of long distance transmission.



11. Compare between Belt, Chain and Gear Drives and give their applications

Belt drive	**Chain drive**	**Gear drive**
Main element Pulleys, belt	Main element Sprockets, chain	Main element Gears
Slip may occur	No-slip	No-slip
Suitability For the large center distance	Suitability For the moderate center distance	Suitability For the short center distance
Large Space requires	Moderate Space requires	Less Space requires
Simplest Design, manufacturing, complexity	Simplest Design, manufacturing, complexity	Complicated Design, manufacturing, complexity
Failure of the belt does not cause the further damage of machine	Failure of a chain may not seriously damage the machine.	Failure of gear may cause serious break down in the machine.
Less Life	Moderate Life	Long Life
Lubrication Not required	Lubrication required	Requires proper lubrication
Less Installation cost	Moderate Installation cost	More Installation cost

Used For low-velocity ratio	Used For moderate velocity ratio	Used For high velocity ratio
The belt drive is used in the Mill industry. Conveyor	It is used in bicycle, motorcycles, agricultural machinery.	uses of gear drives are automotive transmission systems, wheel differentials, marine equipment, turbines, and gear motors.

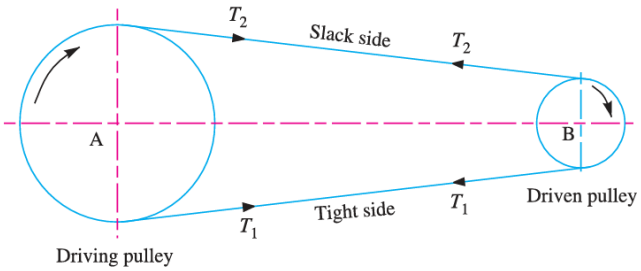


Fig. 18.15. Power transmitted by a belt.

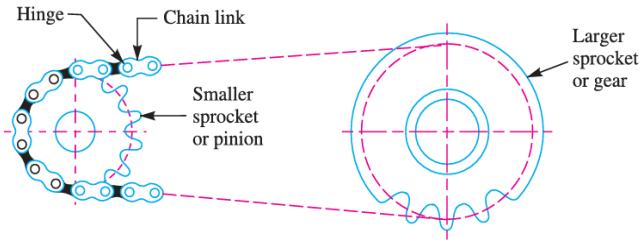


Fig. 21.1. Sprockets and chain.

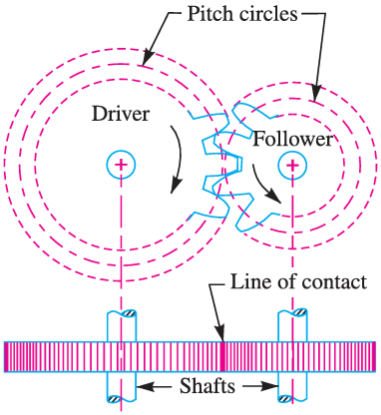


Fig. 28.2. Gear or toothed wheel.