ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

BE8252 BASIC CIVIL AND MECHANICAL ENGINEERING NOTES

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COURSE NAME	**:**	**BASIC CIVIL AND MECHANICAL ENGINEERING**
L T P C	**:**	**4 0 0 4**

Prepared By:

Approved By:

HEAD OF DEPT – MECH **PRINCIPAL**

SYLLABUS

BE8252 BASIC CIVIL AND MECHANICAL ENGINEERING **L T P C 4 0 0 4**

A – OVER VIEW

UNIT I SCOPE OF CIVIL AND MECHANICAL ENGINEERING **10**

Overview of Civil Engineering - Civil Engineering contributions to the welfare of Society Specialized sub disciplines in Civil Engineering Structural, Construction, Geotechnical, Environmental, Transportation and Water Resources Engineering

Overview of Mechanical Engineering - Mechanical Engineering contributions to the welfare of Society –Specialized sub disciplines in Mechanical Engineering - Production, Automobile, Energy Engineering - Interdisciplinary concepts in Civil and Mechanical Engineering

B CIVIL ENGINEERING.

UNIT II SURVEYING AND CIVIL ENGINEERING MATERIALS **10**

Surveying: Objects – classification – principles – measurements of distances – angles – leveling – determination of areas– contours - examples. Civil Engineering Materials: Bricks stones sand cement concrete steel - timber - modern materials

UNIT III BUILDING COMPONENTS AND STRUCTURE **15**

Foundations: Types of foundations - Bearing capacity and settlement – Requirement of good foundations. Civil Engineering Structures: Brickmasonry – stonemasonry – beams – columns – lintels – roofing – flooring – plastering – floor area, carpet area and floor space index - Types of Bridges and Dams – water supply - sources and quality of water - Rain water harvesting - introduction to high way and rail way.

C – MECHANICAL ENGINEERING

UNIT IV INTERNAL COMBUSTION ENGINES AND POWER PLANT **15**

Classification of Power Plants - Internal combustion engines as automobile power plant Working principle of Petrol and Diesel Engines Four stroke and two stroke cycles – Comparison of four stroke and two stroke engines – Working principle of

steam, Gas, Diesel, Hydro - electric and Nuclear Power plants - working principle of Boilers, Turbines, Reciprocating Pumps (single acting and double acting) and Centrifugal Pumps

UNIT V REFRIGERATION AND AIR CONDITIONING SYSTEM **10**

Terminology of Refrigeration and Air Conditioning. Principle of vapour compression and absorption system–Layout of typical domestic refrigerator–Window and Split type room Air conditioner.

TEXTBOOKS:

1. Shanmugam Gand Palanichamy MS,"Basic Civil and Mechanical Engineering",Tata McGraw Hill PublishingCo.,NewDelhi.1996.

REFERENCES:

1. Palanikumar, K. Basic Mechanical Engineering. ARS Publications, 2010.

2. Ramamrutham S.,"Basic Civil Engineering", Dhanpat Rai Publishing Co.(P) Ltd.1999.

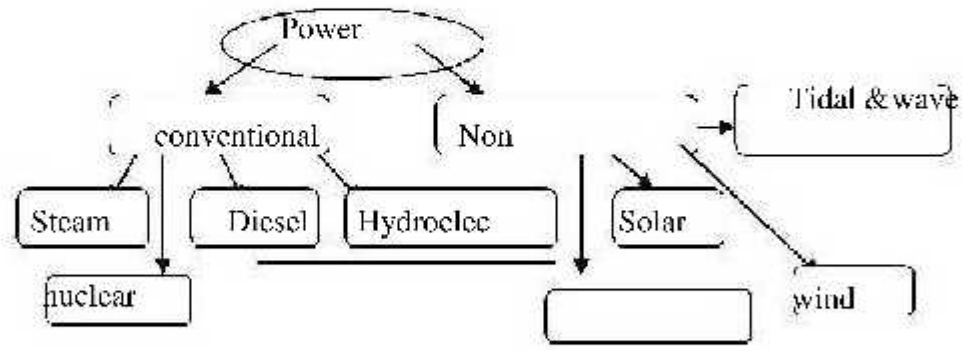
3. Seetharaman S.,"BasicCivil Engineering",AnuradhaAgencies,2005.

4. ShanthaKumar SRJ.,"Basic Mechanical Engineering", Hi-tech Publications, Mayiladuthurai, 2000

BE8252 BASIC CIVIL AND MECHANICAL ENGINEERING

UNIT IV INTERNAL COMBUSTION ENGINES AND POWER PLANTS

CLASSIFICATION OF POWER PLANTS



STEAM POWER PLANT (THERMAL POWER PLANT):

Reasons:

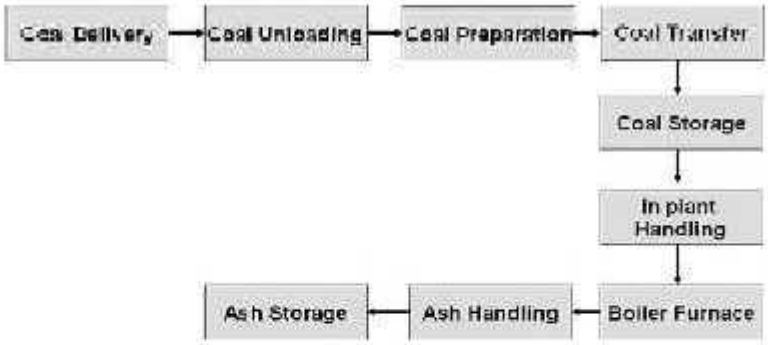
1. Steam can be raised quickly from water
2. It does not react much with materials.
3. It is stable at temperatures required in the plant

LAYOUT OF STEAM POWER PLANT:

The layout of steam power plant has the following circuits:

1. Fuel (Coal) and ash circuit
2. Air and flue gas circuit
3. Feed water and steam flow circuit
4. Cooling water flow circuit.

COAL AND ASH CIRCUIT:



Coal and Ash Circuit:

- Coal from mines is delivered by ships, rails or trucks to the power station.
- Coal received at coal yard.
-
- Coal is sized by crushers, breakers etc.,
- The sized coal is stored in coal storage.
- From stock yard, the coal is transferred to the boiler furnace by means of conveyors, elevators etc.,
- The coal is burnt in the boiler and ash is formed.
- Ash coming out of the furnace will be too hot, dusty and accompanied by poisonous gases.
- The ash is transferred to the ash storage.
- Generally the ash will be quenched to reduce the temperature and the dust content.

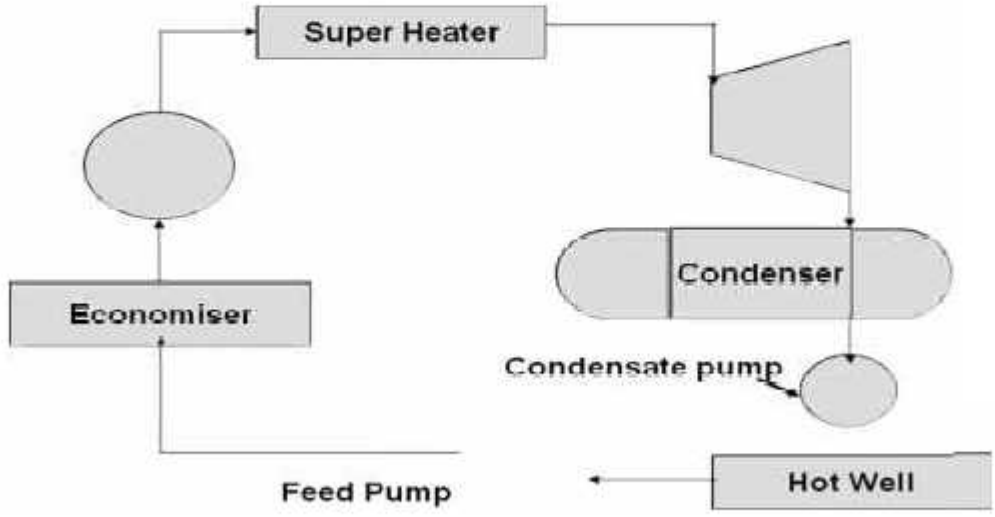
AIR AND FLUE GAS CIRCUIT:

- Air is taken from the atmosphere by the action of FD fan.
- It is passed through an air pre heater
- The air is preheated by the flue gases in the pre heater.
- This preheated air is supplied to the furnace to aid the combustion of fuel.
- Due to the combustion of fuel the flue gases are formed.
- The flue gases from the furnace pass over the boiler tubes and super heater tubes.

- Then the flue gases pass through economizer to heat the feed water.
- After that it passes through a dust collector. It is then exhausted to

atmosphere through chimney

Water and Steam Circuit:



Layout of Steam Power Plant

Water and Steam Circuit:

- The water is preheated by the flue gases in the economiser.
- This preheated water is then supplied to the boiler drum.
- Heat is transferred to the water by the burning of the coal.
- Due to this, water is converted into the steam.
- The steam raised in boiler is passed through a super heater.
- It is superheated by the flue gases.
- The turbine drives generator to produce electric power.
- The expanded steam is then passed through the condenser.
- In the condenser, steam is condensed into water the re circulated.

Cooling Water Circuit:

- The exhaust steam from the turbine is condensed in the condenser.
- In the condenser, the cold water is circulated to condense the steam into water.
- The steam is condensed by loosing its latent heat to the circulating the cold water.

- Hence the cold water gets heated.
- This hot water is then taken to a cooling tower.
- In cooling tower the water is sprayed in the form of droplets through nozzles.
- The atmospheric air enters the cooling tower from the openings provided at the bottom of the tower.
- This cold water is again circulated through the pump, condenser and the cooling
- Some amount of water may be lost during circulation.
- Hence make up water is added to the pond by means of a pump

Layout of Steam (Thermal) Power Plant

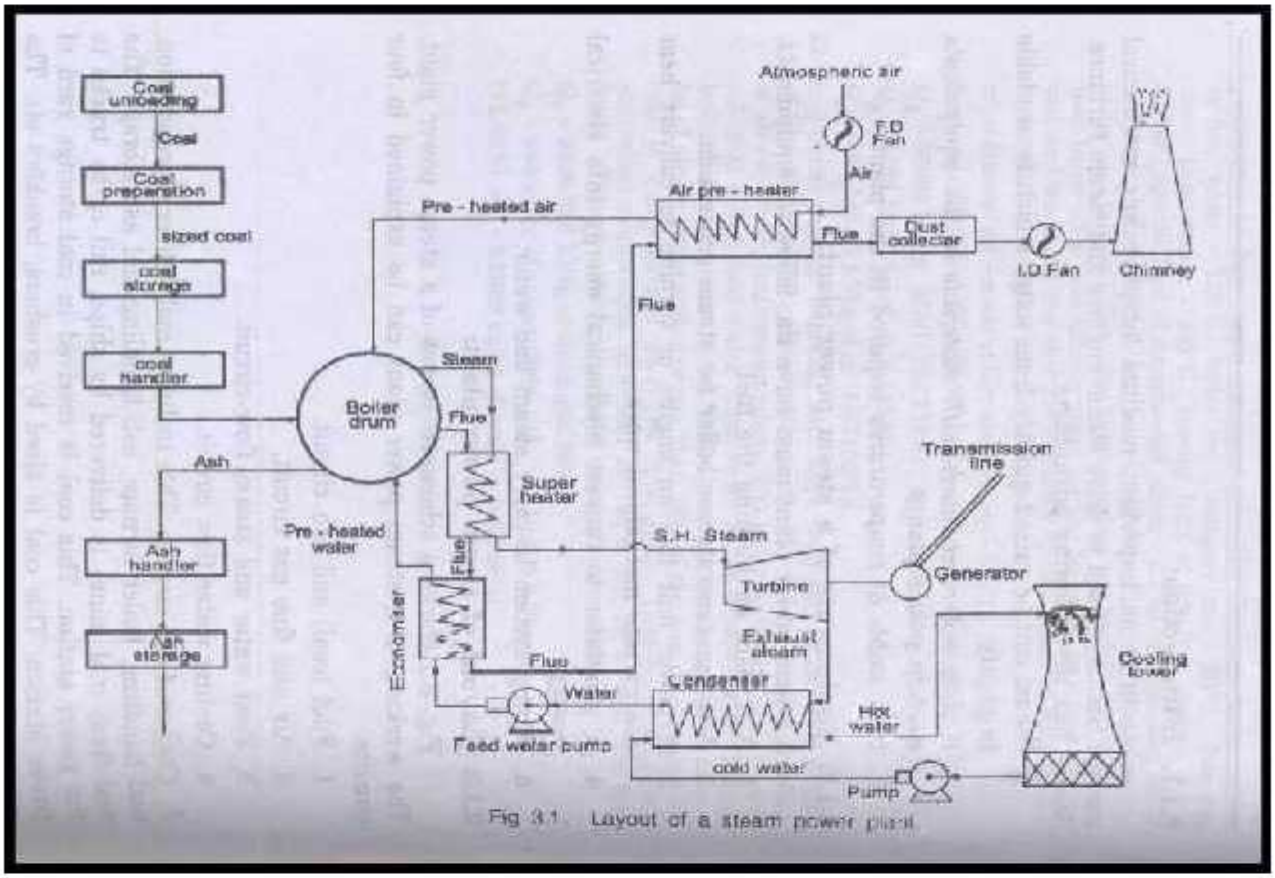
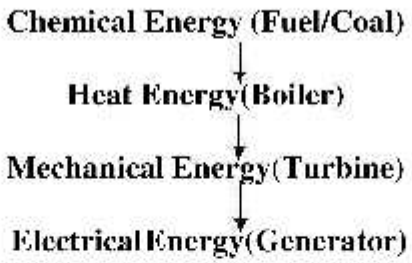


Fig 3.1 Layout of a steam power plant

Energy Conversion Process:



Advantages of Steam Power Plant (Thermal plant)

- Life of plant is more (25-30 years) compared to Diesel plant (2-5 years)
- Repair and maintenance cost is low when compared to diesel plant.
- Initial cost is less compared to nuclear plant.
- Suitable for varying load conditions.
- No radioactive harmful wastes are produced
- Unskilled operators can operate the plant.
- The power generation does not depend on the water storage.
- There are no transmission losses, as they are located near load centres.

Disadvantages of thermal power plant:

- Less efficient than diesel plants.
  - Starting up and bringing into service takes more time.
- Cooling water required is more.
  - Space required is more.
  - Storage required for the fuel is more.
  - Ash handling is a big problem
  - Not economical in areas which are remote from coal fields.
  - Manpower required is more.
  - For large units, the capital cost is more.

List down the factors to be considered for selection of site for thermal power plant:

Availability of coal:

- A thermal plant of 400M, capacity requires nearly 6000 tons of coal every day.
- Power plant should be located near coal

mines. **Ash Disposal Facilities:**

- Ash comes out in hot condition and handling is

difficult. The ash can be disposed into sea or river.

Water Availability :

- Water consumption is more as feed water into boiler, condenser and for ash disposal.
- Water is required for drinking purpose.
- Hence plant should be located near water source. **Transport**

Facility :

Public Problems:

- The plant should be far away from residential area to avoid nuisance from smoke, fly ash and noise.

Nature of Land :

- Many power plants have failed due to weak foundations.
- Land (soil) should have good bearing capacity to withstand dead load of plant.

Thermal power plants in Tamil Nadu:

Neyveli Tuticorin Ennore Mettur

Explain about the pollution caused by Thermal Power Plant (Steam Power Plant):

- Main pollutants from thermal plants are SO_2, CO_2, CO as minute particles such as fly ash.
- SO_2 causes suffocation, irritation to throat and eyes and respiratory for people. It destroys crop.
- CO is a poisonous gas.
- Dust particles cause respiratory troubles like cough, cold, sneezing

etc., Thermal Pollution:

- Thermal plants produce 40 millions kJ of heat to the environment through condenser

water and exhaust gases.

- Thermal pollution of atmosphere can be reduced using the low grade energy exhausted steam.

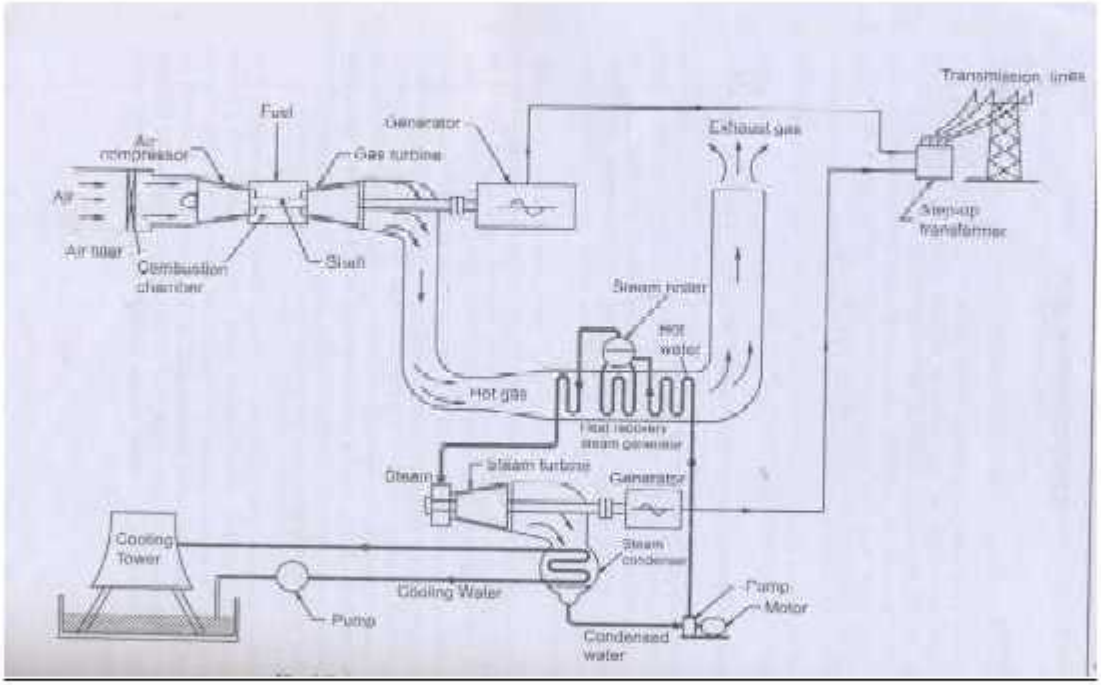
Noise Pollution:

- The sources of noise in a power plant are turbo alternators, fans and power transformers.
- Sound proofing can be done to reduce the noise.

Gas Power Plant

- A gas power plant uses gas turbine as the prime mover for generating electricity.
- It uses natural gas or kerosene or benzene as fuel.
- Gas plant can produce only limited amount of the electricity.
- Efficiency of the plant is only 35%
- Generally a gas plant is expensive to operate.
- Hence it is usually installed with steam power plant in closed combined cycle.
- It is generally used in combination with steam/thermal power plant during peak load
- When the gas power plant is combined with thermal/steam power plant efficiency of the plant is up to 60% - 70%

Layout of the Gas turbine Power plant:



Gas Power Plant – Working Principle:

Combustion and generation of electricity:

- Gas turbine draws clean air into through air filter from atmosphere, with the help of a compressor,
- During the compression pressure of the air is increased.
- Compressed air is passed through to a combustion chamber along with fuel (Natural gas).
- The air fuel mixture is ignited at high pressure in the combustion chamber.
- Combustion takes place.
- The generated hot gas of compression is passed through the gas turbine.
- Hot gases expand, and the turbine blades are connected to the turbine shaft are rotated.
- The turbine shaft which is coupled to the shaft of the electrical generator at the other end also rotates and drives the electrical generator.
- A portion of the energy developed by the hot gases through the gas turbine is used to

run the compressor.

- The residual hot gases from gas turbine are passed through a heat exchanger (heat recovery steam generator)
- The heat exchanger produces steam with high pressure with the help of a steam boiler.
- The steam is allowed to expand in the steam turbine.
- when it passes through the turbine blades, the turbine shaft is rotated. The shaft is coupled to the generator, which generates electricity.
- Gas turbine and steam turbine combination enables increased power generation.

Transmission and distribution :

- The generated electricity from both gas and steam turbines is fed to the step up transformer where its voltage is increased.
- Then the electricity is conveyed through transmission lines for distribution.

MERITS:

- Natural gas is readily available.
- Setting up cost can be reduced if the plant is installed near the source of natural gas.
- Less gas storage cost
- Less space occupation.
- Compared to steam power plant, smaller in size.
- Low operating cost.
- Low maintenance cost.
- No standby losses.
- Cheaper fuels like natural gas.

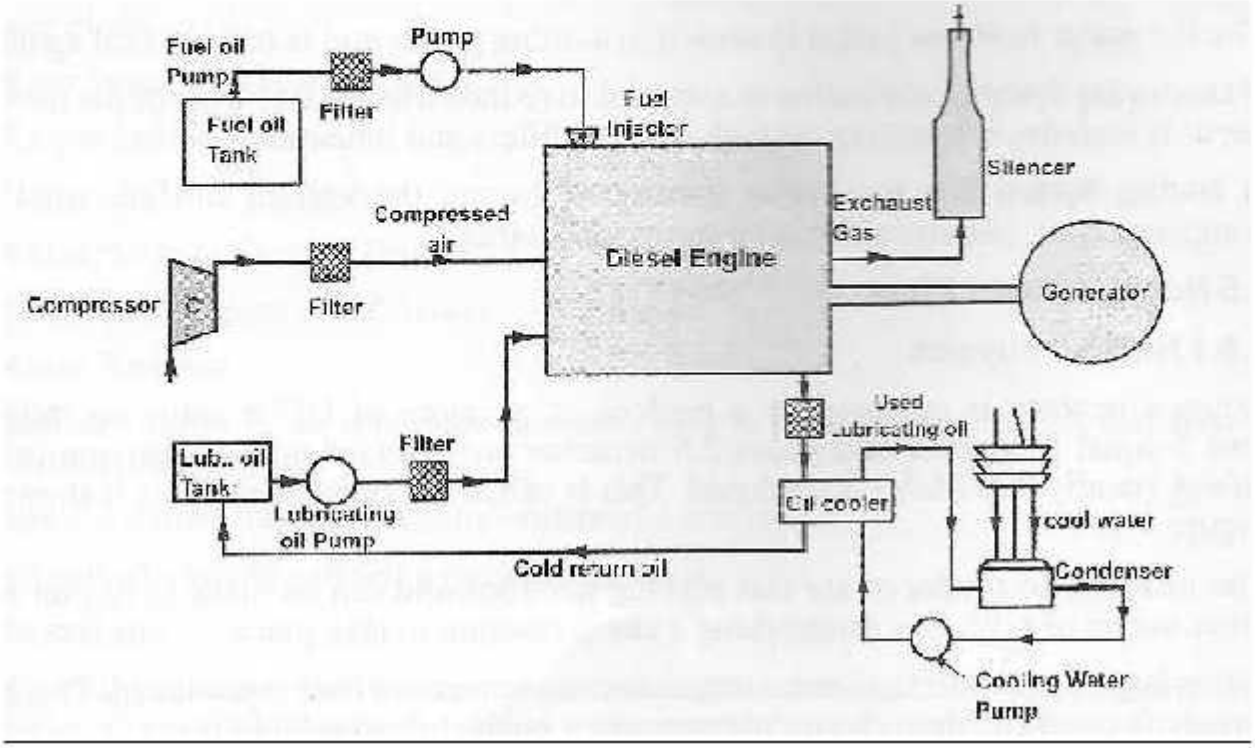
Demerits:

- 2/3 rd of generated power is used for driving the compressor.

- Gas turbine has low thermal efficiency.
- Has starting problem.
- Efficient only in combined cycle configuration.

- Temperature of combustion chamber is too high, which results in shorter life time.

Diesel Power Plant



Working of Diesel Power plant:

- Air from atmosphere is drawn into the compressor and is compressed.
- The compressed air is sent to diesel engine through filter.
- In the filter, dust, dirt from air is filtered and only clean air is sent to diesel engine.
- Fuel oil from tank is passed through filter where it gets filtered and clean oil is injected into the diesel engine through fuel pump and fuel injector
- Mixture of compressed air and spray of fuel oil are ignited into the engine and combustion takes place.
- The heat energy is utilized for driving the generator, which produces power.

Main components of a Diesel power plant:

1. **Fuel Supply system**

   It consists of fuel tank, fuel filter and fuel pump and injector.

2. **Air Intake and Exhaust system**

   It consists of compressor, filter and pipes for the supply of air and pipes for exhaust gases. In the exhaust system silencer is provided to reduce the noise.

3. **Cooling system**

   Circulates water around the Diesel engines to keep the temp at reasonably low level.

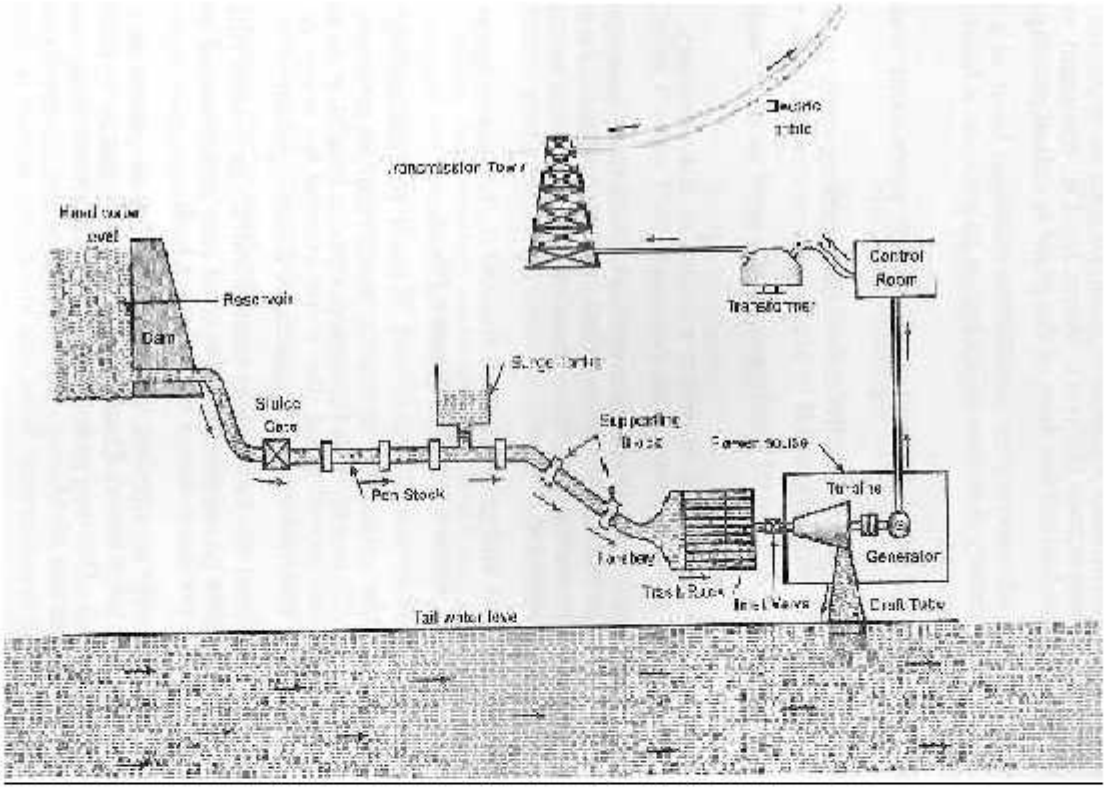
4. **Lubricating system**

   It includes lubricating oil tank, pump, filters and lubricating oil.

5. **Starting system**

   For initial starting the devices used are compressed air, battery, electric motor or self-starter.

`Hydro Electric Power Plant:



Components of Hydro Electric Power

Plant: Reservoir :

- Water is collected during rainy season
- It is stored in the reservoir.
- A dam is built across the river adequate water head.

Penstock :

- It is a passage through which water flows from reservoir to turbine.

Surge Tank :

- It is installed along the penstock (between turbine and reservoir)
- To control or regulate the sudden water over flow and to protect the penstock from bursting.
- It reduces the pressure and avoids damage to the penstock due to the **water hammer** effect.
- When the load on the turbine is decreased there will be a back flow, which causes increase or decrease in pressure. It is known as water hammer.

Power House :

- It is building that houses that water turbine, generator, transformer and control room.

Water Turbine:

- Water turbines such as Pelton, Kaplan and Francis are used to convert pressure and kinetic energy of flowing water into mechanical energy.

Draft Tube:

- It is connected to the outlet of the turbine.

Tailrace:

- It refers to the downstream level of water discharged from turbine.

Generator :

- It is a machine used to convert mechanical energy into electrical energy.

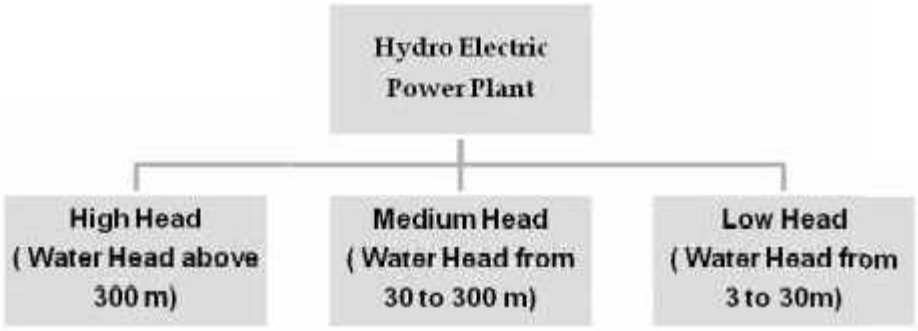
Step up transformer:

- It converts the Alternating Current (AC) into high voltage current suitable for transmission.

Working Principle of Hydro Electric Power Plant:

- It uses the potential energy of water of water stored in a reservoir.
- The water from the reservoir through a penstock and then forced through nozzle or nozzles before reaching the turbine.
- The hydraulic turbine converts the kinetic energy of water under pressure into mechanical energy.
- The shaft of the turbine is coupled to a generator that generates electricity
- The electricity generated is fed to the step-up transformer to increase its voltage.
- Power is fed to the transmission lines for distribution.
- The output power of Hydel power plant depends on the head of water stored in the reservoir and the quantity of water discharged

Classification of Hydro Electric Power Plant:



Factors available for Hydro Electric Power Plant:

Adequate water must be available with good head.

Cost and type of Land:

Bearing capacity of the land should be good to withstand huge structures and equipments.

Storage of Water :

A dam must be constructed to store the large quantity of water in order to cope with variations of water availability throughout the year.

- **Transportation Facilities :**

The site should be accessible by rail and road for easy transportation of equipments and

machinery.

- **Pumped storage facilities :**

  The pumping facilities to reuse the water should be possible.

Merits of Hydro Electric Power Plant:

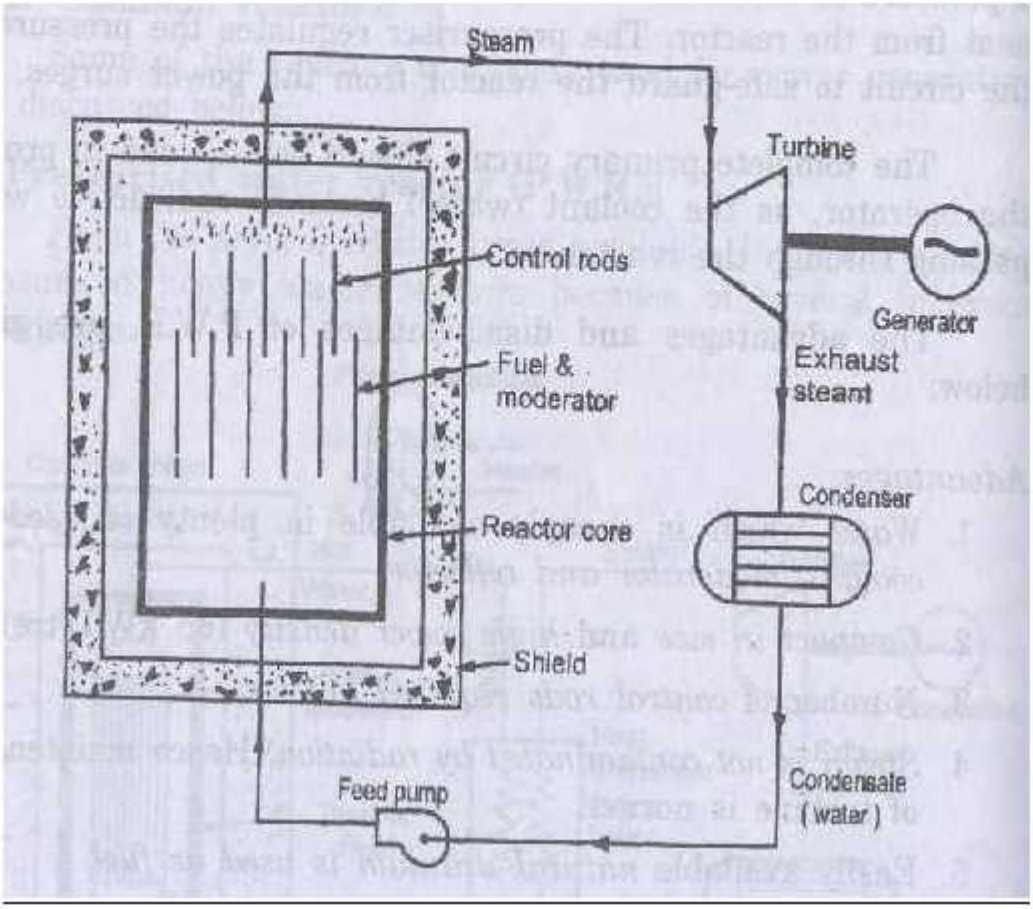
- Requires no fuels and hence pollution free.
- Low operating cost.
- Simple in construction and requires less maintenance.
- Very robust and durable.
- The reservoir and dam can also be used for irrigation.

Demerits of Hydro Electric Power Plant:

- Very high capital cost
- Skilled personnel is required for construction.
- High cost of transmission as plant is normally required far off from hilly areas.
- Period of delay causes the delay in the commissioning of the plant.
- Construction of new hydel plant may need rehabilitation of people and payment compensation for land acquisition.

NUCLEAR POWER PLANT – LAYOUT

Nuclear Power plant:



- Nuclear power plant uses nuclear energy from radioactive element for generating electrical energy.
- More than 15% of the world's electricity is generated from Nuclear power plants.
- It is generally located far away from populated areas.
- In future generation of electricity will be depending on Nuclear Power Plant, as it is economical.
- 1 kg of uranium U -235 can produce electrical power electrical that can be produced by using 3000 -4500 tonnes of high grade coal or 2000 tonnes of oil.

Components of Nuclear Power Plant:

Nuclear Fuel :

Normally used nuclear fuel is uranium (U^{235})

Fuel Rods:

The fuel rods hold nuclear fuel in a nuclear power plant.

Neutron Source: A source of neutron is required to initiate the fission for the first time. A mixture of beryllium with plutonium is commonly used as a source of neutron.

Reactor:

- Nuclear fission takes place in the reactor only.
- Nuclear fission produces large quantity of heat.
- The heat generated in the reactor is carried by coolant circulated through the reactor.

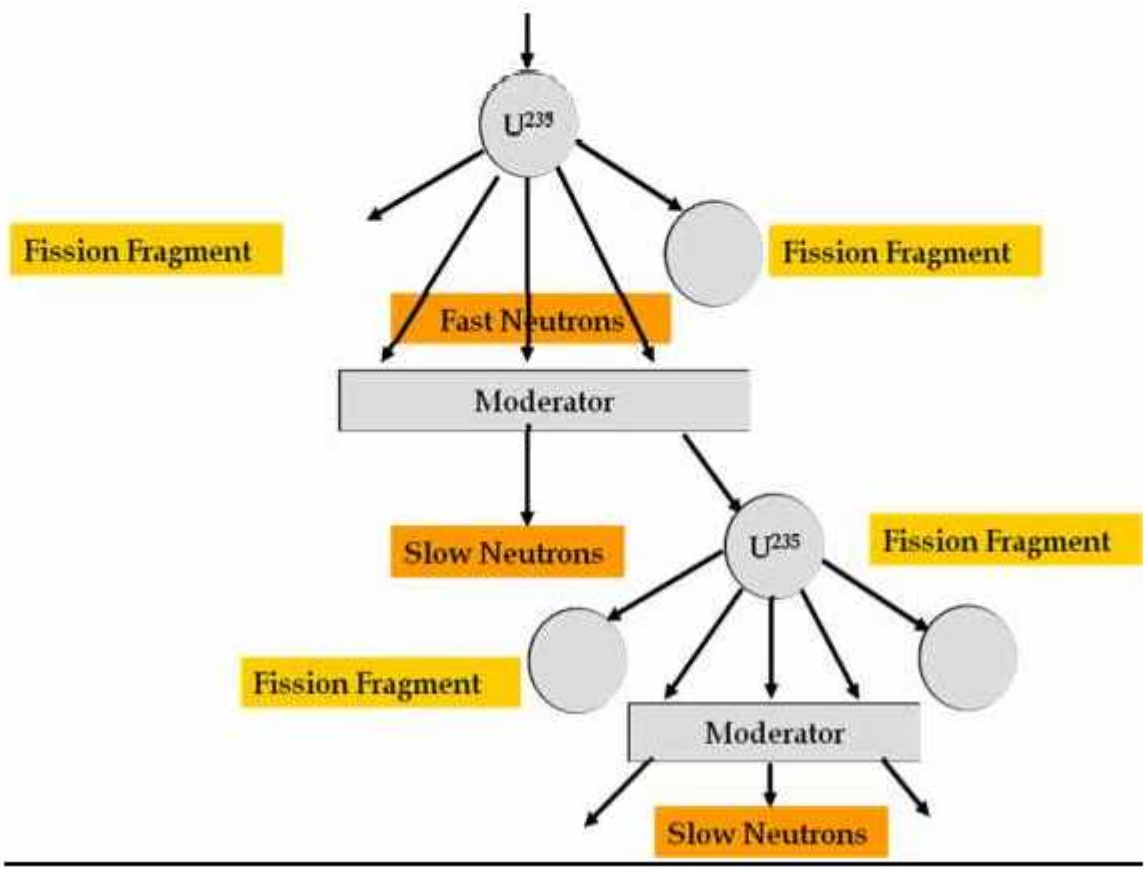
Control Rods:

- They are used to control the chain reaction.
- They are absorbers of neutrons.
- The commonly used control rods are made up of cadmium or boron.

Moderator:

- Moderators are used to slow down the fast neutrons.
- It reduces 2 MeV to an average velocity of 0.025 eV.
- Ordinary or heavy water are used as moderators.
- **Fuel Rods:**
- The fuel rods hold nuclear fuel in a nuclear power plant.
- **Neutron Reflectors:**
- To prevent the leakage of neutrons to large extent.
- In PHWR, the moderator itself acts as reflectors.
- **Shielding:**
- To protect from harmful radiations the reactor is surrounded b a concrete wall of thickness about 2 to 2.5 m.

Nuclear Fission



- It is a process of splitting up of nucleus of fissionable material like uranium into two or more fragments with release of enormous amount of energy.
- The nucleus of U^{235} is bombarded with high energy neutrons

  $U^{235} + {}_0n^1 \rightarrow Ba^{141} + Kr^{92} + 2.5\,{}_0n^1 + 200$ MeV energy.
- The neutrons produced are very fast and can be made to fission other nuclei of U^{235}, thus setting up a chain reaction.
- Out of 2.5 neutrons released one neutron is used to sustain the chain reaction.

  $1\ eV = 1.6X10^{-19}$ joule.

  $1\ MeV = 10^6\ Ev$

Working Principle of Nuclear Power Plant:

- The heat generated in the reactor due to the fission of the fuel is taken up by the coolant.
- The hot coolant then leaves the reactor and flows through the steam generator.
- In the steam generator the hot coolant transfers its heat to the feed water which gets converted into steam.
- The steam produced is passed through the turbine, which is coupled with generator.
- Hence the power is produced during the running of turbine.
- The exhaust steam from the turbine is condensed in the condenser.
- The condensate then flows to the steam generator through the feed pump.
- The cycle is thus repeated.

Advantages of Nuclear Power Plant:

- Requires less space compared to steam power plant.
- Fuel required is negligible compared to coal requirement.
- Fuel transport cost is less.
- Reliable in operation.
- Cost of erection is less.
- Water required is very less.

Disadvantages of Nuclear Power Plant:

- Initial Cost is higher.
- Not suitable for varying load condition.
- Radioactive wastes are hazardous. Hence these are to be handled with much care.
- Maintenance cost is higher.
- Trained workers are required to operate the plant.

Nuclear Power Plants in India:

- **IGCAR, Kalpakkam in Chennai.**
- Rana Pratap Sagar in Rajasthan
- Narora in Uttar Pradesh
- Kakarpur near Surat at Gujarat

- Kaiga Power Plant at Karnataka

Pumps

- A pump is a machine which is used to raise or transfer the fluids.
- It is also used to maintain the constant flow rate or constant pressure.
- It is normally driven by a engine or a motor.
- Pumps are rated by the horse power
- Important specifications for pump maximum discharge flow, maximum discharge pressure, inlet size and discharges size.

Classification of pumps:

It is classified into positive displacement pumps and roto dynamic pumps.

- In **positive displacement pumps.** fluid is drawn or forced into a finite space and it is sealed.
- It is then forced out and the cycle is repeated.

In **roto dynamic pumps.** centrifugal force is used to move the fluid into a pipe.

Reciprocating Pumps:

- It is a positive displacement pump
- It uses a piston and cylinder arrangement with suction and delivery valves integrated with the pump.
- It can be single acting and double acting
- There may be single or multi cylinders also.
- It is a positive displacement pump
- It sucks and raises the liquid by actually displacing it with a piston/plunger that executes a reciprocating motion in a closely fitting cylinder.

Working of single acting Reciprocating Pump:

- During suction stroke the piston moves to the left, causing the inlet valve to open.
- Water is admitted into the cylinder through the inlet valve.
- During the discharge stroke the piston moves to the right closes the suction valve

and opens the out let valve.

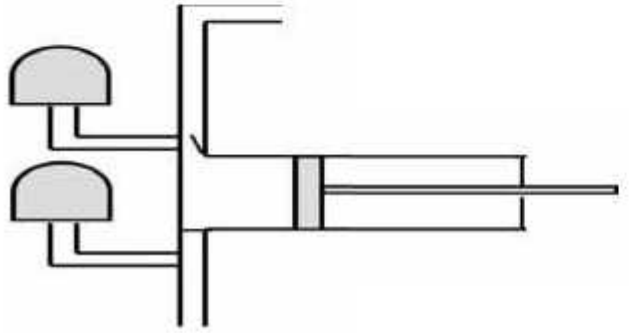
- Through the outlet valve the volume of liquid moved out of the cylinder.

Double Acting Reciprocating Pump – Working:

- Each cycle consists of two strokes.
- Both the strokes are effective, hence it is known as double acting pump
- Liquid is filled at one end and discharged at other end during forward stroke.
- During the return stroke, end of cylinder just emptied is filled and the end just filled is emptied.

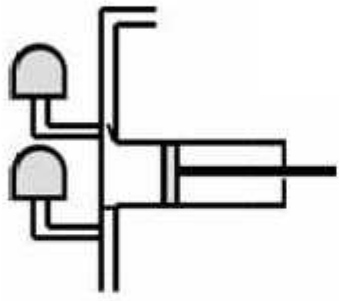
Air Vessels

Air vessel is a closed chamber containing compressed air in the upper part and liquid being pumped in the lower part.



Purpose of using an Air Vessel:

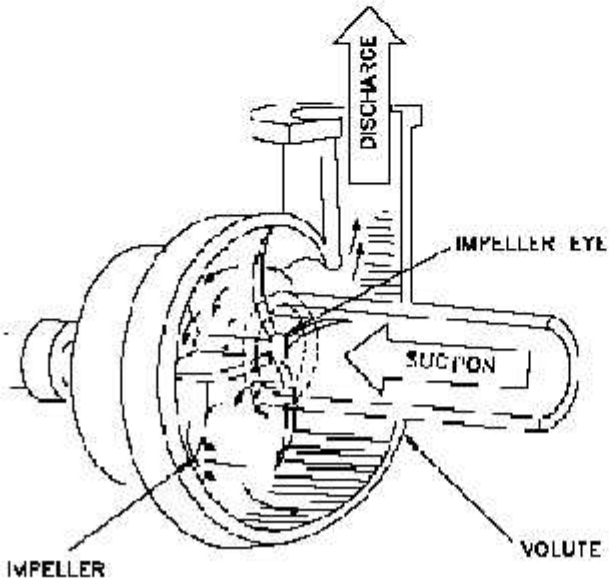
- To get continuous supply of liquid at a uniform rate.
- To save the power required to drive the pump (By using an air vessel the acceleration and friction heads are considerably reduced)
- To run the pump at much higher speed without any danger of separation.



Advantages of reciprocating pump:

- Relatively compact design
- High viscosity performance
- Ability to handle high differential pressure.

Centrifugal Pumps



Components of Centrifugal pump:

- A rotating component comprising of an impeller and a shaft.
- A stationery component comprising a volute (casing), suction and delivery pipe.

Working Principle of Centrifugal pump:

Principle: When a certain mass of fluid is rotated by an external source, it is thrown away from the central axis of rotation and a centrifugal head is impressed which enables it to rise to a higher level.

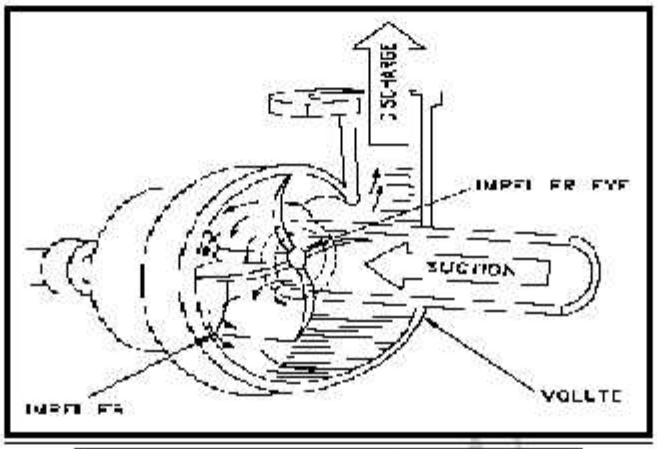
Working:

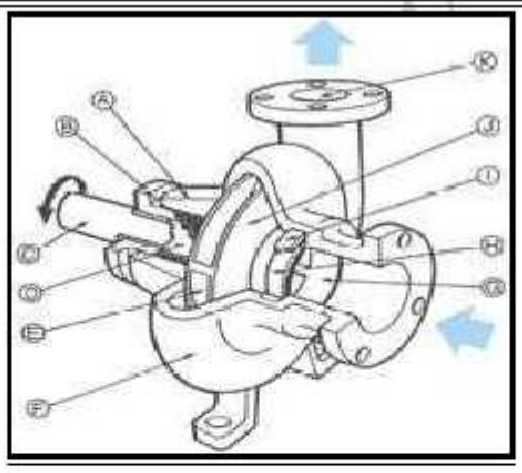
- The delivery valve is closed and the pump is primed, so that no air pocket is left.
- Keeping the delivery valve still closed the electric motor is started to rotate the impeller.
- The rotation of the impeller is gradually increased till the impeller rotates at its

normal speed.

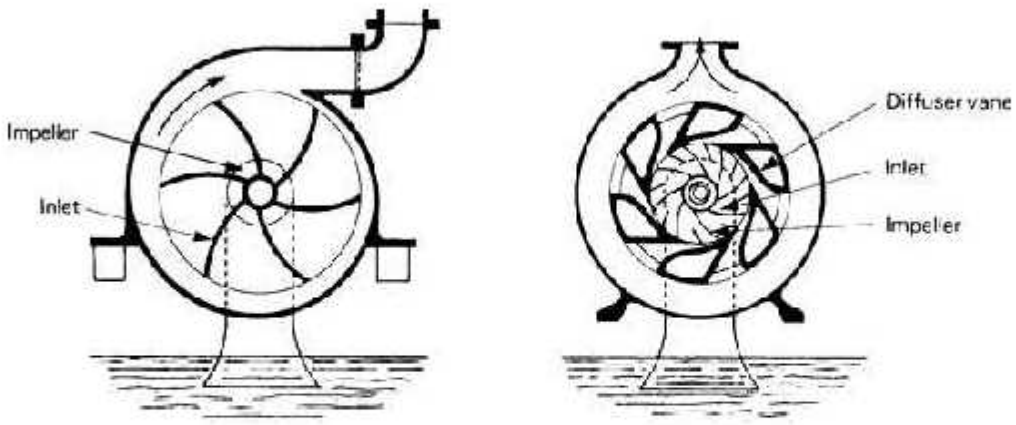
- After the impeller attains the normal speed the delivery valve is opened when the liquid is sucked continuously upto the suction pipe.
- It passes through the eye of the casing and enters the impeller at its centre.
- The liquid is impelled out by the rotating vanes and it comes out at the outlet tips of the vanes into the casing.
- Due to the impeller action the pressure head as well as the velocity heads are increased.
- From the casing the liquid passes into the pipe and lifted to the required height.
- When pump is to be stopped the delivery valve is to be first closed. other wise there may be some backflow of water into the reservoir.

Types of casing Volute and Vortex Casing





Volute and Diffuser casing



A. — Volute Centrifugal Pump. B. — Turbine Centrifugal Pump.

Volute Casing: In this type of casing the area of flow gradually increases from the impeller outlet to the delivery pipe.

Vortex Casing: If a circular chamber is provided between the impeller and volute chamber the casing is known as Vortex Chamber.

Diffuser C :

- The impeller is surrounded by a diffuser.
- The guide vanes are designed in such a way that the water from the impeller enters the guide vanes without shock.
- It reduces the vibration of the pump.
- Diffuser casing, the diffuser and the outer casing are stationery parts.

Priming of a centrifugal Pump:

- The operation of filling the suction pipe, casing and a portion of delivery pipe with the liquid to be raised, before starting the pump is known as Priming
- It is done to remove any air, gas or vapour from these parts of pump.

- If a Centrifugal pump is not primed before starting air pockets inside impeller may give rise to vortices and causes discontinuity of flow

Losses in Centrifugal pump:

Hydraulic Losses:

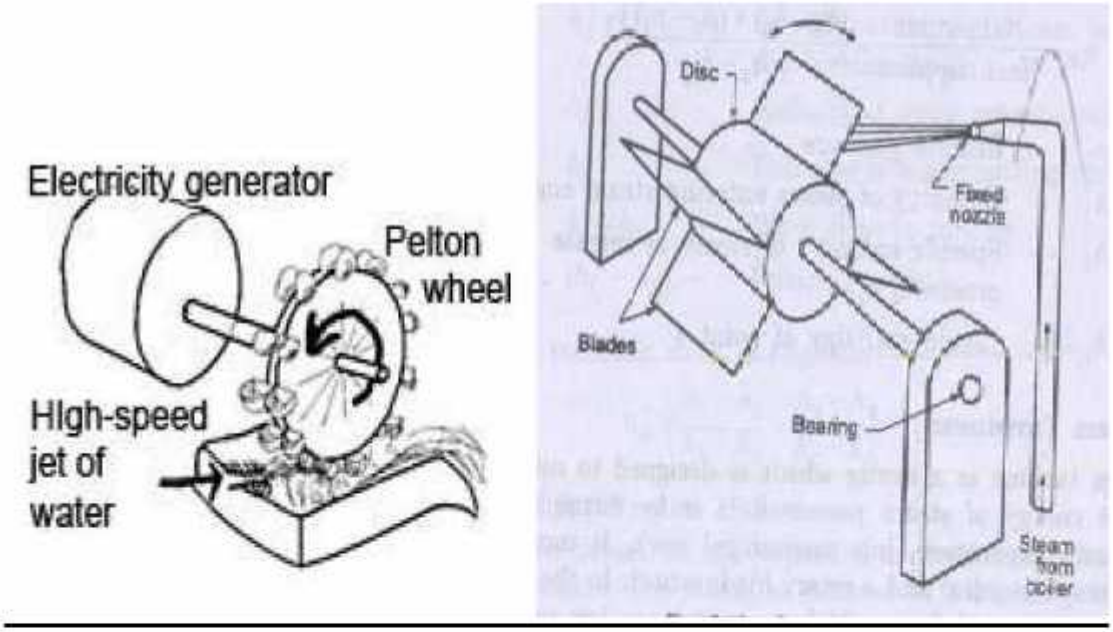
- Shock or eddy losses at the entrance to and exit from the impeller
- Losses due to friction in the impeller
- Friction and eddy losses in the guide vanes/diffuser and casing

Mechanical Losses:

- Losses due to disc friction between the impeller and the liquid which fills the clearance spaces between the impeller and casing
- Losses pertaining to friction of the main bearing and glands.

Specific speed of Centrifugal Pump:

- It is the speed in revolutions per minute at which a geometrically similar impeller would deliver one cubic meter of liquid per second against a delivery head of one meter.



IMPULSE TURBINE:

- The steam coming out at a very high velocity through the nozzle impinges on the blades fixed on the periphery of rotor.

- The blades change the direction of steam flow without change in pressure.
- The resulting force causes the rotation of the turbine.
- *E.g Pelton wheel*

REACTION TURBINE:

- The high pressure steam from the boiler is passed through the nozzles.
- When the steam comes out through these nozzles, the velocity of steam increases relative to the rotating disc.
- The resulting force of steam on nozzle gives the rotating motion to the disc and the shaft.
- The shaft rotates in opposite direction of the steam.

E.g Francis Turbine, Kaplan Turbine.

Comparision between Impulse and Reaction turbine:

S.No.	Impulse Turbine	Reaction Turbine
1	**It consists of nozzles and moving blades**	**It consists of fixed blades which act as nozzles and moving blades**
2	**Steam is expanded completely in the nozzle. All the pressure energy is converted into kinetic energy**	**Steam is partially expanded in the fixed blades. Some amount of pressure energy is converted into kinetic energy**
3	**Pressure of steam is constant over the moving blades.**	**Pressure drop takes place in the moving blades.**
4.	**Because of high pressure drop in the nozzles, blade speed and steam speed are high.**	**Because of small pressure drop, blade speed and steam speed are less.**

5.	**Low Efficiency**	**High Efficiency**
6.	**Occupies less space per unit power**	**Occupies more space per unit power.**
7.	**Suitable for small power requirements**	**Suitable for medium and high power requirements.**

INTERNAL COMBUSTION ENGINES AS AUTOMOBILE POWER PLANT

Introduction:

Heat Engine:

- Heat Engine is a machine which converts heat energy supplied to it into mechanical work.
- Heat energy is supplied to the engine by burning the fuel.

Classification of Heat Engines:

- **Internal Combustion Engines (IC Engines)**
  In IC engines, combustion of fuel takes place inside the engine cylinder.Examples: Diesel Engines, Petrol Engines, Gas engines.
- **External Combustion Engines (EC Engines)**
  In EC engines, combustion of fuel takes place outside the working cylinder.Examples: Steam Engines and Steam turbines
  IC Engines are classified into,

(1) **Cycle of operation (No of Strokes per cycle)**

- Two Stroke cycle Engines
- Four Stroke Cycle Engines

2) **Thermodynamic Cycle or Method of Heat addition:**

- Otto Cycle Engines (Combustion at constant volume)
- Diesel Cycle Engines (Combustion at constant Pressure)

- Semi Diesel Engines (Dual Combustion Engines)

(3) Types of Fuel Used :

- Petrol Engines
- Diesel Engines
- Gas Engines

(4) Ignition Method :

- Spark Ignition

(SI) Compression

Ignition (CI) **(5)**

Cooling System:

- Air cooled Engines
- Water Cooled Engines

(6) Valves Location :

- L head (Side valve) engine
- T Head (Side valve) engine
- I head (over head valve) engine
- F head (over head inlet and side exhaust) engine

Main Components of IC Engines:

Cylinder Block:

- It is the main block of the engine.
- It contains cylinders accurately finished to accommodate pistons
- The cylinder block houses crank, camshaft, piston and other engine parts.
- In water cooled engines, the cylinder block is provided with water jackets for the circulating cooling water.
- The materials used for cylinder are grey cast iron, aluminium alloys etc.,
- It is usually made of a single casting

Cylinder block of motor cycle

Cylinder block of car

Cylinder Head:

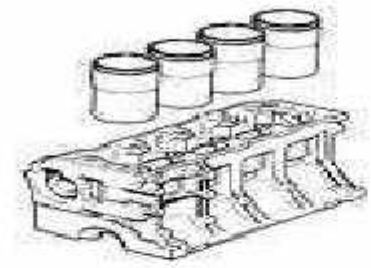
- The cylinder head is bolted to the cylinder Block by means of studs.
- The water jackets are provided for cooling water circulation.
- The materials used for cylinder head are cast iron, aluminium alloy etc.,
- This is also generally made of single cast iron.

Cylinder Liners:

- The liner is a sleeve which is fitted into the cylinder bore.
- It provides wear resisting surface for the cylinder bores.

Liners are classified into:

- (a) Wet liner (b) Dry liner



Cylinder Liners

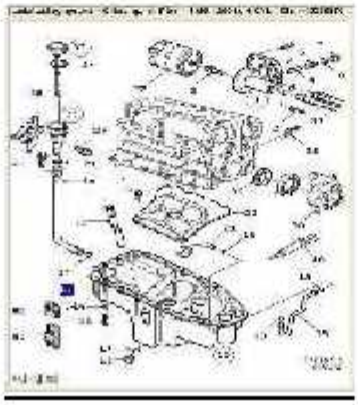
Wet Liner : These liners are surrounded or wetted by cooling water. It provides wear resisting surface for the piston to reciprocate. Also it acts as a seal for the water jacket

Dry Liner : Dry liners have metal to metal contact with the cylinder block. They are not directly in touch with the cooling water.

Liner Materials:

- Liner material should withstand abrasive wear and corrosive.Chromium plated mild teel
- tubes are used as liners.

Crankcase : It may be cast integral with the cylinder block.Some times, it is cast separately and then attached to the block.



These materials are used for crank case are cast iron, aluminium alloys or alloy steels.

Oil pan or oil sump: Oil sump is the bottom part of the engine.It contains lubricating oil.A drain plug is provided the oil sump to drain out the oil.It is made of the pressed sheet.

Piston :

The piston serves the following purposes

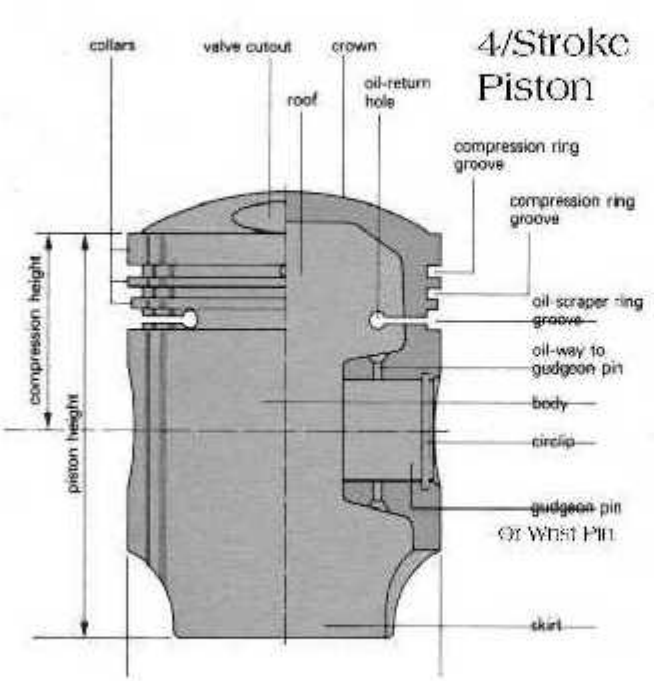
- It acts as a movable gas tight seal to keep the gases inside the cylinder
- It transmits the force of explosionin the cylinder to the crankshaft through the connecting rod.
- Some of the materials used for piston are cast iron, aluminium alloy, chrome nickel alloy, nickel iron alloy and cast steel.

Piston rings :

Piston rings are inserted in the grooves provided in the piston. Two types of piston rings are used in the piston.

1. Compression rings
2. Oil rings or oil control rings

Main Components of IC Engines Piston Rings (Compression and Oil rings)



Compression rings :

- Compression rings provide an effective seal for the high pressure gases inside the cylinder.
- They prevent the leakage of high pressure gases from the combustion chamber into the crank case.
- Each piston is provided with at least two compression rings.

Oil rings :

- Oil rings wipe off the excess oil from the cylinder walls.
- It also returns excess oil to the oil sump, through the slots provided in the rings.

The materials used for piston rings should be wear resistant.Normally piston rings are made of alloy steel iron containing silicon, manganese alloy steels etc.

Connecting Rod:

- It connects the piston and crank shaft.

- It transmits the force of explosion during power stroke to the crankshaft.
- The connecting rod has bearings at both ends.
- The small end of the connecting has a solid or split eye and contains a bush.
- This end is connected to the piston by means of a gudgeon pin.
- The other end is called as big end of the connecting rod.
- The connecting rods must withstand heavy thrusts.
- Hence it must have strength and rigidity.
- They are usually drop forged I sections.
- The materials used are plain carbon steel, aluminium alloys, nickel alloy steels etc,

Crank Shaft :

- It is the main rotating shaft of the engine.
- Power is obtained from the crank shaft.
- The crank shaft is combination with connecting rod converts reciprocating motion of the piston into rotary motion.
- The crank shaft is held in position by the main bearings.
- There are two main bearings to support the crank shaft.
- The materials used for crank shaft are billet steel, carbon steel, nickel chrome and other heat treated alloy steels.

Camshaft:

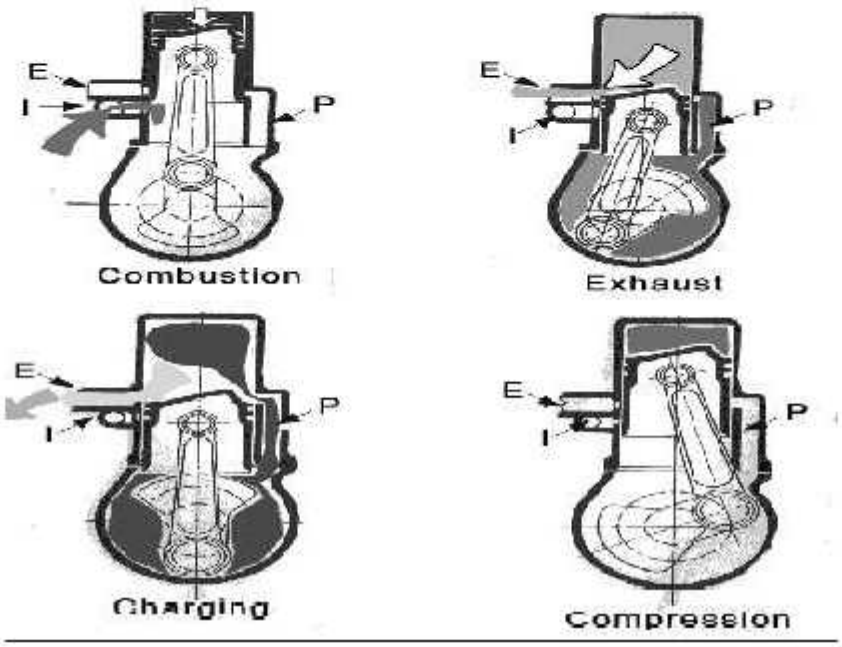
- Camshaft contains number of cams.
- It is used to convert rotary motion into linear or straight line motion.
- It has so many cams as the number of valves in an engine.
- An additional cam is also provided to drive the fuel pump.
- A gear is provided in the cam shaft to drive the distributor or oil pump.
- The opening and closing of the engine valves are controlled by the cams provided on the cam shaft.

Petrol Engines

Classification of Petrol Engines

- Two Stroke cycle Petrol Engines
- Four Stroke cycle petrol Engines

Two Stroke cycle Petrol Engines:



Two Stroke Cycle Petrol Engine

Construction :

- A piston reciprocates inside the cylinder
- It is connected to the crankshaft by means of connecting rod and crank
- There are no valves in two stroke engines, instead of valves ports are cut on the cylinder walls.
- There are three ports, namely **inlet, exhaust** and **transfer** ports.
- The closing and opening of the ports are obtained by the movement of piston. The crown of piston is made in to a shape to perform this.
- A spark plug is also provided.

First Stroke : (Compression, ignition and inductance) (Upward stroke of piston)

(a) compression:

- The piston moves up from Bottom Dead Centre (BDC) to Top Dead Centre (TDC)
- Both transfer and exhaust ports are covered by the piston.
- Air fuel mixture which is transferred already into the engine cylinder is compressed by moving piston.
- The pressure and temperature increases at the end of compression.

First Stroke : (Compression, ignition and inductance) (Upward stroke of piston)

(b) Ignition and Inductance:

- Piston almost reaches the top dead centre
- The air fuel mixture inside the cylinder is ignited by means of an electric spark produced by a spark plug
- At the same time, the inlet port is uncovered by the plane.
- Fresh air fuel mixture enters the crankcase through the inlet port.

Second Stroke: (Downward Stroke of the engine) :

(c) Expansion and Crankcase compression

- The burning gases expand in the cylinder
- The burning gases force the piston to move down. Thus useful work is obtained.
- When the piston moves down, the air fuel mixture in the crankcase is partially compressed. This compression is known as ***Crank case compression.***

Second Stroke: (Downward Stroke of the engine) :

(d) Exhaust and transfer:

- At the end of expansion, exhaust port is uncovered.
- Burnt gases escape to the atmosphere.
- Transfer port is also opened. The partially compressed air fuel mixture enters the cylinder through the transfer port.

- The crown of the piston is made of a deflected shape. So the fresh charge entering the cylinder is deflected upwards in the cylinder.
- Thus the escape of fresh charge along with the exhaust gases is reduced.

Two stroke cycle Diesel Engines- Construction

Construction :

- Two stroke cycle diesel engines require air supply
- This air is used to blow out the exhaust gases and to fill the cylinder with clean air
- This air is supplied by a blower or air compressor which is driven by engine itself.
- These engines may be valve or port type.
- A plate is provided in the crank case to admit air into the crank case.
- Transfer and exhaust ports are provided in the cylinder.
- These ports are covered and uncovered by the moving piston.

First Stroke (Upward Stroke of the piston)

(a) Compression and inductance:

- The piston moves upwards from Bottom Dead Centre (BDC) to Top Dead Centre (TDC).
- Both transfer and exhaust ports are covered.
- Air which is transferred already into the engine cylinder is compressed by moving piston.
- The pressure and temperature of the air increases.
- At the same time, fresh air is admitted into the crankcase through the plate valve (reed valve)

First Stroke (Upward Stroke of the piston)

(b) Ignition and inductance.

- Piston almost reaches the top dead centre.
- The fuel is injected into the hot compressed air inside the cylinder. The fuel mixed with hot air and burns.
- The admission of fresh air into the crankcase continues till the piston reaches the top centre.

Second Stroke (Downward Stroke of the piston)

(c) Expansion and crank case compression:

- The burning gases expand in the cylinder.
- Burning gases force the piston to move down. Thus useful work is obtained.
- At the same time, the air in the crank case is compressed by the movement of piston.
- All the ports and the plate valve are in closed position

Second Stroke (Downward Stroke of the piston) (d)

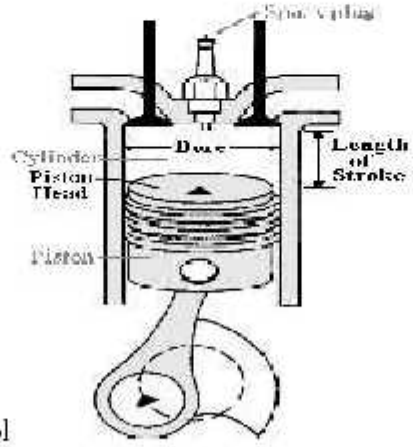
Exhaust and Transfer:

- At the end of expansion, the exhaust port is uncovered.
- The burnt escape to the atmosphere through the exhaust port.
- Transfer port is also uncovered shortly after the exhaust port is opened.
- The partially compressed air from crank case enters the cylinder the transfer port.
- This air is deflected upwards by the deflected shape of the piston.
- Thus the entering air helps in forcing out the combustion products from the cylinder
- The plate valve remains during this period.

Four stroke cycle Petrol Engines

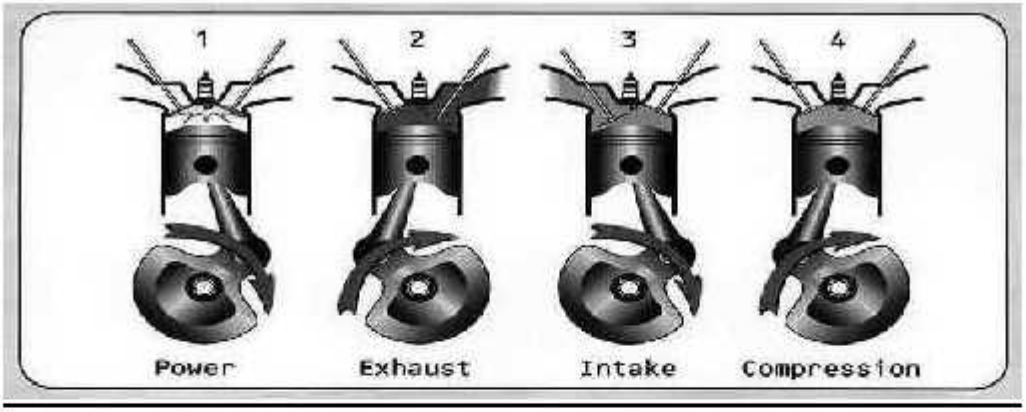
Construction :

- A piston reciprocates inside the cylinder
- The piston is connected to the crank shaft by means of a connecting rod and crank.
- The inlet and exhaust valves are mounted on the cylinder head.
- A spark is provided on the cylinder Head.



- The fuel used is petrol

Four Stroke Petrol Engine- Working



(a) Suction Stroke (First Stroke of the Engine)

- Piston moves down from TDC to BDC
- Inlet valve is opened and the exhaust valve is closed.
- Pressure inside the cylinder is reduced below the atmospheric pressure.

- The mixture of air fuel is sucked into the cylinder through the inlet valve.

(b) Compression Stroke : (Second Stroke of the piston)

- Piston moves up from BDC to TDC
- Both inlet and exhaust valves are closed.
- The air fuel mixture in the cylinder is compressed.

(c) Working or Power or Expansion Stroke: (Third Stroke of the Engine)

- The burning gases expand rapidly. They exert an impulse (thrust or force) on the piston. The piston is pushed from TDC to BDC
- This movement of the piston is converted into rotary motion of the crankshaft through connecting rod.
- Both inlet and exhaust valves are closed.

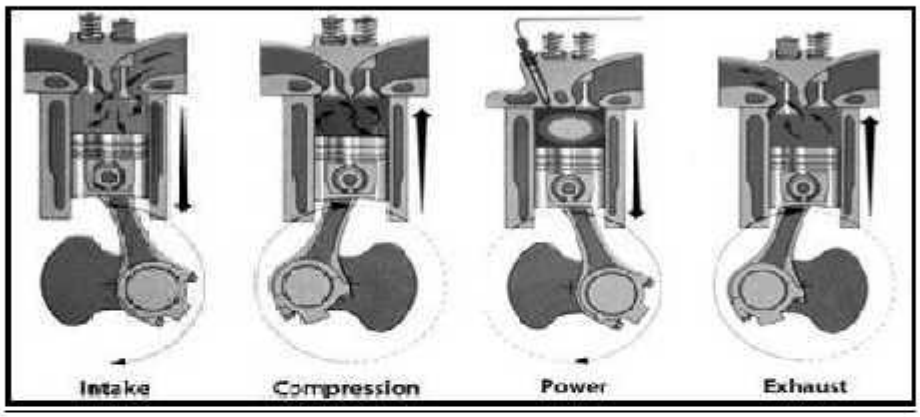
(d) Exhaust Stroke (Fourth stroke of the piston)

- Piston moves upward from BDC
- Exhaust valve is opened and the inlet valve is closed.
- The burnt gases are forced out to the atmosphere through the exhaust valve (Some of the burnt gases stay in the clearance volume of the cylinder)
- The exhaust valve closes shortly after TDC
- The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh charge to start a new cycle.

Summary :

- Compression ratio varies from 5 to 8
- The pressure at the end of compression is about 6 to 12 bar.
- The temperature at the end of the compression reaches 250° C to 350° C

Four Stroke Diesel Engine



Construction:

- A piston reciprocates inside the cylinder
- The piston is connected to the crankshaft by means of a connecting rod and crank.
- The inlet and exhaust valves are mounted on the cylinder head.
- A fuel injector is provided on the cylinder head
- The fuel used is diesel.

(a) Suction Stroke (First Stroke of the piston)

- Piston moves from TDC to BDC
- Inlet valve is opened and the exhaust valve is closed.
- The pressure inside the cylinder is reduced below the atmospheric pressure.
- Fresh air from the atmosphere is sucked into the engine cylinder through air cleaner and inlet valve.

(b) Compression stroke (Second stroke of the piston)

- Piston moves from BDC to TDC
- Both inlet and exhaust valves are closed.
- The air is drawn during suction stroke is compressed to a high pressure and temperature

(c) Working or power or expansion stroke (Third stroke of the piston)

- The burning gases (products of combustion) expand rapidly.
- The burning gases push the piston move downward from TDC to BDC
- This movement of piston is converted into rotary motion of the crank shaft through connecting rod.
- Both inlet and exhaust valves are closed.

(d) Exhaust Stroke (Fourth stroke of the piston)

- Piston moves from BDC to TDC
- Exhaust valve is opened the inlet valve is closed.
- The burnt gases are forced out to the atmosphere through the exhaust valve. (some of the burnt gases stay in the clearance volume of the cylinder)
- The exhaust valve closes shortly after TDC
- The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh air to start a new cycle.

Scavenging :

- It is the process of forcing out the burnt exhaust gases from the cylinder for admitting the fresh charge into the cylinder.
- This action takes place in the two stroke cylinder.

Scavenging Process

- The charge (air fuel mixture or air) enters the engine cylinder from the crank case at a pressure higher than the exhaust gases.
- This fresh charge forces the exhaust gases to the atmosphere through the exhaust port.
- During the period both the transfer and exhaust ports are kept open for a short period.
- Hence there is a possibility of the fresh charge escaping out with the burnt gases.
- This is over come by designing the piston to have a deflected shape.
- This shape of piston deflects the fresh charge upward in the engine cylinder.

- It also helps out in forcing out the exhaust gases to atmosphere.
- This process is known as **Scavenging.**

Comparison between SI and CI Engines (General Comparison):

S. No.	Spark Ignition Engines (SI)	Compression Ignition Engines (CI)
1	It draws air fuel mixture into the cylinder during suction stroke	It draws only air into the cylinder during suction stroke.
2	Petrol engines operate with low pressure and temperature	Diesel engines operate with high pressure and temperature
3.	Pressure ranges from 6 to 12 bar Temperature ranges from 250 to 300 ^{o} C	Pressure ranges from 35 to 40 bar Temperature ranges from 600 to 700 ^{o} C
4	It is fitted with carburetor and spark plugs	It is fitted with fuel injection pump and injectors
5	The burning of fuel takes place at constant volume	The burning of fuel takes place at constant pressure
6.	Ignition of air fuel mixture takes place by an electric spark produced by spark plug	Ignition of air fuel takes placed by a injection of fuel into the hot compressed air.
7	Petrol engines are quality governed engines. The speed of petrol engines are controlled by varying the quantity of air fuel mixture.	Diesel engines are quantity governed engines. The speed of diesel engines are controlled by varying quality of air fuel mixture. (rich or weak mixture)

8	Petrol engines are widely used in automobiles and aeroplanes etc.,	Diesel engines are widely used in heavy vehicles, such as buses, lorries, trucks etc.,

Comparison between SI and CI Engines (Merits and Demerits):

S.No.	Spark Ignition Engines (SI)	Compression Ignition Engines (CI)
1	**Merits:** Otto cycle is employed in petrol engine. Otto cycle is more efficient for a given compression ratio.	**Demerits:** Diesel engines works on diesel cycle. Diesel cycle is less efficient than Otto cycle for a given compression ratio.
2	Operating speed is more. Speed range is 3000 to 6000 rpm	Operating speed is less. Speed range is 400 to 3500 rpm.
3.	Starting is easy, since cranking effort required is less	Starting is difficult since more cranking effort is required.
4	Merits: Initial cost and maintenance cost are less	Demerits: More initial and maintenance costs since the construction is heavy and sturdy.
5	Produces less noise.	Produces more noise.
6	Weight per unit power is less	Weight per unit power is more.
4	Demerits: Thermal efficiency is less. since compression ratio is limited. 5 – 8	Merits: Thermal efficiency is high since compression ratio is high. 12 to 18.
5	Specific fuel consumption is more.	Specific fuel consumption is less
6	The fuel used is petrol. It is costlier than diesel. It is volatile and fire	The fuel used is diesel. It is cheaper than petrol. It is less volatile and fire hazard is

	hazard is more	less.

Comparison between Four stroke cycle and two stroke cycle engine (Merits and Demerits):

S.No.	Two Stroke Cycle Engine (Merits)	Four Stroke Cycle Engine (Demerits)
1	One power stroke in one revolution of the crankshaft	One power stroke in two revolutions of the crank shaft
2	Power developed for the same engine speed theoretically twice that of a four stroke engine	Power developed for the same engine speed is theoretically half that of two stroke engine.
3	Simple design and lighter in construction for the same power	For the same power complicated design and heavier in construction
4	Uniform torque is obtained. Hence a lighter fly wheel can be used	Non uniform torque on the crankshaft. Hence a heavier flywheel is required for balancing.
5	Design of ports is simpler. Hence initial cost is less	Design valve mechanism is difficult. Hence initial cost is more.
6	Mechanical efficiency is high. No moving parts like cam, follower, rocker arm valves etc.,	Mechanical efficiency is less. Power is lost due to friction caused by valve mechanism
7	Starting is easy	Starting is not so easy
8	These engines are generally air cooled	These engines are generally water cooled.

Comparison between Four stroke cycle and two stroke cycle engine (Merits and Demerits):

S.No.	Two Stroke Cycle Engine (DeMerits)	Four Stroke Cycle Engine (Merits)
1	Consumption of lubricating oil is more, because less time is available to remove the heat	Consumption of lubricating oil is less, because more time is allowed for removing heat from the cylinder.
2	More wear and tear of moving parts.	Less wear and tear of parts is less
3	Some of the fresh air fuel mixture may escape with exhaust gases. Hence fuel consumption is more	Fuel cannot escape with exhaust gases. Hence fuel consumption is less.
4	Thermal efficiency is less.	Thermal efficiency is more.
5	It produces more noise due to sudden release of exhaust gases	Noise is less is less. Exhaust gases are released in separate stroke.
6	Scavenging is poor, since exhaust port is open only for a short time	Scavenging is better, since there is a separate exhaust stroke for the removal of exhaust gases
7	Merits: Poor scavenging leads to mixing of fresh charge with exhaust gases. This results in poor performance, slow running	Demerits: Better performance and efficiency is more
8	Used in light vehicles, like	Used in heavy vehicles, like buses, lorries,

	bikes, scooters, mopeds, etc.,	trucks etc.,

I.C ENGINE TERMINOLGOGY

The standard terms used in I.C Engines are

1. Bore: Inside diameter of the cylinder is termed as Bore.
2. Top Dead Center (TDC): The extreme position reached by the piston at the top of the cylinder in the vertical engine is called Top Dead center.
3. Bottom Dead Center (BDC): The extreme position reached by the piston at the Bottom of the cylinder in the vertical engine is called Bottom Dead center.
4. **Stroke:** The nominal distance travelled by the piston in the cylinder between the extreme upper and lower positions of the piston (TDC &BDC) is termed as stroke.
5. **Compression ratio (r):** It is the ratio of Maximum cylinder volume to the Clearance volume.
6. **Cylinder volume (v):** It is the sum of swept volume and the Clearance volume. V = Vs + Vc
7. **Swept volume (Vs):** It is the volume of space generated by the movement of piston from one dead center to another dead center.
8. **Clearance Volume(Vc):** It is the space in the cylinder, when the piston is at Top Dead Center

Major parts of an IC engine

1. Cylinder

- It is a round cylindrical casting in which a piston slides in and out to make strokes.
- Combustion take place inside the cylinder. The cylinder is closed by a cylinder head.

Material: Grey cast iron, Aluminium

2. Cylinder head

It is fitted to the top of the cylinder. It has inlet and outlet values, spark plug, Fuel injector, Water jackets.

Material: C.I, Aluminium

3. Piston

It is a device which transmits the energy (or) force of the expanding gas to the connecting rod. It slides up and down inside the cylinder.

Material: C.I, Aluminium alloy, Cast steel

4. Piston rings: Piston rings are inserted in the grooves of piston. There are two types of rings.

1) Oil ring (One ring is used)

2) Compression ring(Two ring is used)

5. Connecting rod: It converts the reciprocating motion of the piston into rotary motion of crankshaft. The small end of the connecting rod is connected to piston and the big end is connected to the crankshaft.

Material: Plain carbon steel, Aluminium alloys

6. Crank shaft: It is the device used for getting power from the motion of the piston and connecting rod and this power is applied to the flywheel.

Material: Alloys steel.

7. Camshaft: It operates the opening and closing of the engine values. It has number of cams which are driven by crank shaft through timing gears. The function of the cam is to convert the rotary motion into the linear reciprocating motion

Material: Alloys steel

8. Crank case: It is the bottom portion of the I.C engine and holds the cylinder and the crank case. It also serves as a pump for the lubricating oil.

Material: Aluminium alloy, Cast iron

9. Flywheel: It is a big wheel attached with crankshaft. It maintains the speed of the engine.

10. Valves: The function of the value is to admit the fresh charge in the cylinder and to send the exhaust gases out. There are two values namely inlet value and outlet value.

Material: Inlet value: Nickel chrome.

Outlet value: Nickel chrome, Stainless steel etc

11. Water Jackets: Water jackets are provided in the cylinder head. The purpose of water jackets is to keep the walls of the engine cool.

Steam Boilers

- Generates steam by transferring heat by burning of fuel to water.
- Energy released by burning fuel (solid, liquid or gaseous) is transferred to the water in the boiler.

Classification of boilers:

The steam boilers are classified as

- **According to flow of water and hot gases.**

1. Fire Tube Boilers
2. Water Tube Boilers

- **According to the method of firing.**

1. Internally fired boilers
2. Externally fired boilers

- **According to the Pressure developed**

1. Low pressure boilers
2. High pressure boilers

In fire tube boilers,

- The hot gases pass through the tubes surrounded by water.
- The water is get heated up and converted into steam
- The exhaust gases are sent to atmosphere through chimney.

Locomotive boiler, Lancashire boiler.