PART A

1. The pour point of a liquid is the temperature below which the liquid loses its flow characteristics

2. It is the processs of **steam** tapping from different stages of **turbine** according to the required temperature and pressure.

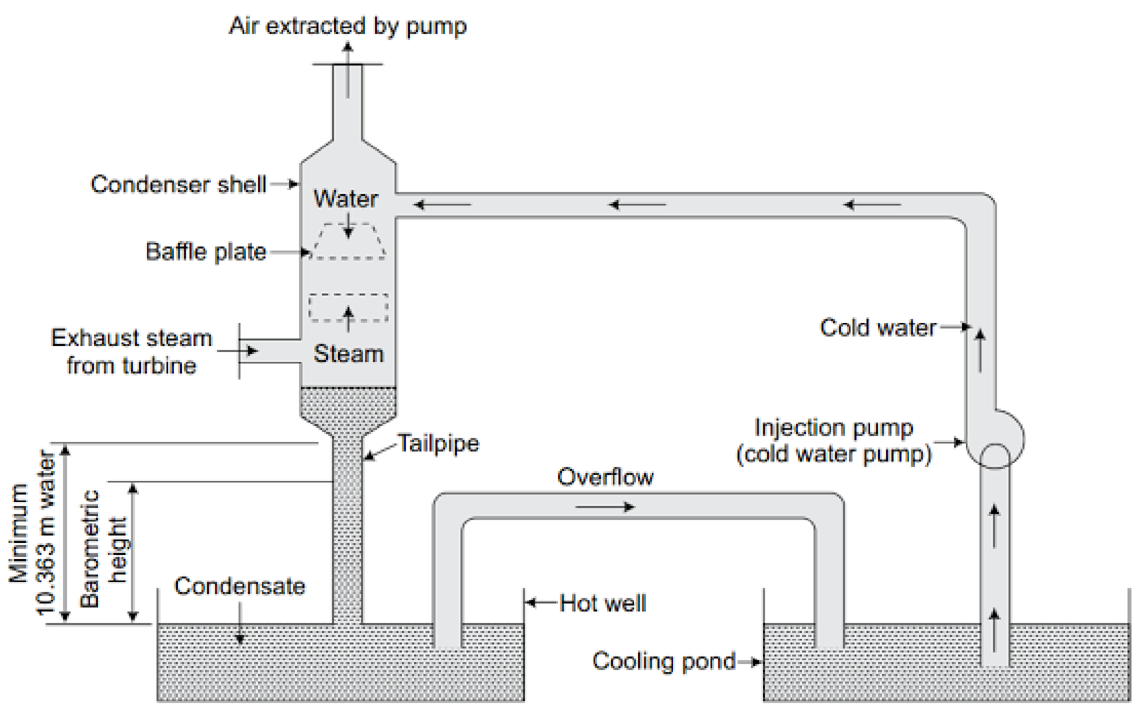
3. In thermal power plants, the purpose of a surface**condenser** is to condense the exhaust **steam** from a**steam** turbine to obtain maximum efficiency, and also to convert the turbine exhaust **steam** into pure water (referred to as **steam condensate**) so that it may be reused in the **steam** generator or boiler as boiler feed water.

4. **flammable** gas or light **distillate petroleum products** such as **gasoline** (**petrol**), **diesel** and**kerosene** (**paraffin**) which happen to be available locally, though **natural gas** is the most commonly used fuel.

5. **Uranium-235, Plutonium-239, Plutonium**-241, **Uranium-233**

PART B

1.



Barometric or High Level Jet Condenser

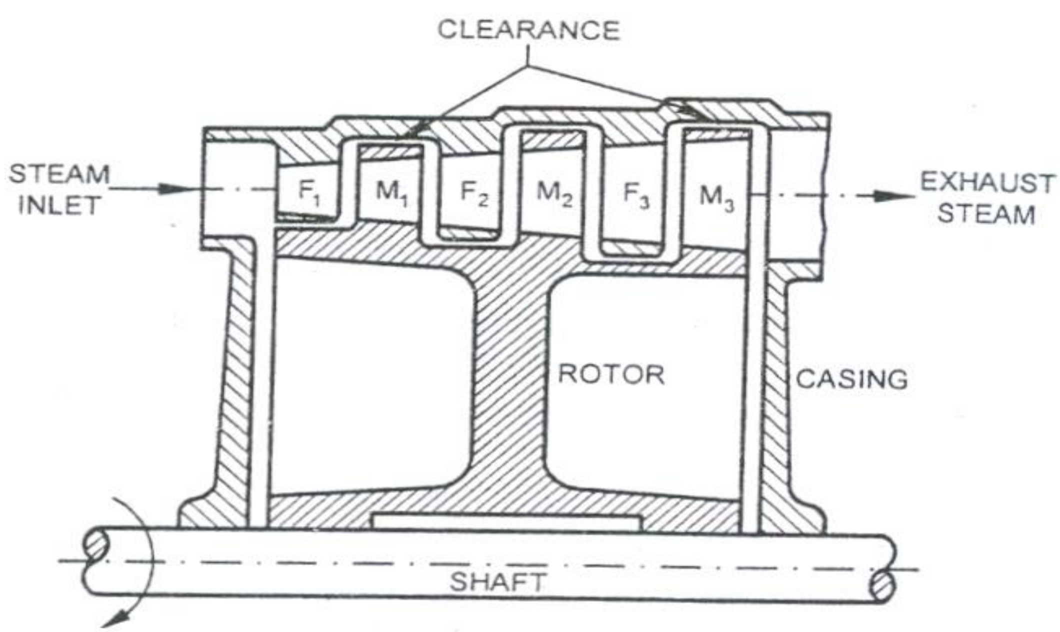
Barometric or high level jet condensers are provided at high level with a long vertical discharge tube or tailpipe. It does not have condensate extraction pump and the condensate and cooling water flows in the hot well because of the gravity. An injector pump is used to flow cooling water at the top of the condenser.

These types of jet condensers are used at a high level with a vertical discharge pipe. In this condenser, the steam enters at the bottom and flows in upward direction and meets with the down coming cooling water. Its working is similar as the low level jet condenser. The vacuum is created at the top of the condenser shell. With the help of vacuum and injector pump, the cooling water is moved to the top of the condenser. The condensate and cooling water comes down in the hot well through a long vertical discharge pipe. And finally the extra hot water flows to the cooling tank or cooling pond by an overflow pipe

2.

NUCLEAR FISSION	NUCLEAR FUSION
A heavy nucleus breaks up to form two lighter nuclei.	Two light nuclei combine to form a heavy nucleus.
It involves a chain reaction.	Chain reaction is not involved.
The heavy nucleus is bombarded with neutrons.	Light nuclei are heated to an extremely high temperature.
We have proper mechanisms to control fission reaction for generating electricity.	Proper mechanisms to control fusion reaction are yet to be developed.
Disposal of nuclear waste is a great environmental problem.	Disposal of nuclear waste is not involved.
Raw material is not easily available and is costly.	Raw material is comparatively cheap and easily available.

3.



Pure reaction turbine is never used in actual practice. In the actual reaction turbine, power is obtained by the impulsive force of incoming steam and reactive force of outgoing steam.

Description

See Fig.   C.A.Parson has built a reaction turbine with three stages. It consists of a wheel or rotor and casing, both are of varying diameters. Equal numbers of fixed and moving blades are attached alternately to the casing and the wheel.

The moving and fixed blades are not symmetrical in shape and are also curved in the opposite direction. The shape of the moving blades is so designed to have the reactive force, when the jet of steam is leaving the blades. Also, there will be some pressure drop in the moving blades. Fixed blades are designed in such a way that the passages between them act as nozzles. Hence, the velocity increases with the decrease of pressure.

Working

Steam passes over the *first fixed blade* F1. The fixed blade changes the direction of steam and at the same time, allows it to expand to a higher velocity, with decrease of pressure.   Then, the steam passes over the *first moving blade* M1. The moving blade converts the kinetic energy into mechanical work with decrease of velocity. But, at the same time, the steam expands as it flows over the moving blade and there is a fall of pressure. This produces a *reaction* on the blade by the expanding steam. Thus, in the reaction turbine, the steam expands both in fixed and moving blades continuously as steam passes over them. So, the pressure drop occurs gradually and continuously over both fixed and moving blades.

4. It is readily available,
   It is less expensive,
   It burns easily in air at a moderate rate,
   It produces a large amount of heat,
   It can transport easily.
   It has high calorific value, and.
   It does not leave behind any undesirable substances.

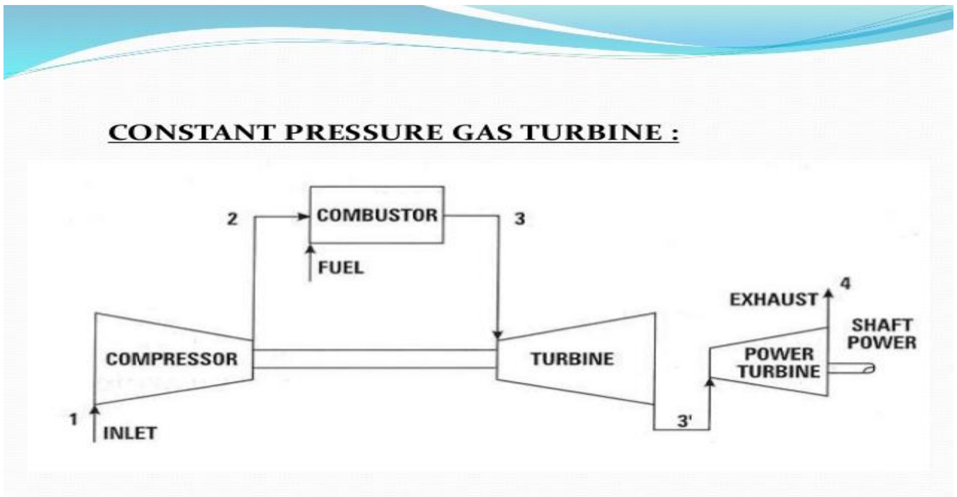
5. The steam condenser is classified as

1. Jet condensers or mixing type condenser
2. Surface condenser or non-mixing type condenser

Jet condenser is a condenser in which the condensate gets mixed with the cooling water. That's why it is also called as mixing type condenser.This type of condenser is used sometime because it lost some of the condensate and requires high power for the pump during the process of condensation.In jet condenser, as the condensate is not free from the salt, so it cannot be used as feed water for the boiler. It can be used at the place where sufficient amount of good quality water is available.

Surface condenser is a type of steam condenser in which the steam and cooling water do not mix with each other. And because of this, the whole condensate can be used as boiler feed water. It is also called as non-mixing types condenser.

6. The high **pressure** air enters the combustion chamber where the fuel is burned at**constant pressure**. The high temperature (and **pressure**) **gas** enters the **turbine**where it expands to ambient **pressure** and produces **work**

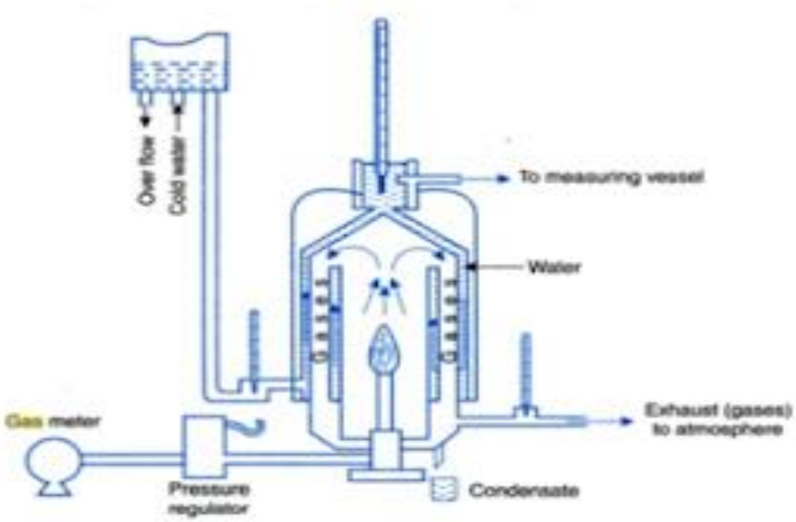


7.

PART C

III

(a)



The junker's gas calorimeter is a device used to measure the calorific value of the gaseous fuels. The device is essentially a Bunsen burner with a cooling jacket. The jacket is cylindrical in shape with water in it. The burner is inside the cylinder. The calorimeter allows the user to measure the temperature of water flowing in and flowing out. Once steady state is reached, the water flowing through is collected for a specified period of time. Measuring the mass of the water and the temperature rise in the water, the operator can calculate the number of joules which went into the water to heat it. There is a flow meter on the fuel gas, so the operator can also calculate the volume of gas that was burned in the same time period. The amount of energy, in J, available per litre of gas can then be calculated. A Junkers calorimeter is a flow calorimeter, with heat transfer happening continuously, as opposed to a batch calorimeter.

The device consist of a cylindrical shell and two paths for water are there which have copper coil arranged in it. One path is the inlet and the other is outlet. Water pass through the copper coils. There is pressure regulator in the path of water flow which is further connected with gas flow meter. Gas flow meter is used to measure the flow rate of gas. Temperature sensors are used in the device to measure the inlet and outlet water temperature and also for the flue gases.

The junker's gas calorimeter works on the principle of burning of a gas whose volume is known. The temperature of water and gas is measured along with flow rate of gas to measure the calorific value. The formula is:

Calorific Value of Gas X Volume of Gas = Volume of water X Rise in Temperature, is then used to determine the Calorific Value of the Gas (assuming that heat capacity of water is unity).

A measured quantity of gas whose calorific value is required supplied to a gas meter which measures the volume of gas and after it the gas pass through the pressure regulator which measures the pressure of gas using the manometer. When the gas inside the chamer is burned, the products produced in the combustion rise into the chamber and then move downward where it is extracted as gas flues. After this gas finally escapse to the atmosphere. There is thermometer at the end of the outlet which measures the temperature of the escaping gas. This temperature should be near room temperature so that whole heat is absorbed by the water. Cold water enters the calorimeter near the bottom of device and leaves from top. Water that was formed by condensation is collected in a pot. The quantity of gas in te process is measured accurately and the temperature of ingoing and outgoing gas is also measured. By using above ccollected data we can measure the calorific value from formula as mentioned earlier.

(b) Advantages

Handling of liquid fuel is easy and they require less storage space

Liquid fuels can be fired easily and maximum temperature is attained in time as compared to solid fuels.

The solid fuels containing higher of moisture burn with great difficulty.

The solid fuels leave a large quantity of ash after burning and then disposal of ash becomes a problem. Whereas the liquid fuels has very little ash after burning.

The combustion of liquid fuel is uniform therefore the change in load can be easily met by controlling the flow of fluid.

Disadvantages

They are costly as compared to solid fuels

They require special type of burners

In cold climate the oil stored in tanks is to be heated in order to avoid the stoppage of flow.

IV

(b) **Forced Draught**

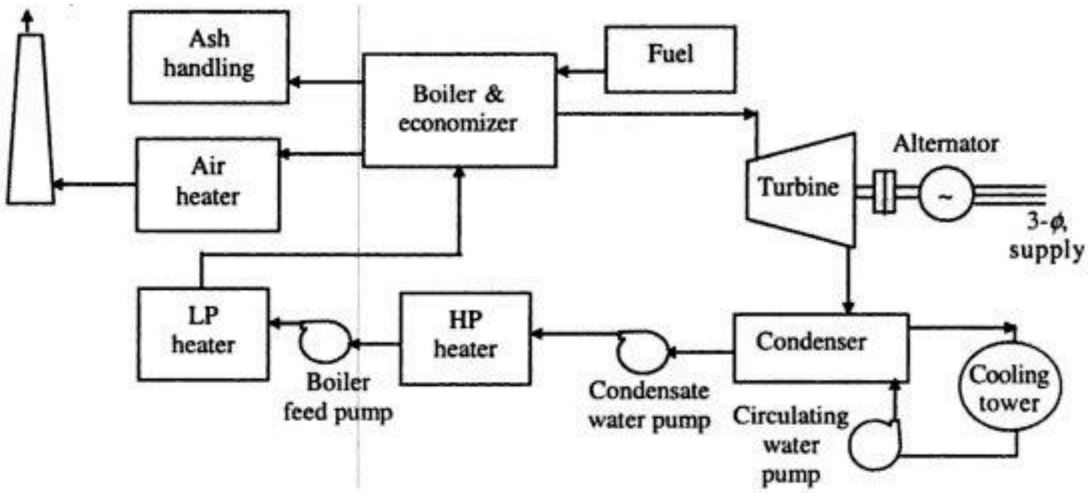
1. Fan or blower is placed before grate or situated within the oil burner assembly in case of oil fired boiler.
2. Pressure inside the flue passages is slightly more than atmospheric pressure.
3. Due to above reason, there is serious danger of fire to come out and injure someone if any leakage in boiler flue passage take place.
4. It forces fresh air into the combustion chamber, which helps in burning of fuel and production of hot combustion gases. Due to this force, the hot flue gases are further pushed through the flue passages in boiler.
5. Forced draught fan require less power because it has to handle cold and dense air, the volume per unit mass of which is less.
6. Flow of flue gases through boiler is more uniform.

Induced Draught

1. The fan or blower is placed after the grate or after the flue passages and before chimney.
2. Pressure inside the flue passages is slightly less than atmospheric pressure.
3. Due to above reason, there is no danger of fire to come out from boiler flue passage in case of a leakage. Hence Induced draught is more safe.
4. It sucks the hot flue gases from the combustion chamber through flue passages and then passes on these to economizer, air pre heater and chimney. Due to this suction, fresh air is also sucked in to combustion chamber.
5. Induced draught fan requires more power because it has to handle hot flue gases, the volume per unit mass of which is more.
6. Flow of flue gases is less uniform

V

(a)



Working fluid cycle steam power plant is a closed cycle, which uses the same fluid repeatedly. First, the water is filled into the boiler to fill the entire surface area of heat transfer. In the boiler water is heated by the hot gases of combustion fuel with air so that turned into vapor phase. Steam produced by boiler with pressure and temperature are directed to do work on the turbine to produce mechanical power in the form of rotation.

The former steam out of the turbine, and then flowed into the condenser to be cooled with cooling water that turned to water. Condensate water is then used again as boiler feed water. Thus the cycle goes on and repeats.

VI

(a) The Carnot cycle is the most efficient cycle operating between two specified temperature levels – it adopted as an ideal cycle. Steam is the working fluid in the Carnot vapour cycle. Below we contemplate why this cycle is not a suitable model for a power cycle. Consider a steady-flow Carnot cycle executed within the saturation dome of a pure substance show in Figure

Process 1 to 2: the fluid is heated reversibly and isothermally in a boiler.

Process 2 to 3: expanded isentropically in a turbine.

Process 3 to 4: condensed reversibly and isothermally in a condenser.

Process 4 to 1: compressed isentropically by a compressor to the initial state.

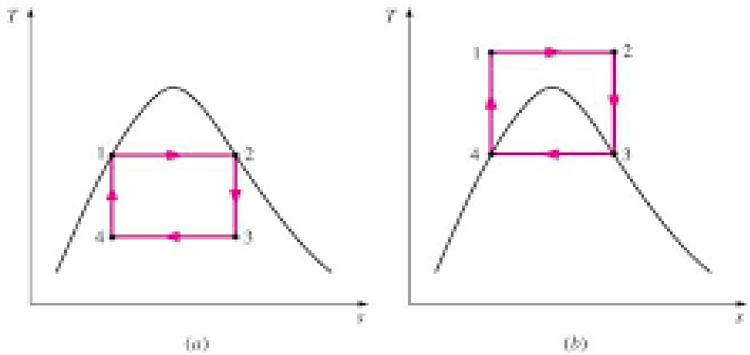
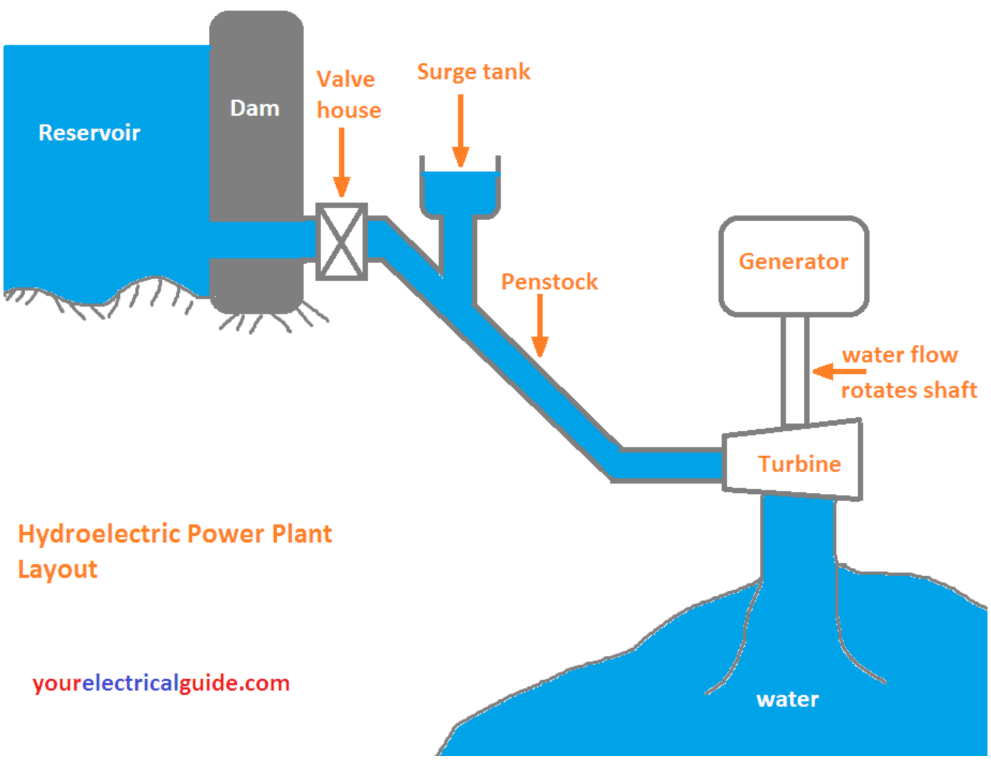


FIGURE 10–1
T-s diagram of two Carnot vapor cycles.

VII

(a) The theory is to build a dam on a large river that has a large drop in elevation .The dam stores lots of water behind it in the reservoir. Near the bottom of the dam wall there is the water intake. Gravity causes it to fall through the penstock inside the dam. At the end of the penstock there is a turbine propeller, which is turned by the moving water. The shaft from the turbine goes up into the generator, which produces the power. Power lines are connected to the generator that carries electricity. The water continues past the propeller through the tailrace into the river past the dam



(b)

Applications of Gas Turbine

1) **Supercharing of I.C.Engine** :

   Small gas turbines are used to drive superchargers of petrol and diesel engines.

2) **Air craft engines** : Gas turbines are lower in weight and smaller in size for same power output than that of I.C. engine, therefore used for aircraft engines.

3) **Marine field** : Gas turbines are used in marine engine for propelling ships.

Applications of Gas Turbine

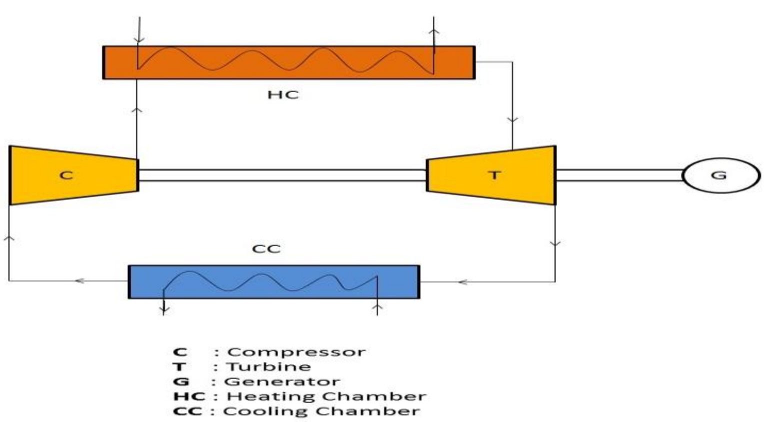
4) **Road transport** : Small cars using gas turbines has been manufactured and tested.

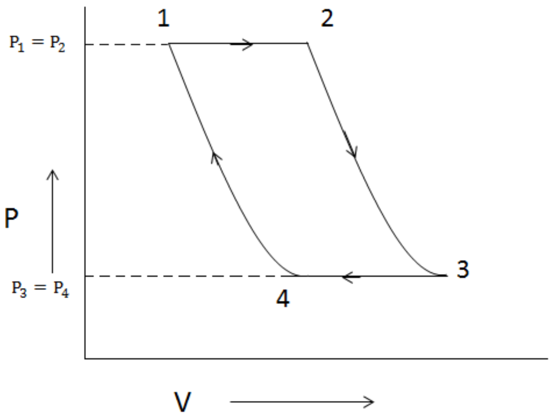
5) **Electric power generation** : Gas turbines can be installed at low cost per KW therefore used for electric power generation.

6) **Industrial** : The output power of gas turbines can be used for crude oil pumping.

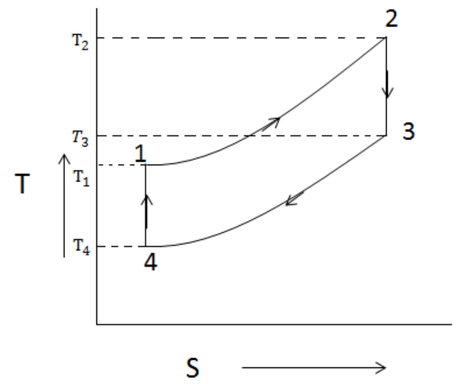
VIII

(a)





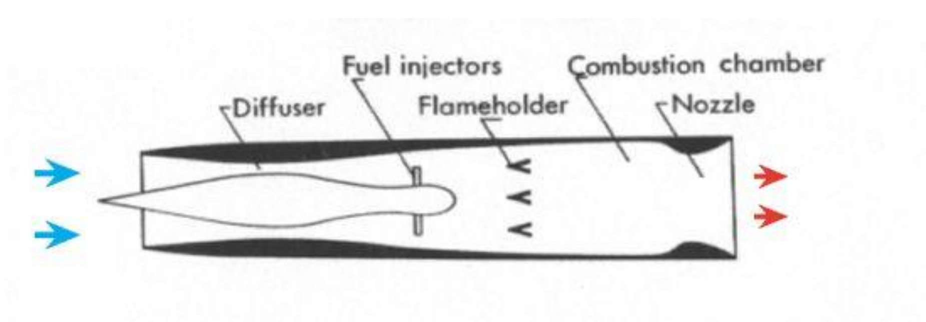
P-V Diagram



T-S Diagram

- In this turbine, the gas is compressed isentropically and then passed into the heating chamber. The compressor generally used is of rotary type.
- The compressed air is heated with the help of some external source and then made to flow over the turbine blades. The turbine used here is of reaction type.
- The gas while flowing over the blades of the turbine, gets expanded. From the turbine the gas is passed to the cooling chamber. Here the gas is cooled at constant pressure with the help of circulating water to its original temperature.
- Now the gas is again made to flow through the compressor to repeat the process.
- Here the same gas is circulated again and again in the working of a closed cycle gas turbine.

(b)



The term ramjet is short for ram-air compression. The ramjet is the simplest form of a jet engine because it has no moving parts. This kind of engine is essentially a hollow tube into which fuel is injected, mixed with air, and burned to produce thrust, as illustrated below. The ramjet only works when it is already moving fast enough that the incoming air is compressed simply by being forced into the engine. This behavior is called the ram effect because when a volume of air is forced into a small space at high enough speeds, it is compressed to a higher pressure.

This compression is accomplished in the diffuser section where the incoming air is squeezed into a small area and compressed to a high enough pressure that it can be burned with fuel. Once the fuel is injected, the mixture is fed into a combustion chamber where the fuel-air mixture is ignited to produce a high-speed exhaust. The exhaust passes out the nozzle at the aft end of the engine to produce thrust.

The advantages of the ramjet are its simplicity and its ability to accelerate a vehicle to high speeds over Mach 3. However, we have already pointed out that the engine must already be in motion before it can work, so there is a minimum Mach number that must be reached before a ramjet can be turned on and start producing thrust. Ramjets typically need to be moving faster than Mach 1 before they can be engaged. Compared to the turbojet, ramjets are also usually much less efficient until around Mach 3 or so.Since a ramjet must already be traveling at high speeds before it will start working, a ramjet-powered aircraft is incapable of taking off from a runway under its own power.

IX

(a) We distinguish two types of nuclear reactors

- **Nuclear research reactors**. This type of reactors used neutrons generated during nuclear fission reactions to produce radioisotopes that are going to be used in other applications of nuclear energy or materials for studies.
- **Nuclear power reactors**. These reactors are based on the use of the thermal energy generated in the fission reactions. The main and most known application of this type of reactor is to generate electricity in nuclear power plants. However, also they are used for desalination of sea water, heating or to propulsion systems.
- There are other classifications of the types of nuclear reactor depending on the criteria used. Among the most common criteria are:
- According the **nuclear fuel used** we can find the nuclear reactors of natural uranium and enriched uranium nuclear. The nuclear fuel of natural uranium contains the same proportion of uranium than in nature, while in the enriched uranium fuel this proportion is artificially increased. Other reactors use mixed oxides of uranium and plutonium.
- Depending on the **speed of the neutrons** (kinetic energy) produced in nuclear fission reactions: fast reactors and thermal reactors are distinguished.
- According to the **moderator used** can be heavy-water nuclear reactors, light water or graphite reactors.

- According to the **material used as refrigerant**: the most common materials are a gas (helium or carbon dioxide) or water (light or heavy). Sometimes these materials also act as a moderator. One can also use steam, molten salt, air, or liquid metal as coolant.

(b)

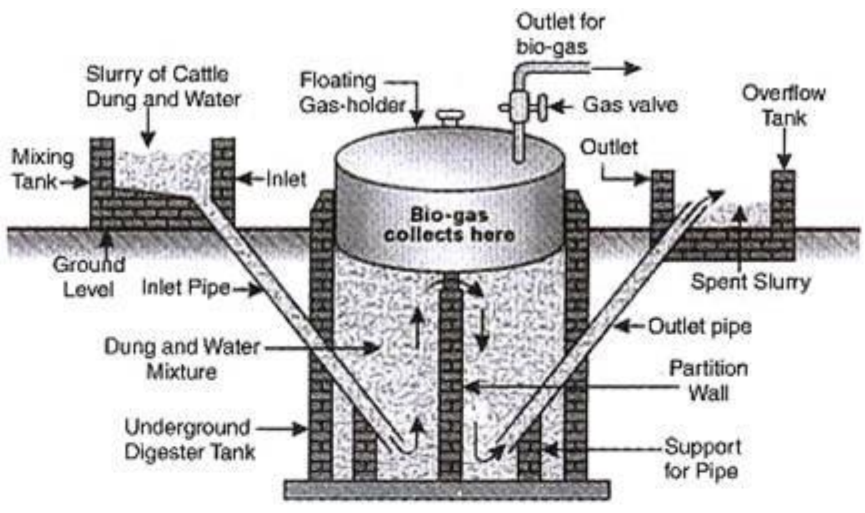


Fig. 4.11. Floating gas holder type plant

A well is made out of concrete. This is called the digester tank. It is divided into two parts. One side has the inlet, from where slurry is fed to the tank. The tank has a cylindrical dome made of stainless steel that floats on the slurry and collects the gas generated.

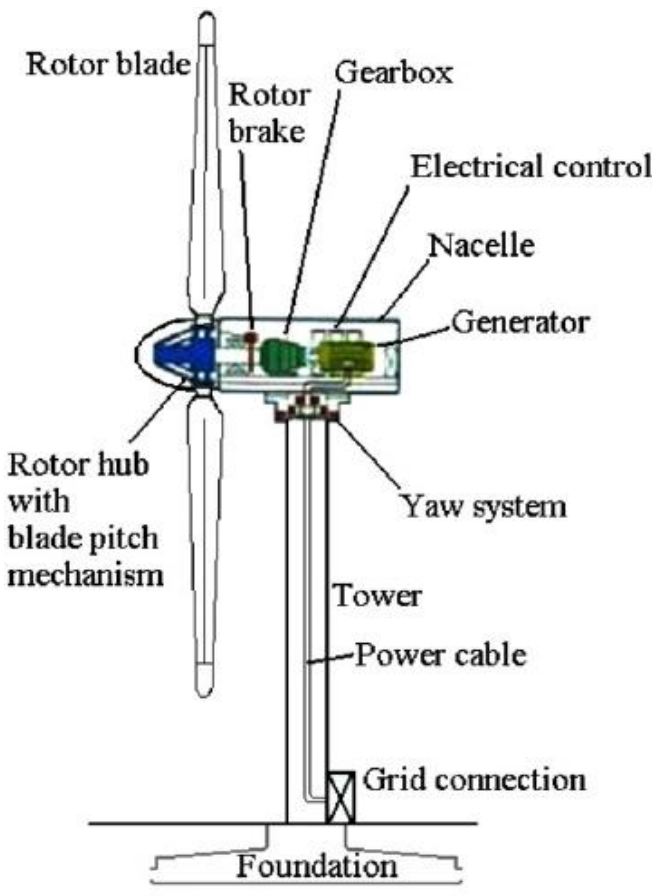
Hence the name given to this type of plant is floating gas holder type of bio gas plant. The slurry is made to ferment for about 50 days. As more gas is made by the bacterial fermentation, the pressure inside cylindrical dome increases.

The gas can be taken out through outlet pipe. The decomposed matter expands and overflows into the next chamber in tank. This is then removed by the outlet pipe to the overflow tank and is used as manure for cultivation purposes.

X

(a) A horizontal-axis wind turbine (HAWT) is a **wind turbine** in which the axis of the rotor's rotation is parallel to the wind stream and the ground. All grid-connected commercial wind turbines today are built with a propeller-type rotor on a horizontal axis (i.e. a horizontal main shaft). Most horizontal axis turbines built today are two- or three-bladed, although some have fewer or more blades. The purpose of the rotor is to convert the linear motion of the wind into rotational energy that can be used to drive a generator. The same basic principle is used in a modern water turbine, where the flow of water is parallel to the rotational axis of the turbine blades.

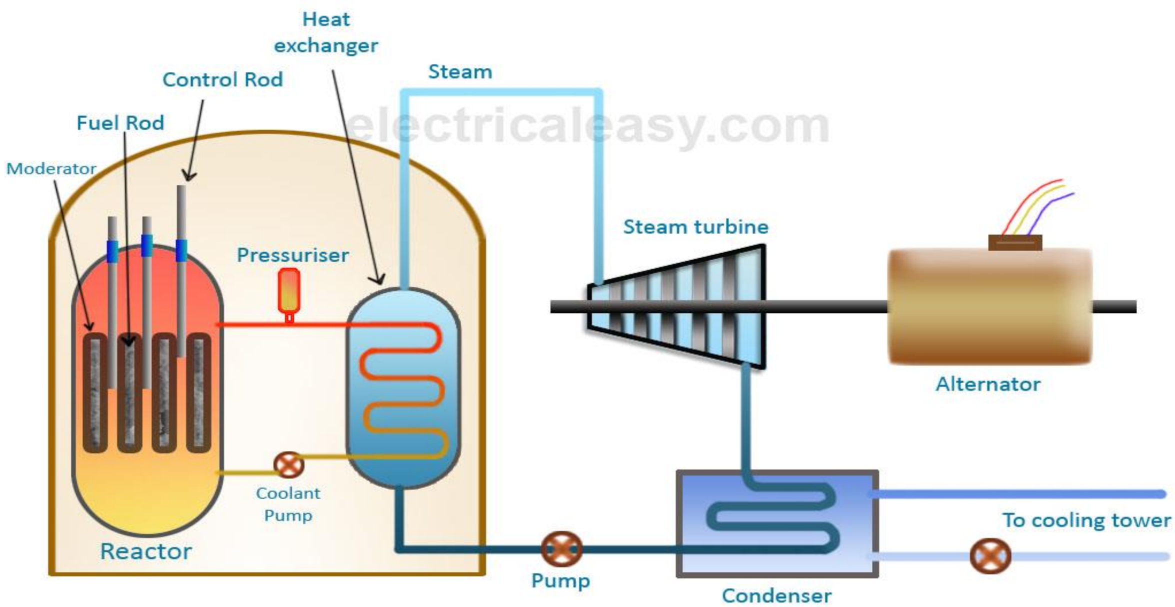
The wind passes over both surfaces of the airfoil shaped blade but passes more rapidly over the longer (upper) side of the airfoil, thus creating a lower-pressure area above the airfoil. The pressure differential between top and bottom surfaces results in aerodynamic lift. In an aircraft wing, this force causes the airfoil to rise, lifting the aircraft off the ground. Since the blades of a wind turbine are constrained to move in a plane with the hub as its center, the lift force causes rotation about the hub. In addition to the lift force, a drag force perpendicular to the lift force impedes rotor rotation. A prime objective in wind turbine design is for the blade to have a relatively high lift-to-drag ratio. This ratio can be varied along the length of the blade to optimize the turbine's energy output at various wind speeds.



(b)

In a **nuclear power plant**, heat energy is generated by a nuclear reaction called as **nuclear fission**. Nuclear fission of heavy elements such as Uranium or Thorium is carried out in a special apparatus called as a **nuclear reactor**. A large amount of heat energy is generated due to nuclear fission. Rest parts of a nuclear power plant are very similar to conventional thermal power plants. It is found that fission of only 1 Kg of Uranium produces as much heat energy as that can be produced by 4,500 tons of high grade coal. This considerably reduces the transportation cost of fuel, which is a major **advantage of nuclear power plants**. Also, there are large deposits of nuclear fuels available all over the world and, hence, nuclear power plants can ensure continued supply of electrical energy for thousands of years. About 10% of the total electricity of the world is generated in nuclear power plants.

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.



IV

a) Solution: Given: $m_f = 1g = 0.001$ kg; $m_w = 2.5$ kg; $t_2 - t_1 = 2.6°C$;

$m_c = 390g = 0.39$ kg; $H_2 = 6\% = 0.06$

Higher calorific value

$$H.C.V = \frac{(m_w + m_c) C_w (t_2 - t_1)}{m_f}$$

$$= \frac{(2.5 + 0.39)\, 4.2 \times 2.6}{0.001} \text{ kJ/kg} \qquad (\because C_w = 4.2 \text{ kJ/kgK})$$

$= 31.560$ kJ/kg

lower calorific value.

$= H.C.V - (9H_2 \times 2466) = 31.560 - 9 \times 0.06 \times 2466$

$= 30228.3$ kJ/kg.

V

b) Solution, Given: Vacuum reading or actual vacuum

$= 700$ mm of Hg ; Barometer reading $= 760$ mm of Hg

; $t = 30°C$

We, know pressure in the condenser $= 760 - 700 = 60$ mm of Hg

from steam tables, corresponding to the temperature of $30°C$, we find that Ideal pressure of steam,

$= 0.0424 \text{ bar} = \frac{0.0424}{0.00133} = 31.88$ mm of Hg

We know that Ideal vacuum = Barometer reading − Ideal pressure

$= 760 - 31.88 = 728.12$ mm of Hg.

$\therefore$ Vacuum efficiency $= \eta = \frac{\text{Actual Vacuum}}{\text{Ideal Vacuum}} = \frac{700}{728.12} = 0.9614$ or 96.14%

VI

b) Solution: $t_i = 27°C$; $t_o = 35°C$

Condenser vacuum = 700 mm of Hg; Barometric pressure = 760 mm of Hg

We know that pressure in the condenser

$= 760 - 700 = 60$ mm of Hg

$= 60 \times 0.00133 = 0.0798$ bar.

From steam tables, corresponding to a pressure of 0.0798 bar, we find that vacuum temperature

$t_v = 41.5°C$

∴ Condenser efficiency

$$\eta_c = \frac{t_o - t_i}{t_v - t_i} = \frac{35-27}{41.5-27} = 0.552$$

or 55.2%