SCHEME OF VALUATION

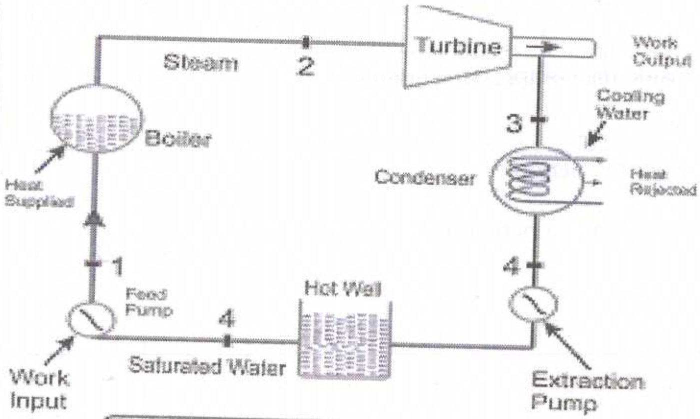
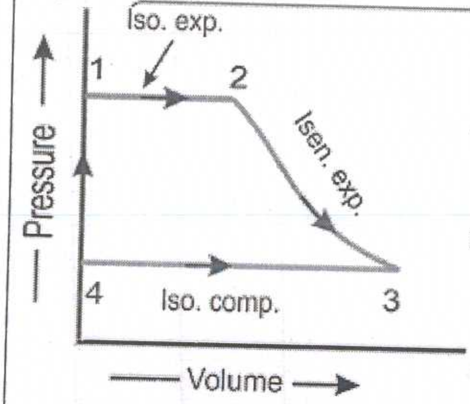
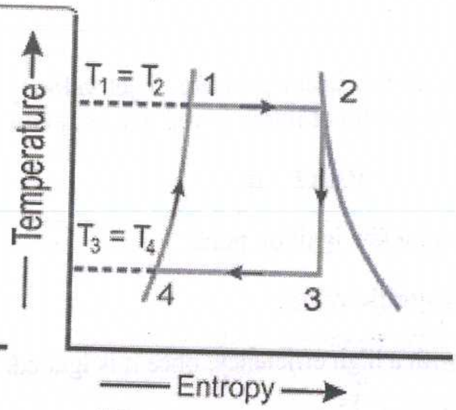
(Scoring Indicators)

Revision: 2015

Course Code:5023

Course Title:POWER PLANT ENGINEERING

Qst No	Scoring indicator	Split up score	Sub Total	Total
	PART - A			
I				
1	Cetane number of a fuel can be defined as the percentage volume of n-hexadecane in the mixture of n-hexadecane and α-methylnaphthalene. or Cetane number measures how quickly the fuel starts to burn inside the compression engine.	2		2
2	Condenser efficiency is defined as the ratio of temperature rise of cooling water to the vacuum temperature minus inlet cooling water temperature	2		2
3	Electric power generation, Marine propulsion, Locomotive propulsion, Supercharging in automobiles.	4x 0.5	2	2
4	Moderator which slows down neutrons, It absorbs neutrons.	2 x 1	2	2
5	Compounding is a process in which steam pressure or jet velocity is absorbed in stages as it flows over multiple system of rotors keyed to a common shaft.	2		2
II	**PART - B**			
1	a) A good fuel should have a low ignition point. b) It should have a high calorific value. c) It should freely burn with a high efficiency, once it is ignited. d) It should not produce harmful gases. e) It should produce least quantity of smoke and gases. f) It should be economical, easy to store and convenient for transportation.	6 x 1	6	
2	There are four processes in the Rankine cycle. • **Process 4–1**: The working fluid is pumped from low to high pressure. As the fluid is a liquid at this stage, the pump requires little input energy. In other words Process 4-1 is [Isentropic compression in pump] • **Process 1–2**: The high-pressure liquid enters a boiler, where it is heated at			

	constant pressure by an external heat source to become a dry saturated vapour. In other words Process 1-2 is [Constant pressure heat addition in boiler] • **Process 2–3**: The dry saturated vapour expands through a turbine, generating power. This decreases the temperature and pressure of the vapour, and some condensation may occur. The output in this process can be easily calculated using the chart or tables noted above. In other words Process 2-3 is [Isentropic expansion in turbine] • **Process 3–4**: The wet vapour then enters a condenser, where it is condensed at a constant pressure to become a saturated liquid.   p - v diagram  T - s diagram	Process - 2 P-V-1 T-S -1 Rankine fig -2	6	6
3	<u>Advantages</u> 1. It requires less space for installation. 2. The installation and running cost of gas turbines are less compare to others. 3. It has very high power to weight ratio. 4. It generates less vibration compare to reciprocating engine. 5. It starts easily and quickly. 6. It can work in changing load condition easily. 7. Its efficiency is higher than IC engines. 8. It can develop uniform torque, which is not possible in IC engines.	6x1 (Adv - 3 & Disadv - 3)	6	6

Limitations

1. Starting problem. It cannot start easily because compressor is driven by the turning itself. So an external unit is required to rotate the compressor to start the turbine.
2. Most of power is used to drive the compressor so it gives less output.
3. Overall efficiency of turbine is low because exhaust gases contain most of heat.

4

SL NO	Gas Turbines	Steam Turbines
1	The important components are compressor and combustion chamber.	The important components are steam boiler and accessories.
2	The mass of gas turbine per kW developed is less.	The mass of steam turbine per kW developed is more.
3	It requires less space for installation.	It requires more space for installation.
4	The installation and running cost is less.	The installation and running cost is more.
5	The starting of gas turbine is very easy and quick.	The starting of steam turbine is difficult and takes long time.
6	Its efficiency is less	Its efficiency is higher.

6 x 1 6 6

5

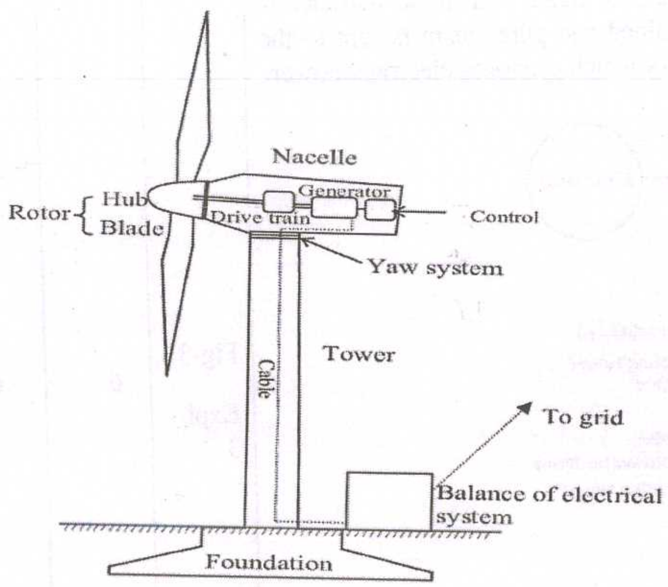


Fig-3 6

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.

Expl - 3

6

SL NO	Jet condensers	Surface condensers
1	Cooling water and steam are mixed up.	Cooling water and steam are not mixed up.
2	Less suitable for high capacity plants	More suitable for high capacity plants.
3	Condensate is wasted.	Condensate is reused.
4	It requires less quantity of circulating water.	It requires a large quantity of circulating water.
5	The condensing plant is economical and simple.	The condensing plant is costly and complicated.
6	Its maintenance cost is less.	Its maintenance cost is high.

6x1 6 6

7

The figure shows the principle of working of a geothermal power plant.

Working - Steam released through bore holes at a pressure of 30 bars and temperature of 200°C to 300°C. This hot stream of steam and liquid particles is passed to a steam separator where water is drained and pure steam is sent to the turbine. Turbine is coupled to electrical generator which produces electrical power.

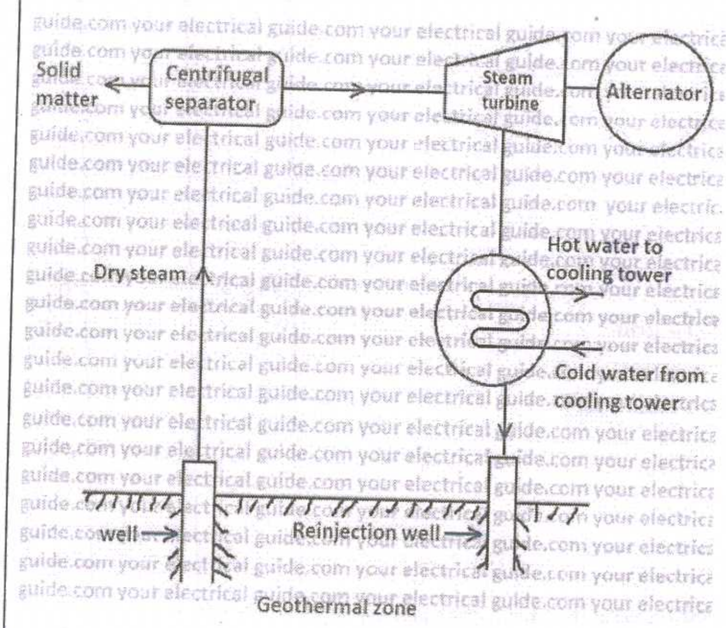


Fig-3

Expl-3

6 6

PART C

UNIT I

III a) **BOMB CALORIMETER**

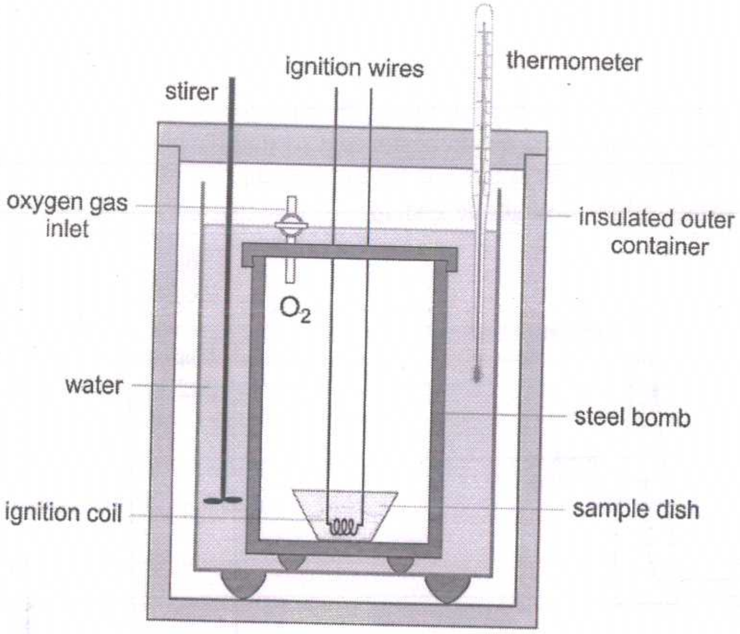


Fig-4 | 8 | 8

Exp-4

Bomb calorimeter is a type of constant-volume calorimeter used for measuring the higher calorific value of solid and liquid fuels which can be burned in oxygen. Four essential parts are required in any bomb calorimeter:

1. A bomb or vessel in which the combustible charges can be burned, and is capable of withstanding high pressure(up to 100 bar)
2. A bucket or container for holding the bomb in a measured quantity of water, together with a stirring mechanism,
3. An insulating jacket to protect the bucket from transient thermal stresses during the combustion process, and
4. A thermometer or other sensor for measuring temperature changes within the bucket.

There is an ignition wire of platinum or nichrome which dips into the crucible. It is connected to a battery kept outside and can be heated by passing current through it.

Bomb is completely immersed in a measured quantity ofwater.The heat liberated by the combustion of fuel is absorbed by this water, the bomb and copper vessel the rise in temperature is measured by a precise thermometer known as Beckmann thermometer which reads up to 0.01 °c

III b) Advantages

i) They are directly used in internal combustion engines

Ii) They are free from solid and liquid impurities.

Iii) They do not produce ash or smoke

7 x 1 (Any six) | 7

iv) They undergo complete combustion with minimum air supply

Disadvantages

i) They are readily inflammable

ii) They require large storage capacity.

iii) High risk of handling.

IV a) **Forced Draught**

In a forced draught system, a blower is installed near the base of the boiler and air is forced to pass through the furnace, flues, economizer, air-preheater and to the stack. This draught system is known as positive draught system or forced draught system because the pressure and air is forced to flow through the system.

Fig- 2x 2
Exp- 2x2 | 8 | 8

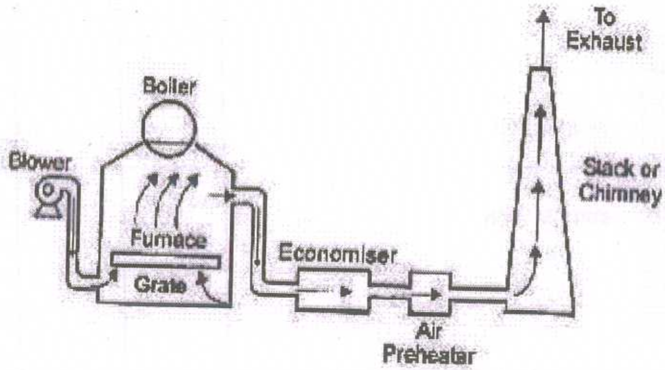
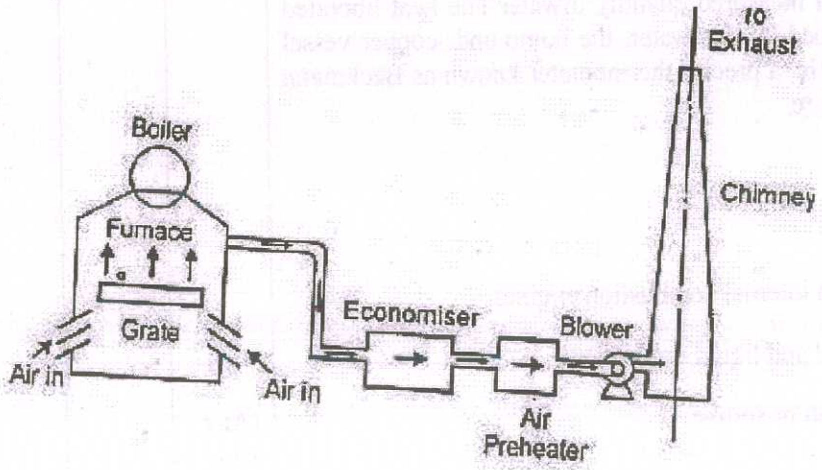


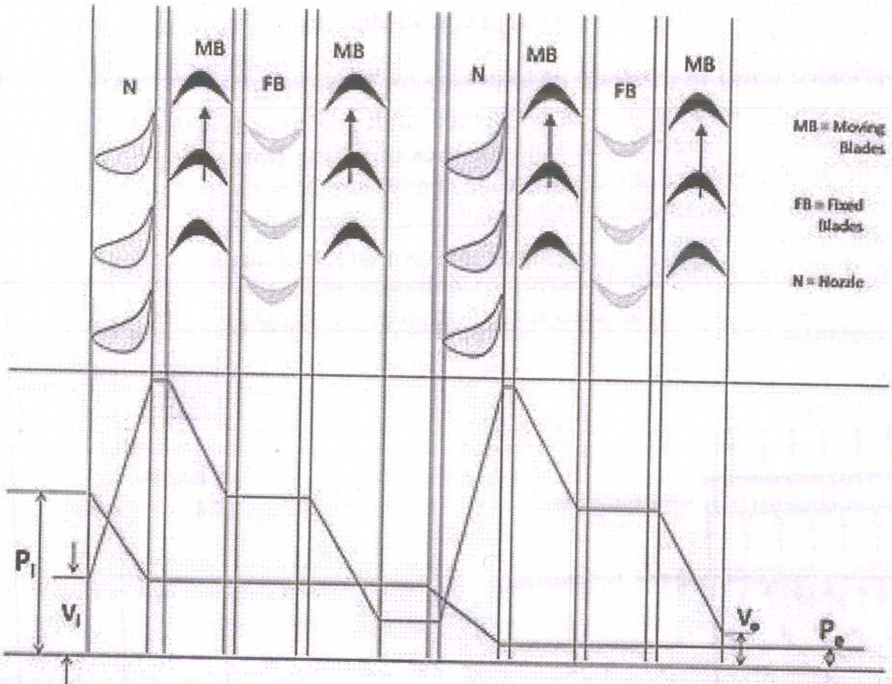
Figure: Forced draught

The arrangement of the system is shown in figure. A stack or chimney is also in this system as shown in figure but its function is to discharge gases high in the atmosphere to prevent the contamination. It is not much significant for producing draught therefore height of the chimney may not be very much.

Induced Draught:

In this system, the blower is located near the base of the chimney instead of near the grate. The air is sucked in the system by reducing the pressure through the system below atmosphere. The induced draught fan sucks the burned gases from the furnace and the pressure inside the furnace is reduced below atmosphere and induces the atmospheric air to flow through the furnace. The arrangement of the system is shown in figure.



IV b)	 This method of compounding is the combination of two previously discussed methods. The total drop in steam pressure is divided into stages and the velocity obtained in each stage is also compounded. The rings of nozzles are fixed at the beginning of each stage and pressure remains constant during each stage as shown in figure. The turbine employing this method of compounding may be said to combine many of the advantages of both pressure and velocity staging By allowing a bigger pressure drop in each stage, less number stages are necessary and hence a shorter turbine will be obtained for a given pressure drop.	Fig-4 Exp-3	7	7

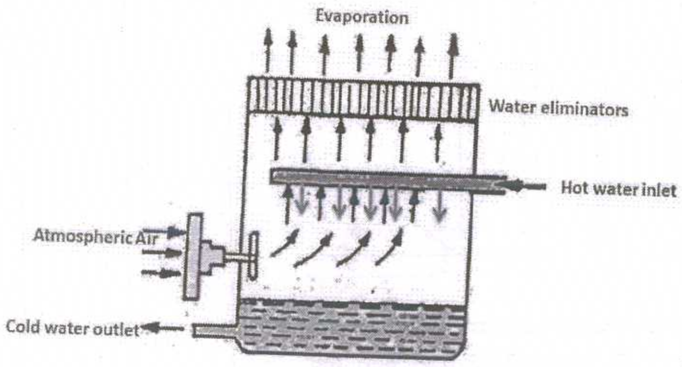
V a) UNIT II

The principle of operation of both Forced and Induced type of cooling towers is same. Warm water from the condenser unit is admitted into the tower at the top section as shown. It is sprinkled down in the form of broken spray. Atmospheric air is forced up the tower from the bottom in case of forced draft tower or is sucked from the top in case of induced draft tower. Fine particles of falling water come in close contact with the unsaturated air drawn from atmosphere into the tower. Air absorbs sensible heat. It also absorbs certain quantity of water vapour from falling water. Evaporation causes cooling of the non-evaporated bulk of water which drops to the bottom of the tower. The atmospheric air warm or humid leaves the tower from the top of it.The cooled water collected at the bottom of the tower is pumped into the inlet of condenser.

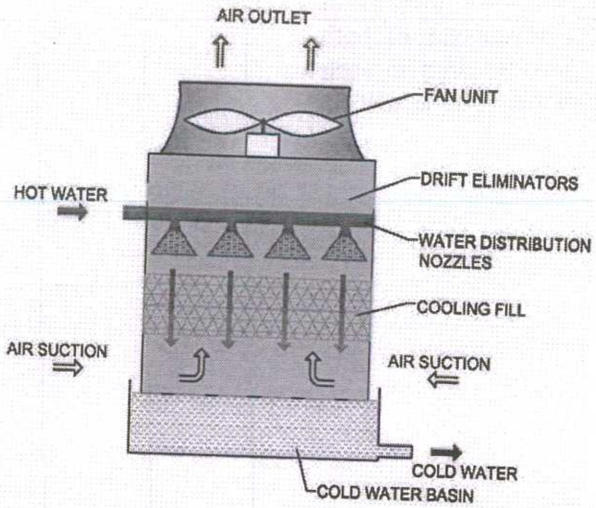
Fig- 2x2 — 4

Expl- 4 — 4

Total: 8



Forced



Induced

V b)

The following are the requirements of a good surface condenser:

1. The steam should enter the condenser with least possible resistance for its easy flow.

2. For effective condensation the steam should be well distributed in the vessel and there should be minimum pressure drop.

3. The circulating cooling water should flow through the tubes with least friction.

7x1 — 7 — 7

The rise in temperature of cooling water should be limited to 10°C for obtaining better thermal efficiency.

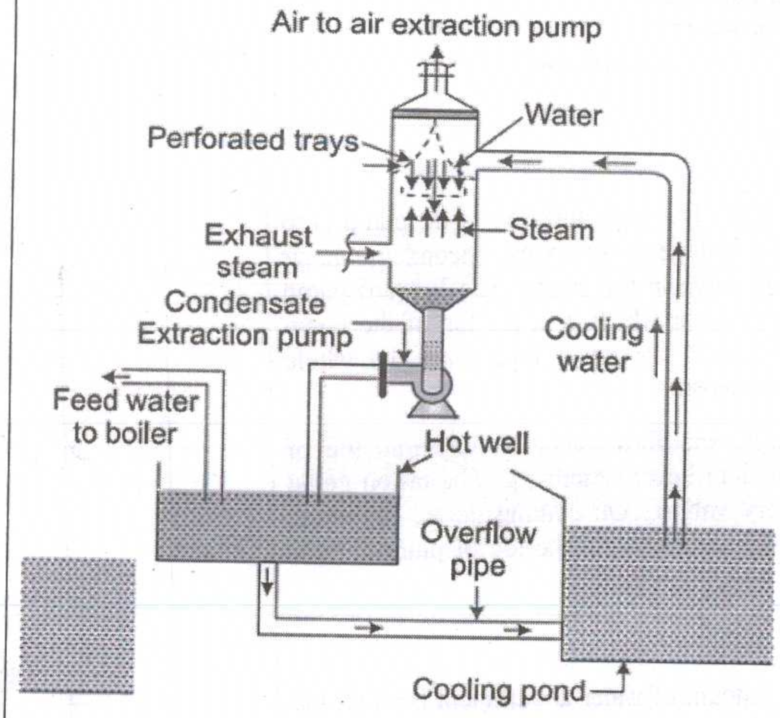
4. There should be no undercooling of the condensate, so the steam should lose only its latent heat to the circulating water.

5. To obtain maximum heat transfer rate the tubes should be made of high thermal conductivity material.

6. There should be no leakage of air from the condenser.

7. Minimum energy should be spent to extract the air from the condenser. This is achieved by fitting a baffle plate at the coolest section where air pump is fitted. This arrangement reduces the specific volume of air and thus reduces the size of the pump.

VI a)



Counter Flow Jet Condenser

Fig-4

8

In counter Flow, the steam enters at the bottom and the cooling water at the top. The steam flows upward and meets the cooling water coming downward.

In these types of steam Condensers, the air pump is located at the top. Air pump creates vacuum and this vacuum draws water from the cooling tower. The cooling water enter into the condenser and falls on the perforated conical plate. The perforated conical plates convert the cooling water into a large number of jets as shown in the figure. The falling jet of water caught in the trays and from there it escapes out in second series of jets and meets the exhaust steam entering at the bottom. As the steam mix with the water, it gets condense. The condensate and cooling water moves down through a vertical pipe to the condensate pump. And finally the pump delivers it to the hot well.

Exp-4

VI b)

Edward air pump

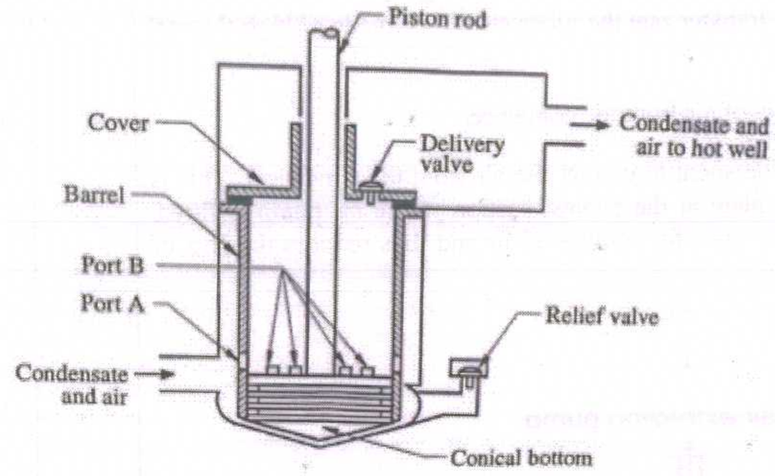


Fig-3

Exp-4

7

It is a wet air pump of reciprocating type .The main function of air pump is to maintain a vacuum in the condenser. This is done by removing incondensable air from the condenser .There is no suction valve in this pump. The Edward pump consists of a delivery valve placed at the cover which is at the top of the pump barrel. Pump barrel has a ring ports around the lower end along the whole circumference. This communicates the condenser.

Working: Air and condensate enter at A, and flow either directly into top of plunger B, (depending on its position) or into lower chamber E. The piston going up forces the water through the delivery valves . On coming down, the water in E is forced up through ports, as shown by arrows, to the top of plunger. This water is removed on the upstroke.

VII a)

Hydroelectric power station needs huge amount of water at sufficient head all the time. So a hydroelectric dam is constructed across the river or lake.an artificial storage reservoir where water is stored, is placed back side of the dam. This reservoir creates sufficient water head. A pressure tunnel is placed in between the reservoir to valve house and water is coming from reservoir to penstock via this tunnel. An automatic controlling sluice valve is placed in valve house and it controls water flow to the power station and the letter cuts off supply of water in case the penstock bursts. Penstock is a huge steel pipe in which water is taken from valve house to turbine. A surge tank is also provided just before the valve house for better regulation of water pressure in the system. Now water turbine converts hydraulic energy into mechanical energy and an alternator which is couple to the water turbine converts this mechanical energy into electrical energy.

Exp-4

8

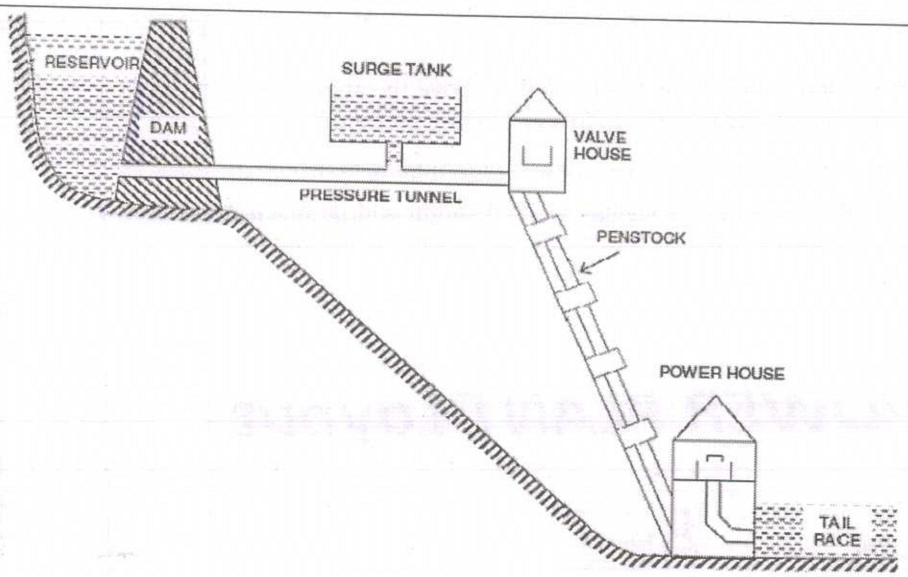


Fig-4

VII b)

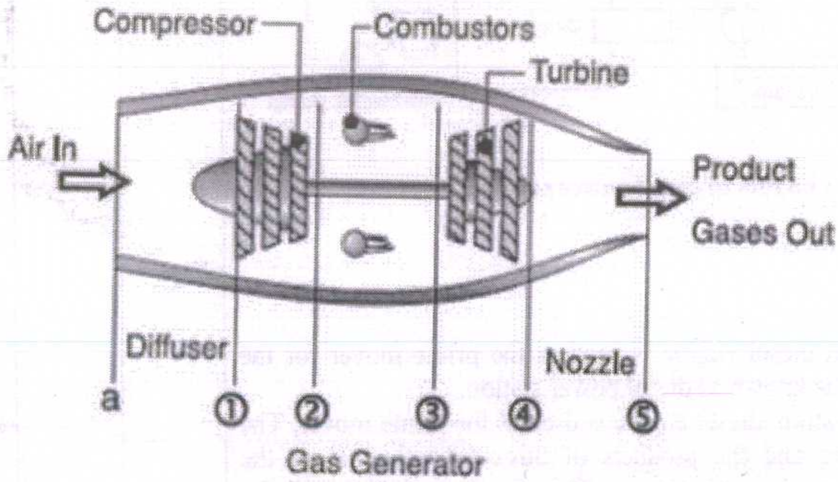


Fig-3

7

Exp-4

The schematic diagram of the turbojet engine is shown in fig above.

The turbojet engine basically comprises of components such as diffuser, compressor, combustor, gas turbine and a set of nozzles.

Atmospheric air at aircraft velocity enters the diffuser at point a. The diffuser converts the kinetic energy of the air into pressure energy and the compression taking place is called as ram compression.

Again the air is further compressed in the compressor. This pressurized air is then passed through the combustors where the fuel is burnt at constant pressure. During this process, the temperature of the gases increases.

The products of combustion then expand over the gas turbine up to a pressure such the turbine develops power which is capable of driving the compressor and the rest of the auxiliaries.

The pressure of the gases at the outlet of the gas turbine is above the atmospheric. Thus, these gases finally expand in the nozzles up to surrounding pressure.

Velocity of gases at the exit is much higher when compared to inlet velocity of air. Thus the thrust produced due to the rate of change of momentum and its reaction generates the necessary propulsive force to propel the jet engine in the forward direction.

VIII a)

DIESEL POWER PLANT Layout

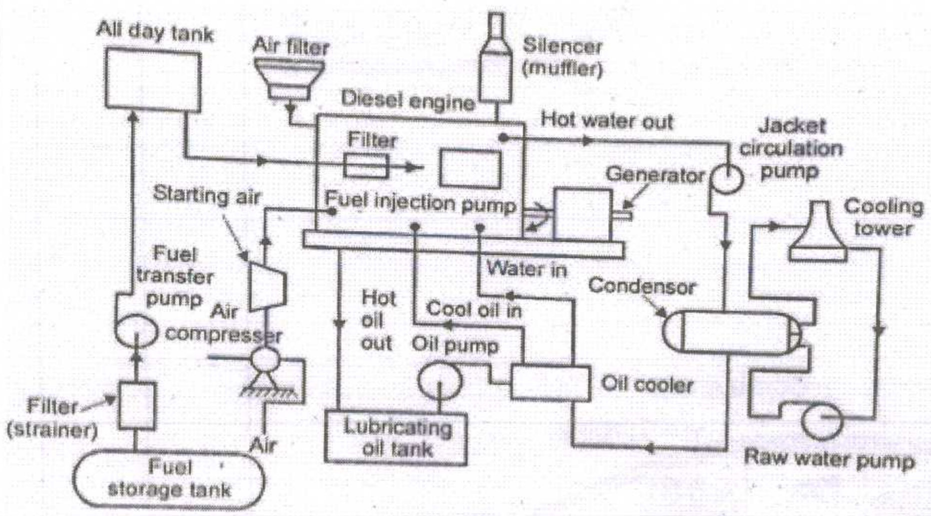


Fig-4

8

Figure : Layout of diesel power plant.

Exp-4

A generating station in which diesel engine is used as the prime mover for the generation of electrical energy is known as diesel power station.

In a diesel power station, diesel engine is used as the prime mover. The diesel burns inside the engine and the products of this combustion act as the "working fluid" to produce mechanical energy. The diesel engine drives the alternator which converts mechanical energy into electrical energy.

VIII b)

Working

The turbojet spins a shaft, which is connected to a gearbox. A gears box slows down the spinning, and the slowest moving gear connects to the propeller.The propeller rotates through the air, producing thrust

Exp-4

Pros:

- Very fuel efficient
- Most efficient at mid-range speed between 250-400 knots
- Most efficient at mid-range altitudes of 18,000-30,000 feet

7

Cons:

- Limited forward airspeed
- Gearing systems are heavy and can break down

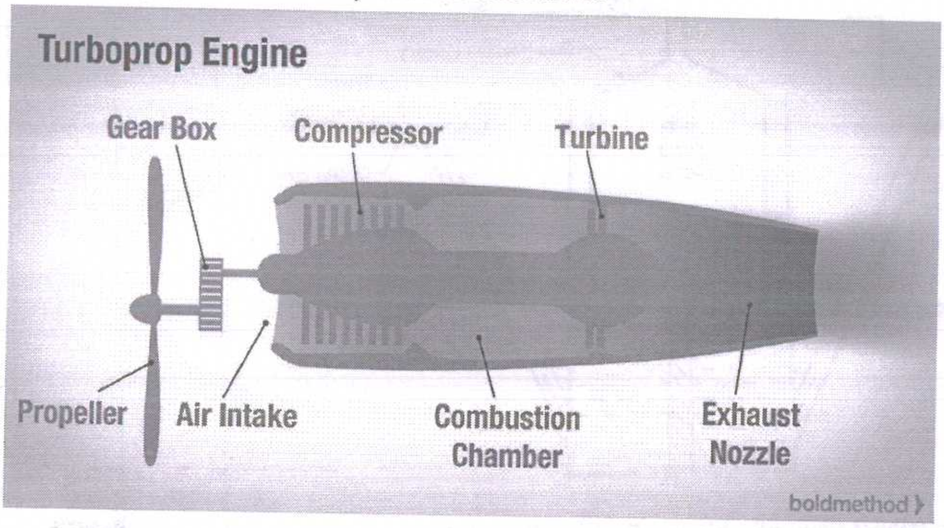


Fig-3

IX a)

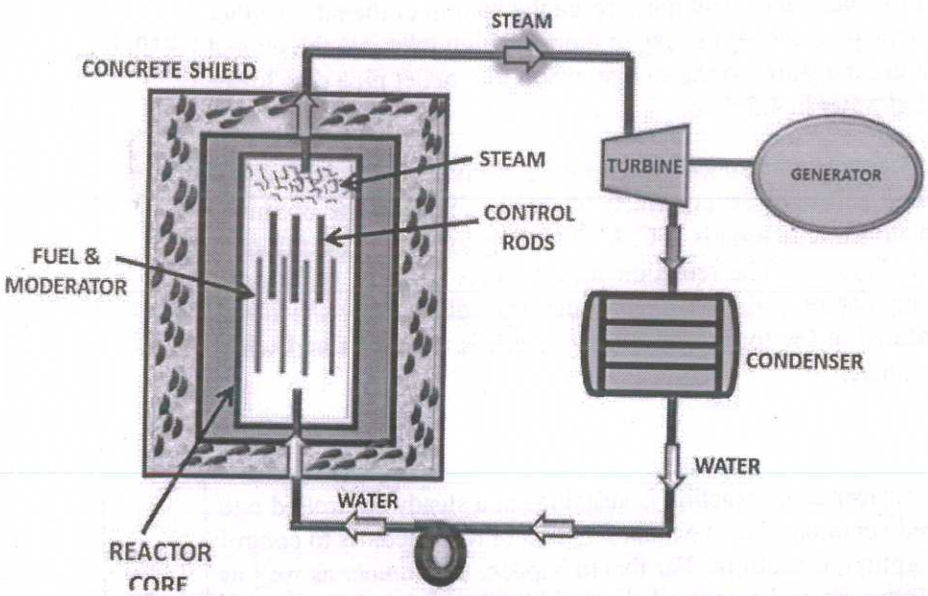


Fig-4

8

This design has many similarities to the PWR, except that there is only a single circuit in which the water is at lower pressure (about 75 times atmospheric pressure) so that it boils in the core at about 285°C. The reactor is designed to operate with 12-15% of the water in the top part of the core as steam, and hence with less moderating effect and thus efficiency there.

The steam passes through drier plates (steam separators) above the core and then directly to the turbines, which are thus part of the reactor circuit. Since the water around the core of a reactor is always contaminated with traces of radionuclide, it means that the turbine must be shielded and radiological protection provided during maintenance. Most of the radioactivity in the water is very short-lived, so the turbine hall can be entered soon after the reactor is shut down.

Exp-4

IX b)

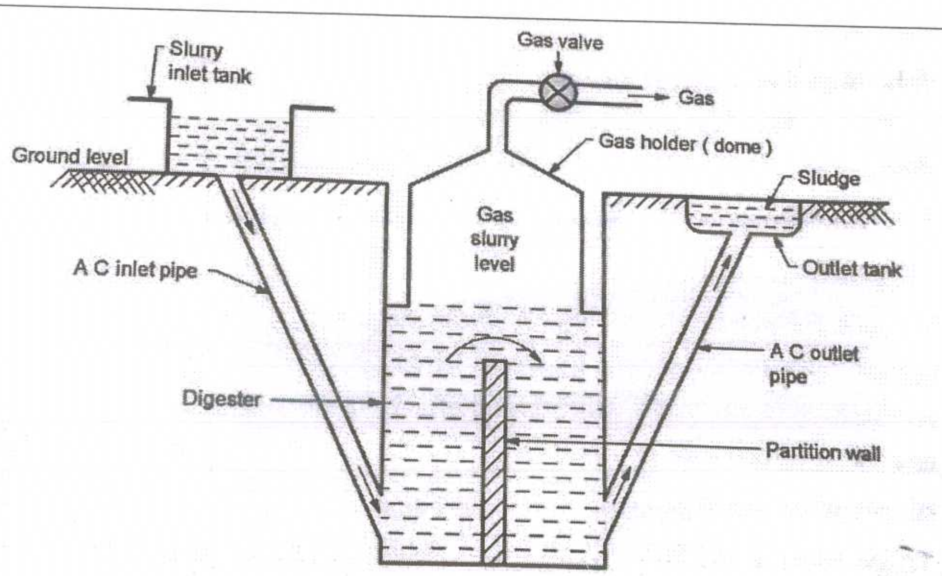


Fig-3

7

Fig shows the cross sectional view of a biogas digestor. It contains a pit excavated below the ground level. It is lined with bricks. The partition wall divides the space in pit into two compartments. The bottom of the pit is finished with cement concrete basement. Two slanting cement pipes reach the bottom of the pit on either side of the partition. One pipe conveys slurry of biomass from inlet into the pit and the other pipe discharges the slurry to the sludge outlet. The outlet pipe dips lower into the cattle dung and water in 4:5 ratio.

Exp-4

Depending on the variation of atmospheric temperature, decomposition of biomass slurry takes place. It is called digestion which liberates methane. The optimum temperature for methanogenic bacteria is 35C. Maintaining constant temperature is essential for effective digestion. The retention period varies from 30 to 50 days depending on the temperature variations. The biogas is collected by the dome shaped gas holder located at the top of digestor. The gas is tapped as and when required from the gas holder.

X a)

It is a plant in which nuclear chain reaction is sustained at a steady controlled rate so that heat is produced continuously. The main function of the reactor is to control the emission and absorption of neutrons. For this to happen, the number as well as the speed of the neutrons has to be controlled. This is affected by absorption of some neutrons by 'control rods' and retarding the neutron speed by moderators.

The basic components of a reactor for controlled release of nuclear energy are shown. The essential components of a nuclear reactor are
(l) Active core (2) Moderator (3) Control rods(4) Thermal shield

(5) Biological shield

8

The core consists of the fuel and moderator, and the control rods are arranged for easy movement in and out of the core.

Exp-4

NUCLEAR REACTOR PARTS

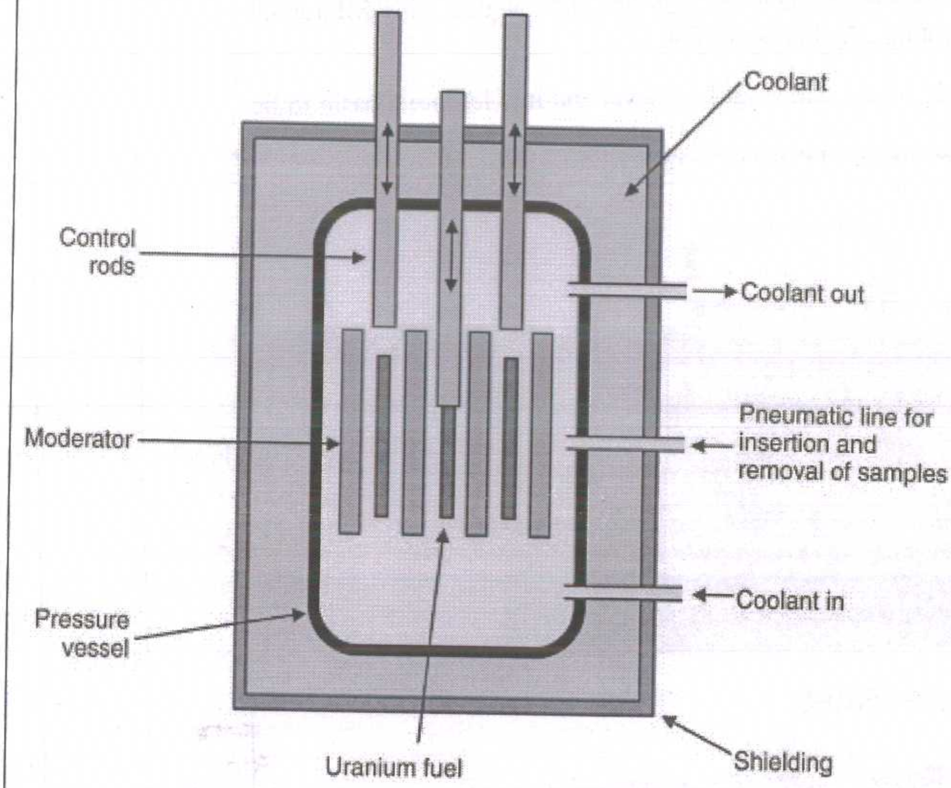


Fig-4

Active Core: It contains mainly the fissionable material(nuclear fuel). For better control of reaction' the fuel may bediluted with non-fissionable material.

Moderator : The function of moderator is to slow down the fast fission neutrons travelling at 4200 km/s to about 1.5 km/s before subsequent fission occurs.

Control Rods : These are meant to absorb as many of the neutrons impinging upon them as possible. Rods made of boron-steel alloy and cadmium are most commonly used as control rods.

Thermal Shielding : It surrounds the entire reactor core and absorbs some of the radiations in the form of α-ray and β-particles, It absorbs escaping neutrons produced by fission. It is usually made of iron' It gets heated but prevents the reactor wall from getting heated. Coolant flows through the shielding to take away the heat.

Coolant: Coolant may be circulated in tubes throughout the reactor to remove heat produced in the process of fission' The coolants generally used are air, water, carbon dioxide, helium, hydrogen fused salts,organic fluids, sodium, potassium, lead and bismuth alloys etc.

X b)

Figure shows the basic principle of working of a tidal power plant.

The main components of the plant are

a) A dam to form a pool or basin.

b) Sluice ways from basin to sea and vice versa

c) Power house

Exp-4

7

The dam serves as a barrier between sea and the basin. The sluice ways are used either to fill the basin during the high tide or empty the basin during the low tide.

These are gate controlled devices. The main features of the tidal cycle is the difference in water surface elevation at the high tide and low tide. This differential head is utilised in operating a hydraulic turbine.

At the time of high tide, water will be at high level and it is let into a basin to be stored at a high level there. Since the basin water level is high and sea water level is low, there is a differential head that can be utilised for running the turbine

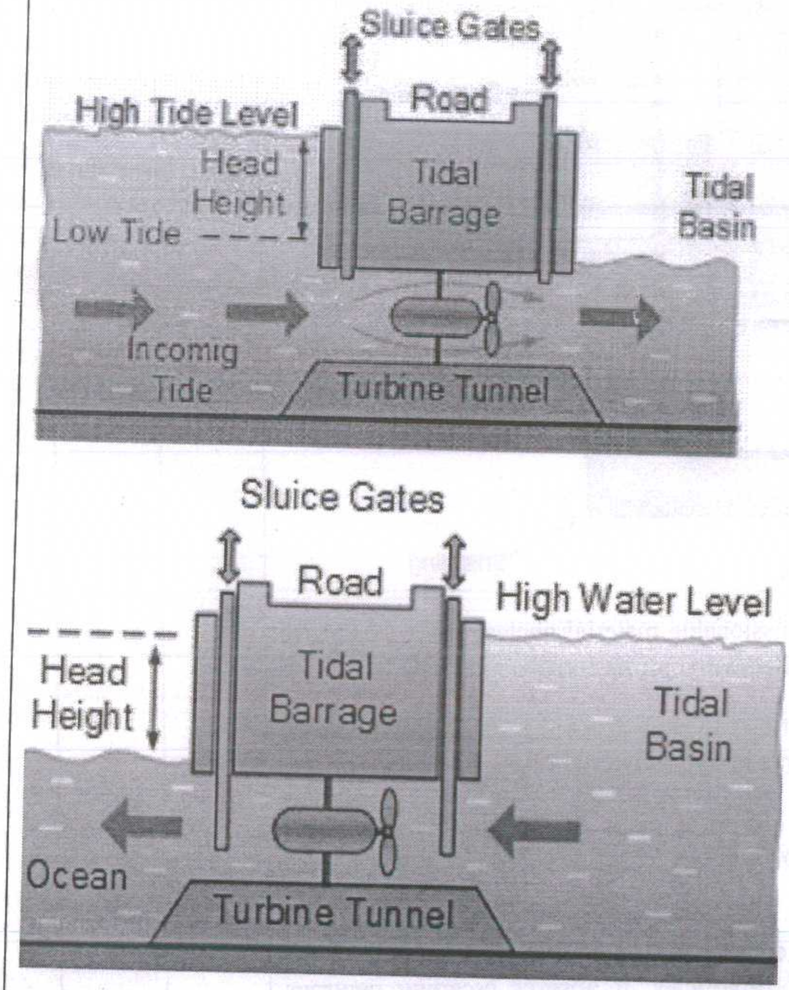


Fig-3