CBCS SCHEME

USN

15ME71

Seventh Semester B.E. Degree Examination, Dec.2019/Jan.2020
Energy Engineering

Time: 3 hrs. Max. Marks: 80

Note: *Answer any FIVE full questions, choosing ONE full question from each module.*

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Enumerate and explain the steps involved in handling of the coal. (08 Marks)
b. Explain the traveling grate stoker, with a neat sketch. (08 Marks)

OR

2 a. What are the different types of cooling ponds and cooling towers? (06 Marks)
b. Define Draught and explain forced draught, with a neat sketch. (06 Marks)
c. Explain the function of air – preheater and superheater in thermal power plant. (04 Marks)

Module-2

3 a. Draw the layout of a diesel power plant. (06 Marks)
b. Show the different methods of engine cooling. (04 Marks)
c. Explain different methods of starting the diesel engine. (06 Marks)

OR

4 a. Classify hydro – electric plants. (02 Marks)
b. Explain the necessity of using the components like surge tank, gates and valves in hydel power station. (06 Marks)
c. At a particular site the mean discharge (in millions of m^3) of a river in 12 months from January to December are 30, 25, 20, 0, 10, 50, 80, 100, 110, 65, 45 and 30 respectively. Draw the flow duration curve on graph sheet. Also estimate the power developed in MW if the available head is 90m and the overall efficiency of generation is 87.4%. Assume each month of 30 days. (08 Marks)

Module-3

5 a. What is Pyrheliometer? With a neat sketch, explain its working principle. (07 Marks)
b. Explain the following : i) Solar constant ii) Extra terrestrial radiation iii) Global radiation. (03 Marks)
c. With a neat sketch, explain the working of space heating and cooling by using solar collectors. (06 Marks)

OR

6 a. Explain with neat figure working of a solar photovoltaic cell. (08 Marks)
b. Explain the applications of solar photovoltaic cells. (08 Marks)

Module-4

7 a. What are the major problems associated with wind power? Explain horizontal axis wind mill with sketch. (08 Marks)

b. A horizontal shaft, propeller type wind turbine is located in area having the following wind characteristics :
Speed of wind 10m/s at 1 atm and 15^0C. Calculate the following :
i) Total power density in wind stream, W/m^2.
ii) Maximum possible obtainable power density in W/m^2.
iii) Actual obtainable power density in W/m^2 assuming 40% efficiency.
iv) Total power from the wind turbine of 120m diameter. **(08 Marks)**

OR

8 a. Describe the principle of power generation methods using tidal energy source. **(08 Marks)**
b. What are the advantages and limitations of Tidal power generation? **(08 Marks)**

Module-5

9 a. Explain Photosynthesis with example. **(08 Marks)**
b. Explain briefly method of biomass gasification. **(08 Marks)**

OR

10 a. Mention the different types of fuel cells. **(02 Marks)**
b. Explain a simple MHD generator and its working with figure. **(08 Marks)**
c. With a sketch, explain the working of "Hot dry rock" geothermal plant. **(06 Marks)**

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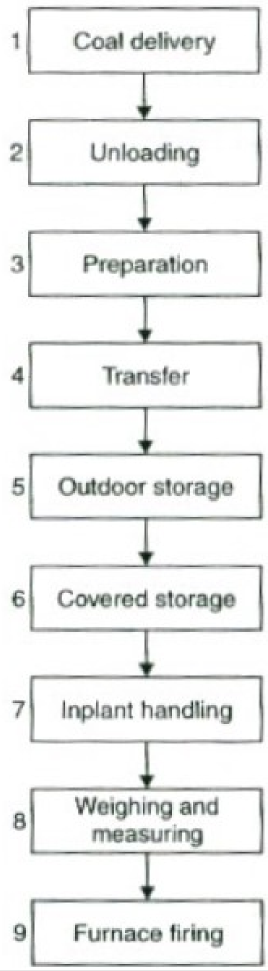
Q1a) Enumerate and explain the steps involved in handling coal.

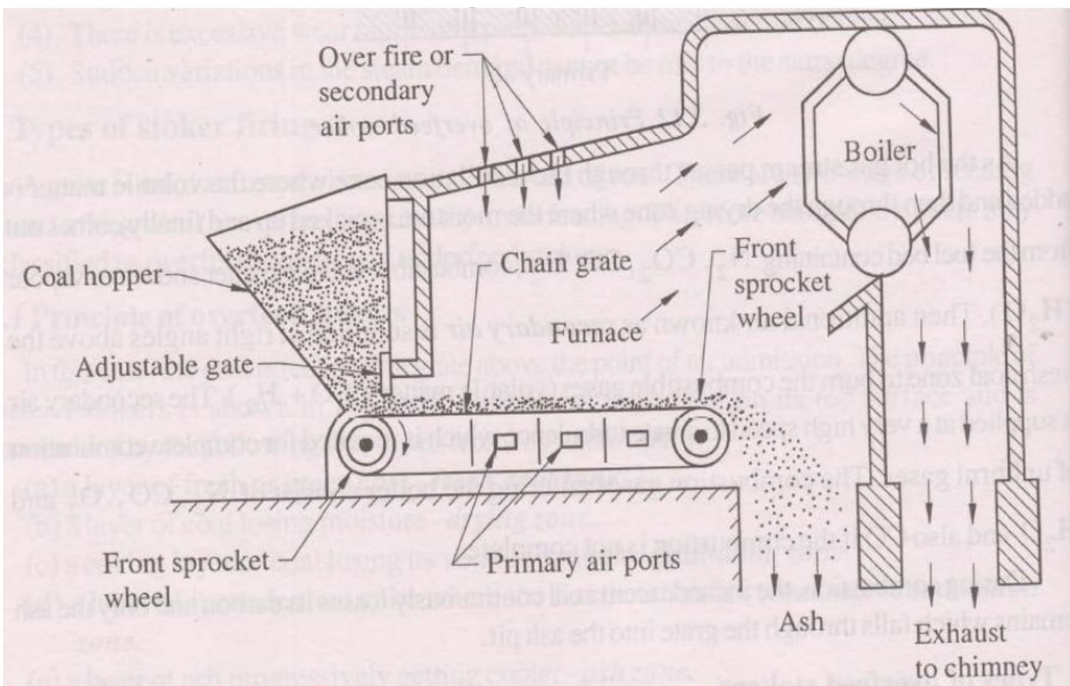


Coal delivery equipment is one of the major components of plant cost. The various steps involved in coal handling are as following:

- Coal delivery: The method of transporting coal to a power station depends on the location of the plant, but may be one or more of the following: rail, road , river or sea. Plants situated near river or sea may make use of the navigation facilities. Stations which cannot make use of these facilities may be supplied coal either by trucks or by rail.
- Unloading: If the coal is delivered in dump trucks and if the plant site is favourable we may not need additional unloading equipment. When coal transported by using by sea or rivers unloading bridge or tower and portable conveyors are used.
- Preparation: When the coal delivered is in the form of big lumps and it is not of pro per size, the preparation (sizing) of coal can be achieved by crushers, breakers and magnetic separator.
- Transfer: Transfer means the handling of the coal between the unloading point and the final storage point from where it is discharged to the firing equipment. The equipments used for the transfer of coal may be any one of the following (a) Belt conveyors (b) Screw conveyors (c) Bucket Elevators (d) Grab bucket Elevators (e) Skip hoists and (f) Flight conveyors.

- Outdoor storage: The coal received at the power station is stored in dead storage in the form of piles laid directly on the ground. In case the coal is to be stored for longer periods the outer surface of piles may be sealed with asphalt or fine coal.
- Covered storage: This is usually a covered storage provided in plants, sufficient to meet day's requirement of the boiler. Storage is usually done in bunkers made of steel or reinforced concrete having enough capacity to store the requisite of coal.
- In plant handling: In plant handling may include the equipment such as belt conveyors, screw conveyors, bucket elevators etc. to transfer the coal from covered storage to the boiler grates.
- Weighing and measuring: Weigh lorries, hoppers and automatic scales are used to weigh the quantity coal. The commonly used methods to weigh the coal are as (i) Mechanical (ii) Pneumatic and (iii) Electronic. The required quantity of coal is then transferred to the furnace for firing.

Q1b) Explain the travelling grate stoker with a neat sketch.



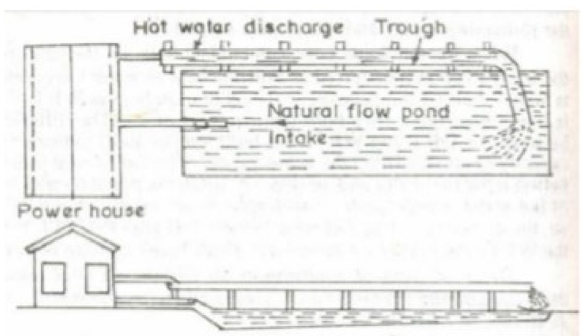
The travelling grate stoker is as shown in the figure. This type of stoker has the grate which is moving from one end of the furnace to the other end. This grate may be chain grate type or bar grate type chain grate stoker is made up of series of Cast Iron chain links connected by pins to form an endless chain. The bar grate stoker is made up of a series of Cast Iron sections mounted on a carrier bars. The carrier bars are mounted and ride on two endless drive chains. The travelling grate stoker consists of an endless chain which forms a support for the fuel bed. The chain travels over the two sprocket wheels which are at the front and rear end of the furnace. The front end sprocket wheel is connected to variable speed drive mechanism. The grate can be raised or lowered as needed. Simultaneous adjustment of grate speed, fuel bed thickness, and air flow control, the burning rate so that nothing but ash remains on the grate by the time it reaches furnace rear. The ash falls on to the ash pit, as the grate turns to make the return trip. A coal gate at the rear of the coal hopper regulates coal. As the raw coal or green coal on the grate enters the furnace, surface coal gets ignited from heat of furnace flame and radiant heat rays reflected by ignition arch. The fuel bed becomes thinner towards the rear of furnace as combustible matter burns off. The secondary air supplied helps in mixing the gases and supplies oxygen to complete combustion. The coal should have minimum ash content which will form an layer on the grate. It helps in protecting grate from overheating.

Q2a) What are the different types of cooling ponds and cooling towers?

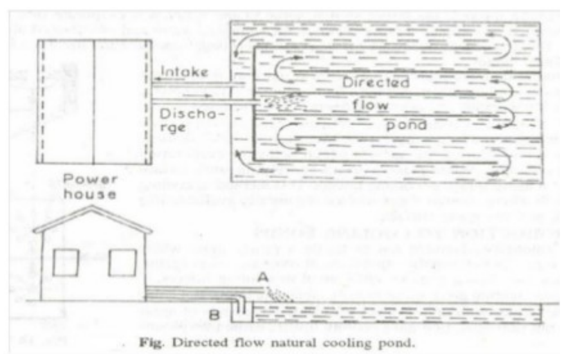
Cooling Ponds: It is sometimes advisable not to locate a power plant where condensing water facilities in the usual form of river are not available. In such cases, the choice goes to spray pond or cooling towers. The spray cooling pond is one of the simplest methods of cooling the condenser water although it is not efficient.

Types of Cooling Ponds

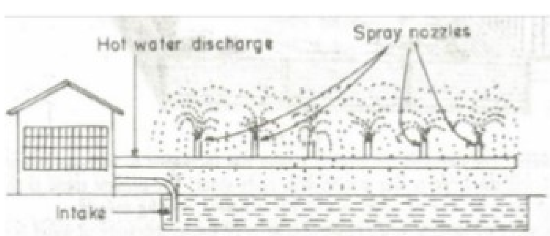
- Natural System
- Directed Flow System
- Single Deck System
- Double Deck System



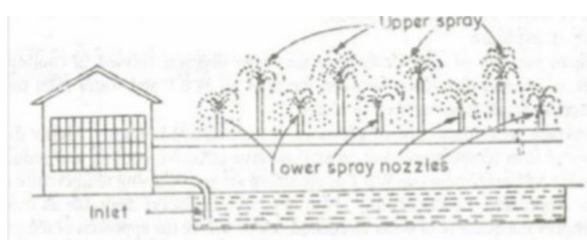
Natural System



Directed Flow System



Single Deck System



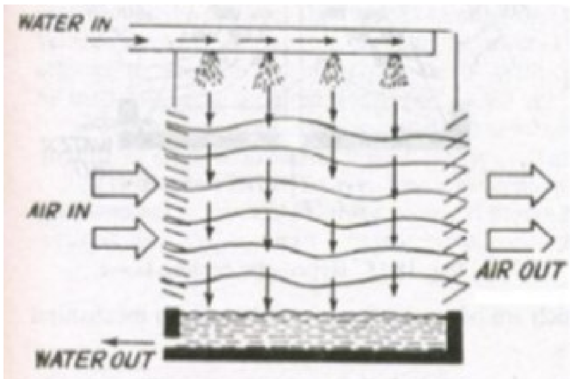
Double Deck System

Cooling tower: The cooling towers are desired when positive control on the temperature of water is required, the space occupied by the cooling system is considerable factor and the plant is situated near load centre and far away from the adequate natural resources of cooling water.

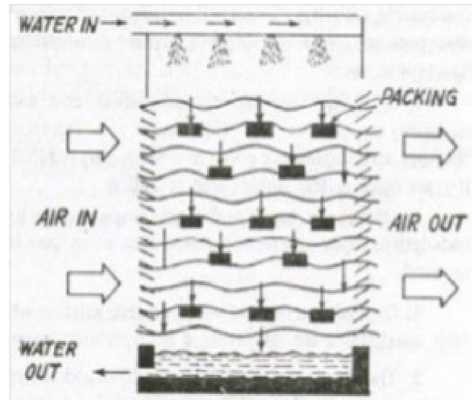
Types of cooling tower:

- Natural draft or Atmospheric cooling towers

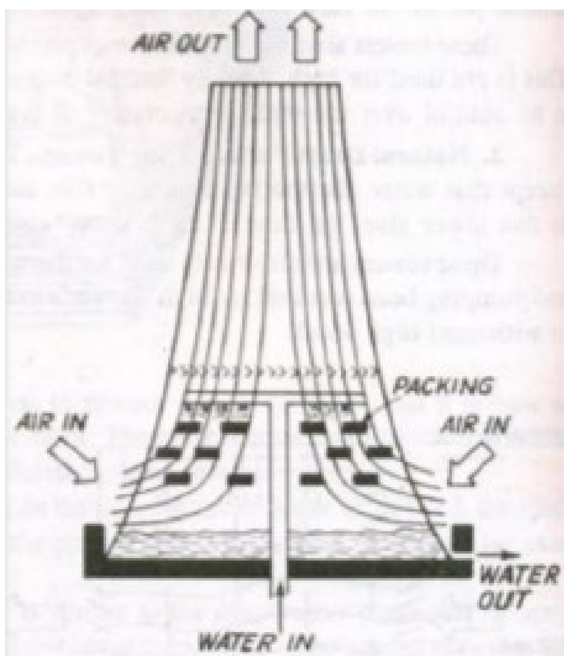
  - Natural Draft Spray Filled Tower
  - Natural Draft Packed Type Tower
  - Hyperbolic Cooling Tower
- Mechanical draft towers
  - Forced draft
  - Induced draft.



Natural Draft Spray Filled Tower



Natural Draft Packed Type Tower

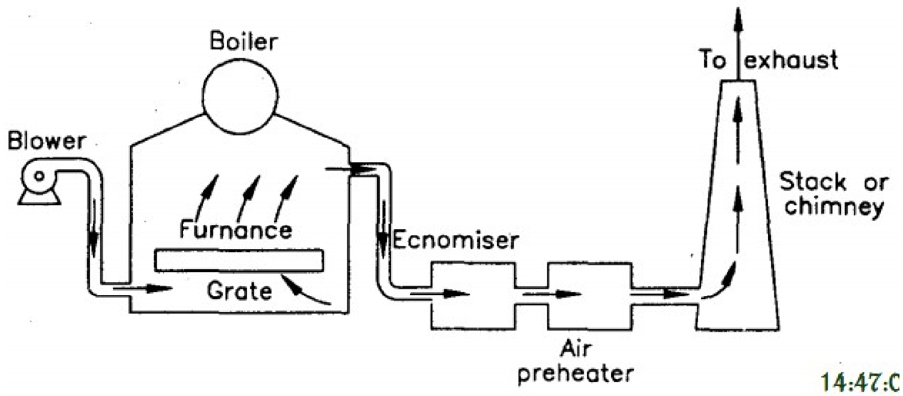


Hyperbolic Cooling Tower

Q2b) Define draught and explain forced draught with a neat sketch.

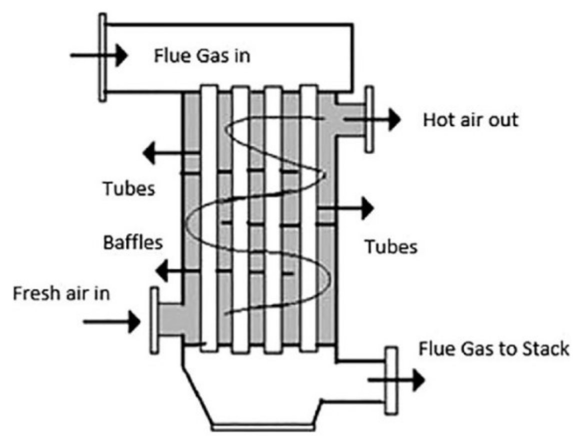
The small pressure difference which causes a flow of gas take place is termed as draught. The function of the draught, in case of a boiler is to force air to the fire and to carry away the gaseous products of combustion. In a boiler furnace, proper combustion takes place only when sufficient quantity of air is supplied to the burning fuel.

In a forced draught system, a blower is installed near the base of the boiler. This draught system is known as positive draught system or forced draught system because the pressure of air throughout the system is above atmospheric pressure and air is forced to flow through the system. The arrangement of the system is shown in figure. A stack or chimney is also used in this system as shown in figure but it is not much significant for producing draught.



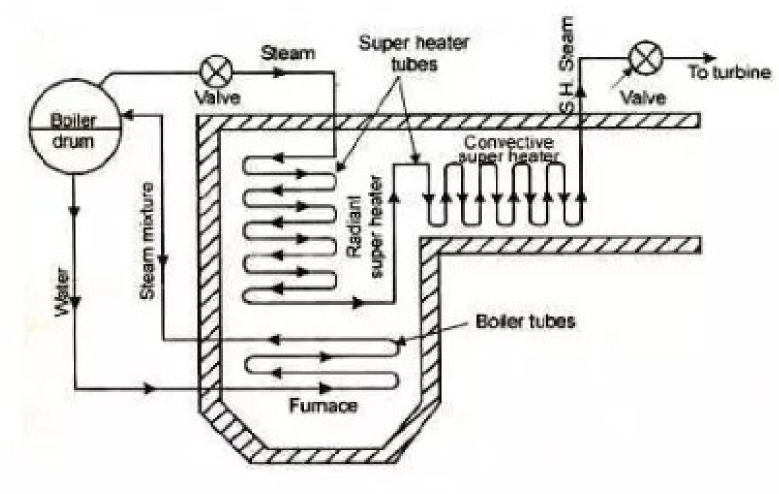
The main advantages of mechanical draught over natural draught are:
1. The artificial mechanical draught is better in control and more economical than natural draught.
2. The rate of combustion is high as the available draught is more. The better distribution and mixing of air with fuel is possible therefore the quantity of air required per kg of fuel is less.
3. The air flow can be regulated according to the requirement by changing the draught pressure.

Q2c) Explain the function of air-preheater and superheater in thermal power plant.

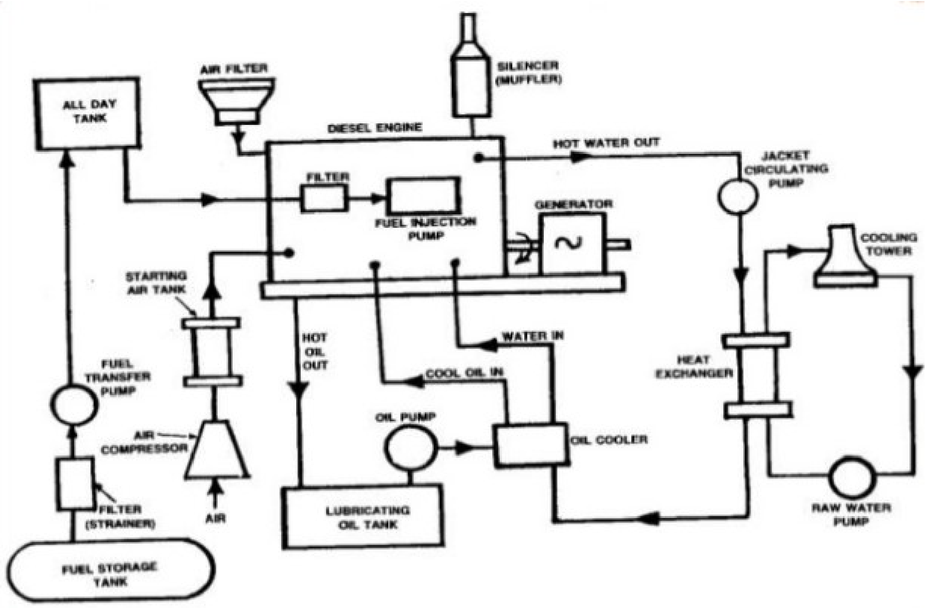


Air-preheater: It consists of plates or tubes with hot gases on one side and air on the other. It preheats the air to be supplied to the furnace. Preheated air accelerates the combustion and facilitates the burning of coal. Degree of preheating depends on the type of fuel, type of fuel burning equipment and the rating at which the boiler and furnace operated. The principal benefits of preheating the air are increased thermal efficiency and increased steam capacity per square metre of boiler surface.

Superheater: The steam produced in the boiler is nearly saturated. This steam as such should not be used in the turbine because the dryness fraction of the steam leaving boiler will be low. This results in the presence of moisture which causes corrosion of turbine blades etc. To raise the temperature of steam super-heater is used. It consists of several tube circuits in parallel with one or more return bends connected between headers. Super-heater tubes range from 1 to 2 inch of diameter. Super-heater supplies steam at constant temperature at different loads. The use of super-heated steam increases turbine efficiency.



Q3a) Draw the layout of a diesel power plant.

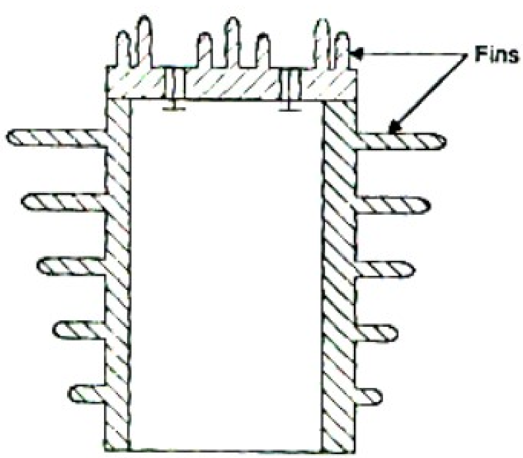


The essential components of diesel engine power plants are shown in the figure. It consists of the following components.

1) Engine: This is the main component of the plant which develops required power by burning fuel and is directly coupled to the generator.

2) Air filters and super chargers: Air filters remove dust from the air which is taken by the engine. Super charger is used to increase the pressure of air supplied to the engine to increase the engine power output.
3) Exhaust system: This includes the silencers, connecting ducts. The high temperature of exhaust gas is utilized for heating oil or air supplied to the engine.
4) Fuel system: It includes the storage tank, fuel pump, fuel transfer pump, strainer and heaters. The fuel is supplied to the engine according to the engine load on the plant.
5) Cooling system: It includes water circulating pumps, cooling towers, or spray ponds, water filters on plants. This system helps in maintaining the temperature of engine within the allowable limits.
6) Lubrication system: It includes the oil pumps, oil tank filters, coolers and connecting pipes. It helps in reducing the wear and tear of the moving parts.
7) Starting system: This includes compressed air tank. The function of this system is to start the engine from cold condition by supplying compressed air.
8) Governing system: The function of the governing system is to maintain the speed of the engine constant irrespective of load. This can be done by varying the fuel supply to the engine according to the load.

Q3b) Show the different methods of engine cooling.
Based on cooling medium used cooling systems are classified in to 1) Air cooling system and 2) Liquid or indirect cooling system.
Air cooling:

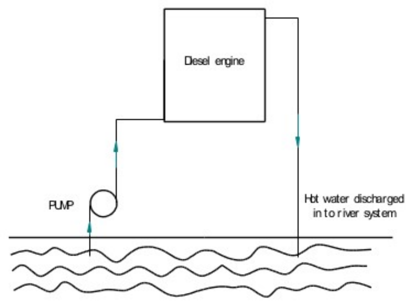


It can be used in very small engines and portable engines by providing fins on the cylinder. The fins are arranged in such a way that they are at right angles to the cylinder axis and air flow should be such that the fin surfaces are exposed to maximum air flow.

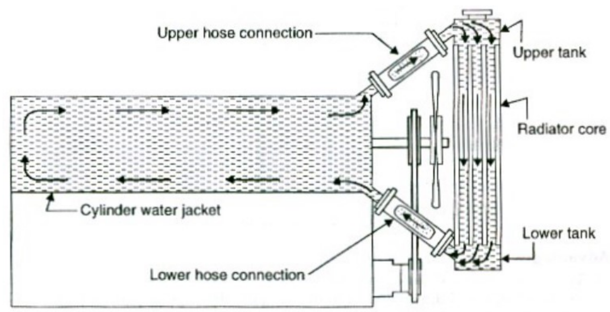
Liquid cooling system:
Water jackets are provided in the cylinder wall and cylinder head through which cooling liquid can be circulated. Heat is transferred from the cylinder barrels and cylinder head to the liquid by conduction and convection. The cooling fluid is cooled by transferring heat to the air in a radiator or in cooling towers.

Diesel engines are always water cooled. Big diesel engines are always liquid cooled. Liquid cooling system is further classified as

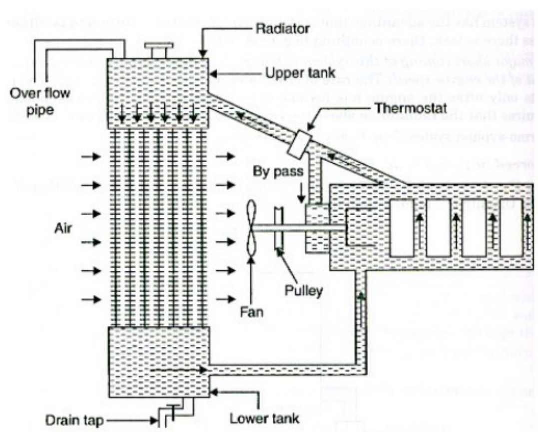
1) Open cooling system.
2) Natural circulating system.
3) Forced circulation system.
4) Evaporation cooling system.



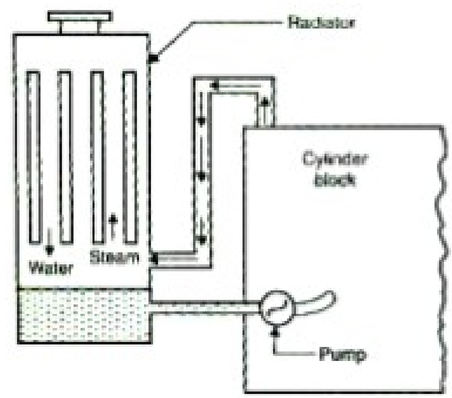
Open cooling system



Natural circulation system



Forced circulation system.

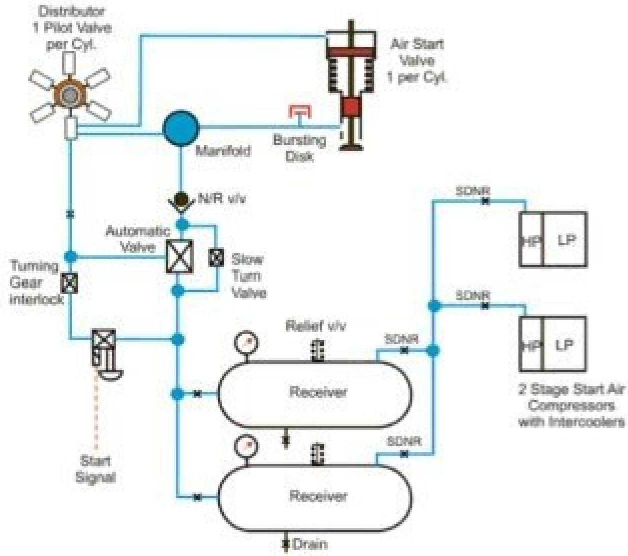


Evaporation cooling system.

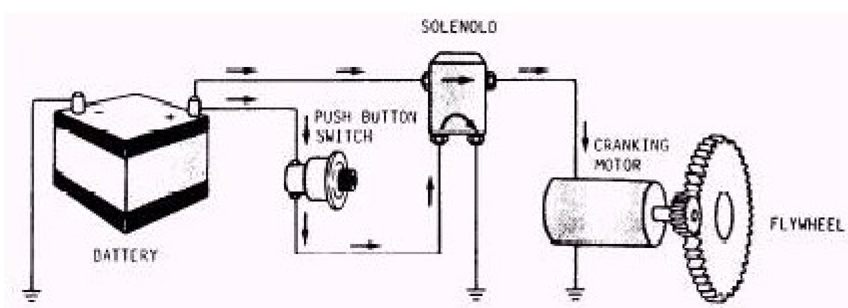
Q3c) Describe different methods of starting the diesel engine.

The various methods used for the starting of diesel engine are as follows:

1. Compressed Air System: Compressed air system is used to start large diesel engines. In this system compressed air at a pressure of about 20 kg per sq. cm is supplied from all bottles to the engine an inlet valve through the distributor or through inlet manifold. In a multi-cylinder engine compressed air enters one cylinder and forces down the piston to turn the engine shaft. Meanwhile the suction stroke of some other cylinder takes place and the compressed air again pushes the piston of this cylinder and causes the engine crank shaft assembly to rotate. Gradually the engine gains momentum and by supplying fuel the engine will start running.



2. Electric Starting. Electric starting arrangement consists of an electric motor which drives pillion which engages a toothed rim on engine flywheel. Electric power supply for the motor is made available by a small electric generator driven from the engine. In case of small plants a storage battery of 12 to 36 volts is used to supply power to the electric motor. The electric motor disengages automatically after the engine has started. The advantages of electric starting are its simplicity and effectiveness.



3. Starting by an Auxiliary Engine. In this method a small petrol engine is connected to the main engine through clutch and gear arrangements. Firstly, the clutch is disengaged and petrol engine is started by hand. Then clutch is gradually engaged and the main engine is cranked for starting. Automatic disengagement of clutch takes place after the main engine has started.

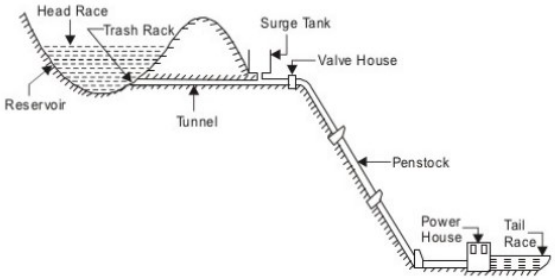
Q4a) Classify hydro-electric plants.

The hydro-power plants can be classified as below:

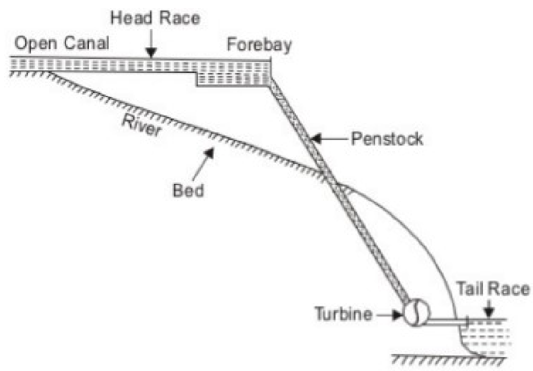
Storage plant: These plants are usually base load plants. The hydro-plants cannot be classified directly on the basis of head alone as there is no clear line of demarcation between a high head and a medium head or between medium head and low head. The power plant can be classified on the basis of head roughly in the following manner:

- High head plants: About 100 m and above.
- Medium head plants: about 30 to 500 m.

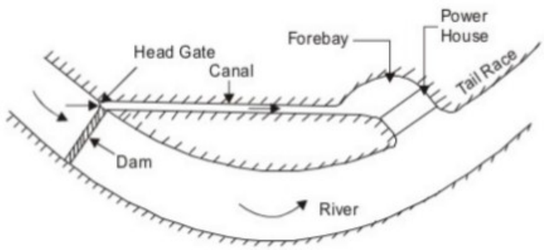
 Low head plants: Upto 50 m



High Head Plant



Medium Head Plant

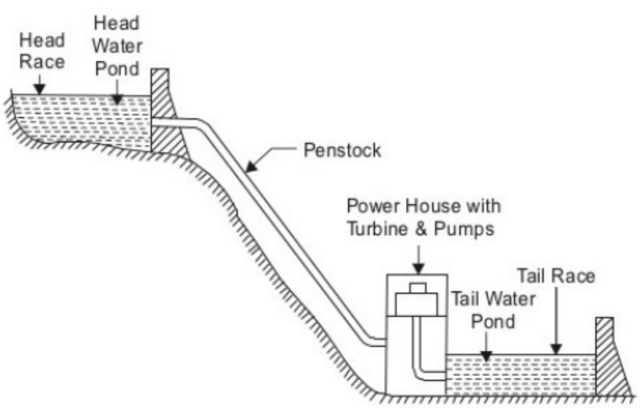


Low Head Plant

Run-of-river power plants

- With pondage
- Without pondage.

Pumped storage power Plants: These plants supply the peak load for the base load power plants and pump all or a portion of their own water supply. The usual construction would be a tail water pond and a head water pond connected through a penstock. The generating pumping plant is at the lower end. During off peak hours, some of the surplus electric energy being generated by the base load plant, is utilized to pump the water from tail water pond into the head water pond and this energy will be stored there. During times of peak load, this energy will be released by allowing the water to flow from the head water pond through the water turbine of the pumped storage plant.



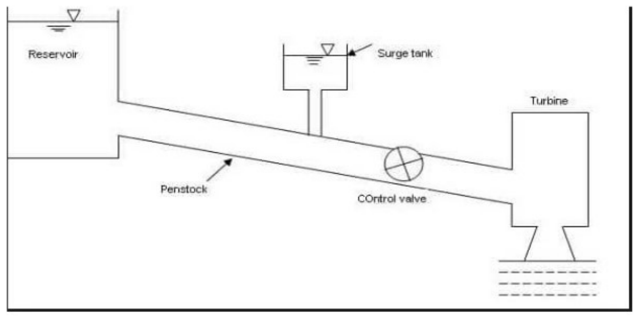
Pumped Storage Power Plants

Q4b) Explain the necessity of using the components like surge tank, gates and valves in hydel power plant.

Surge tank is an open tank which is often used with pressure conduit of considerable length. The main purpose of providing surge tank is to reduce the distance between the free water surface and turbine there by reducing the water hammer effect on penstock and also protect upstream tunnel from high pressure raises. It also serves as a storage tank when the water is accelerating during increased load conditions and as a storage tank when the water is decelerating during reduced load conditions.

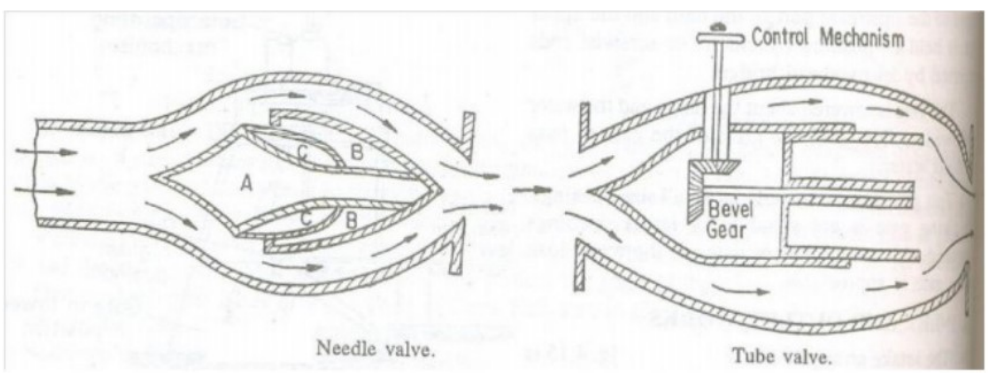
Function of Surge Tank:

- Reduce the water hammer effective
- Acts as a temporary reservoi
- Acts as a relief valve

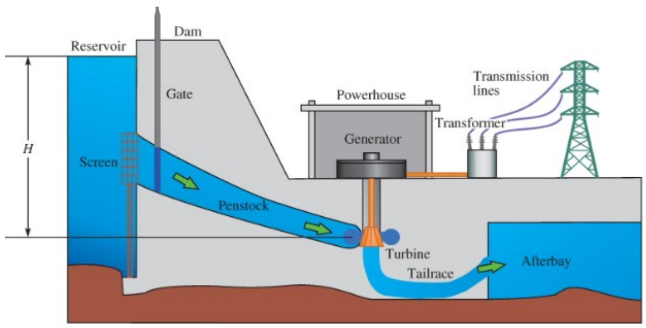


The control valves are used in hydel plants to regulate the flow of water at the intake and the discharge end. Two types of valves are:

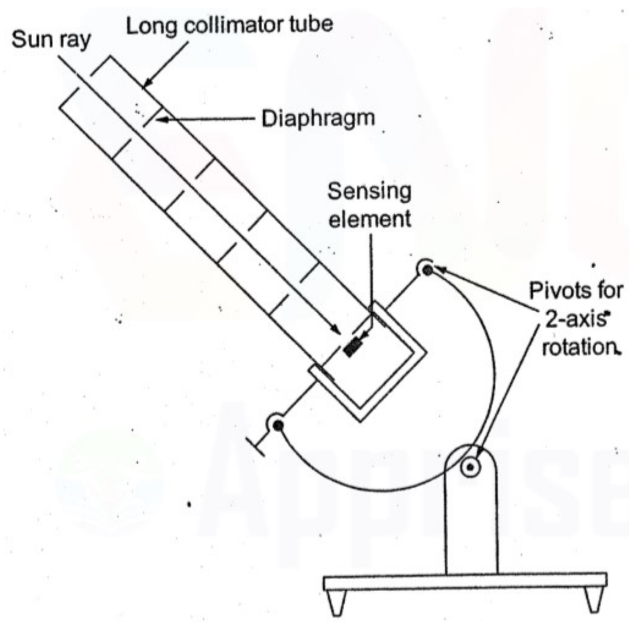
- Needle valve
- Tube valve



At intake gates are provided with hoist to control the entry of water. In front of the gates trash racks are provided to prevent debris, trees, etc., from entering into the penstock. Rakes are also provided to clean the trash racks at intervals.



Q5a) What is Pyrheliometer? With a neat sketch, explain its working principle.



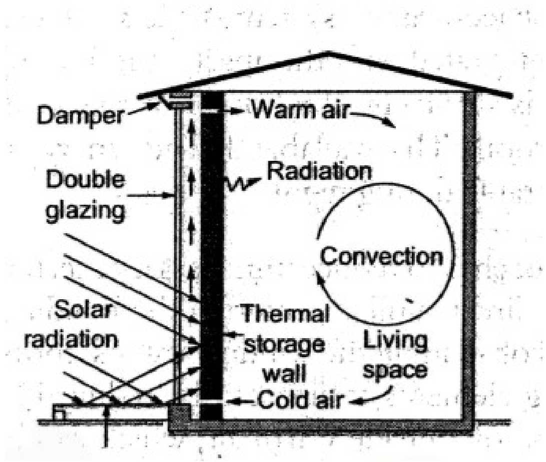
Pyrheliometer uses a long collimator tube to collect beam radiation whose field of view is limited to a solid angle of 5.5° (generally) by appropriate diaphragms inside the tube. The inside of the tube is blackened to absorb any radiation incident at angles outside the collection solid angle. At the base of the tube a wire wound thermopile is provided. The tube is sealed with dry air to eliminate absorption of beam radiation within the tube by water vapour. A tracker is needed if continuous readings are desired.

Q5b) Explain the terms:
Solar constant: The solar constant is defined as the energy received from the sun per unit time, on a unit area of surface perpendicular to the direction of propagation of radiation at the top of the atmosphere and at the earth's mean distance from the sun. The value of solar constant is 1367W/sq. m

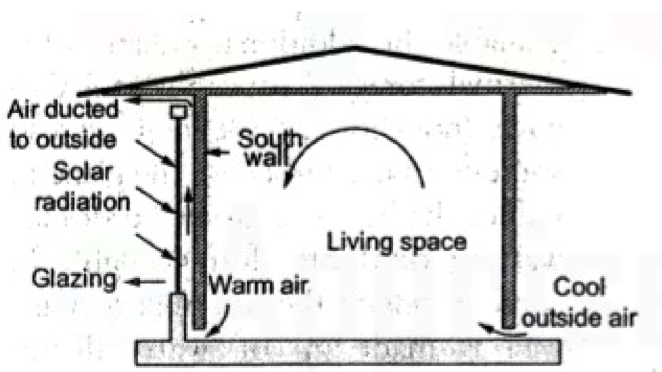
Extra terrestrial radiation: The intensity of solar radiation keeps on attenuating as it propagates from the surface of the sun, although its wavelength remains unchanged. Solar radiation incident on the outer atmosphere of the earth is known as extra terrestrial radiation.

Global radiation: Solar radiation propagating in a straight line and received at the earth's surface without change of direction, ie, in line with the sun is called beam radiation. Solar radiation scattered by aerosols, dust and molecules is known as diffuse radiation. It does not have a unique radiation. The sum of beam and diffuse radiation is called global radiation.

Q5c) With a neat sketch, explain the working of space heating and cooling using solar collectors.



A solar passive space-heating system is shown in figure above. The south-facing thick wall, called Trombe Wall is made of concrete, adobe, stone or composites of brick blocks and sand, designed for thermal storage. In order to increase the absorption, the outer surface is painted black. The entire south wall is covered by one or two sheets of glass or plastic with some air gap (usually 10-15 cm) between the wall and inner glazing. Solar radiation after penetration through the glazing is absorbed by the thermal storage wall. The air in the air gap between the glazing and the wall thus gets heated, rises up and enters the room through the upper vent while cool air from the room replaces it-from-the bottom vent. The circulation of air continues till the wall goes on heating the air. Thus, the thermal wall collects, stores and. transfers the heat to the room. Heating can be adjusted by controlling the air flow through the inlet and outlet vents by shutters. Opening the damper at the top of the glazing allows the excess heat to escape outside, when heating is not required.



The figure above shows the scheme for solar passive cooling through ventilation. This scheme utilizes a solar 'chimney effect' and is effective where outside temperatures are moderate. Solar radiation is allowed to heat up the air between the glazing and the interior south wall. The heated air rises up, is ducted outside and the warm air from the room is drawn into this space due to the natural draught thus produced. As a result, cool outside air enters the room from the bottom air vent on the other side of the room.

Q7a) What are the major problems associated with wind power. Explain horizontal axis wind mill with neat sketch.
Disadvantages of Wind Energy:

- Wind energy requires expensive storage during peak production time.
- It is unreliable energy source as winds are uncertain and unpredictable.
- There is visual and aesthetic impact on region.
- Setting up wind farms requires large open areas.
- Noise pollution problem is usually associated with wind mills.
- Wind energy can be harnessed only in those areas where wind is strong enough and weather is windy for most parts of the year.
- Usually places, where wind power set-up is situated, are away from the places where demand of electricity is there. Transmission from such places increases cost of electricity.
- The average efficiency of wind turbine is very less as compared to fossil fuel power plants. We might require many wind turbines to produce similar impact.
- It can be a threat to wildlife. Birds do get killed or injured when they fly into turbines.
- Maintenance cost of wind turbines is high as they have mechanical parts which undergo wear and tear over the time.

The main parts of horizontal axis wind turbine are as follows:

Turbine Blades Turbine blades are made of high-density wood or glass fibre and epoxy composites. They have an airfoil type of cross section. The blades are slightly twisted from the outer tip to the root to reduce the tendency to stall. In addition to centrifugal force and fatigue due to continuous vibrations, there are many extraneous forces arising from wind turbulence, gust, gravitational forces and directional changes in the wind. All these factors are to be taken care of at the designing stage. The diameter of a typical, MW range, modern rotor may be of the order of 100 m.

Hub: The central solid portion of the rotor wheel is known 9s hub. All blades are attached to the hub. The mechanism for pitch angle control is also provided inside the hub.

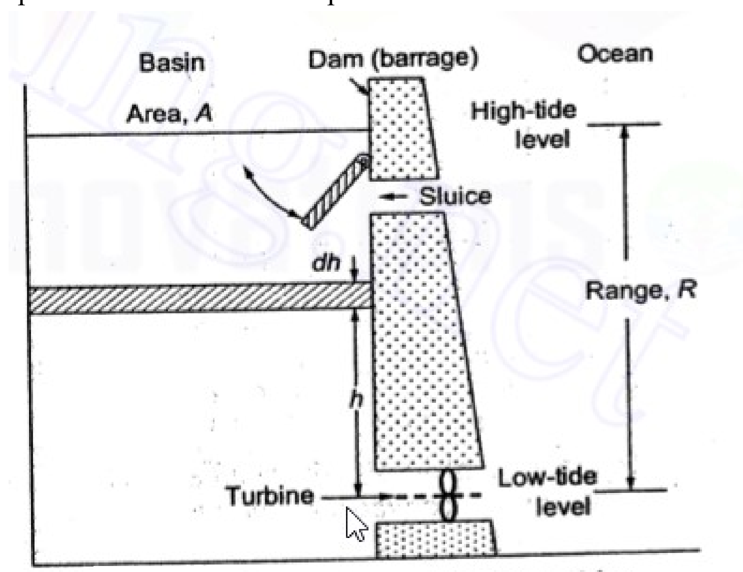
Nacelle: The rotor is attached to the nacelle, and mounted at the top of a tower. It contains rotor brakes, gearbox, generator and electrical switchgear and control. Brakes are used to stop the rotor when power generation is not desired. The gearbox steps up the shaft rpm to suit the generator. Protection and control functions are provided by switchgear and control block. The generated electric power is conducted to ground terminals through a cable.

8a) Describe the principal of power generation methods using tidal energy source.
The main components of a tidal plant are

(i) dam, barrage or dyke: a barrier constructed to hold water,

(ii) sluice ways: rapid controlled gates, used to fill a basin during high tides or emptying it during low tides, and

(iii) a special, bulb-type power turbine-generator set steel shell containing an alternator and special Kaplan turbine with variable pitch blades.



Power generation from tides

The tidal power associated with single filling or emptying of a basin may be estimated as follows.

Tidal Range Power Consider water trapped at high tide in a basin of area A, and allowed to run out through a turbine at low tide. The potential energy in the mass of water stored in incremental head *dh* above the head *h* is:

$$dW = dm \, . \, g \, . \, h$$

but $dm = \rho \, . \, A \, . \, dh$

Thus $dW = \rho \, . \, A \, . \, g \, . \, h \, . \, dh$

Total potential energy of water stored in the basin is:

$$W = \int_0^R \rho \, . \, A \, . \, g \, . \, h \, . \, dh$$

$$W = \frac{1}{2} \rho \, . \, A \, . \, g \, . \, R^2 \text{ joules}$$

where ρ = density of water

The actual power generation by a practical system would be less than the average theoretical power given in the above expression due to frictional losses of the fluid, conversion efficiency of the turbine and generator and due to the fact that the turbine cannot be operated down to zero head, and thus full power generation potential cannot be utilized. The turbine has to be stopped when the head reaches a minimum value *r* below which the operation becomes uneconomical; the above expressions are modified as:

$$W = \int_r^R \rho \, . \, A \, . \, g \, . \, h \, . \, dh \quad \text{joules}$$

$$W = \frac{1}{2} \rho \, . \, A \, . \, g \, . \, (R^2 - r^2)$$

$$P_{av} = 0.225 \times A \times (R^2 - r^2) \text{ watts}$$

$$P_{av}/A = 0.225 \times (R^2 - r^2) \text{ MW/km}^2$$

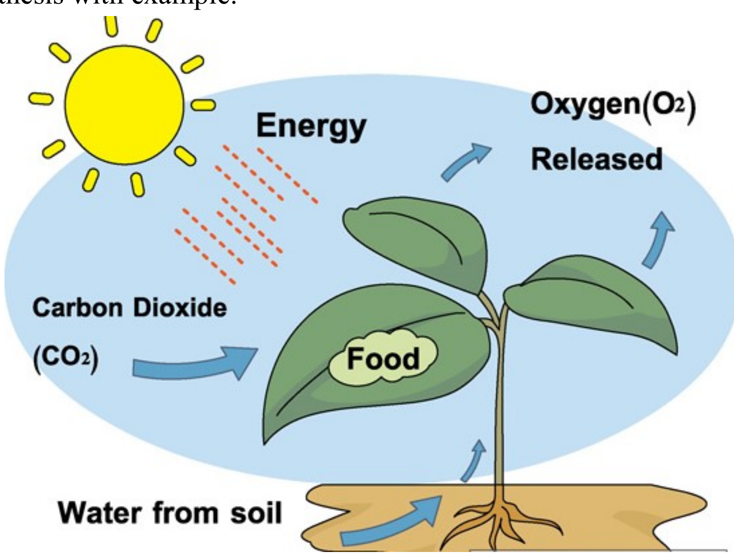
8b) What are the advantages and disadvantages of tidal power generation?
Advantages of tidal energy:

- Tidal power is completely independent of the precipitation (rain) and its uncertainty, besides being inexhaustible.
- Large area of valuable land is not required.
- When a tidal power plant works in combination with thermal or hydro-electric system, peak power demand can be effectively met with.
- Tidal power generation is free from pollution.

The main limitations of tidal energy are the following:

- Economic recovery of energy from tides is feasible only at those sites where energy is concentrated in the form of tidal range of about 5 m or more and the geography provides a favourable site for economic construction of a tidal plant. Thus it is site specific.
- Due to mismatch of lunar driven period of 12 hours 25 min and human (solar) period of 24 hours, the optimum tidal power generation is not in phase with demand.
- Changing tidal range in two-week periods produces changing power.
- The turbines are required to operate at variable head.
- Requirement of large water volume flow at low head necessitates parallel operation of many turbines.
- Tidal plant disrupts marine life at the location and can cause potential harm to ecology.

9a) Explain photosynthesis with example.



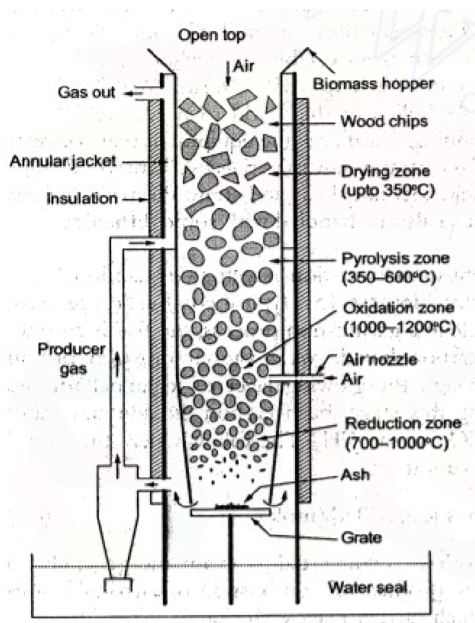
Solar radiation incident on green plants and other photosynthetic organisms performs two basic functions: (i) temperature control for chemical reactions to proceed, and (ii) photosynthesis process. The fundamental conversion process in green plants is photosynthesis, which is the process of combining CO_2 from the atmosphere with water plus light energy to produce oxygen and carbohydrates (sugars, starches, celluloses and hemicelluloses). They are the ultimate source of most of our foods and other necessities of daily life-such as clothes (in the form of cotton), furniture (in the form of wood), etc.

$$x\,CO_2 + y\,H_2O + \text{light energy} \xrightarrow{\text{Photosynthesis}} x\,O_2 + C_x(H_2O)_y$$

More complex hydrocarbons (sucrose, starch, cellulose etc.) are formed by a chain of these simple structures. The reverse of this process is called respiration, in which CO_2, H_2O and energy are produced using carbohydrate and oxygen. The energy produced in the plants by respiration is used in several processes such as to draw moisture and nutrients through its roots. In green plants, both photosynthesis and respiration occur during the day and only respiration at night. There is a net overall gain of energy in the process, as the rate of energy loss in respiration is much less as compared to the rate of energy gain during photosynthesis process. The process also results in net gain of oxygen and fixation of carbon in the form of biomass.

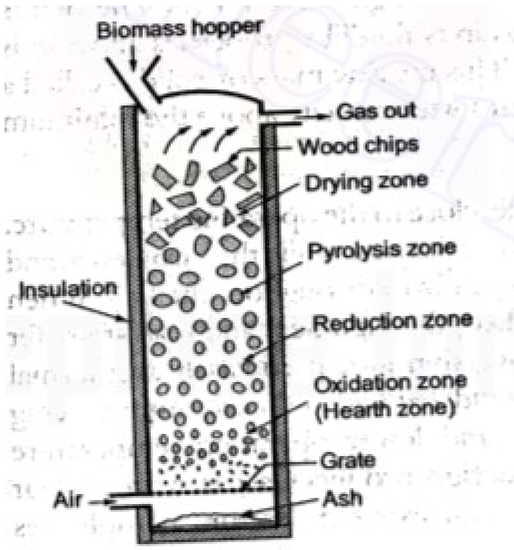
9b) Explain briefly method of biomass gasification.
Gasifiers are broadly classified into @ fixed-bed gasifier and (a) fluidized-bed gasifier. The fixed-bed gasifiers are further classified as (a) downdraft, (b) updraft, and (c) cross-draft types, depending upon the direction of air flow.

The downdraft type is best suited for a variety of biomass. Its design forces the raw products to pass through a high-temperature zone so that most of the unburned pyrolysis products (especially tars) can be cracked into gaseous hydrocarbons, thus producing a relatively clean gas. A recently developed open-top downdraft-type gasifier is shown below

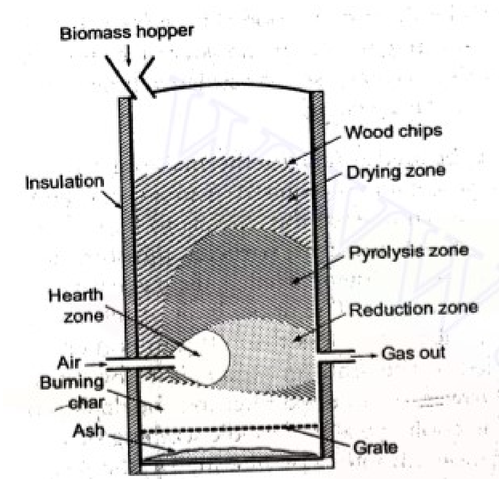


In steady-state operation, heat from the combustion zone, near the air nozzle is transferred upwards by radiation, conduction and convection causing wood chips to pyrolyse and lose 70-80% of their weight. These pyrolysed gases burn with air to form CO, CO_2, H_2 and H_2O, thereby raising the temperature to 1000-1200°C. The product gases from the combustion zone further undergo reduction reaction with char to generate combustible products like CO, H_2 and CH_4.Generally about 40-70% air is drawn through the open top depending on the pressure drop conditions due to the size of wood chips and gas-flow rate. This flow of air opposite to the flame front helps in maintaining homogeneous air/gas flow across the bed.

The updraft-type gasifier (also called counterflow gasifier) is the simplest as well as the first type of gasifier developed. This type of gasifier is easy to build and operate. The air enters below the combustion zone and the, gas is drawn off at the top. The updraft gasifier achieves highest efficiency as the hot gas passes through the fuel bed and leaves the gasifier at a low temperature. The gas produced has practically no ash but contains tar and water vapour because of passing of gas through unburnt fuel. Hence, the updraft gasifers are suitable for tar-free feed stock (fuels like charcoal.) They are most unsuitable for high volatile fuels.



updraft-type gasifier



crossdraft-type gasifier

A crossdraft-type gasifier is shown above. Air enters the gasifier through a water-cooled nozzle mounted on one side of the firebox. It operates at a very high temperature and confines its combustion and reduction zone near the air nozzle. Because of short path length for gasification reactions, this type of gas producer responds most rapidly for change in gas production. The high exit temperature of the gas and low CO_2 reduction results in poor quality of gas and low efficiency. Therefore, this type of gasifier is not in common use.

10a) Mention the different types of fuel cell.
Fuel cells can be classified in several ways.
<u>Based on the Type of Electrolyte</u>

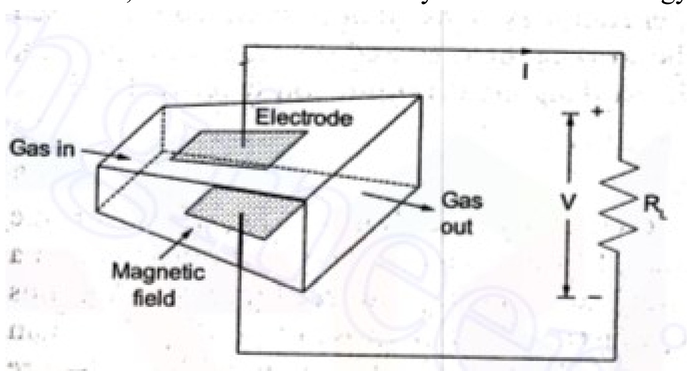
- Phosphoric Acid Fuel Cell (PAFC)
- Alkaline Fuel Cell (AFC)
- Polymer Electrolytic Membrane Fuel Cell (PEMFC) or Solid Polymer Fuel Cell (SPFC) or Proton Exchange Membrane Fuel Cell (PEMFC)
- Molten Carbonate Fuel Cell (MCFC)
- Solid Oxide Fuel Cell (SOFC)

<u>Based on the Types of the Fuel and Oxidant</u>

- Hydrogen (pure)—Oxygen (pure) fuel cell
- Hydrogen rich gas—air fuel cell

- Hydrazine—Oxygen/hydrogen peroxide fuel cell
- Ammonia—air fuel cell
- Synthesis gas—air fuel cell
- Hydrocarbon (gas)—air fuel cell
- Hydrocarbon (liquid)—air fuel cell

10b) Explain a simple MHD generator and its working with figure.
A magneto-hydrodynamic (MHD) power generator is a device which converts the kinetic energy of the conducting (electrically) material, flowing in the presence of magnetic field directly into electrical energy. In a practical MHD generator, the energy of motion of the conducting fluid is derived from heat obtained by the burning of fossil fuel. Thus, heat is converted directly into electrical energy.



An MHD generator is a divergent channel or duct made of a heat-resistant alloy (e.g., inconel) as shown above. A magnetic field is applied at right angles to the channel length and electrodes are provided at right angles to both the magnetic field and flow of gas. A conducting fluid (ionized gas) is forced into the MHD channel at high speed and high temperature through a nozzle. It expands as it moves forward and leaves the duct at lower temperature and pressure. In this respect, an MHD converter system is a heat engine, which receives heat at high temperature, converts a part of it into useful work (electricity in this case) and rejects the remaining heat at a lower temperature. The efficiency of an MHD converter alone is about 20-25 %. In practice, however, an MHD converter is never made to operate alone. The exhaust of an MHD system is used to raise steam for a conventional steam plant. Thus, by using MHD as a topping cycle for the conventional steam system, an overall efficiency of 50-60% should be possible.

10c) With a neat sketch, explain the working of a "hot dry rock" geothermal plant.
There are regions underground at temperatures exceeding 200°C, with little or no water. The rocks are impermeable and/or there is no surface water in the vicinity. Such resources up to a depth of 5 km are estimated to be significant and worthy of development as a source of energy. Hot dry rocks are much more common than hydrothermal reservoirs and more accessible.
The recovery of heat from HDR involves forming a man-made reservoir by drilling deep into the hot rocks and then cracking it to form cavity or fractures. Such a system is known as an Enhanced Geothermal System (EGS), sometimes also called Engineered Geothermal Systems. This can be achieved by (i) detonating high explosives at the bottom of the well, (ii) nuclear explosion, or (iii) hydraulic fracturing. Hydraulic fracturing, which is performed by pumping of water at high pressure into the rock formation, is commonly used in oil and gas fields to improve the flow. It appears that the quantity of

conventional explosives required would be uneconomically large. Nuclear explosives are associated with environmental and safety issues and, therefore, hydraulic fracturing seems to be more promising.

To recover heat, water is pumped into the cracks from the surface, and withdrawn by another well at a distance. Injection and production wells are joined to form a circulating loop through this man-made reservoir to achieve a steady flow of high temperature water (or water—steam mixture). Electricity can be generated by a binary fluid system as shown below. When heat is extracted, the rock cools down and new cracks are developed due to temperature gradient. Thus, the resource keeps on expanding. The technique was tested at a location near Valles Caldera, USA, where fractures were made at a depth of about 2.76 km. The temperature at the location was 185°C. Freon (R-114) was used as the working fluid for a turbine in a binary system. Only 5 per cent of the water introduced was lost in the ground and a small proportion of make-up water was required. The largest EGS project in the world is currently (year 2008) being developed in the Cooper Basin, Australia, with the potential to generate 5,000-10,000 MW