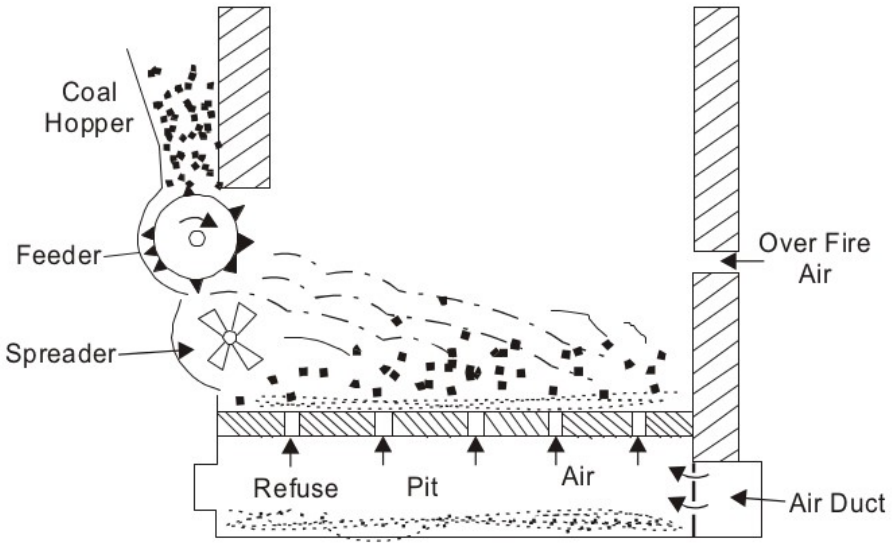
Energy Engineering (15ME71)

Seventh Semester B.E. Degree Examination, Dec 2018/Jan 2019 Solution

1(a) Explain with neat sketch, Spreader Stokers.



Mechanical stokers are commonly used to feed solid fuels into the furnace in medium and large size power plants. A spreader stoker is a type of mechanical stoker in which the coal from the hopper is fed on to a feeder which measures the coal in accordance to the requirements. Feeder is a rotating drum fitted with blades. Feeders can be reciprocating rams, endless belts, spiral worms etc. From the feeder the coal drops on to spreader distributor which spread the coal over the furnace. The design of the spreader system is such that it distributes the coal evenly over the entire grate area. The spreader speed depends on the size of coal.

Advantages of spreader stoker

- Its operation is simple and economical.
- A wide variety of low quality coals can be burnt successfully.
- Preheated air can be used for improving the efficiency of operation.
- The fuel burns rapidly and hence the caking tendency is very low, even with the use of caking coals.
- It can responds quickly to load variations

Disadvantages

- It is not possible to burn varying sizes of coal.
- A part of the charge is burnt in suspension and hence fly ash is discharged with flue gases. This necessitates a suitable dust (or fly ash) collector system.
- Unburned carbon particles may escape through the flues and reduce the combustion efficiency.

1(b) What is pulverized coal? What are the advantages and limitation of pulverized coal?

Pulverized coal is coal, which has been ground (i.e., pulverized) into a fine dust, of about 70 micrometers (i.e., microns) mean diameter. Pulverized coal combustors are suspension burners - that is, the coal dust is carried by the furnace air and gases and burned in suspension.

Advantages of using pulverized coal:

- A wide variety of low grade fuels (coal) can be used and burnt easily.
- Greater surface area is exposed for combustion and hence combustion is faster and efficient.
- The system is free from clinker troubles.
- Combustion control is easy, and hence the system gives fast response to load changes.
- Preheated secondary air (up to 350°C) can be used, resulting in rapid flame propagation and faster heat supply to the boiler.
- The pulverizing system can be maintained or repaired without affecting the combustion process.
- It has a very high rate of heat release.
- The boilers can be started from cold very rapidly.
- Usually combustion will be smokeless.

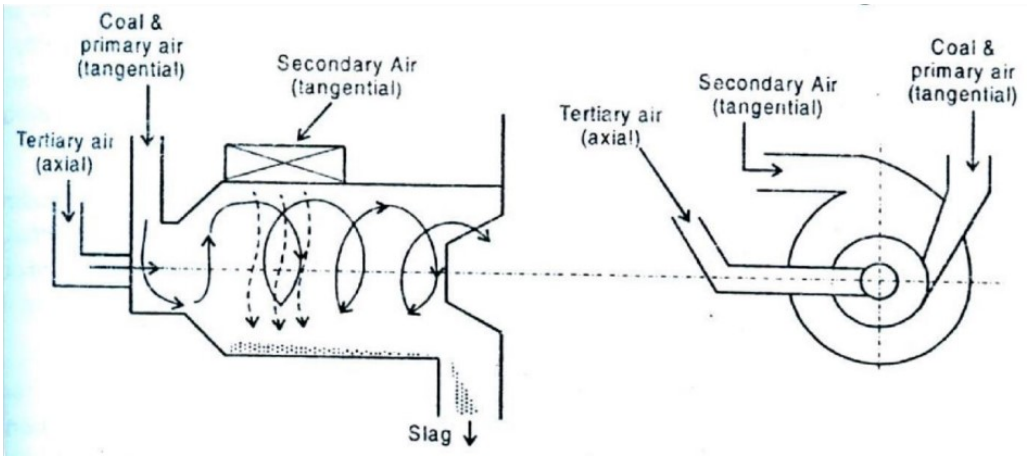
Disadvantages of pulverized system

- The capital investment of the system is high as it requires additional equipments (for pulverizing, and handling).
- Its operation and maintenance costs are very high.
- It produces fly-ash/fine dust and needs costly fly-ash removal equipments like electrostatic precipitators.
- The chances of explosion are high as coal burns like a gas.
- The storage of powdered coal requires special attention as it has possibilities of fire hazards.
- Skilled workers are required for safe-operation and maintenance.
- Air pollution takes place by the emission of fine particles of grit and dirt.
- The removal of liquid slag formed from low fusion temperature ash requires special handling equipments.

2(a) Explain with a neat sketch, Cyclone burner.

The cyclone burner consists of a horizontal cylinder of about 3m diameter and about 4m long. The cylinder wall is water cooled, while the inside surface is lined with refractory material. The horizontal axis of the burner is slightly inclined towards the boiler. The coal used in cyclone burner is crushed to about 6 mm size. Coal and primary air (about 25% of the combustion or secondary air) are admitted tangentially into the cylinder so as to produce a strong centrifugal motion to the coal particles. The

primary air and fuel mixture flows centrifugally along the cylinder walls towards the furnace. From the top of the burner, the secondary air is also admitted tangentially, at a high velocity (about 100 m/s).The high velocity secondary air causes further increase in the centrifugal motion, leading to a highly turbulent whirling motion of the coal air mixture. Tertiary air (about 5 to 10% of the secondary air) is admitted axially at the centre so as to move the turbulent coal-air mixture towards the furnace. The coal is burnt completely within the burner and only hot gases enter the furnace. Such burners produce high temperatures (about 1000°C). Due to high temperature burning, the ash melts in the form of slag, and is drained out periodically at the bottom.



Advantages of cyclone burner

- Since it uses crushed coal, it saves the cost of pulverization.
- All the incombustible are retained in cyclone burner, and hence the boiler fouling problems are reduced.
- It requires less excess air, as it uses forced draught.
- Slag-recovery is around 80% and dust passing to the stack is about 10%. Thus simple equipment can be used for dust removal.
- Fly ash problem is reduced to a great extent.
- Low grade fuels can be used.

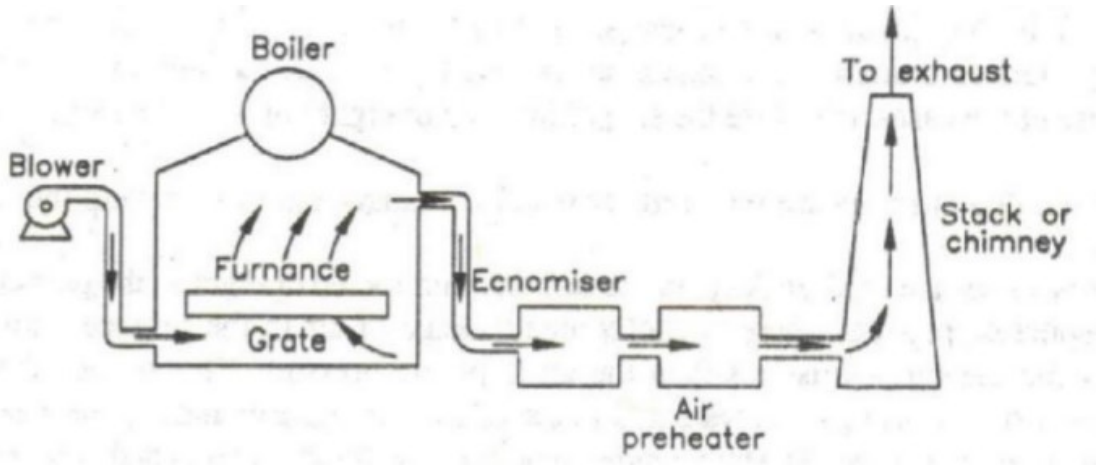
Disadvantages

- It requires high pressure draught and consumes higher power.
- It produces more oxides of nitrogen, which creates atmospheric pollution.

2(b) Explain Forced Draught system.

The small pressure difference which causes a flow of gas to take place is termed as a 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 order to met the draught requirement on actual power plant a draught system needs to be installed.

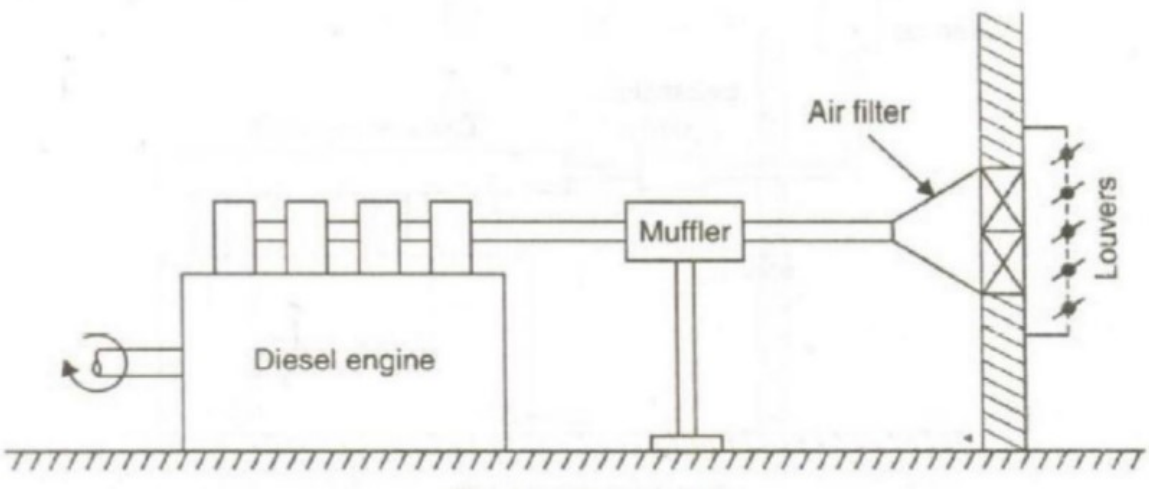


In a forced draught system, a blower is installed near the base of the boiler and air is forced to pass through the furnace, flues, economizer, air pre-heater and to the stack. This draught system is known as positive draught or forced draught system because the pressure of air throughout the system is above atmospheric pressure and air is forced to flow through the system. A stack or chimney is also used in the system as shown in the figure but its function is to discharge gases high in the atmosphere to prevent contamination. It is not much significant for production of draught; therefore the height of the chimney is smaller compared to natural draught system.

3(a) Explain with neat sketch air intake and exhaust system.

Air Intake System

The air intake system conveys fresh air through pipes or ducts to: (i) Air intake manifold of four stroke engines (ii) The scavenging pump inlet of a two stroke engine and (iii) The supercharger inlet of a supercharged engine.



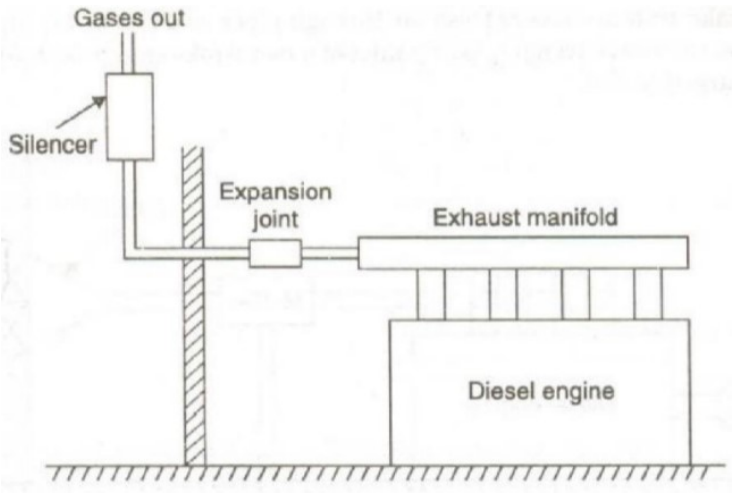
Following precautions should be taken while constructing a suitable air intake system:

- Air intakes may not be located inside the engine room.
- Air should not be taken from a confined space otherwise air pulsations can cause serious vibration problems,
- The air-intake line used should neither have too small a diameter not should be too long, otherwise there may crop up engine starvation problem.
- Air intake filters may not be located close to the roof of the engine room otherwise pulsating air flow through the filters can cause serious vibration of the roof.
- Air intake filters should not be located in an inaccessible location.

Exhaust system

The purpose of the exhaust system is to discharge the engine exhaust to the atmosphere outside the building. The exhaust manifold connects the engine cylinder exhaust outlets to the exhaust pipe which is provided with a muffler to reduce pressure in the exhaust line and eliminate most of the noise which may result if gases are discharged directly to atmosphere.

The exhaust pipe leading out of the building should be short in length with minimum number of bends and should have one or two flexible tubing sections which take up the effects of expansion and isolate the system from the engine vibration. Every engine should be provided with its independent exhaust system.



3(b) List the advantages, limitations and application of Diesel power plant.

Applications of Diesel Power Plant

Peak load plant: The diesel plants are used in combination with thermal or hydro-plants as peak load plants. This plant is particularly preferable as peak load plant as it can be started quickly and it has no standby losses as in the case of thermal plants where boilers always must be kept hot.

Mobile plants: Mobile diesel plants mounted on skids or trailers can be used for temporary or emergency purposes such as for supplying power to large civil engineering works for supplementing electricity supply systems that are temporarily short of power.

Stand-by Units: This can be used as a standby unit to supply part load when required. For example, this can be used with hydro-plant as stand-by unit. If the water available is not sufficient due to reduced rainfall, a diesel station supplies power in parallel with hydro-station. The use is made temporarily till the water is available to take the full load.

Emergency plant: The plants used for emergency purposes are also standby units, normally idle but are used where power interruption would mean financial loss or danger in key industrial processes, tunnel lighting and operating rooms of hospitals. They are also used for telecommunication and water supply under emergency conditions.

Advantages:

- Design and installation are very simple and occupy less space.
- A diesel power plant can respond to varying loads without any difficulty. . It can be started and put on load quickly
- The standby losses are less compared to thermal power plant.
- Require less operating and supervising staff as compared to that for steam plants. The efficiency of such plants at part loads does not fall so much as that of a steam plant. The cost of building and civil engineering works is low.
- These plants can be located very near to the load centers, many times in the heart of the town.
- No problem of ash handling.

- The diesel power plants are more efficient than steam power plants in the range of 150 MW capacity.

Disadvantages:

- High operating cost.
- High maintenance and lubrication cost.
- The capacity of diesel power plants is limited. These cannot be constructed in large size. In a diesel power plant noise is a serious problem.
- Diesel plants cannot supply overloads continuously whereas steam power plant can work at 25% overload continuously.
- The diesel power plants are not economical where fuel has to be imported.

4(a) How the hydel power plants are classified and explain with a neat sketch pumped storage plants.

Hydel power plants can be classified as follows:

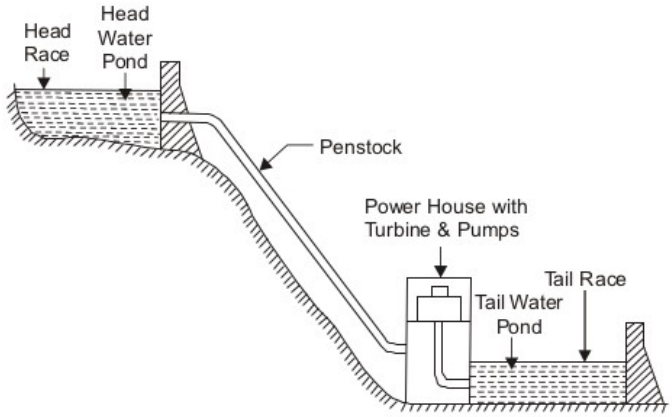
- Based on quantity of water available
  - Run-off river plants without pondage
  - Run-off river plants with pondage
  - Pumped storage plant
- Based on Head of water
  - Low head plant
  - Medium head plant
  - High head plant
- Based on Nature of load
  - Base load plant
  - Peak load plant
- Based on capacity of plant
  - Low capacity plant (100-999 kW)
  - Medium capacity plant (1 MW-10 MW)
  - High capacity plant (above 10 MW)

Pumped Storage Plants

Such plants are most suitable for supplying sudden peak load requirements. However, such demands can be met only for a short duration. In the normal operation they can meet the average demand only. Such type of plant consists of two storage reservoirs. The upstream reservoir is the main (head race) storage reservoir to which water flows from the catchment area.

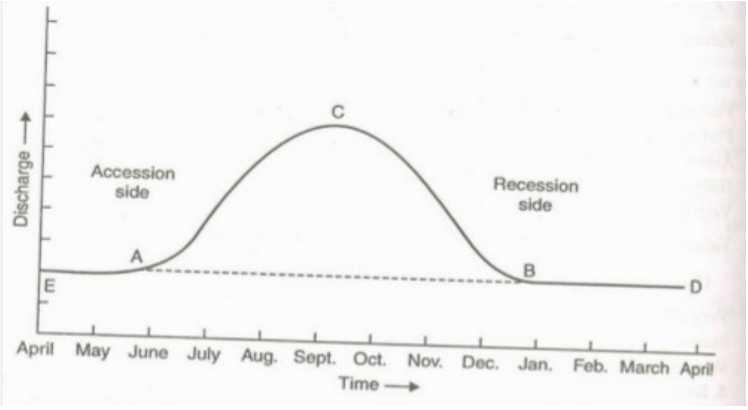
The second reservoir is the downstream (tail race) reservoir, in which the used water from the upstream is collected. The water in the downstream reservoir is pumped back to the main upstream reservoir, during off peak periods. This facilitates making use of the excess water during peak hours. A pumped storage

plant is a peak load plant operates in combination with other base load plants such as a thermal power plant. The off peak load capacity of the thermal plant is used for pumping water from the downstream reservoir to the upstream reservoir. The schematic arrangement of pumped storage plant operating along with a thermal plant to meet the peak load demands is shown in figure.

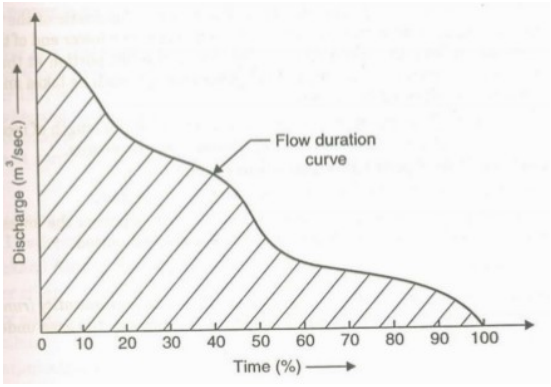


4(b) Define i) Hydrograph, ii) Flow duration curve iii)Surge tank

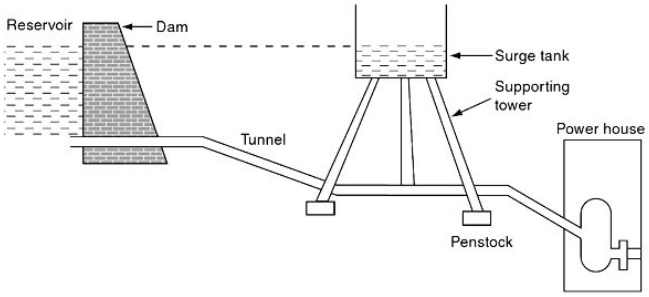
Hydrograph: A hydrograph indicates the variation of discharge or flow with time. It is plotted with flows as ordinates and time intervals as abscissas. The flow is in m3/sec and the time may be in hours, days, weeks or months.



Flow duration curve: A flow duration curve shows the relation between flows and lengths of time during which they are available. The flows are plotted as the ordinates and lengths of time as abscissas. The flow duration curve can be plotted from a hydrograph.



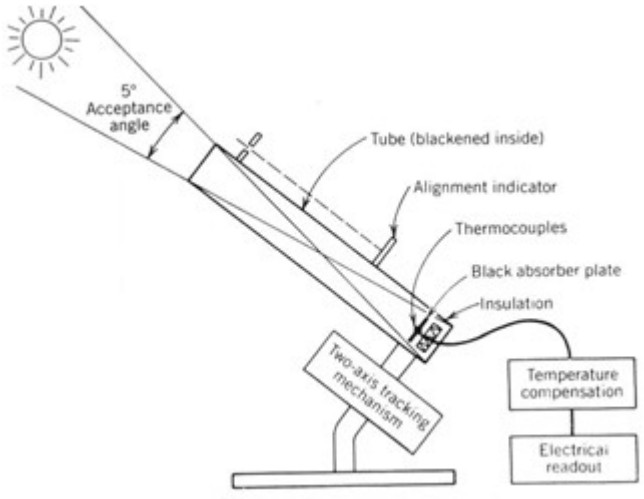
Surge tank: Surge tank is an open tank which is often used with pressure conduit of considerable length. The main purpose of providing surge tank is to reduce the distance between the free water surface and turbine there by reducing the water hammer effect on penstock and also protect upstream tunnel 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.



5(a) What is Beam radiation? Explain working principle of pyrheliometer for measuring beam radiation.

Beam Radiation: Solar radiation propagating in a straight line and received at the earth surface without change of direction, i.e., in line with the sun is called beam or direct radiation.

Pyrheliometer



The normal incidence pyrheliometer, shown in figure uses a long collimator tube to collect beam radiation whose field of view is limited to a solid angle of 5º (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 thermopile is provided whose sensitive surface consists of circular, blackened, hot junctions, exposed to the sun, the cold junctions being completely shaded. The temperature difference between the hot and cold junctions is the function of radiation falling on the sensitive surface. The tube is sealed with dry air to eliminate absorption of beam radiation within the tube by water vapor. A tracker is needed if continuous readings are desired.

5(b) The angle of inclination is the angle between the sun's rays and its projection on a horizontal plane

$\alpha = 60^{o}$; $I = 1\ kW/m^2$; $A = 120 m^2$

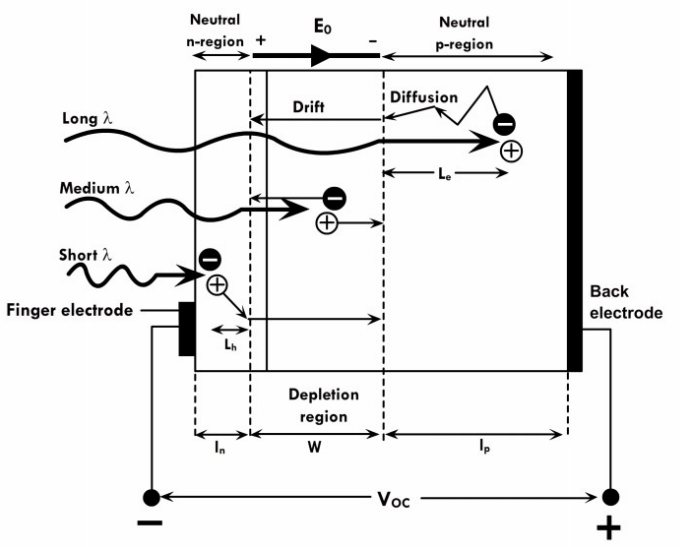
Net energy incident on surface $= I A\ sin(\alpha)$

$= 1 \times 120 \times\ sin(60^{o})$

$= 103.92\ kW$

6(a)Explain with neat sketch, working principle of a Solar cell.

A simple solar cell is a *pn* junction diode. The schematic of the device is shown in figure below. The *n* region is heavily doped and thin so that the light can penetrate through it easily. The *p* region is lightly doped so that most of the depletion region lies in the *p* side. The penetration depends on the wavelength and the absorption coefficient increases as the wavelength decreases. Electron hole pairs (EHPs) are mainly created in the depletion region and due to the built-in potential and electric field, electrons move to the *n* region and the holes to the *p* region. When an external load is applied, the excess electrons travel through the load to recombine with the excess holes. Electrons and holes are also generated with the *p* and *n* regions. The shorter wavelengths (higher absorption coefficient) are absorbed in the *n* region and the longer wavelengths are absorbed in the bulk of the *p* region. Some of the EHPs generated in these regions can also contribute to the current.



6(b) Explain three basic methods of Thermal Energy Storage.

The need of thermal energy storage may often be linked to the following cases:

- there is a mismatch between thermal energy supply and energy demand,
- when intermittent energy sources are utilized, and
- for compensation of the solar fluctuation in solar heating systems.

There are three main ways of storing thermal energy:

Sensible heat: The storage is based on the temperature change in the material and the unit storage capacity [J/g] is equal to heat capacitance times the temperature change. Sensible heat energy storage has the advantage of being relatively cheap but the energy density is low.

Phase-change: If the material changes its phase at a certain temperature while heating the substance then heat is stored in the phase change. Reversing, heat is dissipated when at the phase change temperature it is cooled back. The storage capacity of the phase change materials is equal to the sum of phase change enthalpy at the phase change temperature and the sensible heat stored over the whole temperature range of the storage.

Chemical reactions: The thermo chemical reactions can also provide thermal storage capacity. The basic principle is:

$$AB + \text{heat} \Leftrightarrow A+B;$$

using heat a compound AB is broken into components A and B which can be stored separately; bringing A and B together AB is formed and heat is released. The storage capacity is the heat of reaction or free energy of the reaction. Thermo-chemical storage materials have the highest storage capacity of all storage media. Some of the materials may even approach the storage density of biomass.

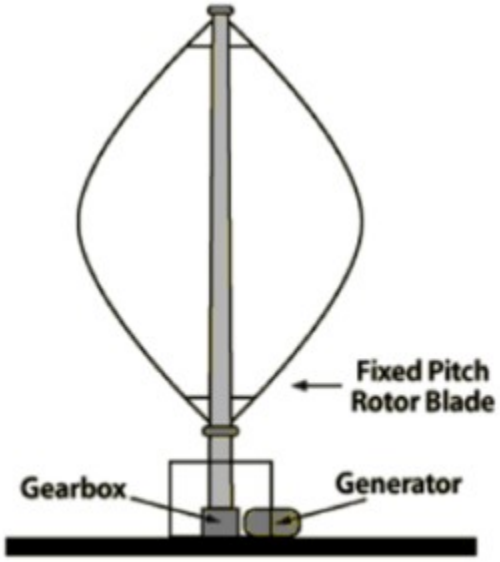
7(a) Explain with neat sketch, Vertical axis type wind mill.

Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically. Key advantages of this arrangement are that the turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where the wind direction is highly variable. The key disadvantages include

- the low rotational speed with the consequential higher torque and hence higher cost of the drive train,
- the inherently lower power coefficient,
- the 360 degree rotation of the aerofoil within the wind flow during each cycle and hence the highly dynamic loading on the blade,
- the pulsating torque generated by some rotor designs on the drive train,
- and the difficulty of modeling the wind flow accurately and hence the challenges of analyzing and designing the rotor prior to fabricating a prototype

With a vertical axis, the generator and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, hence improving accessibility for maintenance.

When a turbine is mounted on a rooftop, the building generally redirects wind over the roof and these can double the wind speed at the turbine. If the height of the roof top mounted turbine tower is approximately 50% of the building height, this is near the optimum for maximum wind energy and minimum wind turbulence.



7(b) Given p = 101.325 kPa, R = 287 J/kgK , T = 293K, U = 15 m/s, d = 120m

Density of air = $\rho = p / RT = 1.226 kg/m^3$

Total power density in wind stream = $0.5\rho U^3 = 2068 W/m^2$

Max obtainable power density = (16/27)* Total power density in wind stream = $1226 W/m^2$

Reasonably obtainable power density ($\eta = 35\%$) = 0.35 * Total power density in wind stream = 724 W/m^2

Area = $\pi d^2/4 = 11309 m^2$

Total power = Reasonably obtainable power density * Area = 8.19MW

8(a) How tidal power plants are classified and what are the limitations of Tidal power plant.

The tidal power plants are broadly classified into:

1. Single Basin Arrangement
2. Double Basin Arrangement

The generation of power in a single basin system can be carried out either as

a) Single ebb- cycle system
b) Single tide cycle system
c) Double cycle system.

Single ebb- cycle system: When high tide comes, the sluice gates are opened to permit the sea water to enter the reservoir, while the turbines sets are shut. The reservoir thus starts filling while its level rises, till the maximum tide level is reached. At the beginning of the ebb tide the sluice gates are closed. Then the generation of power takes place when the, sea is ebbing (Flowing back of tide) and the water from the basin flows through the turbine in to the lower level sea. The-generation of power can be continued till there is sufficient head difference between the levels of water in the reservoir and the sea. The turbines are closed when the level of water becomes same on both the sides; sluice gates are opened to repeat the cycle.

Single tide cycle system: In a single tide cycle system, the generation of power is carried out when sea is at flood tide. The water of the sea is admitted into the basin through the turbines. As the flood tide period is over and the sea level starts falling again, the generation is stopped. The basin is drained in to the sea through the sluice ways. This system needs large size plant, operating for short period and hence less efficient as compared to ebb tide operation.

Double cycle system: In this system, power generation is carried out during both high tide as well as ebb tides. The flow of water in both the directions is used to drive a number of reversible water turbines, each driving an electrical generator.

Double Basin System:

Two basin systems is one that is much less dependent on tidal fluctuation but at the expense of more complex and hence more costly dam construction. An inland basin is enclosed by dam A and divides into a high pool and a low pool by dam B. By proper gating in the dam A, the high pool gets periodically filled at high tide from the ocean and the low pool gets periodically emptied at low tide. Water flows from the high to the low pool through the turbines that are situated in the dam B. The power generation thus

continues simultaneously with the filling up the high pool. The capacities of these two pools are large enough in relation to the water flow between them that the fluctuations in the head are minimized, which results in continuous and much more uniform power generation. At the end of the flood tide when high pool is full and the water level in it is minimum; its sluice gates are closed. When ebb tide level gets lower than the water level in low pool, its sluice gates are opened whereby the water level in low pool, which was rising and reducing the operating head, starts falling with the ebb. This continues until the head and water level in high pool is sufficient to run the turbines. With the next flood tide cycle repeats. With this twin pool system, a longer and more continuous period of generation per day is possible.

Limitations:

- Due to variation in tidal range the output is not uniform.
- Since the turbines have to work on a wide range of head variation (due to variable tide range) the plant efficiency is affected.
- There is a fear of machinery being corroded due to corrosive sea water.
- It is difficult to carry out construction in sea.
- As compared to other sources of energy, the tidal power plant is costly.
- Sedimentation and siltation of basins are the problems associated with tidal power plants.
- The power transmission cost is high because the tidal power plants are located away from load centers.

9(a) Write short notes on i) Photosynthesis ii) Energy Plantation

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities. This chemical energy is stored in carbohydrate molecules, such as sugars, which are synthesized from carbon dioxide and water. Radiant energy of sun is absorbed by the green pigment chlorophyll in the plant and is stored within the plant in the form of chemical bond energy. Photosynthesis in the plants is an example of biological conversion of solar energy into sugars and starches which are energy rich compounds.

The chemical reaction occurring during photosynthesis can be expressed as

$$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$$

Solar radiation incident on green plants and other photosynthetic organisms relates to two main effects: (1) temperature control for chemical reactions to proceed, especially in leaves, and (2) photo excitation of electrons for the production of oxygen and carbon structural material. It is so important to maintain leaf temperature in the correct range that some solar radiation is reflected or transmitted, rather than absorbed.

Energy plantation is the practice of planting trees, purely for their use as fuel. Terrestrial biomass i.e., the wood plants has been used since long time to generate fire for cooking and other purposes. In recent years, to meet the demand of energy, plantation of energy plants has been re-emphasized. The chief objective of energy plantation is to produce biomass from the selected trees and shrub species in the shortest possible time (generally 5-10 yrs) and at the minimal cost, so as to satisfy local energy needs in the decentralized manner. This would certainly relieve the pressure on the consumption of fossil fuel like kerosene and prevent the destruction of plant cover which is one of the primary components of the life support system. The main advantages of energy plantations are:

- High yield per unit of land area,
- Smaller land requirements for given biomass output,
- Shorter time span from initial stand establishment to harvestable crop,
- Increased labor efficiency through mechanization and other methods similar to those used in agriculture

9(b) With neat sketch, explain downdraft gasifier.

Biomass gasification, or producing gas from biomass, involves burning biomass under restricted air supply for the generation of producer gas. The following reactions occur inside a biomass gasifier:

Drying: Biomass fuels usually contain 10%–35% moisture. When biomass is heated to about 100°C, the moisture is converted into steam.

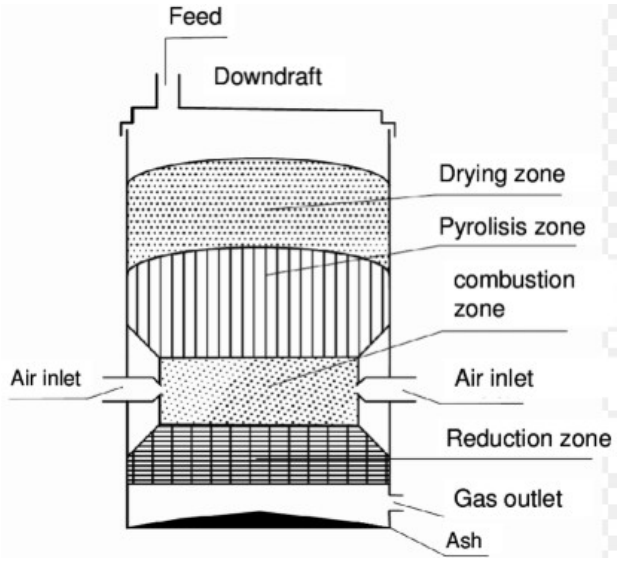
Pyrolysis: Pyrolysis involves burning biomass completely without supplying any oxygen. As a result, the biomass is decomposed or separated into solids, liquids, and gases. Charcoal is the solid part, tar is the liquid part, and flue gases make up the gaseous part.

Oxidation: During oxidation, which takes place at about 700–1,400 °C, charcoal, or the solid carbonized fuel, reacts with the oxygen in the air to produce carbon dioxide and heat.

Reduction: At higher temperatures and under reducing conditions, that is when not enough oxygen is available, the following reactions take place forming carbon dioxide, hydrogen, and methane.

$C + CO_2 \rightarrow 2\ CO$
$C + H_2O \rightarrow CO + H_2$
$CO + H_2O \rightarrow CO_2 + H_2$
$C + 2H_2 \rightarrow CH_4$

Downdraft gasifiers: The downdraft gasifier is the most common type of gasifier. In downdraft gasifiers, the pyrolysis zone is above the combustion zone and the reduction zone is below the combustion zone. Fuel is fed from the top. The flow of air and gas is downwards (hence the name) through the combustion and reduction zones. A downdraft gasifier is so designed that tar, which is produced in the pyrolysis zone, travels through the combustion zone, where it is broken down or burnt. As a result, the mixture of gases in the exit stream is relatively clean. The position of the combustion zone is thus a critical element in the downdraft gasifier, its main advantage being that it produces gas with low tar content, which is suitable for gas engines.



10(a) What is Fuel Cell? How fuel cells are classified?

Fuel cell is an electrochemical cell that converts the energy from a fuel into electricity through an electrochemical reaction of hydrogen fuel with oxygen or another oxidizing agent. Fuel cells are different from batteries in requiring a continuous source of fuel and oxygen (usually from air) to sustain the chemical reaction, whereas in a battery the chemical energy comes from chemicals already present in the battery. Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.

Types of fuel cells differ primarily by the type of electrolyte they employ. The type of electrolyte, in turn, determines the operating temperature, which varies widely between types.

Molten Carbonate Fuel Cells: Molten carbonate fuel cells use an electrolyte that conducts carbonate ions from the cathode to the anode. The electrolyte is composed of a molten mixture of lithium and potassium carbonates. This mixture is retained by capillary forces within a ceramic support matrix of lithium aluminate. At the fuel cell operating temperature, the electrolyte structure is a thick paste, and the paste provides gas seals at the cell edges.

Solid Oxide Fuel Cells: Solid oxide fuel cells use an electrolyte that conducts oxide ions from the cathode to the anode. This is the opposite of most types of fuel cells, which conduct hydrogen ions from the anode to the cathode. The electrolyte is composed of a solid oxide, usually zirconia (stabilized with other rare earth element oxides like yttrium), and takes the form of a ceramic.

Alkaline Fuel Cells: Alkaline fuel cells use an electrolyte that conducts hydroxyl ions from the cathode to the anode. The electrolyte is typically composed of a molten alkaline mixture such as potassium hydroxide. The electrolyte can be mobile or immobile. Mobile alkaline electrolyte fuel cells use a fluid electrolyte that continuously circulates between the electrodes. The product water and waste heat dilute and heat the liquid electrolyte but are removed from the cell as the electrolyte circulates.

Phosphoric Acid Fuel Cells: Phosphoric acid fuel cells use an electrolyte that conducts hydrogen ions (H+) from the anode to the cathode. As its name implies, the electrolyte is composed of liquid phosphoric acid within a silicon carbide matrix material. (Some acid fuel cells use a sulfuric acid electrolyte.)

Proton Exchange Membrane (PEM) Fuel Cells: Proton exchange membrane (PEM) (or "solid polymer") fuel cells use an electrolyte that conducts hydrogen ions (H+) from the anode to the cathode. The electrolyte is composed of a solid polymer film that consists of a form of acidified Teflon.

10(b)What is Green energy? What are the benefits of green energy?
Green electricity is energy produced from sources or in such a manner that very little or no harm is done to the environment. Conventional methods of power generation like the burning of coal and gas in power stations cause millions of tons of carbon dioxide emissions into the atmosphere. The large quantities of carbon dioxide in the air play a major role in the green house effect which is the primary cause of global warming. Though it is believed that electrical power production will always generate pollutants, there are sources that are exponentially cleaner than others. Some such energy sources are:

- Wind Energy takes advantage of wind motion to generate electricity. Wind motion is brought about by the heat from the sun, and rotation of the earth, mainly via the Coriolis Effect.
- Solar energy taps heat from the sun to produce energy for generation of electricity, heating, lighting homes and commercial buildings.
- Hydropower involves utilizing moving water to produce electricity. Moving water creates high energy that can be harnessed and turned into power.
- Biomass: Together with snow and rain, sunlight is essential for plant growth. Organic matter that constitutes plants is referred to as biomass, which can be utilized to generate electricity, chemicals or fuels to power vehicles.
- Ocean: Takes advantage of rising and falling of tides to generate electricity
- Geothermal: Leverages heat from underneath the earth to generate electricity.

Benefits of green energy:

- It is a clean source of energy, meaning, it has low or zero carbon and greenhouse emission. Fossil fuels emit high levels of greenhouse gas and carbon dioxide, which are greatly responsible for global warming, climate change, and degradation of air quality. The use of renewable energy dramatically reduces the dependence on fossil fuel as a source of energy, hence, cutting back on air pollution.
- They do not deplete over a lifetime and there is zero possibility that they will run out (sustainable source of energy). Sources of energy like fossil fuels (oil, gas, and coal) are considered limited resources and there is strong possibility that they will run out in the future.
- Once infrastructure for the harnessing of the renewable resource is laid down, there is low to zero maintenance required.