CBCS SCHEME

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BME515D

Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Energy Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Briefly explain the various steps involved in coal handling.	10	L3	CO1
	b.	Explain the working principle of Benson boiler with a neat sketch.	10	L3	CO1
		OR			
Q.2	a.	Draw the layout of a diesel power plant.	10	L3	CO1
	b.	List and explain the different methods of starting a diesel engine.	10	L3	CO1
		Module – 2			
Q.3	a.	Explain the solar radiation incident on the earth's surface.	10	L3	CO2
	b.	With the help of neat sketch, explain the method of extraction of solar energy from solar ponds.	10	L3	CO2
		OR			
Q.4	a.	Explain the working of floating drum biogas plant with a neat sketch.	10	L3	CO3
	b.	Explain the working of down draft gasifier with a neat sketch.	10	L3	CO3
		Module – 3			
Q.5	a.	With a neat sketch, explain the working of Hot dry rock geothermal plant.	10	L3	CO3
	b.	With a neat sketch, explain double basin arrangement of harnessing of tidal energy.	10	L3	CO3
		OR			
Q.6	a.	With a block diagram, explain the basic components of wind energy conversion system.	10	L3	CO3
	b.	With a neat sketch, explain horizontal axis and vertical axis wind machines.	10	L3	CO3
		Module – 4			
Q.7	a.	With a neat sketch, explain pumped storage hydroelectric power plant.	10	L3	CO3
	b.	The runoff data of a river at a particular site is tabulated below :	10	L4	CO3

Month	Mean discharge per month (millions of m^3)
January	40
February	25
March	20
April	10
May	0
June	50
July	75
August	100
September	110
October	60
November	50
December	40

(i) Draw a hydrograph and find the mean flow.
(ii) Also draw the flow duration curve.
(iii) Find the power in MW available at mean flow if the head available is 80 m and overall efficiency of generation is 85%. Take each month of 30 days.

		OR			
Q.8	a.	With a neat sketch, explain closed Rankine cycle OTEC system.	10	L3	CO2
	b.	List the problems associated with Ocean Thermal Energy Conversion (OTEC).	4	L2	CO2
	c.	Explain the following terms related to hydroelectric power plant: (i) Pen stock (ii) Draft tube	6	L3	CO3
		Module – 5			
Q.9	a.	Explain the principle of release of nuclear energy by fusion and fission reactions.	10	L3	CO3
	b.	Explain with a neat sketch, the general components of a nuclear reactor.	10	L3	CO3
		OR			
Q.10	a.	With a neat sketch, explain the working of Pressurized Water Reactor (PWR).	10	L3	CO3
	b.	Explain the following : (i) Reactor shielding (ii) Radio active waste disposal.	10	L3	CO3

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Fifth Semester B.E. Degree Examination
Dec. 2024/Jan. 2025
Sub: Energy Engineering (BME515D)
(CBCS scheme)

Max. Marks: 100

Q. 1 a) Briefly explain the various steps involved in coal handling

Ans. Coal handling involves several key steps:

1) Coal delivery: Coal is transported to the plant via rail, truck, or ship

2) Unloading: The coal is unloaded from the delivery vehicles using specialized equipment such as rotary tipplers or side tipplers for rail cars, or other methods for trucks and ships.

3) Preperation: This stage involves preparing the coal for efficient combustion. It may include crushing the coal into smaller sizes, screening to seperate different sizes, drying to remove excess moisture and magnetic seperation to remove ~~excess~~ metallic impurities.

4) Transfer: Conveyor belts, bucket elevators and other equipment transfer the coal between different stages of handling process.

such as from unloading point to storage or from storage to the boiler house.

5) Storage: Coal is stored in piles or bunkers until it is needed. Outdoor storage is common, but covered or enclosed storage may be used to minimize oxidation and dust generation.

6) In-plant handling: Various equipment within the plant, such as feeders and conveyors, move the coal from storage to furnace.

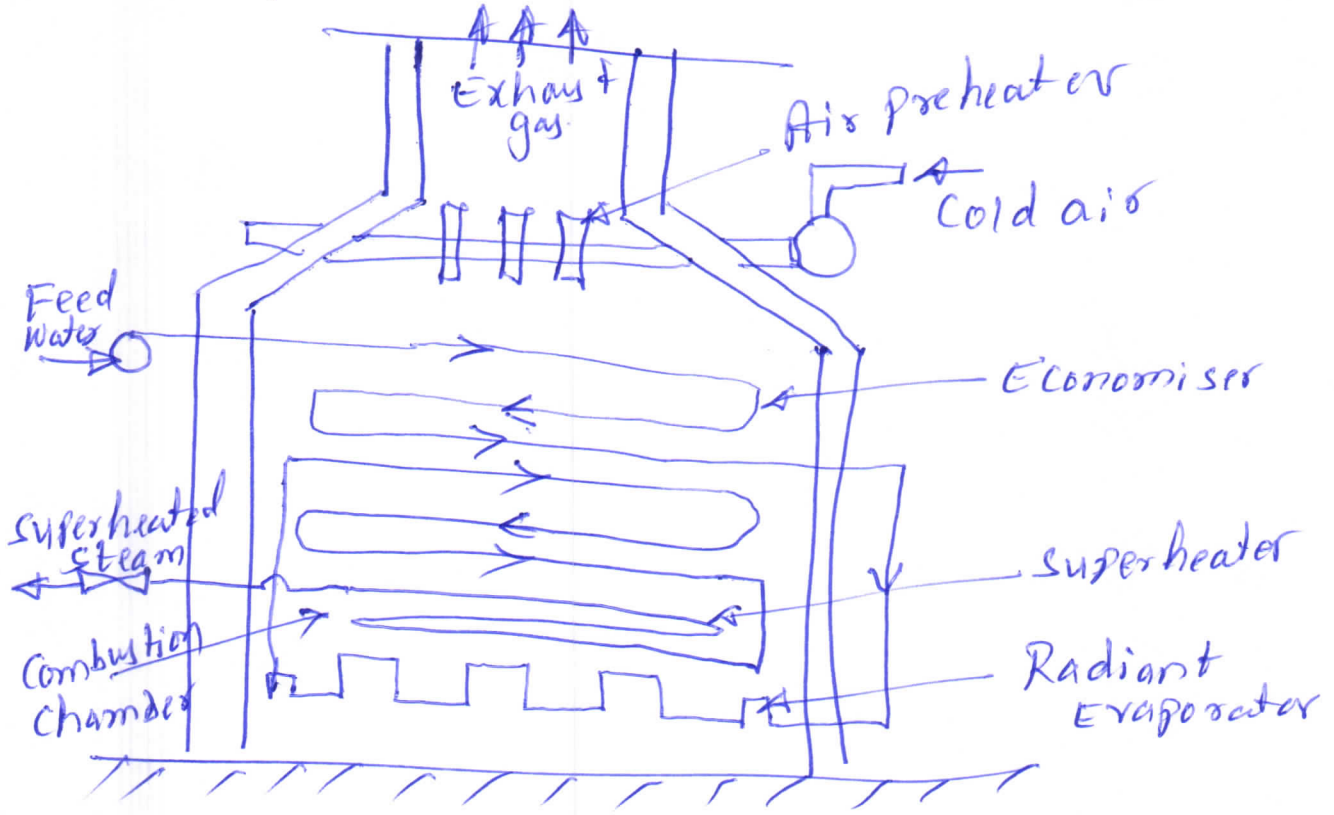
7) Weighing and measuring: The coal is weighed and measured to ensure the correct amount is fed into the furnace for optimal combustion and energy generation.

8) Feeding the coal into the furnace: Finally, the prepared coal is fed into the boiler furnace to produce steam, which drives a turbine to generate electricity.

Q.1 b) Explain the working principle of Benson boiler with a neat sketch.

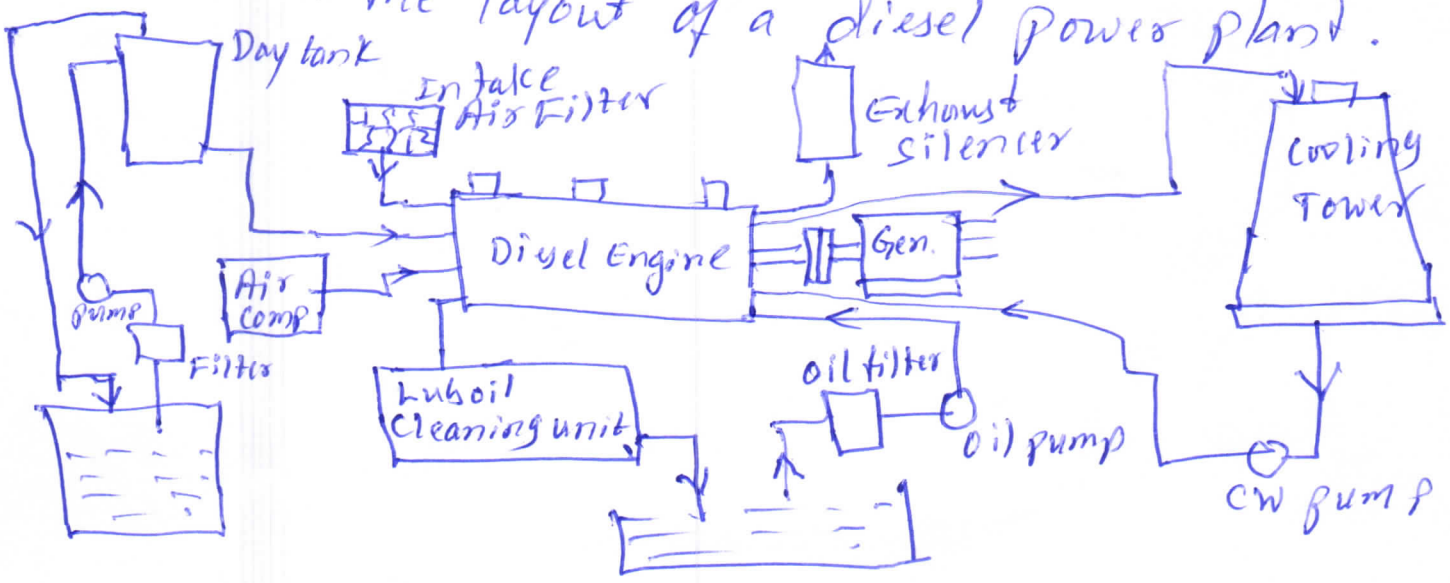
Ans. Benson boiler is innorative design that eliminated the salt and water bubble formations in the evaporator tubes. The speciality of this boiler is that there is no boiler drum. This boiler is also known as "once through boiler"

Since the feed water is converted directly into superheated steam through the pipe lines and evaporators without being stored in drums



This boiler can work with a capacity of 150 tonnes per hour, upto a pressure of 500 bar and temperature of 650°c.

Q.2a) Draw the layout of a diesel power plant.



Q. 2b) List and explain the different methods of starting a diesel engine. (4)

Ans. Since the diesel engine have a high compression ratio (1:12 to 1:20) it is difficult to start them by simple means. This necessitates a seperate starting system for diesel engines. Generally used starting systems are as follows:

1) Compressed Air system.

This is the most suitable method for starting medium and large diesel engines. In this system high pressure compressed air (20-30 atm) is supplied to the engine through the intake manifold. In a multi-cylinder engine the compressed air enters one cylinder and forces down the piston, in the mean time some other piston performs suction and some compression strokes. With few suction and compression strokes, fuel injection takes place and engine starts and slowly gains momentum to reach its full speed.

2) Electric Motor starting system.

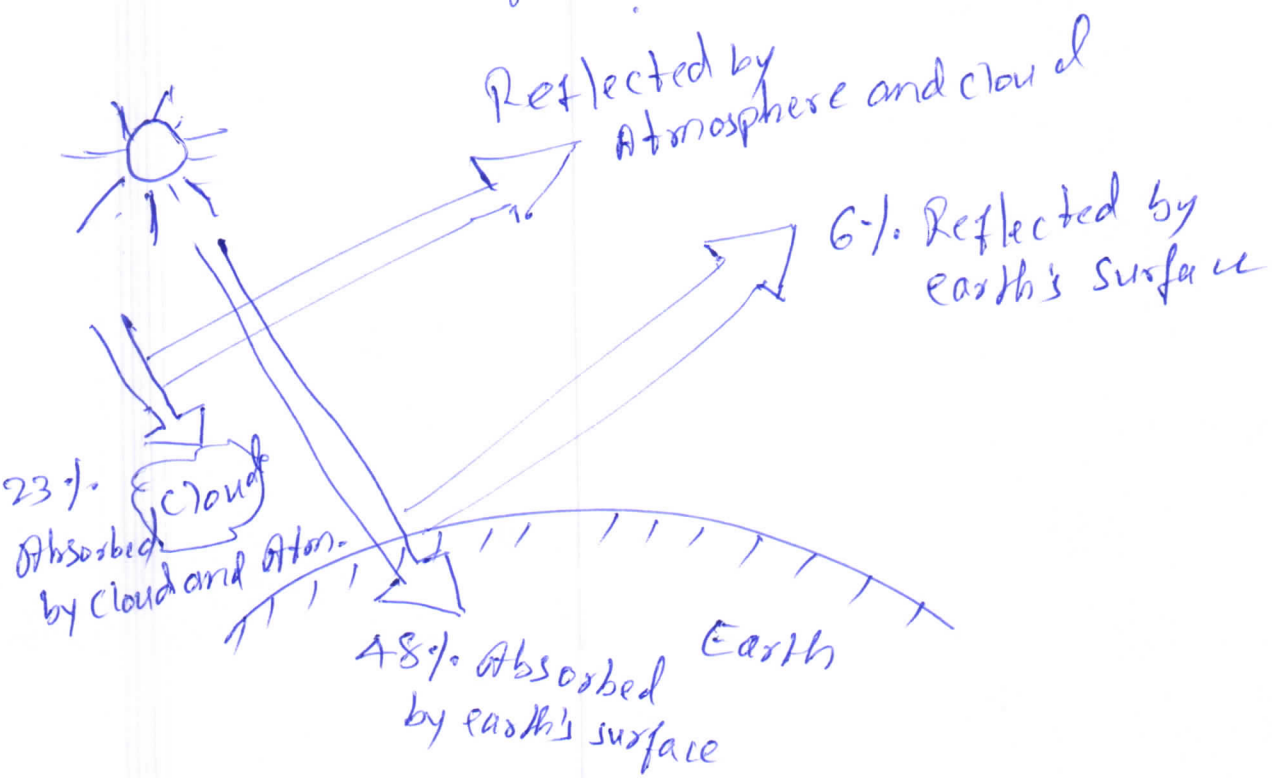
In this method, an electric motor (starter motor) is connected to the engine crank-shaft and operated by batteries. The starter motor is run till the engine starts properly and then disconnected automatically. This method is simpler and faster.

3) Use of Auxiliary Engine.

In this method, a small petrol engine is connected to the diesel engine crankshaft through suitable clutch and gear arrangement. In disengaged position the petrol engine is started by hand or by a battery starter. Clutch is then gradually engaged, so that the diesel engine is coupled and the diesel engine starts. Clutch is automatically disengaged when the main engine starts and reaches its full speed.

Q.3 a) Explain the solar radiation incident on the earth's surface.

Ans.



Solar energy reaches earth's surface in the form of electromagnetic radiation which includes visible light, ultraviolet and infrared radiation. The amount of solar energy that reaches

Earth's surface varies depending on several factors, including:-

a) Lattitude: The angle at which the sunlight hits the earth's surface varies depending on lattitude. Area closed to the equator receives more direct sunlight than the area closer to the poles.

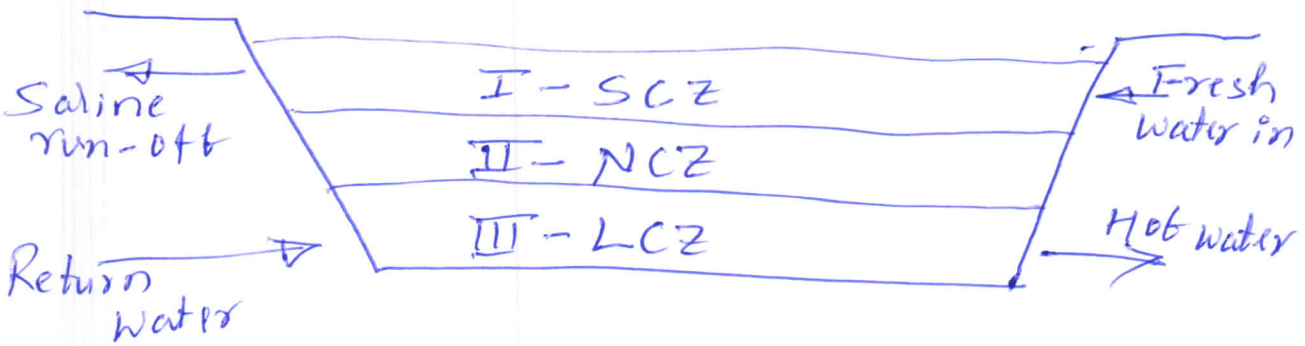
b) Season: In summer, more Solar energy reaches the earth and less energy in winter.

c) Time of day: Most of the solar energy reaches the earth's surface at noon. Also it varies with cloud.

On average, about 1000 Watts of solar energy per sq. metre reaches earth's surface on a clear day.

Q.3 b) With the help of neat sketch, explain the method of extraction of solar energy from solar ponds.

Ans.

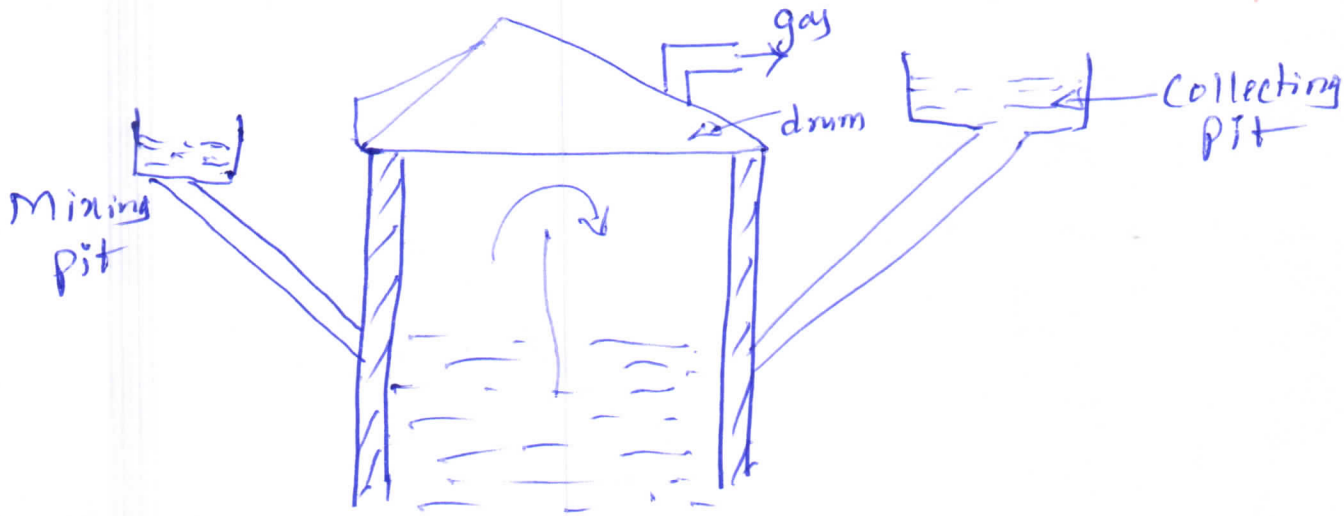


SCZ - Surface convective zone
NCZ - Non-Convective Zone
LCZ - Low Convective Zone

A solar pond is a large body of water that acts as a solar collector and thermal energy storage system. It utilises a gradient of salt concentration, where salt dense water sinks to the bottom. sunlight penetrates the pond and is absorbed throughout, but heat loss to the surrounding is minimized by the insulating effect of less saline upper layer. This creates a layer of hot salty water at the bottom of the pond that can be used for various applications such as electricity generation, space heating, desalination, and aqua culture etc.

Q. 4a) Explain the working of floating drum biogas plant with a neat sketch.

Ans.



Floating drum Biogas plant.

The floating drum biogas plant is also known as Khadi Village Industries Commission Model (KVIC). It is erected on strong foundation made of cement concrete and brick. Its digester is a cylindrical shaped well like structure with foundation as its base.

Digester (Fermentation chamber) is made of cement concrete and bricks. It is made of stone with cement lining. Gas holder is made of mild steel sheet. It is supported on digester wall. It floats up and down on guide pipe at the centre of drum. It has rotary movement so that it can break scum mat formed on the top of the slurry.

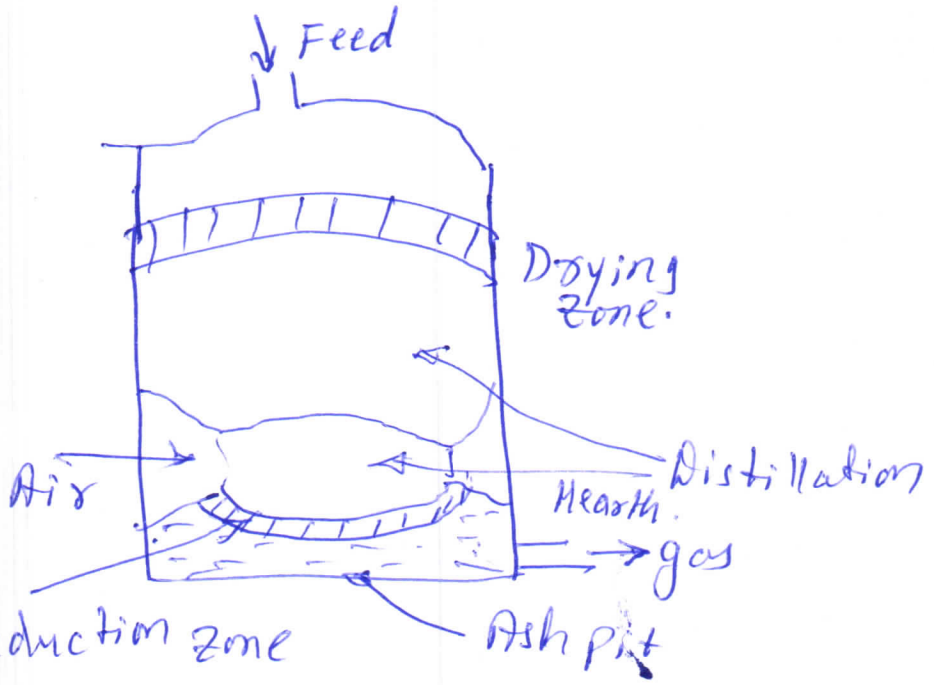
Inlet pipe is made of cement concrete. One end is inside the mixing tank and other end is inside the digester.

Outlet pipe is also made of cement concrete with one end inside the digester and other end is connected to the outlet tank.

The biogas outlet pipe is fixed on top of the biogas holder which is made of GI pipe fitted with socket and gate valve. The biogas generated in the gas holder drum is taken out through outlet pipe to the place of utilization.

Q. 4 b) Explain the working of down draft gasifier with a neat sketch.

Ans.



In a downdraft gasifier, biomass and air are both fed from top of the gasifier and travel downward together. The process zone are.

Drying Zone: Incoming air removes the moisture from biomass.

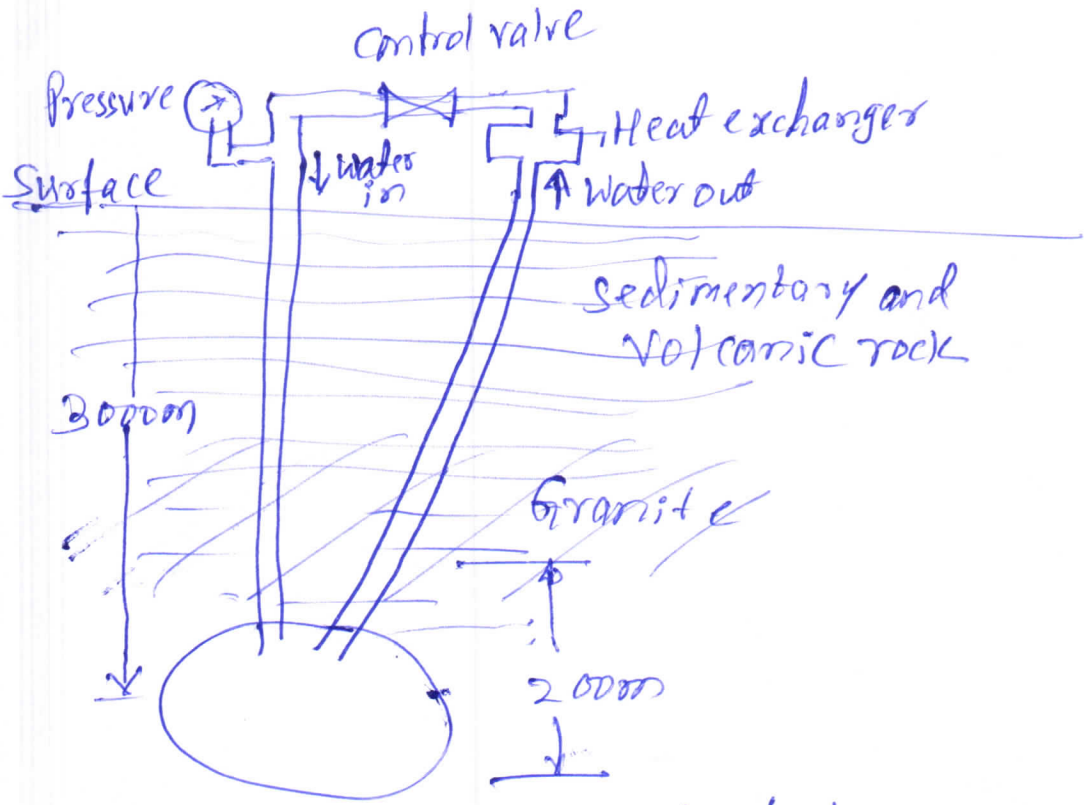
Pyrolysis Zone: Heat from hot gas releases volatile gases from breaking of biomas leaving behind @ char (tar).

Combustion Zone: A portion of air reacts with char to generate heat to sustain the process.

Reduction Zone: The remaining char reacts with steam and CO_2 from combustion zone producing syngas which is a mixture of H_2, CO_2, CO and CH_4.

Q. 5 a) With a neat sketch explain the working of Hot dry rock geothermal plant.

Ans.



Hot dry rock Geothermal plant.

This system composed of hot dry rock but no underground water. They represent largest geothermal resource available. The rock occuring at moderate depths has very low permeability and needs to be fractured to increase its heat transfer surface.

Thermal energy of hot dry rock is extracted by pumping water through a well drilled to the lower part of the fractured rock. The water moves through the fractures picking up heat. It is then travels up by second well that is drilled to the surface. Then it is used in a power plant to

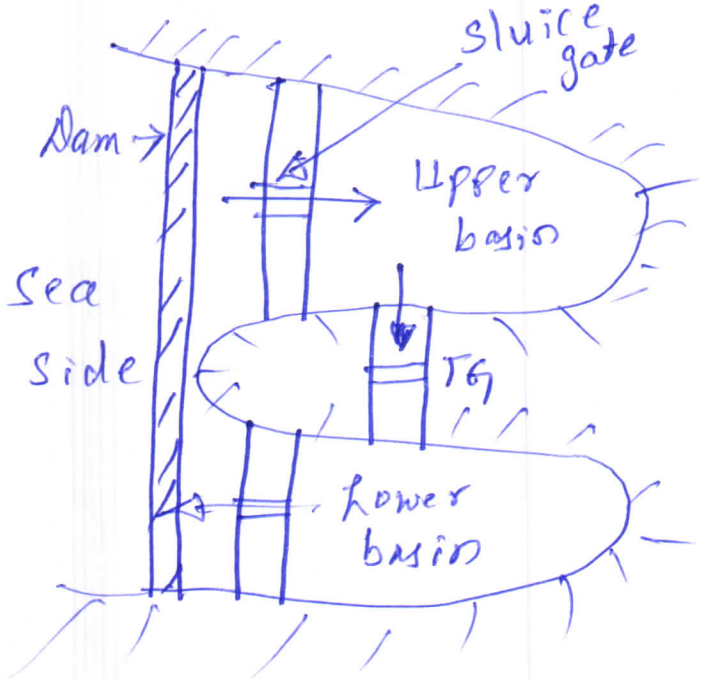
Produce electricity.

The rock temperatures exceeding 200°C at a depth upto 5 km are estimated to be significant and worthy as a resources.

Rocks are fractured either by using explosives at the bottom of the well drilled into rock or by using hydraulic fracturing which is performed by pumping water at high pressure.

Q. 5 b) With a neat sketch explain double basin arrangement of harnessing of tidal energy.

Ans.



The double basin power plant has two basins at different levels. The dam is provided between basins and as well as sea.

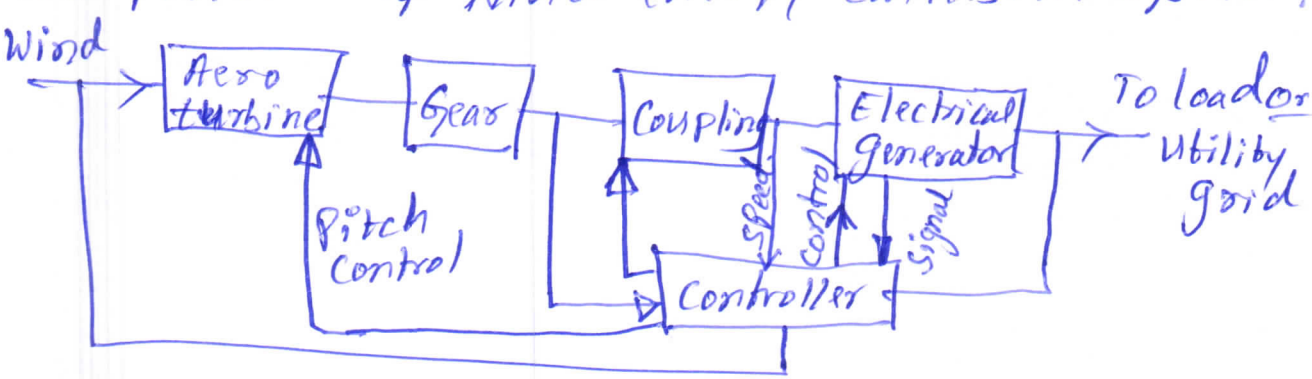
One basin is called upper basin as the water level in this basin is always maintained higher level than that of the lower basin.

The lower basin discharges water to the sea at low tides, while the upper basin is filled up with sea water at high tides.

The turbines are provided in the constructed dam seperating upper and lower basins. When water is made to flow through turbines from upper basin to lower basin, the turbines run and generates power.

Q. 6a) With a neat block diagram explain the basic components of Wind energy Conversion System.

Ans. Components of Wind energy Conversion system.

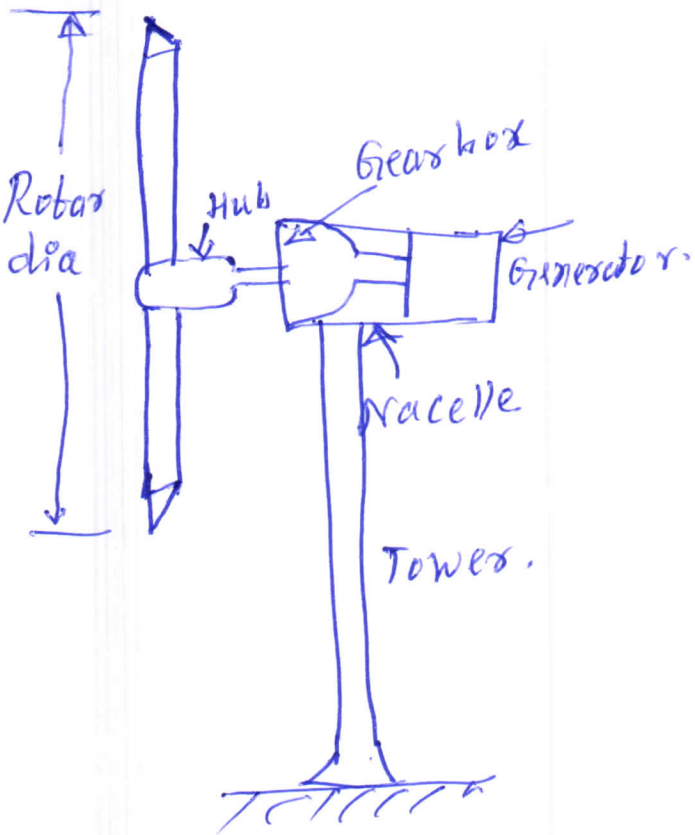


The basic principle of every wind mill is to convert kinetic energy of wind into mechanical energy which is used to rotate the turbine. The turbine shaft is coupled to electric generator to produce the electricity.

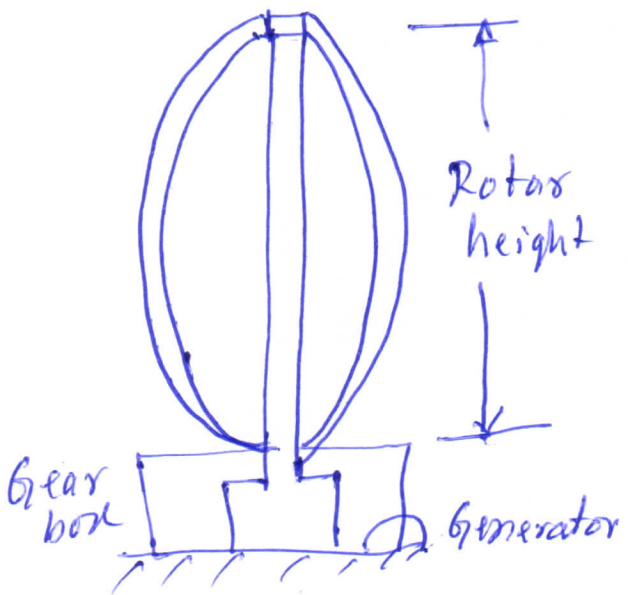
Q. 6 b) With a neat sketch, explain horizontal and Vertical axis wind machines.

Ans.

Horizontal Axis wind Turbine (HAWT)



Vertical Axis wind Turbine (VAWT)



Horizontal Axis Wind Turbine (HAWT)

* The axis of rotation (Horizontal axis) of blades is parallel to the wind flow direction.
* Generally these requires massive tower construction to support heavy nacelle.
* An additional yaw control is required to turn the rotar towards the wind direction.
* Electrical generator and gearbox are installed at the top of the tower.

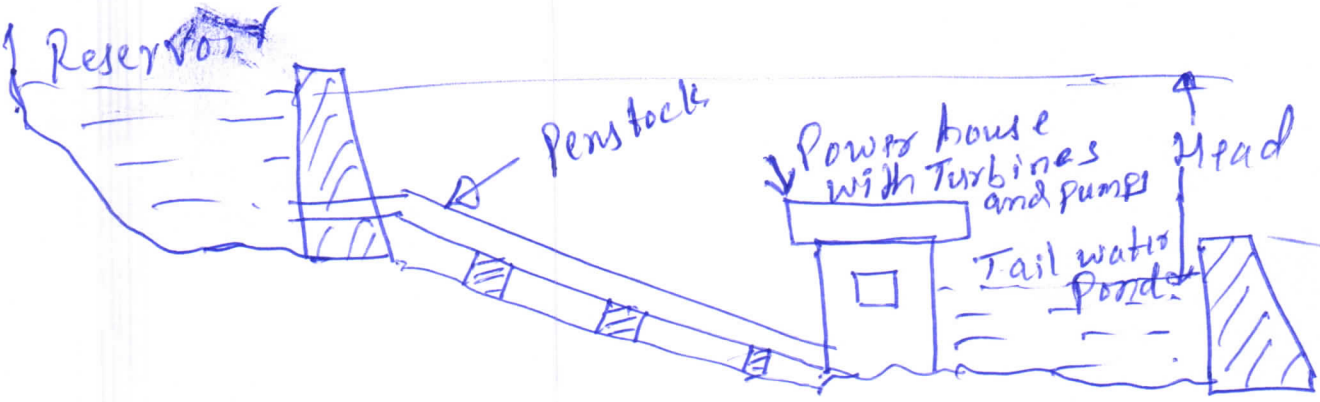
* HAWT performs at higher efficiency and most used turbines.

Vertical Axis Wind Turbine (VAWT)

* The axis of rotation (vertical axis) of blades is perpendicular to the wind flow direction.
* Additional equipment mechanism is required to start it from a stationary position.
* It does not require a yaw mechanism because it receive wind from all direction.
* There is no need of nacelle in VAWT.
* The overall efficiency of VAWT is lower as compared to HAWT.

Q.7a) With a neat sketch, explain pumped storage hydraulic power plant.

Ans.



Pumped storage hydraulic plants are employed when quantity of water available for power generation is inadequate. The water flowing through the turbine is stored in tail race pond. During low ~~head~~ load periods this water is pumped back to the head reservoir using pumps. This water can be used for power generation during peak load periods. It uses reversible turbine pump which can be used as turbine while generating electricity and as pump while pumping water to storage. With the use of reversible turbine pump sets, additional capital investments on pump and its motor can be saved.

(9.7 b) The runoff data of a river at a particular site is tabulated below:

Month	Mean discharge per month Millions of m^3
January	40
February	25
March	20
April	10
May	0
June	50
July	75
August	100
September	110
October	60
November	50
December	40

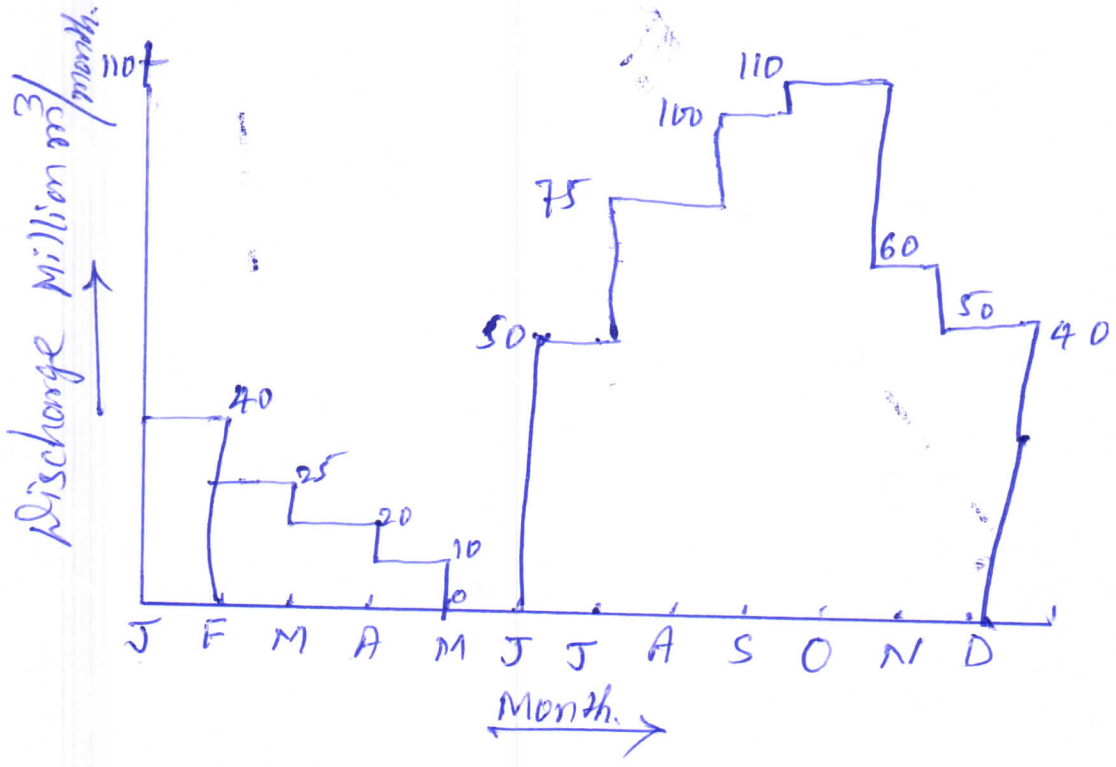
(16)

i) Draw a hydrograph and find mean flow.

ii) Also draw the flow duration curve.

iii) Find the power in MW available at mean flow if the head available is 80m and overall efficiency of generation is 85%. Take each month of 30days.

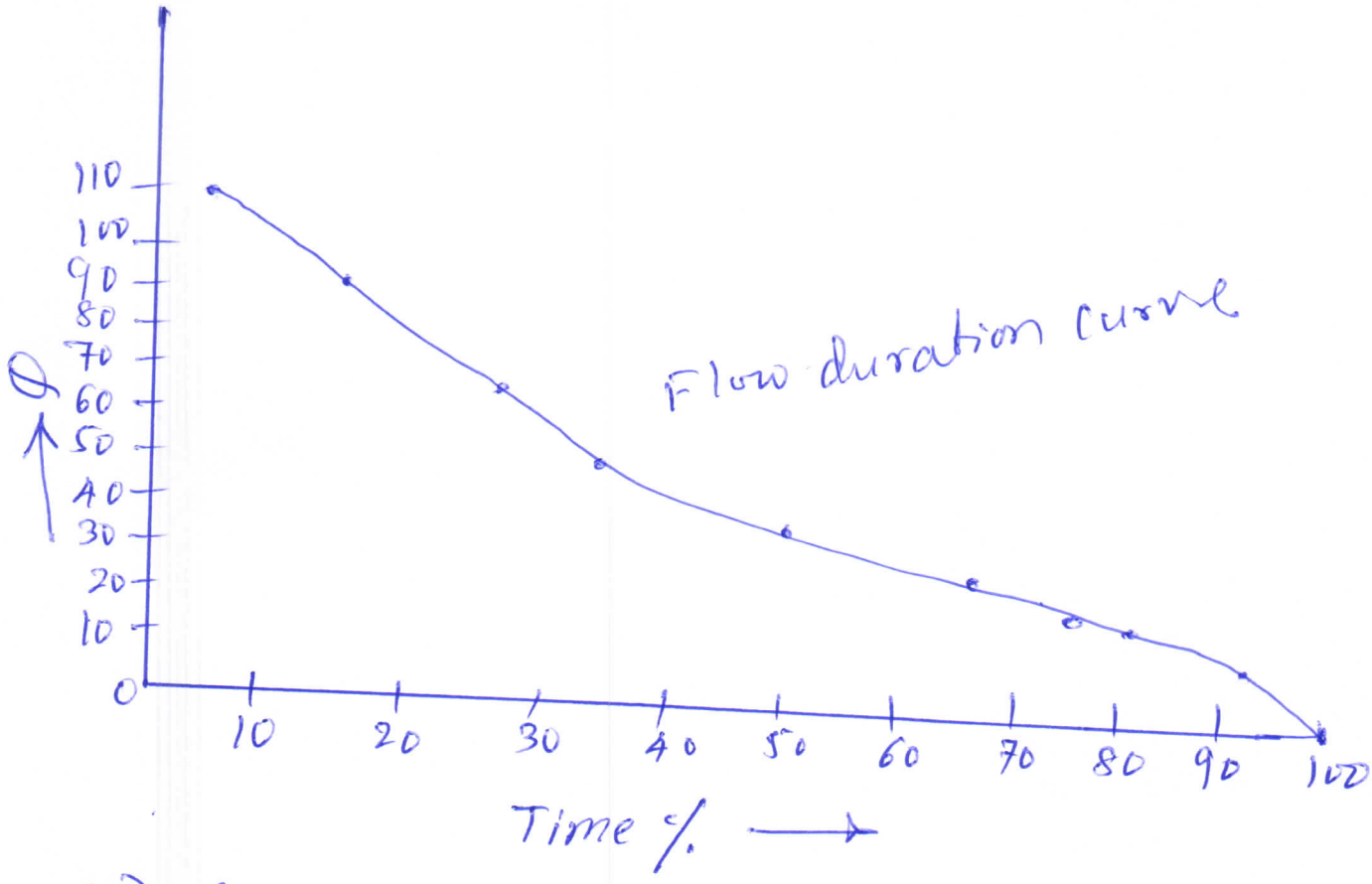
Sol^{n}



ii) Mean discharge $= \frac{580}{12} = 48.33$ Million m^3/month

iii)

Discharge	No. of months flow available	% Time
0	12	100
10	11	91.7
20	10	83.3
25	9	75
40	8	66.7
50	6	50.0
60	4	33.3
75	3	25
100	2	16.7
110	1	8.3



iv) Avirage MW energy available

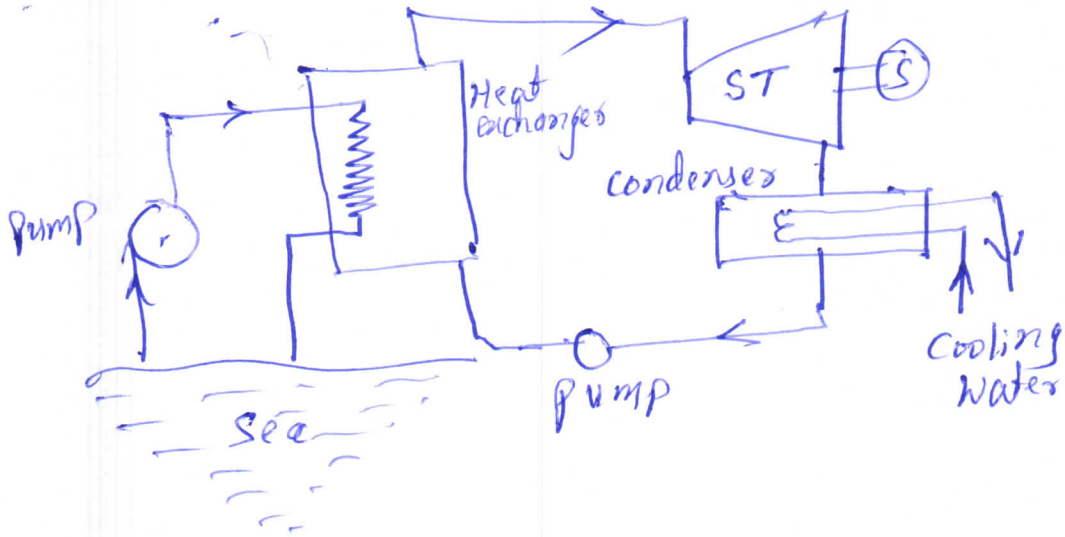
$$P = \frac{\eta_o \, 9 Q H}{1000} \text{ KW}$$

$$P = \frac{0.85 \times 1000 \times 48.33 \times 10^6 \times 80}{1000}$$

$$P = 12.4 \text{ MW}$$

Q.8 a) With a neat sketch, explain closed Rankine OTEC system.

Ans.



In a closed cycle, warm surface water is used to evaporate a low boiling point refrigerant (Ammonia or Freon) and refrigerant vapour is made to flow through the turbine to extract energy.

The vapour coming out from the turbine after performing work is cooled and condensed in a condenser cooled by cold water from the ocean depths. The closed cycle is shown in above fig. Such a plant is much compact in size and less costly compared to open cycle.

Q.8 b) List the problems associated with OTEC.

Ans 1) Low efficiency: The temperature difference

between warm surface and deep ocean water is limited, even in tropics. This translates to lower efficiency in converting thermal energy to electricity compared to other sources.

2) High Costs: OTEC systems requires massive heat exchanges, long pipes for cold water intake, and special designs to survive harsh offshore environments. All this adds up to a high price tag for building and maintaining OTEC plants.

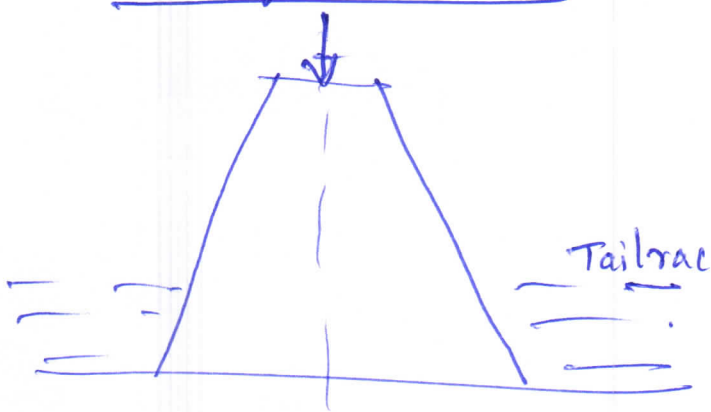
3) Environmental Impacts: Bringing up cold, nutrient-rich deep ocean water can disrupt marine ecosystems. Additionally, large volume of seawater moving through the system can injure or kill marine organisms caught in the intake pipes.

4) Technical Hurdles: OTEC is a developing technology, and challenges remain in designing efficient cold water pipes (CWP) for large-scale OTEC plants beyond 10MW capacity.

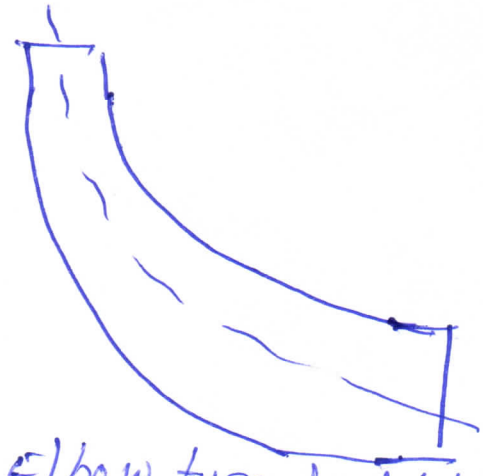
Q.8 c) Explain the following terms related to hydroelectric power plant: i) Penstock ii) Draft tube.

Ans. i) Penstock: Penstock is a large pipe that carries water under pressure from reservoirs to the turbine in hydraulic power plants. Penstocks are made of steel or RCC and can be several kilometers long and many meters in diameter depending on the size of the plant. The intake of the penstock at the dam should be positioned in such a way that it always provides water even at low head. They are inclined towards the power house and sharp bends are avoided to reduce head loss.

ii) Draft Tube:



Conical draft tube

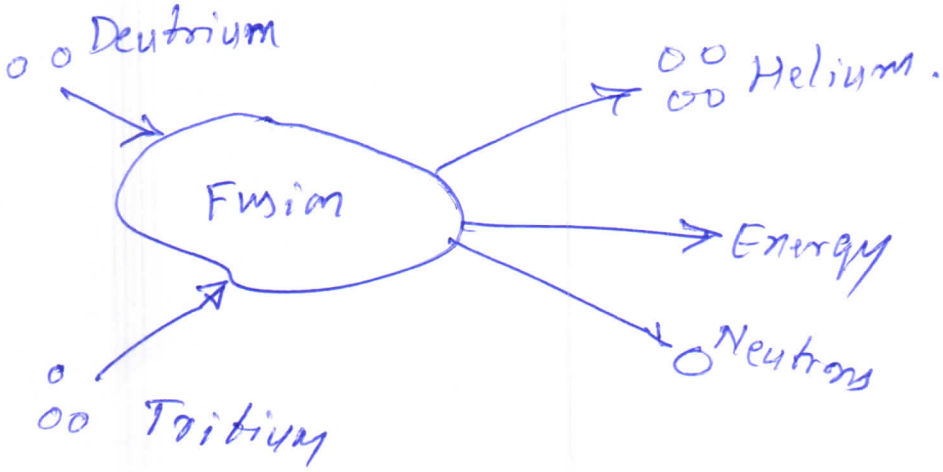


Elbow type draft tube.

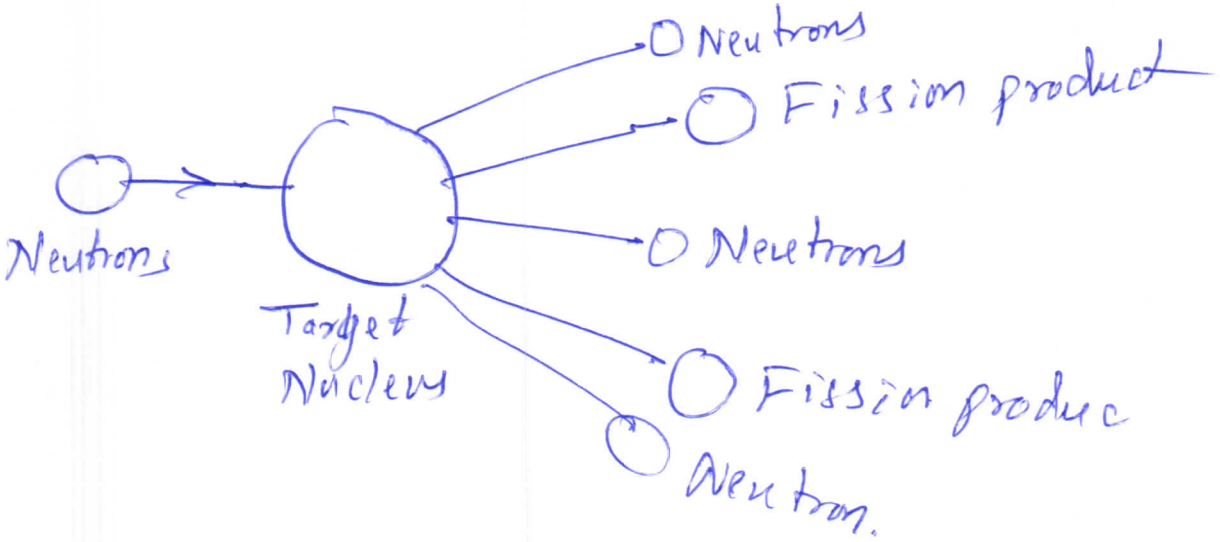
It allows the turbine to be set above the tailrace without loss of head to facilitate inspection and maintainance. The water leaving the turbine runner still posses some kinetic energy. The draft tube design helps convert this remaining KE into pressure energy. This recoved pressure helps increase the overall efficiency of the turbine by extracting more energy from the flowing water.

9.9a) Explain the principle of release of nuclear energy by fusion and fission reactions.

Sol^{n}:



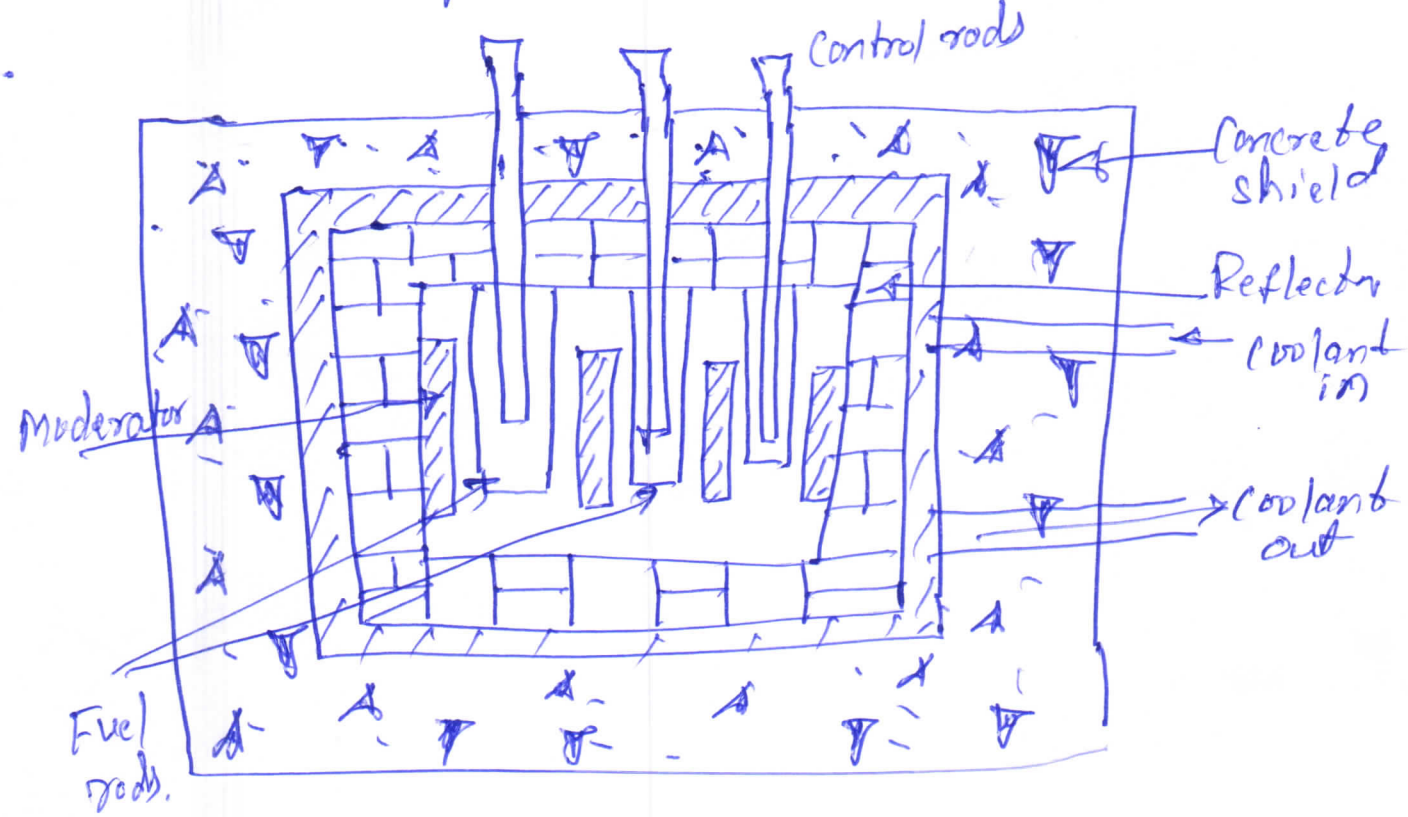
Fusion reaction



Fission reaction

Q.9b) Explain with a neat sketch, the general components of a nuclear reactor.

Ans.



Nuclear reactor is the heart of a nuclear power plant. It must be given utmost importance in design, operation and maintainance.

Important components of nuclear reactor are

1) Fuel rods
2) Control rods
3) Moderator
4) Reflector
5) Reactor vessel
6) Coolant.

Q.10 a) With a neat sketch explain the working of Pressurized Water Reactor (PWR).

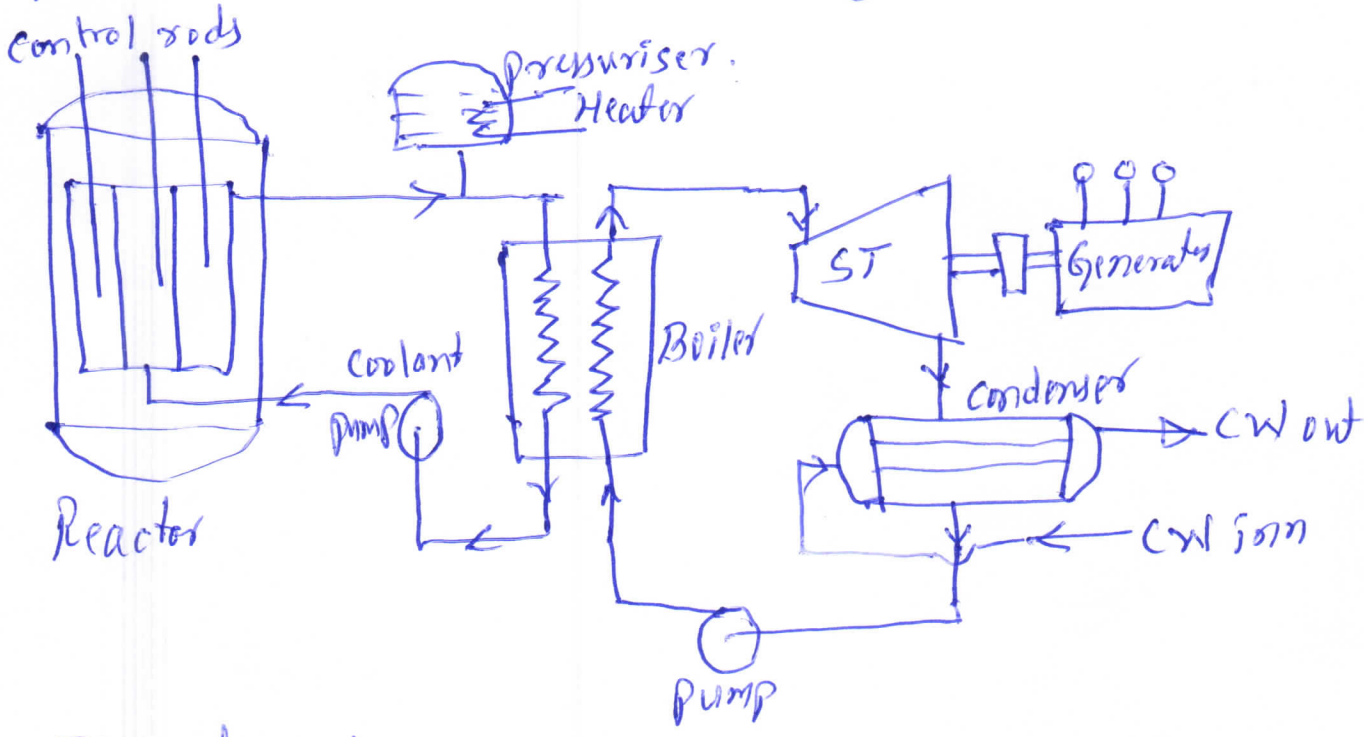


Fig shows the schematic arrangement of a PWR. This reactor falls under the category of a single Circuit coolant cycle type of reactors. This uses enriched Uranium as fuel and water as the moderator like a BWR. The only difference is that the coolant itself is not the working medium, but transfers heat to water in the steam cycle as shown in fig.

The coolant enters the reactor from the bottom, Picks up heat and comes out from the side. In the same circuit a pressurizer is provided, the function of which is to maintain a constant high pressure in the coolant circuit (80–100 bar). This is achieved by heating water in the pressurizer by an external heating element which generates steam and collected at the ~~drum~~ dome. The steam generated then maintains its pressure on the water in the coolant cycle. Due to this the water in the reactor doesn't boil but carries more heat and transfers to the water in the steam cycle through heat exchanger (Boiler). The steam raised is used to generate power.

Q.NO.10b) Explain the following:
i) Reactor shielding
ii) Radio active waste disposal.

Ans. Reactor shielding: This is a thick concrete or lead wall which surrounds the whole reactor system. The main purpose of shielding is to avoid radiation hazards that may be caused by the escape of various radio active

radiation from the reactor core due to the nuclear reaction. The radiation particles released are neutrons, gamma, alpha, and beta rays. Of these the neutrons and gamma rays are deadly particles.

ii) Radio active waste disposal: In a nuclear power plant operation, the reactor produces α, β, γ and neutron radiations. Of all these, γ radiation is the most dangerous which is capable of destroying all the biological matter and living being with which it contacts. However the nuclear operation waste are more dangerous which emits a high intensity nuclear radiation.

The solid wastes are usually dumped under deep ground or sea. The wastes are to be protected from the external environment so that the radiation does not spread. For this some sealing methods are used. There are two common methods adopted for sealing the solid waste.

a) Cement Casting: The wastes are cast in Cement in a steel drum. The main advantage of sealing with cement is that Cement ones sets it is quite strong, non combustible

resists leaching of ground water and completely protects from the environment. The steel drum provides additional safety against handling damages and exposes to Cast wastes.

b) Borosilicate glass capsule: In this, the wastes are sealed in a borosilicate glass capsule and stored in leak tight steel capsules. The borosilicate glass capsules are corrosion resistant, they avoid any physical Contact and Contamination with external environment. The steel covers protect against handling damages and keep the glass capsule safe and strong.

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