Assignment - II

1. Explain the advantages, Disadvantages and classification of hydro-electric plant -> ?

A:-

Hydro-electric plants use the energy of flowing or falling water to generate electricity.

Here is an overview of their advantages, disadvantages, and classification:-

Advantages:-

1. Renewable Energy Source: Hydro-electric plants use water, a renewable resource, which makes them a sustainable option for generating electricity.

2. Low operating costs:- once constructed, the costs for operating and maintaining hydro-electric plants are relatively low compared to fossil fuel-based plants.

3. clean Energy:- They produce no direct emissions, helping to reduce greenhouse gas emissions and air pollution.

4. High Efficiency: Hydro-electric plants have a high energy conversion efficiency, often exceeding 90%.

5. Long lifespan :- properly maintained hydro-electric plants can operate for several decades.

Disadvantages of Hydro-Electric plants :-

1. High initial cost :- The construction of dams and hydro-electric plants requires significant capital investment.

2. Enviromental Impact :- The creation of reservoirs can lead to the displacement of communities and wildlife, and affect aquatic ecosystems.

3. Geographical limitation :- Suitable sites for hydro-electric plants are limited to areas with sufficient water flow and appropriate topography.

4. Seasonal variability: The efficiency of hydro-electric plants can be affected by seasonal variations in water availability.

5. potential for catastrophic Failure: -
Dam failures, though rare, can have catastrophic consequences for downstream areas.

6. Impact on water quality: -
Alteration of water flow can affect the quality and temperature of water downstream, impacting aquatic life.

Classification of Hydro-Electric plants: -

1. Based on capacity: -
→ Micro Hydropower: up to 100kW
→ Mini Hydropower: - 100kW to 1MW
→ Small Hydropower: - 1MW to 10MW
→ Medium Hydropower: - 10MW to 100MW
→ Large Hydropower: - More than 100 MW

2. Based on the water flow regulation: -
→ Run of the River plants: utilize the natural flow of rivers without significant storage.

→ Reservoir plants: use dams to store water and regulate flow for consistent power generation.

→ pumped storage plants :-
pump water to a higher elevation during low demand and release it during peak demand.

3. Based on the Type of turbine :-

→ Impulse Turbine plants :-
use high-head water flow to spin turbine.

→ Reaction Turbine plants :-
utilize low head and high flow water to spin turbines.

2. With a neat sketch, Explain: Hydrographs and flow duration curves, storage and pondage, pumped storage plants.

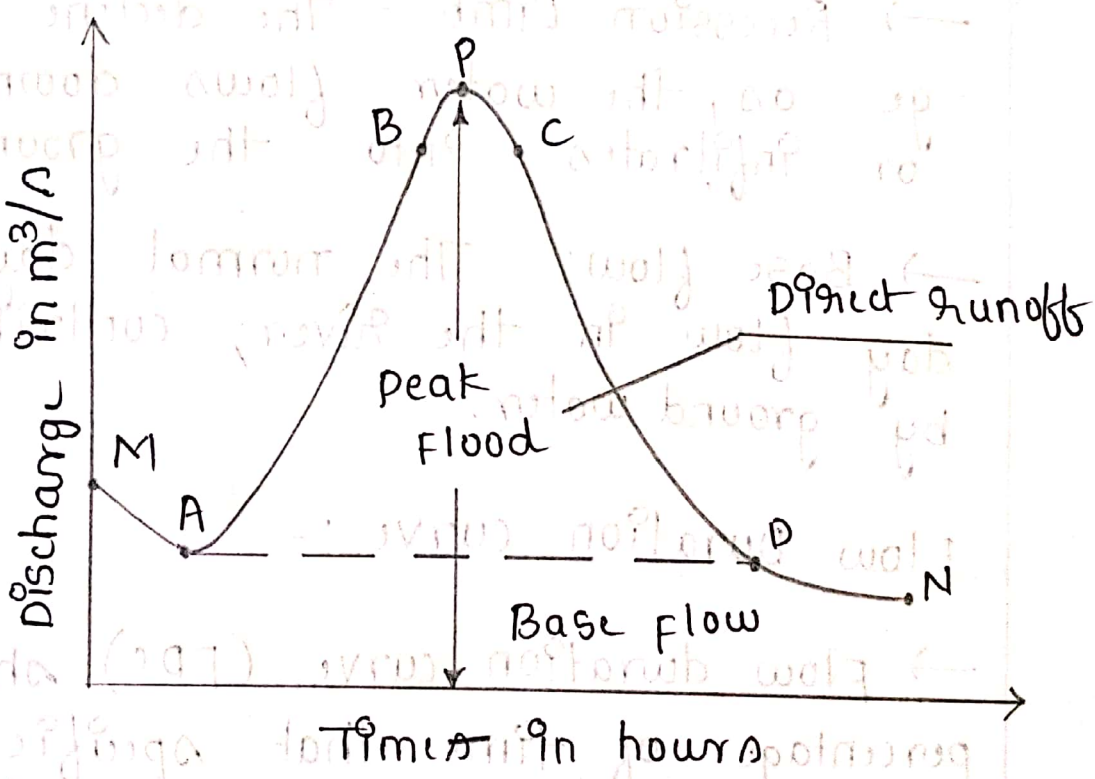
A :-

Hydrograph :-

→ A hydrograph is a graphical representation of river discharge over time at a specific point in the river. It typically shows how water flow varies throughout different seasons or during specific events like storms.

→ Hydrographs are essential for understanding the water availability and flow patterns in a river, which is crucial for designing and operating hydroelectric plants.

→ Key components of a Hydrograph:-



MA = Base flow recession
AB = Rising limb
BC = Crest segment
CD = falling limb
DN = base flow recession
points B and C = Inflection points.

→ Rising Limb :- Represents the increase in river discharge following a rain event.

→ peak Discharge: The highest flow rate observed during the event.

→ Recession Limb :- The decline in dischar-ge as the water flows downstream or infiltrates into the ground.

→ Base flow :- The normal day-to-day flow in the river, contributed by ground water.

Flow Duration curve :-

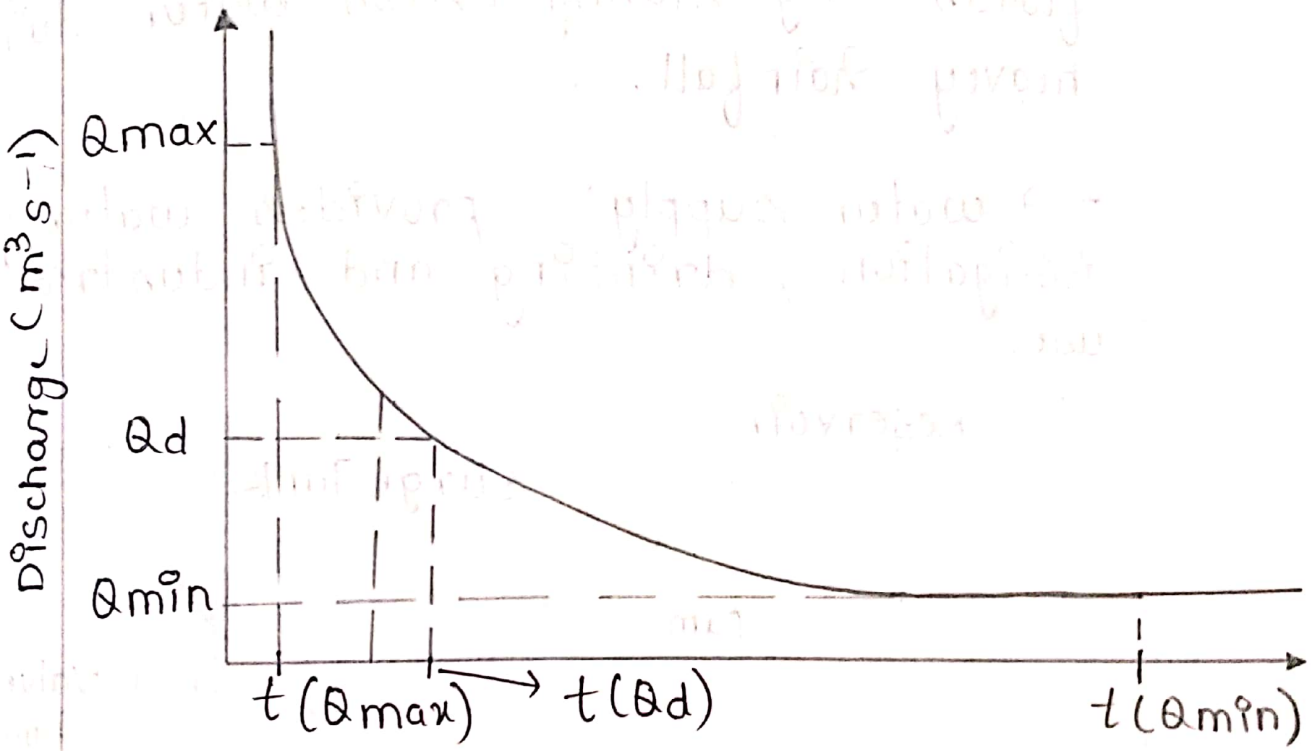
→ Flow duration curve (FDC) shows the percentage of time that specific discharge rates are equaled or exceeded over a given period. It helps in understanding the variability and reliability of river flows.

→ Key features :-

1). High flow periods :- Represent the period when the river flow is high.

2). Median flow : The flow that is equaled or exceeded 50% of the time.

3). Low Flow periods :- Represent the period of low discharge, crucial for knowing the minimum flow available.



→ percentage of time indicated flow was equaled or exceeded

Storage :-

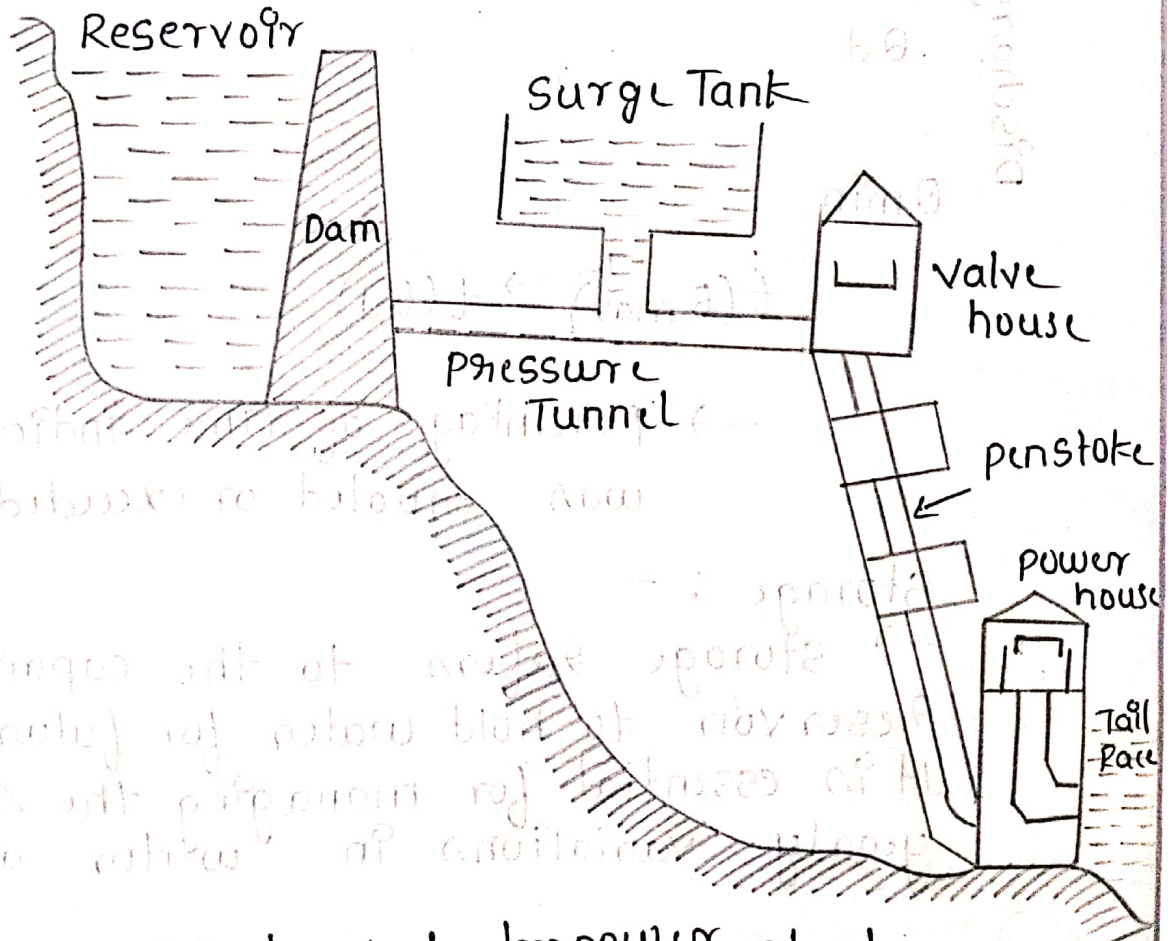
→ Storage refers to the capacity of a reservoir to hold water for future use. It is essential for managing the seasonal and yearly variations in water availability.

Key functions:-

→ Regulating flow: Ensures a consistent flow of water for power generation.

→ Flood control: Helps in controlling floods by storing excess water during heavy rainfall.

→ water supply:- provides water for irrigation, drinking and industrial use.



High head hydropower plant

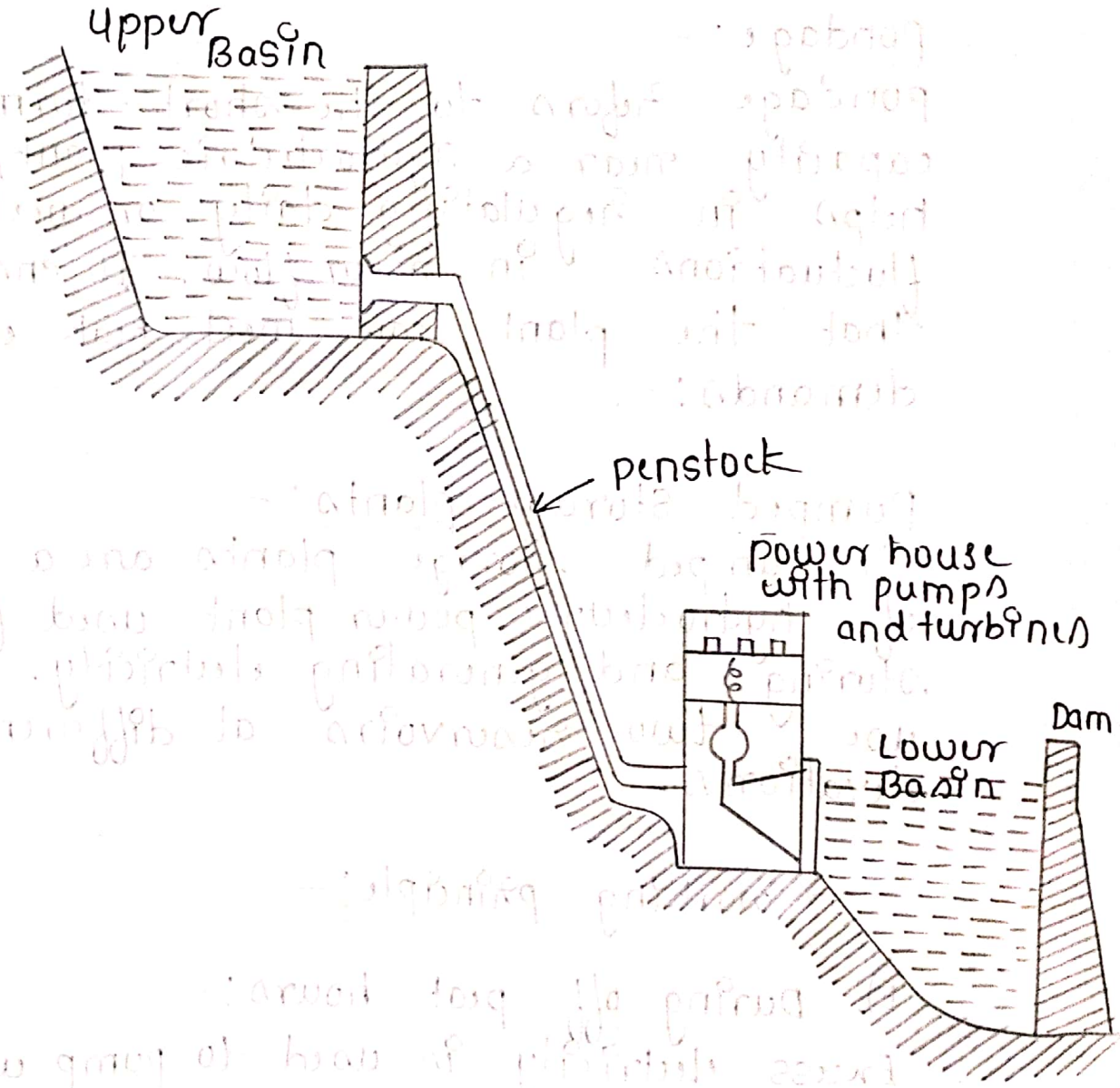
pondage :-
pondage refers to the short-term storage capacity near a hydroelectric plant, which helps in regulating daily or weekly fluctuations in river flow. It ensures that the plant can meet peak electricity demands.

Pumped storage plants :-
→ pumped storage plants are a type of hydroelectric power plant used for storing and generating electricity. They use two reservoirs at different elevations.

⟶ working principle :-

1). During off-peak hours :-
Excess electricity is used to pump water from the lower reservoir to the upper reservoir.

2). During peak hours :-
water is released from the upper reservoir to the lower reservoir through turbines to generate electricity.



pumped storage power plant

Benefits:

→ Energy Storage:- Efficiency in storing energy for use during peak demand.

→ Grid stability:- Helps in balancing supply and demand on the electrical grid.

3. With a neat diagram, explain the Dam hydrograph Electric plant and state the importance of penstock, water hammering, surge tanks, spill ways, and Draft tube and its Applications.

A:-

- **Dam Hydroelectric plant:** -

→ A dam hydroelectric plant converts the potential energy stored in a reservoir into electrical energy.

→ This is achieved by directing water through turbines, which in turn drive generators to produces electricity.

- **Key components and Their importance:** -

1. **penstock**

→ Function:- penstocks are large pipes or conduits that transport water from the reservoir to the turbines.

→ Importance:- pentocks ensure that water is delivered at high pressure to the turbines, maximizing the kinetic energy available for electricity generation.

→ Application:- Critical in Hydroelectric plant to maintain high efficiency and effective power generation.

2. Water Hammering :-

→ Explanation :- water hammer refers to the surge of pressure caused by a sudden stop or change in the flow of water within a pipeline.

→ Importance :- This phenomenon can cause severe damage to pipelines, penstocks, and other hydraulic structures due to high pressure surge.

→ Mitigation :- To mitigate water hammering, surge tanks and pressure relief devices are employed.

→ Application :- Essential in hydroelectric plants to ensure the safety and integrity of the water conveyance system.

3. Surge Tanks :-

→ Function :- Surge tanks are reservoirs installed along the penstock to absorb sudden pressure changes and fluctuations in water flow.

→ Importance :-
They help stabilize the pressure within the penstock, preventing water hammer -ing and ensuring smooth operation of the turbines.

→ Application :-
used in hydroelectric systems to manage transient flow conditions and consistent water delivery to the turbines.

4. Spillways :-
→ Function : Spillways are structures that allow excess water to be released from the reservoir to prevent overtopping dam.

→ Importance : Spillways are crucial for flood control and protecting the dam structure from potential damage due to excessive water pressure.

→ Application :- Implemented in dam designs to safely manage high inflow events such as heavy rainfall and snowmelt.

5. Draft Tube :-
→ Function : The draft tube is a conduit which connects the turbine outlet to the

downstream water level, creating a partial vaccum that improves turbine efficiency.

→ Importance:- By reducing the pressure at the turbine exit, the draft enhances the energy conversion efficiency of turbi-nes.

→ Application:- Integral in the Hydro-electric plants to improve/optimize turbi-ne performance and maximize electricity generation.

4. Explain the following: Advantages, Limita-tions, fundamental characteristics, single Basin and Double Basin Arrangements of Tidal power generation.

A:-

Tidal power generation:-

→ Tidal power generation harnesses the energy from the rise and fall of tides to produce electricity.

→ This is achieved by capturing the potential and kinetic energy of seawater during tidal movements.

Single Basin Arrangement:-

→ A single basin tidal power system uses one basin to capture to capture water at high tide and release it at low tide.
→ This system can operate in one of two modes: ebb generation or flood generation.

a). **ebb Generation**:- water is allowed to fill the basin during high tide. At low tide, the water is released through turbines to generate electricity.

b). **Flood generation**:- water is stored in the basin during low tide. At high tide, the water is released through turbines to generate electricity.

Advantages:-

→ Simpler design and construction compared to double basin systems.
→ Lower initial cost due to fewer components.

Limitation:-

→ power generation is limited to tidal cycles,

leading to intermittent production.

→ Environmental impact on the estuary and marine life due to altered Tidal flows.

Double Basin Arrangement

→ A double basin tidal power system uses two basins to enhance control over the timing and quantity of water flow, allowing for more continuous power generation.

→ Upper Basin: Filled with water during high tide and releases it to generate power.

→ Lower Basin:- Receives water from the upper basin and releases it to the sea during low tide.

→ Advantages:-

1). More consistent power generation as water flow can be controlled between the two basins.

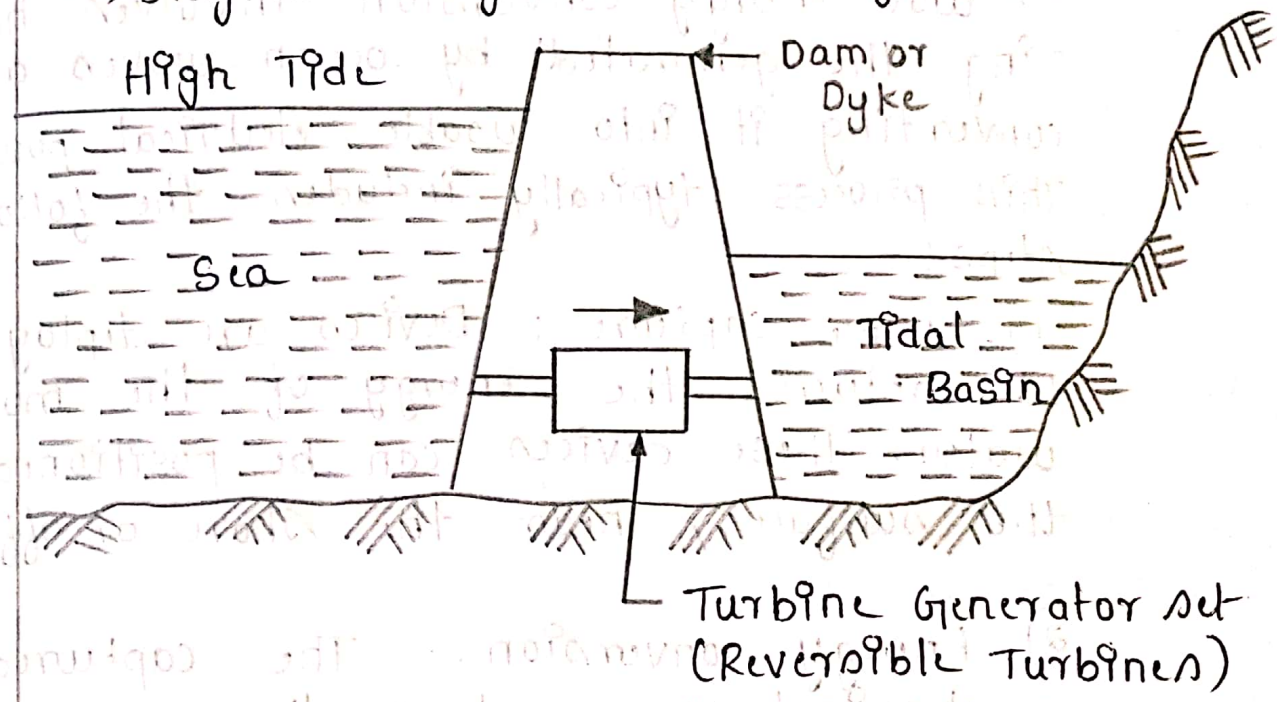
2). Reduced environmental impact as water flow can be managed more effectively.

→ Limitation :-

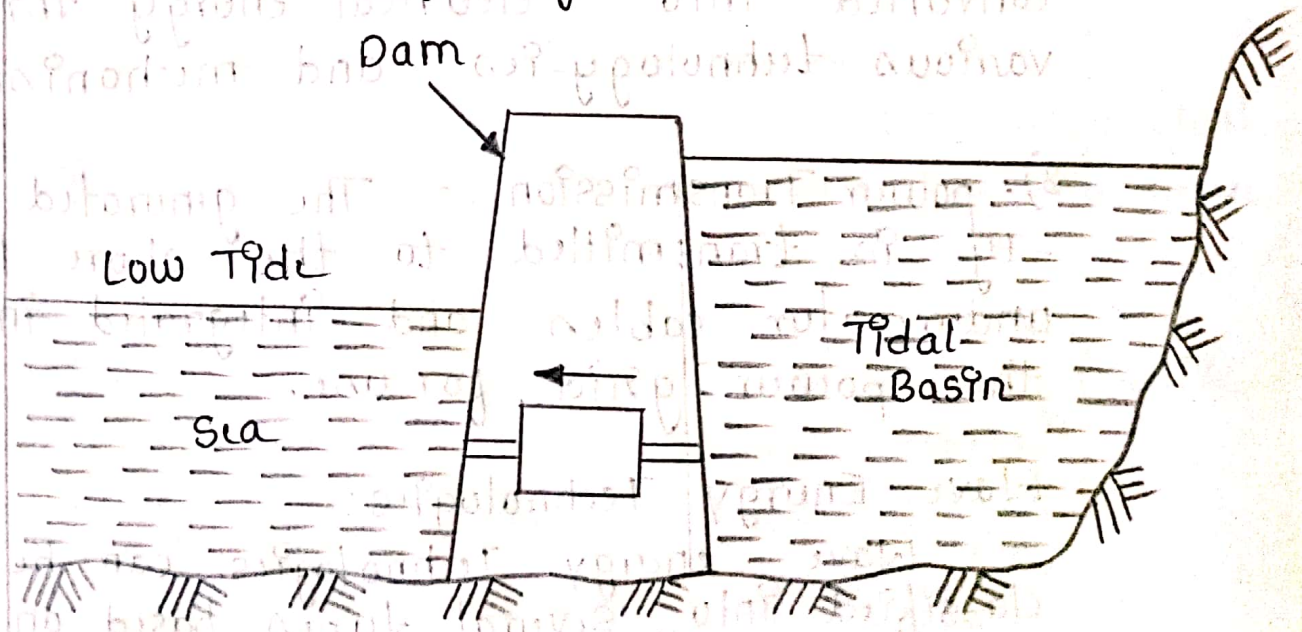
→ Higher initial cost due to more complex design and construction.

→ Requires more land and can have greater impact on local ecosystems.

→ Diagram :- single Basin arrangement



(a). High Tide



(b) Low Tide

5. Explain the following :- Wave Energy conversion process, wave Energy Technologies, Advantages and disadvantages.

A :-

Wave Energy conversion process :-

→ wave energy conversion involves harness -ing the generated by ocean waves and converting it into usable electrical power. This process typically includes the following steps :-

1). Wave capture : Devices are deployed to capture the energy of the moving water. These devices can be positioned on the surface, near the shore or offshore.

2). Energy conversion :- The captured mechanical energy from the waves is converted into electrical energy through various technologies and mechanisms.

3). power Transmission :- The generated electrici -ty is transmitted to the shore through underwater cables and integrated into the power grid for use.

Wave Energy Technologies :-

→ Wave energy Technologies can be broadly classified into several types based on their

operating principles and locations:-

1. point Absorber :-
→ These are floating structures that absorb energy from all directions. They typically consist of a buoy that moves with the waves, generating electricity through mechanic -al or hydraulic systems.
→ Eg:- power Buoy

2. Oscillating water columns (OWC):-
→ These systems use the rise and fall of water levels within a chamber to drive air through a turbine, generating electricity. The air is compressed by the oscillating water column.
→ Eg:- Limpet.

3. Attenuators :-
→ These are long, multi-segmented floating structures aligned parallel to the wave direction.
→ They capture energy by flexing and moving with the wave, driving hydraulic pumps or other conversion system.
→ Eg:- Pelamis.

4. Overtopping Devices
→ These devices capture water as waves break over a structure, channeling it into a reservoir. The stored water is then released through low-head turbines to generate electricity.
→ Eg:- Wave Dragon.

5. Terminators:-
→ These are devices that are placed parallel to the waves direction and capture or reflect the energy of the wave. They include various designs like oscillating wave surge converters.
Eg:- oyster.

→ Advantages of wave energy:-

1. Renewable and sustainable: wave energy is a renewable resource, driven by wind, which is in turn driven by the sun. It is inexhaustible as long as there are winds to generate waves.

2. Low Environmental Impact:- Wave energy devices have a relatively small environmental footprint compared to other energy generation methods, with minimal emissions and pollution.

3. High energy density :- waves have higher energy density as compared to other renewable sources like wind and solar, providing more efficient means of capture.

4. predictability :- wave patterns are more predictable than wind and solar energy, allowing generation and integration of more reliable energy into the power grid.

→ Disadvantages :-

1). High initial cost :- The development and deployment of wave energy technologies require significant capital investment due to complexity of the systems

2). Technological challenges :- Wave energy technologies are in the developmental stage, facing challenges related to durability, efficiency and scalabity.

3). Environmental concern :- while the impact is generally low, the installation and operation of wave energy devices can affect marine life and ecosystems, particulary during construction and maintenance.

4). Intermittent Energy production :- It is dependent on wither conditions.

6. Explain : open and closed cycle OTEC system using Rankine cycle.

A:- • Open Thermal Energy conversion (OTEC):-

→ OTEC systems exploit the temperature difference between warm surface seawater and cold deep seawater to generate electricity. This Temperature difference drive a heat engine, typically following the Rankine cycle, to produce power.

Rankine cycle overview:-

→ The Rankine cycle is a thermodynamic cycle that converts heat into mechanical work, which is then used to generate electricity.

→ It consists of 4 main processes:-

1). Evaporation:- A working fluid is evaporated by heat from the warm surface seawater.

2). Expansion:- The vapourized fluid expands through a turbine, producing mechanical work.

3). condensation:- The vapour is condensed using cold deep sea water.

4). pumping : The condensed fluid is pumped back to the evaporator, completing the cycle.

→ open cycle OTEC :-

In an open cycle OTEC system, warm seawa-ter itself acts as the working fluid.

• process :-

1). warm Seawater Evaporation : warm surf-ace sea water is pumped into a low-press-ure chamber, where it boils and turns into steam due to the reduced pressure.

2). Steam Expansion :- The steam expands thro-ugh a turbine, generating electricity.

3). condensation :- The low pressure steam is then condensed using cold deep seawater

4). Discharge :- The condensed water, now desa-linated, is discharged back into the ocean.

→ closed cycle OTEC :-

In a closed cycle OTEC system, a working fluid low boiling point, such as ammonia or a refrigerant, is used.

• process :-

1). working Fluid Evaporation :-

→ warm surface seawater heats and evaporates the working fluid in a heat exchanger (evaporator).

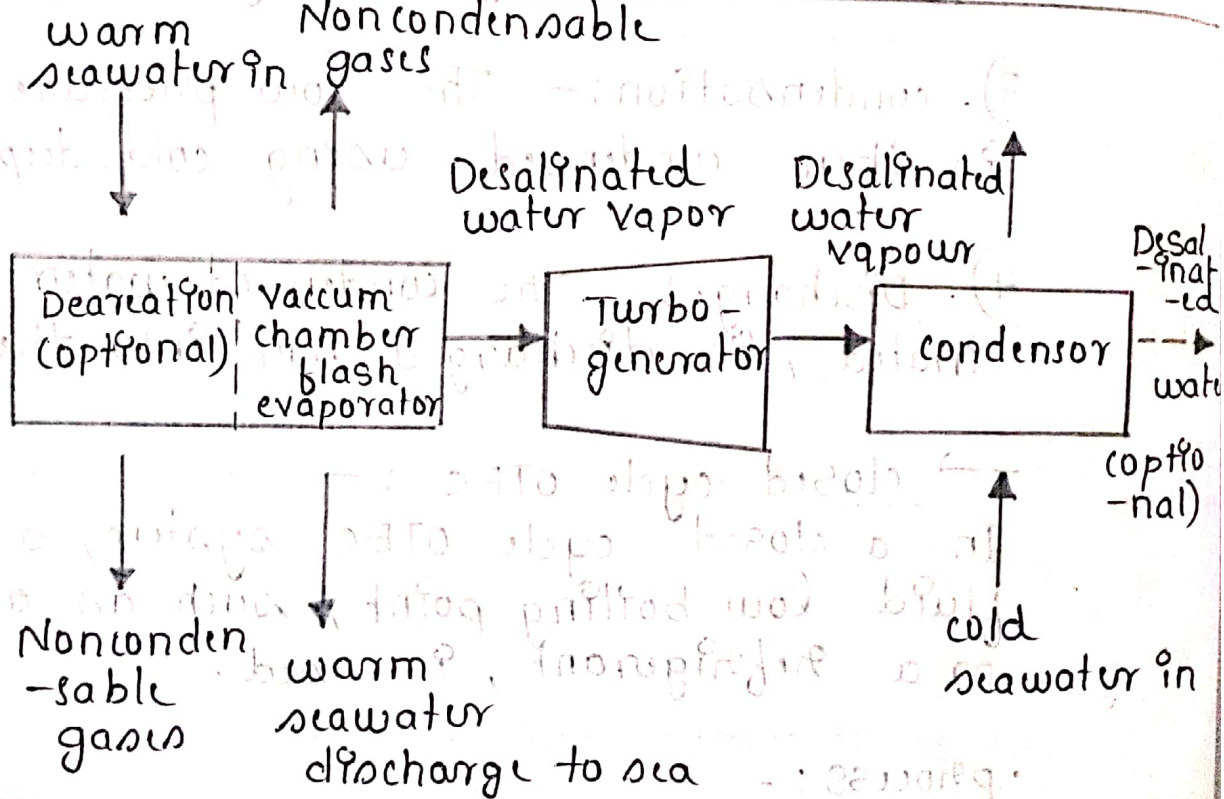
2). Steam Expansion:-

→ The vaporized working fluid expands through a turbine, generating electricity.

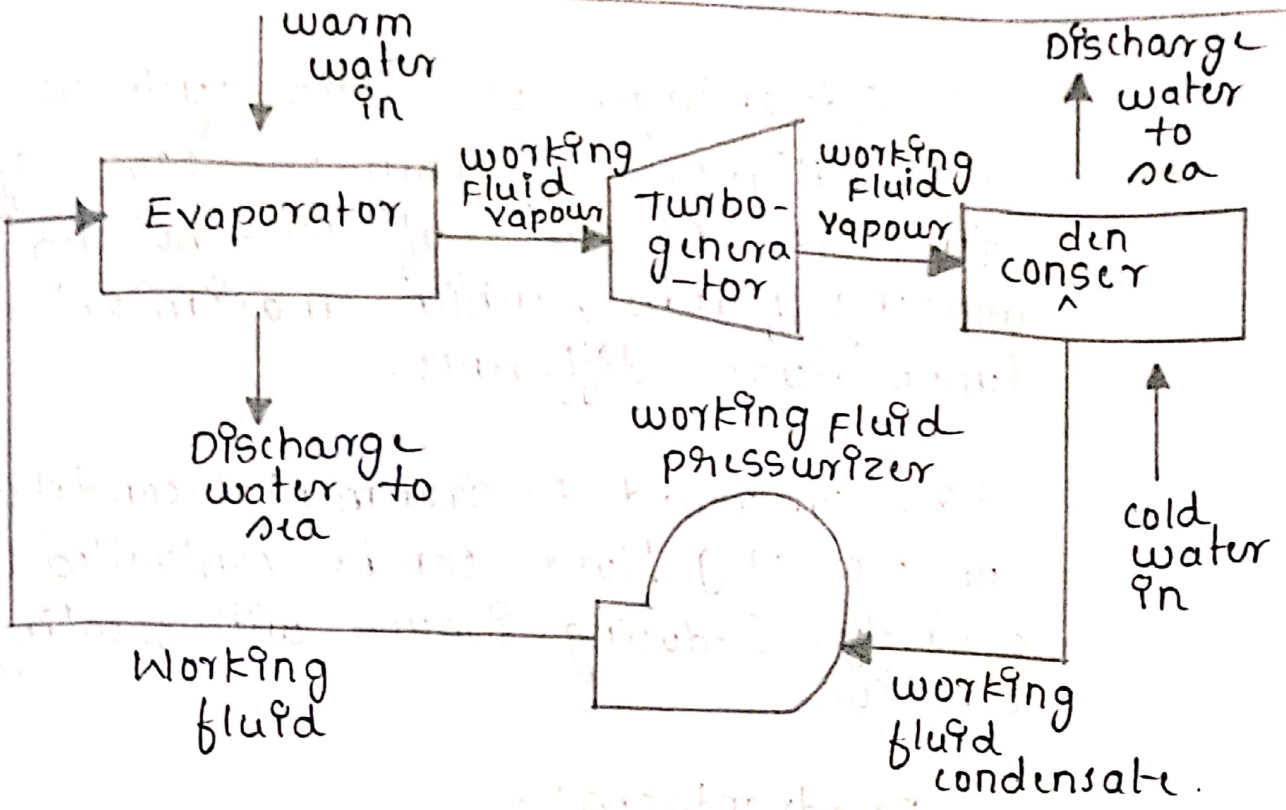
3). condensation:-

→ The vapour is condensed using cold deep seawater in a condensor.

4). pumping back:- The condensed working fluid is pumped to the evaporator to repeat the cycle.



open-cycle OTEC



closed - cycle OTEC

→ Advantages of open cycle OTEC :-

1). Desalination : produces fresh water as a by product, which is valuable in costal and island region.

2). Simpler system :- Direct use of seawater simplifies the system and reduces the need for the working fluid.

→ Disadvantages of open cycle OTEC :-

1). Lower efficiency : Typically less efficient than closed cycle systems due to lower temp. difference.

2). Scaling and corrosion :- seawater can cause scaling and corrosion in system compon-ents.

→ Advantages of closed cycle OTEC:-

→ 1). Higher Efficiency :- More efficient due to the use of low-boiling point working fluids, which maximize the temperature difference.

→ 2). Controlled Environmental condition:- The working fluid can be controlled more precisely, reducing issues with scaling and corrosion.

→ Disadvantages:-

1). complexity :- More complex system with additional components such as heat exchangers.

2). Environmental Impact:- potential environmental impact from the leakage of working fluids.

7. List the OTEC power stations in the world and problems associated with it.

A:- List of OTEC power stations in the world:-

1. Natural Energy Laboratory of Hawaii Authority (NELHA), Hawaii, USA. (100 kW)
2. Saga university OTEC plant, Japan (30kW)
3. kumejima OTEC plant, Japan. (50kW)
4. Nauru OTEC plant, Nauru. (100kW)

5). Themis OTEC pilot plant, Martinique, Caribbean. (100 MW)
6). NTT Facility, Okinawa, Japan. (50kW)
7). Hainan OTEC project, China. (10MW)
8). Karina project, Jamaica. (5-10 MW)
9). National Institute ocean Technology, India.

→ problems associated with OTEC:-

1). High initial cost:- significant capital investment required for specialized equipment and infrastructure.
2). Environmental concerns:- potential impacts on marine ecosystems and local biodiversity.
3). Limited suitable locations:- requires a significant temperature gradient, typically found in tropical region.
4). Energy transmission:- Expensive and technically challenging to transmit electricity from offshore to onshore.
5). operational and Maintenance challenges:- High salinity, biofouling and corrosion increase maintainance costs.

8. List the Geothermal stations in the world, and state its advantages, disadvantages, working principle and Nature of Geothermal fields.

A:- List of Geothermal power stations:-

1). The Geysers, USA
· Location = California, capacity: 900MW

2. Larderello, Italy :- Location : Tuscany
capacity : 769 MW

3. Makban Geothermal complex, philippines :-
→ Location : Luzon
→ capacity : 458MW.

4. Salak Geothermal plant :- Location :- west Java, Indonesia.
→ capacity :- 377 MW

5. Darajat Geothermal plant, Indonesia :-
→ Location :- west Java
→ capacity :- 270MW.

→ Advantages of Geothermal Energy :-

1). Renewable :- Geothermal energy is a sustaina-ble and virtually inexhaustable.

2). Low Emission :- produces significantly lower greenhouse gas emissions as compared to fossil fuels.

3). Baseload power :- provides a constant and reliable source of electricity, unlike intermitten renewables like wind and solar.

4). Small footprint :- Requires less land area compared to wind and solar farms.

5). Local Job creation :- promotes local employ-ment opportunities in drilling, plant construction, and maintainance.

→ Disadvantages :-

1). High initial cost :- significant upfront investment is required for drilling and plant construction.
2). Geographic Limitation :- Effective only in regions with accessible geothermal resources.
3). Environmental Impact :- potential for land subsidence, water contamination and induce -d seismicity.
4). Resource Depletion :- over time, the geo - thermal reservoir can cool down if not managed sustainably.
5). corrosion and scaling :- Geothermal fluids can be corrosive, leading to maintainance challenges.

• Working principle of Geothermal power plant.

1). Heat Extraction :- Geothermal power plant -s tap into underground reservoirs of hot water and steam.
2). Fluid production :- wells are drilled into geothermal reservoirs to bring hot water or steam to the surface.
3). Energy conversion :-
→ Dry steam plants :- use steam directly from a geothermal reservoirs to turn turbin -es.

→ Flash steam plants :- Hot water is depressurized to produce steam, which drives turbines.

→ Binary cycle plants :- use a secondary fluid with a lower boiling point than water, which is vaporized by geothermal heat to turn turbines.

4). Electricity Generation :- The steam or vapour turns a turbine connected to a generator, producing electricity.

5). Reinjection :- used geothermal fluids are reinjected into the earth to sustain the reservoir.

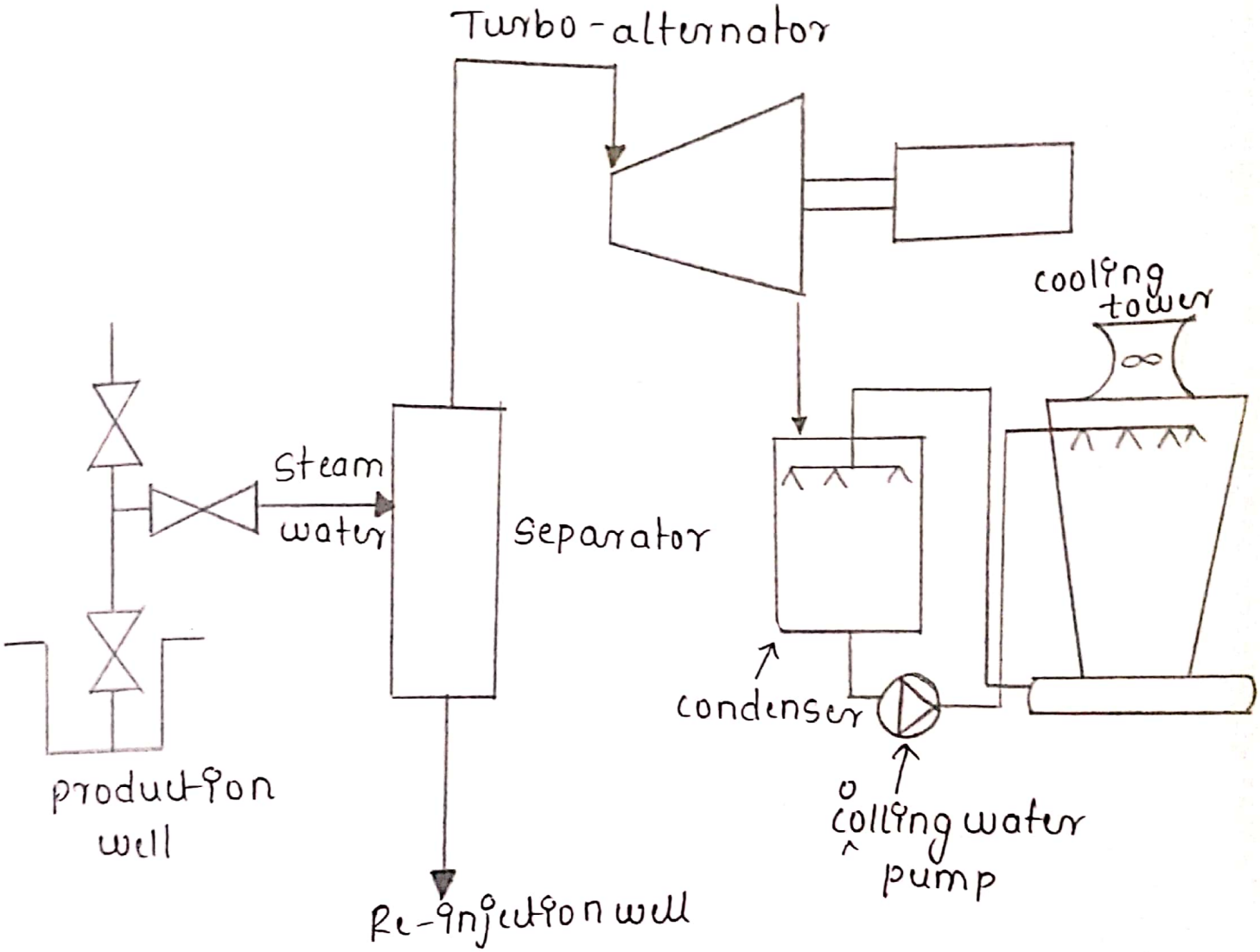
→ Nature of Geothermal Fields :-

1). Hydrothermal Fields :- contain hot water or steam reservoirs accessible via drilling. commonly used for electricity generation and direct heating.

2). Hot Dry Rock (HRD) Fields :- consist of high-temp. rocks lacking significant water content. Enhanced Geothermal systems (EGS) are use to fracture the rock and introduce water.

3). Geopressured Fields :- contain hot water and natural gas under high pressure. These fields have the potential to produce both geothermal energy and natural gas.

4. Magna Resources :- utilize the immense heat from molten rock (magma) beneath the earth's surface. This type of resource is still largely experimental.



geothermal condensing power plant