UNIT-03

RENEWABLE ENERGY RESOURCES

ONE SHOT VIDEO

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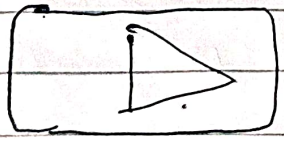
Topics :-

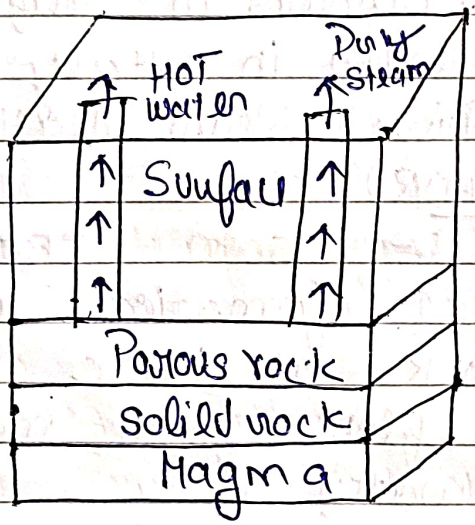
- Geothermal Energy
- Classification of Geothermal Energy
- System used for generating the power using G.E
- MHD Generating system and its type
- Fuel cells and its types and reaction
- Application
- Fuel cells vs Battery
- Geothermal Power plant vs thermal Power plant



GEOTHERMAL ENERGY

- Geothermal energy is the heat that comes from inside the Earth
- This heat is natural energy resource that can be use for thing like making electricity and heating building.

=> The word "geothermal" is made up of "geo", which means Earth and "thermal", which means heat



=> Classification of Geothermal Energy Resources

1. Hydrothermal Systems
-> Temperature Range :- 90°C – 300°C (194°F – 572°F)
-> These are reservoirs of hot water and or steam stored underground in porous rocks or fractures
=> They are the most common type of gothermal

resource and are used for both electricity generation and direct heating
→ Example :- Geothermal power plants in Iceland and California.
→ Direct uses :- Heating, Agriculture, Industrial
2. Vapor-Dominant Resources
→ Temperature Range :- Typically 240°C - 320°C (464°F - 608°F)
→ These resources contains mostly steam under high pressure, making efficient for electricity production.
→ Steam is brought directly to the surface to drive turbine for power generation
→ Example :- The Geysers in California, USA
Larderello in Italy
→ Direct uses :- Direct Steam Heating, Industrial heating
3. Hot Dry Rock (HDR)
→ Temperature Range :- 150°C - 350°C (302°F - 662°F)
→ This is a geological formation with high temperature rock at 650°C heated by conductive heat flow from magma but contains no water
→ To trap its energy the impermeable rock is fractured and water is injected to create an artificial reservior
→ Water circulates and hot fluids returns to the surface through the other drilled well as steam and hot water, which are used to generate electricity
→ Direct use :- District Heating, Industrial Process

4. Geopressured Systems

→ Temperature range :- 90°C – 200°C (194°F – 392°F)

→ These systems contain hot water and dissolved natural gas trapped under high pressure. Both the hot water and gas can be used as energy sources

→ Example :- Geopressured resources in the Gulf Coast of the United States

→ Direct use :- Industrial Heat Applications

5. Magma - Based Systems

→ Temperature range :- can exceed 600°C (1112°F) and even reach up to 1200°C (2192°F)

→ Found near magma or molten rock, these resources have extremely high temperatures.

→ They are mostly in the research stage due to the technical challenges involved

→ Example :- Volcanic area like Hawaii and Iceland

→ Direct use :- Future Industrial Heat

Q Explain detail about different geothermal energy resources and mention its direct uses

[AKTU – 2023-2024]

Ans Done ! (Above Part)

Q Explain the working of geothermal power plants. Discuss the various technical development [AKTU – 2021-2022]

Sol Geothermal power plants generate electricity by tapping into the Earth's natural heat, which is stored in hot water and rocks beneath the surface.

Working :-

- Drilling and Accessing the Heat :- Wells are drilled into the Earth to reach geothermal reservior that contain hot water or steam

- Steam production :- The hot water or steam from the geothermal reservoir is extract through there wells.

→ The type of steam production system used depend on the temperature and pressure condition of the reservoir.

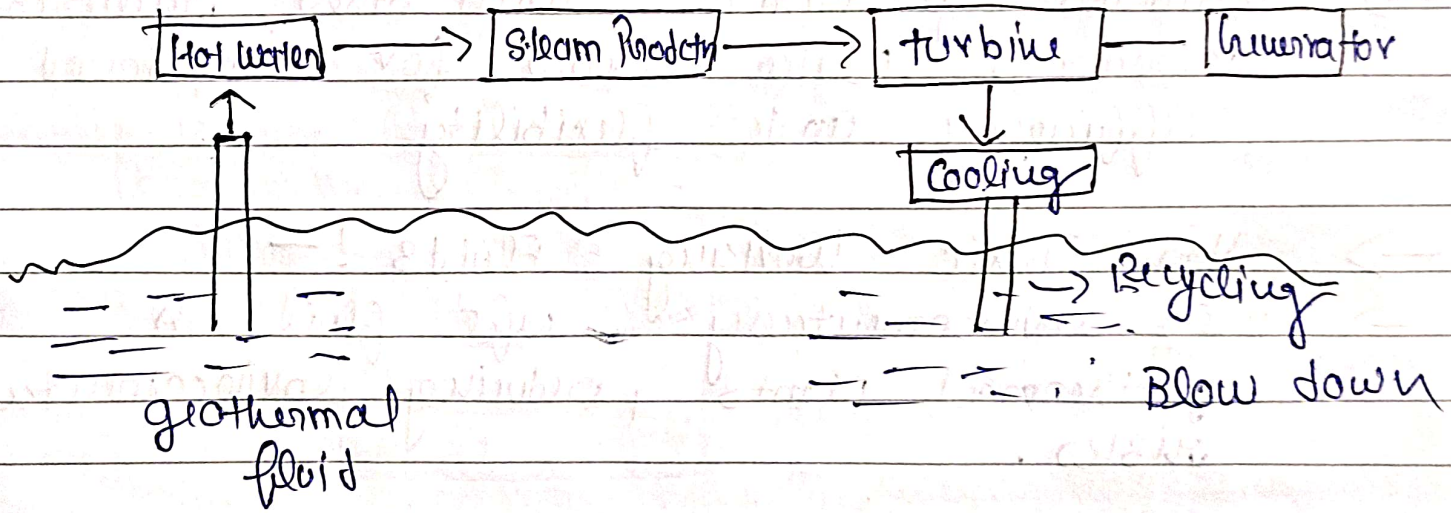
- Power Generation :- The steam, or in some cases hot water is directed towards turbines that spin when the steam hits them

• The spinning turbines are connected to generators which convert this mechanical energy into electricity.

① Cooling and Recycling

→ After passing through the turbine, the steam or water is cooled down, often in a cooling tower

→ The cooled water is then re-injected back into the ground to sustain the geothermal reservoir.



⇒ The various technical development are :-

→ Enhanced Geothermal Systems (EGS) :- (creates geo thermal energy by injecting water into hot dry rock to generate steam.

→ It expands geothermal use to areas without reservoirs (natural)

→ Advanced Drilling Technologies :-
→ New drilling techniques, like directional drilling, make it possible to access deeper, hotter geothermal resource more efficiently and at lower cost.

→ Supercritical Geothermal fluid :-
→ Harnessed superheated fluid (above 374°C) that carry more energy, increasing power generation efficiency.

→ Hybrid Geothermal system :-
→ Combines geothermal with other renewable resources (like Solar) for improved efficiency and flexibility.

→ Non-Toxic Working Fluids :-
→ Uses environmentally safe fluids in geothermal plants, reducing environmental risks.

→ Geothermal from low-Temperature Resources
→ Extract energy from low-temperature geothermal sources.

Q dry steam, wet steam and hot water geothermal system ?

=> Dry steam Geothermal System :-
-> In a dry steam system, steam directly comes from the Earths geothermal reservoir.
-> The steam is extracted from the ground and sent directly to from the ground and sent to turbines to generate electricity
Example :- The Geysers in California.

=> Wet steam Geothermal System :-
-> In a wet steam system, hot water is extracted from the geothermal reservoir, and when the pressure is lowered (flashed), some of it turns into steam.
-> The high-pressure hot water from the Earth is "flashed" (rapidly depressurized), causing part of it to turn into steam. The steam is then used to drive turbines
Example :- Flash steam plants are common and can operate in moderate to high temperature geothermal resources

=> Hot Water Geothermal System :-
-> These fields are similar to wet, steam fields but heat transfer from the dpth in much higher
-> These reservoirs produce superheated steam at pressure above atmosphere

-> The permeability of these fields is lower than wet fields.
-> The degree of superheating may reach up to 100°C

⇒ DIFFERENT SYSTEM USED FOR GENERATING THE POWER USING GEOTHERMAL PLANT

1. Vapour Dominated power plant

-> A vapour - dominant power plant uses steam (vapor) directly from the geothermal reservoir to generate electricity

components :-

1. Production Wells :- These wells bring steam from the underground reservoir to the surface.
2. Steam Turbine :- The steam from the reservoir spins this turbine to generate electricity
3. Generator :- Convert the mechanical energy from the turbine into electrical energy.
4. Condenser :- Cools the steam back into water, which is then re-injected into the geothermal reservoir
5. Re-injection Wells :- After condensation, the water is pumped back into the ground to maintain the pressure and supply

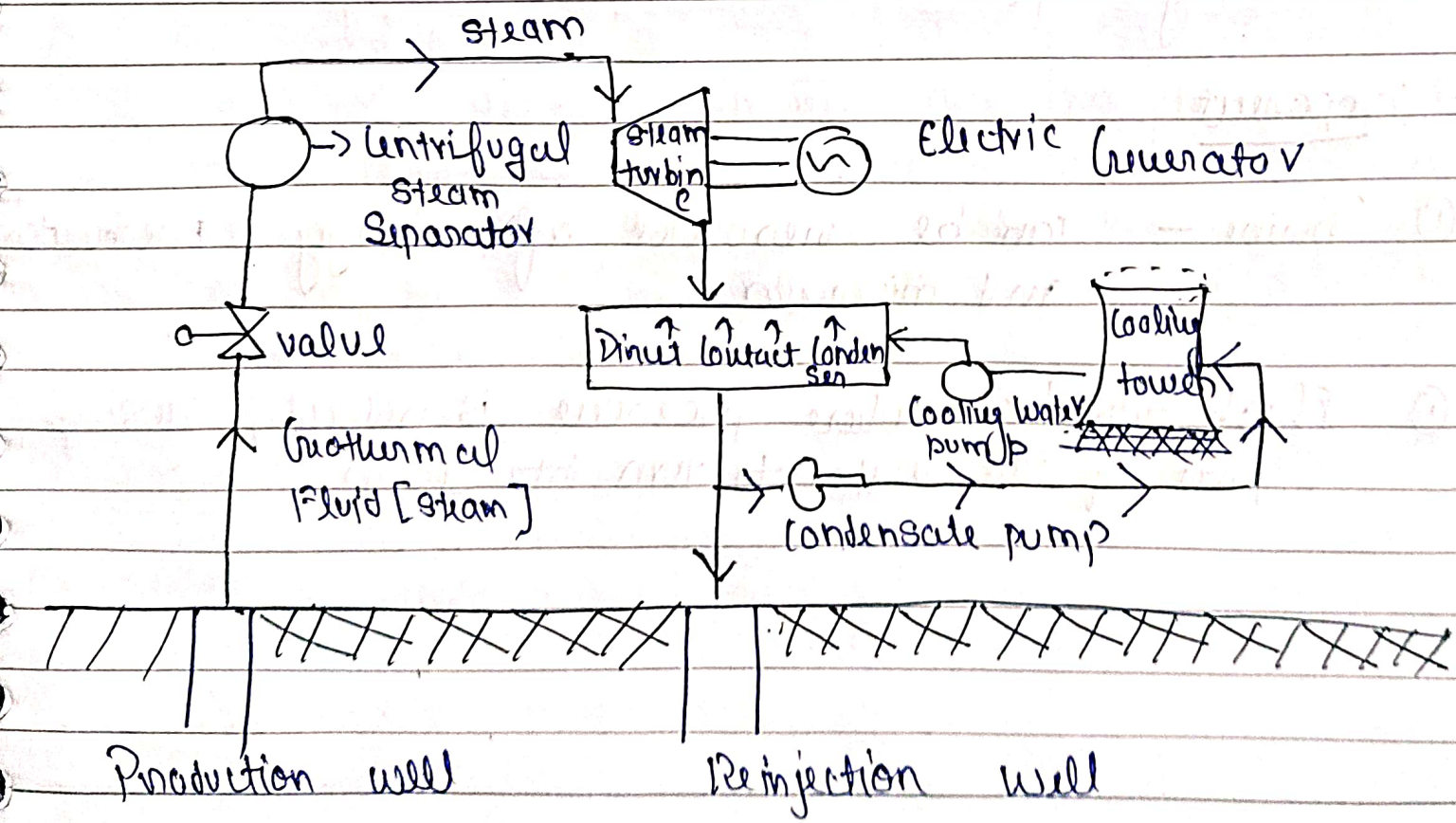
6. Valve :- Manage flow of water & steam. like start / stop, reduce / increase flow control the direction of flow.

7. Centrifugal steam separator :- Device from separating water droplets from steam & other impurities

8. Direct contact condenser :- One in which coolant is brought into contact with the vapour

9. Condensate pump :- Used in condensers to pump out the condensed steam as water

10 - Cooling water Pump :- Provide the fresh water to cool the exhaust steam in the condenser



2. Liquid - dominant Geothermal power plants

-> The liquid - dominant geothermal power plant can be classified based on how they handle and utilize hot water from the geothermal reservoir to generate electricity

a. Flashed Steam System :-

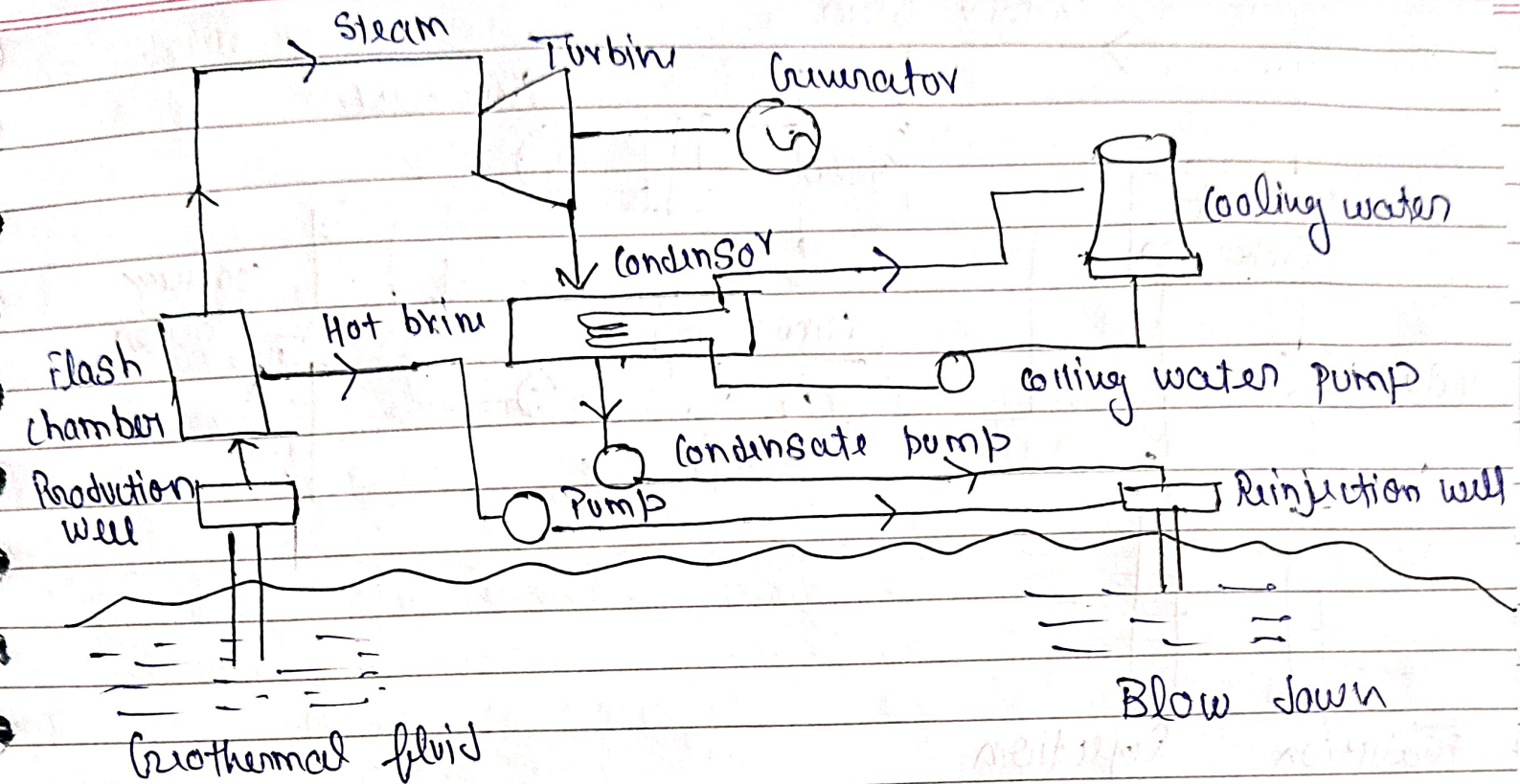
-> Flashed steam is preferred for high temperature mixture of geothermal brine and steam with low dissolved impurities

-> In this type hot water from the geothermal reservoir is brought to the surface under high pressure

Component

① Brine - can be resource of energy, Freshwater and minerals

① Flash tank :- Where pressure is reduced, causing part of the water to turn into steam



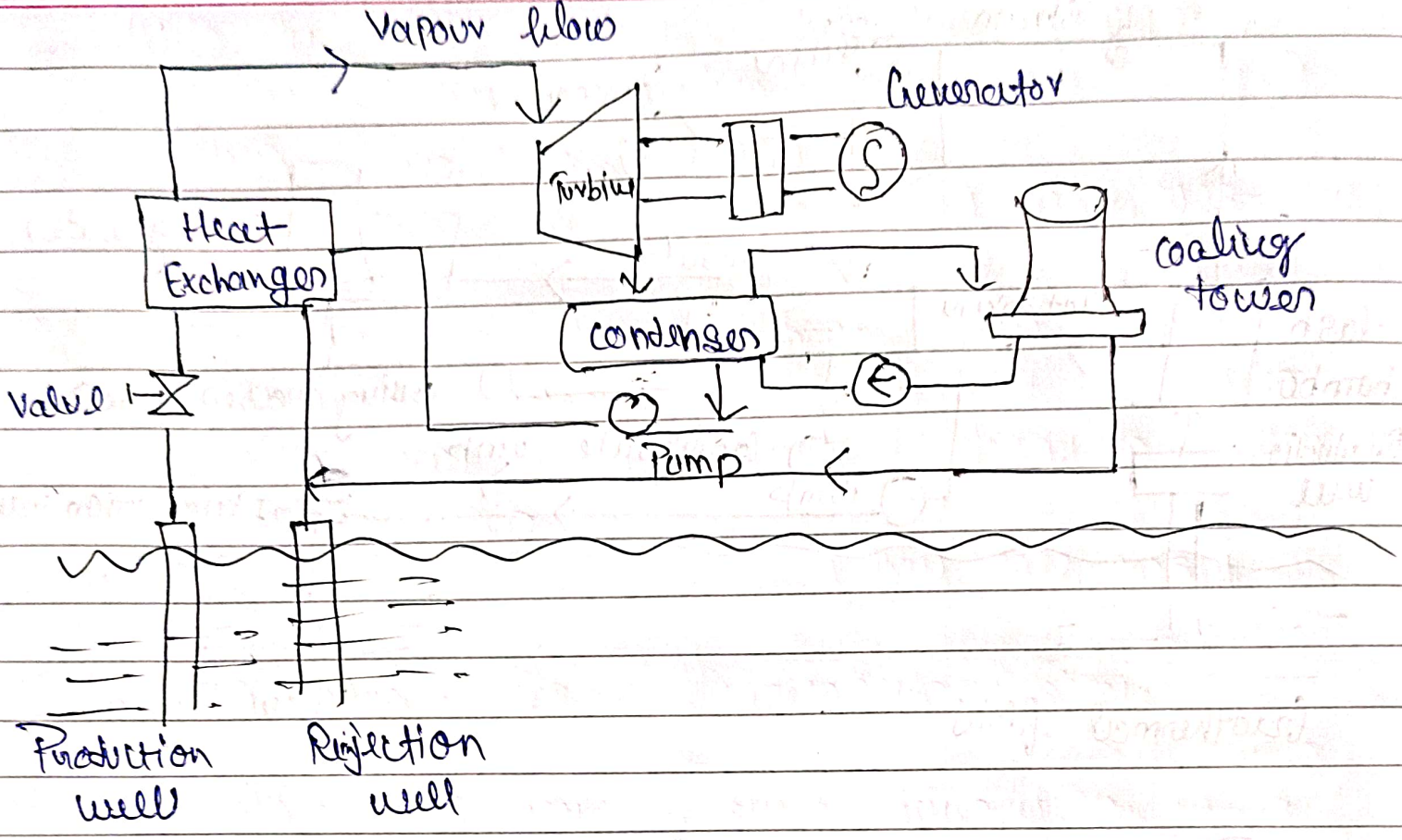
b. Binary cycle system :-

⊙ A binary cycle is used where geothermal fluid is hot water with temperature less than 100°C

⊙ This plant operates with a low boiling point working fluid (Isobutene or Freon) in a thermodynamic closed Rankine cycle.

Component :-

⊙ Heat Exchanger :- Transfer heat from the geothermal water to a secondary fluid with a lower boiling point



Application of Geothermal Energy

- Generation of electric power
- Space heating for building
- Production of salt from sea
- Textile industry

Geothermal Power Plant	Thermal Power plant
• It used inexhaustible sourc of energy	• It used exhaustible source of energy
• It is more environment friendly	• It is less environment friendly
• There power plants in some dangerous cases can caused earthquake	• There is no such problem
• It is mainly used for power generation process	• It can be used for various industrial processes
• Set up cost is high	• Setup cost is low
• Byproduct of there plants are not used	• Byproducts of there plant can be used
• There plant are less flexible	• There plants are more flexible
• Specified area is required	• There have no such restriction

Q With the help of a schematic diagram, explain the operation of closed cycle MHD generating system?

{AKTU 2021-2022, 2023-2024}

Q Illustrate in detail about MHD power generation system. Classify its system with clear flow chart diagram, application and it uses

{AKTU 2022-2023}

Sol MHD stands for Magnetohydrodynamic.

-> Magneto hydro dynamic power generation is a method of producing electricity by using a hot, electrically conductive gas (called plasma) that flows through a magnetic field.

-> This system does not have any moving part like turbines or piston. Instead the movement of the plasma within a magnetic field generates electricity.

-> MHD power generation is based on the Faraday's law of electromagnetic induction

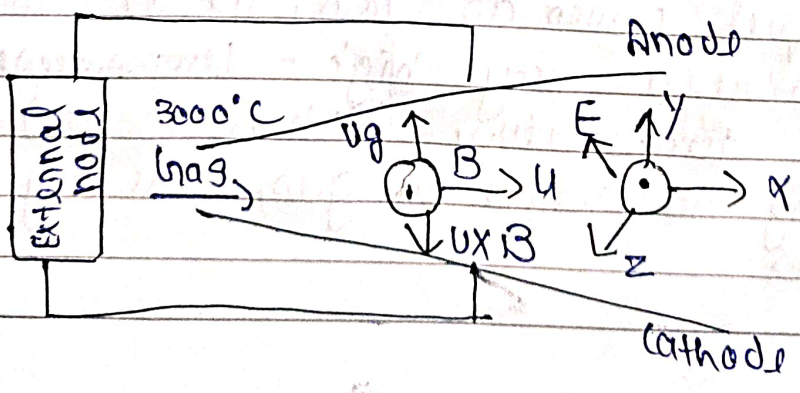
-> MHD system converts the kinetic energy of fast-moving ionized gases into electricity without using moving part

→ The MHD generator should meet the following requirements :-

- The magnet material should have high melting point
- The electrodes are made of SiC or ZrC material to withstand high temperature for preventing the chemical erosion
- To prevent the chemical erosion from hot gases the ceramics are chosen to construct the duct
- The insulation and conduction materials should be able to withstand high temperature around 2500°C

⇒ Working Principle :-

- In MHD power generation conversion process depends upon Faraday's law of electromagnetic induction, which state when a conductor and a magnetic field move relative to each other, a voltage is induced in the conductor.
- This induced voltage produces an electric current



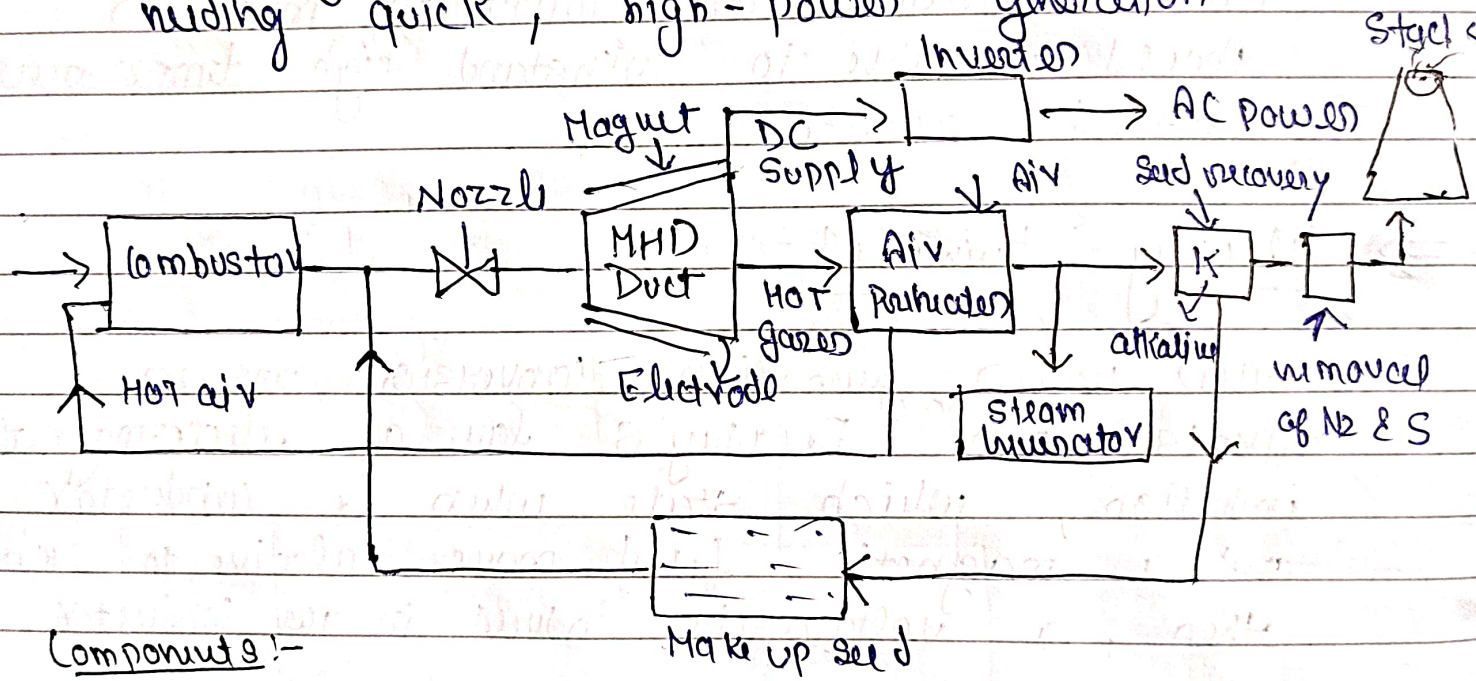
⇒ Classification of Hydrodynamic System :-

a). Open Cycle MHD System :-

Sol In Open-cycle systems, air or combustion gases are used as the working fluid

→ The gas flows through the MHD generator once is then released.

→ These systems are ideal for applications needing quick, high-power generation



Components :-

⊙ Combustion (Fuel Burner) :-

→ Burns fuel (such as coal, oil or natural gas) to produce a very high-temperature gas

→ The high temperature (above 2000°C) are necessary to ionize the gas, creating a conductive plasma

① Seeding Material Injector :-
→ Inject seeding material (usually potassium or cesium salts) into the gas
→ Enhances the electrical conductivity of the gas

② MHD Duct (channel) :-
→ A specially designed duct where the plasma (ionized gas) flow through
→ The duct is positioned b/w magnetic poles allowing the plasma to pass through the magnetic field, where it generates electricity according to Faraday's law

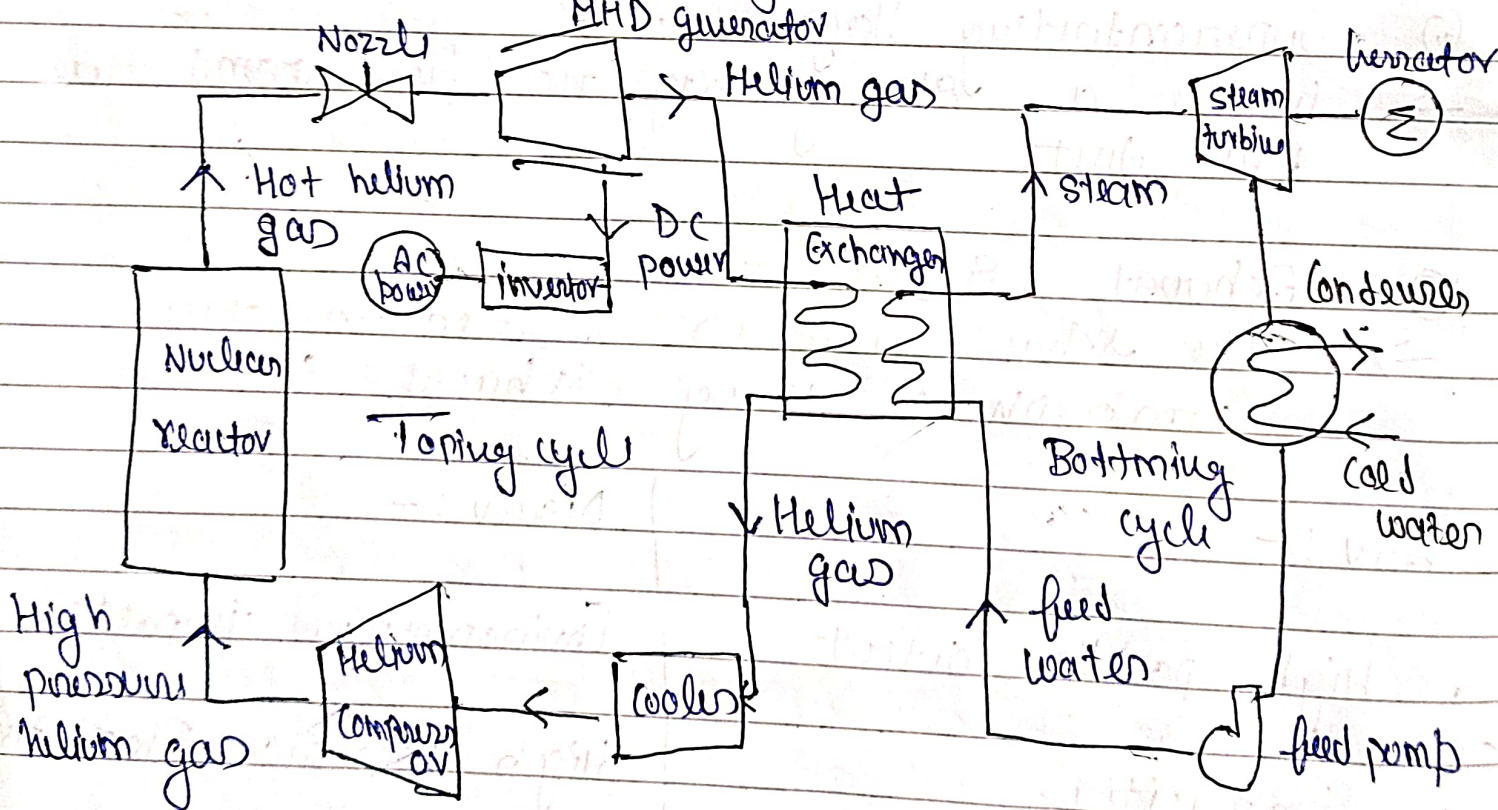
③ Superconducting Magnet :-
→ Create a strong magnetic field around the MHD duct

④ Exhaust System :-
→ The exhausted gas released to the atmosphere using exhaust system

Adv :-	Disadv :-
• High power output	Environmental impact
• Simplicity	High operation Temperature
• Ideal for temporary use	short - Term use

Closed cycle MHD system :-

- A closed cycle MHD can either operate on seeded inert gas (helium or argon) or liquid metal.
- In closed-cycle MHD systems, noble gases like argon are used as the working fluid, and the gas is continously recirculate.
- This make it more eco-friendly and suitable for continous power generation



Working :-

① The hot helium gas is passed through a nozzle to increase its velocity and then supplied to MHD duct to produce DC power. Here some part of the internal energy of the gas is directly converted into DC power.

② In next step, the gas is passed through the heat exchanger (i.e steam generator) to convert feed water into steam. Now this steam is used in a conventional steam power plant to generate electricity.

③ The exhausted helium gas from steam generator is cooled in the cooler and compressed in the compressor. Thereafter it is supplied back to the nuclear reactor and complete cycle is repeated again.

Advantage	Disadvantage
① Environmentally friendly	① Complex setup
② Continous operation	② High initial cost
③ lower maintenance	③ limited fuel options
④ Moderate Temperature	

FUEL CELLS

{AKTU 2022-2023}

① A fuel cell is an electro-chemical device that coverts chemical energy into electricity and heat without combustion.

② The conversion of chemical energy into electrical power in case of fuel cell is an isothermal process

Main Component

1. Anode (Fuel electrode)
2. Cathode (Oxident electrode)
3. Electrolyte.
4. Container
5. Separator
6. Sealing
7. Fuel Supply
8. Oxidant Supply

Working of a Fuel cell

1] Fuel Supply :- Hydrogen gas is supplied to the anode. (+ve side of the fuel cell)

2] Oxygen Supply :- Oxygen from the air is supplied to the cathode (-ve side of the fuel cell)

Chemical reaction :-

- At the anode, hydrogen molecules split into protons (H^+) and electrons (e^-).
- The protons travel through an electrolyte to reach the cathode
- The electrons creates an electrical current as they flow through an external circuit from the anode to the cathode, powering devices or machinery

Water formation :- At the cathode, the protons and electrons recombine oxygen to form water, remove from the container

At Anod

$$2H_2(g) \longrightarrow 4e^- + 4H^+$$
$$4H^+ + 4OH^- = 4H_2O$$
$$2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^-$$

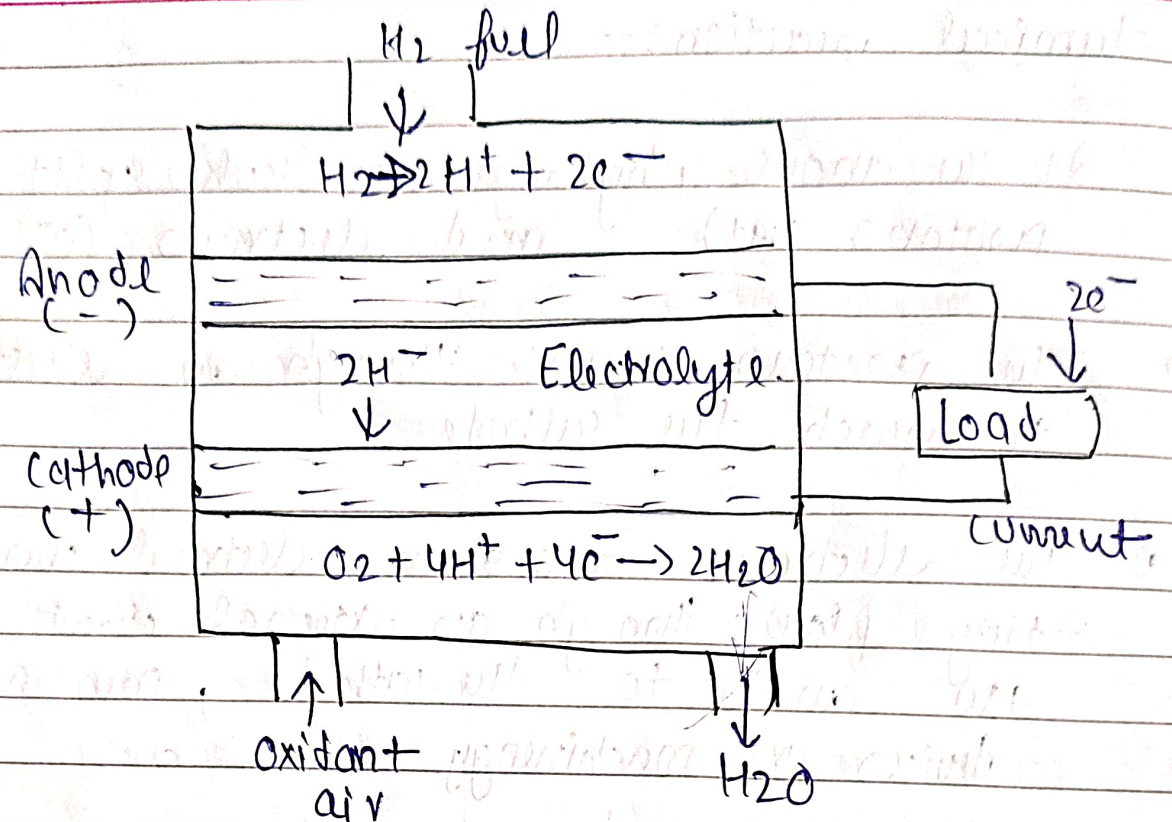
At Cathode

~~$O_2 + 4e^- + H_2O \rightarrow 4OH^-$~~

$$O_2 + 4e^- + 2H_2O \longrightarrow 4OH^-$$

Overall reaction

$$2H_2 + O_2 \longrightarrow 2H_2O$$



Types :-

1. PEM (The Polymer Electrolyte Membrane) Fuel cell
→ Also known as proton exchange membrane fuel cells, these cells are (PEMFCs).
→ The temperature range → 50°C to 100°C
→ Pure hydrogen fuel is used
→ Efficiency → 40 — 60%.
→ Application used in vehicles, backup power system

2. AFC (Alkaline Fuel cell)
→ Alkaline solution, typically potassium hydroxide.
→ The temperature → 70°C - 100°C
→ Hydrogen or other hydrocarbon fuels
→ Efficiency → 60 - 70%
→ Application used in spacecrafts

3 PAFC (Phosphoric Acid fuel cells)
→ liquid phosphoric Acid
→ Temperature → 150°C – 200°C
→ Hydrogen fuel is used
→ Efficiency → 40 – 50%
→ Application :- used in stationary power generation

4. Molten Carbonate Fuel cell (MCFC)
→ Molten Carbonate Salt mixture
→ Temperature — 600 – 700°C
→ Hydrogen, methane and Natural gas, fuel is use
→ Efficiency 45 – 60%
→ Application :- used for large-scale power generation

5. Solid Oxide Fuel cell (SOFC)
→ ceramic material, usually zirconium oxide.
→ Temperature — 700 – 1000°C
→ Hydrogen, Carbon-monoxide, natural gas
→ Efficiency Around 50 – 60%
→ Applications :- large power generation plan

Adv :-
- Clean Energy Production
- High Efficiency
- Quiet Operation
- Scalability

Disadv :-
- High cost
- Hydrogen storage and safety
- Limited operating temperature

Application :-

→ It is used in automotive vehicles
→ It is used in domestic power unit
→ It is used in Untral power station
→ It is used in military and aerospace.

Fuel cell	Battery
• The fuel cell is a primary cell and cannot be recharged but can be refueled	• The battery is rechargeable
• The fuel and oxidizer do not mix together	• Fuel and oxidizer are not used seperately
• Fuel and oxidizer need continous replacement as per requirment	• Battery stores fixed charges of chemical, used up during reaction
• It produces electricity continously as long as fuel oxidizer is supplied	• Battery stores energy

UNIT-3 COMPLETED

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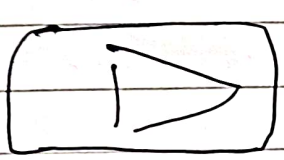

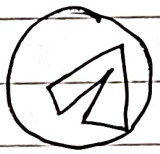

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