BAPATLA ENGINEERING COLLEGE :: BAPATLA
(AUTONOMOUS)
(Affiliated to Acharya Nagarjuna University)

Department of Mechanical Engineering

III/IV B.Tech Regular Degree Examination July/August 2023
Semester : Sixth semester
Subject title: Non-Conventional Energy sources
Code : 20ME604B/ PE II

1a) **Enumerate different applications of solar energy**.

Ans: (a) Solar Water Heating
(b) Solar Heating of Buildings
(c) Solar-distillation
(d) Solar-pumping
(e) Solar Drying of Agricultural and Animal Products
(f) Solar Furnaces
(g) Solar Cooking
(h) Solar Electric Power Generation…etc

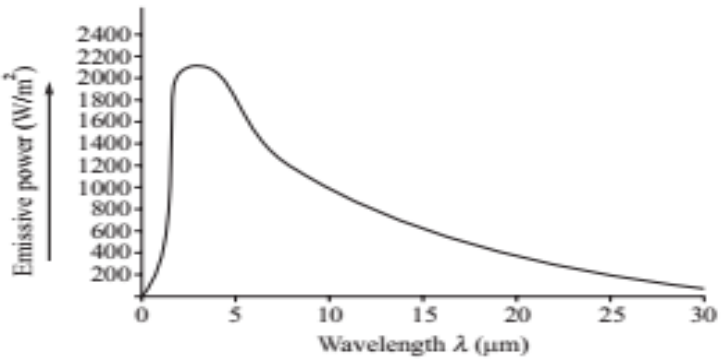
1b) **Define solar constant**.

Ans: It is defined as the energy received from the sun per unit time in a unit surface area perpendicular to the direction of propagation of solar radiation at the top of earths atmosphere when earth is at its mean distance from the sun. The value of solar constant is taken as 1367 W/m^2

1c) **At what wave lengths are the radiation's emitted from the sun and that reflected from the earth centered?**

Ans :

Sun can be considered for all practical purposes as a black body having high surface temperature of 6000 K. The radiation spectrum consists of emission at various wavelengths but more at shorter wavelengths as shown in Figure 2.2(a). The maximum emissive power of the radiation takes place at wavelength of 0.48 μm. Similarly the earth can also be considered a black body at temperature of 288°C. The radiation spectrum from the earth consists of emission generally of longer wavelengths as shown in Figure 2.2(b). The maximum emission is taking place at wavelength of about 10 μm.



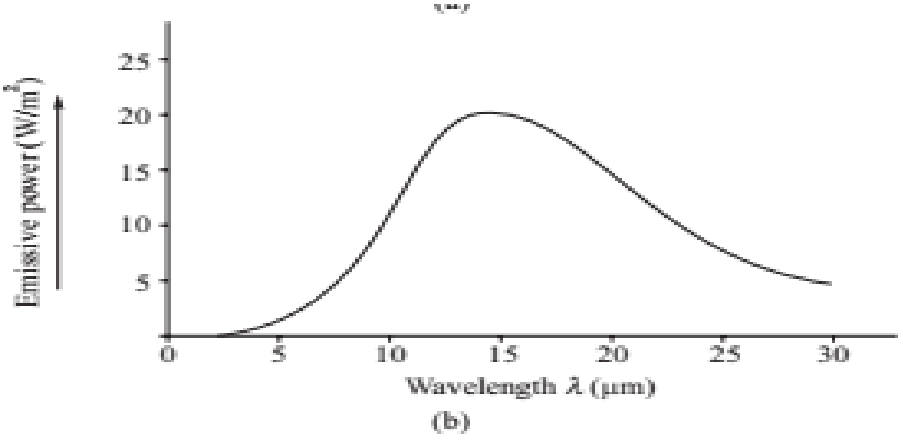


Figure 2.2 Radiation spectrum from sun and earth. (a) Radiation spectrum from the sun. (b) Radiation spectrum from the earth.

1d) **Write any two advantages of vertical axis machines over horizontal type**

Ans: Easy to install , easy maintenance, low noise, economical, requires less space for installation

1e) **Define a geothermal source.**

Ans: Geothermal energy can be usefully extracted from four different types of geologic formations. These include hydrothermal, geopressurized, hot dry rock, and magma. Hydrothermal reservoirs have been the most common source of geothermal energy production worldwide.

1f) **Show the main effects due to a wind turbine environmental aspect?**

Ans: A recent National Wind Coordinating Committee (NWCC) review of peer-reviewed research found evidence of bird and bat deaths from collisions with wind turbines and due to changes in air pressure caused by the spinning turbines, as well as from habitat disruption.

A key challenge facing the wind industry is the potential for turbines to adversely affect wild animals both directly, via collisions, as well as indirectly due to noise pollution, habitat loss, and reduced survival or reproduction.

1g) **Classify the difference between biomass and biogas?**

Ans: Biomass is the solid material obtained from various resources like animal wastes, vegetable wastes, and other biodegradable material whereas biogas is the byproduct which will be evolved from aerobic or anaerobic digestion or by fermentation process or any other biogas production techniques

1h) **Tell about pyrolysis**.

Ans: Pyrolysis is a process by which a solid (or a liquid) undergoes thermal degradation into smaller volatile molecules, without interacting with oxygen or any other oxidants.

1i) **Define aerobic and anaerobic digestion**

Ans: In an anaerobic system the majority of the chemical energy contained within the starting material is released by methanogenic bacteria as methane. In an aerobic system, such as composting, the microorganisms access free, gaseous oxygen directly from the surrounding atmosphere.

1j) **Classify fuel cells according to the temperature range**

Ans: Low temperature fuel cell (below 150^0 C)

Medium Temperature fuel cell (150^0 C – 250^0 C)

High temperature fuel cell (250 ^{0}C – 800 ^{0}C)

Very high temperature fuel cell (800^0 C – 1100 ^{0}C)

1k) **Show how does a Magneto hydrodynamic generator work?**

Ans: It is based on faraday's law of electromagnetic induction, which states that when a conductor and a magnetic field moves relative to each other then voltage is induced in the conductor , which results in flow of current across the terminals.

1l) **Infer the process in which aerobic bacteria convert animal dung into biogas?**

Ans: Biogas is produced by the activities of bacteria that breaks down the biodegradable components of the manure in the absence of oxygen in an airtight chamber. The process is called anaerobic digestion.

1m) **Relate Pyranometer and pyrheliometer?**

Ans: A pyranometer is a dome-shaped device that measures diffused solar energy, whereas a pyrheliometer monitors direct solar radiation. In meteorological research stations, both are frequently used together. The pyrheliometer measures direct sun irradiance, whereas the pyranometer examines global solar radiation.

1n) **Write the applications of geothermal energy?**

Ans: Heat Pumps. Heat pumps use the Earth's shallow ground temperature for heating and cooling. Learn more about heat pumps.

Electricity Production. Electricity production generates electricity from the earth's heat. ...

Direct Use. Direct use produces heat directly from hot water within the earth.

Unit-I

2a) Explain the working of a flat plate collector with a neat sketch

Ans: A flat plate collector is simple in construction and does not require sun tracking. Therefore, it can be properly secured on a rigid platform and thus becomes mechanically stronger than those requiring flexibility for tracking purpose.

As the collector is installed outdoors and exposed to atmospheric disturbances (rain, storm, etc.), the flat plate type is more likely to withstand harsh outdoor conditions.

Also because of simple stationary design, a flat plate collector requires little maintenance.

The principal disadvantage of flat plate collector is that because of absence of optical concentration, the area from which heat is lost is large. Also due to same reason high temperatures cannot be attained.

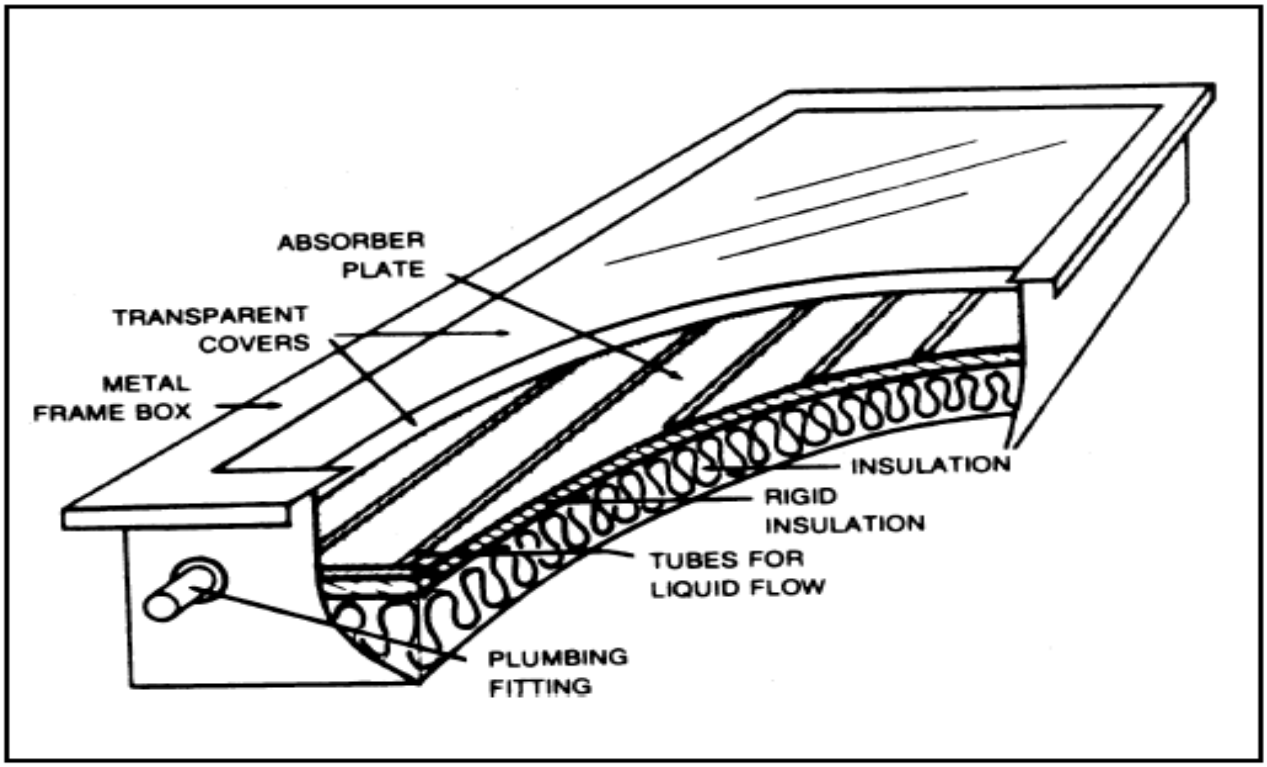


Figure 1. Flat-Plate Solar Collector

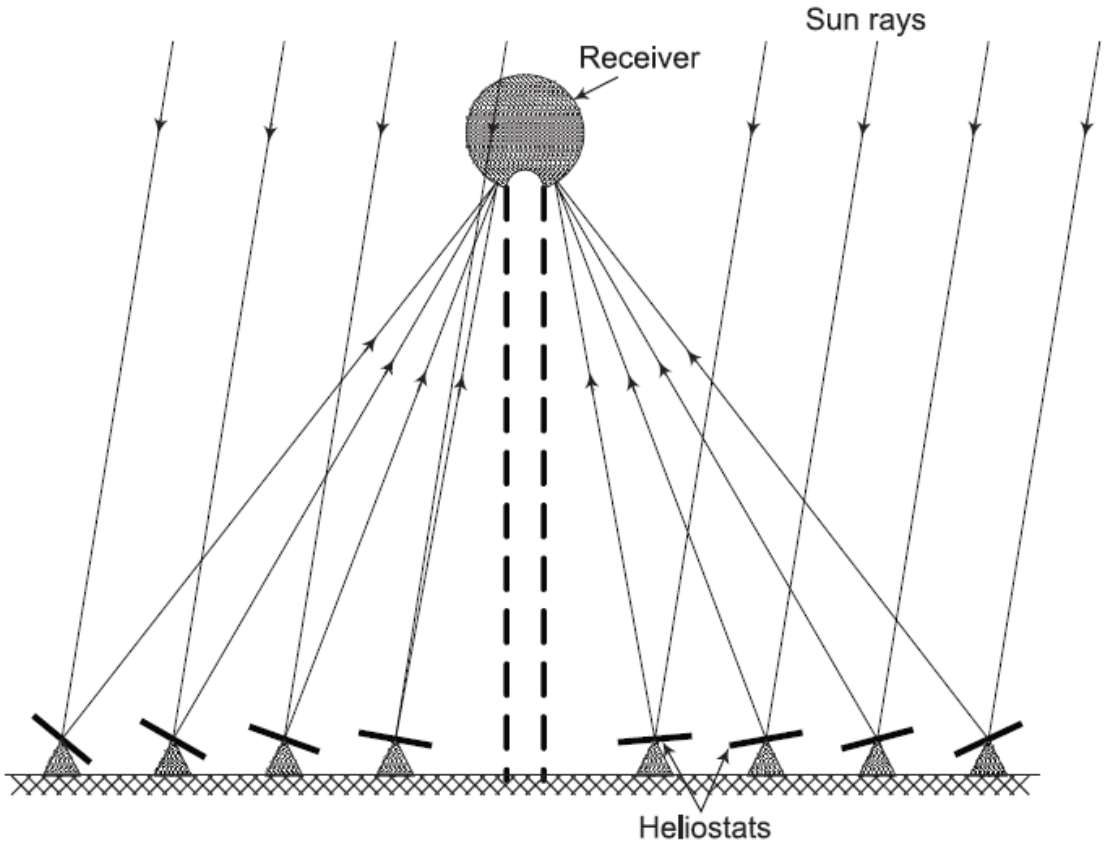
2b) Explain the working of a central tower receiving system with a neat sketch

Ans: In central tower receiver collector, the receiver is located at the top of a tower. Beam radiation is reflected on it from a large number of independently controlled; almost flat mirrors, known as heliostats, spread over a large area on the ground, surrounding the tower.

Thousands of such heliostats track the sun to direct the beam radiation on the receiver from all sides.

The heliostats, together act like a dilute paraboloid of very big size. Concentration ratio of as high value as 3000 can be obtained.

The absorbed energy can be extracted from the receiver and delivered at a temperature and pressure suitable for driving turbines for power generation.



3a) **Outline the advantages and disadvantages of concentrating collectors over the flat plate type collectors**

Ans:

Flat collectors	*Focussing collectors*
The absorber area is large	Absorber area is small
Concentration ratio is 1	Concentration ratio is high varying from 4 to 3000
Temperature range is low, generally not more than 70°C	Tmperature range is high, which is up to 3000°C
It uses both beam and diffuse radiation	It uses mainly beam radiation
Simple in construction and maintenance, no tracking system is required	More complicated design and difficult maintenance, tracking system is required
Less costly	More costly
Application limited to low temperature uses	High temperature applications such as power generation
Suitable for all places as it can work in clear and cloudy days	Suitable where there are more clear days in a year

3b) State various subsystems in a solar thermal energy conversion systems.

Ans: Solar Thermal energy conversion syatems can be

Sloar ponds ,solar water heaters , solar cookers , solar room heaters etc..

Solar pond:

Solar Ponds are solar thermal energy systems that collect and store solar energy, thereby providing a sustainable source of heat and power.These are typically sizable human-made bodies of water that use the sun's heat as a stable temperature source in areas where traditional cooling technologies cannot be implemented.Solar ponds differ from other solar thermal energy systems as they store the collected heat instead of transferring it through fluids or devices. Solar ponds may use any number of different fluid heating and cooling mechanisms.

Solar ponds work based on a fundamental principle. When the sun's rays heat the water in an ordinary pond, the heated water becomes lighter and rises upward, losing its heat in the atmosphere. This means that the pond water remains at its atmospheric temperature.However, the Solar pond prevents this occurrence by dissolving salt in the bottom layer of the pond, which makes the water heavier and unable to rise.Simply, solar ponds work by using the sun to collect solar radiation and absorb it as heat, which is stored in the top layers of the pond. It is used to provide temperature stability, allowing processes that rely on high temperatures to run continuously without interruption.

Solar Pond Zones

Solar ponds typically have three layers: top, bottom, and gradient.

Solar_Pond_Zones

Top Zone

The top layer is the sun-activated heating portion of the Solar Pond; it consists of a surface liquid layer containing salts that absorb solar energy.The Solar Pond's top layer also has a deep bottom, which serves as insulation preventing Solar Pond heat from escaping.

Bottom Zone

The Solar Pond's bottom zone is located under the top zone and absorbs Solar Pond heat.It uses a high melting point substance that can store collected Solar Pond heat until it is ready for use. Solar Pond bottom zones can be almost any material, such as concrete, fiberglass, or plastic.

Gradient Zone

The Solar Pond's gradient zone is located between the top and bottom zones and absorbs energy from the top zone and transports it to the bottom zone.This portion of Solar Pond technology is a thermal diode; it absorbs heat from the top zone and sends it to the Solar Pond's bottom zone.

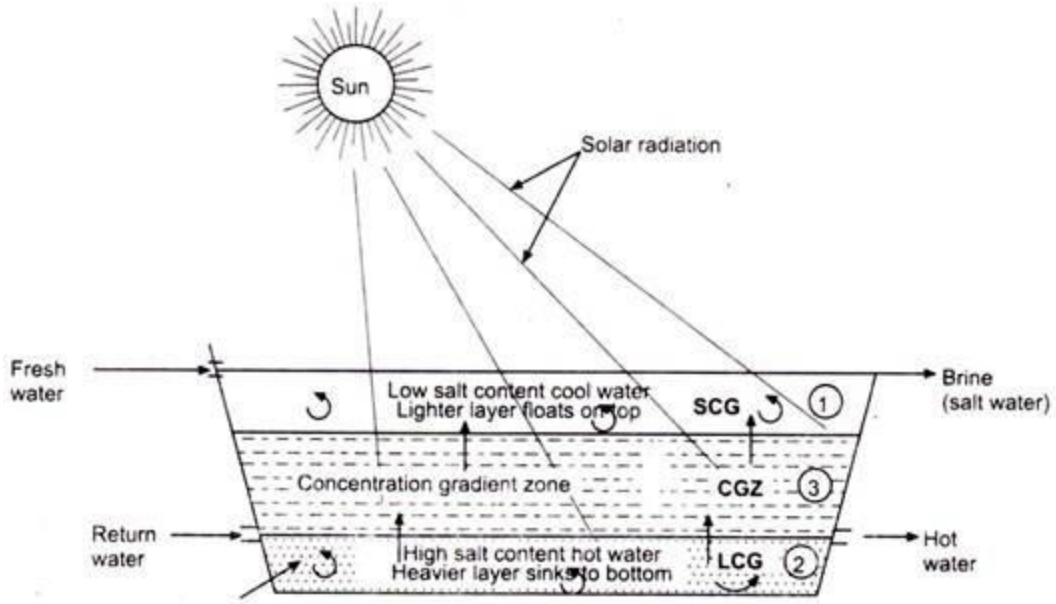


Fig. 4.3. Principle of solar pond.

Unit – II

4a) Interpret the design considerations of Horizontal Axis machines

Ans: Aerodynamic design: Blade profile and airfoil selection: The aerodynamic design of the rotor blades is crucial for efficient energy capture. Engineers carefully select airfoil shapes and blade profiles to optimize lift and minimize drag, which ultimately determines the turbine's performance.

Lift and drag considerations: The lift force is generated by the pressure difference between the upper and lower surfaces of the blade's airfoil as wind flows over it. This lift force contributes to the rotation of the blades. Drag, on the other hand, is the resistance force experienced by the blades as they move through the air. Engineers aim to maximize lift and minimize drag to improve overall turbine efficiency.

Wind tunnel testing: Before constructing full-scale wind turbines, small-scale models are tested in wind tunnels to evaluate their aerodynamic performance. Wind tunnel testing helps identify potential design improvements and ensures that the final turbine design is efficient and stable under various wind conditions.

Structural Design: Material selection: HAWTs are subjected to significant stresses and loads due to wind forces and their rotating nature. Engineers carefully choose materials, often composites or metals, that offer a balance of strength, weight, and durability to withstand these forces over the turbine's operational lifespan.

Stress and fatigue analysis: The structural components, including the blades, hub, tower, and supporting structures, undergo stress and fatigue analysis to ensure their integrity and safety during their operational lifetime. Continuous cyclic loading from wind forces requires a thorough analysis of potential fatigue failure to prevent unexpected damage.

Site consideartions: Wind speed and direction: The success of a wind farm heavily depends on the wind resource at the site. Engineers perform detailed wind resource assessments to determine the average wind speed, direction, and turbulence intensity. This data helps in optimizing the turbine layout and selecting appropriate turbine models.

Environmental impact: Before constructing wind farms, an environmental impact assessment is conducted to evaluate potential effects on local ecosystems, wildlife, and nearby communities. This assessment helps ensure that wind farms are developed responsibly, minimizing negative impacts on the environment.

Grid integration: Wind farms need to integrate with the existing electrical grid to deliver the electricity they generate. Engineers work to ensure that the wind farm's power output is stable and consistent, adhering to grid requirements and regulations for reliable power transmission. Grid integration may involve implementing energy storage systems and smart grid technologies to manage fluctuations in wind power output.

4b) **Identify the main considerations in selecting a site for wind power generators**

Ans: **Site selection parameters**:

The power available in wind increases rapidly with wind speed. Therefore main consideration for locating a wind power generation plant is the availability of strong and persistent wind. A suitable site should preferably have some of the following features:

1. No tall obstructions for some distance (about 3 km) in the upwind direction (i.e. the direction of incoming wind) and also as low a roughness as possible in the same direction
2. A wide and open view, i.e. open plain, open shoreline or offshore locations
3. Top of smooth well-rounded hill with gentle slopes (about 1:3 or less) on a flat plain
4. An island in a lake or the sea
5. A narrow, mountain gap through which wind is channeled
6. The site should be reasonably close to power grid
7. The soil conditions must be such that building of foundations of the turbines and transport of road construction material loaded on heavy trucks must be feasible
8. If there are already wind turbines in the area, their production results are an excellent guide to local wind conditions.

5a) Describe the liquid dominated geothermal system

Ans:

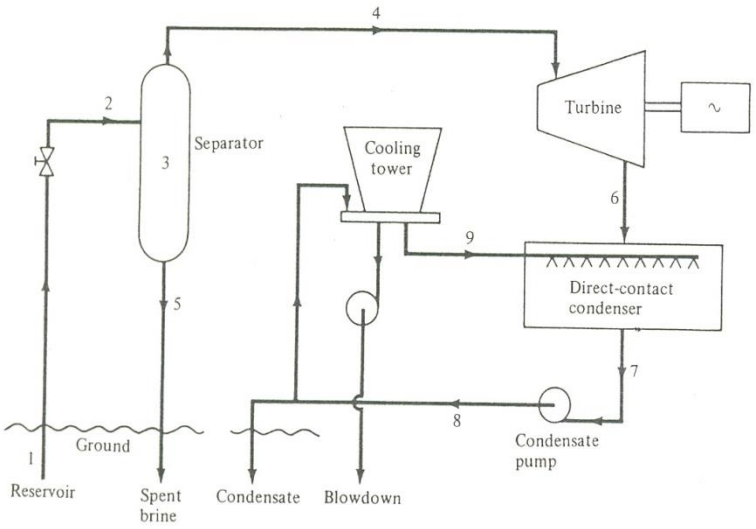


Figure 12-8 Schematic of a liquid-dominated single-flash steam system.

Hot water is available above 150°C to 315°C underground. When tapped, the water can flow naturally under its own pressure or be pumped to the surface of the earth. The drop in pressure causes it to partially flash into steam and a liquid-dominated, low-quality, two-phase mixture of water and stream is avail-able at the well head. The water contains dissolved solids.

Hot water from reservoir (1) reaches the well head (2) Pressure p2 is lower than P1 and process 1-2 is a constant enthalpy throttling process. The two-phase mixture of low quality (2) is passed through a flash separator (3) the quality of steam is higher at point 3. The dry saturated steam (4) at pressure of about 8 bars is expanded in the steam turbine. The separated brine (5) is re-injected into the ground.

The exhaust steam from turbine is mixed with cooling water in a direct- contact condenser. The mixture is cooled in a cooling tower.

5b) What are the sub classification of hydrothermal convective systems? Describe a vapour dominated or dry steam field.

Ans: The hydrothermal resources are located at shallow to moderate depths (from approximately 100 m to 4,500 m). Temperatures for hydrothermal reserves used for electricity generation range from 90 °C to 350 °C but roughly two-thirds are estimated to be in the moderate temperature range (150 °C to 200 °C). For practical purposes, hydrothermal resources are further subdivided into

(i) vapour dominated (dry steam fields),

(ii) liquid dominated (wet steam fields) and

(iii) hot water resource.

Vapour dominated system:

Dry steam power plants draw from underground resources of steam. The steam is piped directly from underground wells to the power plant, where it is directed into a turbine/generator unit. There are only two known underground resources of steam in the United States: The Geysers in northern California and Yellowstone National Park in Wyoming, where there's a well-known geyser called Old Faithful. Since Yellowstone is protected from development, the only dry steam plants in the country are at The Geysers.

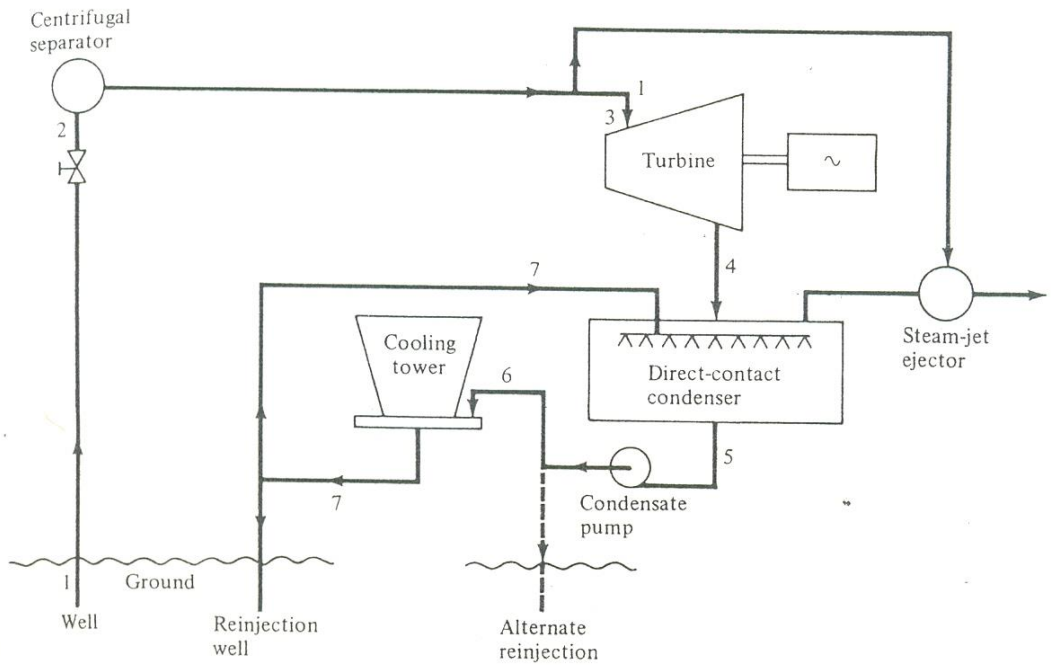


Figure 12-5 Schematic of a vapor-dominated powerplant.

Unit – III

6a) Describe the closed cycle OTEC system, with its advantages over open cycle system

Ans:

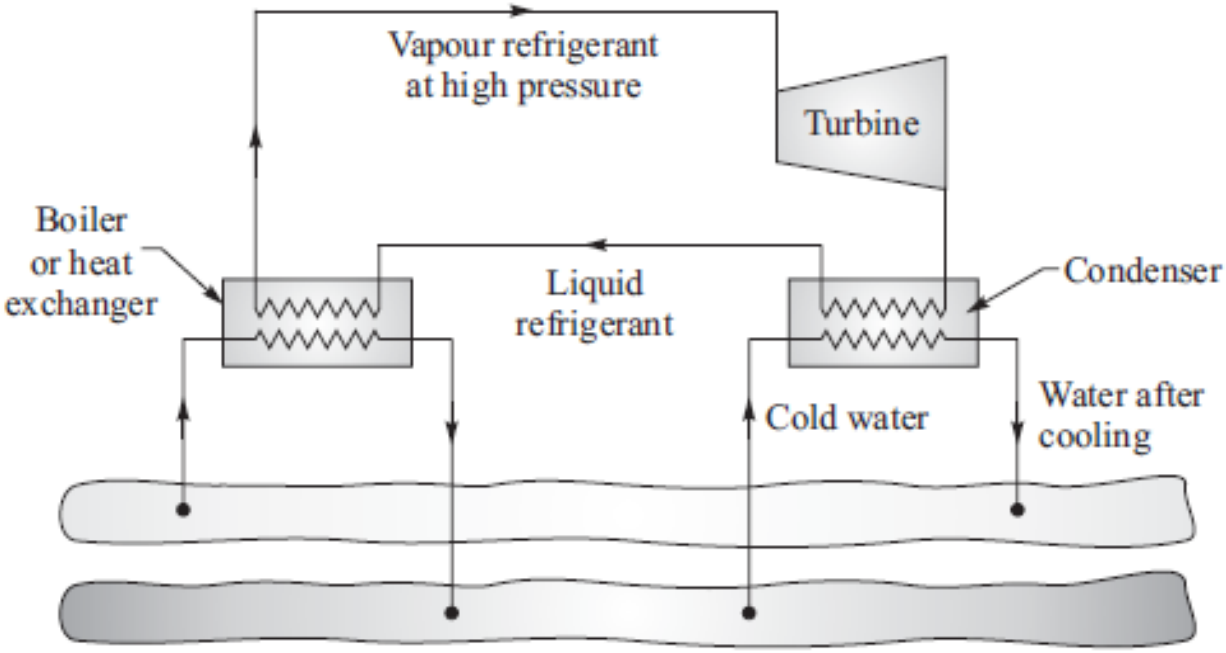


Figure 13.2 Closed cycle OTEC plant.

In closed-cycle ocean thermal energy conversion, a working fluid with a low-boiling point, such as ammonia or propane, is circulated. Warm, surface seawater is pumped through a heat exchanger where the working fluid is vaporized and driven through a turbine, which then generates electricity.

Advantages: The advantage of closed cycle OTEC is its energy efficiency and water conservation capability, compared to open cycle system. Open cycle is different from closed cycle OTEC system in design, operational detail, efficiency, and environmental impact.

6b) Classify the different types of biomass resources development in India

Ans:

S.N.	Biomass source	Biofuel produced	Conversion technology	Available energy (MJ/ kg)
1.	Wood chips, saw mill dust, forest residues etc.	(Direct heat)	Incineration	16-20
2.	,,	Gas Oil Char	Pyrolysis	40 (Nitrogen removed) 40 20
3.	Grain crops	Straw	Incineration	14–16
4.	Sugarcane residue	Bagasse	,,	5–8 (fresh cane)
5.	Urban refuse	(Direct heat)	,,	5–16 (dry input)
6.	Sugarcane juice	Ethanol	Fermentation	3–6 (fresh cane)
7.	Animal waste	Biogas	Anaerobic digestion	4–8 (dry input)
8.	Municipal sewage	,,	,,	2–4 (dry input)

7a) **Discuss the source of tidal energy and the minimum tidal range required for the working of tidal plant.**

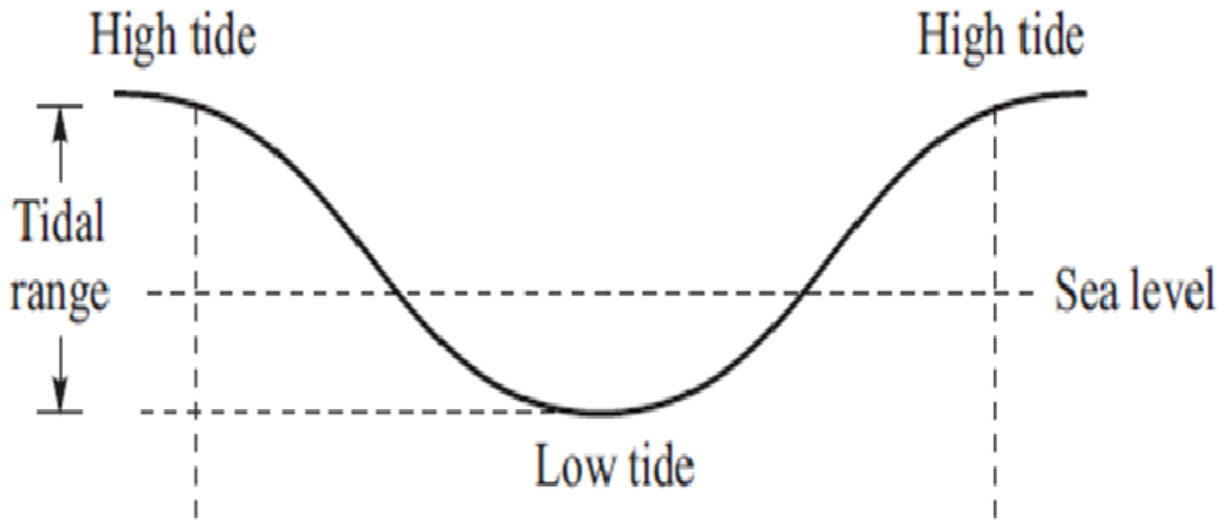
Ans:The main source for the production of tidal energy is the attraction force between sun and the moon.

The gravitational pull of the earth drags the ocean water down while the attractive force from the moon and the sun will continuosly tends to lift the ocean water up. The key point to remember is the attraction force or pull force of the moon will be much greater than the attraction pull of the sun.

Due to these force day time tides will have low heights and evening time tides will have high heights.

The minimum range required for the energy generation from the tides is 5 – 15m

The difference between the high tide and the low tide from the mean sea level is called the tidal range.



As moon takes 24 h and 50 min to complete a rotation on its axis, high tide is formed about two times at a place in its one rotation; that is, a high tide due to moon is formed after a period of 12 h and 25 min. The effect of gravitational pull by the sun is the same, but it is 2.2 times lesser than what is exerted by the moon. Earth revolves around the sun in 24 h. Owing to this slight difference in periods of rotation, solar tides move in and out of phase with lunar tides

7b)**Explaion how tides are formed ? Write the advantages and disadvantages of TIDAL power generation**

Ans:

Tides are produced due to gravitational pulls exerted by both the moon and the sun. As moon is nearer to the earth, the gravitational pull of moon is about 2.33 times stronger than that of the sun. Owing to the gravitational pull of the moon, surface water on the earth facing moon is pulled and raised towards the moon, and so water moves from poles to equator where the moon pull is maximum. This movement of water results in the formation of a high tide at the earth surface facing the moon. A corresponding high tide is also formed on the opposite side of the earth as solid earth is pulled away from the water surface, which results in the apparent rise of water as shown in Figure 10.1.

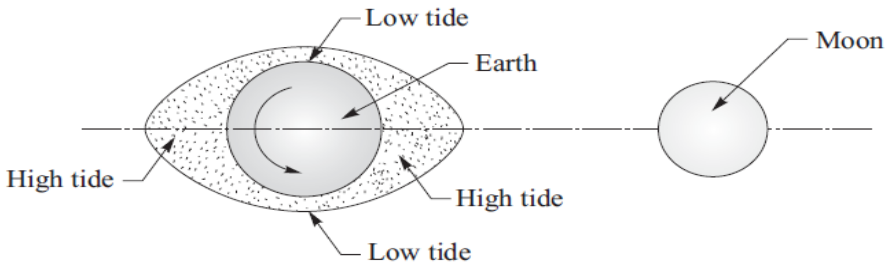


Figure 10.1 Origin of tides.

The merits of tidal energy are as follows:

(i) It is free from pollution.
(ii) It is inexhaustible.
(iii) The site of the plant can be generally dam at bays and its construction does not uproot the villages or disturb the ecology of the place.
(iv) No submerging of land occurs while constructing basins.
(v) Its operation is not adversely affected by variations of weather, such as the failure of monsoon. Tide cycle is always definite.
(vi) Basins can also be used for fish farming.

The limitations of tidal energy are as follows:

(i) It can be harnessed only if natural sites are available.
(ii) Its suitable sites are mostly bays which are far away from the load centres. Therefore, the transmission cost of power is high.
(iii) Its operation is uneven as turbines have to work with varying water heads. The power output is variable.
(iv) The construction period of a dam for basin is long. The basin and plant construction is costly.
(v) Sedimentation and silt deposition in the basin take place in regular manner which is costly to be removed.
(vi) Power output varies with lunar cycle.

Unit – IV

8a) **Illustrate Updraft and down draft gasifiers**

Ans: **Updraft gasifier**

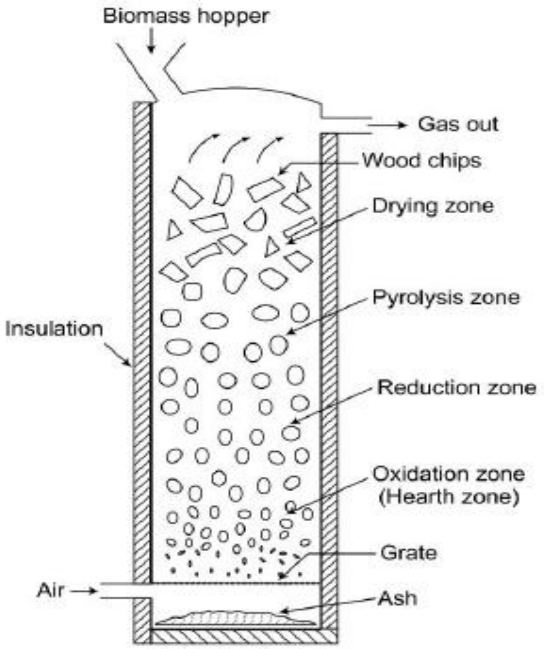


Figure 8.5 Updraft biomass gasification plant

Updraft type gasifier (also called counter flow gasifier) is the simplest as well as first type of gasifier developed. This type of gasifier is easy to build and operate. The air enters below the combustion zone and the gas is drawn off at the top. The updraft gasifier achieves highest efficiency as the hot gas passes through the fuel bed and then leaves the gasifier at low temperature. The gas produced has practically no ash but contains tar and water vapor because of passing of gas through unburnt fuel. Hence updraft gasifier is suitable for tar free feedstock (fuels like charcoal, etc.). It is most unsuitable for high volatile fuels. The zones of various reactions are shown in Fig. 8.5.

Down draft Gasifier:

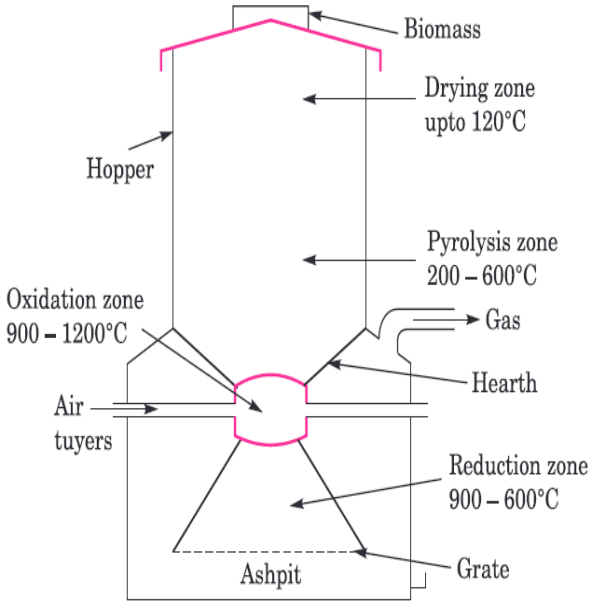


Fig. 7.27. Schematic diagram of a downdraft gasifier.

The downdraft gasifier, also called the cocurrent moving bed gasifier, is most commonly used for engine, applications because of its ability to produce a relatively clean gas. However, the presence of the throat poses problems of fuel movement. In the recent years, so called throatless gasifiers have been developed at Solar Energy Research Institute, Colorado, USA, Indian Institute of Science Bangaluru; Nimbkar Agricultural Research Institute, Phaltan; and Tata Energy Research Institute, New Delhi. For large sizes, fluidized bed gasifiers and entrained bed gasifiers have also been considered.

8b) **Classify different Biogas plants and explain with neat sketches.**

Ans:

Comparison between fixed dome and floating drum biogas digesters

Fixed dome biogas system	Floating drum digesters
Equivalent gas output	Equivalent gas output
Relatively easier to maintain	Harder to maintain in terms of comparison
Comparatively difficult to estimate the amount of gas available for use	It is relatively easier to estimate the gas available for use
In terms of comparison, it is less expensive	More expensive in comparison
Better insulated, with the option of internal heating	Less insulated than fixed dome biogas system in comparison
Higher life expectancy	Relatively lower life expectancy in comparison

Fixed dome type biogas digester

This plant is more economical as only masonry work is required. Gas pressure in the dome varies depending on the production/consumption rate. By construction a dome structure is very strong for outside pressures but a weak one for inner pressures. As gas pressure is exerted from inside out, the dome structure may fail if proper care is not taken in its construction. The dome is constructed underground to maintain pressure over it. Skilled masonry workmanship is required for construction of dome. In case of any leakages/cracks the plant may fail. A typical family size Chinese model (Janata Model) is shown in Fig. 8.13. Many variations of this basic design are developed to reduce the cost by making use of different materials to suit local conditions.

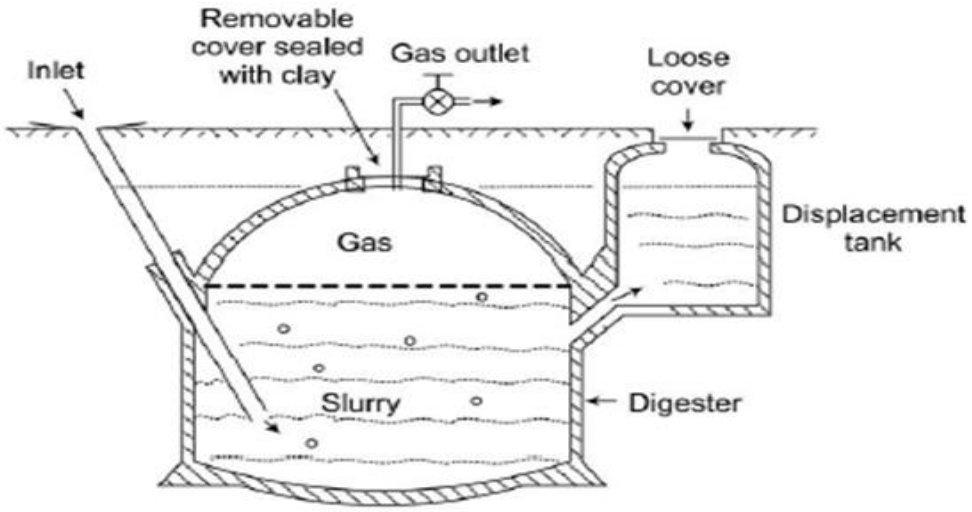
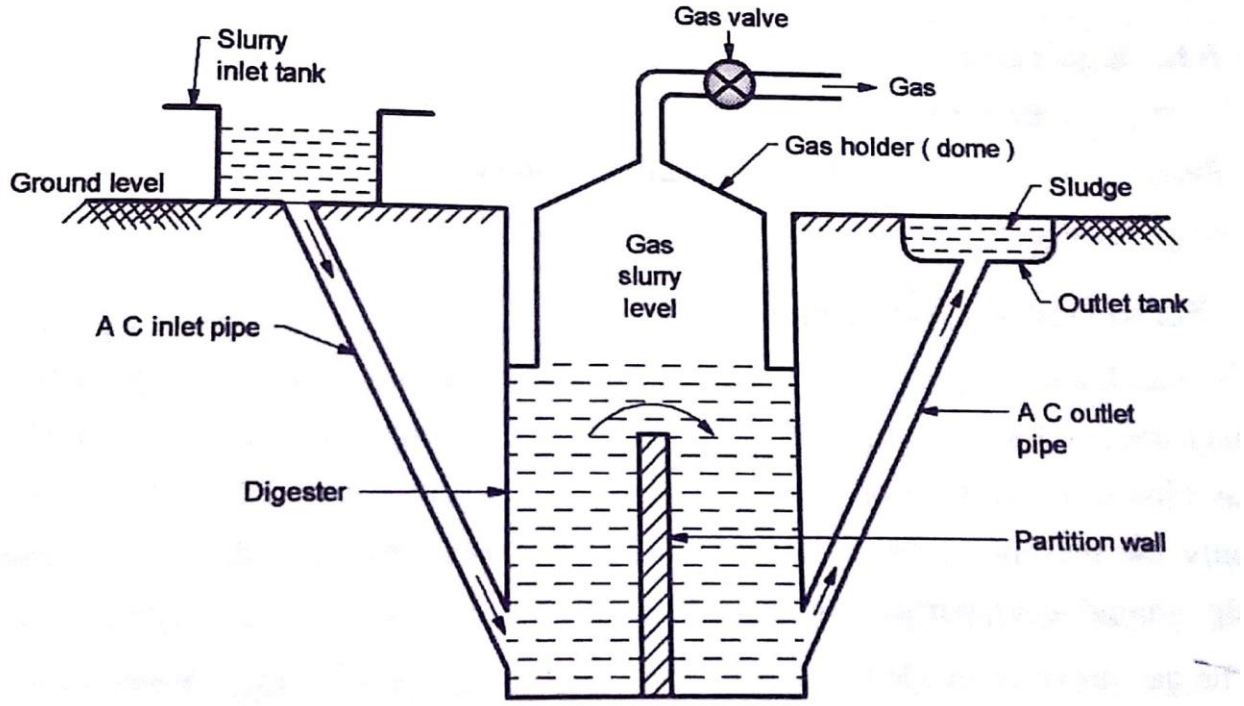


Figure 8.13 Fixed dome type biogas plant

Floating drum type biogas digester



Floating Drum Biogas, or FDB, is a low-cost biogas digester designed and developed to reduce the environmental impact of animal waste. This anaerobic digestion process transforms animal and plant waste into valuable energy used for electricity or cooking

These digesters are usually built to convert human and animal wastes of one household to biogas for cooking and lighting. Typically, the average volume of the digester is approximately 5-7 m 3 and provides about 0.5 m 3 biogas per m 3 digester volume.

9.a) Discuss the principle of MHD generation with a neat diagram.

A magnetohydrodynamic (MHD) generator is a device that generates power directly by interacting with a rapidly moving stream of fluid, usually ionized gases/plasma. MHD devices transform heat or kinetic energy into electrical energy. The typical setup of an MHD generator is that both turbine and electric power generator coalesce into a single unit and has no moving parts, thus, eliminating vibrations and noise, limiting wear and tear. MHDs have the highest thermodynamic efficiency as it operates at higher temperatures than mechanical turbines.

Principle of MHD Generator

MHD generator is commonly referred to as a fluid dynamo, which is compared to a mechanical dynamo – a metal conductor when passed through a magnetic field generates a current in a conductor.

However, in the MHD generator, conducting fluid is used instead of a metal conductor. As the conducting fluid (conductor) moves through the magnetic field, it produces an electrical field perpendicular to the magnetic field. This process of electric power generation through MHD is based on the principle of Faraday's law of electromagnetic induction.

When the conducting fluid flows through a magnetic field, a voltage is generated across its fluid and it is perpendicular to both the fluid flow and the magnetic field as per Fleming's Right Hand Rule.

Applying Fleming's Right-Hand Rule to the MHD generator, a conducting fluid is passed through a magnetic field 'B'. The conducting fluid has free charge particles moving with a velocity 'v'.

The effects of a charged particle moving with a velocity 'v' in a constant magnetic field are given by the Lorentz Force Law. The simplest form of this description is given below by the vector equation.

$$F = Q (v \times B)$$

Where,

'F' is the force acting on the particle.

'Q' is the charge of the particle,

'v' is the velocity of the particle, and

'B' is the magnetic field.

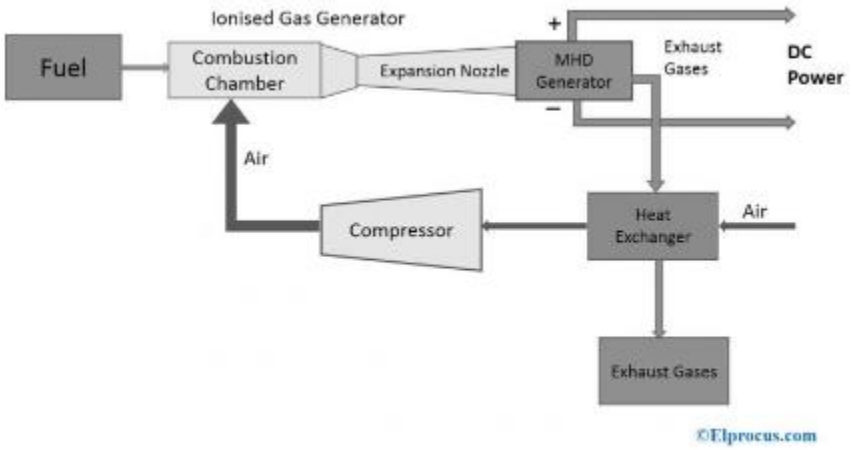
The vector 'F' is perpendicular to both 'v' and 'B' according to the right-hand rule.

MHD Generator Working

The MHD electricity generation diagram is shown below with possible system modules. To begin with, the MHD generator requires a gas source of high temperature, which can be either a coolant of a nuclear reactor or can be high-temperature combustion gases produced from coal.

MHD-Generator-Working

As the gas and fuel pass through the expansion nozzle, it decreases the pressure of the gas and increases the speed of fluid/plasma through the MHD duct, and increasing the overall efficiency of the power output. The exhaust heat produced from the fluid through the duct is the DC power. It used to run the compressor to boost the fuel combustion rate.



mhd-generator-working

MHD Cycles and Working Fluids

Fuels like coal, oil, natural gas, and other fuels that are capable of producing high temperatures can be utilized in MHD generators. Besides this, MHD generators can use nuclear energy to generate electricity.

MHD generators are of two types – open cycle and closed-cycle systems. In an open cycle system, the working fluid is passed only once through the MHD duct. This produces exhaust gases after generating electrical energy, which is released to the atmosphere via a stack. The working fluid in a closed cycle system is recycled to the heat source for reusing it repeatedly.

The working fluid used in an open cycle system is air, whereas helium or argon is used in a closed cycle system.

9b) How does MHD Systems are classified ? Describe them in brief

1.Open cycle MHD system

2.Closed cycle MHD system

Open cycle MHD system:

Atmospheric air at very high temperature and pressure is passed through the strong magnetic field. Coal is first burnt in combustor at a high temperature of about 2700 C and pressure at 12 Atp with preheated air from Plasma {electrically conducting fluid}. The seeding material such as Potassium Carbonate is injected to the plasma to increase high electrical conductivity. The resulting material having a high electrical conductivity about 10 siemens /m is expanded through a nozzle to have high velocity and then passed through magnetic field of MHD generator. During expansion of the gas at high temperature the positive and negative ions move to the electrodes and thus constitute an electric current the gas is then made to exhaust through the generator.

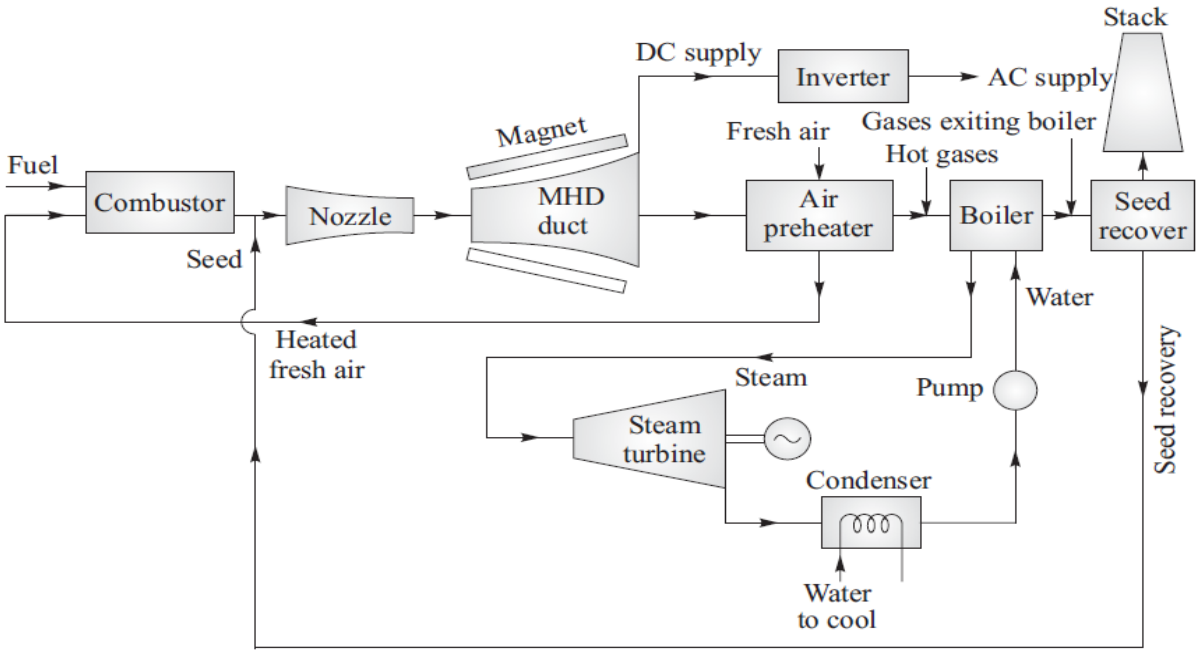


Figure 9.10 An open cycle MHD generator.

Closed cycle MHD system:

1. Seeded inert gas carrier system
2. Liquid Metal inert gas carrier system.

1.Seeded inert gas carrier system:

A closed cycle MHD system using helium or argon gas seeded with Cesium is shown in Figure. Step by step working of the system is as under:

In this system, helium gas seeded with Cesium is heated to a very high temperature in a nuclear reactor.

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.

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. 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.

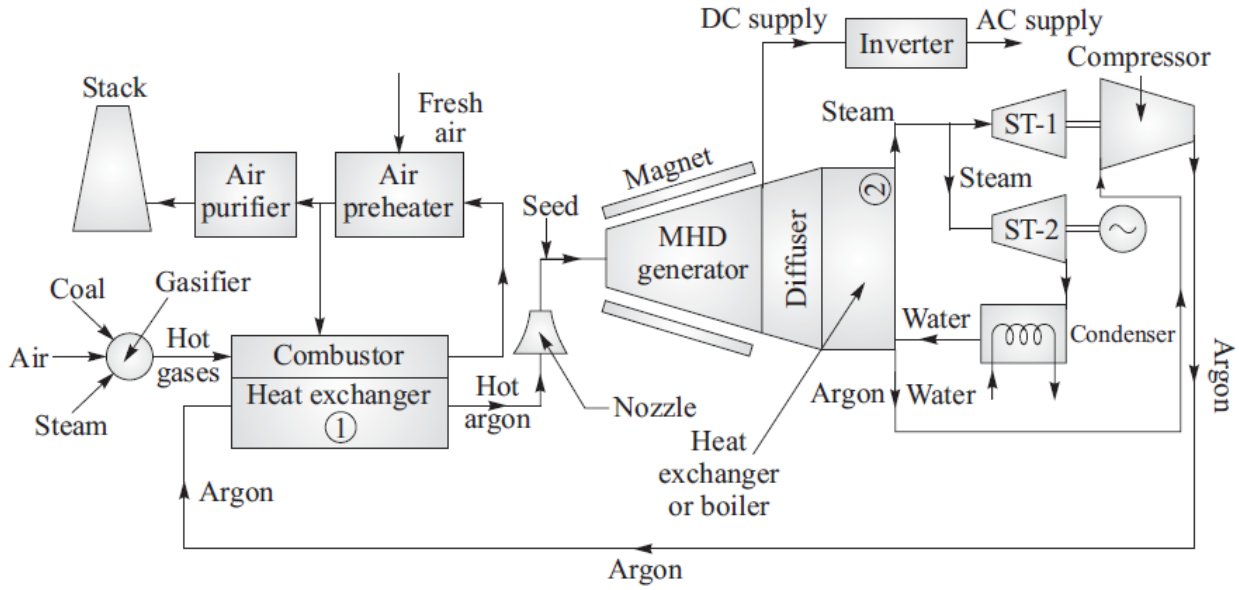


Figure 9.11 A closed MHD system.

Liquid metal Closed Cycle System:

It is similar to the inert gas system except that it uses liquid metal (potassium) in place of helium gas as the working fluid.Liquid potassium is heated in the nuclear reactor and is passed through the nozzle to increase its velocity. Thereafter, the high-velocity liquid metal is passed through the MHD duct to produce DC power. The liquid potassium leaving the MHD duct is fed to the heat exchanger where it transfers heat to feed water and feed water is converted into steam. This steam is used in a conventional steam power plant.

The liquid potassium, leaving the heat exchanger is supplied back to the nuclear reactor and complete cycle is repeated again. A closed-cycle system can provide more useful power conversion at lower temperatures (around 1900 K as compared to 2500 K for open cycle system). However, its use is still a distant dream. The heat exchanger design is one of the difficulties because the heat exchanger works up to the highest temperature of the gas. Moreover, the working fluid must be kept pure.