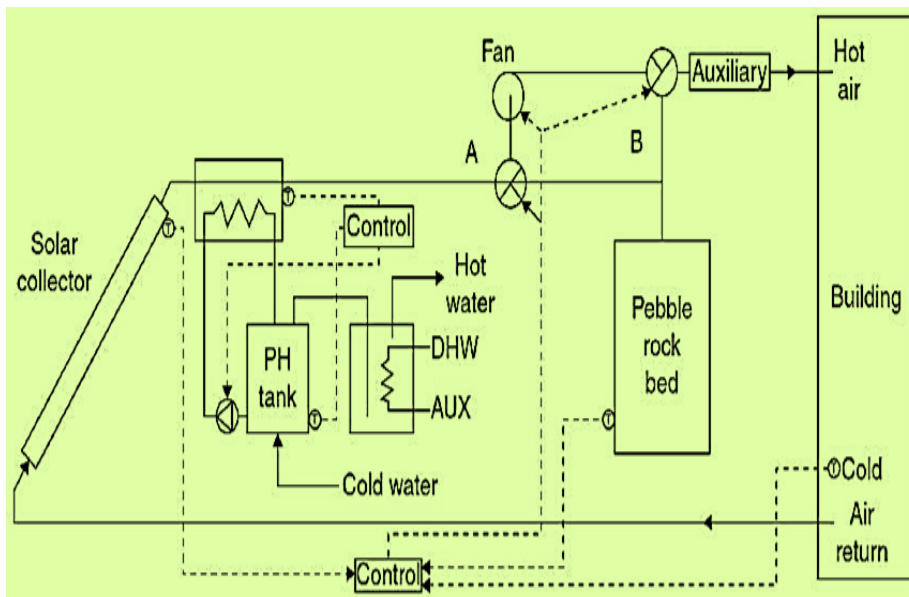


Solution of IAT-2
Subject: Renewable Energy Resources (18EE653)

1 (a) Write short notes on solar Air heating.

Solar Air Heating Systems

- The major components are
 1. Air handling Unit: a fan and two motor driven dampers
 2. Heat storage unit(rock bed)
 3. Temperature Control System
 4. Solar collectors



- Depending on position of Dampers there are 3 modes of operation
- **Damper A & B open:**
 - Normal day time solar heating mode.
 - The storage unit is bypassed.
 - If the temperature is below a limit as measured by sensor placed in the top of collector, auxiliary furnace is turned on automatically
- **Damper A open, B closed:**
 - This mode is used when solar energy is collected, but no heating is required
 - It gets collected in the rock bed(heat storage)
- **Damper A closed, B open:**
 - Used for cloudy periods or at night
 - The return air from the building is passed through rock bed, where it picks up solar heat.
 - If temperature is insufficient, auxiliary furnace is activated

(b) A certain 120V, 60Hz AC motor is to be powered by solar cell array during the day and at night, by a 120V public utility. A DC to AC converter is available that changes the array DC output into a 120V, 60Hz AC with 90% efficiency independent of load phase angle, while running motor has a DC resistance of 300Ω and an inductance of 0.3H. How much power output must the array provide?

Inductive reactance of AC motor, $X = X_L = 2\pi fL = 2\pi * 60 * 0.3 = 113\Omega$

$Z = R + jX_L = 300 + j113$

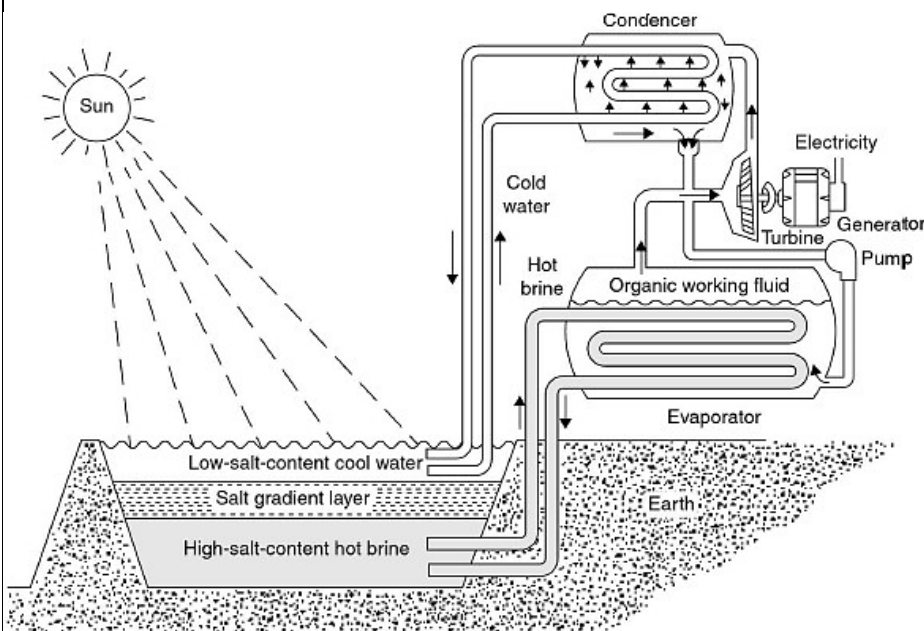
$|Z| = (300^2 + 113^2)^{1/2} = 320$

Motor current, $I = V/Z = 120/320 = 0.375A$

Power drawn by the motor $P_m = I^2R = (0.375)^2 * 300 = 42.2W$

The array output power = input power of motor = $P_m/\eta_{mc} = 42.2 / 0.9 = 46.9 W$

2 Write short notes on (i) Solar Pond

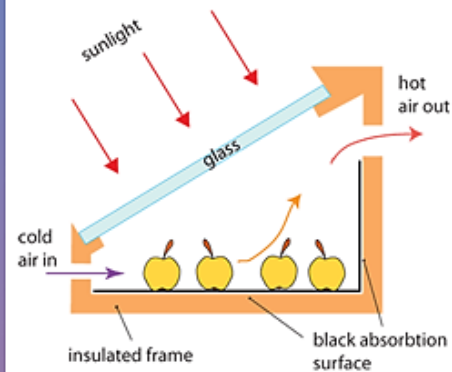


- A pool of water that collects and also stores solar energy
- It has three different layers of water which differs by their density
- Density difference is achieved by adding salt solutions of different concentration
- Relatively cold top layer with low salt content
- Intermediate layer with salt gradient that maintains the density gradient, acts as the thermal insulator
- Hot bottom layer (up to 100 degree Celcius) with high salt content
- Difference in densities prevent convection currents which would have transferred heat to the surface of pond and then to air
- Heat is trapped in the highly dense, salty bottom layer which can be used
- But low solar to electricity conversion efficiency -15%

- **Advantages of solar pond**
- Low cost per unit area of collection
- Inherent capacity for storage purposes
- Great source for production of electricity
- Reduced Pollution
- Will help in saving conventional energy sources
- Since it is coupled with desalting units ,it can be used for purification of water

(ii) Solar Dryer

The following drawing depicts one tray solar dryer.



Solar Drying

- The basic function of a **solar dryer** is to heat air to a constant temperature with **solar** energy, which facilitates extraction of humidity from crops inside a **drying** chamber.
- The food is not exposed to direct sunlight in indirect sun driers as the fresh air is heated separately from the food chamber.
- Used for domestic as well as Industrial applications.

Advantages

- Hygienic and eco-friendly method.
- Economical compared to dryers which uses conventional fuels or electricity.
- Solar dryers last longer. A typical dryer can last 15–20 years with minimum maintenance.

Limitations

- Comparatively Slow Process.
- Intermittent availability of sun.
- Upto 40 -50° Celsius.

Solar Drying

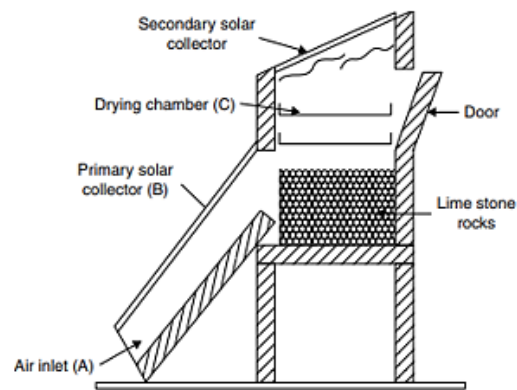


Figure 3.23 Rock-bed solar dryer

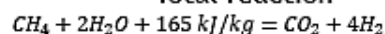
- In this solar dryer, air drawn by natural convection through an air inlet (A), circulates the heat collected by the primary solar energy collector (B), throughout the drying chamber (C), which is packed with limestone rocks of relatively uniform diameter.
- The heat would then stratify across the rock bed but, since rocks are poor thermal conductors, temperature differences would slowly disappear when air is not moving through the rock bed. Thus, samples positioned above the rock bed can continue drying during the night.
- This type of a solar dryer requires very little maintenance. Solar heated air can be used for drying most crops that require warm air.
- This air is ideal for drying delicate foods since it will not burn or risk potential damage from high temperature steam heat. Solar heat is non-polluting and best of all, it incurs no fuel costs.
- Solar-heated air can be used to dry
 1. Crops, timber, distillers' grains, and textiles
 2. Tea, coffee, beans, tobacco, etc.
 3. Food for dehydration or processing
 4. Sludge, manure, and compost

3 (a) Explain the Thermochemical production techniques used to produce Hydrogen energy.

1. Steam reforming

- ▶ Methane or methanol reacts with steam over nickel alumina
 - ▶ $CH_4 + H_2O + 206\text{kJ/kg} = CO + 3H_2$
- ▶ Carbon monoxide reacts with water
 - ▶ $CO + H_2O = CO_2 + H_2 + 41\text{kJ/kg}$

Total reaction



Natural gas 48%

Oil 30%

Coal 18%

Electrolysis 4%

2. Partial oxidation or ceramic membrane reactor

- ▶ Natural gas and oxygen at high pressure
- ▶ Carbon and oxygen ratio has to be maintained to avoid soot formation
- ▶ The carbon dioxide formed can be removed by providing oxygen and also purifies hydrogen
- ▶ Catalytic partial oxidation reaction
 - ▶ $CH_4 + \frac{1}{2}O_2 = CO + 2H_2$
 - ▶ This is exothermic reaction
 - ▶ Reduced size and capital cost
 - ▶ Less efficient than steam reforming

3. Biomass gasification or pyrolysis

plant material or fossil fuels

- ▶ Organic material at high temperatures
- ▶ Burning of wood
- ▶ Liquid product bio oil is produced

(b) Mention the problems associated with the application of Hydrogen energy.

- ▶ Hydrogen storage
- ▶ High reactivity
- ▶ Cost & methods of hydrogen production
- ▶ Consumer demand
- ▶ Cost of changing the infrastructure

4 Discuss about the factors or guidelines for wind turbine site selection. Also discuss about various parts of wind turbine.

Considerations & guidelines

Factors to be considered

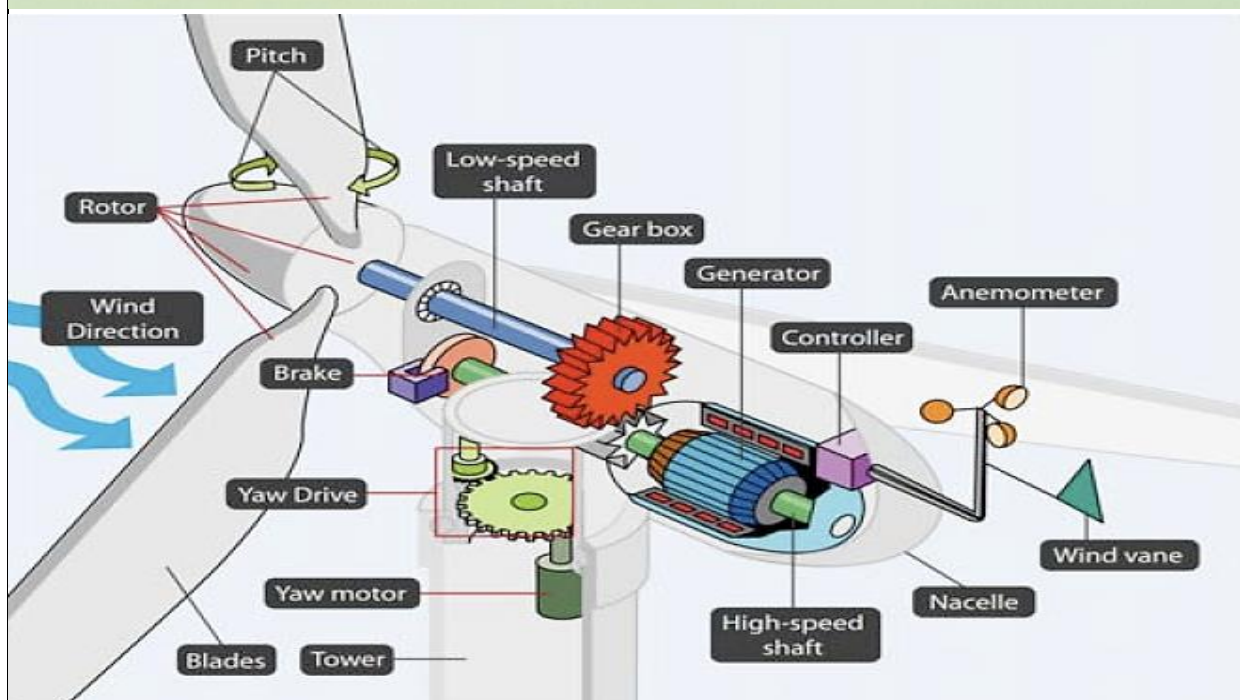
- 1. Hill effect** – wind pressure increases as it reaches the hill top and increases speed
- 2. Roughness or amount of friction that earth's surface exerts on wind** – Oceans have very little roughness, but city or forest has a great deal of roughness, which slows the wind.
- 3. Tunnel effect** – high wind pressure and speed
- 4. Turbulence** – It causes fluctuations in the wind speed and wear and tear on the turbine
- 5. Variations in wind speed**- During day sun heats the air so the wind blow faster compared to night. Wind speed varies on Season as well.
- 6. Wake**: the air coming out of the blade sweep has less energy because it has been slowed. The abrupt change in the speed makes the wind turbulent, a phenomenon called wake. Wind turbines in the wind farms are placed 3 rotor diameter away
- 7. Wind obstacles** – Trees, Buildings and rock formation
- 8. Wind shear**: It is the difference in wind speeds at different heights of turbine blades. Top pointing blade can experience wind speed of 14km per hour but bottom blade experiences 11km per hour. This causes stress on the blades results in wind shear and causes the turbine to fail.

Guidelines

1. Turbines work good on high and exposed sites. costal sites are good.
2. ❌ Town and highly populated area
3. ❌ roof mounted turbines
4. Distance of caballing, more power loss in cables
5. Turbine height is twice obstacle distance
6. Speed of wind must be 4.5 m/s to produce electricity
7. Remote location sites are expensive as it is required to connect it with grid

Parts of wind turbine

- The nacelle contains the key components of wind turbine, gearbox and generator
- Tower of wind turbine carries the nacelle and rotor
- Rotor blades capture wind energy and transfers its power to the rotor hub
- Generator converts mechanical energy of the rotating shaft to electrical energy
- Gear box increases the rotational speed of the shaft for the generator



Blade count

- Aerodynamic efficiency, component cost, reliability
- Optimal Number of blades is 3
- Effects in increase of number of blades increases efficiency of 6% from one to two, 3% from two to three
- Blade must be thin relative to width
- Aesthetics
- Wood & canvas sails
- Aluminium

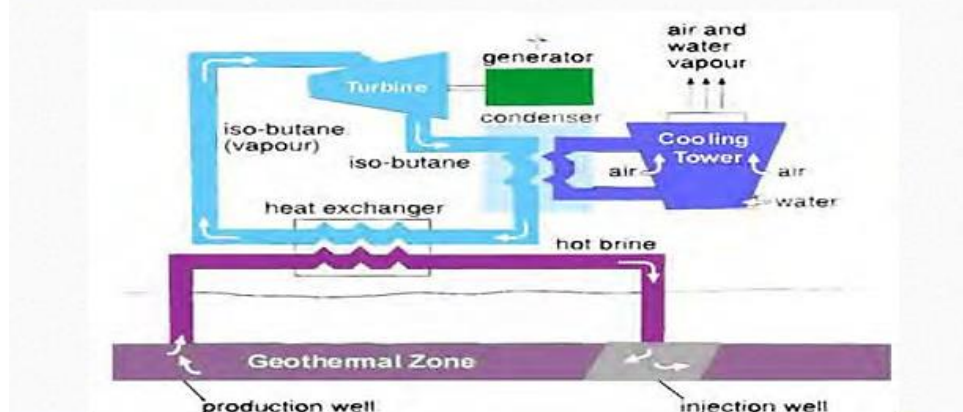
Blade materials

- Wood & Canvas sails
- Aluminium for small blades
- Carbon Fibre-reinforced spare load bearing to reduce weight and increase thickness
- **Carbon fibres** are 14% less on cost and 38% less in mass



5 (a) With the help of neat diagram, explain the Binary cycle geothermal electric power plant.

- Insufficiently hot resource to efficiently produce steam
- Too many chemical impurities to allow flashing.



Binary Cycle Power Plant:

- ❑ In the binary cycle process, the geothermal fluid is passed through a heat exchanger.
- ❑ The secondary fluid, which has a lower boiling point than water (e.g., isobutane or pentane), is vaporised, and expanded through a turbine to generate electricity.
- ❑ The working fluid is condensed and recycled for another cycle.
- ❑ **All of the geothermal fluid is reinjected into the ground in a closed-cycle system. Binary cycle power plants can achieve higher efficiencies than flash steam plants, and they allow the utilisation of lower temperature resources.**
- ❑ In addition, corrosion problems are avoided.
- ❑ However, binary cycle plants are more expensive, and large pumps are required which consume a significant percentage of the power output of the plants.

(b) Discuss about the environmental effects associated with geothermal energy.

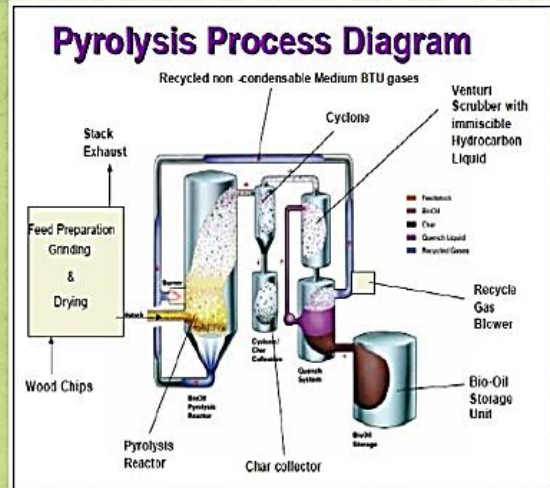
- ❑ **Gaseous and Particulate Emission**
- ❑ Emits CO₂, H₂S, CH₄, NH₃, Mercuric components, lead 210 and radon 222, and dissolved arsenic, boron, and antimony
- ❑ Contributes to global warming, acid rain, and noxious smells if released
- ❑ **Land Pollution**
- ❑ Degradation of usable soil
- ❑ Disposition of pollutant on surface may harm plant, soil sterility and may enter into the food chain
- ❑ **Subsidence Effect**
- ❑ Lowering of ground level when fluids are removed
- ❑ **Seismic Hazards**
- ❑ Geothermal resources are mostly associated with the regions of high geologic activity, which is manifested commonly as earthquakes
- ❑ Researches are directed towards the effects of geothermal fields on the seismic hazards
- ❑ **Water Pollution**
- ❑ Contamination of surface water and ground water by geothermal fluid is a big risk
- ❑ Specific research is required to identify those chemical constituents, which may have adverse effect
- ❑ **Biological Effects**
- ❑ Numerous unknown effects exists regarding the impact of geothermal operation on the bionature
- ❑ It is considered that the delicate balance of environment may be affected due to the chemical changes in soil and water caused by geothermal fields
- ❑ **Social Effects**
- ❑ Problems of noise and land use

6

With neat diagram, explain the process of Pyrolysis. Also mention its advantages and disadvantages.

Pyrolysis

- Burning in absence of oxygen
- It converts waste into gas liquid and solid components
- Gases(CO CH_4 H) are cooled to produce oil or tar residue
- Pyrolyzed liquid has to be cleaned before utilization



PYROLYSIS

- **Process:**
- Organic waste is burnt at relatively low temperature
- **Chemical mining of waste**
- Chemical decomposition of waste materials by heat in the absence of oxygen under pressure and operating temperature above 430 degree Celsius
- Transforms organic materials into gases, small quantities of liquid and a solid residue containing carbon and ash
- **By Products :**
- Combustible gases, including CO , Hydrogen and methane and other hydrocarbons
- If the off gases are cooled ,liquids condense producing an oil or tar residue and contaminated water
- Pyrolysis liquids can be used directly or refined for high quality fuels, chemicals, adhesives and other products
- Direct pyrolysis liquids can be toxic or corrosive

Advantages of Pyrolysis

- Significant reduction in volume of waste
- By Products are very useful
- Storable and transportable fuel or feedstock is obtained
- Environment friendly than incineration
- Environmental Problem is reduced
- More efficient than incineration
- Sustainable process
- Modular plants, Hence easy to operate
- Easy to control the contaminated air emissions
- Replaces coal and natural gas as viable fuel sources

Disadvantage of Pyrolysis

- Generates possible toxic residues such as inert mineral ash, inorganic compounds and unreformed carbon
- Possible toxic air emissions such as acid gases, dioxins , furans, nitrogen oxides, SO_2 ,and particulates
- Requires a certain amount of materials to work efficiently