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Internal Assessment Test 2 – June 2022

Sub:	Renewable Energy Resources					Sub Code:	18EE653	Branch:	ECE, Civil & Mechanical
Date:	10.06.2022	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VI		OBE

Answer any five questions, and Question No 4 is mandate

Answer Key

1 State the advantages and disadvantages of concentrating collectors over Flat plate collectors.

Solution: -

ADVANTAGES

(1) No Fuel Cost: Solar thermal concentrator does not require any fuel like most other sources of renewable energy. This is a huge advantage over other fossil fuels whose cost are increasing at drastic rate every year. Electricity prices are increasing by rapidly in more parts of the world much faster than general inflation. Price shocks due to high fuel costs are a big risk with fossil fuel energy these days.

(2) Predictable 24/7 Power: Solar thermal energy can generate power 24hours a day. This is made possible as solar thermal power plants store the energy in the form of molten salt etc. Other forms of Renewable energy like solar PV and wind energy are intermittent in nature.

(3) No Polution and Global Warning Effects: Solar thermal energy does not cause pollution which is one of the biggest advantages. Note there are costs associate with equipment used to build transport solar thermal energy equipment.

(4) Using existing industrial base: Solar thermal energy uses equipment like solar thermal mirror and turbines which is made in large scale at low cost by existing industrial base and require no major changes in equipment and materials unlike new technologies such as GIGs panels.

(5) Concentrated solar power production have been shown to create more permanent job and stimulate the economy as compared to its natural gas counterparts.

(6) The heat delivered by concentrating solar collectors is available at much higher temperature. Higher temperatures allow the use of power generation equipment to produce both electricity and heat.

(7) Large economy of scale effects are observed when moving towards large concentrating systems, rendering such technology very cost effective (compared with PV for example)

DISADVANTAGES

(1) High Costs: Solar thermal energy cost atleat 3.5Euro/watt and has not declined sola much in the last 3-4 years. However these costs are too high as solar PV already costs 2.5Euro/watt and even on a conservative basis will have it costs reduced by 5% in the next 10 years making it attain half the cost of thermal technology by 2020.

(2) Future Technology has a probability of marking CSP obsolete: Solar energy has become a hot bed of innovation with daily news of some new breakthrough in material and process in PV technology. "**Oerlikon**" has come out with a radial new a-si technology while GIGs players are touting increased efficiencies. Chinese solar companies have captured large chunks of the solar market through low cost leadership while number of Global Heavyweight like POSCO, Samsung, Hyundai, Sharp, GE, TSMC, promise to further decrease these costs.

(3) Water Issue: Solar thermal plant use lot of water which is major problem in desert areas. Using non-water cooling raises the cost of CSP projects too much. While using sea water has been proposed it remains to be seen If it possible to implement this solution as this would imply building plants very near the coastline.

(4) Ecological and Cultural Issue: This usage of massive arrays of Mirrors is noted to heavily impact the Desert wildlife endangering the endangered species. California has already seen massive fight on this issue with project Developers Curtailing the size of their plants and spending money to move wildlife (applicable only to CSP)
(5) Since concentrators can focus only direct solar radiation, this performance is poor on cloudy days.
(6) Tracking mechanisms must be used to move the collectors during the day to keep then focused on the sun.
(7) Maintaince and construction costs of the system is high.
(8) Concentrators are only practical in areas of high direct insolation, such as arid and desert areas.

2 Explain the principle of conversion of solar energy into heat. Explain with a neat diagram how this is employed in Flat plate collectors.
Solution: -

Heat transfer occurs mainly by three mechanisms. The first is by conduction through solid materials in the presence of a temperature difference. The second mechanism is radiation in which energy moves in space by electromagnetic waves. In a moving fluid, the fluid molecules gain heat or lose it by conduction or radiation and carry it by their movement from one place to another. This process, the third mechanism is called convection. The heat transfer may be accompanied by other physical phenomena such as heat generation with in the medium, vapour condensation, liquid evaporation etc.

1. Conduction

The phenomenon of heat conduction is a process of propagation of energy between the particles of a body which are indirect contact and have different temperatures.

The Basic equation for steady state heat conduction is known as Fourier's equation. According to this the quantity o heat(dQ), passing through an isothermal surface(dA), per time interval (dt) is proportional to the temperature gradient($\delta T/\delta n$) and can mathematically expressed as, $dQ = -K(\delta T/\delta n).dA\ dt$.

2. Radiation

Radiation is a process by which heat flows from a body at a higher temperature to a body at a lower temperature when the bodies are separated in space or even a vacuum exists between them. The heat energy transmitted by radiation is called radiant heat.

Radiation is the mode of heat transfer by which the Sun transfer energy to the Earth. The quantity of energy leaving a surface as radiant heat depends on the absolute temperature and the nature of the surface.

A perfect radiator, so called black body emits radiant energy from its surface at a rate 'q' given by,

3. Convection

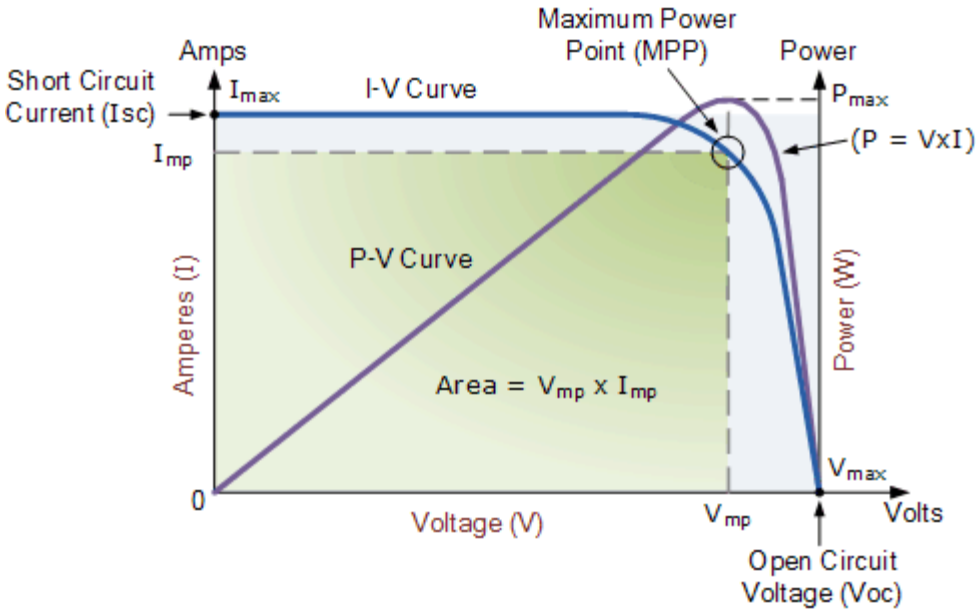
Convection is a process that transfer heat from one region to another by motion of a fluid. The rate of heat transfer by convection qc, between a surface and a fluid can be calculated from the relation.

Principle of Flat Plate Collectors

The principal behind a flat collector is simple. If a metal sheet is exposed to solar radiation, the temperature will rise until the rate at which energy is received is equal to the rate at which heat is lost from the plate; this temperature is termed as the 'equilibrium' temperature. If the back of the plate is protected by a heat insulting material, and the exposed surface of the plate is painted black and is coved by one or two glass sheets, then the equilibrium temperature will be much higher than that for the simple exposed sheet. This plate may be covered into a heat collector by adding a water circulating system, either by making it hollow or by soldering metal pipes to the surface, and transferring the heated liquid to a tank for storage. For heat with withdrawal from the system the equilibrium temperature must decrease, since no useful heat can be extracted at he maximum equilibrium temperature at which the collection efficiency is zero. The other extreme condition is when the flow of liquid is so flat that the temperature rise is very small; in such a case although the losses are small and the efficiency of the heat collection approaches 100 percent, yet no useful heat can be extracted. The optimum is approximately midway between the equilibrium temperature, whereby an output of hot liquid at a useful temperature is obtained.

3 Plot the graph of a typical I-V characteristic of a solar cell. Show the relation between the output voltage and output current of a solar cell.

Solution: -



The main electrical characteristics of a PV cell or module are summarized in the relationship between the current and voltage produced on a typical solar cell I-V characteristics curve. The intensity of the solar radiation (insolation) that hits the cell controls the current (I), while the increases in the temperature of the solar cell reduces its voltage (V). Solar cells produce direct current (DC) electricity and current times voltage equals power, so we can create solar cell I-V curves representing the current versus the voltage for a photovoltaic device. Solar Cell I-V Characteristics Curves are basically a graphical representation of the operation of a solar cell or module summarising the relationship between the current and voltage at the existing conditions of irradiance and temperature. I-V curves provide the information required to configure a solar system so that it can operate as close to its optimal peak power point (MPP) as possible.

4 (i) Define (i) fill factor; and (ii) conversion efficiency of a solar cell.

(ii) List the various advantages and disadvantages of a solar PV

Solution

i) i) fill factor

Fill factor (FF) is the ratio of the actual maximum obtainable power, represented by the dark blue box, to the product of short circuit current Is/c and open circuit voltage Vo/c,

(ii) conversion efficiency of a solar cell

The conversion efficiency of a photovoltaic (PV) cell, or solar cell, is the percentage of the solar energy shining on a PV device that is converted into usable electricity.

(ii) List the various advantages and disadvantages of a solar PV

Advantages

- Electricity produced by solar cells is clean and silent. Because they do not use fuel other than sunshine, PV systems do not release any harmful air or water pollution into the environment, deplete natural resources, or endanger animal or human health.
- Photovoltaic systems are quiet and visually unobtrusive.
- Small-scale solar plants can take advantage of unused space on rooftops of existing buildings.
- PV cells were originally developed for use in space, where repair is extremely expensive, if not impossible. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.
- Solar energy is a locally available renewable resource. It does not need to be imported from other regions of the country or across the world. This reduces environmental impacts associated with transportation and also reduces our dependence on imported oil. And, unlike fuels that are mined and harvested, when we use solar energy to produce electricity we do not deplete or alter the resource.
- A PV system can be constructed to any size based on energy requirements. Furthermore, the owner of a PV system can enlarge or move it if his or her energy needs change. For instance, homeowners can add modules every few years as their energy usage and financial resources grow. Ranchers can use mobile trailer-mounted pumping systems to water cattle as the cattle are rotated to different fields.

Disadvantages

- Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.
- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion efficiencies of the equipment. As the conversion efficiencies continue to increase and the manufacturing costs continue to come down, PV will become increasingly cost competitive with conventional fuels.
- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which

could lead to an energy shortage if too much of a region's power comes from solar power.

5 What are thermo-chemical methods of hydrogen production? Explain steam methane reforming technique of hydrogen production.

Solution: -

Hydrogen bound in organic matter and in water makes up 70% of the earth's surface. Breaking up these bonds in water allows us produce hydrogen, and then, to use it as a fuel. There are numerous processes that can be used to break these bonds. Following sections discuss a few methods for producing hydrogen that are currently used or are under research and development. Most of the hydrogen now produced on an industrial scale by the process of steam reforming, or as a by-product of petroleum refining and chemical production.

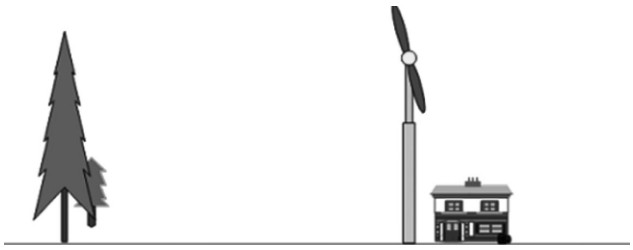
- ***Steam Reforming***
- ***Partial Oxidation or Ceramic Membrane Reactor***
- ***Biomass Gasification and Pyrolysis***

Steam reforming uses thermal energy to separate hydrogen from the carbon components in methane and methanol and involves the reaction of these fuels with steam on catalytic surfaces. The first step of the reaction decomposes the fuel into hydrogen and carbon monoxide. Then, a 'shift reaction' changes the carbon monoxide and water to carbon dioxide and hydrogen. These reactions occur at temperatures of 200oC or greater.

Steam reforming of natural gas is currently the least expensive method and is responsible for more than 90% of hydrogen production worldwide. Natural gas is first cleared from sulphur compounds. It is then mixed with steam and send over a nickel–alumina catalyst inside a tubular reactor heated externally, where carbon monoxide (CO) and hydrogen (H2) are generated. This step is followed by a catalytic water-gas shift reaction that converts the CO and water to hydrogen and carbon dioxide (CO2). The hydrogen gas is then purified. The residual stream from the initial purification step is part of the fuel gas burned in the reformer in order to supply the required heat. Hence, the CO2 contained in this gas is currently vented with the flue gas. If CO2 were to be captured, an additional separation step would be needed.

6 Using indicative sketches compare horizontal and vertical axis wind turbines.

Solution: -



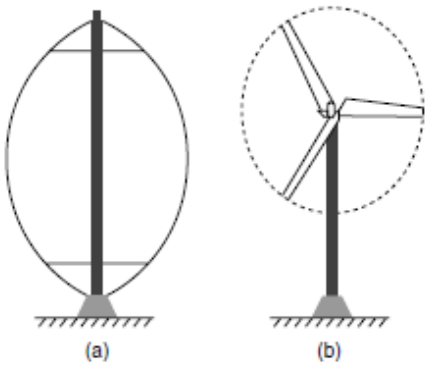


Figure 6.8 Wind rotor configurations (a) Vertical axis (b) Horizontal axis

The basic wind energy conversion device is the wind turbine. Although various designs and configurations exist, these turbines are generally grouped into two types depending on the position of the rotor axis. Figure 6.8 illustrates the two types of turbines and typical subsystems for an electricity generation application.

Two important wind rotor configurations are as follows:

1. In vertical-axis wind turbines (VAWT), the axis of rotation is vertical with respect to the ground (and roughly perpendicular to the wind stream), as shown in Figure 6.8(a). The following are the two main types of VAWT:

(a) Darrieus (which uses lift forces generated by aerofoils)

(b) Savonius (which uses drag forces)

2. Horizontal-axis turbines, in which the axis of rotation is horizontal with respect to the ground (and roughly parallel to the wind stream), as represented in Figure 6.8(b). Horizontal-axis wind turbines (HAWT) can be further divided into three types:

(a) Dutch windmills

(b) Multi-blade water-pumping windmills

(c) High-speed propeller-type wind machines

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