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T. Y. B.Sc. (Physics) Semester : III
Elective-I : Renewable Energy Sources

Module : 2

PHOTOTHERMAL APPLICATIONS

Content :

- Introducation
- Liquid flat plate collector
- Construction and working of liquid flat plate collector
- Energy balance equation (without thermal analysis)
- Concentrating collectors : Advantages and disadvantages
- Solar distillation
- Solar drying
- Solar cooker (Box type)
- Solar water heating systems .

Introduction :

The solar energy option has been identified as one of the promising alternative energy sources for the future .

Various devices are used for thermal collection of solar radiation .

The actual and proposed application of solar energy may be considered in three general categories :

1) Direct thermal applications :

In this , the use of heat , resulting from the direct absorption of solar radiation is used. This can be done by space heating or cooling of residences and other buildings to provide hot water service and also supply heat for agricultural , industrial and other processes that require moderate temperature .

2) Solar electrical applications :

In this the solar energy is converted directly or indirectly into electrical energy . There are four

general methods used for solar electrical applications .

1. Solar thermal electric conversion
2. Photovoltaic method
3. Thermo-electric conversion
4. Wind energy and ocean thermal energy conversion .

3) Energy from biomass and biogas :

It includes conversion into clean fuels or energy related product of organic matter derived directly or indirectly from plants , which uses solar energy to grow .

Solar collectors :

A solar collector is a device designed to absorb incident solar radiation and to transfer the energy to a fluid passing in contact with it.

Utilisation of solar energy requires solar collectors .

Solar collectors may be classified according to their collecting characteristics , the way in

which they are mounted and the type of transfer fluid they employ .

There are three general types of solar collectors:

1. Flat Plate Collector (FPC)

2. Evacuated Tube Collector (ETC)

3. Concentrating (Focusing) collector

1. Flat Plate collectors :

There are two types of flat plate collector :

(A) Liquid flat plate collector

(B) Air flat plate collector .

(A) Liquid flat plate collector :

The liquid flat plate collector is the most widely used solar collector because it is simple in design , has no moving parts and requires low maintenance .

The basic parts that make up a conventional liquid flat plate collector are as follows ,

a) **The absorber plate**
b) **The tubes fixed to the absorber plate through which the liquid to be heated flows**
c) **The transparent cover**
d) **The collector box .**

Liquid flat plate collector is that it utilises both the beam and diffuse components of the solar radiation .

The liquid heated is generally water. However , sometimes mixtures of water and ethylene glycol are used if ambient temperatures below 0^0 C are likely to be encountered .

The absorber plate is usually made from a thin metal sheet ranging in thickness from 0.2 to 0.7 mm , while the tubes , which are also of metal , range in diameter from 1 to 1.5 cm .

The tubes are soldered , brazed or pressure bonded to the bottom of the absorber plate with the pitch ranging from 5 to 12 cm .

In some designs , the tubes are bonded to the top or are in line and integral with the absorber plate .

The metal most commonly used , both for the absorber plate and the tubes , is copper .

The header pipes , which lead the liquid in and out of the collector and distribute it to the tubes.

These pipes are made up of the same metal as the tubes and have slightly larger diameter (2 to 2.5 cm).

The cover should be made up of a material which is highly transparent to incoming solar radiation and at the same time , opaque to long wavelength re-radiation emitted by the absorber plate .

Glass with a low ferric oxide content satisfies these requirements .

Toughened glass of 4 or 5 mm thickness is the most favoured material .

This type of glass is able to withstand thermal shock as well as the impact of objects which may fall on the collector face .

The bottom and sides are usually insulated by mineral wool , rock wool or glass wool with a covering of aluminium foil and has a thickness ranging from 2.5 to 8 cm .

Whole assembly is contained within a box which is tilted at a suitable angle.

The present rate of production of liquid flat plate collectors in the world , as well as in India , is low . However , it is increasing rapidly .

Liquid Flat Plate Collector :

Construction:

1. Absorbing plate :

It basically consists of a flat surface with high absorbptivity for solar radiation , called the absorbing plate .

It is basically a flat metal plate , usually made of highly conductive and corrosion resistant copper or steel or aluminium with a black surface .

The thickness of this metal sheet is 1 to 2 mm in thickness.

These tubes circulate the liquid require for removing the thermal energy from the plate .

3. Transparent cover plate :

It is one or two sheets of glass of thickness 3 to 4 mm , transparent to incoming solar radiation and opaque to the infrared re-radiation from the absorber plate .

It should have a high transmittance for solar radiation and should not deteriorate with time .

It reduces upward convective and radiative heat losses from the absorber plate.

4. Enclosure or Insulation :

It is generally made from steel , aluminium or fibre glass .

This prevent the heat from escaping through the back of the collector , a layer of insulation is placed behind the absorber plate .

It is a weather tight container to enclose the above components .

It facilitates installation of the collector on a roof or in appropriate frame .

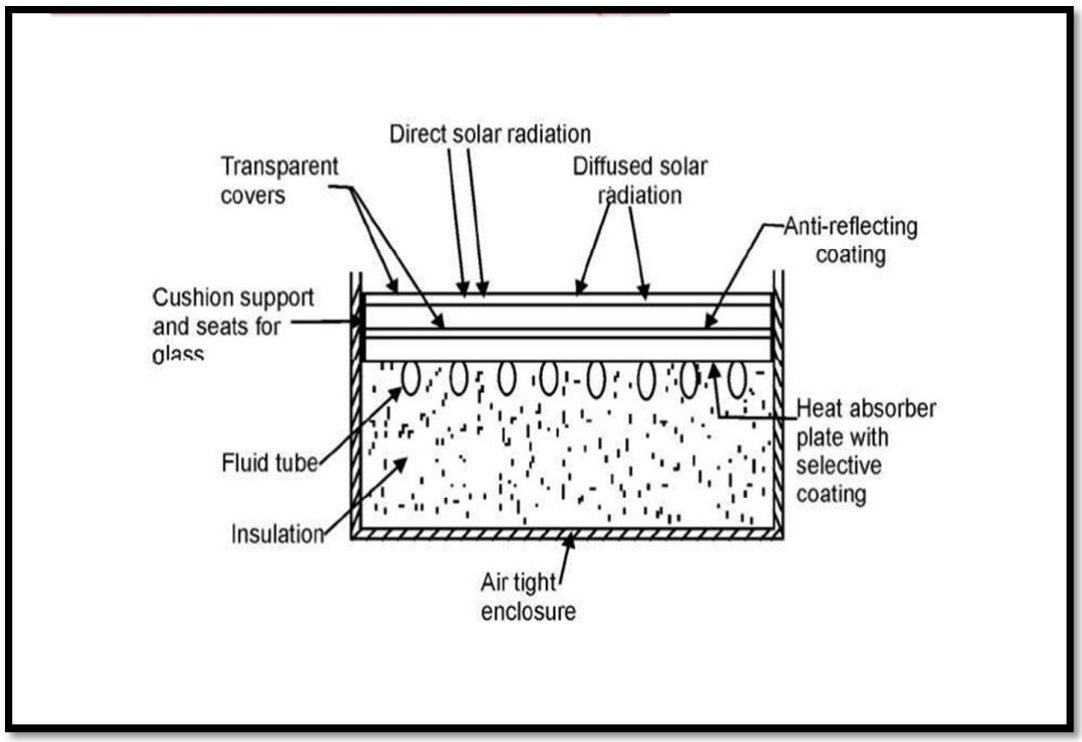

Figure : Schematic cross section of liquid flat plate collector .

- **Working of liquid flat plate collector :**

When sunlight passes through the transparent cover and strike the absorber plate , its temperature increases until the rate at which the energy received is equal to the rate at which the

heat lost from the plate . This temperature is called as equilibrium temperature .

This equilibrium temp is much higher than the simple exposed sheet or transparent cover .

There is conversion of solar energy into heat energy.

This heat is transferred to the liquid (water or oil) paasing through pipes attached to the absorber plate by means of convective heat transfer .

Therefore liquid gets heat and after that this liquid is transferred to a tank for storage .

Advantages :

1. It is simple in design , has no moving parts and requires little maintenance.

2. The main advantage is that it utilises both the beam and diffuse radiation .

Disadvantage :

1. Because of absence of optical concentration , the area from which heat is lost is large . As a result , the collection efficiency is generally low.

Applications :

1. Water heating

2. Space heating and cooling

3. Low temperature cycles for power generation .