T. Y. B.Sc. (Physics) Semester: III

Elective-I: Renewable Energy Sources

Subject Code: PH-336

By Assistant Professor Wabale R.K.

Module: 2 PHOTOTHERMAL APPLICATIONS

Advantages of solar concentrating collectors :

- Reflecting surfaces requires less material and are structurally simpler than flat plate collector .
- The absorber area of a concentrator system is smaller than that of a flat plate collector . Therefore , the solar intensity is greater for solar concentrators.
- Due to small absorber area , the heat lost per unit area is smaller in solar concentrators and hence the working fluid can attain higher temperature.
- 4. Due to high temperature attained by concentrators , the heat energy stored per unit volume is larger than the flat plate collector .
- 5. Concentrating systems can be used for eletric power generation when not used for heating or cooling .
- 6. Total useful time in a year is larger for solar concentrators than the flat plate collectors .

Disadvantages of solar concentrating collectors :

- 1. Only beam radiation can be collected and diffuse radiation can not be collected .
- 2. Due to reflecting system , tracking is required and it introduces a certain amount of complexity in the design .
- 3. Therefore the cost of the concentrating collectors is high .
- 4. Additional requirement is required to retain the quality of reflecting surface against dust , weather and oxidation .
- 5. In concentrating collector heat is lossed due to reflectance loss and intercept of radiations .

- 6. The concentrating collectors have non–uniform flux on the absorber whereas in flat plate collector is uniform .

Solar distillation :

- **Basic Principle :**
- Solar water distillation is the process of using energy from the sunlight to seperate fresh water from salts or other contaminants.
- The untreated water absorbs heat, slowly reaching high temperatures.
- The heat causes the water to evaporate, cool, and condense into vapour, leaving the contaminants behind.

Construction :

- The principle of solar distillation is simple and can be explained with reference to following figure , in which a conventional basin type solar still is shown .
- The still consists of a shallow air tight basin lined with a black coating , impervious material which contains saline water .
- A sloping transparent cover is provided at the top and which is usually glass or may be plastic .
- The solar radiation is transmitted through the cover and is absorbed in the black lining .

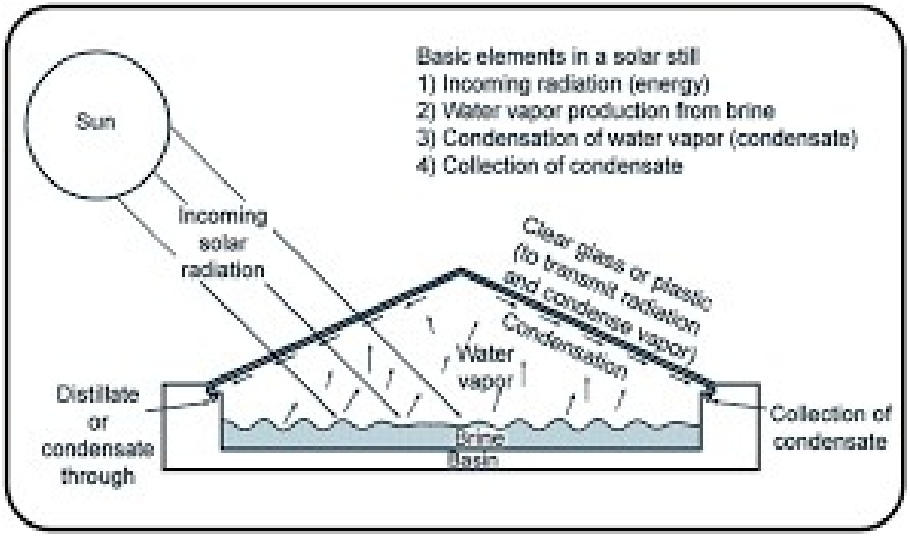


Figure : Schematic diagram of a basin type solar still .

Working :

- Solar still works on the principle of solar distillation . A solar still duplicates the way as rain water that is evaporation and condensation .
- The saline water is filled in the black painted basin of the solar still .
- This is enclosed in a completely air tight surface and a sloping transparent cover is provided at top .
- The solar radiation is transmitted through the cover is absorbed in the black lining .
- The distillator or solar still is designed so that an efficient amount of solar radiations get trapped inside it .
- This increases the internal temperature of system causing the saline water to evaporate leaving behind all the salt contents , insectisides , bacteria ,viruses , etc .
- Transparent cover material is cooler than the water surface as it does not absorb the solar radiation .
- This temperature difference produces convection currents in the air which is trapped inside the enclosure .
- These currents bring the humid air into contact with realatively cool cover and results in condensation .
- After that this condensate pure water is collected in the condensate channel due to inclination provided to the glass covers . Finally fresh water obtained .
- An output of about 3 litres/ m^2 with an assosciated efficiency of 30 to 35 % can be obatined in a well designed still on a good sunny day .

Advantages of solar distillation :

- 1. It is pollution free and simple in designing .
- It requires low maintaince .
- It produces pure water from highly saline water even sea water .
- It does not require skilled operator to operate it .
- It does not require any conventional energy .

- It does not have any movable parts .

Disadvantages of solar distillaton :

- The cracking , breakage or scratches on glass , which reduce solar transmission .
- Damage over time to the blackened absorbing surface .
- To avoid growth of algae and deposition of dust stills need to be cleaned regularly every few days .
- There is acccumulation of salt on the bottom , which needs to be removed periodically .
- **Applications of solar distillation :**

s. no.	PLACE	USES
1.	Industries	for industrial processes
2.	Hospitals and Dispensaries	for sterilization
3.	Garages and Automobile Workshop	for radiator and battery maintenance
4.	Telephone Exchange	for battery maintenance
5.	Laboratory Use	for analytic work
6.	Marshy and costal area	To get fresh potable water

Solar drying :

- One of the traditional uses of solar energy has been for drying of agricultural products .
- The drying process removes the moisture and helps in the preservation of the product .
- Traditionally , drying is done on open ground . The disadvantages associated with this are the process is slow and the insects and dust get mixed with the product .
- The use of dryers help to eliminate these disadvantages .

Basic principle :

- 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.

Construction :

- The dryer consist of following different parts such as ,
- 1. An enclosure with a transparent cover .
- 2. A perforated trays on which product is placed , which to be dried .
- 3. Hot air outlet .
- 4. For natural circulation there is some windows .

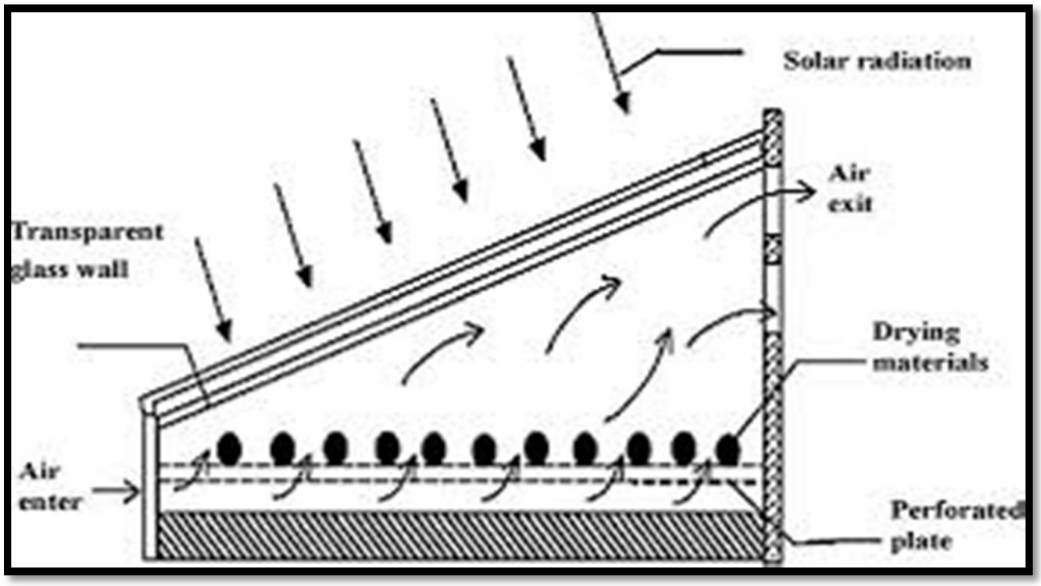


Figure : Schematic diagram of solar dryer .

Working :

- The dryer consists of an enclosure with a transparent cover .
- The material to be dried is placed on perforated trays .

- Solar radiation entering the enclosure is absorbed in the product itself and the surrounding internal surfaces of the enclosure .
- As a result , moisture is removed from the product and the air inside is heated .
- The heated air is allowed to flow through/over the wet crop or any material that provides the heat for moisture evaporation by convective heat transfer between the hot air and the wet crop.
- Drying takes place due to the difference in moisture concentration between the drying air and the air in the vicinity of crop surface .
- Suitable openings at the bottom and top ensure a natural circulation .
- Temperature ranging from 50^0 C to 80^0 C are usually attained and the drying time ranges from 2 to 4 days .
- Typical products which can be dried in such devices are dates , apricots , chillies , grapes , etc .

Advantages :

1. It is pollution free .
2. Drying can be done faster and in a controlled fashion as compare to the open ground process .
3. In this process dust particles , flies, pests, rain can not be mixed with the product .
4. The quality of the product is better in terms of nutrients, hygiene and colour.
5. It does not require any fuel for drying .
6. It does not contain any movable parts .

Disadvantages :

1. For solar dryer initial installation cost is high .
2. It gives better efficiency only in perfect sunny days .
3. Not workable at night .
4. Over heating may occur if regular attention is not paid .

5. Due to over heating it can decrease the quality of food .
6. Change in taste and flavor of food may occur if regular monitoring is not done .

Solar cooker (Box type) :

- A device that utilises solar energy for cooking purposes is called a solar cooker. The most commonly used form of solar cooker is known as box-type solar cooker.
- **Basic working :**
- A solar box cooks because the interior of the box is heated by the energy of the sun .
- It turns to heat energy when it is absorbed by the dark absorber plate and cooking pots .
- This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain .
- The food is cooked in a shallow vessel of the container.

Construction :

- A box-type solar cooker consists of the following components :
- **Box :** This is an insulated metal or a wooden box. It is painted black from inside because black surface absorbs more heat. The box may be provided with four roll-wheels.
- **Glass cover :** A cover made of two sheets of toughened glass held together in an aluminium frame is used as a cover of the box . It is 3 mm thick and fixed in frame .
- **Plane mirror reflector :** Collector area of solar cooker is increased by providing a plane refelcting mirrors .
- A plane mirror reflector fixed in a frame is fixed to the box with the help of hinges.
- The mirror reflector can be positioned at any desired angle to the box.
- The mirror is positioned so as to allow the reflected sunlight fall on the glass cover of the box.

- **Cooking containers :**
- A set of containers made of aluminium and blackened from outside are kept in the box .
- These containers are also painted black because black surface absorbs more heat.
- **Insulation :**
- The loss due to convection is minimised by making the box air tight by providing a rubber strip all round between the upper lid and the box .
- Insulating material like glass – wool , paddly husk , sawdust are filled in space between blackened tray and outer cover box . This minimizes the heat loss due to conduction .

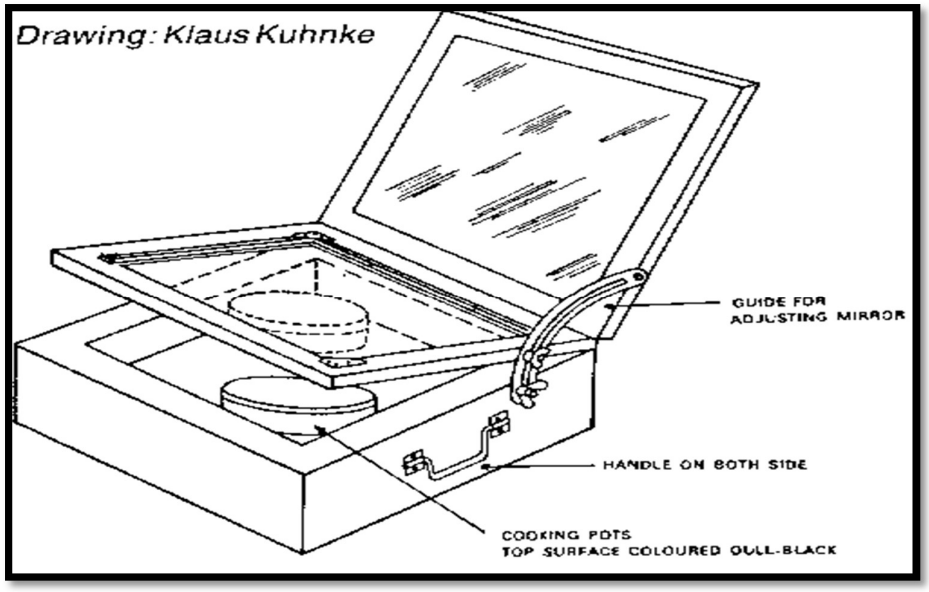
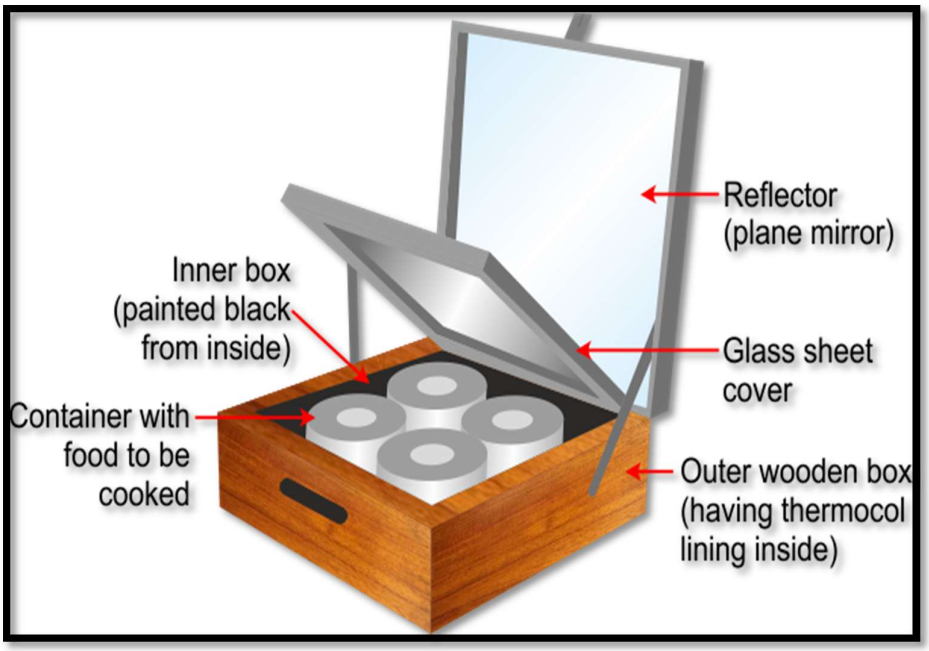


Figure : Box type solar cooker .



Working :

- The food is cooked in a shallow vessel of the container. The box has a transparent covering of glass sheet over it.
- The solar cooker is placed in sunlight and reflector (plane mirror) is adjusted in such a way that a strong beam of sunlight enters the box through the glass sheet.
- The blackened metal surfaces in the wooden box absorb infra-red radiations from the beam of sunlight and heat produced raises the temperature of blackened metal surface to about 100°C.
- The temperature attained depends upon the intensity of solar radiation and the material of insulation provided .
- The amount of solar radiation intensity can be increased by providing mirror .
- The food absorbs heat from the black surface and gets cooked.
- The thick glass sheet does not allow the heat produced to escape and thus, helps in raising the temperature in the box to a sufficiently high degree to cook the food .

- The time required for cooking is reduced if metallic vessels with a tight lid and painted dull black from outside , are used .
- The time required for cooking is inversely proportional to the collector area .

Advantages :

1) The use of solar cooker does not cause pollution.
2) The solar energy used by solar cooker is available for free of cost.
3) There is no problem of charring of food and no over flowing .
4) It is simple to use and easy to manufacture .
5) Orientation or sun tracking is not needed .
6) Vitamins in the food are not destroyed and food cooked is nutritive and delicious with natural taste .
7) One can relay on cooker's efficiency for longer period .

Disadvantages :

1) Solar cooker cannot be used during night and cloudy days.
2) It takes longer time to cook food.
3) One has to cook according to the sunshine , the menu has to be preplanned .
4) Chapaties and purees are not cooked because they require high temperature for baking .

Solar water heating systems :

- Solar water heating systems can be classified into two categories :

1. Natural circulation (Thermosyphon) systems .

2. Forced circulation systems .

1. Natural circulation (Thermosyphon) systems :-

- It is also called as domestic hot water system . A typical system for domestic water system is shown in figure .

Construction :

- The two main components of the domestic hot water system are as ,

  a) The liquid flat plate collector .

  b) The storage tank .

- The storage tank is located above the level of the collector .

Working :

- As the water is heated by solar energy it flows automatically to the top of the tank and is replaced by the cold water from the bottom of the tank .
- Hot water for use is withdrawn from the top of the tank .
- Whenever this is done cold water automatically enters at the bottom of the tank .
- An auxiliary heating system is sometimes provided for use on cloudy or rainy days .
- Most of the system have capacities of 100 to 200 litres per day and uses one or two flat plate collectors having area of 2 m^2 each .

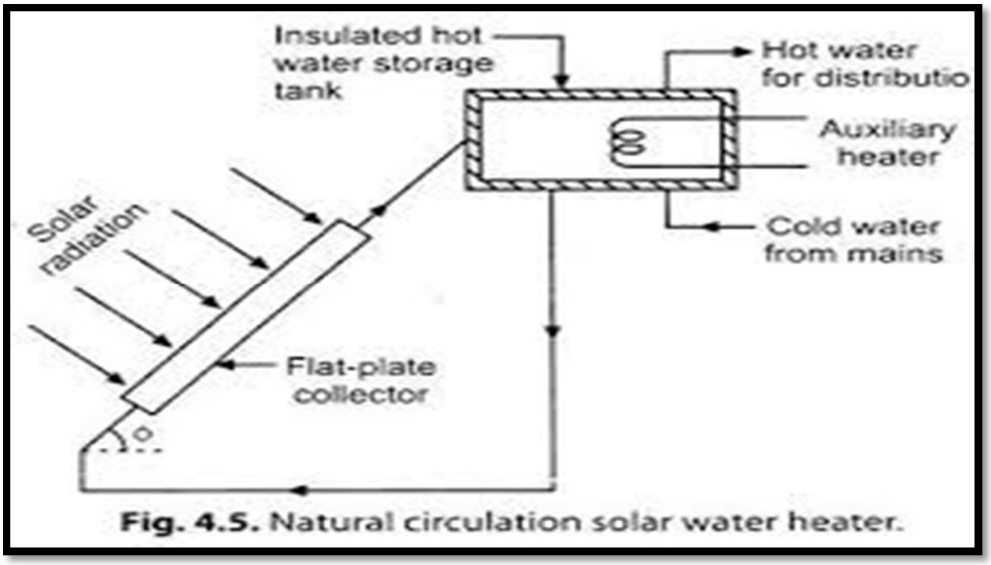


Fig. 4.5. Natural circulation solar water heater.

Advantages :

- 1. It is simple to construct and install .
- 2. It requires very low maintenance and running cost is also less .
- 3. Save time and energy .

- 4. It is pollution free and free of cost .
- 5. Required temperature easily achieved with simple equipments .

Disadvantages :

- 1. It can not be used during night and cloudy days .
- 2. It gives better efficiency only in sunny days .

2. Forced circulation systems :-

It is also known as industrial solar water heating systems .

When large amount of hot water is required for supplying process heat in industry or in a commercial establishment , a natural circulation system is not suitable .

Large array of flat plate collectors are then used and forced circulation is maintained with a water pump .

These are classified into two categories :

A) Close loop configuration

B) Open loop configuration .

A) **Close loop configuration :**

- A typical industrial solar water heating system in close loop configuration is shown in figure .
- The water from the storage tank is pumped through the collector array where it is heated and then flows back into the storage tank .

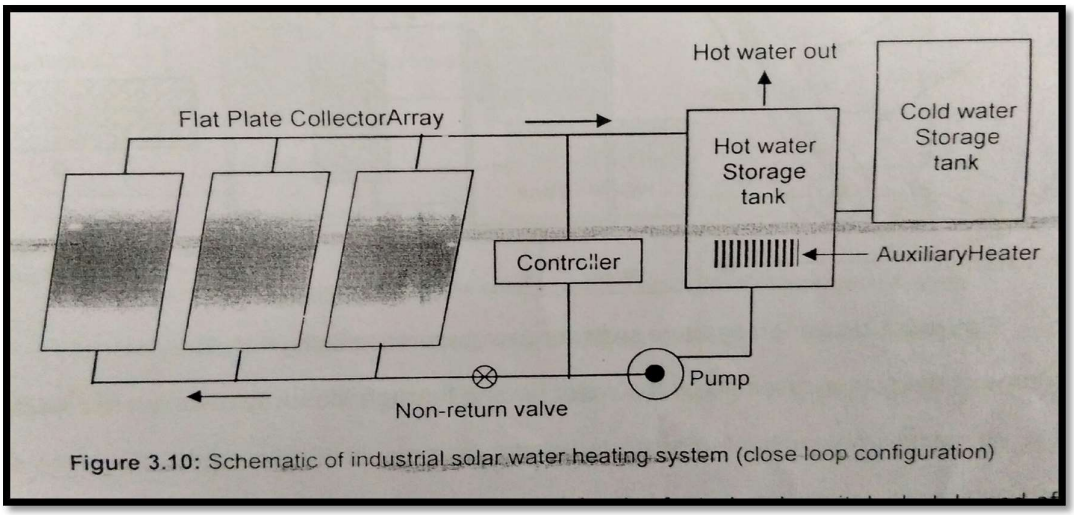


Figure 3.10: Schematic of industrial solar water heating system (close loop configuration)

- Whenever hot water is withdrawn for use , cold water takes its place using a ball float controll ,which senses the difference between the temp of the water at the exit of the collector and a suitable location inside the storage tank .
- The pump is switched on whenever this difference exceeds a certain value and off when it falls below certain value .Provision is also usually made for an auxiliary heater .
- The solar water systems of this type are well suited for the factories , hospitals , hotels and offices .

B) Open loop configuration :

- A typical industrial solar water heating system in open loop configuration is shown in figure .
- In such configuration , the hot water flows from a cold water tank through the collectors to an insulated hot water storage tank from where it is withdrawn for use .

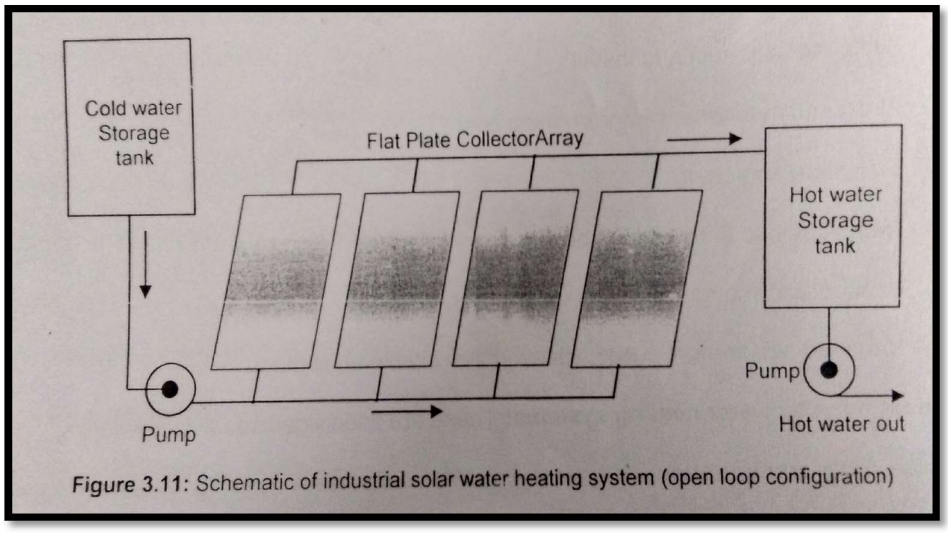


Figure 3.11: Schematic of industrial solar water heating system (open loop configuration)

- The control of such system is usually designed so that hot water at the required temperature flows out of the collector array with required temperature .
- The required outlet temperature of water is near about 80 ^{0}C .
- It is also used for the same purpose like a close loop configuration that is in factories , hospitals, hotels , etc .