UNIT-II

SOLAR THERMAL COLLECTORS

ESSAY QUESTIONS

Q. 6. *Explain construction and working and types of solar water heating system.*

Solar water heaters — sometimes called solar domestic hot water systems — can be a *cost-effective way* to generate hot water your home. They can be used in any climate, and the fuel they use.

Working of Solar water heaters :

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive.

Active Solar Water Heating Systems :

There are two types of active solar water heating systems:

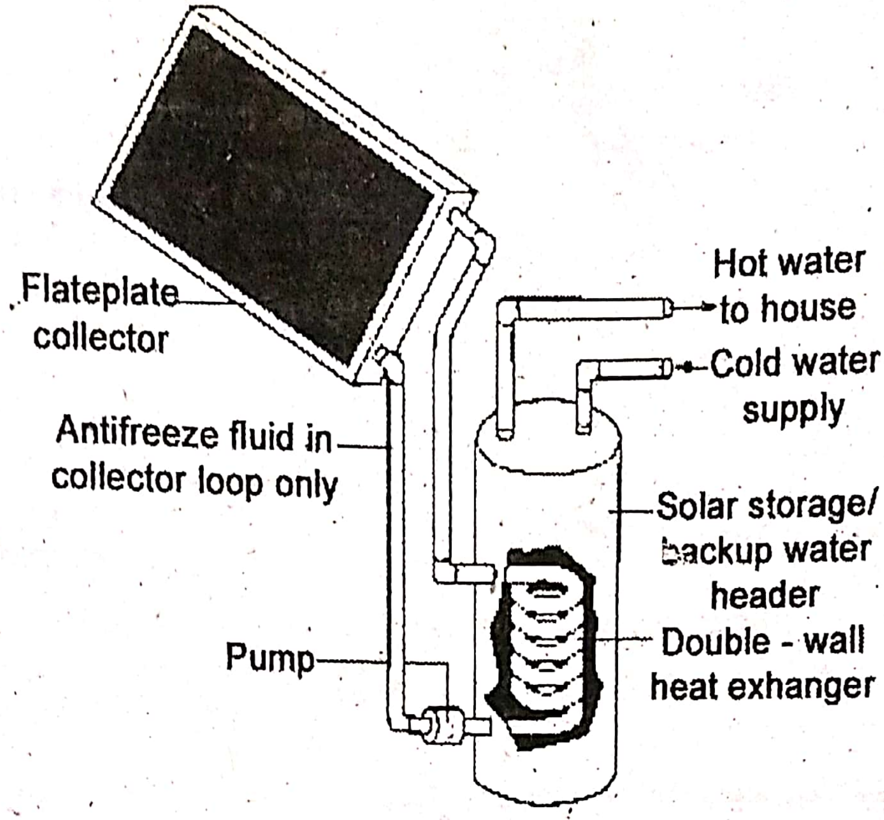
Direct circulation systems :

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

Indirect circulation systems :

Pumps circulate a non-freezing, *heat-transfer fluid* through the collectors and a *heat exchanger.* This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

Active, Closed Loop Solar Water Heater



Passive Solar Water Heating Systems :

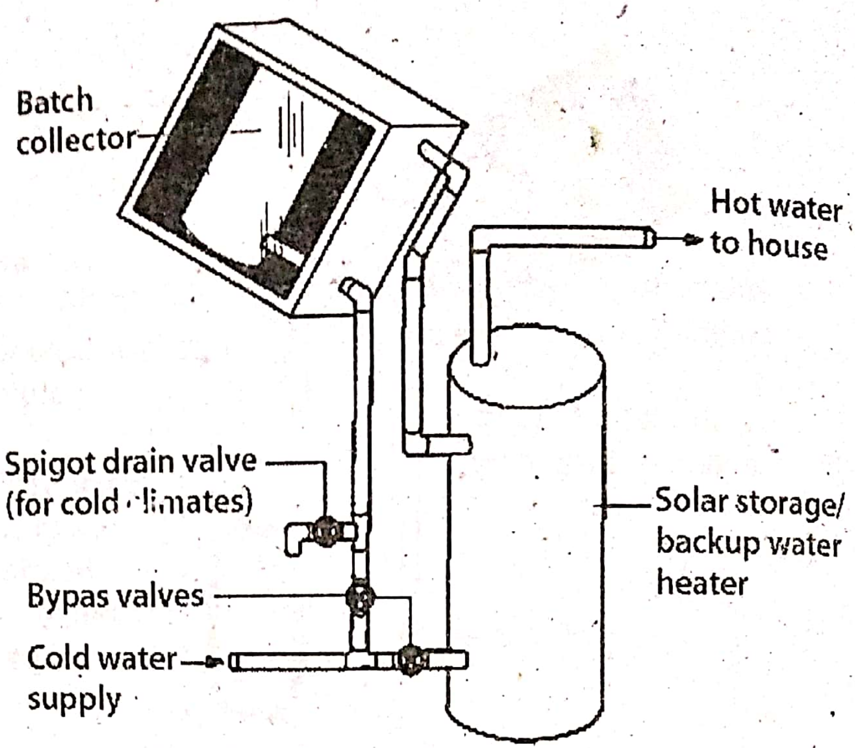
Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems.

Integral collector-storage passive systems :

These consist of a storage tank covered with a transparent material to allow the sun to heat the water. Water from the tank then flows into the plumbing system. These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

Thermosyphon systems :

Water is heated in a collector on the roof and then flows through the plumbing system when a hot water faucet is opened. The majority of these systems have a 40-gallon capacity.



Storage Tanks and Solar Collectors :

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Three types of solar collectors are used for residential applications:

Flat-plate collector :

Glazed flat-plate collectors are insulated, weather proofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors — typically used for solar pool heating — have a dark absorber plate, made of metal or polymer, without a cover or enclosure.

Integral collector-storage systems :

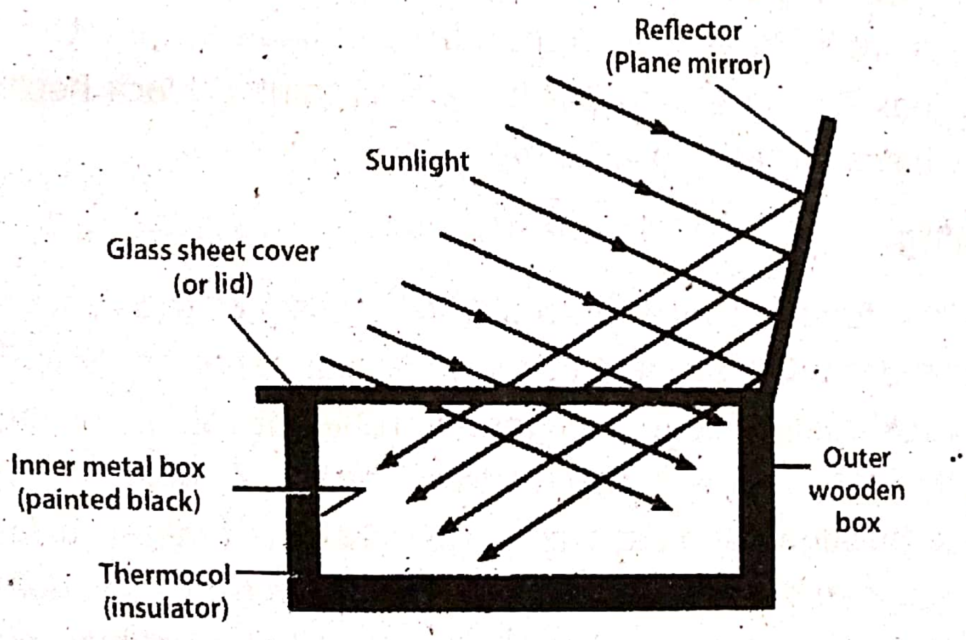
Also known as ICS or *batch* systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

Evacuated-tube solar collectors :

They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss.

Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a tankless or demand-type water heater for backup.

Q. 7. *Give the construction and working of a solar cooker.*



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. A box-type solar cooker is shown above in the figure.

Construction of a box-type solar cooker: A box-type solar cooker consists of the following components:

1. **Box (B)**: 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.

2. **Glass cover (G):** A cover made of two sheets of toughened glass held together in an aluminium frame is used as a cover of the box B.

3. **Plane mirror reflector:** A plane mirror reflector fixed in a frame is fixed to the box B 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.

4. **Cooking containers (C):** A set of containers made of aluminium and blackened from outside are kept in the box B. These containers are also painted black because black surface absorbs more heat.

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 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.

SHORT ANSWER QUESTIONS

Q. 1. *Explain energy balance equation and efficiency of solar thermal collectors.*

Energy Balance in Flat-Plate Collectors :

A fundamental concept for thermal analysis of any thermal system is the conservation of energy, which can be analysed through energy balance calculation under steady state conditions. In steady state, the useful energy output of the collector is the difference between the absorbed solar radiation and the total thermal losses from the collector.

Useful energy = Absorbed solar energy - Thermal losses.

Obviously, the higher the useful energy output from a particular design, the higher the expected efficiency. Thermal efficiency of the collector is an important parameter to consider in this kind of analysis as it creates the basis for comparison of different materials and modifications of collector systems.

Thermal efficiency $\eta = Qu/AcG_T$

Where

Q_u is the useful energy output from a collector,

G_T is the incident solar radiation flux (irradiance),

and A_c is the collector area.

Q. 3. How does a forced circulation solar system work?

A forced circulation *solar. system* is a *solar thermal installation* in which the water circulates within the circuit driven by a pump. Unlike solar installations with a thermosyphon, forced circulation water heating systems do not move the hot water to the highest point of the closed circuit. Instead, the pump makes water go down from the solar collectors to the accumulation tank. On many occasions, installing solar thermal energy equipment to obtain sanitary hot water by thermosyphon is not feasible since the solar collectors often are above the accumulator.

This renewable energy system is a must-have in underfloor solar water heating.

In these types of solar thermal systems, the water that circulates between the solar collectors and the storage tank cannot do so by natural convection since the hottest water is already at its highest point. Instead, it will require a conventional water pump and, therefore, an external electrical power source.

The forced systems are always indirect, except for pool heating, where the proper impulsion system for filtering the water in the glass can be used.

Using an external energy source can no longer be considered a passive solar energy system by harnessing solar energy.

Advantages of the Forced Circulation System :

These solar domestic hot water systems have the following advantages:

(i) First, the structure of the house does not determine its location. Therefore, the hot water accumulator can be inside the building, and outside it will only be necessary to install the solar panels.

(ii) Better protection of the accumulator: The possibility of placing the accumulator inside the house allows you to install a larger accumulator; it is better insulated. By not being exposed to the weather, it will improve its durability.

(iii) **Better thermal efficiency:** the solar heat efficiency to heat the water is higher than in the thermal solar system with thermosyphon because it can be optimized to obtain the highest thermal performance.

Disadvantages of the Forced Circulation System :

(i) The system requires the installation of a water pump to allow the water to circulate. The presence of the pump implies an increase in the cost of maintenance since more elements appear with the possibility of suffering breakdowns.

(ii) We need to have an electricity point to be able to use electrical energy.

(iii) The overall energy efficiency is lower than with the thermosyphon system. Although the thermal efficiency is higher, it is necessary to add the electricity consumption for the operation of the water pump.

VERY SHORT ANSWER QUESTIONS

Q. 1. *What is a thermal collector used for?*

A solar thermal collector collects heat by absorbing sunlight. The term "solar collector" commonly refers to a device for solar hot water heating, but may refer to large power generating installations such as solar parabolic troughs and solar towers or non-water heating devices such as solar air heaters.

Q. 3. What is the efficiency of a solar energy collector? and how it is calculated?

The solar collector efficiency represents the ratio between the heat absorbed by the solar receiver Q. r and the incident solar radiation I_{T0}, normal on the collector's aperture of area A_a. Thus the thermal efficiency of the solar collector is.

$\eta_{coll} = Q_r$ / ITOAa.