(b) Hydraulic energy (or) Water power

Water power is developed by allowing water to fall under the force of gravity. It is used almost exclusively for electric power generation, in fact, the generation of water power on a large scale became possible around the beginning of the twentieth century only with the development of electrical power plants or Hydro electric plants were usually of small capacities usually less than 100 KW.

Potential energy of water is converted into Mechanical energy by using prime moves known as hydraulic turbines. Water power is quite cheap where water is available in abundance. Although capital cost of hydro electric power plants is higher as compared to other types of power plants but their operating Costs are quite low, as no fuel is required in this case. The development rate of hydropower is still low, due to the following problems:

1. In developing a project, it will take about 6-10 years time for planning, investigation and construction.
2. High capital investment is needed, and some parts of the investment have to be designed from foreign sources.
3. There are growing problems on relocation of villages, involved, compensation for damage, selecting the suitable resettlement area and environmental impact.

Because of long transmission line to the villages with low load factor, the electric power will be available to the people in rural areas may not be economical. This leads to the development of Mini or Micro hydroelectric projects to supply the electric power to remote areas. The Importance of Micro hydroelectric projects have been observed in some parts of the country with availability of river flow through out the year.

In order to reduce the cost of development several Measures have been considered as follows:

(a) Development of low cost turbines and generators.
(b) Participation of villages in the development and operation of the project.
(c) Using the appropriate technology and tolerable substandard requirement and project civil work component at the beginning stage.

(c) Nuclear energy

According to modern theories of atomic structure, matter consists of minute particles known as atoms. Heavier unstable atoms such as U^{235}, Th^{239}, liberate large amount of heat energy. The energy released by the complete fission of one Kg of Uranium (U^{235}), is equal to the heat energy obtained by burning 4500 tonnes of coal (or) 220 tons of oil. The heat produced by nuclear fission of the atoms of fissionable material is utilized in special heat exchangers for the production of steam which is then used to drive turbogenerators as in the conventional power plants.

However there are some limitations in the use of nuclear energy namely high capital cost of nuclear power plants, limited availability of raw materials, difficulties associated with disposal of radio active waste and shortage of well trained personnel to handle the nuclear power plants.

The Uranium reserves in the world at present are small. These reserves are recoverable but are expensive. The presently working power plants are:

1. Tarapur atomic power station in Maharashtra
2. Ranapratap sagar atomic power station near Tota, Rajasthan
3. Kalpakkam atomic power station near Madras, Tamilnadu.
4. Narora atomic power station in U.P.

About 3% of the energy produced in India is obtained from nuclear power plants.

1.4.2. Non-Conventional Energy Sources

The sources of energy which are being produced continuously in nature and are in exhaustible are called renewable sources of energy (or) non-conventional energy.

Some of these sources are:

(a) Wind energy

(b) Tidal energy

(c) Solar energy

(a) Wind energy

Winds are caused because of two factors.

1. The absorption of solar energy on the earth's surface and in the atmosphere.
2. The rotation of the earth about its axis and its motion around the Sun.

A wind mill converts the kinetic energy of moving air into Mechanical energy that can be either used directly to run the Machine or to run the generator to produce electricity.

(b) Tidal energy

Tides are generated primarily by the gravitational attraction between the earth and the Moon. They arise twice a day in Mid-Ocean. The tidal range is only a Meter.

Basically in a tidal power station water at high tide is first trapped in a artificial basin and then allowed to escape at low tide. The escaping water is used to drive water turbines, which in turn drive electrical generators.

(c) Solar energy

Brief history of solar energy (or) Importance of solar energy:

Energy from the sun is called solar energy. The Sun's energy comes from nuclear fusion reaction that take place deep in the Sun. Hydrogen nucleus fuse into helium nucleus. The energy from these reactions flow out from the sun and escape into space.

QUESTIONS

Short Questions

1. Define energy?
2. What are the different forms of energy?
3. What are the compounds present in coal?
4. What products can obtain from crude oil?
5. What are the conventional sources of energy?
6. What are non-conventional sources of energy?

Essay Type Questions

1. What are the Conventional sources of energy and explain briefly?
2. What are the non-conventional sources of energy and explain briefly?

CHAPTER – 2
SOLAR ENERGY

2.1. Introduction

Energy from the sun is called solar energy. The Sun's energy comes from nuclear fusion reaction that takes place deep in the sun. Hydrogen nucleus fuse into helium nucleus. The energy from these reactions flow out from the sun and escape into space.

Solar energy is some times called radiant energy. These are different kinds of radiant energy emitted by sun. The most important are light infrared rays. Ultra violet rays, and X- Rays.

The sun is a large sphere of very hot gases. It's diameter is $1.39x10^6$KM. While that of the earth is $1.27x10^4$ KM. The mean distance between the two is $1.5x10^8$KM. The beam radiation received from the sun on the earth is reflected in to space, another 15% is absorbed by the earth atmosphere and the rest is absorbed by the earth's surface. This absorbed radiation consists of light and infrared radiation with out which the earth would be barren.

All life on the earth depends on solar energy. Green plants make food by means of photosynthesis. Light is essential from in this process to take place. This light usually comes from sun. Animal get their food from plants or by eating other animals that feed on plants. Plants and animals also need some heat to stay alive. Thus plants are store houses of solar energy.

The solar energy that falls on India in one minute is enough to supply the energy needs of our country for one day. Man has made very little use of this enormous amount of solar energy that reaches the earth.

2.2 Solar Constant

The sun is a large sphere of very hot gases, the heat being generated by various kinds of fusion reactions. Its diameter is $1.39x10^6$ KM. While that of the earth is $1.27x10^4$ KM. The mean distance between the two is $1.50x10^8$ KM. Although the sun is large, it subtends an angle of only 32 minutes at the earth's surface. This is because it is also a very large distance. Thus the beam radiation received from the sun on the earth is almost parallel. The brightness of the sun varies from its center to its edge. However for engineering calculations, it is customary to assume that the brightness all over the solar disc in uniform. As viewed from the earth, the radiation coming from the sun appears to be essentially equivalent to that coming from a back surface at $5762^{o}k$.

"The rate at which solar energy arrives at the top of the atmosphere is called solar constant Isc". This is the amount of energy received in unit time on a unit area perpendicular to the sun's direction at the mean distance of the earth from the sun. Because of the sun's distance and activity vary through out the year, the rate of arrival of solar constant is thus an average from which the actual values vary up to 3 percent in either direction. The National Aeronautics and Space Administration's (NASA) standard value the solar constant, expressed in three common units, is as follows:

(i) 1.353 kilowatts per square meter

(ii) 116.5 Langleys per hour (1 langely being equal to $1cal/cm^2$ of solar radiation received in one day)

(iii) 429.2 Btu per Sqr.ft. per hour.

The distance between the earth and the sun varies a little through the year. Because of this variation, the extra – terrestrial flux also varies. The earth is closest to the sun in the summer and farthest away in the winter. This variation in the Intensity of solar radiation (I) that reaches the earth. This can be approximated by the equation.

$$\frac{I}{ISC} = 1 + 0.033 \ \text{Cos} \ \frac{360(n-2)}{365}$$

$$= 1 + 0.033. \ \text{Cos} \ \frac{360 \times n}{365}$$

where n is the day of the year.

2.3 Solar Radiation at the Earth's Surface

The solar radiation that penetrates the earth's atmosphere and reaches the surface differs in both amount and character from the radiation at the top of the atmosphere. In the first place. Part of the radiation is reflected back in to the space, especially by clouds. Further more, the radiation entering the atmosphere is partly absorbed by molecules in the air. Oxygen and Ozone (o_3), formed from oxygen, absorb nearly all the Ultraviolet radiation, and water vapour and carbon dioxide absorb some of the energy in the infrared range. In addition, part of the solar radiation is scattered (i.e. its direction has been changed) by droplets in clouds by atmosphere molecules, and by dust particles.

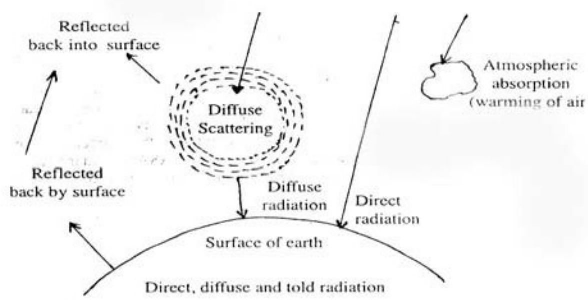


Fig 2.1 Solar Radiation at the Earth's surface

Solar Radiation that has not been absorbed or scattered and reaches the ground directly from the sun is called "Direct Radiation" or Beam Radiation. Diffuse radiation is that Solar Radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere. Because of the Solar Radiation is cattered in all directions in the atmosphere, diffuses radiation comes to the earth from all parts of the sky. The sum of the beam and diffuse radiation flux is referred to as total or global radiation.

2.4 Instruments for measuring solar radiation and sun shine

Solar Radiation flux is usually measured with the help of a pyranometer or a Pyrheliometer, sunshine recorder is used for measuring sunshine.

2.4.1. Pyranometer

A pyranometer is an instrument which measures either global or diffuse Radiation over a hemispherical field of view. A sketch of the Instrument as

Installed for the measurement of global radiation is shown in fig.2.1. Basically the pyranometer consists of a 'black' surface which heats up when exposed to solar radiation. Its temperature increases until its rate of heat gain by solar radiation equals its rate of heat loss by convection, conduction and radiation. The hot Junctions of a thermopile are attached to the black surface. While the cold Junctions are located in such a way that they do not receive the radiation. As a result, an e.m.f. is generated. This emf which is usually in the range of 0 to 10MV can be read, recorded or Integrated over a period of time and is a measure of the global radiation.

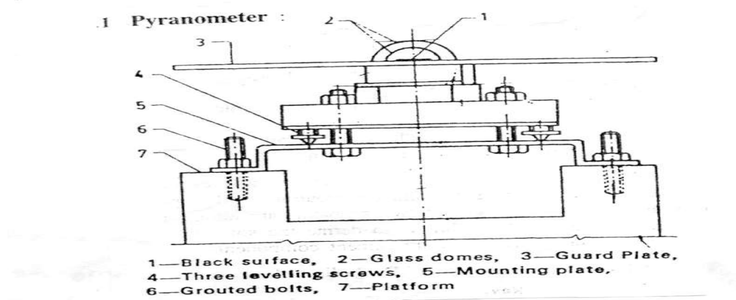


Fig 2.2. Pyranometer

The pyranometer shown in fig 2.2 is used commonly in India it has its hot Junctions arranged in the form of a circular disc of diameter 25MM and is coated with a special black lacquer having a very high absorptivity in the solar wave length region. Two concentric hemispheres, 30 and 50MM in diameter respectively made of optical glass having excellent transmission characteristics are used to protect the disc surface from the weather. An accuracy of about ±2 percent can be obtained with the Instrument.

2.4.2 Sun Shine Recorder

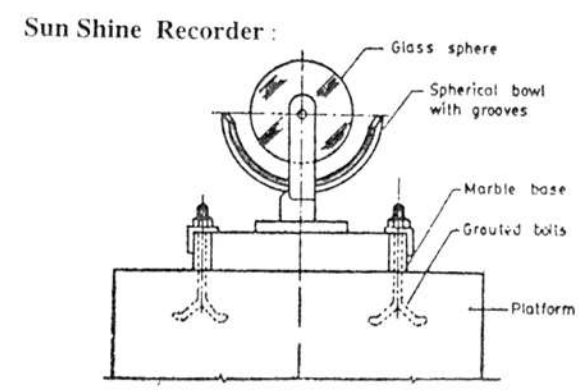


Fig 2.3 Sun Shine Recorder

The duration of bright sun shine in a day is measured by means of a sunshine recorder shown in fig2.3 the sun's Rays are focussed by a glass sphere to a point on a card strip held in a groove in a spherical bowl mounted concentrically with the sphere. Whenever there is bright sunshine, the image formed is intense enough to burn a spot on the cord strip. Though the day as the sun moves across the sky, the image moves alone the strip. Thus, a burnt trace whose length is proportional to the duration of sunshine is obtained on the strip. A photograph of the instrument is shown in plate 3 (bottom).

2.5 Solar Energy Utilization – Basic ideas about the pre-historic way of using solar energy

Energy is a common Man's daily commodity: The world energy consumption in 1975 was 8002 million tons of coal equivalent and is expected to shoot up to 27,400 million tons of coal equivalent in the year 2000. It is becoming scarce day by day even then its demand is on the increase. The increased population has led to depletion of energy. The process of mankind has influenced the subsequent exploitation of new sources of energy from time to time. The utilization of coal, the development of hydro electricity, the discovery of oil and gas and the advents of nuclear energy are significantly mile stones in human history. Each new source brought about a preformed change in the life style of the people. Each new source supplemented the other.

The size of the balance of fossil fuels will be over within a hundred years. Hence it is essential to tap the other sources of energy to supplement the existing energy demands of all non-conventional energy source, solar energy holds the greatest promise as it is abundant, renewable and pollution free. Its collection, storage on conversion is also easy. Hence worldwide attention is now focused on various methods of utilization of solar energy.

All life on the earth depends on solar energy. Green plants make food by means of photosynthesis. Light is essential from in this process to take place. This light usually comes from sun. Animals get their food from plants are store houses of solar energy.

The solar energy that falls on India in one minute, is enough to supply the energy needs of our country for one day. Man has made very little use of this enormous amount of solar energy. That reaches the earth he has used solar energy indirectly, for many thousands of years. Wind mills which are driven by wind that results from infrared solar energy.

2.6 Solar Energy applications

1. Heating and cooling of residential building.
2. Solar water heating.
3. Solar drying of agricultural and animal products.
4. Salt production by evaporation of seawater.
5. Solar cookers.
6. Solar engines for water pumping.
7. Solar Refrigeration.
8. Solar electric power generation.
9. Solar photo voltaic cells, which can be used for electricity.
10. Solar furnaces.

2.6.1 Solar Collectors

A solar collector is a device for collecting solar radiation and transfer the energy to fluid passing in contact with it. Utilization of solar energy requires solar collectors. These are generally of two types.

(i) Non- concentrating (or) flat plate solar collector.

(ii) Concentrating (focusing) type solar collector.

The solar energy collector, with its associated absorber, is the essential component of any system for the conversion of solar radiation in to more usable form (e.g heat or electricity). In the non-concentrating type, the collector area is the same as the absorber area. On the other hand, in concentrating collectors, the area intercepting the solar radiation is greater. By means or concentrating collectors, much higher temperatures can be obtained than with the non-concentrating type. Concentrating collectors may be used to generate medium pressure steam. They use many different arrangements of mirrors and lenses to concentrate the sun's rays on the boiler. This type shows better efficiency than the flat plate type. For best efficiency, collectors should be mounted to face the sun as it moves through the sky.

(i) Flat plate collectors (non-concentrating)

Where temperatures below about 90°C are adequate as they are for space and service water heating flat plate collectors, which are of the non-concentrating type, are particularly convenient. They are made in rectangular panels from about 1.7 to 2.9 sq.m, in area, and are relatively simple to construct and erect. Flat plates can collect and absorb both direct and diffuse solar radiation, they are consequently partially effective even on cloudy days when there is no direct radiation.

Flat plate solar collectors may be divided into two main classifications based on the type of heat transfer fluid used.

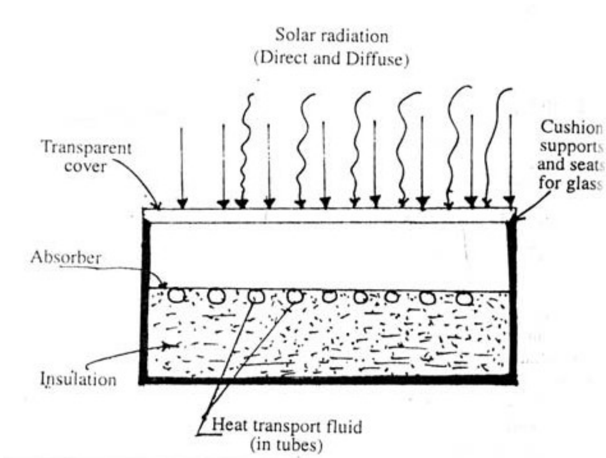


Fig. 2.4. Liquid heating flat plate collector

A. Liquid heating Flat Plate Collector

Liquid heating flat plate collectors are used for heating water and non-freezing aqueous solutions.

There are many flat-plate collector designs, but most are based on the principle shown in fig 2.4. It is the plate and tube type collector. It basically consists of a flat surface with high absorptivity for solar radiation called the absorbing surface. Typically a metal plate, usually of copper, steel or aluminum material with tubing of copper in thermal contact with the plates are the most commonly used materials. The absorber plate is usually made from a metal sheet 1 to 2 mm in thickness, while the tubes, which are also of metal, range in diameter from 1 to 1.5cm. They are soldesed, brazed or clamped to the bottom of the absorber plate with the pitch ranging from 5 to 15 Cm, In some designs, the tubes are also in line and integral with the absorber plate.

The primary function of the absorber is to absorb maximum radiation reaching it through the glazing, to lose maximum heat upward to the atmosphere and down ward through the back of the container and to transfer the retained heat to the working fluid. Black painted absorbers are preferred because they are considerably cheaper and good absorbers of radiation.

Heat is transferred from the absorber plate to a point of use by circulation of fluid (usually water) across the solar heated surface. Thermal insulation of 5 to 10cm. Thickness is usually placed behind the absorber plate to prevent the heat losses from the rear surface. Insulation materials is generally mineral wool or glass wool or fiber glass.

The front covers are generally glass that is transparent to incoming solar radiation and opaque to the infra-red re-radiation from the absorber. The glass covers act as a convection shield to reduce the losses from the absorber plate beneath. The glass thickness of 3 and 4 mm are commonly used. The usual practice is to have 2 covers with specific ranging from 1.5 to 3cm.

Advantages of second glass which is added above the first one are

(i) Losses due to air convection are further reduced. This is important in windy areas.

(ii) Radiation losses in the infra-red spectrum are reduced by a further 25%, because half of the 50% which is emitted out wards from the first glass plate is back radiated.

(ii) Concentrating (focusing) type solar collector

Focusing collector or concentrating type solar collector is a device to collect solar energy with high intensity of solar radiation on the energy absorbing surface. Such collectors generally use optical system in the form of reflectors or refractors. A focusing collector is a special form of flat-plate collector modified by introducing a reflecting or refracting surface between the Solar Radiation and the absorber. In these collectors radiation falling on a relatively large area is focused on to a receiver or absorber of considerably smaller area. As a result of the energy concentration, fluids can be heated to temperatures of 500^0C or more.

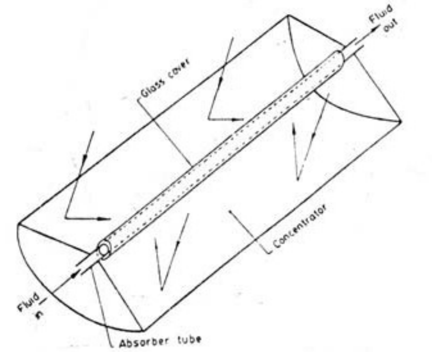


Fig. 2.5 Parabolic concentrating collector

A Schematic diagram of a typical concentrating collector is shown in fig 2.5 the collector consists of a concentrator and a receiver. The concentrator shown is a mirror reflector having the shape of a cylindrical parabola. It focuses the sunlight on to its axis where it is absorbed on the surface of the absorber tube and transferred to the fluid flow through it. A concentric glass cover around the absorber tube helps in reducing the convective and radiative losses to the surroundings. In order that the sun's rays should always be focussed on to the absorber tube, the concentrator has to be rotated. This movement is called tracking in the case of cylindrical parabolic concentrators, rotation about a single axis is generally required. Fluid temperatures up to around 300^oC can be achieved in cylindrical parabolic focussing collector system.

The generation of still higher working temperatures is possible by using parabolic reflectors as shown in fig 2.6 which have a point focus.

A paraboloidal dish collector brings solar radiation to a focus at a point actually a small central volume. A dish 6.6m diameter has been made from about 200 curved mirror segments forming a paraboloidal surface. The absorber, located at the focus, is a cavity made of zirconium-copper alloy with a black chrome selective coating. The heat-transport fluid flows into and out of the absorber cavity through pipes bonded to the interior. The dish can be turned automatically about two axes so that the sun is always kept in a line with the focus and the base of the paraboloidal dish. Thus, the can be fully tracked at essentially all times.

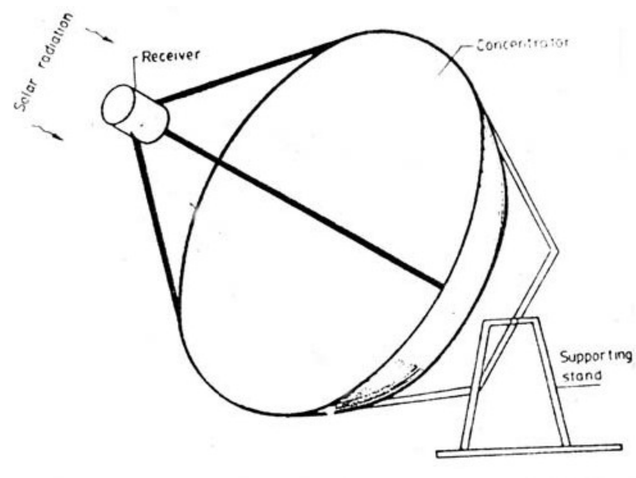


Fig 2.6 Dish Collector (Point Focus)

2.6.3. Solar Cooker

In our country energy consumed for cooking shares a major portion of the total energy consumed in a year. In villages 95% of the consumption goes only to cooking. Verity of fuel like coal, kerosene, cooking gas, firewood, dung cakes and agricultural waste are used the energy crisis is affecting everyone. It is affecting the fuel bills for those who use it for heating the houses and cooking their food. The poor of the developing countries who have been using dry wood, picked up from the fields and forests as domestic fuel, have been affected in their own way, due to scarcity of domestic fuel in the rural areas. At present, fire wood and cow dung too precious to allowed to be used for burning and cooking. It is very useful to improve the fertility of the soil, it should be used in proper way. The supply of wood is also fast depleting because of the indiscriminate felling of trees in the rural areas and the denudation of forests. There is a rapid deterioration in the supply of these fossil fuels like coal, kerosene or cooking gas. The solution for the above problem is the hardnesing of solar energy for cooking purpose.

The most important is that the solar cooker is a great fuel saver. The department of new conventional energy source has calculated that a family using a solar cooker 275 days a year would save 800kgs of fire wood or 65 liters of kerosene. Similarly an industrial Canteen or a Hostel mess using the larger community solar cooker which can cook for 20 to 25 people could save 400kgs of fire wood or 335 liters of kerosene per year.

Types of Solar Cooker

Basically there are three designs of solar cooker;

(i) Flat plate box type solar cooker with or with out Reflector.

(ii) Multi Reflector type solar cooker.

(iii) Parabolic disc concentrator type solar cooker.

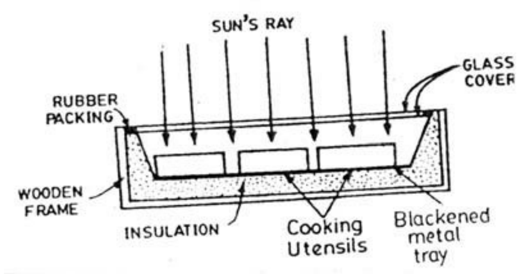


Fig 2.7 Flat Plate box type solar cooker

Flat plate box type design is the simplest of all the designs. This cooker allows. Solar radiation to enter through a double walled glass cover placed inside a blackened box which is well insulated and made airtight. Maximum no load temperature with a single reflector reaches up to 160^{o}C.

In Multi Reflector type, four square or triangular or rectangular reflectors are mounted on the oven body. They all reflect the solar radiation into the cooking zone in which cooking utensils are placed. Temperature obtained is of the order of 200^{o}C. The maximum temperature can reach to 250^{o}C if the compound cone reflector system is used.

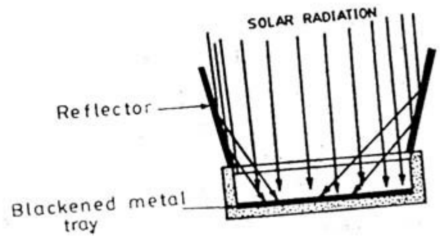


Fig 2.8 (a)

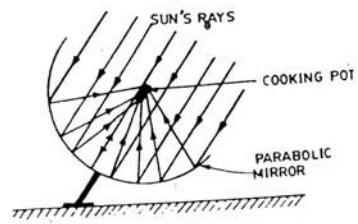


Fig 2.8 (b)

In parabolic type cooker, parallel sun's rays are made to reflect on a parabolic surface and concentrated on a focus on which the Utensils for cooking are placed. The temperature of the order of 450^{o}C can be obtained in which solar radiation are concentrated on to a focal point. Principle of operations of solar cookers is shown in fig 2.8 (b).

Design principle and constructional details of a box type Solar Cooker

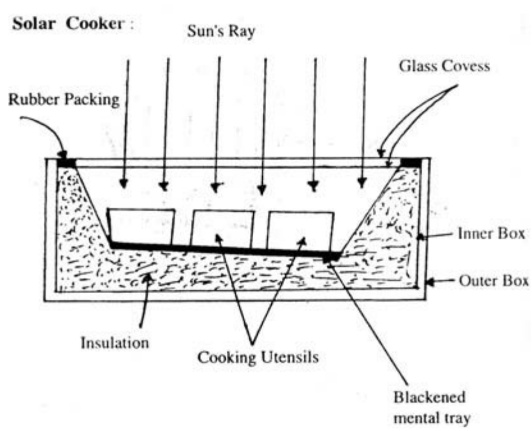
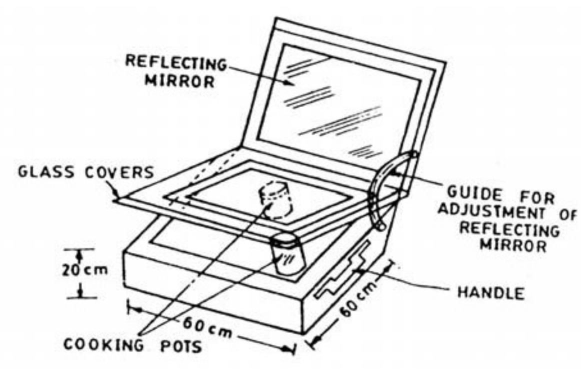


Fig 2.9 Box Type Solar Cooker

The principal of operation of box type solar cooker is illustrated in fig2.9. The solar rays penetrate through the glass covers and absorbed by a blackened metal tray kept inside the solar box. The solar radiation entering the box are of short wave length. Two glass covers are provided to minimize the heat loss. The loss due to convection is minimized by making the box air tight by providing a rubber strip all around between the upper lid and the box. Insulating materials like glass wool, saw dust or any other material is filled in the space between blackened tray and outer cover of the box. This minimize heat loss due to conduction with type of cooker is placed in the sun the blackened surface starts absorbing sun rays and temperature inside the box starts rising. The cooking pots, which are also blackened are placed inside with food material get heat energy and food will be cooked in a certain period of time depending upon the intensity of solar radiation and material of insulation provided. The amount of solar radiation intensity can be increased by provided mirror or mirrors. The solar cooker is made up of inner and outer metal or wooden box with double glass sheet on it. Absorber tray or blackened tray is painted black with suitable black point like black board point. This point is dull in colour and can with stand the maximum temperature attained inside the cooker as well as water vapour coming out of the cooking utensils. The top cover contains 3mm thick two plain glasses fixed on wooden or metal frame, keeping about 25mm distance between the two. The entire top cover can be made tight with padlock hasp. Neoprene rubber sealing is provided around the contact surfaces of the glass cover and hinged on one side of the glass frame. A mechanism (guide for adjusting mirror) is provided to adjust the reflector at different angles with the cooker box when the reflector is adjusted to shine in the cooker box, 115^{o}C to 125^{o}C. Temperature is achieved inside the cooker box. Addition of the reflector is useful in cooking earlier particularly in winter. The solar cooker is able to cook about 1.25kg dry food materials, which is enough for a family of 5 to 7 persons. The total weight of the cooker is about 22kgs. Overall dimensions of a typical model are 60x60x20cm height.



Merits and limitations of a Solar Cooker

Following are the some merits of a solar cooker;

(1) No attention is needed during cooking as in other devices.

(2) No fuel is required.

(3) Negligible maintenance cost.
(4) No pollution.
(5) Vitamins of the food are not destroyed and food cooked is nutrition and delicious with natural taste.
(6) No problem of over flowing of food.

Limitations of a Solar Cooker are

(i) One has to cook according to the sunshine, the menu has to preplanned.
(ii) One cannot cook at short notice and food can not be cooked night or during cloudy days.
(iii) It takes comparatively more time.
(iv) Chapaties are not cooked because high temperature for baking is required.

2.6.4 Solar Water heater

It is a device to heat water using solar energy. Solar water heaters are one of the best options to be adapted in the developing country. Solar water heating systems are commercially produced in the country. Most of the systems available in India are designed to give water temperature from 60 to 90^{o}C. These are suitable for pre heating feed water to boiler and processing industries and hot water application in Hotels, Bakeries, Industries etc.

The term solar water heater includes conventional flat plate collector with either thermosiphon or forced circulation flow system. A solar water heater normally consists of the following components:

(a) A flat plate collector to absorb solar radiation and convert it into thermal energy.
(b) Storage tank to hold water for use and cold water feeding the flat plate collector.
(c) Connecting pipes inlet and out let, for feeding cold water from the storage tank and taking hot water to the storage tank or point of use.

A diagram of a simple, small capacity, natural circulation system suitable for domestic purpose is shown in fig 2.11. The two main components of the storage tank, the tank being located above the level of the collector. As water in the collector is heated by solar energy, it flows automatically to the top of the water tank and its place is taken by colder water from top of the tank. Whenever this is done, cold water automatically enters at the bottom. An auxiliary heating system is provided for use on cloudy or rainy days.

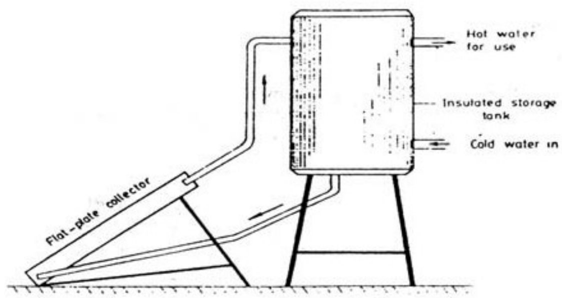


Fig 2.11 Solar Water Heater

Typically, such system have capacities ranging from 100 to 200 liters and adequately supply the needs of a family of four or five persons. The temperature of the hot water delivered ranges from 50 to 70^{o}C. Solar water heating is a good example to illustrate one of the assets of the direct use of solar. This is the possibility of matching the temperature achieved in the heating device with the temperature required for end use. As a result of this matching, the thermodynamic efficiency based on considerations of availability of energy can be shown to be higher in the case of solar water heating system than a water heating system using natural gas or electricity.

Solar water heaters of the natural circulation type were used fairly widely from the beginning of the twentieth century till about 1940 until cheap oil and natural gas became available. Now they are a being installed again. They are in wide spread use in countries like Israel, Australia and Japan.

2.6.5. Solar distillation

Fresh water is a necessity for the sustenance of life and also the key to Man's prosperity. It is generally observed that arid, semi arid and coatal areas which are thinly populated and scattered, one or two family members are always busy in bringing fresh water from a long distance. In these areas solar energy is plentiful and can be used for converting saline water into distilled water. The pure can be obtained by distillation in the simplest solar still, generally known as the “basin type solar still”.

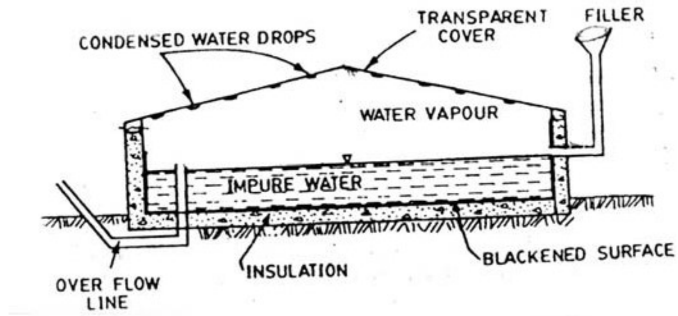


Fig 2.12 Solar Distilluation

Solar water still is shown schematically in fig 3.1, it consists of a blackened basin containing saline water at a shallow depth, over which is a transparent air tight cover that encloses completely the space above the basin. It has a roof-like shape. The cover which is usually glass may be of plastic, is sloped towards a collection through solar radiation passes through the cover and is absorbed and converted into heat in the black surface. Improve water in the basin or tray is heated and the vapor produced is condensed to purified water on the cooler interior of the roof. The transparent roof material transmits nearly all radiation falling on it and absorbs very little; hence it remain cool enough to condense the water vapor. The condensed water flows down the sloping roof and is collected in through at the bottom. Saline water can be replaced in the operation by either continuous operations or by batches.

2.6.6 Solar Pumping

Solar pumping consists in utilizing the power generated by solar energy for water pumping useful for irrigation.

Solar energy offers several features that make its utilization for irrigation pumping quite attractive, first, the greatest need for pumping occurs during the summer months when solar radiation is greatest second, pumping can be intermittent to an extent, during periods of low solar radiation when pumping decreases, evaporation losses from crops are also low. Finally relatively in expensive pumped storage can be provided in the forms of bonds.

A number of recently constructed solar irrigation pump installations are now operational. The major obstacle to increase use of solar irrigation system at this time is their Relatively high capital cost. If the costs of solar pumps can be substantially reduced and assuming that conventional fuel costs continue to rise, solar; irrigation could become economical, and increased use of such system might be anticipated in future.

The basic system consists of the following components:
(1) The solar collector.
(2) The heat transport system.
(3) Boiler or Heat exchanges.
(4) Heat engine.
(5) Condenser.
(6) Pump

The solar pump is not much different from a solar heat engine working in a low temperature cycle. The sources of heat is the solar collector, and sink is the water to be pumped. A typical solar powered water pumping system is shown in fig2.3.

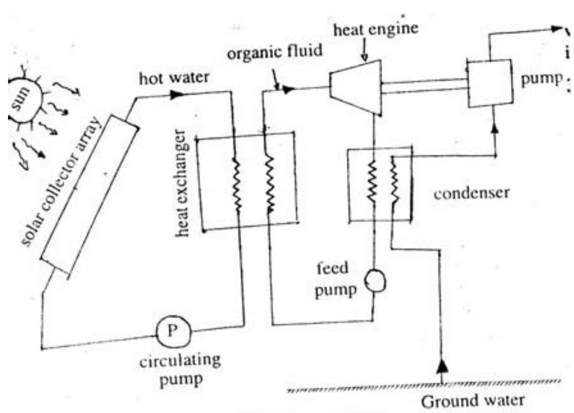


Fig 2.13 Solar Water Pumping

The primary components of the system are an array of flat-plate collectors and an Rankine engine with an organic fluid as the working substance. During operation a heat transfer fluid (Pressurized water) flows through the collector arrays. Depending upon the collector configuration, solar flux and the operating conditions of the engine, the fluid will be heated in the collector to a higher temperature, the solar energy which is thus converted to the thermal energy. The fluid (water) flows into a heat exchanger (boiler), due to temperature, gradient, and comes back to the collector. This water yields its heat to an intermediate fluid in the boiler. This fluid evaporates and expands in the engine before reaching the condenser, where is condenses at low pressure. The condenser is called by the water to be pumped. The fluid is then reinjected in the boiler to close the cycle. The expansion engine or Rankine engine is coupled to the pump and it could of course be coupled to an electric generation.

2.6.7 Electricity from Solar Energy

Electricity energy is the most convenient form of energy. It is easy to use, transport, control and transform into other forms of energy.

Modern society has an insatisfiable hunger for energy. This need for energy will continue to increase as the newly developing countries become more industrialized and the mature nations increase their scope of Mechanization. To satisfy this need, vast quantities of coal and petroleum products are required. More recently, the advent of nuclear energy has added vast quantities for future needs.

Although sun is the ultimate source of all the power which man has at his disposal, the conversion of solar radiation directly into electrical power by some cheap and efficient means has been sought for several decades. Many different methods have been tried for this purpose, but none of these could complete with conventional fossil fuel or hydro electric power plants.

2.6.8 Solar Photo Voltaics

The direct conversion of solar energy in to electrical energy by means of the photo voltaic effect, that is the conversion of light (or other electromagnetic radiation) in to electricity. The photo voltaic effect is defined as the generation of the electromotive force as a result of the absorption of ionizing radiation energy conversion devices which are used to convert sun light to electricity by the use of the photo voltaic effects are called solar cells. A single converter cell is called a solar cell or more generally, a photo voltaic cell, and combination of such cells, designed to increase the electric power out put is called a solar module or solar array.

Photo voltaic cells are made of semi conductors that generate electricity when they absorb light. As photons are received, free electrical changes are generated that can be collected on contacts applied to the surface of the semi conductors. Because solar cells are not heat engines, and therefore do not need to operate at high temperatures, they are adopted to the weak energy flux of solar radiation, operating at tome temperature. These devices have theoretical efficiencies of the order of 25 percent. Actual operating efficiencies are less than this value, and decrease fairly rapidly with increasing temperature.

The best known applications of photo voltaic cells for electrical power generation has been is spacecraft, for which the Silicon cell is the most highly developed type. The Silicon cell consists of a single crystal of silicon into which a doping material is diffused to from a semi conductor. Since the early day of solar cell development, many improvement have been manufactured with areas 2x2Cm, efficiencies approaching 10 percent, and operating at 28^{o}C. The efficiency is the power developed per unit area of array divided by the solar energy flux in the free space (1.353 KW/m^2).

For terrestrial applications, silicon solar cells have shown operating efficiencies of about 12 to 15 percent. Though Silicon is one of the earth's most abundant materials, it is expensive to extract (from sand, where it occurs mostly in the from SiO_2) and refine to the purity required for solar cells. The greater barrier to solar cell application lies in the costs of the cells themselves. Reducing the cost of Silicon Cells is difficult because of the cost of making single crystal. One very promising method is being developed to produce continuous thin ribbons of single-crystal Silicon to reduce fabrication costs.