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BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

SOLAR WATER HEATER

Introduction

With the increasing consumption of fuel like coal and electricity the use of solar energy is thought to be a potential alternative. From times immemorial, solar energy has been used in a variety of ways. Solar water heating is one process which is used more economically in modern times.

Solar water heaters are popular in Australia, Israel, Japan, Latin America, South Africa, France and New Zealand. Persistent research for several years were conducted at the Central Building Research Institute, Roorkee on the design of solar water heaters. As a result, low-cost prototype solar water heaters were designed, fabricated and tested (Fig. 1). This Digest describes some of the technical details of an improved design.

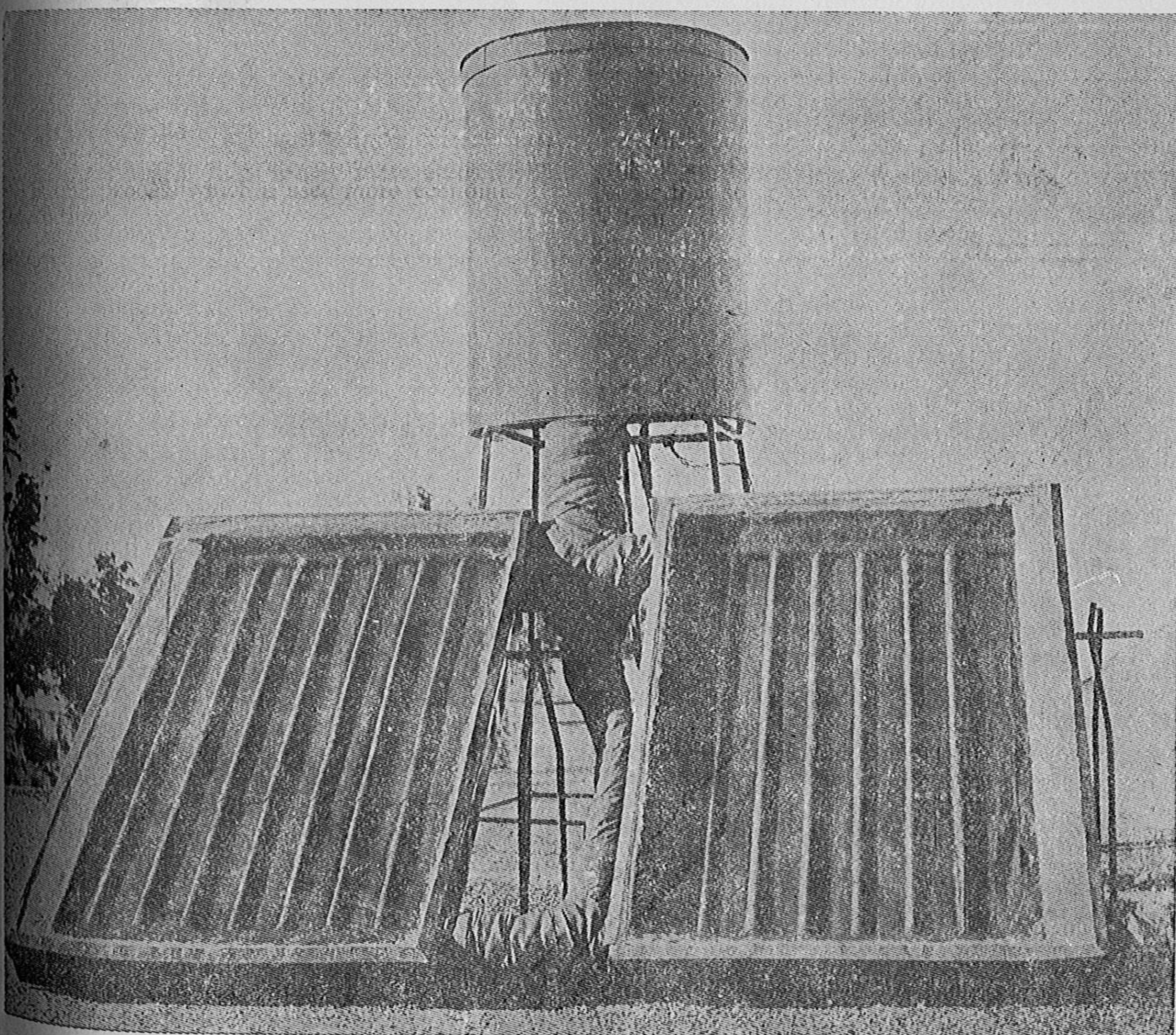

Fig. 1 Solar Water Heater

Tropical areas lying between the latitudes 35° North and South and which have at least 2000 hours of bright sunshine per year are ideal for the utilization of sun's energy. Equatorial zones are unsuitable for the utilization of Sun's energy because of excessive humidity. Indian climate is well suited to the utilization of Sun's energy.

Principle of Operation

The essential components of solar water heater are (a) the solar collector, (b) storage tank, and (c) the circulation system.

(a) Solar Collector

Solar collectors may be of two types, flat plate type or concave type. Flat plate collectors are simple in operation, easy to fabricate, absorbs diffuse as well as direct radiation intensity and are of low cost, though the temperature attained is below the boiling point of water. On the other hand concentration type devices are quite expensive, bulky and require diurnal and periodical adjustments. So, flat plate collectors are the most preferred means of getting low grade heat from Sun's energy. The corrugated type of flat plate collector has the maximum heat exchanger efficiency but it suffers from many other defects such as bulging under high hydrostatic pressure, leaking through the rivets and comparatively shorter life. So, tube-in-plate type collectors were studied. These are mainly (1) the soldered bond type, and (2) the contact bond type.

The soldered bond type is expensive, its bond may crack due to heating and cooling. There is also considerable difficulty in soldering tubes to a thin sheet and whole of the frame with plate has to be discarded if there is scale formation in the tubes. Contact bond type is therefore, preferred. The simplest is a wrapped and wired wound type.

The basic principle of all the flat plate collectors are the same, i. e. absorb the Sun's energy and transfer it to the fluid flowing within. In the equation form we can write :

Heat from Sun=useful heat+heat losses.

To increase the equilibrium temperature of the collector, it is coated with a paint of high absorptivity.

Absorber Box

Solar collector is encased in an insulated and watertight cover box having a single glass cover on the exposed side. The insulation (say mineral wool) generally 5.0 cms thick is placed betweed the absorber box and the collector. The insulation reduces the losses through the rear and sides of the absorber and thus increases the efficiency of the unit.

The glass cover has a "glass house" effect. It traps the high temperature level radiation of the Sun and acts as a perfect barrier for low temperature radiation from the absorber.

Orientation

The whole unit is installed at a clear site. The collector is mounted at an optimum inclination and orientation depending on the latitude of the site. Orientation should be due South preferably with a few degrees towards the West, to take advantage of the greater heating effect of the afternoon Sun. The optimum angle of tilt is latitude plus 15 degrees for winter use and 0.9 times the latitude for the year round use.

(b) Storage Tank

A large storage tank is required because of the intermittent nature of the Sun's radiation. The size of the storage tank depends on the daily demand of hot water and also on the radiation intensity available at the place. Because of the Indian custom of taking bath in the morning hours, the tank should be well insulated and double walled.

(c) Circulation system

There are various methods for circulating the water. The simplest one originates from thermo-syphon action and is suitable for the domestic solar water heater. Cold water from the bottom of the tank flows down to the absorber and the heated water, because of lower density, rises to the top of the tank. This automatic circulation starts a little after sun-rise and stops with the sun-set. This circulation requires short and insulated connecting pipes and the tank at a certain height above the absorber.

Size of the system

For an average family of five persons of a household in India, 140 liters of water at a temperature of 50°C is adequate. A solar cum-electric water heater has been found suitable because of the intermittent nature of the sunshine. This tank contains an immersion heater fitted at one third the height of the tank. The temperature is controlled by a safety thermostat fitted at the middle of the tank.

The collector area depends on the climatic conditions such as radiation intensity, shade air temperature, turbidity of the atmosphere and the operating conditions such as season and time of use and the amount of hot water drained. Here the load is distributed in such a way that the overnight cooling could be compensated by the electric heating, thus reducing the size of the system.

Construction

For the construction of various components, standard sizes of material are used, reducing there by the wastage.

(a) Absorber

Two absorbers each of area 1.0 m² are used. The absorber consists of seven numbers of galvanised iron tubes of 19 mm nominal diameter and fitted at 10 cm centre to centre on to two GI pipe headers 25 mm nominal dia. A 28 SWG aluminium sheet is wrapped on to the pipe network overlapping half the diameter for each pipe (fig. 2) and then tied to this with a GI binding wire. Thus, each tube is in good thermal contact with the plate. Two fine coats of lamp black paint (lamp black dispersed in spirit shellac solution) with an additive (zinc dust), to make the paint more adhesive and thermally stable, are then sprayed to the absorber plate. This absorber configuration has a plate efficiency factor of 0.94. The recommended absorber configuration is on the basis of maximum efficiency per unit cost.

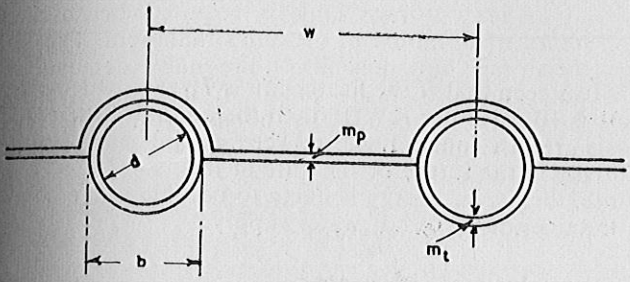

Fig. 2 Absorber Pipe type

(b) Cover Box

The absorber is then encased in an airtight and weather-resistant box. The box is made of 18 gauge M.S. sheet. The over-all dimensions of box are 138×92×15 cm. It is finished with grey paint. A section of the box is shown in Fig. 3.

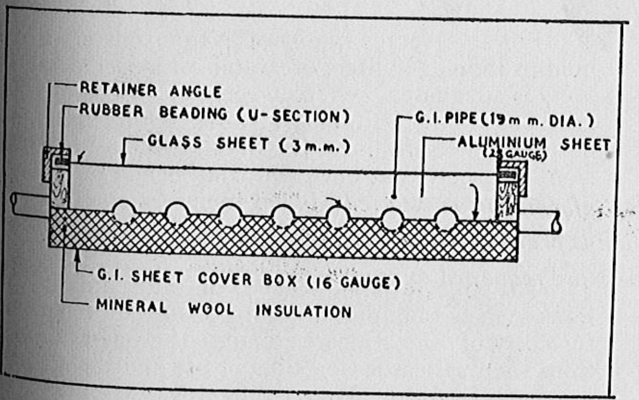

Fig. 3 Cross Section of Collector Unit

(c) Storage tank

An empty petrol drum may be used as the storage tank. The diameter of the tank being 57 cms the height is kept as 73 cms. Float valve is fitted at a height (fig.4) so that the water capacity of tank becomes 140 litres.

The inner tank is insulated all-around by 10 cm thick mineral wool which is again protected from weather by a cover box of 20 gauge M.S. sheet,

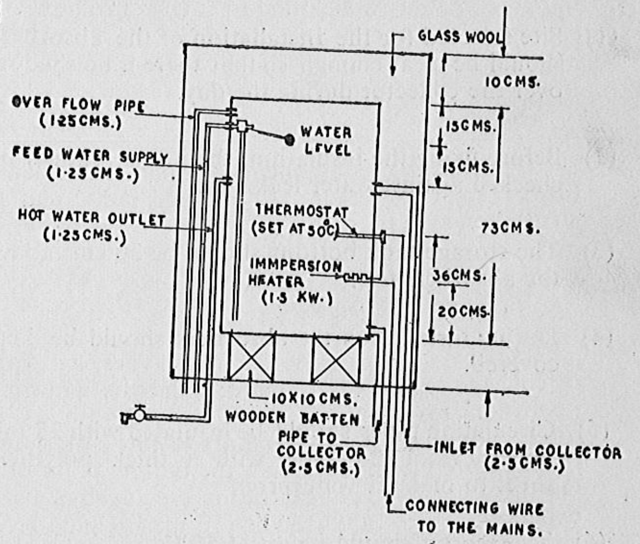

Fig. 4 Cross section of Storage Tank

This heater is designed to heat 140 litres of water upto about 55°C in the afternoons of winter season. In the morning the water temperature is about 48°—50°C. On cloudy days or when the load is more than the design value, thermostatically controlled immersion heater 1.5 KW, may be pressed into service.

(d) Cold water supply

Cold water enters the tank through a float valve which maintains the level of water in tank. Beneath the float outlet is fitted a G.I. pipe of 12 mm dia. The other end of pipe goes right to the bottom. Thus cold water goes directly to the bottom of the tank.

(e) Stands

(i) **For Storage tank:**--For maintaining the pressure head necessary for the thermosyphon action, the tank is placed at a convenient height over a stand (say 137 cm high) framed from 22 m square section rods.

(ii) **For the absorber:**—To keep the absorbers in tilted position, one stand is provided at the back of it. It is fabricated from rods of 12 mm dia.

(f) Circulation system

Galvanised iron pipes 25 mm dia, connect the absorbers to the storage tank. Bigger diameter pipes are not recommended because of no extra advantage. To accelerate the thermosyphon action and to minimize the reverse flow at night, the circulation pipes are insulated by mineral wool about 25 mm thick. It is then protected from weather by wrapping around thick polythene paper.

Installation

Follwing precautions are necessary during installation :

(1) Site selected for the installation of the absorbers should be clear enongh so that there is no shadow over the collector during the day.

(2) Before fixing the insulation, the joints should be checked against water leakages.

(3) The storage tank bottom should be 30 cms above the absorbers top.

(4) During installation the absorbers should be kept covered.

(5) Circulation pipes should be insulated with 25 mm mineral wool and then with a thick polythene sheet to make it waterproof

(6) Thermostat should be set at 50°C.

Performance

Preformance tests on a prototype unit were conducted during two winter seasons. It was observed that maximum mean tank temperature was of the order of 56°C and the morning temperature was 50° C, which were the design values. These values were obtained without having resorted to the use of any electric heater. On clear days there was no electric consumption; nevertheless it was limited to only 10 to 20 percent of that required in a normal electric-geyser.

Economics of solar water heating

The annual distributed costs assuming different life expectancies for solar collector and for different unit costs of electricity are shown in table 1.

Table I

Life years	Annual Distributed Cost (Rs.)				
	Solar heating	Electric heating			
		@0.05	@0.10	@0.15	@0.20
3	278	—	—	—	—
7	146	—	—	—	—
10	117	—	—	—	—
15	94	107.0	146.0	185.0	224.0

It is seen that if the heater life is 7 years and power cost is 10 paisa per KWH then the annual distributed costs are just equal. If the power rate increases substantially in the future or the life of the solar heater is more, then solar energy is likely to become a far more attractive source of hot water supply.

Cost analysis of the heater

The manufacturing cost of the solar cum electric heater at the 1968 market rates on a single unit basis is Rs. 680/-. The collector unit costs Rs. 300/-(Rs.150/- per sq. metre) and the fixed charges for tank and installation are nearly Rs. 300/-. The electric heater with a safety thermostat costs Rs. 80/-. It is quite possible that mass production methods may reduce the cost.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 61st in the series. Readers are requested to send to the Institute their experience of adopting the suggestion given in this Digest.

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