Acknowledgement Of Evacuated Tube Solar Water Heater Over Flat Plate Solar Water Heater

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Abstract

This paper presents acknowledgement to one of the latest solar water heater which is evacuated solar water heater based on a Thermo siphon principle used for heating water for domestic purposes in household by utilizing solar radiations. As the air is evacuated from the solar tube to form a vacuum, this greatly reduces conductive and convective heat loss from the interior of tube. As a result wind and cold temperature have less effect on the efficiency of evacuated solar water heater. Result of less heat loss is fastly heating of water as compared to flat plate solar water heater/collector.

Keywords: Evacuated tube 1, Solar water heater 2, Radiations 3

1. INTRODUCTION

Solar water heaters save electricity and thus money; electricity is becoming more and more expensive; they could even turnout to be more reliable than electric power supply (at least in many parts of our country); they are clean and green and thus reflect one's commitment for preservation of environment; they are safer than electric geysers as they are located on the roof; and, if well designed, may even look good on the house top.

Solar heater is a device which is used for heating the water, for producing the steam for domestic and industrial purposes by utilizing the solar energy. Solar energy is the energy which is coming from sun in the form of solar radiations in infinite amount, when these solar radiations falls on absorbing surface, then they gets converted into the heat, this heat is used for heating the water. When numbers of evacuated tubes are used for heating the water then solar heater is called evacuated tube solar water heater. Although there are many type of solar water heater like flat –plate solar water heater, evacuated tube solar water heater, concentrated solar water heater. Flat-plate solar water heaters are being used from earlier days. Now a day, they are being replaced by evacuated tube solar water heater because of number of advantages. Concentrated solar water heaters are used when we need very high temperature water or a steam. But here we would concern only with evacuated tube solar water heater. Evacuated tube solar water heaters are mainly two types according to loop system open Circuit, non-pressurized system, close Circuit, pressurized system.

2. DESCRIPTION OF EVACUATED TUBE SOLAR WATER HEATER (OPEN TYPE, NON PRESSURISED)

Main components of evacuated tube solar water heater **(**open Circuit, non-pressure system)

- Evacuated glass tubes and Barium Getter
- Storage tank
- Mounting frame
- External water supply source

FIGURE 1: Evacuated glass tubes

2.1 Evacuated glass tubes and Barium Getter

Figure1 shows the Structure of evacuated glass tube is similar to a Dewar flask which has a double wall with a vacuum between the walls. Each evacuated tube consists of two glass tubes made from extremely strong borosilicate glass with high chemical and thermal shock resistance. The outer tube is transparent allowing light rays to pass through with minimal reflection. The outer side of the inner tube is coated with a sputtered solar selective coating (Al-N/Al or AlN/AlN-SS/Cu) which features excellent solar radiation absorption and minimal reflection properties.
The top of the two tubes are fused together and the air contained in the annular space between the two layers of glass is evacuated to eliminate conductive and convective heat loss. This is why the tubes are able to absorb the energy from infrared rays which can pass through clouds. Wind and low temperatures also have less of effect on the function of evacuated tubes when compared to flat plate solar collectors due to the insulating properties of the vacuum. The top end of these parallel tubes is fitted in to the inner storage tank.

In the process of pulling the vacuum, a Barium Getter is inserted into the base of the outer glass tube. The inner glass tube is then inserted into the outside tube with the Getter centering the inner glass tube.

The Glass Tubes are heated to a high temperature, and the vacuum is pulled. The two glass tubes are then fused together at the open end. The Barium Getter also serves another purpose. When the glass tubes are heated before the ends are fused together the Barium Getter also becomes very hot and emits a pure layer of Barium at the bottom of the tube which will look like a chrome plate on the inside of the outer glass tube. If in the future, the glass becomes fractured or broken, the shiny chrome look will change to a milky colour, thus, making it easy to see if the vacuum has been lost in a particular glass tube. The barium layer also provides a clear visual indicator of the vacuum status.

2.2 Storage tank

It is a tank which stores the water and come from external water source like water tank. It is mainly consist of two tank i.e. inner tank and outer tank. The inner tank is placed inside the outer tank. The gap is maintained between two tanks. This gap is filled by high tech insulating material (Rock Wool or mineral wool) in order to reduce the heat losses from the heated water exist inside the inner tank heated by the evacuated tube solar water heater. Rock wool is a man made fiber and has many excellent characters like non-combustible, non-toxic, low thermal conductivity, long service life and so on. Storage tank is placed at the top of frame and tubes. The top open end of the tubes is connected to the storage tank. The bottom end of tubes is placed in a holder provided at bottom of the frame. A complete model of evacuated tube solar water heater **(**open Circuit, non-pressure system) is shown in figure2.

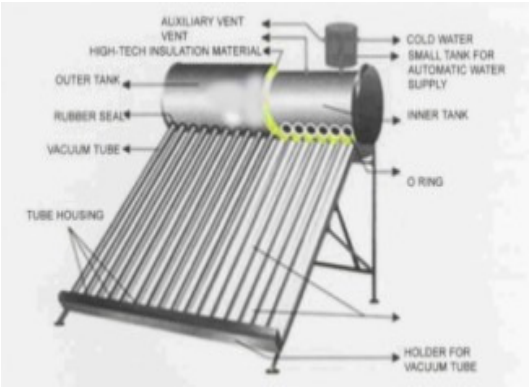

FIGURE 2: Evacuated tube solar water heater

2.3 Mounting frame

It is structure made of no. of metallic angle or plate, on which no. of units like storage tank (in case of open circuit), manifold box, tubes etc. are mounted.

2.4 External water supply source

It supplies the water to the storage tank of evacuated tube solar water heater.

2.4.1 WORKING PRINCIPLE (EVACUATED TUBE SOLAR WATER HEATER)

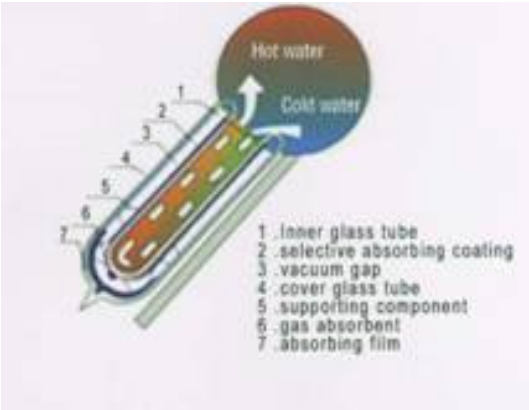

FIGURE 3: Water heating in Glass Tube

The working of evacuated solar water heater is based on a natural Principle--'Thermosiphon' as shown in figure3. The key important point of these systems is that: the storage tank is always located higher than the collector.
As the sun's rays after passing through outer glass tubes falls on the inner glass tubes which are coated with absorbent materials. So these sun's rays are absorbed by the absorbent materials and inner tube and gets converted in to heat after absorption. Due to absorption, surface of inner tubes gets heated up and this heat is transferred to the water exist inside the inner tubes. The temperature of the water in the tubes rises making it less dense or lighter and hot and lighter water naturally moves up to the top of collector and through the evacuated collector tube goes to the storage tank. This makes the colder and heavier water in water tank moves down to the bottom of the collector. That continuous displacement occurs naturally. So the users can get the hot water (30 - 90℃) from the tank. The tilt angle of these collectors varies from 15 - 90°.

2.4.2 TECHNICAL INFOMATIONS

Capacity of storage tank is depends on the water requirements used by the people. It is normally 200-250 liter for 4-5 adult people. Further technical terms are shown in Table 1 as below:

Length (Nominal)	1500 mm-1800 mm
Outer tube diameter	47 mm-58 mm
Inner tube diameter	37 mm-47 mm
Glass thickness	1.6mm-2.0mm
Material	Borosilicate glass 3.3
Absorptive coating	Graded A1/N/A1 ALN/AIN-SS/CU
Vacuum	$P < 5 \times 10^{-3}$ Pa
Thermal expansion	$3.3 \times 10^{-6}/^{0}C$
Stagnation temperature	$\geq 250^{0}C$
Absorbance (AM 1.5)	>93 %(A1/N/A1) / >96 %(ALN/AIN-SS/CU)
Emittance ($80^{0}C/176^{0}F$)	<8 %(A1/N/A1) / <5 %(ALN/AIN-SS/CU)
Heat loss	<0.8W/(m2℃)
Start up temperature	<= 25℃ (77□)

TABLE 1: Technical information

3. ADVANTAGES

When comparing peak efficiency levels it may seem that there is little difference between flat plate and evacuated tubes, in fact flat plate may actually be higher, but this is during minimal heat loss conditions. When averaged over a year evacuated tube collector have a clear advantage. The key points are:

1) Due to the cylindrical shape of the evacuated tube, the solar tubes are able to passively track the sun throughout the day. Flat plate collector only provides peak energy output at midday when the sun is perpendicular to the collector's surface.
2) Air is evacuated from the solar tube to form a vacuum. This greatly reduces conductive and convective heat loss from the interior of the tube. As a result wind and cold temperatures have less effect on the efficiency of the evacuated tube collector.
3) Lotusino solar collectors can often be used in subzero temperatures without the system sustaining damage. Flat plate systems often require expensive and complicated "antifreeze" systems to be installed.
4) Evacuated tubes are strong, long lasting, and should one be broken, inexpensive and easy to replace. If a flat plate collector panel is damaged the whole panel must be replaced.
5) Due to the high efficiency absorption of solar radiation even during overcast conditions, combined with excellent insulative properties of the solar tube, solar tube collectors can heat water all year round (backup from gas and electricity is still required).
6) Due to the various advantages of evacuated tube collector over flat plate collectors, a smaller collector can be used to provide the same heating performance. For example, a standard household of 4-5 people would usually require a 250-300L water storage tank. Depending on your location, only 30 evacuated tubes would be required to provide all summer hot water needs and a large percentage in other seasons. Flat plate solar collectors can produce similar heat output to evacuated tube collectors, but generally only during hot, sunny conditions. When averaged over an entire year, evacuated tube collector heat output per net m2 of absorber area is between 25% to 40% greater than a flat plate collector.

4. CONCLUSION

This paper introduced the benefits of evacuated tube solar water heater. In India, it is still new model of solar water heater which can be used in our household to face the challenge of climate change, global warming, energy crisis etc.

5. REFERENCES

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