Solar Water Heaters-A Hardware Experiment Model to Increase Efficiency

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Abstract: The hot water is very much required in our daily life. In cities, nearly 20-30% of electricity is used to heat the water every day. The alternative source is solar energy to heat water. But this can't be used by many people because the initial cost of these products (solar water heater) are very high. In this paper a model is described that uses the same methodology and principle of solar water heaters, but reduces initial cost and more efficient. The solar water heater can be developed in two phases. In phase -1, a copper tube is kept inside the glass bottle where the bottom half of glass bottle is vertically filled with charcoal powder or sand. The addition of these particles will add to the improvement of heating effect. Phase 2 deals with the addition of storage tank to store hot water. This

type of model is not only useful for homes, but also for the commercial buildings, hostels, small scale industries, pre-heaters in generation unit etc.

Keywords: solar water heater, glass tubes, copper tubes, storage water tank.

Introduction

Hot water is necessary in our daily life. It may be for cooking, bathing, industries, power generation in thermal power plants etc. So to heat the water, different sources of energy such as coal, kerosene, electricity, fire wood, charcoal, dung cakes are used in villages, towns and cities. Solar energy is used in many places as it does not pollute the environment. But this form is not much reliable due to variations in sun's radiations throughout the year. In many places backups such as electric and gas heaters are used. Also, people are not coming ahead to buy the products, due to its unreliable and less efficient in nature.

Here is a paper describing how a model of Solar Water Heater can be developed at low cost and increased efficiency. This setup can be more efficiently used at commercial buildings and small scale industries.

The principle of working is same as evacuated tube type solar water heater. But cost is reduced by directly taking the copper tubes and placing them inside the glass tube. As preliminary analysis, a test is carried out to check the effect due to addition of sand or charcoal. Firstly, the glass bottles are taken and copper tubes are placed inside it, with addition of sand or charcoal powder. Storage tank is fitted to store the hot water. Generally the storage tank capacity depends upon the application. Different applications in industry and homes require hot water during different times of the day. Also some industries require it instantly and continuously.

Conventional water heaters

Fig 1&2 shows the Glass tube and copper tube arrangement of conventional water heaters. This type of tubes are costly to design and manufacture. In evacuated water heaters the copper sheets are combined with glass materials and

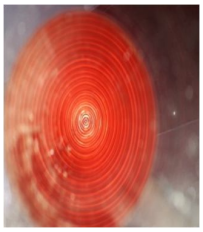

Fig 1-Inside view of copper tube inside glass tube of conventional water heaters

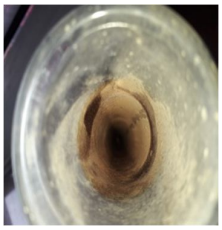

Fig 2-View of Copper made tube inside conventional solar water heaters

coated black on outside layer and these tubes are kept inside the glass tubes. One more disadvantage is that after developing these kinds of tubes, still they are not suitable throughout the year as their efficiency is very low. This is because their surface area of copper tubes is more and so to heat this material on non- sunny days takes more time and hence the efficiency of the solar heaters reduces.

Methodology and Design

Materials used are Glass bottles, Copper tubes, Storage tank, Charcoal powder and sand. Copper tubes are directly taken and placed inside the glass bottles. To increase its efficiency the surface area of copper tubes is also reduced. This gives the same effect of heating throughout the year. The area exposed to sun is less, so less time is taken to heat i.e. the water inside gets heated fast. The water that gets heated enters the storage tank, while the cool/cold water enters the copper tubes. This process takes place continuously so the heat transfer will be at a faster rate. The disadvantage of this design is the capacity of water gets reduced. But with same design and spending little on automation, a good model can be developed.

Phases of experiment

Phase 1: Preliminary test to check the heating effect of adding elements into glass tube

In fig-3, three glass bottles are used, in which one is filled with sand, one with

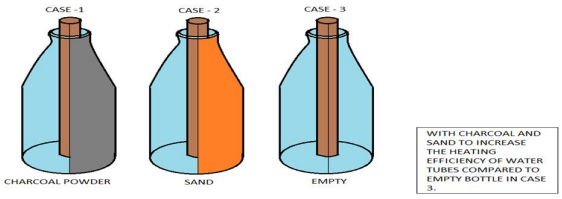

Fig 3-Measurement of temperature by addition of different materials into the glass bottle

charcoal powder and one is kept empty. This is done, to know the heating effects in the glass bottles filled with different materials. The glass bottles are kept in the sun with thermometers in them to measure the temperatures. After knowing which will give better heating efficiency, phase 2 is taken up.

As vertical part of bottle is spread (filled) with charcoal powder/sand, it covers more surface area and transfers its heat energy to bottom part of copper tube. Top of copper tube is directly exposed to sunlight to give better heating effect than the bottle with no added materials in it. Considering this design the first bottle is kept as reference i.e., without any added materials and the other two bottles are filled with sand and charcoal. The readings are taken by measuring the temperature of the water inside copper tubes with the different materials, during different times of the day. And after noting these values and analyzing them, the next phase is carried out.

Phase-2: Addition of storage tank

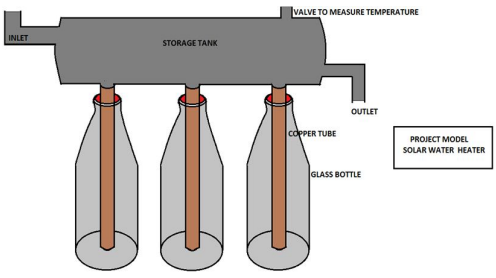

Fig 4-Experiment setup similar to solar water heater

In fig-4 the copper tubes inside the glass bottles are fitted with a storage tank with an inlet and outlet. The copper tubes in the glass bottles are connected to the storage tank to store the hot water. In conventional water heaters, during the heating process, the hot water from the copper tubes enters the storage tank due to temperature gradient, and the cold water will enter into the copper tubes. Thus the hot water is stored in storage tank and can be used for various purposes. From phase-1 it was found that the addition of charcoal powder is very effective than the sand and no added material. In phase-2 the storage tank is designed and built and charcoal powder is added to glass bottles. The readings are taken by placing the storage tank, glass tubes filled with charcoal powder as added material for an entire day in sunlight to check the temperature.

Design and Fabrication of water storage tank

Specifications of storage tank

- TANK DIMENSIONS : 13.5X12X8.8 cm (LXBXH)
- GROUND CLEARANCE: 3.5cm
- BODY: MILD STEEL
- Storage capacity: 1 Litre

Storage Tank Design Specifications

Storage tanks are containers that hold liquids, compressed gases, or mediums used for the short or long term storage. Tank design basically includes capacity, design code, materials, design conditions, external loads can be used for reservoirs. Storage tanks operate under no pressure. Storage tank is in cuboidal shape, perpendicular to the ground with flat bottoms. The Above-Ground Storage tank (ASTs) is used for storing water.

Description

Horizontal Cuboidal single skin design, for the collection and storage of the water is designed and fabricated. Arc welding is used for joining 12 sides of the cube

and it is grinded to get smoother surface finish. Inlet and outlets provision is made for the storage tank using mild steel of 12mm pipe for water flow. Copper tubes are used and placed on the surface of storage tank at an acute angle to the ground surface, copper tubes help in transferring hot water to the storage tank. Copper tubes are welded to the storage tank using helium wielding.

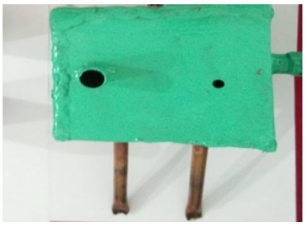

Fig 5-Copper tubes connected to storage tank

Results and Conclusion

Results for Phase-1

Table 1: Experimental readings of phase 1

Timings	**Water in a bowl (temperature in degree Celsius)**	**Glass bottles filled with sand (temperature in degree Celsius)**	**Glass bottles filled with charcoal powder (temperature in degree Celsius)**
8am	19.4	20.2	22.5
9am	20	23.2	23.8
10am	23.6	25.3	24.8
11am	26.9	29.5	28.8
12pm	29.62	32.8	30.8
1pm(13)	30.2	38.2	37.7
2pm(14)	31.7	40.3	43.4
3pm(15)	28.9	39.6	45.1
4pm(16)	26.5	37.8	40.0
5pm(17)	24.8	30.8	35.5
6pm(18)	24.2	24.3	26

Table-1 gives the experimental readings and results for phase 1 respectively and can be seen that the sand gets heated at a faster rate and there is significant increase of temperature of water by 24% on an average than the normal ones.

Next is charcoal powder, the charcoal powder heats up very fast due to black body radiation and addition of this increases the temperature of water by 40% than the normal ones (the increase in efficiency of water heater due to additions added during the experimentation mentioned above are based on our hardware experiment results only.). Hence, it can be concluded that either sand or charcoal can be used to get a better heating efficiency of water. Also, there is a significant drop in temperature during night. So, a storage tank is added in phase 2 to maintain the temperature even during the night.

Phase 2:

Table 2: Experimental readings of phase 2

Timings	**Addition of charcoal powder with storage tank) (temperature in degree Celsius)**	**Addition of sand with storage tank (temperature in degree Celsius)**	**Water in a bowl (temperature in degree Celsius)**
8am	25.2	25.2	25.2
9am	31.1	31.9	28.48
10am	34.5	37.05	31.2
11am	38.05	37.83	31.2
12pm	42.5	40.5	31.2
1pm(13)	41.8	44.8	32.1
2pm(14)	41.44	42.44	32.5
3pm(15)	41.04	44.94	32.9
4pm(16)	40.72	37.72	32.1
5pm(17)	40.38	33.8	31.05
6pm(18)	40.02	30.8	28.34

Table-2 gives the experimental readings for phase 2 respectively. By using a storage tank, the heated water can be stored for more duration without losing its temperature during the night. There is a significant drop in temperature of water without storage tank as the atmospheric temperature reduces during the night. So, the water that gets heated up can be stored and used later when a storage tank is added. The water that gets heated is stored in the tank and is used for various

purposes. Thus, this method can be used at homes, industries and commercial purpose. The production cost is less and suitable for urban and rural areas. The system should be maintained regularly for it to work properly. The maintenance is required for battery, storage tank, glass bottles and charcoal powder. Also, jobs can be provided in the field of maintenance.

Scope for future work

The main purpose of this experiment is to assure hot water whenever needed. The disadvantage of this experiment is hot water is not available on non-sunny days. To overcome this, an alternate setup can be included that can be used when there is no hot water. This setup can include solar panels, heating coils etc., which can be turned on automatically when needed. By doing so, it is ensured that hot water is available throughout the day.

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