PERFORMANCE OF A CONICAL SHAPED SOLAR WATER HEATER WITH THAT OF A CONVENTIONAL SOLAR WATER HEATER

Suhas V[1], Sukeerth Calastawad[2], Sawan Kumar S[3], Purujeeth R[4], Shyam sharma[5]

[1 2 3 4 5] Student, Mechanical Engineering Department, Maharaja Institute of Technology, Karnataka, India

---***---

Abstract - ***Various solar technologies are been developed to harness the available environmentally friendly and sustainable solar radiation. New ways of utilizing free power for different energy consuming process continued to be created .In this report a conical shaped solar energy absorber has been developed and its feasibility when compared to conventional flat plate solar collector decreases. Solar water heater has been designed in a conical shape in order to utilize maximum amount of solar energy available and convert it into heat energy for the purpose of heating the water. Low cost materials have been used in the construction of the solar water heater and the heating has been achieved without the usage of the solar panels or solar cells and mirrors which decreases the cost of the equipment, thereby making it economically feasible. The flow system for water heater has been placed in a spiral manner due to its configuration. Heating efficiency of water has been increased by placing sand in a conical basin which is in contact with the surface of the tubes. A glass covering has been provided over the surface of the tubes thereby decreasing the reflectivity of the sunlight and enhancing maximum absorption. Based on the above design considerations the solar water heater has been fabricated and tested.***

Key Words: *Solar heater, Spiral tubing , conical shape collector, Low cost, Thermo siphoning (natural cooling)*

1. INTRODUCTION

In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared [1]. As we know Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. [3] Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet [4].

Earth's land surface, oceans and atmosphere absorb solar radiation, and this raises their temperature. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle. The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anti- cyclones [5]. Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of 14 °C [6]. By photosynthesis green plants convert solar energy into chemical energy, which produces food, wood and the biomass from which fossil fuels are derived [7].

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 Exa joules (EJ) per year. In 2002, this was more energy in one hour than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The technical potential available from biomass is from 100–300 EJ/year. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined, Solar energy can be harnessed at different levels around the world, mostly depending on distance from the equator.

Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis [1] [2].

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 02 Issue: 04 | June-2015 www.irjet.net p-ISSN: 2395-0072

1.1 Analysis of conical frame

Inclining solar collectors positioned at up to 60 degrees from the horizontal achieve by increasing the effective aperture area of the collector in the cooler months – by more effective positioning towards the sun. A thermo siphoning (close coupled) system has the secondary benefit of increasing efficiency by reducing the resistance that the water heated in the collector encounters when wanting to rise freely into the storage tank.
A tertiary benefit is that in the middle of summer when too much solar heating can be an issue, the 60 degree collector angle reduces the effective aperture area during this time – when compared to collectors at 10-30 degrees that significantly better year-round performance than standard angles of between 10 and 30 degrees virtually face the midday sun in summer. Plenty of 100 per cent solar heated water is still expected. To achieve the required 60 degree angle the inner circle diameter is made half of that of the outer circle diameter (i.e 3 ft and 1.5 ft) to get the required aperture area. The conical structure of solar water heater has been fabricated using mild steel. It is built robust by use of mild steel, it has been bent into two concentric circles of the required dimension and they are joined using mild steel bars to obtain the required structure.

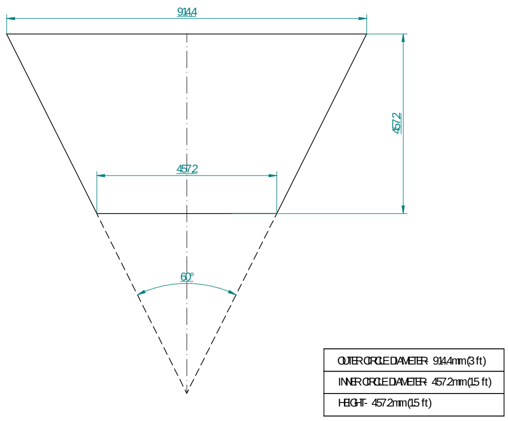

Fig 1: Dimensions of the Conical frame

1.2 Conical shaped absorber

Solar collectors are the devices which are used to trap the sunlight and store them for future use , they have been in use for over a long period. They have been classified into two types namely, Flat plate solar collectors and parabolic solar collectors. By taking the principles of the parabolic solar collector, it has been modified into a conical shape for better heat entrapment. The conical shape proves advantageous for the better absorption of sunlight due to its shape. Due to its configuration the tubes for water flow have been arranged in a spiral manner which gives water enough time to get heated by absorbing maximum amount of heat during its travel through tubes, thereby giving the water its highest possible temperature by the time it reaches the outlet. The conventional flat plate and parabolic solar collectors make use of photovoltaic cells for the absorption of solar energy, whereas in our conical shaped absorber no use of photovoltaic cells have been made, instead of which sand has been used as a medium for better absorption of heat. By adopting the above conical design we may get more heat absorbing efficiency.

Fig 2: 3-D Representation of Conical frame with spiral tubing

2. FEATURES OF THE CONICAL SHAPED SOLAR WATER HEATER

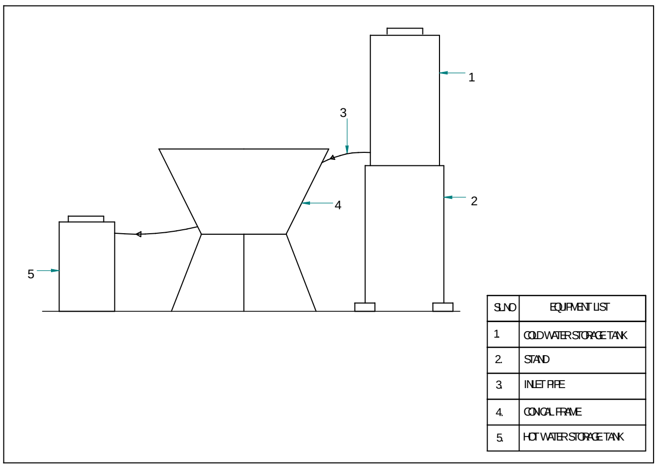

Fig 3: Line diagram of solar water heater

Fig 4: Actual experimental setup of solar water heater

The above figure shows the experimental setup of the Conical shaped solar water heater, it mainly consists of a main conical solar frame, two water storage tanks and spirally placed tubes. The main conical frame has been fabricated using mild steel. The water tubes have been spirally placed over the frame with the help of aluminum binding wires which holds the tightly to the frame. The tubes have been painted with a light absorptive color (black paint), which collects the heat and transfers the heat to the flowing water. The storage units can be divided into two systems such as:

1) Single unit storage system: In case of single unit storage system, a single storage tank acts as a single unit wherein the cold water and hot water remains in the same storage tank.

2) Double unit storage system: A double unit storage system, consists of two storage tanks one being for cold water and other for the hot water storage.

The cold water inlet for the tubes is provided from water storage tank placed at a height of about 4ft which gives a suitable head for the water to flow easily. Flow control valves have been connected to the cold water storage tank which controls the flow rate of water through the tubes, the tubes have been tightly fixed to valve using the rings.

The main conical frame along with the tubes is most important part of the solar water heater; it is because of this shape the water gets heated to a maximum temperature by the time it is received at the outlet. Thus the highest possible temperature of the water is achieved by placing the sand between the conical sheet metal and the conical frame. During daytime the sand as well as the black surface collects the heat from sun and store the heat for the future use, the sand retains the heat there by making the heat to be available even in the minimal sunlight.

3. COMPARISION BETWEEN CONICAL SHAPED SOLAR WATER HEATER AND CONVENTIONAL SOLAR WATER HEATER

1. On September 15th Mysore, Karnataka India

Table 1: Temperature comparisons and efficiencies of flat plate solar heater and conical solar heater

Sl.no	Timings	Rise in temperature of water in flat plate solar heater (T_f) ^0C	Rise in temperature of water in conical shaped water heater(T_c) ^0C	Efficiency (T_C-T_f)/T_f (%)
1.	9.00 am	27	29	7.40
2.	11.00 am	34	40	17.60
3.	13.00 pm	37	44	18.90
4.	15.00 pm	40	50	25.00
5.	17.00 pm	34	36	5.88

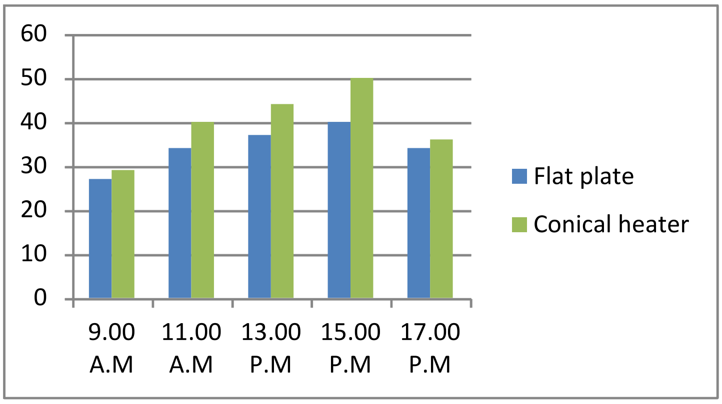

Chart 1: Temperature comparison chart

(NOTE: X- axis represents timings and Y-axis represents temperature in ^{0}C)

Inference:-

The above bar graph shows a plot of the temperature versus timings for flat plate solar water heater and conical solar water heater. The Blue bar represents the temperature recorded for different timings for a flat plate solar water heater, similarly the green bars for conical shaped solar water heater. It can be inferred from the graph that the latter shows a maximum temperature at 15.00 hrs when compared to conventional flat plate solar water heater.

4. COST ESTIMATES

Cost analysis is the total expenditure that has been made to fabricate the collector. There are two elements mainly involved in cost analysis. It is cost of the raw materials and additional materials that are used for the manufacture of a product. There are two types of material cost, i.e. direct material cost and indirect material cost. Direct material cost is basic cost of the raw material which is available in the market and in direct material cost is one that is useful for the processing of the material. E.g.: nuts &bolts, hollow square pipe, etc.

Table 2: Cost incurred for fabrication

Sl.No	MATERIALS USED	COST (in Rs.)
1.	Fabrication of the conical frame	1900
2.	½ inch braided fiber pipe	1600
3.	Aluminum binding wires	20
4.	Pipe connectors	30
5.	Water storage tanks	1100
6.	Aluminum foil	40
7.	Ball valves	200
8.	Conical sheet metal	2000
9.	Fasteners	50
	Total	6940

5. CONCLUSIONS

An attempt as been made to design and fabricate a conical type solar heater and it was successful by comparing the performance and efficiency of conical solar water heater to that of flat plate solar heater. Test was conducted on September 15th Mysore, Karnataka, India. It was found that maximum heat was absorbed between 2 to 3pm and it shows steep raise in temperature. This design can be applied by commercially for domestic purposes due to its feasible price.

REFERENCES

1. "Solar Energy Perspectives: Executive Summary"(PDF). International Energy Agency, 2011.
2. "Solar Fuels and Artificial Photosynthesis", Royal Society of Chemistry, 2012
3. Philibert, Cédric (2005). "The Present and Future use of Solar Thermal Energy as a Primary Source of Energy". IEA.
4. "Natural Forcing of the Climate System". Intergovernmental Panel on Climate Change.
5. Somerville, Richard. "Historical Overview of Climate Change Science" (PDF). Intergovernmental Panel on Climate Change.
6. Vermass, Wim. "An Introduction to Photosynthesis and Its Applications". Arizona State University.
7. "Renewables for Heating and Cooling"(PDF). International Energy Agency
8. S P Sukhatme and J K Nayak. "Principles of thermal collection and storage".

