International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 04 | Apr 2019 www.irjet.net p-ISSN: 2395-0072

CONCRETE SOLAR COLLECTOR

Vikas Kataria[1], Sahil Mahajan[2], Shivam Singh[3,] Vishal Rana[4], Parv Mittal[5]

[1]Assistant Professor, Department of Civil Engineering, Dr. Akhilesh Das Gupta Institute of Technology & Management, New Delhi, India
[2,3,4,5]Student, Department of Civil Engineering, Dr. Akhilesh Das Gupta Institute of Technology & Management, New Delhi

---

Abstract - *The main Purpose behind this project is to reduce the cost of solar water heating system so that it could become affordable to common people. The conventional solar water heater is very expensive due to its solar panel, which is very delicate and is not affordable by the masses. Unlike the solar water heaters, this model involves the use of a concrete slab with copper pipes running in it for transferring heat to the water efficiently. A reinforcement has been added to the concrete slab for improving the heat conducting properties of the slab and increasing the strength of the slab. The design of the copper piping is chosen in such a way that the heat transfer to the water running inside the pipes is transferred effectively. Some fine results have been obtained in the tests conducted. On an average winter noon, the temperatures which we obtained range from 42°C to 48°C. This solar concrete collector will help reduce the average cost of water heating by more than 50% as compared to other water heating devices. This experimental model can be used as an independent assembly or can be accumulated in the unused roof structures of existing buildings.*

Key Words: Solar water heater; Concrete Collector; Efficient water heating system; Serpentine shape; Alternatives to Fossil Fuels

1. INTRODUCTION

1.1 GENERAL

Amongst all the types of fuels available, solar energy is considered as the most economic and efficient fuel for the generation of energy. This is mainly because it is inexhaustible and abundantly available in nature. Also, combustion of fossil fuels is the primary cause of pollution and hence leading to global warming. Our aim is to install the setup onto the roofs of buildings. Roof is the uppermost part of the structure which is exposed to maximum sunlight for most hours of the day. The solar heat energy which is getting wasted everyday can be made into use for heating water. This large amount of unused roof area is used for water heating purposes. We can obtain hot water at a temperature of 48°C in buildings during the daytime even in winters using this installed in the roofs of the structures. This technique is easy to install by the common people in their houses by a little guidance.

Solar energy is widely used today for the generation of heat. There were many suggestions like using evacuated tubes as collector, higher quality insulation etc for improving solar water heating systems but they could not be used because they increased the overall cost of the assembly manifolds. This water heating system will minimize this drawback and this is what we wanted to achieve in the first place, i.e to fabricate and economic and efficient water heating system. Economical water heating system will minimize this drawback to a notable extent, that is what our main motto is and which has been achieved by using concrete slab. In is system concrete slab replaces the costlier solar collector of conventional solar water heating system.

1.2 OBJECTIVE OF STUDY

To make concrete slab solar water collector. Our main objective is to reduce the cost of solar water heating system, which could be affordable to common people. In this, we eradicate the use of solar panels, which are the most expensive part of the solar water heating systems.

2. LITERATURE REVIEW

2.1 REVIEW

Different research papers on this model have been studied before beginning this project. This idea has been seen to work in various studies. Several experiments and analyses have been conducted to find ways of improving efficiency of this concrete collector. Turner et al. [1] studied concrete collectors for applications ranging from de-icing of roads and bridges to water heating required for various applications. S.P. Sukhatme et al. [2] used wire mesh concrete embedded with PVC pipes. Tube to tube spacing was considered as an important parameter and and optimal value was found out. Changes in water pressure through the tube was also studies. P.B.L. Chaurasia [3] performed similar experiment as those of Sukhatme but the only thing different was that he replaced PVC pipes with aluminium pipes. The best arrangement of the pipes was in serpentine shape, I.e pipes arranged in a parallel orientation with some portion exposed to the outer open environment and some embedded inside the concrete collector. Sokholof & Reshef [4] studied this collector and they have stated that this model can be utilised in already constructed structures and serve as an economical. Hajami et al. [5]

have studied the working of this collector of area 5m^2 on buildings.

2.2 MATERIALS USED

- Reinforcement
- Cement
- Sand
- Aggregates
- Wooden frame
- Copper pipes
- Inlet water container
- Rubber pipes
- Water storing container
- Metallic stand

Fig -1: Wooden Frame, Reinforcement, Copper Pipes

2.3 WORKING PRINCIPLE

This solar concrete collector works in a similar was as conventional solar heater. When the solar energy is incident upon a surface, not all the energy is utilized for heating of water. But most of the energy is consumed in heating of the cold water in the copper tubes by the concrete. Water in the system flows only because the density of water decreases when it gets heated. The water get heated during the sunlight and also for sometime after that due to the water storing capacity of concrete. After this, the water can be stored in an insulated tank for further use.

3. CONSTRUCTION

Solar collector here is a concrete slab which is embedded with steel reinforcement at a height of 2 cm from the bottom. Concrete slab is tilted at an angle from the horizontal painted black and absorbs the solar radiations radiated on it surface. Copper tubes are embedded in the solar collector such that some part of them resides out of the surface of slab. These tubes absorb heat energy directly from the solar radiations as well as by conduction from the solar collector. The solar collector is inclined to a fixed angle. The angle can vary from place to place.

3.1 METHODOLOGY

The cement concrete collector in the form of thin slab have been fabricated and tested for water heating purpose. These reinforced cement concrete slabs have been made from common building materials like cement, sand and coarse aggregate. Steel reinforcement which is 80 x 30 cm is used in the fabrication of the slab which gives structural strength to the slab. The thermal conductivity of the slab increases due to steel reinforcement. Wire mesh is embedded at a height 1 cm from the bottom which provides reinforcement for the concrete slab. The dimensions of the slab are 90 x 40 cm with an absorbing surface area of 3600 cm2. The thickness of slab is 8 cm. The copper tubes were embedded on the top surface. The arrangement of the copper tubes was made into serpentine flow arrangement. The copper tubes arranged in a manner that 80% of its portion, along its length, remains inside the concrete slab while concrete remains exposed directly to the sunlight. Water proof plywood was used to make the base and sides of the wooden cabinet. With reference to the copper grid sizes, two rectangular cuts are made at the side flank to have access to inlet and outlet pipes. The collector is painted with black paint to increase the absorptivity.

4. SUMMARY AND CONCLUSIONS

4.1 APPLICATIONS OF SOLAR CONCRETE COLLECTOR

Fig -2: Solar Concrete Collector

If the roof of a concrete structure is blackened, more hot water will be taken. If the normal water from the water tank of the house is passed through a network of the copper pipes embedded in the unused roof area of the structure, hot water at a moderate temperature can easily be supplied (36°C to 58°C) for doing various household

chores during the day. About 25-40 litres of hot water above the human temperature can be drawn easily from one square meter area of roof structure after slight modifications in the regions where the horizontal solar radiation exceeds 4kWh/ m2. This concrete collector can also be integrated into the house during the construction process. This solar roof can also be employed as a pre-heater to any water heating system. This passive cement concrete solar water heating system can also be used in the summer season for supplying the hot water at relatively higher temperature which may be used according to the requirements of the buildings. After this, we have studied the relation between the temperature of water obtained from the Solar Water Collector and the temperature of the day at that time as shown on the Internet. The reading which we obtained are shown in Table 6 as shown below. A graph has been plotted with the help of readings obtained from Table 6, taking Temperature on Y axis and Time on X axis.

Time	Temperature (Inlet)	Time	Temperature (Outlet)	Time	Outside Temperature
0	16	0	16	0	20
0.5	18	0.5	25	0.5	22
1	18	1	30	1	22
1.5	19	1.5	36	1.5	23
2	21	2	40	2	25
2.5	21	2.5	42	2.5	26
3	22	3	44	3	26

Table 1: Variations of Temperatures during the day.

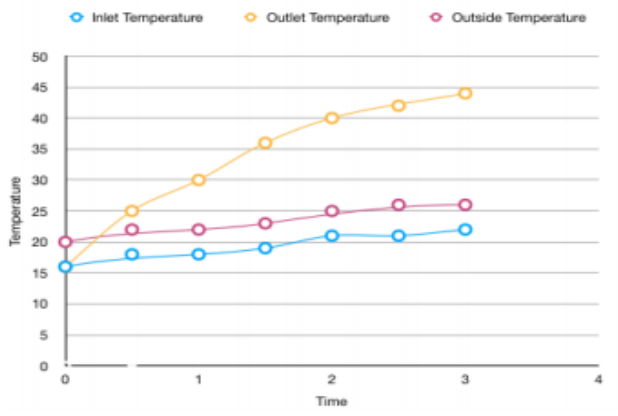

Fig -3: Graph for comparing the Temperature differences obtained

4.2 CONCLUSION

Hot water at moderate temperature (up to 54°C) can be obtained in buildings during the daytime in winter by using reinforced cement concrete slabs or by slightly modifying the roof structure and laying down the network of copper pipes over it which can offer a low cost passive solar water heating system in the building itself. Inbuilt cement concrete solar water heating system can also be made during the construction of the building. This passive solar water heating technique is easy to fabricate and he mason o skilled person can do this type of job after a little training for it.

4.3 FUTURE IMPLEMENTATION

Previous studies performed on SWH economic and environmental benefits are based on energy absorbed by SWH, quantity of water collected in an insulated storage tank, usage of hot water even in summer, considering a room temperature as initial temperature throughout the year and not taking into account SWH as preheater in rainy or foggy days. Those methods thus slightly overestimate and don't give actual SWH benefits. Therefore, this study proposes the concept of yearly benefits based on - actual usage of hot water by persons, exclusion of usage of hot water for 45 days of summer, consideration of different initial temperatures for different months as per climate of Pune and then calculating average temperature as 21 °C [6]; also considered 50 rainy, 4 foggy and 6 squally days in a year [7], where water is heated up to 35 °C only and acts as a preheater for another water heating equipment during these 60 days. The study has been done considering the energy saving, cost saving and sustainable development aspects.

REFERENCES

1. R.H. Turner, Concrete Slabs as winter solar collectors, ASME solar energy conference, page no. 9-13.
2. S.V. Bopshetty, J. K. Nayak, S. P. Sukatme, Performance Analysis of Solar Concrete Collector, Energy Converse. Manage, 33(11), 1007-1016.
3. P. B. Chaurasia, Solar water heaters based on concrete collectors, Energy, 33(11),1007-1016.
4. M. Sokholof and M. Reshef, Performance Simulation of Solar Collectors made of concrete with embedded Conduit Lattice, Solar Energy,48(6),403-417.
5. M. Hazami, Performance of Solar storage Collector, Desalination, 183,167-172.
6. Pune Climatological Information 1951–1980, India Meteorological Department.
7. Energy Sources of Indian Households for Cooking and Lighting, 2011-12, NSS 68th Round, Ministry of Statistics and Programme Implementation, Government of India, 2015.
8. IS 456:2000
9. IS 800:2007
10. Design of Steel Structures. N Subramanian
11. Reinforced Concrete Design, Devdas Menon