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A Review on Polycarbonate Collector for Solar Water Heating System

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Abstract — Heating water for domestic purpose is a simple and effective way of utilizing solar energy but initial cost of solar water heating system is high. The conventional solar water heating technologies faces the major challenges of installation, bulkiness and reliability, which acts as a bump in growth of the world wide solar market penetration. It is necessary to find some reliable, cost effective material to bridge this gap through technology development. The Solar Water Heating System having Polycarbonate sheet as a collector is studied by different researchers. The aim behind such performance evaluation is to find new material for solar thermal collector and develops the feasible technology. This paper shows comprehensive review on polycarbonate solar water heater.

Keywords — Polycarbonate Sheet; Solar Water Heating; Control Device; Collector.

I. INTRODUCTION

The increasing need of energy consumption, shrinking resources and rising costs of fossil fuel will have significant impact on our standard of living for future generations. In this situation, the development of alternative, cost effective sources of energy has to be a priority. One of the major renewable energy resources is the solar energy which sun emits to the earth. Since ancient time, the solar energy is always remaining prime source of our uses. The technology development dependent to solar energy in last few decades, the solar water heater is most commercializing technology yet, against a technical potential of 45 million sq.km. of collector area only a little over 2.5 million sq. km of collector area has been installed. Solar water heater is a mature technology, but the fact remains that solar water heaters are not cost effective against the current price of natural gas and other fossil fuels.

Research and Development can lead to significant advances in materials, design, and manufacturability, which can contribute to lowering the cost of SWHs, improving their performance, and easing installation-both in new construction and in retrofit markets. The Higher Cost, Poor performance and Lesser Reliability are the major reason behind this identified Gap results into the lesser penetration of actual market lead. These have lead to research and development on new materials like polycarbonate.

The various technologies have been developed in last few decades. The flat plate collector and evacuated tube collector are widely accepted by the manufacturers and consumers. A Simple flat plate collector consists of an absorber plate in an insulated box covered with transparent sheets. An Evacuated Tube Collector works on the principle of using vacuum as an excellent insulating barrier, preventing heat loss primarily due to convection and conduction.

II. SOLAR WATER HEATING SYSTEMS

SWH systems are generally very simple using only sunlight to heat water. A working fluid is brought into contact with dark surface expose to sunlight which causes the temperature of the fluid to rise. This fluid may be the water being heated directly, also called direct system, or it may be a heat transfer fluid such as water/glycol mixture that is passed through some form of heat exchanger called indirect system. This system can be classified into three main categories, Active System, Passive System and Batch System.

A. Active Systems

Active systems are electric pumps, bulbs and controllers. To circulate water or heat transfer fluid towards a controller. Therefore they are also called as forced circulation systems. Further divides into two categories:

1) Open Loop Active System: These systems use pump to circulate water through the collectors. Design of open system is efficient and lowers operating cost but is not appropriate if the water is hard or acidic because scale and corrosion quickly disable the system. These open loop systems are popular in non freezing climates.

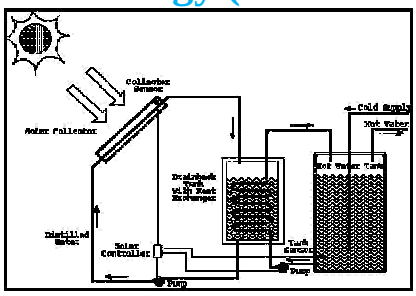

Fig. 1. Open Loop Active System

2) Closed Loop Active System: These systems pump heat transfer fluids through collectors. Heat exchanger transfers the heat to the household waters store in the tank. These systems are popular in areas subjected to extend freezing temperature, because they give good freeze protection.

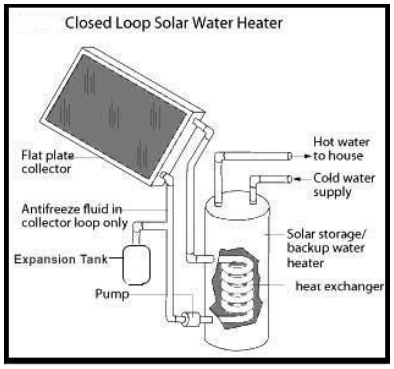

Fig. 2. Closed Loop Active System

B. Passive System

Passive system simply circulated water or heat transfer fluid by natural convection between a collector and an elevated storage tank. Passive systems can be less expensive than active systems, but they can also be less sufficient. Thermo siphon system is the best example of passive system.

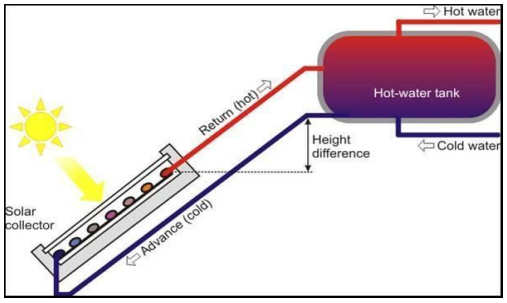

Fig. 3. Thermo siphon passive system

C. Batch System

Batch systems are also known as integral collector storage systems. It consists of one or more storage tanks placed in an insulating box that has a glazed side facing the sun. Batch systems have combined collection and storage functions.*[4]*

III. COMPONENTS OF SOLAR WATER HEATING SYSTEM

SWH generally consists of a solar radiation collector panel, a storage tank, a pump, a heat exchanger, piping units and auxiliary heating unit.

A. Solar Collectors

The choice of collector is determined by the heating requirement and the environmental conditions in which it is employed. There

are mainly three types of collectors, flat plate collector which is simple in design and no moving parts so require less maintenance another one is Evacuated Tube Collector made up of rows of parallel, transparent glass tubes. The air is withdrawn (evacuated) from the space between the tubes to form a vacuum, which eliminates conductive and convective heat loss. In Concentrating Collectors mirror surface is use to concentrate the sun rays on the absorber tube.

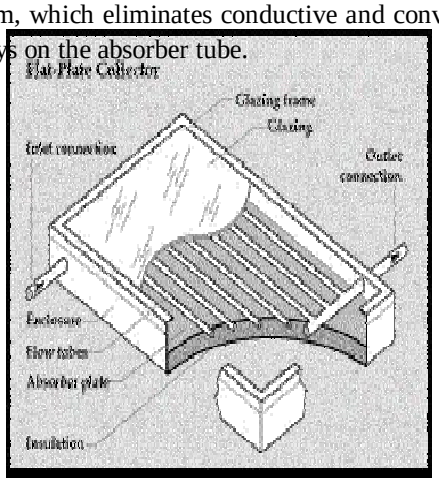

Fig. 4. Flat plate collector

B. Storage Tank

Most commercially available solar water heaters require a well insulated storage tank. Thermal storage tank is made of high pressure resisted stainless steel covered with the insulated fiber and aluminum foil. Insulation is provided to the storage tank to reduce heat losses.*[4]*

IV. POLYCARBONATE COLLECTOR

A. Sharad Parekh, Ripen Shah [1], Carried out performance evaluation of polycarbonate sheet as a collector. The motive behind this work was to find out new material as solar thermal absorber and to develop feasible technology. Main drawbacks of conventional collectors are high cost reduction in performance with time leakage losses etc. A polycarbonate sheet of 6 mm thickness, area of 2 m^2 and mass 2.6 kg, where volume of heat carrier fluid in to the absorber was 6 lit. That collector sheet worked efficiently in the temperature range of -25^{o}c to 125^o c.

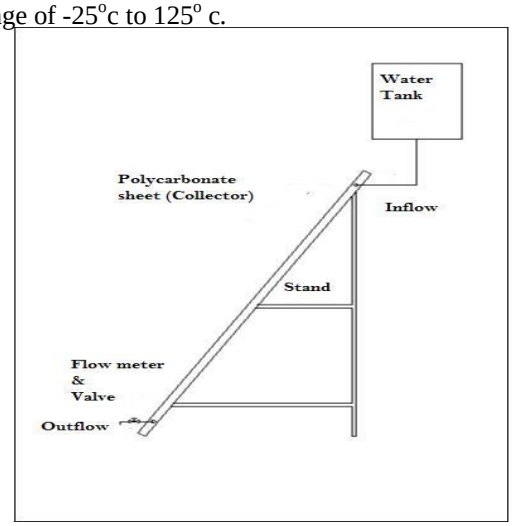

Fig. 5. Functional Arrangement of solar water heating system.

Setup consisted of polycarbonate heat carrier in flow out flow header fluid tank and control devices. They took different parameters in the proximity of the collector fields main parameters were heat energy produced coefficient of efficiency inflow and out flow temperature to analysis the data. The experiment was connected on 10th April 2013 the maximum efficiency achieved was 72% at 830 w/m^2 solar radiation and mass flow rate of 30 kg/hr of water.

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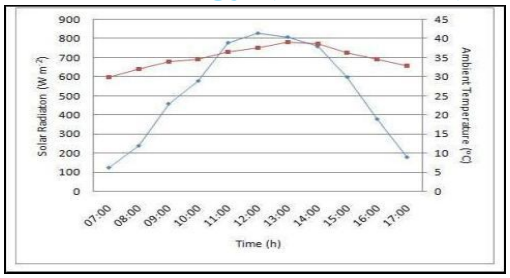

Fig. 6. Variation of solar intensity and ambient temperature along the local time.

The experiment was connected on 10th April 2013 the maximum efficiency achieved was 72% at 830 w/m^2 solar radiation and mass flow rate of 30 kg/hr of water.
From the above experiment it seems that optimum efficiency of the polycarbonate collector was achieved at temperature difference (inlet-outlet) 17^{o}c and mass flow rate of 30 kg/hr.

B. Henriks Putans, Zanis Jesko, et. al [2] done experimental investigation on cell Polycarbonate absorber and transparent cover. The collector consisted of a wooden box, into which, a layer of heat insulation with a mirror film and 4 mm thick cell Polycarbonate sheet, as the absorber, are placed. The area of absorber working surface was 2m² and of mass about 27 kg. The volume of the heat carrier into the absorber was about 5 litres. The coefficient of linear expansion was 0.067 mm/°c. They provided manual solar tracker mechanism to increase the efficiency of the prototype. They have also compared the theoretical and practical efficiency with various kinds of other collectors.

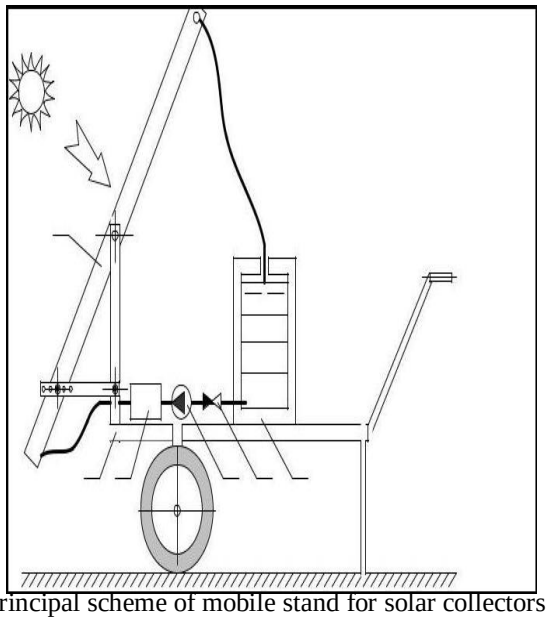

Fig. 7. Principal scheme of mobile stand for solar collectors experimental investigation

The collector's optical coefficient does not depend on the solar radiation intensity, as well as the temperature difference between the heat carrier and surrounding air. The coefficient of solar collector efficiency (3) is the ratio between the amounts of heat energy produced by the collector and received by the working surface of the collector
Following resultant curves of water heating processes on August 16, 2010 are given. When intensity was 780 W/m². During 3 hrs reached temperature 43°c. During the heating time, efficiency decreased from 60% to 30%.

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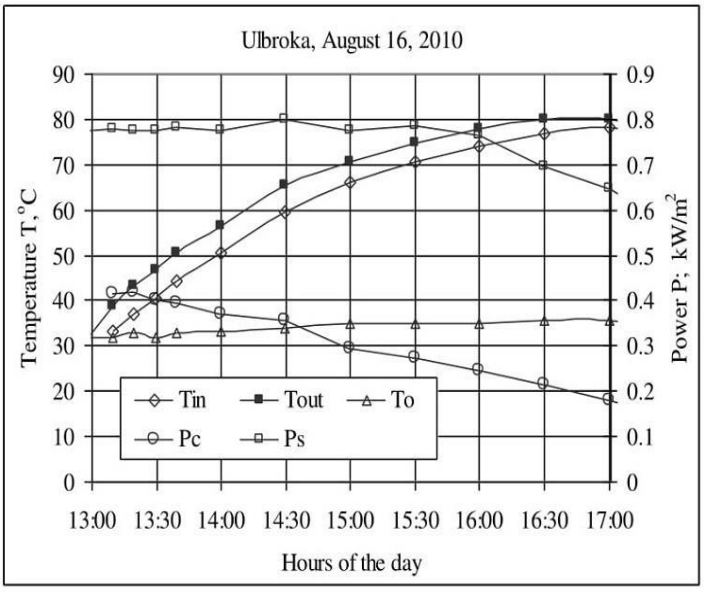

Fig. 8. Parameters of the CPC collector depending on the heating time

C. *B. S. Bhadouriya , M.K. Gaur, et al [3],* developed a new panel for utilizing polycarbonate (PC) sheet with water supply in the channels, and solar cells are attached on top of the sheet. Also, in both the system a phase change material (PCM) was integrated as short term heat storage media. Panel fabrication details and results are discussed in this paper. Prototypes were developed and tested for indoor conditions at MITS Gwalior, India. It was observed that water and PCM can remove the excess heat of solar cell. Simultaneously, this excess heat is also exploited to obtain thermal energy as heating water. Thus, this system may be called as a polycarbonate-photovoltaic thermal system. The developed PVT panel contains phase change material as well as polycarbonate sheet. The PV converts visible and ultra-violet parts of the solar spectrum; whereas the solar thermal absorber utilizes infra-red (IR) parts of the spectrum and waste heat from the PV, the PCM reduces the temperature of the PV which increases PV efficiency.

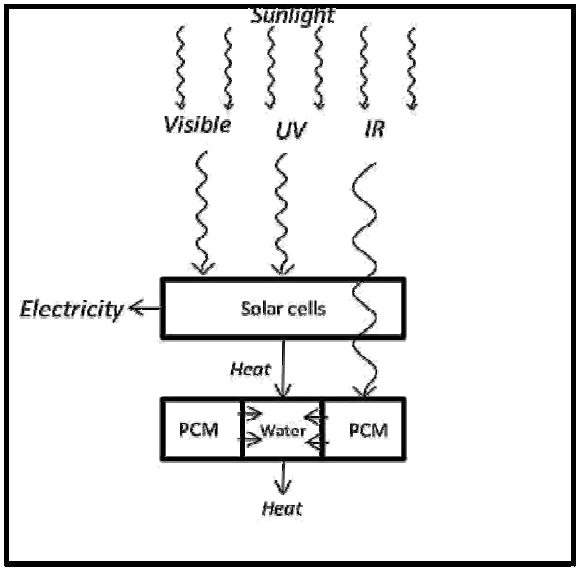

Fig. 9. Principle phenomenon of CPC PVT/PCM panel

Water gets heat from two sources; first the excess heat from solar cell (which is actually the unused IR spectrum) and secondly heat from PCM from side channels.

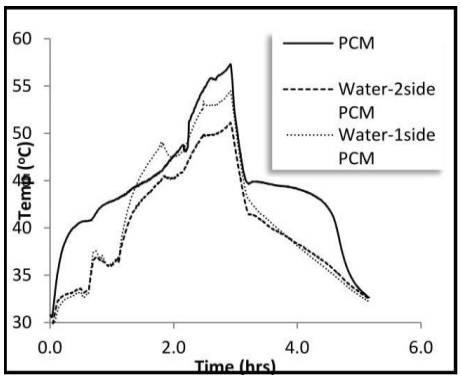

Fig. 10. Relation between water and PCM OM46

That generic system was tested in the lab under a halogen lamp to evaluate thermal performance. It was assumed that excess heat of cell is transferred to the panel which consisted of water and PCM alternatively, and the water got heated. Secondly, PCM was heated and melted at its on respective PCM's melting point.

V. CONCLUSION

From this literature study, we can conclude as follows:

A. The successful demonstration of heating the water can be done with polycarbonate sheet based collector. However, it needs lot of research to make it commercialize product in future.

B. The optimum efficiency of 72% is achieved at the intensity of solar radiation about 0.83 kW/m² and ambient temperature about 37°c.

C. It is possible to manufacture PC Solar Water Heater with easily available material at low cost.

D. Therefore PC Solar Water Heater seems to be the best alternative to conventional solar water heater.

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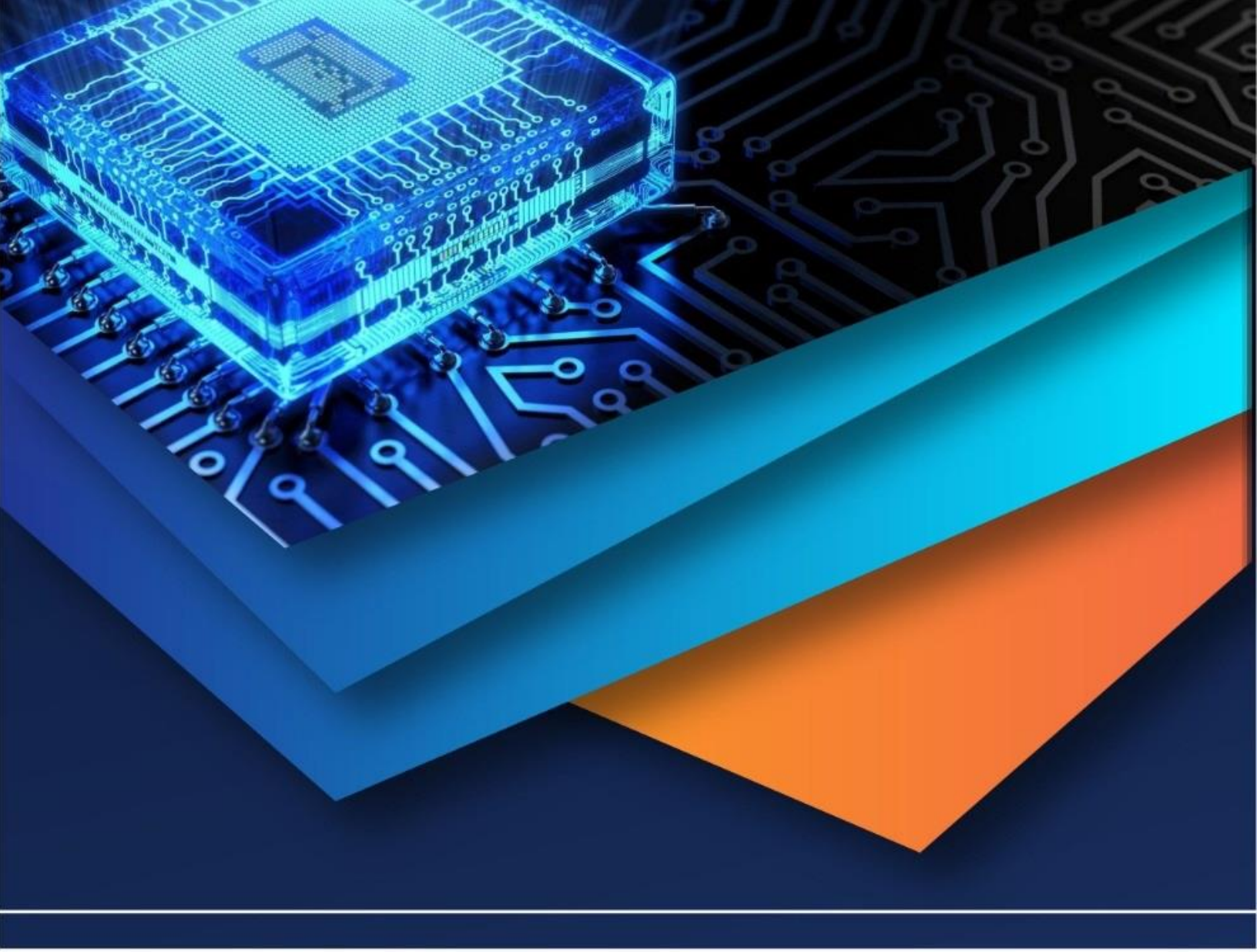

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