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Comparative Studies Of Acrylic Covered Solar Water Heater With Conventional Solar Water Heater

J.H.Patel[1], Ankit Doshi[2], Hitesh Mariya[3], Jaydip Pethani[4], Vandan Pokar[5]

[1]*Assistant professor, Mechanical Department, Sigma Institute of Engineering, Vadodara, Gujarat.*
[2,3,4,5] *UG Student, Mechanical Department, Sigma Institute of Engineering, Vadodara, Gujarat.*

Abstract — *As we know that application of solar energy for domestic and industrial heating purposes has been become very popular. The utilization of solar energy for heating of water is common application but efficient water heating is the toughest because it depends on weather condition.Three main components associated with flat plate collector (FPC) namely, absorber plate, cover plate and heating pipes.And to overcome such difficulty various modifications have been proposed by different researchers in various fields in terms of modification in pipe shape or in terms of change in the material of absorber plate etc. And so the objective of present work is to analyze the performance of cover plate of glass sheet to acrylic sheet. This paper presents a study of the all researches conducted on the cover plate of solar water heater and its efficiency in terms of temperature in recent years.*

Keywords- *Solar water heater, flat plate collector, thermocouple, storage tank, Absorber plate*

I. INTRODUCTION

Sun is soul of everything that exists on the earth. Since society is developing, at each step it utilizes energy in various forms. The energy consumption per capita decides the degree of development of that country. This gives rise to more general statement that, larger the consumption of energy per capital, more developed be the country. There are varieties of energy sources which can be classified in the category of conventional and non-conventional sources. However, looking towards the limitations and polluting behaviour of the conventional sources, switching over to non-conventional sources becomes a need of the time. Basically solar energy itself is a versatile source of energy since solar radiations are available worldwide, non-polluting, and eases of conversion of solar energy in to various required forms.
Today we are witnessing a shift from use of metals to non-metals as the basic raw material in physical products. Plastics of various kinds offer many advantages over other materials as a manufacturing raw material. Re-usability of plastics makes it particularly attractive. This project aims to use solar energy to melt plastics.
The solar collectors employed could be flat plate, concentrating, or evacuated tube types. But, the flat-plate-type collector appears to be the most commonly used. Its low cost and ease of design and construction are basically responsible for the use. They are often used for low-medium temperature application but may be applied on high load situation by using more than one collector, connected in series. The concentrating and evacuated tube collectors are used for industrial or commercial applications where high temperatures of up to 100 ° C are required.

Advantages of Solar Energy:

After initial investment all the electricity achieving will be free, benefits of incentives and rebates from governments, getting a credit from the utility company, reduce or completely eliminate electric bill, water heater will not produce noise with the use of solar energy.

Disadvantages of Solar energy:

Solar power cannot be produce at night, power generated is also reduced during times of cloud cover, once can maximize the solar energy when its panel directly facing the sun.

II. SOLAR WATER HEATING SYSTEM

Solar water systems are generally very simple as they are usually using only sunlight to heat water. The working fluid is brought into contact with a dark surface exposed to sunlight which in turn causes the temperature of the fluid to raise. This fluid might be water, that is being heated directly, is also known a direct system, or it may be a heat transfer fluid such as a glycol/water mixture that is passed through some form of heat exchanger called an indirect system.

2.1. Active solar systems:

Active solar power setups rely on external energy sources-or backup systems, such as radiators and heat pumps- to capture, store and then convert solar energy into electric energy.

Depending on the complexity of the design, it can heat or cool the home or provides power.it also uses some external devices to circulate the water thus; it's also called as forced circulation heating system.

Merits of active solar system:

A special building design is not necessary, solar radiations are collected using some kind of separate collectors, it can be employed to any location.

Demerits of active solar system:

More expensive, difficult to construct and operate, external devices needed to operate its function.

2.2. Passive solar system:

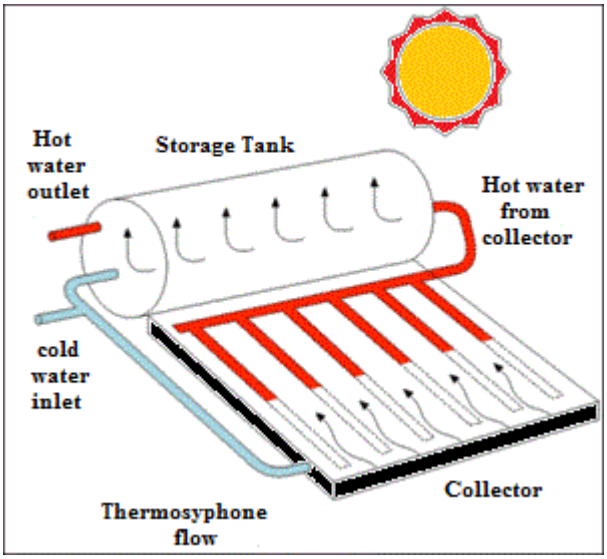

Fig 1: Passive solar system

Fig1 shows passive solar systems operate without the reliance on external devices. Rather such as in greenhouses, solarium and sun-rooms, solar energy captures sun beams through glass windows that absorbs and retain heat. The water circulated in tubes is of natural circulation, it is also called natural circulation solar water heating or thermo-syphon water heating system.

Selection of passive solar system:

To get rid of all the problems facing in active system, use of passive solar system will be more effective and easy to operate.

III. SOLAR COLLECTORS

The choice of collector depends on the heating requirements and the environmental conditions in which it is employed. There are basically three types of solar collectors like flat plate solar collector, evacuated tube solar collector and concentrated solar collector.

3.1. Flat plate collector (FPC):

Flat-plate collectors are commonly used for domestic water heating applications. The design is simple and has no moving parts hence it requires very less maintenance. It is basically an insulated, weatherproofed box containing a dark absorberplate under one or more transparent covers. They collect both direct and the diffuse radiation.

3.2. Evacuated-Tube Collectors (ETC):

Evacuated-Tube Collectors are usually made of rows of parallel and transparent glass tubes. In which each of tube consists of outer glass tube and an inner tube, or absorber, which is covered with a selective coating which can absorb solar energy well but also inhibits radiation heat loss. The air is withdrawn ("evacuated") from the space between the tubes to form a vacuum. They are most suited to extremely cold ambient temperatures or in situations of consistently low-light. They are also used in industrial applications, where high water temperatures or steam need to be generated where they become more cost effective.

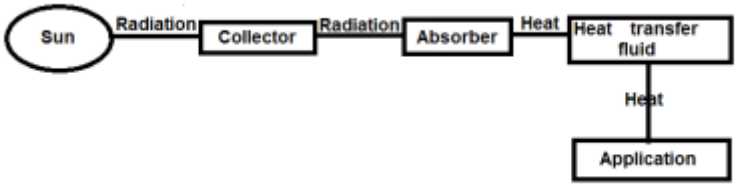

Fig 2: Block diagram of solar flat plate collector

3.3. Storage Tank:

Thermal storage tank is constructed of high pressure stainless steel, which is covered with the insulated fiber and aluminum foil. Some solar water heaters use electric motors to re-circulate hot water from storage tanks via collectors and exposed piping which is generally made to protect the pipes from freezing when outside temperatures drop to freezing, 0^{o}C or below it.

IV. COLLECTOR EFFICIENCY

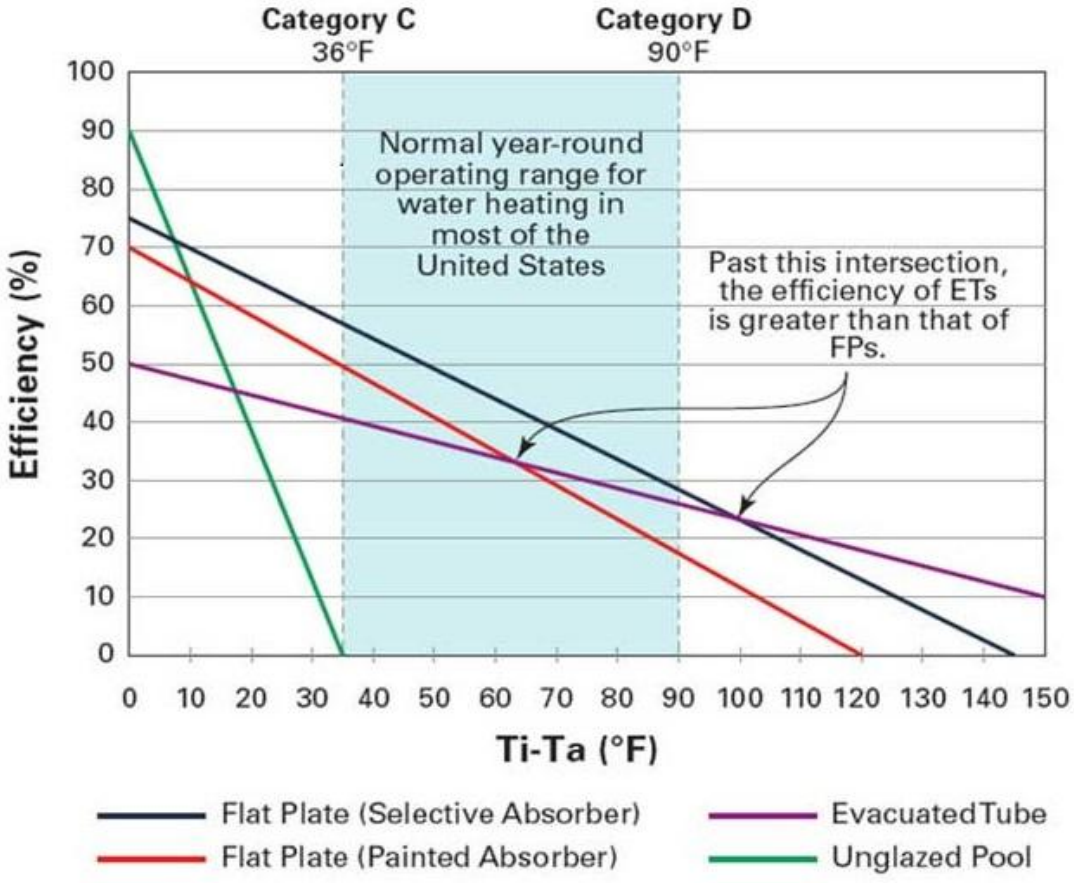

Fig 3: Collector efficiency

V. MATERIALS:APPLICATION OF COATING

4.1. Epoxy

To the aluminum plate that maintenance could not be performed, the original coating was removed and simply cleaned with soap and water and allowed to dry. Thus, the original coating was used as the base. Two layers of epoxy paint were applied with air gun prepared by mixing catalyst with 1:1 and allowed to dry for 2 hours at room temperature. Subsequently, the polyurethane paint mixed in a 2:1 ratio with its respective catalyst and thinner in a ½ portion for a

more liquid consistency. Five layers were applied with air gun. It was then allowed to dry at room temperature for two days before being used for the evaluation tests, and to be used in the rehabilitated flat plate solar collectors.

4.2. Acrylic

New foils of aluminum and cooper were simply cleaned with soap and water, then dry sanded to create roughness on the surface and to obtain good adhesion and be free of grease, moisture and any other contaminants. Two layers of epoxy anti corrosive red oxide were applied with an air gun and allowed to dry for two days. Subsequently, two coats of semi-matt acrylic finish were applied and then allowed to dry for two days to achieve a solid layer. These films were used for property evaluation.

Advantages and features:

Acrylic is tough transparent plastic, it is durable than glass, weight is also less than glass covered plate, it has tensile strength of 8000 lbs per square inch with impact resistance six to 17 times greater than ordinary glass.

VI. REQUIREMENT OF NEW MATERIAL

The current solar water heater technologies face the major challenges of cost, efficiency and reliability, which acts as amajor growth of the world wide solar market penetration. It is necessary to find some reliable, cost effective material to bridges this gap by technology development. One of the solutions is to replace flat plate collector with new material such as polymer, glass tube etc.

The favourable properties of polycarbonate when applied to solar collector are: low density, mechanical strength, no special surface treatment required, processing technique adapted to mass production; but it has low thermal conductivity, large thermal expansion and limited surface temperature. Polycarbonate sheet is lighter and tougher with-light transmission which is useful as solar panel collector purpose. Toughness combined with transparency and high temperature resistance makes polycarbonate a perfect onefor demanding application.One more reason to replace polycarbonate collector with copper tube based flat plate collector is to achieve very low cost. This reduces material and manufacturing cost and weight, which can help reduce installation costs as well.

Table-1 Material Selection and Design of the two collectors

	Conventional	New
Absorber Tube	Copper	GI
Fins	Copper	-
Insulation	Polystyrene	Polystyrene
Casing	Wood	Wood
Selective Coating	Si based black paint	Si based black paint
flow cross section	circular	elliptical
Internal Diameter of the tube	12.7 cm	Major-15cm Minor-12cm
Width of the fins	0.14m	0.14m
Length	0.95m	0.95m
Area	$0.266m^2$	$0.266m^2$

VII. TEMPERATURE MEASURING INSTRUMENT-THERMOCOUPLE

A thermocouple is an electric device consisting of two dissimilar conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature dependent voltage as a result of thermoelectric effect, and this voltage can be interpreted to measure temperature.

Table 2: Different type's thermocouples with different temperature range

Thermocouple Type	Useful/General Application Range
E*	200-1650°F (95-900°C)
J	200-1400°F (95-760°C)
K*	200-2300°F (95-1260°C)
N	200-2300°F (95-1260°C)
R	1600-2640°F (870-1450°C)
S	1800-2640°F (980-1450°C)
T*	32-660°F (0-350°C)

K-Type thermocouple:
K-type thermocouple is the standard thermocouple measurement configuration.

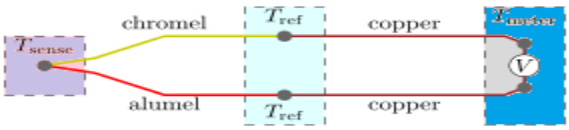

Fig 4: working principle of K-type thermocouple

Benefits:
Fast response time, available in small sheath sizes, low initial cost and it is durable.

VIII. LITERATURE SURVEY

Sr.no	*Author name*	*Year of published*	*Description and conclusion*
1.	Raj ThundilKaruppa R., Pavan P and Reddy Rajeev D.	2012	Studied the performance of sandwich type solar water heater in which pipes through which water is flowing placed in the cavity of absorber plates to enhance the rate of heat transfer. This work is primarily concerned with the possibility of replacing the conventional collectors with the GI plate sandwiched collectors. So, only the important practical parameters like the steady state outlet temperatures and the efficiency can be compared.
2.	M.V. Kulkarni, Dr. D. S Deshmukh	*2014*	Focused on PCM type solar water heater. The system consists of two simultaneously functioning heat-absorbing units. One of them is a solar water heater and the other a heat storage unit consisting of PCM (paraffin). The water heater functions normally and supplies hot water during the day. The storage unit stores the heat in PCMs during the day supplies hot water during the night.
3.	R. Sivakumar, V. Sivaramakrishnan, M. Vivekenandan	*2015*	Obtained CFD results for Depth of fins immersed in water, V-grooved and dimpled absorber surface

			in a solar thermal collector are important geometric parameters that influence the maximum temperature rise during peak solar irradiation and hence the losses.
4.	Eze J. I. and Ojike O.	*2012*	Investigated the thermal efficiency of a passive solar water heater is undertaken. The solar water heater has two storage tanks and is used for cold and warm waters, respectively. Here copper pipes are placed in the spiral form only.
5.	FouedChabane, NourddineMoummi, Said Benramache	*2012*	Deal with the influence of the tilt angle of solar collectors. The optimum angle is measured by searching for the values for which the total radiation on the collector surface is a maximum for a particular day or a specific period.
6.	Sharad B. Parekh1, Ripen Shah	*2014*	Aimed behind such performance evaluation is to find new material as solar thermal absorber and develop the feasible technology. The one more reason to replace polycarbonate collector with copper tube based flat plate collector is to achieve low cost. This reduces material and manufacturing cost and weight, which can reduce installation costs as well.
7.	Santosh Kumar Singh,Arvind Kumar Singh andSantosh Kumar Yadav	*2012*	Studied two different absorber tubes were taken and the efficiencies of the PTSC where compared without glass cover on the absorber tubes.The efficiencies for the PTSC were as follows: when without glass cover: aluminum tube receiver: 18.23%, copper tube receiver 20.25%. The efficiencies observed for parabolic trough concentrator demonstrates that this technology with appropriate absorber tube systems can produce hot water that is hot enough for solar thermal conversion power systems.
8.	S.Rajasekaran, M.Chandrasekar, T.Senthil Kumar	*2015*	Studied the effect of various material like steel, copper and aluminum used for water tubes as part of solar water heater. This research introduces a new heating system which has flat plate collector

			of effective performance at low cost even though stainless steel and aluminum has low thermal conductivity. Experiments have been conducted by using copper, stainless steel and aluminum tubes as header and riser tubes. The result shows that copper, aluminum and stainless bestow same performance. Also cost of stainless tube with epoxy-polyether and aluminum with copper oxide are less than that of copper tube.
9.	SethuramanRamasamy	*2015*	Discussed about the experiment is to maintain the velocity at the outlet and the better outlet water temperature by selecting the correct shape and measurement of fins. Maintaining the pressure drop, increasing the heat transfer rate by increasing the area of the tube is also the main motto of the conducting this experiment. The implementation of fins in solar water heater is one of the promising techniques to enhance the heat transfer rate from set up to water.
10.	R. Meenakshi Reddy, N. Nallusamy, and K. Hemachandra Reddy	*2012*	focused on the present experimental results of a combined sensible and latent heat TES system integrated with a varying (solar) heat source is presented. Investigations are carried out in the TES system for different phase change materials (paraffin and Stearic acid) by varying HTF flow rates and for various sizes of spherical capsules (68, 58, and 38mm in diameter).
11.	Vikram D, Kaushik S, Prashanth V, Nallusamy N		Investigated the thermal behavior and feasibility of a cylindrically encapsulated PCM as a LHTES . A storage tank containing latent heat storage material is constructed to analyze the performance of latent heat thermal energy storage system. Experiments have been carried out at a constant flow rate of HTF for which the thermal characteristics of the LHTES system and efficiency of the system is calculated. The discharge characteristics for batch-wise discharge are also studied.

IX. CONCLUSION:

The major result and conclusion of presented all literature survey is that various researchers have been contributed to improve the performance of solar water heater in all kinds but no one has carried out comparative study between conventional solar water heater and acrylic covered solar water heater satisfactorily.

X. SUGGESTION FOR FUTURE WORK:

In this study, the flat plate collector is considered for analysis from all researchers' survey and it would be a good initiative to explore the impact of other types of solar collector such as an evacuated tube or a concentrated collector.And greater comparison between conventional solar water heater and acrylic covered solar water heater can be achieved.

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