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Assorted Performance Investigation of Flat Plate Solar Collector - A Review

Vijayan S N[1], Karthik S[2], Vijayaraj V T[3]

[1, 2, 3] Assistant Professor, Department of Mechanical Engineering,
Karpagam Institute of Technology, Coimbatore, TamilNadu

Abstract - *Solar energy is become an alternative for the limited fossil fuel resources. One of the simplest and most direct applications of this energy is the conversion of solar radiation into heat. Flat plate solar collectors are the most common thermal collectors used among the various solar collectors for domestic and industrial purposes. The performance of any solar collector is largely affected by various parameters such as Glazing, Absorber plate, Top covers and Heating pipes. The collector efficiency is dependent on the temperature of the plate which in turn is dependent on the nature of flow of fluid inside the tube, solar insulation, ambient temperature, and top loss coefficient, the emissivity of the plate and glass cover, slope. This paper briefly discusses the various performance analysis of flat plate solar collector system.*

Keywords: *Solar Collector, Solar Energy, Flat plate collector*

I. INTRODUCTION

Nowadays most of the world energy is produced from the fossil fuels. Massive exploitation is leading to the exhaustion of these resources and imposes a real threat to the environment, apparent mainly through global warming and acidification of water cycle. The distribution of fossil fuels around the world is equally uneven. Middle-East possesses more than half of the known oil reserves. This fact leads to economical instabilities around the world, which affect the whole geopolitical system as it cannot be maintained for more than two. Moreover there is a danger arising from the increase of the energy use from the countries of the third world. It is expected that these countries will try to increase their standard of living, which is at the minimum level for decades. This will have as a result the increase of the depletion of the limited stock, creating an even more logical problem. These countries even today cannot afford the cost of protecting the environment consequently they will increase the rate of combustion of oil and coal, will accelerate the deforestation or they will turn to nuclear energy. Keeping the above in mind as well as the fact the oil is running out fast, alternatives should be adopted. Renewable energy is one of the most promising alternatives to the above problems.

The amount of heat deliver by solar system is 7kw/hour in a day. Solar collectors are commonly used for active conversion of solar energy to heat. Solar water heating system is a relatively mature solar thermal technology. In solar water heating systems incident solar radiation is converted to heat and transmitted to the transfer medium such as water. Solar water heating is often viable for replacement of electricity and fossil fuels used for water heating. Flat plate collector is an extension of the basic idea to place the collector in an oven like box; here riser tubes connected with the header tube is placed inside the box under absorber plate. Various studies reviewed above have shown the importance of performance improvement to the collector of the solar water heating.

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II. Flat Plate Collector

A typical flat-plate collector made up of an absorber which is in an insulated box together with transparent cover sheets (Glazing). The absorber is usually made up of a metal sheet of high thermal conductivity such as copper or aluminium, with integrated or attached tubes. Its surface is coated with a special selective material to maximize radiant energy absorption while minimizing radiant energy emission. The insulated box reduces heat losses from the back and sides of the collector. These collectors are used to heat a liquid or air to temperatures. Less than 680°C. Cross-section of a typical liquid flat plate collector is shown in figure 1 in which absorbing surface is approximately as large as the overall collector are that intercepts the sun's rays. Concentrating collectors in which large areas of mirrors or lenses focus the Sun light onto a smaller absorber.

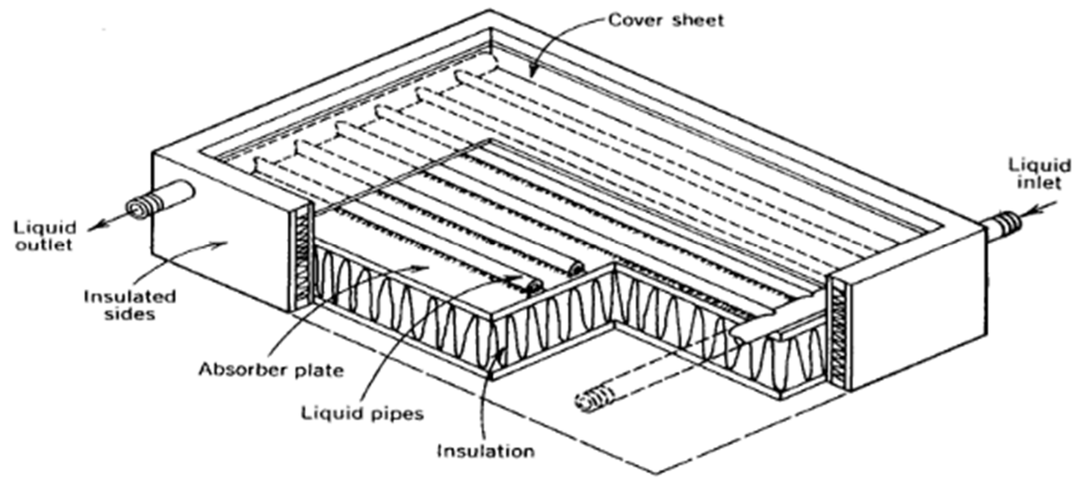

Figure 1. Cross-section of a typical liquid flat plate collector

Flat-plate collectors consist of

(1) A dark flat-plate absorber,
(2) A transparent cover that reduces heat losses,
(3) A heat-transport fluid (air, antifreeze or water) to remove heat from the absorber, and
(4) A heat insulating backing

Flat-plate collectors are in wide use for domestic household hot-water heating and for space heating, where the demand temperature is low. Many excellent models of flat-plate collectors are available commercially to the solar designer. Solar flat plate collectors are used for water heating applications and the efficiency of these systems are around 70% which is very high as compared to solar direct energy conversion systems having efficiency around 17%.

Three main components associated with FPC namely, absorber plate, top covers and heating pipes. The absorber plate is selective coated to have high absorptive. It receives heat by solar radiation and by conduction heat is transferred to the flowing liquid through the heating pipes. The fluid flow through the collector pipes is by natural or by forced circulation (pump flow). For small water heating systems natural circulation is used for fluid flow. Conventionally, absorbers of all flat plate collectors are straight copper/aluminum sheets however, which limits on the heat collection surface transfer area.

III. Literature Review

In order to overcome the drawback of conventional solar collectors in winter, that is, its unavailability due to low water temperature or even freezing, presented a new design of solar collectors based on combination of a novel compound curved surface concentrator and an aluminum concentric solar receiver contained in a double-skin glass evacuated tube. The experimental results indicate that when the average ambient temperature was below 0°Cthe water temperature canbe heated up to 80°C with a daily average efficiency of about 50% (1). The air flow patterns in performance of flat plate solar collectors by designing different air flow pattern inside the collector. Results shows that collector efficiency of single duct front pass, double duct front pass and double duct counter flow were 30.6, 36.1, and 38.2% respectively. From this result solar collectors' designs with double duct counter flow can improve collector performance for up to 8.3% compared to single duct front pass (2). Performed the Theoretical and experimental analysis on a flat plate collector with a single glass cover. The efficiency of FPC is found to increase with increasing ambient temperature (3). Analyzed the performance of coated solar flat plate collector by introduces a new heating system which has flat plate collector of effective

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performance at low cost. Experiments have been conducted by using copper, stainless steel and aluminium tubes as header and riser tubes. The result shows that copper, aluminium and stainless bestow same performance. Also cost of stainless tube with epoxy-polyether and aluminium with copper oxide are less than that of copper tube (4). Thermal performance testing of flat plate solar air heater size of 1m x 0.5m x 0.1m was fabricated. Three designs namely (i) plane absorber (ii) transverse V- porous ribs and (iii) inclined V-porous ribs of absorber are tested. All the experiments are conducted with artificial solar radiation and in natural convection. Performances of these three designs have been compared on the basis of overall thermal efficiency and thermal gradient along normal to the base. The overall thermal efficiencies of these designs have been found as 14.91%, 17.24% and 20.04% respectively. It has also been seen that thermal gradient tends to reduce with increase in efficiency (5). Created uniform velocity in solar water system by using variable header. The solar water heater is designed with a larger diameter of the header is 5.08 cm and smaller diameter of 2.54 cm with the length of 100 cm. The existing solar water heating systems the overall thermal performance reduces due to non-uniform flow in riser tubes. The overall thermal performance and efficiency is higher in variable header system due to uniform velocity (6). The Performance of Solar Flat plate by using Semi Circular Cross Sectional Tube When using semi circular type tube blow the absorber plate, the area of intimate contact is increases between fluid and absorber plate and also resistance due to adhesive is decreases. Due to this reason performance of solar flat plate collector is increased (7). The design and testing of a new type of efficient solar dryer, particularly meant for drying fruit. A detailed performance analysis was done on both dryers with granite (thermal storage medium) and without granite then drying time reduction and moisture loss rate is found out and compared (8). The performance of conventional absorber plate is compared with the newly proposed absorber plate having concavities. The result shows that there is an improvement in the heat transfer rate. The heat transfer rate is increased by 5.12%. It shows that the increase in outlet temperature due to the provision of concavities which increase the diffusion area for radiation reducing the reflection losses (9). Investigated the Solar Flat Plate Collector Using Ceramic Coated Panel to diminish the cost of panel, insulation, maintenance, durability and its life considerations (10).

The Numerical analysis of a three dimensional fluid flow in a flat plate solar collector using CFD tool to simulate the solar collector for better understanding of its heat transfer capability (11). determined the Effect of Glass Thickness on Performance of Flat Plate Solar Collectors for Fruits Drying. All collector performances were analysed and compared using a glass of 5mm thickness and then with glass of different thickness. The results showed that change in glass thickness results into variation in collector efficiency. Collector with 4mm glass thick gave the best efficiency of 35.4% compared to 27.8% for 6mm glass thick (12). Implemented an explicit finite difference scheme in order to study the flow of air inside flat-plate air solar collectors. That is performed by solving the continuity, momentum and energy equations governing the problem with the choice of the appropriate boundary conditions. The application of the explicit finite difference scheme in this case proved to be reliable and convergent in the range of the studied parameters. The velocity field and the temperature distribution are calculated and showed good agreement with other published experimental results (13). Analyzed a Single and Double Pass Smooth Plate Solar Air Collector with and without Porous Media. The aim is to analyze thermal efficiency of flat plate solar air heater. Found that Smooth plate double pass solar air heater is 3-4% more efficient than single pass solar air heater. If we use the porous media in double pass solar air heater increase the air heater efficiency to be 5% efficient than air heater in single pass, and 2-3% more in double pass without porous media (14). studied the theoretically and experimentally work done with respect to flow and temperature distribution inside the solar collector using computational fluid dynamics (CFD) tool to simulate the solar collector for better understanding the heat transfer capability (15). Investigated the Theoretical and experimental analysis of flat plate collector with a single glass cover. The emissivity of the absorber plate has a significant impact on the top loss coefficient and consequently on the efficiency of the Flat plate collector. The efficiency of FPC is found to increase with increasing ambient temperature (16).

Evaluated a performance of a passive flat-plate solar collector. The variations of top loss heat transfer coefficient with absorber plate emittance and air gap spacing between the absorber plate and the cover plate. The effects of these parameters on the performance of the solar collector were also investigated. It was observed that high plate emittance tends to dissipate more heat to the atmosphere and consequently resulted to increase in top loss heat transfer coefficient which led to reduced system performance (17). Fabricated and tested for studying the effects of different nano particle concentrations of TiO_2 in water as base fluid. Adding nano particles to water brought about an improvement of initial efficiency of FPSC between 3.5 and 10.5% and the index of collector total efficiency between 2.6 and 7% relative to base fluid (18). Determined the thermal performance analysis of a glazed solar flat plate collector system with heat storage tanks. Special attention is focused on the influence of the system parameters such as the capacity of thermal storage and thermal load on the performance of the collector system. Results show that the variation of temperature inside the storage tank becomes smaller as the capacity of the tanks increases and the final temperature decreases with increasing the heat load (19). Estimated the Flat Plate Solar Collector Productivity. By using the present method average monthly and annual productivity calculation of the solar collector was estimated (20).

IV. Conclusion

Based on the thorough review, the performance of flat plate solar collector is largely affected by various parameters such as Glazing, Absorber plate, Top covers and Heating pipes. The collector efficiency is dependent on the temperature of the plate which in turn is dependent on the nature of flow of fluid inside the tube, solar insulation, ambient temperature, and top loss coefficient, the emissivity of the plate and glass cover, slope.

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