© 2016 IJSRSET | Volume 2 | Issue 5 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Performance of Solar Flat Plate Collector System Based on Different Absorber Plate

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ABSTRACT

In the present work, a comparative study on the performance and optimization of the different absorber plate. In order to establish the performance of solar air heater/solar water heater depends significantly on the heat transfer rate between the absorber plate and water, on the amount of solar radiation incident on the absorber plate. In this investigation of heat transfer and thermal conductivity results have been compared with those for different absorber plate under similar flow and thermal boundary condition to determine thermo hydraulic performance. Correlations have shown that (heat transfer factor, friction factor, fin efficiency factor, collector efficiency factor and heat removal factor).
Keywords : Solar Radiation, Absorber Plate, Solar Collector, Thermal Conductivity, Thermal Efficiency, Thermo-Hydraulic Performance.

I. INTRODUCTION

Solar heater system from the major components of solar energy utilization which absorbs the incoming solar radiation converting in to thermal energy at the absorbing plate and transferring the energy to a fluid following through the collector.

Solar heater system because of their inherent simplicity is cheap and most widely used collection devices. In SWH aluminium, copper or mild steel plate embedded with galvanized iron, mild steel pipes are used as absorber plate and glass wool or coir is used as insulation material.

The common application of the flat plate collector is mostly found in solar hot water, space heating, industrial processes, vapour absorption refrigeration and air conditioning system. The solar flat collector well developed collector consisting of a black flat absorber plate, the transparent cover, heat transfer fluid and insulating the selective black surfaces to increase collector efficiency and other kind of extended surface geometries mainly produce augmented heat transfer surface as compared to a flat surface and this higher heat transfer rates. In thermal performance evaluation and as s comparison of the thermal efficiency of the collector with different absorber plate reported in the literature. Absorber is the main component of the collector responsible for absorbing for solar radiation of different length. To improve the performance of the collector, selective material and different profile shape on absorber is necessary.

II. METHODS AND MATERIAL

Flate Plate Collector

The flat plate collector is the heart of any solar energy collection system designed for operation in the low temperature range 50°C or in the medium temperature range 100°C. it is used to absorb solar energy, convert in to heat and then to transfer that heat to a stream of liquid or gas. It absorbs both the beam and the diffusion radiation and usually planted on the top of building or other structures. It does not require tracking of the sun and requires little maintenance.

A flat plate collector usually consists of the following components. Glazing, which may be one or more sheets of glass or some other diathermanous (radiation transmitting) material.

Tubes, fin or passages for conducting or directing the heat transfer fluid from the inlet to the outlet. Absorber plate which may be flat, corrugated or grooved with tubes, fins or passages attached to it.
Header or manifolds, to admit and discharge the fluid, Insulation which minimize the heat from the back and sides of the collector.

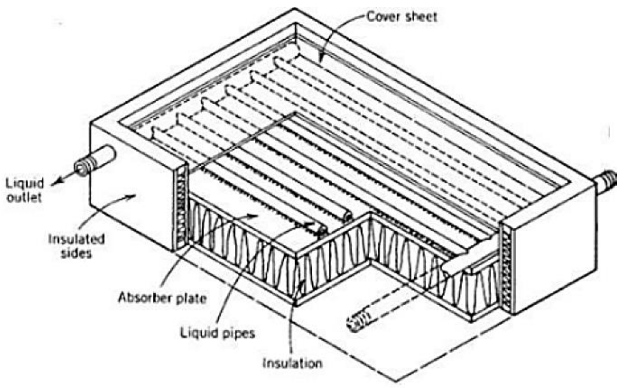
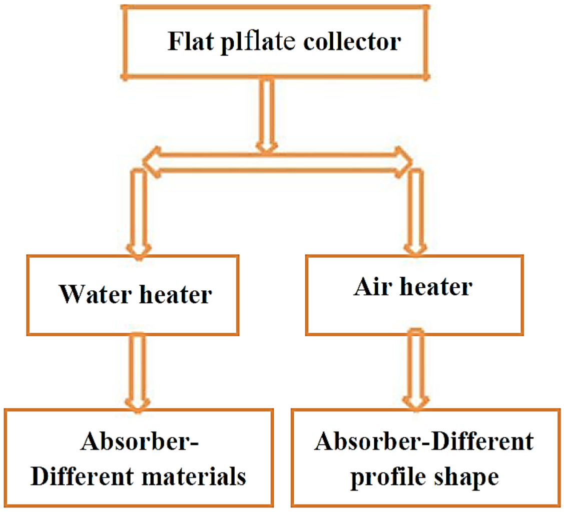


Figure 1: Flat Plate Collector

Container or casing, which surrounds the varies components and protects them from dust, moisture, etc.



Flow Chat 1 : Flat Plate Collector Solar water heating system

The conventional solar water heating system essentially consists of two units, the collection unit and the storage unit. The collection unit is, usually a blackened plate to absorb most of the solar energy incident on it. The flowing water in thermal contact with the absorber gets heated and is transferred to the storage unit. The storage unit is a well-insulated tank, to reduce the possible heat losses.

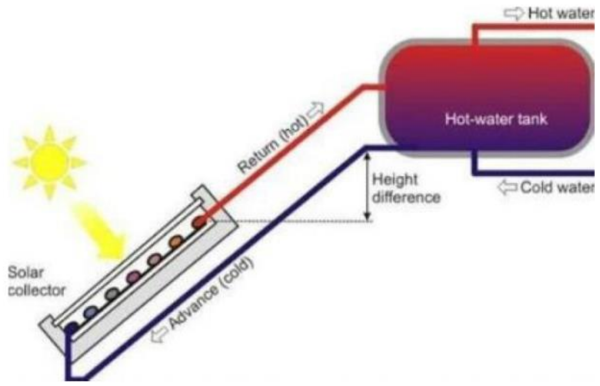


Figure 2: Solar Water Heater

The transportation of the heated liquid from the collector to the storage unit takes places by two modes : The thermosyphon mode, in which the circulation of heated water is accomplished by the natural convection. The forced circulation mode, where a small pump is required for the flow of water.

Different Kind of Absorber Materials

SWH system commonly used as absorber plate material such as copper, aluminium, steel. The variation of the collector's characteristic factor F, F' and FR with the thermal conductivity, k, of the absorber plate is shown in fig when material such as copper, aluminium, and steel are examined, lower values characteristic factor is found to correspond to steel due to lower thermal conductivity. Using aluminium instead of steel will result in an increase in the characteristic factor by about 12% to 19%, whereas instead of the aluminium plate by a copper plate will improve the characteristic factor by only about 3%.

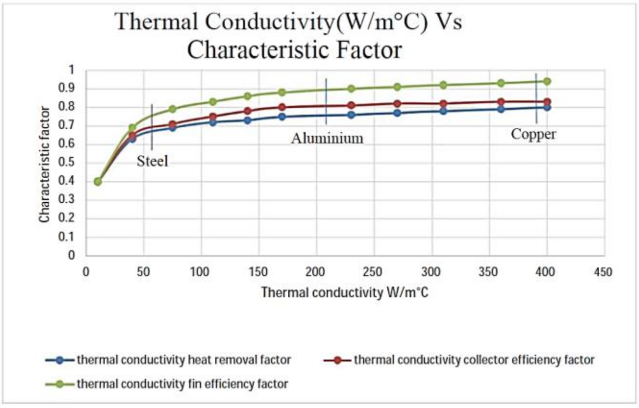


Figure 3 : Thermal Conductivity(W/m°C) Vs Characteristic Factor

The effect of the thermal conductivity on the annual solar fraction of the system is shown in fig the operating temperature 80°C. The load volume is changed three times in order to organize different solar fraction values. When steel, copper and aluminium are examined. For aluminium instead of steel for the absorber plate improves the solar fraction by about 4% to 7%. Whereas using copper instead of aluminium improves the solar fraction by about 1% only. This is due to the fact that the collected energy may exceed the load energy in summer even if the steel is used for the absorber plate.

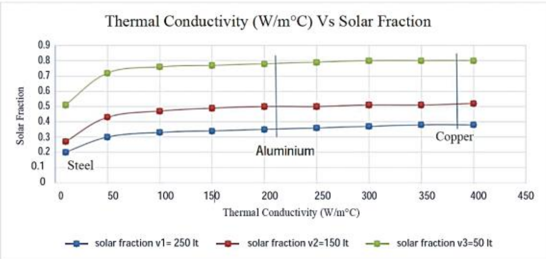


Figure 4 : Thermal Conductivity (W/m°C) Vs Solar Fraction

III. RESULTS AND DISCUSSION

Solar Air Heater System

A conventional solar air heater generally consists of an absorber plate with a parallel plate below forming a small passage through which the air to be heated flows. As in the case of the liquid flat plate collector, a transparent cover system is provided above the absorber plate, while a sheet metal container filled with insulation is provided on the bottom and sides. In different arrangement of the solar air heater they are, the air to be heated flows between the cover and the absorber plate itself instead of through a separate passage and the air flows between the cover and the absorber plate, as well as through the passage below the absorber plate. Like a liquid flat plate collector, a solar air heater is simple in design and requires little maintenance. In addition, since the fluid does not freeze the solar air heater has the advantages of not requiring any special attention at temperatures below 0°C. Corrosion and leakage problems are also less severe. A further disadvantages associated with the use of a solar air heater is that large volumes of fluid have to be handled. As a result, the electrical power required to blow the air through a system can be significant if the pressure drop is not kept within prescribed limits.

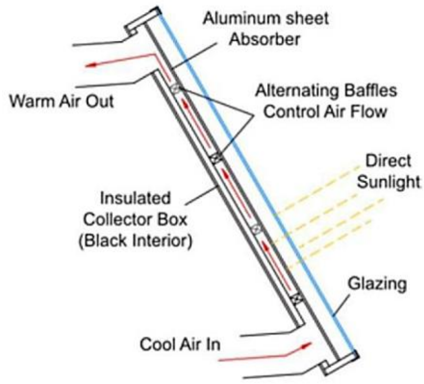


Figure 5 : Solar Air Heater

Different Profile Shape

SAH, the cross sectional area of the absorber plate has been taken constant. However, the collector receives energy from the sun that is absorbed by the plate and is then transferred to the fluid. For energy is transferred to increase in the direction of flow of energy in a plate. It is fact that for effective design, the profile shape of the absorber plate should be divergent in nature in the direction of heat transfer. Among different profile shapes is more efficient for transfer of energy. On the other hand, fabrication of such profile is needs some manufacturing technique and is bound to very expensive.

Figure 6 show the comparison of the experimental values of v-shaped and w-shaped and by correlation for Reynolds number and friction factor. The absolute percentage deviation between the v-shaped and w-shaped experimental results has been found to be less than 2% respectively for Reynolds number and friction factor. This comparison and resultant excellent agreement between the experimental values of v-shaped and w-shaped.

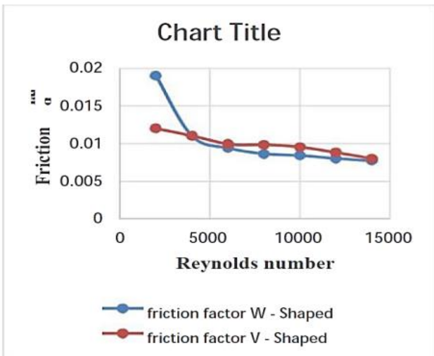


Figure 6 : Reynolds Number Vs Friction Factor

Figure7 has been drawn to show the enhancement in the heat transfer achieved by using v-shaped profile.

The comparison of experimental values of Nusselt number as a function of Reynolds number has been drawn for v-shaped 60^0 ribs. inclined 60^0 ribs and that for smooth absorber plate. It is Seen that the V-shape enhance the values of nusselt number by 1.15 and 2.30 over inclined ribs and smooth plate case at Reynolds number of 14000, while the corresponding percentages of enhancement for Reynolds number of 14000 are 10% and 45%.

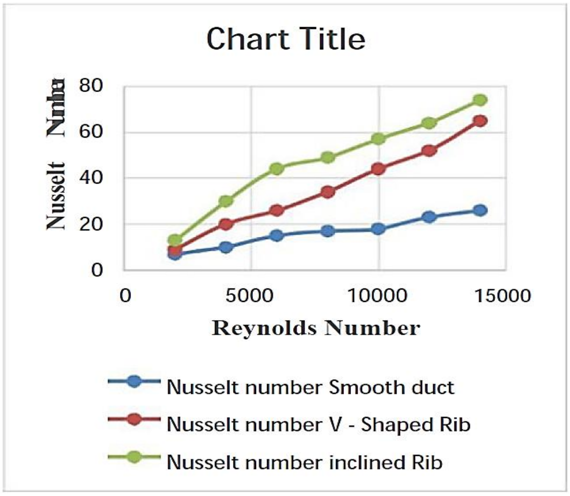


Figure 7 : Reynolds Number Vs Nusselt Number

From the figure 8 it can also be seen that the efficiency of a rectangular profile is higher than that of the trapezoidal ones but the efficiency is higher compared other profile. There to increase the plate parameter Zo namely decrease of thermal conductivity of the absorber plate, increase of plate length and decrease of plate thickness at the root of increase the overall plate loss coefficient.

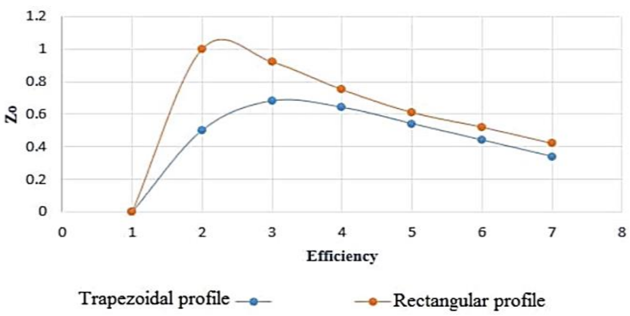


Figure 8 : Efficiency Vs Zo

IV. CONCLUSION

The annual solar fraction of the system increase only by 4% to 7% when a steel absorber plate is replaced by an aluminium plate, whereas the collectors characteristic factor increases by 12% to 19% and increase by about 3%. Results that there is almost no advantage by using copper plate, in aluminium is less expensive and other factor such as corrosion problem or health hazards could affect the choice of the material for the absorber plate.

The comparison of experimental values of friction factor and Reynolds number by the correlation shows the 20 data points lie within the deviation of ±10% for V and W shaped profile.

The rectangular profile absorber plate transfers more amount of energy than other profiles with different plate volume and trapezoidal also better choice for transferring energy of a solar collector but difficulties for manufacturing.

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