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Experimental Studies on Aero Profile Thermosyphon Solar Water Heating System

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Abstract

Solar water heating system proves to be an effective technology for converting solar energy into thermal energy. The convective heat loss by wind which would reduces the glass surface temperature. Hence introducing aero profile wings on the flat plate collector which would increases the glass surface temperature and enhances the thermal efficiency about 19.47% than the conventional collector.

Keywords: Flat plate collector, Glass temperature, Aero profile wings, Thermal efficiency.

1. INTRODUCTION

Flat plate collector is the central unit of solar water heating system. Three major losses occurring in flat plate collectors such as conduction, convection and radiation. Proper insulation and selective absorber coating will reduce the conduction and radiation losses respectively. Techniques to reduce the convective losses are limited. Kalogirou et al [1] presents a survey of the various types of solar thermal collectors and applications. All the solar systems which utilize the solar energy and its application depends upon the solar collector such as flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish and heliostat field collectors. Chong et al [2] discussed optical analysis, experimental study and cost analysis of the stationary V-trough solar water heater system are presented. The novel stationary V-trough solar water heater with the maximum solar concentration ratio of 1.8 suns has been proposed to improve the thermal efficiency of the whole system.

The collected data has shown that the prototype has achieved the optical efficiency of 70.54% or 1.41 suns and the temperature of 85.9 0C. Sivakumar et al [3] addressed to improve the performance of a flat plate solar energy collector by changing the design parameters of the number of riser tubes and the arrangement of riser tubes in zig-zag pattern from the existing flat plat collector system. The performance shows that the efficiency is 59.09% when increasing the number of riser tubes and its 62.90% in the zig-zag arrangement Herero et al.[4] describe the enhancement techniques for flat-plate liquid solar collectors. Tube-side enhancement passive techniques can consist of adding additional devices which are incorporated into a smooth round tube such as twisted tapes, wire coils. An evacuated solar water heater is introduced by Omara et al. [5] with the desalination stills to evaluate the continuity production of distillate. The increased water productivity as 114% over conventional still. Extensive research work available in solar water heater. But the experimentation on convective heat losses is limited. Hence this study mainly focuses to improve the thermal efficiency by using aero profile wings.

2. EXPERIMENTAL SET UP AND EXPERIMENTATION

The experimental setup consists of a flat plate collector of 1 m^2 aperture area connected to a well insulated storage tank of 100 liters capacity and named as plain tube collector as shown in Fig.1. The cold water from the storage tank enters the collector from the lower header and is evenly distributed in the nine parallel riser tubes. The riser tubes are brazed to the bottom of a black absorber plate and the absorbed solar energy is conducted to the riser tubes. The heat is transferred by convection from the riser tube wall to the fluid. Finally the hot water is collected from the upper header and stored in the insulated storage tank. The temperature difference in storage tank accelerates the driving force and the cycle is repeated until the temperature difference between the inlet and outlet water is zero. A digital flow meter connected between the collector outlet and the storage tank measures the flow rate. A single transparent glass cover of 3 mm thickness transmits the solar energy to the absorber plate. T-type thermocouples used to measure the absorber plate, riser tube and glass surface temperature. The pressure difference measured by differential pressure transmitter. The global solar radiation is measured by Kipp and Zonen pyranometer. Aero profile wings are made up of galvanised iron- sheet metal of thickness 0.5 mm. The breadth of the wings is 6 inch. The wings are bended in curved shape and fitted in the sides of the water heater. The angle between collector surface and aero profile wings are 30 degree. The aero profile solar water heater is shown in Fig.1. Both conventional and Aeroprofile collectors are kept in open atmosphere and readings are recorded continuously.

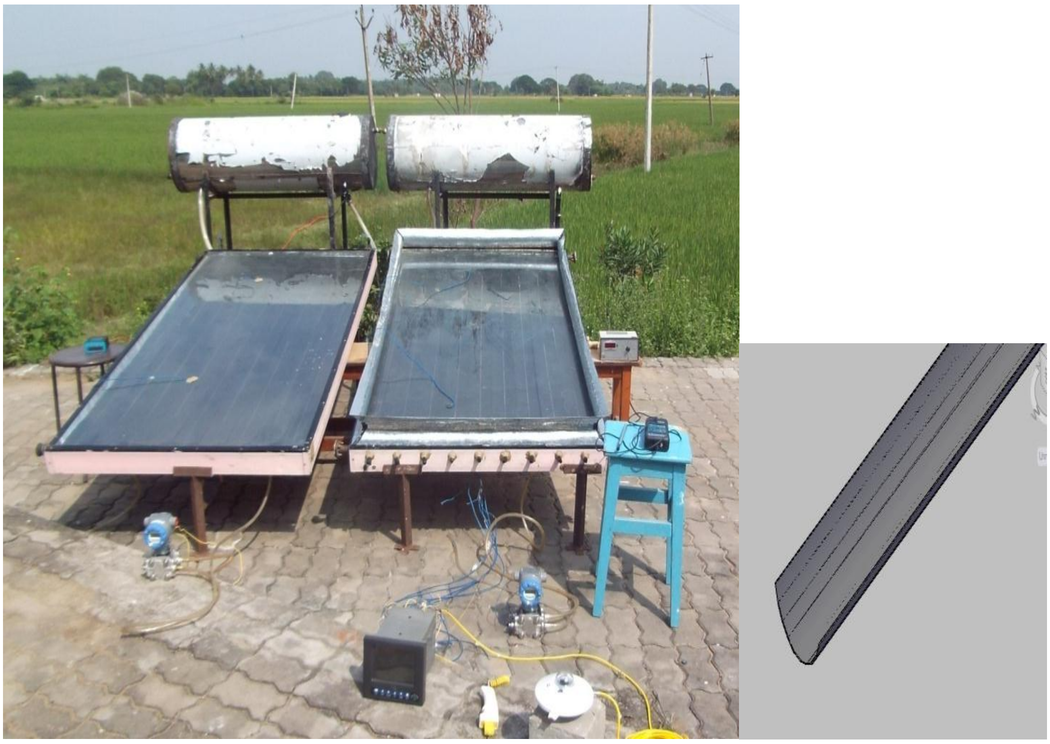

Fig.1 Experimental setup for conventional and Aero profile water heater

3. RESULT AND DISCUSSION

The experimental results for conventional SWH and AFSWH are obtained and discussed as follows:

3.1 Mass flow rate and heat Enhancement

Fig.2 shows the mass flow rate comparison between aero profile and conventional solar water heater. Mass flow rate increases in phase1 and decreases in phase2 due to solar intensity. Compared the above for specified solar intensity the mass flow rate for areo profile is 0.0174m/s and conventional is 0.0163.The mass flow rate increases nearly 6.32% higher in aero profile collector, because the convective loss can be minimized and glass surface temperature can be retained by aero profile. The Reynolds number versus Nusselt number shown in Fig3. The average Nusselt number for Aero profile collector and conventional collector are 4.67 and 4.02. It is clear from the above heat enhancement has been obtained by aeroprofile is nearly 13.9% higher than conventional one.

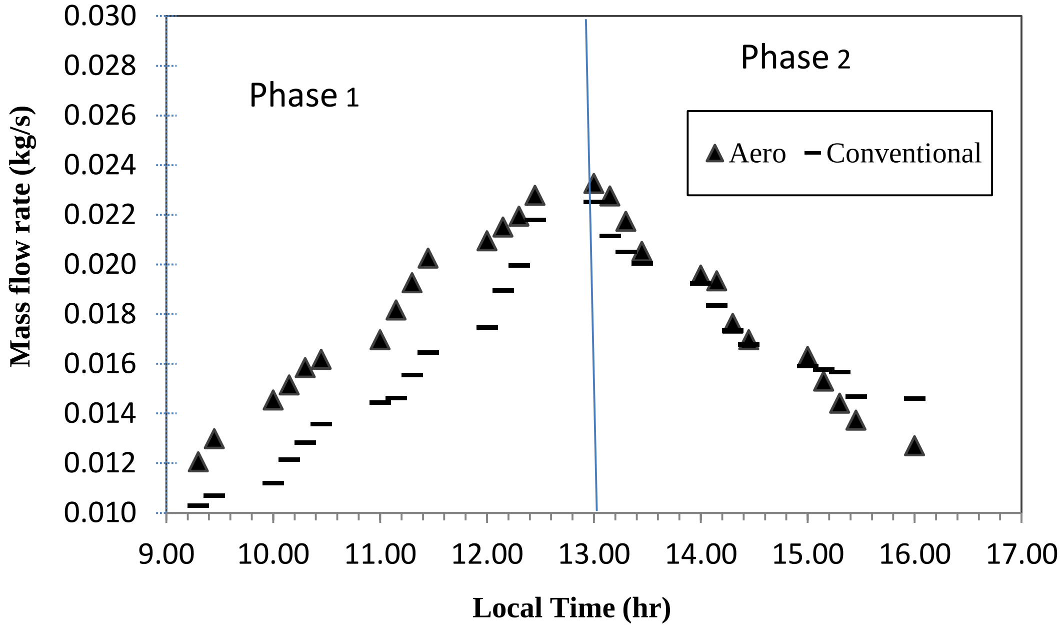

Fig.2 Mass flow rate comparison

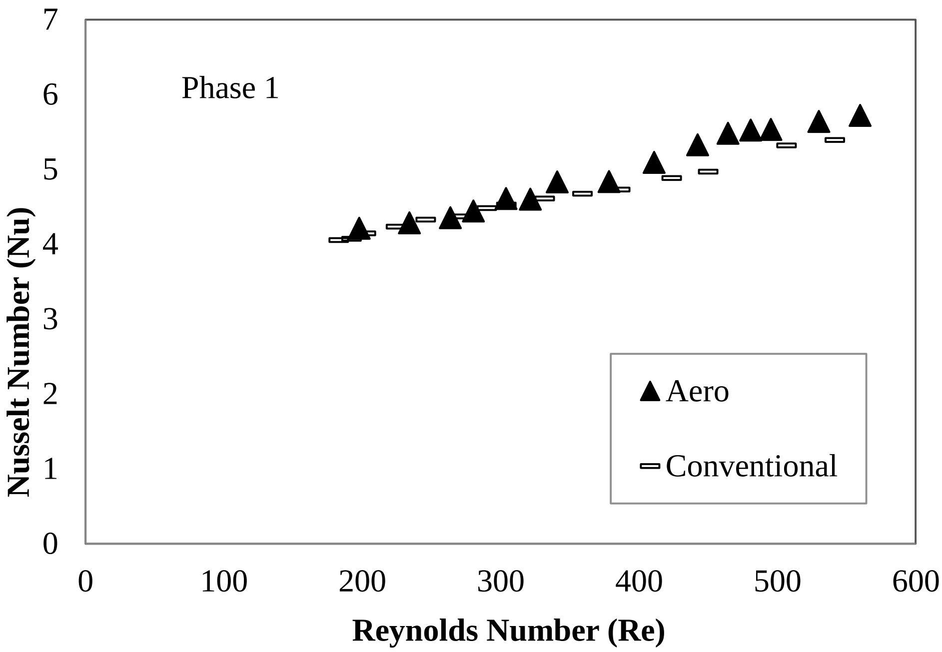

Fig.3. Variation of Reynolds number with Nusselt number

Fig.4 depicts the Glass surface temperature and absorber plate temperatures versus solar radiation. For higher solar intensity at 1100 w/m2 the glass surface temperature of aeroprofile and conventional are 52 and 45o C. It is clear from the evident the glass surface temperature is around 13.4% higher in aero profile rather than conventional one.

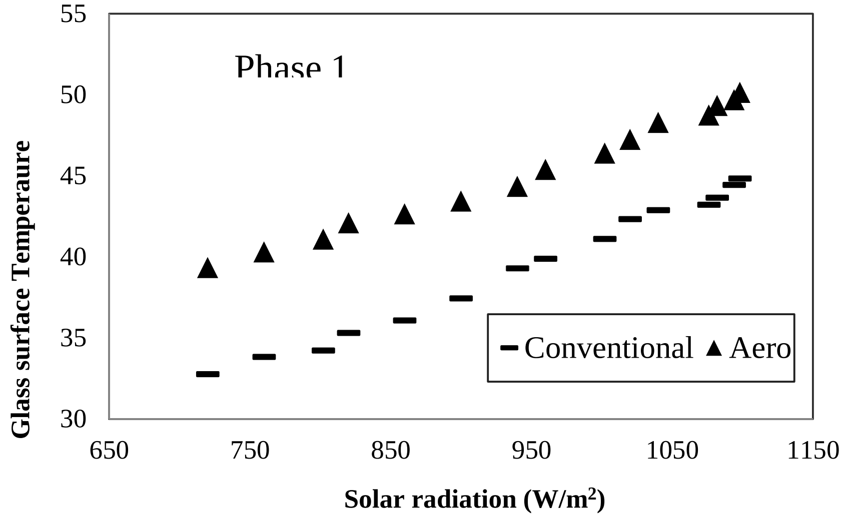

Fig.4. Relationship between Glass surface temperatures with solar radiation

3.2. Thermal Performance

From the Fig.5 the thermal efficiency increasing when increase of Intensity of radiation and decreasing with decrease of intensity. For known solar radiation the average thermal efficiency of aero profile is 56.63% and conventional is 43.18%. From this comparison it is clear from that, the aero profile curvature has obtained 19.47% higher thermal efficiency than conventional one.

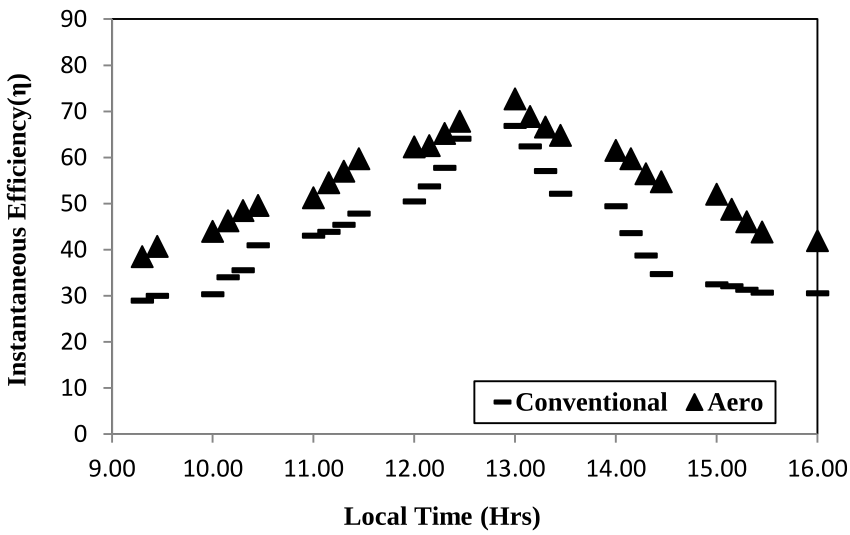

Fig.5. Relationship between local time with efficiency

CONCLUSION

Compared to conventional water heater, aeroprofile water heater has 6.32% , 13.9% and 19.4% higher mass flow rate, heat transfer and thermal performance respectively.

ACKNOWLEDGEMENT

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