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Research Article

CYLINDRICAL FINS WITH FLAT PLATE COLLECTOR IN A SOLAR AIR HEATER

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ABSTRACT

The main objective of this work is to increase the efficiency of solar air heater (SAH). The efficiency of SAH is increased with increasing the rate of heat transfer. The rate of heat transfer can be increased by increasing the surface area by cylindrical fins. The cylindrical fins are arranged tangent to the absorber plate. The flat plate solar air heater with and without cylindrical fins on the absorber plate is constructed and tested for five different mass flow rates of air. From the experimental results, optimum mass flow rate is found for maximum collector efficiency.

INTRODUCTION

Environmental pollution and human health threatening diseases are composedof the consumption of fossil based energy sources. In parallel with the increase in human population, energy requirements, the development of economic and technological, industrialization and energy demand have increased worldwide. Therefore, researchers have focused on renewable energy sources. (Abhishek Saxena, *et al*., 2015) experimented solar heaters are used for applications at low and moderate temperatures like as, crop drying and space heating. In the recent work efforts are made to improve the rate of heat transfer and to advance the efficiency of flat plate collector on both natural and forced convection. (Deniz Alta, *et al*., 2010) presented the three types of collectors, two collectors having fins and the one without fins, one of the collectors with a fin had one glass cover and the others had two glass covers. (Fatih Bayraka, *et al*., 2013) investigated the porous baffles inserted in SAHs using exergy and energy analysis methods. The different thickness of baffles is used as passive element inside heaters. They are located sequentially and staggered manner on to the air heater. (Muneesh Sethi, *et al*., 2012) analyzed the influence of artificial roughness on heat transfer rate and friction features in SAH duct which is having dimple shaped elements prepared in angular fashion as roughness components on absorber plate. (Huseyin Benli, *et al*., 2012) proposed the exergy investigation of different types of solar collectors; corrugated and reverse trapeze, reverse corrugated and a base flat plate collector are experimented.

(Anil Singh Yadav and Bhagoria, 2013) designed the CFD based on five different turbulence models of the obtained results are tested. It performs from the calculations that the renormalization set k–e model produces the good results for 2D flow through conventional SAHs. (Mohammadi and Sabzpooshani, 2013) investigated the impact of baffles and fins fixed over the absorber plate on the upward single pass air heater. It is found that assigning baffles and fins well increases the temperature of outlet and efficiency in comparison to a simple predictable device. (Pin Yang Wang, *et al*., 2014) simulated a novel type all glass evacuated tubular heater with simplified CPC. The system is made up of 10 linked assembling panels and each panel contains a simplified CPC and an all glass evacuated tube with a U-shaped copper tube heat exchanger fitted inside. Air is steadily heated when transient through each U-shaped copper tube. (Ming Yang, *et al*., 2014) analyzed an offset strip fins in SAH was optimized by mathematical modeling. The number of sequence of experimentations

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created on ASHRAE Standard 93-2003 was directed to assessment the performance of the heater in the time constant, efficiency, incident angle modification device and the coefficient of synthetically resistance. The work would be valuable for developing energy effective one and cost effective solar air heaters. (Ammari, 2003) proposed a SAH that has slats connecting the absorbing plate to the bottom plate as a progress to improve the collector performance. (Hussain H. Al Kayiem and Tadahmun, 2015) predicted the coefficient of free convective heat transfer between the apparent area and the flowing air. The optimal inclination angle to attain the better performance was found to be 50°. The experiment results of the present work can assist in resolving the problem of expecting the free convection in thermal passages. (Sukhmeet Singh, *et al*., 2015) presented the thermo hydraulic performance evaluation of rib roughness under experimentation, V-down ribs with gap and similar reported roughness geometries used in solar air heater duct. This work presents the air heater efficiency improved in terms optimization of mass flow rate. The flat plate solar air heater with cylindrical fins is fabricated and tested the efficiency of collector with and without fins is compared.

DESIGN AND SPECIFICATIONS

Collector thermal efficiency

The efficiency (η) of flat plate collector is defined as the ratio of the useful energy (Q_u) to the incident solar radiation over a particular time differences:

$$\eta = \frac{\int Qu\,dt}{A\int I\,dt} \qquad (1)$$

The thermal efficiency of the collector is:

$$\eta = \frac{Qu}{I.Ac} = \frac{mc_p(T_{out} - T_{in})}{I.Ac} \qquad (2)$$

Where,

C_p – Specific heat capacity at constant pressure J/kg K

m– Mass flow rate kg/s

T_{out} – Outlet temperature of air °C

T_{in} - Outlet temperature of air °C

The equation for flow rate is:

m = ρ × A × C

Where ρ is the density of fluid, which depends on the air temperature and A is the area of the pipe, C is the velocity of air.

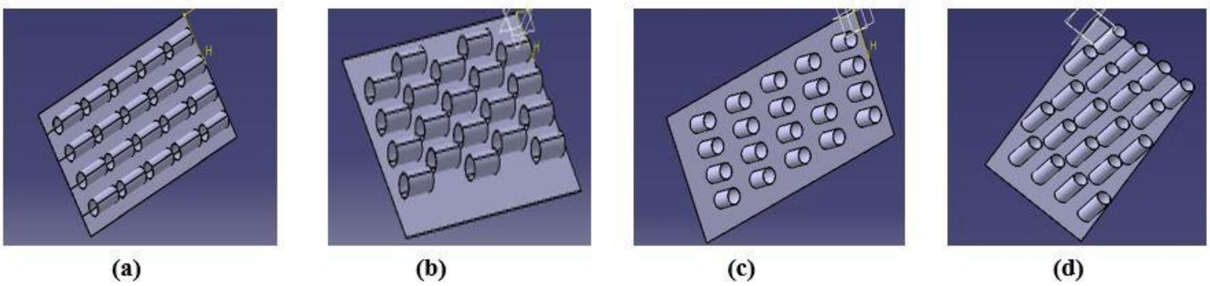
Optimum orientation of fins

Fig. 1 represents the different orientation of cylindrical fins on absorber plate. These are Cylindrical fins with linear arrangement (Parallel to plate), Cylindrical fins with staggered arrangement (Parallel to plate), Cylindrical fins with linear arrangement (perpendicular to plate), Cylindrical fins with staggered arrangement (perpendicular to plate). Cylindrical fins with staggered arrangement (Parallel to plate) orientation are decided for optimum condition.

EXPERIMENTAL ANALYSIS

Experimental setup

The The experimental setup consists of transparent cover, absorber plate, blower, solar collector support, wooden duct as shown in (Fig. 2 and 3). The atmospheric air freely enters in to the duct through inlet. The inlet air is connected with blower to suck the air from the atmosphere and sucked air absorbs the heat from absorber plate. The other end is free to atmosphere. The schematic diagram of flat plate solar air heater as shown in Fig. 2. The various components of solar air heater are absorber plate, transparent glass cover, insulation, wooden duct, blower and tubes. The absorber plate is usually metallic or with a black surface, although a wide variety of other materials can be used with air heaters. The glass cover is employed in the system, to cover the top surface of the air heater and eliminating the heat loss in the upper part of the system. Insulation, which should be provided at the back sides to minimize the heat losses. Standard insulating materials such as fiber glass or styro foam are used for this purpose. The casing or container which encloses the other



(a) (b) (c) (d)

Fig. 1 Different orientation of cylindrical fins.

components and protects them from the weather. Blower is a mechanical device, such as a fan, that produces a current of air. Air flow tubes are used to transfers fluid from blower to wooden duct. Detailed specifications of the flat plate solar collector are tabulated in Table 1.

RESULTS AND DISCUSSION

Impurity the results of the experiments on collector performance of the solar air heater with cylindrical

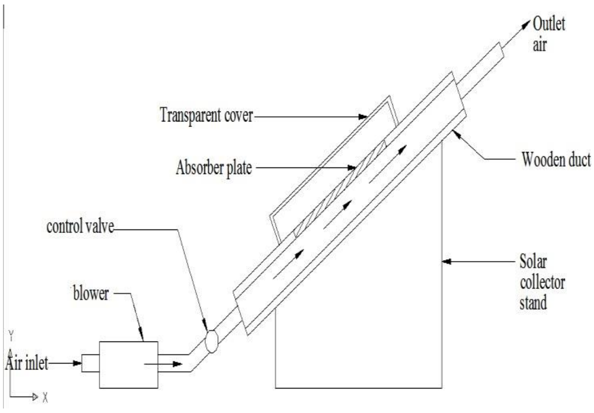


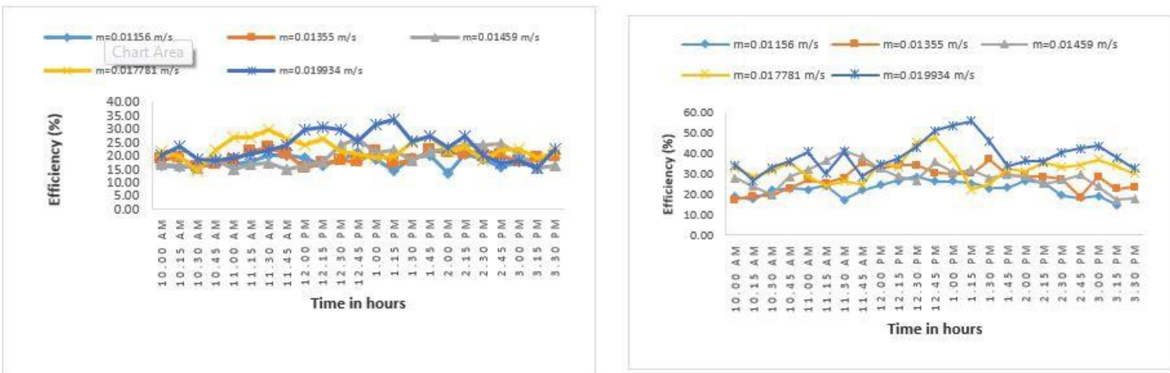
Fig. 2 Schematic view of the solar air heater.

Fig. 3 Photocopical view of experimental setup.

fins and compared to that of flat plate have been presented in this work. The absorber plates with fins have been created to increase; heat exchange surface, outlet temperature and thermal efficiency. The increases of the mass flow rate affect the temperature of the absorber plate. The efficiency of the flat plate with fins higher than that of type without fins. The maximum efficiency of the flat plate with cylindrical fins for the flow rate of 0.01156 kg/s and 0.019934 kg/s are 28.57%, 55.85% as shown in Fig. 4. Due to variation of solar intensity, the collector efficiency is changed depends upon the time of the day. Solar intensity generally increases up to 1.00pm after that it decreases as shown in Fig. 4. Because of that time having high solar radiation. Efficiency is plotted for two different modes of absorber plate with and without cylindrical fins. Efficiency of flat plate collector with and without fins for three different mass flow rates as shown in Fig 4. The effect of mass

Table 1. Detailed specifications of the flat plate solar collector are tabulated.

Absorber material	**Aluminium**
Plate thickness (t)	1 mm
Dimension of plate (L × w)	1200 mm × 500 mm
Absorber coating	Dull black paint
Glazing	Normal window glass
Thickness of glazing (t_g)	4 mm
Number of glazing	1
Insulation material	Ply wood
Back/side insulation thickness (t_i)	30 mm/15 mm
Fins material	Aluminum
Number of fins	20
Dimension of each fins	Length=100 mm, Diameter D=50 mm, d=48 mm.
Type of convection	Forced convection
Velocity of air (U)	14– 25 m/s



(a) without fins (b) with fins

Fig. 4 Time of the day versus performance comparison of flat plate collectors without and with fins for five different mass flow rates.

flow rate in thermal efficiency is important one. Efficiency increases with respect to increase in the mass flow rate. (Fig. 4a and 4b) shows performance comparison of flat plate collectors with and without fins for five different mass flow rates (Sachdeva, 2015).

CONCLUSION

The flat plate solar air heater with and without cylindrical fins on the absorber plate is constructed and tested for five different mass flow rates of air. The following conclusions are drawn. The thermal efficiency is higher for the flat plate solar air heater with cylindrical fins on the absorber plate than that of without fins for the highest mass flow rate of air. In addition, the temperature difference between the outlet and inlet temperature decreases with increasing air flow rate in the range between 0.01156 kg/s and 0.019934 kg/s. Finally, the results show that there is an improvement with the use of cylindrical fins in the absorber plate.

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