PERFORMANCE ANALYSIS OF A FLAT PLATE AIR HEATER WITH COMPOSITE ABSORBER MATERIAL

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Abstract : An investigation was carried out on solar air heaters (SAHs) of different absorber materials. The experiments were conducted to establish the performance of both modified type with composite absorber (black painted GI absorber placed below the toughened glass) and conventional type (black painted GI absorber plate) for flows of air on either sides of schemes.

In the modified type, mass flow rate of 0.0169 kg/s, has resulted in increased efficiency for top side, bottom side and both side flow. Compared to top side and bottom side flow, the efficiency was more in both side flow due to increase in the rate of heat transfer. The composite absorber in the modified type, higher solar radiation absorption has provided a larger amount of heat transfer to air.

***Index Terms* - Solar air heater, Galvanised Iron plate, Absorbers, Toughened glass, Composite absorber, Outlet air temperature, Efficiency**

I. INTRODUCTION

Solar energy is one of the most significant sources of renewable energy. The radiation rate of solar energy at various areas around the world is variable and the solar girdle of the earth contains the highest amount of solar energy. Heating air with solar energy is much cleaner than heating with fossil fuel.

Solar air heater is a unique type of heat interchange that absorbs and converts solar radiant energy to heat. The delivered heat from the solar air heater can be used for drying agricultural products such as crop, grain, seeds, fruits and vegetables, and also for timber seasoning and paint spraying operations.

In solar air heater, air is heated by solar radiation which is absorbed by the absorber plate. Air is flown over the absorber plate and heat is transferred from absorber to the air. A blower is used to suck the air from the exit of the air heater.

In the present work, an attempt has been made to perform energy analysis of solar air heater at 0.0169 kg/s mass flow rate of air, and the passing of air for top side, bottom side and both side flow of the middle toughened glass in the composite absorber SAH.

II. LITERATURE SURVEY

Sorour *et.al*., [1] carried out an experimental investigation on the performance of flat-plate with a long straight channel and a group of short subsequent channels type solar air heaters, with different inter-plate spacing and additionally compared with the behaviours of three different flow arrangements. Shorter channels have higher efficiencies than long channels. Maheshwari *et al*., [2] presented an experimental performance of solar air heater having perforated baffles on the air flow side of the absorber plate. The heat transfer enhancement due to the perforated baffles on the absorber plate was higher than that of the smooth duct solar air heater. Shadi Ayyad *et al*., [3] compared three single-passage solar air heaters (SAHs) with different modifications. The maximum efficiency at higher mass flow rates, was obtained in the SAH having finned absorber plate, than in the SAH with square aluminium tubes. Bhupendra *et al*., [4] investigated experimentally the effect of porous media (glass wool and steel wool) on double pass solar air heater. The thermal efficiency of the double pass solar air heater with porous media was more efficient than that of the single pass solar air heater with porous media. Umang *et al*., [5] worked on the performance of conventional solar heater which was modified by using double pass solar air heater with the aluminium can, placed in series and zigzag position in double pass solar air heater higher outlet temperature when compared to other types in the same mass flow rate. Vikas kumar *et al*., [6] carried out an **e**xperimental study to compare three solar air heaters with different absorber area. The single flow solar air heater having aluminium fins improved the maximum thermal efficiency of 46.02% at the air flow rate of 4.20 m/s. Abhishek Priyam *et al*., [7] investigated analytically the effect of mass flow rate and the number of fins on the absorber solar air heater. The wavy finned absorber solar air heater gave higher values of thermal efficiency and effective temperature rise in flat plate collector operating under similar conditions.

Aravindh *et al*., [8] have done a complete review on efficiency enhancement in solar air heaters. Optimized levels of modifications were to be developed and implemented on absorber plate, for better performance of the solar air heater. Rakesh Chaudhary *et al*., [9] experimentally studied the method for substantially improving the collector efficiency by increasing the fluid velocity and enhancing the heat-transfer coefficient between the absorber plate and air. The efficiency of the double pass was found to be higher than that of the single pass. Jay K Patel *et al*., [10] presented the experimental investigation of Double Pass Solar Air heater (DPSA) without obstacles on absorber plate, with the aluminium spring in perpendicular to direction of the air inlet and the aluminium spring in zigzag direction to the packed bed. DPSA with aluminium spring in zig zag was more efficient than those of the other two types. Madhav *et al*., [11] experimented an investigation of thermal performance of solar air heater, with 'W' shaped copper wire mesh placed on the copper absorber plate. The 'W' shaped copper wire mesh is far better than the flat plate air collectors of conventional design. Ammar A Farhan [12]. investigated theoretically and experimentally the single glass parallel flow double pass solar air hear with V-corrugated absorber plate, and single pass solar air heater and double glass parallel flow for the same mass flow rate of air, the outlet air temperature of the double pass solar air heater is greater than the single pass solar air heater. Rudra Nandan Pramanik *et al*., [13] analysed experimentally the performance of double pass solar air heater with bottom extended surface. The Collector efficiency improved in reverse flow double-pass solar air heaters with extended surface at the bottom. Raheleh Nowzari *et al*., [14] experimentally studied on a solar air heater, the thermal performances of single-flow and counter-flow on a solar air heater with a normal cover and with quarter- and half-perforated covers. The efficiency of the air heater with the quarter-perforated cover was slightly higher than that of the one with the half-perforated cover for both single and counter-flow collectors.

From the above review of literature it has been found that no experimental or simulation analysis of composite absorber material solar air heater has been reported.

III. EXPERIMENTAL SET-UP

The modified solar air heater was designed, fabricated and constructed with a dimension of 2 m x 1 m x 0.15 m having double toughened glass cover. In modified type, composite absorber plate was used and tested by placing it to face due south to receive maximum solar intensity.

The schematic diagrams of the Air flow of solar air heater for this study are shown Fig. 1. The frame of modified solar air heater was made of galvanised iron. It has top toughened glass cover plate and middle toughened glass, GI composite absorber and glass wool insulation material. The glass wool insulation material which was used on bottom and all sides, helped to control the heat loss. The air passages were provided with shutters to open and close the passage of air. The modified type was made of black coated GI absorber plate of 20 gauge placed below the strong glass.

IV. EXPERIMENTAL PROCEDURE

Experiments were performed on solar air heaters modified type with composite absorber plate. First, it was ensured that there was no leakage at all the links, joints and fittings and all the instruments were in good working conditions before the experiments were conducted.

Experimental tests were conducted during day time on two different types of SAHs i.e. Conventional and Modified (with composite absorber). The solar air heaters were facing South direction to receive more solar radiation which was measured using Pyranometer. T-type copper constantan thermocouples were used to measure temperature. Top and bottom of the absorber temperatures, ambient air temperature, inlet and outlet air temperatures were measured for every 30 minute intervals. Anemometer was used to measure the air velocity.

Tests were conducted for different air flow paths at a flow rate of 0.0169 kg/s. Useful heat output and efficiencies of both the SAHs were then obtained from the observed data

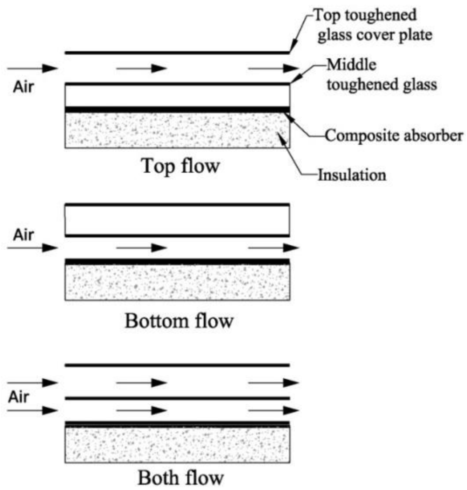

Fig. 1: Air flow diagram of solar air heater

Fig. 1 shows the air flows above the composite absorber and middle toughened glass is top side flow, the air flows above the composite absorber and below the middle toughened glass is bottom side flow, the air flows above the middle toughened glass and above the composite absorber both side flow.

Fig.2 shows the photographic view of the experimental setup of the two identical solar air heaters with absorber material in different positions.

Fig. 2 Photographic view of experimental setup.

V. RESULTS AND DISCUSSION

The performance analysis of flat plate solar air heater with two types of absorber plate materials was done experimentally in solar energy Laboratory, Department of Mechanical Engineering, Annamalai University, Annamalai nagar, Tamil Nadu, India(N Latitude - 11° and E Longitude - 79°)

The global solar radiation intensity and efficiencies of conventional and modified types of SAHs, during the experimental period are shown in Fig 3.

Graphs were plotted between time and efficiency with solar intensity. Inlet, outlet temperature and absorber plate's temperatures are as shown in Figs. 3 to 5. The variation of flow efficiencies of modified absorber was due to the passing of air flow at mass flow rate of air 0.0169 kg/s. The test was conducted between 9.30 am and 4.00 pm solar time.

Fig 3 shows that, when the mass flow rate of air 0.0169 kg/s and passing of air flow for top side, bottom side and both side flow, more heat transfer has occurred and due to that the efficiency is also increased. The efficiency of top side flow, bottom side flow and both side flow are 34%, 46% and 48% respectively. When compared to the top side and bottom side flow, the maximum efficiency at 1 p.m in both side flow occurred due to increase in the solar intensity. The solar intensity is also shown in the secondary axis. At 1 p.m the maximum solar intensity is 829.876 W/m^2

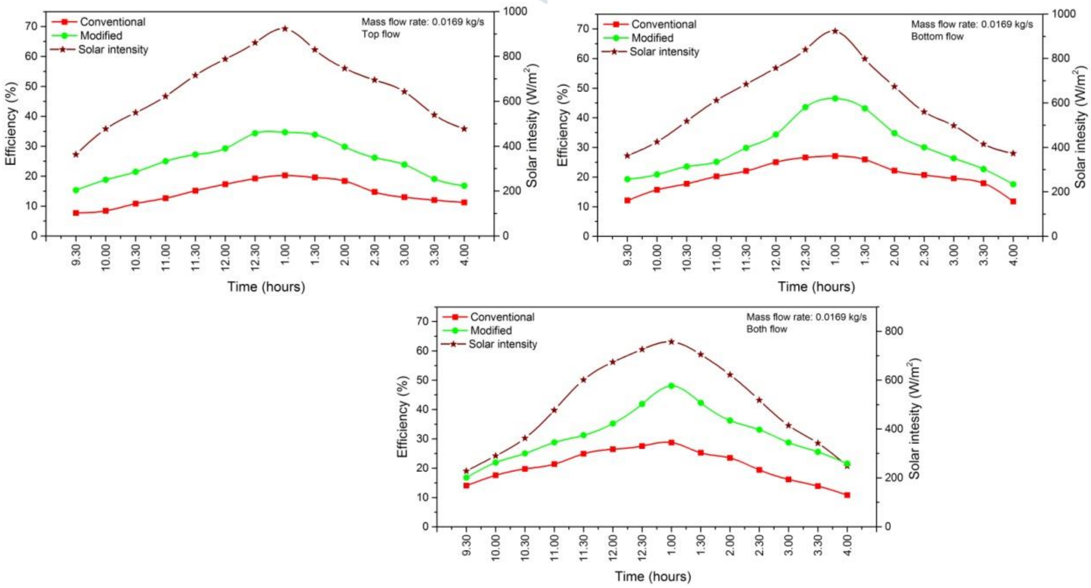

Fig. 3 Variation of thermal efficiency for different flow.

Fig 4 shows that at the mass flow rate of 0.0169 kg/s, the outlet air temperature is increased in both side flow compared to top side and bottom side flow. This is due to more heat transfer on the air. The highest outlet temperature is 86°C. In both side flow when compared to top side and bottom side flow and this is because to the air flow strikes top side and bottom side of the middle glass and composite absorber.

It is found that the outlet temperature in both side flow is higher than top side and bottom side flow for the same air flow rate when the solar intensity increases.

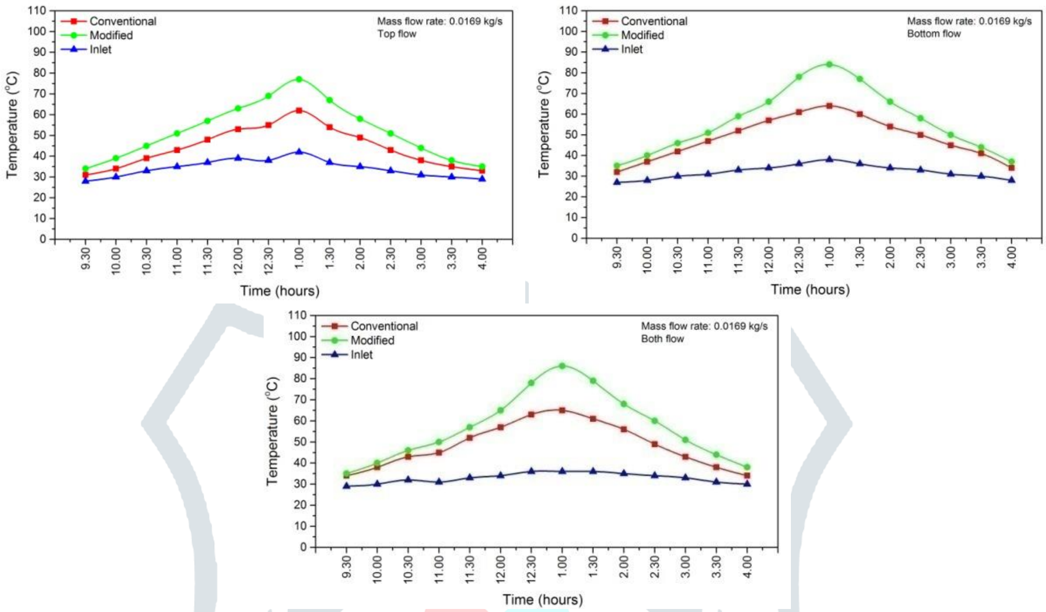

Fig. 4 Variation of different temperatures for different flow.

Fig. 5 shows the absorber plate temperature for the mass flow rate 0.0169 kg/s of air and passing of air in top side, bottom side and both side flow. For both side flow absorber plate temperature is maximum at the same air flow rate when compare to top side and bottom side air flow.

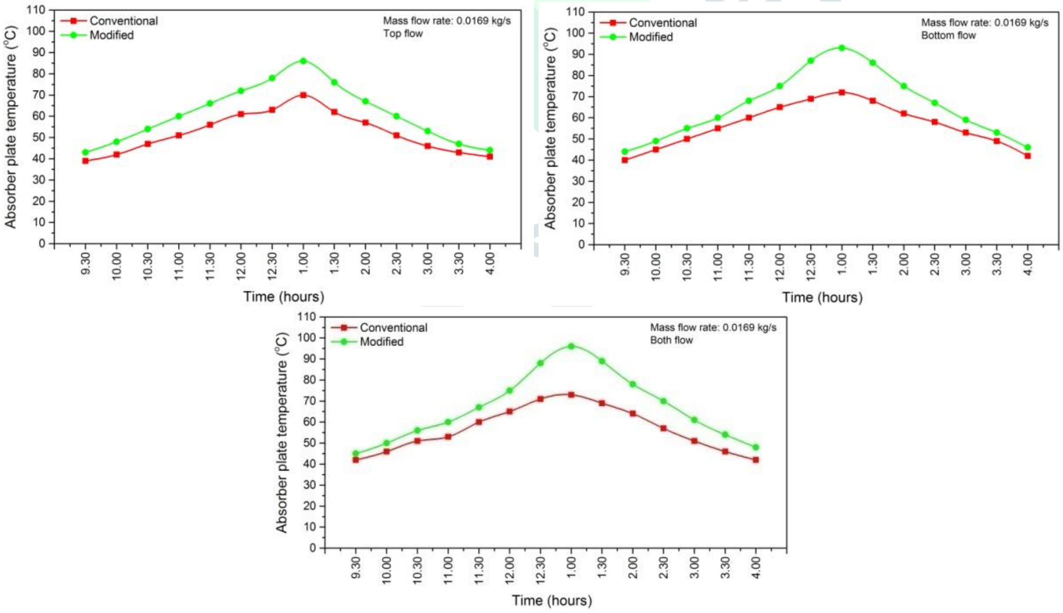

Fig. 5 Variation of Absorber plate temperatures for different flow.

VI. Conclusion

The following conclusions were arrived based on the analysis and experimental results. The performance of flat plate solar air heaters, depended upon the selection of absorber materials. More radiation and maximum output temperature of air were obtained for modified SAH type.

The efficiency, outlet temperature and absorber plate's temperatures were higher in both side flow, compared to top side and bottom side flow. The maximum thermal efficiency for both side flow is 48% in the modified composite absorber SAH at the air flow rate of 0.0169 kg/sec. The composite absorber in the modified type, absorbed higher solar radiation and provided a larger amount of heat transfer to air. It was concluded that the modified SAH had higher thermal efficiency compared to the conventional type.

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