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Performance Analysis of Double Pass Solar Air Heater with Bottom Extended Surface

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Abstract

A model of solar air heater with selective absorber coating with longitudinal fins at the bottom of absorber has been prepared to produce hot gases by consuming solar energy in day time. It is kept in position in such a way that air will flow due to forced convection and the entire setup placed at an angle of 15° to 17° inclination as per the considered global position (20.2961° N, 85.8245° E). Air flow rate is increased by applying a DC suction fan at outlet which sucks the air to flow over extended surfaces which are present at bottom inlet channel. Special selective coating applied over the entire Aluminum absorber plate to increase the heat absorbing capacity. Average ambient, inlet and plate temperatures are recorded daily along with solar flux. It is found that the instantaneous efficiency and air outlet temperature increased up to 69% and 94°C respectively. Theoretical analysis has been made as well for the present set up. The difference between the theoretical and experimental values lies within 1.23-9.75%.

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Keywords: Heat-transfer efficiency; Recycling double-pass; Instantaneous Efficiency; Solar air heater.

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1. **Introduction**

Solar air heaters (SAH) have vast applications both in industrial and agricultural sectors. So, huge research is going on to enhance the performance of solar air heaters by putting number of effort in various enhancement techniques like increasing the heat transfer rate, proper tracking geometry and better heat absorbing medium of high Absorptivity and putting various thermal energy storage mediums. Dong Ho et al.[1] studied wire mesh packed solar air heaters where due to high turbulence intensity and enlarged heat transfer area, the heat transfer efficiency is enhanced. The technical feasibility of the recycle-effect on heat transfer rate of air through extended surface up to small height has been confirmed by different researchers worldwide [2,3]. Application of the concept of double-pass in the design of a double-pass solar air heater with fins attached has been mentioned along with technical and economical feasibility which provides better performance [4]. Its proven that, by using pack bed SAH with various thermal storage devices can increase the performance from 45% to 53% [5,6]. Nowzari et al. [7] involved in optimization and experimentation of SAH where they found that double pass solar air heater with quarter perforated cover with 3cm hole to hole distance with 0.032kg/s mass flow provide best result in its class. Computational Fluid Dynamics (CFD) based approach has been implemented extensively in design and performance analysis of various solar air heaters [8,9].

From literatures, we found that most of researchers analyzed the performance of SAH having air entry at top channel and released at the bottom. Present approach is an exercise to obtain the performances of different kind of SAH with reversed air flow. In this present setup, air initially flows between heated fins in the lower channel generating rise in turbulence which helps in absorbing heat capacity. During the flow of air in top channel carrying hot air, further heat transfer occurs to the incoming air from absorber plate of top channel. The purposes of present experimental approach is to check the overall output performances over existing ones as the flow direction is just reversed in comparison with the conventional. Comparison with respect to (a) Instantaneous efficiency Vs Useful heat gain (b) Collector efficiency factor Vs Collector heat removal factor and (c) Theoretical outlet temperature Vs Actual measured value are found out and mentioned.

Nomenclature

$(\tau\alpha)_{av}$ Average Transmissivity and Absorptivity

I_T Solar flux incident on collector face (W/m^2)

U_t Top loss co-efficient

U_b Bottom loss co-efficient

F' Efficiency factor

h_e Effective heat transfer co-efficient

F_R Collector heat removal factor

m' Mass of air circulate (kg)

C_p Specific heats (kJ/kgK)

U_l Total loss co-efficient

A_p Area of absorber Plate (m^2)

q_u Useful heat gain (W)

L_1 Length of absorber plate (m)

L_2 Width of absorber plate (m)