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Effect of W Rib Absorber Plate on Thermal Performance Solar Air Heater

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Abstract
The solar air heater is heater having wide application in case of drying of pulses and many agricultural products. The major issue with conventional solar air heater is that its thermal performance is poor due to low heat transfer between absorber plate and air in case of solar air heater. To enhance the heat transfer in case of solar air heater the turbulence in the flow is necessary and to obtain such objective artificial roughness is good option. The aim of present work is fabricating W ribs on absorber plate of solar air heater to create turbulence in the air flow and evaluate the thermal performance. The Blower is used to supply air and K type thermocouple is used for temperature measurement purpose.
Keywords: *Solar air heater, W-rib.*

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I. INTRODUCTION

The essence of energy to our society is growing to ensure the quality of life and to smoothly run the other elements of our economy. Energy is traditionally derived from fossil fuels, massive hydroelectric systems, and wood products, such as coal, oil, and gas. Solar energy is the source of all forms of energy. The solar energy is widely used in heating of air for residential and industrial purposes. Although, its usage is still very limited because of it's certain limitations such as low efficiency of solar air heaters (SAH). The solar air heater performance mainly depends upon the heat transfer rate from the absorber plate to the air. Since the air is a poor conductor of heat, the heat transfer rate is also poor from the absorber plate to the air in its simple form of arrangement. The falling solar radiations on the absorber plate of the solar air heater are absorbed by the absorber plate and the absorbed heat is transferred to the air surrounding the plate. Different researchers have modeled the heat transfer in heater.

Arun Kumar Yadav et al [1] carried out CFD Based Performance Analysis of Artificially Roughened Solar Air Heater. Alok Bharti et al [2] reviewed the various methods used for enhancement of the heat transfer rate with little penalty of friction in SAH. Varun Pratap Singh et al [3] focused on comparative evaluation of thermal performance of several roughness geometries and kinds of SAH. Ashish Ranjan et al [4] studied the effect of half rhombus on thermal performance of solar air heater. Ekechukwu et al [5] conducted a detailed review on different designs, construction and principles of operation of a wide variety of SAHs for drying. Chabane et al. [6] fabricated a single pass solar air heater and evaluated its thermal performance. Bayrak et al. [7] investigated the performance of five collectors using baffles made of Closed-cell aluminum foams. El-Sebaii et al. [8] constructed an experimental test rig for double pass SAH. Gao et al. [9] constructed a baffled double-pass SAH and carried out thermal performance of same. Bouadila et al. [10] constructed an experimental test-rig to study the performance of a SAH with latent storage collector. Krishnananth et al [11] fabricated a counter flow double pass SAH. Yamali et al [12] fabricated the double-pass solar air heater in which copper sheet with black color coating is used. Tyagi et al. [13] experimentally studied the solar air heating system with and without thermal energy storage (TES) material for energy and exergy analysis. Jurinak et al [14] have made a study to determine the optimum physical properties of phase-change energy storage materials for solar air-heating systems. Kaygusuz [15] have investigated experimentally and theoretically the performance studies of a solar heating system with a heat pump. Nallusamy et al.[16] have experimentally investigate the thermal behavior of a packed bed of combined sensible and latent heat thermal energy storage (TES) unit. Alkilani et al. [17] achieved indoor prediction for output air temperature due to the discharge process in a solar air heater integrated with a PCM unit, for eight different values of mass flow. Saman et al. [18] studied the thermal performance of a phase change thermal storage unit based solar roof integrated heating system. Nidal H. Abu-Hamdeh [19] focused on numerical prediction of thermal efficiency, heat gain and air outlet temperature in case of solar air heater. Rajesh Kumar et al [20]. The exergetic efficiency of a finned and baffling solar air heater (SAH) was studied by Sabzpooshani et al. [21]. Ajam et al. [22] used a MATLAB toolbox to optimize the SAH's exergy efficiency after developing a correlation for predicting its exergy efficiency. Kar [23] confirmed that there is an optimal inlet temperature for the solar collector with a flat plate in order to provide maximal exergy production at a certain mass flow rate. The theoretical framework for modelling forced convection solar air heaters with one or dual glass cover was created by Bahrehmand et al. [24]. Ucar et al. [25] put a SAH through its paces with six distinct configurations of absorber surface fins. The study on the many forms of thermal energy storage employed in SAH was summarized by Abhishek Saxena et al. [26]. The thermal conductivity of SAHs with a porous textile absorbers sandwiched between two PVC foils has been studied by Bansal et al. [27]. Double-glazed Flat typed plate-Solar Air Heaters (FP-SAHs) coupled in series with a combined rock bedded collectors-cum-storages units were the subject of an experimental study and theoretical model provided by Bhargava et al. [28]. Experimental research towards improving the thermal efficiency of SAH by filling its duct with blacked wired-screen matrices was shown by Sharma et al. [29]. Rizzi et al. [30] developed and manufactured an FP-SAH-integrated solar collector storing (bricks) system. Bhagoria et al. [31] conducted experiments to determine the impact of wedge-shaped ribs on a variety of factors. Experiments were conducted by Sahu and Bhagoria [32] on transversely cracked ribs, and their effects on heat transmission characteristics were evaluated. The impact of Discrete and Transverse ribs on SAH thermal performance was studied by Varun et al. [33]. The transfer of heat and friction factor features were investigated by Aharwal et al. [34] by experimental testing and analysis of the impact of gap width and gap position. W-shaped discrete ribs were the subject of Arvind et al.'s [35] research on the absorption plate of a single-pass solar air heater. The V-shaped ribs on the absorber plate were discovered experimentally by Hans et al. [36]. The transfer of heat and friction factor correlations with individual V-down ribs was studied by Sukhmeet et al. [37]. [38-44] [50] [51] [61, 62, 63] Patel, Anand et al. documents the research article which includes thermal performance by varying the geometry, dimension of the solar collectors in the solar heater. [45] [46] Patel, Anand et al. evaluates the phenomenon of heat transfer in a heat spreader application similar application like solar heater. [47-48] Nikul K Patel et. al [49] SK Singh et al. evaluates biofuel study which is similar alternative energy to Solar Collector applications to understand the efficacy of the thermal performance comparison to the other renewable energy. [52-60] includes research thermal performance and experimental study of heat transfer in solar air heater with W-Rib and V-Rib configuration.

II. EXPERIMENTAL SET UP

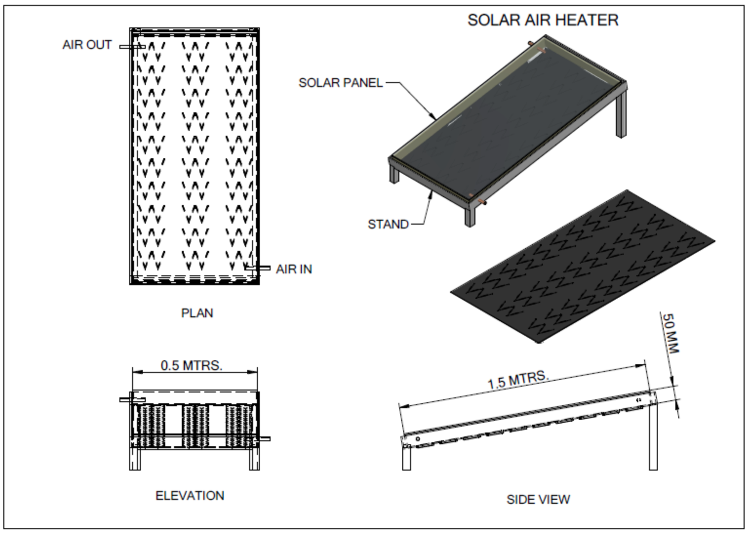

Figure 1 CAD Model of Experimental Set up

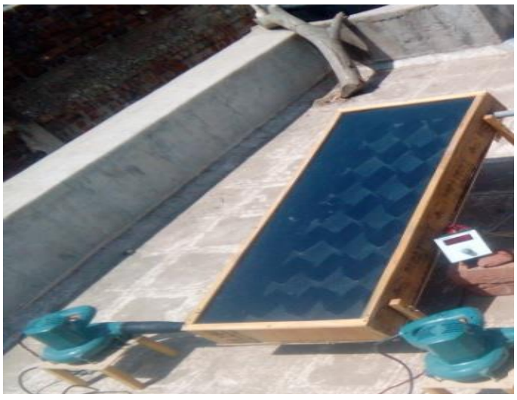

Plate 1 Experimental set up

In the preset case initially the wood structure with dimensions of 1.5 m X 0.5 m from 10 mm thick plywood sheet is fabricated and the top of structure is covered with 2 mm transparent glass sheet. While in case of W- shaped rib Solar Air Heater 1 mm thick and 4” X 2” in cross section mild steel pieces are welded on 0.5 mm in W shape and three W are placed in one raw and such 12 rows are placed at equal spacing in liner and lateral direction and that absorber plate is placed at the bottom of another solar air heater which is painted with black colored to enhance the rate of heat transfer. To supply air in the both solar air heater blower is used. At entry and exit of both air heater 12.5 mm copper pipe is attached though which air can enter and exit from both solar air heater.

III. EXPERIMENTAL METHODOLOGY

First for all experimental set up is placed in north south direction with respect to position of sun; then start air flow in the set up using blower and measure air velocity with the help of anemometer and for set value of air velocity take air inlet, air outlet as well as absorber plate and W rib surface temperature at time interval of 15 minutes for both solar air heater.

IV. RESULT AND DISCUSSION

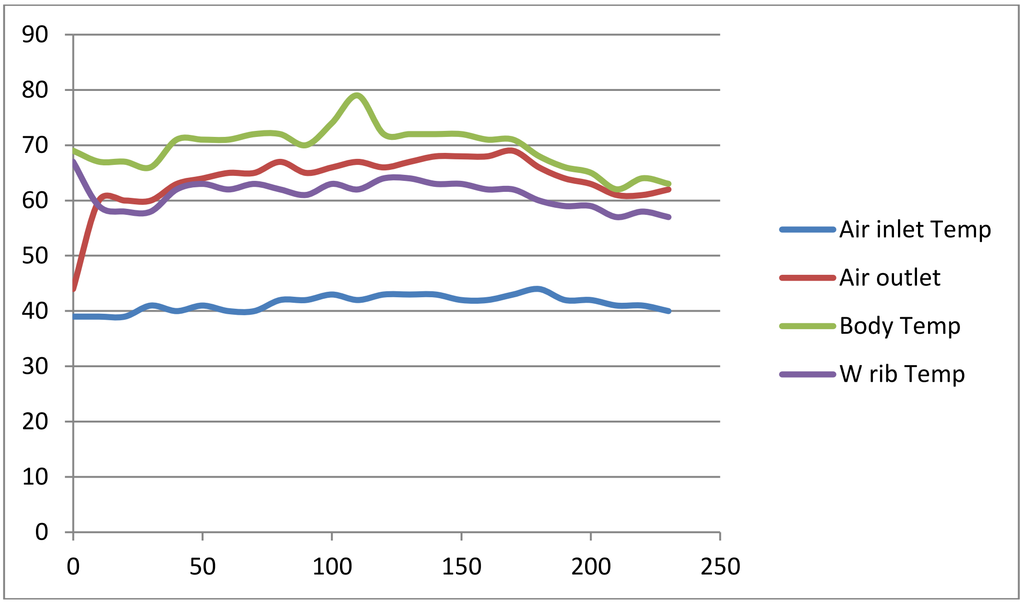

Fig 2 Temperature Variation W.R.T Time for W Rib type Solar Air Heater

Table 1 Result Table

Mass of Air	**Heat to Air**	**Heat in**	**Efficiency**
m_a kg/s	**Qa** kW	**Q** kW	%
0.0009	0.026626	0.825	3.2
0.0009	0.024851	0.825	3.0
0.0009	0.024851	0.825	3.0
0.0009	0.022189	0.825	2.7
0.0009	0.027514	0.825	3.3
0.0009	0.026626	0.825	3.2
0.0009	0.027514	0.825	3.3
0.0009	0.028401	0.825	3.4
0.0009	0.026626	0.825	3.2
0.0009	0.024851	0.825	3.0
0.0009	0.027514	0.825	3.3

0.0009	0.032839	0.825	4.0
0.0009	0.025739	0.825	3.1
0.0009	0.025739	0.825	3.1
0.0009	0.025739	0.825	3.1
0.0009	0.026626	0.825	3.2
0.0009	0.025739	0.825	3.1
0.0009	0.024851	0.825	3.0
0.0009	0.021301	0.825	2.6
0.0009	0.021301	0.825	2.6
0.0009	0.020413	0.825	2.5
0.0009	0.018638	0.825	2.3
0.0009	0.020413	0.825	2.5
0.0009	0.020413	0.825	2.5

Table 1 represent the results obtained after performing experimentation and Fig 2 shows variation of temperature with respect time of air inlet and outlet, body and W rib temperature. Due W rib air flow get obstructed and which leads to create turbulence in the flow also contact time between absorber plate and air increases so it enhances air temperature though the air outlet flow is discontinuous and pulsating type. The maximum efficiency is just 4% as air is poor thermal conductor but maximum temperature is obtained as 67 ^{0}C.

V. CONCLUSION

The major conclusion from present work is by providing artificial surface roughness better performance of solar air heater can be obtained but to fabricate such surface is difficult.

VI. FUTURE WORK

The present solar air results can be compared with V rib type and conventional solar air heater.

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