JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Literature Review on Solar Air Heater with Roughened Duct having S-Shaped Wire

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Abstract: The scientific literature extensively mentions the use of a solar air heater (SAH) by utilizing solar energy for heating purposes. The poor heat-transfer rate of an SAH with a flat plate is caused by developing a laminar sub-layer near the heated base plate. The plate temperatures improve significantly, resulting in losses and a decrease in performance. Solar air heater is one of the basis equipment through which solar energy is converted into thermal energy. The solar air heater has an important place among solar heat collectors. It can be used as sub-systems in many systems meant for the utilization of solar energy. Possible applications of solar air heaters are drying or curing of agricultural products, space heating for comfort regeneration of dehumidifying agents, seasoning of timber, curing of industrial products such as plastics. When air at high temperature is required the design of a heater becomes complicated and very costly. As far as the ultimate application for heating air to maintain a comfortable environment is concerned, the solar air heater is the most logical choice. In general solar heaters are quite suitable for low and moderate temperatures application as their design is simple.

Keywords: Heat strip; Acceleration cooling; Electronics Heat transfer; Numerical simulation; Power engineering and energy.

I. INTRODUCTION

The growing need for renewable energy in many forms has prompted researchers to look for alternate energy sources. Renewable energy resources have become a popular topic of discussion in recent years. Solar energy is a free and infinite source of energy that does not pollute the environment. Solar energy can be converted into thermal energy for use in heating applications using a solar air heater, which is a simple and efficient method of doing so. The most common type of solar air heater is a flat plate collector that produces hot air for uses such as crop drying, industrial heating, space heating, and timber seasoning. Heat losses to the close and inadequate heat convection are two drawbacks of traditional solar air heaters.

[1] Using roughness in the form of ribs on the underside of the absorber is an appropriate and effective approach of boosting thermal efficiency and performance of conventional solar air heaters. Enhancement of heat transfer on ribs in rectangular and square duct for turbine blades and small heat exchanger applications. Ribs improve heat transfer by preventing a viscous and thermal boundary barrier from forming on the heat transfer surface. However, ribs in the channel cause more pumping power. When choosing a rib roughness for a channel, both better heat transfer and pumping power must be considered. [2]

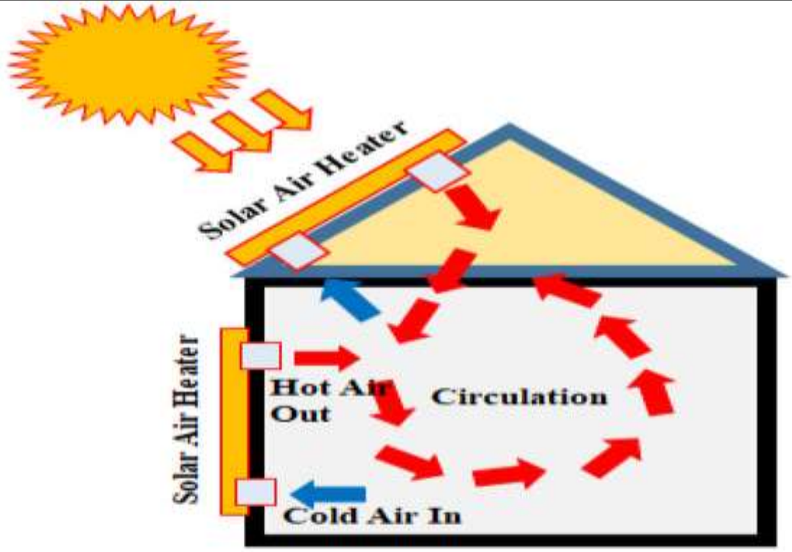

Figure1. Domestic application of flat - plate collector for house heating [18]

CLASSIFICATION OF AIR HEATERS:- Solar air heater is a device in which energy transfer is from a distant source of radiant energy to air. Solar air heaters can be used for many purposes such as crop drying, space heating, marine products, heating a building to maintain a comfortable environment especially in the winter season. Here an attempt is made to classify the solar heater on the basis of with and without energy storage, numbers of covers, extended surface and their tracking axis is presented.

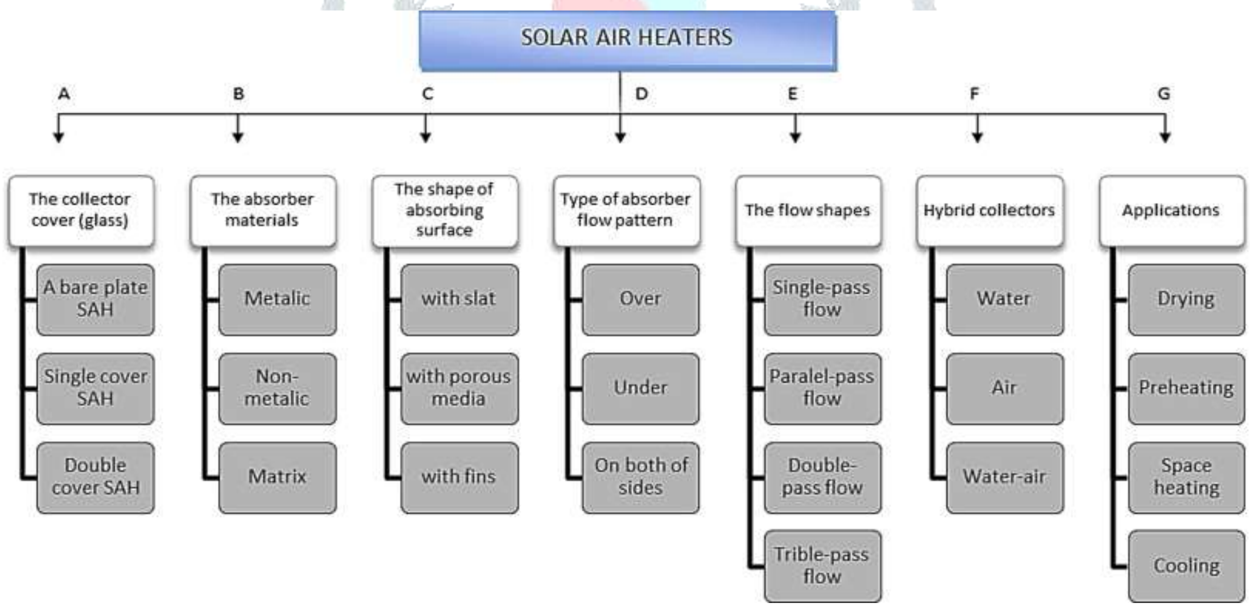

Figure2. Classification of solar air heater [18]

II. LITERATURE REVIEW

Alam et al. [3] suggested that the roughness of a conical protrusion rib has a considerable impact on a solar air heater (SAH) duct's net effective efficiency. The Reynolds number appears to have a considerable influence on net effective efficiency: Because of the extremely high frictional power requirements, a higher Reynolds number always results in a relatively low effective efficiency rating, regardless of roughness factors. The temperature increase parameter affects the optimal values of relative rib pitch and relative rib height, and the temperature increase parameter's ranges for optimum roughness parameters shift significantly with insulation.

Abdelkader et al. [4] used two methodologies in this investigation. The energetic and exergetic performance of a SAH was assessed under four air flow working circumstances in comparison to a smooth absorber SAH covered with the same coating. According to the findings, the Nusselt number of the roughened SAH with the new coating showed a significant improvement over that of a smooth absorber SAH and a roughened SAH without a coating.

Imtiyaz et al. [5] worked for finding out nusselt number and friction factor which are also functions of Re, e/D, P/e, Rib shape, and Duct form for SAH. The roughness height should be slightly greater than the thickness of the transition sub layer. In addition, sloping ribs are recommended to reduce the creation of stationary vortices, improving the effectiveness of the solar air heater.

Kumar D. et al. [6] quoted that an artificial roughness on the underside of the absorber plate improves heat transfer from the collector to the air in a solar air heater duct in a cost-effective and cost-effective manner. This research examines the thermal and thermo hydraulic efficiency, sometimes referred to as "effective efficiency," of a solar air heater with multiple v-shaped wire rib roughness on the absorber plate's bottom. The study found a significant increase in thermal efficiency when comparing solar air heaters to plane ones. Due to the increased friction factor, the increased thermal efficiency is accompanied by a significant rise in the pumping power needed.

Naveen Kumar Gupta et al. [7] suggested that the Nusselt number increases with the increase in Reynold's number and friction factor decreases as Reynolds number increases. The staggered arrangement of roughness turbulators has high heat transfer rate as comparison to linear arrangement. Delta winglet type of roughness increases heat transfer without too much increase in the friction factor. The gap produced between the ribs show higher heat transfer coefficient as comparison to continuous rib. Perforated rib roughness has greater thermal performance as comparison to solid roughness elements.

Maithani et al. [8] suggested that, the number of gaps has a considerable influence on the Nusselt number. The largest Nusselt number is observed for number of gaps 3 in the range of number of gaps. The heat transfer rate degrades as the number of gaps increases beyond three. Similarly, as the relative gap width widens, the Nusselt number rises until it reaches 4 and then falls.

Ho et al. [9] investigated the improvement in heat transfer efficiency by employing a cross crinkled dual run collector plate. By using a dual pass appliance with welding cross corrugated captivating plates instead of a flat plate device, the heat exchange area is doubled and turbulence is increased, resulting in a significant boost in efficiency. The primary goal of using cross corrugated absorber plates is to increase turbulence severity while also increasing heat transfer area. They discovered that increasing the recycle ratio and lowering the air mass flow rate increased efficiency.

Jamal-Abad et al. [10] investigated convection radiation heat transfer in a porous medium-filled solar air-heater. The implications of the collector efficiency on the form parameter of the porous medium and the radiation parameter are addressed. The perturbation approach is used to produce estimated analytical solutions for the dimensionless velocity, temperature, and Nusselt number.

Ravi et al. [11] suggested that how the performance of a traditional solar air heater can be improved by reducing losses from the collector surface by insulating it and increasing the convective coefficient between the heat collecting surface and the working fluid by increasing the heat transfer area, which can be increased by using a double pass design. To increase the performance of double pass solar air heaters equipped with a performance improvement method, a variety of practical and theoretical inspections have been studied, using corrugated/grooved absorbent surfaces and extended surfaces from packed bed materials.

Kishore Kulkarni et al. [12] worked on multi-objective optimization of a solar air heater with obstructions on an absorber plate for optimum heat transmission and minimum pressure loss. Shape optimization is performed in this study using 3-D Reynolds-averaged Navier–Stokes analysis and two basic surrogate models: response surface approximation and Kriging models. For the optimization, three geometric factors were employed as design variables. The two objective functions were defined using the average Nusselt number and friction factor. The design points in the design space were chosen using the Latin hypercube sampling technique. The Pareto-optimal solutions were determined using a hybrid multi-objective genetic algorithm and a surrogate model.

Wang et al. [13] shows how to build a set of evacuated tube solar high temperature air heaters with a simplified CPC (compound parabolic concentrator) and concentric tube heat exchanger for industrial manufacturing. The solar air heater consists of 30 interconnected collecting units. A streamlined CPC and an all-glass evacuated tube absorber with a concentric copper tube heat exchanger connected inside are included in each unit. Between the evacuated tube and the concentric copper tube, a stainless-steel mesh layer with high thermal conductivity is filled. As air passes through each collecting unit, the temperature gradually rises. According to the empirical findings, the given high-temperature solar air heater has a good collecting performance.

Singh et al. [14] investigated the thermal performance of the packed bed solar heat storage system under various solar and ambient circumstances. Rock pebbles were used to fill the insulated packed bed heat storage unit. It is possible to obtain the solar collecting and heat cure efficiency of a heat storage system. When compared to a packed bed loaded with phase change material, the heat improvement efficiency of the created packed bed was shown to be superior.

Kabeel et al. [15] investigated flat and v-corrugated plate solar air heaters with built-in PCM as thermal energy storage material, under current weather conditions, the incorporated solar air heater with paraffin wax as PCM was built and tested. With and without PCM, the parameters affecting the thermal performance of the flat and v-corrugated plate solar air heater were reported.

Jin et al. [16] used the ANSYS FLUENT code and the Re normalization-group key turbulence model to investigate heat transfer and fluid flow in a solar air heater duct with numerous V shaped ribs on the absorber plate. Different Reynolds values are used to compute for diverse rib configurations with varied span wise V-rib number, relative rib pitch, relative rib height, and angle of attack. The Nusselt number, friction factor, and flow structure are calculated and studied as a function of the rib geometrical characteristics.

Acir et al. [17] investigated heat transfer, friction factor, and thermal performance factor originality of a novel solar air heater (SAH) with circular type turbulators of various relief angles and distances. The effect of the pitch ratio (PR) and angle rat io (AR) on heat transport in SAHs was examined.

III. OBJECTIVE

- Modifying a solar air heater to allow the heating of cold air.
- To assess the performance of a blower inside the pipe, a solar collector-equipped air heater, and a solar drier.
- The effectiveness of the Solar Air Dryer will be evaluated both with and without the usage of an air heater. Additionally, the effectiveness would be evaluated in connection to the impacts of climate variables.

IV. Expected Outcome

- The thermal performance of solar air heaters is improved when ribs are used as absorbers.
- Increase the heat transfer area to improve the thermal performance of the solar air heater.
- Thermal efficiency rises together with an increase in air mass flow rate.
- Outlet air temperature and mass flow rate are inversely related.

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