



A Review on Development of Artificially Roughed Solar Air Heater

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Abstract

Solar air heaters are commonly utilized in both residential and industrial settings. The researchers were forced to focus on improving the thermal performance of solar air heaters by providing artificial flow modification techniques in the flow field due to the reduced thermal efficiency of solar air heaters. As a result, the laminar sub layer beneath the absorber plate is disturbed, increasing air turbulence. The heat transmission rate from the absorber plate is increased as a result of this. The impact of various shaped tabulators on increasing the thermal performance of air heaters is discussed in this paper. Flow conditions and their impact on turbulence, heat transfer rate, absorber temperature, and the thermo-hydraulic enhancement factor have all been comprehensively examined. Finally, concluding remarks are made, as well as the future potential for improving the performance of solar air heaters. Moreover it is required to understand how flow field is affected by particular roughness geometry so that direction of future researches could be conceived. So as to elucidate the useful findings an attempt has been made to review roughness geometries employed in solar air heaters. This paper covers the types of technique used in enhance heat transfer coefficient in field of heat transfer and review a variety of papers dealing with artificial roughness on heat transfer field.

1. Introduction

This energy is driving the whole system of our planet but a major part of this energy is absorbed by earth and some part of this reflex back to the atmosphere which increases the temperature of surroundings as the sun radiations have the heating effect. Energy in various forms has played a significant role in world wide economic progress and industrialization. [1]. Solar energy is the sun's radiant light and heat. It is the largest and most promising renewable

energy source currently available to meet energy demand. The energy of the sun falling on the Earth's surface is roughly ten thousand times that of today's energy requirements. The atmosphere and cloud absorption have lowered the amount of radiation that falls on the earth's surface. The amount of diffuse radiation falling on the earth owing to the atmosphere and clouds is roughly 15%–20%. A portion of the radiation that strikes the earth is reflected into the atmosphere. The incoming solar radiation energy is converted into useable heat energy by a solar air heater. It's a flat plate solar collector with a non-concentric design. It is inexpensive, easy to fabricate, and primarily used in moderate and low temperature applications. When compared to liquid collectors, it is more appealing in some applications since it reduces heat transfer from one fluid to another.[2].

2. Literature Review

Khanlari et al. [3] uses computational and experimental analysis to examine the impact of putting a nano-enhanced absorber coating on the energetic and exergetic performance of an unglazed vertical solar air heating system. In the initial phase of the study, computational fluid dynamics was used to examine different vertical solar air heater topologies, such as hollow, baffled, and perforated baffled systems. The system with perforated baffles provided the best performance metrics, according to the numerically acquired findings.

Nidhul, et al. [4] used numerous types of ribs in SAH, which may be useful for future research. Heat transfer has been significantly improved at the expense of a pressure decrease that is insufficient to compensate for the advantages. Energetic performance analysis is carried out in addition to energy analysis to evaluate the many types of energy losses that occur in a SAH. The influence of ribs on SAH energy gain is also discussed. Energetic performance of V-ribs, multiple V-ribs, and multiple V-ribs with gaps was also performed to investigate the effect of multiple ribs and gaps on the energetic performance. The findings of the preceding study highlight the following key points: The primary flow separates and reattaches in the inter-rib zones because of ribs beneath the absorber plate. This reduces the thermal barrier to heat transfer by preventing the formation of a thermal boundary layer near the heated plate. The cross-flow formed by inclined ribs, its movement, and subsequent mixing with the primary flow stream adds turbulence and improves heat transfer.

Raju et al. [5] investigated that experiments were conducted on a double pass packed bed SAH with encapsulated PCM on its absorber plate capsules in two different geometries, square and circular in cross sections were used. Four absorber plates with capsules in inline and staggered grid arrangements were attached one by one to SAH and experimental analysis was carried out with mass flow rate of air changed in between 0.008643 and 0.01454 kg/s. It was found that intensity of solar radiation steadily increases before noon, reaching to its maximum at noon and decreases after the noon. Accordingly, absorber plate temperature and PCM temperature in capsules were recorded as higher compared to other temperatures in the experimental setup during charging period, that is, from 10:00 AM to 2:00 PM. • Efficiency of SAH was found to be increasing with increase in mass flow rate of air for all the arrangements.

Tarek Kh. et al. [6] suggested that SAH quality has been proven to be improved by artificial roughness in the shape of repeating ribs. Ribs interrupted the viscous sub-layer and created local wall turbulence without stopping the principal turbulent stream, resulting in an increase in the convective heat transfer coefficient between the air and heated surface as a result of fluid separation and reattachment. As a result, in this investigation, a SAH roughened with aluminum separation and reattachment. As a result, in this investigation, a SAH roughened with aluminum broken arc ribs was covered with a novel solar selective coating composed of 4% CNTs/CuOblack paint.

Aamir et al. [7] worked for finding out nusselt number and Friction factor are also functions of Re , e/D , P/e , Rib shape, and Duct form, according to the literature review. 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 et al. [8] showed a solar air heater duct, artificial roughness on the underside of the absorber plate promotes heat transfer from the collector to the air in a cost-effective and cost-effective way This study looks at the thermal and thermo hydraulic efficiency of a solar air heater with many v-shaped wire rib roughness on the bottom of the absorber plate, also known as "effective efficiency."When comparing solar air heaters to plane heaters, the study indicated a considerable boost in thermal efficiency. Increasing thermal efficiency is accompanied by a large increase in the pumping power required due to the increased friction factor.

Ho et al. [9] researched whether using a cross crinkled dual run collector plate may improve heat transfer efficiency. The heat exchange area is doubled and turbulence is created when a dual pass appliance with welding cross corrugated captivating plates is used instead of a flat plate device, giving in a significant increase in efficiency. Cross corrugated absorber plates are used to increase turbulence severity while also boosting heat transfer area. They discovered that lowering the air mass flow rate and raising the recycle ratio boosted efficiency.

Katzka et al. [10] showed 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.

Kulkarni et al. [11] used Shape optimization 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. The ideal Pareto optimal solutions were chosen to investigate the relationship between the two goals.

Wang et al. [12] 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.

Panna Lal et al. [13] investigated the thermal performance of the packed bed solar heat storage system was investigated. 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. . Inspection of flat and v-corrugated plate solar air heaters with built-in PCM as thermal energy storage material was investigated by A.E. Kabeel et al. (2016). 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. [14] 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.

Bhagoria et al. [15] investigated fluid flow characteristics of fully developed turbulent flow in a rectangular duct having repeated transverse square sectioned rib roughness on the absorber plate using ANSYS FLUENT. They examined twelve different configurations of square sectioned rib. They concluded that the best thermo-hydraulic performance parameter were the square sectioned transverse rib roughened duct with $P/e= 10$ and $e/D= 0.0367$

Karwa R et al. [16] Studied and found that the artificial roughness in the form of chamfered ribs groove on the absorber plate result in considerable enhancement of heat transfer. This enhancement is, however, accompanied by a substantial increase in the friction factor. It is therefore desirable to select the roughness geometry such that the heat transfer coefficient is maximized while keeping the friction losses at the minimum possible value. Considering the heat transfer and friction characteristics can fulfill this requirement the collector simultaneously.

Verma SK et al.[17] , investigated the thermo hydraulic performance of a wire screen matrix packed solar air heater using a mathematical model created to explore the effect of various system and operating elements. Evaluation of efficiency for packed bed systems by numerically solving the governing equations utilizing pertinent heat transfer coefficient correlations.

3. Conclusion

After an extensive review of various kinds of ribs employed in SAH, this article reports the concise summary which may be of use for future research. Significant enhancement on heat transfer has been achieved at the expense of pressure drop not large enough to offset the gains. Apart from energy analysis, energetic performance analysis is carried out to assess the different kinds of energy losses occurring in a SAH. The impact of ribs on the energy gain of SAH is also reviewed. In addition, the performance of the Solar Air Dryer will be evaluated with and without the use of an air heater. The impact of climate variables on its performance would also be investigated.

4. Research Scope

1. To adapt a solar air heater so that cold air can be converted to hot air.
2. To test the efficiency of a solar air heater with a solar collector, a blower in the pipe, and solar dryer.
3. The performance of the Solar Air Dryer will be evaluated both with and without the use of an air heater. The impact of climate variables on its performance would also be investigated.
4. The current research focuses on the heat transfer properties of a solar air heater with various design changes to increase air travel length.

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