An Extensive Literature Review on Heat Transfer Mechanism & Energy Efficiency of Artificially Roughened Solar Air Heaters

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Abstract:- The Solar technologies has been studied with its classification falls into two groups; passive and active heating. There is a still possibility to enhance system efficiency solar air heater. The Passive solar techniques include designing spaces according to natural circulation, locating buildings with reference to the Sun or selecting high thermal conductive materials. On the other hand, active solar techniques include using solar panels, pumps or fans to convert solar energy into useful outputs. Solar air heaters are devices that utilize solar radiation for a variety of purposes. These devices are simple and can be constructed inexpensively. Mainly, solar air heaters consist of a transparent cover, an absorber plate and insulation material. The air flow enters through the channel that is formed by the absorber plate and the transparent cover. Solar radiation absorbed by the absorber plate. The absorbed heat transferred to the air as it flows along the channel increases its temperature. This heated air can be used in several applications such as drying agricultural products, space heating and air conditioning, water heating and industrial process heating. There are many advantages of solar air heater systems. Firstly, they are simple to maintain and design. After the set-up cost, a solar air heater system has no fuel expenditure. There is less leakage and corrosion when compared to the systems that use liquid. It is also an eco-friendly system which has zero greenhouse gas emissions.

Keywords - Heat Transfer, Energy Efficient, Solar Air Heaters.

I. INTRODUCTION

Indoor climate in buildings

Indoor climate in a building depends on following parameters:

- *Air quality (air changes)*
- *Humidity*
- *Temperature*
- *Light (windows)*

First three of them can create a risk of health damages if the parameters will not be on the right level (not enough air changes, too high humidity, and too low temperature). It is important to focus on these risks as they can cause asthma or other allergy types which are very dangerous for people's health. They can also have bad influence on the buildings, because of damp, moulds, dust mites.

That is the reason why recently there is a growing interest not only in ventilation but also in proper indoor environment. It can help to minimize risk of sick building syndrome, moulds or others. One solution to improve the conditions in the building can be solar air system.

Solar air system

Solar air system is a type of system which collects solar energy and transforms it into heat. The general idea is that the air is flowing through solar collector and heat from sun naturally raises the temperature of the air. In other words cold, outside air is heated and delivered to the room. The collector has on outer layer of glazing/polycarbonate which is exposed to sun. Circulation of the air in the building can be by natural driving forces (buoyancy effect) or by fan which is more certain. Optionally the fan can be powered by solar cell mounted on collector.

Preheating of air supplied to buildings has gained much interest during recent years. The advantage of this technology is that it is cheap and simple. It is especially efficient for summer houses as it can work without anyone's attendance. It can help to get rid of mould and bad smells as well as increase the temperature inside without need of additional heating. In this way the indoor environment in such houses is maintained on a good level after winter.

This type of air collector is similar to typical conventional water collector, but instead of water there is air in pipes.

Variations of solar air collectors

Type 1 (ambient ^ collector ^ room)

Outside air is circulated through the collector directly to the space which should be ventilated and heated. This collector has got a very high efficiency because the outside air is supplied directly to the collector.

This type of solar air collector can be used for vacation cottages and spaces which are normally closed and used only temporarily to minimize damp and mould.

Type 2 (collector ^room ^ collector)

This system was created by Bara Constantini and that is the origin of the name of this system. Air is circulated from the bottom part of the room by collector (where the air is heated) into upper part of the room which constitute storage ceiling. All is driven by natural convection without any fan support. The thermal mass ceiling releases into the room after sunset. In summer the air in the coMector collector can be released to the outside and replaced by fresh cold air from northern part of the room.

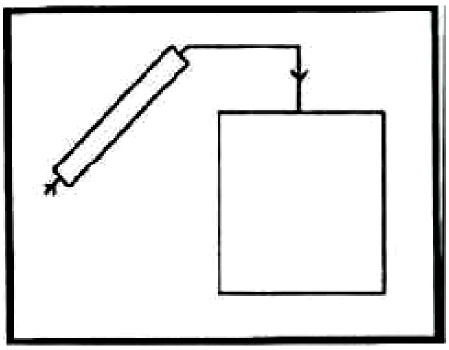

Figure 1.1 Type 1 solar air collectors

This type of system can be utilized for apartment buildings.

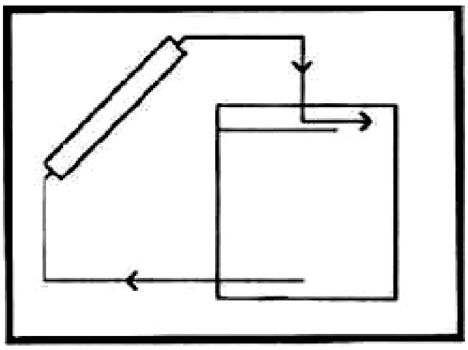

Figure 1.2 Type 2 solar air heat

Type 3 (collector ^ shell ^ collector)

Warm air is circulated between the collector and open space - buffer which is situated between outer insulated wall and inner wall. This type of system minimizes heat losses from the building what reduces energy consumption for the building. This collector can be inexpensive and very weak solar radiation causes this investment cost-effective. This system is utilized in poorly insulated existing buildings or new apartment buildings.

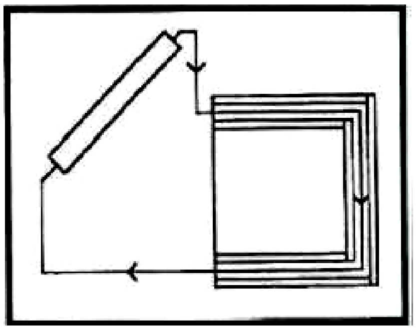

Figure 1.3 Type 3 solar air collector

Type 4 (collector ^ storage ^ collector)

This is a popular type of solar heating system. Air is circulated in close circuit from thermal mass wall or floor to collector. Heat is released through the convection to maximum 4-6 hours after sunset. Advantage of this system is a huge radiating surface (whole floor). Cooperation with fan increases the efficiency of this system.

This system has got practical usage in buildings with large floor area.

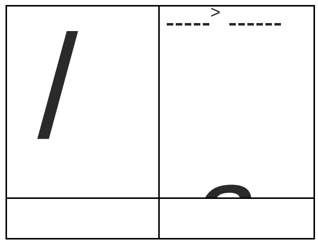

Figure 1.4 Type 4 solar air collector

Advantages of solar air system

• Better absorbance of solar energy without restriction of direct solar gains in comparison to typical solar passive technologies,

• Better timing of solar heat with usage of thermal wall, when there is no sunshine heat is released from the wall,

• They reduce costs of energy consumption for the building,

• In comparison with water collectors no chemicals for antifreeze are needed and in case of damage they do not cause any loss for the building,

• They can cooperate with HVAC systems, for example for preheating air,

• They can be utilized for very low energy residence and commercial, institutional buildings.

II. LITERATURE REVIEW

K. Prasad, S. C. Mullick [2] A temperature r & e of only 3 to 6 °C above ambient has been recommended Jor drying cereal grains. Such temperatures can be attained in a simple unglazed solar air heater. However, the plate efficiency factor is low. The present work involves the provision of protruding wires on the underside of the absorber plate to improve the heat transfer characteristics and hence the plate efficiency factor. The agreement of the measured heat transfer coefficients with theoretical predictions is found to be satisfactory. The improvements in the plate efficiency factor of the unglazed collector with a corrugated galvanised iron absorber are considerable, i.e. from 0"63 to O"72for a Reynolds number of 40 000.

B. N, PRASAD, J. S. SAINI [3] Convective heat transfer coefficient between absorber plate and air in a flat-plate solar air heater can be enhanced by providing the absorber plate with artificial roughness. An investigation of fully developed turbulent flow in a solar air heater duct with small diameter protrusion wires on the absorber plate has been carried out and expressions for prediction of average Stanton number and average friction factor have been developed. The results of these expressions have been compared with available data. The results have been found to compare with a mean deviation of 6.3% for friction factor and - 10.7% for the Nusselt number. The effect of height and pitch of the roughness elements on the heat transfer rate and friction has also been investigated.

Vishavjeet Singh Hans , R.P. Saini , J.S. Saini [4] The conversion, utilization and recovery of energy invariably involve a heat exchange process, which makes it imperative to design more efficient heat exchanger. The use of artificial roughness in different forms, shapes and sizes is the most common and effective way to improve the performance of a solar air heater. Several studies have been carried out to determine the effect of different roughness element geometries on heat transfer and friction in solar air heaters. This study reviews various roughness element geometries employed in solar air heaters for performance enhancement. Based on the correlations of heat transfer and friction factor developed by various investigators, an attempt has been made to compare the thermo hydraulic performance of roughened solar air heaters.

Brij Bhushan , Ranjit Singh [5] In order to enhance rate of heat transfer to flowing air in the duct of a solar air heater, artificially roughened surface of absorber plate is considered to be an effective technique. Investigators reported various roughness geometries in literature for studying heat transfer and friction characteristics of an artificially roughened duct of solar air heaters. In the present paper an attempt has been made to categorize and review the reported roughness geometries used for creating artificial roughness. Heat transfer coefficient and friction factor correlations developed by various investigators for roughened ducts of solar air heaters have also been reported in the present paper.

Anil Kumar , R.P. Saini , J.S. Saini [6] Artificial roughness in the form of repeated ribs is one of the effective way of improving the performance of a solar air heater ducts. Various studies have been carried out to determine the effect of different artificial roughness geometries on heat transfer and friction characteristics in solar air heater ducts. The objective of this paper is to review various studies, in which different artificial roughness elements are used to enhance the heat transfer coefficient with little penalty of friction factor. On the basis of correlations developed by various investigators for heat transfer coefficient and friction factor, an attempt has been made to compare the thermo hydraulic performance of roughened solar air heater ducts. It has been found that lot of experimental and analytical studies reported in the literature.

III. PROBLEM IDENTIFICATION

The careful review of the heat transfer mechanisms prevails in case of principle geometrical patterns of rib roughness and sub sequent energy based performance analysis to meet the following important conclusions: Roughness in the form of ribs arranged in transverse, oblique, V and multi V pattern were mainly explored by different investigators to achieve better thermal performance of solar air heater. Fluid flows patterns over the roughened surface have been discussed with a view to understand the effect of a particular roughness pattern on fluid friction and heat transfer. Change of rib roughness pattern of the elementary form, i.e., transverse rib roughness to the compound form, i.e., multi V-rib roughness, leads to intricate fluid flow pattern comprising secondary fluid flow vortices.

IV. PROPOSED METHODOLOGY

Proposed methodology can be explained with the help of following steps that is given below :

Step 1 First of all in geometry the X-Y plane has been selected and now this plane would be extrude to form a rectangular duct.

Step 2 Planes would be selected and at a particular point small circles of aluminum wire are drawn with the collinear centers.

Step 3 In this the sweep operation would be performed in this the profile (front plane) and path (upper plane) with aluminium wire would be freezed as it was applied in previous step.

Step 4 In pattern operation step number of rows with aluminium wires required would be obtained.

Step 5 Aluminium wire (Tool Body) shell be subtracted from the rectangular duct (Target Body)using Boolean operation.

Step 6 In this step a rectangle is drawn on the right plane according to the geometrical parameters for Extrusion of rectangle.

Step 7 Here Boolean operation would be applied in order to tool unite all bodies.

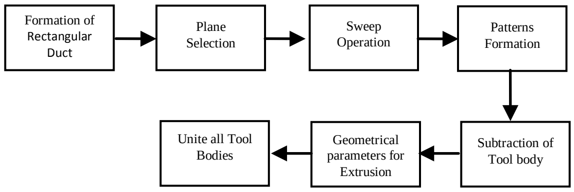

Figure 5.1 shows the block diagram of design flow to achieve the proposed methodology

V. CONCLUSION

The enhancement of heat transfer in a solar air heater collector by using porous medium is studied in this research work. A solar air heater is designed and constructed for this research. A set of analysis are analyzed the porous layers made no significant temperature enhancement on the exit temperature of air. Air enters the collector at similar temperatures for each and at the end of each analysis the exit temperatures are similar, too. The clear channel and fulfilled channel exit temperatures are 55, 34 °and 55, 67°C, respectively. By adding porous layers the absorber temperature is decreased significantly. This makes the temperature distribution inside the channel more uniform. Another benefit of reduced surface temperature is it decreases the heat loss between the surface and surroundings. High absorber surface temperature losses much heat to the surroundings from the bottom of constructed setup. But when the temperature distributed uniformly inside the channel, the absorber temperature decreases therefore the heat loss decreases. The heat transfer calculations would be made on CFD. The heat gain and the heat consumed shell are studied.

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