Surface Improvement For Heat Transfer In Solar Air Heater-A Review

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Abstract - Solar energy is being utilized in the form of heat in several applications. This heat is useful in heating of water or air for domestic purposes. Air heaters are employed to heat air which may further be used in space heating. Solar radiations when fall on an absorber plate heat is absorbed and further transfer to the fluid flowing over it. Researchers have found that the roughness of the absorber plate has significant role in heat transfer and therefore heating of the fluid flowing over it. Thermal performance of the absorber plate can be improved by providing artificial roughness on the absorber plate. Experimental findings represent that the roughness geometry provided on the absorber plate increases the pumping power requirement of the pump. Researchers are continuously working o finding the effect of roughness geometry on heat transfer and friction in heating of air in solar air heater. This paper presents the review of the various studies in the heat transfer enhancement by surface roughness of different geometries and effect of it on friction. Researchers have also developed correlations for the artificially roughened surfaces. Paper also presents the important parameters of artificial roughness and processes in associated heat transfer.

Keywords— artificial Roughness, Reynolds number, Solar air heater, Friction factor.

1. INTRODUCTION

The energy is prime source of the development of mankind since the inception of social life. All the developments in the world rely on the need and availability of the energy. Development not only limited to the development of physical and materialistic property but the development of society and economics are also very much affected with the availability of energy. We have several sources of energy on our earth and many are being utilized since centuries. Several of them are affecting adversely our environment because of the abundant use of them. This not only affecting the environment but increases our dependencies that future scarcity of these fuels society may be severely affected. The researchers are continuously finding the alternatives of the conventional fuels on one way and on the other way many researches are undergoing to reduce the bad effect of the mass usage of these fuels. The world is facing problems of pollution in air, water and soil. The pollution is affecting human health, environmental disorders and cause of natural disasters too. A solar air collector is shown in fig. 1.

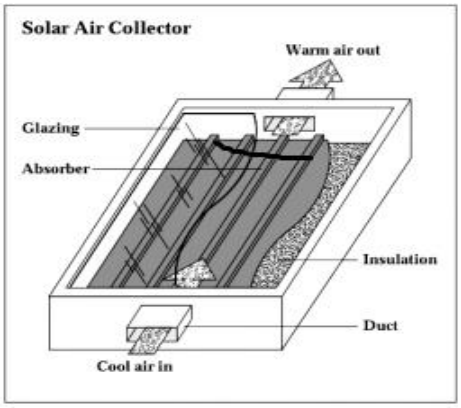


Fig. 1 Solar air collector

Other problems associated with the usages of fossil fuels are global warming and imbalance in eco system.

2. SOLAR ENERGY

The rising problems due to growing usage of fossil fuels and increasing demand of energy are the significant reasons for finding alternative sources of energy which can prevent our environment. Among various alternatives available, solar energy is one of the major sources of energy available to us in inexhaustible amount. This is free from pollution and environmental friendly source of energy.

Solar energy available on earth can be collected easily and anywhere. The energy from the sun is obtained because of the nuclear reactions occurring in the sun. The radiations in the form of visible, infra-red and ultra violet light are continuously received all around the sun.

3. SOLAR AIR HEATER

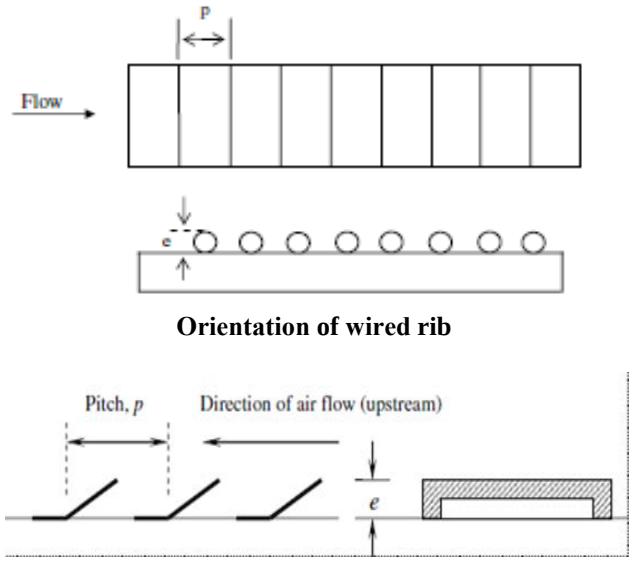
The solar energy conversion into thermal energy and transfer of this thermal energy to the air is done by the solar air heater. This system as a solar heat collector essentially has an absorber plate which receives and absorbs the solar radiations falling on it and then the energy is transferred to the air flowing over it.

Solar air heater is basically used for warming of air with the help of heat received from the solar radiations for space heating, processing of wood, curing, drying of agricultural

products etc. although they are of wide applications in domestic, agriculture and industry use. These heaters may be designed for the high temperature requirement and low or moderate temperature requirements. The design is simple and most widely used for the low and moderate temperature requirements. Solar air heaters possess advantage over liquid heaters due to low cost of the equipment of the system and simple design. Since they may be used as an independent system which are not using conventional source of energy, they may be used in conjunction with the conventional systems to reduce the consumption of conventional fuels.

4. HEAT TRANSFER IMPROVEMENT THROUGH THE ABSORBER PLATE

The heat of solar radiations is absorbed by the absorber plate for further transfer to the air. When the surface of the absorber plate is not smooth, the heat transfer rate increases. One of the ways of reducing smoothness of the surface is developing roughness on the surface artificially in a fixed and regular pattern. Available literature on solar air heater research provides information that the performance of solar air heater improves on providing artificial roughness on the absorber plate. The heat transfer coefficient has low value in the solar air heater for the heat transfer between absorber plate and air flowing over it. The cause of it is the formation of laminar sub layer over the absorber plate which acts as the heat transferring surface. When the artificial roughness is provided beneath the absorber plate, this breaks the laminar sub layer and creates turbulence. Further to this the artificial roughness helps in providing recirculation and causing improvement in convective heat transfer. For this arrangement a blower is needed to make the flow possible. The turbulence is created near the heat transferring surface so that the power consumption in blower can be kept to minimum.



Orientation of wired rib

Fig. 2 Orientation of Inverted U shape rib

The roughness elements of various geometries have been considered to represent the flow characteristics and thermo hydraulic performance of the heater. Some of the geometries used are Wire rib, V-shaped rib, Chamfered rib, Arc shaped rib, Metal grit rib, Discrete W-shaped rib, Inverted U-shaped rib, Transverse Wedge rib etc. The effect of these ribs is importantly to produce flow separation on both the sides of the rib. The turbulence is generated and due to this heat transfer and losses due o friction also increases. Some of the elements of roughness are shown in fig. 2.

The past researches have provided various parameters for the application of artificial roughness in solar air heaters and characteristics of the roughness element. The parameter employed by them includes Relative roughness pitch, Relative roughness height, Angle of attack, Aspect ratio and Shape of roughness element.

5. ANANLYSIS METHODS FOR PERFORMANCE OF SOLAR AIR HEATER

For the analysis of the solar air heater to obtain flow parameters and heat transfer study most of the researchers have adopted experimental and numerical techniques. Experimental investigations have been performed on experimental setup consisting of a duct in which artificial roughness was created with the particular type of rib geometry. Heaters have been used in place of solar radiations by some researchers and a blower is used to make the air flow through duct.

In Numerical Analysis Computational Fluid Dynamics is most popular technique. This provides results with acceptable accuracy. Many researchers have validated CFD analysis with their experimental outcomes. This technique is gaining importance because of its feature of less time requirement in analysis and less cost of analysis. A skill and knowledge of CFD analysis is required.

The research papers reviewed using experimental and numerical methods show that heat transfer improves by providing artificial roughness.

6. CONCLUSION

In this paper a study on solar air heater and surface improvement for heat transfer is presented. It is shown that the heat transfer from the surface of the absorber plate of a solar air heater can be improved by providing artificial roughness over the absorber plate. The artificial roughness elements of various shapes used by the researchers have been mentioned. It is also found through the review that the investigators have provided several parameters to investigate the performance features of the solar air heater by calculating heat transfer and friction.

The methods of investigation for the analysis of heat transfer and performance evaluation used by the investigators and found in literature review is presented. The methods mostly used in these studies are experimental and numerical techniques. Numerical techniques are found to be gaining popularities because of its advantages of less time requirement at low cost of analysis. The results of numerical studies have been obtained within the acceptable limits as compared to experimental results.

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