Analysis of Performance and Thermal Efficiency of Air Heater by Using Passive Heat Transfer Enhancement Technique:-A Review

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ABSTRACT

In the field of power generation heat energy plays most important role which involves the heat transfer in domestic as well as industrial purposes. The heat transfer coefficient between heat transferring surface and air is low which leads to lower thermal efficiency of the system. From Literature it is important to increase heat transfer coefficient between heat transferring surface and air. The passive heat transfer enhancement technique is the most promising technique to enhance heat transfer coefficient is artificial roughness on heat transfer field. Artificial roughness applied on the absorber plate is the most acclaimed method to improve thermal performance of solar air heaters at the cost of low to moderate friction penalty. Experimental investigations pertinent to distinct roughness geometries unfolds that the enhancement in heat transfer is accompanied by considerable rise in pumping power. In view of the fact, a designer needs to carefully examine shape and orientation of roughness elements in order to choose the best fit roughness geometry for intended application.

This dissertation work will cover the types of technique used in enhancing the heat transfer coefficient in field of heat transfer and thermal efficiency.

Keyword: - *Artificial roughness, Air heater, Roughness geometry, Thermal performance*.

1. INTRODUCTION

Heater is the devices that can be used to transfer heat from solid to fluid (liquid or gas) at different temperature. Electrical heater is devices which exchange of energy take place between heating element to air or liquid at different temperature. A heat exchanger utilized a fact that, whenever there is a difference in temperature flow of energy occurs, heat will flow from higher temperature heat reservoir to lower temperature heat reservoir. The heated surface provides a necessary temperature difference and thus force of energy to flow between them. Heat exchanger are used in different processes raging from conversion, utilization and heat recovery of thermal energy in various industrial, commercial and domestic applications. This include power production, processes, chemical and food reservation, waste heat recovery, manufacturing industry and air conditioning, refrigeration and space application. Examples of heat exchanger that can be found in all homes are heat radiators, the coil in your refrigerator and air conditioner and hot water tank.

The performance of conventional air heater can be substantially improved by number of enhancement technique. The research effort has been devoted to develop an apparatus and performing experiments to define the conditions under which an enhancement technique will improve heat transfer. The goal of enhanced heat transfer is to accommodate high heat fluxes. This reduces air heater size which generally leads to less capital cost. Another advantage is the reduction of temperature driving forces. The heat transfer enhancement enables air heater to work at less speed but still achieve the same or even higher heat transfer coefficient. This means the reduction of pressure drop, corresponding to less operating cost may be achieved. All these advantages have made heat transfer enhancement technology attractive in air heater applications. For air heaters the turbulators wire geometry insert technology, additional exchanger can often avoided and thus significant cost saving can be achieved. Heat transfer rate can be improved by including a disturbance in air flow by different enhancement techniques (breaking the thermal boundary layer). In this project, a review of heat transfer enhancement tool i.e. inserting turbulated wire geometry.

A conventional air heater generally consists of an absorber plate with a parallel plate below forming a passage of high aspect ratio through which the air to be heated flows. As in the case of the liquid flat-plate collector, a transparent cover system is provided above the absorber plate, while a sheet metal container filled with insulation is 'provided on the bottom and sides. Air heaters are being used for many applications at low and moderate temperatures. Some of these are crop drying, timber seasoning, space heating, chicken brooding and curing / drying of building components.

A schematic of a typical Air collector is shown in figure which one can see heat radiations are incident to the absorber directly and these absorbers supply this heat directly to the air flowing inside the duct and hence increasing the temperature of the supply air to the system

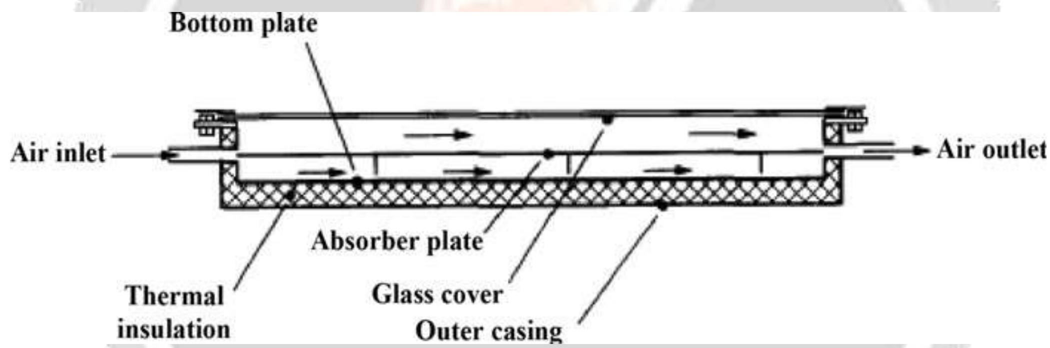

Fig -1 Typical air heater

One of the most promising and economical method of increasing the heat transfer rate is providing the artificial roughness on the absorber plate, which creates turbulence in the flowing air. It has been found that the artificial roughness applied on the heat transferring surfaces breaks the viscous sub-layer, which reduces thermal resistance and promotes turbulence in a region close to artificially roughened surface

Abdul-Malik Ebrahim Momin, J. S. Saini, S. C. Solanki [1] experimentally investigated the effect of geometrical parameters of V-shaped ribs on heat transfer and fluid flow characteristics of rectangular duct of solar air heater with absorber plate having V-shaped ribs on its underside. The range of parameters for this study has been decided on the basis of practical considerations of the system and operating conditions

J.C. Han [2] carried out an experimental study of fully developed turbulent air flow in square ducts with two opposite rib roughened walls was performed to determine the effects of the rib pitch to height and rib height to equivalent diameter rations on friction factor and heat transfer coefficients. Reynolds number is varied from 7,000 to 90,000. Results of roughened wall were compared with those of smooth wall and observed that the average friction factor was 2.1 to 6 times that for four sides smooth duct.

N. Sheriff and P. Gumley [3] investigated experimentally the heat transfer and friction characteristics of a surface with discrete roughness. They used metal wires as roughness elements of different sizes varying in a wide range of diameter

Santosh B. Bopche and Madhukar S. Tandale [4] investigated on heat transfer coefficient and friction factor by using artificial roughness in the form of specially prepared inverted U shaped turbulators on the absorber surface of an air heater duct. The roughened wall is uniformly heated while the remaining three walls are insulated

M. M. Sahu and J. L. Bhagoria [5] carried out investigation to study the heat transfer coefficient by using 90° broken transverse ribs on absorber plate of a solar air heater; the roughened wall being heated while the remaining three walls are insulated. The roughened wall has roughness with pitch (P), ranging from 10–30 mm, height of the rib of 1.5 mm and duct aspect ratio of 8. The air flow rate corresponds to Reynolds number between 3000–12,000. The heat transfer results have been compared with those for smooth ducts under similar flow and thermal boundary condition to determine the thermal efficiency of solar air heater

2. OBJECTIVES

In this work it is intended to investigate experimentally the effect of wire geometry (transverse wires) of thin circular wire used as artificial roughness on heat transfer coefficient and friction factor in air ducts. To develop correlations for heat transfer coefficient and friction factor in terms of roughness and operating parameters. To develop experimental setup for below figure roughness geometry. Effect of relative roughness pitch (p/e) 10 to 40, for a fixed parameter relative roughness height (e/d_h) 0.034 and reynolds number (re) range from 3000 to 8000 for above roughness shapes are planned to be determined. Finally different roughness configurations will be compared with smooth surface.
The experimentation consists of different roughness provided to absorber plate as an wire geometry shown in the bllow figure having specifications listed in below table

Table -1: Experimental test setup specifications (Font-10)

Duct	2600mm long,150mm wide,30mmdeep
Test section	1200mm long
Entry length	800mm
Exit length	600mm
Absorber plate	2mm thick, 1200mm×150mm
Relative roughness pitch, p/e	10 to 40
Relative roughness height, e/D	0.034

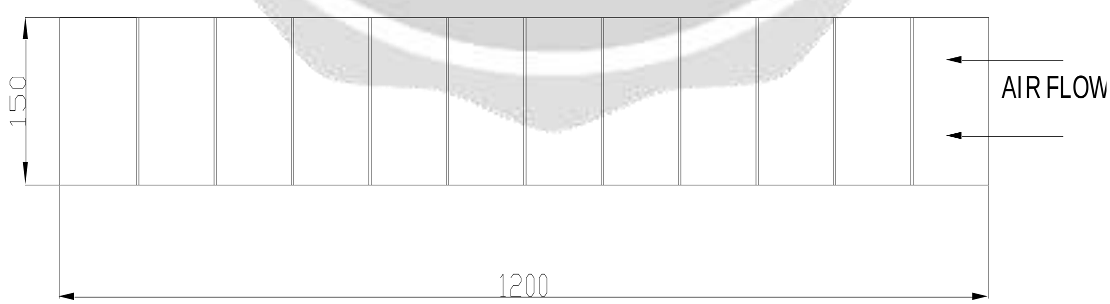

Fig - 2 Schematic diagram of transverse wire roughness geometry on absorber plate.

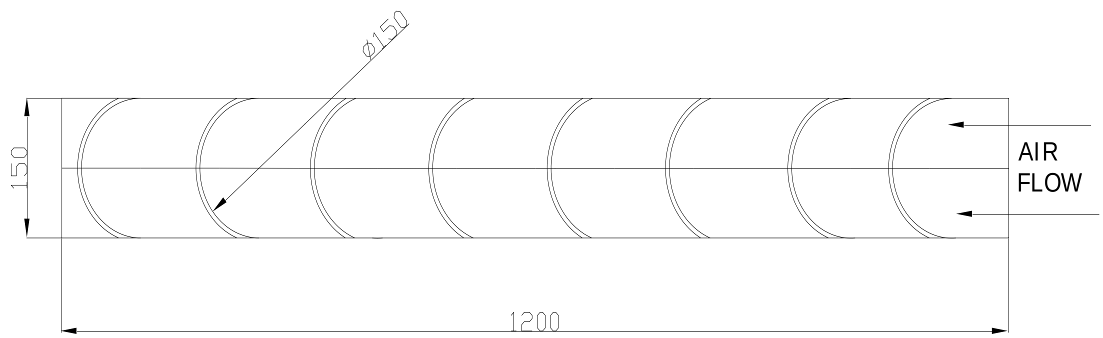

Fig - 3 Schematic diagram of single arc wire roughness geometry on absorber plate.

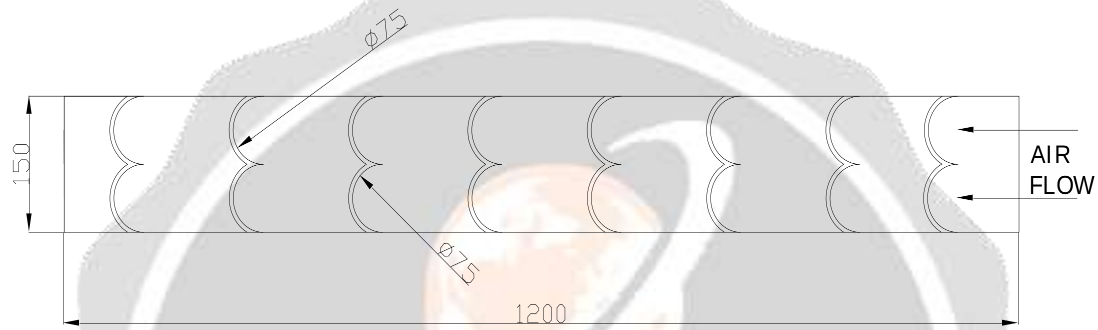

Fig -4 Schematic diagram of double arc wire roughness geometry on absorber plate

3. EXPERIMENTAL SETUP

Experimental test setup consists of electrical motor, blower, gate valve, Utube manometer, mixing chamber, micro manometer, heater, temperature sensor and indicator. The duct is of size 2600mm × 150mm × 30mm made of wooden panels. Test section is of length 1200mm. The length of smooth entrance section and exit section are 800mm and 600mm respectively. An electric heater is used to provide a uniform heat flux up to a maximum of 1500 W/m^2 to the absorber plate. Calibrated chromel–alumel thermocouples are used to measure air and plate temperatures at various locations. Micrometer is used to measure the pressure drop in the test section.

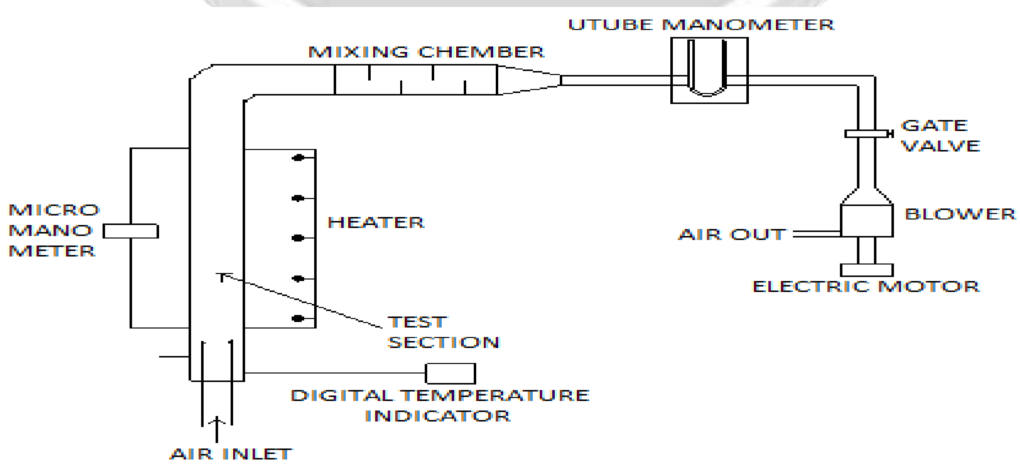

Fig -5 Experimental setup

4. REFERENCES

[1] Abdul-Malik Ebrahim Momin, J. S. Saini, S. C. Solanki, Heat transfer and friction in solar air heater duct with V-shaped rib roughness on absorber plate, International Journal of Heat and Mass Transfer 45 (2002) 3383-3396.

[2] J.C. Han, Heat transfer and friction characteristics in rectangular channels with rib turbulators, ASME J. Heat Transfer 110 (1988) 321-328.

[3] N. Sheriff and P. Gumley, Heat Transfer and Friction Properties of surface with Discrete Roughness, International Journal of Heat and Mass Transfer (9) (1996) 1297-1320.

[4] Santosh B. Bopche and Madhukar S. Tandale, Experimental Investigation oh heat and friction characteristics of a turbulator roughned solar air heater duct, International Journal of Heat and Mass Transfer 52 (2009) 2834-2848.

[5] M. M. Sahu and J. L. Bhagoria, Augmentation of heat transfer coefficient by using 90° broken transverse ribs on absorber plate of solar air heater, Renewable Energy 30 (2005) 2057-2073.

[6] A. M. Lanjewar, J. L. Bhagoria and R. M. Sarviya, Enhancement of heat transfer ratio in a solar air duct with W-shaped roughned absorber plate, Journal of environmental Research And Development, Vol.5 No.1, July-September 2010.

[7] Varun, R. P. Saini, S. K. Singal, Investigation of thermal performance of solar air heater having roughness element as a combination of inclined and transverse ribs on the absorber plate, Renewable Energy 33 (2008) 1398-1405.

[8] Apurba Layek J.S. Saini S.C. Solanki, Heat tramsfer and friction characteristics for artificially roughned ducts with compound turbulators, International Journal of Heat and Mass Transfer 50 (2007) 4845-4854.

[9] R.P. Saini and Jitendra Verma, Heat transfer and friction factor correlations for a duct having dimple-shape artificial roughness for solar air heaters, Energy 33 (2008) 1277-1287.

[10] Suman Saurav, M. M. Sahu, Heat transfer and Thermal Efficiency of Solar Air heater having artificial roughness: A Review, International journal of Renewable Energy Research.

[11] Prashant Kumar kori, A. R. jaurker, Enhancement of heat transfer rate by using different types of ribbed solar air heater- A review, International Journal of Engineering trends in Engineering and Development, Issue 2, Vol. 2, ISSN: 2249-6149.