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Experimental Analysis of Double Flow Solar Air Heater by using Multiple Arc Shape Baffle as Artificial Roughness- A Review

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***Abstract:** In the present paper, a comprehensive investigation on solar air heater for heating air having circular wire rib with artificial roughness in the form of arc shape on the back side of absorber plate, has been carried out. Artificial roughness used on the absorber plate is efficient method to improve performance of solar air heater. In present investigation on performance calculation of Solar Air Heater with arc shaped wire rib with artificial roughness absorber plate has been carried out by mathematical model and it is compared with a plane absorber Solar Air Heater. Multiple arc shaped ribs of double flow gives better heat transfer. All the parameters in this investigation has been decided on the basis of practical consideration of the system and operating condition of solar air heaters. In this investigation the parameters are taken such as relative roughness height(e/d) and angle of attack(α/90) have been studied on Nusselt number(Nu) and friction factor(f) with Reynolds number(Re) varies from 2000 to 17000.*

***Keywords:** Artificial Roughness, Solar air heaters, Roughness Geometry, Nusselt number, friction factor, angle of attack thermal efficiency, Reynolds number.*

I. INTRODUCTION

A solar air heater is very useful in thermal energy application. It is most usage in the area of space heating, curing the timber and drying of agricultural products etc due to its simple construction and it is very easy to use. The thermal efficiency of solar air heater is low due to its low heat transfer coefficient between air and the heat absorbing plate. The use of multiple arc shaped artificial roughness in solar air heater (SAH) duct is a efficient method to create turbulence near the absorber plate. It enhances the rate of heat transfer between absorber plate and air flowing through between absorber plate and air flowing through duct. Artificial roughness provides on the absorber plate, due to this increase the heat transfer coefficient and thereby the thermal efficiency. Energy is a basic requirement for human. Energy resources may be defined in two different ways conventional and non-conventional energy resources. It can be used in many kind of ways. The very simplest and the most economic way to utilize solar energy are to convert it into thermal energy for heating applications by using solar collectors.

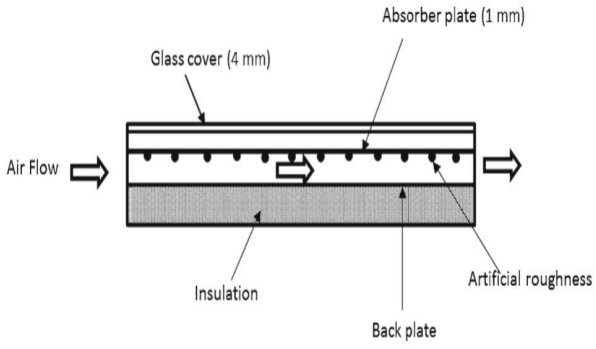

Fig.1. Solar Air Heater

In solar air heater the is passed through a rectangular cross-section duct below a absorber plate with it sun facing side blackened to absorption of solar radiation and incident on it. This heated air is to be used for many applications, such as drying for industrial,

space heating and agricultural purposes. There are many types of solar air heaters, but we consider the multiple arc shaped solar air heater, conventionally it consist mainly a panel, insulated hot air duct, a glass cover and an air blower. In solar air heater, if we want to attain higher convective heat transfer coefficient then it is desirable that the flow at the heat transfer surface should be turbulent. And this approach can be achieved by using artificial roughness surface on the air side. However, turbulence has to come from the blower or fan

II. LITERATURE REVIEW

There are many uses and applications of solar air heaters that are used at low and moderate temperatures. Some of these are drying for industrial, agricultural purposes, space heating, and curing of concrete/clay building components.

Mohit kumar et al.[1] Statistical correlations were developed for Nusselt number, friction factor, Stanton number and thermohydraulic performance parameter which gives maximum average deviations below 12% with reasonable accuracy.

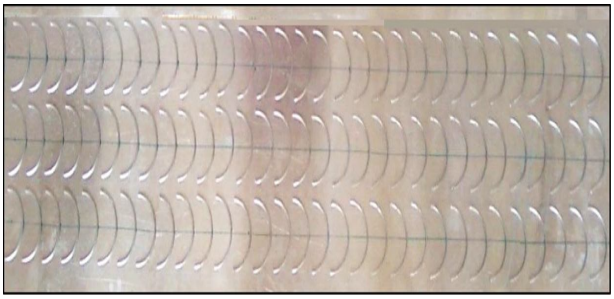

Fig.2. Multiple arc shape roughened absorber.

Singh et al. [2] performed an experimental investigation by varying roughness pitch (P) using five different rib pitch-to-height ratio (P/e) 4 – 12 on the thermohydraulic performance of V-down with gap roughened solar air heater.

Hans et al. [3] carried out experimental investigation on multiple V-shape roughened absorber plate solar air heater.

Kumar et al.[4] use multiple V-shaped ribs with the gap as roughness geometry and obtained maximum enhancement of Nu and f of 6.74 and 6.37 times respectively.

Alam et al.[5] referred Reynolds number, relative roughness height (e/D), relative roughness pitch (P/e), sphericity, roughness angle (a) and open area ratio as the affecting parameters.

Hans et al.[6] used multiple V-shaped AR in single pass SAH and obtained a maximum Nusselt number (Nu) for P/e value of 8.

Ho et al.[7] Collector efficiency of double pass SAH is evaluated.

Han et al. [8] seen the effect of artificial roughness on heat transfer and friction factor for two opposite roughened surfaces.

Mukesh Kumar et al.[9] A comprehensive theoretical analysis to evaluate thermal (Ƞth) and thermohydraulic (Ƞeff) efficiency of arc shaped roughened solar air heater has been done.

Prasad et al. [10] An analytical investigation for 3-sided transverse wire rib roughness in the duct of solar air heater, has been carried out.

Singh et al. [11] Experimental investigation was carried out on the solar air heater using multi V- shape with a gap as rib geometry on the absorber plate to know the effect of varying flow-attack-angle(α) from 30°-75° on the thermohydraulic performance factor.

Kumar et al. [12] performed experiments on discrete V-down shape rib roughened absorber plate and explored the effect of flow-attack-angle (α) on the thermohydraulic performance of solar air heater.

Bhushan and Singh et al. [13] carried out numerical analysis for thermal and thermohydraulic performance of solar air heater with protruded roughened absorber plate.

Patil et al.[14] Effect of gap position on thermohydraulic performance of solar air heater having broken V-rib roughness combined with staggered Rib have been investigated and found its thermohydraulic performance higher as compared to continious single V-shape and discrete V-down rib roughness.

Prasad B.N.et al. [15] carried out an outdoor experimental investigation for transverse wire rib roughness and found thermal performance enhancement ratio of 1.842 as compared to collector with smooth absorber plate.

Kumar and Saini et al. [16] The various roughness geometries, studied by the previous investigators, were reviewed and reported in the literature.

Behura et al. [17] An experimental investigation was carried out for 3-sided transverse rib roughness and found 40-48% enhancement in thermal performance over the 1-side artificially roughened solar air heater.
Singh et al. [18] Thermal efficiency and effective efficiency based analysis has been carried out numerically for the solar air heater having discrete V-down wire rib roughness.
Lanjewar et al. [19] studied a very narrow channel (AR = 8:1) with W-shaped, discrete W- shaped, v-shaped, angled ribs.
Singh et al. [20] conducted an experimental study on solar air heater roughened with circular transverse rib in actual atmospheric condition.

III. OBJECTIVE

A. The Objective of this Research Paper is

1) The objective of solar air heater is to maximize the rate of heat transfer , create maximum turbulence on absorber plate and minimize the pressure drop.
2) To discuss the variation of Reynolds number and Nusselt number.
3) To discuss the variation of Reynolds number and Thermal efficiency.
4) To discuss the variation of Nusselt number and Friction factor.
5) To compare the performance of conventional double flow solar air heater by using multiple C shape roughness with modified double flow solar air heater by using arc shape baffle roughness.

IV. PROPOSED METHODOLOGY

In this paper a complete experiment on thermal and thermohydraulic performances of solar air heater having arc shape baffles on both side of absorber plate at its air flow side and for the Reynolds number range of 2000-17000 has been carried out.
In this experiment we considered the double flow solar air heater , which gives better turbulence and better efficiency.
In this investigation we conclude copper baffle on absorber plate , which has better thermal conductivity.

V. CONCLUSION

A. There are Many Conclusion Has Been Drawn.

1) Double flow solar air heater gives better performance over single flow arrangement.
2) Multiple arc shaped arrangement on both side of absorber gives more heat transfer then single side arrangement
3) Arc shaped wire roughened solar air heater shows the appreciable enhancement in thermal and Effective efficiencies for all values of Reynolds number. The maximum values of thermal efficiency and effective efficiency are found to be 78.00% and 75.00% respectively corresponding to rib-height-to-duct hydraulic diameter ratio (e/D) = 0.0422 and flow-attack-497 angle ($\alpha/90$) = 0.3333
4) The set of rib-roughness parameters e/D = 0.042, P/e = 10 and $\alpha/90$ = 0.3333 for which the effective efficiency has its optimal value with temperature rise parameter ($\Delta T/I$) can be used for the design of solar air heater with its absorber plate integrated by wire roughness in the form of arc
5) Statistical correlation were advanced for friction factor ,Stanton number, Nusselt number and thermohydraulic performance parameters .

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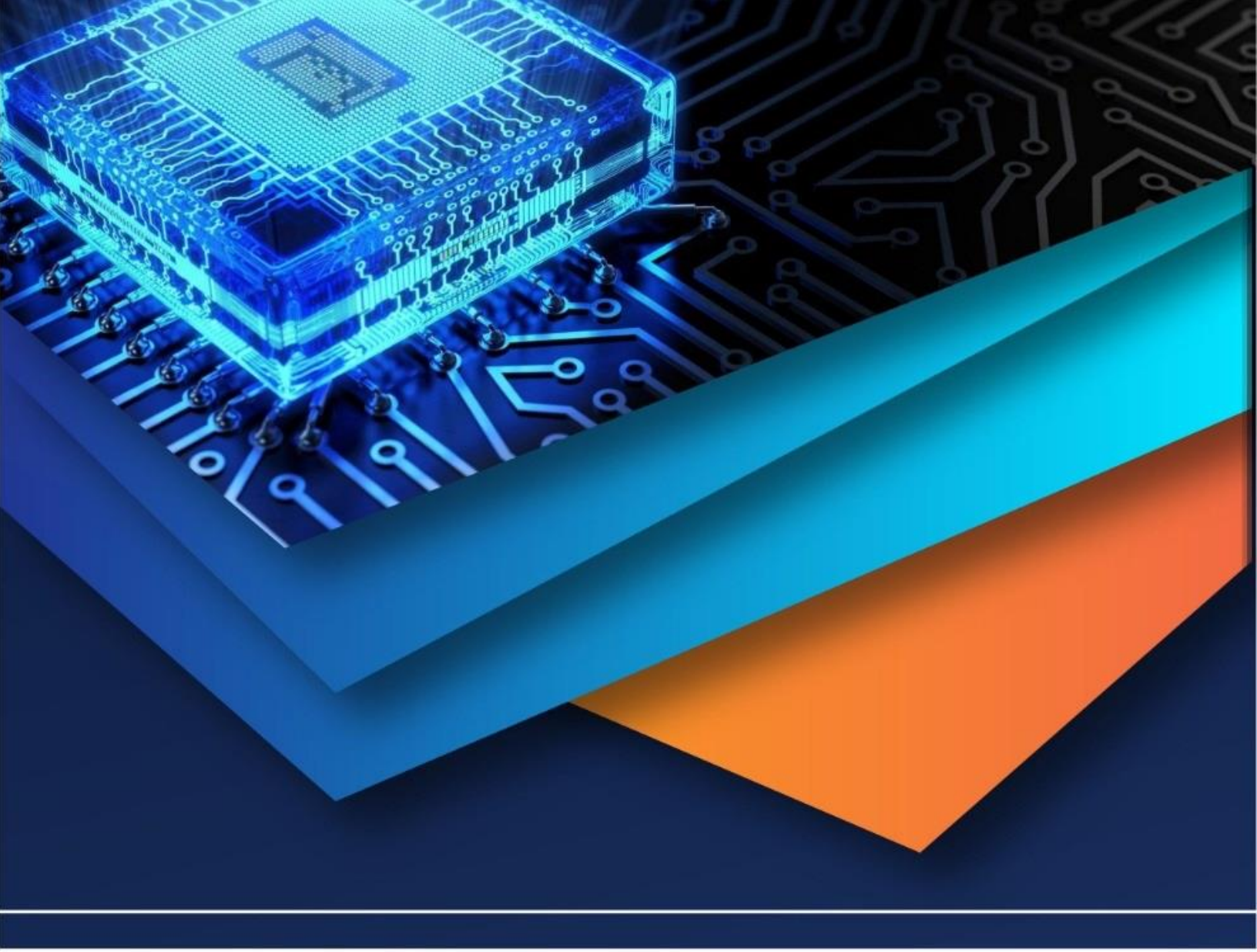

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