SOLAR AIR HEATER

Review of Solar Air Heater

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Abstract : This study has been undertaken to investigate Solar air heater that absorbs the incoming solar radiations and converts them to thermal energy. It has been observed that the efficiency of the flat plate solar air heater is low because of low convective heat transfer coefficient between the absorber plate the air flowing over it. The most effective way to improve the performance of the solar air heater is to provide artificial roughness elements beneath the absorber plate .So,the investigators studied different artificial roughness of the different geometry and has made analysis using various parameters like Reynolds Number,rib height ,pitch height ,test section containing the geometry.And correspondingly studied the output of these parameters on Nusselt number and the friction factor.

With the help of review we found that working numerically on different parameters with the help of CFD analysis that is working On ANSYS Fluent has made our work easier and we get better devices with maximum heat transfer rates using the geometry employed for eg geometry of W-shaped rib,V-shaped rib roughness.

Results states that the thermal efficiency obtained in the different works by CFD simulation results were found to be in good agreement as compared with simple duct and with the standard theoretical approaches. It has been found that the Nusselt number increases from 2 to 4times in every cases.

Moreover,thermo hydraulic performance parameter (THPP) is also evaluated for different geometry to predict the overall performance and also for selecting the best geometry for the range of parameter investigated.

I.INTRODUCTION

Artificially roughened solar air heater has been the topic of research for last thirty years. Several designs for artificially roughened solar air heaters have been proposed and discussed in the literature.Several investigators have attempted to optimize a roughness element, which can enhance convective heat transfer with minimum pumping power requirement by adopting experimental and numerical approaches. Most of the experiments are also conducted to specifically understand the influence of pitch-to-rib height ratio (P/e) and/or rib height-to-hydraulic diameter ratio (e/D) on average heat transfer and flow friction characteristics,and distributions of the mean velocities, pressure and turbulent statistics in the flows through the duct of an artificially roughened solar air heater. Literature search in this areas revealed that the heat transfer enhancement is strongly dependent on the relative roughness pitch (P/e) and relative roughness height (e/D) of roughness elements together with the flow Reynolds number (Re). There are lot of experiments have been done and so many experiments are going on right now to optimize roughness parameters for heat transfer enhancement in roughened duct of solar air heaters.The major experimental works for different roughness geometries and configurations applied on the absorber plate of a solar air heater.

Conventional techniques used for the design and development of an artificially roughened solar air heater are mostly tedious expensive and time consuming. CFD approach has emerged as a cost effective alternative and it provides speedy solution to design and optimization of an artificially roughened solar air heater. Computational fluid dynamics (CFD) is a design tool that has been developed over the past few decades and will be continually developed as the understanding of the physical and chemical phenomena underlying CFD theory improves. The goals of CFD are to be able to accurately predict fluid flow, heat transfer and chemical reactions in complex systems, which involve one or all of these phenomena. CFD uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. High speed computers are used to perform the calculations required to simulate the interaction of gases and liquids with surfaces defined by boundary conditions. With the development of numerical methodology and high speed computers, better solutions of fluid flow problems can be achieved. Ongoing research yields software that improves the speed and accuracy of complex simulation scenarios such as turbulent flows, transonic flows etc. Literature search in the area of artificially roughened solar air heater revealed that very few CFD investigation of artificially roughened solar air heater has been done to evaluate the optimum rib shape and configuration, which can enhance convective heat transfer with minimum pumping power requirement.

1.Prasad and Saini- has worked on Transverse wire rib roughness with the range of parameters of the following-

e/D: 0.02–0.033

P/e: 10–20

Re: 5000–50,000

<u>Output of the results-</u>

2.38 and 4.25 times enhancement in Nusselt number and friction factor respectively as compared to smooth duct.

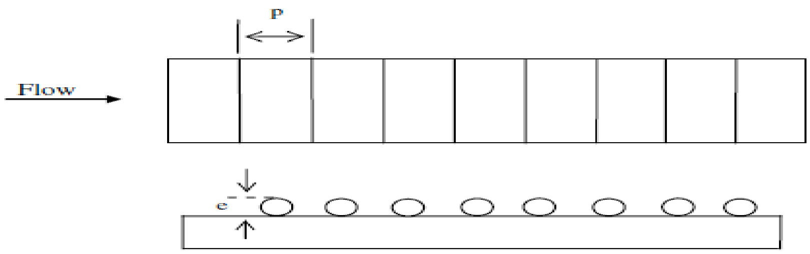

Fig- Transverse wire rib roughness

2.Saini and Saini- has worked on Expanded Metal Mesh roughness with the range of parameters of the following-

e/D: 0.012–0.0390

L/e: 25–71.87

Re: 1900–13,000

S/e: 15.62–46.87

Output of the results-

4 and 5 times enhancement in Nusselt number and friction factor respectively as compared to smooth duct.

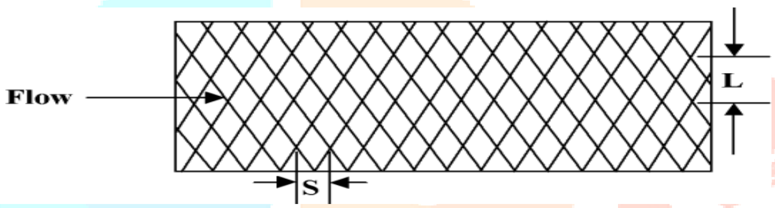

Fig- Expanded Metal Mesh roughness

3. Momin- has worked on V-shaped rib roughness with the range of parameters of the following-
e/D: 0.02–0.034
P/e:10
Re: 2500–18,000
W/H: 10.15
Output of the results-
2.30 and 2.83 times enhancement in Nusselt number and friction factor respectively as compared to smooth duct.

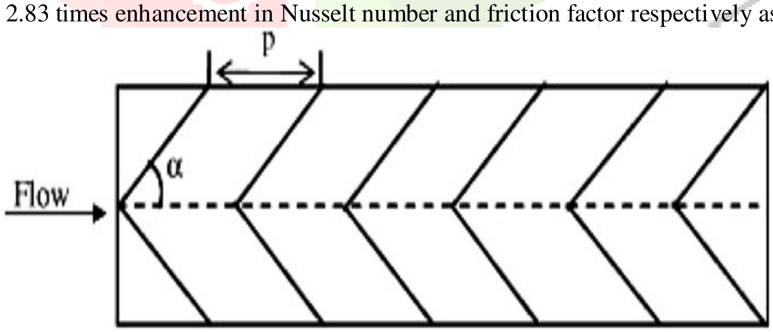

Fig-V-shaped rib roughness

4. Bhagoria- has worked on Transverse wedge shaped rib roughness with the range of parameters of the following-
e/D: 0.015–0.033
P/e: 60.17x

Re: 3000–18,000
W/H:5

Output of the results-
2.4 and 5.3 times enhancement in Nusselt number and friction factor respectively as compared to smooth duct.

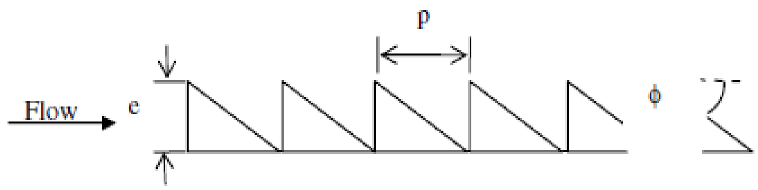

Fig- Transverse wedge shaped rib roughness

5. Sahu and Bhagoria-- has worked on 90degree broken rib roughness with the range of parameters of the following-

e/D: 0.0338
e: 1.5
P: 10, 20, 30
Re: 3000–12,000
W/H:8

<u>Output of the results-</u>

1.25–1.4 times enhancement in heat transfer coefficient was as compared to smooth duct.

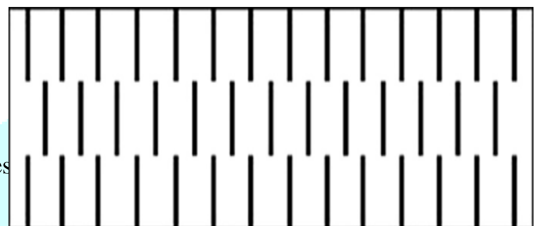

Fig-90degree broken rib roughnes

6. Saini and Saini- has worked on Arc shaped rib roughness with the range of parameters of the following-

e/d: 0.0213–0.0422
P/e:10
Re: 2000–17,000
W/H:12
a/90: 0.3333–0.6666

<u>Output of the results-</u>

3.8 and 1.75 times enhancement in Nusselt number and friction factor respectively as compared to smooth duct.

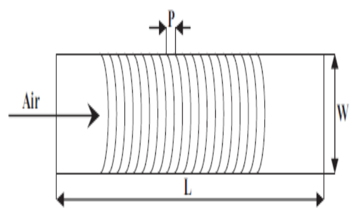

Fig- Arc shaped rib roughness

7. Varun- has worked on Combination of transverse and inclined rib roughness with the range of parameters of the following-

e/D: 0.030
e: 1.6 mm
P/e: 3–8
P: 5–13
Re: 2000–14,000
W/H:10

<u>Output of the results-</u>

Best thermal performance was reported over smooth duct for P/e = 8.

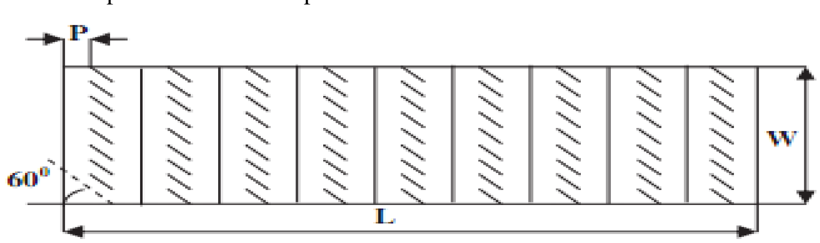

Fig- Combination of transverse and inclined rib roughness

8. Kumar- has worked on Discrete W-shaped rib roughness with the range of parameters of the following-
e/D: 0.0168–0.0338
e: 0.75–1.5 mm
P/e:10
Re: 3000–15,000
W/H: 8:1
<u>Output of the results</u>-2.16 and 2.75 times enhancement in Nusselt number and friction factor .

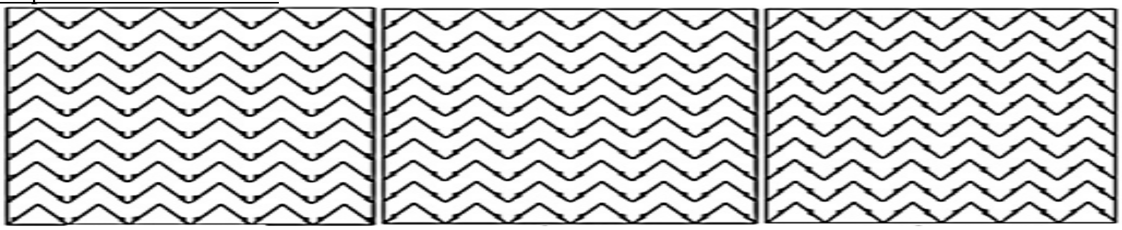

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Fig- Discrete W-shaped rib roughness

9. Lanjewar-- has worked on W-shaped rib roughness with the range of parameters of the following-
e/D: 0.018–0.03375
e: 0.8–1.5 mm
P/e:10
Re: 2300–14,000
W/H:8
<u>Output of the results-</u>
2.36and2.01 times enhancement in Nusselt number and friction factor as compared to smooth duct.

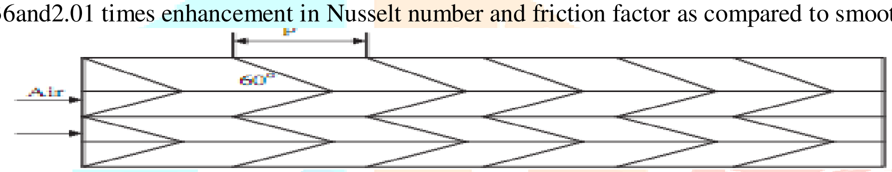

Fig- W-shaped rib roughness

10. Yadav and Bhagoria- has worked on equilateral triangular roughness with the range of parameters of the following-
'Re' 3800–18,000 ,
Pr' 0.71 p/e is from 7.14–35.71,
e/D -0.021–0.042.

<u>Output of the results-</u> Nusselt number has been found to be 3.073 times over the smooth duct corresponding to Reynolds number (Re) of 15,00 and the maximum enhancement in the friction factor has been found to be 3.356 times as compared to smooth duct.

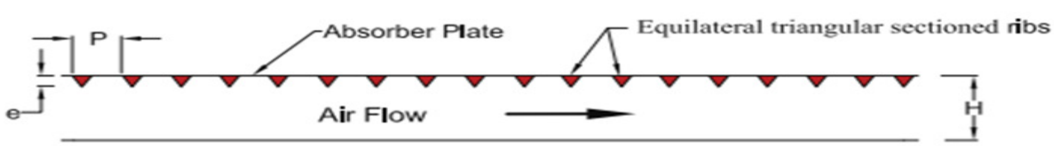

Fig-Equilateral Triangular Roughness

II. CONCLUSION-

Results states that the thermal efficiency obtained in the different work by CFD simulation results were found to be in good agreement as compared with simple duct and with the standard theoretical approaches. It has been found that the Nusselt number increases with increase in Reynolds number. The heat transfer and friction factor values obtained are compared with those of smooth duct under similar flow conditions. Investigation shows the better performance by reducing the friction factor and thus increasing the Nusselt number like we see in V and W shape roughness which enhance efficiency of solar air heater.

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