EVALUATING THE EFFECT OF USE OF RIB INSIDE THE SOLAR AIR HEATER THROUGH CFD ANALYSIS

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***Abstract*: Here in this work ribs were places inside the convex shape solar air heater. For analysing the effect of different pitch ratio, four different pitch ratio geometry was analysed numerically using ansys fluent. Through CFD analysis 25 mm pitch ratio shows the maximum heat transfer as compared to other pitch ratio. Effect of different shapes of ribs on heat transfer was also analysed, for that four different shapes of ribs was considered. Rectangular, triangular, right angle triangular and trapezoidal shapes of ribs was considered during the CFD numerical analysis. In the triangular shape of ribs shows the maximum heat transfer rate. It also analysed the effect of change in heat flux on absorber plate and measure the value of Nusselt number and heat transfer enhancement factor for each case in each type of solar air heater design.**

***Keywords*: Solar air heater, Ribs, Pitch ratio, Thermal performance, Shape of ribs, Heat flux**

1. Introduction

Renewable energy has long been of interest in electricity generation. Considering the different sources of renewable energy, solar energy is considered to be the main energy source on earth, but it depends on time and place. Radiant heat, as well as light approaching the sun, can be returned directly or indirectly in various forms of energy. However, solar energy is known to have disadvantages due to the low efficiency of the energy conversion system. One disadvantage of solar energy systems is the initial investment cost, which limits the amount of money many people invest in energy systems. The economic disadvantage is accompanied by an increase in the cost of installing solar energy technology, while the less energy produced, which is associated with other conventional energy systems, is therefore characterized by lower yields. As a result, solar energy is still a very expensive alternative to conventional energy sources such as fossil fuels, nuclear power and hydropower. Solar conversion systems are used to generate electricity indirectly from solar energy. Solar heating systems can be classified as low temperature or high temperature solar systems. High-powered solar heating systems include solar collectors, parabolic, solar towers (paralysis), parabolic reflectors, linear transformers, solar panels, food absorbers, and more. Discover its origins. Solar energy is considered a form of pure energy that can be used to generate electricity without harming the environment. Santhosh Bopche B and Madhukar Tandale S 2009.

In natural convection solar air heater, heat transfer mainly due to convection whereas heat transfer through radiation is avoided. With the used of chimney effect natural convection solar air heater performance get increase. For further improvement of performance in convex shape solar air heater, here in this work ribs are used inside the solar air heater. This work performs the effect of different pitch on the performance of solar air heater and optimize the conditions on the basis of Nusselt number and heat transfer enhancement factor. It also analyzed the effect of different shapes of ribs on the performance of solar air heater. Effect of different heat flux at different geometric conditions was also analyzed.

Here in this work, first numerical analysis of flat inclined plate solar air heater was analyzed using Ansys fluent, the value of Nusselt number at different heat flux was calculated and compare with the experimental result performed by Gilani et.al [1]. After validating the CFD analysis of flat solar air heater, convex shape curved solar air heater was analyzed. For this 50-degree curvature radius convex shape solar plate profile was considered as considered by Singh et.al [1]. Singh analyzed the effect of concave and convex shape solar air heater with chimney at different curvature radius and find that convex shaped profile with 50-degree curvature shows the maximum heat transfer. So here in this work, for enhancing the heat transfer capacity of convex shape profile by using ribs, 50-degree curvature radius profile was considered for each case of analysis.

2. Meshing

For finding the optimum value of number of nodes and elements, solid model of solar heater is discretized with different numbers of node and elements using different tools. The mesh used during the numerical analysis and validation of flat inclined plate solar air heater is shown in the below fig.

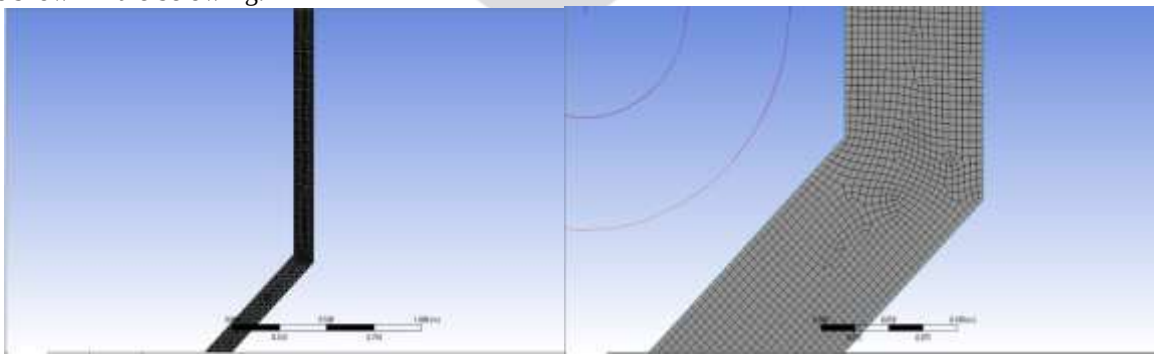

Fig.1 Mesh of solar air heater

32457 number of elements was considered during the analysis. For applying the different boundary conditions at different components of the system, name selection of different components of solar air heater was done. For performing the CFD analysis of solar air heater K-epsilon standard wall function model was considered. Different heat flux was applied at the absorber plate of solar air heater, basically for analyzing the effect of different heat flux on absorber plate four different flux was considered that are 500, 700, 900 and 1100 W/m^2. Through glass sheet heat transfer form the system was considered only through natural convection and 5.7 heat transfer coefficient was applied on the glass sheet.

3. Validation of Convex shaped solar air heater

For validating the CFD analysis Convex shaped solar air heater, same boundary conditions were considered during the numerical analysis was considered by Gilani et.al [1] and calculates the value of Nusselt number at different heat flux. Compare the value of Nusselt number with the value obtained through experimental analysis done by Gilani et.al [1].

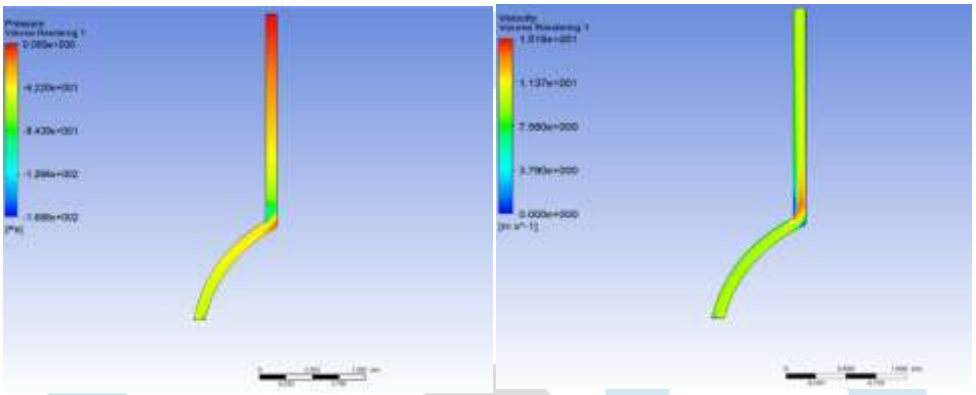

Fig.2 pressure and velocity variation for 500 W/m^2

From above graph it is found that the value of Nusselt number calculated through CFD analysis for convex shaped solar air heater is close to the value calculated by Singh et.al. The percentage error is also under permissible limit; hence it can say that the CFD analysis of convex shaped solar air heater is correct. So, after validating the numerical model for inclined and convex shaped solar air heater, effect of different pitch ratio and different shape of ribs was analyzed and calculated the heat transfer enchantment factor for each case of analysis.

4. Effect of Pitch

For increasing the heat transfer rate from the convex shape solar air heater, here in this work ribs are used inside the solar duct. For analyzing the effect of ribs at different pitch, rectangular shape ribs having 4 mm width and 5 mm height is used. This work considered four different pitch that are 15, 20, 25 and 30 mm. Calculate the value of Nusselt number for different pitch geometry at different heat flux.

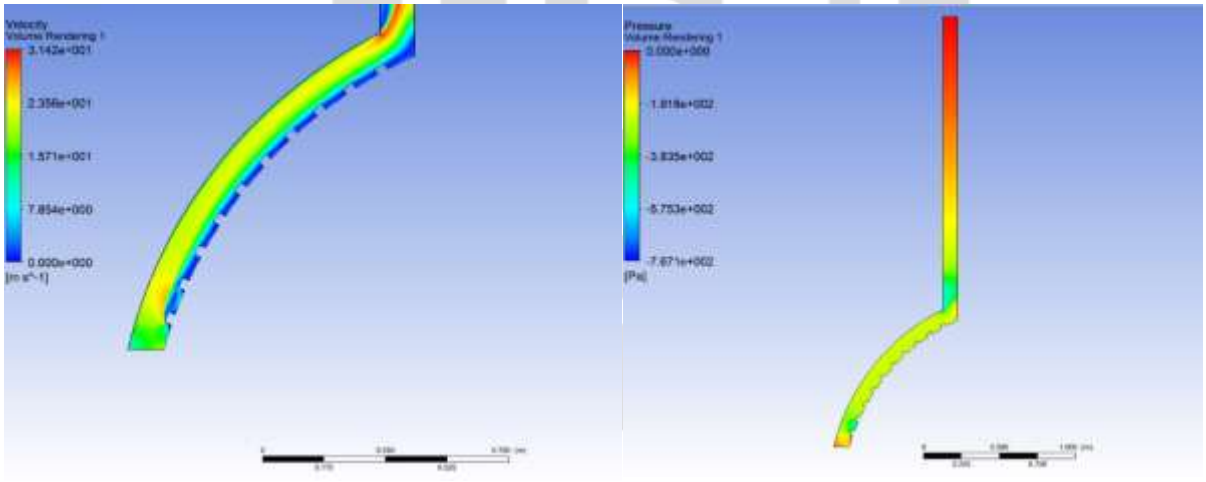

Fig.3 Velocity and Pressure variation for 20 mm pitch solar air heater

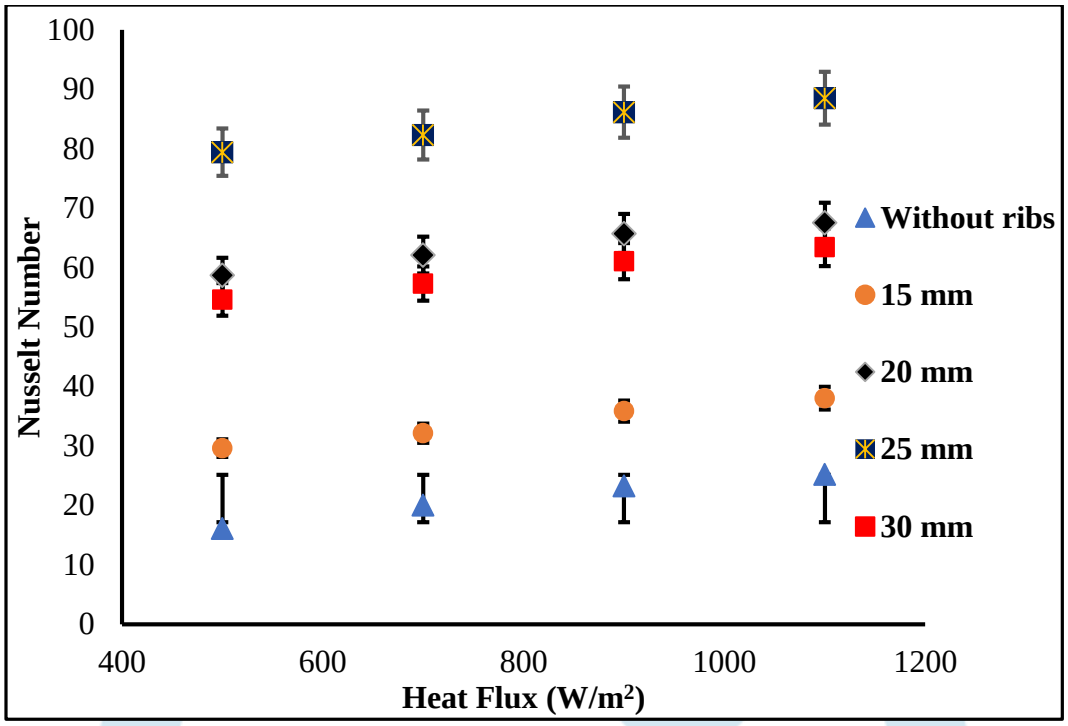

Fig.4 Value of Nusselt number for different pitch ratio

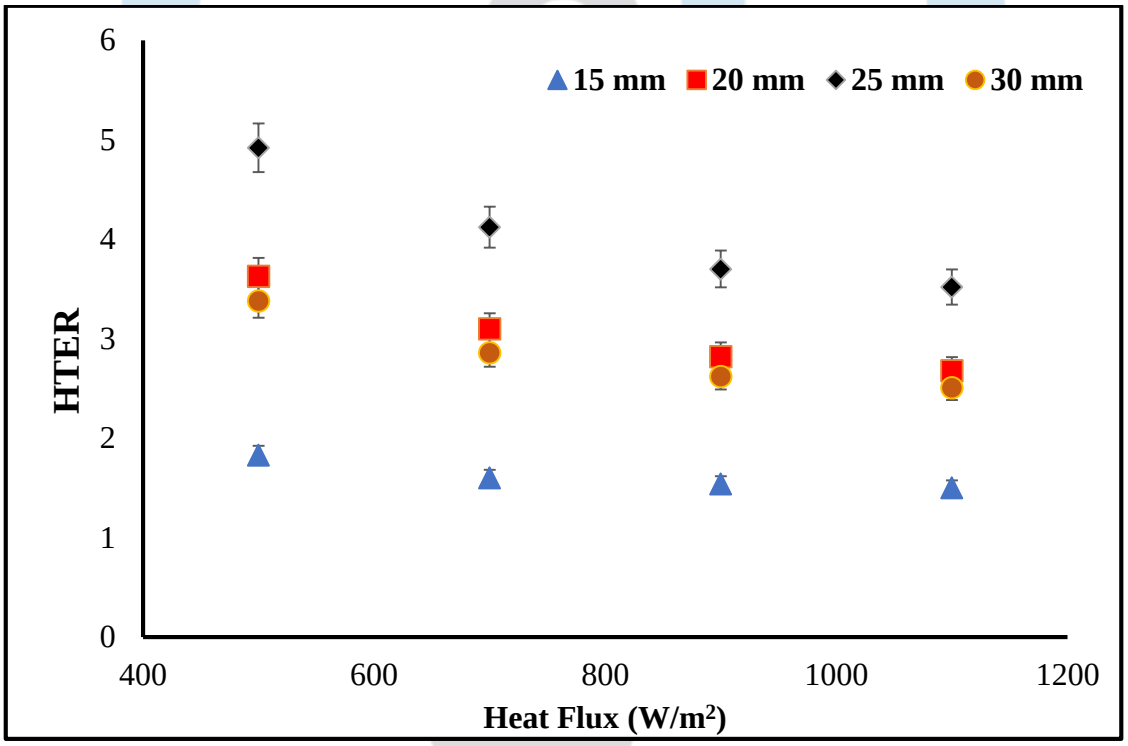

Fig.5 Heat transfer enhancement factor for different pitch ratio

The Nusselt number of convex shape solar air heater having ribs is higher than the simple convex shape solar heater. From above graph it is found that for 25 mm pitch, heat transfer from solar heater is maximum as compared to other pitch. There is very marginal difference in between 20- and 30-mm pitch. Through graph it is concluded that convex shape solar air heater having rectangular ribs with 25 mm pitch ratio shows the maximum heat transfer. Through analysis it can say that with 25 mm pitch rectangular rib solar air heater work more efficiently than the other pitch ratio. After analysing the effect of different pitch ratio on the performance of solar air heater having rectangular ribs

5. Effect shapes of ribs

For analysing the effect of different shapes of ribs, four different shapes of ribs that is rectangular, triangular, right angel triangle and trapezoidal were analysed in this work. In each case of shapes of ribs effect of different heat flux was also analysed and measure the value of Nusselt number for each case.

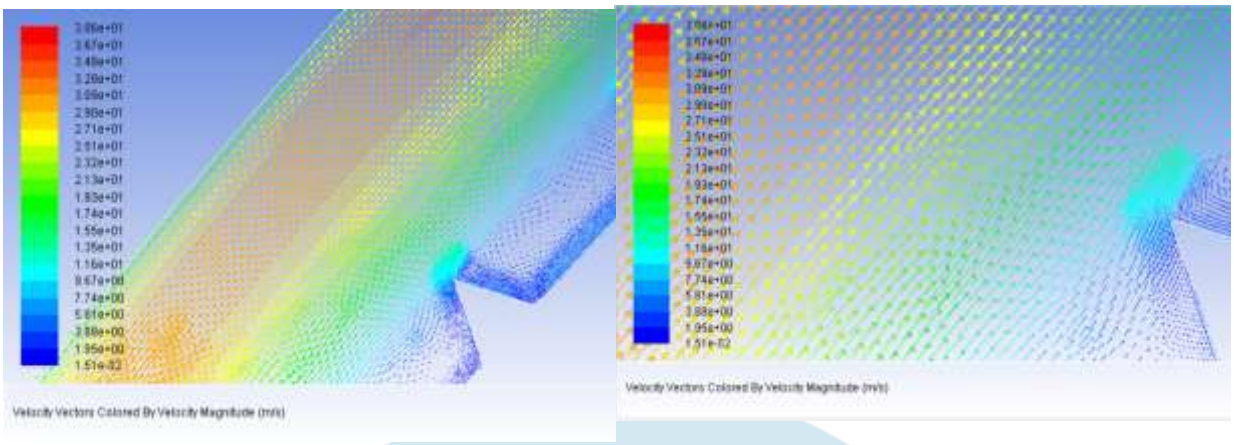

Fig.6 The velocity vector for triangular ribs

6. Comparison of shapes of ribs

After numerically analysing the solar air heater having different shape of ribs, comparison was done on the basis of Nusselt number at different heat flux. The value of Nusselt number for different shapes of ribs was mention in the below figure.

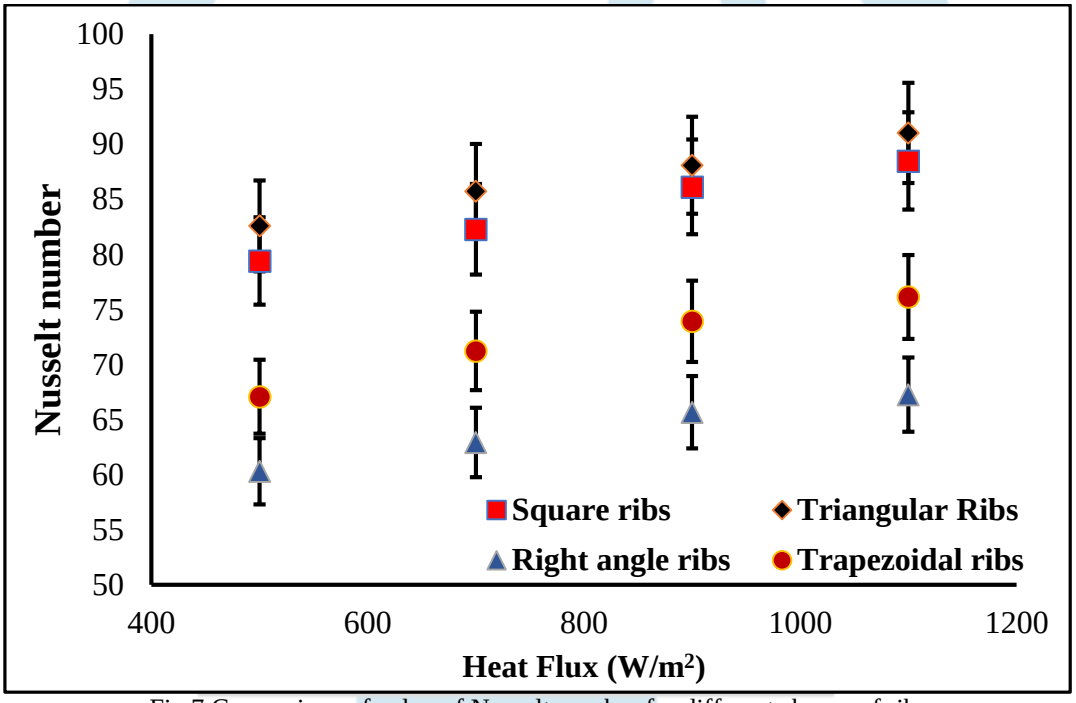

Fig.7 Comparison of value of Nusselt number for different shapes of ribs

Table.1 Value of heat transfer enhancement ratio (HTER) for different shapes of ribs

S.No	Heat flux (W/m^2)	HTER for rectangular	HTER for Triangular	HTER for Trapezoidal	HTER for Right angle triangle
1	500	4.92	5.12	4.15	3.73
2	700	4.12	4.28	3.55	3.14
3	900	3.7	3.78	3.17	2.82
4	1100	3.52	3.61	3.02	2.67

From above fig. it is found that, solar air heater with triangular shape of ribs shows the maximum value of HTER, which means that it shows the maximum heat transfer capacity as compared to other shapes of ribs.

Conclusion

Through analysis it is found that value of Nusselt number increases marginally for convex shape as compared to flat plane inclined solar air heater. For further improvement of heat transfer from solar air heater, ribs are used inside the solar duct. Through CFD analysis it is found that heat transfer increases significantly while using ribs as compared to simple convex shape solar air heater.

With 25 mm pitch ratio value of heater transfer and HTEF is maximum as compared to other pitch ratio. After analysing the effect of different pitch ratio effect of different shapes of ribs was also analysed, and through numerical analysis it is found that solar air heater having triangular shape ribs shows the maximum heat transfer as compared to other shape of ribs.

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