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AN ANALYSIS OF V SHAPES OF RIBS AT CONSTANT PITCH RATIO IN SOLAR AIR HEATER

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Abstract: *Experiments are conducted to assess turbulent forced convection heat transfer and friction loss behaviors for air flow through a constant heat flux channel fitted with different shaped ribs. The rib cross-sections used in the present study are triangular (isosceles), wedge (right-triangular) and rectangular shapes. Two rib arrangements, namely, in-line and staggered arrays, are introduced. Measurements are carried out for a rectangular channel of aspect ratio, AR = 15 and height, H= 20 mm with single rib height, e= 6 mm and rib pitch, P= 40 mm. The flow rate is in terms of Reynolds numbers based on the inlet hydraulic diameter of the channel in a range of 4000 to 16,000. The experimental results show a significant effect of the presence of the ribs on the heat transfer rate and friction loss over the smooth wall channel. The in-line rib arrangement provides higher heat transfer and friction loss than the staggered one for a similar mass flow rate. In comparison, the wedge rib pointing downstream yields the highest increase in both the Nusselt number and the friction factor but the triangular rib with staggered array shows better thermal performance over the others.*

Key Words*: Nusselt number, Reynolds numbers, hydraulic diameter, friction loss, friction factor and heat flux etc …*

1. INTRODUCTION:

In view of the world’s depleting fuel reserves, that provide the important resource of energy, the growth of non-conventional renewable energy sources has received an impetus. energy is vital for the existence and development of group and could be a key issue in international politics, the economy, military preparation, and diplomacy. to cut back the impact of conventional energy sources on the atmosphere, plethoric attention ought to be paid to the development of recent energy and renewable energy resources. solar energy, that's atmosphere friendly, is renewable and should function a property energy supply. hence, it'll positively become an important a part of the long run energy structure with the progressively evaporation of the terrestrial fossil fuel. however, the lower energy density and seasonal doing with geographical dependence are the foremost challenges in characteristic acceptable applications mistreatment solar energy because the heat resource. consequently, exploring high efficiency solar energy concentration technology is very important and realistic [ref. (xie et al., 2011)]. solar energy is free, environmentally clean, and then is recognized together of the foremost promising energy recourses choices. in close to future, the large-scale introduction of solar energy systems, directly changing radiation into heat, are going to be looked forward. however, solar energy is intermittent by its nature; there is no sun in the dark. its total obtainable worth is seasonal and depends on the environmental condition of the placement. Undependability is that the biggest retarding issue for extensive solar energy utilization. Of course, defence of solar energy could also be long-drawn-out by storing its serving once it's in way over the load and exploitation the keep energy whenever needed. Extensive research is being conducted in this field by many authors, whose work generally involves performing experiments or carrying out numerical simulations with different types, sizes and patterns of ribs/ baffles and finding the right parameters at which the heater gives optimal performance (minimum friction loss and maximum heat transfer). Some scientists, after performing research work on solar air heaters, develop a set of correlations for calculating Darcy’s friction factor and Nusselt number in terms of operating and roughness parameters. The mechanism by which heat transfer, between air and roughened absorber plate, increases is breakage of laminar sub-layer. The introduction of ribs leads to local wall turbulence and 3 breakage of laminar sub-layers leading to periodic flow reattachment and separation. Vortices are formed near these baffles, which leads to a significant rise in Nusselt number. As compared to experimental activities being carried on solar air heaters, very less numerical work has been done in this field. Numerical study of solar air heaters using CFD software is an excellent method to understand in detail how flow behaves under the presence of obstacles in solar air heaters. CFD results are more accurate as compared to experimental results. Other benefits of using CFD software are saving of time and less costs required to complete the work. Some commercially available CFD software packages are FLUENT, FLOVENT, CFX, STARCD and PHOENICS**.**

1.1 Fiber Glass Duct Board - Fiber glass duct board panels provide built-in thermal insulation and the internal superficial gripsall-encompassing, facilitating to offer quiet procedure of the hvac system. the duct board is made by sliding a specially-designed knife along the board employing a straightedge as a guide. the knife automatically trims out a groove with 45° sides that doesn't quite penetrate the whole depth of the duct board, so providing a thin section acting as a hinge. the duct board will then be collapsed along the groove to provide 90° folds, creating the rectangular duct shape in the fabricator's desired size. the duct is then closed with outward-clinching staples and special aluminium or similar metal-backed tape.

1.2 Flexible Ducting –Flexible ducts (also referred to as flex) are usually made from flexible plastic over a metal wire coil to shape a tube. they need a variety of configurations. in the u.s., the insulation is usually glass wool, however different markets like Australia, use both polyester fibre and glass wool for thermal insulation. a protecting layer surrounds the insulation, and is typically composed of polyethylene or metalized pet. it’s unremarkably sold-out boxes containing 25' of duct compressed into a 5' length. it’s out there in diameters starting from as tiny as 4" to as massive as 18", but the widely used are uniform sizes reaching from six to eleven. versatile duct is extremely convenient for attaching offer air shops to the rigid ductwork. it’s unremarkably connected with long zip ties or metal band claps. however the pressure loss is more than for many totally different kinds of ducts. as such, originators and installers try to keep their installed measurements like length small, e.g. less than fifteen feet, and try to minimalize turns. kinks in flexible ducting should be escaped. flexible duct on the return air portions of hvac systems, however versatile duct will tolerate moderate negative pressures. the ul181 test requires a negative pressure of 200 pa.

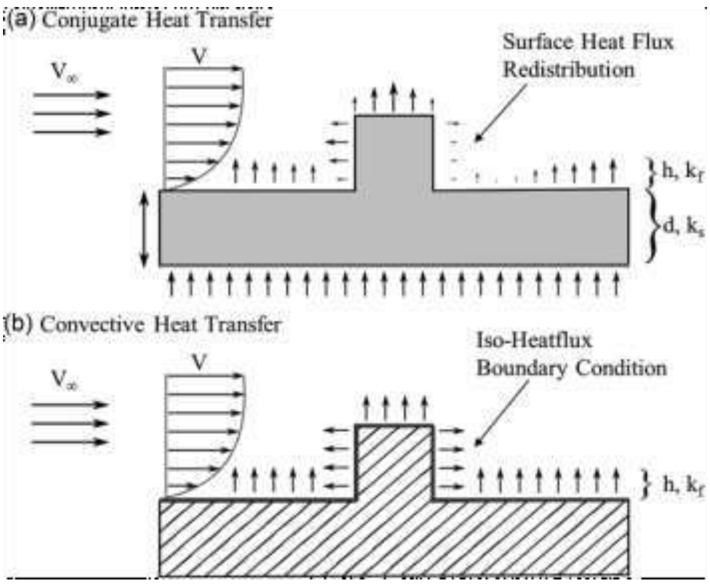

Fig. 1. breakage of laminar sub-layer

2. MODELLING AND ANALYSIS

Geometry is formed in modelling software CREO 5.0 and it's imported to the ANSYS workbench 15.0 where meshing is completed, and exports the mesh to FLUENT. The boundary conditions, material properties, and encompassing properties are set through parameterized case files. FLUENT solves the problem until either the convergence limit is met, or the amount of iterations specified by the user is achieved.

The procedure for resolving the problem is:

- Create the geometry.
- Meshing of the domain.
- Set the material properties and boundary conditions.
- Obtaining the solution

2.1 Preparation Of The Cad Model

The dimensions of the computational domain heat sink were based on the work by Rajesh Maithani, J.S. Saini. After this process the constraint are applied and this way the model is achieved in modelling software CREO 5.0.The following Table (3.1) & (3.2) shows the parameters of solar air heater duct roughened artificially with V-ribs and Semicircular V-ribs.

Table 1 Geometry Parameters of Duct

Duct Length, L(mm)	Duct Thickness, t(mm)	Rib Number ,N	Duct Width (mm)	Rib-to-Rib distance,
1100	25	5	300	200

Table 2 Dimensions of Roughness on Duct

Model	Rib Height (mm)	Rib Gap(mm)
V-Rib Roughness	1.5	2
V-Rib Roughness	2.5	2
V-Rib Roughness	3.5	2
V-Rib Roughness	4.5	2
V-Rib Roughness	5.5	2
V-Rib Roughness	6.5	2

As we have to vary the Solar Duct with Semi Semi-circular V-Rib roughness (1.5mm-6.5mm) and gap is constant 200mm is constant and also the profile (Semi-circular) so this is taken into the consideration and another various models are prepared.

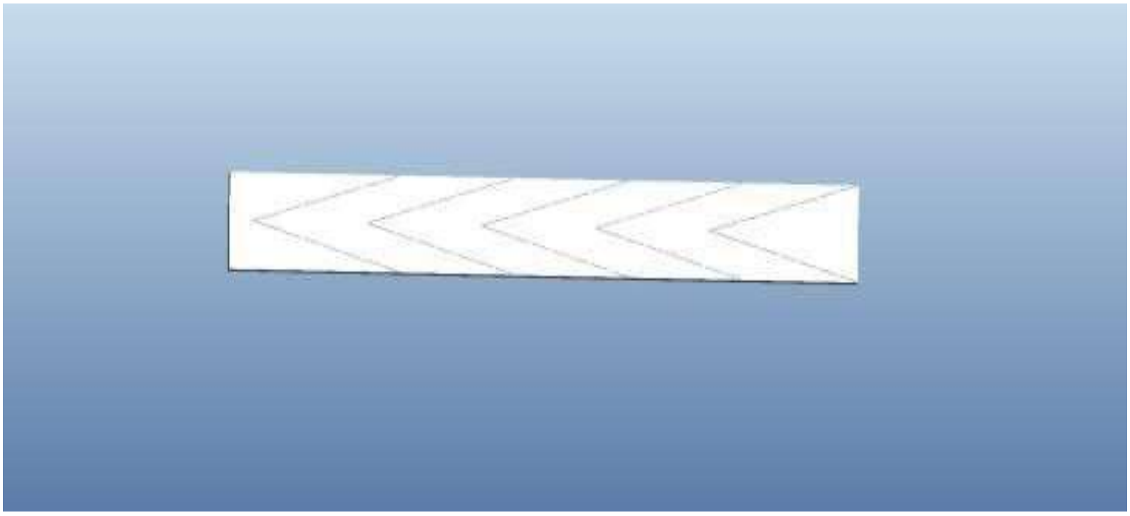

Fig. 2, 3D Model 1.5 Solar Duct with Semi Semi-circular V-Rib roughness

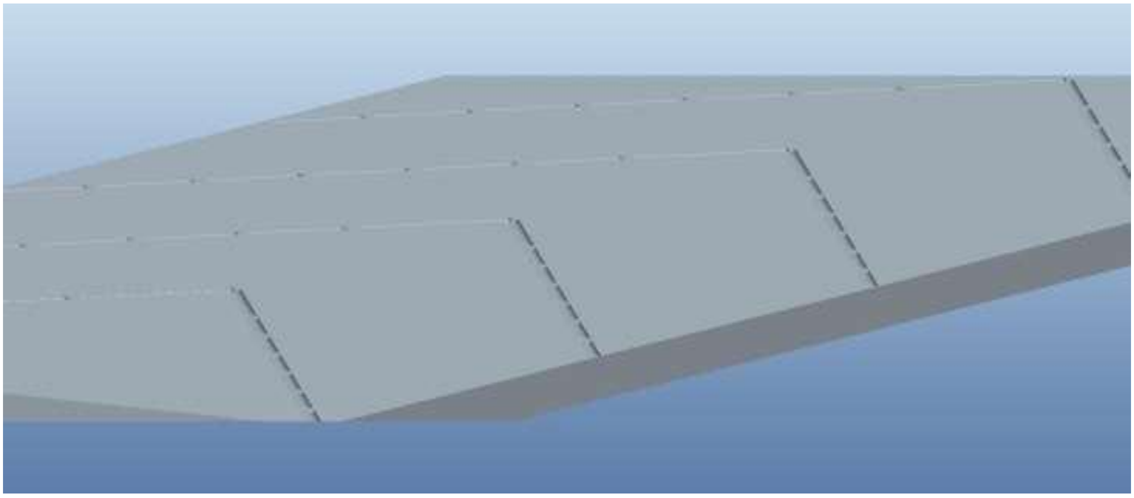

Fig. 3, 3D Model of 2.5 Solar Duct with Semi Semi-circular V-Rib roughness

2.2 Meshing Of The Domain

Experimental in Para solid format (: .x-t) to the ANSYS workbench Design modular. Then defining the air domain and solid domain. There for further Processing. Defining the mesh to the domain. The second part of pre-processing is the mesh generation. When the model is imported to ANSYS workbench it's then launched within the meshing module for the mesh generation Coarse, medium, and fine mesh types are obtainable. Mesh density varies based upon the assigned Refinement factor. Mesh is the key part of a high quality convergence. There are 3 types of meshing domain. These are Hexahedral Cartesian, Hexahedral Unstructured and Tetrahedral mashers. Hexahedral Cartesian mesher is the one generating totally structured meshes. Total number of elements 22886 & nodes 35743 were employed to assess the grid independence in the Solar Duct with Semi Semicircular V-Rib roughness case. A total number of elements higher than above meshes were employed in the Solar Duct with Semi Semicircular V-Rib roughness case. It is clear that the present results have good relations with the available data in the literature. The results of the grid refinement study showed that the simulations based on the Solar Duct with Semi Semicircular V-Rib roughness case the meshes provide satisfactory numerical accuracy and are essentially grid independent in these cases

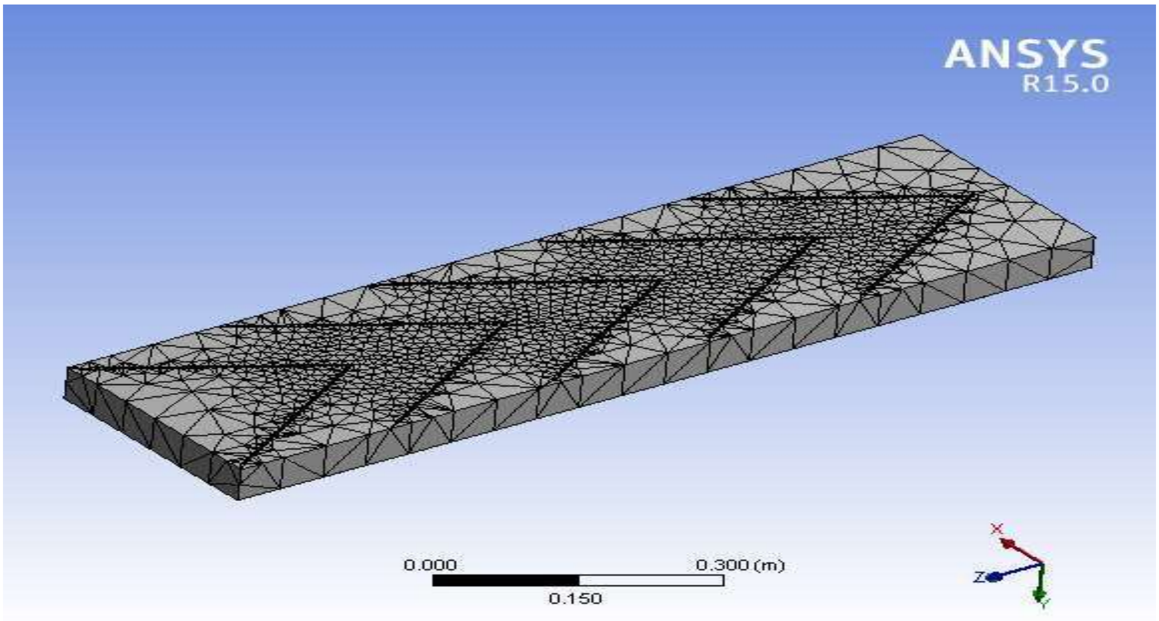

Fig. 4 Mesh of the Solar Duct with Semi Semi-circular V-Rib roughness

3. RESULT ANALYSIS DISCUSSION

A three-dimensional model is developed to investigate flow and conjugate heat transfer in the Solar Duct for comfort cooling applications. A series of numerical calculations have been conducted by FLUENT and the results are presented in order to show the effects of temperature distribution, Friction factor, and Surface Nusselt number with respect to relative gap width in the Solar Duct with Semi Semicircular V-Rib roughness.

3.1 Experimental And Simulation Result

The friction factor of the Solar Duct with Semi Semi- circular V-Rib roughness, f, can be defined by-

$$F = \frac{2(\Delta P)_d D}{4\rho L V^2} \quad (1)$$

Where ΔP is Pressure drop between the highest pressure on the solar duct and the ambient air pressure, and Q is heat dissipation power applied on the duct base. Properties of the working fluid are the same as those of ambient air, and the material of solar duct is aluminium with thermal conductivity of 202 W/ (m-K).Both simulation results and Rajesh Maithani, J.S. Saini experiment results for friction factor and nusselt no. of the Solar Duct with Semi Semicircular V-Rib roughness are plotted in Fig 4 and 5 respectively. As can be seen in these figures.

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Observation Table-

(a) Friction Factor :Table-(3) Experimental and Simulation Result for the Solar Duct

Relative Gap Width	Experimental Result	Simulation Results
1	0.005	0.004
2	0.006	0.006
3	0.007	0.008
4	0.008	0.007
5	0.009	0.006
6	0.010	0.004

(b) Nusselt no.: Table-(4) Experimental and Simulation Result for the Solar Duct

Relative Gap Width	Experimental Result	Simulation Results
1	5	8
2	10	12
3	20	26
4	30	37
5	40	44
6	50	56

Roughness Model	Wind Velocity (m/s)	Heating Power (w/m^2)	Friction Factor (f)	Reynolds no. (k)	Nusselt Number (Nu)
Plane Model	6.5	1000	0.002	2000	10
1.5mm	6.5	1000	0.004	4000	14
2.5mm	6.5	1000	0.006	6000	28
3.5mm	6.5	1000	0.004	8000	39
4.5mm	6.5	1000	0.003	10000	46
5.5mm	6.5	1000	0.002	12000	58

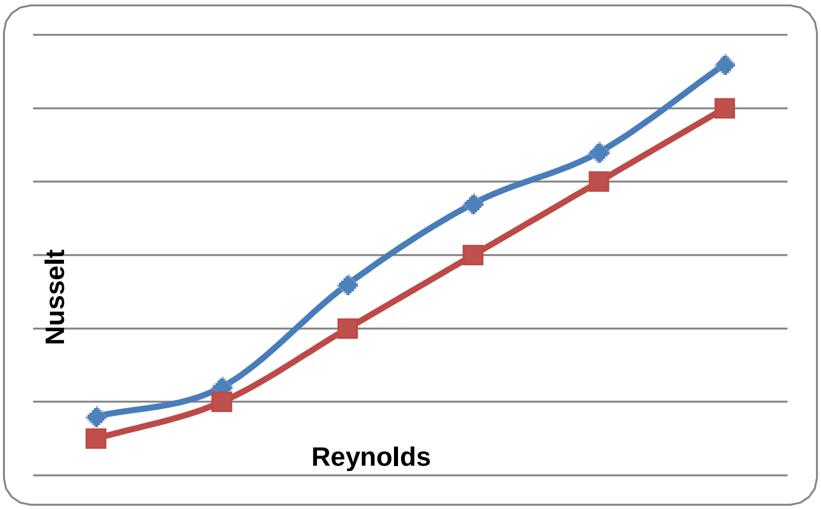

Fig. 5.Experimental and Simulation results for the Solar Duct: Nusselt no. vs. Reynolds no.

The above figure 4. shows the Nusselt no for Solar Duct with Semi Semicircular V-Rib roughness with experimental and simulation gives a constant deviation but in similar manner.

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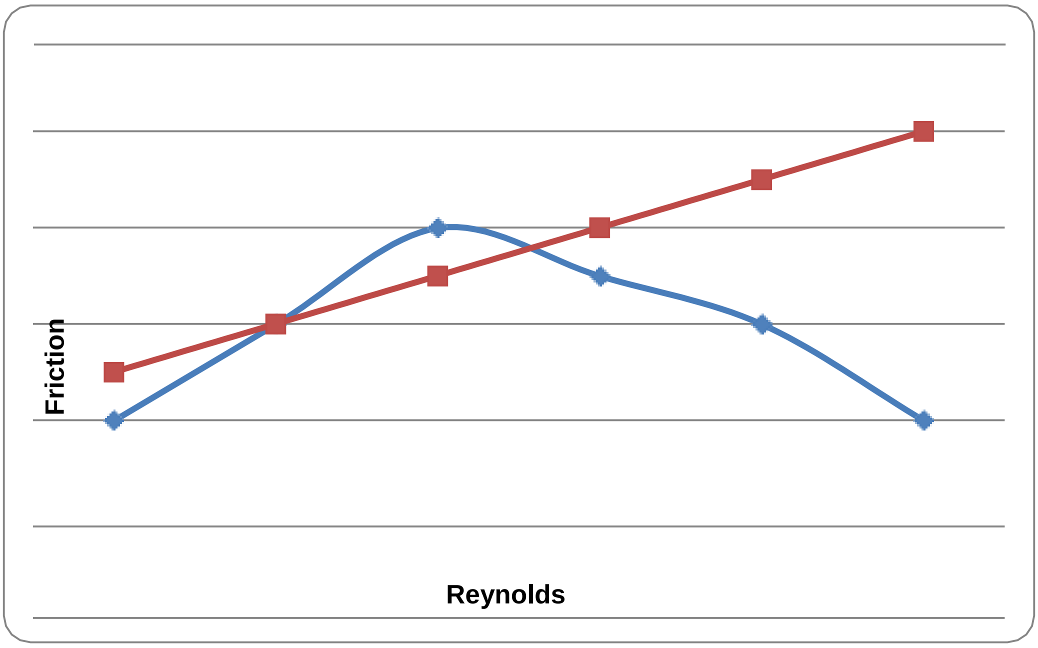

Fig. 6 Experimental and Simulation results for the Solar Duct: Friction factor vs. Reynolds no.

This figure 5 shows the experimental and simulation result of Solar Duct Friction factor. The results are slightly above than experimental values, the deviation almost constant.

3.2 Simulation of various Heats sinks Pin Model

The Solar duct with semi-circular roughness is simulated and the results of temperature contours, velocity vectors, Surface Nusselt number and the effects of heat flux at different roughness of artificially roughened solar duct are presented.

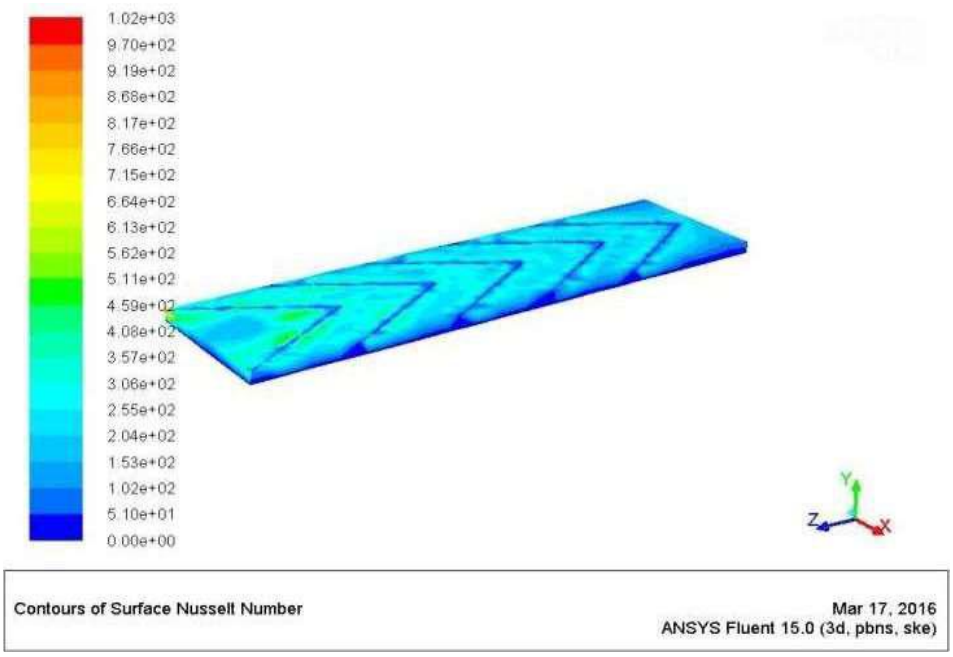

Fig. 7: Nusselt Relative gap width of semicircular shaped roughened duct with 6.5m/s velocity

The above figure 6 shows the Friction Factor variations for different profile of semicircular roughness with compare the experimental result(1) of smooth & circular duct and simulation result of various fin profile of semicircular roughness gives a constant deviation in semicircular roughened duct but in similar manner of experimental results. This figure shows the decrease in the friction factor with increase in the Reynolds no.

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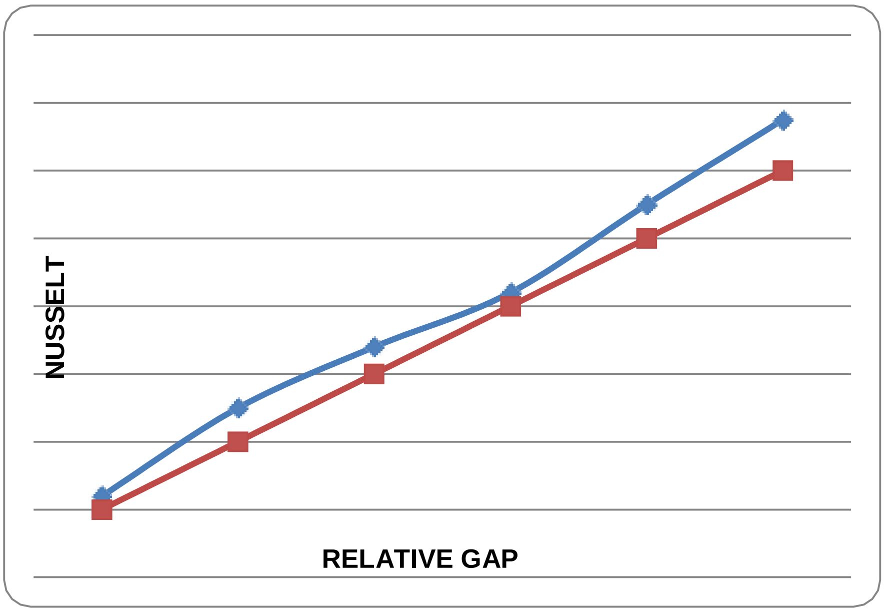

Fig. 8 Nusselt Number Variations for Different Profile of Relative Gap Width of Solar Duct with Semi Semi-circular V-Rib roughness

The above figure 4.33 shows the Nusselt number variations for different Relative gap width with compare the experimental result(1) of circular and smooth duct a simulation result of various duct roughened profile of solar duct gives a constant deviation. This figure shows the increase in the Nusselt number with different relative gap width. This is better result of experimental result.

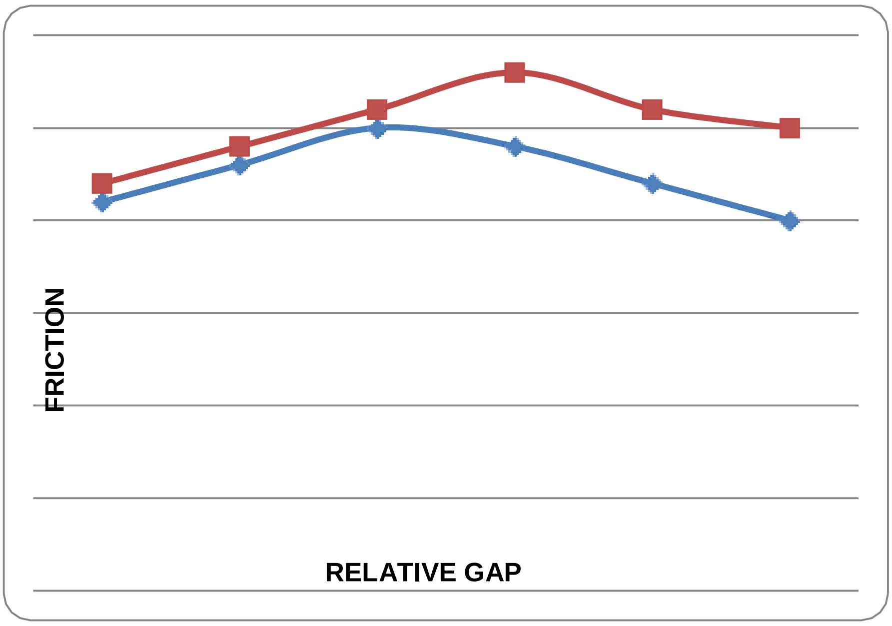

Fig. 9 Friction Factor Variations for Different Profile of Relative Gap Width of Solar Duct with Semi Semi-circular V-Rib roughness.

1. As the Relative gap width increases the friction factor decreases along the Duct length because of growing boundary layer thickness. in Nussle number. and reduce in friction issue with compared experimental result.

5. CONCLUSION:

- The prediction of CFD model shows smart relation with experimental result gift in literature [1].

- Simulated the star dust of curving roughness having different Relative gap breadth constant speed of (6.5m/s) and at constant heat input of 1000(W/m2).
- From the on top of result we've got least friction think about curving cracked duct of 1.5mm i.e. 0.002, then one.5mm i.e.0.002
- From the higher than result we've best Nussle variety in curving roughness with 1.5mm relative gap breadth i.e. 58, then 4.5mm relative gap breadth i.e. 46
  So, from the on top of we will conclude that the 5.5mm relative gap breadth at constant speed having higher heat transfer rate thanks to increase in Nussle no. and reduce in friction issue with compared experimental

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