FLOW AND HEAT TRANSFER ANALYSIS OF VARIOUS RIBS FOR FORCED CONVECTION HEAT TRANSFER

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***Abstract—* Heat transfer enhancement techniques are used in heat exchanger systems in order to enhance heat transfer and improve the thermal performance. Several methods are applied in order to improve thermal performance of heat transfer device such as treated surface, rough surface and incorporation of inserts. My work focuses on use of various Ribs to enhance heat transfer. The ribbed wall destabilized the flow. The separations and reattachments over the ribbed wall increase fluid mixing, create flow unsteadiness, interrupt the development of the thermal boundary layer and enhance the heat transfer. In this paper CFD analysis of different shape ribs such as V-ribs, (simple and broken v-ribs), triangular and rectangular ribs placed in rectangular duct has been performed.**
The work carried out in two stages:
1. Modeling of ribs for different shapes. It has been done in CATIA.
2. Analysis of flow and predict the best suited Rib among the various ribs considered. Analysis has been done in ANSYS CFD.

***Index Terms—* heat transfer enhancement, Ribs, V and Broken v ribs, CFD analysis of ribs...**

I. INTRODUCTION (HEADING 1)

Ribs are used on heat exchange surfaces to promote turbulence and enhance convective heat transfer. Roughness elements such as ribs are mounted on walls have been widely used in engineering applications to enhance heat transfer, for example, heat exchangers and mixing chambers, turbine blade cooling. Computational fluid dynamics (CFD) is the science of predicting the fluid flow, heat and mass transfer, chemical reactions, and related phenomenon. To predict these phenomena CFD solves equation for conservation of mass, momentum, energy etc. with a numerical manner on a computer. Computer is used to perform the calculation required to simulate the interaction of liquids and gases with surface defined by boundary condition.

In this paper CFD analysis of flow through rectangular duct on rib surfaces of different shapes such as rectangular rib, triangular rib, v-rib with 45 degree, v rib with 60 degree, broken v ribs, semicircular v ribs. Has been performed.

The work carried out in two stages:

1. Modeling of different shaped ribs mentioned above. It has been done in CATIA.
2. Analysis of flow and predict the best suited rib among the ribs considered. Analysis has been done in ANSYS CFD.

The objectives of this study is,

1. To predict the flow behavior of various ribs.
2. To investigate the best suited Rib that gives high heat transfer rate.
3. To investigate the best suited rib that gives high thermal performance.

Recently some researcher works on CFD analysis for heat transfer enhancement devices are

[1] Sandip jaiswal and Dr K.R.Aharwal– They work on three dimensional CFD simulations to investigate heat transfer and fluid flow characteristics of artificially roughened duct , And they conclude that Heat transfer performance decreases with an increment of Reynolds number for both the roughness pattern, and reasonable difference is found between the heat transfer simulation data for different roughness configurations, and the Ansys-Fluent software has been sufficient for simulating the flow field in rectangular duct.

[2] Miss. Ashwini Vasant Thakare, Dr. J. A. Hole-They work on an experimental investigation for heat transfer enhancement with the help of three shapes of rib for heat exchanger application. They conclude that the heat transfer in rectangular duct with different -shaped ribs is found to be more as compared to without ribs.

[3] Shital B. Salunkhe, Dr.Rachayya R.Arakerimath- They work on the experimental and CFD analysis of different fins. They concluded that CFD and experimental result shows that copper material having high heat transfer coefficient.

[4] Suman Saurav, V.N.Bartaria -This paper presents The study of heat transfer in a rectangular duct of a Solar air heater having triangular rib roughness on the Absorber plate by using Computational Fluid Dynamics (CFD). It has been found that the nusselt number increases with increase in Reynolds number.

[5] Ravi Teja, Pathan F Z, Mandar Vahadne- Simulation study has been conducted on the response of turbulent flow in a rectangular duct in order to evaluate the heat transfer rate along rectangular. A result shows that the correlation between flow structure and heat transfer is found to be strong. It is found that the onset of flow oscillations is important as it dramatically enhances heat transfer.

[6] Bhattacharyya et al. Presented experimental friction factor and Nusselt number data for laminar flow through a circular duct having integral transverse ribs and fitted with center-cleared twisted-tape have been presented. Predictive friction factor and Nusselt number correlations have also been presented. The thermo hydraulic performance has been evaluated. The major findings of this experimental investigation are that the center-cleared twisted tapes in combination with transverse ribs perform significantly better than the individual enhancement technique acting alone for laminar flow through a circular duct up to a certain amount of center-clearance. This result is useful for the design of solar thermal heaters and heat exchangers

[7] Onur yemenici and Habib Umur -works on experimental study of convective heat transfer of flows over concave ,convex, and consecutive ribbed walls in a turbulent boundary layer were studied. Outcome of his work is the measurements indicate that the concave and ribbed wall effectively enhances the heat transfer performance while convex wall reduced.

[8] Giovanni Tanda-works on Heat transfer in rectangular channels with transverse and V-shaped broken ribs. Results were such that features of the inter-rib distributions of the heat transfer coefficient are strongly related to rib shape and Geometry and Transverse broken ribs, in a staggered arrangement, lead to higher levels of turbulence over the heated surface.

[9] J. C. Han and J. S. Park – studied Developing heat transfer in rectangular channels with rib turbulators and Experimental results were compared for various angular positions of rib.

[10] P.R. Chandra a, C.R. Alexander, J.C. Han –studied the Heat transfer and friction behaviors in rectangular channels with varying number of ribbed walls. An experimental study of surface heat transfer and friction characteristics of a fully developed turbulent air flow in a square channel with transverse ribs on one, two, three, and four walls is reported. The Heat transfer coefficient and friction factor results were enhanced with the increase in the number of ribbed walls.

II. MODELING OF RIBS USING CATIA:

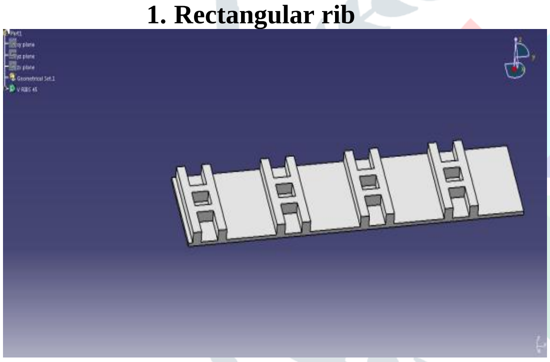
There are 10 different types of ribs used in this project for analyzing the best out of them. These ribs are as follows:

1. Rectangular rib.
2. Rectangular rib with taper.
3. Triangular rib.
4. Triangular broken rib.
5. V-rib (45 degree).
6. Broken V rib (45 degree).
7. V rib (60 degree).
8. Broken V rib (60 degree).
9. V rib semicircular.
10. Broken V rib semicircular.

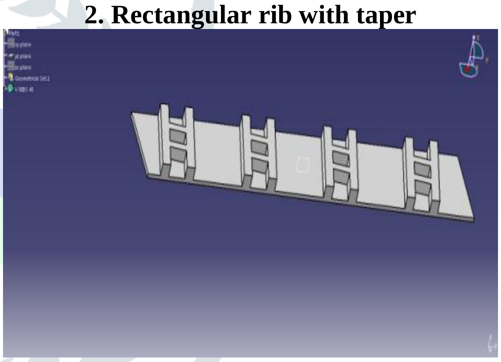
<u>These ribs are modeled by using CATIA as shown below, and there dimensions are:</u>

All ribs having height of 6mm and pitch 50mm so there will be rib pitch to rib height ratio ,p/e=8.3and broken ribs having a break of 2mm.

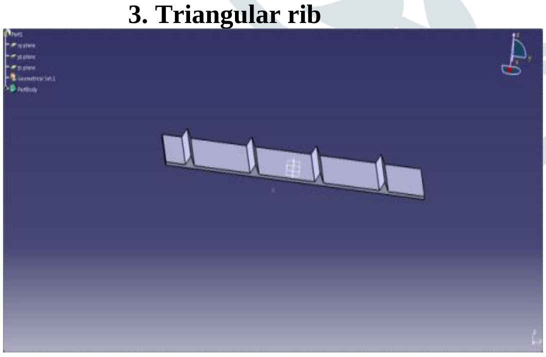
1. Rectangular rib



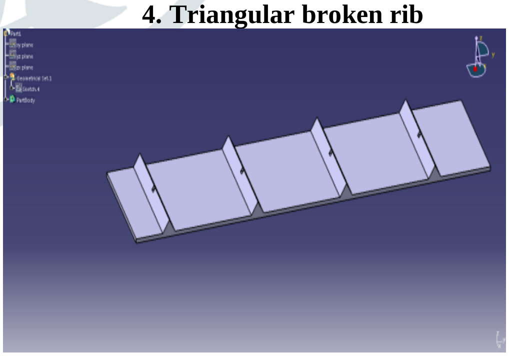
2. Rectangular rib with taper



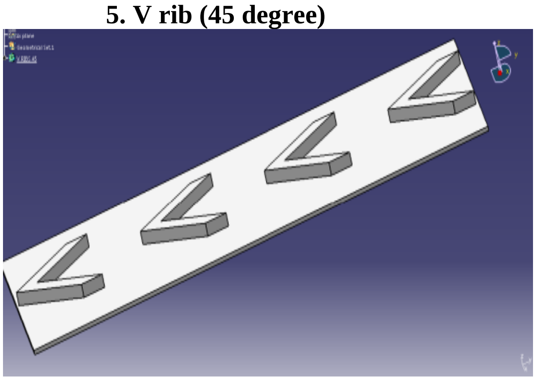
3. Triangular rib



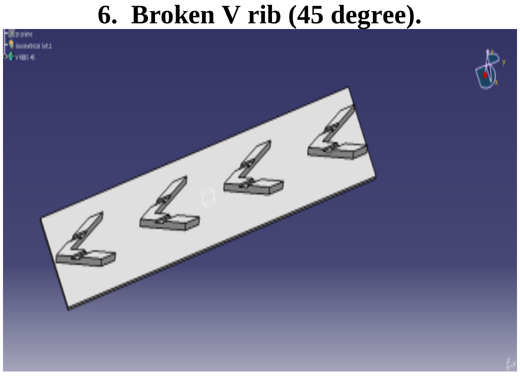
4. Triangular broken rib



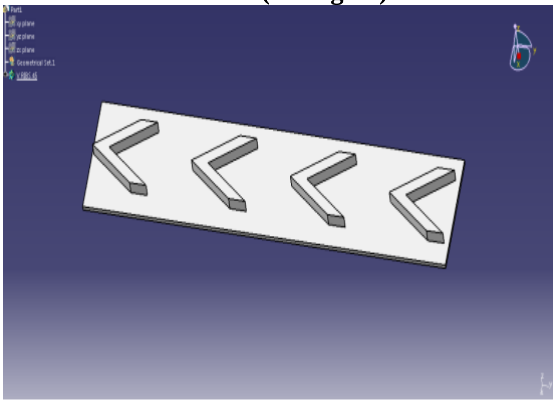
5. V rib (45 degree)



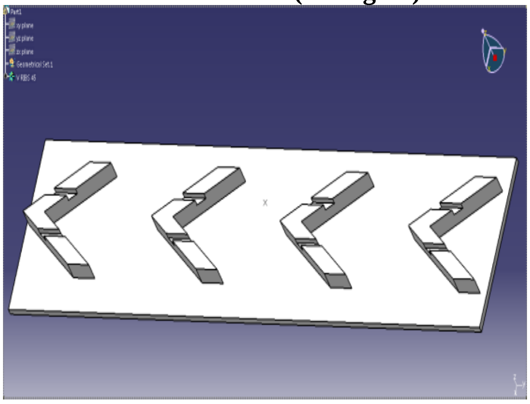
6. Broken V rib (45 degree).



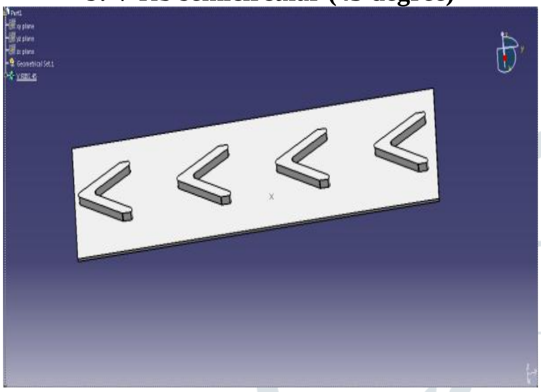
7. V rib (60 degree)



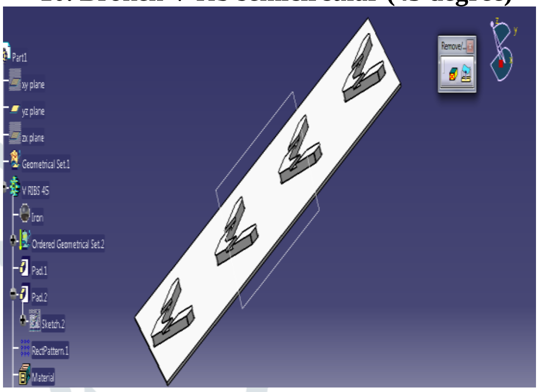
8. Broken V rib (60 degree)



9. V rib semicircular (45 degree)



10. Broken V rib semicircular (45 degree)



III. COMPUTATIONAL FLUID DYNAMICS: -

Computational Fluid Dynamics (CFD) is the science of predicting fluid flow, heat and mass transfer, chemical reactions, and related phenomena. To predict these phenomena, CFD solves equations for conservation of mass, momentum, energy etc., with a numerical manner on a computer.

The CFD analysis provides useful data and information which can be used as basis for making experimentation of our project.it will helps us to understand that how we will get results after doing experimentation of our project.

3.1 Operating parameters:

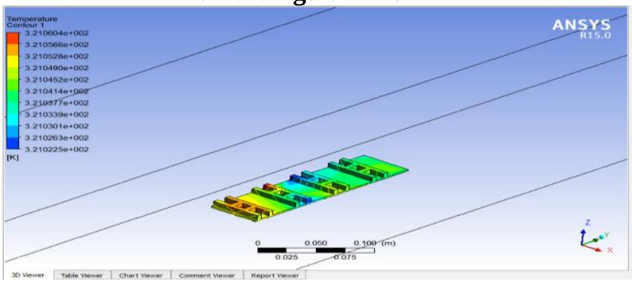
Sr.no	Inputs	Values
1	Velocity of air	1 m/s
2	Operating temperature	321 k
3	Operating pressure	1.013 bar
4	Air density	1.184 kg/m^3
5	Fluid	Air
6	Duct size	2100x200x150mm
7	Plate material	Acrylic
8	Rib material	Copper

3.2 Steps in CFD Analysis:-

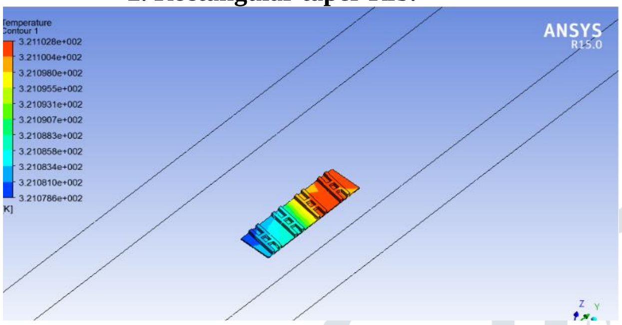
1. Modeling of component using CATIA software.
2. Conversion of CAD model into .igesformat.
3. Import the .iges (Initial graphics exchange specification) format in to ANSYS workbench.
4. To select the process under which we want to analyze the imported model. (In our case fluent analysis).
5. Next we define enclosure, for the model.
6. Meshing of model.
7. Setup the model foranalysis; by applying all the constraints.
8. Run the solver.
9. Generate thermal graphs from results and solution section.

3.3 Temperature contours for ribs after analysis:-

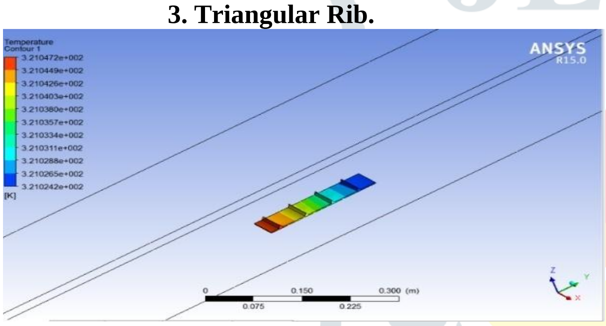
1. Rectangular rib.



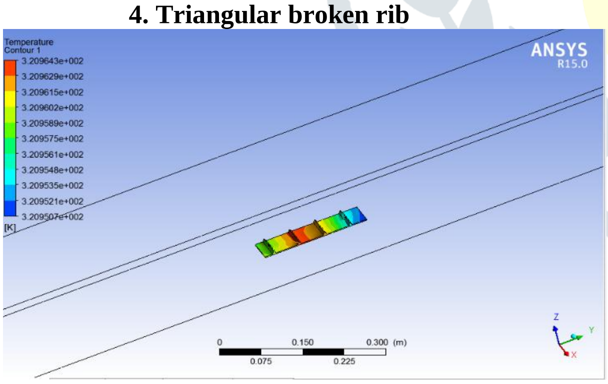
2. Rectangular taper Rib.



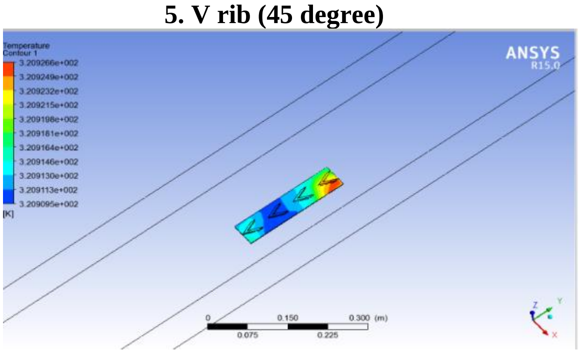
3. Triangular Rib.



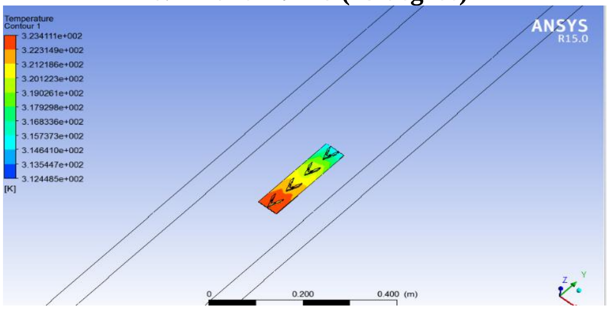
4. Triangular broken rib



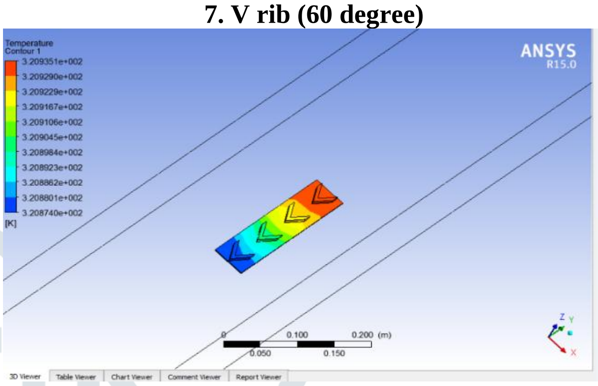
5. V rib (45 degree)



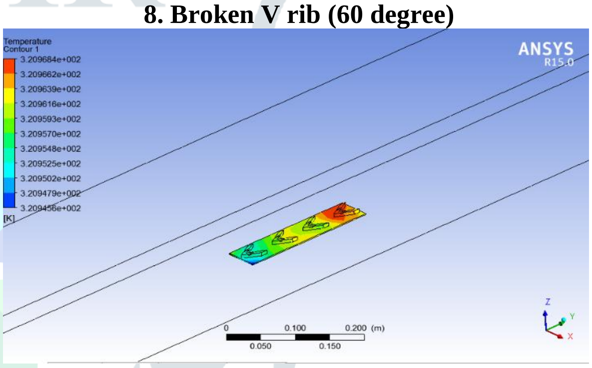
6. Broken V rib (45 degree)



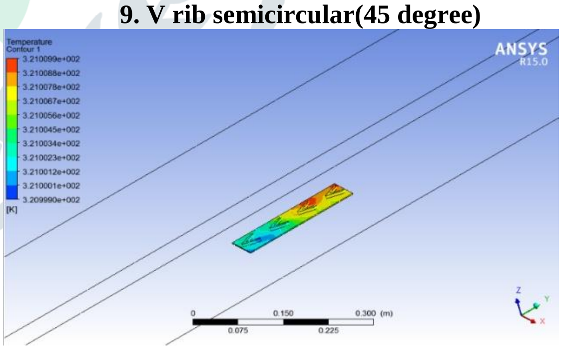
7. V rib (60 degree)



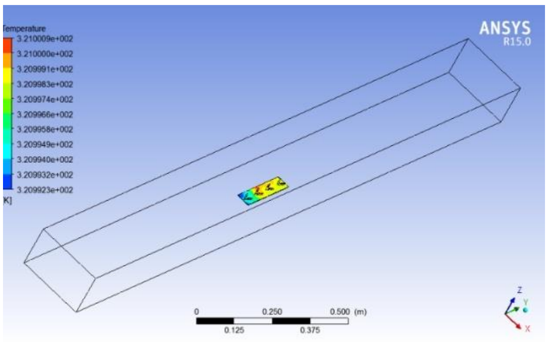
8. Broken V rib (60 degree)



9. V rib semicircular(45 degree)



10. Broken V rib semicircular



3.4 Result and discussion:-

Table 3.4.1- Temperature results.

Name of rib	Maximum temperature(k)	Minimum temperature(K)
Rectangular rib	321.0604	321.0225
Rectangular taper rib	321.1028	321.0786
Triangular rib	321.0472	321.0242
Triangular broken rib	320.9643	320.9507
V rib (45 degree)	320.9266	320.9095
Broken v rib (45 degree)	323.411	312.44
V rib (45 degree) semicircular	321.009	320.990
Broken V rib (45 degree) semicircular	321.0	320.9923
V rib (60 degree)	320.93	320.8740
Broken V rib (60 degree)	320.9684	320.9450

Table 3.4.2- Heat flux & heat transfer coefficient

Rib	Maximum Heat flux (w/m2)	Heat transfer coefficient.(w/m2k)
Rectangular rib	28	76
Rectangular taper rib	29	78
Triangular rib	27	19
Triangular broken rib	10	29
V rib 45	26	28
V rib 45 break	28	74
V rib 45 semi	24	19
V rib 45 semi break	23	20
V rib 60	25	38
V rib 60 break	26	41

Discussion:-

Analysis is done for different types of ribs placed in a rectangular duct of cross section 2100x150x200 mm. a heated air of temperature 321K was passed over the ribs.

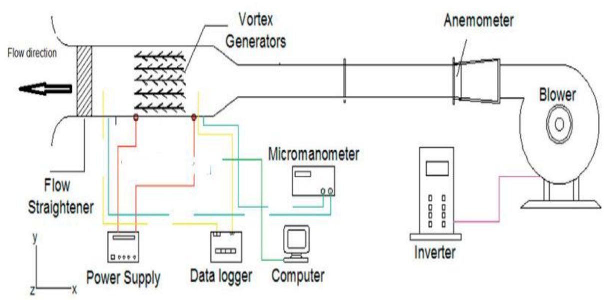
We will assume that rib as best geometry of ribs to enhance the heat transfer rate whose temperature will be highest after heated air is passed over it.

From above all temperature contour graphs we understand that temperature is highest for broken v 45 degree rib i.e.323.411K , rectangular taper rib having good temperature as 321.1028K and also heat flux values and heat transfer coefficient values we can understand that rectangular taper rib and V 45 broken rib having much good analysis resultsamongst all other ribs.

IV. FUTUREWORK: -

From above results we are going to manufacture the ribs and for them we are going to take experimental results by placing it actually in rectangular duct and passing hot air by forced convection over it and taking readings for temperature, heat flux and heat transfer coefficient.

4.1 Experimental set up



4.1.1 Experimental Methodology

1. Fit the specimen inside the duct which consists of a nine thermocouples inside a Duct to measure the temperature at various points of ducts and specimen.
2. Switching ON the supply and adjust the voltage at 60 V, 120 V and 180 V.
3. Switching ON the blower units and allowing the flow of air.
4. Measure the flow of air through anemometer.
5. After attaining the steady stage note the temperature (T1 to T9) at an interval of 10 minutes and tabulate it
6. Repeat same procedure for other specimens also.
7. Compare the result of three Design and Material specimens analytically and
8. Conduct CFD Analysis of the same.
9. The Results obtained will be Heat Transfer Coefficient, Reynolds number and Nusselt Number.

V. CONCLUSIONS

1. The results obtained by CFD analysis shows that we Get the temperature of 321.102K with the maximum heat flux of 29 w/m2 and maximum heat transfer coefficient of 78 w/m2 k for Rectangular taper rib.
2. The results also shows that broken v (45degree) rib has highest temperature of 323K,with maximum heat flux of 28 w/m2 and maximum heat transfer coefficient of 76 w/m2.

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