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Review of Heat Transfer Enhancement Techniques of W Ribs

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Abstract: ***This paper is a review about the early studies on the heat transfer enhancement in a rectangular duct with rib turbulators. Heat transfer enhancement has been always a significantly interesting topic in order to develop high efficient, low cost, light weight heat exchangers. There are different kinds of ribs to enhance the heat transfer rate such as V-ribs (simple and broken v-ribs), triangular and rectangular ribs, segmented and circular ribs. W Ribs on the opposite walls of internal cooling passages of gas turbine blades are often used for heat transfer enhancement. Rib Turbulators is an efficient and economic tool in heat transfer enhancement. Combination of various ribs and duct artificial roughness provided promising results. In case of using various rib type, heat transfer enhancement was depend on no. of ribs and height of ribs and various arrangement of ribs.***

Keywords: Heat transfer Enhancement, Ribs, V and Broken v ribs, W-Ribs

1. Introduction

To promote turbulence and enhance convective heat transfer many roughness element such as ribs are used on heat exchanger surfaces. These various types of ribs are mounted on wall have been widely used in engineering application to enhance heat transfer, for example heat exchangers and mixing chambers, turbine blade cooling, electronic equipment cooling.

Heat Transfer enhancement techniques are classified as follows:

a) Active method: In this method, some external power input for the enhancement of heat transfer is required Few examples of active method include induced pulsation by cams and reciprocating plunger, use of magnetic field to disturb the seeded light particle in a flowing stream, etc.
b) Passive method: In passive heat transfer method, no external power input is needed. Few examples of this method are rough surfaces, inserts, etc.
c) Compound method: The combination of above two mentioned methods is the compound method.

1.1 Passive Heat Transfer Techniques

In conventional cooling method that are based on forced convection one way to enhance heat transfer is by increasing the effective surface area and residence time of the heat transfer fluid. Passive heat transfer method uses surface or the geometrical modification to the flow channel by incorporating inserts or additional devices. Due to this geometrical modification, most of the turbulence enhancement and boundary layer break down are localized near the heat transfer surface and consequently heat transfer coefficient in the existing system is increased. The following methods are generally used.

1.2 Ribs

Placing ribs periodically on the heat transfer surface increases the turbulence and since these ribs are small they do not disturb the core flow hence a high heat transfer performing surface could be achieved without incurring the penalties of frication and pressure drop.

1.3 Baffles

Inserting baffles into the heat transfer devices promote mixing of coolants. These baffles can significantly disturb the bulk flow.

1.4 Extended Surfaces

Use of heat sink such as fins increases the surface area in contact with the coolant. These extended dissipation areas are widely recognized to improve the heat transfer. Various examples are plain fin, wavy fin, louvered fin, offset-strip fin, etc.

1.5 Twisted Tapes and Wire Coils

Twisted tapes are metallic strips twisted in some ratio known as twist ratio, inserted in the flow.

Wire coil inserts are made by tightly wrapping a coil of spring wire on a rod. When the coil spring is pulled up the wires forms a helical roughness.

1.6 Surface Modification

This section includes such surface which has fin scales or coating which may be continuous or discontinuous. It also includes rough surfaces which promotes turbulence in the flow field.

1.7 Impingement Cooling

It involves high velocity jet to cool directly the surface of inserts. It also involves the direction of heating or cooling fluid perpendicularly or obliquely to the heat transfer surface.

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1.8 Additives

These include addition of solid particles, liquid droplets, gas bubbles, etc. which are introduced in single phase flow. Additive for gas is introduced as a dilute phase (gas-solid suspension) or as dense phase (fluidized bed). Liquid additives usually depress the surface tension of liquids for boiling system.

2. Rib Geometry

Large number of Rib geometries has been proposed for the use of heat transfer enhancement and more are still being developed

2.1 Common Attributes of Ribs are

a) **Shape**: Most of the Ribs found in literature are Rectangular Ribs, Square Ribs, Triangular Ribs, M-shaped, W-shaped, V-Shaped. In the present work, W-shaped ribs have been studied.

b) **Height**: Small heights of ribs are preferred to minimize the pressure drop.
c) **Spacing:** It is the distance between two consecutive Ribs.

d) **Width:** Small widths of ribs are preferred to minimize the pressure drop.

2.2 Arrangements of Ribs

Arrangement of Ribs on a flat plate plays a crucial role to enhance the heat transfer within the channel without incurring the penalties of friction and pressure drop that are severe enough to negate the benefits of heat transfer augmentation. Inline, Staggered, Offset, Zig-Zag are the possible arrangement of Ribs in a flow channel.

2.3 Types of Ribs

Implementation of Ribs are decided on the basis of size, cost and their ability to lend support to the tube bundles and direct flow, often this is linked to available pressure drop and the size and number of passes within the exchanger. Special allowance changes are made for finned tubes. The different types of Ribs are:

- V-Shaped ribs
- M-shaped ribs
- W-shaped ribs
- Circular ribs
- Rectangular ribs

Some of the common rib configurations are shown in following figure.

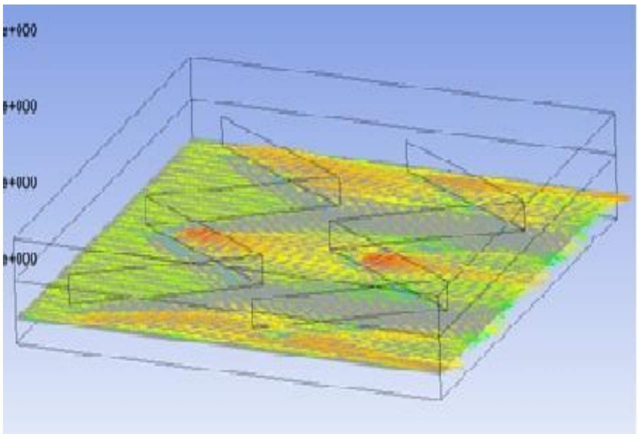

Figure 1: W Ribs with flat plate

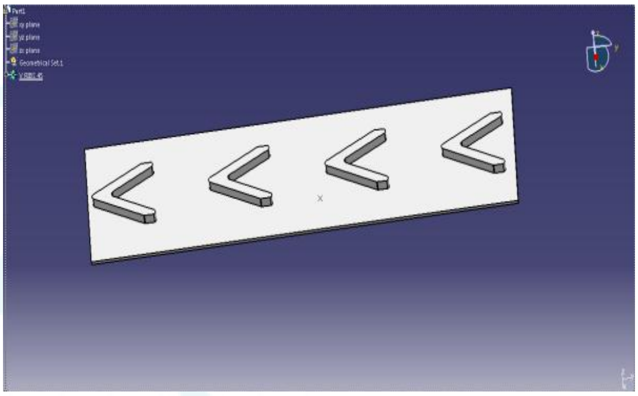

Figure 2: V Ribs with flat plate

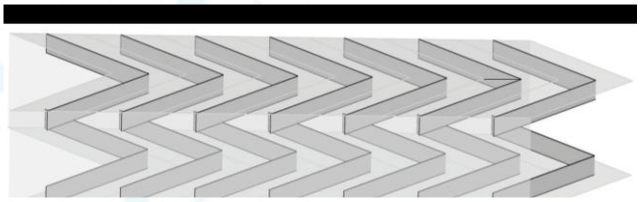

Figure 3: W Ribs with Inline arrangements

3. Literature Survey

Literature survey of work carried out by various authors using different arrangements and types of ribs for heat transfer enhancement techniques can be studied.

[1] Priyank Lohiya and Shree Krishna Choudhary, Studied heat Transfer Enhancement in a Rectangular Duct with Rib Turbulators**.** In which Ribs have been used as a tool to enhance heat transfer by increasing the level of turbulence mixing in the flow. Rib roughness on the underside of the top wall of a duct has been found to substantially enhance the heat transfer coefficient. A two-dimensional CFD investigation is conducted to study forced convection of fully developed turbulent flow in a rectangular duct having ribs on the underside of the top wall.

[2] Aravind Rohan Sampath, presented a detailed investigation of effect of rib turbulators on heat transfer performance in stationary ribbed channels where they examined thermal performance computationally for the stationary channels with rib turbulators oriented at 90 degrees. Ribs were placed on opposite walls and the heat

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transfer coefficients and frictional loss were calculated. The results obtained for all the channels with different rib configuration proved that the increase in rib width reduced the thermal performance of the channels. By combined effect of rib width, rib spacing and flow parameters, the optimal cooling configuration was obtained.

[3] S. Srinivasan, A.U. Jeevan Kumar, Carried out CFD Analysis of Air and Steam in a Rectangular Channel Having Parallel RIBS. The effects of Reynolds numbers (Re), rib spacing ratio (P/e), and rib angles (α) on steam and air convective heat transfer were obtained. The modeling has been done on the Creo parametric 2.0 software and to get the exact mesh of the duct the meshing was done in Hypermesh and the analysis were done in CFD Fluent software. Angle rib turbulators positively affect the heat transfer enhancement for both steam and air flow. Rib spacing has a relative weaker effect on heat transfer enhancement. Nusselt numbers for steam and air increase with decrease in rib angle.

[4]Priyank Lohiya, Shree Krishna Choudhary, conducted a numerical study on heat transfer of turbulent duct flow through ribbed duct.Ribs have been used as a tool to enhance heat transfer by increasing the level of turbulence mixing in the flow. Rib roughness on the underside of the top wall of a duct has been found to substantially enhance the heat transfer coefficient. A two-dimensional CFD investigation is conducted to study forced convection of fully developed turbulent flow in a rectangular duct having ribs on the underside of the top wall. CFD solutions are obtained using commercial software ANSYS FLUENT v12.1. The working fluid in all cases is air.

[5]Satyanand Abraham, Rajendra P. Vedula, presented a similar investigation of heat transfer and pressure drop measurements in a square cross-section converging channel with V and W rib turbulators. In which Ribs on the opposite walls of internal cooling passages of gas turbine blades are often used for heat transfer enhancement. These passages can be straight, converging or diverging. In the present study, experimental data for local heat transfer coefficients are presented for a converging channel with rib roughening elements with the cross-section being maintained square from inlet to exit. The local heat transfer coefficient distribution shows the same qualitative behavior observed for the straight channel.

[6] P.R. Chandra, C.R. Alexander, J.C. Han, carried out an experiment to examine 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. Tests were performed for Reynolds numbers ranging from 10,000 to 80,000. The heat transfer roughness function, increased with roughness Reynolds number and compared well with previous work in this area. Both correlations could be used to predict the friction factor and heat transfer coefficient in a rectangular channel with varying number of ribbed walls.

[7] Gurav utekar, Vivekanand Navadagi, investigated performance analysis of solar collector with inline and perforated W shape rib roughened absorber plate for air heating application .investigation have been carried out by testing the collector under clear sky with available solar radiation intensity with variation in mass flow rate of air passing through collector ranging from 0.01484kg/sec to 0.01726kg/sec for three different absorber plates. Collector efficiency has been evaluated for plane absorber plate and compare with absorber plate having inline and staggered shape plate. It is found that instantaneous collector efficiency for staggered w shape perforated fin roughened absorber plate solar collector is 18% higher as compared with plain absorber plate solar collector for mass flow rate of 0.01726kg/sec and 12% heigher than the absorber plate with inline w shape rib roughened absorber plate collector. Enhancement in collector efficiency is due to increase in the turbulence of the air for staggered w shape absorber plate solar collector

[8]Jianhua Wang, Zhixin Feng, Qian Zhang, Xiangyu Wub, Shiyan Mab, presented Experimental investigations on overall cooling effect of ribbed channel with air bleeds.

In this experimental investigation on overall heat transfer performance of a rectangular channel, in which one wall has periodically placed oblique ribs to enhance heat exchange and cylindrical film holes to bleed cooling air, has been carried out in a hot wind tunnel at different mainstream temperatures, hot mainstream Reynolds numbers, coolant Reynolds numbers and blowing ratios. Based on the experimental data, the overall cooling effectiveness is correlated as the functions of Rem (Reynolds number of hot mainstream) and Rec (Reynolds number of internal coolant flow at entrance) for the parametric conditions examined.

[9] Giovanni Tanda performed an experimental study to investigate the Effect of rib spacing on heat transfer and friction in a rectangular channel with 45^0 angled rib turbulators on one/two walls. An experimental investigation of forced convection heat transfer in a rectangular channel (aspect ratio AR = 5) with angled rib turbulators, inclined at 45^0, is presented. The angled ribs were deployed with parallel orientations on one or two surfaces of the channel. The convective fluid was air, and the Reynolds number varied from 9000 to 35,500.

[10] X. Gao, B. Sunden, Investigation carried out to examine heat transfer distribution in rectangular duct with V-shaped ribs. Heat transfer distributions are presented for a rectangular duct with two opposite wide walls arranged with V-Shaped ribs pointing upstream or downstream relative to the main flow direction. The parallel V-Shaped circular ribs are arranged staggered on the two wide walls. Local Nusselt's numbers are presented between a pair of adjacent ribs, and based on these the average Nusselt numbers are calculated to investigate the augmentation of heat transfer by the presence of the V-shaped ribs.

4. Conclusion

The literatures about various heat transfer enhancement technique using rib turbulators and effect of rib turbulators on

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heat transfer characteristics have been reviewed. Different types of ribs in various condition and arrangement have been considered.

The main conclusions can be drawn as follows:

(i) There is a definite increase in heat transfer in ribbed duct with increase in friction to the flow when its surface is roughened. However the different investigation finds different values of increment in heat transfer and friction factor for each type of rib geometry used.
(ii) The Nusselt number ratio and friction factor ratio in ribbed-grooved channel are higher than that in ribbed channel without grooves.
(iii) The thermal performance of channel or duct with rib turbulators are obviously affected by Reynolds numbers, rib height, rib spacing ratio. rib angle and different arrangement of ribs.

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References

[1] "Heat Transfer Enhancement in a Rectangular Duct with Rib Turbulators" by Priyank Lohiya and Shree Krishna Choudhary.
[2] "Effect of rib turbulators on heat transfer performance in stationary ribbed channels" by Aravind Rohan Sampath.
[3] "CFD Analysis of Air and Steam in a Rectangular Channel Having Parallel RIBS" by S. Srinivasan, A.U. Jeevan Kumar.
[4] "Numerical Study on heat transfer of Turbulent duct flow through ribbed duct" by Priyank Lohiya, Shree Krishna Choudhary.
[5] "Heat transfer and pressure drop measurements in a square cross-section converging channel with V and W rib turbulators" by Satyanand Abraham, Rajendra P. Vedula.
[6] "Heat transfer and friction behaviors in rectangular channels with varying number of ribbed walls" P.R. Chandra, C.R. Alexander, J.C. Han.
[7] "Performance analysis of solar collector with inline and perforated W shape rib roughened absorber plate for air heating application" by Garav Utekar, Vivekanand Navadagi.
[8] "Experimental investigations on overall cooling effect of ribbed channel with air bleeds", by Jianhua Wang, Zhixin Feng, Qian Zhang, Xiangyu Wub, Shiyan Mab.
[9] "Effect of rib spacing on heat transfer and friction in a rectangular channel with 450 angled rib turbulators on one/two walls", by Giovanni Tanda.
[10] "Heat transfer distribution in rectangular ducts with V-Shaped ribs", by X. Gao, B. Sunden

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