International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume 2 Issue 5, pp : 347-350 1 May 2013

Review of Heat Transfer Augmentation Within A Plate Heat Exchanger By Different Shapes Of Ribs

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Abstract: **Heat transfer augmentation techniques (passive, active or a combination of passive and active methods) are commonly used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc. Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger. In design of compact heat exchangers, passive techniques of heat transfer augmentation can play an important role if a proper passive insert configuration can be selected according to the heat exchanger working condition (both flow and heat transfer conditions). In the past decade, several studies on the passive techniques of heat transfer augmentation have been reported. Twisted tapes, wire coils, ribs, fins, dimples, etc., are the most commonly used passive heat transfer augmentation tools. In the present paper, emphasis is given to works dealing with different shapes of ribs, and there arrangement because, according to recent studies, these are known to be economic heat transfer augmentation tools. The present review is organized in four different sections: circular ribs with staggered at 90º; circular ribs with staggered at 45º, triangular ribs with staggered at 90ºand triangular ribs with staggered at 45º.**

Keywords*:* **Heat Transfer Augmentation, Passive Techniques, Circular Ribs,Triangular Ribs**

Introduction

Categories

A. **Active method:** This method involves some external power input for the enhancement of heat transfer; some examples of active methods include induced pulsation by cams and reciprocating plungers, the use of a magnetic field to disturb the seeded light particles in a flowing stream, fluid vibration, jet impingement etc.
B. **Passive method:** These methods generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. For example, use of inserts, use of rough surfaces, extended surface etc.
C. **Compound method:** When any two or more techniques employed simultaneously to obtain enhancement in heat transfer that is greater than that produced by either of them when used individually, is termed as compound enhancement .This technique involves complex design and hence has limited application

Passive heat transfer augmentation methods

Passive heat transfer augmentation methods as stated earlier does not need any external power input. In the convective heat transfer one of the ways to enhance heat transfer rate is to increase the effective surface area and residence time of the heat transfer fluids. The passive methods are based on the same principle. Use of this technique causes the swirl in the bulk of the fluids and disturbs the actual boundary layer so as to increase effective surface area, residence time and consequently heat transfer coefficient in existing system.

Following Methods are used generally used

- Extended surface
- Use of Additives
- Inserts

Extended Surface

Extended or finned surfaces increase the heat transfer area which could be very effective in case of fluids with low heat transfer coefficients. This technique includes finned tube for shell & tube exchangers, plate fins for compact heat exchanger and finned heat sinks for electronic cooling. Finned surfaces enhance heat transfer in natural or forced convection which can be used for cooling of electrical and electronic devices. Plate fin or tube and plate fin type of compact heat exchangers, where the finned surfaces provide a very large surface area density, are used increasingly in many automotive, waste heat recovery, refrigeration and air conditioning , cryogenic, propulsion system and other heat recuperative applications. A variety of extended surfaces typically used include offset strip fins, louvered fins, perforated fins and wavy fins.

Use of additives

Pressure drop in tube flow is consequence of the frictional losses with solid surface. The frictional loss occurs because of the drag force of fluid. This technique is basically concerned with reducing the drag coefficient using some additives to fluid in single phase flows. Additives when added to fluids are found to have operational benefits by lowering the frictional losses. Polymeric additives induce a viscoelastic characteristic to solution which promotes secondary circulation in bulk flow.

Inserts

Inserts refer to the additional arrangements made as an obstacle to fluid flow so as to augment heat transfer. Different types of inserts are

- Twisted tape and wire coils
- Ribs, Baffles, plates

Ribs & Baffles

The present paper Contributes for review of Ribs, baffle in duct and insert in tube.

Use of ribs and baffles

The main roles of a ribs and baffle in a shell and tube heat exchanger are

- To prevent the effect of vibration which is increased with both fluid velocity and the length of exchangers
- To increase the heat transfer area
- To promote mixing in static mixture in a chemical reactor, baffles are often attached to interior walls to promote mixing and thus increase heat transfer and chemical reaction rates.
- To increase the stiffness of the system

Types of Ribs & baffles

Implementation of ribs & baffles is 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 allowances/changes are also made for finned tubes. The different types of ribs & baffles include:

- Circular Shaped Ribs.
- Triangular Shaped Ribs.
- Air-foiled shaped ribs.
- Z-shaped ribs.
- Segmented ribs.
- Corrugated surface Inclined ribs.
- Porous ribs.
- Segmental Baffles (of which single segment is the most common)
- Longitudinal Flow Baffles (used in a two-pass shell)
- Orifice Baffles.

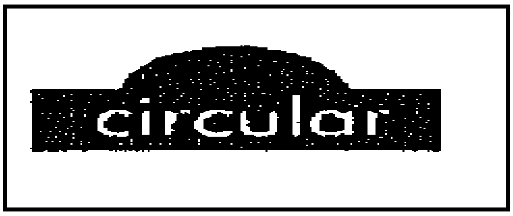

Figure 1: Circular Shaped Ribs

Figure 2: Triangular Shaped Ribs

Figure 3 : Wing shape Ribs

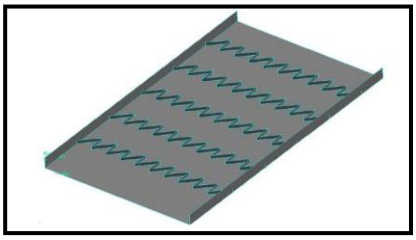

Figure 4: Z-Shaped Ribs

Literature survey of work carried out by various authors using heat transfer enhancement techniques

Literature survey

R. Tauscher, F. Mayinger, [1]: This paper deals with experimental and numerical investigation of the forced convective heat transfer in flat channels with rectangular cross section. To enhance the heat transfer, rib roughened surfaces are applied to the wider walls of the duct. Various rib shapes, rib spacing and rib arrangement have been investigated. Temperature fields and velocity fields in the heat exchanger channel were obtained by holographic interferometer and laser droppler anemometry, enabling measurement of the thermo hydraulic behavior of the flow without disturbing the flow pattern in the channel. By measuring the mean fluid temperature at the entrance and the exit of the test section as well as the pressure drop, the mean heat transfer and the heat exchanger performance could be judged. Simultaneously with the experimental investigations numerical calculations with a commercial code (TASCflow3D) have been performed.

Monsak Pimsarn,et al, [2]: Experiment is focused on the design of the suitable ribs used for enhancing heat transfer in a rectangular duct heat exchanger by using wall heat transfer (Nusselt number), friction loss (friction factor) and thermal performance (thermalenhancement factor) data. The Z-shaped ribs were set on the rectangular duct at 30°, 45° and 60° and flat rib was set at 90° relative to the air flow direction. Reynolds numbers studied ranging from 5000 to 25,000 in the test section. The rectangular duct has aspect ratio(ratio of width to height) AR = 10 and height, H = 30 mm with the Zrib height (e), elH = 0.2 and the rib pitch (P), PIH = 3. The ribs were fitted in Z-shape (Z-rib) aligned in series on the whole area of the upper plate. The results of the Z-ribs show the significant increase in heat transfer rate and friction loss over the smooth channel. The 45° Z-rib provides the highest increase in the heat transfer rate and the best thermal performance.

Ting Maa,b, Qiu-wang Wang,[3]: In this paper, the effects of inlet temperature and rib height on the fluid flow and heat transfer performances performances of the ribbed channel inside the high temperature heat exchanger are presented. The inlet temperature varies from 850 K to 1250 K and the ratio of rib height to channel height varies from 0.083 to 0.333. The results indicate that increasing the rib height can enhance the flow disturbance and hence improve the heat transfer performance. The inlet temperature has little effect on the basic structure of fluid flow and the heat transfer is enhanced due to the increased velocity. Compared to increasing the rib height, more heat can be transferred by increasing the inlet temperature with less pressure drop. The high pressure drop is more serious as the inlet temperature increases. It is proposed to use the compact heat transfer structure at the low temperature region and replace it by loose heat transfer structureat the high temperature region. It also demonstrates that the Nusselt number and friction factor are unsuitable to compare the heat transfer and pressure drop performances among different temperature conditions because the physical properties of fluid change with temperature variation.

Seyhan Uygur Onbasioglu, [4]: A liquid crystal based experimental investigation of the heat transfer enhancement supplied by ribs on a vertical plate, has been presented. Since the ribs were adiabatic, they did not work as extended heat transfer surfaces but by redirecting the flow, were used to enhance the heat transfer. Four different rib heights (H ¼ 10, 20, 30, 40 mm) and have different angles of inclination (h ¼ 0_, 10_, 20_, 30_, 45_) are considered. Local heat transfer coeffcients and the mean Nusselt numbers for the considered experimental cases are compared to those of the that plate without ribs. The enhanced flow is always found to have higher heat transfer values. On the other hand, both the rib height and the angle of inclination a.ect the magnitude of the local and total heat transfer coeffcients.

Giovanni Tanda, [5]: This paper deals with Repeated ribs are on heat exchanger surfaces to promote turbulence and enhance convective heat transfer. study of heat transfer from a rectangular channel (width-to-height ratio equal to five) having one surface heated at uniform heat flux and roughened by repeated ribs. The ribs, having rectangular or square sections, were deployed transverse to the main direction of flow or V-shaped with an angle of 45 or 60 deg relative to flow direction. The effect of continuous and broken ribs was also considered. Local heat transfer coefficients were obtained at various Reynolds numbers, within the turbulent flow regime. .

A.N. Mahure and V.M. Kriplani, [6]: This paper deals with experimentation with Z- shaped ribs in rectangular duct. The experimental study was to investigate the local heat transfer characteristics and friction factor in rectangular duct with flat and Z- shaped ribs. A constant surface heat flux is provided on top surface and other surfaces are maintained at adiabatic conditions. The Reynolds number was varied between 9000 to 25000.The increase in heat transfer coefficient of air found to be 14.6% higher for flat ribs,58.16% for 30˚ Z-shaped ribs, 76% for 45˚ Z-shaped ribs and 89.37 % for 60˚ Z- shaped ribs over when there is no ribs in the duct. Experimentation shows the heat transfer depend on the angle of Z- shaped ribs.

K. H. Dhanawade, [7]: - Rapid heat removal from heated surfaces and reducing material weight and cost become a major task for design of heat exchanger equipments like Cooling of I C engines. Development of super heat exchangers requires fabrication of efficient techniques to exchange great amount of heat between surface such as extended surface and ambient fluid. The present paper reports, an experimental study to investigate the heat transfer enhancement in rectangular fin arrays with circular perforation equipped on horizontal flat surface in horizontal rectangular duct. The data used in performance analyses were obtained experimentally by varying flow, different heat inputs and geometrical conditions.

Xiaokui Maa, Guoliang Ding,[8]:- The airside heat transfer and friction characteristics of 14 enhanced fin-and-tube heat exchangers with hydrophilic coating under wet conditions are experimented. The effects of number of tube rows, fin pitch and inlet relative humidity on airside performance are analyzed. The test results show that the influences of the fin pitch and the number of tube rows on the friction characteristic under wet conditions are similar to that under dry surface owing to the existence of the hydrophilic coating. The Colburn j factors decrease as the fin pitch and the number of tube rows increase. For wavy fin, the Colburn j factors increase
with the increase of the inlet relative humidity, but for interrupted fin, the Colburn j factors are relatively insensitive to the change of the inlet relative humidity. The friction characteristic is independent of the inlet relative humidity.

Conclusion: - Various type of possible and cost effective technique of the heat transfer enhancement were presented in this literature review. It is clear that Rib insertion technique is one of the promising approaches of heat transfer enhancement. Lot of work been carried out on various designs and use of simulation software made it easier.

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