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Experimental Investigation Of Heat Transfer In Heat Exchanger Using Different Geometry Of Inserts – A Review

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Abstract-Heat transfer enhancement techniques are used to increase the rate of heat transfer forthfor developing efficient heat transfer enhancement devices with several designs in order to enhance the turbulence, enhance the friction factor, sepration of boundry layer and thereby improving the heat transfer efficiency leading a way to improve the efficiency of heat exchanger without altering the size of heat exchanger. This paper contains the literature survey of enhancement techniques in heat transfer using inserts.
Keywords— Heat Transfer, Heat Exchanger, Enhancement Techniques, Inserts

I. INTRODUCTION

The study of improved heat transfer performance is referred to as heat transfer enhancement, augmentation, or intensification. In general, this means an increase in heat transfer coefficient. Energy- and materials-saving considerations, as well as economic incentives, have led to efforts to produce more efficient heat exchange equipment. Common thermal-hydraulic goals are to reduce the size of a heat exchanger required for a specified heat duty, to upgrade the capacity of an existing heat exchanger, to reduce the approach temperature difference for the process streams, or to reduce the pumping power. The study of improved heat transfer performance is referred to as heat transfer enhancement, augmentation, or intensification. In general, this means an increase in heat transfer coefficient.

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy and heat between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occur simultaneously in the same system. To improve the performance of heat exchanging devices for reducing material cost and surface area and decreasing the difference for heat transfer thereby for reducing external irreversibility, lot of techniques have been used. Among different passive means to increase heat transfer coefficient various types of inserts are promising. The secondary flow (swirl flow) generated by inserts effects fluid flow across inserts-partitioned tube, promotes greater mixing and higher heat transfer coefficients.

Heat transfer augmentation techniques (passive, active and compound) 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 applied in an existing application. In the past decade, several studies on the passive techniques of heat transfer augmentation have been reported.

Existing enhancement techniques can be broadly classified into three different categories:

Passive Techniques

Active Techniques

Compound Techniques

A. Passive Techniques

These techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior (except for extended surfaces) which also leads to increase in the pressure drop. In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. Heat transfer augmentation by these techniques can be achieved by using:

Treated Surfaces
Rough surfaces
Extended surfaces
Swirl flow devices
Coiled tubes

B. Active Techniques

These techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in many practical applications. In comparison to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases. Various active techniques are as follows:

Mechanical Aids
Surface vibration
Fluid vibration.
Electrostatic fields.
Injection 6. Suction.

C. Compound Techniques

A compound augmentation technique is the one where more than one of the above mentioned techniques is used in combination with the purpose of further improving the thermo-hydraulic performance of a heat exchanger. The objective of this project work is to analyses the heat transfer coefficient by using different geometry of twisted tape.

II. REVIEW OF WORK CARRIED OUT

Bodius Salam et al. experimentally investigated heat transfer enhancement efficiency of water for turbulent flow in a circular tube fitted with rectangular-cut twisted tape insert. A stainless steel rectangular-cut twisted tape insert of 5.25 twist ratio was inserted into the smooth tube and the Reynolds numbers were varied in the range 10000-19000. They concluded that the Nusselt number increased with the increase of Reynolds number. An average of 68% enhancement of heat flux was observed for tube with rectangular-cut twisted tape insert than that of smooth tube. The experimental Friction factors with inserts were found to be 39% to 80% higher than Friction factor for smooth tube values. Heat transfer enhancement efficiencies were found to be in the range of 1.9 to 2.3 and increased with the increase of Reynolds number.

Alberto Garcia et al., experimentally studied on three wire coils of different pitch inserted in smooth tube in laminar and transition regimes. Heat transfer experiments had been performed in the flow ranges: Re=10-2500; Pr=200-700.It concluded that at Reynolds number below 200, wire coils do not enhance heat transfer for Reynolds number between 200 and 1000 wire coils increase heat transfer. At Reynolds number around 1000, wire inserts increase the heat transfer coefficient up to eight times with respect to the smooth tube. The friction factor increase in the fully laminar region lie between 5% and 40%.

P. Promvonge investigated the effects of the conical ring turbulators inserts on the heat transfer rate and friction factor on several conical rings used as turbulators were mounted over the test tube. Conical rings with three different diameter ratios of the ring to tube diameter (d/D = 0.5, 0.6, 0.7) were introduced in the tests, and for each ratio, the rings were placed with three different arrangements (converging conical ring, referred to as CR array, diverging conical ring, DR array and converging–diverging conical ring, CDR array). It was used as cold air at ambient condition for Reynolds numbers in a range of 6000–26,000. It was concluded that conical ring inserts to a higher heat transfer rate than that of the plain surface tube, and the DR array yields a better heat transfer than the others. The enhancement efficiency increases with decreasing Reynolds number and diameter ratio. The effect of using the conical ring causes a substantial increase in friction factor.

P. Sivashanmugam, S. Suresh in this paper, they studied experimental investigation of heat transfer of water for laminar flow in circular tube fitted with full-length helical screw element of different twist ratio, increasing and decreasing order of twist ratio and it was compared with plain tube. They concluded that the heat transfer coefficient increases with the twist ratio and friction factor also increases with the twist ratio. There was no much change in the magnitude of heat transfer coefficient with decreasing twist ratio and with increasing twist ratio.

P. Bharadwaj et al. their aim was to investigate experimentally determined pressure drop and heat transfer characteristics of flow of water for Laminar to fully turbulent ranges in a 75-start spirally grooved tube with twisted tape insert. They had been considered Laminar to fully turbulent ranges of Reynolds numbers. The grooves were clockwise with respect to the direction of flow and compared to smooth tube, the heat transfer enhancement due to spiral grooves is further augmented by inserting twisted tapes having twist ratios Y =10.15, 7.95 and 3.4. They concluded that smooth tube shows that the spirally grooved tube without twisted tape yields maximum heat transfer enhancement in the laminar range than the turbulent range. Spirally grooved tube with twisted tape shows maximum enhancement in the laminar range than the turbulent range. Among the three twist ratios (Y = 10.15, 7.95 and 3.4) tested, heat transfer performance of clockwise twisted tape with Y = 7.95 is found to be the highest at in laminar, transitional and turbulent ranges of Reynolds numbers.

Haydar Eren et al. experimentally studied the heat transfer Characteristics of circular coil-spring turbulators. These results were parameterized by Reynolds numbers in the range of 2500 < Re < 1200, outer diameters of the springs (Ds=7.2 mm, 9.5 mm, 12mm, and 13 mm), numbers of the springs and the incline angles of the springs (Ø=0 deg, 7 deg, and 10 deg). They concluded that increasing spring number, spring diameter, and incline angle result increases on heat transfer, comparatively 1.5–2.5 times of the results of a smooth empty tube. Friction factor increases 40–80 times for a smooth tube. For the smallest incline angle of the springs Ø =0 deg heat transfer and friction factor have the lowest values, while for Ø =10 deg the heat transfer and friction factor have the highest values. If consider the design parameter, the incline angle has the dominant effect on heat transfer and friction loss while spring number has the weakest effect.

Naga Sarade S et al. experimentally investigated of the augmentation of turbulent flow heat transfer in a horizontal tube by means of mesh inserts with air as the working fluid and it was compared with plain tube. Sixteen types of mesh inserts with screen diameter of 22mm, 18mm, 14mm and 10mm for varying distance between the screens in porosity range of 99.73 to 99.98 were considered for experimentation. The Reynolds number was varied from 7000 to 14000. They concluded that enhancement of heat transfer by using mesh insert s when compared to plain tube at same mass flow rate was more by factor of 2 times. As the mesh diameter decreases turbulence created in the tube decreases causing an increase in surface temperature. As Reynolds number increases higher heat transfer rates were observed. The increase in pressure drops by increasing ratio of porous material.

Ahmet Tandiroglu studied effect of the flow geometry parameters on transient forced convection heat transfer for turbulent flow in circular tube with baffle inserts. The characteristic parameter of the tubes was different range of pitch to inlet diameter ratio H/D=1, 2, 3and the baffle orientation angle $\beta=45^0$, 90^0 and 180^0. Air was used as working fluid in the range of Reynolds number 3000 to 20,000. It was varied different geometrical parameter such as baffle spacing H and the baffle orientation angel β. It was conclude that the tubes with baffle inserts give higher heat transfer rate than smooth tube. The time averaged Nusselt number increases with increasing Reynolds number. The rate of pressure drop increases with increasing Reynolds number for transient flow conditions but decreases with increasing Reynolds number for the steady state flow conditions. The rate of average pressure drop in the baffle inserted tubes for transient flow conditions was higher than that of steady state flow conditions.

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