Review on Heat Transfer Characteristics for Corrugated Tube in a Double Pipe Heat Exchanger

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Abstract— The corrugated plate heat exchangers are widely used in food industry especially for pasteurization operations. The Double pipe heat exchanger is one of the Different types of heat exchangers because one fluid flows inside a pipe and the other fluid flows between that pipe and another pipe that surrounds the first in a parallel flow, both the hot and cold fluids enter the Heat exchanger at same end and move in same direction. In a counter flow, both the hot and cold fluids enter the Heat exchanger at opposite end and move in counter direction. The present study will be taken up to carry out review work for the calculation of heat transfer rate in Double-Pipe Heat Exchanger made of corrugated tube .It is observed that In experimental set up hot water and cold water will be used working fluids. The inlet Hot water will be around 70 °C and cold water temperature will be varied from between 20 to 38 °C. It has been planned to find effects of the inlet condition of both working fluid flowing through the heat exchanger for the heat transfer characteristics.

Key words: Corrugated Tube, Double Pipe Heat Exchanger, Heat Transfer Coefficient, Pressure Drop

I. INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperature sand in thermal contact. The fluids may be single compounds or mixtures. Typical applications Involve heating or cooling of a fluid stream of concern, evaporation or condensation of a single or multi component fluid stream, and heat recovery or heat rejection from a system. In other applications, the objective may be to sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control process fluid. In some heat exchangers, the fluids exchanging heat are in direct contact. In other heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In most heat exchangers, the fluids are separated by a heat transfer surface, and ideally they do not mix. Such exchangers are referred to as the direct transfer type, or simply recuperators. In contrast, exchangers in which there is an intermittent heat exchange between the hot and cold fluid mesh via thermal energy storage and rejection through the exchanger surface or matrix--are referred to as the indirect transfer type or storage type, or simply regenerators.

The principal types of heat exchanger used in the chemical process and allied industries are listed below:

1) Double-Pipe Exchanger: Used For Cooling and Heating.
2) Shell and tube exchangers: used for all applications.
3) Plate and frame exchangers (plate heat exchangers): used for heating and cooling.
4) Plate-fin exchangers.
5) Spiral heat exchangers.
6) Air cooled: coolers and condensers
7) Direct contact: cooling and quenching.
8) Agitated vessels.
9) Fired heaters.

A. Flow Arrangements

Flow arrangement determines the order in which the hot fluid and cold fluid interact.

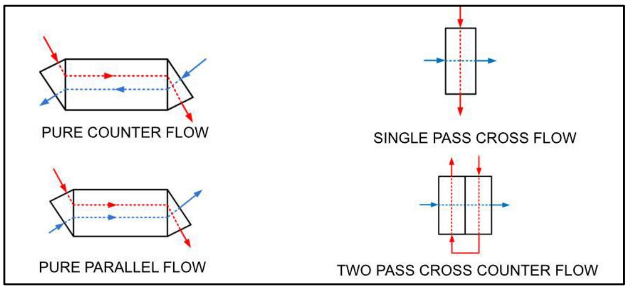

Fig. 1: Flow Arrangements

B. Double Pipe Heat Exchanger

A double-pipe heat exchanger (Figure) is perhaps the simplest type of heat exchanger possible, consisting of two concentric tubes, and appropriate end fittings to move the fluids from one section of the exchanger to the next. If one or the other fluid has much lower heat transfer coefficient, the inner tube can be equipped with longitudinal fins on inner or, more commonly, external surface.

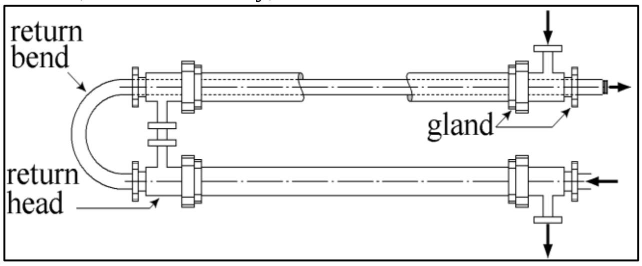

Fig. 2: Double Pipe Heat Exchanger

C. Corrugated Tubes

- Higher heat transfer co-efficient: Corrugated tubes increase the turbulence in the flow that enables a more effective mixing and agitation that generates a higher heat transfer coefficient compared to smooth tubes at the same conditions. In many cases, the heat transfer coefficient is almost doubled.
- Economical: The cost of corrugated tube heat exchanger is 25% To 50% less than the cost of a plain tube heat exchanger for the same duty. When exotic materials are used significant savings can be made on the overall cost of the unit.
- Reduced Fouling: Corrugation carries a self-cleaning effect that reduces fouling on the tube surface. Less

fouling means smaller heat exchanger and longer production cycles.

- Low maintenance & operating cost.
- Small product and service hold up volumes due to the compact size of the Heat Exchanger.
- Longer running times without stopping for cleaning. Higher response to CIP cleaning.
- Homogenous Thermal treatment due to the mixing capacity.

II. LITERATURE REVIEW

Hamed Sadighi Dizaji et al.[1] studied on Heat exchange, Pressure drop and viability in a double pipe heat exchanger made of corrugated external as well as internal tubes have been experimentally explored in this paper. Both of the inward and external tubes were ridged by method for an extraordinary machine. New different plans of inner and outer tube were examined. Heat exchange coefficient was resolved utilizing Wilson plots. Hot water (inward tube) and cool water (external tube) channel temperatures were kept up at around 40 oC and 8 oC separately. Tests were performed over the Reynolds number scope of 3500-18000 based on the water powered distance across of the annular space between the two tubes. Boiling point water Reynolds number was kept steady at around 5500. Discoveries showed that the external tube creases and course of action sort of creased tubes have significant impact on thermal and frictional qualities. Greatest effectiveness was acquired for warmth exchanger made of concave corrugated external tube and convex corrugated inward tube. As a result, arrangement type and Reynolds number, the use of corrugated tube as the inner tube of the double pipe heat exchanger increased the Nusselt number and friction factor about 10e52% and 150e190% respectively. When both of the inner and outer tubes were corrugated, the Nusselt number and friction factor increased about 23-117% and 200-254%.

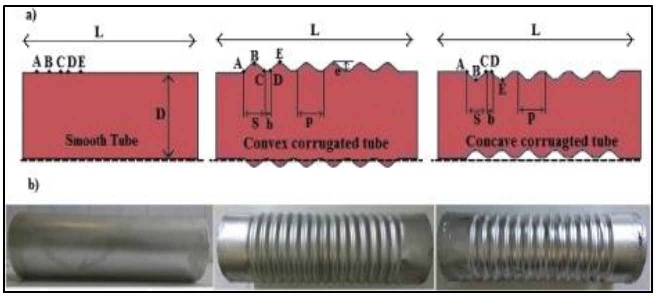

Fig. 3: Schematic diagram of smooth tubes and corrugated tubes

Suriyan Laohalertdecha et al.[2] studied on heat exchange coefficient and pressure drop of R-134a inside a level smooth tube and corrugated tubes are experimentally researched. The test segment is a 2.0 m long counter-flow concentric double tube heat exchanger with refrigerant flowing in the inward tube and cooling water flowing in the annulus. A smooth tube and creased tubes having internal distances across of 8.7 mm are utilized as an inward tube. The crease pitches are 5.08, 6.35, and 8.46 mm, separately. The crease depth of all corrugated tubes is fixed at 1.5 mm. The external tube is produced using smooth copper tube having an inward measurement of 21.2 mm. The test runs are performed at the immersion temperatures of 40, 45, and 50 .C, heat fluxes of 5 and 10 kW/m^2 and mass fluxes extending from 200 to 700 kg/m2 s. The outcomes obtained from the ridged tubes are compared to that of the smooth tube. It is found that the groove pitches have a significant impact on the heat exchange coefficient and pressure drop augmentations. The maximum heat transfer coefficient ratio and frictional pressure drop ratio of the corrugated tube are up to 50% and 70% higher than those of the smooth tube respectively.

P.G. Vicente and A. Viedma et al.[3] presented the mixed convection heat transfer and isothermal Pressure drop in a corrugated tubes for a laminar and transition flow. They use water and ethylene glycol As a test fluid. They also observed that increase in friction between 5-25% depend on roughness severity Index. Mixed convection is occur in heat transfer, they show that heat transfer of up to 30% at high Reynolds number is obtained.

Fig. 4: Photograph of helically-corrugated/smooth tube

S. Pethkool et al.[4] studied the expansion of convective warmth move in a solitary stage turbulent flow by utilizing helically folded tubes has been tentatively explored. Impacts of pitch-to-width proportion (P/DH= 0.18, 0.22 and 0.27) and rib-stature to distance across proportion (e/DH= 0.02, 0.04 and 0.06) of helically ridged tubes on the warmth exchange improvement, isothermal contact and warm execution component in a concentric tube heat exchanger are inspected. The analyses were led over an extensive variety of turbulent fluid flow of Reynolds number from 5500 to 60,000 by utilizing water as the test fluid. Test results demonstrate that the warmth exchange and warm execution of the ridged tube are impressively expanded contrasted with those of the smooth tube. The mean increment in warmth exchange rate is somewhere around 123% and 232% at the test range, contingent upon the rib pitch proportions and Reynolds number while the most extreme warm execution is observed to be around 2.3 for utilizing the folded tube with P/DH= 0.27 and e/DH= 0.06 at low Reynolds number. Additionally, the weight misfortune result uncovers that the normal rubbing variable of the folded tube is in a reach somewhere around 1.46 and 1.93 times over the smooth tube. What's more, relationships of the Nusselt number, grating variable and warm execution component as far as pitch proportion (P/DH), rib-tallness proportion (e/DH), Reynolds number (Re), and Prandtl number (Pr) for the ridged tube are resolved, taking into account the bend fitting of the test information.

Suriyan Laohalertdecha et al.[5] presented the Connections for the dissipation heat exchange coefficient and two-stage grinding variable of R-134a flowing through flat creased tubes are proposed. In the present study, the test area is a level counter-flow concentric tube-in-tube heat exchanger with R-134a flowing in the inward tube and boiling point water flowing in the annulus. Smooth tube and ridged tubes with inward distances across of 8.7 mm and lengths of 2000 mm are utilized as the internal tube. The layering pitches are 5.08, 6.35, and 8.46 mm and the groove profundities are 1, 1.25, and 1.5 mm, separately. The external tube is produced using smooth copper tube with an inward breadth of 21.2 mm. The connections displayed are shaped by utilizing around 200 information focuses for five diverse ridged tube geometries and are then proposed as far as Nusselt number, proportional Reynolds number, Prandtl number, folding pitch and profundity, and inside width.

Kadir Bilen et al.[6] study shows the exploratory investigation of surface warmth exchange and grinding attributes of a completely created turbulent air flow in various notched tubes is accounted for. Tests were performed for Reynolds number extent 10,000–38,000 and for various geometric score shapes (round, trapezoidal and rectangular). The proportion of tube length-to-width is 33. Among the notched tubes, heat exchange improvement is acquired up to 63% for roundabout section, 58% for trapezoidal depression and 47% for rectangular score, in correlation with the smooth tube at the most elevated Reynolds number (Re = 38,000). Relationships of warmth exchange and contact coefficient were acquired for various scored tubes. In assessment of warm execution, it is seen that the furrowed tubes are thermodynamically profitable (Ns, a < 1) up to Re = 30,000 for round and trapezoidal depressions and up to Re = 28,000 for rectangular sections. It is watched that there is an ideal estimation of the entropy era number at about Re = 17,000 for all examined grooves.

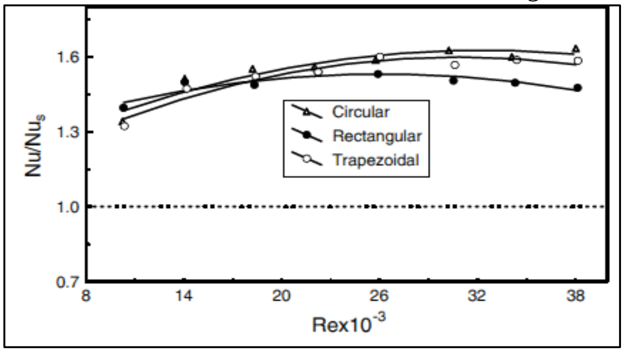

Fig. 5: Variation of Nusselt number ratio with Reynolds number for different grooved tubes

As a result, they found that for the grooved tubes, maximum heat transfer enhancement is obtained up to 63% for circular groove, 58% for trapezoidal groove and 47% for rectangular groove, in comparison with the smooth tube. For the rectangular grooved tube, less increase heat transfer enhancement is obtained, because it is speculated that the fluid flows resulting in by pass of the flow over the groove and increases the formation of the recirculation region inside the rectangular grooves.

J.P.Solano et al.[7] shows the influence of artificial roughness shape on heat transfer enhancement on Corrugated tubes, dimpled tubes and wire coils. This work dissects the thermal hydraulic conduct of three sorts of improvement method taking into account artificial unpleasantness: layered tubes, dimpled tubes and wire loops. The examination has been performed from the three best examples chose among the extensive variety of geometries explored by the creators in past works. Heat exchange and weight drop trial information in laminar, move and turbulent administrations are utilized as a part of this examination. Results demonstrate that the state of the artificial unpleasantness applies a more prominent influence on the weight drop qualities than on the warmth exchange increase. In like manner, this shape firmly influences the development of the move to turbulence and its qualities: smooth or sudden. The study reasons that for Reynolds numbers lower than 200, the utilization of smooth tubes is prescribed. For Reynolds numbers somewhere around 200 and 2000, the work of wire loops is more invaluable, while for Reynolds numbers higher than 2000, the utilization of creased and dimpled tubes is favoured over the wire loops in view of the lower weight drop experienced for comparable warmth exchange coefficient levels.

Paisarn Naphon[8] investigates the heat transfer characteristics and pressure drop results in the corrugated channel under constant heat flux. The test segment is the channel with two inverse corrugated plates which all design crests lie in an in-line course of action. The folded plates with three diverse creased tile points of 20°, 40°, and 60° are tried with the tallness of the channel of 12.5 mm. The examinations are accomplished for the heat flux and the Reynolds number in the scopes of 0.5– 1.2 kW/m2 and 500–1400, individually. Impact of other parameters on the heat exchange attributes and pressure drop are talked about. Because of the nearness of distribution zones, the corrugated surface has huge impact on the upgrade of heat exchange and pressure drop.

Parth P. Parekh and Neeraj K. Chavda[9] carried out Experimental and Exergy Analysis of a Double Pipe Heat Exchanger for Parallel- stream Arrangement. The Double pipe heat exchanger is one of the Different sorts of heat exchangers. Double pipe exchanger since one liquid streams inside a channel and the other liquid streams between that pipe and another channel that encompasses the first. In a parallel stream, both the hot and frosty liquids enter the Heat exchanger at same end and move in same direction. The present work is taken up to convey exploratory work and the exergy examination in light of second law examination of a Double-Pipe Heat Exchanger. In trial set up high temp water and cool water will be utilized working liquids. The delta Hot water will be differed from 400 C and 500 C and chilly water temperature will be differed from somewhere around 15 and 20. It has been wanted to discover impacts of the delta state of both working liquid moving through the warmth exchanger on the warmth exchange qualities, entropy era, and Exergy misfortune. The Mathematical displaying of warmth exchanger will taking into account the protection condition of mass, vitality and in view of second law of thermodynamics to discover entropy era and exergy losses.

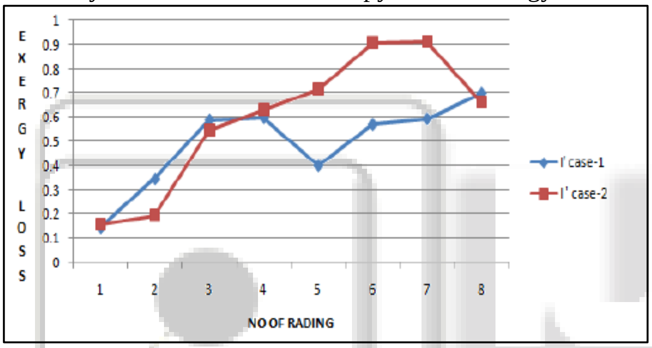

Fig. 6: Exergy losses for Case-1 and Case-2

Antony A. luki and Ganesan.M[10] shows the augmented surface has been achieved with dimples strategically located in a pattern along the tube of a concentric tube heat exchanger with the increased area on the tube side. Augmented surfaces to increasing the heat transfer coefficient with a consequent increase in the friction factor. In this analysis to modify the inner tube of double pipe heat exchanger using dimpled tube. The concentric tube heat exchanger is design from Juin Chen a.et.al. Correlation. In this design the inner tubes consider as the hot flue gas and outer tube is nano fluid. Here In this study the properties of nano fluid from the alumina as the nano fluid with ethyl glycol as the base fluid. a. From this design calculation the heat transfer co efficient is increased Compared to plain concentric tube heat exchanger. Similarly the effectiveness is 8% increased compared to plain concentric tube heat exchanger. The theoretical results show that the using dimpled tube in concentric tube heat exchanger gives better performance. The modeling and analysis is carried out to vary the dimple tube cross sections, ellipsoidal and spherical shapes using CFD. Finally the enhanced dimple tube is compare with the theoretical, analytical and analysis the results and obtained that dimpled tube heat exchanger gives better performance and is used in concentric tube heat exchanger in various applications will give high heat transfer.

III. CONCLUSIONS

- The heat transfer coefficient and friction factor increases with the decrease in baffle spacing compared with smooth tube.
- Numerical and trial investigation has been done in various studies on viability, general warmth exchange coefficient and grating elements are broke down by utilizing specified warmth exchange growth strategies. The CFD displaying and trial results demonstrated that an expansion in turbulence force could be one of the purposes behind higher execution growth techniques with the plain tubes heat exchanger.
- It is concluded that from theoretical calculation the overall heat transfer coefficient is increased and also effectiveness of the dimpled tube with concentric tube heat exchanger is increased 8% compare to plain tube concentric tube heat exchanger. From theoretical results shows that dimpled tube heat exchanger gives better performance. So we suggest the dimpled tube is used in concentric tube heat exchanger in various applications will give high heat transfer.
- The effect of corrugation angle has been analyzed and it has been observed from the experimental results that the corrugation angle is the major parameter that affects the pressure drop and the friction factor. As the corrugation angle increases, pressure drop offered by the channel increases and the friction factor deceases.
- Results shows that the external tube corrugated and course of action sort of ridged tubes have significant impact on heat and frictional attributes. Most extreme viability was acquired for heat exchanger made of inward layered external tube and raised folded inward tube.
- Arrangement type of corrugated tubes (concave and convex) had greater effect on thermal and frictional characteristics. Depending on arrangement type and Reynolds number, the use of corrugated tube as the inner tube of the double pipe heat exchanger increased the Nusselt number and friction factor about 10-52% and 150-190% respectively. When both of the inner and outer tubes were corrugated, the Nusselt number and friction factor increased about 23-117% and 200-254%.
- It is found that the Nusselt number, Friction factor and thermal performance component increment with expanding the pitch proportion (P/DH) and the rib-tallness proportion (e/DH). In expansion, the exact relationships of the Nusselt number, grinding variable and warm execution component are likewise decided for double pipe smooth tubes and corrugated tubes heat exchanger.
- Experimental investigations of heat transfer and friction factor characteristics of double pipe heat exchanger fitted with inserted semicircular disc baffles with spacing of 15cm and 45 cm carried out for turbulent flow and they concluded that The heat transfer coefficient and friction factor increases with the decrease in baffle spacing compared with smooth tube.

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