A review: Heat Transfer Characteristics of tube in tube heat exchangers

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Abstract- *Effective utilization of Heat Exchangers depends on optimization of size, heat transfer rate and pressure drop. In order to increase heat transfer rate among the heat exchangers, different techniques are used like external fins, internal micro-fins, coiled wire inserts, internal grooves, electro hydrodynamic technique etc. Internal grooves in heat exchanger pipe finds very suitable because of its ease of manufacturing. Internally grooved pipes are used in heat exchanger so as to improve heat transfer rate, but at the same time pressure drop is also a problem so that additional power is required to overcome this pressure drop. This paper discussed the analysis done by various researchers.*

Keywords- Q_h - Heat loss by hot air, Q_c - Heat gain by cold water, h- Convective heat transfer coefficient, f- Friction factor, A-surface area,, Re- Reynolds number, Nu- Nusselt number, Pr- Prandtl number, Cp- Specific heat, ΔP- pressure drop, Thi –hot air inlet temperature, Tho –hot air outlet temperature, Tci –cold water inlet temperature, Tco –cold water outlet temperature

I. INTRODUCTION

Heat transfer rate can be increased by increasing internal and external surface area, turbulence to the flow of fluid inside a pipe. Internal grooves in a heat exchanger pipe increases internal surface area as well as turbulence to the flow, which increases heat transfer rate. Increase of turbulence causes increase of pressure drop so optimum groove size is need to be found which will give minimum pressure drop and maximum heat transfer rate.

In the proposed work mathematical analysis of internally grooved (IG) pipe has been carried out to investigate the performance enhancement due to the variation of helix angle and depth of cut of internal grooves in a concentric double pipe heat exchanger. Mathematical model is compare with experimental result.

II. LITERATURE SURVEY

Paisarn Naphon et al. [1] investigated the heat transfer characteristics of the horizontal double pipes with and without coiled wire inserts. The results obtained from the micro-fin tube with coiled wire insert are compared with those obtained from smooth and micro-fin tubes. They found that the coiled wire insert has a significant effect on the enhancement of heat transfer. The pressure drop is found maximum with the coiled wire inserts.

Suriyan Laohalertdecha et al.[2]presented The results of the condensation heat transfer enhancement and pressure drop of HFC·134a by using the electro hydrodynamic (EHD) technique. They found that the maximum enhancement by EHD for average heat transfer coefficient in smooth and micro-fin tubes is 1.1 times and1.08 times, respectively. The pressure drop obtained from the application of an EHD voltage of 2.5 kV in micro-fin tubes is higher than that in smooth tubes across the range of average quality.

Raush G. et al.[3]presented a methodology for analyzing the influence of the heat transfer and friction factor correlations in the prediction of the two-phase flows inside horizontal ducts under evaporation phenomena. The experimental approach they presented has been revealed useful to reproduce similar conditions found in industrial applications using any kind of refrigerant fluids.

Graham D. et al. [4] performed condensation experiments over a axially grooved micro fin tube having inside diameter 8.91mm with R134a.They found that the axially grooved tube performs marginally better than a smooth tube. but worse than a similarly grooved tube with an 18^0 helix angle. Pressure drop characteristics of the axially grooved tube are similar to those found in an 18^0 helix angle tube.

Paisarn Naphon [5] presented experimental and theoretical investigations on the entropy generation, exergy loss of a horizontal concentric micro-fin tube heat exchanger. He employed central finite difference method to solve the model for obtaining temperature distribution, entropy generation and exergy loss of the micro-fin tube heat exchanger. Then the obtained results from the model are verified by comparing with the measured data. He obtained reasonable agreement from the comparison between predicted results and those obtained from the measured data.

Passos J.C. et al. [6] presented experimental data for R-113 pool boiling, at atmospheric pressure and moderate heat flux, inside vertical and horizontal aluminium open-ended tubes, whose internal surfaces are either smooth or grooved. They found that for all the tests, the heat transfer coefficient of the grooved tube is higher than that of the smooth tube.

Eiamsa-ard Smith et al.[7] performed experimental work to examine the combined effects of rib-grooved turbulators on the turbulent forced convection heat transfer and friction characteristics in a rectangular duct under a uniform heat flux boundary condition. They found that all rib-groove arrangements significantly enhance the heat transfer rate in comparison with the smooth duct and the heat transfer can also be promoted by increasing the turbulence degree with reducing the pitch ratio.

Bilen Kadir et al. [8] performed experimental study of surface heat transfer and friction characteristics of a fully developed turbulent air flow in different grooved tubes. They performed test for Reynolds number range 10,000–38,000 and for different geometric groove shapes (circular, trapezoidal and rectangular). They observed that there is an optimum value of the entropy generation number at about Re = 17,000 for all investigated grooves.

Tang xinyi et al. [9] conducted experimental and numerical investigations to study turbulent flow of water and heat transfer characteristics in a rectangular channel with discontinuous crossed ribs and grooves. They found experimentally that the Nusselt number ratio and friction factor ratio in ribbed-grooved channel are higher than that in ribbed channel without grooves.

Bharadwaj P. et al. [10] determined experimentally pressure drop and heat transfer characteristics of flow of water in a 75-start spirally grooved tube with twisted tape insert. They found that the direction of twist (clockwise and anticlockwise) influences the thermo-hydraulic characteristics. Constant pumping power comparisons with smooth tube characteristics show that in spirally grooved tube with and without twisted tape, heat transfer increases considerably in laminar and moderately in turbulent range of Reynolds numbers.

III. MATHEMATICAL MODELS AND RESULTS

The performance of a triple concentric pipe heat exchanger is studied experimentally under steady state conditions for two different flow arrangements, called N–H–C and C–H–N, and for insulated as well as non-insulated conditions of the heat exchanger by G. A. Quadir, et.al [11]

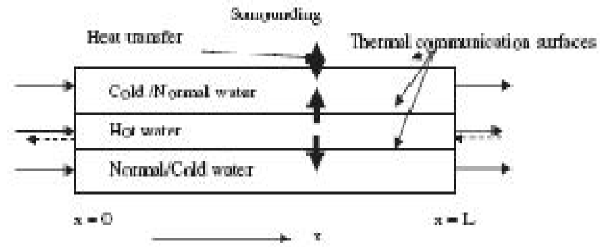
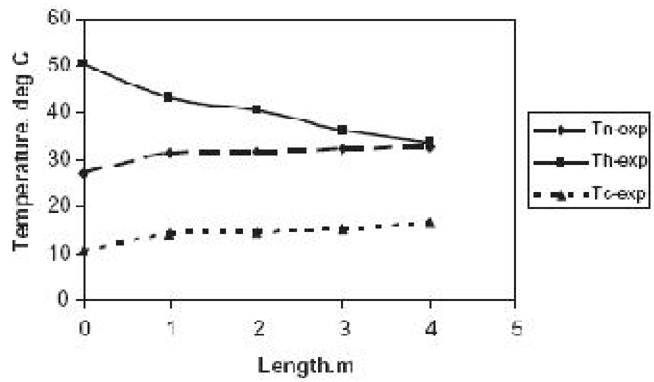


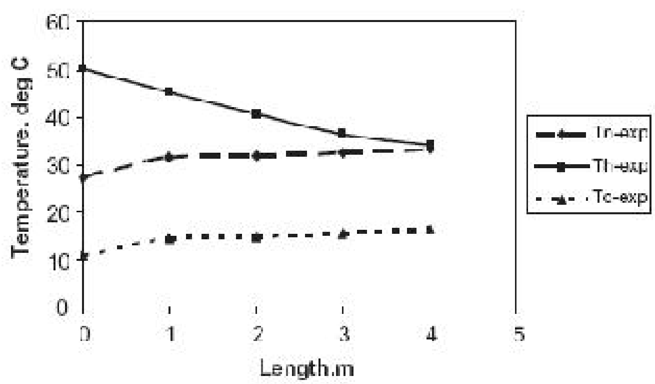
Figure1. Flow arrangements of triple fluid

They have got Temperature distribution of three fluids along the length of heat exchanger under (C–H–N)and co-current configuration (a)Insulated (b) Non-insulated, as



(a)

Figure2. Insulated



(b)

Figure3. Non insulated

Ebru Kavak Akpinar [12] evaluated heat transfer and exergy loss in a concentric double pipe exchanger equipped with helical wires. Inner fluid is used as air and outer fluid is used as water. Various parameters are obtained as below.

Heat loss by hot air,

$$\dot{Q}_h = \dot{m}_h C_{ph}(T_{hi} - T_{ho}) = H_h A_i \Delta T_{li},$$

Heat gain by water

$$\dot{Q}_c = \dot{m}_c C_{pc}(T_{co} - T_{ci}) = H_c A_o \Delta T_{lo}.$$

Nusselt number

$$Nu = \frac{H_h d_i}{k}.$$

Overall heat transfer coefficient abtained by

$$\dot{Q}_h = U_i A_i \Delta T_L,$$

Maximum heat transfer can be obtained by

$$\dot{Q}_{max} = C_{min}(T_{hi} - T_{ci}) = \dot{m}_h C_{ph}(T_{hi} - T_{ci}).$$

Number of transfer units are obtained by

$$\mathrm{NTU} = \frac{UA}{C_{min}}.$$

He has found that results in counter flow heat exchanger are very good compared with parallel flow, the variation of Reynolds number with nusselt number are as follows

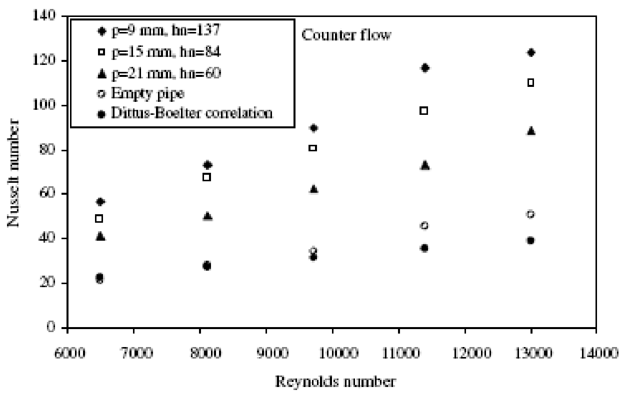


Figure 4. Variation of Nusselt number with Reynolds number

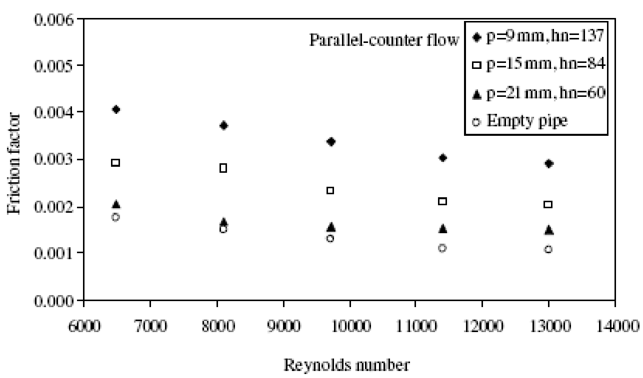


Figure 5. Variation of friction factor with Reynolds number

Mohsen Sheikholeslami, et.al [13] studied turbulent flow and heat transfer in an air to water double-pipe heat exchanger is investigated experimentally. They have found friction factor as

$$f = \frac{\Delta P}{(\rho u^2/2)(L/d_H)}$$

They have used Gnielinski co relation to get Reynolds number

$$Nu = \frac{\left(\frac{f}{2}\right)(Re - 1000)Pr}{1 + 12.7\left(\frac{f}{2}\right)^{0.5}(Pr^{2/3} - 1)}, \quad 2300 < Re < 5 \times 10^6,$$

$$0.5 < Pr < 2000$$

They have got the effect of flow rate on nusselt number for inner and outer tube and friction factor

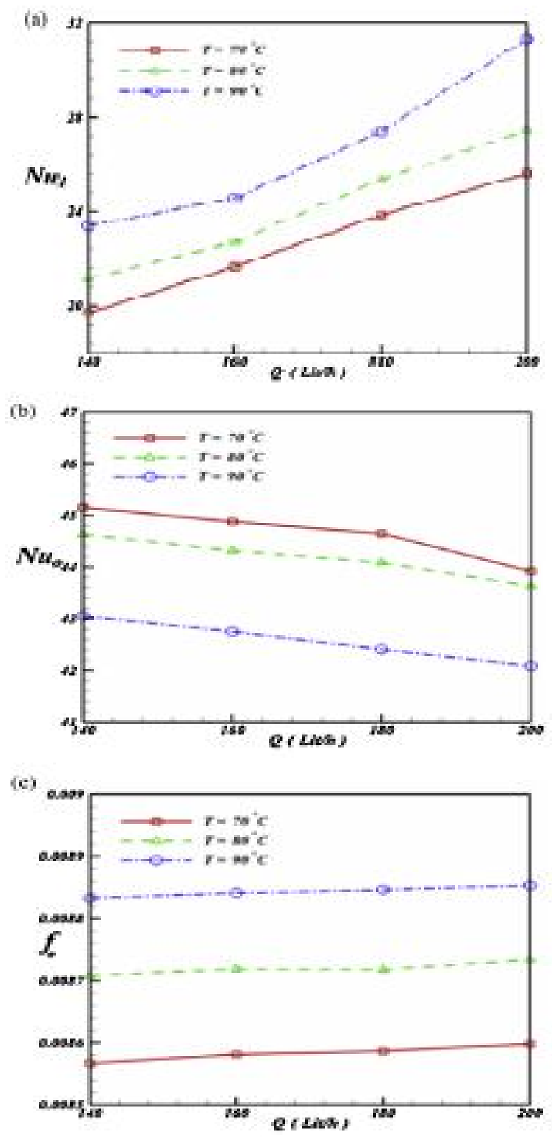


Figure 6. Effect of flow rate on Nusselt number for a) inner tube, b)outer tube, c) friction factor

Shriram S. Sonawane et.al [14] presented the heat transfer characteristics of Al_2O_3 – water nano fluids as a coolant used in concentric tube heat exchanger they have got Variation of overall heat transfer coefficient for different coolant Reynolds number. (Condition: Nanoparticles concentration in base fluids 2 and 3%, Reynolds number range of 300–4000)

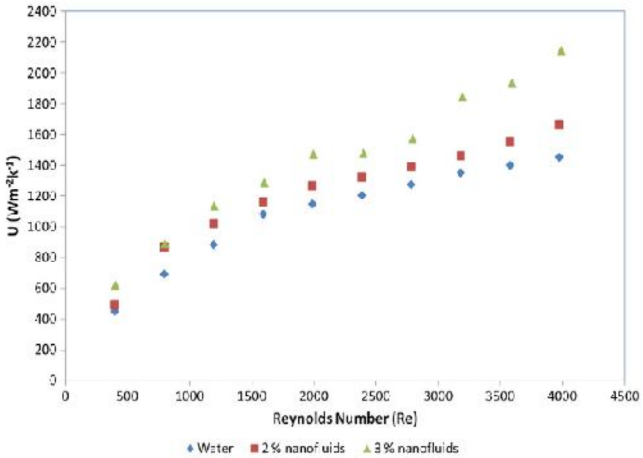


Figure 7. Variation of overall heat transfer coefficient for different coolant Reynolds number

Marco Cavazzuti, et.al [15] Presented a numerical application in which a finned concentric pipes heat exchanger is simulated by means of CFD, and optimized by the Nelder and Mead simplex downhill optimization algorithm. They have obtained Temperature distributions along the heat exchanger; the contour lines in the images are traced every 100^0C.

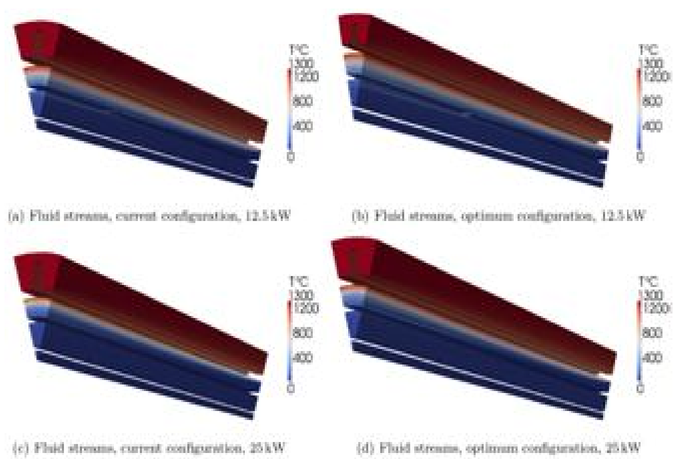


Figure8. Temperature distributions along the heat exchanger

IV. CONCLUSIONS

1. Internal grooves improve heat transfer rate in a heat exchanger.
2. The heat transfer rate and pressure drop inside IG pipe depends upon the helix angle and depth of cut of grooves, flow pattern of the fluid like laminar or turbulent.
3. Less research was directed towards the optimisation of helix angle and depth of cut of internal grooves.
4. IG pipe is easy to manufacture so that variation of helix angle and depth of cut can be easily achieved.

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