Heat Transfer Enhancement Using Internal Fins of same Hydraulic Diameter

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Abstract-This experimental study has been carried out to increase the heat transfer rate in single tube heat exchange. This experiment has been working with laminar flow of working fluid water. Fins provided at the internal periphery of the tube. In this study measured the effect of two types of fins on heat exchanger and compare its results to the plain tube type heat exchanger. Rom this experimental work it has been observed that the heat transfer rate was maximum in the rectangular fin with square section and it slightly higher from the cylindrical fins used in the heat exchanger. NU and friction factor maximum for rectangular fin and it decreased for cylindrical and plain tube respectively.

Keywords- *heat exchanger, single tube, fins, cylindrical, rectangular, plain tube.*

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Introduction

Heat exchangers are popular used in industrial and engineering applications. The design procedure of heat exchangers is quite complicated, as it needs exact analysis of heat transfer rate, efficiency and pressure drop apart from issues such as long- term performance and the economic aspect of the equipment. Whenever inserts technologies are used for the heat transfer enhancement, along with the improvement in the heat transfer rate, the pressure drop also increases, which induces the higher pumping cost. Therefore any augmentation device or methods utilized into the heat exchanger should be optimized between the benefits of heat transfer coefficient and the higher pumping cost owing to the increased frictional losses. In general, heat transfer augmentation methods are classified into three broad categories:

Heat Transfer Enhancement

Tubes with rough surfaces have much higher heat transfer coefficients than tubes with smooth surface. Therefore tube surface are often intentionally roughened, corrugated, or finned in order to enhance the convection heat transfer coefficient and thus convection heat transfer rate. Heat transfer in turbulent flow in a tube has been increased by as much as 400% by roughing the surface also increased the friction factor and thus the power requirement for the pump or fan.[1]

Following research study have been observed for the use of fins for different heat exchanging system.

KarthikPooranachandran et al. " Experimental And Numerical Investigation Of A Louvered Fin And Elliptical Tube Compact Heat Exchanger" carried out an experimental investigation to analyse the heat transfer characteristics of a louvered fin and elliptical tube compact heat exchanger used as a radiator in an internal combustion engine. A Numerical analysis has been carried out using fluent software (a general purpose Computational fluid dynamics simulation tool) for three chosen data from the experiments. The numerical air-side temperature drop is compared with those of the experimental values. A good agreement between the experimental and numerical results validates the present computational methodology.[1]

PegaHrnjak Et Al. "Effect of Louver Angle on Performance of Heat Exchanger with Serpentine Fins and Flat Tubes in Frosting" Measured an Effect of louver angle on performance of heat exchanger with serpentine fins and flat tubes in frosting. The results of an experimental study on the air-side pressure drop and overall heat transfer coefficient characteristics for serpentine-louvered-fin, micro-channel heat exchanger in periodic frosting. It focuses on quantification of the effects of louver angle on heat transfer and pressure drop and on defrost and refrost times. Nine heat exchangers differing in louver angle and fin pitch are studied. The face velocity was 3.5 ms/ and inlet air relative humidity of 70% and 80%. [2]

M.J. Sable and et al. "Enhancement Of Natural Convection Heat Transfer On Vertical Heated Plate By Multiple V-Fin Array" In this investigation work a totally new heat transfer technique is found out to increase the rate of natural convection heat transfer on vertical heated plate. The V–type fin array can be seen as the combination of a horizontal and vertical partition plates. For the same surface areas, V-type partition plates gave better heat transfer performance than vertical rectangular fin array and V-fin with bottom spacing type array. It is thus anticipated that a low pressure suction region is created in the nose region on the downstream side of each This immensely helps to allow the inflow of the low temperature fluid into the separation region and increases the heat transfer rate. [3]

R.Borrajo-Peláez et al. "A three-dimensional numerical study and comparison between the air side model and the air/water side model of a plain fin-and-tube heat exchanger" Work based on CFD air flow models assuming constant temperature of fin-and-tube surface. 3-D Numerical simulations were accomplished to compare both an air side and an air/water side model. The influence of Reynolds number, fin pitch, tube diameter, and fin length and fin thickness was studied. The exchanger performance was evaluated through two non-dimensional parameters: the air side Nusselt number and a friction factor. It was found that the influence of the five parameters over the mechanical and thermal efficiencies can be well reported using these non-dimensional coefficients. Therefore, a higher accuracy of the heat transfer was achieved, yielding better predictions on the exchanger performance.[4]

Y.-G. Park and A. M. Jacobi "Air-Side Performance Characteristics of Round- and Flat-Tube Heat Exchangers: A Literature Review, Analysis and Comparison" work on the air-side thermal-hydraulic performance of serpentine-fin, flat-tube heat exchangers and compared it to that of conventional plate-fin, round-tube designs for various fin geometries and surface conditions. The result shows a clear advantage of lattube design under dry, low-Reynolds-number conditions in comparison to round-tube heat exchangers. The parametric effects on heat exchanger performance reported in the literature, the reasons of discrepancies, and the practical ranges of geometrical and operational parameters in applications are identified and summarized in this study.[5]

Tomozaki Et Al. "Fin-And-Tube Type Heat Exchanger" Work on a joint construction for a fin-and-tube type heat exchanger formed of aluminium. It is suitable for use as an evaporator of a cooling system for an automotive vehicle, wherein an end plate near the open ends of tubes is formed with openings larger in diameter than the openings formed in fin to which the tubes are securely fixed. The brazed joint produced has higher reliability in performance than brazed joints of the prior art. The use of the improved joint construction enables brazing to be carried out automatically and allows a compact size to be obtained in a fin-and-tube type heat exchanger. Omega Company work and improve the finned tubular air heating elements. They are constructed like basic tubular elements with the addition of continuous spiral fins, 4-5 per inch permanently furnace brazed to the sheath. Fins greatly increase surface area and permit faster heat transfer to air, resulting in lower surface element temperatures.

Nabati "Optimal Pin Fin Heat Exchanger Surface" represents the results of numerical study of heat transfer and pressure drop in a heat exchanger that is designed with different shape pin fins. The heat exchanger used for this research consists of a rectangular duct fitted with different shape pin fins, and is heated from the lower plate. The pin shape and the compact heat exchanger (CHE) configuration were numerically studied to maximize the heat transfer and minimize the pressure drop across the heat exchanger. A three dimensional finite volume based numerical model using FLUENT© was used to analyze the heat transfer characteristics of various pin fin heat exchangers.[7]

Pankaj N. Shrirao et al. "Convective Heat Transfer Analysis in a Circular Tube with Different Types of Internal Threads of Constant Pitch" Work on Convective Heat Transfer Analysis in a Circular Tube with Different Types of Internal Threads of Constant Pitch. This work presents an experimental study on the mean Nusselt number, friction factor and thermal enhancement factor characteristics in a circular tube with different types of Internal threads of 120 mm pitch under uniform wall heat flux boundary conditions. In the experiments, measured data are taken at Reynolds number in range of 7,000 to 14,000 with air as the test fluid. The experiments were conducted on circular tube with three different types of internal threads viz. acme, buttress and knuckle threads of constant pitch. The heat transfer and friction factor data obtained is compared with the data obtained from a plain circular tube under similar geometric and flow conditions. They have been observed that at all Reynolds number, the Nusselt number and thermal performance increases for a circular tube with buttress threads as compared with a circular tube with acme and knuckle threads. These are because of increase in strength and intensity of vortices ejected from the buttress threads. Subsequently an empirical correlation is also formulated to match with experimental results with ± 8% and ± 9%, variation respectively for Nusselt number and friction factor. [8]

PongjetPromvonge a,*, Smith Eiamsa-ard b,1 "Heat transfer augmentation in a circular tube using V-nozzle turbulator inserts and snail entry" Experimental investigations have been conducted to examine the effect of V-nozzle turbulator inserts together with a snail entry on heat transfer rate and flow friction characteristics in a uniform heat flux tube using air as the test fluid. Depending on the flow conditions and pitch ratios, the maximum improvements of heat transfer rate over the corresponding plain tube are found to be about 294%, 258% and 244%, for PR = 2.0, 4.0, and 7.0, respectively. The enhancement efficiencies for all pitch ratios having nearly the same values, are found to be peak at the lowest Reynolds number and lower than those of the V-nozzle alone. Except for Reynolds number below 6000, the efficiency of both the V-nozzle and the snail entry is also lower than that of the snail. Enhancement efficiencies for Reynolds number ranging from 5000 to 18000 vary between 0.71 and 0.91; 0.70 and 0.90; and 0.69 and 0.89 for PR = 2.0, 4.0 and 7.0, respectively. In addition, the V-nozzle alone provides the best thermal performance over other turbulator devices.[9]

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Line diagram Of Experimental Setup

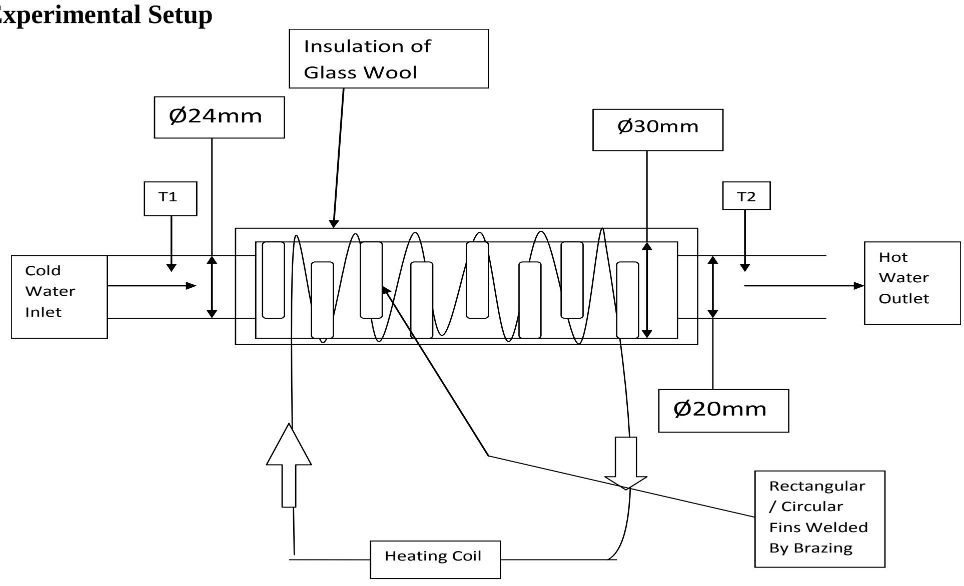

Fig.1 Line Diagram of Experimental Setup

Figure 1 show the line diagram of experimental setup. Single tube heat exchanger has been made up of copper. It has length of 1050mm, inner dia of 27mm and outer dia of 30mm. internal periphery of heat exchanger has been set with cylindrical fins, rectangular fins of same hydraulic diameter respectively for comparative study. Outer periphery of single tube heat exchanger has been wounded by nicrome wire to provide electrical heating uniformly in the test section. Mica tape has been wounded between nicrome wire and copper tube to separation of the electrical flow of current. It only transfers the heat from heating coi to the heat exchanger. Different temperature has been measured with the help of J-type thermo couples such as inlet water, outlet water, surface of tube at inlet and surface of tube at outlet. Length of fin is 24mm and hydraulic diameter was 6mm.whole heat exchanger tube has been insulated by glass wool with 10mm thickness for negligible heat losses.

RESULT AND DISCUSSION

This experimental work has been done to increase the heat transfer rate of single tube heat exchanger for laminar flow of water. In this experimental work fluid flows at Re<2000 and completely laminar flow. In this experimental study cylindrical and rectangular types of fins provided at the inner periphery of the tube respectively. Measure the effect of it on the heat transfer rate, NU and friction factor. And compare these results to the results of single plain tube type heat exchanger.
Following charts has been shown the results of single tube type heat exchanger with plain tube, with cylindrical fins and with rectangular type fins.

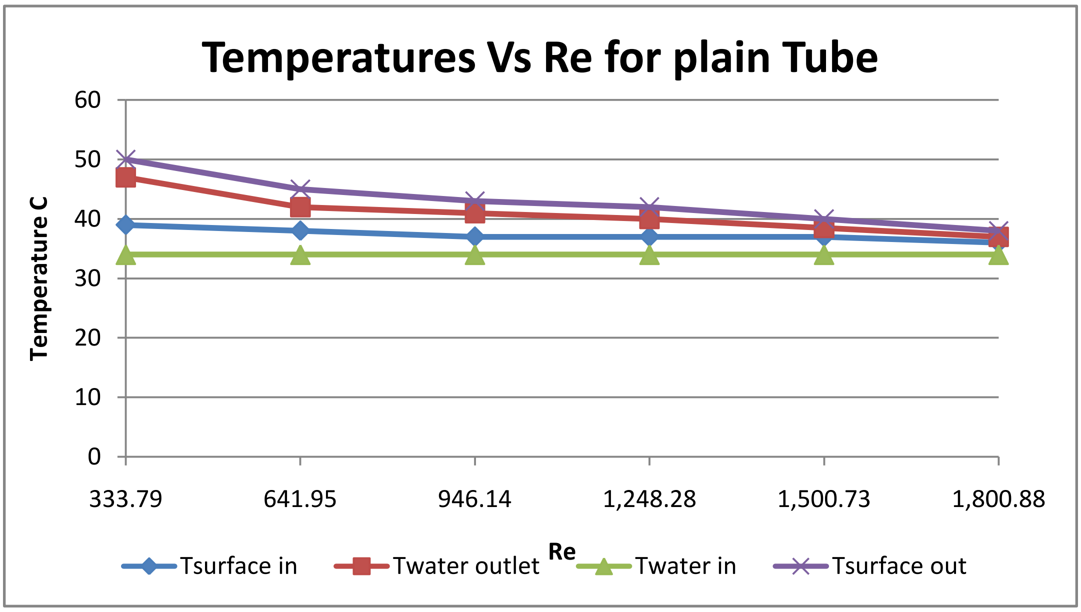

Figure 2 Variation in Temperatures with respected to Reynolds number for HE with Plain Tube.

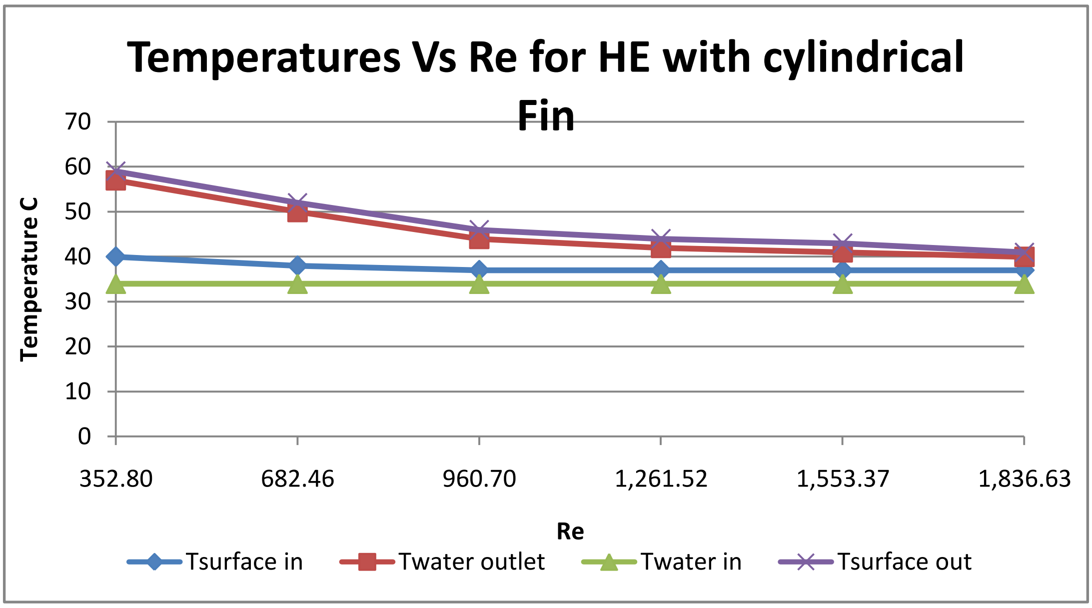

Figure 3 Variation in Temperatures with respected to Reynolds number for HE with Cyl. Fin.

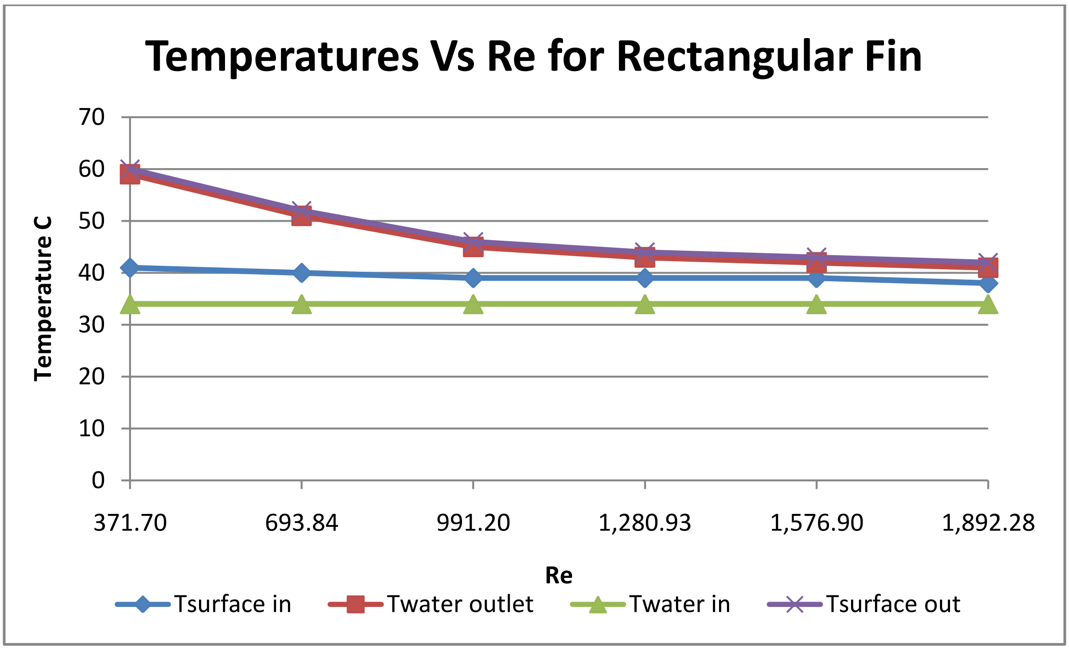

Figure 4 Variation in Temperatures with respected to Reynolds number for HE with Rect. Fin.

Figure 2, Figure 3 and figure 4 shows the variation in temperatures with respected to Reynolds number for single tube heat exchanger with plain tube, with cylindrical fin, and with rectangular fin. From this case study it has been observed that the temperature of surface of heat exchanger at outlet and temperature of water at outlet was decreased gradually with increasing the Re or mass flow rate. The small decrement in temperature of surface at inlet has been observed b increasing the re or mass flow rate. When the rectangular type fins used in the heat exchanger than the temperature difference between outlet surface of tube and outlet temperature of water has been reduced gradually.

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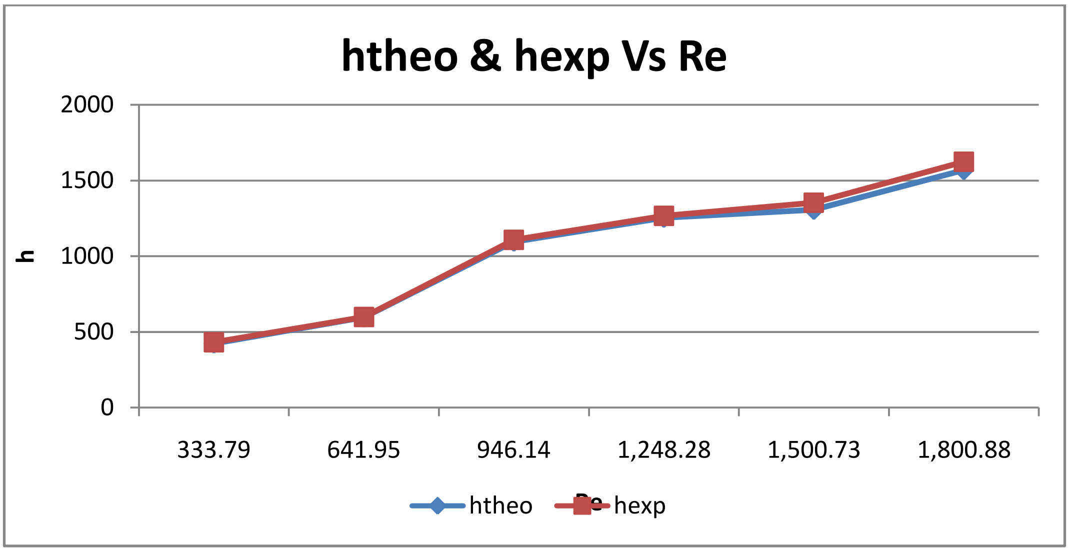

Figure 5 Variation in heat transfer co-eff. with respected to Reynolds number for HE plain Tube.

Figure 5 show the variation in overall heat transfer coefficient and also it shows the results comparison of theoretical and experimental heat transfer coefficient with respected to the Re for plain tube. Fromthese results it has been observed that the heat transfer coefficient was gradually increased with increasing of Reynolds number.

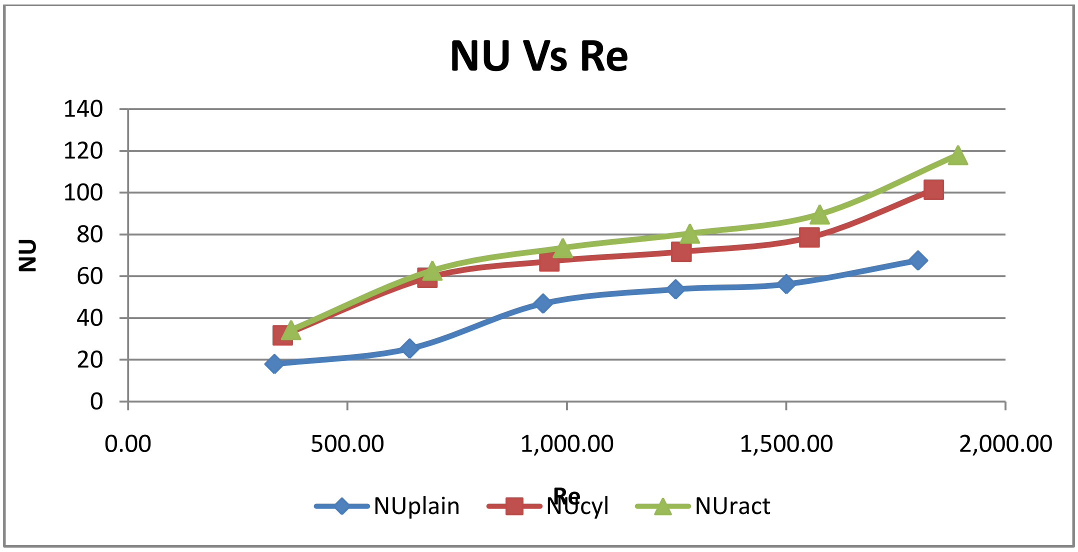

Figure 6 Variation in NU with respected to Reynolds number for HE.

Figure 6 shows the variation in Nussle number for single tube heat exchanger with plain tube, with cylindrical fins, and with rectangular fins. This chart shows the variations in NU with respected to increases the Reynolds number. From these results it has been measured that the NU was gradually increased with increasing the Reynolds number. There is small difference have been observed in NU between rectangular fins and cylindrical fins used in HE. From this results observed that the NU for rectangular section was maximum and its value decreased for cylindrical and for plain tube respectively.

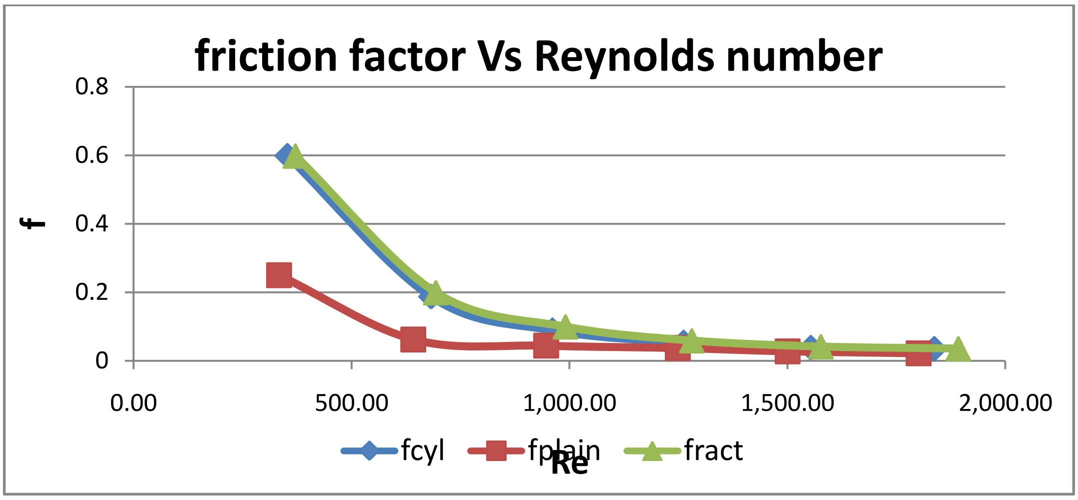

Figure 7 Variation in f with respected to Reynolds number for HE.

Figure 7 shows the variation in friction factor of heat exchanger with plain tube, with cylindrical fin, with rectangular fin. From this result it has been observed that the maximum value of friction factor comes in heat exchanger with rectangular fins. The friction of the heat exchanger has been gradually decreased with increasing the Reynolds number. The value of friction factor in heat exchanger with use of rectangular fin observed maximum and in cylindrical and in plain tube it has been decreased reactively.

This experiment has been carried out for heat transfer in laminar flow and different types of internal fins has been added at the internal periphery of the tube type heat exchanger. Comparative study has been made to define effect of same hydraulic diameter of different section (cylindrical and rectangular) on the heat transfer rate of single tube heat exchanger. From this experiment it has been observed that the heat transfer rate have been maximum in heat exchanger with the use of rectangular fins of same hydraulic diameter as in cylindrical fins. It happens because of effective heat transfer area for heat transfer has been higher in rectangular fin as compared to the cylindrical fins. The maximum NU and friction factor has been observed in rectangular fins used in heat exchanger. Small difference in NU and friction factor has been observed between cylindrical section and rectangular section.

Conclusion

This experimental investigation has been carried out to measure the effect of internal fins of different cross section with same hydraulic diameter. From this experimental study it has been conclude that the rectangular fins with same hydraulic diameter as cylindrical fin has higher heat transfer rate. The NU and friction factor observed in heat exchanger with rectangular fin was higher as compared to the cylindrical fin and plain tube. The internal Fins can perform a measure role to transfer heat in working fluid water.

Scope of Thesis Work

To measure the effect of different cross section such as elliptical, parabolic, and etc. with same hydraulic area on single tube heat exchanger.

Measure the effect of internal fins in counter flow heat exchanger.

Measure the effect of different materials of internal fins on heat exchanger.

References

[1] KarthikPooranachandran et al. " Experimental And Numerical Investigation Of ALouvered Fin And Elliptical Tube Compact Heat Exchanger"

[2] PegaHrnjak Et Al. "Effect Of Louver Angle On Performance Of Heat Exchanger With Serpentine Fins And Flat Tubes In Frosting", *2501*, Page 1

[3] M.J. Sable and et al. "Enhancement Of Natural Convection Heat Transfer On Vertical Heated Plate By Multiple V-Fin Array"

[4] R.Borrajo-Peláez et al. "A three-dimensional numerical study and comparison between the air side model and theair/water side model of a plain fin-and-tube heat exchanger", Applied ThermalEngineering30(2010)1608-1615

[5] Y.-G. Park and A. M. Jacobi "Air-Side Performance Characteristics of Round- and Flat-Tube Heat Exchangers: A Literature Review, Analysis and Comparison",Acrccr-36, May 2001

[6] Tomozaki Et Al. "Fin-And-Tube Type Heat Exchanger", Appl. No.: 593,963Filed: Mar. 27, 1984

[7] Hamid Nabati "Optimal Pin Fin Heat Exchanger Surface"

[8] Pankaj N. Shrirao et al. "Convective Heat Transfer Analysis in a Circular Tube with Different Types of Internal Threads of Constant Pitch"

[9] PongjetPromvonge a,*, Smith Eiamsa-ard b,1 "Heat transfer augmentation in a circular tube using V-nozzle turbulator inserts and snail entry"