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Manufacturing and Comparative Analysis of Threaded Tube Heat Exchanger with Straight Tube Heat Exchanger

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ABSTRACT: *To intensify the heat transfer from the heat exchanger surface to fluid, it is possible to increase convection coefficient, widen temperature difference between surface and fluid or increase the surface area across which convection occurs. Extended surfaces, in the form of longitudinal or radial fins are common in applications where the need to enhance the heat transfer between a surface and an adjacent fluid exists. Fins are commonly used in extended surface exchangers. To minimize the size of heat exchangers, fins are used to increase the surface area and the heat transfer rate between the heat exchanger surface and the surroundings. Both the conduction through the fin cross section and the convection over the fin surface area take place in and around the fin, the temperature value is limited by the type of material and production technique. Due to all above, finned tube heat exchangers are used in different thermal systems for applications where heat energy is exchanged between different media. Applications range from very large to the small scale (tubes in heat exchangers, the temperature control of electronic components).The subject, which is investigated in this paper, is concentrated on increasing heat transfer rate by provided extended surfaces like threads. By providing threads, heat transfer area increases and it leads to better heat transfer due to turbulence.*

KEYWORDS: *Heat transfer co-efficient, Nusselt number, Reynolds number, Thermal conductivity,*

I. INTRODUCTION

The performance of a conventional heat exchanger, which is an essential unit in heat extraction and recovery systems, can be substantially improved by a number of augmentation techniques. Common thermal-hydraulic goals are to reduce the size of heat exchanger required for 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. A preferred approach to the problem of increasing heat exchanger effectiveness, while maintaining minimum heat exchanger size and operational cost, is to increase the heat transfer exchange rate.The addition of fins reduces the thermal resistance on that side and thereby increases the net heat transfer from/to the surface for thesame temperature difference. The heat transfer coefficient can also be higher for fins.To develop the correlations for forced convection for the inner pipe in tube in tube heat exchanger having threaded shape using experimental and numerical techniques. This geometry is expected to augment heat transfer for vortex shedding and turbulence because of internal curvatures and enhanced area available for heat transfer.In order to do so, the experiments employ tube in tube heat exchanger with two configurations of the inner tube namely straight smooth tube and threaded tube. The experimentation will be conducted for the Reynolds number in turbulent region ranging from 6000 to 25,000.

A.E. Bergles, [1] showed that heat energy is conserved by heat transfer enhancement.C.A. Balaras, [2] reviewed of augmentation techniques for heat transfer surfaces in single-phase heat exchangers.Wolverine INC [3] An engineering data book was referred to have a insight for enhanced heat exchangers. Kim[4]Studied the characteristics of flat plate finned-tube heat exchangers with large fin pitch. In this study, 22 heat exchangers were tested with a variation of fin pitch, number of tube row, and tube alignment. The air-side heat transfer coefficient decreased with a reduction of the fin pitch and an increase of the number of tube row. The reduction in the heat transfer coefficient of the four-row heat exchanger coil was approximately 10% as the fin pitch decreased from 15.0 to 7.5 mm over the Reynolds number range of 500–900 that was calculated based on the tube diameter. For all fin pitches, the heat transfer coefficient decreased as the number of tube row increased from 1 to 4. The staggered tube alignment improved heat transfer performance more than 10% compared to the inline tube alignment. A heat transfer correlation was developed from the measured data for flat plate finned-tubes with large fin pitch. The correlation yielded good predictions of the measured data.HT-307[5] was referred to determine the efficiency of given longitudinal /pin fin and compare it with the theoretical value for the given fin. Creed Taylor [6] researched on types of heat exchangers used in refrigeration system and its environmental impact. Friedrich Frass[7] studied principles in heat exchanger designing and constructing heat exchangers with transverse finned tubes in cross-flow, it is necessary to know correlations for calculating heat transfer and pressure drop. In addition to the common use of the Reynolds and Nusselt groups of dimensionless numbers, heat conduction in the fins also has to be accounted for calculating the heat transfer. A reduction coefficient termed “fin efficiency” is therefore introduced, by which the actual heat transfer coefficient is multiplied in order to get the apparent heat transfer coefficient. J.A. Livinstone [8] studied heat transfer enhancement with different types of fins and studied the heat transfer rates. Shiv Kumar Rathor [9] identified the advantages of low-finned tube Heat Exchangers over Plain tube (Bare Tube) units. To use finned tubes to advantage in this application, several technical issues were to be addressed. Shell side and tube side pressure, cost, weight and size of heat exchanger. Hamid Nabati[10] studied on results of heat transfer rates and pressure drop with different types of 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.D.Kadam[11] carried out simulation of fin and tube type heat exchanger with the help of computer simulation software. Sandeep R. Desai [12]carried out analysis of fluid elastic vibrations of heat exchanger tubes and its determination of modal parameters (natural frequency and damping ratios) of the tubes. Kevin Lunsford [13] published a technical paper on how to improve the heat exchanger performance with simulation programs commercial feasibility etc.K P M Wipplinger [14] designed a stainless steel finned tube heat exchanger. M V Ghori [15] experimented three-dimensional CFD simulation and carried out investigation on heat transfer and fluid flow characteristics of two-row plain Tube and Fin heat exchanger using FLUENT software. Jiin-Yuh Jang [16] this paper suggests a method for finding the optimal louver angle of a fin heat exchanger by use of simplified conjugate-gradient method (SCGM) and a three-dimensional computational fluid dynamics model. AlaHasan [17] conducted the performance of two evaporatively cooled heat exchangers is investigated under similar operating conditions of air flow rates and inlet hot water temperatures. The heat exchangers are plain and plate-finned circular tube types which occupy the same volume. Chi-ChuanWang[18] the objective of this paper is to summarize the recent progress of fin pattern designs. Some of the designs are from the applied patents and some are from the recent literatures. The fin patterns include interrupted surfaces, enhanced wavy and the vortex generators. Benefits and the associated constraints of these designs are discussed. S.F Tsai [19]A three-dimensional numerical study was conducted to assess the heat transfer performance of extended fins in a two-row finned tube heat exchanger. Fins under investigation were plane and slit types. A finite volume discretization method and a SIMPLE-based solution algorithm were, respectively, applied to working differential equations and their discrete counterparts to compute the gas velocities and pressure. W. K. Ding [20] .A circuit data structure (circuit connection network) for a general description of different circuit configurations in computer programs is presented. On basis of this data structure, a general tube-by-tube simulation model and the corresponding code for prediction of plate fin-and-tube heat exchanger performance are developed.

Dimensional Parameters	Threaded tube (mm) (Aluminium)	Straight Tube (mm) (Aluminium)
Length of the heat exchanger	1000	1000
Inner diameter of the inner tube, d_i	16	16
Outer diameter of the inner tube, d_o	26	25
Inner diameter of the outer tube, D_i	36	36
Outer diameter of the outer tube, D_o	42	42
Pitch distance between threads	2.4	-
Depth of threads	1.5	-

II. METHODOLOGY AND EXPERIMENTATION

Geometry is ascertained based on literature survey, pipe sizes available in market and heat duty.
Manufacturing and fabrication of threaded tube.
Insertion of simple instrumentation for thermal measurement.
Study of variation of Reynolds number on the Nusselt number.
Reduction of data to construct useful heat transfer correlations.
A schematic diagram of the experimental apparatus is shown in Fig 1. The test loops consists of a test section, hot water loop, cold water loop and data measuring systems.

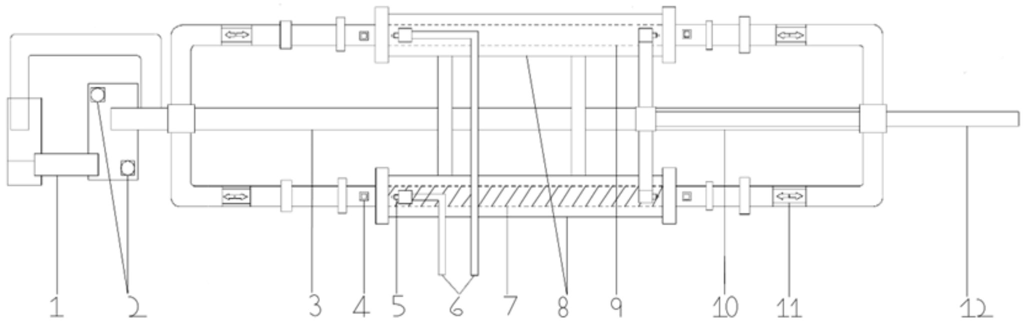

Fig1. Schematic Diagram

1. Suction Pipe 2.Heaters 3. Cold Water Pipe 4. Hot Water Sensor 5. Cold Water Sensor
6. Cold Pipe Outlet 7. Threaded Heat Pipe. 8. M.S Outer Pipes 9. Non Threaded Heat Pipe
10. Delivery Pipe 11. FCV 12.Cold Pipe Inlet

The test section is the water-to-water single-phase horizontal double pipe heat exchanger with two different configurations of the inner tube (threaded and non threaded).

2.1experimental Analysis

A basic strategy to evaluate the heat exchanger's performance is through the study of parameters like Nusselt Number, Reynolds number, etc and their impact on the overall heat transfer coefficient of the heat exchanger. In result table, LMTD, overall heat transfer coefficient, Nusselt numbers across the inner tube are calculated. The collected data is processed, analyzed and presented Reynolds number (1500 – 31000 range) and mass flow rates (0.055 to 0.220 kg/s)

III. DESIGN OF DOUBLE PIPE HEAT EXCHANGER BY KERN METHOD FOR GIVEN SPECIFICATIONS

Hot fluid inlet temperature, Thi= 65°C = 338K
Cold fluid inlet temperature, Tci= 30°C = 303K
Mass flow rate for hot fluid (water), qh = 200LPH
Mass flow rate for cold fluid (water), qc = 200LPH
For the process conditions specified above, design the double pipe heat exchanger of 2000W heat duty.

Thermo-physical properties	Hot fluid (water) at 65°C	Cold fluid (water) at 30°C
Density, ρ (kg/m^3)	987.7	997.46
Thermal conductivity, k (W/m-K)	0.658	0.619
Specific heat, C_p (J/Kg-K)	4182	4182
Viscosity, μ (Pa-s)	0.422 x 10^{-3}	0.777 x 10^{-3}
Prandtl number, Pr	2.6062	5.1078

Various heat transfer equations and empirical correlations are used to determine various parameters such as Reynolds number, Nusselt number, heat transfer coefficient etc. The readings and observations are taken prior to calculation of above mentioned parameters In present work, experimentation is done for single-phase water to water tube in tube heat exchanger with threaded and non threaded inner pipe. This analytical work is further studied in detail and presented.

results And Discussions

Effect of flow rate on Nusselt Number

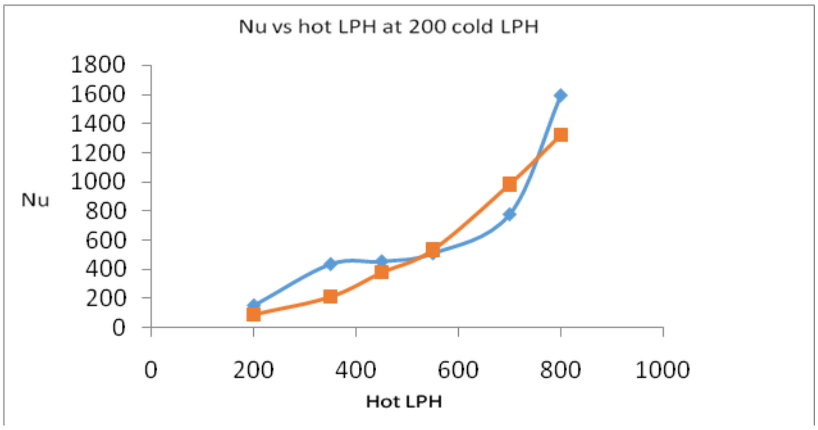

Fig 2.Variation of inner tube Nusselt Number with Threaded and Straight inner tube flow rate for cold 200 LPH

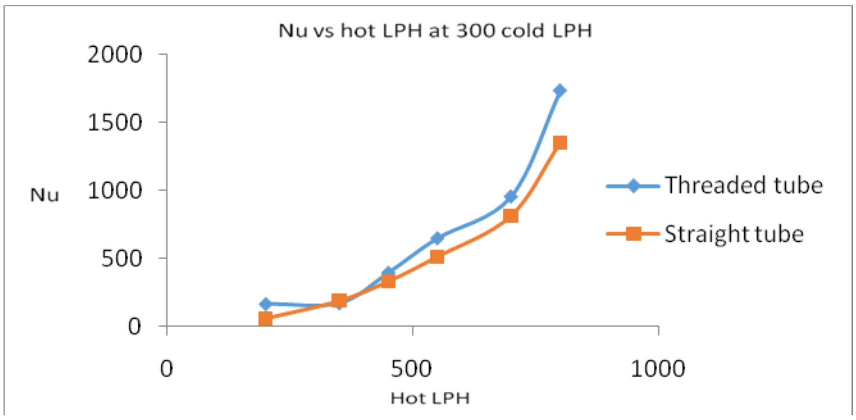

Fig.3.Variation of inner tube Nusselt Number with Threaded and Straight inner tube flow rate for cold 300 LPH

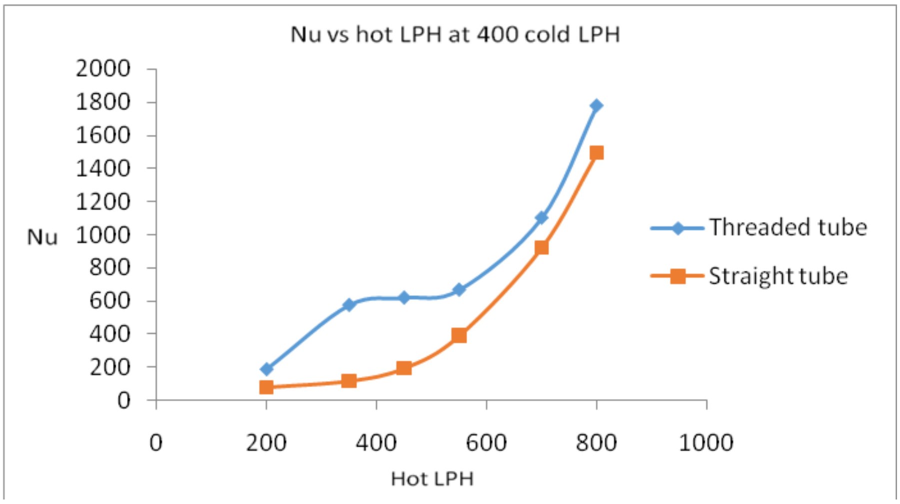

Fig.4.Variation of inner tube Nusselt Number with Threaded and Straight inner tube flow rate for cold 400 LPH

Effect of Nusselt Number on inner tube side Reynolds Number for different configurations of the inner tube (threaded and Straight)

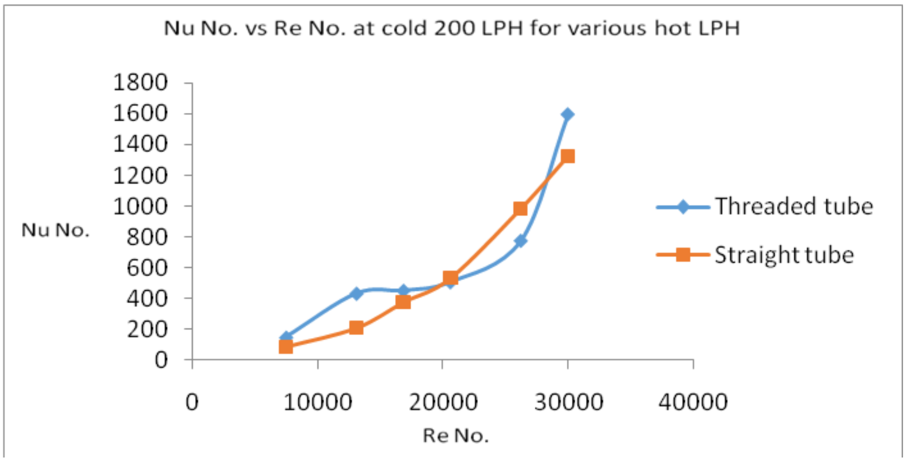

Fig 5.Variation of inner tube Nusselt Number with Reynolds number for threaded and Straight tube for cold 200 LPH.

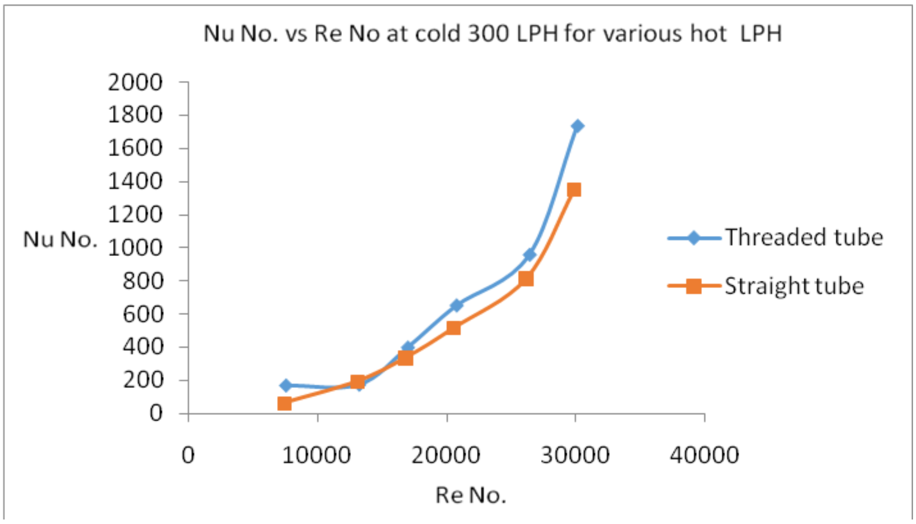

Fig 6. Variation of inner tube Nusselt Number with Reynolds number for threaded and Straight tube for cold 300 LPH

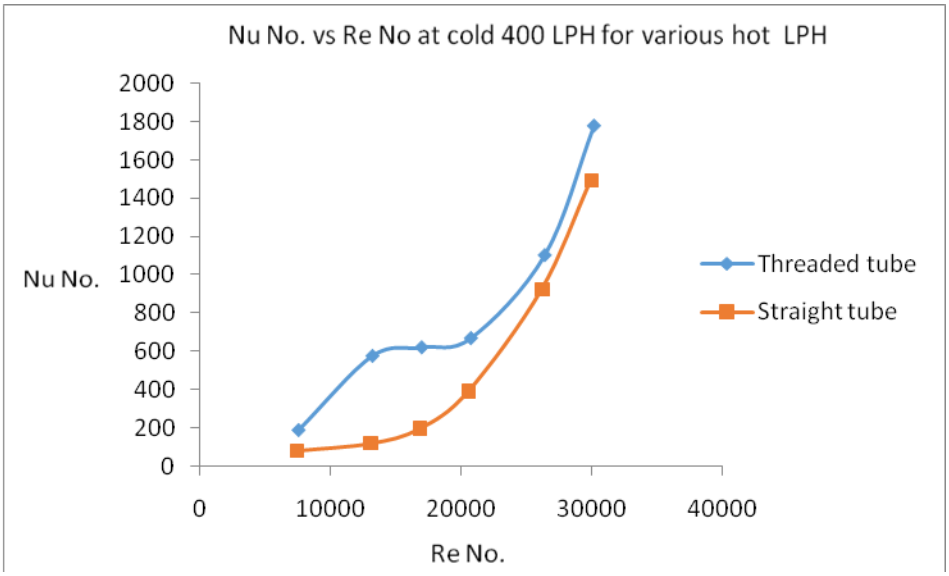

Fig 7. Variation of inner tube Nusselt Number with Reynolds number for threaded and Straight tube for cold 400 LPH

Effect of Convection coefficient for different configurations of the inner tube (threaded and Straight)

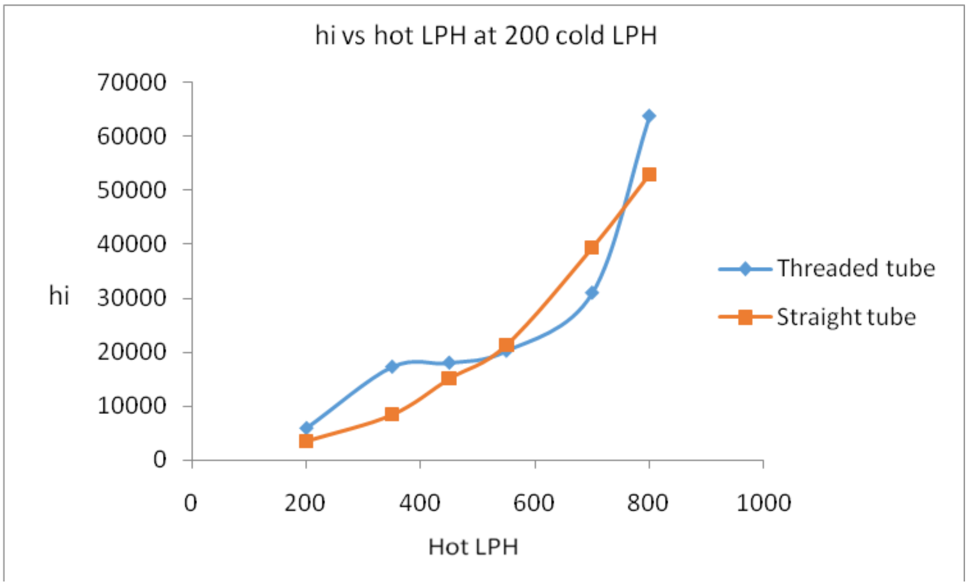

Fig.8 Variation of inner tube Convection coefficient with Threaded and Straight inner tube flow rate for cold 200 LPH

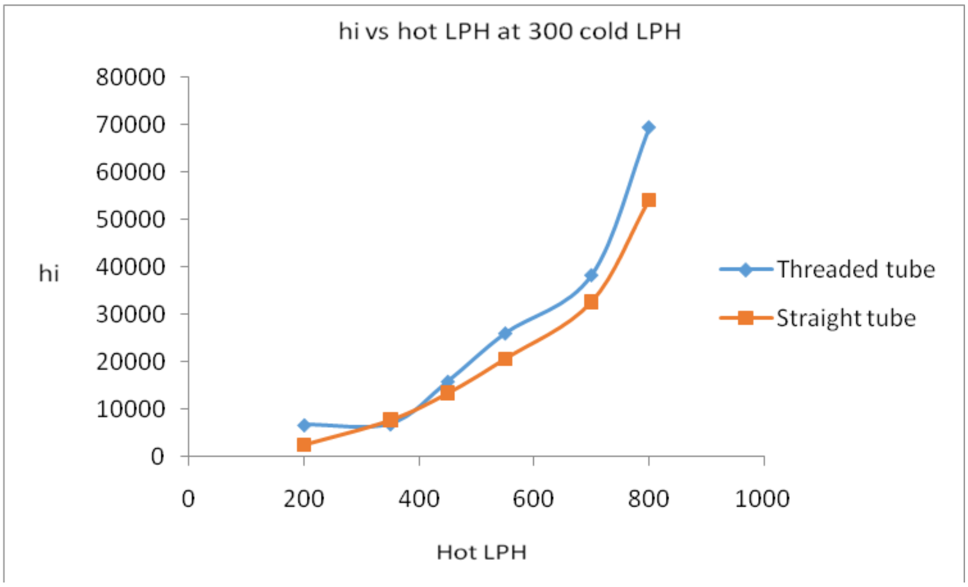

Fig 9.Variation of inner tube Convection coefficient with Threaded and Straight innertube flow rate for cold 300 LPH

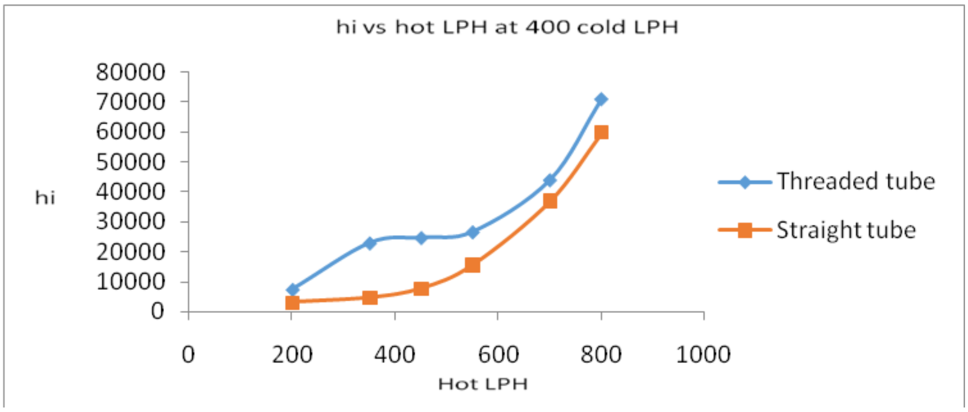

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Fig.10.Variation of inner tube Convection coefficient with Threaded and Straight inner tube flow rate for cold 400 LPH

Qavgfor different configurations of the inner tube (threaded and Straight)

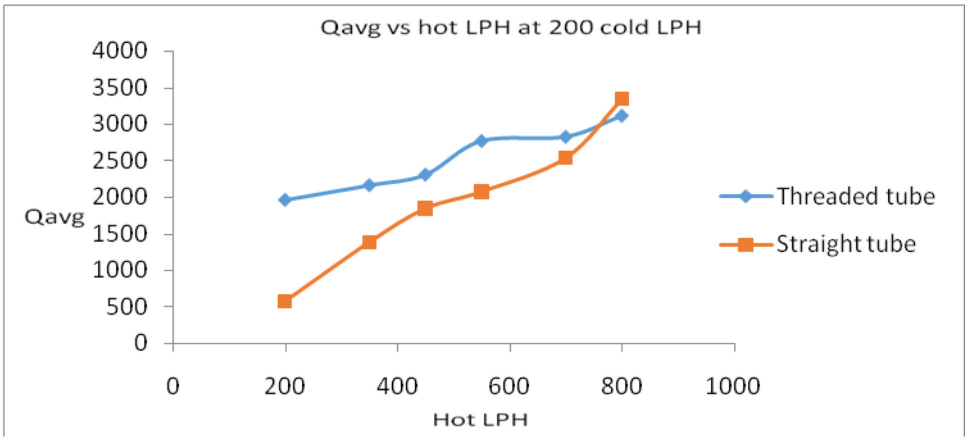

Fig 11.Variation of Q_{avg} with Threaded and Straight inner tube flow rate for cold 200 LPH

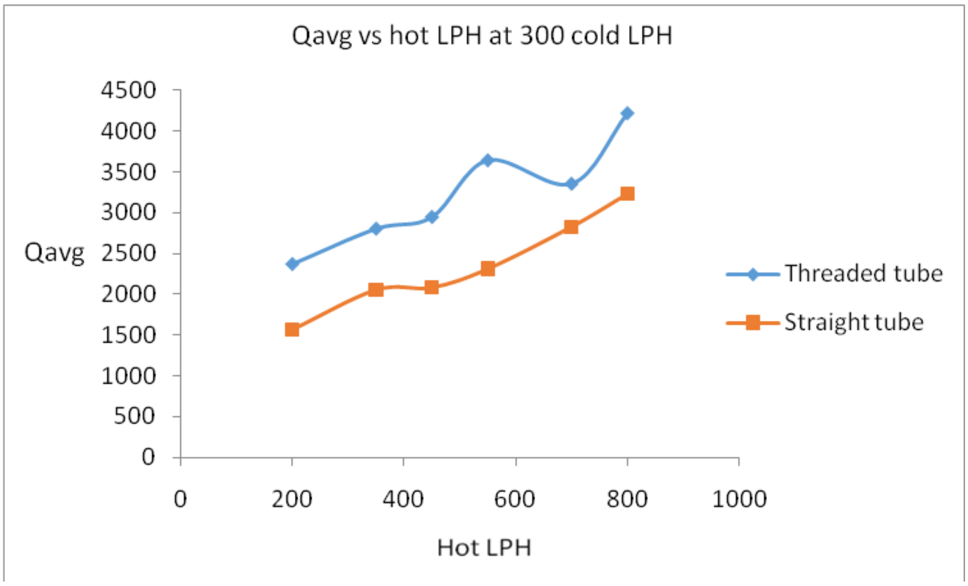

Fig 12.Variation of Q_{avg} with Threaded and Straight inner tube flow rate for cold 300 LPH

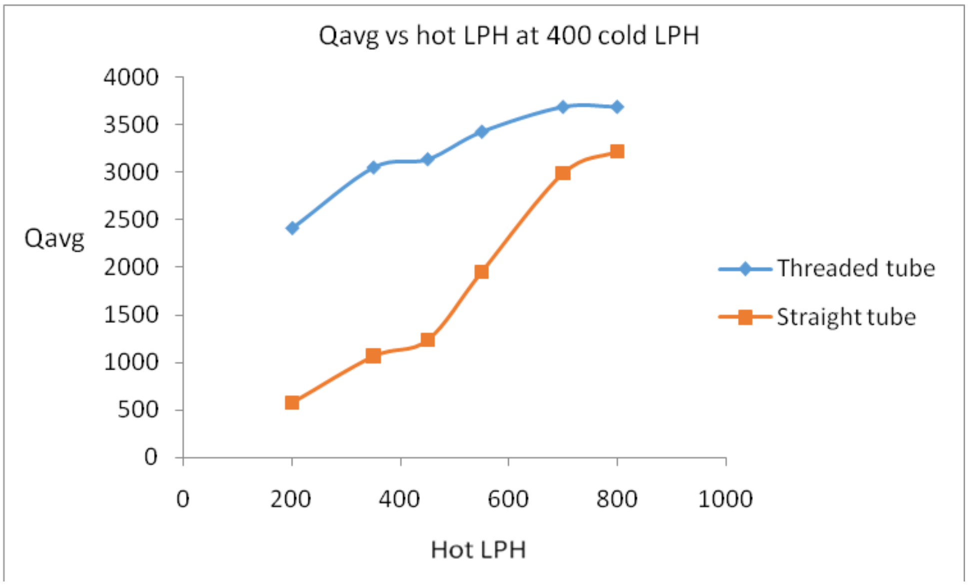

Fig.13.Variation of Q_{avg} with Threaded and Straight inner tube flow rate for cold 400 LPH

1. It is observed from the graph that the heat transfer rates of threaded pipe are more as compared to non-threaded pipe, keeping the cold flow rate (LPH) constant.
2. It is also observed from the graphs, that heat transfer rate for threaded pipe is more than non-threaded pipe for respective cold mass flow rate.
3. It is clear that the Nusselt Number of inner tube increases with increasing flow rate of water through inner tube.

IV. CONCLUSIONS

An experimental study has been performed to investigate the performance (pressure drop and Nu characteristic) for the two configurations of inner tube in the single phase water-to-water tube in tube heat exchanger (TTHE) i.e. threaded; non threaded. A two to four times more heat transfer enhancement is observed experimentally for the aforesaid heat exchanger with increased pumping power requirement of twice or thrice. Thus this work concludes that significant heat transfer enhancement is achieved for the threaded inner tube in TTHE. The work can be extended further for heavy heat duty industrial applications with wide operating conditions, different fluids and more precise instrumentation, provided that time and money are not constraints.

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