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Experimental Comparative Analysis of Overall Heat Transfer Coefficient in Counter-Flow Heat Exchanger by using Helical Ribs

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ABSTRACT

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More performance or reduced the size of heat exchanger can be achieved by heat transfer enhancement technique. Tube helical ribs have been used as one of the passive heat transfer enhancement technique and are most widely used tube in a several heat transfer process. The results of the heat transfer characteristics in horizontal double pipe with helical ribs are presented. Six test section with different characteristics parameters of helical rib depth 1.0mm, 1.25mm, 1.5mm and helical rib pitch 4mm, 6mm, 8mm, are tested. Cold water and hot water are used as the working fluids in the shell side and tube side respectively. Experiments are performed under the condition of mass flow rate varying from 0.030 to 0.130kg/s for cold water and 0.040 to 0.140kg/s for hot water respectively. The inlet cold and hot water temperature are between 28-300C and between 68-710C respectively. The results obtained from the tubes with helical ribs are compared with those without helical ribs. It is found that the helical ribs have a significant effect on the heat transfer coefficient and the heat transfer increases with the helical rib pitches and depth. Based on fitting the experimental data, on- isothermal correlations of the heat transfer coefficient and friction factor are proposed.

Keywords : Helical ribs, heat transfer coefficient, Reynolds number, Nusselt number.

I. INTRODUCTION

A heat exchanger is a device built for different heat transfer from one fluid to another, whether the fluids are separated by a solid wall so that they never mix, or the fluids are directly contacted. Heat exchanger are widely used in refrigeration, air conditioning, space heating, power generation, and chemical processing. One common example of a heat exchanger is the radiator in a car, in which the hot radiator fluid is cooled by the flow of air over the radiator surface.

1.1 Classification of heat Exchanger

(1) Nature of the heat exchanger process.
(2) Relative direction of motion of fluids.
(3) Mechanical design of heat exchange process.
(4) Physical state of heat exchanging fluids.

1.1.1 Nature of heat exchanger.

(a) Direct contact heat exchanger

In direct contact heat exchanger the exchanger of heat takes place by direct mixing of hot and cold fluids and transfer of heat and mass takes place simultaneously. Example: cooling tower, jet condenser, and direct contact feed water.

(b) Indirect contact heat exchanger

which separates the two fluids. Example: Regenerator, Recuperators.

1.1.2 Relative direction of motion of fluids

(a)Parallel-flow Heat Exchanger:-In parallel flow, both fluids move in the same direction.

(b) Counter-flow heat exchanger:-In counter flow, the fluids move in opposite direction.

(c) Cross-flow heat exchanger:-In cross flow the fluids move at right angles to each other. The required surface area for cross flow heat exchanger is in between the counter-flow and parallel-flow heat exchanger i.e.

$A_{\text{counter-flow}} < A_{\text{cross-flow}} < A_{\text{parallel flow}}$

1.1.3 Mechanical design of heat exchange process.

(a) Shell and tube heat exchanger

Shell and tube heat exchanger consists of a series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provided the heat or absorb the heat required.

There are several thermal design features that are to be taken into account when designing the tube in the shell and tube heat exchangers. These include:

(b) Plate heat exchanger

One is composed of multiple, thin, slightly-separated plates that have very large surface areas and fluid flow passages for heat transfer.

(c) Regenerative heat exchanger

In this, the heat (heat medium) from a process is used to warm the fluids to be used in the process, and the same type of the fluid is used either side of the heat exchanger. These exchangers are used only for gases and not for liquids. The major factor for this is the heat capacity of the heat transfer matrix.

1.1.4 Physical state of heat exchanging fluids.

Depending upon the physical state of fluid the heat exchanger is classified as follows:-

(a) Condenser: -In a condensers, the condensing fluid remains at constant temperature throughout the exchanger while the temperature of the colder fluid gradually increases from inlet to outlet. The hot fluid loses latent part of heat which is accepted by the cold fluid.

(b) Evaporators: - The boiling fluid (cold fluid) remains at constant temperature while the temperature of hot fluid gradually decrease from inlet to outlet.

II. LITERATURE REVIEW

[1]**R.K. Ali, K.M. Elshazly et. al.** studied on "Experimental investigation on the hydrothermal performance of a double pipe heat exchanger using helical tape insert", in this study they give experimentally examines the hydrothermal performance of horizontal Double Pipe Heat Exchangers (DPHEs) with and without continuous Helical Tape Insert (HTI) conducted on the outer surface of the internal pipe for enhancing the thermal performance of heat exchanger By this study we come to know that installing a continuous HTI around the outer surface of the inner pipe of DPHEs significantly increases the heat transfer rate in addition to the pressure drop in the annulus-side when compared with that in the plain annulus heat exchangers.

[2].**Sunil Shinde, UmeshChavan.** has studied on " Numerical and experimental analysis on shell side thermo-hydraulic performance of shell and tube heat exchanger with continuous helical FRP baffles", in this study they give that the numerical and experimental investigation of heat and fluid in shell and tube heat exchanger with continuous helical baffles on shell side. By this study we come to know that the Numerical & experimental results it is confirmed that the performance of tubular heat exchanger can be improved by helical baffles instead of conventional segmental baffles and the fabrication cost of producing helical baffles is simple, easy and cost effective with the help of woodenpattern.

[3] **Juan Du ,Yuxiang Hong et. al.** studied on "Summary and evaluation on the heat transfer enhancement techniques of gas laminar and turbulent pipe flow", in this study they give that the A systematic survey and evaluation on the thermal-hydraulic performance of gas inside internally finned, twisted tape or swirl generator inserted, corrugated, and dimpled, totally 436 pipes is conducted in this work. The encouragement and requirement to fabricate ultra- compact heat exchangers have driven the development of many types of surfaces to enhance the heat transfer. Because heat transfer enhancement of gases usually needs large surface area and the intensification from tube side is limited by space, the enhancement techniques typically locate in outside of tubes. By this study we come to know that the number of investigations on the tubes fitted with twisted tapes, coil loops, and swirl generators are the largest. The pressure drop of twisted tape inserts increased appreciably at the turbulent flow compared with liquids. In the performance evaluation plot, most of data fall into the Regions of 2 and 3. The efficiency are lower compared with other three enhancement techniques in this survey.

[4] **Wen-Tao Ji, Anthony M. Jacobi et. al.** studied on "Laminar thermal and fluid flow characteristics in tubes with sinusoidal ribs", in this study they give that effect of novel sinusoidal ribs transversely mounted in a tubular heat exchanger on convective heat transfer and flow pressure loss characteristics. The numerical study was performed under a constant heat flux condition for laminar water flow with Reynolds number (Re) ranged from 400 to 1800. The sinusoidal rib tubes were investigated at four rib height to diameter ratios (H/D = 0.026, 0.042, 0.058 and 0.074), three rib amplitude to diameter ratios (A/D = 0.211, 0.316 and 0.421), four rib width to diameter ratios (W/D = 0.158, 0.263, 0.368 and 0.474), three rib pitch to diameter ratios (P/D = 1.053, 1.316 and 1.579) and six circumferential rib numbers (N = 1, 2, 3, 4, 5 and 6 . By this research we come to know that the heat transfer rate in the tube can be improved by adopting sinusoidal ribs mounted on the tube wall, resulting from the enhanced flow mixing and increased temperature gradient facilitated by the multiple longitudinal vortices in the flow domain. Due to the boosted flow disturbance coming from flow separation and surface drag, the pressure drop in the SRTs is also augmented compared with their counterpart of the plain tube.

[5]**AbdallaGomaa, M.A. Halimet. al.** studied on "enhancement of cooling characteristics and optimization of a triple concentric-tube heat exchanger with inserted ribs", in this study they give that the experimental and numerical investigation of the triple concentric-tube heat exchanger with inserted ribs has been carried out. By this research we come to that higher values of the Nusselt number and heat exchanger effectiveness are obtained at counter current flow pattern and increasing the rib height slightly improves the hot water-side heat transfer coefficient by 6.2%; however, it much increases the pressure drop for the hot fluid side by79.8%.

[6] **M.R. Salem ,M.K. Althafeeri et. al.** studied on "Experimental investigation on the thermal performance of a double pipe heat exchanger with segmental perforated baffles", in this study they emphasize that the experimentally investigates the characteristics of convective heat transfer and

pressure drop of water flow in the annulus-side of horizontal double pipe heat exchangers. The experiments are performed for annulus-side Reynolds number from 1380 to 5700, and for Prandtl number from 5.82 to 7.86. By this study we come to know that the installing segmental perforated baffles inside double pipe heat exchangers increases the heat transfer rate in addition to the pressure drop in the annulus side when compared with that in un-baffled heat exchangers and the annulus average Nusselt number and friction factor increase with increasing SSPBs holes spacing ratio, void ratio and inclination angle, and with decreasing SSPBs cut ratio and pitch ratio.

[7] **HosnyZ. Abou-Ziyanet.al.studiedon**"Enhancement of forced convection in wide cylindrical annular channel using rotating inner pipe with interrupted helical fins", in this study they give the results of heat transfer and pressure drop in concentric annular wide channel with inner plain or finned pipe under stationary and rotating conditions in Taylor–Couette–Poiseuille flow.
By the study of this research paper we come to know that the The annular channel with interrupted helical fin spacing of 75 mm that rotates at 400 rpm attains ratio of heat exchange to pumping power of about 26 that is 7.6 times the ratio attained by plain stationary pipe at Re = 1.5 × 105.

[8]**NianbenZheng, Peng Liu et. al.** has studied on "Numerical investigations of the thermal- hydraulic performance in a rib-grooved heat exchanger tube based on entropy generation analysis", in this study they give that the numerical simulation has been conducted to examine the turbulent flow characteristics and heat transfer performance in a rib-grooved heat exchanger tube. By this study we come to know that multiple longitudinal swirl flows are generated in the rib grooved tube due to the disturbances of ribs and grooves.

[9] **Peng Liu, Feng Shan et. al.** has studied 0n "Effects of rib arrangements on the flow pattern and heat transfer in an internally ribbed heat exchanger tube", in this study they give that the numerical simulation was carried out to investigate the effects of rib arrangements on the flow pattern and heat transfer in an internally ribbed heat exchanger tube. By this study we come to know that Rib arrangements have perceptible effects upon the flow patterns in the ribbed tube. Longitudinal swirl flow with multiple vortices is induced in the V-type ribbed tube while longitudinal swirl flow with single vortex is generated in the P-type ribbedtube.

[10] **SmachiSripattanapipat, SombatTamna at al.** has been studied on ‘‘ Effects of rib arrangements on the flow pattern and heat transfer in an internally ribbed heat exchanger tube" in this study they give that the hexagonal conical ringmodifiedfrom the typical conical ring(CR) are used as a turbulence promoter for producing the vortex flows to enhance the heat transfer rate in a heat exchanger tube. By this study we come to know that A numerical investigation on thermal behaviors of fully turbulent periodical tube-flow through the HCR/V-HCR has been conducted. The V-HCR yields higher heat transfer enhancement in a uniform heat fluxed tube.

[11] **Qing Zhang, Huixiong Li et. al.** has studied on "Experimental study on heat transfer to the supercritical water upward flow in a vertical tube with internal helical ribs", in this study they give that the results of experimental research performed at the Hi-TaP-XJTU test loop on heat transfer to the supercritical water (SCW) upward flow in a vertical tube with internal helical ribs. By the study of this research paper we come to know that the heat transfer to SCW flow in the test ribbed tube is enhanced as compared with the smooth tube both under the heat transfer deterioration (HTD) and without it. The average heat transfer coefficient (HTC) in the cases without HTD is about 1.41–1.85 times and the critical heat flux of HTD is about 1.8 times higher than those in the smooth tube.

[12] **Wen-Chieh Huang, Cheng-An Chen et. al.** has studied on "Effects of characteristic parameters on heat transfer enhancement of repeated ring-type ribs

in circular tubes" Heat transfer enhancement of repeated ring-type ribs in circular tubes was experimentally investigated. By this study we come to know that The Nu value of the heat transfer enhancing tube increases with the Re and e/d values, whereas it increases with a decreases of the p/d value. The f value also increases with the e/d value and increases with a decrease of the p/d value. But it increases with a decrease of the Revalue.

[13]Ali Najah Al-Shamani, K. Sopian at al. has study on "Enhancement heat transfer character is tic sin the channel with Trapezoidalrib–groove using nano fluids"Numerical study of heat transfer due to turbulent flow of nano-fluids through rib–groove channel have been in vestigated. The continuity, moment umandenergy equation sare solved by the finite volume method (FVM).Four different rib–groove shape shave been examined. Four different types of nano particles,Al2O3, CuO,SiO2, and ZnO with different volumes fraction sin the range of 1–4% and different nano particle diameter in the range of 25–70 nm, have been also studied. The computation sare performed under constant temperature over arrange of Reynolds number (Re)10,000–40,000.Results indicate that the Trapezoidal with increasing height in the flow direction rib–trapezoidal groove has the best heat transfer rate and high Nusselt number.It is also found that the SiO2 – na-no fluid has the highest value of Nusselt number in comparison with other typeof nanofluids.TheNusseltnumberincreasesasthevolumefr actionincreasesanditde- creases as the nano particle diameter in creases. The present study shows that the Tra- pezoidal rib–groove using nano fluids have the potential to dramatically in crease heat transfer character is tics and thus can be good candidates for the development of efficient heat exchanger device.

[14] **Zhongyuan Shi, Tao Dong.** has studied on "Thermodynamic investigation and optimization of laminar forced convection in a rotating helical tube heat exchanger", in this study they give that the entropy generation investigation is carried out under given dimensionless parameters. By this research we come to know that the thermodynamic analysis of laminar convective flow in rotating helical tube heat exchanger has been carried out in this article.

[15]. **SubhankarSaha, Sujoy Kumar Saha.** has studied on "Enhancement of heat transfer of laminar flow through a circular tube having integral helical rib roughness and fitted with wavy strip inserts", By this research we come to know that the experimental friction factor and Nusselt number data for laminar flow through a circular duct having integral helical ribs and fitted with center-cleared wavy strip inserts have been presented. The major findings of this experimental investigation are that the center-cleared wavy strip inserts in combination with integral helical rib roughness perform significantly better than the individual enhancement technique acting alone for laminar flow through a circular duct up to a certain amount of wavy strip center-clearance. This research finding is useful in designing tubes for heat exchangers.

[16] S. Pethkool, S. Eiamsa-ardatal. The augmentation of convective heat transfer in a single-phase turbulent flow by using helically corrugatedtubes has been experimentally investigated. Effects of pitch-to-diameter ratio (P/DH=0.18, 0.22 and 0.27) and rib-height to diameter ratio (e/DH=0.02, 0.04 and 0.06) of helically corrugated tubes on the heat transfer enhancement, isothermal friction and thermal performance factor in a concentric tube heat exchanger are examined. The experiments were conducted over a wide range of turbulent fluid flow of Reynolds number from 5500 to 60,000 by employing water as the test fluid. Experimental results show that the heat transfer and thermal performance of the corrugated tube are considerably increased compared to those of the smooth tube. The mean increase in heat transfer rate is between 123% and 232% at the test range, depending on the rib height/pitch ratios and Reynolds number while the maximum thermal performance is found to be about 2.3 for using the corrugated tube with P/DH=0.27 and e/DH=0.06 at low Reynolds number. Also, the pressure loss result reveals that the average friction factor of the corrugated tube is in a range between 1.46 and 1.93 times over the smooth tube. In addition, correlations of the Nusselt number, friction factor and thermal performance factor in terms of pitch ratio (P/DH), rib-height ratio (e/DH), Reynolds number (Re), and Prandtlnumber (Pr) for the corrugated tube are determined, based on the curve fitting of the experimental data.

[17**PongjetPromvonge, SomsakPethkool, et. al.** has studied on "Heat transfer augmentation in a helical-ribbed tube with double twisted tape inserts", in this study they give that the Turbulent convective heat transfer characteristics in a helical-ribbed tube fitted with twin twisted tapes have been investigated. By this study we come to know that for the inserted ribbed tube, the Nu tends to increase with the rise in Re while the f and TEF give the opposite trends and the TEF obtained from the inserted ribbed tube is found to be much higher than unity and compound enhancement devices of the ribbed tube and the twin twisted tapes show a considerable improvement of heat transfer rate and thermal performance relative to the smooth tube and the helical-ribbed tube acting alone, depending on twistratios.

[18] **Junyewang,**has studied that a bent copper-water heat type pipe with grooved inner surface has been investigated experimentally. A comparison between the bent and the straight heat pipes was performed at different inclination angle. It was also found that the bent heat pipe is more sensitive to the change of the inclination angle than the straight in terms of the thermal response time and the heat flux of the condenser. The heat flux of the bent decreases faster than that of the straight after the horizontalorientation.

[19] **S.Rainieri, G. Pagliarini**studied the experimental investigation is aimed to the thermal performances of the thermal performances of corrugated wall tubes employed in a broad variety of industrial applications in order to intensify the convective heat transfer. Both axil symmetrical and helical corrugation with different pitch valves, have been considered in the present analysis. Regarding to this phenomena a critical local Reynolds number, proportional to the dimensionless corrugation pitch has been identified. The dependence of the local Nusselt number on the corrugation pitch has been investigate,too.

[20]**Zhengguo Zhang, Zhaoshengyu at al**. studied the performances of shell-side heat heat transfer and pressure drop were experimentally studied in a helically baffled single tube heat exchanger, where water was used as a working medium. The Nusselt numbers increased with the fin height and decreased with the fin pitch. In the range of the present experiments, it was found that the Nusselt numbers for the PF tubes were increasedbyupto23%,whilethepressuredropwasincreasedbylessthan1-11%,ascomparedwith that for the smooth tube.

[21]Ventsisla v Zimparov. Heat transfer and isothermal friction pressure drop results have been obtained experimentally for two three-startspirally corrugated tubes combined with ®ve twisted tape inserts with different relative pitches in the range of Reynolds number 3 _ 103±6 _ 104. The characteristic parameters of the tubes are: height to diameter ratio, e/Di=0.0407 and 0.0569; and relative pitch, H/Di=15.3, 12.2, 7.7, 5.8, 4.7. Significantly, higher friction factor and inside heat-transfer coefficients than those of the smooth tube under the same operating conditions have been observed. Extended performance evaluation criteria (PEC) equations for enhanced heat transfer surfaces have been used to assess the multiplicative effect. Thermodynamic optimum can be defined by minimizing the entropy generation number compared with the relative increase of heat transfer rate or relative reduction of heat transfer area. 7 2001 Elsevier Science Ltd. All rights reserved.

[22]**Jun-Cheng Li, Chung-Cheng at al.** has been studied in spray type evaporators using conventional overhead spray method, a dry-out phenomenon occurs on the lower surface of the evaporator tubes under high surface heat flux conditions, and thus the heat transfer performance of the evaporators system is seriously impaired. This study show that in a compact triangular-pitch shell-and-tube evaporator, the dry-

out problem can be delayed through the use of an interior spray method, in which each heater tube within the bundle is sprayed simultaneously by two nozzles.

III. OBJECTIVE OF THE PRESENT INVESTIGATION

(i) Fabrication of experimental setup for counter flow arrangement Experimental setup has been fabricated with G.I. pipes and other accessories required for the complete setup

(ii) Engraving of helical rib on the outer periphery of inside G.I. tube(Diameter =2.54cm) with the help of lath machine different helical rib pitch has been maintained for different pipes to complete the setup

(iii) Observation and data analysis of heat transfer coefficient.

IV. EXPERIMENTAL INVESTIGATION

4.1 Experimental Setup

A schematic diagram of the experimental apparatus is shown in fig. 3.1 the test loop consist of a test section, hot water loop, and cold water loop and data acquisition system. The test section and the connections of the piping system are designed such that parts can be changed or repaired easily. The closed loops of hot and cold water consist of 0.12m3storage tanks, an electric heater controlled by adjusting the voltage. The hot water is adjusted to desired temperature level and controlled by the temperature controller.

After the temperature of the cold and hot water are adjusted to achieve the desired levels, the water of each loops is pumped from the storage tank and passed through the test section and returned to the storage tank. The flow rates of the water is controlled by the adjusting valve and are measured. The temperature of hot and cold water is measured by Mercury in glass thermometer.

The test section, made from a straight G.I. tube, consists of an outer tube and an inner tube with length of 2000 mm. The inner diameter and outer diameter of the inner tube are 25.4 mm and 28.4 mm, respectively. The helical ribs are fabricated by a cold rolling sharp edged wheel on the outer surface of the G.I. tube as shown in figure 3.2. Mercury thermometers are used to measure the temperature of hot and cold fluid.

Experiments were conducted with various inlet temperatures and flow rates of hot water and cold water entering in the test section. In the experiments, the hot water flow rate and the cold water flow water were increased in small increments, while, inlet cold water and hot water temperatures were keep constant.

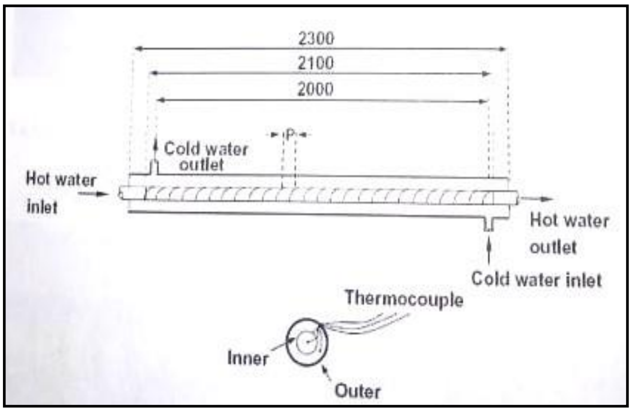


Fig 4.1(a)Line Diagram of Experimental Setup

4.2Helical Ribs on inner Pipe

Fig 4.2.1 Helical rib, Pitch = 8mm, Depth

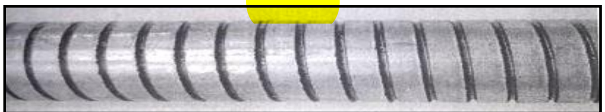
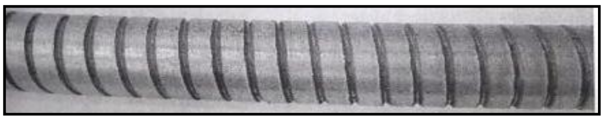
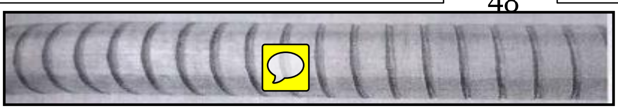


Fig 4.2.2 Helical rib, Pitch = 6mm, Depth





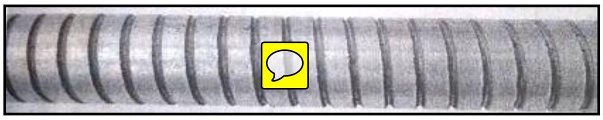


Fig 4.2.4Helical rib, Depth = 1mm, Pitch =

4.3 Dimensions of the Test Section

Parameters	Dimensions
Outer Diameter of	53.8mm
Inner Diameter of the	50.8mm
Outer Diameter of	28.4mm
Inner Diameter of	5.4mm
Length of test section	2000mm
Pitches of helical rib	4mm, 6mm,
Depth of helical rib	1.5mm

4.4 DataReduction

The data reduction of the measured results is summarized in the following procedures. Heat transferred to the cold water in the test section, Qc, can be calculated from

i.$Q_c=m_cC_pT_c$

Where,m_h is the mass flow rate of hot water, Cp is the specific heat of water and Tc is the change in temperature of the cold water respectively.

ii.$Q_h=m_hC_pT_h$

Where,m_h is the mass flow rate of hot water, C_p is the specific heat of water and T_h is the change in temperature of hot water respectively.

The average heat transfer rate, Q_{avg}, used in the calculation is determined from the hot water side and cold water side as follows:

iii.$\theta_1= T_{h1} - T_{c2}= T_{h2}-T_{c1}$

iv. Reynolds Number.

$R_e=4m_h\div(\pi D\mu)$

Nu =$(h_iD_i)\div k$

v.$f_r=\Delta P/((\mu 2\rho/2)(L/di))$

The overall heat transfer coefficient, U_i can be determined from

vi.$Q_{avg}= U_iA_i\theta_m$

Where θ_m is the logarithmic mean temperature difference.

LMTD= $(\theta 1-\theta_2)$ (ln $\theta_1/\theta 2$)

U_i is the overall heat transfer coefficient based on the tube side.

V. RESULTS AND DISCUSSION

Fig.5.1 shows the variation of the heat transfer coefficient with the tube side Reynolds number for the different helical rib pitches at constant depth=1.5mm. The heat transfer coefficient is increases with increasing the Reynolds number. This is because the heat transfer coefficient depends on the heat transfer rate **Fig.5.1** also shows the effect of helicalrib pitches on the heat transfer coefficient. It can clearly seen from the fig.5.1 that the heat transfer coefficient at higher helical rib pitches is lower than that a lower pitches. This is because the helical rib pitches has a significant effect on the mixing of the fluid in the boundary layer and increasing the turbulent intensity of the fluid flow. Therefore the heat transfer coefficient increases with decreases helical pitches. In the above **Fig.5.1** three pitches P=4mm, P=6mm, P=8mm taken.

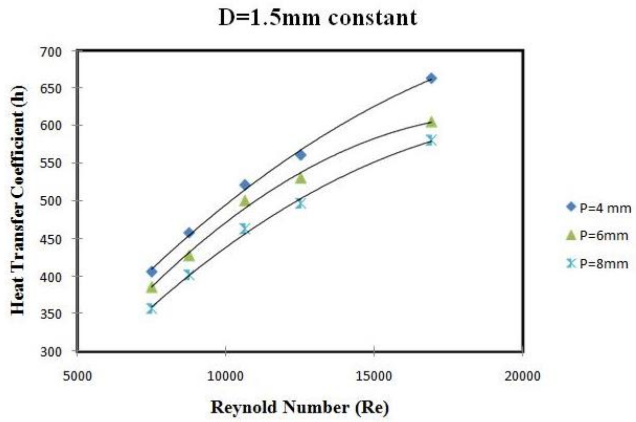


Fig. 5.1 Variation of Heat Transfer Coefficient With Reynolds Number For Different Helical Rib Pitches

Fig.5.2 shows the variation of the average heat transfer coefficient with the Reynolds number for the different helical rib depth at constant pitch=4mm the heat transfer coefficient increases with increasing Reynolds number. This is because the heat transfer coefficient depends on the heat transfer rate. Fig.5.2 also shows the effect of helical rib depth on the heat transfer coefficient. It can be clearly seen from Fig.5.2 that the heat transfer at higher helical rib depth is higher than that at lower depth. This is because the helical rib depth has a significant effect on the mixing of the fluid in the boundary layer and increasing the turbulent intensity of the fluid flow. Therefore the heat transfer coefficient increases with increasing helical rib depth. In the Fig.5.2 three depth, D=1.5mm, D=1.25mm, D=1mm are taken

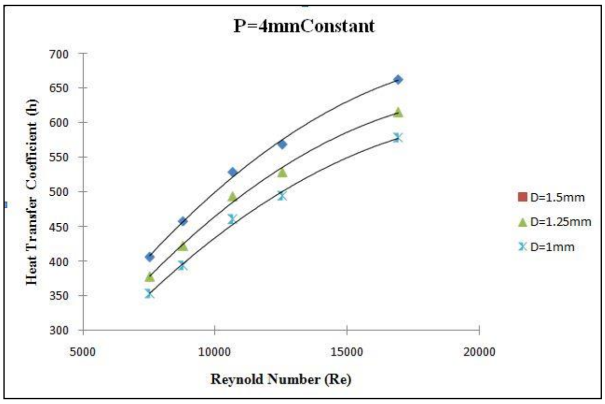


Fig.5.2 Variation of Heat Transfer Coefficient With Reynolds Number for Different Helical Rib Depth

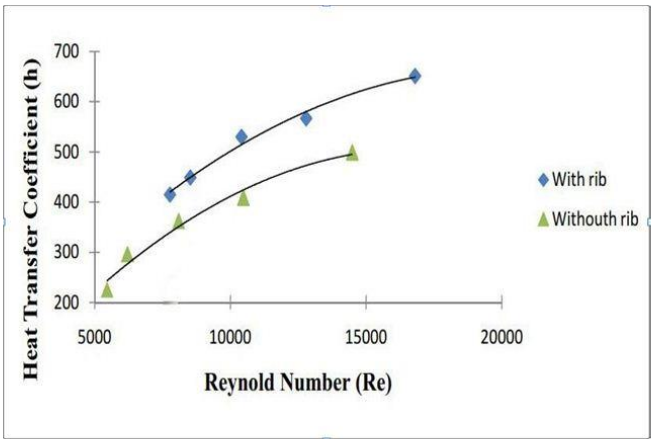


Figure 5.3 Comparison of variation of heat transfer coefficient with and without Rib

5.1.iDiscussion

the fig.5.3 shows the variation of the average heat transfer coefficient with Reynolds number for the pipe with helical rib and for the pipe without helical rib. The effect of the helical rib on the outer periphery of the inner pipe can be clearly seen in the figure 5.3. There is an increase of 17-34% of heat transfer coefficient on providing different helical rib depths and helical rib pitches,respectively.

In the figure 5.4 graph has been plotted between the Reynolds number on the X-axis and the ratios of Nusselt number i.e. with rib and without rib on the Y-axis. The fig5.4 it is clear that the ratio decreases as the Reynolds number increases this is due to the fact that at higher Reynolds number the Nusselt number without helical rib also increases. It is also clear from the fig5.4 that the higher value of the pitch the value of the ratio decreases and hence it is more for the pitch=4mm and it is low for pitch=8mm

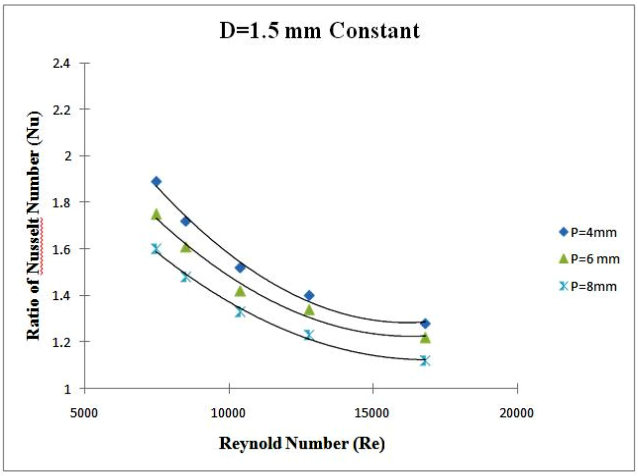


Figure 5.4 Variation of Nusselt Number Ratios with Reynolds Number for Different Depths

5.1.ii Discussion

It can be seen from Fig 5.4 and 5.5 that low Reynolds number, the Nusselts number ratio is (Nu)rib÷(Nu)without rib = 1.91. However, the effect of the helical rib on the enhancement of heat transfer tends to decreases the Reynolds number increases. This is because the effect of the higher flow rate on the fluid mixing in the boundary layer is more than that of the helical rib. Therefore, the nusselt number enhancement decreases with increases Reynolds number. In addition, the Nusselt number enhancement at higher depth and lower pitch of the helical rib are higher than those at lower depth and higher pitch, as shown in the Fig5.4and 5.5.

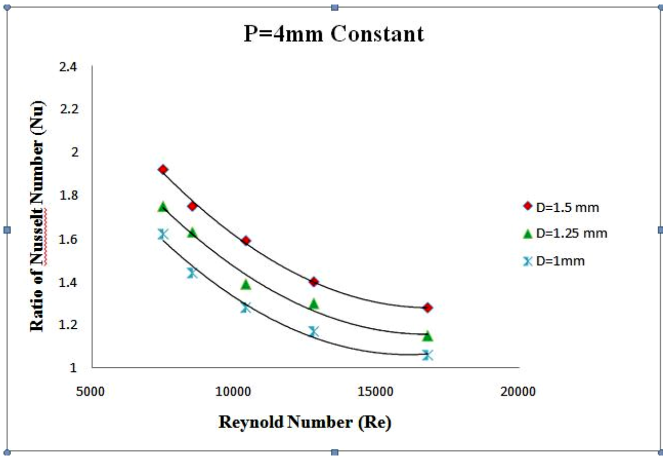


Figure 5.5 Variation of Nusselt Number Ratios with Reynolds Number for Different Depths

VI. CONCLUSION

New experimental data on the heat transfer coefficient and the friction factor characteristics of the horizontal tubes with helical rib are presented. The effect of the helical rib configuration on the heat transfer and pressure drop characteristics is also considered. The results obtained from the tube with helical rib are compared with those without helical ribs. The tube side heat transfer coefficient correlations for the tube with helical ribs are proposed in simple mathematical function. It is found that the helical ribs have a significant effect on the heat transfer coefficient. And the heat transfer increases with the helical rib pitches and depth. The comparison between the predicted heat transfer coefficient and the measured ones are in reasonable agreement. The following points have been concluded for the above experimental setup.

1. The effect of the helical rib on the enhancement of heat transfer tends to decreases as the Reynolds number increases.
2. Nusselt number ratio decrease from 25-30% with increasing Reynolds number from 7733-16801.
3. TheNusselt number ratio at higher depth i.e. 1.5mm and lower pitch i.e. 4mm of the helical rib are 38-43% higher than those at lower depth i.e. 1mm and higher pitch i.e. 8mm.
4. The heat transfer coefficient increases from 48-62% with increasing Reynolds number from7733-16801.
5. Heat transfer coefficient increases from 34-39% with increasing helical rib depth from 1mm-1.5mm.
6. Heat transfer coefficient increases from 34-39% with decreasing the helical rib pitches from8mm-4mm

VII. SCOPE OF FUTUREWORK

There is wide scope of further investigation and studies on the same experimental set up with the present investigation and resulting data on the helical rib.

Few of them can be:

1. Further investigation of heat transfer rate with different pitch keeping depth is constant.
2. Further investigation of the heat transfer rate with different depth keeping pitch is constant
3. Further investigation of heat transfer coefficient with increase or decrease the depth of the helical rib.
4. Further investigation of heat transfer coefficient with increase or decrease of the depth of the helical rib.
5. Further investigation of effect of heat transfer coefficient with Nusselt number by changing the pitch and depth of the helical rib.

6. Further investigation of effect of heat transfer coefficient with Reynolds number by changing the pitch and depth of the helical rib.

VIII. REFERENCES

[1]. R.K. Ali, K.M. Elshazlyet. al. Experimental investigation on the hydrothermal performance of a double pipe heat exchanger using helical tape insert" International Journal of Thermal Sciences, Vol.124, pp.497-507,2018.

[2]. Sunil Shinde, UmeshChavan. Numerical and experimental analysis on shell side thermo-hydraulic performance of shell and tube heat exchanger with continuous helical FRP baffles" Thermal Science and Engineering Progress, Vol.5, pp. 158- 171,2018.

[3]. Juan Du ,Yuxiang Hong et. al. Laminar thermal and fluid flow characteristics in tubes with sinusoidal ribs" International Journal of Heat and Mass Transfer, Vol.120, pp.635-651,2018.

[4]. Wen-Tao Ji, Anthony M. Jacobi et. al. Summary and evaluation on the heat transfer enhancement techniques of gas laminar and turbulent pipe flow" International Journal of Heat and Mass Transfer, Vol.111, pp.467-483,2017.

[5]. AbdallaGomaa, M.A. Halimet. al. Enhancement of cooling characteristics and optimization of a triple concentric-tube heat exchanger with inserted ribs" International Journal of thermal science, Vol.120, pp.106-120,2017.

[6]. M.R. Salem ,M.K. Althafeeri et. al. Experimental investigation on the thermal performance of a double pipe heat exchanger with segmental perforated baffles" International Journal of thermal science, Vol.122, pp.39-52,2017.

[7]. Hosny Z. Abou-Ziyanet. al. Enhancement of forced convection in wide cylindrical annular channel using rotating inner pipe with interrupted helical fins" International Journal of Heat and Mass Transfer, Vol.95, pp.996-1007,2016.

[8]. NianbenZheng, Peng Liu et. al. Numerical investigations of the thermal-hydraulic performance in a rib-grooved heat exchanger tube based on entropy generation analysis" Applied Thermal Engineering, Vol.99, pp.1071-1085,2016.

[9]. Peng Liu, Feng Shan et. al. Effects of rib arrangements on the flow pattern and heat transfer in an internally ribbed heat exchanger tube" International Journal of Thermal Sciences, Vol.101, pp. 93-105,2016.

[10]. SmachiSripattanapipat, SombatTamna at al. "Numerical heat transfer investigation in a heat exchanger tube with hexagonal conical-ring inserts", Energy Procedia,Vol.100pp.522-525,2016.

[11]. Qing Zhang, Huixiong Li et. al. Experimental study on heat transfer to the supercritical water upward flow in a vertical tube with internal helical ribs" International Journal of Heat and Mass Transfer, Vol.89, pp.1044-1053,2015.

[12]. Wen-Chieh Huang, Cheng-An Chen et. al. "Effects of characteristic parameters on heat transfer enhancement of repeated ring-type ribs in circular tubes" Experimental Thermal and Fluid Science, Vol.68, pp.371–380,2015.

[13]. Ali Najah Al-Shamani, K. Sopian at al. ''Enhancement heat transfer characteristics in the channel with Trapezoidalrib–groove using nanofluids'',CaseStudiesinThermalEngineering vol.5 pp.48–58, 2015.

[14]. Zhongyuan Shi, Tao Dong Thermodynamic investigation and optimization of laminar forced convection in a rotating helical tube heat exchanger" Energy Conversion and Management, Vol.86, pp.399-405,2014.

[15]. SubhankarSaha, Sujoy Kumar Saha. Heat transfer augmentation in a helical- ribbed tube with double twisted tape inserts" Experimental Thermal and Fluid Science, Vol.50, pp.107-113,2013.

[16]. 16S. Pethkool, S. Eiamsa-ard at al. ‘’Turbulent heat transfer enhancement in a heat exchanger using helically corrugated tube.’’International Communications in Heat and Mass Transfer, vol. 38 pp. 340–347, 2011.

[17]. PongjetPromvonge, SomsakPethkool, et. al. Heat transfer augmentation in a helical-ribbed tube with double twisted tape inserts’’ International Journal of Heat and Mass Transfer, Vol.39, pp.953-959,2012.

[18]. Junye Wan. Experimental investigation of the transient thermal performance of a bent heat pipe with grooved surface, Applied Energy 2009;86:2030-2037.

[19]. S.Rainieri,G.Pagliarini. Convective heat transfer to temperature dependent property fluids in the entry region of corrugated tubes, International Journal of Heat and Mass Transfer 2002;45:4525-4536.

[20]. Zhengguo Zhang, Zhaoshengyu at al. An experimental heat transfer study for helically flowing outside petal-shaped finned tubes with different geometrical parameters, Applied Thermal Engineering 2007; 27:268-272.

[21]. VentsislavZimparov‘’Enhancement of heat transfer by a combination of three- start spirally corrugated tubes with a twisted tape’’ International Journal of Heat and Mass Transfer, vol. 44 pp. 551-574, 2001.

[22]. Jun-Cheng Li, Chung-Cheng at al.enhancing the heat transfer performance of triangular-pitch shell-and-tube evaporators using an interior spray technique, Applied Thermal Engineering 2009;29:2527-2533.

[23]. Zhengguo Zhang, Zhaoshengyu at al. An experimental heat transfer study for helically flowing outside petal-shaped finned tubes with different geometrical parameters, Applied Thermal Engineering 2007; 27:268-272.

[24]. Metha MH, Rao MR. Investigations on heat transfer and frictional characteristics of enhanced tubes for condensers. Advances in enhanced heat transfer. New York: ASME; 1979. p. 11–21.

[25]. Gupta RK, Rao MR. Heat transfer and friction characteristics of Newtonian and power law type of non-Newtonian fluids in smooth and spirally corrugated tubes. Advances in enhanced heat transfer. New York: ASME; 1979. p. 103–13.

[26]. Withers JG. Tube-side heat transfer and pressure drop for tubes having helical internal ribbing with turbulent/transitional flow of single phase fluid. Part I—single helix ribbing. Heat Transfer Eng J 1980;1:48–58.

[27]. Li HM, Ye KS, Tan YK, Deng SJ. Investigation of tube-side flow visualization, friction factor and heattransfer characteristics of helical-ribbing tubes. Proceedings of the 7th heat transfer conference. Washington: Hemisphere Publishing Corp.; 1998. p. 75–80.

[28]. Sethumadhavan R, Rao MR. Turbulent flow friction and heat transfer characteristics of single andmulti-start spirally enhanced tubes. J Heat Transfer 1986; 108:55–61.

[29]. Ravigururajan TS, Bergles AE. Prandtl number influence on heat transfer enhancement in turbulent flow of water at low temperatures. Trans ASME 1995; 117:276–82.

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