Experimental Studies of Double Pipe Helical Coil Heat Exchanger with and without Micro Fins

Katkar Ashutosh Tukaram[1], Prof. Mrs. S. S. Jadhav[2]
[1, 2] Department of Mechanical Engineering
[1, 2] Government College Of Engineering, Karad.

Abstract- *This paper shows that friction characteristics, heat transfer characteristics of single phase heat transfer in tube in tube heat exchanger. The various techniques used to improve heat transfer are like "heat transfer augmentation" or "heat transfer enhancement". The material used for coil of heat exchanger is copper, because of its high thermal conductivity.*

The main objective is to reduce as many of the factors like capital, power and maintenance cost, reduce space and weight, with high safety and reliability. By using Micro fins in heat exchanger, the heat transfer rate is high. Also pressure drop is of no significance. In the part of results show that the Nusselt number of the tube having micro fins grows up. In the part of observation the heat transfer rate increases in finned tube heat exchanger as compared to plain tube heat exchanger, based on constant mass flow rate. The working fluid of heat exchanger is water.

Keywords- Micro fins, Nusselt number, Prandtl number

I. INTRODUCTION

Heat exchangers are used to interchange the heat energy between two different fluids at different temperatures when it keeping them from mixing each other. Heat exchanges are used in various industrial, domestic and commercial applications. The common example of heat exchanges is steam generation and condensation in power plants and cogeneration plants; thermal processing of chemical, agricultural products and pharmaceutical; manufacturing industries; waste heat recovery etc. Heat exchangers performance increase when change in more economical design of heat exchanger which helps to saving material energy and cost related to heat exchange process.

Heat exchangers are most common equipment found in many industrial applications ranging from chemical and food industries, power production, electronics, environmental engineering, air-conditioning and waste heat recovery. Especially helical coil heat exchanger is mostly used. The flow of fluid in helical coil is developed due to curvature and mainly centrifugal force is acting. Due to curvature of tube develop a secondary flow field with circular motion. It causes the particles of fluid moves toward the core region of coil. Secondary flow increase heat transfer rate and reduces temperature gradient.

II. EXPERIMENTAL INVESTIGATION

The experimental set-up used in the present study shown in fig. the apparatus is conducted experiment to study the heat transfer with micro fins inserts. Experimental apparatus consisting hot water tank, cold water tank, flow control valves, temperature sensors, temperature indicators, water heaters, monoblock pumps. The main test section is double pipe helical coil heat exchanger. It consists of two tubes which are concentric. In that cold water flows through outer tube and hot water flows through inner tube at counter flow. The inner tube is having outer and inner diameters of 13 mm and 10 mm respectively. Its material is copper. Outer tube made of mild steel material having inner and outer 22 mm and 25 mm diameters respectively. The length of coil is 2.0 meters. Flow meters are used to maintain mass flow rate of water. The ranges of flow meters are from 1 lpm to 10 lpm. One flow meter is used to measure hot water side mass flow rate and another is to measure annulus side of cold water mass flow rate. Temperature data was recorded in data acquisition unit. PT100 type temperature sensors are used to measure temperature of hot and cold fluid in the tubes.

Figure 1. Pictorial View of Experimental Set-Up

The experimental setup is shown in Fig.1 In that test section consists of data acquisition system, hot and cold water tank. In hot water tank electric heaters are provided which are adjusted to desired temperature range and controlled by temperature controller. Hot and cold water temperatures were adjusted to the desired level.

A. Specifications Experimental set-up

The experimental study was carried on double pipe helical coil heat exchanger with micro fins. The specification and dimension are based on literature review used for enhancement technique. Specifications are listed below.

Table 1. Dimensions of Heat Exchanger

Dimensions	Outer Tube (mm)	Inner Tube (mm)
Outer Diameter	25	13
Inner Diameter	22	10
Wall Thickness	1.5	1.5
Turns of coil	4	4
Coil Diameter	200	200
Coil Pitch	20	Concentric
Material of Construction	MS	Copper
Velocity (m/s)	0.09-0.16	0.004-0.024

B. Experimental Procedure

Experiments were performed with constant inlet temperatures and flow rates of water complete the test section. During experiment, inlet hot water temperature was reach desired level of temperature using electric heater. Hot water flow rate was increased, while cold water flow rate were kept constant. Flow rate was measured by two flow meters with the range of 0-10 LPM and flow rate are adjusted by flow control valve. In experimental set up two heat exchangers was manufactured one is with micro fins and another, without micro fins.

Experimental Procedure:

i. Filled the water in hot water tank and cold water tank up to certain level.
ii. Switch ON electrical heater in hot water tank.
iii. Start electric motor (1)to pump water from hot tank and passed in inner coil.
iv. Hot water mass flow rate is controlled by control valve(1)and flow measured by rotameter1.
v. For cold water is passed through outer coil.
vi. Cold water mass flow rate is controlled by flow control valve(2) and flow measured by rotameter2.
vii. The tests were conducted for counter flow heat exchanger.
viii. Inlet and outlet temperatures of hot and cold fluid were measured by temperature indicator.
ix. For first observation,
Outer coil mass flow rate = 100LPH
Inner tube mass flow rate =100LPH.
Likewise vary the inner side mass flow rate of (100LPH to500LPH) and keep outer side mass flow rate constant.
x. Take pressure drop (mercury difference), mass flow rates and inlet-outlet temperatures in observations.
xi. For next observation, vary the tube side mass flow rate and kept annulus side mass flow rate is constant.
xii. Take readings of outlet temperatures (inner and outer tube), head loss due to friction and mass flow rates in observation table. This procedure is continuous for all reading.
xiii. For another heat exchanger repeat the above procedure for changing different mass flow rates and take observations.

C. Material selection for Test Section

We have to choose such a material which will provide high heat transfer rate as well as maintain economy of system. We choose such kind of materials which improve thermal efficiency, reduce cost, easy availability, high heat transfer rate, good machinability etc.

For inner tube copper material was selected. It has advantageous properties for thermal efficiency and long lasting heat exchangers. Copper have magnificent conductor of heat. This means it allows heat to pass through it rapidly. Other properties of copper which helpful in heat exchanger working are corrosion resistance, bio fouling resistance, creep rupture strength, fatigue strength, maximum allowable stress and internal pressure, tensile strength, thermal expansion, hardness, antimicrobial property, easy fabrication, easy of joining.

Performance advantages of copper material high heat exchange, resistance to corrosion, long term durability, lower maintenance cost. Main purpose of micro grooves is develop is that heat transfer enhanced by grooves on surface of tube. Grooves are increases the surface to volume ratio.

For outer tube mild steel material is selected. It has good properties such as good strength at high temperature and low temperature, resistance to fouling, easy fabrication and availability of material at economical cost.

Table 2. Thermal Conductivity Material.

Sr .No.	Material	Thermal Conductivity (W/m K)
1	Copper	385.0
2	Mild Steel	45.0

III. RESULTS AND DISCUSSION

The experimental studies are conducted for water to water heat transfer application. The helical coil heat exchanger has been analyzed with temperature variation. The thermal performance of the helical coil heat exchanger is depend on Nusseit number, heat transfer rate, overall heat transfer coefficient. The shell side flow rate is varied from the 100 to 500 LPH same time tube side flow rate is maintained constant. Five tube side flow rates are taken 100 to 500 LPH. Test were conducted only for counter flow.

Table 3. Results for plain heat exchanger for hot side constant 300 LPH

v(m/s)		Re		Nu		f		Q	LMTD	H
hot	cold	hot	cold	hot	Cold	hot	cold	Kw	^{0}C	W/m ^{2}K
0.227	0.076	3132.01	1044.65	14.46	8.36	0.061	0.170	812.77	14.79	888.05
0.227	0.151	3132.01	2075.55	14.46	14.48	0.061	0.089	1567.50	15.49	1272.17
0.227	0.227	3132.01	3120.20	14.46	20.07	0.061	0.062	1915.83	13.44	1466.19
0.227	0.302	3132.01	4151.11	14.46	25.21	0.061	0.049	2090.00	14.35	1373.15
0.227	0.377	3132.01	5182.01	14.46	30.11	0.061	0.041	2264.16	15.36	1603.67

Table 4. Results for fined heat exchanger for hot side constant 300 LPH

v(m/s)		Re		Nu		f		Q	LMTD	H
hot	cold	hot	cold	hot	cold	hot	cold	Kw	^{0}C	W/m ^{2}K
0.227	0.076	3132.01	1044.65	14.46	6.79	0.061	0.171	1103.05	15.23	1078.36
0.227	0.151	3132.01	2075.55	14.46	15.42	0.061	0.089	1509.44	16.45	1397.62
0.227	0.227	3132.01	3120.20	14.46	25.08	0.061	0.062	2264.16	15.49	1908.26
0.227	0.302	3132.01	4151.11	14.46	35.25	0.061	0.049	2554.44	15.45	2126.21
0.227	0.377	3132.01	5182.01	14.46	45.94	0.061	0.041	2554.44	15.91	2064.11

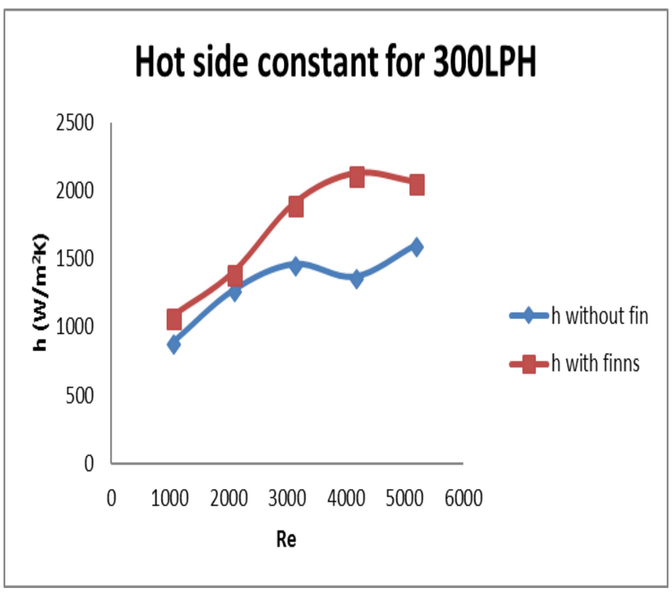

Figure 2. Constant hot flow for 300 LPH

Figure shows the relationships between the h and the Reynolds number for plain and fined heat exchangers. Heat transfer coefficient increases with increase in Reynolds number. With the increase in Reynolds number the turbulence increases which in turns increases the h.

From Table II and Table III it can be clearly observed that finned exchanger having more heat transfer coefficient than plain heat exchanger due to increase in heat transfer area.

Similarly we have varied mass flow rate up to 100 LPH TO 500 LPH for both of the finned and plain heat exchanger and we found satisfactory results.

A. Heat transfer rate with varying flow rates

1. For Plain Tube

Figure shows heat transfer rate with varying cold flow rate by keeping constant hot fluid flow in plain heat exchanger.

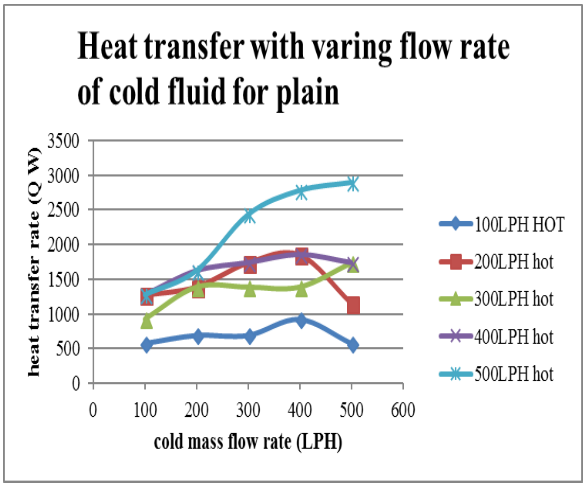

Figure 3. Varying cold flow rate

When 100 to 300 LPH hot fluid constantly flows through inner tube and flow rate from 100 LPH to 500 LPH varying of cold fluid in outer tube then small increase in heat transfer rate was observed but for 400 LPH and 500 LPH heat transfer rate more increases.

2. For Fined Tube

Figure shows heat transfer rate with varying cold flow rate by keeping constant hot fluid flow in finned heat exchanger.

For 100 LPH hot fluid constantly flows in inner tube and varying flow rate from 100 to 500 LPH of cold fluid in outer tube then small increase in heat transfer rate was observed. For 200, 300 and 400 LPH constantly increase in heat transfer rate. More heat transfer rate occurred for 500 LPH.

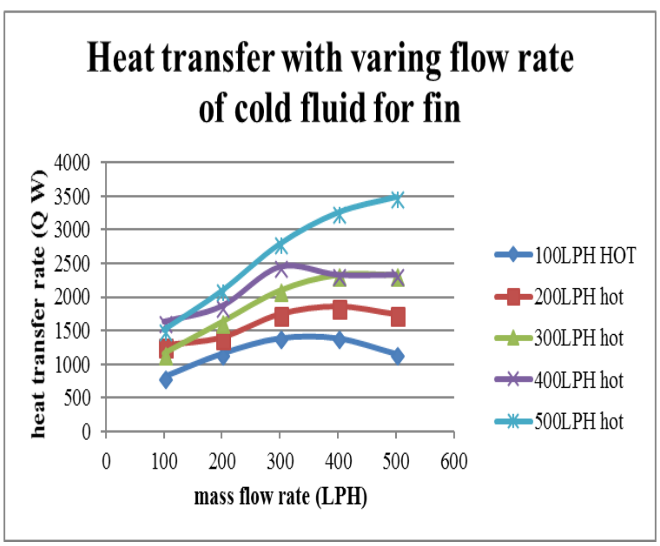

Figure 4. Heat transfer rate with fin for varying flow rates of cold fluid

From Fig.3 and Fig.4 it was clear that heat transfer rate increases by micro fins insertions for all fluid flow rates.

IV. CONCLUSION

In the experiment results will show comparison between with and without micro-fin helical coil heat exchanger. The effects of parameters such as Reynolds number on the heat transfer and overall enhancement ratio were studied.

1. When fins can be used to enhance the heat transfer rate, they also causes an increase in the pressure drop. It increases pumping power. Therefore it increases the operating cost.
2. The heat transfer rates for finned were higher than the plain heat exchanger.
3. Straight tube heat exchanger of same dimensioned helical tube heat exchanger having heat transfer coefficient is less, in straight tube.
4. Flow rate did not affect the heat transfer coefficient, most likely from the fact that the flow was turbulent and increasing the flow rate does not greatly change the wall effects.
5. Criteria based on constant flow rate, we can say that the, the micro fin heat exchanger gives the highest maximum value of heat transfer rate more than Plain tube.

REFERENCES

[1] Ebru Kavak Akpinar, "Heat transfer enhancements in concentric double pipe exchanger equipped with swirl elements", Int. Comm. Heat mass transfer, vol.31,No 6, pp.857-868, (2004)

[2] Smith Eiamsa-ard, Somsak Pethkool, Chinaruk Thianpong b, Pongjet Promvonge "Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with louvered strip inserts" International Communications in Heat and Mass Transfer 35 (2008) 120–129

[3] Ventsislav Zimparov, "Enhancement of heat transfer by a combination of three start spirally corrugated tubes with a twisted tape", International Journal of Heat and Mass Transfer 44 (2001) 551-574

[4] Mansoor Siddique, Majed Alhazmy, "Experimental study of turbulent single-phase flow and heat transfer inside a micro-finned tube", international journal of Refrigeration, 31, (2008), pp. 234-341.

[5] D. G. Prabhanjan, "Comparison of heat transfer rates

between a straight tube heat exchanger and a helically coiled heat exchanger", lnt. Comm. HcnrMas.s Tnm& Vol. 29. No. 2. pp. 185-191, (2002)

[6] 6)Prabhata K. Swamee, Nitin Aggarwal, Vijay Aggarwal , "Optimum design of double pipe heat exchanger" International Journal of Heat and Mass Transfer 51 (2008) 2260–2266.

[7] Timothy J. Rennie, Vijaya G.S. Raghavan, "Experimental studies of a double-pipe helical heat exchanger", Experimental Thermal and Fluid Science 29 (2005), pp.919–924.

[8] Vimal Kumar, "Numerical studies of a tube-in-tube helically coiled heat exchanger", Chemical Engineering and Processing 47 (2008) 2287–2295

[9] Pongjet Promvonge, "Heat transfer augmentation in a helical-ribbed tube with double twisted tape inserts", International Communications in Heat and Mass Transfer 39 (2012) 953–959

[10] M.A. Akhavan-Behabadi a, Ravi Kumar b, M.R. Salimpour c, R. Azimi, "Pressure drop and heat transfer augmentation due to coiled wire inserts during laminar flow of oil inside a horizontal tube" International Journal of Thermal Sciences 49 (2010), pp. 373–379

[11] Paisarn Naphon, "Study on the exergy loss of the horizontal concentric micro-fin tube heat exchanger", International Communications in Heat and Mass Transfer 38 (2011) 229–235.

[12] N. Sahiti, F. Krasniqi, Xh. Fejzullahu, J. Bunjaku, A. Muriqi, "Entropy generation minimization of a double-pipe pin fin heat exchanger", Applied Thermal Engineering, 28, (2008), pp. 2337–2344.