ENHANCEMENT TECHNIQUES OF DOUBLE PIPE HEAT EXCHANGER

¹S. Girish, ²Monica. T, ³L. Praveen

Assistant Professor Department of Mechanical Engineering, ^{1,3}MLR Institute of Technology, Hyderabad ²Vaagdevi Engineering College, Warangal

ABSTRACT: Thermal performance of heat transfer devices can be improved by heat transfer enhancement techniques In the present work, experimental investigations were conducted in a double pipe heat exchanger with hot and cold water as working fluids. The hot water is flowing in inner pipe and cold water in the annulus. Inserts when placed in the path of the flow of the liquid, create a high degree of turbulence, resulting increase in the heat transfer rate and the pressure drop. Nusselt number, heat transfer coefficient and overall heat transfer coefficient for different cold water mass flow rates is estimated keeping hot water flow rate is constant. Similar experiments were conducted for twisted tape having a twist ratio of 7.69. The Nusselt number and overall heat transfer coefficient with twisted tape are compared with those of base fluid. Then we will observe, overall heat transfer coefficient increasing with twisted tape insert. The experimental results indicates enhancement in heat transfer coefficient at 7.69 twist ratio when compared with plain tube at Reynolds number range of 2300 - 10,000. There would be a good agreement between the results obtained from the experimental and the analytical data.

Keywords: Enhancement techniques, heat exchanger, Nusselt number, twist ratio.

I. INTRODUCTION

Temperature can be defined as the amount of energy that a substance has. Heat exchangers are used to transfer the energy from one substance to another. In process units, it is necessary to control the temperature of incoming and outgoing streams. These streams can either be gases or liquids. Heat exchangers raise or lower the temperature of these streams by transferring heat to or from the stream. Heat exchangers are devices that exchange the heat between two fluids of different temperatures that are separated by a solid wall. The temperature gradient or the differences in temperature facilitate this transfer of heat. Transfer of heat happens by three principle means: radiation, conduction and convection. In the use of heat exchangers radiation does take place. However, in comparison to conduction and convection, radiation does not play a major role. Conduction occurs as the heat from the higher temperature fluid passes through the solid wall. To maximize the heat transfer, the wall should be thin and made a very conductive material. The biggest contribution to heat transfer in a heat exchanger is made through convection. In a heat exchanger, forced convection allows for the transfer of heat of one moving stream to another moving stream. With convection as heat is transferred through the pipe wall it is mixed into the stream and the flow of the stream removes the transferred heat. This maintains a temperature gradient between the two fluids.

The double-pipe heat exchanger is one of the simplest types of heat exchangers. It is called a double-pipe exchanger because on fluid flows inside a pipe and the other fluid flows between the pipe and another pipe that surrounds the first. This is a concentric tube construction. Flow in a double-pipe heat exchanger can be co-current of countercurrent. There are two flow configurations: co-current is when the flow of the two streams is in the same direction, counter current is when the flow of the stream is in opposite directions.

2. EXPERIMENTAL SETUP

2.1 Set Up

The double pipe heat exchanger consists essentially of concentric pipes welded in series. The inner pipe is made of mild steel and inside diameter of inner pipe is 10mm and outside diameter of inner pipe is --mm, and for the outer tube, inner diameter is --mm and outer diameter is -mm which is made of M.S pipe. The unit is composed of 2 sections in series. Each section is approximately 1 meter long. Hot water, which comes from the heater, is passed through the inner pipe and cold water, coming from the supply main is passed through the outer pipe. Valves on both lines are also provided to control the flow rates of the streams. Each section is provided with thermocouples, to measure the temperature of the streams at appropriate points along the heat exchanger.



Figure 1 Experimental setup of Double pipe Heat Exchanger



Figure 2 Experimental setup with thermocouples





1 Igure 2 Line Diagram of Double pipe from Exchanger



Figure 4 twisted tape inserts with 7.69 twist ratio

Thermocouples are used to measure the flow temperature at different locations, (inlet thermocouples and exit of the hot and cold flow streams). Each thermocouple is an Omega Model T-Type. The thermistor accuracy is ± 0.1 a C in the range 0°C to 70°C. A change in the thermistor resistance, caused by a change in the medium temperature, yields a voltage change in the thermistor bridge circuit. A data acquisition system has been set up to measure the temperatures based on a pre-existing calibration.

3 OBJECTIVES AND METHODOLOGY

3.1 The objectives of this research are as follows

- To find out convective heat transfer co-efficient and over all heat transfer coefficient of base fluid is water.
- After finding convective heat transfer coefficient of base fluid this process will carried with a twisted tape insert which is having a twist ratio of 7.69, in inner tube of heat exchanger.
- Compare the convective heat transfer coefficients of base fluid and over all heat transfer coefficient, with tube insert having a twist ratio of 7.69.

3.2 Methodology

- The experiment is conducted in parallel flow under turbulent condition keeping hot water flow rate as constant and by varying cold water flow rate.
- Firstly the water is heated by inbuilt heater in hot water tank about 60°C and allows passing through the annular side of heat exchanger at constant flow rate (4 lpm).
- Then the cold water is allowed to pass through the outer tube of heat exchanger at different flow rates (2, 3 and 4 lpm).
- The temperatures of inlet and outlet of cold water as well as hot water are taken by thermocouples which are at inlet and outlet of both the pipe and the annuals.
- The same experiment is conducted with a twisted tape insert having a twist ratio of 7.69 and at different flow rates of cold water keeping hot water flow rate as constant.

RESULTS

The results obtained from the calculations by using different correlations are tabulated and the corresponding graphs are shown below:

The tables and graphs include the relation between,

- i. Experimental heat transfer coefficient with different correlations with plain tube, keeping hot water flow rate as constant by varying cold water mass flow rate.
- ii. Experimental heat transfer coefficient with different correlations by using twisted tape inserts having a twist ratio of 7.69, keeping hot water flow rate as constant by varying cold water mass flow rate.

Table 1 Heat exchanger without any tape inserts (plaintube)

m _c (lpm)	m _h (lpm)	Q _{avg} (Watts)	U (w/m ² k)	$h_{exp} (W/m^2K)$
2	4	90.524	332.9	454.6
3	4	156.678	558.9	1016.2
4	4	166.118	634.3	1302.4

m _c (lpm)	m _h (lpm)	Q _{avg} (Watts)	U (w/m ² k)	h_{exp} (W/m ² K)
2	4	111.0281	399.78	588.745
3	4	153.678	523.25	905.5
4	4	194.983	728.167	1768.9

CONCLUSION

Experimental investigation of heat transfer coefficient and overall heat transfer coefficient of double pipe heat exchanger without inserts at different flow rates under turbulent conditions has been investigated.

- 1. It is observed that swirl flow increases residence time of water in the tube, resulting improvement in conductive heat transfer in double pipe heat exchanger.
- 2. It is observed that as the flow rate of cold fluid increases the Nussult number also increases, resulting increasing in heat transfer coefficient and decrease of friction factor.
- 3. As the twist ratio decrease the heat transfer coefficient increases.

REFERENCES

- [1] Anil Singh Yadav et al., "Effect of half length twisted- tape tabulators on heat transfer and pressure drop characteristics inside a double pipe U- Bend heat exchanger", *Jourdan Journal of Mechanical and Industrial engineering*, 2009, Vol. 3, pp.17-22.
- [2] S.D. Patil et al., "Analysis of Twisted tape with winglets to improve the thermo hydraulic performance of tube in tube heat exchanger", *International journal of Advanced Engineering Research*, pp. 2249-8974.
- [3] S.S Pachegaonkar and S.G Taji, "Performance Analysis of Double Pipe Heat Exchanger With Annular Twisted Tape Inserts", *in International Journal of Engineering and Advanced Technology*, 2014, Vol. 3, pp. 448-443.
- [4] K.V. Sarma, P. K.Sharma and L. Shyam sunder., "Estimation of heat transfer coefficient and friction factor in the transition flow with volume concentration of Al₂O₃ nanofluid flowing in a circular tube and twisted tape insert", *International Communication in Heat and In Heat and Mass transfer*, 2009, Vol. 36, pp. 503-507.
- [5] W.H. Azmi, K.V. Shrma, P.K. Sarma, R. Mamat, S. Anuar and V. Dharma Rao, "Experimental determination of turbulent forced convection heat transfer and friction factor with SiO₂ nanofluid, *Exp. Therm. Fluid sciences*, 2013, Vol. 5, pp. 103-111.

- [6] Murugesan P, Mayilsamy K, Suresh S and Srinivasn P, "Heat transfer and Pressure drop characteristics of turbulent flow in a tube fitted with trapezoidal-cut twisted tape insert", *in International journal of Academic Research*, 2009, Vol. 1, pp.123-127.
- [7] Watcharian Noothong et al., "Effect of twisted tape Inserts on heat transfer in a tube", International conference on Sustainable Energy and environment", 2006, pp. 21-23.
- [8] Yu-Wei Chiu, Jiin-Yuh Jang, "3D numerical and experimental analysis for thermal-hydraulic characteristics of air flow inside a circular tube with different tube inserts", Applied Thermal Engineering, 2009, Vol.29, PP. 250-258.
- [9] J.U. Ahmed et al., "Forced convection Heat transfer performance of porus twisted tape Insert", *Engineering e-Transaction*, 2010, Vol. 5(2), pp. 67-79.
- [10] Prof. Naresh B. Dhamane et al. "Heat Transfer analysis of Helical Strip with Regularly Spaced cut sections placed inside a Circular pipe", International Journal of Modern Engineering Research, 2012, Vol. 2, PP. 3711-3716.