 ISSN: 2321-8169
1845 - 1847

A Double Pipe Heat Exchanger – Fabrication and Standardization For Laboratory Scale

Prof.P.B.Dehankar*
Assistant Professor, Chemical Engineering Department
T.K.I.E.T, Warananagar
Kolhapur, India
e-mail:dehankarpr@gmail.com

K.K.Pandhare, M.J.Vagare, V.M.Nerlekar
UG Students, Chemical Engineering Department
T.K.I.E.T, Warananagar
Kolhapur, India

Abstract— Heat exchangers are using in processes to recover heat between two process fluids in industries like chemical, petrochemical, food, beverage, thermal etc. Although the necessary equations for heat transfer and the pressure drop in a double pipe heat exchanger are available, using these equations the optimization for heat transfer parameter to standardization of experimental set up in laboratory. In this paper, fabrication of double pipe heat exchanger and standardized in laboratory scale by studied theoretical and experimental values for parameters friction factor, Reynold number along the mass flow rate range between 0.02 Kg/sec – 0.033 Kg/sec. Here standardized the new fabricated double pipe heat exchanger using Wilson plot and found out the value of constant 'K' for mass flow rate range between 0.02 Kg/sec – 0.033 Kg/sec.

Keywords- Double pipe heat exchanger; Heat transfer coefficient; Reynold number

*****

I. INTRODUCTION

In process industries like chemical, petrochemical, food, beverage, thermal etc, recovery heat between fluids using double pipe heat exchanger. The design, analysis and implementation of heat exchangers are an important part of heat transfer that should be familiar to them. Fabrication of any lab double pipe heat exchanger required inner pipe, outer pipe, fitting material, thermometer, manometer, measuring cylinder and stop watch etc. once fabricate the double pipe heat exchanger it should be standardized by calibrating different heat exchanger parameter such as Reynold number, friction factor, pressure drop, heat transfer coefficient with standard equation and graph. Standardization of the new fabricates experimental setup at lab scale is the most important step before going to perform any experimentation on it. Here standardized the new fabricated double pipe heat exchanger using Wilson plot and found out the value of constant 'K' for mass flow rate range between 0.02 Kg/sec – 0.033 Kg/sec.

II. SPECIFICATIONS OF FABRICATED HEAT EXCHANGER

The experimental study is done in a double pipe heat exchanger having the specifications as listed below:-

Table 1. SPECIFICATIONS

Material of outer pipe	PVC
Material of inner pipe	Copper
Diameter of Inner pipe ID	0.013 m
Diameter of Inner pipe OD	0.015 m
Diameter of Outer pipe ID	0.023 m
Diameter of Outer pipe OD	0.025 m
Heat transfer length	1 m

Water at room temperature was allowed to flow through the outer pipe while hot water has 60°C flowed through inner pipe in the counter current direction.

III. EXPERIMENTAL SETUP

The fabricated double pipe heat exchanger experimental Setup has shown in Figure 1 consisting of a double pipe heat exchanger having of test section(0.76 m), manometer, basin pipe for supplying cold water & a constant temperature overhead tank (10 litre capacity having continuous supply of hot water) for supplying hot water. Hot water flow rate was constant at 0.02 Kg/sec – 0.033Kg/sec by manually. Two pressure tapings, one just before the test section and the other just after the test section are attached to the U-tube manometer for pressure drop measurement. Carbon tetrachloride was used as the manometric fluid. Iodine crystals were dissolved in it to impart brown colour to it for easy identification.

Figure 1. Fabricated Double Pipe Heat Exchanger Experimental Setup

ISSN: 2321-8169
1845 - 1847

IV. STANDARDIZATION OF EXPERIMENT

Standardization of the experimental setup is done by obtaining the friction factor & heat transfer results for the smooth tube & comparing them with the standard equations available. Friction factor determination by Pressure drop was measured for each flow rate with the help of manometer at room temperature. The U-tube manometer used carbon tetrachloride with fraction of iodine crystal as the manometric liquid. Air bubbles are removed from the manometer so that the liquid levels in both the limbs were equal when the flow is stopped. Water at room temperature is allowed to flow through the outer pipe of the heat exchanger.

Heat transfer coefficient calculation by heater is put on to heat the water to 60°C in a constant temperature water tank of capacity 10 liters(continuous supply of hot water). Valve was used for recirculation of hot water to the tank & to the experimental setup. Hot water at about 60°C is allowed to pass through the inner side of heat exchanger between 0.02 Kg/sec – 0.033 Kg/sec. Cold water is now allowed to pass through the outer pipe of heat exchanger in countercurrent direction at a desired flow rate. The water inlet and outlet temperatures for both hot water & cold water (T 1 -T 4) were recorded. The procedure was repeated for different hot water flow rates ranging from 0.02 Kg/sec – 0.033 Kg/sec.
Wilson chart equation,

$$1/U_i = 1/h_i + h_i/(d_o \cdot h_o) + (x_w \cdot d_i)/(k_w \cdot d_i) + R_d \quad \text{----(1)}$$

where R_d is the dirt resistance

$$K = h_i/(d_o \cdot h_o) + (x_w \cdot d_i)/(k_w \cdot d_i) + R_d \quad \ldots\text{.. constant}$$

For Re>10000, Seider Tate equation,

$$h_i = A \times Re^{0.8} \quad \text{----(2)}$$

$$Nu = 0.023 \cdot Nre^{0.8} \cdot Npr^{0.4} \quad \text{----(3)}$$

V. RESULT AND DISCCUSION

Wilson chart Preparation

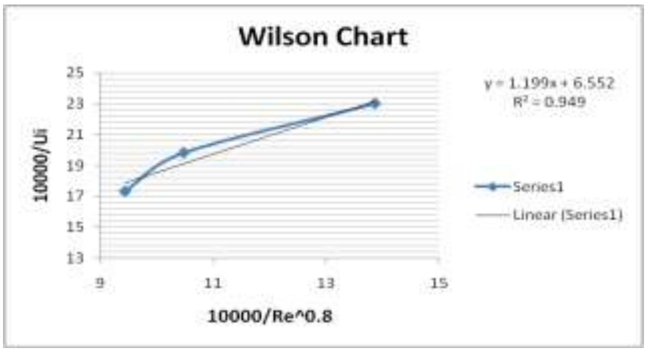

Figure 2. Wilson Plot

As shown in figure 2, standardized the experimental setup having R2 = 0.949 that indicate most of the experimental result near to the linearity. It means that, experimental setup can be use for further experiment which will give accuracy in result. 'K' is to be found from the Wilson chart (1/U i vs. 1/Re 0.8) as the intercept on the y-axis. K=6.552×10 -4 as constant value and can be use in further heat transfer calculation.

Friction Factor

Table 2. Calculation for Friction Factor

Friction Factor

v	m(Kg/sec)	T(0C)	dH(m)	dP(N/m2)	fexp	u	Re	ftheo	%diff
0.150376	0.02	56	0.004	23.66172	0.00894931	0.000535	3661.607593	0.00775	0.119888
0.218045	0.029	50	0.007	41.40801	0.00744889	0.000575	4942.163901	0.007299	0.014967
0.24812	0.033	48	0.009	53.23887	0.00739612	0.000591	5475.21446	0.007151	0.024491

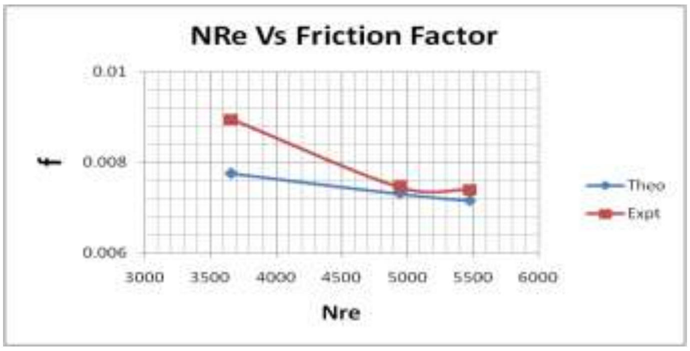

Figure 3. N_{Re} Vs Friction Factor for Theoretical and Experimental values

As shown in figure 3, larger deviation between f_{expt} & f_{theo} for low Re is due to limitations of experimental setup. Except at low Re, the difference between f_{expt} & f_{theo} is limited to ±10%, so easily assume that the theoretical friction factor equations hold true for our experimental setup. As the ΔH values were very small (0.004-0.009 m) for low Re & the manometer's least count was 0.004 m, so we cannot measure those low pressure drops with higher accuracy.

Heat Transfer Coefficient

Table 3. Calculation for Heat Transfer Coefficient

m(Kg/sec)	Re	hexpt	htheo	hdev
0.02	3738.32473	607.5415	610.9340314	3.392546
0.029	5309.33101	753.9155	766.1237443	12.20824
0.033	6041.65253	927.6254	865.9832477	-61.6421

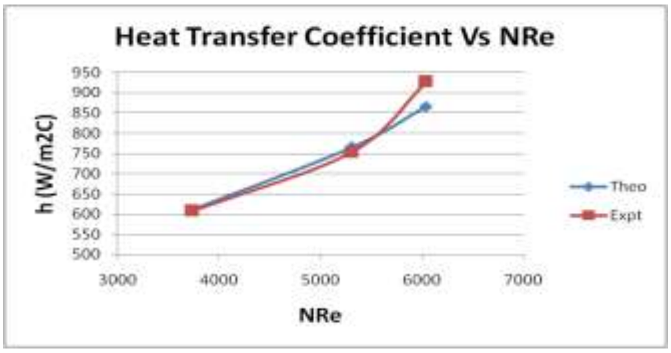

Figure 3. Heat Transfer Coefficient Vs N_{Re} for Theoretical and Experimental values

As shown in figure 3, there is a very small difference between h_{expt} & h_{theo}, so easily assume that the theoretical heat transfer equations hold true for our experimental setup. Higher deviation (-15.3471%) between h_{expt} & h_{theo} for Re>6000 can be attributed to the phenomenon of natural convection taking place along with forced convection. The phenomenon of natural convection is negligible in comparison to forced convection for higher Re but is significant at low Re. The percentage difference for Re<6000 were found to be well within ±9% for some of the readings. This can be taken as an indication of heat transfer results in the case of experiment to be reasonably accurate.

VI. CONCLUSION

The experimental result and theoretical result value are very significant to the fabricated double heat exchanger by standardization. There is a very small difference between h_{expt} & h_{theo}, so easily assume that the theoretical heat transfer equations, friction factor equations and 'K = 6.552×10 -4' has found from the Wilson chart (1/U i vs. 1/Re 0.8) hold true for our experimental setup and can be use in further heat transfer calculation. It means that, experimental setup can be use for further experiment on fabricated double pipe heat exchanger which will give accuracy in heat transfer calculation.

ACKNOWLEDGMENT

The author acknowledges to my colleges who have helped in the present work as well as students those performed experimental work which present in the paper. This work will be very helpful in further experiments.

REFERENCES

[1] Tomasz Sobota, "Experimental Prediction of Heat Transfer Correlations in Heat Exchangers," Cracow University of Technology Poland,pp. 293–307.

[2] Timothy J. Rennie, "Numerical and experimental studies of a double-pipe helical heat exchanger", Department of Bioresource Engineering McGill University, Montreal, August 2004, pp.01–69.

[3] N. R. Chaudhari, F. N. Adroja, "A Review on Design & Analysis of Double Pipe Heat Exchanger," International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 2, February - 2014, pp. 2502–2505.

[4] Prof.P.B.Dehankar, Prof. N.S.Patil, "Heat Transfer Augmentation - A Review for Helical Tape Insert", International Journal of Scientific Engineering and Technology, Volume No.3 Issue No.10, Oct 2014, pp : 1236-1238.

[5] M A Mehrabian, S H Mansouri and G A Sheikhzadeh, "The overall heat transfer characteristics of a double pipe heat exchanger: comparison of experimental data with predictions of standard correlations," IJE Transactions B: Applications, Vol. 15, No. 4, December 2002 , pp:395-406.

[6] M.Kannan, S.Ramu, S.Santhanakrishnan, G.Arunkumar, Vivek.M, "Experimental and analytical comparison of heat transfer in double pipe heat exchanger," International Journal of Mechanical Engineering applications Research – IJMEAR, Vol 03, Issue 03; July 2012, pp. 170–174.

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

[8] Snehal S. Pachegaonkar, Santosh G. Taji, Narayan Sane, "Performance Analysis of Double Pipe Heat Exchanger with Annular Twisted Tape Insert," International Journal of Engineering and Advanced Technology (IJEAT), Volume-3, Issue-3, February 2014, pp. 402-406.

[9] Dr. J. Michael Doster, "forced convection heat transfer in a double pipe heat exchanger", Department of Nuclear Engineering Box 7909 North Carolina State University Raleigh, NC 27695-7909.

[10] Donald Q. Kern, "Process heat transfer", McGraw Hill Education, Edt 1997, pp : 62-127.

.