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Performance Analysis of Heat Transfer and Effectiveness on Laminar Flow with Effect of Various Flow Rates

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Abstract: In this paper investigation the heat transfer and effectiveness of the double pipe heat exchanger with two flow directions; one is parallel flow and counter flow direction. In these two directions, deem the laminar flow and from the experimental setup in use the exit temperature of both hot and cold fluid with different mass flow rate. Finally work out the heat transfer and effectiveness of the parallel flow heat exchanger and analysis these data with the counter flow heat exchanger. A commercial CFD package, Ansys fluent version are used for this study. Generate and mesh the 3D model heat exchanger. As a final point the experimental assessment is validate with the numerical values.

Introduction

The performance of heat exchanger analysis for single phase flows can be enhanced by many techniques. In general, the heat transfer can be alienated into two categories; one is active heat transfer and passive heat transfer. Therefore computational fluid dynamics modeling technique is utilized as a powerful tool to put on and accepting many industrial processes. Kumar et.dt studied the heat transfer characteristic of tube in a helical heat exchanger fitted with semicircular plate in annular area using a commercial CFD package to predict the flow and thermal properties in the heat exchanger tube. To facilitate they found Nusselt Number and friction factor in the inner tube and outer tubes from the CFD results covered with experimental statistics[1]. Seong won hwang studied about the CFD examination of fin tube heat exchanger exhibited a pressure loss lower than that of a plain tube and the heat transfer performance was enhanced at very high velocity[2]. The several experimental studies on heat transfer augmentation techniques using twisted tape have been reported in the literature. The prediction of friction coefficients and convective heat transfer characteristics of heat exchanger is reported with twisted tape inserts[3-5]. The heat transfer characteristic in a tube fitted with helical screw and shows the performance of the heat transfer[6]. The conducted experimental investigation on heat transfer with the nano fluids and twisted tape inserts. The results found to be the enhanced heat transfer given good agreement in the data[7]. Heat transfer enhancement and pressure drop is calculated in the experimental analysis of performance on heat transfer[8]. The heat transfer and friction factor is analyzed with nano fluids and turbulent flow characteristics[9]. The thermal performance characteristics are studied with combined non uniform wire coil and twisted tape inserts and also improved the heat transfer characteristic[10]. The heat transfer is enhancing dimpled tube with the twisted tape inserts[11]. The combined conical ring and twisted tape inserts are considered to develop the heat transfer quality[12]. The converging – diverging tube with twisted tape inserts is used to validate the compound heat transfer examination[13].So the solution of this problem is entrenched as experimental data were taken for parallel flow and counter flow outlet temperature of together hot fluid and cold fluid. Experimentally evaluate the heat transfer, effectiveness and LMTD, friction factor and validate these statistics with CFD package were used to execute the solution.

Experimental Investigation

An experimental setup is designed and fabricated to the flow and convective heat transfer co-efficient and heat transfer feature of the water flowing in a plain tube. The experimental system mainly consists of storage system, pipe line and test section. The geometry pattern of plain tube with a thickness (t) 0.075 cm, length (L) 220 cm is utilized for simulation. In a double pipe heat exchanger it consists of two concentric tubes in which hot water flows in an inner tube and cold water flows outer tube in the test section. The outer tube is made up of an aluminum having inside and outside diameters of 20 mm and 18 mm respectively. The outer tube is made of a cast iron having inside and outside diameters of 28 mm and 32 mm respectively. For calculate the experimental value the following equation are used to calculate Nusselt number and Heat transfer co-efficient.

$Nu = hD/K$
$Re = \acute{\rho}vD/\mu$
$€ = Q_{max}/Q_{total}$
$LMTD = (\Delta T_1-\Delta T_2)/\ln(\Delta T_1/\Delta T_2)$

NUMERICAL INVESTIGATION

In the present work, navior strokes equation were namely solved for the hot fluid flow inner side tube and cold fluid flow outer side tube. Three dimensional continuity equation and momentum equation are used in the numerical significance. Figure 1 shows the representative geometry of plain tube heat exchanger considered for the numerical assessment. In inlet boundary velocity is established in from inlet to outlet temperature are specified. A constant temperature was set at the inner tube surface and following expression were analyzed the data. Numerical simulation were in use computational fluid dynamics and calibrate the heat transfer and heat transfer co-efficient, Reynolds number from CFD numerical examination.

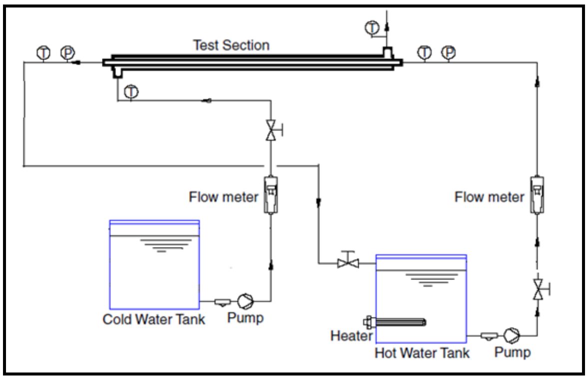

Figure 1. Experimental setup of heat Exchanger

Numerical analysis

$Q = mc\,[T_{in} - T_{out}]$
$h = Q/(A\,\Delta T_m)$
$f = \Delta p/[\acute{\rho}(v^2/2)] \times [D/4L]$
where
Q-Heat transfer rate, W/m^2
m-flow rate, m/s
h-Heat transfer coefficient, w/m^2K
F-Friction factor
ΔP-Pressure drop
$\acute{\rho}$-Density, kg/s

Result and Discussion

The evaluation of the experimental and simulated test result consisted of the comparison of the inlet and outlet properties in both cases.

Parallel flow heat exchanger

Figure 2 show the results of an experimental record compared to the results of the simulation at the different mass flow rate and inlet conditions. The figure illustrates the exit hot fluid temperature with varying the mass flow rate as measured from the heat exchanger. The validation takes place with exit temperature of hot fluid of both experiment and simulation assessment. These value are very good agreement with the simulated values. Figure 3 calibrated between the flow rate and heat transfer coefficient. The actual value of the heat flux is well validating with predicted value of CFD modeling. Figure 5 shows the results with comparison of heat transfer coefficient and mass flow rate, these two data are well validate with predicted assessment of heat exchanger. Figure 5 investigate with the friction factor and Reynolds number of actual experimental data. Figure 6,7,8,9 shows the simulated results for the parallel flow direction. Table 1,2,3 shows the experimental and simulated records.

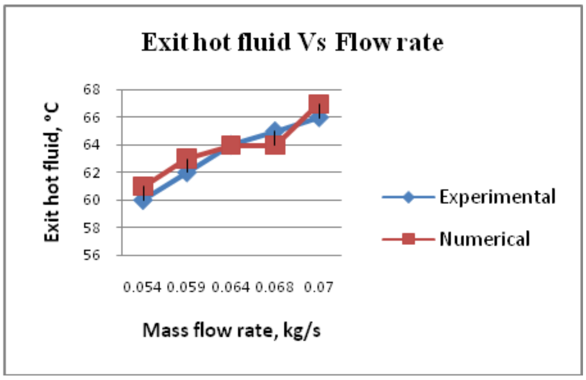

Figure.2 Exit Temperature variation

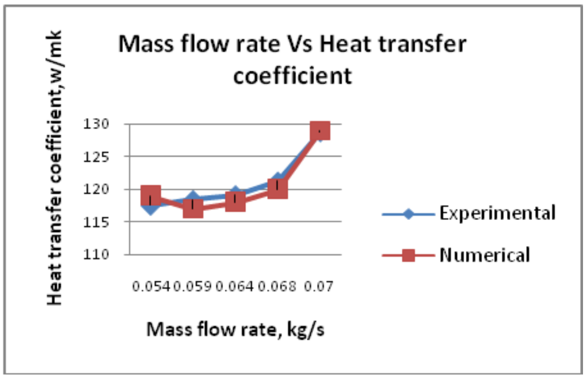

Figure.3 comparison of Heat transfer coefficient and flow rate

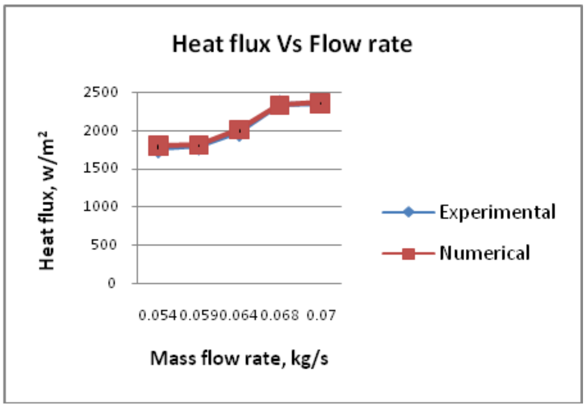

Figure.4 Result of heat flux and Mass flow rate variation

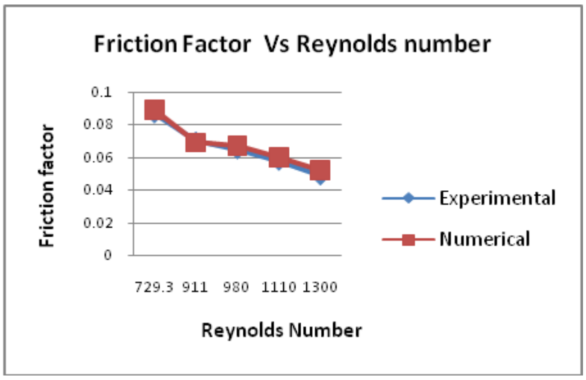

Figure.5 comparison of friction factor and Reynolds number

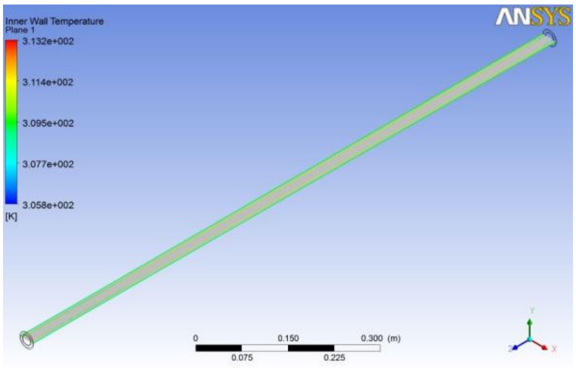

Figure 6.CFD temperature profile

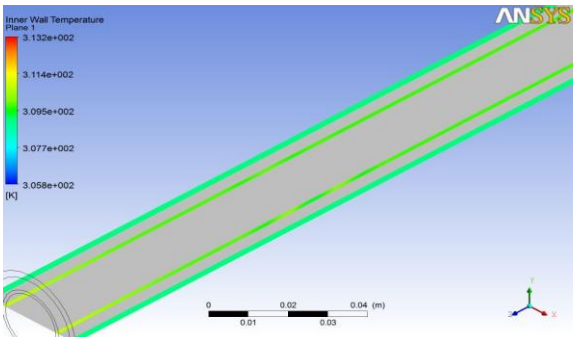

Figure 7. Simulated inner wall temperature

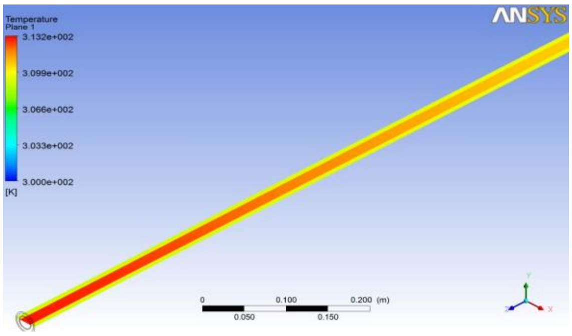

Figure 8. Temperature variation

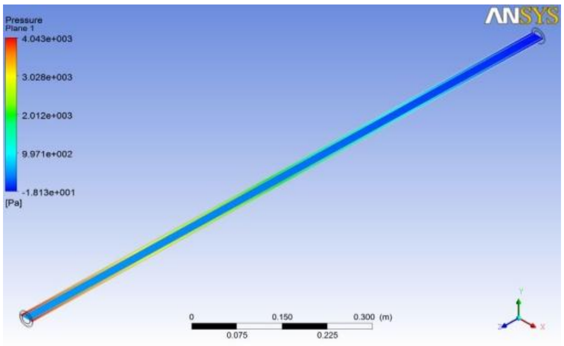

Figure 9. Pressure variation

Table 1 Comparison of Experimental and Numerical Exit temperature of hot fluid and cold fluid

Mass flow rate [Kg/s]	**Experimental Exit Temp °C**		**Numerical Exit Temperature °C**	
	Hot Fluid	**Cold fluid**	**Hot Fluid**	**Cold fluid**
0.05	61	34	61.5	35
0.07	63	34	62	37
0.08	64	35	63	37
0.09	65	34	64.5	38
0.10	68	35	67	39

Table 2 Mass flow rate and Heat flux values used in simulations

Mass flow rate [kg/s]	**Experimental Heat flux [W/m^2]**	**Numerical Heat flux [W/m^2]**
0.05	1759.12	1802.30
0.07	1797.52	1810.00
0.08	1975.26	2010.30
0.09	2330.21	2392.00
0.10	2350.70	2400.00

Table 3 Experimental Values of Exit Temperature Of Fluids

Mass flow rate [kg/s]	**Hot fluid Inlet Temp °C**	**Hot fluid Exit Temp °C**	**Cold fluid Inlet Temp °C**	**Cold fluid Exit Temp °C**
0.05	68	61	28	35
0.07	70	63	29	37
0.08	71	64	30	37
0.09	74	65	29	38
0.10	78	68	28	39

Counter flow heat exchanger

All the results from the measurement of counter flow heat exchanger shows the results in the following figures. Figure 10 shows the variation of exit hot fluid temperature with different mass flow rate, the counter flow heat exchanger extract more exit temperature as compared with the parallel flow heat exchanger. The experimental values well bonded with the predicted values of the simulations. Figure 12 shows the results comparison with heat flux and mass flow rate. Here the heat flux is increases with 5% as compared with the parallel flow direction and also well coincide with the numerical data's. Figure 13 shows the variation of friction factor and Reynolds number, the results investigate the Reynolds number increases with decreases in friction factor. Figure 14, 15 shows the simulated results for the counter flow direction. Table 4,5,6 shows the experimental and simulated records.

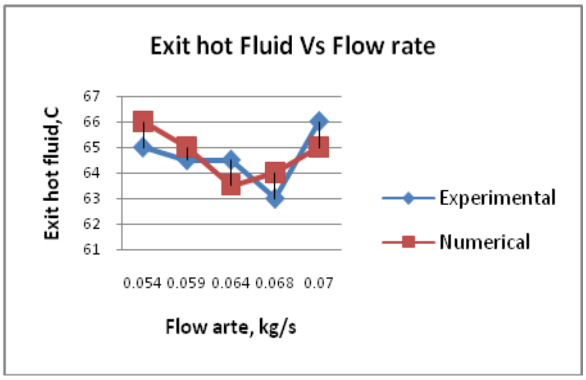

Figure 10.Exit hot fluid temperature and flow rate

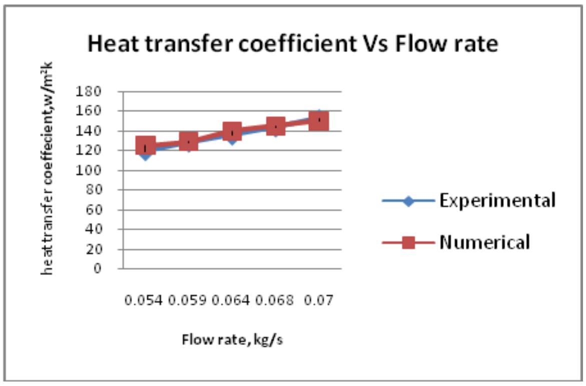

Figure 11.Heat transfer coefficient and flow rate

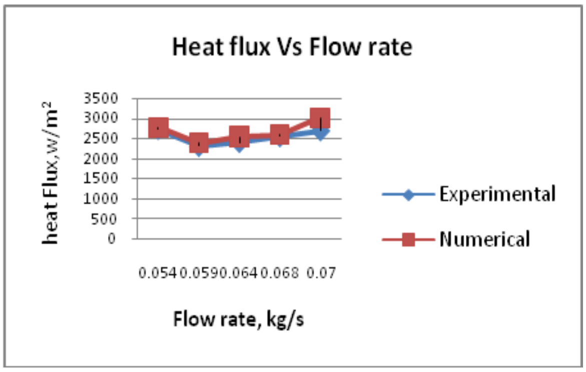

Figure 12. Comparison of Heat flux and flow rate

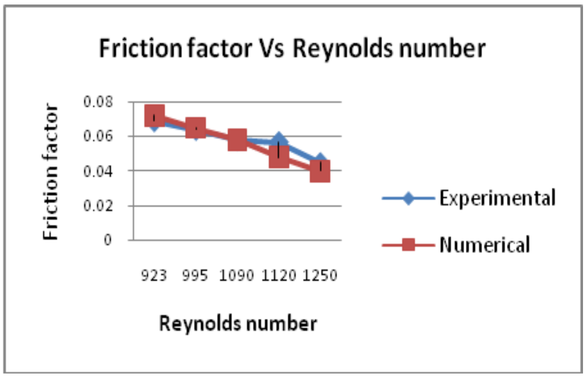

Figure 13.Friction factor and Reynolds number

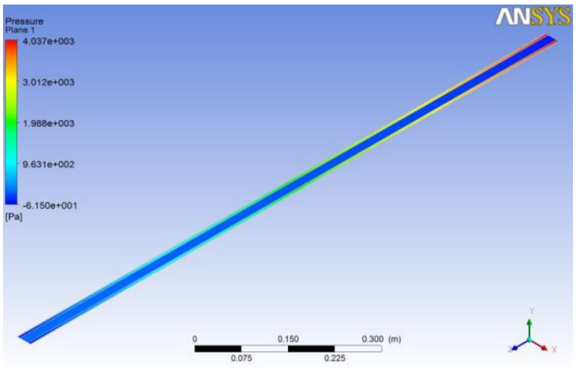

Figure 14. CFD simulation pressure variation

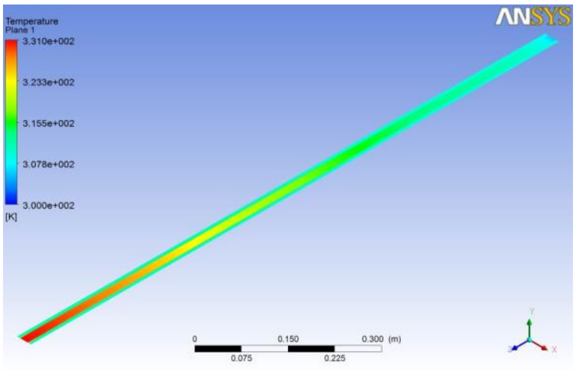

Figure 15. Temperature variation

Table 4 Comparison of Experimental and Numerical Exit temperature of hot fluid and cold fluid

Mass flow rate [Kg/s]	Experimental Exit Temp °C		Numerical Exit Temperature °C	
	Hot Fluid	Cold fluid	Hot Fluid	Cold fluid
0.05	66	38	66	39
0.07	64	40	63	38
0.08	65	42	64	40
0.09	63	43	64	42
0.10	66.5	44	65.5	43

Table 5 Mass flow rate and Heat flux values used in simulations

Mass flow rate [kg/s]	Experimental Heat flux [W/m^2]	Numerical Heat flux [W/m^2]
0.05	2734.6	2790.5
0.07	2310.5	2390
0.08	2411	2495
0.09	2551.8	2600
0.10	2930.2	3010

Table 6 Experimental Values of Exit Temperature Of Fluids

Mass flow rate [kg/s]	Hot fluid Inlet Temp °C	Hot fluid Exit Temp °C	Cold fluid Inlet Temp °C	Cold fluid Exit Temp °C
0.05	70	66	28	38
0.07	72	64	29	40
0.08	74	65	30	42
0.09	75	63	29	43
0.10	76	66.5	30	44

Conclusion

In the present study, the heat transfer and friction factor of plain tube fitted with laminar flow conditions were simulated using Ansys fluent version. The data obtain from the experimental record are well matched with computational fluid dynamics simulated values. The presence of different mass flow rate is considered; heat transfer enhancement obtained good result and also increases Reynolds number with decreasing friction factor. The comprehension of experimental and simulated is helped to identify the characteristics of heat transfer and friction factor.

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References

1. V.Kumar, S.Saini, M.Sharma, and K.D.P.Nijam,"pressure drop and heat transfer study in tube- in –tube helical heat exchanger," chemical Engineering science, Vol.61,no.13, pp. 4403-4416, 2006.
2. Seong Won Hwang, Dong Hwan Kim, June Kee Min and Ji Hwan Jeong, "CFD analysis of fin tube heat exchanger with pair of delta winglet vortex generators,"Journal of Mechanical Science and Technology, Vol. 26, no. 9, pp.2949-2958, 2012.
3. P. K. Sarma, P. S. Kishore, V. D. Rao, and T. Subrahmanyam,"A combined approach to predict friction coefficients and convective heat transfer characteristics in A tube with twisted tape inserts for a wide range of Re and Pr," International Journal of Thermal Sciences, vol. 44, no. 4, pp. 393–398, 2005.
4. S. Eiamsa-ard, C.Thianpong, and P. Promvonge, "Experimental investigation of heat transfer and flow friction in a circular tube fitted with regularly spaced twisted tape elements," International Communications in Heat and Mass Transfer, vol. 33, no. 10, pp. 1225–1233, 2006.
5. S. Eiamsa-ard, "Study on thermal and fluid flow characteristics in turbulent channel flows with multiple twisted tape vortex generators," International Communications in Heat and Mass Transfer, vol. 37, no. 6, pp. 644–651, 2010.
6. S. Eiamsa-ard and P. Promvonge, "Heat transfer characteristics in a tube fitted with helical screw-tape with/without core rod inserts," International Communications in Heat and Mass Transfer, vol. 34, no. 2, pp. 176–185, 2007.
7. L. S. Sundar, K. V. Sharma, and S. Ramanathan, "Experimental investigation of heat transfer enhancements with Al2O2 Nano fluid and twisted tape insert in a circular tube," International Journal of Nanotechnology and Applications, vol. 1, pp. 21–28, 2007.
8. V. Hejazi, M.A. Akhavan-Behabadi and A. Afshari, Experimental investigation of twisted tape inserts performance on condensation heat transfer enhancement and pressure drop, International Communications in Heat and Mass Transfer, Vol. 37 (2010), pp. 1376–1387.
9. L. Syam Sundar and K.V. Sharma, Turbulent heat transfer and friction factor of Al2O3 Nanofluid in circular tube with twisted tape inserts, International Journal of Heat and Mass Transfer, Vol. 53 (2010), pp. 1409–1416.
10. S. Eiamsa-ard, P. Nivesrangsan, S. Chokphoemphun and P. Promvonge, Influence of combined non-uniform wire coil and twisted tape inserts on thermal performance characteristic, International Communications in Heat transfer, Vol. 37 (2010), pp. 850–856.
11. Chinaruk Thianpong, Petpices Eiamsa-ard, Khwanchit Wongcharee and Smith Eiamsa-ard, Compound heat transfer enhancement of a dimpled tube with a twisted tape swirl generator, International Communications in Heat and Mass Transfer Vol. 36 (2009), pp. 698–704.
12. P. Promvonge and S. Eiamsa-ard, Heat transfer behaviors in a tube with combined conical ring and twisted-tape inserts, International Communications in Heat and Mass Transfer Vol. 34 (2007), pp. 849–859.
13. HONG Mengna, DENG Xianhe, HUANG Kuo and LI Zhiwu, Compound heat transfer enhancement of a converging-diverging tube with evenly spaced twisted-tapes, Chinese Journal of Chemical Engineering, Vol. 15 No.6 (2007), pp. 814—820.

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