Experimental Study on Effect of Length of Twisted Tape on Performance of Externally Helical Wire Wound Double Pipe Heat Exchanger for Parallel and Counter Flows

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Abstract— Externally Helical wire wound Double pipe heat exchanger (DPHE) or concentric tube heat exchanger is a modified form of simple DPHE as in this case a copper wire is externally wounded over outer periphery of inner tube of DPHE. This modification increases some thermal efficiency as compare to simple DPHE. This kind of heat exchanger is widely used in chemical, food, oil and gas industries. Commonly methods used by the researchers to enhance the heat flow rate are Active method, Passive method and compound method. And present work is based on passive method. In the present work experiment is carried out on double pipe heat exchanger in which hot water is flowing through inner tube where as cold water is flowing through the annulus and hot water to cold water heat exchange is taken into consideration. During the experiment cold water flow rate is kept constant at 45LPH (liters per hour) where as hot water flow rate is varies from 15LPH to75LPH. Two twisted tape inserts of different lengths as one is full and another is half of same pitch length of 2.5" insert are used and inlet and outlet temperature of hot and cold water is measured by K type thermocouple to calculate different parameters of double pipe heat exchanger like Effectiveness, LMTD, Overall Heat Transfer Coefficient and Heat Transfer for performance in parallel and counter flow arrangement.

Key words: Heat Transfer Rate, Heat Exchanger, Helical Wire, Twister Tape

I. INTRODUCTION

The effect of baffle spacing and mass flow rate compare to the conventional annulus side gives result increased convective heat transfer by different cases(on an average) respectively 5%,17%,30% and 40% and increase in pressure drop 2,5,11 and 21 using Twisted tape-helical baffle-counter flow [1]. Self-rotating Inserts compare with stationary inserts gives result as increase of heat transfer rate, pressure drop and achieve best performance of heat transfer rate with lower resistance loss [2]. Concluded that here worked on fully developed turbulent flow, pitch ratio and twist ratio depends on change in Q and f.

"Q and f are increase with decrease of pitch ratio and twist ratio and dimpled tube with twisted tape compared to plain tube Q_{rate} and f are 1.66-3.03 and 5-6.31 times dimpled tube with a twisted tape swirl generator by chinaruk [3]. The performance of heat exchangers can be improved to perform a certain heat-transfer duty by heat transfer enhancement techniques. The heat transfer enhancement enables the size of the heat exchanger to be significantly decreased [4]. Through these years, a plethora of researches have been carried out which fall into various categories [5]. In some cases, just the working fluids characteristics and their modifications were studied; some investigated active methods, passive methods, compound methods, geometry change and the other heat enhancement methods [6]. The boundary condition of constant heat flux finds application in electrically heated tubes and nuclear fuel elements. [7].However, the case of fluid-fluid heat exchange has not been studied well [8].

II. METHODOLOGY

Method for calculating effectiveness, LMTD, overall heat transfer coefficient, heat transfer rate in hot fluid and capacity ratio formulas used in calculation given in Straight Steel 10 mm inner diameter and length 1.5 m straight tube and externally helical wire wound DPHE. Copper wired tube 10 and 12 mm inner and outer diameter with 1 mm thickness of copper. Hot water flows from top positioned hot tank to the inner steel tube where it loses heat by cold water flowing through outer tube. The inlet and outlet of cold water in outer tube kept at top so outer tube should be filled completely and complete inner tube must be immersed in water. The flow of cold water is controlled by rotameter at the inlet in the outer tube, this cold water then carries heat to drainage. Hot water mass flow rate controlled by rotameter at the inlet of inner tube and the outlet of hot water is circulated to hot water boiler for the purpose of again utilizing that hot water. By collecting this hot water into boiler we saved the wastage draining of outlet hot water. Now in this bottom positioned hot water boiler we use a high capacity heater of 9 KW powers, who give us hot water of ranges 60º-90ºC in just few minutes so we can save our time of waiting for hot water of upper hot tank. In bottom positioned boiler we also have a pump of 0.5 HP capacities that pumped this hot water in top positioned hot water tank for further utilization. Four thermocouples are used to note down temperature at inlet and outlet of hot and cold water flows respectively as shown in figure 1.Twisted tape changes fluid flow direction made of aluminimum 1.5 mm long tip machined in lathe.

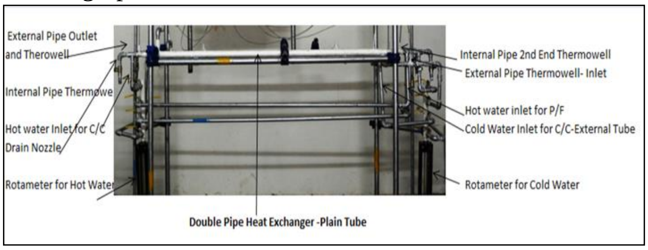

Fig. 1: Double pipe heat exchanger plain tube

III. RESULTS AND DISCUSSION

Comparative analysis of effectiveness when cold water is constant at 45 LPHs for straight steel tube, copper wire helical wound steel tube without inserts and copper wire helical wound steel tube DPHE with 2.5” full & half-length inserts in counter flow arrangement.

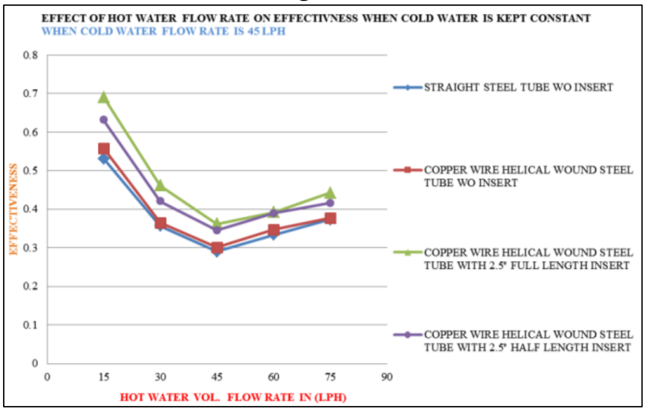

Fig. 2: Effect of hot water flow rate on effectiveness when cold water is kept constant at rate 45 LPH

Comparative analysis of effectiveness when cold water is constant at 45 LPH for straight steel tube, copper wire helical wound steel tube without inserts and copper wire helical wound steel tube DPHE with 2.5” full & half-length inserts in parallel flow arrangement.

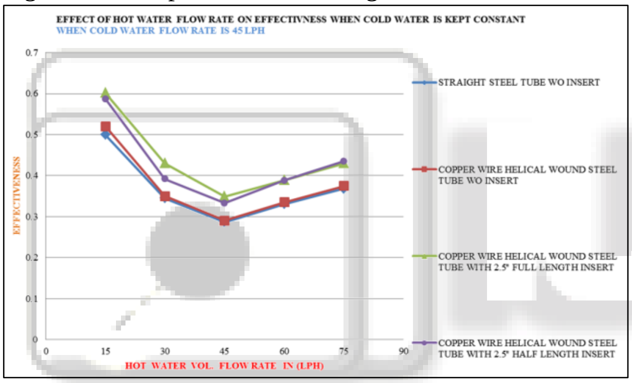

Fig. 3: Effect of hot water on LMTD when cold water is kept constant when cold water flow rate is 45 LPH

Comparative analysis of LMTD when cold water is constant at 45 LPH for straight steel tube, copper wire helical wound steel tube without inserts and copper wire helical wound steel tube DPHE with 2.5” full & half-length inserts in counter flow arrangement.

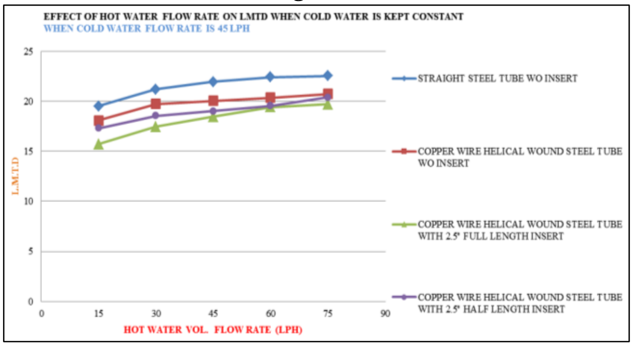

Fig. 4: Effect of hot water flow rate on LMTD when cold water is kept constant when cold water flow at 45 LPH

IV. CONCLUSION

It was observed that the heat transfer rate increases with increase from volume flow rate of hot water in both the cases parallel and counter flow and heat transfer rate in counter flow was greater than the heat flow rate in parallel flow. In both cases it was observed that the heat transfer rate in case of 2.5” pitch full length insert was greater than the other three arrangements. The maximum value of heat transfer rate was found in counter flow arrangement with 2.5” full length insert was 638.52 Watt and it is 14% greater than the heat transfer rate in plane steel tube without insert, 12% greater than the copper wire tube without insert and 4% greater than the 2.5” half-length insert. Heat transfer rate on relative direction of fluid motion, variation in volume flow rate of hot fluid and insert length of twisted tape. Maximum value of effectiveness was obtained in case of counter flow arrangement with 2.5” full length insert and it was 0.69 and it is 30%, 24% and 9% greater than the maximum value of effectiveness in counter flow arrangement in case of plane steel tube without insert, copper wire tube without insert and 2.5” half-length insert respectively.

It was observed that the value of overall heat transfer coefficient increases with increase in volume flow rate of hot fluid and maximum value of overall heat transfer coefficient was found in case of 2.5” full length insert was 573 W/m^{2}K and it is 31%, 18%, and 7% greater than maximum value of overall heat transfer coefficient in plane steel tube without insert, copper wire tube without insert and 2.5” half-length insert respectively.

It was observed that the value of LMTD increases with increase in volume flow rate of hot fluid and maximum value of LMTD was observed in case of plane steel tube without insert was 22.52 and it was 11%, 9% and 15% greater than the value found in 2.5” half-length insert, copper wire tube without insert and 2.5” full length insert respectively.

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