Experimental Determination of Effectiveness of Triple Tube Heat Exchanger with Dimple Tubing

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Abstract— A double tube heat exchanger is conventionally used because of cheaper cost of construction. But the problem associated with it is that it occupies larger tube length and space. To overcome this a modified version of double tube heat exchanger is developed which is a triple tube heat exchanger. Triple tube heat exchanger provide larger heat transfer area per unit length of heat exchanger as compared to double tube heat exchanger. Our experiment will experimentally calculate effectiveness of triple tube heat exchanger. To enhance the effectiveness dimples have been made on the middle tube. The fluid used is water. Hot water will flow through the middle annular space while cold fluid will flow through the inner tube and outer annular space. The study is carried out to determine the effectiveness of triple tube heat exchanger with dimple tubing.

Key words: Triple Tube Heat Exchanger, Effectiveness, Dimple

I. Introduction

Heat exchanger is defined as a device which transfer heat from hot fluid and cold fluid, but while transferring heat it must be with maximum rate and minimum capital cost. There are several kinds of heat exchangers are used in industry such as plate type heat exchanger, shell and tube heat exchanger, double pipe heat exchanger, helical tube heat exchanger etc. Double tube heat exchanger is conventionally used because of its cheaper cost and simple construction. But it occupies more space. To resolve this problem a new heat exchanger was introduced i.e. triple tube heat exchanger. It provides compact design and greater heat transfer area per unit length of heat exchanger as compared to the double pipe heat exchanger. Dimple tubing is also introduced to enhance the heat transfer. Experimental study is carried out to find the effectiveness of triple tube heat exchanger.

Dimples on the tube surface can significantly increase the heat transfer rate. Introduction of dimples on the tube surface can increase surface area available for heat transfer. Also it reduces the hydrodynamic resistance of fluid flow over the surface by disturbing hydrodynamic boundary layer. Also the vortices formed inside the dimples results in thinning and disturb thermal boundary layer. These two effects ultimately results in heat transfer enhancement.

II. Literature review

Dharmikkumar A. Patel [1] carried theoretical study of triple tube heat exchanger. He found that various factors which affect the performance of triple tube heat exchanger. He also found that the effectiveness in counter flow arrangement is higher than parallel flow arrangement. In triple tube heat exchanger there is saving of considerable amount of space as well as material as compared to double pipe heat exchanger. Heat transfer rate are affected by number of fins, fin length and fin thickness. He also suggested that in triple tube fouling occurred greater extend toward the outlet and with the increase in time.

N. R. Parthasarathy [2] carried an experimental study on one modification of triple tube heat exchanger which is triple U tube heat exchanger. He found that heat transfer rate of triple U tube heat exchanger is greater than conventional model. The model is compact and unique one. This U tube design can also be implemented to double pipe heat exchanger. The implementation may result in high heat transfer rate.

Tejas Ghiwala [3] carried a numerical analysis on sizing of triple tube heat exchanger. During this analysis they compared triple tube heat exchanger with double tube heat exchanger for same heat transfer rate. For this they kept all input parameter same for both heat exchanger. It was found that length of triple tube heat exchanger was less as compared with double pipe heat exchanger. The analysis can be used for determining the dimension size of triple tube heat exchanger. He also concluded that the double pipe heat exchanger provide better heat transfer efficiencies per unit length of heat exchanger as compared to double pipe heat exchanger.

Vishwa M. Bahera [4] carried a computational simulation of triple tube heat exchanger. He investigated heat transfer occurring between three fluids at different temperature. They assumed that outer tube is thermally isolated from surrounding. He considered hot water in middle space which cold water and normal water in inner and outer space. He obtained various graphs showing variation of temperature with various parameters such as length, Reynolds number etc. He changed the mass flow rate. But he found that heat transfer most likely or predominantly takes place between hot fluid and cold fluid because of the greater temperature difference between them.

Rajasekar k. [5] has carried design and analysis of triple tube heat exchanger with fins. He found that fins provide greater extent of heat transfer in the tubing. But the fin size should be optimum so that it can allow maximum heat transfer. It was found that at particular fin height the effectiveness and efficiency is maximum is 72%. Hence more compact design can be implemented to achieve desired effectiveness

Yogesh D. Banekar [6] studied the effect of dimpled tube in pipe in pipe heat exchanger. He compared the flows over plane tube as well as dimpled tube. He found that when the Reynolds number varied from 2900 to 6000 the Nusselt number with dimpled tube where greater than 30-40% than with plane tube. Also the convective heat transfer coefficient has slightly increased when we use dimpled tube. Also the effectiveness of heat exchanger with dimpled tube was 37% greater than effectiveness of heat exchanger with plane tube.

Vilas Apte [7] compared 4 types of dimpled tube with plane tube in his research work. He varied the inlet temperature as well as the mass flow rate of both hot and cold fluid. He related heat transfer to the geometry of the dimpled. He concluded that convective heat transfer coefficient is inversely proportional to depth of the dimple. Also the as the dimple diameter or depth decreases significant increase in Nusselt number is observed.

Shekhar S Babar [8] studied various type heat transfer enhancement process. Swirl generation is one of future scope method heat transfer enhancement. Both by active and passive method give good heat transfer rate as compared with other type methods. He conveyed that swirl generation effectively increases the heat transfer rate as well as reduces boundary layer generation which may result low pumping power.

III. EXPERIMENTAL SETUP

Experimental setup comprises of 3 tubes which are concentrically fitted into each other. First tube is of copper and of inner diameter 16mm, outer diameter 19mm and length 800mm.Second tube is of aluminium with inner diameter 32mm, outer diameter 38mm and length 750mm. Third tube is of mild steel with inner diameter 44mm, outer diameter 48mm and length 650mm. Also for the flow measurement we have used 3 rotameters in 3 tubes. Also 2 separate reservoir for hot water and cold water of 64 liter each. One pump is used for flow creation of hot water and one pump is used for flow creation of cold water. For heating water is geyser is used. Water first passes through pump and then through geyser where it get heated. Thermocouple sensor is fitted to each inlet and outlet of each tube for measuring temperature and is connected to the temperature indicator. Second tube used is of aluminium and comprises of 2 dimples over it. These two dimples are made by using hammering on the tube. More dimples will destroy the tube in our case so we have limited number of dimples to 2. At various position brass valves are provided to adjust the in the tubes whose measurement is done through rotameters. Also there is bypass to both pump provide with a valve so that low flow can be obtained by adjusting the bypass valve.

IV. EXPERIMENTAL PROCEDURE

During the testing of setup by keeping hot water flow rate constant and varying cold water flow rate various reading are taken. The flow rates are adjusted by using the rotameters. For hot water flow rate of 150 LPH, 200 LPH, 250LPH, 300 LPH readings are taken for cold water flow of 240LPH, 300LPH, 360LPH, 420LPH. After achieving steady state various temperature are recorded and according to the various procedures effectiveness is calculated. Also the flow in both tubes through which cold water is flowing are kept same.

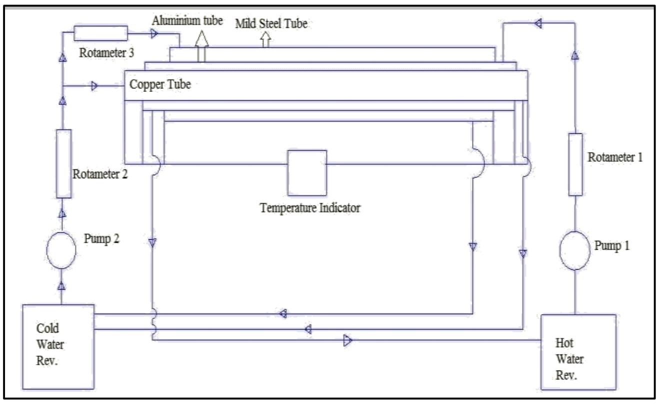

Fig. 1: Line diagram of setup

The main objective to find out effectiveness of triple tube heat exchanger. The analysis is done for properties of hot water. Below figure shows the experimental setup.

Fig. 2: Pictorial view of setup.

V. RESULTS AND DISCUSSIONS

The effectiveness for various flow rates of cold water are determined and are shown in figure 3 which shows variation of effectiveness with cold fluid flow for various hot water flow rates. The effectiveness goes on increasing as the cold water flow increases.

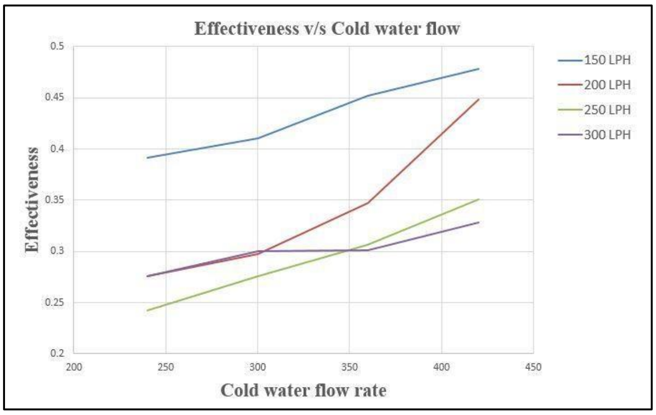

Fig. 3: Effectiveness Vs Cold Water Discharge

Figure 4 shows variation of Nusselt number with Reynolds number both of which are calculated for hot fluid flow. It shows that as the Reynolds number increases Nusselt number increases. This is because as flow rate increases heat transfer increases. That increases also the Reynolds number. It is very important consideration in the heat exchanger effectiveness determination and heat exchanger design and analysis.

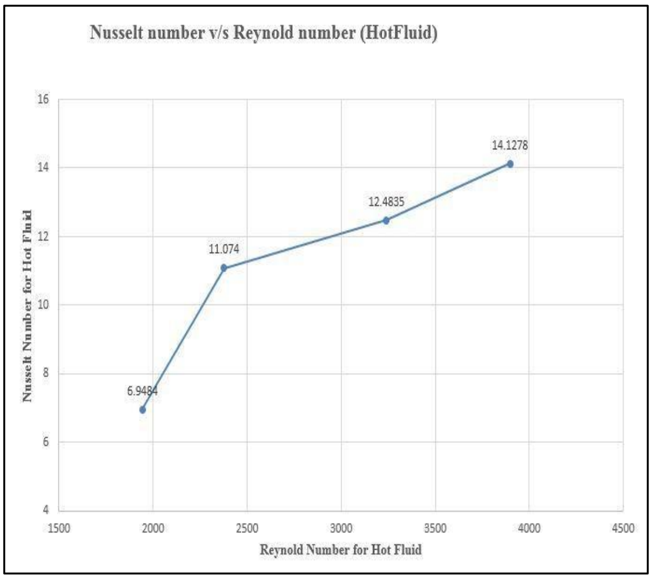

Fig. 4: Reynolds Number vs. Nusselt Number

VI. Conclusion

Thus triple tube heat exchanger provides good heat transfer area per unit length of heat exchanger. The effectiveness of the heat exchanger is greater than the double pipe heat exchanger. The another aspect is that for lesser flow rate of hot water and higher flow rate of cold water, there is higher value of effectiveness. This is mainly because the more cold water comes in contact with the hot water and the flow rate of hot water is low, so it remains in heat exchanger for more time. Also the triple tube heat exchanger is compact in design so it can be called as compact version of double tube heat exchanger.

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