Experimental Analysis of Triple Tube Heat Exchanger

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Abstract

In this research work, experimental setup has made for the study carried out for triple tube heat exchanger. Triple tube heat exchanger experiment performed for the N-H-N and C-H-C configuration for the study purpose. In N-H-N, normal temperature water passes from the inner tube and outer annulus and hot water from the inner annulus. In C-H-C, cold temperature water passes from the inner tube and outer annulus and hot water from the inner annulus. The decrease in hot water temperature in both the cases is given in this work.
Keywords: Heat Exchanger, Triple Tube Heat Exchanger, Double Tube Heat Exchanger, Tube in Tube Heat Exchanger

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ABBREVIATIONS AND ACRONYMS

- i: inlet
- o: outlet
- b: bulk men
- in: inside
- out: outside
- h: Hydraulic
- lm: Logarithmic Mean
- Cold fluid in the Inner tube
- Hot Fluid in intermediate tube
- Cold fluid in the Outer tube
- TTHE: Triple Tube Heat Exchanger
- DTHE: Double Tube Heat Exchanger
- LMTD: Logarithmic mean Temperature Difference

I. INTRODUCTION

Heat exchangers are one of the mostly used equipment in the process industries. Heat exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Double pipe heat exchanger design is rather straightforward. It uses one heat exchanger pipe inside another. After determining the required heat exchanger surface area, for either counter flow or parallel flow, the pipe sizes and number of bends for the double pipe heat exchanger can be selected.

A primary advantage of a hairpin or double pipe heat exchanger is that it can be operated in a true counter flow pattern, which is the most efficient flow pattern. That is, it will give the highest overall heat transfer coefficient for the double pipe heat exchanger design.

Also, hairpin and double pipe heat exchangers can handle high pressures and temperatures well. When they are operating in true counter flow, they can operate with a temperature cross, that is, where the cold side outlet temperature is higher than the hot side outlet temperature.

Triple concentric tube heat exchanger has major advantage of increase in heat transfer area and compactness (lesser length) over double tube heat exchanger. Which subsequently increases the heat transfer rate and efficiency of heat exchanger.This improvement is very welcoming as far as the energy conservation is concern.

Various studies and research work has already been done on the performance of double concentric tube heat exchanger but very less work has been done in the triple concentric tube heat exchanger despite of having advantages over double tube heat exchanger. So this overview will present the basic understanding and fundamentals of triple concentric tube heat exchanger. It will give the brief findings of researchers who have done work on this heat exchanger over the past few years. It consists design, mathematical models, experimental works, experimental analysis for different parameters, simulation etc.

Triple Concentric Tube Heat Exchanger can be used at each and every place the Double Tube Heat Exchanger is used. Mainly TCTHE can be used in dairy, food, beverage and pharmaceutical industries for pasteurization, sterilization, drying , evaporation, cooling, or freezing applications. It can also be used for decreasing the temperature of coolant for various machineries like CNC machine tools, CNC grinding etc.

II. Experimental Setup

Triple Concentric Tube Exchanger has three concentric tube in which heat exchanges between water at different temperature. Main components of the triple concentric tube heat exchanger are the following:

A. Heat Exchanger Tubes

There are three concentric tubes used for heat exchange in which inner tube and intermediate tubes are of copper material and outer tubes is of mild steel material. At inner and intermediate tubes surface, heat exchange occurs. Copper has high thermal conductivity (401W/m.K), so it is used as inner and intermediate tube. But copper is also quite costly, so outer tube where heat transfer is not desirable, we have used mild steel. Outer Tube is also insulated with rubber nitrile tape.

B. Storage Tank

TCTHE has six storage tanks of size 30cm*40cm*30cm which are used to store water at inlet and outlet of the heat exchanger.Three storage tanks are at the inlet of the heat exchanger and three storage tanks are at the outlet of the heat exchanger.It has storage capacity of 40 liters which is more than sufficient for performing the experiment.It has drainage valve at the bottom to clear out the water from it. The storage tank is insulated with rubber nitrile tape.

C. Insulation

The rubber nitrile tape insulation is used on the outer tube so as to minimize all the heat exchanges between outer tube fluid and the atmosphere during the transport of working fluid from the outer tube. This insulation is easily available from the market in the Air Conditioners and Refrigerators spare parts shop.

D. Thermocouple with DTI (Digital Temperature Indicator)

The temperature of the working fluid i.e. water is measured by the use of a thermocouple. The measured temperature is shown on the digital temperature indicator (DTI) which is called as RTPTD-100. Figure 3.4 shows the RTPTD-100 used to indicate the temperature of water in (ºC) in the storage tank. There are three thermocouples used at 1/3 length of the heat exchanger at each of the tube (inner, intermediate and outer) and other three at the 2/3 length of the heat exchanger for measuring the temperature of water along the length of heat exchanger.

III. Experimental Analysis

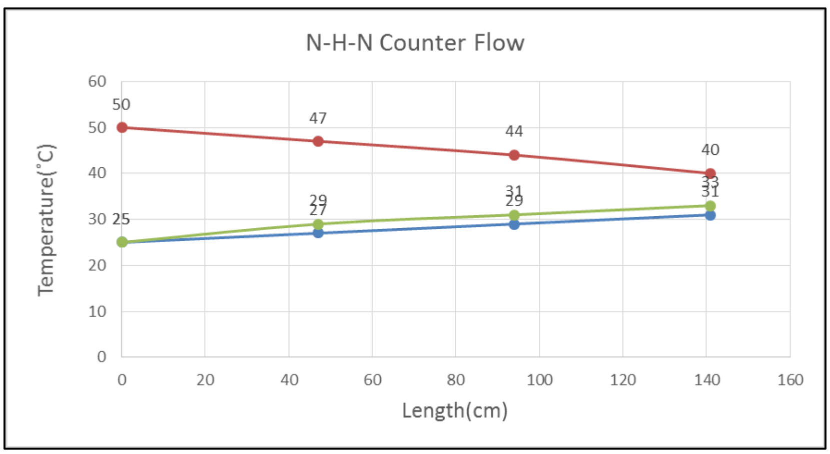

Fig. 2: Temperature variation in N-H-N Counter Flow in TTHE

Triple Tube Heat Exchanger has three flowing fluids which are inner tube, inner annulus and outer annulus.

In N-H-N, normal temperature water passes from the inner tube and outer annulus and hot water from the inner annulus. The normal temperature water temperature is 25 ˚C and hot water initial temperature is 50 ˚C. Hot water temperature reduces to 40 ˚C and more heat transfer in the outer surface of intermediate tube.

In C-H-C, cold temperature water passes from the inner tube and outer annulus and hot water from the inner annulus. The cold temperature water temperature is 15 ˚C and hot water initial temperature is 50 ˚C. Hot water temperature reduces to 35.5 ˚C and more heat transfer in the outer surface of intermediate tube.

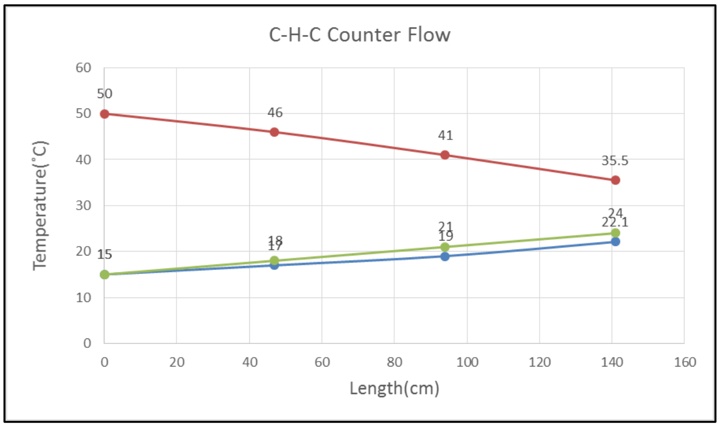

Fig. 3: Temperature variation in C-H-C Counter Flow in TTHE

IV. Conclusion

Triple Tube Heat Exchanger has better performance in C-H-C configuration and has better performance in counter flow than in the double tube heat exchanger in terms of heat transfer rate and effectiveness. More heat transferoccurs in the outer surface of intermediate tube.

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