DESIGN AND EXPERIMENTAL INVESTIGATION OF PERFORMANCE OF MODIFIED HEAT EXCHANGER

Ankita Balpande[1], S. S. Jaware[2]
[1,2]Mechanical Engineering, Shri. Shankarprasad Agnihotri College Of Engineering ,Wardha

1. ABSTRACT

A heat exchanger utilizes the fact that, with temperature difference, flow of energy occurs. So, That Heat will Flow from higher Temperature heat reservoir to the Lower Temperature heat Reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them. The heat exchanger is widely used equipment in industries. Energy and material saving considerations as well as environmental challenges in the industry have stimulated the demand for high efficiency heat exchanger.

Now there is need of such type of heat exchanger which increases the effectiveness with saving in cost. To improve the efficiency of heat exchanger one must think of heat transfer enhancement in heat exchanger. The purpose of this project is to determine the relative advantage of using a helically coiled regenerative method and mix flow heat exchanger. It is found that the heat transfer in helical circular tubes is higher due to their shape. Helical coils offer advantages due to their compactness and increased heat transfer coefficient.

This project tries to increase the effective surface area Contact with fluid to increases the heat transfer rate in the heat exchanger. This project works on new type of heat exchanger in which use of helical tube is preferred.

Keywords: heat transfer, helical coil, regenerative, mix flow, fluid

1.1 Introduction to Heat Exchanger

A heat exchanger is a device to transfer heat from a hot fluid to cold fluid across an impermeable wall. Fundamental of heat exchanger principle is to facilitate an efficient heat flow from hot fluid to cold fluid. This heat flow is a direct function of the temperature difference between the two fluids, the area where heat is transferred, and the conductive/convective properties of the fluid and the flow state .Heat exchanger is an important device in all the thermal systems. A heat exchanger utilizes the fact that, wherever there is a temperature difference, flow of energy occurs. The Heat will Flow from higher Temperature heat reservoir to the Lower Temperature heat Reservoir. The flowing fluids provide the necessary temperature difference and thus force the energy to flow between them. In heat exchangers, there are usually no external heat and work interactions. Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single or multi-component fluid streams. The heat exchanger is widely used equipment in different industries such as process, petroleum refining, chemicals and paper etc. Energy and material saving considerations as well as environmental challenges in the industry have stimulated the demand for high efficiency heat exchanger.

Now there is need of such type of heat exchanger which increases the effectiveness with saving in cost. To improve the efficiency of heat exchanger one must think of heat transfer enhancement in heat exchanger. The purpose of this project is to determine the relative advantage of using a helically coiled heat exchanger against a straight tube heat exchanger. It is found that the heat transfer in helical circular tubes is higher as compared to Straight tube due to their shape. Helical coils offer advantages over straight tubes due to their compactness and increased heat transfer coefficient.

Research Gap

Many researchers has perform experiments on various heat exchanges, They made changes in structure of heat exchanges to increase it's performance. They made changes in structures of heat exchanger to increase its performers they also performed experiment with fins on internal structure of heat exchanger. Also in previous heat exchanger parallel flow arrangement and counter flow arrangement was used one at a time but no researches have use combination of parallel and counter flow arrangement at a time in a double shell heat exchanger hence this work is taken in to consideration for this research

1.2 Objectives

- To investigate the performance characteristics of new type of heat exchanger.
- To Improve the Effectiveness of new type of heat exchanger through novel cost effective method.
- Comparison and modification of new type of heat exchanger and gives experimental data to the user.
- To determine the relative advantages by using helical coil, mixed flow and regenerative concept.
- To compare the relation between R_e and Q, Nu and Re.

1.3. Problem Statement

The straight tube heat exchanger is used mostly in industries such as condenser for chemical process and cooling fluid process. The straight tube heat exchanger consumes large space but offers less surface area of contact. Helical tubes on the other hand offer more surface area of contact in the same space due to its space. For this investigation, a new type of heat exchanger with helical tubes is constructed which wants to test the advantages of helical tube over straight tube in the context of heat transfer and effectiveness. To make this new type of heat exchanger with helical tubes become practicality, best design for the heat exchanger was chosen.

Calculations

A) Mass Flow Rate (ṁ)

$Q_h = \frac{1}{14} = 0.07$ lit/sec

$Q_c = \frac{1}{6} = 0.166$ lit/sec

$\dot{m}_h = \rho Q_h$

$\dot{m}_h = 1000 \times 0.07 \times 10^{-3}$

$\dot{m}_h = 0.07$ kg/sec

$\dot{m}_c = \rho Q_c$

$\dot{m}_c = 1000 \times 0.166 \times 10^{-3}$

$\dot{m}_c = 0.166$ kg/sec

B) Logarithmic Mean Temperature Difference (LMTD)

$$\mathrm{LMTD} = \frac{Q_1 - Q_2}{\ln(Q_1/Q_2)} = \frac{(72-44)-(58-35)}{\ln\left(\frac{72-44}{58-35}\right)}$$

$$\mathrm{LMTD} = 25.41$$

C) Reynold's Number (Re):

$$\mathrm{Re} = \frac{4\dot{m}_c}{\pi d u} = \frac{4\mathrm{x}0.07}{\pi \mathrm{x}10\mathrm{x}10^{-3}\mathrm{x}3.61\mathrm{x}10^{-4}}$$

Re= 24688.85

D) Nusselt Number (Nu):

$Nu = 0.023 \mathrm{x} (24688.85)^{0.8} \mathrm{x} (2.22)^{0.4}$

Nu=103.34

E) Heat Transfer Coefficient (h):

$$103.34 = \frac{h_i \mathrm{x}10\mathrm{x}10^{-2}}{\pi/4\, \mathrm{x}(10\mathrm{x}10^{-2})^2 \mathrm{x}6.53\mathrm{x}10^{-4}}$$

$h_i = 9004.08\ \mathrm{W/m^2\,K}$

For Outer

$$\mathrm{Re} = \frac{0.166\mathrm{x}10\mathrm{x}10^{-2}}{\pi/_4\,\mathrm{x}(10\mathrm{x}10^{-2})^2\mathrm{x}6.53\mathrm{x}10^{-4}}$$

Re = 3236.71

$$\frac{h_o\mathrm{x}10\mathrm{x}10^{-2}}{0.628} = 0.023\mathrm{x}(23397.97)^{0.8}\mathrm{x}(4.34)^{0.4}$$

H_o = 957.456

F) Overall Heat Transfer Coefficient (U):

$$U = \frac{1}{\left(\frac{6\mathrm{x}10^{-3}}{5\mathrm{x}10^{-3}}\right)\mathrm{x}\left(\frac{1}{9004.08}\right) + \ln\left(\frac{6\mathrm{x}10^{-3}}{5\mathrm{x}10^{-3}}\right)\mathrm{x}\left(\frac{6\mathrm{x}10^{-3}}{0.668}\right) + \left(\frac{1}{957.456}\right)}$$

U = 865.43 W/mK

$Q = \dot{m}hCp_h[(Th_i - Th_e) + (Th_i - Th_e)]$

Q = 0.07 x 4.187 [(72-58) + (72-53)]

Q = 9.6719 kW

Q = 9671.97 W

G) Length of Copper Tube (l):

$$Q = UA\theta m$$

$$9671.97 = 865.43\mathrm{x}\pi\mathrm{x}10\mathrm{x}10^{-3}\mathrm{xlx}25.41$$

$$l = 14.25m$$

$$l \approx 15m$$

CONCLUSION

Experimental investigations have been carried out on new type of helical tube heat exchanger on heat transfer enhancement. From the graphs plotted, the following conclusions are made.

- Heat transfer increases with increase in temperature difference it means that heat transfer is directly proportional to temperature difference
- From the second graph it is observed that there is an increase in Nusselt number with Reynolds number as Reynolds number increases the water flow will cause more turbulence due to which heat transfer rate will increase
- Rom the graph it is observed that as Reynolds number increases decrease in frictional factor is observed.

REFERENCES

1. N sahiti , F.Durst, A Dewan, International journal of heat and mass transfer 48(2005) 4738-4747,Heat Transfer Enhance By Pin Element
2. Mahesh kumar J.Patel, K.S.Parmar, U. R. Soni ,International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169,Improve the Performance of Heat Exchanger: Twisted Tape Insert With Metallic Wiry Sponge
3. Prabhat Gupta , M.D.Atray International journal of Cryogenics 40 (2000) 469-474,Performance evaluation of counter Flow heat exchangers considering the effect of heat in leak and longitudinalconduction for low-temperature applications
4. Dipayan Mondal, Md. OwalIkram, Md. Fazla Rabbi, Md. Nawsher Ali Moral International journal of Scientific & Engineering Research, Volume 5,Experimental Investigation and Comparison of Bend Tube Parallel & Counter Flow and Cross Flow Water to Air Heat Exchanger.
5. J. Kragh , J. Rose, T.R. Nielsen, S. Svendsen, international journal of Energy and Buildings 39 (2007) 1151–1158, New counter flow heat exchanger designed for ventilation systems in cold climate.
6. Shewal eOmkar , Mane Pravin, Gazge Sajid Hameed, Pasanna Pradeep, International journal of Research in Engineering and Technology eISSN: 2319-1163,Experimental Investigation Of Double-Pipe Heat Exchanger With Helical Fins On The Inner Rotating Tube.
7. Patankar S. V. and Prakash C. 1981 An Analysis of Plate Thickness on Laminar

Flow and Heat transfer in Interrupted Plate passages. International Journal of Heat and Mass Transfer 24:1801-1810.

8. Joshi H. M. and Webb R. L. 1987. Heat Transfer and Friction in Offset Strip Fin Heat Exchanger, International Journal of Heat and Mass Transfer. 30(1): 69-80
9. Suzuki, K., Hiral, E., Miyake, T., Numerical and Experimental studies on a two Dimensional Model of an Offset-Strip-Fin type Compact Heat Exchanger used at low Reynolds Number.International Journal of Heat and Mass Transfer 1985 28(4) 823-836.
10. Tinaut F. V., Melgar A. and Rehman Ali A. A. 1992 Correlations for Heat Transfer and Flow Friction Characteristics of Compact Plate Type Heat Exchangers. International Journal of Heat and Mass Transfer. 35(7):1659:1665
11. Michna J. G., Jacobi A. M. and Burton L. R. 2005. Air Side Thermal- Hydraulic Performance of an Offset Strip Fin Array at Reynolds Number up to 12, 0000.Fifth International Conference on Enhanced Compact and Ultra Compact Heat Exchangers. Science, Engineering and Technology 8-14.
12. DawitBogale,, international journal ofAmerican Journal of Engineering Research e-ISSN : 2320-0847, Design and Development of Shell and Tube Heat Exchanger for Harar Brewery Company Pasteurizer Application (Mechanical and Thermal Design)