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Heat Transfer Augmentation in Tube in Tube Type Heat Exchanger Using Spring Coil Insert

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Abstract- The present research is on performance of tube in tube type heat exchanger using different types of wire coil (spring) insert of different diameter and pitch. These parameters of spring affecting the heat transfer rate which can be determined by using Regression equation. In heat exchanger heat is transfer in the form of latent heat or sensible heat. There are four spring having length 1500 mm and diameter 8mm in which two spring, wire diameter is 0.5 mm and pitch are 10 mm and 20 mm other two spring has wire diameter is 1mm and pitch are 10 mm and 20 mm. In this research heat transfer rate can be improved through augmentation technique using wire coil (spring) insert for both parallel and counter flow. For increasing heat transfer rate use passive method in this method do not required external power source for flowing fluid. The result show that overall heat transfer rate is increases when using spring in tube in tube type heat exchanger compared with no spring result.

Keyword- Heat Exchanger1, Counter Flow2, Parallel Flow3

1. INTRODUCTION

Energy is basic needs of any country, they may be thermal or nuclear energy. Availability of that energy indicate the power and development of that country in world, like as USA & china both are super power country in all world. In India also many power plant was installed like chandrapur power plant. In that power plant heat exchanger is used. Heat exchanger is a process equipment designed for the effective transfer of heat energy between two fluid may be hot or cold fluid. Heat exchanger is used in power plant automobile radiator, evaporator of an ice plant, water & air heater & cold fluid, chemical industries. In heat exchanger heat is transfer in the form of latent heat ex. boiler and condenser or sensible heat ex. heater & coolers. In this research heat transfer rate of tube in tube in tube type heat exchanger, can be improved through augmentation technique using wire coil (spring) insert

2. BASIC THEORY

In heat exchanger heat is transferred between two fluids at different temperature. [1]. The classification of heat exchanger are as follows.

1) Nature of heat exchange process:

A) Direct transfer:- It is also called as recuperative type heat exchanger in which cold and hot fluids flow simultaneously through device and heat is transferred through wall separating the fluids

B) Regenerator:- it is also called as storage type heat exchanger in which heat transfer from hot fluid to cold Fluid occurs through coupling medium in the form of porous solid matrix

C) Direct contact or Heat exchanger:- The name of heat exchanger indicate its own definition means complete physical mixing eg. Jet condenser and water cooling tower in steam power plant.

2) Direct transfer type heat exchanger:- this classification is based on the geometry of their construction. The classification of direct transfer type heat exchanger are as follows.

A) Tubular heat exchanger:- It is generally built out of circular tubes. In which one fluid is flowing into the inside tube and other on the outside. The tubular heat exchanger can be further classified as follows.

a) Concentric tube or double pipe

b) Shell and tube

B) Plate heat exchanger :- It consist of series number of rectangular thin metal plate which are clamped together to form narrow parallel plate channels in which hot fluid flows through one set of alternate channels in one direction while the cold fluid flows through the other set in opposite direction.

C) External surface heat exchanger:- Extended surface means fins, fins attached on the primary heat exchanger surface with the object increasing the heat exchanger area. The fins are classified in to two type in which first one is plate fin and another is tube fin.

3. Classification according to flow arrangement:- This are three basic flow arrangement

i) Parallel flow:- In parallel flow heat exchanger the two fluid enter one end of heat exchanger and flow through in the same direction and leave at one end.

ii) Counter flow:- In counter flow heat exchanger the two fluid enters into two different ends of heat exchanger and flow in opposite direction.

iii) Cross flow:- In cross flow heat exchanger one fluid moves through the heat exchanger at right angles the flow path of the other fluid.

This research paper is on parallel flow and counter flow heat exchanger actually it is one heat exchanger but due to different valve arrangement it is used as both counter flow as well as parallel flow heat exchanger.

3. AUGMENTATION TECHNIQUE

In tube in tube type heat exchanger for increase the rate of heat transfer use augmentation technique. It can be classified as follows

Passive technique, Active technique and Compound technique

1) Passive technique: - In passive technique use some geometrical modification to the flow channel using extra devices. this technique can be achieved by using treated surface ,rough surface, extended surface, displaced enhancement devices, swirl flow devices, coiled tubes, surface tension devices, additives for liquids.

In this experiment use passive technique we used wire coil (spring) insert used in to the copper tube this additional wire coil promote higher heat transfer by disturbing actual flow. The passive technique does not require external power for circulating fluid

S.S. Joshi [2] The wire coil (spring) of different diameter and thickness causes more turbulence hence heat transfer is more and improvement in effectiveness of heat exchanger he concluded that diameter of wire coil decreases than heat transfer is also decreases.

2) Active technique:- The active technique are complicated for use. It required some external input power for circulating fluid. There are different types of active techniques it include mechanical aids, surface vibration fluid vibration, electrostatic fields, injection, suction, jet impingement

Compound technique:- The name indicate its own definition means in this technique use more than one technique that combination of both active and passive technique for increasing rate of heat transfer

4. EXPERIMENTATION

Assembled a tube in tube type heat exchanger in which inner tube is made up of copper and outer tube is made up of mild steel. The inner diameter of copper tube is 10mm and thickness is 1mm. The inner diameter of mild steels tube is 30mm and thickness is 2mm. shown in figure1.The length of test section is 1500mm. There are four valve, the arrangement of that valve in such a way that it use in both way, that is counter flow as well as parallel flow through one heat exchanger. The hot water is always fowl through the copper tube and cold water is flow through the mild steel tube in both flows that is counter flow as well as parallel flow heat exchanger. There are four wire coil (spring) each of length 1500mm and diameter of spring is 8mm. In which first spring has wire diameter 0.5mm. And pitch of spring is 10 mm. Second spring wire diameter is 0.5 mm and pitch of spring is 20 mm. Third spring diameter of wire is 1mm and pitch of spring is 10 mm. and fourth spring diameter of wire is 1mm and pitch is 20 mm. All four spring inserted one by one in copper tube in both counter and parallel flow heat exchanger. The hot water inlet temperature is , , 60 and cold water inlet temperature is and 40 the rate of flow of water is 120 LPH (liter per hour) in this way for one spring there are nine reading for counter flow and parallel flow means for one spring eighteen reading. Total four spring then reading is seventy-two. In counter flow nine reading for no spring that is without spring similarly for parallel flow also nine reading therefore total counter flow reading is forty-five and parallel flow is also forty-five hence total ninety reading is obtained.

5. STATISTICAL MODELING

Regression is the best method for the mathematical modeling of experimental data [3-17].The important controlling process parameters in heat exchanger include inlet temperature and outlet temperature. In this study, LMTD has been chosen as the main process response characteristics to investigate the influence of the above parameters. We first develop a mathematical model to relate the process control parameters to the process response characteristics. The empirical model for the prediction of LMTD in terms of the controlling parameters will be established by means of piecewise linear regression analysis. To generate the model the experimental data was used.

The general form of a regression mathematical model is as follows:

For counter flow

Y=a*x1+b*x2+c*x3+d*x4+e……………1

Where, Y- Temperature of cold water out let (Hout)

X1-Diameter of wire coil

X2-Pitch of spring

X3-Temperature of hot water inlet

X4-Temperatureof cold water inlet

From above equation regression output that is $R^2 = 0.9273$ for hot water outlet and cold water outlet is $R^2 = 0.9529$ it for counter flow similarly for parallel flow Hot water outlet is $R^2 = 0.8769$ and could water outlet is $R^2 = 0.9911$

Different regression functions (linear, curvilinear, logarithmic, etc.) are fitted to the above data and the coefficients values (a_i) are calculated using regression analysis. The summary of various functions used for mathematical model is shown in table 4.The best model is the most fitted function to the experimental data. Such a model can accurately represent the actual process. Therefore, in this research, the adequacies of various functions have been valuated using analysis of variance (ANOVA) technique.

The model adequacy checking includes test for significance of the regression model and test for significance on model coefficients. ANOVA results recommend that the quadratic model is statistically the best fit in this case. Statistical analysis show that the associated P-value for the model is lower than 0.05; i.e. $\alpha=0.05$, or 95% confidence. This illustrates that the model is statistically significant. This means that regression model provides an excellent explanation of the relationship between the independent variables and response parameter (Undercut).The predicted undercut versus a actual value is shown in figure 2

6. CONCLUSION

From the experimental investigations based on full factorial method and the analysis of the results, the following conclusions are drawn.

- It is observed from the Analysis of variance technique (ANOVA), the input variables time and temperature both have statistically significant effects on the LMTD.
- The above discussion confirmed the validity of the full factorial methodology for enhancing the heat exchanger performance and optimizing the input parameters.

Statistical regression analysis has been employed to develop mathematical models relating such process parameters as inlet and outlet temperature, diameter and pitch to the LMTD. A set of experimental data, based on full factorial method, has been used for model development. Various functions were fitted on the data among which the second order model was found to be the best one to represent relationship between input process parameters and LMTD. The adequacy of the proposed model was then investigated using ANOVA technique

Fig.1 Tube in tube type heat exchanger

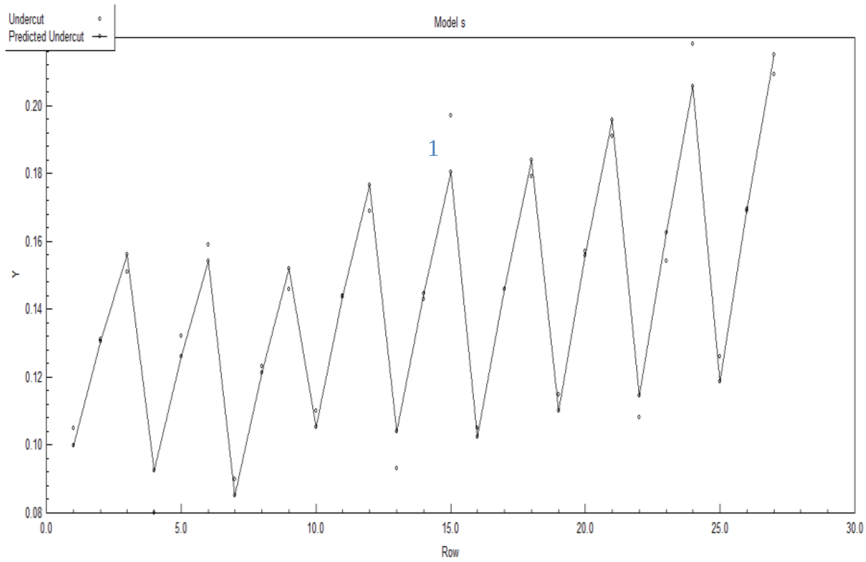

Fig.2 Predicted undercut versus actual values

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