An Effect of Spiral Coil on Heat Transfer in a Double Pipe Heat Exchanger

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Abstract: *Nowadays heat exchanger is the most effective mean to interchange thermal energy of one fluid to other. This is done by using miscellaneous techniques which improves heat transfer rate includes active, passive and compound augmentation techniques. In most of the mechanical process industries, heat exchanger is the principal device used for heat transfer phenomenon. The present article is about the review on research work has been done on various augmentation technique used to enhance the heat transfer rate in last decade. This paper contains literature estimation of heat transfer enhancement using spiral inserts. The present study deals with the passive augmentation techniques used in a double pipe heat exchanger using spiral coil. The mass flow rate is 0.0167 Kg/s. The inlet temperature of hot water has varied from 45 °C to 70 °C. Overall heat transfer coefficient has compared in this study for both counter flow as well as parallel flow. Overall heat transfer coefficient is enhanced up to 39.18 % at mass flow rates mh = 0.0167 Kg/s and mc = 0.0167 Kg/s at hot water inlet of 70 °C and cold water inlet of 30 °C. Experimentally, Overall heat transfer enhancement has been studied and also, the experimental results have been validated with CFD simulation (ANSYS Software).*

Keywords: *Spiral coil, passive augmentation technique, double pipe heat exchanger, heat transfer coefficient.*

1. Introduction

Heat exchanger is a device used to exchange the heat from one fluid (hot fluid) to another fluid (cold fluid) with or without direct contact at different temperature. This exchange of heat takes place either to remove the heat from a fluid or to add heat to a fluid. For example, the heat exchanger used to remove the heat from the fluid is known as condenser or the heat exchanger used to add the heat to a fluid is known as boiler. Heat exchangers are broadly used in the refrigeration and air conditioning, petrochemical plants, sewage treatment, refineries, pharmaceuticals, food beverage and dairy industries, automobile radiators. According to application heat exchangers are classified on the basis of design features, nature of heat exchange process, relative direction of fluid motion and physical state of fluids.

1.1. Sorting of Augmentation Techniques

In general, Augmentation Techniques are categorized into three different techniques:

1. Active
2. Passive
3. Compound

Active Technique: The technique used to enhance the heat transfer rate by applying external power input is known as active augmentation technique.

Passive Technique: This method is used to create turbulence in the path of fluid flow by using inserts in tube. This turbulence in fluid flow increases the heat transfer rate from one fluid to other.

Compound Technique: In this case, combination of two methods is used to raise the heat transfer rate. The result obtained is greater than using any one technique individually.

2. Literature Review

Some experimental investigation has been done on double pipe heat exchanger using spiral coil for the enhancement of the heat transfer. Most of the industrial researchers as well as academic researchers contributed in this field, the review of the research work carried out in this area are as follows:

E.I. Jassim [1], did the experimental study on transient natural convection heat transfer from spiral coil in a spiral coil heat exchanger. He had compare the efficiency of spiral coil heat exchanger in horizontal as well as in vertical position of spiral coil in which he found that spiral coil in vertical position had shown more effectual than horizontal position in terms of transferring heat. He also found that by increasing number of loops of spiral coil per unit length could improve the heat transfer rate.

Jay J. Bhavsar , V K. Matawala , S. Dixit [2] , they did the experimental analysis on spiral tube heat exchanger over the shell and tube heat exchanger. They concluded that with the use of spiral tube by varying mass flow rate of working fluid, the temperature of hot fluid decreases at the exit with increasing in mass flow rate of cold fluid. For the performance of the experiment they used hot oil and cold water as a working fluid. A coil is fabricated by bending the 12mm diameter copper tube into spiral coil of four turns. The investigation had done on the mass flow rate of working fluid i.e cold water and hot oil which ranges in the middle of 0.075 and 0.25 kg/s, and between 0.008 and 0.04 kg/s. The temperature of cold water and hot oil at the inlet had between 29 and 37^{o}C and between 70 and 56^{o}C.

Kartik M. Vyas, Rajdip J. Gohil, Neel S. Patel, Prof. Mitesh B. Lalwani [3] , gives the thermal analysis of tube in tube liquid spiral heat exchanger over shell and tube heat exchanger. A two copper pipes had used in the fabrication of the experimental set up in which ½” copper pipe used as a inner tube and 1” copper pipe used as outer tube , both the coil had shaped into spiral form to fabricate the set up of tube in tube heat exchanger. They used water as a working fluid. During the experimental analysis, the result obtained had the effectiveness of 33.80% in case of parallel flow and 40% in counter flow. By using tube in tube heat exchanger, more turbulence had offered to flow and better effectiveness can be obtained.

N.C kanojiya , V.M Kriplani , P.V Walke [4] , they did the review on heat transfer enhancement in heat exchangers with inserts ,they concluded that if the swirl flow is generated by passive method using perforated twisted tape inserts and nanofluid, the heat transfer rate as well as heat transfer coefficient and friction factor increases while decrease in pressure drop takes place . It was shown that used of inserts in heat exchanger was beneficial for the heat transfer enhancement.

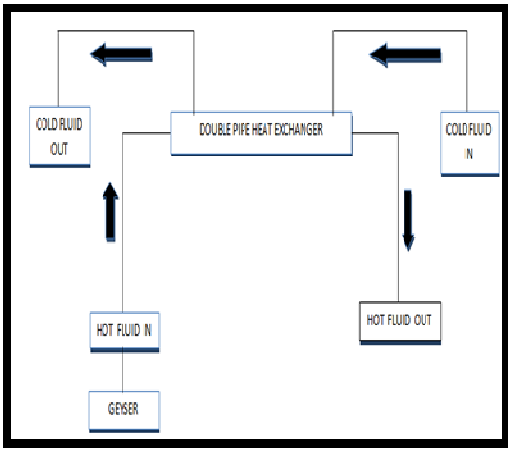
Nikhil Lokhande, Dr. S. R. Nikam, Dr. K.N. Patil [5] , had comparatively analysis the spiral heat exchanger and gasketed plate type heat exchanger using stainless steel as a material for plate making of plate heat exchanger with thermal conductivity 16.2 W/mK . This investigation concluded that the performance of gasketed plate heat exchanger was better than spiral plate heat exchanger, by using gasketed plate heat exchanger the overall heat transfer coefficient increased by 86.8% over spiral plate heat exchanger. The experimental investigation of plate heat exchanger had done on two different plate

chevron angles , 65^O and 30^O in which it was found that the overall heat transfer coefficient increased by 26% in case of 65^O chevron angle as compared to 30^O.

Ruchal G. Humbare, Suraj R. Gurav, S. B. Trimbake [6] , had gone through the comparative study between helical coil heat exchanger and straight tube heat exchanger for parallel flow and counter flow. The overall heat transfer coefficient increases with flow rate in case of helical coil heat exchanger and 10 to 20% more than that of straight tube heat exchanger. Effect of curvature ratio and pitch of helical coil had shown as the curvature ratio increases, the heat transfer coefficient also increases while the pitch increases the overall heat transfer coefficient decreases.

3. Experimental Set-up

The purpose of present study is to examine experimentally the performance of double pipe heat exchanger in parallel and counter flow using spiral coil.



Schematic View of Experimental Set-up

Photographic View Of experimental set-up

3.1. Specifications

Table1: Specification of Experimental Set-up

Sr No.	Elements	Dimension
1	Outer Plain Tube	OD=50.8 mm , ID= 48.8 mm, L=700 mm
2	Inner Plain Tube	OD=25.4 mm, ID=23.4 mm , L=800 mm
3	Inner Spiral Coil	L= 4, No. of loops=20
4	Pitch	35 mm
5	Material	Copper
6	Thermal conductivity	385 W/mk

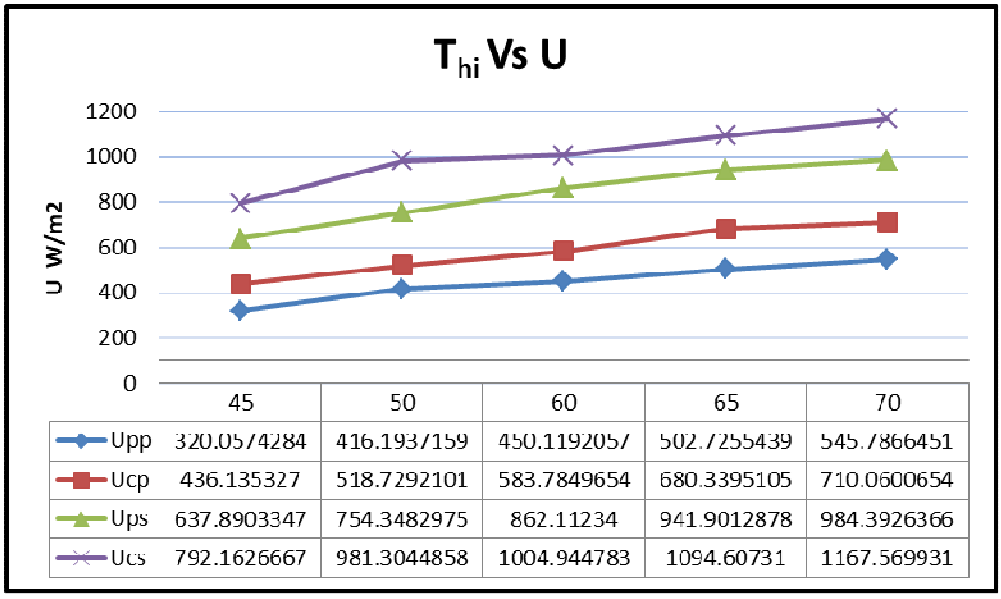
3.2. Experimental Procedure

- Experiments have been studied by varying input parameters like mass flow rate of cold water as well as hot water and input temperature of hot water.
- The mass flow rates used in experimentation is 0.0167 kg/sec for both cold and hot water.
- The inlet temperatures of hot water have been varied from 45°C to 70 °C i.e. 45°C, 50ºC, 60°C, 65°C, and 70 °C.

- These input temperatures were achieved by controlling power input given to the water geyser. This power is controlled by dimmerstat. Input temperature of 50°C.
- Cold water is kept 27°C and 30 °C throughout the experimentation which have been taken directly from tap.
- Results are taken at steady state condition. Above experimental procedure are repeated for with spiral coil and without spiral coil for counter flow as well as parallel flow heat exchanger.

4. Results and Discussions

Variation of overall heat transfer coefficient under influence of plain tube and spiral coil at various hot water inlet temperature:



	45	50	60	65	70
Upp	320.0574284	416.193159	450.119205	502.7255439	545.7866451
Ucp	436.135327	518.7292101	583.7849654	680.3395105	710.0600654
Ups	637.8903347	754.3482975	862.11234	941.9012878	984.3926366
Ucs	792.1626667	981.3044858	1004.944783	1094.60731	1167.569931

Figure 1: Variation of Variation of overall heat transfer coefficient under influence of various hot water inlet temperatures.

Above figure shows variation of overall heat transfer coefficient for different hot water inlet temperature varied from 45°C and 70°C and mass flow rates for hot water and cold water are 0.0167 kg/s with cold water inlet temperature of 30°C.

It has been observed that the increase in hot water inlet temperature , the overall heat transfer coefficient also increase when mass flow rates of hot water and cold water remain same. Hence, the enhancement of overall heat transfer coefficient is 39.18%.

5. Conclusion and Future Scope

5.1. Conclusion:

The motive of experimentation is to examine the performance of double pipe heat exchanger in parallel flow and counter flow with or without spiral coil at different hot water inlet temperature and cold water inlet temperature kept at 30°C with mass flow rate for hot and cold water are 0.0167 kg/s. As per the result obtained from experiment, it can be concluded as:

- Overall heat transfer coefficient is enhanced up to 39.18% at hot water inlet temperature 70°C and m_c=0.0167 kg/s, m_h=0.0167 kg/s and cold water inlet temperature 30°C.
- The performance of double pipe heat exchanger is improved by using spiral coil as compared to without coil in parallel and counter flow.

5.2. Future Scope:

The present study needs to be extended further as suggested below.

- The similar experimental data should be generated for different fluids and materials.
- Mathematical models should be developed for heat transfer characteristics and must be compared with the experimental data generated. This mathematical model will be helpful in selecting optimum dimensions for design purpose.
- The experimental set-up can also develop for spiral coil with fins to predict the overall heat transfer coefficient.
- The spiral coil of different shapes such as square, triangular can be used to predict the overall heat transfer coefficient.

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