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Experimental Study of Heat Transfer Enhancement of Pipe-in-Pipe Helical Coil Heat Exchanger

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Abstract : *Heat transfer enhancement in pipe in pipe helical coils has been research by many researchers. While the many literatures available on heat transfer characteristics of helical coil heat exchangers. There is very few published on validate experimental results through Computational Fluid Dynamics. This paper focuses on experimental investigation of fluid-to-fluid heat transfer enhancement of pipe-in-pipe helical coil tubes. The methodology of experimental analysis of a helical tubes heat exchanger, the effect of the inside tubes at constant value of mass flow rate in Dean Number and also established the surface heat transfer coefficient. Heat transfer characteristics inside pipe-in-pipe helical coils for various boundary conditions, that the specification of a constant temperature at hot water inlet, constant mass flow rate. Hence, the pipe-in-pipe heat exchanger is considering different mass flow rate inside and annulus. The fabrication of experimental setup is estimate the heat transfer enhancement in inside helical coil tubes.*
Keywords: *Dean Number, Heat Transfer, Helically Pipe, Nusselt Number, Overall Heat Transfer Coefficient.*

I. Introduction

There are many literature reported on heat transfer enhancement in helical coils tube are high heat transfer rate as compare to straight tubes heat exchanger, because of compactness and higher heat transfer coefficient. Pipe-in-pipe helical coil Tubes are typically used in industrial process such as food processing, power generation, refrigeration, nuclear, chemical and process industries.

Helical coils are very alluring for many processes in heat exchanger and reactors because of it accommodate higher heat transfer rate in small space. The fluid motion in curved pipe was observed by Eustice in 1911.Since then numerous studies have been reported on the flow fields that arise in curved pipes (Dean 1927, 1928; White, 1929; Hawthorne,1951; Horlock,1956; Barua,1962; Austin and Seader,1973) including helical coils, which is a subset of curved pipes. Jayakumar et. al.[1] was investigated in helical coil tubes at various process parameters. Mohamed A. Abd Raboh et al.[2] carried out an experimental study for condensation heat transfer inside helical coil. Pablo Coronel et. al.[3] have been reported the helical heat exchanger is higher than that in straight tubular heat exchanger. Rahul Kharat et. al. [4] analyzed the heat transfer coefficient correlation for concentric helical coil heat exchanger. Ashok Reddy et. al.[5] studies the effect of dean number on heat transfer coefficient in an agitated vessel. Timoty et. al. [6] studies on experimental studies of double pipe heat exchanger.

Basically a study on helical coil tubes has been carried out on heat transfer characteristics of fluid-to-fluid flowing in pipe-in-pipe helical coil heat exchanger. In helical coil have lot of variation in coil configurations such as pitch circle diameter, coil diameter and pitch variations, curvature ratio so on. The objective of this work is to effect of dean number and surface heat transfer coefficient at different flow parameters at different temperature. The experimental result is validating through Computational Fluid Dynamics.

II. Experimental Specification Details

The geometry of the pipe-in-pipe helical coil of experimental studies is done having the two different inner coil configuration as following specification; inner pipe Specimen-1 = 6 mm and Specimen-2 = 8 mm, outer pipe ID = 16 mm, Pipe Thickness is 1 mm, Material of construction = Cu, Heat transfer length = 2 m, Pitch circle diameter = 170 mm, Insulation surface = 4 mm working fluid = water.

Measurements are taken only after the temperature attains study state. Experiments are conducted for four different mass flow rates such as 0.028 kg/s, 0.056 kg/s, 0.084 kg/s and 0.112 kg/s at constant hot water inlet temperatures in inner pipe. During the experiment, the flow rates of through the inner side are to be constant. The experiments are carried out by changing the flow rate in annulus. Once the steady state is achieved, temperature at inlet and outlet of the hot and cold fluid, and the power input to the pump and heater are noted.

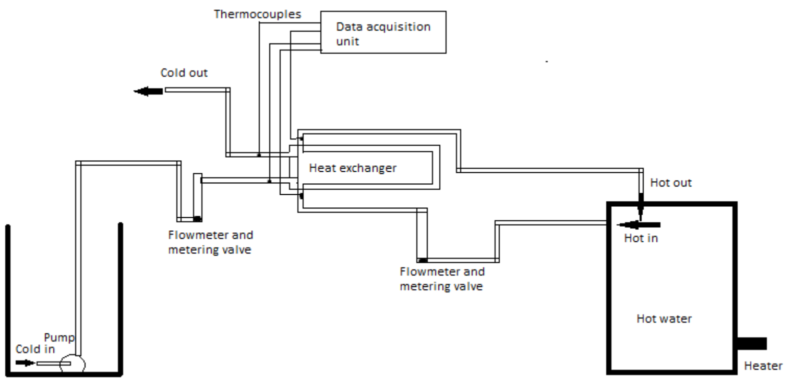

Figure – 1 Schematic diagram of experimental setup

III. Experimental Procedure

Flow rates in the inner and in the annulus pipe are varied. The following four levels were used: 0.028, 0.056, 0.084 and 0.112 kg/s. All possible amalgam of these flow rates in both the inner and annulus coils has tested. These were done for both flow conditions likes parallel and counter flow. Furthermore, four replicates were done for every amalgam of coil configurations and flow rates. This results in a total of 300 trials. Temperature data was recorded every 300 seconds. The data used in the calculations was from after the system had stabilized. After stabilized the temperature the outlet temperature of hot water and cold water is recorded and also recorded the outlet mass flow rate of inner and annulus coils.

IV. Results And Discussion

1.1. Overall heat transfer coefficients (OHTC)- In Figure 2, figure 3, figure 4 and figure 5 are presented Overall heat transfer coefficients for parallel and counter flow for the two different coils. The overall heat transfer coefficient is drawing the graph against the inner Dean number for all flow rates of the annulus. A fluid-to-fluid helically coils heat exchanger with overall heat transfer coefficient increases in inner as well as annulus flow rates. Figure shows that in the annulus and inner flow rate, increasing the overall heat transfer coefficient of the helically coils.

The results come from the experiments to shows that the value of counter-flow configuration has similar to the parallel flow configuration, as is expected, if changing the flow configuration should have negligible effect on the overall heat transfer coefficients. Due to the increased LMTD, heat transfer rates, are much higher in the counter-flow configuration.

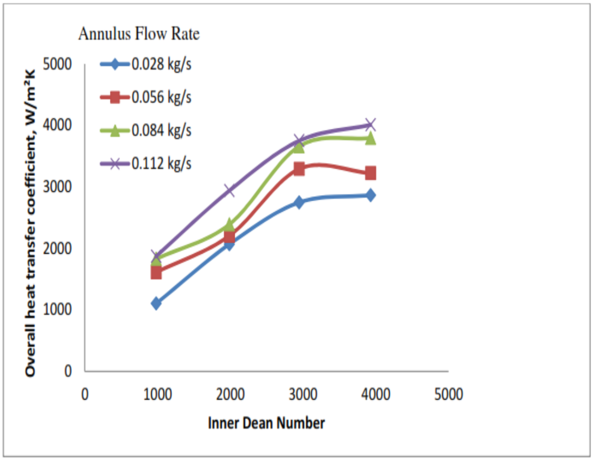

Figure: 2 OHTC versus inner Dean No. for the large (8 mm) coil of each annulus mass flow rate in parallel flow.

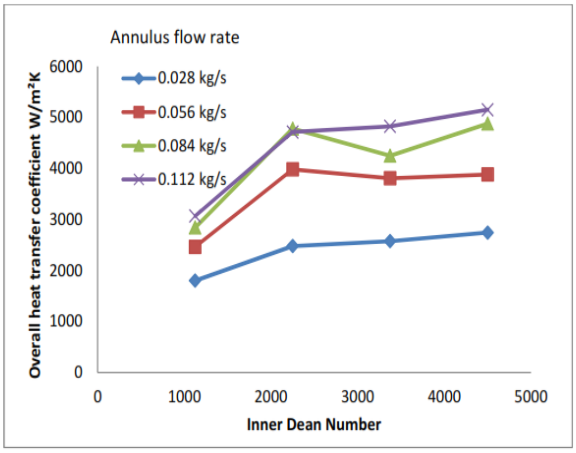

Figure: 3 OHTS versus the inner Dean number for the small (6 mm) coil for each annulus mass flow rate in parallel flow

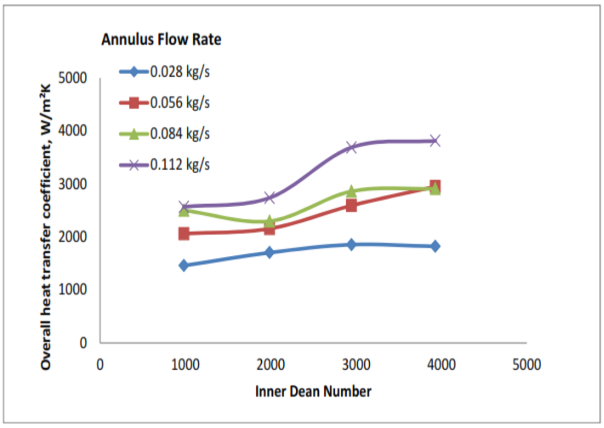

Figure : 4 OHTC versus the inner Dean number for the large (8 mm) coils for each annulus mass flow rate in Counter flow

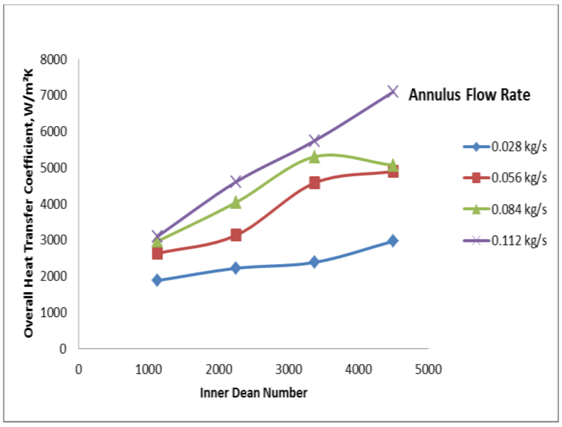

Figure: 5 OHTC versus the inner Dean number for the small (6 mm) coils for each annulus mass flow rate in counter flow.

From figure-6, has to be plotted graph between counter flow verses the parallel flow overall heat transfer coefficients, where the values plotted against each other are from the same experimental parameters. There is a reasonable agreement between the two values.

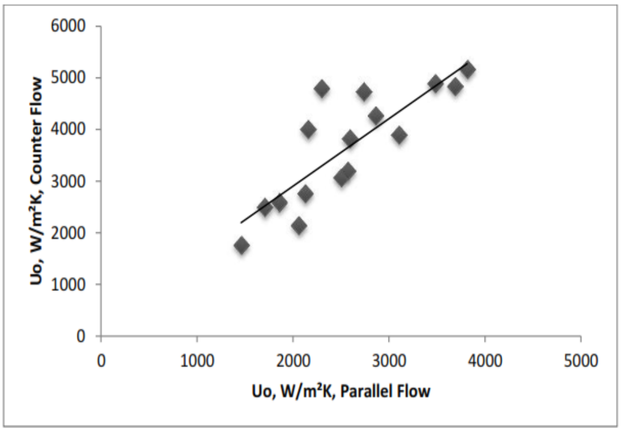

Figure: 6 Counter flow OHTC versus parallel flow OHTC for all trails.

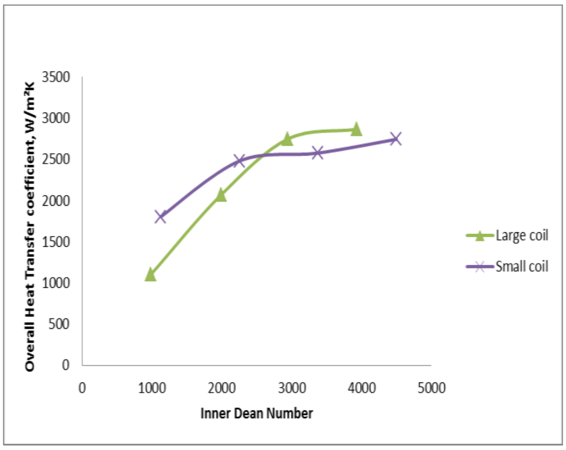

Figure: 7 OHTC versus inner Dean Number when mass flow rates are taken identical.

1.2. Inner Nusselt Number-

Inner Nusselt Number From figure 8 and figure 9 shows that the inner Nusselt numbers are presented. The graph shows that the values of Inner Nusselt Number at each and every Dean Number under parallel and counter flow direction. An experimental result has to be comparing to the Manlapaz-Churchill correlation (1981). From below figure shows that the experimental value in parallel flow is similarly to Manlapaz-Churchill correlation and in counter flow for both coil configurations is much higher.

V. Conclusion

An experimental works of pipe-in-pipe helical coil heat exchanger was performed under two different sized specimens. The mass flow rates in the inner tubes and the annulus were both varied at two different flow conditions were tested. Overall heat transfer coefficients are slightly difference between parallel flows and counter flow configuration. However, the heat transfer rate in counter flow direction is much higher due to large average temperature. Comparing to small coil configuration is in overall heat transfer coefficient is slightly high from large coil configuration. The inner nusselt number in both coil configurations is to be in the counter flow direction is higher as compared to the parallel flow and Manlapaz-Churchill Correlation (1981). Further work needs to be done to modifying this effect. There are so many parameters like pressure variation, density, coil configuration, etc. are to be analyzing in pipe-in-pipe helical coil heat exchanger for better efficient and work in refrigeration system and heat transfer equipment's.

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