Experimental Analysis and Performance Characteristics of Shell and Helical Coil Heat Exchanger with Pin Fin Attachment

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*Abstract:***In this present study the convective heat transfer coefficient of a shell and helical coil heat exchanger is investigated experimentally with pin fin arrangement. Shell and helical coil heat exchanger are beneficial due to their high heat transfer coefficient and firmness compared to straight tubes. The increased heat transfer coefficient is a significance of the curvature of the coil, which induces the centrifugal forces to act on the moving fluid. The centrifugal action is governed by the curvature of the coil. The centrifugal force results in development of secondary flow. This study focuses on the thermal analysis of various parameters that affects the effectiveness, heat transfer coefficient and heat transfer enhancement due to pin fin arrangement. Results were taken for different mass flow rate of the cold fluid by keeping mass for rate of hot fluid constant. Results were taken for the mass flow rates of cold fluid ranging from 0.05 kg/s to 0.2 kg/s. heat transfer coefficient, effectiveness, Nusselt number, Reynolds number, Pressure drop and friction factor were analyzed.**

Keywords: Shell and helical coil heat exchanger, Pin fin arrangement

I. INTRODUCTION

Heat exchangers are used in various industrial applications, which are installed to permit the transfer of thermal energy between two (or more) fluids at different temperatures without having direct contact. Helical coil heat exchangers are a compact shell and tube apparatus, consisting of several layers of coiled tubes within a closed shell. Tube bundle of helical coil heat exchanger consist of a number of tubes wound helically around a central supporting tube and placed in a cylindrical shell. Several studies have indicated that helically coiled tubes are superior to straight tubes when employed in heat transfer applications. The centrifugal force due to the curvature of the tube results in the secondary flow development which enhances the heat transfer rate.

This phenomenon can be beneficial especially in laminar flow regime, the employment of dimples has been suggested to increase the effective heat transfer from surfaces. To achieve both an increase in heat transfer coefficient and a moderate increase in heat transfer area, flow inserts such as twisted tapes, wire coils or cross-bar grids are used. Recently, the employment of dimples has been suggested to increase the effective heat transfer from surfaces. Extended surfaces characterized with high heat transfer coefficients and a substantial increase in heat transfer area provides appreciable heat transfer enhancement compared with the all above-mentioned passive techniques. Both effective surface enhancement elements and the optimal flow arrangement were employed during the experimental investigation of the pin fin heat exchanger described in the present work.

II. EXPERIMENTAL SETUP

The figure.1 shows the experimental setup used for the analysis and the figure 2 shows pin fin which is attached in the setup. The setup consists of shell in which helical coil with pin fin attachment is fixed in center of the shell. Water tank is used for supplying and collecting of hot water. Submersible type of water pump is used to pump the hot water at the inlet of shell front head & then water is passing to helical coil. The tube length including the circular end is 540 mm, inner diameter of tube is 11.7mm, outer diameter of tube is 12.7mm, & shell length is 600 mm, Outer diameter of the shell is 152.4 mm, inner diameter of the shell is 149.4 mm. The tube material is copper and shell material is mildsteel.K type thermocouple with four junctions is used with a digital temperature indicator to measure the temperature of the working fluids. The pin fin is attached inside to the helical coil and extended towards outwards. Ball valve is used to control the flow rate.

Figure.1Experimental setup

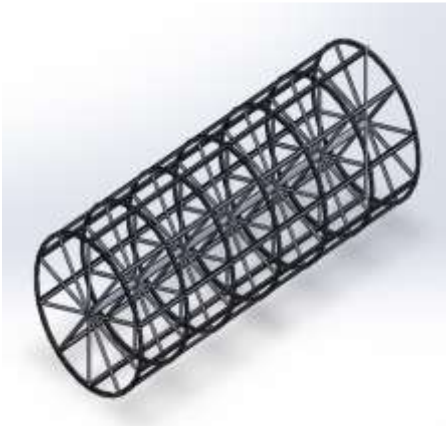

Figure.2Pin fin attachment

III. EXPERIMENT PROCEDURE

Figure 3 shows the schematic representation of experimental procedure. Hot fluid at a temperature Thi enters into the helical coil with a pressure Phi and velocity Vh1. Cold fluid enters at a temperature Tci enters into the shell with a pressure Pc1 and Velocity Vc1. In the heat exchanger heat transfer takes between the hot fluid and cold fluid and the hot fluid and cold fluid leaves the heat exchanger at the temperature Tho and Tco. Pump is used to circulate the hot fluid throughout the process. Ball valves are used to control the flow rates of the water. K-Type thermocouple is used to measure the temperature. Temperature readings are noted in two cases.

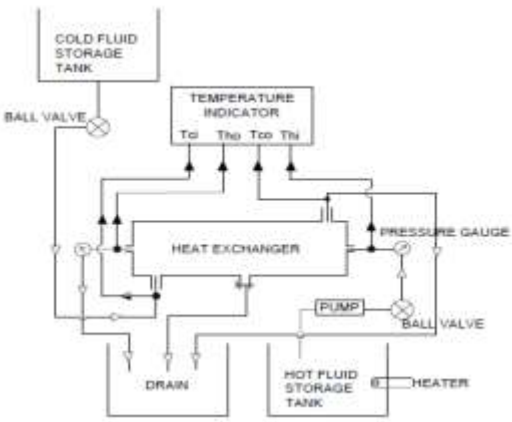

Figure.3Experiment procedure

In first case readings are taken without the pin fin arrangement, in second case readings are taken with pin fin arrangement Readings are taken in such a way that the flow rate of hot fluid is kept constant and by changing the flow rate of water. Using the formulas the parameters such as heat transfer co efficient, effectiveness, Renolds number, Nusselt number, pressure drop and friction factors are calculated and the values are compared and plotted in graph.

IV. RESULT & DISCUSSION

Experimental analysis is done to determine the behavior of helical coil heat exchanger with pin fin attachment and compared with the plain shell and helical coil heat exchanger.Based on the calculations the following results are plotted for interpretation.

4.1 Flow Rate Vs Effectiveness

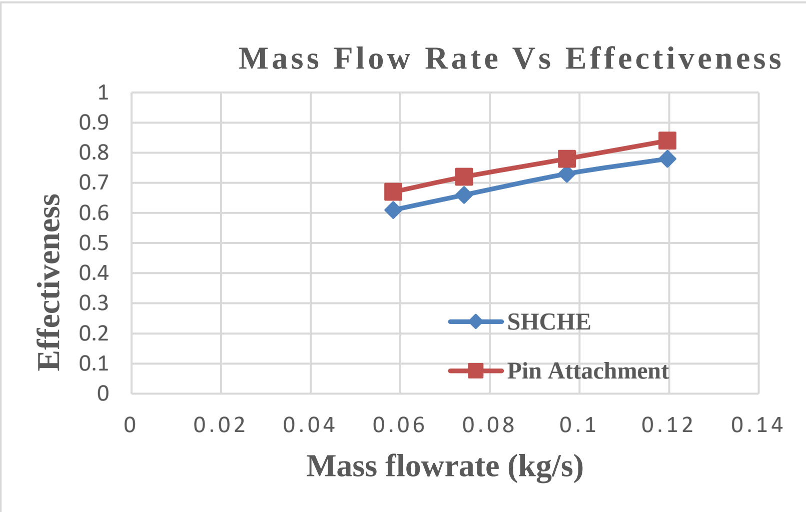

Figure.4Flow rate vs Effectiveness

The figure 4 shows the performance of effectiveness in the heat exchanger. From above graph it is observed that the effectiveness increases with increase in mass flow rate, the maximum effectiveness obtained in pin fin attachment is 0.87. Pin fin attachment creates more turbulence than plain tube which gives higher heat transfer coefficient than plain tube. The maximum percentage of increase in effectiveness is 7.6%

4.2 Flow Rate vs. Heat Transfer Co Efficient

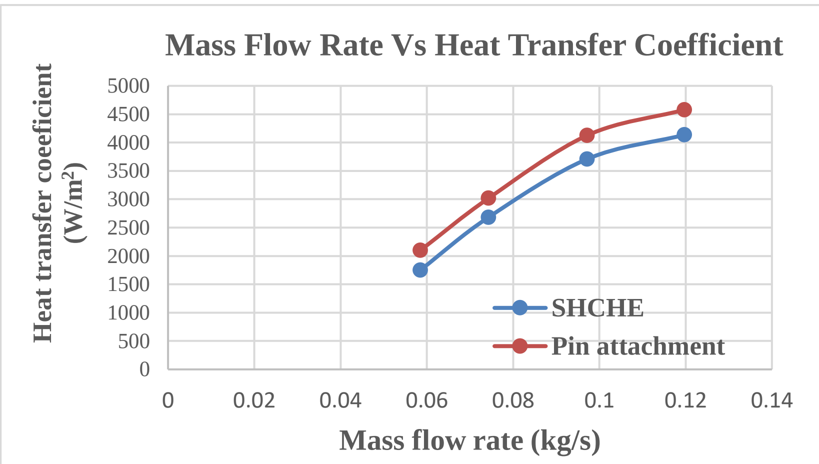

Figure.5Flow rate vs EffectivenessFlow rate vs Heat transfer coefficient

The figure 5 shows the performance of heat transfer coefficient in the heat exchanger.From the above graph it is observed that the heat transfer coefficient increases with increase in mass flow rate, the maximum heat transfer coefficient obtained in pin fin attachment is 4576.7 W/m2. Pin fin attachment creates more turbulence than plain tube which gives higher heat transfer coefficient than plain tube. The maximum percentage of increase in Heat transfer coefficient is10.7%

4.3 Flow Rate Vs.Nusselt Number

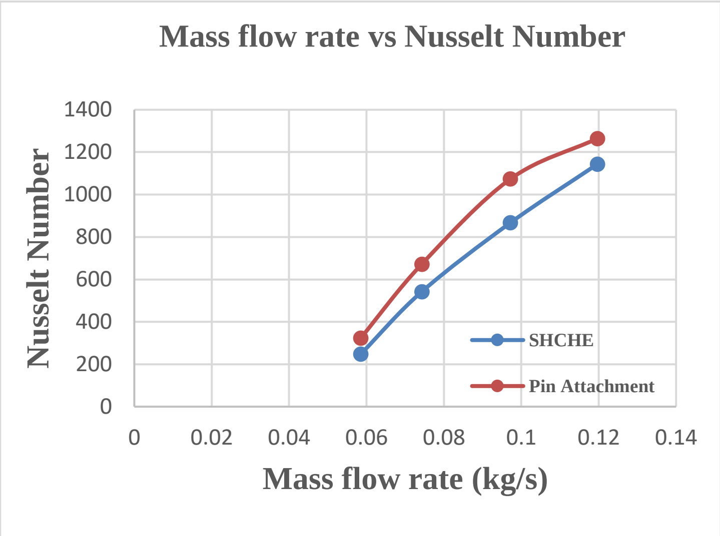

Figure.6Flow rate VS Nusselt Number

The figure 6 shows the performance of Nusselt number in the heat.From the above graph it is observed that the Nusselt number increases with increase in mass flow rate, the maximum Nusselt number obtained in pin fin attachment is 1264.73. Pin fin attachment creates more turbulence than plain tube which gives higher Nusselt number than plain tube. The maximum percentage of increase in Nusselt number is 10.5%

4.4 Flow Rate vs. Reynolds Number

The figure 7 shows the performance of Nusselt number in the heat exchanger.From the above graph it is observed that the Reynolds number increases with increase in mass flow rate, the maximum Reynold number obtained in pin fin attachment is 15228. Pin fin attachment creates more turbulence than plain tube which gives higher Reynolds number than plain tube. The maximum percentage of increase in Reynolds number is 9.7%

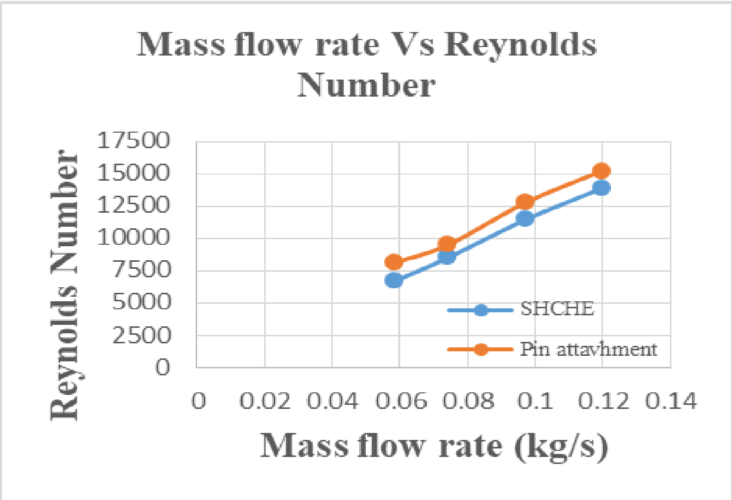

Figure.7Flow rate vsReynols number

4.5 *Flow Rate vs. Pressure Drop*

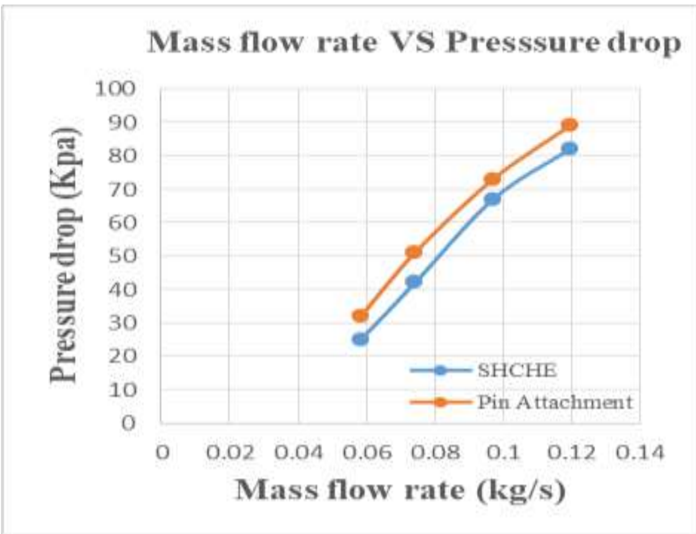

Figure.8Flow rate vs Pressure drop

The figure 8 shows the performance of Pressure drop in the heat exchanger.From the above graph it is observed that the Pressure drop increases with increase in mass flow rate, the maximum Pressure drop obtained in pin fin attachment is 90Kpa. Pin fin attachment gives higher Pressure drop than plain tube. The maximum percentage of increase in Pressure drop is 8.5%

4.6 *Flow Rate vs. Friction Factor*

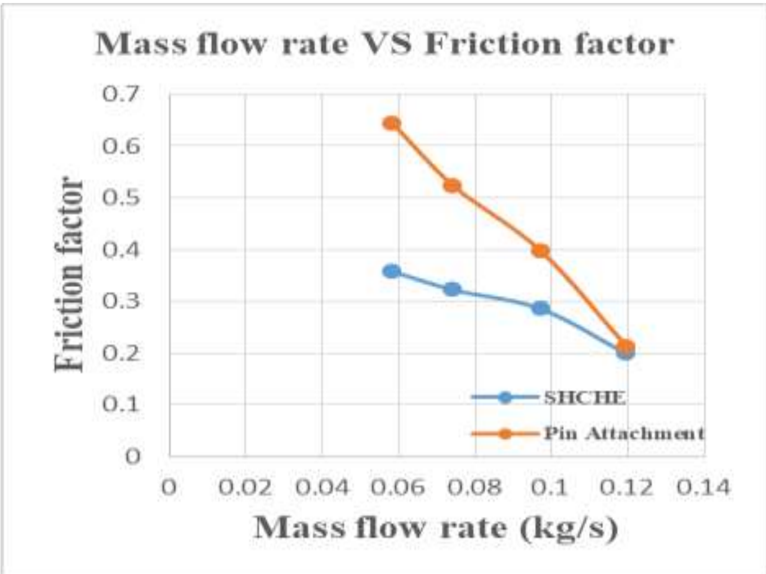

Figure.9flow rate vs friction factor

The figure 9 shows the performance of friction factor in the heat exchanger.From the above graph it is observed that the friction factor decreases with increase in mass flow rate, the minimum friction factor obtained in pin fin attachment is 0.212. Pin fin attachment gives lower friction factor than plain tube. The minimum percentage of decrease in friction factor is 7%

V. CONCLUSIONS

The thermal analysis of various parameters that affect the effectiveness and the heat transfer coefficient of a heat exchanger is investigated experimentally with pin fin arrangement and has following conclusion.

- The percentage of increase in effectiveness due to pin fin arrangement in 7.6%
- The percentage of increase in heat transfer coefficient due to pin fin arrangement in 10.7%
- The percentage of increase in Nusselt number due to pin fin arrangement in 10.5%
- The percentage of increase in Reynolds number due to pin fin arrangement in 9.7%
- The percentage of increase in Pressure drop due to pin fin arrangement in 8.5%
- The percentage of increase in Pressure drop due to pin fin arrangement in 7%

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