Study on experimental investigation of curved tube

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***Abstract* - In the present study, the thermal performance and pressure drop of the helical-coil heat exchanger with and without helical crimped fins are studied. The heat exchanger consists of a shell and helically coiled tube unit with two different coil diameters. Each coil is fabricated by bending a 9.50 mm diameter straight copper tube into a helical-coil tube of thirteen turns. Cold and hot water are used as working fluids in shell side and tube side, respectively. The experiments are done at the cold and hot water mass flow rates ranging between 0.10 and 0.22 kg/s, and between 0.02 and 0.12 kg/s, respectively. The inlet temperatures of cold and hot water are between 15 and 25 °C, and between 35 and 45 °C, respectively. The cold water entering the heat exchanger at the out channel flows across the helical tube and flows out at the inner channel. The hot water enters the heat exchanger at the inner helical-coil tube and flows along the helical tube. The effects of the inlet conditions of both working fluids flowing through the to section on the heat transfer characteristics are discussed.**

INTRODUCTION

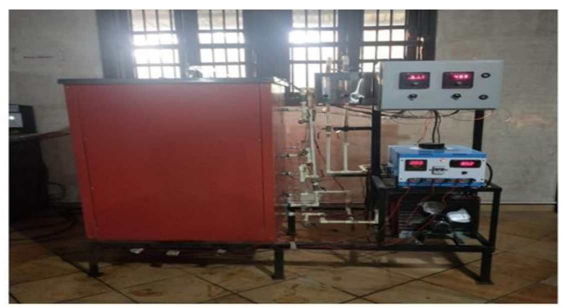
Helically coiled tubes are effective as heat transfer equipment due to their compactness and increased heat transfer coefficients in comparison with straight tube heat exchangers. Due to their high heat transfer coefficient and smaller space requirement compared with straight tubes, curved tubes Helical and spiral coils are well known types of curved-tubes which have been used in a wide variety of applications. For helically coiled tubes, numerous theoretical and experimental works have been reported on heat transfer and flow characteristics.

Curved coil tubes are classified as tubes with constant curvature and tubes with variable curvature. In constant curvature coil tubes, the Spiral coil tubes are used in process heat exchangers, to improve mass flow rates such as in membrane blood oxygenators and in refrigeration and air-conditioning systems, heat recovery systems, and food industries and chemical processing.

Turbulent flow and convective heat transfer in a spirally coiled tube are complicated as comparing the straight tube. Helical and spiral coils are well known types of curved tubes which have been used in a wide variety of applications.

However, most studies for curved tubes are concerned with the helically coiled heat exchanger, curvature ratio of the coil remains constant throughout the length of the coil.

Helical coil tubes and torus are the examples of constant curvature coils whereas spiral coil tube is an example of variable curvature coil. Frictional drop increases in case of variable curvature coils because of intense mixing of fluid particles due to continuously varying curvature of the coil. Helical coil tubes are generally used to either cool or heat fluid in industry, chemical reactors.



EXPERIMENTAL APPARATUS AND METHOD

A schematic diagram of the experimental apparatus is shown in Fig. The test loop consists of a test section, refrigerant loop, hot water loop, cold water loop and data acquisition system.

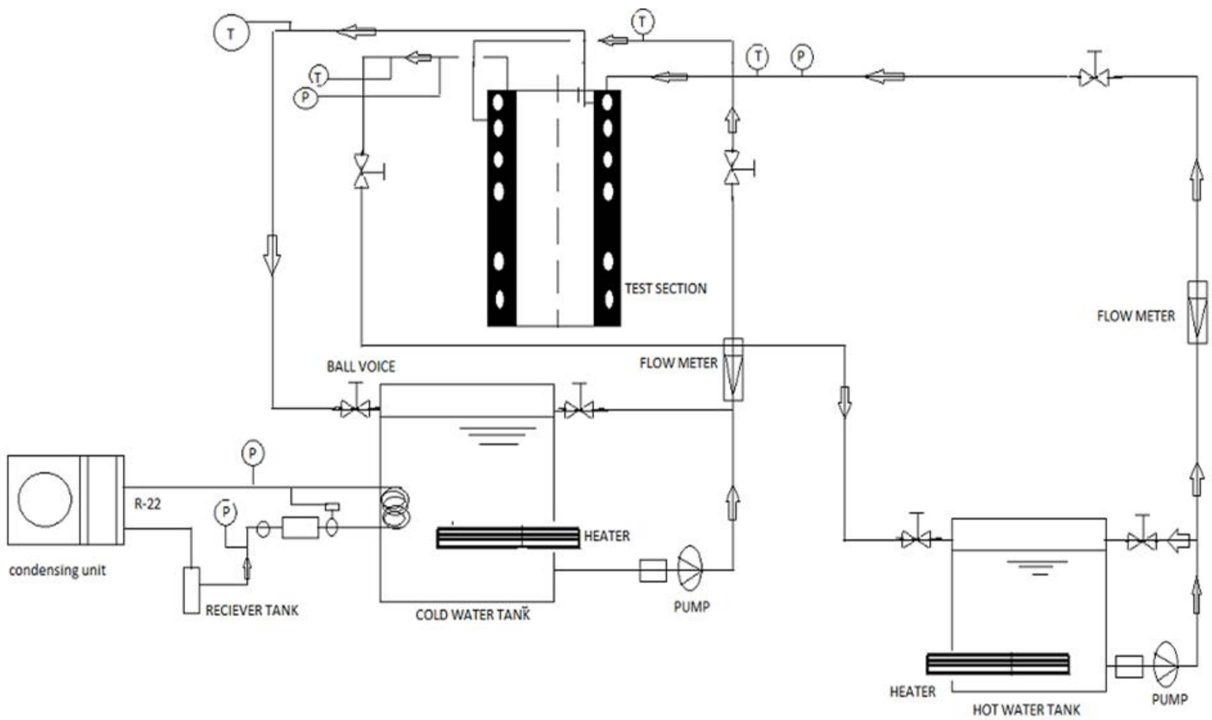
The test section is a helical-coil heat exchanger consisting of a shell and helically coiled finned tube unit. The test section and the connection of the piping system are designed such that parts can be changed or repaired easily.

In addition to the loop component, a full set of instruments for measuring and control of temperature and flow rate of all fluids is installed at all important points in the circuit.

It has been reported by many investigators in the literature that heat transfer coefficient in helical coil is higher as compared to straight tube.

0.4 mm and height of 9.6 mm are placed helically around the coil tube.

T-copper-constantan thermocouples are installed to measure the hot water and tube wall temperatures at the inlet, middle, and outlet sections. The accuracy of the thermocouple is 0.1% of full scale. all the The digital manometer (YOKOKAWA, MT120) with the accuracy of 0.02% of full scale is employed to measure the pressure drop in the tube side. The dimensions of the test section are listed in Table 1. An overall energy balance was performed to estimate the extent of any heat losses or gains from the surrounding. In the experiments, the hot water flow rate was increased in small increments while the cold-water flow rate, inlet cold water and hot water temperatures were kept constant.



The close loops of hot and cold water consist of the 0.5 m^3 storage tanks, the electric heaters controlled by adjusting the voltage, and a cooling coil immerged inside a storage tank. R22 is used as the refrigerant for chilling the water. The hot water is adjusted to the desired level and controlled by temperature controller. After the temperatures of the cold and hot water are adjusted to achieve the desired level, the water of each loop is pumped out of the storage tank, and is passed through a filter, flow meter, test section, and returned to the storage tank.

The flow rates of the water are controlled by adjusting the valve and measured by the flow meters with an accuracy of 0.2% of full scale.

The heat exchanger consists of a steel shell and a helically coiled finned tube unit. The helical-coil tube unit consists of two different coil diameters. Each coil is constructed by bending a 9.5 mm diameter straight copper tube into a helical-coil of thirteen turns. The minimum and maximum diameters of helical-coil are 127.0 and 197.0 mm, respectively.

CONCLUSION

Illustrates the variation of the outlet temperature of cold water with hot water mass flow rate for helically coiled finned tube heat exchanger.

It is found that when the inlet hot and cold water temperatures, and cold water mass flow rate are kept constant, the outlet cold water temperature increases with increasing hot water mass flow rate.

This is because the heat transferred from the hot water to cold water increases with increasing hot water mass flow rate. Therefore, the outlet cold Water temperature also tends to increase when hot water mass flow rate increases.

Considering the effect of cold water mass flow rate on the outlet cold water temperature, it is clearly seen that at a specific inlet cold and hot water temperatures, and hot water mass flow rate, when the outlet hot water temperature decreases, the temperature difference between inlet and outlet hot water temperature increases.

Therefore, one way of keeping the heat transfer rate equal to the hot Water-side is by increasing the cold water mass flow rate.

In This paper presents new experimental data from the measurement of the average in-tube convective heat transfer characteristics and thermal performance of helical-coil heat exchanger.

The heat exchanger consists of thirteen turns concentric helically coiled tubes with and without helically crimped fins. The conclusion can be summarized as follows Outlet cold water temperature increases with increasing hot water mass flow rate.

An average heat transfer rate increases as hot and cold water mass flow rates increase. The friction factor decreases with increasing hot water mass flow rate. Inlet hot and cold water mass flow rates and inlet hot water temperature have significant effect on the heat exchange effectiveness.

The inlet hot and cold water temperatures were adjusted to achieve the desired level by using electric heaters controlled by temperature controllers. Before any data were recorded, the system was allowed to approach the steady.

In the experiments, the hot water flow rate was increased in small increments while the cold water flow rate, inlet cold water and hot water temperatures were kept constant. The inlet hot and cold water temperatures were adjusted to achieve the desired level by using electric heaters controlled by temperature controllers before any data were recorded, the system was allowed to approach the steady.

REFERENCE

[1] A.N. Dravid, K.A. Smith, E.W. Merrill, P.L.T., Brian, Effect of secondary fluid on laminar flow heat transfer in helically coiled tubes, AIChE Journal 17 (1971) 1114-1122.

[2] D.S. Austen, H.M. Soliman, Laminar flow and heat transfer in helically coiled tubes with substantial pitch, Experimental Thermal and Fluid

[3] B.V.S.S.S. Prasad, D.H. Das, A.K. Prabhakar, Pressure drop, heat transfer and performance of a helically coiled tubular exchanger. Heat Recovery Systems & CHP 9 (1989) 249-256.

[4] G. Yang, M.A. Ebadian, Turbulent forced convection in a helicoidal pipe with substantial pitch, International Journal of Heat and Mass Transfer 39 (1996) 2015-2022

[5] R.C. Xin, A. Awwad, Z.F. Dong, M.A. Ebadian, An experimental study of single-phase and two-phase flow pressure drop in annular helicoidal pipes, International Journal of Heat and Fluid Flow 18 (1997) 482-488.

[6] Y. Inagaki, H. Koiso, H. Takumi, I. loka, Y. Miyamoto, Thermal hydraulic study on a high-temperature gas-gas heat exchanger with helically coiled tube bundles, Nuclear Engineering and Design 185 (1998) 141-151.

[7] Y. Chen, M. Fiebig, N.K. Mitra, Conjugate heat transfer of a finned oval tube: flow pattern, Numerical Heat Transfer. Part A, Applications 33 (1998) 371-385.

[8] N. Acharya, M. Sen, HLC. Chang, Analysis of heat transfer enhancement in coiled-tube heat exchangers, International Journal of Heat and Mass Transfer 44 (2001) 3189-3199.

[9] H. Jo, Z. Huang, Y. Xu, B. Duan, Y. Yu, Hydraulic performance of small bending radius helical coil-pipe, Journal of Nuclear Science and Technology 18 (2001) 826-831.