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Comparison Between Thermal Performance of Coiled Tube and Straight Tube Inserted in a Cylindrical Reservoir in the Transient Convection Heat Transfer; Experimental Study

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ABSTRACT: The main purpose of this study is to experimentally investigate transient convective heat transfer from a fluid stored inside a closed reservoir. Different cooling methods using helical and straight tubes are considered for heat transfer from the fluid reservoir. This paper attempts to determine the thermal advantages of helically coiled versus a straight tube. Fluid stored in the reservoir is cooled by water flow in the tube section at 27°C inlet temperature. The pressure drop and heat transfer parameters are measured over a wide range of Reynolds numbers (covers 500 to 5500). In these experiments, the effects of a couple of different parameters such as Reynolds number, time and geometrical parameters have been studied. Both heat transfer and pressure drop fluid flow in two test sections have been also reported and discussed. The experimental data indicate that using of helical coil instead of straight tube leads to increase heat transfer sharply. The coiled tube results show 42% reduction in of reservoir temperature compared to straight tube.

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1- Introduction

Helical coil heat exchangers are widely used in industrial applications such as nuclear industry, refrigeration, heat recovery systems, air conditioning systems, an food industries [4]. In spite of their widespread use, there is little information available in the literature on natural convection from such coils. There are studies available about the outside heat transfer coefficients by Ali [5] and Xin and Ebadian [6] but even these studies deal with a constant wall temperature or a constant wall heat flux. Neshat et al. [7] experimentally studied unsteady natural convection from outer surface of helical coil with different curvature ratios. The Nusselt number of outer surface of the coil is calculated by authors for both vertical and horizontal helical coils. Devanahalli [8] studied natural convection from outer surface of helical coils. In this study coil height was considered as characteristics length and different characteristic lengths were used for representing the relation between Nusselt number and Rayleigh number.

In this article we determine the relative advantage of using helically coiled heat exchangers versus a straight tube heat exchanger and study geometry effect on natural convection heat transfer in closed reservoir.

2- Experimental Setup

In this article, we intend to investigate and compare transient heat transfer in a closed reservoir by using different cooling methods (helical coil and the common straight tube). The experimental setup and test section used for this study are shown schematically in Figure 1. The closed reservoir is fabricated by teflon and a layer of glass wool is used to insulate the outer surface. Fluid passing through the test section is the working fluid. At first, working fluid is pumped from the storage tank and is passed through the test section. The range of Reynolds numbers in this experiment covers 500 to 5500.

Water at 70 oC is used for filling the reservoir at initial time then cooling water circulating for 600 s in the cooling tube. Couple of PT100 sensors are used for temperature measuring in the system and a ADAM 4015 data acquisition is used to record the data paired with a computer. A Rosemount 3051 intelligent differential pressure transmitter device was used to measure the pressure drop across the test section.

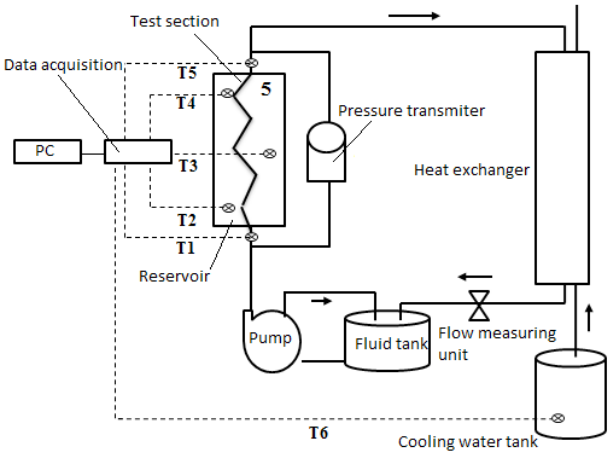

Figure 1. Schematic of experimental setup

3- Results and Discussion

After measuring temperature, related formulation is used to calculate goal parameters such as Nusselt number, Rayleigh number, non-dimensional temperature of reservoir and tube outlet. Figure 2 shows temperature of reservoir versus

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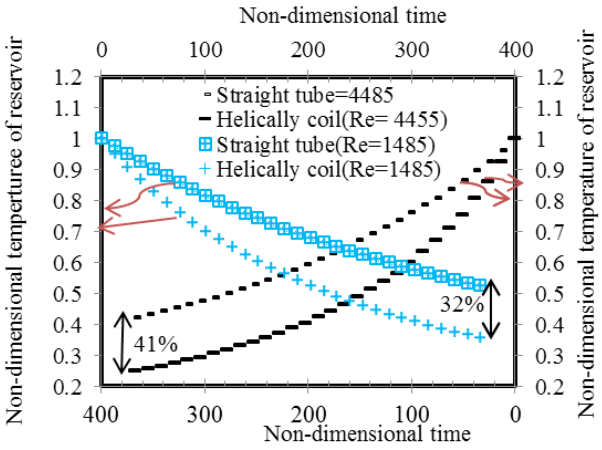

Figure 2. Non-dimensional temperature of reservoir as non-dimensional time

non-dimensional time for both cooling tubes. The Rayleigh number as an important non-dimensional number in transient flow is presented in Figure 3 as non-dimensional heat flux. Figure 4 shows pressure drop and heat transfer parameters for both cooling tube. As seen, the result shows a significant increase in heat transfer rate by using coiled tube instead of straight tube. Maximum 42% increase in Rayleigh number is observed in the experiments.

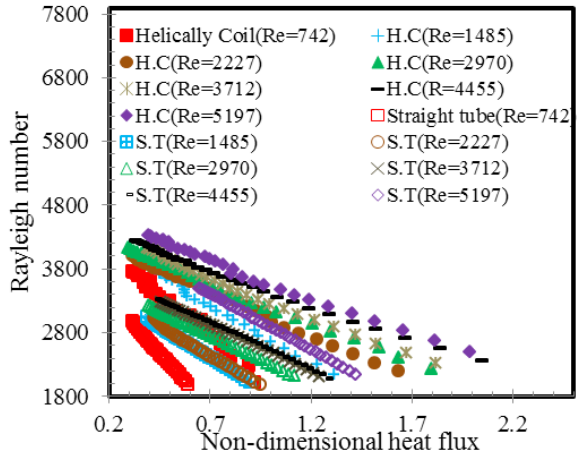

Figure 3. Rayleigh number as non-dimensional heat flux

4- Conclusions

In this article, transient convection of fluid in reservoir is investigated experimentally. From this study it can be concluded that:

- Using of helical tube leads to heat transfer rate enhancement.
- The reservoir temperature and outlet temperature of cooling tube decreased sharply by using of coiled tube.

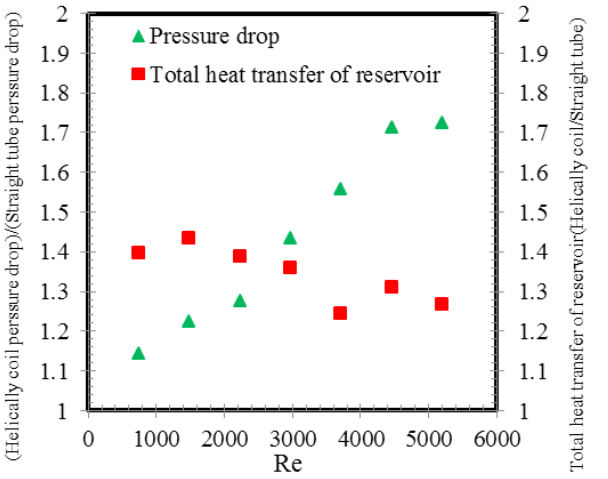

Figure 4. Comparing performance of coiled tube on heat transfer and pressure drop

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