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Single-phase heat transfer and pressure drop in the micro-fin tubes with coiled wire insert[B]

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Abstract

The heat transfer characteristics and the pressure drop of the horizontal double pipes with and without coiled wire insert are investigated. The inner and outer diameters of the micro-fin tube are 8.92 and 9.52 mm, respectively. The coiled wire is fabricated by bending a 1-mm-diameter iron wire into the coil wire with coil diameter of 7.80 mm. Cold and hot water are used as working fluids in shell side and tube side, respectively. The test runs are performed at the cold and hot water mass flow rates ranging between 0.01 and 0.07 kg/s and between 0.04 and 0.08 kg/s, respectively. The inlet cold and hot water temperatures are between 15 and 20 °C and between 40 and 45 °C, respectively. The results obtained from the micro-fin tube with coiled wire insert are compared with those obtained from the smooth and micro-fin tubes.

Keywords: Heat transfer characteristics; Pressure drop; Micro-fin tube; Coiled wire insert

1. Introduction

The heat transfer duty or thermal performance of heat exchangers can be improved by heat transfer enhancement techniques. Coiled wire insert has been used as one of the passive heat transfer enhancement techniques and are the most widely used tubes in several heat transfer applications, for example, heat recovery processes, air conditioning and refrigeration systems, chemical reactors, food and dairy processes. Prasad and Shen [1] proposed a new criterion for evaluating the effectiveness of a passive heat transfer enhancement device. In their second paper, Prasad and Shen [2] studied the enhancement of heat transfer by using several wire-coil inserts based on energy analysis. Twelve different wire-coil inserts were tested in turbulent flow region. Ravigururajan and Bergles [3] presented the general correlations for friction factor and heat transfer coefficient for single-phase turbulent flow in internally augmented tubes. Kang et al. [4] developed the flooding correlation for a fluted tube with a twisted insert. Effects of the twisted tape insert and the angle of inclination on flooding were examined. Al-Fahed et al. [5] compared the pressure drop and heat transfer coefficients obtained from a plain, micro-fin, and from twisted-tape insert-tubes. Agrawal et al. [6] experimentally studied the heat transfer enhancement by coiled wire inserts during forced convection condensation of R-22 inside horizontal tubes. Liao and Xin [7] carried out to study the heat

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transfer and friction characteristics for water, ethylene glycol, and ISO VG46 turbine oil flowing inside four tubes with three-dimensional internal extended surfaces and copper continuous or segmented twisted-tape inserts. Kim et al. [8] visualized the flow pattern, void fraction and slug rise velocity on counter-current two-phase flow in a vertical round tube with wire-coil inserts. Wang and Sund [9] studied the heat transfer enhancement technology in heat exchanger. Rahai and Wong [10] experimentally studied the turbulent jets from round tubes with coil inserts. Zimparov [11,12] theoretically studied a simple mathematical model for predicting the heat transfer coefficients and friction factor in a spirally corrugated tube combined with a twisted tape insert for a fully developed turbulent flow. The results obtained from the model were compared with those from experiment. Recently, Ozceyhan [13] numerically studied the conjugate heat transfer and thermal stress in tube with wire coil inserted tube under uniform wall heat flux. A finite-difference scheme was employed to solve the energy and governing flow equations.

To the best of authors' knowledge, the heat transfer characteristics and pressure drop in the micro-fin tube with coiled wire insert have rarely been reported. In the present study, the main concern is to study experimentally on the heat transfer characteristics and pressure drop of the micro-fin tube with coiled wire insert. The effects of various relevant parameters on the heat transfer characteristic and pressure drop are also investigated. The results obtained from the micro-fin tube with coiled wire insert are compared with those from smooth and micro-fin tubes.

2. Experimental apparatus and method

A schematic diagram of the experimental apparatus is shown in Fig. 1. 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 concentric tube heat exchanger as shown in Fig. 2. 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.

The close loops of hot and cold water consist of the 0.5-m^3 storage tanks, 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 a temperature controller. After the temperature 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 a range of 0–0.063 kg/s.

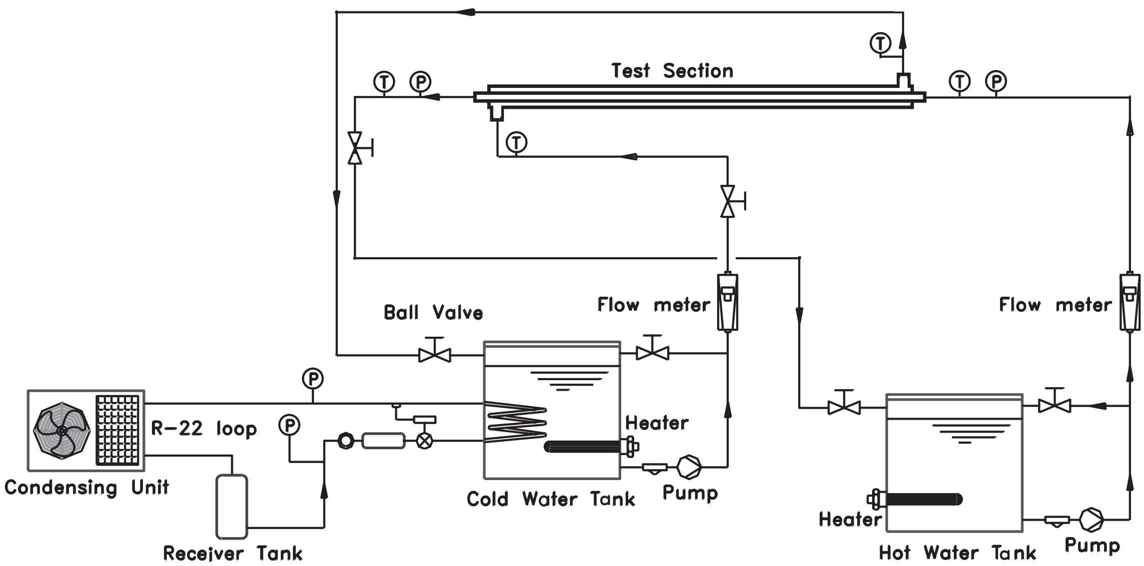

Fig. 1. Schematic diagram of experimental apparatus.