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Heat transfer and pressure drop in the horizontal double pipes with and without twisted tape insert ☆

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Abstract

The heat transfer characteristics and the pressure drop in the horizontal double pipes with twisted tape insert are investigated. Two test sections with different relative pitches are tested. The inner and outer diameters of the inner tube are 8.10 and 9.54 mm, respectively. The twisted tape is made from the aluminium strip with thickness of 1 mm and the length of 2000 mm. Cold and hot water are used as working fluids in shell side and tube side, respectively. The test runs are done 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 tube with twisted insert are compared with those without twisted tape. Non-isothermal correlations based on the data gathered during this work for predicting the heat transfer coefficient and friction factor of the horizontal pipe with twisted taped insert are proposed. The majority of the data falls within ±15%, ±10% of the proposed correlations for heat transfer coefficient and friction factor, respectively.

Keywords: Heat transfer; Twisted tape insert; Pressure drop

1. Introduction

The centrifugal force is generated as fluid flow in the tube with twisted insert. The secondary flow induced by the centrifugal force has significant ability to enhance heat transfer rate. Tubes with twisted tape insert have 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, and chemical reactors. Agarwalt and Rao [1] studied the isothermal and non-isothermal friction factor and mean Nusselt number under uniform wall temperature conditions. The isothermal friction factor and the Nusselt number correlations were proposed. Kang et al. [2] developed the flooding correlation for a fluted tube with a twisted insert. The effects of the twisted insert and the angle of inclination on flooding were considered. Al-Fahed et al. [3] compared the pressure drop and heat transfer coefficients obtained from a plain, microfin, and twisted tape insert tubes. Three different twist ratios each with two different widths were tested. Kumara and Prasad [4] studied the heat transfer in a solar water

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heater with twisted tapes. Liao and Xin [5] carried out to study the heat transfer and friction characteristics in tube with continuous and segmented twisted tape inserts. Zimparov [6,7] experimentally studied the heat transfer and isothermal friction pressure drop in two single-start and three-start spirally corrugated tubes combined with five twisted tape inserts with different relative pitches. Next, Zimparov [8,9] theoretically studied a simple mathematical model for predicting the heat transfer coefficients and friction factor for a fully developed turbulent flow in a spirally corrugated tube combined with a twisted tape insert. The results obtained from the model were compared with the measured data. Ray and Date [10,11] predicted the heat transfer characteristics in the square duct with twisted tape insert for laminar and turbulent flow regions. The heat transfer characteristics were predicted under axially and peripherally constant heat flux conditions. Correlations for friction factor and Nusselt number were proposed. Neshumayev et al. [12] experimentally studied the heat transfer augmentation by various turbulator inserts. Twisted tape insert, the straight tape insert, and the combined turbulator insert were tested. Sarma [13,14] presented a new approach for predicting the convective heat transfer coefficient in a tube with twisted tape inserts for different pitch to diameter ratios. The predicted results were compared with various correlations. Recently, Sarma et al. [15] proposed the generalized correlations for predicting friction factors and convective heat transfer coefficients with twisted tapes in a tube. Reasonable agreement was obtained from the comparison between the predicted results and the measured data.

The objective of this paper is to study the heat transfer characteristics and pressure drop of the horizontal double pipes with and without twisted tape insert. The effects of various relevant parameters on the heat transfer characteristics and pressure drop are also investigated. New correlations based on the data gathered during this work for predicting the heat transfer coefficient and friction factor for the horizontal pipe with twisted taped insert are proposed for practical applications.

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 the horizontal double pipes with twisted tape insert as shown in Fig. 2. The test section and the connections 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.

The close loops of hot and cold water consist of the 0.5 m^3 storage tanks, an electric heater 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 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 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.

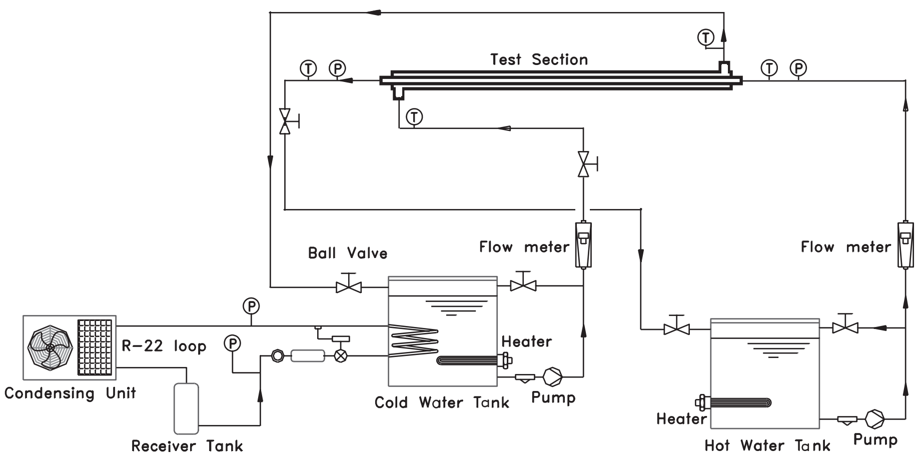

Fig. 1. Schematic diagram of experimental apparatus.