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Study on the exergy loss of the horizontal concentric micro-fin tube heat exchanger ☆

Paisarn Naphon *

Thermo-Fluids and Heat Transfer Enhancement Laboratory (TFHT), Department of Mechanical Engineering, Faculty of Engineering, Srinakharinwirot University, 63 Rangsit-Nakhornnayok Rd., Ongkharak, Nakhorn-Nayok, 26120, Thailand

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ABSTRACT

Experimental and theoretical investigations on the entropy generation, exergy loss of a horizontal concentric micro-fin tube heat exchanger are presented. The experiments setup are designed and constructed for the measured data by using hot water and cold water as working fluids. The micro-fin tube is fabricated from the copper tube with an inner diameter of 8.92 mm. The experiments are performed for the hot and cold water mass flow rates in the range of 0.02–0.10 kg/s. The inlet hot water and inlet cold water temperatures are between 40 and 50 °C, and between 15 and 20 °C, respectively. The effects of relevant parameters on the entropy generation, and exergy loss are discussed. A central finite difference method is employed to solve the model for obtaining temperature distribution, entropy generation, and exergy loss of the micro-fin tube heat exchanger. The predicted results obtained from the model are verified by comparing with the present measured data. Reasonable agreement is obtained from the comparison between predicted results and those from the measured data.

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1. Introduction

Energy saving aspects is very important in the design, construction and operation of the heat transfer devices. For this reason, various active or passive methods have been introduced to save energy by increasing the heat transfer coefficients and/or increasing heat transfer surface area in the cold and hot fluid sides in the heat exchangers. The first law of thermodynamics deals with the quantity of energy and asserts that energy cannot be created and destroyed. The second law, however, deals with the quality of energy. More specifically, it is concerned with the degradation of energy during a process, entropy generation, and the lost opportunities to do work. Decreasing energy losses and using lost energy is becoming more and more important. Recently, many studies have been done on the entropy generation and the second law analysis in order to determine optimum parameters of engineering system. Leiner et al. [1,2] were interested in the design of solar air heaters with high heat transfer rates and low friction losses. Das and Roetzel [3] presented a second law analysis for thermally dispersive flow through a plate heat exchanger. Can et al. [4] experimentally studied the influence of the process variables on the exergy losses at the double tube heat exchanger. San and Jan [5] studied a second law analysis of a wet crossflow heat exchanger for various weather conditions. Yilmaz et al. [6] applied the second law to evaluate the performance of heat exchangers. Rakopoulos et al. [7] presented a computational method for the combustion irreversibility and working fluids availability in internal combustion engine cylinder. Mahmud et al. [8–10] analytically investigated the first and second law characteristics of fully developed non-newtonian fluid flow and heat transfer of the channel with two parallel plates with finite gap and rotating concentric cylinder. Sahin [11] studied the entropy generation and pumping power for a turbulent flow in a smooth pipe with constant wall heat flux. Tasnim et al. [12] simplified the governing equations in cylindrical coordinates to analyze mixed convection flow, heat transfer, and entropy generation characteristics. Reddy et al. [13] presented work on the entropy generation in the waste heat recovery steam generator, which consists of an economizer, an evaporator and a super heater. Hasan et al. [14] analyzed the power and refrigeration cycle using the first and second laws of thermodynamics. Durmus [15,16] experimentally studied the heat transfer and exergy loss in a concentric heat exchanger with snail entrance. Wang et al. [17] numerically studied the exergy destruction due to mean flow and fluctuating motion in incompressible turbulent flows through a tube. Fartaj et al. [18] theoretically and experimentally studied the second law and exergy of the automotive air conditioning systems. Khaliq et al. [19] used the second law approach for the thermodynamic analysis of the reheat combined Brayton/Rankine power cycle. Akpinar and Bicer [20,21] considered the effect of swirl generators on the heat transfer rates, friction factor and exergy loss in a concentric double pipe exchanger with helical wires insert. He at al. [22] analyzed the first and second law of thermodynamics of the orifice type and the double-inlet type of pulse tube refrigerator. Dung and Yang [23] applied the entropy generation minimization method for optimizing a saturated vapor flowing slowly onto and condensed

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* Corresponding author.
E-mail address: paisarnn@swu.ac.th.

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