Investigation of thermal behavior a two-phase closed thermosyphon at medium input heat

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Abstract

Although numerous works have been carried out in the field of high temperature applications, there is a lack of sufficient data on the actual thermal performance of thermosyphons for low input heat especially the geometric effects and inclination angle under normal operating conditions. Therefore, it is the objective of this work to examine the thermal behaviors in a thermosyphons by taking into consideration the evaporator geometry, inclination angle of tube, coolant flow rate and filling ratio. To obtain this objective, distilled water was used as the working fluid and two copper tubing of inside diameters of 14 and 20 mm with different ratios of evaporator length to the inside diameter of 15, 20 and 29.3 were implemented in this work. In addition, the temperature distribution along the thermosyphons, input heat to the evaporator and output from the condenser section was monitored. The results reveals that the thermosyphons has the highest rate of heat transfer in the inclination angle of 60° for all the three aspect and filling ratios adopted in this work. Furthermore, a good agreement was observed between the experimental results of the present study and the previous published correlations.

Keywords: Two-Phase Closed Thermosyphon, Medium Input Heat, Inclination Angle, Evaporator Geometry

Introduction:

Recently, investigators have been paid a great deal of attention to the heat pipe and two-phase closed thermosyphons (TPCT) due to its wide range of applications in different process industries. The mechanism of a heat pipe is easily understood by using a cylindrical geometry, as shown in Figure 1. The heat pipe is comprised of a sealed container (pipe wall and end caps), a wick and a small amount of working fluid in liquid state which is in equilibrium with its own vapor. The length of the heat pipe is divided into three parts: the evaporator, adiabatic and condenser section. In the selection of a suitable combination of three basic components, inevitably a number of conflicting factors may arise, and the principal bases for selection are discussed Faghri [1]. thermosyphon is actually a wickless gravity-assisted heat pipe with a small amount of working fluid which is in equilibrium with its own vapor sealed inside container (pipe wall and end caps). The length of the thermosyphon similar to heat pipe and is divided into three parts: evaporator section, adiabatic section and condenser section.

Relevant research under normal operating condition is quite scarce. Negishi and Sawada [2], made an experimental study on heat transfer performance of an inclined thermosyphon. They used water and ethanol as working fluids. They found that highest heat transfer rates are obtained when the filling ratio is between 25% and 60% for water, and between 40% and 75% for ethanol. The inclination angle should be between 20° and 40° for water, and more than 5° for ethanol. Amornkitbumrung et al. [3] studied the effect of inclination angle on heat transfer rate of a thermosyphon, using a copper-water tube. They concluded that the highest heat transfer rate occurred at 22.5°, with a filling ratio of 30%. Payakaruk et al. [4] investigated heat transfer characteristics of copper thermosyphons with 7.5, 11.1 and 25.4 mm inner diameters. They used water, ethanol, R-22, R-123, and R-134a as working fluids. They found that the optimum inclination angle for water is between 40° and 70°. Terdtoon et al. [5] investigated the effect of aspect ratio and Bond number on heat transfer characteristics of an inclined thermosyphon experimentally. They realized that the optimum inclination angle for water is between 70° and 80° from a horizontal axis.

Park et al. [6] investigated the heat transfer characteristics of a thermosyphon. For the test, a thermosyphon (copper container, FC-72 (C6F14) working fluid) was fabricated with a reservoir which could change the fill charge ratio. The experiments were performed in the range of 50–600W heat flow rate and 10–70% fill charge ratio. Ong and Haider-E-Alahi [7] investigated the thermal performance of a filled with R-134a. R-134a is an environmentally friendly refrigerant and has been generally accepted as a substitute for R-12 and R-22. A 780 mm long, 28.2 mm O.D. and 25.5 mm I.D. copper tube was used. The effects of temperature difference between bath and condenser section, fill ratio and coolant mass flow rates on the performance of the thermosyphon were determined. Shalaby et al. [8] investigated the performance of a thermosyphon. They adopted R22 as a working fluid. A smooth copper tube of total length 1500 mm and 21 mm inside diameter was used as a container of the thermosyphon. Each of the evaporator section and the condenser section had a length of 600 mm, while the remaining part of the tube was the adiabatic section. The

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