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Numerical simulation and experimental verification on thermal performance of a novel fin-plate thermosyphon

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ABSTRACT

Numerical investigation of a novel fin-plate thermosyphon (FPT), used to cool the high heat dissipation electronic devices, was performed. Three dimensional model of FPT is established using the Fluent software. The effects of fin pinch, fin thickness and fin type at the air side on thermal characteristics of FPT are presented with the air flow velocity various from 1.0 m/s to 4.0 m/s. The numerical results showed a good agreement with the corresponding experimental data. The heat transfer efficiency and pressure drops of FPT for plain fins were reduced by increasing the fin space. It also can be indicated that the cooling performance of FPT with serrated fins was better than plain fins for the same structural parameters.

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1. Introduction

With the tremendous advances in the electronics industry, technologies of heat dissipation are facing unprecedented challenges. The power consumption and the heat generation per unit area of the electronic equipments have been increased. The importance of the thermal management in these devices will be growing more and more for reliability and life-time, especially for highly integrated electronic systems.

It is difficult to apply the traditional cooling techniques, e.g. heat sink, fan, water-cooling etc., to the high heat flux electronic devices. In this regard, two-phase closed thermosyphon (TPCT) is considered as one of the most potential solutions in the field of electronic cooling [1–7]. A TPCT usually does not have capillary structures, and the driving head is mainly from gravity or centrifugal force. This often results in better heat transfer characteristics for a TPCT than other capillary-structured heat pipes.

Many experimental investigations were carried out to understand the thermosyphon's characteristics and the effect of various parameters on their performance. Noie [8] experimentally studied the effects of the aspect and filling-ratios on the heat transfer characteristics of a TPCT under the normal operating conditions. Researchers widely studied the influences of entrainment and flooding phenomena to the cooling sections of TPCTs [9–11]. Researchers also endeavored to scale the size and weight down and discussed the size effects of the TPCTs for more and more compact electronic equipments are designed and presented [12,13]. Besides the traditional vertical TPCTs, studies about the two-phase thermosyphons also flourished lately [14–18].

Beside the experimental studies, substantial numerical works were carried out to predict and analyze the behavior of thermosyphones. Basran and Kücüka [19] solved two-dimensional numerical models in the vertical sections of a thermosyphon loop using uniform wall temperature boundary condition. Results for laminar flow case were obtained by solving the momentum and the energy equations through the SIMPLEX Algorithm. Numerical analysis of the effect of Rayleigh number and the aspect ratio on the performance of a thermosyphon was presented by Mohammad and Sezai [20]. Benne and Homan [21] employed a numerical method to analyze the behavior of a thermal storage device incorporating an integrated thermosyphon at constant heat flux. Consequently, they developed their research by employing a constant temperature boundary condition [22].

These researches offered notable contributions for the understandings of the effects of dimensions, system pressure, heating power, properties and filling ratio of working fluids in two-phase thermosyphon systems.

Regarding to the above mentioned investigations for studying of the phase-change or two-phase flow using CFD method, it has been tried to model a combination of the phase-change flow in a thermosyphon. For this purpose, a set of experiments in a novel and high efficient diffusion welded fin-plate thermosyphon (FPT) were

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