International Communications in Heat and Mass Transfer 61 (2015) 140–145

Contents lists available at ScienceDirect

International Communications in Heat and Mass Transfer

journal homepage: www.elsevier.com/locate/ichmt

Thermal cooling enhancement techniques for electronic components ☆

P. Naphon [a,*], S. Wiriyasart [a], S. Wongwises [b]

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

[b] Fluid Mechanics, Thermal Engineering and Multiphase Flow Research Lab. (FUTURE), Department of Mechanical Engineering, King Mongkut's University of Technology Thonburi, 91 Suksawas 48, Bangmod, Bangkok 10140, Thailand

ARTICLE INFO

Available online 27 December 2014

Keywords:
Thermal cooling enhancement
Vapor chamber
Electronic cooling

ABSTRACT

Due to highly effective thermal spreaders, the vapor chambers have been widely applied on the electronic cooling. An effective thermal spreader can achieve more uniform heat flux distribution and thus enhance heat dissipation of heat sinks. This work investigates the thermal performance characteristics plate-fin vapor chamber. Parametric studies including different operating operation of CPU, coolant types, working fluids, filled ratios, flow direction of coolants, heat sink configurations, and the effect of the relevant parameters on the cooling performance in terms of the thermal resistance was considered and discussed. The results showed that the relevant parameters have a significant influence on the thermal resistance of the vapor chamber.

1. Introduction

One of the most common questions any computer manufacturer receives from customers is “Why does my notebook/PC generate so much heat?”. Heat is a normal by-product of electronic devices operation which depends on the model of a particular computer or electronic devices. For instance, a high performance computer generates considerably more heat than a lower performance computer. In fact, heat output is generally a sign that this device is operating as safely and as efficiently as possible. If the computer/electronic devices cannot disburse its heat, it may overheat and develop problems. It is normal for a high performance device to feel warm to the touch due to the high-performance processor and graphics capabilities.

All electronic devices require electricity to function, and some computer components require more electricity than others. Some components only require a small amount of electricity to function and their generated heat is negligible. Other components, the Central Processing Unit (CPU) and Graphics Processing Unit (GPU), require considerably more electrical input. The amount of electricity used by those components depends on the kind and number of applications running. The following components generate the most heat in a computer or electronic components:

- The Central Processing Unit (CPU) generally handles processes that are not graphics intensive, such as number crunching data in a spreadsheet program or handling text input in a word processor.
- The hard disk drive (HDD) contains small disks that spin as information is written and accessed by other components. A steady flow of electricity is needed to keep the disks spinning and this generates heat.
- The optical disk drive (ODD) can play CDs and/or DVDs. A HDD which uses magnets to read and write data, an optical disk drive uses a laser. Both the spinning and the laser require a large electrical input, and both can potentially generate considerable heat.

The generated heat from the various hardware components must be dispersed from the system. Heat is safely dispersed from electronic devices in the various ways. Numerous publications have reported on the heat transfer characteristics of the vapor chamber. Koito et al. [1] applied the mathematical model for predicting the heat transfer characteristics of the vapor chamber. Fairly good agreement was obtained from the comparison between the predicted results and the measured data. Chen et al. [2] studied the flat plate vapor chambers for cooling the electronic components. The calculated results have shown good agreements with the existing results. Hsieh et al. [3] performed to examine the effects of heat fluxes and operating temperatures on the vapor chamber thermal resistance. Vasiliev et al. [4] developed a new of loop heat pipe for cooling of high-power IGBT elements. Ming et al. [5] considered effects of heat flux, filling amount and gravity to the performance of the vapor chamber. Wang et al. [6] analyzed the thermal performance of a board-level high performance flip-chip ball grid array package equipped with copper particles. The effect of different heat source sizes was also examined. Wong et al. [7] studied the performance of a novel vapor. Both the evaporation resistance and the condensation resistance decreased with increasing heat load. Wang et al. [8] investigated the thermal performance of the vapor chamber

☆ Communicated by W.J. Minkowycz.

* Corresponding author.
E-mail address: paisarnn@g.swu.ac.th (P. Naphon).

http://dx.doi.org/10.1016/j.icheatmasstransfer.2014.12.005
0735-1933/

and apply to high-power LEDs. Li et al. [9] experimentally studied the effects of the width, height and number of fins and of the Reynolds number on the thermal performance of plate-fin vapor chamber heat sinks. Tsai et al. [10] experimentally investigated a two-phase closed thermosyphon vapor-chamber system for electronic cooling. Effects of heating power, fill ratio of working fluid, and evaporator surface structure on the thermal performance of the system were considered. Harmand et al. [11] applied a transient model with the coupling 3D thermal model to analyze the thermal cooling of a flat heat pipe for cooling of multiple electronic components. Li and Chiang [12] investigated the effects of a shield on the thermal and hydraulic characteristics of plate-fin vapor chamber heat sinks under cross flow cooling. Attia and El-Assal [13] considered the effects of working fluid surfactant on the thermal performance vapor chamber with different charge ratios. Ji et al. [14] considered the effects of an extended vapor chamber which consisting of an evaporator part and an extended condenser part on the vapor chamber thermal performance. Tsai et al. [15] investigated the influence of inclination on the vapor chamber performance and temperature uniformity. Chen et al. [16] studied thermal resistance of sintered aluminum powders vapor chamber. Hassan and Harmand [17] applied the three-dimensional transient model for considering the thermal performance of vapor chamber. A good agreement was obtained between the predicted results and the measured data. Peng et al. [18] designed and analyzed a new pattern of wick on the vapor chamber thermal resistance. Peng et al. [19] experimentally investigated the heat transfer performance of a novel flat plate heat pipe for electronic cooling. The experimental results indicated that the filling ratio and vacuum degree had a significant influence on thermal performance of the heat pipe.

As mentioned above, the numerous papers presented the study on the heat transfer characteristics of the vapor chamber for cooling electronics devices with air or water as working fluids. However, in modern CPU, the temperature inside the CPU can rise to as high as 100 °C. The heat transfer capability is limited by the working fluid transport properties. In this work, an experimental study is conducted to thermal cooling of CPU of personal computer with different cooling techniques as follows;

- CPU cooling with heat sink using air as coolant
- CPU cooling with heat sink using de-ionized water as coolant
- CPU cooling with vapor chamber (water) using water as coolant
  - ○ Conventional flow cooling system
  - ○ Jet impingement cooling system
- CPU cooling with vapor chamber (refrigerant R141b) by using water as coolant
  - ○ Conventional flow cooling system
  - ○ Jet impingement cooling system

2. Experimental apparatus and method

2.1. Experimental apparatus for CPU cooling with vapor chamber/heat sink by using air as coolant

The test loop consists of a set of PC, a set of vapor chamber cooling system and data acquisition system. A schematic diagram of the vapor chamber cooling system with air as coolant is shown in Fig. 1(c). The

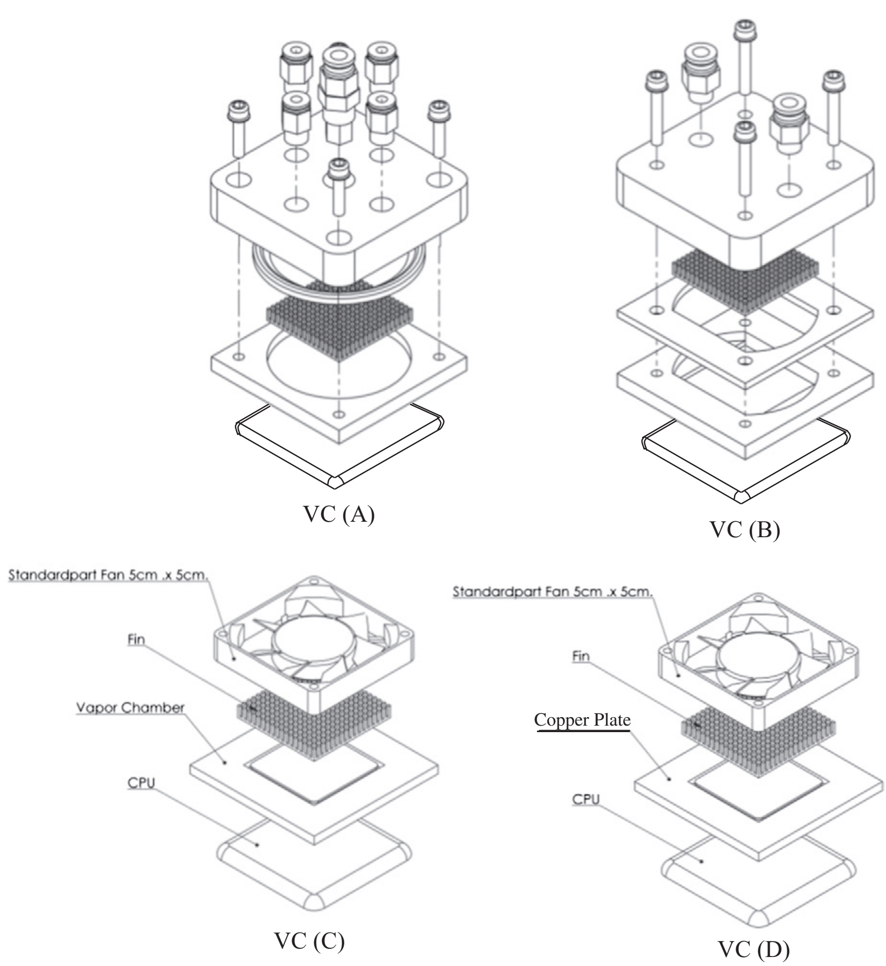

Fig. 1. Schematic diagram of the cooling techniques.