THERMAL PERFORMANCE OF COMPUTER MICRO-PROCESSOR USING MICROCHANNEL HEAT SINK WITH NANOFLUIDS

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by

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u	Fluid flow velocity component in x-direction
v	Fluid flow velocity component in y-direction
w	Fluid flow velocity component in z-direction
P	Pressure
x, y, z	Cartesian coordinates
T	Temperature
k	Thermal conductivity
c_p	Specific heat capacity
Re	Reynolds Number
h	Heat transfer coefficient
ρ	Density
μ	Dynamic viscosity
φ	Volume fraction of nanoparticle
R	Thermal resistance
ΔT	Temperature difference
Q	Heat input
Q_f	Flow rate
ΔP	Pressure difference
P_{pump}	Pumping power
q	Heat transfer

LIST OF ABBREVIATIONS

FVM	Finite Volume Method
IMCHS	Interrupted Microchannel Heat Sink
MCHS	Mircochannel Heat Sink
3-D	Three-Dimensional

PRESTASI THERMA DALAM MIKRO-PEMPROSSESAN KOMPUTER DENGAN MENGGUNAKAN NANOFLUID DALAM MIKRO PENYERAP HABA

ABSTRAK

Dalam perkembangan teknologi elektronik yang pesat, permintaan terhadap komputer berkapasiti tinggi semakin meningkat setiap tahun. Apabila kapasiti komputer semakin meningkat, haba yang dihasilkan daripada komponen pemprosesan semakin meningkat semasa berfungsi. Dengan ketiadaan pengurusan haba yang sesuai, haba tinggi yang dihasilkan tersebut akan menyebabkan suhu tinggi pada komponen pemprosesan komputer dan akibatnya prestasi komputer akan menurun sehingga pada akhirnya komponen akan mengalami kerosakan. Pada masa yang sama, proses pengecilan saiz komponen elektronik yang berterusan itu menyumbang kesan impak terhadap saiz sistem penyejukkan yang dihubungkan kepada komponen pemprosesan komputer tersebut. Secara amnya, dalam teknologi sistem penyejukkan yang sedia ada, saiz sistem penyejukkan konvensional telah digunakan dalam pasaran and pelbagai jenis medium penyejukkan digunakan untuk menyerap dan membebaskan haba. Walaubagaimanapun, kapasiti penyejukkan bagi sistem penyejukkan konvensional tersebut adalah terhad dan tidak mampu mengeluarkan haba tinggi daripada komponen pemprosesan komputer yang berkapasiti tinggi. Selain itu, saiz yang besar tidak dapat dimuatkan ke atas komponen pemprosesan komputer yang semakin kecil. Dengan itu, langkah - langkah yang sesuai untuk menangani masalah pengurusan haba yang tinggi dan fizikal saiz yang kecil bagi sistem penyejukkan adalah diperlukan. Sebagai penyelesaiannya, mikro penyerap haba telah diperkenalkan. Dalam penyelidikan tersebut, pelbagai parameter (hilang tekanan [range: 20Pa – 38Pa], suhu [range: 342K – 354K] and Reynolds Number [range: 70 – 1150]), fizikal dimensi dan bentuk saluran penyerap haba (segi empat panjang, tiga segi dan trapezoid) telah dipertimbangkan and

dianalisis terhadap impaknya ke atas prestasi mikro penyerap haba. Penyelidikan tersebut telah dijalankan melalui kaedah simulasi. Dalam kaedah eksperimen, pelbagai medium penyejukkan digunakan iaitu air penyulingan dan nanofluid (air penyulingan + alumina Al_2O_3, dan air penyulingan + silica SiO_2) dengan kandungan zarah-zarah nano yang berlainan (1%, 2% and 3% kandungan). Manakala dalam kaedah simulasi, komputer pengisian FLUENT berdasarkan Finite Volume Method (FVM) telah digunakan untuk menyimulasikan keupayaan mikro penyerap haba. Keputusan kajian tersebut menunjukkan bahawa faktor fizikal dimensi dan bentuk memberikan kesan impak yang tinggi terhadap prestasi haba bagi mikro penyerap haba. Dengan itu, saluran berbentuk segi empat panjang mampu memindahkan haba yang tinggi berbanding dengan bentuk saluran mikro yang lain, tetapi ia menunjukkan prestasi hidrodinamik yang rendah. Sebaliknya, mikro saluran segi tiga menunjukkan prestasi pemindahan haba yang rendah walaupun prestasi hidrodinamik yang tinggi. Analisis terhadap kesan jenis zarah – zarah nano (Al_2O_3 dan SiO_2) dan kandungannya (1%, 2% dan 3% kandungan) dalam asas medium penyejukkan ke atas prestasi mikro penyerap haba telah dijalankan dalam kajian tersebut. Hasil analisis tersebut menunjukkan bahawa kehadiran zarah – zarah nano dalam asas medium penyejukkan dapat meningkatkan prestasi penyejukkan sebanyak 40% berbanding dengan penggunaan air penyulingan sahaja. Manakala dengan peningkatan kandungan zarah – zarah nano dalam asas medium penyejukkan, kadar penyejukkan meningkat. Walaubagaimanapun, kuantiti kandungan zarah – zarah nano yang rendah tidak mempengaruhi prestasi hidrodinamik bagi mikro penyerap haba. Sebagai kesimpulannya, kesan fizikal dimensi, bentuk saluran mikro dan kehadiran zarah – zarah nano dalam asas medium penyejukkan merupakan faktor – faktor penting dan menunjukkan impaknya yang jelas ke atas prestasi saluran mikro penyerap haba. Bagi menunjukkan keputusan simulasi yang dihasilkan itu menyakinkan, kaedah eksperimen telah dijalankan bagi mengesahkan keputusan tersebut.

THERMAL PERFORMANCE OF COMPUTER MICRO-PROCESSOR USING MICROCHANNEL HEAT SINK WITH NANOFLUIDS

ABSTRACT

In the rapid development of electronic technology, the demand of high capacity in computer performance is increasing every year. The higher the performance of computer the higher the heat will be released from the computer processor. Without proper management of the heat release, the generated high heat will cause computer performance deteriorate due to high temperature and may cause damage consequently. Furthermore, the continuous miniaturization process of electronic component has contributed impact to the size of cooling system which is incorporated with the electronic component. As commonly found in the current technology of cooling system, the conventional size of cooling system is used, and various medium are applied through the cooling system for heat removal purpose. The heat removal capacity of conventional cooling system is limited which is not able to dispel the high heat that generated from high performance computer processor. Furthermore, the larger size of the conventional cooling system can not be fitted into the smaller size of electronic components of the processor. As a result, a proper approach of managing the high heat issue and proper physical size of cooling system is required, in which microchannel heat sink is introduced. In the research work, various operating conditions (pressure drop [range: 20Pa – 38Pa], temperature [range: 342K – 354K] and Reynolds Number [range: 70 – 1150]), physical dimensions and channel configurations (rectangular, triangular and trapezoidal) are considered and analysed in order to investigate their impact on the microchannel heat sink performance in terms of pressure drop, pumping power, thermal resistance, and heat transfer coefficient. Besides this, various cooling working medium has been used such as distilled water and nanofluid (Distilled Water H_2O + Alumina

Al_2O_3 and Distilled Water H_2O + Silica SiO_2) with various concentrations of nanoparticles (1%, 2% and 3% concentration). Simulation work by applying Finite Volume Method (FVM) in FLUENT software has been carried out to simulate the engineering results for the performance of microchannel heat sink. It is found that the physical dimension and geometrical channel configuration have obvious impact on the microchannel heat sink performance in which the case of rectangular channel that provides the highest heat transfer performance. Besides this, the research work also shows that the effect of different types and concentrations (1%, 2% and 3% concentrations) of nanoparticles within cooling medium plays important role onto the microchannel heat sink performance. The increment of cooling performance by 40% can be achieved by adding nanoparticles into cooling medium as compared with pure distilled water. Furthermore, the increment of cooling rate also can be achieved by the increment of nanoparticles concentration. In the research work, nanofluid Alumina provides the higher cooling rate as compare with pure distilled water and nanofluid Silica due to the effect of high thermal conductivity. However, the small amount of nanoparticles concentration would not affect hydrodynamic performance of microchannel heat sink. As a result, the physical dimension, channel geometrical configurations, existence of nanoparticles within cooling medium are vital factors that able to affect and incur obvious impact on the performances of microchannel heat sink hydrodynamically and thermally. To ensure the result of the simulation work above is reliable, the experimental works have been carried out for validation and comparison.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Cooling is a very important process in removing the generated heat from an equipment, like electronic components, air-conditioning systems, engine, fuel cells, etc. Without cooling process, the successive generated heat will cause high temperature and the high temperature effect will then causes deterioration in performance and may damage seriously. In order to overcome the high temperature that generated from heat, the cooling process is required. There are various cooling equipments are available in industrial technology such as heat exchanger systems, heat pipe, radiator, condenser, and heat sink. Figures 1.1 and 1.2 show the examples of cooling equipment for electronic component. In conjunction with the use of these cooling equipments, there are various types of working medium are used in these cooling equipments, such as air, water, R-12, R-113, R-141b, R-124, R-134a, ethanol, etc, as coolant to absorb and transport the heat for removal.

In electronic industries for computer technology, cooling process for the electronic components is vital in order to maintain their high performance in function and prevent any damage that caused by the high temperature effect. For instant, microprocessor in CPU (Central Processing Unit) of the high performance computer system. The study of fluid flow and heat transfer for cooling process of the processor has been carried out substantially by various researchers around the world. However, there is still having several issues which have not been investigated. Hence, the related issues have been identified and studied in this research as complimentary for the previous research works, and finally reported / documented in the following chapter in this thesis.

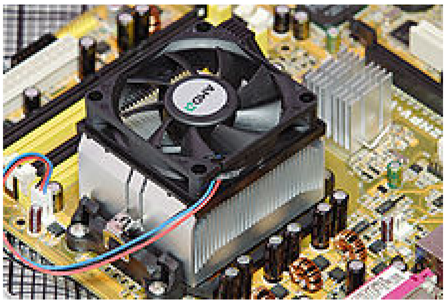
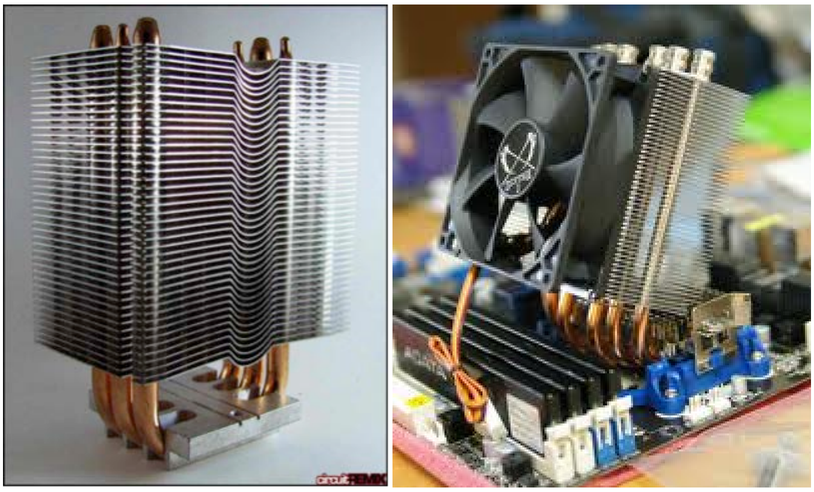


Figure 1.1: Computer processor cooling by heat sink with the application of fan.

(Source: https://en.wikipedia.org/wiki/Computer_cooling#/media/File:AMD_heatsink_and_fan.jpg)



(a) (b)

Figure 1.2: Heat pipe with fins for cooling.

(Source: Figure (a)-http://liquid-cooling.org/wp-content/uploads/2014/05/Figure-9-Sample-heat-sink-with-heat-pipe-Source-circuitremix.com-.png,

Figure (b)-https://en.wikipedia.org/wiki/Computer_cooling#/media/File:Heatsink_with_heat_pipes.jpg)

1.2 Problem Statement

As can be seen in the available cooling heat sink design, various configuration of fin has been designed to suit specific engineering application as shown in Figures 1.3. The example of heat sink assembly onto computer CPU board is also shown in Figure 1.3(e).