UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ENHANCE THE CPU COOLER PERFORMANCE USING EVAPORATIVE COOLING METHOD

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) (Hons.)

by

MOHD ARIFF BIN NORDIN

B071310555

931118145199

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Name : **MOHD ARIFF BIN NORDIN**

Date : **9 DECEMBER 2016**

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Refrigeration and Air-Conditioning System) (Hons.). The member of the supervisory is as follow:

....

(Noor Saffreena Binti Hamdan)

NOOR SAFFREENA BINTI HAMDAN
Pensyarah
Jabatan Teknologi Kejuruteraan Mekanikal
Fakulti Teknologi Kejuruteraan
Universiti Teknikal Malaysia Melaka

ABSTRACT

The central processing unit (CPU) is a part of computer that executes instructions of a software program. The CPU is responsible for processing most of the data within the systems and as data is processed within a system, heat is generated. To overcome the CPU overheating, cooling systems that help to regulate the temperature and maintaining efficient operation had been introduced. This study introduces CPU cooler using evaporative cooling method to enhance the performance of the current CPU cooler. Evaporative cooling method cools the air through evaporation of water. The temperature of dry air can be dropped significantly through the phase transition of liquid to vapour which can cool air with less energy consumption. To overcome the overheating of the CPU is vital as it can prevent the CPU from damaged or malfunction. Current CPU cooler that using air system only is lack in efficiency as it uses only air to cool the CPU. It doesn't produce enough cooling to reduce temperature of the CPU while it is running on its full power. The objective of the project is to design and to fabricate the CPU cooler that using evaporative cooling method as its cooling system made up of PVA sponge, electric cable junction box and CPU cooler. Plus, the objectives of this project also to test the efficiency of the designed CPU cooler and to compare it with current CPU. This project will focus on designing and fabricating the CPU cooler that using evaporative cooling method as its cooling system. The design process of this product will be carried out using SolidWork software. The CPU cooler will be tested on a desktop computer running with AMD Athlon (tm) Dual Core Processor with 1gb RAM located in the living room under normal condition temperature. At the end of this project, after the implementation of the evaporative cooling, the temperature of the CPU can be reduced up to 5^{0}C. The humidity inside the desktop casing increased only 2% from normal condition.

ABSTRAK

Unit pemprosesan pusat adalah salah satu komponen di dalam komputer yang bertanggungjawab untuk memproses data di dalam sesebuah sistem dan apabila data diproses, haba terhasil. Untuk mengatasi masalah unit pemprosesan pusat menjadi terlalu panas, sistem penyejukan untuk mengawal suhu optimum dan menyelaras operasi yang berkesan telah diperkenalkan. Kajian ini memperkenalkan penyejuk unit pemprosesan pusat menggunakan penyejukan penyejatan untuk menambah baikkan prestasi penyejuk unit pemprosesan pusat sedia ada. Penyejukan penyejatan menyejukkan angin melalui penyejatan air. Suhu angin boleh diturunkan dengan mendadak dengan menggunakan tenaga yang kurang. Untuk menyejukkan unit pemprosesan pusat penting untuk mengelakkan kerosakan sistem ataupun kerosakan unit pemprosesan pusat itu sendiri. Penyejuk unit pemprosesan unit yang menggunakan angin seebagai medium penyejukan tidak memberikan penyejukan yang mencukupi untuk menurunkan suhu unit pemprosesan unit apabila ia bekerja dalam kuasa yang penuh. Objektif kajian ini adalah untuk mereka dan membina penyejuk unit pemprosesan pusat yang menggunakan penyejukan penyejatan sebagai medium penyejukan dibuat daripada PVA span, kotak kabel dan kipas CPU. Tambahan itu, objektif kajian ini adalah untuk melihat keupayaan penyejukan penyejuk unit pemprosesan pusat yang direka dan membandingkan ia dengan penyejuk unit pemprosesan pusat yang sedia ada. Proses rekaan akan dibuat menggunakan perisian SolidWork. Penyejuk unit pemprosesan unit itu akan diuji di komputer yang AMD Athlon (tm) Dual Core Processor dan 1gb RAM yang terletak di ruang tamu dengan suhu bilik. Di akhir projek ini, selepas penggunaan penyejukan penyejatan, suhu unit pemprosesan pusat dapat dikurangkan sebanyak 5^{0}C. Kelembapan di dalam bekas komputer itu meningkat sebnayak 2% sahaja daripada keadaan asal.

DEDICATION

I dedicate this Thesis to my beloved parents who inspired me to become who I am now. My parents who taught me a lot in life. Without my parents, I am no one. I dedicate my sincere gratitude to them for their scarification to raise me and to love me wholeheartedly without any doubt. I cannot find any suitable words that could properly describe my appreciation towards their devotion, support and have faith in my ability to do anything that I like. Their support that keeps me going to persuade my dreams and goals in life. Also, I would like to send my gratitude to all the person that contributes for this final year project directly or indirectly. I would like to acknowledge their ideas and suggestions which help for the completion of this report.

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LIST OF SYMBOLS AND ABBREVIATIONS

CPU	-	Central Processing Unit
PC	-	Personal Computer
C	-	Capacitance
V	-	Voltage
f	-	Frequency
P	-	Power

CHAPTER 1

INTRODUCTION

In this chapter, introduction is the most important topics that involved background study, problem statement, objectives, and works scope of the project and the thesis organization of overall chapters.

1.1 Background study

Nowadays the usage of personal computer (PC) is increasing as many things can be done using PC. The central processing unit (CPU) is a part of computer that executes instructions of a software program. The CPU is responsible for processing most of the data within the systems and as data is processed within a system, heat is generated. Moore's Law appears to be still holding as CPU speed increases, the heat generated is also increases (Davis, Weymouth, & Clarke, 2006). Modern CPU is built compact and thinner that can lead to increase in heat dissipation and higher heat density, making CPU temperature rise and causing malfunction or permanent damage. To overcome the CPU overheating, cooling systems that help to regulate the temperature and maintaining efficient operation had been introduced. CPU cooling devices are important for the computer manufacturers to offer an optimal performance (Chemieingenieurwesen et al., 2007). This study introduces CPU cooler using evaporative cooling method to enhance the performance of the current CPU cooler. Evaporative cooling method cools the air through evaporation of water. Energy is lost as water evaporates (Bucklin, Henley, McConnell, Florida Cooperative Extension Service, & Palmm Project, 2004). The temperature of dry air can be dropped significantly through the phase transition of liquid to vapor which can cool air with less energy consumption. The evaporative cooling method is efficient to use for the relief of stress (Berman, 2006).

1.2 Problem statement

To overcome the overheating of the CPU is vital as it can prevent the CPU from damaged or malfunction. Current CPU cooler that using air system only is lack in efficiency as it uses only air to cool the CPU. It does not produce enough cooling to reduce the temperature of the CPU while it is running on its full power. Plus the air-based CPU cooler performance is depend on the surrounding temperature as it blows air from the outside to cool the CPU.

1.3 Objectives

In order to complete this project, the objectives have been declared and must be achieved. The most important objectives of the project are:

1. To design and to modify the conventional air CPU cooler
2. To test the cooling performance of the designed CPU cooler
3. To compare the cooling performance of the designed CPU cooler with conventional air CPU cooler

1.4 Project scope

This research will focus on designing and fabricating the CPU cooler that using evaporative cooling method as its cooling system. The design process of this product will be carried out using AutoCAD software. The fan cooler dimensions that will be used is 140x140x25mm and PVA sponge is the type of sponge that will be used. The CPU cooler will be tested on a custom desktop computer running with

AMD Athlon (tm) Dual Core Processor with 1gb RAM located in the living room under normal condition temperature.

1.5 Organization of the thesis

This report has been divided into five chapters. The five chapters are introduction, literature review, methodology, findings and results and conclusion and recommendation. Chapter 1 is the introduction of the project including the background study, problem statement, objectives and work scope. Chapter 2 is written about the literature review based on the theories and experiment from previous journals. Chapter 3 is the methodology that is used in this project. Chapter 4 indicates all results and discussion with analysis. Chapter 5 shows the most important conclusion and recommendation for future work.

CHAPTER 2

Literature review

The review in this chapter focuses on the introduction on CPU, factors and effect of CPU heat generation, introduction on CPU cooler and types of CPU cooler. Additionally, evaporative cooling method also has been covered in this chapter including its advantages.

2.1 Central processing unit (CPU)

Central processing unit (CPU) is the electronic circuitry that is located within a computer and it functions as to carry out the instructions of a computer program by performing operations such as basic arithmetic, logical, control and input/output operations specified by the instructions (Weik, Martin H, 1961). Traditionally, the term "CPU" refers to a processor, emphasize on its processing unit and control unit. The form and the design of CPU have changed over time but their basic operation remains the same. The principal components of a CPU include the arithmetic logic unit (ALU) that performs arithmetic and logic operations, processor registers that supply operands to the ALU and store the results of the ALU operations and a control unit that fetches instructions from memory and executes them by directing the coordinated operations of the ALU, registers and other components (Kuck, David, 1978).

Most of the current CPUs are microprocessors. They are placed on a single integrated circuit (IC) chip. An IC that contains a CPU may also contain memory, peripheral interfaces and other components of a computer. Some of the computers nowadays employ a multi-core processor, which is a single chip containing two or more CPUs called cores (Thomas Willhalm, Roman Demntiev, Patrick Fay, 2014). Array processors or vector processors have multiple processors that operate in parallel with no unit considered central. Figure 2.1 shows one of examples of microprocessor. It is the first Pentium microprocessor that was introduced by Intel. Its micro architecture was the fifth generation for Intel and the first superscalar IA-32 micro architecture. As a direct extension of the 80486 architecture, it included dual integer pipelines, a faster floating-point unit, wider data bus, separate code and data caches and features for further reduced address calculation latency. There were two versions, specified to operate at 60MHz and 66MHZ respectively. This first implementation of the Pentium used a traditional 5 volt power supply and resulted in relatively high energy consumption for its operating frequency when compared to the later models (Suzanne Deffree, 2016).

Figure 2.1: Central processing unit

(tomshardware.com)

2.2 Factors and effects of CPU heat generation

CPU produces heat while it is running just like all electronic components. However, heat in excess is not good for the CPU and this can lead the CPU to malfunction or even can cause permanently damage to the CPU. Microprocessors heat due to Joule effect which is the process of transforming electrical energy into heat. Joule's first law expresses the relationship between the heat generated and current flowing through a conductor. Inside the CPU, there are several wires or conductors in charge of its internal interconnections. The joule effect appears due to the shock between electrons and the conductor ion mesh, leading to an increase in the temperature of the conductor (Torres G and Lima C, 2007). Plus, Moore's Law appears to be still holding and as CPU speed increases, the heat generated also increases (Davis et al., 2006).

There are several factors that contribute to the CPU power consumption that is dynamic power consumption, short-circuit power consumption and power loss due to transistor leakage currents where Pcpu = Pdynamic + Pshort + Pleak(Vogeleer, Memmi, Jouvelot, & Coelho, 2013). Heat is produced by these three basic sources of power consumption in a processor. The dynamic power consumption comes from the activity of logic gates inside a CPU. When the logic gates toggle, energy is flowing as the capacitors inside them are charged and discharged. The dynamic power consumed by a CPU is approximately proportional to the CPU frequency, and to the square of the CPU voltage. It can be shown in the below equation;

$$P = CV^2 f$$

Equation 2.1(Paper, 2004)

Where C is capacitance, f is frequency and V is voltage.

When logic gates toggle, some transistors inside may change states. As this takes a finite amount time, it may happen that for a very brief amount of time some transistors are conducting simultaneously. A direct path between the source and ground is the results in some short-circuit power loss. The magnitude of this power is dependent on the logic gate and is rather complex to model on a macro level (Vogeleer et al., 2013).

Power consumption due to leakage power emanates at a micro-level in transistors. Small amounts of currents are always flowing between the differently doped parts of the transistor. The magnitude of these currents depends on the state of the transistor, its dimensions, physical properties and sometimes temperature. The total amount of leakage currents tends to inflate for increasing temperature and decreasing transistor sizes (Vogeleer et al., 2013).

There are some other factors that can affect the CPU temperature range. Room temperature is one of them. Ambient room temperatures can affect CPU temperature by 5C to 10C. As a rough calculation, 1C rise in room temperature is equal to 1C to 1.5C rise in CPU temperature (Matt Bach, 2012). Other than that, casing of the computer also can affect the CPU temperature range. A CPU can run 8C to 10C cooler in a spacious computer case with good ventilation compared to a small, cramped case filled with dust. The heat inside the casing of the computer needs to be carried out with good ventilation as it can affect the CPU temperature range (Hei tue, 2015).

2.3 Central processing unit(CPU) cooler

To prevent the CPU from overheated, computer cooling is required to remove the waste heat produced by computer components to keep all the components inside within permissible operating temperature limits. Components that are susceptible to temporary malfunction or permanent failure if overheated include integrated circuits such as CPU, chipset, graphics card and hard disk drives. Usually, components are designed to generate little heat as possible. Computers and operating systems designed to reduce power consumption and consequent heating according to workload but more heat may still be produced than can be removed without attention to cooling. Use of heat sinks cooled by airflow reduces the temperature rise produced by a given amount of heat. Generally, computer fans are widely used along with heat sinks to reduce temperature by actively exhausting hot air. There are also more exotic cooling techniques such as liquid cooling. Modern processors are designed to cut out or reduce their voltage or clock speed if the internal temperature of the processor exceeds a specified limit. Cooling may be designed to reduce the ambient temperature within the case of a computer for example by exhausting hot air or to cool a single component or small area. Components commonly individually cooled include the CPU, GPU and the northbridge (Rittidech, Boonyaem, & Tipnet, 2005).

2.4 Types of CPU cooler

2.4.1 Air Cooling

Air cooling type of CPU cooler uses fan to remove the excessive heat of the CPU. The main function of fan is to pump air so that heat is effectively blown away from the CPU assembly. Air pressure can vary by incorporating fans in series or parallel configurations. The parallel setup increases the areas coverage while the series setup increases the discharge pressure. With the growing requirements of CPU cooling in the marketplace, air-cooling technology is insufficient to keep and as a result of these deficiencies, a number of new cooling technologies have been developed while other advanced cooling technologies are currently under study(Carr, 2013). Figure 2.2 shows the conventional air cooling type of CPU cooler.

Figure 2.2: Air CPU cooler

(www.corsair.com)

2.4.2 Heat Sink

Heat sink is also one of the simple CPU cooling solutions. Heat sink is a component assembly that transfers heat generated within a solid material to a fluid medium such as air or a liquid (Mohammed,R.K; Yi Xia: Sahan, R.A; Pang. Y, 2012). Heat sink uses its extended surface to extend the surface of the material that is in contact with air or liquid. There are several factors that affect the heat sink that are air velocity, choice of material and fin design (Carr, 2013). Figure 2.3 shows the basic heat sink.

Figure 2.3: Heat sink

(www.globalspec.com)

2.4.3 Heat Pipe

Heat pipe is an evacuated and sealed pipe that contains a small amount of working fluid and a wick structure (Ye Li, Tong Zhengming, Huang Liping, Chen Hao, 2012). Heat pipe is structure that is added to a heat sink. Inside the heat pipe contains liquid that flows to cool the CPU and the heat sink functions as to carry the heat away from the liquid. The liquid in the pipe does not require power source as it uses the natural convection of liquid for distribution (Carr, 2013). Heat pipes have three primary advantages that are the heat pipes help to distribute heat thereby increasing thermal conductivity. Plus, heat pipes also serve as a heat conductive path for transmitting heat from one location to another. And lastly the heat pipe effectively increases the conductivity and the efficiency of the traditional heat sink (Ye Li, Tong Zhengming, Huang Liping, Chen Hao, 2012). Figure 2.4 shows the basic heat pipes system.