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The effect of changes in the fluid flow rate of Virgin Coconut Oil (VCO) on the immersion cooling process

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Abstract. The cooling system in computer equipment generally uses a conventional fan, where the heat transfer occurs by radiation so that the level of heat absorption is not optimal in computer components that generate heat. In overcoming these problems, a cooling system using the immersion cooling method is used. The use of an immersion cooling system on computer equipment aims to compare the temperature drop on CPU performance using conventional cooling and immersion cooling. In testing the computer system will be operated for 24 hours with maximum CPU performance. Variations of the immersion cooling system in the form of flow rates of 2, 4 and 6 lpm with variations in the rotation of the radiator fan at 200, 400 and 600 rpm. The results of the test show that the temperature reduction that can be achieved by conventional cooling is 71.2°C, while the temperature decrease in the immersion cooling system with the best variation is at a water rate of 6 lpm and a fan rotation of 600 rpm is 42.8°C. The results of the test can be seen that the immersion cooling system can significantly reduce the working temperature of the CPU.

1. Introduction

In line with the development of information technology, the use of the internet in the world is increasing. Reporting from the digital report We Are Social in 2020 the number of internet users reached 4.5 billion million people in the world. This figure shows that internet users have reached more than 60 percent of the world's population with a total of 7.7 billion million people. This data continues to increase compared to the previous year which was only 4.3 billion. Internet users in Indonesia itself has also increased. According to the Association of Indonesian Internet Service Providers (APJII) in 2020 there were almost 197 million. This number increased by 8.9% compared to 2019 with the figure of 195 million, in addition to the increase in the number of internet usage due to the rapid development of technology, it is also influenced by the outbreak of the covid 19 virus that has hit Indonesia since March 2020 [1]. During the pandemic, all activities are required to be carried out at home. Internet access is the main choice so that activities such as education, work, and others can still be carried out.

The development of the internet which has increased significantly has an effect on the data center, because the higher the use of the internet, the greater the need for processes and internet data. A data center is a centralized repository, both physical and virtual, for the storage, management, dissemination of data and information. Data center which literally means data center, is a facility to place computer systems and related equipment, such as data communication systems and data storage. Development in the data center will require the addition of new servers in order to meet the increasing spike in access. This equipment consumes 270 TWh of energy and reaches 1.4% of the world's total energy with 60% electrical power requirements and the cooling system reaches 40% of the total operational costs of the data center [2]. Based on these facts, the data center is currently facing two major problems, how to develop new services but with the consequence that power consumption for computing and cooling continues to increase. If this trend continues, the data center's ability to add new services will be hampered [3].

The data center cooling system consumes relatively a lot of electrical energy because most data centers use cooling by air cooling method where cooling uses a conventional fan. Computer cooling system is a device used to reduce or eliminate heat in computer components or CPU, especially in the processor [4]. Excessive heat in a computer system can cause overheating where it will affect computer performance and be followed by damage to computer components [5]. In general, there are two cooling systems used in a computer, namely the water cooling and liquid cooling systems [6].

In recent years, the liquid cooling system has developed because the cooling system using air cooling method, which uses fans and heatsinks, is not able to significantly reduce CPU temperature on computers with high specifications [7]. The use of a liquid cooling system has several advantages, such as the temperature reduction is faster and more efficient because it goes directly to the intended heat source, so that it can significantly reduce the working temperature of the CPU even in a state of maximum computer workload [8]. The use of a liquid cooling system also reduces noise on computer devices [7].

There are two cooling systems in liquid cooling, indirect cooling and direct cooling. Indirect cooling is the process of removing heat without direct contact, by flowing the fluid at the heat source through a hose, while direct cooling has direct contact between the heat source and the cooling fluid by immersing it directly into the coolant [6]. The direct cooling system began to be developed on electronic components, especially in the data center [9]. The advantage of the direct cooling system is that components that are immersed directly into the coolant experience direct heat transfer or convection so that the heat generated by the components can be directly transferred to the coolant [6]. Direct cooling or immersion cooling system is a cooling method by immersing the motherboard components of a computer into a non-conducting liquid so that the heat generated from the components can be transferred directly into the cooling liquid [10]. The dielectric fluid used in this test as a cooling fluid is virgin coconut oil (VCO).

The immersion cooling system works by absorbing heat from components that are immersed in coolant in a vessel, the fluid that absorbs heat from the components will be flowed into a heat exchanger in the form of a radiator, the fluid that has dropped its temperature in the radiator is then flowed back into the vessel to absorb heat back from the components. The process takes place in a circulation with the help of a pump [11,12]. In this study, the testing was conducted on the central processing unit (CPU) using virgin coconut oil (VCO) fluid with variations in flow rates of 2, 4 and 6 lpm and variations in radiator fan rotation of 200, 400 and 800 rpm. This study aims to compare the conventional cooling system and immersion cooling on CPU performance and determine the effect of immersion cooling with variations in flow rate using Virgin Coconut Oil on CPU temperature.

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2. Methodology

2.1. Design of Immersion Cooling System

The research method used is an experimental method which is carried out in several stages of research. The first stage is the design of the immersion cooling system on a central processing unit (CPU) as shown in Figure 1. The working system of the tool is to put the motherboard into a glass vessel with a volume of 11,250 cm^3 filled with VCO liquid. The radiator with the fan functions as a liquid cooling device for the VCO that carries heat away from the motherboard components. The flow meter is used as a regulator of the size of the flow rate while the thermocouple is used to measure the temperature of the VCO before and after passing through the radiator. after passing through the radiator the VCO will flow back into the glass vessel. The process takes place in circulation with the help of a submersible pump.

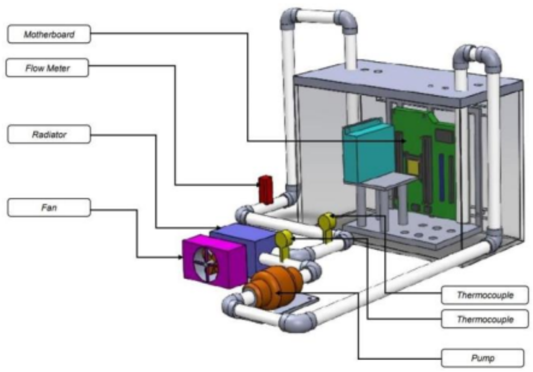

Figure 1. Design of immersion cooling system

2.2. Tools and Materials

The tools needed in this research include a glass vessel (30 x 25 x 15 cm), flow meter, thermocouple, hose 1.5 inch in diameter, radiator, radiator fan and submersible pump. While the materials needed are Virgin Coconut Oil (VCO) with specifications in Table 1 and Central Processing Unit (CPU) with specifications in Table 2.

Processing of instructions on the CPU consists of the operation of reading instructions (fetch) and instructions for controlling work functions or execute. On the CPU, the part that tends to generate heat when the computer is operated is the motherboard. On the motherboard there are several important components such as Processor, RAM, VGA, VGA slot, AGP, AGP slot and additional card slots [9].

Table 1. Specifications of Virgin Coconut Oil (VCO)

Parameter	
Kinematic Viscosity	49.5 mm^2/s
Flash Point	232°C
Pour Point	15.5°C
Kinematic Viscosity Temperature	40°C

Table 2. Specifications of Central Processing Unit (CPU)

Operating System	Microsoft windows 7 ultimateCopyright © 2009
System Manufacture	PCCHIPS
System Type	64-bit operating system
BIOS	Default System Bios
Processor	Intel (R), Core (TM), Dual CPUE28300, @2.83GHz 2.83 GHz
Memory	2,00 GB RAM
Direct Version	DirectX 9.0c (4.09.0000.0904)

2.3. Data Retrieval and Analysis
The variations used in testing the immersion cooling system are the fluid flow rate and the rotational speed of the radiator fan. Variations in flow rates are 2, 4 and 6 lpm while the fan speeds used are 200, 400 and 600 rpm which aims to determine the rate of decrease in computer temperature in each variation. Testing the computer system will be operated for 24 hours by running various software with the assumption of daily use so that the CPU works in maximum condition. CPU temperature data retrieval is done by running the HW monitor application on the computer which is carried out every 3 hours. The measurement data are CPU temperature, inlet channel temperature, and outlet channel temperature. The data obtained will be analyzed and presented in graphical form.

3. Results and Discussion

3.1. CPU Temperature with Conventional Cooling System
In this study, the computer system is operated for 24 hours with the assumption of daily use. In a period of 24 hours the CPU will work optimally so that the temperature measurement of the CPU can be carried out using a conventional cooling system and an immersion cooling system with a predetermined variable flow rate and radiator fan rotation. The aim is to find out how effective the influence of each variable in lowering the CPU temperature when working optimally. The conventional cooling temperature is the basis for comparison with the maximum temperature using immersion cooling. Figure 2 shows the initial CPU temperature reaching 86.4°C. The temperature that can be achieved by a conventional cooling system within 24 hours is the final temperature reaching 71.2°C. The room temperature tends to be normal, 31°C during the day and 28°C at night.

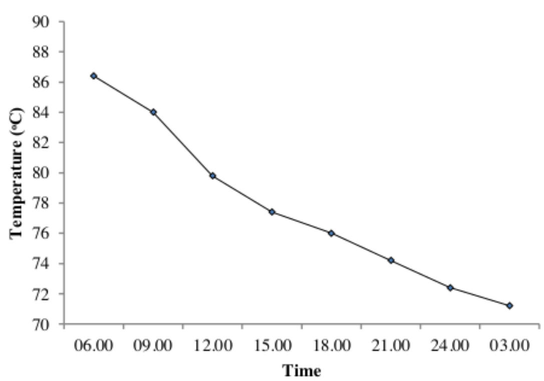

Figure 2. Conventional cooler CPU temperature graph

3.2. CPU temperature at a flow rate of 2 lpm
CPU temperature using an immersion cooling system at a flow rate of 2 lpm showed a greater temperature drop than conventional coolers. This shows that the immersion cooling system is able to

reduce the CPU working temperature more significantly. The graph of the decrease in CPU temperature is shown in Figure 3. At a fan rotation speed of 200 rpm there is a decrease in temperature, but the decrease in temperature is not significantly different compared to conventional coolers, the temperature is recorded at 72.8 °C. Fan rotation with 400 rpm temperature drop is more stable and there is no spike when compared to the rotation speed of 200 rpm. The final temperature that can be achieved on this variable is 64.8 °C. At a speed of 600 rpm, it shows that the decrease in temperature is more significant than the previous variation with a final temperature of 63.2 °C. The speed of 600 rpm cools the VCO faster so that the VCO has a lower temperature after passing through the radiator.

The spike in CPU temperature at a fan rotation of 200 rpm occurred in the 3rd to 6th measurements. The spike occurred because the VCO temperature in the vessel continued to increase because it absorbed heat from the CPU components when at maximum workload. The recorded VCO temperature at the time of the CPU temperature spike was 42°C to 46°C. It can be concluded that the reduced flow rate will impede the flow circulation so that heat tends to be trapped in a vessel, the slow fan rotation also causes the fluid heat transfer from the system to the environment not to be maximal [9].

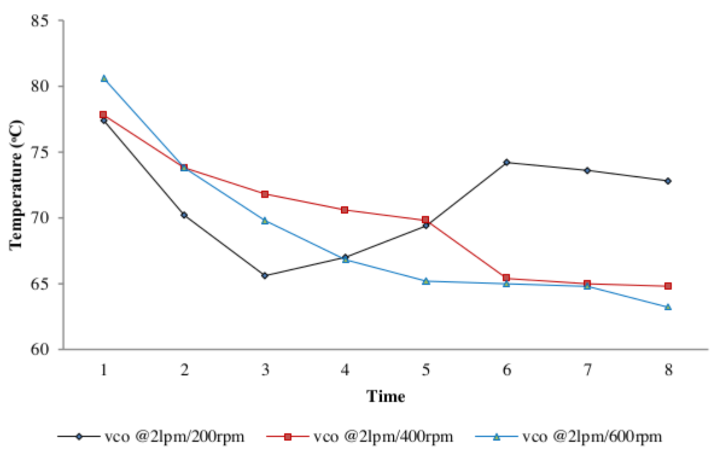

Figure 3. Graph of CPU temperature at a flow rate of 2 lpm

3.3. CPU temperature at a flow rate of 4 lpm

Measurement of CPU temperature at a flow rate of 4 lpm showed a greater decrease in temperature compared to a flow rate of 2 lpm. The maximum working temperature that can be achieved at a flow rate of 4 lpm is shown in Figure 4. The decrease in CPU temperature at a flow rate of 4 lpm with a fan rotation speed of 200 rpm indicates that the decrease that can be achieved is 64.2 °C. The decrease in temperature is smaller than the flow rate of 2 lpm with a fan rotation of 600 rpm, which is 63.2 °C because the rotation of the radiator fan at 600 rpm is more significant to restore the VCO temperature after carrying heat from the glass vessel.

In variations of fan rotation with a speed of 400 rpm the temperature decrease is more stable with an average decrease of 2 °C every 3 hours. At the initial measurement, the CPU temperature reached 85.2 °C. The initial temperature tends to be higher because the computer system does not experience a pause or off after testing at 200 rpm. The maximum temperature reduction that can be achieved on this variable is 62.8 °C. The CPU temperature at a flow rate of 4 lpm with a fan rotation speed of 600 rpm indicates that the maximum temperature that can be achieved is 61.8 °C. The decrease in temperature at 09.00-15.00 West Indonesia time tends to be slower than the previous two variables because the room temperature during the day increases by 32.2 °C compared to the normal temperature which is in the

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range of 30-31 °C. The decrease in CPU temperature is stable at 18.00-24.00 West Indonesia time because the temperature is back to normal, which is 28 °C so that the VCO is able to absorb heat from the motherboard optimally. At a flow rate of 4 lpm with 3 variations of fan speed, 200, 400, 600 rpm, it can be seen that the maximum temperature that can be lowered is 61.8 °C with a radiator fan speed of 600 rpm.

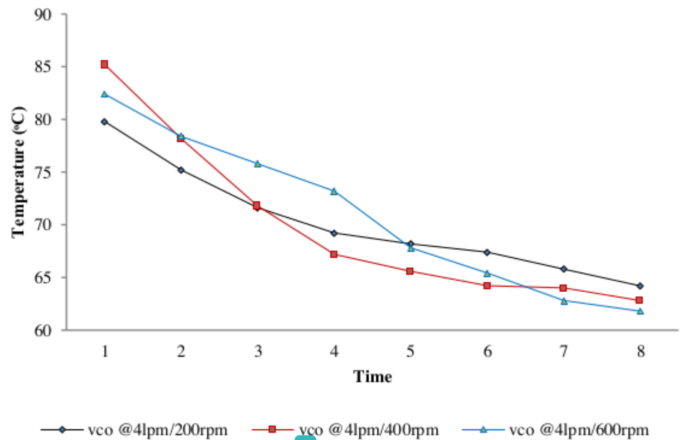

Figure 4. Graph of CPU temperature at a flow rate of 4 lpm

3.4. CPU temperature at a flow rate of 6 lpm

Figure 5, graph of CPU temperature at 6 lpm flow rate shows that the temperature drop is more significant than 2 lpm and 4 lpm flow rates. CPU temperature at a flow rate of 6 lpm decreased more rapidly than at a flow rate of 2 or 4 lpm. At a flow rate of 6 lpm with a radiator fan rotation of 200 rpm the temperature can be lowered to 56.4 °C, meanwhile, the decrease in temperature in the CPU with a radiator fan rotation speed of 400 rpm is greater than the previous variable. At 400 rpm the CPU temperature decreased with an initial temperature of 77.2 C to 49.4 °C with the same CPU workload.

At 600 rpm fan rotation, CPU temperature decreased more significantly than the previous variable. The temperature that can be achieved in this variable is 42.8 °C. The increase in flow rate causes the VCO to carry heat away from the CPU in the vessel. The glass will quickly flow to the radiator, while increasing the fan rotation on the radiator will quickly restore the VCO temperature. At a flow rate of 6 lpm the maximum working temperature of the CPU experienced a much more significant decrease than the previous variable which indicated that the flow rate and rotational speed of the enlarged radiator fan had a significant effect on the decrease in the working temperature of the CPU.

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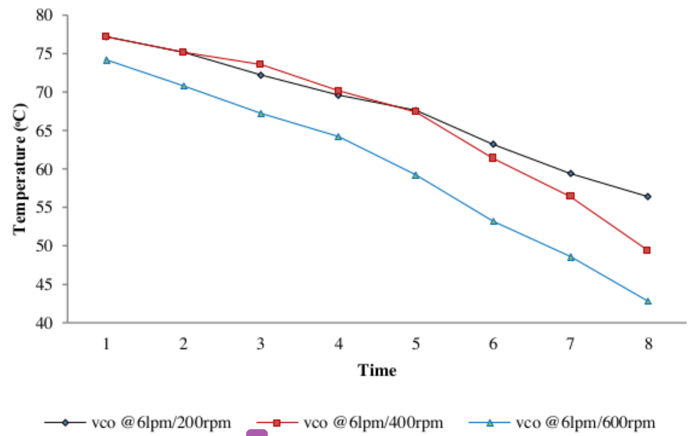

Figure 5. Graph of CPU temperature at a flow rate of 6 lpm

3.5. *Evaluation of Radiator Fan Flow Rate and Rotation Speed*

Immersion cooling is a cooling system by immersing the motherboard and other components that function to reduce heat in the Central Processing Unit (CPU). The heat generated by the CPU will be absorbed by convection by Virgin Coconut Oil (VCO) and then flowed to the radiator to be cooled by the fan. In this study, the data obtained show that the use of an immersion cooling system is better at lowering the temperature on the CPU compared to a conventional system. The maximum temperature that can be achieved within 24 hours when using a conventional cooling system is 71.2 °C while the maximum temperature that can be achieved by an immersion cooling system is 42.8 °C at the highest flow rate and fan rotation.

The heat transfer system in the immersion cooling process occurs by convection. Convection heat transfer is heat transfer that occurs due to a temperature difference followed by the flow of medium particles. The faster the fluid movement, the greater the rate of convection heat transfer that occurs. In an immersion cooling process, the CPU temperature has a higher temperature than the fluid (VCO) so that the VCO will absorb heat from the CPU work, then the VCO will carry heat from the vessel through the inlet channel to the radiator, the VCO which has been cooled by the radiator is then flowed through the outlet channel. to the vessel to carry out the process of re-absorption of heat.

In the Immersion Cooling system, the flow rate and rotational speed of the fan affect the decrease in the working temperature of the CPU. At a flow rate of 2 lpm the maximum temperature that can be achieved is 63.2 °C, at a flow rate of 4 lpm the maximum temperature is 61.8 °C, while at a flow rate of 6 lpm the decrease in CPU temperature is more significant, namely 42.8 °C. The difference in temperature reduction is due to the heat generated by the CPU will be absorbed by the VCO but with a small flow rate, the VCO flowing to the radiator will be slow, resulting in the VCO temperature increasing and the circulation process not optimal. This is inversely proportional to if the flow rate is accelerated, the process occurs is the working heat generated by the CPU will be quickly flowed by the fluid to the radiator so that the heat absorption process and circulation process take place optimally.

Each flow rate with a variation of the speed of the fan rotation occurs a different temperature reduction process. At a flow rate of 4 lpm with a fan rotation of 600 rpm, the temperature drop is unstable at 09.00-15.00 Western Indonesia time, this is due to the environmental temperature increasing from 30 °C to 32 °C so that the temperature reduction process is slower. At night the temperature drop is faster because the room temperature is relatively lower 28 °C, such as at a flow rate of 6 lpm at a fan rotation of 600 rpm at 18.00-03.00 West Indonesia time, the CPU temperature can be lowered quickly from 59 °C to 42 °C. The ambient temperature affects the process of decreasing the temperature.

The flow rate factor and the rotation of the radiator cooling fan in the immersion cooling system have also been proven in the research of Krisian et al (2018)[8], where the variation of the flow rate used is 0.5 lpm, 1 lpm and 1.5 lpm with a maximum fan rotation of 800 rpm which resulted in a decrease in CPU temperature of 51 °C, 48 °C, and 47 °C. The practical implication obtained from this research is the use of immersion cooling with a flow rate variation of 1.5 lpm to achieve the highest temperature reduction with the same room conditions.

4. Conclusion
The immersion cooling system is proven to be more significant in lowering the working temperature of the CPU than cooling systems with air cooling or conventional fans. The maximum temperature drop that can be achieved with the immersion cooling system with the best variation is 42.8 °C, while the temperature drop that can be achieved with the conventional cooling system is only 71.2°C. Variation of flow rate 6 lpm with fan rotation of 600 rpm is the best combination in reducing CPU temperature significantly in this study. The increased flow rate will speed up the circulation process in the VCO to the radiator, while the accelerated fan rotation can cool the VCO more optimally.

5. Acknowledgments
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References
[1] Anon Asosiasi Penyelenggara Jasa Internet Indonesia
[2] Amirullah A, Ijtihadie R M and Studiawan H Optimasi Daya Data Center Cloud Computing Pada Workload High Performance Computing (HPC) Dengan Scheduling Prediktif Secara Realtime | Amirullah | JUTI: Jurnal Ilmiah Teknologi Informasi
[3] Anon Central Processing Unit (CPU) Sebuah mesin tipe von neumann
[4] Testi D 2018 Heat transfer enhancement by an impinging ionic jet in a viscous transformer coolant *Int. Commun. Heat Mass Transf.* **91** 256–61
[5] Septiadi W N, Budiarsa I N, Tnunay I A and Desy I 2018 Sistem Pendingin Central Processing Unit (CPU) Berbasis Cascade Straight Heat Pipe 7
[6] Habibi Khalaj A and Halgamuge S K 2017 A Review on efficient thermal management of air- and liquid-cooled data centers: From chip to the cooling system *Appl. Energy* **205** 1165–88
[7] Kheirabadi A C and Groulx D 2016 Cooling of server electronics: A design review of existing technology *Appl. Therm. Eng.* **105** 622–38
[8] Krisian S N 2018 Analisis Efek Variasi Flow Rate Terhadap Performa CPU dan PSU pada Immersion Cooling dengan Mineral Oil
[9] Kuncoro I W, Pambudi N A, Biddinika M K, Widiastuti I, Hijriawan M and Wibowo K M 2019 Immersion cooling as the next technology for data center cooling: A review *J. Phys. Conf. Ser.* **1402** 044057
[10] Kuncoro I W 2019 Performa Pendinginan Immersion Cooling Menggunakan Mineral Oil Pada Server Rackmount Tipe 1u
[11] Yusuf A M 2018 Analisis Performa Pendinginan Celup (Immersion Cooling) Terhadap Data Center dengan Variasi Cairan Pendingin
[12] Wang Y, Pambudi N A, Bugis H, Kuncoro I W, Setiawan N D, Hijriawan M, Rudiyanto B and Basori B 2019 Preliminary experimental of GPU immersion-cooling *E3S Web Conf.* **93**

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