STUDY ON IMPACT OF VARIOUS NANOFLUID TYPES ON HEAT EXCHANGER COOLING PERFORMANCE

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DECLARATION

I declare that this Choose an item. entitled "Study On Impact Of Various Nanofluid Types On Heat Exchanger Cooling Performance" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
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Date	:	15/1/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Cooling and Air Conditioning System) with Honours.

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Date : ....

DEDICATION

I dedicate my work to my family supervisor and many friends. I feel gratitude to my supportive parents, Hassan bin Ahmad and Karmina binti Tamso who have been providing me the encouragement to pursue this study until completion. Gratitude for my suppervisor. Encik TS. Qamar Fairuz bin Zahmani who have granted me with the opportunity to complete this research and for providing the technical knowledge on the equipment and testing. I also dedicate this dissertation to all of my friends, and in particular. Lastly, I will always appreciate all of those who have provided me with the input and knowledge throughout the whole experiment and research.

ABSTRACT

Nanofluids containing scattered nanoparticles have been demonstrated to be a viable option for heat removal applications. Nanofluid nanostructures might be utilized to cool electrical devices in novel ways. The microchannel heat sink is more effective in dissipating heat. As a result, the electrical equipment is more excellent than if the microchannel heat sink was not used. In this study, the impact of various types of nanofluid in straight microchannel heat sink is, to determine the impact of various nanofluid by using simulation on heat exchanger cooling performance and to analyze the effect of flow characteristic with various types of nanofluid. Examined respectively, by using TiO_2 and ZnO nanofluid in the simulation by using ANSYS Fluent software. Overall, the dimension of the test piece is 4mm(W) × 4mm(L) × 2mm(H) and consists of 11 channels. The dimension of channel is 0.1mm(W) × 0.2mm(H) Meanwhile for the nanofluid is using concentration (1%, 2%, and 8%) for both nanofluid and the velocity is applied 2m/s. The heat flux generated at the bottom surface of the microchannel used was 160000 W/m². The result show the output velocity and velocity vector when the viscosity of nanofluid is higher, the heat transfer coefficient becomes lower because the flow of nanofluid becomes slower. It shows that all various types of nanofluid be the same result because of the viscosity of nanofluid. The comparison is being made between nanofluid TiO_2/water and ZnO/water with different concentrations. The best for cooling performance is TiO_2/water. The temperature is 297.11 K because it can absorb more thermal conductivity at the same velocity of 3.34 m/s. The nanofluid ZnO/water has the same velocity; the temperature is 296.95 K. Using ANSYS Fluent software, an analysis has been made to determine the impact of various nanofluids and analyze the effect of flow characteristics with various types of nanofluid. Based on the result, both nanofluids with different concentrations have different outcomes for velocity and temperature. They both have the same characteristic flow, laminar flow because there is no obstacle in the channel nanofluid.

ABSTRAK

Nanofluid yang mengandungi nanopartikel bertaburan telah ditunjukkan sebagai pilihan yang berdaya maju untuk aplikasi penyingkiran haba. Struktur nanofluid mungkin digunakan untuk menyejukkan peranti elektrik dengan cara yang baru. Sinki haba saluran mikro lebih berkesan dalam menghilangkan haba. Akibatnya, peralatan elektrik adalah lebih baik daripada jika sink haba saluran mikro tidak digunakan. Dalam kajian ini, impak pelbagai jenis cecair nano dalam sink haba mikro saluran lurus adalah, untuk menentukan kesan pelbagai cecair nano dengan menggunakan simulasi ke atas prestasi penyejukan penukar haba dan menganalisis kesan ciri aliran dengan pelbagai jenis cecair nano. Diperiksa masing-masing, dengan menggunakan TiO_2 dan *ZnO* nanofluid dalam simulasi dengan menggunakan perisian ANSYS Fluent. Secara keseluruhannya, dimensi bahagian ujian ialah 4mm(W) × 4mm(L) × 2mm(H) dan terdiri daripada 11 saluran. dimensi saluran ialah 0.1mm(W) × 0.2mm(H) Manakala bagi cecair nano menggunakan kepekatan (1%, 2%, dan 8%) untuk kedua-dua cecair nano dan halaju digunakan 2m/s. Fluks haba yang dihasilkan pada permukaan bawah saluran mikro yang digunakan ialah 160000 W/m^2. Hasilnya menunjukkan halaju keluaran dan vektor halaju apabila kelikatan bendalir nano lebih tinggi, pekali pemindahan haba menjadi lebih rendah kerana aliran bendalir nano menjadi lebih perlahan. Ia menunjukkan bahawa semua jenis cecair nano adalah hasil yang sama kerana kelikatan cecair nano. Perbandingan sedang dibuat antara cecair nano TiO_2/air dan ZnO/air dengan kepekatan yang berbeza. Yang terbaik untuk prestasi penyejukan ialah TiO_2/air. Suhu ialah 297.11 K kerana ia boleh menyerap lebih banyak kekonduksian terma pada halaju yang sama iaitu 3.34 m/s. Bendalir nano ZnO/air mempunyai halaju yang sama; suhu ialah 296.95 K. Menggunakan perisian ANSYS Fluent, analisis telah dibuat untuk menentukan kesan pelbagai cecair nano dan menganalisis kesan ciri aliran dengan pelbagai jenis cecair nano. Berdasarkan keputusan, kedua-dua cecair nano dengan kepekatan yang berbeza mempunyai hasil yang berbeza untuk halaju dan suhu. Kedua-duanya mempunyai aliran ciri yang sama, aliran laminar kerana tiada halangan dalam cecair nano saluran.

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Finally, this thesis is dedicated to my beloved father and mother. This piece of victory is dedicated to both of you. Alhamdulillah.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Heat is the form of energy that can be transferred from one system to another due to temperature difference. Heat transfer is deal with the determination rates of such energy transfer as well as variation of temperature. It also energy as heat is always from the higher temperature medium to lower temperature and heat transfer stop when two mediums reach the same temperature. Nowadays, with this technology, many companies and industries have the same problem to solve this waste energy and cannot get better efficiency. It has been discussed that thermal systems are the most critical problem in many industrial applications due to the lack of energy sources (Ganvir et al., 2017).

From the last few decades, we have seen strange growth in various fields such as electronics, communication and computing technologies and will continue to grow faster than ever (Ganvir et al., 2017). Many systems nowadays use these technologies such as microprocessors, electric vehicle, and aerospace applications. All the applications need to be cooling because electricity can produce hot temperature from these applications. It is essential to deal with the energy waste problem by reducing energy losses using the heat transfer method.

Nanofluid is a fluid that containing nanometer-sized particles. It is called nanoparticles. There are engineered colloidal suspensions of nanoparticles in a base fluid. Nanofluid can be classified into four categories: metal-based, metal oxide base, carbon-based, and hybrid mixed metal-based. (Chakraborty & Panigrahi, 2020)

These nanoparticles are suspended in the base fluid, i.e. water, methanol, ethylene glycol, kerosene, transformer oil, to form nanofluid. The selection of nanofluid for any application should consider the improvement in its physical properties and its stability.

Nanoparticles have an enormous surface area, which allows for increased heat transfer. Particles with a diameter of less than 20 nm have 20% of their atoms on their surface, making them instantly ready for thermal interaction. Another advantage is the particles' mobility due to their small size and may result in micro-convection of fluid and hence more excellent heat transmission. Micro-convection and increased heat transfer may also accelerate heat dispersion in the fluid.

1.2 Problem Statement

Since the microchannel heat sink development continues to advance, it allows the electronic device to work more efficiently and long time. But the technology will keep more expands than before make the electronic device generate more heat. Therefore, many researchers have studied the impact of various types of nanofluid in the heat exchanger. Several computational and experimental investigations have been conducted to determine the heat transfer and fluid flow characteristics of straight rectangular microchannels. Nowadays, by using the air-cooled method, this cannot deliver the best performance and cannot work for a long time. Many systems in this world avoid using water-cooled because of an afraid leak in the system and only make the higher cost to repair, but a system has run water-cooled with have issue that cannot deliver better results. Using nanofluid in water-cooled can solve and give more efficiency for fluid flow and get a better result performance.

1.3 Research Objective

There are two objectives of the study to be achieved as the listed below :

a) To study on impact of various nanofluid types on heat exchanger cooling performance.

b) To determine the impact of various nanofluid by using simulation on heat exchanger cooling performance.

c) To analyze the effect of flow characteristic with various types of nanofluid.

1.4 Scope of Experiment

This study will be using simulation to study the impact of heat transfer and flow characteristic using various types of nanofluid in heat exchanger cooling performance. In addition, this study wants to analyze the characteristic of each nanofluid performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this literature review, since all electronic devices and circuits create excessive heat, thermal management must increase dependability and prevent premature failure. If no other energy exchanges occur, the quantity of heat generated equals the amount of power input. Cooling techniques include various heat sinks, thermoelectric coolers, forced air systems, fans, heat pipes, etc. In icy environments, it may be essential to heat the electronic components to ensure good function. Although these passive cooling solutions have piqued the interest of researchers and industrialists, they have the potential to compensate for all of the shortcomings of active cooling technologies by increasing the running duration of electronic devices under user-friendly working conditions (Ali et al., 2018).

By the advent of nanotechnology, numerous traditional techniques went through a huge shift, and there have been multifarious applications in which nanotechnology improved the properties and the functionality of many systems. Such a development in the technology is a consequence of the unique and sometimes unexpected properties observed at the nanoscale. To gain deeper insight regarding nanotechnology, the following provide essential information related to nanoscale.

2.2 Introduction to Nanofluid

Nanoparticles are the core element of the more general term, nanotechnology. Nanotechnology generally refers to the techniques applied to manipulate materials in the scale of atoms and molecules. Even though there are different definitions of nanotechnology, the most common one established by National Nanotechnology Initiative, defines nanotechnology as technologies of making particles within the range of 1-100 nanometer in one dimension (Roco, 1999). Accordingly, the particles with one dimension in nanoscale are called nanoparticles. Nanoscale has attracted tremendous attention as it is a bridge between the bulk material and molecular structures. The bulk materials are known to have constant properties regardless of their size. The nanoparticles, however, have scale dependent physical properties (Grassian, 2008). This implies that materials at nanoscale have different properties than at macro scale. The unique properties of nanoparticles are usually attributed to the high surface to volume ratio which leads to higher number of atoms in the surface and therefore higher contribution of small entities in the interactions with neighbor particles (Grassian, 2008).

The strict control over the nanoparticle fabrication in terms of size, crystalline structure, and shape of nanoparticles, resulted in wide application of such particles. The properties of the particles, as mentioned before, are controlled by their size, shape, structures, and surface functionality and therefore a specific particle with unique properties can be developed using cutting-edge fabrication techniques (Grassian, 2008).

2.3 Stability of Nanofluid

Nanoparticles are usually agglomerated in powder form and are typically turned into nanoscale by dispersing them in liquids using different techniques such as sonication and homogenization. Although nanoparticles dispersed in the fluid are separated, their high surface energy often leads to agglomeration and deposition (Kocjan et al., 2017). Nanoparticles also have a strong tendency to migrate to the interface of different phases and therefore tend to adsorb on the solid surface they encounter in the nanoflow (Dugyala et al., 2016). In the particular case of porous media, the adsorption of nanoparticles is a critical factor as the solid surface is abundant in such systems. The adsorption and deposition are two main limiting factors in nanoparticle applications, making the applications economically unfavorable (Esfandyari Bayat et al., 2015). Saying that nanoparticles adsorption/deposition is sometimes a positive factor and therefore beneficial in specific applications. For example, in the wettability alteration process, the adsorption of nanoparticles on the solid surface helps change the wettability in a good way (Li & Torsæter, 2015). These retention phenomena, deposition and adsorption, can be somehow controlled by manipulating the physical and chemical properties of the liquid media, the particles, and the solid surface. As such, depending on the application, the properties can be adjusted accordingly.

2.4 Types of Nanofluid

Stability is an important aspect in the preparation stage of nanofluids. In general, a nanofluid has superior suspension in a typical base fluid than a microfluid; nonetheless, nanoparticles have a strong tendency to form clusters or agglomerates owing to van der Waals forces and settle to the bottom, resulting in poor property improvement (Rashmi et al., 2014). Two approaches may typically be employed to scatter nanoparticles homogeneously for a longer time: the physical dispersion method and the chemical dispersion method. Figure 2.1 depicts the most common nanoparticles, base fluids, and additives used by various studies.

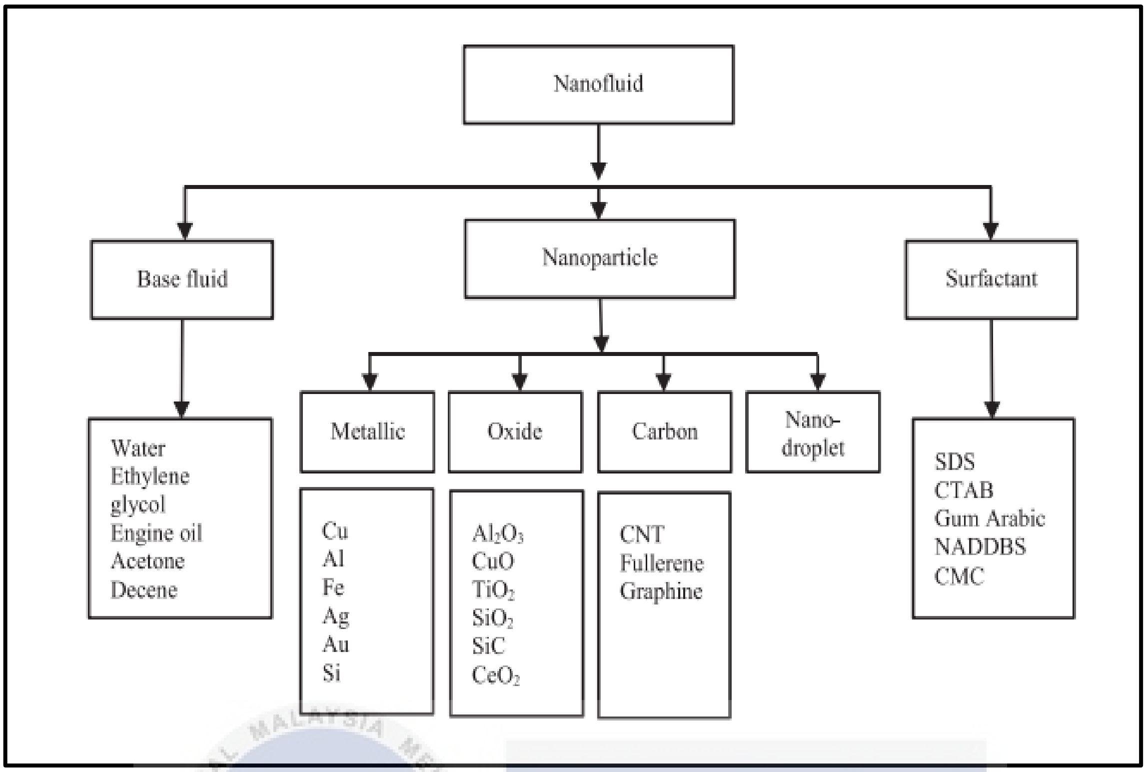

Figure 2.1 Various base fluids, nanoparticles and additives used in nanofluid preparation (Rashmi et al., 2014).

2.5 Nanofluid equations

2.5.1 Thermal conductivity:

Modern equations of effective thermal conductivity (Ahmed et al., 2015) are presented based on the basic correlation (Koo & Kleinstreuer, 2004) which was developed (Vajjha & Das, 2009) to be two equations which are static and Brownian thermal conductivity (equation 2.1). The static thermal conductivity is proposed by (Ghasemi & Aminossadati, 2010) (equation 2.2) as below:

$$k_{eff} = k_{static} + k_{brownian} \quad 2.1$$

$$k_{static} = k_f\left[\frac{(k_s + 2k_f) - 2\varphi(k_f - k_s)}{(k_s + 2k_f) + \varphi(k_f - k_s)}\right] \quad 2.2$$

where k_s and k_f are the thermal conductivities of the particles and the fluid respectively. The Brownian motion thermal conductivity equation (Vajjha & Das, 2009) is :

$$\boldsymbol{k_{brownian} = 5 \times 10^4 \beta\varphi\rho_f Cp_f \sqrt{\frac{KT}{\rho_s d_s}} f\,(T, \varphi)} \qquad \textbf{2.3}$$

Where

$$\boldsymbol{f\,(T, \varphi) = (2.8217\ \times 10^{-2}\varphi\ + 3.917 \times 10^{-3})\left(\frac{T}{T_0}\right) + (-3.0669 \times 10^{-2}\varphi - 3.91123\ \times 10^{-3})} \qquad \textbf{2.4}$$

with K being the Boltzmann constant, T is the fluid temperature, and T_0 is the reference temperature.

2.5.2 Viscosity equation:

The viscosity of the nanofluid is approximately the same as the viscosity of a base fluid if containing dilute suspension of fine spherical particles, as shown below (Ghasemi & Aminossadati, 2010):

$$\boldsymbol{\frac{\mu_{eff}}{\mu_f} = \frac{1}{1 - 34.87\left(d_p/d_s\right)^{-0.3}\varphi^{1.03}}} \qquad \textbf{2.5}$$

$$\boldsymbol{d_f = [\frac{6M}{N\pi\rho_{fo}}]^{1/3}} \qquad \textbf{2.6}$$

where μ_{eff} and μ_f are the viscosity of nanofluid and base fluid respectively, d_p is the nanoparticle diameter, d_s is the base fluid equivalent diameter and φ is the nanoparticles volume fraction. *M* is the molecular weight of the base fluid and *N* is the Avogadro number, and ρ_{fo} is the mass density of the base fluid calculated at temperature T = 293 K.

2.5.3 The density equation:

The effective density consists of three main parameters which are nanofluid concentration (φ), nanoparticle density ρ_s and base fluid density ρ_f (Albadr et al., 2013):

$$\boldsymbol{\rho_{eff} = (1 - \varphi)\rho_f + \varphi\rho_s} \quad \textbf{2.7}$$

2.5.4 The effective heat capacity equation:

With Cp_s being the heat capacity of the solid particles, and Cp_f being that of the base fluid, the effective heat capacity of the nanofluid is given by (Corcione, 2010):

$$\boldsymbol{(Cp)_{eff} = \frac{(1-\varphi)(\rho Cp)_f + \varphi(\rho Cp)_s}{(1-\varphi)\rho_f + \varphi\rho_s}} \quad \textbf{2.8}$$

2.5.5 The effective thermal expansion equation

The thermal expansion for solid parts β_s and for base β_f fluid with φ can produce the effective thermal expansion as follow (Kherbeet et al., 2015), (Vajjha et al., 2010):

$$\boldsymbol{\beta_{eff} = \frac{(1-\varphi)(\rho\beta)_f + \varphi(\rho\beta)_s}{(1-\varphi)\rho_f + \varphi\rho_s}} \quad \textbf{2.9}$$

2.6 Impact of nanofluid

Ali Abdollahi, Mohammad Hossein Karimi Darvanjooghi, Arash, and Mohammad Reza Safaei are doing an experimental study to obtain the viscosity of CuO-loaded nanofluid: effects of nanoparticles' mass fraction, temperature and basefluid's types to develop a correlation. They result show the impact of temperature, nanofluid viscosity by using CuO nanoparticles and nanoparticles mass fraction. For the temperature, the viscosityis