STUDY ON EFFECT OF NANOFLUID CONCENTRATION ON THE PERFORMANCE OF HEAT EXCHANGER

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (REFRIGERATION AND AIR-CONDITIONING SYSTEM) WITH HONOURS

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
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2021

DECLARATION

I declare that this Choose an item. entitled "Study On Effect Of Nanofluid Concentration On Performance Of Heat Exchanger" 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.

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Name : *Salman Bin Mohd Zainudin*

Date : 18 January 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 (Refrigeration and Air-Conditioning system) with Honours.

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DEDICATION

First of all, i would like to thank Allah for giving me strength to complete this study and to see this report become reality. I am dedicated this project and research work to my beloved parents, Mr Mohd Zainudin Bin Mohd Esin and Mrs Huda Binti Zainuddin who have always give me support backup to finish my studies. Not forget also to my siblings, my supervisor Ts. Siti Norain Binti Mokhtar who always give me guidence on completetion of this study. I would like to also say thank my friends who help me throughout my study journey. Thank you for all the helping and I always appreciate it and will not forgot the moments about it

ABSTRACT

To get the optimum heat transfer performance, a heat exchanger device that uses nanofluid must run at the optimum nanoparticle concentration ratio. In this study, various nanoparticle in nanofluid volume fractions were optimised based on maximal heat transfer rate, total heat transfer coefficient, and performance index. The originality of this study is the optimization of particle volume fraction of different nanofluids based on simulation in the MHCS heat exchanger for a wide range of nanoparticle volume fraction (0–5 %). The nanofluid that will be use in this study is Al2O3/water nanofluid. Other operational conditions' effects on optimization have also been explored. The MCHS dimension is 4(W) × 4(L) × 2(H) milimeter and consists of 11 channels. It will be put into the test section heat exchanger. Based on litterature studies, The expected of this experiment the is the most optimum concentration of all the type of nanofluid is at 1% with Al2O3/water give the best heat transfer performance. The higher concentration of nanofluid will also resulting of increasing reynold number and viscousity. This can result in higher pressure drop and friction loss in the system.

ABSTRAK

Bagi mendapatkan prestasi pemindahan haba yang optimum. Penukar haba yang menggunakan “nanofluid” perlulah beroperasi dengan kandungan nisbah kepekatan nanopartikel yang optimum. Dalam kajian ini, pelbagai isipadu nanopatikel di dalam cecair nano di optimumkan berdasarkan kadar maksimum pemindahan haba, jumlah pekali pemindahan haba, dan indeks prestasi. Keaslian kajian ini adalah pengoptimuman kepekatan partikel dalam cecari nano yang berbeza berdassarkan simulasi di dalam penukar haba sinki haba saluran mikro untuk pelbagai nisbah pecahan partikel nano (0-5 %). Cecair nano yang akan digunakan dalam kajian ini adalah Al2O3/air cecair nano. Kesan kondisi operasi lain juga akan diteroka. Ukuran bagi sinki haba saluran mikro adalah 4(L) x 4(P) x 2(T) milimeter dan ia mempunyai 11 saluran. Ia akan dimasukkan kedalam bahagian ujian penukar haba. Berdasarkan kajian literatur, jangkaan hasil kajian ini adalah kepekatan optimum bagi semua cecair nano adalah menghampiri 1% dimana Al2O3/air memberikan prestasi pemindahan haba yang paling bagus. Dapatan juga mengatakan, lebih tinggi kepekatan cecair nano akan menyebabkan peningkatan kepada nombor Reynold serta kelikatan cecair nano. Perkara ini boleh menyebabkan penurunan tekanan yang tinggi serta geseran yang lebih tinggi.

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LIST OF SYMBOLS AND ABBREVIATION

MCHS	-	Micro Channel Heat Sink
CFD	-	Computational Fluid Dynamic
W	-	Width
L	-	Length
H	-	Height
Al2O3	-	Aluminium Oxide
TiO2	-	Titanium Dioxide
SiO2	-	Silicon Dioxide
H2O	-	Water
Re	-	Reynold Number
ρ	-	Density
V	-	Flow Velocity
q	-	Heat Transfer Rate
ΔT	-	Temperature Difference
CFD	-	Computational Fluid Dynamic

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CHAPTER 1

INTROUCTION

1.1 Background

Technology has become a very importance thing in nowadays. This thanks to Industrial Revolution 3.0 (IR 3.0) that introduced automated system in industries to perform human task such as assembly. This automated system using Artificial Intelligence (AI) which consist of Computer or Programable Logic Circuit (PLC).

Computer or machine produce huge amount of heat that need to be cooled otherwise it can affect the performance of the computer and can damaged the component of the computer because of overheating. Therefore, cooling component is needed to ensure the component temperature not exceeding the maximum temperature. Traditionally, in computer heat sink is being used to cool the computer component. A heat sink is a passive heat exchanger that transfers heat from an electronic or mechanical device to a fluid medium, typically air or liquid coolant, where it is dissipated away from the device, allowing temperature regulation. Heatsink works by increasing the surface area resulting the rate of heat transfer increasing.

However due to technological advancement, high powered computer is more widely used to coup with the processing of more advance data. This resulting in increasing of heat produced by the computer. New medium of cooling is needed in order provide more efficient cooling to the computer.

In this simulation, nanofluid will be used to increase the efficiency of cooling in the heat exchanger. Aluminium Oxide nanofluid with pure water as a base fluid (Al2O3-H2O) is chosen as a coolant. The concentration of the nanofluid also will be changed to find the best concentration of nanofluids that give the most efficient rate of heat transfer in the heat exchanger.

1.2 Problem Statement

Cooling is a major process in industries. Cooling is one of the highest energy consumptions processes. Cooling process is very important to keep the equipment whether in daily equipment or industries runs efficiently. Heat exchanger is widely being used to cool such an equipment. but sometimes the cooling performance cannot cope with the heat produced by the equipment. therefore, new method of cooling needs to be implied such as using nanofluid in the heat exchanger to increase the performance of cooling also the rate of heat transfer of the heat exchanger. Many researchers have done the research about application of nanofluid in the heat exchanger. But there no definite concentration of nanofluid that has been agreed by the researchers which give the best performance of heat transfer.

1.3 Objectives

To investigate concentration of nanofluid with several types of nanofluid. Then to make comparison between the result. by using experimental method in the lab using heat exchanger. The parameters that will be collect is the temperature of water at the inlet and the outlet of the heat sink, the concentration of the nanofluid, velocity of water, pressure and the heat transfer coefficient.

The objective of the study is:

I. To determine the effect of nanofluid concentration on the performance of heat exchanger.

II. To compare the nanofluid heat transfer by carry out simulation work on the nanofluid effect in the heat exchanger with difference concentration.

III. To determine the best concentration on Aluminium Oxide nanofluid (Al2O3-H2O) that give the best heat transfer performance in heat exchanger application from the range of study.

1.4 Scope of Research

The study will be using simulation method to study the effect of nanofluid concentration on performance of heat exchanger. This study also to find the suitable concentration ratio on various type of nanofluid. After that, based on the ratio, the heat transfer performance will be test with different operating condition. The simulation will be carried out using software. Solidworks software to model the microchannel heat sink (heat exchanger). Then, the simulation work on Ansys software to simulate the heat transfer of the nanofluid.

CHAPTER 2

LITERARURE REVIEW

2.1 Introduction

In today's technological advancement era, electronic are being used almost in everything. Cooling is one of the most importance elements in technology. most of electronic produce heat as a waste product from using electrical energy to do works. This waste product which is heat need to be removed from the electronic component to ensure the component can operate efficiently. Therefor heat exchanger need to be used to remove the heat from the component efficiently. In this chapter, heat exchanger or heatsink that include of using nanofluid as concept will be explained in detail based on previous studies that has been done. Using nanofluid as heat transfer is more efficient way to remove heat from the electronic component.

2.2 Nanofluid and Preparation of Nanofluid

A nanofluid is a fluid that contains nanoparticles in addition to a base fluid. These fluids are colloidal nanoparticle suspensions in a base fluid that have been engineered. Nano particles are particles of dimension approximately of 10-1000nm in size (figure 2.1). Metals, oxides, carbides, and carbon nanotubes are the most common nanoparticles employed in nanofluids. Some common nanoparticle which is oxide is Zinc Oxide (ZnO), Copper Oxide (CuO), Aluminum Oxide (AL203), while some metal nanoparticles are Gold (Au), Silver (Ag). Water ethylene glycol and oil are some of common base fluid for nanofluid.

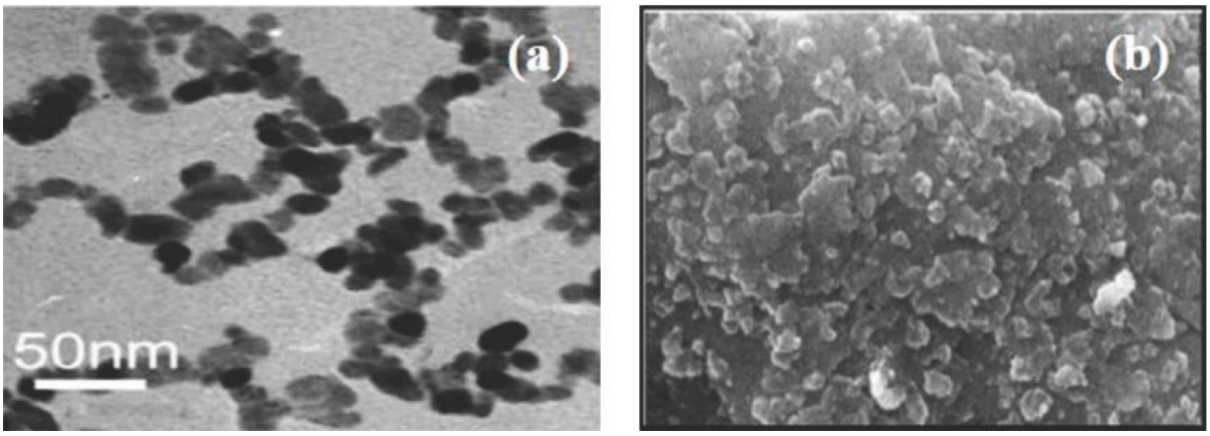

Figure 2.1 Nanoparticles of Copper Oxide (CuO) (Ali et al., 2018)

The nanofluid is prepared by dissolving nanoparticles in base fluid in a homogeneous, stable, and uniform suspension at the desired volume fraction. Nanofluid can be prepared using two methods: the one-step method and the two-step method. In the one-step procedure, nanoparticles are synthesized to a desired volume concentration and prepared using a combination process that minimizes agglomeration. Physical vapor deposition and the liquid chemical process are frequently used in the one-step approach for low pressure fluids. In the two-step procedure, nanoparticles of desired size and shape are produced and then uniformly dispersed into the based fluid at a specific volume fraction. Surfactants and/or additives are used to improve stability, reduce sedimentation, and adjust pH to a desirable level. Grinding, milling, sol-gel, wet chemical techniques, laser ablative technology, hydrothermal technique, gas phase synthesis, and other technologies can be used to create nanoparticles in a two-step approach. (Devendiran & Amirtham, 2016). The choice of method whether to used one-step method or two-step method depend on types of the nanoparticles, shapes, and applicability.

2.2.1 Types of Nanofluids

Nanofluid has a wide range of types which can be from Metals, oxides, carbides, and carbon nanotubes. But there is several common nanofluids that are regularly used whether in researching or application in real systems. Aluminum (Al), copper (Cu), silver (Ag), iron (Fe), titanium (Ti), silicon (Si), zinc (Zn), magnesium (Mg), carbon nanotubes (CNTs), graphene, graphene oxide, and diamond are the most widely utilized nanoparticles for nanofluids formulation. Water, ethylene glycol (EG), EG – H_2O mixes, and oils are common foundation fluids for nanofluid formulation. Chemical stability, thermophysical characteristics, toxicity, availability, compatibility with the base fluid, and cost are all factors to consider when selecting nanomaterials for producing nanofluids for heat transfer applications. (Ali et al., 2018).

An Assessment of nanofluid on the performance and energy-environment interaction of Plate-Type-Heat exchanger has been carried by Esam I. Jassim & Faizan Ahmed Prince. They used TiO_2 and Al_2O_3 at various Volume Fractions to evaluate the performance of nanofluids in plate heat exchanger. They prepared the nanofluids using two-steps method. Three volume fractions of 1%, 2% and 3% were prepared for both Al_2O_3 and TiO_2 nanofluids with no surfactant added to the nanofluids. They find out that the addition of nano-sized Titanium Oxide particles to distilled water improves exchanger performance. Al_2O_3 has a similar pattern. However, as compared to TiO_2 behavior, the inclusion of nanoparticles significantly increases the leak factor. (I Jassim & Ahmed, 2021)

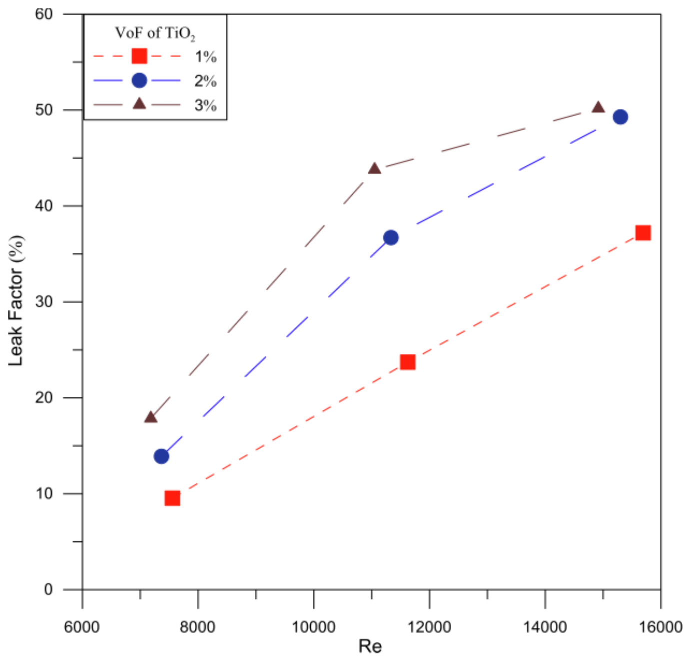

Figure 2.2 Variation of leak factor with Reynolds number for variable TiO2 volume fraction. (I Jassim & Ahmed, 2021)

Roberto Bubbico et al, carried research on Comparison of the Heat Transfer Efficiency of Nanofluids which there compared between three nanoparticles Titanium Dioxide (TiO2), Zirconium Dioxide (ZrO2), and Aluminum Oxide (Al2O3). The nanofluids used in the tests were created by suspending the nanoparticles in a thermal fluid and adding tiny amounts of surfactants to avoid particle agglomeration. They all found out that the heat transmission coefficient increases as the particle concentration in the nanofluids increases. The Al2O3 has the most heat transfer coefficient compared to the ZrO2 and TiO2. (Bubbico et al., 2015)

2.2.2 Concentration Ratio of Nanofluid

The amount of a material in a specific region is referred to as concentration. Concentration is sometimes defined as the ratio of solute in a solution to either solvent or total solution. Concentration is often stated as mass per unit volume. The solute concentration, on the other hand, can be represented in moles or units of volume. The concentration of nanofluid is one of the most important factors in getting the most heat transfer coefficient of the nanofluids. The concentration of the nanofluids also affect the flow of nanofluids in the heat exchanger where when the concentration of the nanofluid is higher, the higher the friction it will produced when in flows.(I Jassim & Ahmed, 2021) (Bubbico et al., 2015) (Arora & Gupta, 2020)

Other than that, to proves that nanofluids concentration is very important in the heat transfer coefficient, many researchers experimenting with the nanofluid concentration. They finding are the more concentrate the nanofluid the higher heat transfer coefficient can be achieved (Ponangi et al., 2021) (Ali et al., 2018) (Fares et al., 2020). The usual that being studies is around 1%-2.5% concentration of nanoparticles with the most common nanoparticle types of Aluminum oxide. concentration. Because there is less inter-particle spacing between particles at larger nanoparticle concentrations, the clustering phenomenon is more pronounced. Significant clusters of large mass, on the other hand, settle down quickly due to gravity and cause instability problems in nanofluids.(Arora & Gupta, 2020)