INVESTIGATION ON THERMAL CONDUCTIVITY OF FUNCTIONALIZED MULTIWALLED CARBON NANOTUBES BASED NANOFLUIDS

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This thesis is submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids) with honours

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APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of bachelor of Mechanical Engineering (Thermal-Fluids)

Signature   :   ....

Supervisor's Name : IMRAN SYAKIR BIN MOHAMAD

Date   :   ....

DECLARATION

I declare that this project report entitled "Investigation On Thermal Conductivity Functionalized multiwalled Carbon Nanotubes Based Nanofluids" is the result of my own work except as cited in the references.

Signature   :   ....

Name   :   SITI SYAHIRAH BINTI MOHD YUNUS

Date   :   ....

DEDICATION

I dedicate this thesis to both my beloved parents, Mohd Yunus bin Abdull Hamid and Sabariah bt Mansoor, Ayon, Babyngah, Wawa and also my friends for nursing me with affection and love for their dedicated partnership for success in my life.

ABSTRACT

Industry nowadays has been focusing on nanofluids to be the next cooling agent on improving the cooling processes due to its special characteristic upon thermal conductivity. This study was proposed due to the cooling agents problems in practical application especially in thermal conductivity. The objective is to prepare stable nanofluids consist of carbon nanotubes based fluids with the addition of surfactant also analyzing and investigating the thermal conductivity of the nanofluids. In this research, functionalized multi-walled carbon nanotubes (fMWCNT) is used as the nanoparticles, deionized water as the base fluids and the addition of Polyvinylpyrrolidone (PVP) as the surfactant to enhance the stability of the nanofluids. The samples are formulated with different weight percentages (0.1 wt% - 1.0 wt%) of fMWCNT and 10% of PVP in order to analyze thermal conductivity performance. All the samples (NF01-NF10) were tested for thermal conductivity at an increment of 1°C temperatures starting from 6°C up to 40°C. The thermal conductivity enhancement of nanofluids is compared to the thermal conductivity of standard deionized water and results showed that the thermal conductivity increased with the addition of nanoparticles into the base fluids. Based on the results, the highest thermal conductivity enhancement was recorded for 31.51% (1.0 wt% of CNT) at 40°C.

ABSTRAK

Industri pada masa kini semakin fokus kepada bendalir nano untuk menjadi ejen penyejukan yang baru dan boleh menambahbaik proses penyejukan cecair kerana ciri-ciri kekonduksian terma khas yang ada padanya. Kajian ini dihasilkan kerana terdapat masalah ejen penyejukan pada aplikasi praktikal terutama kekonduksian terma. Objektif kajian adalah untuk menghasilkan bendalir asas yang mengandungi bendalir nano yang stabil dengan tambahan surfaktan disamping mengkaji dan menganalisa kekonduksian terma oleh bendalir asas. Kajian ini menggunakan zarah nano jenis Tiub Nano Karbon Berbilang Dinding yang berfungsi (fMWCNT) dan kestabilannya telah meningkat dengan adanya kumpulan fungsi hidroksil pada permukaannya. Selain itu, bendalir asas yang digunakan adalah air ternyah ion ditambah dengan Polivinilpirrolidon (PVP) sebagai surfaktan untuk menambah kestabilan yang lebih jitu. Sampel-sampel ini diformulasikan dengan pelbagai peratusan berat (0.1wt%-1.0wt%) fMWCNT dan 10% PVP untuk menganalisa kekonduksian terma. Semua sampel (NF01-NF10) diuji pada setiap suhu bermula pada 6°C sehingga 40°C. Peningkatan prestasi daya pengaliran terma bendalir nano dibandingkan dengan kekonduksian terma piawai air ternyah ion. Berdasarkan kepada hasil kajian, pengaliran terma piawai air ternyah ion yang terbaik dicatatkan adalah pada 31.51% (1.0wt% CNT) pada suhu 40°C.

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I am grateful to my true self for not giving up as this struggle is real. Yes, damn real. I am thankful for my brain to withstand some unnecessary temptations from the heart, and my eyes for going through countless nights of facing the computer screens, also to my ears for allowing me to listen to all kinds of comments, soft and supportive whisper of "You can do it" with eyes soaking with tears. Finally, I thank The Almighty and my parents for their blessing and putting faith on me and constant source of motivation for me to perform better.

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CHAPTER 1

INTRODUCTION

1.0   Introduction

Nowadays, nanotechnology has been a highlight for worldwide researcher for the technology development in every industry. The development is critical and every industry seems like doing further research in nanotechnology field.

The terms 'nano particles' comes from its particle sizes as the diameter is less than 100 nm and can be as thin as one or two nm. Carbon nanotubes (CNT) is labelled as the nanotechnology and its advantages can be applied to a wide range of applications including chemical processing, energy management, material science, electronic and automotive. The CNT can be a very good conductor, hundreds time better than conductor used in many application these days such as copper. This is because the structural properties that can be change according to the design and chemical group besides its molecules can be manipulated both chemically and physically such as structure modification to optimize the dispersion and solubility due to the richness of the element as the pure carbon polymers.

CNT nanoparticles can be dispersed in the various types of based fluids including engine oil, water, ethylene glycol and known as nanofluids once it mixed together and the nanofluids are very useful in the engineering applications.

1.1   Problem statement

Water is a conventional fluid which normally used as coolant in industries around the world. However, the thermal property like thermal conductivity of water is low but this problem can be solve in an effective way with addition of carbon nanotubes. CNT which have a higher thermal conductivity can enhance or increase the thermal conductivity of the water. In addition, the smaller size of the CNT also resulting to a better dispersion in water thus it is easier to obtain the stable nanofluids. As the Multi-walled Carbon Nanotube (MWCNT) have hydrophobic surface area, the surfactant such as Polyvinylpyrrolidone (PVP) have to be added to get the better stability. Even though the PVP is added, the problem still occurs because of the presence of hydrophobic solvent will affects the self-arrangement of the surfactant and this can results the porous microstructures. Therefore, in order to overcome this problem, the functional group such as COOH (carboxyl group) and OH (hydroxyl group) are crucial on the MWCNT surface area as to avoid the surfactant self- arrangement. Hence, this research are focused on the functionalized MWCNT being merged and dispersed into the based fluids as nanofluids thus to investigating the thermal conductivity performance .

1.2   Objectives

i.   To prepare stable nanofluids consists of fMWCNT in water-based fluids with the addition of surfactant.

ii.   To analyse and investigate the thermal conductivity.

1.3 Scope of research

i. To prepare the formulation of the nanofluids sample as it consist of fMWCNT, PVP (polyvinylpyrrolidone) as the surfactant and deionized water (DI) as the based fluids.

ii. To identify and improve the homogeneity and stability of the nanofluids through homogenizing and ultrasonicating processes.

iii. To conduct the thermal conductivity test for all the stable samples at an increment of 1°C starting from 6 °C up to 40 °C.

CHAPTER 2

LITERATURE REVIEW

2.0   Introduction

Nanotechnology keeps gaining attention of the scientist around the world. It has a lot of potential that can be explored and the application of the nanotechnology can be widen even though the current research on nanotechnology nowadays focusing more on micro electric application and microprocessor. The conventional fluids ability to conduct heat is significantly inferior to solids. Initial experiments involved by adding solid particles with more desirable properties to the base fluid under the hypothesis that the overall mixtures thermal behaviour would be more favourable. Although in some cases enhancement was observed, for reasons behind it did not prove to be of any practical use until the technology's recent ability to manufacture the nanoparticles. Thus, the nanofluids become more compromising in term of the potential and its application.

2.1 Carbon Nanotubes

The past research showed that the carbon nanotubes have very high thermal conductivity compared to diamond crystal and in-plane graphite sheet. Carbon nanotubes are molecular-scale tubes of graphitic carbon with outstanding properties. The bonding in carbon nanotubes is [sp²], with each atom joined to three neighbors, as in graphite. The tubes can therefore be considered as rolled up graphene sheets (graphene is an individual graphite layer) In addition, nanotubes bundles show very similar properties for example the graphite crystal have dramatic difference in thermal conductivities along different crystal axis.

The enhancement of thermal conductivity of carbon nanotubes was higher than those predicted for conventional models. It found that the Brownian motion (the random movement of microscopic particles suspended in a liquid or gas, caused by collisions with molecules of the surrounding medium) of nano particles at the molecular and nano scale level can affect the thermal behaviour of carbon nanotubes. The increment of Brownian motion of the nano particles can be prove by the increase in volume fraction and heat.

Carbon-based materials such as diamond and in-plane graphite, display the highest measured thermal conductivity of any known material at moderate temperatures. Based on M. S. Dresselhaus *et. al* (2004) , carbon nanotubes (CNTs) are tubular structures that are typically of nanometer diameter and many micrometres in length. It showed in Figure 2.1.
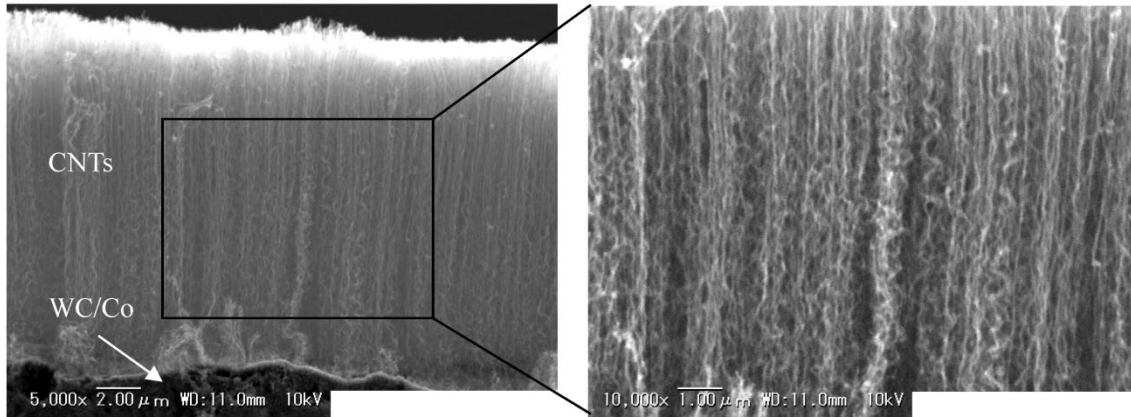
Figure 2.1: CNT"s

(Source: K.W.Guo *et al*, 2015)

Apart from the well-known graphite, carbon can build closed and open cages with honeycomb atomic arrangement. This fascinating new class of materials was first observed by Endo (1975), and later by Iijima (1991) in the soot produced in the arc-discharge synthesis of fullerenes or in simple words, form of carbon having a large spheroidal molecule consisting of a hollow cage of atoms. Carbon nanotubes consist of rolled graphene sheets built from hybridized carbon atoms. Based on Figure 2.2, it shows an individual layer of carbon called graphene and work mechanism of the carbon to form a carbon nanotube. In addition, carbon nanotubes can be categorized as single walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs) and Figure 2.3 showed both SWCNT and MWCNT sizes.
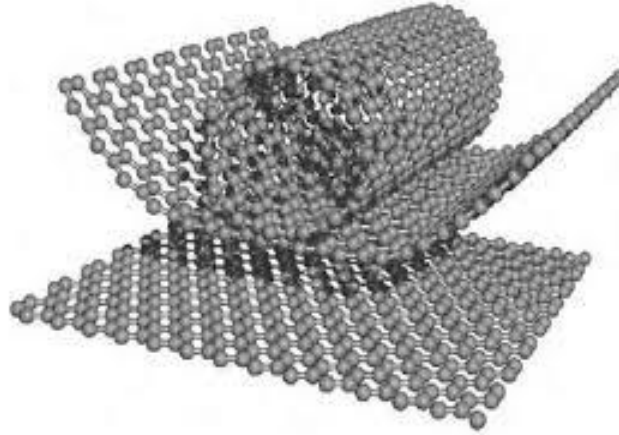
6

Figure 2.2: Schematic of an individual layer of carbon called graphene and work mechanism

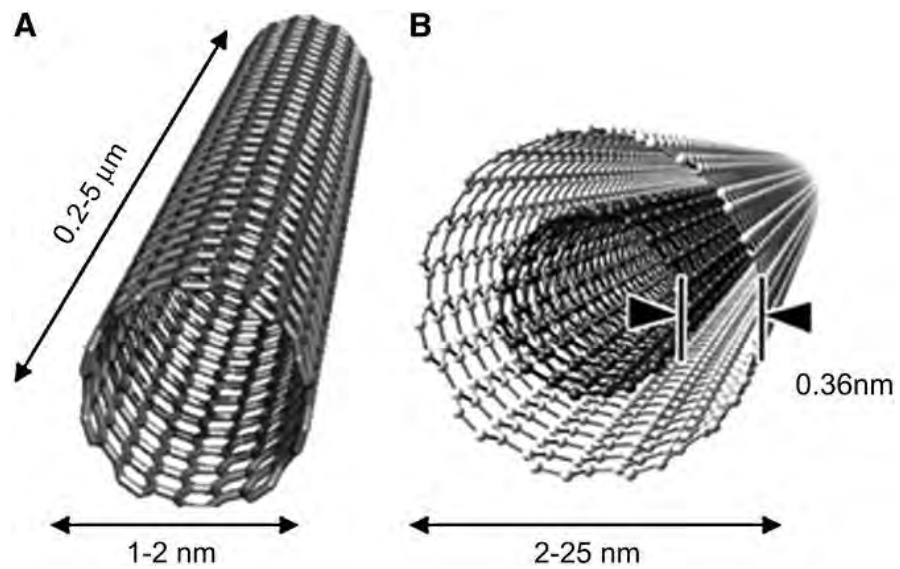of the carbon to form CNTs

(Source:M.Endo, 2004)

Figure 2.3:(a) SWCNT and (b) MWCNT sizes.

(Source: A.Penn, 2014)

2.1.1   Single-Walled Carbon Nanotubes

Most single-walled nanotubes (SWNT) have a diameter of close to 1 nanometer, with a tube length that can be many millions of times longer. The structure of a SWNT can be conceptualized by wrapping a one-atom-thick layer of graphite called graphene into a seamless cylinder. In the Figure 2.4, it shows SWCNT.
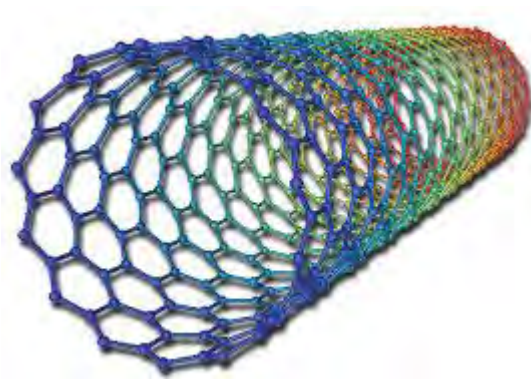

Figure 2.4: Single-walled carbon nanotube structure

Single-walled nanotubes are an important variety of carbon nanotube because they exhibit electric properties that are not shared by the multi-walled carbon nanotube (MWNT) variants.

2.1.2 Multi-Walled Carbon Nanotubes

Multi-walled carbon nanotubes (MWCNT) consist of multiple rolled layers (concentric tubes) of graphite. Such cylindrical graphitic polymeric structures have novel or improved properties that make them potentially useful in a wide variety of applications in electronics, optics and other fields of materials science (A. Hajar, *et. al* 2009). Multi-walled nanotubes are multiple concentric nanotubes precisely nested within one another.

Carbon nanotubes are endowed with exceptionally high material properties, very close to their theoretical limits, such as electrical and thermal conductivity, strength, stiffness, and toughness. Moreover, MWCNTs are polymers of pure carbon and can be reacted and manipulated using the rich chemistry of carbon. On the Figure 2.5, it shows the structure of multiwalled carbon nanotube.
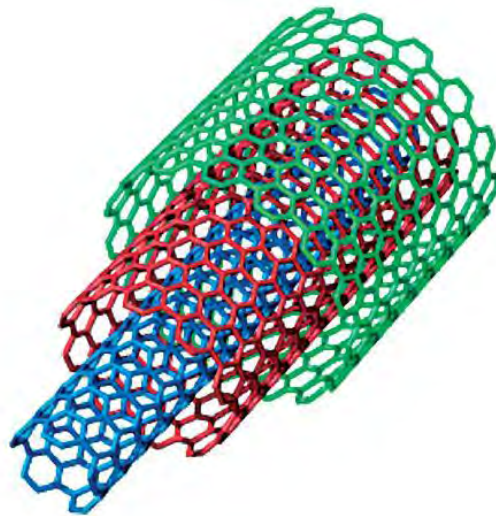

Figure 2.5: Multiwalled carbon nanotube (MWCNT) structure

(Source: Bayer Material Science)