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PERFORMANCE EVALUATION OF NANO-COOLANT MULTI-WALLED NANOTUBE (MWNT) PARTICLES IN ETHYLENE GLYCOL

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"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluid) with Honours"

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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

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For my beloved and inspiring

Parents and Siblings

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ABSTRACT

This thesis is focused on formulating nanofluid from carbon nanoparticles to improve the performance of ethylene glycol in heat transfer application. This is because the limitation on the amount of heat that can be absorbed by ethylene glycol. This project is carried out with the aim to develop highly efficient nano-coolant produced from the mixture of nanocarbon, commercial coolant and dispersing agent. The project is based on to formulate nanofluid using carbon nanotubes namely functionalized Multi-Walled Carbon Nanotube. These nanofluids are formulated by using various ratios of carbon nanotubes and dispersing agent, namely Polyvinylpyrolidone (PVP). Then, the stability test of the nanofluids was carried out through the experimental processes. The thermal properties of the nanofluids are determined at three different temperatures, which are 6 °C, 25 °C and 40 °C. The thermal properties that need to be determined are thermal conductivity, viscosity, specific heat capacity and heat transfer coefficient. The apparatus used to determine the mentioned properties are KD2-Pro TC analyzer, viscometer and calorimeter bomb. The formulation of nanofluid starts by mixing the carbon nanotube and dispersing agent into ethylene glycol. Then, the mixture needs to be homogenize by using homogenizer machine at 10000 rpm for five minutes. After that, ultrasound machine is used to avoid the particles in nanofluids coagulate by the agglomeration process. Then, the pH value being checked and need to be maintained around 9. If not, the nanofluid needs to be added either sodium hydroxide (NaOH) or nitric acid (HNO_3). The nanofluids are then left aside for 100 hours to check its stability. Lastly, the determination of the thermal properties takes place. As a result, NFR01 is chosen as the best sample of nanofluid with enhanced thermal properties and has a relatively low viscosity. This potential nanofluid will be highly used in the industries such as biomedical application, cooling application, energy application and mechanical application.

ABSTRAK

Tesis ini adalah bertujuan untuk menyediakan bendalir nano daripada zarah-zarah nano agar dapat meningkatkan prestasi etilena glikol di dalam aplikasi proses pemindahan haba. Ini disebabkan prestasi etilena glikol yang terhad. Projek ini dijalankan dengan matlamat untuk menghasilkan bendalir nano bercekapan tinggi yang dihasilkan daripada campuran karbon nano, penyejuk komersial dan ejen penyurai. Projek ini difokuskan untuk merumus bendalir nano menggunakan karbon nano bernama Karbon Nano Tiub Berbilang Dinding Berfungsi. Projek ini juga dijalankan dengan menggunakan pelbagai jenis nisbah daripada karbon nano dan ejen penyurai iaitu Polivinilpirrolidon (PVP). Kemudian, ujian kestabilan dijalankan kepada bendalir nano tersebut. Ujian pemindahan haba juga diuji pada suhu 6 °C, 25 °C dan 40 °C. Sifat-sifat haba yang perlu ditentukan adalah kekonduksian terma, kelikatan, haba tentu dan pekali pemindahan haba. Peralatan yang digunakan untuk menentukan sifat-sifat tersebut adalah peranti penganalisis KD2-Pro TC, viskometer, dan bom kalorimeter. Proses membuat bendalir nano ini bermula dengan mencampurkan karbon nano dan ejen penyurai ke dalam etilena glikol. Kemudian, campuran perlu diseragamkan dengan menggunakan mesin penghomogen berkelajuan 10000 rpm selama lima minit. Selepas itu, mesin ultrasonik digunakan untuk mengelakkan zarah-zarah nano bergumpal di dalam bendalir nano yang mana dihasilkan oleh proses pengagglomeratan. Kemudian, nilai pH akan diperiksa dan perlu dikekalkan sekitar 9. Jika tidak, bendalir nano perlu ditambah sama ada natrium hidroksida (NaOH) atau asid nitrik (HNO_3). Bendalir nano ditinggalkan selama 100 jam untuk memastikan kestabilannya. Akhir sekali, penentuan sifat haba dilakukan. Hasilnya, NFR01 dipilih sebagai sampel bendalir nano terbaik dengan sifat haba yang dipertingkatkan dan mempunyai kelikatan yang rendah. Bendalir nano yang berpotensi ini akan digunakan secara meluas dalam pelbagai industri seperti aplikasi bioperubatan, penyejukan, tenaga dan mekanikal.

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LIST OF SYMBOLS

C_p	=	Specific Heat Capacity, J/kg·K
ρ	=	Density, kg/m^3
μ	=	Viscosity, Pa·s
T	=	Temperature, °C
K	=	Thermal Conductivity, W/m·K

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CHAPTER I

INTRODUCTION

1.0 INTRODUCTION

An engine coolant is a heat transfer fluid designed to remove excess heat from an internal combustion engine. It also serves to prevent freezing and most importantly protection from corrosion. An operating engine typically converts only one third of the energy derived through the combustion of fuel into work that moves the vehicle. The other two thirds are converted into heat, of which one third goes out with the exhaust. This leaves the remaining third in the engine block, requiring the need for a coolant to absorb this heat, transport it to the radiator and dissipate it to the environment. Through the removal of this heat by the coolant fluid, the engine is able to operate in an efficient manner. Therefore, engine coolant is a generic term used to describe fluids that remove heat from an engine, in effect “cooling” the engine.

Conversely, during engine operation the fluid must possess the ability to remain a fluid as it is heated during operation. It must resist the tendency to boil and form a vapor as this reduces its ability to transfer heat. An efficient heat transfer fluid for use in combustion engines may require a low freeze point as well as an elevated boiling point, ensuring its capacity to perform in all situations encountered in the environment. Such characteristics are exhibited when glycols are combined with water and for this reason form the basis for all engine coolants.

The two main glycols that are used as engine coolants are ethylene glycol and propylene glycol. Both can be used in automotive or heavy-duty engine coolants or glycol-based heat transfer fluids, although it is generally accepted that ethylene glycol based fluids when used as directed, offer the greatest cost-effective performance advantage. Propylene glycol based engine coolants or low-temperature heat transfer fluids tend to be used in locations where a low toxicity product is required and due to the toxicity of ethylene glycol, it cannot be used. Currently, the majority of engine coolants in the global market place are ethylene glycol based.

1.1 PROBLEM STATEMENT

A cooling system requires a coolant to increase its cooling performance whereby commercial coolant such as ethylene glycol is generally used as it has good thermal conductivity and heat capacity. However, there is a limitation on how much amount of heat can be absorbed by the ethylene glycol. Therefore, in order to overcome this limitation, ethylene glycol is mixed with solid carbon nanotube (CNT) which will improve its thermal properties such as thermal conductivity, viscosity, specific heat capacity and heat transfer coefficient. Thus, increase its performance.

1.2 OBJECTIVE

The main objective of this project is to develop highly efficient nano-coolant produced from the mixture of nanocarbon, commercial coolant and dispersing agent.

1.3 SCOPE OF RESEARCH

i. To formulate a stable nano-coolant from the mixture of functionalized Multi-Walled Carbon Nanotube (MWCNT) and ethylene glycol.

ii. To find a suitable ratio of the ethylene glycol, functionalized MWCNT and dispersing agent for the stability of the nanofluids mixture.

iii. To analyze the thermal properties of the nanofluids on thermal conductivity, viscosity, specific heat capacity and heat transfer coefficient.

CHAPTER II

LITERATURE REVIEW

2.0 INTRODUCTION

Nanotechnology is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced. In its original sense, nanotechnology refers to the projected ability to construct items from the bottom up, with atomic precision, using techniques and tools being developed today to make complete, high performance products.

The ideas and concepts behind nanotechnology started with a talk entitled "There is Plenty of Room at the Bottom" by physicist Richard Feynman long before the term nanotechnology was used. In his talk, Feynman described a process in which scientists would be able to manipulate and control individual atoms and molecules. Over a decade later, in his explorations of ultra-precision machining, Professor Norio Taniguchi coined the term nanotechnology.

Nanotechnology also sometimes referred to as a general-purpose technology (Debnath *et al.* 2009). That is because in its advanced form it will have significant impact on almost all industries and all areas of society. It will offer better built, longer lasting, cleaner, safer, and smarter products in various fields such as communication, medicine, transportation, agriculture and industry in general.

Today, scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of light spectrum, greater chemical reactivity and better thermal properties than their larger-scale counterparts.

2.1 NANOFLUID

2.1.1 Definition

Nanofluids are the most recent approach in more than a century of work to improve the thermal properties of liquids. The low thermal properties of conventional heat transfer fluids are a serious limitation in improving the performance and compactness of engineering equipment. What began with millimeter to micrometer sized particles in the late 19^{th} century has become a part of the modern adventure into the new realm of the very small: the world of nanoparticles. Specifically, nanofluids are a new class of nanotechnology-based heat transfer fluids that are engineered by stably suspending a small amount of particles, fibers or tubes with lengths on the order of 1–50 nm in traditional heat transfer fluids.

Unlike heat transfer fluids containing microparticles, nanofluids are both stable and dilute. The key to their success as engineered heat transfer fluids is the synergy through mechanisms yet still poorly understood between the solid and liquid materials.

2.1.2 Applications

Very high thermal conductivity and extreme stability have always been desired for heat transfer fluids with particles. Fluids having this important combination of features did not exist till the advent of nanofluids. Nanofluid technology could make the process more energy efficient and cost-effective. These nanofluids could be used in a wide range of industrial applications. Demand for ultra-high performance cooling in electronics has been increasing and conventional enhanced surface techniques have reached their limit with regard to improving heat transfer. Since nanoparticles are relatively much smaller than the diameter of microchannel flow passages, smooth-flowing nanofluids could provide the solution. Since nanofluids can flow in microchannels without clogging, they would be suitable coolants. These could enhance cooling of microelectro mechanical system (MEMS) under extreme heat flux conditions.

Engine coolants (ethylene glycol/water mixtures), engine oils, automatic transmission fluids, and other synthetic high-temperature heat transfer fluids currently possess inherently poor heat transfer capabilities, they could benefit from the high thermal conductivity offered by nanofluids.

Nanofluids could be used as metalworking coolant fluids for grinding and polishing components. Solar energy systems could take advantage of nanofluids to enhance heat transfer from solar collectors to storage tanks. Nanofluids could improve the heat transfer capabilities of current industrial heating, ventilation and air-conditioning (HVAC) and refrigeration systems. Many innovative concepts are being considered; one involves the pumping of coolant from one location, where the refrigeration unit is housed to another location. Other potential nuclear applications include lightwater reactor coolants, standby safety system, spent-fuel storage pool, fusion diverters and others.

Nanofluids could also be designed for properties other than industrial heat transfer. For example, the biomedical field could disperse magnetic nanoparticles into blood, guide these magnetically to a cancerous tumor, and then use a laser or magnetic field that transfers energy to the particles to destroy the tumor without significantly heating the blood or damaging healthy tissue nearby. Targeted local delivery of drugs or radiation would also be possible using magnetically-guided nanoparticles in the bloodstream.

2.2 CARBON NANOTUBE (CNT)

Carbon nanotubes or CNT consist of long tube of carbon allotropes and thin fullerenes. They also have characteristics such as pentagonal rings at the end of the tube cap and hexagonal carbon wall. Figure 2.1 shows the computer-generated image of CNT. Its size could be about 1/50000 from the human's hair thickness. Moreover, they have physical, thermal and chemical properties which are beneficial in nanotechnology field (Wang *et al.* 2003). For example, the thermal conductivity of CNT is about two times from the diamond (Hone, 2001) which is why it is best used in coolant based nowadays.

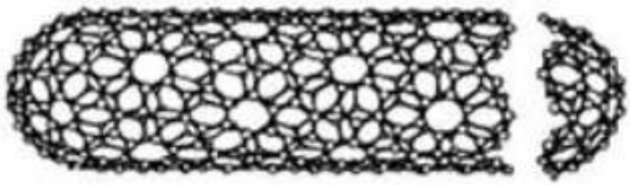

Figure 2.1: Computer-generated images of carbon nanotubes
(Source: Dresselhaus *et al.* 1995)

2.2.1 Types of Carbon Nanotube

2.2.1.1 Single-Walled Carbon Nanotube (SWCNT)

SWCNTs usually have a diameter close to 1 nm and have a tube length which is millions of times longer. One can imagine the structure of SWCNT by wrapping a graphene into a seamless cylinder. This type of CNT usually used for miniaturizing electronics products as it can be excellent conductors. One example is the electric wire. It is forecast that SWCNT could make large impact in electronics applications by year 2020 but one obstacle that become a problem nowadays is that it is too expensive for widespread application. Figure 2.2 is the illustration of SWCNT.

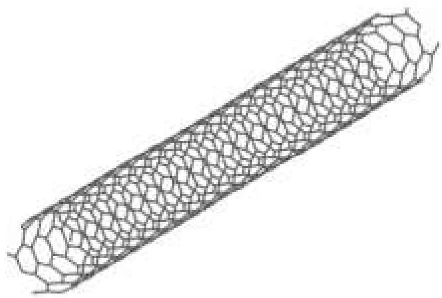

Figure 2.2: Single-Walled Carbon Nanotube structure
(Source: Patel, 2008)

2.2.1.2 Multi-Walled Carbon Nanotube (MWCNT)

This type of CNT consists of graphene that has multiple concentric tubes or rolled layers as shown in Figure 2.3. To describe the structure of MWCNT, one can use two types of models which are Russian Doll Model and Parchment Model. However, Russian Doll Model is more commonly used. Basically, MWCNT is thicker than SWCNT (Iijima, 1991). In terms of high mechanical quality and chemical stability, the MWCNT is more popular than SWCNT.