FORMULATION OF NANOFLUID FROM CARBON NANOPARTICLE BASED FOR NATURAL CONVECTIVE HEAT TRANSFER APPLICATION

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SUPERVISOR DECLARATION

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quantity for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)”

Signature: ……..

Supervisor: ……..

Date: ……...

DECLARATION

"I hereby declare that the work in this report is my own except the summaries and quotations which have been duty acknowledge."

Signature: ……..……..

Author: ……..……..

Date: ……...……..

Laporan ini di dedikasi kan kepada kedua-dua ibu bapa saya yang tercinta

Syed Saidin bin Syed Mahmod

dan

Sharifah Fadzlun binti Syed Jaafar

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ABSTRACT

This report is focusing on formulating nanofluid from carbon nanoparticles based for natural convective heat transfer application. This project carried out the aim to design and formulate stable of nanofluid with additional of carbon nanoparticles and to improve heat transfer convection of the nanofluid by 10%. This project based on formulate nanofluid using carbon nanotubes namely Pyrograph HHT 24 carbon nanotube. The nanofluid is formulate by using various ratio of carbon nanotubes and dispersing agent namely Polyvinylpyrolidone (PVP). Then the stability test of the nanofluid has been carried through experiment process. The heat transfer also being tested at three different temperatures which is 6°C, 25°C and 40°C. Heat transfer analyzer machine was used to test the heat transfer. The formulating of nanofluid started by mix the carbon nanotube and dispersing agent into based water. Then the mixture needs to homogenize by using homogenizer machine at 10000 rpm for one minute. Then ultrasonic machine was be used to avoid the particles in nanofluid coagulate by alglomeration process. Then pH value being checked and being adjust the nanofluid using sodium hydroxide (NaOH). The nanofluid are been leave for 100 hours. Lastly, heat transfer analysis test takes place. Nanofuid with 0.1 wt%, 0.2 wt%, 0.4 wt%, 0.5 wt%, 0.6 wt%, 0.8 wt%, and 1.0wt% of carbon nanotube being choose to test the heat transfer. 0.5 wt% of carbon nanotube shows optimum result at every each of temperature. As coclusion nanofluid with high heat transfer coefficient has highly potential in industry such as cooling application, energy application, mechanical application, and biomedical application.

ABSTRAK

Laporan projek ini adalah bertujuan untuk membuat bendalir nano daripada zarah-zarah nano berdasarkan aplikasi proses pemindahan haba. Projek ini juga mengeluar dan mensasarkan untuk mencipta bendalir nano yang dalam keadaan kukuh dengan penambahan zarah-zarah karbon nano dan untuk mempertingkatkan pemindahan haba daripada bendalir nano sebanyak 10%. Projek ini juga mensasarkan dalam mencipta bendalir nano dengan menggunakan pelbagai jenis nisbah daripada tiub-tiub karbon nano dan ejen surai yang bernama polivinilpirolidon (PVP). Kemudian proses menguji kestabilan bendalir nano telah dikenalpasti melalui projek ini. Ujian pemindahan haba juga diuji pada suhu 6°C, 25°C dan 40°C. Mesin analisa pemindahan haba telah digunakan dalm kajian ini. Proses membuat bendalir nano ini bermula dengan mencampurkan tiub-tiub karbon dan ejen surai ke dalam air tulen. Kemudain campuran tersebut telah dihomogenize menggunakan mesin homogenize pada kadar 10000 rpm selama seminit. Kemudain mesin ultrsonik digunakan untuk mengelakkan daripda berlakunya gumpalan zarah-zarah. Kemudian jumlah pH bendalir nano disukat dan diubah menggunakan sodium hikdrosida (NaOH). Bendalir nano ditinggalkan selama 100 jam. Akhirnya analisa pemindahan haba dilakukan. Bendalir nano dengan 0.1 wt%, 0.2 wt%, 0.4 wt%, 0.5 wt%, 0.6 wt%, 0.8 wt%, dan 1.0wt% telah dipilih untuk diuji dalam proses analisa pemindahan haba 0.5wt% kandungan karbon nanotube dalam bendalir nano menunjukkan keputusan yang sesuai dalam ujian pada setiap suhu yang berbeza. Sebagai kesimpulan, bendalir nano dengan kadar pemindahan haba yang tinggi berpeluang untuk digunakan dalam aplikasi penyejukkan, aplikasi tenaga, aplikasi mekanikal dan aplikasi perubatan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The rapid development of technology gives many advantages in human resource human become easier in making their life comfort and help human in many field of scope of life. It helps human in making money especially in business. A process in making a new product for a long time ago takes a long time and need to through a few stages and some for a simple product maybe need go through a few stages and for complex product need to go through many stages. For the product relates to electrical, manufacture and mechanical is rapid growth and has a high customer requirement in this new era globalisation.

In this new rapid growth of technology are in air conditioning system. Air conditioning system that are being one of important for human comfort are widely use and being interpolate and combine many of technology and did on purpose to increase the human comfort. Now days air conditioning are use as ventilation system for home, buildings, factories of production and many of other fields of mechanical. we are noted that the air conditioning system are to dissipate heat and reduces the temperature of environment into temperature of human comfort. Heat is the removal product that we are gone to expel it from as system. Heat are given more disadvantages than advantages of a system, one of the disadvantages are heat can cause a system down and wear for some of hardware application. Heat also can increase the pressure for some of machine and system and lastly can destroy them.

The technology need some touch of giving the heat can be dissipating easily and did not harm to the system. Based on theory heat can being absorbed and being

been release by a system. Process of reducing heat known as medium and this medium are easy to get or produce. The medium can dissipate or removing heat is exists in such some of forms. There can be in solid state, liquid state and gas state. The characteristic of the medium are can dissipate heat and absorb heat from a system. Technology are found it by supply the coolant liquid also can remove heat for application that are using in process cutting or even though in process on making a product. The coolant liquid is not suitable for some other of applications. In this project, research on formulation of nanofluid from carbon nanoparticles based for natural convective heat transfer application. This research is focusing in making some medium in form of liquid and has it heat transfer characteristics which is high value of heat transfer by formulate the nanofluid by controlling the amount of ratio carbon nanotubes and the chosen dispersing agent are being solved in water. The pure water that now used as one of medium does not have a better heat transfer and this research are being to investigate in formulating nanofluid based on water to improve the heat transfer. Water is being easier to found and it will be a reason why water has been used as a medium to reduce heat and the problem is the water does not have better characteristic of heat transfer like nanofluid.

Fluid of nano or nanofluid is a liquid form that contain of nanometer in size particles called nanoparticles. Meaning that nanofluid consist condensed nanomaterials which are nanoscale cooloidal suspensions. There to phases of sytems and one of it is in solid phase and the second one in form liquid phase. The advantages of nanofluids and characteristics of nanofluid are it has it own value of thermophysical properties like thermal conductivity, thermal diffusivity, viscosity and convective of heat transfer coefficients different with base fluids such as oil and base water. And in more extra condition it has been found that has a great potential In many fileds of application that need liquid not are like base water or oil. Nanofluids has its own different characteristic and make it so being valuable that be used in some application in heat transfer included micro electrical, hybrid engine air conditioning system, domestic refrigerator, heat exchanger, nuclear reactor, grinding field and also flue of gas system. Nanofluid is related to the stabilities and it is hard to maintain and to achieve the stability of nanofluid.

1.2 Problem statement

This is about formulation of nanofluid from carbon nanoparticle based for natural convection heat transfer application. This research is based on the combination of solid particle in nano sizes (Pyrograf HHT24 CNT) with dispersing agent Polyvinylpyrrolidone (PVP) in distilled water. The problem is in formulating nanofluid using various ratio of carbon nanotube and dispersing agent. Water was been used in heat transfer system and it is limited. Then nanofluid are purpose to increase the percentage of heat transfer.

1.3 Objectives

The objective is:

1. To design and formulate the stable of nanofluid with carbon nanoparticles.
2. To improve heat transfer convection of the nanofluid by 10%.

1.4 Scope

The study limit:

1. To formulate nanofluid using nanotubes namely pyrograf HHT 24 CNT.
2. To formulate nanofluid using various ratio of carbon nanotube and dispersing agent namely polyvinylpyrrolidone (PVP).
3. To investigate the stability of the nanofluid.
4. To analyze the heat transfer performance of the nanofluid prepared.

CHAPTER 2

LITERATURE REVIEW

2.1 Carbon nanomaterials

As well as nanotube ended up being drastically ignited with the first survey remark as well as tubules involving nanometer sizes (Dresselhaus et al. 1995) and there exists a huge development inside nanotechnology today (Lee et al. 2009). As well as nanomaterials (CNM) is generally offering physical objects pertaining to numerous purposes in several parts such as photonics, gadgets, supercapacitors and drug delivery (Baughman et al. 2009). There are many kinds of carbon nanomaterials. Carbon nanomaterials can be carbon nanotube.

2.2 Carbon nanotube

Carbon nanotubes (CNT) are generally cylindrical nano objects that are viewed as rolled-up graphene bed sheets and forms single-wall and multi-wall carbon nanotube (CNT). Single wall CNT in diameter which has in range from 0.4 to 3mm. Rapidly composition of an SWNT is comparable on the composition of an one graphene published, which in turn owns semi-conductor components, SWNTs might be both metallic as well as semiconducting. Single wall nanotube (SWNT) can be determined through the direction of the graphene sheet is rolled to form SWNT (Baughman et al. 2009). The special of carbon nanotubes which is has unique properties in electronic perspective. Carbon nanotubes can be metallic and can be semiconductor where as it depends on their chirality (Che et al. 2000).

2.2.1 Single wall carbon nanotube. (SWNT)

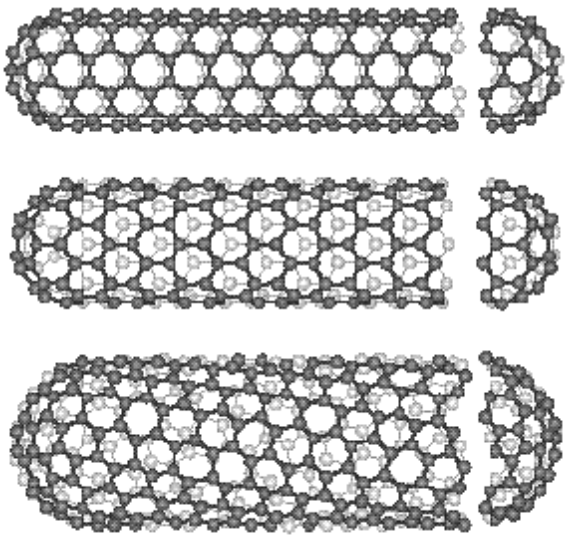

Figure 2.1: Single wall carbon nanotube.
Source: (McEun, et al. 2002)

Carbon nanotube (SWNT) in form single wall nanotube as shown in figure 2.1 which are in nanometer size in cylindrical shape consist of single graphene sheer rolled up to a tube, (McEun et al. 2002). Creating a single wall carbon nanotube by a single slap of graphite is being rolled and form to cylindrical shape. A single wall carbon nanotube build start with one layer of graphite. For a single wall nanotube has diameter in range 0.4-2.0 nm which in small micrometers in length (Nevin 2004).

2.2.2 Multi-walled carbon nanotube (MWNT)

Multi-walled carbon nanotube consists of concentric cylinders which are hollow in the middle of cylinders with a constant separation between the graphite layers spacing (Tang et al. 2003). In case additional graphite cellular levels are generally draped, a new cylindrical tube using a number of partitions may possibly consequence. This specific cylindrical tube is termed a new multi-walled as well as nanotube (MWNT). Multi-wall CNT diameters are larger up to 2 nm to 10 μm in length (Nevin 2004).

2.3 Dispersing agent

Dispersing agent acts as both the wetting agent along with a dispersing agent. Wetting is essential to enhance the speed where the fluid replaces the environment on the actual pigment area. Thereafter the mechanism must be stable in order to it is essential how the additive offers good dispersing qualities. The dispersing characteristics could be defined through two concepts: electrostatic repulsion or steric hindrance between your pigment contaminants, (Clariant international ltd 2011).

2.3.1 Polyvinylpyrolidone (PVP)

Surfactants utilized in nanofluid will also be called dispersants. Adding dispersants into blend carbon nanotube as well as water base is simple way to improve the stability from the nanofluid (Yu and Xie 2011). According to Zhu et al. (2007) the normal preparation associated with graphite suspension follow a graphite nano-powder had been dispersed inside required quantity distilled water and also the pH value of blend was modified to regarding 9.5 along with ammonia 0.5 wt% polyvinylpyrrolidone (PVP-K30) had been added like a dispersant.

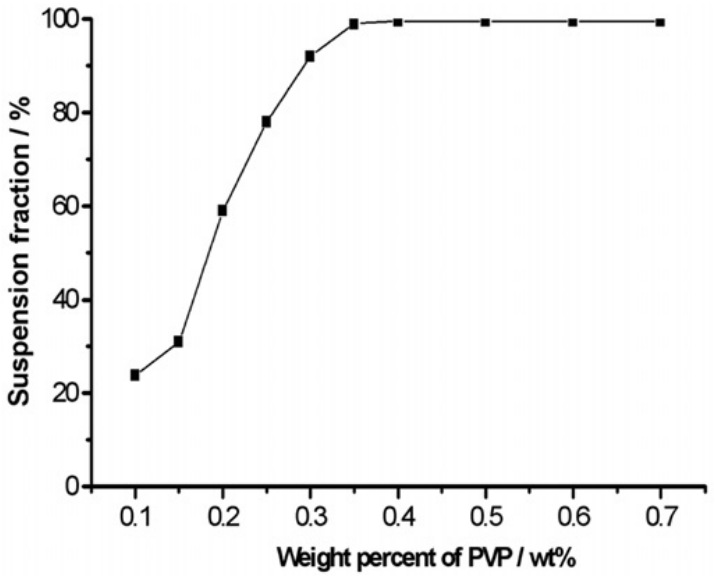

Figure 2.2: Stability of graphite suspension at different PVP concentration sedimentation for three weeks, pH=9.5
(Source: Zhu et al. 2007)

Zhu et al. (2007) stated PVP concentration on the steadiness of graphite suspension while shown throughout figure 2.2. According to Zhu et al. (2007) the weight percent of PVP below than 0.35wt% the suspension fraction in percent are increase from 0 until 100%. That is directly proportional to weight percent of PVP. If the weight percent of PVP is larger than 0.35wt% the stability graphite suspension remain unchanged within 100%. The weight percent of PVP is 0.6wt% the viscosity of suspension increase (Zhu et al. 2007). Once the PVP concentration is less in weight percent, with the actual increase associated with PVP, the top of graphite contaminants is progressively coated through PVP substances. The growing steric impact of PVP enhances the balance of graphite suspension. Once the PVP concentration is 0.35-0.6 wt%, probably all of the particles had been fully covered by PVP, leading to the greatest stability. Along with further growing of PVP, the repetitive PVP substances in water increase the viscosity associated with suspension (Zhu et al. 2007).

2.4 Nanofluid

Nanofluid is actually imagined to explain the liquid by which nanometer size contaminants tend to be hanging within traditional warmth move fundamental liquids. Traditional heat transfer , such as essential oil, water, as well as ethylene glycol mixture which are poor in heat transfer, because the actual energy conductivity of those liquids perform essential part upon heat transfer coefficient between heat transfer medium and surface of heat transfer. Consequently several techniques possess already been come to enhance the energy conductivity of those liquids through suspending nano/micro or even larger-sized particle supplies within fluidsm (Kakac and Pramuanjaroenkij 2009). According to choi (1995) nanofluid suspended particles which is less than 1% volume of nanoparticles will increase the thermal conductivity of the nanofluid up to doubles from the original heat transfer. According to Masuda et al. (1993) and Xuan and Roetzel (2000) the nanofluid consist of low concentration of nano particles 1 to 5 % can caused the the thermal conductivity can increase up to 20%. Nanofluid consists of nanoparticles which are made from many materials which have going process of synthesis and physical process (Kakac and Pramuanjaroenkij 2009). Nanoparticles in current research is using in the mechanical miling, technique condensation. Chemical reaction thermal sprying and usually the nanoparticles are form in powder which is light (Yu et al. 2007).

2.4.1 Preparation methods for Nanofluid

Preparation of nanofluid for two phases system have important issues that should be highlighted and it is the most toughest challenge to achieve the stability of nanofluid (Yu and Xie 2011). According to Yu and Xie (2011) there are three types of method in order to achieve nanofuid preparation. That is two-step method, one-step method and the last one is other novels methods.

2.4.1.1 Two-step method

According to Yu and Xie (2011) , Nanoparticle or nanotube that being used in producing nanofluid exist in form of dry powders by going the method of physical and chemical. The nanosize powder it can dispersed in distilled water then proceed for the second step that is by using the external forces from the ultrasonic agitation, high-shear mixing, homogenizing and lastly ball milling. The agglomerations make the fluids tend to achieve the stability of nanofluid in effective way therefore the agglomeration being the critical step cause it is the key for achieving the stability of the fluids (Yu et al. 2007). According to Yu et al. (2007) the agglomeration step cause the heat transfer occurs between the processes of agglomeration to break the bond nanoparticle in liquid.

2.4.1.2 One-step method

Single-step process is much better than the two-step process it is due to avoid from the oxidation process for example high-conductivity metals like copper. Nanofluid are going to dispersed and form nanofluid by single process for one-step method (Yu et al. 2007). According to Yu et al. (2007) noted that the one step process using direct evaporation tin creating non-agglomerating copper that dispersed and achieve the stability in ethylene glycol. According to Feng et al. (2006), agglomeration of nanoparticle can be reduce by one-step process which involve physical vapour condensation to prepare ethylene glycol nanofluid and Li et al. (2009) stated that one-step process is the simultaneously process which is the particles are dispersed in the fluids where as the process of drying, transportation fluids to avoid from nanoparticle dispersion process take place. In fact the agglomeration of nanoparticle can be reduces and at the same time the stability of the fluid can be achieved. The one-step process which can make the nanoparticle dispersed in water uniformly and being stable in base fluid (Yu et al. 2010).

2.4.1.3 Other novel methods

Preparation of nanofluid using other novel method has their own particles geometrics. According to Yu et al. (2007) stated that the nanoparticles which has special geometrics, density, porosity, charge, and surface of chemistries can build by the process of electrolysis metal deposition and undergoes the layer by layer assembly, micro droplet and finally the colloid chemistry methods Yu et al. (2007) also stated that there has another one process that is chemical vapour condensation method which is within this process to control particles size, scability and it is possible way n producing novel core –shell nanostructures. According to Yu and Xie (2011) the other novel methods which are the process continuously flow process of microfluid micrometer. The micrometer of the nanofluid can be adjust by controlling the parameters such as reactant concentration, flow rate and lastly additive.

2.4.2 The stability of nanofluid

The nanoparticles in nanofluid are being agglomerate which is that not only clogging of microchannels but it also effected until the nanofluids are in low thermal conductivity of nanofluid (Yu and Xie 2011). According Yuand Xie (2011) the stability of nanofluid is the main issues there are three ways of method that can achieve the stability of the nanofluid. There are three step that was being proposed by Yu and Xie (2011) that is (a) the stabilation evaluation methods for nanofluid, (b) the ways of enchance stability of nanofluid and lastly (c) the stability mechanism of nanofluids.

2.4.2.1 The stability evaluation methods for nanofluid

Yu and Xie (2011) state the stability evaluation method can be evaluate by sedimentation and centrifugation method, zeta potential analysis and spectral absorbency analysis. There are several methods that has been develop in order to evaluate the stability of nanofluid (Yu et al. 2010) and (Li et al. 2007).