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: ……………………………………..

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DECLARATION

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

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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)

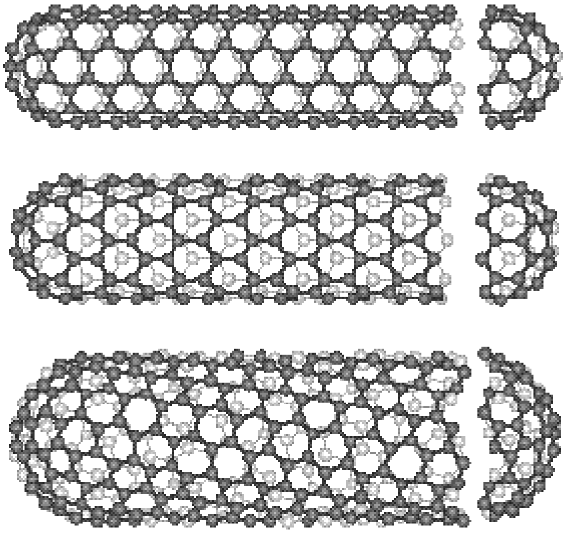


Figure 2.1: Single wall carbon nanotube.

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.

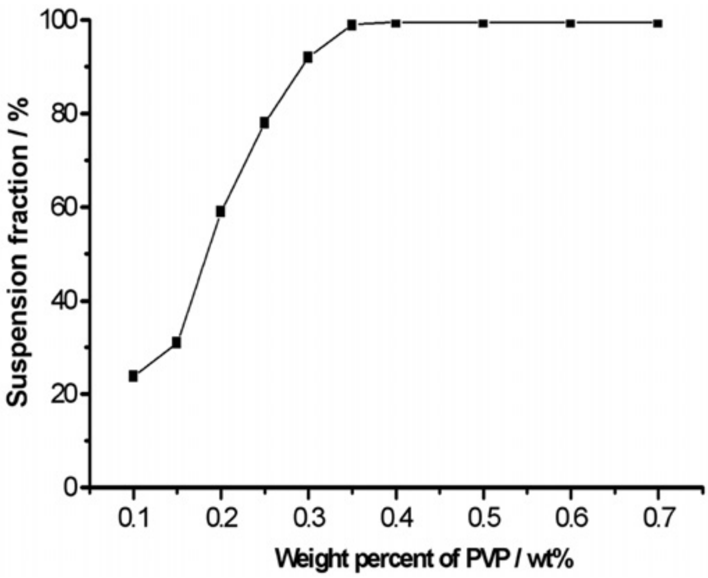


Figure 2.2: Stability of graphite suspension at different PVP concentration sedimentation for three weeks, pH=9.5

(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).

2.4.2.1.1 Sedimentation and centrifugation method

According to Li et al. (2009) state that the actual sediment pounds or even the actual sediment amount of nanoparticles inside a nanofluid below a good exterior pressure area is actually a sign from the balance from the indicated nanofluid. The actual variance associated with focus or even particle dimension associated with supernatant particle along with sediment period can be acquired through unique equipment. The particular nanofluid are usually regarded as being secure any time the particular awareness or perhaps particle dimensions regarding supernatant allergens maintains continual. Sedimentation photo regarding nanofluid inside analyze pontoons obtained by way of a photographic camera can be any normal way for noticing the particular stableness regarding nanofluid (Li et al. 2009). According to Zhu et al. (2007) utilized the sedimentation stability solution to calculate the actual balance from the graphite suspension. In other point the particular dish regarding sedimentation equilibrium immerged inside the refreshing graphite suspension. The particular weight regarding sediment nanoparticles within a specific period of time has been assessed. The particular suspension portion regarding graphite nanoparticles with a specific moment could possibly be computed. For the sedimentation approach, long period regarding statement could be the problem (Zhu et al. 2007).

2.4.2.1.2 Zeta potential analysis

Zeta potential is actually electrical potential within the interfacial dual coating in the area from the sliding plane as opposed to a place within the mass liquid from the actual user interface, also it exhibits the actual possible distinction in between the actual distribution moderate and also the fixed coating associated with liquid mounted on the actual spread particle (Yu and Xie 2011). According to Yu and Xie (2011) stated that the importance associated with zeta possible is actually which it is worth could be associated with the actual balance associated with colloidal dispersions. Therefore, colloids along with higher zeta possible (negative or even positive) tend to be electrically stable, whilst colloids along with reduced zeta possibilities often coagulate or even flocculate.

2.4.2.1.3 Spectral absorbency analysis

Spectral absorbency evaluation is actually an additional effective method to assess the balance associated with nanofluid. Generally, there's a linear relationship between absorbency strength and also the focus associated with nanoparticles within the fluid (Yu and Xie 2011). The actual sedimentation kinetics may be based on analyzing the actual absorbency associated with particle solution (Zhu et al. 2009).

2.4.2.2 The ways to enchance the stability of nanofluid

In order to enchance the stability of nanofluid, Yu and Xie (2011) stated that there are three factors on enchancing the stability of nanofluid. There are surfactants used in nanofluid, surface modification techniques by free methods and stability mechanism of nanofluid.

2.4.2.2.1 Surfactants used in nanofluid

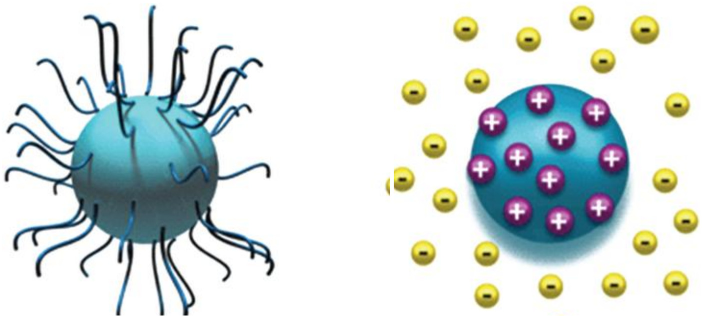
Nanofluids formulation using the surfactant called dispersants. According to Yu and Xie (2011) by adding dispersants is the easy way and economic method to enchance the stability of nanofluid Yu and Xie (2011) noted that the exits of dispersant are effected the surface characteristics of a nanofluid with in a small range, it is due the dispersant consist of hydrophobic tail portion and it is normally form in long chain hydrocarbon and has special characteristics that is hydrophilic polar head group. Dispersants are utilized to improve the actual get in touch with associated with two types of materials, occasionally referred to as wet ability. Inside a two-phase system, the dispersant has a tendency to find in the user interface from the two phases, exactly where this presents a degree of continuity between nanoparticles and fluids (Yu and Xie 2011).

2.4.2.2.2 Surface modification techniques

Usage of functionalized nanoparticle can be a encouraging way of attain long-term stableness regarding nanofluid. That symbolizes represent the free technique method. According to Yang and Liu offered the focus on the actual functionality associated with functionalized silica (SiO_2) nanoparticle through grafting silanes straight to the top associated with silica nanoparticle within unique nanoparticle options (Yang et al. 2010). Among the distinctive features from the nanofluids had been which absolutely no depositing coating created about the warmed area following a pool boiling process. According to Hwang et al. (2007) found and introduced hydrophilic functional groups upon the top of nanotubes through mechanochemical response (Hwang et al. 2007). The wet mechanochemical response had been put on put together surfactant-free nanofluid that contains double- as well as single-walled CNTs. Outcomes in the infrared range as well as zeta possible dimensions demonstrated how the hydroxyl groups have been introduced on to the treated CNT areas (Chen et al. 2010).

2.4.2.2.3 Stability mechanism of nanofluid

Contaminants within distribution might stick collectively as well as type aggregates associated with growing dimension which might negotiate away because of the law of gravity. Stability means that the actual contaminants do not aggregate at a significant rate. The rate of aggregation within common based on the actual rate of recurrence associated with collision and also the probability associated with cohesion throughout collision (Yu and Xie 2011). When the attractive force is actually bigger than the actual force, boths particles may collide and also the suspension are not stable. When the contaminants possess an adequate higher repulsion, the actual suspensions may can be found within steady condition. With regard to steady nanofluid or even colloids, the actual repulsive force causes in between contaminants must be dominant (Yu and Xie 2011).



Steric stabilization Electrostatic stabilization

Figure 2.3: Types of colloidal stabilization.
Source: Yu and Xie (2011)

According to Yu and Xie (2011) stated that there are two kinds of repulsion, the fundamental mechanism which impact colloidal stability tend to be split in to two types, the first is steric repulsion, as well as an additional is actually electrostatic (charge) repulsion as shown in Figure 2.3. With regard to steric stabilization, polymers tend to be involved to the suspension system, and it adsorb on to the actual particles area, generating one more steric repugnant pressure (Yu and Xie 2011).

2.4.3 Application of nanofluids

According to Yu and Xie (2011) the application there are several application of nanofluid such as application of nanofluid in heat transfers intensification, mass transfer enchancement, energy application, mechanical application, and biomedical application.

2.4.3.1 Heat transfer intensification

Tthe actual possibilities associated with nanofluids within heat transfer system possess drawn increasingly more attention (Yu and Xie 2011). According to Yu and Xie (2011) nanofluids which consist of oxides that is MgO, TiO_2, ZnO, Al_2O_3, and SiO_2 nanoparticles MgO, TiO_2, ZnO, Al_2O_3, and SiO_2 nanoparticles cause the nanofluids has highest thermal conductivity and lowest viscosity and in fact can enchance the effectiveness in heat transfer system.

2.4.3.2 Mass transfer enchancement

Researcher all over the world have studied that the enchancement of nanofluid through mass transfer (Yu and Xie 2011). Kim et al. (2006) are used nanofluid application as the effect of nanoparticle for NH_3/H_2O absorption system on the bubble absorption (Kim et al. 2006). The actual add-on associated with nanoparticle improves the actual assimilation overall performance as much as 3 times. After that, these people visualized the actual bubble behaviour throughout the NH_3/H_2O absorption process as well as analyzed the result associated with nanoparticle as well as sucfactants upon the actual assimilation characteristics (Kim et al. 2007).

2.4.3.3 Energy application

With regard to energy application associated with nanofluid, two special properties have been defined associated with nanofluid, one is the greater thermal conductivities associated with nanofluid, improving heat transfer , and the second is the assimilation qualities associated with nanofluid (Yu and Xie 2011).

2.4.3.4 Mechanical application

Nanoparticles within nanofluid type the protecting film along with reduced hardness as well as elastic modulus about the worn surface viewed as because the main reason which a few nanofluid display superb lubricating properties. Permanent magnetic liquids tend to be types of special nanofluid. Permanent magnetic liquid rotary operate without any maintenance and reduced leakage in wide range of application and it based on the property magnetic properties in nanoparticles in fluid (Yu and Xie 2011).

CHAPTER 3

METHODOLOGY

3.1 Introduction

Formulating the nanofluid need a correct step so that can achieve the stability of the nanofluid. Then the correct step and planning should be come out along the process of formulating the nanofluid carry on. Figure 3.1 belows shows the flow chart process formulating the nanofluids.

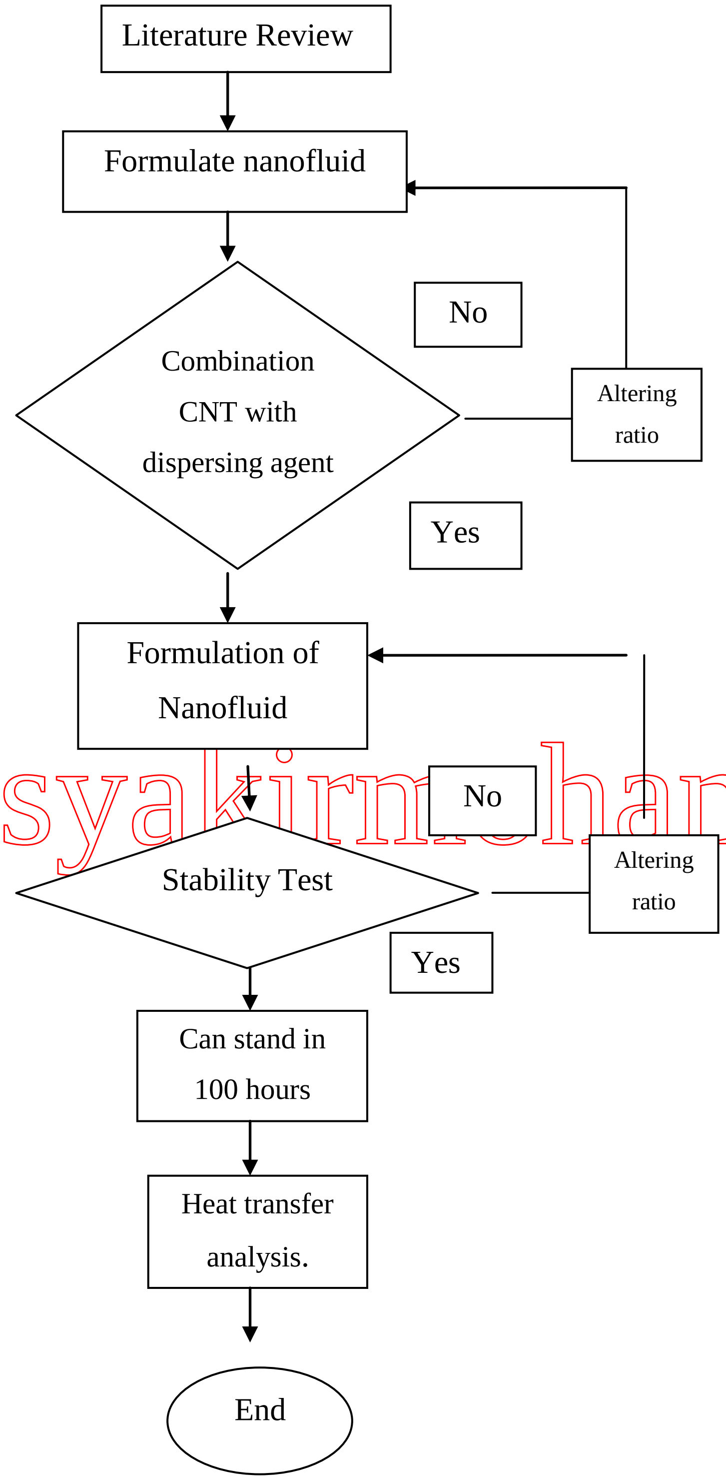


Figure 3.1: Flow chart process.

3.2 Parameter set up in experiment

3.2.1 Deionized water

The deionized water commonly used as experiment parameter because it has the special characteristics which is good thermal conductivity compared to other based fluids. The deionized water can be produced and found easily compare to the other based fluids. According to Walther et al. (2001) the application based fluid for formulate nanofluid stated that typical aspect of those applications may be the interaction from the CNT using the surrounding moderate, and particularly the hydrophobic-hydrophilic behaviour from the CNT. Since the single-wall CO_2 nanotube includes graphene linen rolled as much as form the tube, expect the properties associated with CNT-water interface to become similar in order to those from the graphite-water user interface to very first order.

3.2.2 Carbon nanotube (CNT)

The pyrograf HHT 24 CNT is the types of carbon nanotube used in this experiment. According to the Applied sciences, Inc. (2012) catalogue the density of pyrograf HHT 24 CNT are 2-4 lbs/ft as shown in Table 3.1.

Table 3.1: Pyrograf properties table

Source: Applied sciences, Inc. (2012)

Nano fiber type	Nano fiber grade	Density (lbs/ft)
PR-19	PS	2-4
PR-19	LHT	2-4
PR-19	HHT	2-4
PR-24	PS	2-4
PR-24	LHT	2-4
PR-24	HHT	2-4

3.2.3 Dispersing agent.

In this experiment the dispesing agent surfactants use is Polyvinylpyrolidone (PVP). PVP is better from the others dispersing agent because it produce less foam. According to Zhu et al. (2007) the polyvinypyrolidone weight percent (wt %) in big quantity can increase the stability of graphite suspension. The density of the polyvinylpyrolidone (PVP) is 1.6 g/cm^3, J & K Scientific ltd. (2008).

3.2.4 Ratio between CNT and Dispersing agents

Table 3.2 shows the ratio of carbon nanotubes (pyrograf HHT 24 CNT), dispersing agent pyrograf polyvinylpyrolidone (PVP) and deionized water based from the equation below.

$$\text{Volume of substances} = \frac{\text{weight percent of the subtance decide (wt\%)}}{\text{the actual weight percent of subtance (wt\%)}} \text{ ---------Eq 3.1}$$

Table 3.2 shows total volume of the nanofluid is 40 ml consists of volume carbon nanotubes, dispersing agent and deionized water.

Table 3.2: Weight percent of ratio of the substances in nanofluid experiment.

CNT (wt %)	V CNT (cm^3)	PVP (wt %)	V PVP (cm^3)	Deionised water (ml)
0.04	0.0200	0.0000	0.00000	39.98000
0.04	0.0200	0.0080	0.00500	39.97500
0.04	0.0200	0.0160	0.01000	39.97000
0.04	0.0200	0.0240	0.01500	39.96500
0.04	0.0200	0.0320	0.02000	39.96000
0.04	0.0200	0.0400	0.02500	39.95500

V= volume

3.3 Apparatus

There are several types of apparatus that was used in this experiment from the weighting the substances until the process stability test. The apparatus that was use is analytical balance, mechanical homogenizer, ultrasonic cleaning, pH meter, stability test rig and the last one is heat transfer analyzer.

3.3.1 Analytical balance

The function of the analytical balance is to weighting the mass of the substances. The special of the analytical balance is it has four decimal place that influence for the exactly value for the mass weighting.

3.3.2 Mechanical Homogenizer

The mechanical homogenizer machine functions as to stir the solution at 10000 rpm. The homogenizer machine can stir at 27000 rpm and it will be the advantages of this machine. The homogenizer machine manufactured by Lab Genius Company shown in Figure 3.2.

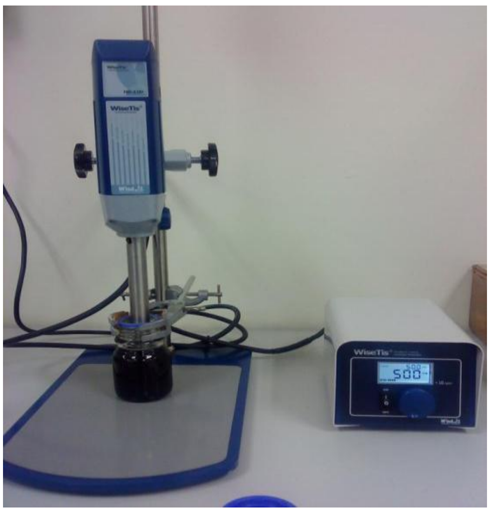


Figure 3.2: Homogenizer machine.

3.3.3 Ultrasonic cleaning

Figure 3.3 shows the ultrasonic cleaning machine which is manufactured by Elma Hans Schmidbauer GmbH & Co. KG, a German company. The ultrasonic cleaning function to break down the agglomeration produce in the nanofluid and the clogging produce in the nanofluid the nanofluid disperse completely in ultrasonic cleaning machine and this process is about 60 minutes.

Figure 3.3: Ultrasonic cleaning machine.

3.3.4 pH meter

pH meter is one important apparatus to measure and checking the pH value of solution. The pH meter sticks is immersed in the solution and give the pH value of the solution.

3.3.5 Stability test rig

Figure 3.4 shows the stability test rig. This apparatus function as to check the stability of the nanofluid after 100 hours left the nanofluid. Nanofluid solution in bottle being put into the stability test rig and laser light kit penetrate laser ray into the hole parallel to the stability test rig and observe the light that going through the hole.

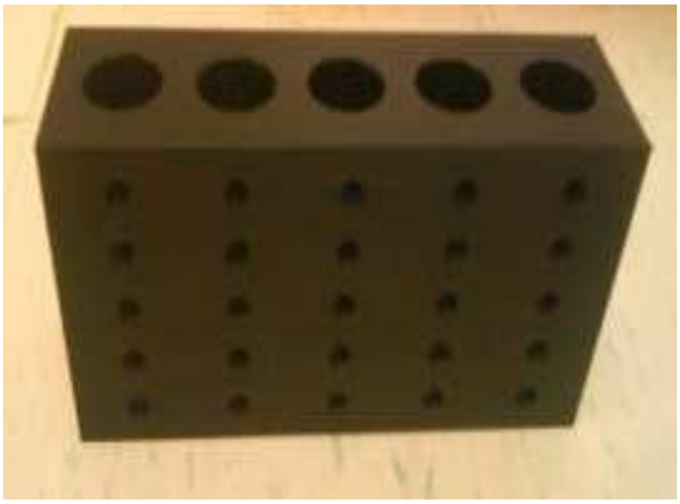


Figure 3.4: Stability test rig

3.3.6 Heat transfer analyzer

Heat transfer analyzer use for to test the stable nanofluid suck in the nanofluid in the test apparatus then measure the temperature inlet and outlet of the apparatus.

3.4 Experimental procedure

The following procedure will discuss about the preparation of nanofluid including the thermal conductivity and viscosity:

1. All the parameter for nanofluid preparation was weighed up which is CNT,PVP , and water

2. Then, the CNT, PVP is mixed together in the deionized water by following the correct ratio in the glass beaker. The bottle was shook in order to make the solution well-mixed

3. The homogenizer was setup with the mixture of nanofluid. The propeller of the homogenizer is placed a few centimetres from the bottom of glass beaker. The speed of the homogenizer is set to 10000 rpm and this process took 60 second to complete.

4. After the mixture of nanofluid is well homogenized, the ultrasonic cleaner wasset up. The mixture of nanofluid is placed inside the ultrasonic cleaner. The temperature was set to 25°C at the highest frequency in order ensure the CNT and dispersing agent disperse evenly and completely inside the deionized water. This process took 60 minutes to complete.

5. The pH of the nanofluid was measured by using the pH metre before carry out the stability test.

6. The mixture of nanofluid once again being homogenized by mechanical homogenizer by set the 1000 rpm of propeller speed in a few minutes like stated in procedure number 3.

7. For the stability test to determine whether the actual CNT had been totally dispersed within the deionized water, it will begin right following the mixture had been produce and it might take a week to check on if any kind of

agglomerate occurs in the beaker. These types of stability assessments were examined periodically inside 1 in order to 100 several hours.

8. After the nanofluid passes the stability test, the mixture of nanofluid can be tested with heat transfer test by using heat miniature heat transfer analyzer test.

3.5 Safety Precaution

Every time doing the experiment, safety precaution should be the first. This is due to avoid from accident. The proper wearing clothes (lab coat) should be wear every time conduct and handling in laboratory area. Wearing the mask face is important when handling the carbon nanotube and dispersing agent because all this two substances are in nano size and light so it can harm our respiratory organs if we inhale freely. After the experiment done, take 5 to 10 minutes to clean all the apparatus and make sure wash hands in correct ways.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Heat transfer analysis is process start after the stability test process test takes placed. The heat transfer begins with chosen the selected ratio of carbon nanotube. The ratio of the carbon nanotube was chosen from discussion student with lecturer. The heat transfer analyzer equipment has been set up. A water pump has been used as medium to transfer the nanofluid from beaker into copper coil and being circulated back into the beaker. Tube was been used as a medium of transfer mechanism of the nanofluid into the beaker. The nanofluid need to be reproducing about 300ml based on the carbon nanotube and dispersing agent. The types and size of the water pump are being considerate so it did not need to have large space so that it can immerse in beaker. Nanofluid has been test into three different temperatures which is 6°C, 25°C and 40°C.

4.2 Stability test for nanofluid.

Stability test process is one of the major parts on this experiment. The stability test is the process to determine the stability of the nanofluid. This process takes place after all the samples of nanofluid are leaving for 100 hours equal to four days.

4.2.1 Nanofluid formulation

Table 4.1 shows the nanofluid formulation of the nanofluid base of carbon nanotube (pyrograf HHT 24 (CNT) with dispersing agent polyvinylpyrolidone (PVP). The density of CNT is 2.0 g/cm^3 and the density for dispersing agent PVP is 1.2 g/cm^3. The result shows the nanofluid code NF13001 is not stable after tested using stability test rig.

Density of carbon nanotube (g/cm^3) = 2.0
Density of polyvinylpyrolidone (g/cm^3) = 1.2
Volume water (mL) = 100

Table 4.1: Formulation of nanofluid

Code	CNT (wt%)	PVP (wt%)	V CNT (cm^3)	V PVP (cm^3)	Water (mL)	stable
NF13001	0.1000	0.0000	0.0500	0.0000	99.9500	**no**
NF13002	0.1000	0.0200	0.0500	0.0167	99.9333	**yes**
NF13003	0.1000	0.0400	0.0500	0.0333	99.9167	**yes**
NF13004	0.1000	0.0600	0.0500	0.0500	99.9000	**yes**
NF13005	0.1000	0.0800	0.0500	0.0667	99.8833	**yes**
NF13006	0.1000	0.1000	0.0500	0.0833	99.8667	**yes**
NF13007	0.2000	0.0800	0.1000	0.0667	99.8333	**yes**
NF13008	0.4000	0.1600	0.2000	0.1333	99.6667	**yes**
NF13009	0.5000	0.2000	0.2500	0.1667	99.5833	**yes**
NF13010	0.6000	0.2400	0.3000	0.2000	99.5000	**yes**
NF13011	0.8000	0.3200	0.4000	0.2667	99.3333	**yes**
NF13012	1.0000	0.4000	0.5000	0.3333	99.1667	**yes**
NF13013	1.2000	0.4800	0.6000	0.4000	99.0000	**yes**
NF13014	1.4000	0.5600	0.7000	0.4667	98.8333	**yes**
NF13015	1.5000	0.6000	0.7500	0.5000	98.7500	**yes**
NF13016	1.6000	0.6400	0.8000	0.5333	98.6667	**yes**
NF13017	1.8000	0.7200	0.9000	0.6000	98.5000	**yes**
NF13018	2.0000	0.8000	1.0000	0.6667	98.3333	**yes**

V= volume

4.2.2 Stability of nanofluid

Based on the eighteen samples that was been formulated or formed shows the stability of the nanofluid. The result show the nanofluid sample which is NF13001 is not stable compare to the other samples of nanofluid. The sample code NF13001 is formulation of nanofluid without dispersing agent that is polyvinylpyrolidone (PVP). All the samples was been observing through the stability test rig which shows result of the stability. Nanofluid was been formulated by adjusting the ratio of carbon nanotube (HHT 24) and dispersing agent (PVP). The different ratio of the CNT and PVP give the stability of the specimen. Characteristic of carbon nanotube is hydrophobic which is unable disperse in water so dispersing agent (PVP) will be the solver of this problem because the dispersing agent (PVP) are purpose to make the CNT disperse well in water. The nanofluid being test by using stability test device which is LED light devices are penetrating towards the nanofluid if LED light are light it shows that the nanofluid are stable. It is same goes to laser test device which same concept and same way of observing. Both the method was used to identify whether the nanofluid stable or not stable.

4.2.3 Heat transfer analysis test

Nanofluid that was produced was be chosen based on the ratio carbon nanotube. Carbon nanotube 0.1wt %, 0.2wt%, 0.4wt%, 0.5wt%, 0.6wt%, 0.8wt% and 1.0wt% has been chosen as sample to be tested through the heat transfer analysis process. The ratio of CNT is being adjusted to determine the enhancement of heat transfer through nanofluid. All the samples were being chosen must be reproduced about 300mL so that the heat transfer test can be done. The experimental equipment like cooper coil, beaker, water pump, tube are being setup to test the heat transfer. All the connection tube must be insulated with insulator so that the nanofluid heat transfer does not affected by the surrounding area.

4.2.4 Heat transfer nanofluid formulation

Table 4.2 shows the nanofluid formulation for heat transfer test process. For the heat transfer analysis test we must produce about 300 mL of nanofluid so that the heat transfers test can be done to circulate the nanofluid about 15 minutes. Table shows the carbon nanotube (CNT) and dispersing agent (PVP). The density of CNT is 2.0 g/cm^3 and the density for dispesing agent PVP is 1.2 g/cm^3.

Density of carbon nanotube (g/cm^3) = 2.0

Density of polyvinylpyrolidone (g/cm^3) = 1.2

Volume water (mL) = 300

Table 4.2: Ratio of CNT and dispersing agent for 300mL

Code	CNT (wt%)	PVP (wt%)	V CNT (mL)	V PVP (mL)	Water (mL)
N13001	0.1000	0.0400	0.1500	0.1000	299.7500
N13002	0.2000	0.0800	0.3000	0.2000	299.5000
N13003	0.4000	0.1600	0.6000	0.4000	299.0000
N13004	0.5000	0.2000	0.7500	0.5000	298.7500
N13005	0.6000	0.2400	0.9000	0.6000	298.5000
N13006	0.8000	0.3200	1.2000	0.8000	298.0000
N13007	1.0000	0.4000	1.5000	1.0000	297.5000

V= volume

4.2.5 Heat transfer analysis between water and nanofluid

Water is commonly used in industry as fluid to cool down things or use to dissipate heat. Water molecule consists of oxygen and hydrogen molecule that can be found at domestic water pipe where it will be test the heat transfer ability. The heat transfer result being recorded and being compared to nanofluid. Both of nanofluid and water being test about 15 minutes meaning that when the water pump start to operate and the temperature reading at inlet and outlet start being taken by using thermal couple. Heat transfers being test in three different temperatures. Every each of the samples is being tested under temperature 6°C, 25°C and 40°C. Then every each of samples is compared to determine the best result.

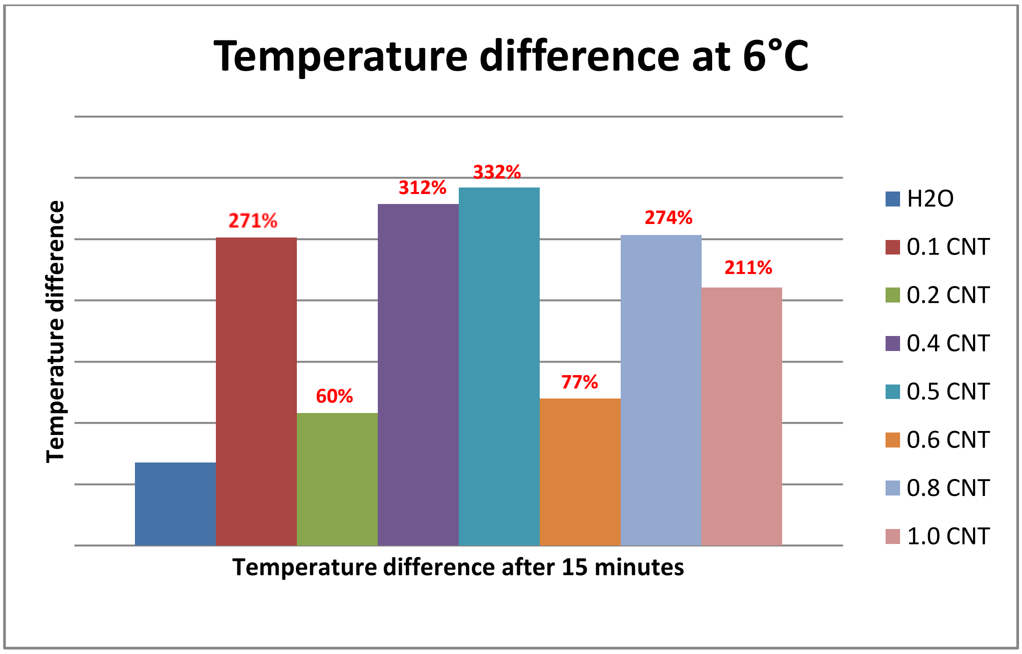


Figure 4.1: Graph temperature difference after 15 minutes at 6°C

Figure 4.1 shows the graph of temperature difference after 15 minutes at 6°C. The graph shows the increasing of the heat temperature difference through the nanofluid compared to water. 0.1wt%, 0.4wt%, 0.5wt%, 0.8wt% and 1.0 wt% CNT shows the extremely increasing of the heat temperature difference compared to 0.2wt% and 0.6wt% CNT that is 60% and 77%. It is due to the different of weight percent of carbon nanotube in every each samples. The highest percentage of enhancement is 0.5wt% CNT with 0.2wt% of PVP which is 332% of enhancement. It is prove that 0.5wt% CNT is effective in low temperature. It shows that nanofluid contain with carbon nanotube and dispersing agent giving the better result of heat transfer. Other than that the others samples shows average percentage of enhancement and it is good sign of heat transfer medium. 15 minutes is enough for the heat transfer analysis process, it is due to avoid from the pump a getting hot because it's running at a long time.

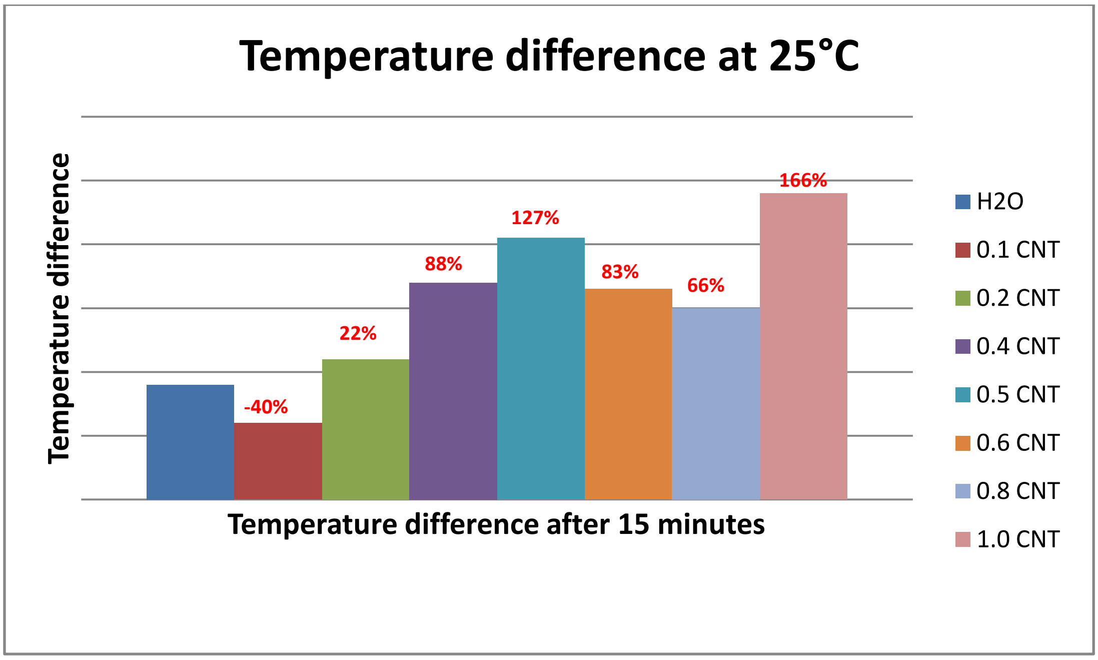


Figure 4.2: Graph temperature difference after 15 minutes at 25°C

Figure 4.2 shows the graph of temperature difference after 15 minutes at 25°C. There graph shows the increasing of temperature difference for every samples of carbon nanotube. For 1.0wt% CNT with 0.4wt% of PVP show the highest temperature difference which is 166% of enhancement. It shows that the 1.0wt% CNT is the best result and effective at 25°C that is room temperature. For 0.1 wt% CNT shows negatively result because the decreased of heat transfer difference. Meaning that for 0.1wt% of CNT performance of heat transfer is not suitable at room temperature condition. For 0.2wt%, 0.4 wt%, 0.5 wt%, 0.6 wt% and 0.8 wt% shows increased of heat transfer which is 22%, 88%, 127%, 83% and 66% of enhancement. Samples with high percent of carbon nanotube give better result. Carbon nanotube act like such a solid particles which is good in absorption of heat. More amount of ratio carbon nanotube in nanofluid, more heat will dissipate. At temperature 25°C all the samples shows average heat transfer percentage. It is because the 25°C is the temperature of the surrounding temperature and it does not affect the heat transfer coefficient. Overall performance of heat transfers 0.5wt% of CNT nanofluid will be optimum percentage of heat transfer because it show the good result in every single of temperature tested.

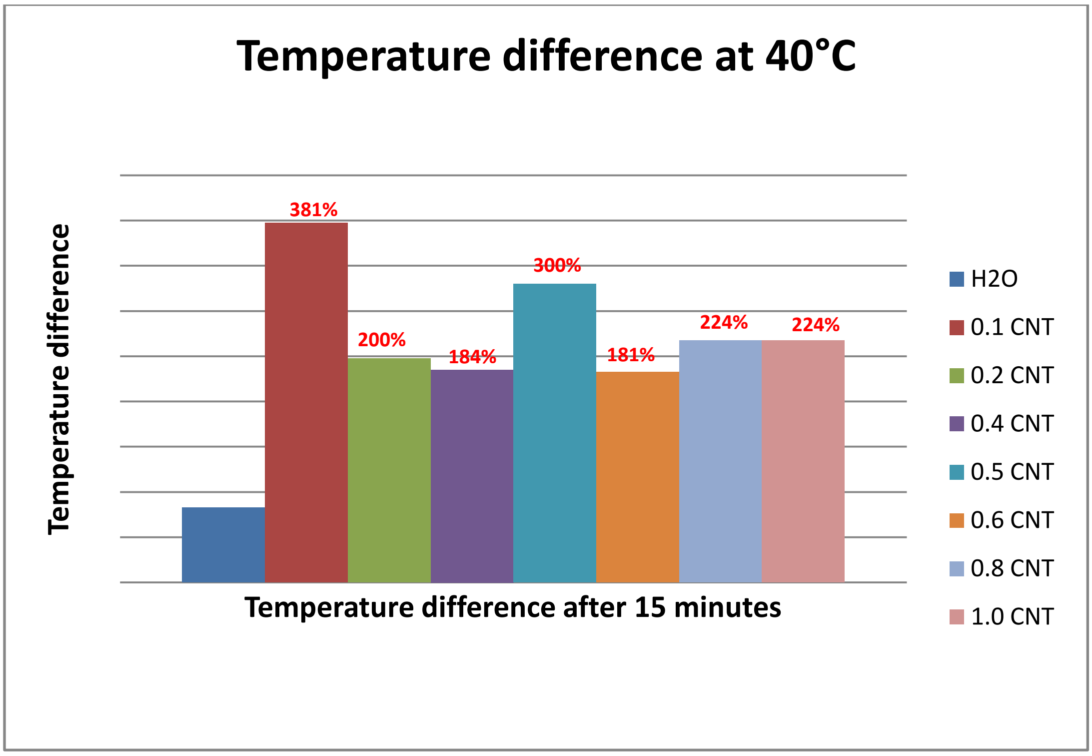


Figure 4.3: Graph temperature difference after 15 minutes at 40°C

Figure 4.3 shows the graph of the temperature difference of carbon nanotube at 40°C. The graph show 0.1wt% CNT is the highest temperature difference compared to the others sample which is 381% of heat transfer enhancement. 0.8wt% and 1.0wt% shows same value of heat temperature difference that is 1.07°C with 224% heat transfer enhancement. At temperature 40°C it does not giving so much difference at every sample of nanofluid. It is due to the dispersing agent (PVP) give reaction at high temperature. At high temperature the dispersing agent it will damage which mean that it cannot hold the bond between molecule of water and carbon nanotube lastly sedimentation of nanofluid takes place. At temperature at 40°C overall samples shows average temperature difference. The other samples of nanofluid which is 0.2wt%, 0.4 wt% and 0.6wt% of CNT shows average percentage of heat transfer with 200%, 184%, 181% and 181%. The optimum heat transfer percentage is 0.5wt% of CNT and 4wt% of PVP which is 300%. At temperature 40°C nanofluid are able to stand and it is shows positive result for it to be good heat transfers medium.

4.3 Discussion

The result shows that pyrograf HHT 24 CNT have higher heat transfer if compared to water. Water is widely used as a medium of heat transfers so the objective of this research to increase the percentage of heat transfer of water which is by replace it to nanofluid. Then it is proven that the nanofluid is much better than water as a medium to transfer heat. There are many factors that make the nanofluid is much better that water.

Nanofluid is consisting of carbon nanotube which is in solid in nano size meter and as we know solid is a good conductor of heat. In three different temperatures, the nanofluid shows enchancement of heat transfer. From that we can conclude that nanofluid contains of pyrograf HHT 24 CNT and dispersing agent polyvinylpyrolidone (PVP) give better enhancement of heat transfers if compared to water base. But there are explanation of nanofluid contain pyrograf HHT 24 CNT gave such extremely result. There are some factors that gave such extremely result which is molecules structure of pyrograf HHT 24 CNT, surface area of carbon nanotube, and properties of dispersing agent.

4.3.1 Comparison between CNT (pyrograf HHT 24 CNT) and water

Types of CNT are one of the factors that influence nanofluuid become good as heat transfer. Based from Dresselhaus, et. el. (2001) pyrograf HHT 24 is carbon nanotube which type carbon nanofiber (CNF) and its different from water which contain hydrogen and oxygen molecule. The advantages of carbon nanofiber are easier to disperse, easier to process and easier to functionalize.

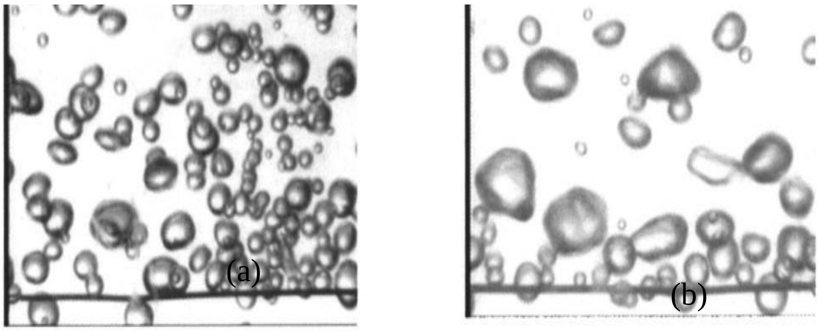


Figure 4.4: (a): Figure of water molecule (b): Nanofluid with carbon nanotube.

(Source: Prevenslik, T. 2013)

Figure 4.4 (a) water molecule (b) nanofluid consists of carbon nanotube and dispersing agent. The structure of carbon nanofiber is the main reason the pyrograf HHT 24 CNT give the better result on heat transferof nanofluid.

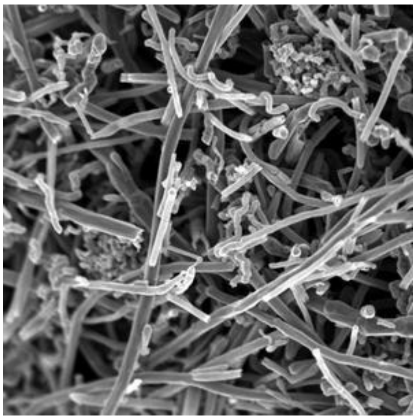


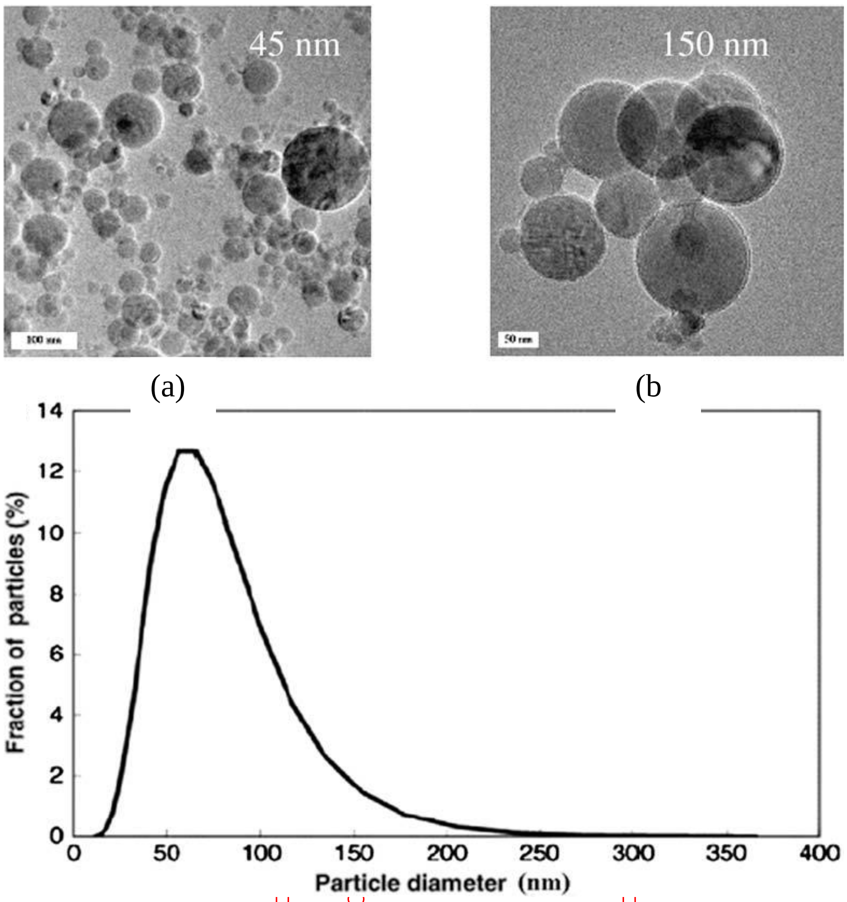
Figure 4.5: Structure of carbon nanofibre (CNF)

(Source: Anoop et. al 2009)

Figure 4.5 shows the structure for pyrograf HHT 24 CNT, for pyrograf structure it shows that pyrograf structure has longer and continuous length of tubes where more heat can dissipate through the length tube and make it the better for the heat transfer than water. The longer the tube, the higher surface area of CNT hence the higher heat transfer will be obtained.

4.3.2 Surface area carbon pyrograf HHT 24 CNT

Surface area of pyrograf HHT 24 CNT wiil be the major reason why the nanofluid can be the best heat transfer from water. If the surface are increase, it will more heat dissipate into the carbon nanotube. Smaller particles of carbon nanotube it more bigger surface area than the large size particles in same mass. Based from Anoop et. al (2009) state that nanofluid with size between in range 45nnm to 15onm particles showed higher heat transfer characteristic than the base water.



(c)

Figure 4.6: (a) Carbon nanotube with in 45nm size (b) carbon nanotube with in size 150nm (c) Graph of fraction (%) vs particles diameter (nm)

(Source: Anoop et. Al 2009)

Figure 4.6 shows the particles of nanofluid that are effect the heat transfer coefficient for nanofluid. The nanotube size within range 45nm and 150nm show increased heat transfer. Table 4.3 shows the properties pyrograf HHT 24 CNT. Pyrograf HHT 24 CNT particles size is 100nm so it is within the range of 45nm to 150nm. It would be high in heat transfer coefficient.

Table 4.3 : Properties of pyrograf HHT 24 CNT

Fibre diameter, nm	100
CVD carbon overcoat present on fibre	no
Surface are, m^2/gm	41
Dispersive surface energy, mJ/m^2	135
Moisture, wt%	<5
Iron, ppm	<100

(Source: Pyrografproducts, 2013)

4.3.3 Dispersing agent polyvinylpyrolidone (PVP)

Nanofluid that was produced is combination of carbon nanotube pyrograf HHT 24 CNT and dispersing agent polyvinylpyrolidone (PVP). The present of dispersing agent are really helps in achieve the stability of the nanofluid. Characteristic of PVP is very good in solubility in water which PVP can dissolve in water well. Dispersing agent is really helped improved adhesion between carbon nanotube and water. Dispersing agent structure consists of oxygen and hydrogen so it wills it be able for carbon nanoparticle can dissolve in water well. PVP also is non-toxic, odourless and chemically stable. Based from the observation, if the PVP are leaving a few minutes in open air the PVP powder are melt in form of liquid and there no more powder. From the observation it shows that the characteristic of PVP are very suitable and be a main factor for the nanofluid can stand for a long time and achieve the stability of the nanofluid.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As conclusion formulation of nanofluid based on carbon nanoparticle is consist some of the stages and factors. the formulation start with the process stability of nanofluid. The formulation of nanofluid has been discovered through some of the stages. For a better result, there must be the best of carbon nanotube use in this formulation. Pyrograf HHT 24 CNT has been chosen as the carbon nanotube and it is proven from some of the experiment stages in this research. The characteristic of the carbon nanotube that is size in nano size about 100 nm give the advantages for it been used in this research. The structure of the carbon nanotube which long in length is one of the criteria that were unique for the carbon nanoparticle. The formulation does not achieve if there no present of dispersing agent because the characteristic of carbon nanotube are hydrophobic. There are some special characteristic of this dispersing agent polyvinylpyrolidone (PVP) are very help to improve the adhesion bond between carbon nanoparticle and based water. Therefore PVP are very sensitive to open air and it can easily to melt. Heat transfer has been discovered through this research, which is use of nanofluid test in heat transfer miniature test. The nanofluid is been produced by adjusted the ratio of carbon nanotube in wt% and ratio of dispersing agent in wt%. 0.1wt%, 0.2wt%, 0.4wt%, 0.5wt%, 0.6wt%, 0.8wt% and 1.0wt% of carbon nanotube has been test through heat transfer tested. 0.5wt% of carbon nanotube it is show the best result every single temperature test which is 6°C, 25°C and 40°C.heat transfer of nanofluid was compared to water which is water are commonly widely used as medium of cooling. At temperature 6°C, every samples of nanofluid shows the positive result of heat transfer enhancement. For temperature 25°C there are negative percent of heat transfer that is 0.1wt% of CNT. There are some several factors that influence the negative effect on that sample. It is due to the ratio of carbon nanotube and dispersing agent. 0.5wt% shows an optimum result of heat transfer which is optimum heat transfer. For temperature 40°C every samples shows the positively effect of heat transfer which the highest heat transfer is 0.1wt%. Shows the extremely result. In other words nanofluid gives the better heat transfer and it was been proved by the structure of the carbon nanotube which is nanofibre types. If the small size of the particle gives large surface area and large surface area give more surface contact and heat been absorbed into the carbon nanotube which is in nanofluid. Nanofluid with high heat transfer coefficient has highly potential in industry such as cooling application, energy application and mechanical application

5.2 Recommendation

In future improvement the stability test analyzer can be modified as it used laser beam detector which is more sensitive and accurate.The copper coil use in the miniature heat transfer test should be longer it is due to give more time for nanofluid have contact with temperature in water bath.

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APPENDIX A

Table 5.1: Result temperature inlet and outlet for heat analysis at 6°C

Ratio of CNT	H_2O		0.1		0.2		0.4		0.5		0.6		0.8		1	
Temperature (°C) / time (minute)	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}
0	9.76	8.92	13.37	10.89	11.33	9.04	14.32	9.82	14.63	9.16	14.57	9.67	14.6	10.54	13.9	10.86
1	9.69	8.89	13.63	10.4	11.81	9.3	14.83	9.98	14.07	9.32	14.23	9.34	14.03	10.08	13.31	10.22
2	9.62	8.86	13.39	9.73	11.3	9.77	14.93	9.12	14.44	9.1	14.8	9.23	13.1	10.26	13.1	9.32
3	9.59	8.85	12.65	9.23	12.86	9.02	14.97	9.28	13.46	9.41	14.64	9.2	12.96	9.45	13.9	8.9
4	9.59	8.84	12.19	8.94	11.68	8.71	14.81	8.94	13.33	9.09	12.17	8.99	12.42	9.13	13.31	8.74
5	9.66	8.84	12.32	8.81	11.3	8.57	14.43	8.8	13.31	8.97	11.12	8.86	13.17	8.96	12.92	8.66
6	9.71	8.84	12.56	8.76	11.3	8.51	13.96	8.75	13.08	8.89	11.03	8.79	13.44	8.9	12.71	8.63
7	9.84	8.83	13.02	8.72	11.05	8.47	13.82	8.73	13.4	8.85	11.07	8.75	13.46	8.84	12.67	8.62
8	9.99	8.82	13.29	8.71	10.87	8.46	13.91	8.72	13.63	8.83	11.16	8.73	13.64	8.82	12.67	8.61
9	10.04	8.8	13.18	8.71	10.95	8.46	14.24	8.71	13.92	8.8	11.06	8.74	13.57	8.78	12.7	8.62
10	10.1	8.79	13.1	8.71	10.85	8.46	14.31	8.72	14.13	8.8	11.34	8.74	12.93	8.77	12.72	8.62
11	10.12	8.77	13.05	8.71	10.62	8.46	14.3	8.73	14.27	8.78	11.46	8.75	13.34	8.75	12.79	8.63
12	10.1	8.76	13.41	8.71	10.52	8.5	14.33	8.74	14.4	8.77	11.36	8.76	13.57	8.75	12.6	8.64
13	10.13	8.76	13.55	8.71	10.57	8.5	14.33	8.74	14.46	8.74	11.21	8.76	13.74	8.75	12.85	8.64
14	10.12	8.75	13.64	8.71	10.66	8.5	14.3	8.74	14.56	8.74	11.07	8.76	13.79	8.75	12.85	8.64
15	10.12	8.77	13.73	8.71	10.66	8.5	14.31	8.74	14.58	8.74	11.16	8.76	13.81	8.75	12.85	8.64

Table 5.2: Result temperature inlet and outlet for heat analysis at 25°C

Ratio of CNT	H_2O		0.1		0.2		0.4		0.5		0.6		0.8		1	
Temperature (^{o}C) / time (minute)	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}
0	26.25	26.51	27.63	26.53	26.24	26.67	26.26	26.68	25.9	26.57	25.78	26.54	25.79	26.52	25.75	26.56
1	26.33	26.49	27.25	26.81	26.32	26.66	26.32	26.69	26.05	26.61	25.98	26.59	25.98	26.56	25.99	26.65
2	26.35	26.49	26.74	26.73	26.33	26.69	26.4	26.7	26.2	26.64	26.21	26.66	26.18	26.66	26.11	26.67
3	26.36	26.49	26.54	26.7	26.34	26.68	26.38	26.71	26.28	26.68	26.29	26.67	26.26	26.69	26.14	26.68
4	26.36	26.49	26.58	26.71	26.36	26.67	26.41	26.7	26.33	26.69	26.26	26.69	26.26	26.7	26.16	26.68
5	26.37	26.51	26.52	26.72	26.42	26.7	26.39	26.71	26.34	26.69	26.3	26.7	26.3	26.67	26.2	26.67
6	26.37	26.5	26.52	26.71	26.43	26.7	26.43	26.73	26.37	26.69	26.36	26.73	26.3	26.68	26.21	26.68
7	26.37	26.52	26.54	26.72	26.43	26.7	26.45	26.75	26.4	26.72	26.38	26.72	26.28	26.68	26.2	26.7
8	26.36	26.52	26.52	26.72	26.41	26.71	26.43	26.78	26.42	26.75	26.41	26.71	26.31	26.67	26.21	26.69
9	26.36	26.51	26.53	26.73	26.4	26.71	26.42	26.76	26.59	26.77	26.41	26.72	26.3	26.67	26.21	26.7
10	26.35	26.52	26.61	26.74	26.43	26.71	26.38	26.74	26.6	26.78	26.4	26.73	26.31	26.67	26.24	26.71
11	26.35	26.53	26.63	26.74	26.48	26.72	26.38	26.74	26.64	26.78	26.4	26.73	26.35	26.68	26.23	26.74
12	26.35	26.54	26.61	26.74	26.49	26.72	26.42	26.74	26.54	26.78	26.39	26.73	26.31	26.69	26.27	26.71
13	26.36	26.54	26.61	26.74	26.5	26.72	26.47	26.74	26.37	26.78	26.4	26.73	26.32	26.69	26.26	26.71
14	26.36	26.54	26.6	26.74	26.5	26.72	26.42	26.74	26.32	26.78	26.4	26.73	26.34	26.69	26.23	26.71

Table 5.3: Result temperature inlet and outlet for heat analysis at 40°C

Ratio of CNT	H_2O		0.1		0.2		0.4		0.5		0.6		0.8		1	
Temperature (^oC) / time (minute)	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}	T_{in}	T_{out}
0	41.24	41	39.61	38.2	27.38	38.81	39.39	38.29	39.4	38.27	39.92	39.16	39.25	39.9	39.81	40.33
1	41.27	41	39.09	38.98	30.51	39.49	39.07	39.09	39.89	39.93	39.26	40.39	39.96	39.66	39.38	40.74
2	41.29	41	39.11	40.32	34.39	40.51	39.9	40.41	39.91	40.28	39.33	40.84	39.88	40.27	39.02	40.79
3	41.3	40.98	39.74	40.72	36.51	40.88	39.13	40.82	39.93	40.7	39.41	40.98	39.46	40.54	39.19	40.78
4	41.29	40.97	39.78	40.88	38.11	41.01	39.57	40.93	39.16	40.81	39.3	41.02	39.24	40.68	39.36	40.75
5	41.28	40.97	39.57	40.96	39.35	41.02	39.6	40.96	39.7	40.85	39.67	41	39.62	40.74	39.33	40.73
6	41.26	40.96	39.6	40.99	39.05	41.06	39.52	40.97	39.88	40.86	39.08	40.94	39.75	40.73	39.31	40.76
7	41.25	40.94	39.51	41.01	39.66	41.1	39.56	40.97	39.81	40.91	39.3	40.93	39.26	40.7	39.22	40.72
8	41.26	40.93	39.89	41.04	39.46	41.11	39.77	40.91	39.73	40.93	39.33	40.93	39.97	40.74	39.11	40.66
9	41.26	40.94	39.55	41.07	39.38	41.11	39.65	40.89	39.63	40.91	39.34	40.94	39.04	40.74	39.04	40.68
10	41.27	40.94	39.65	41.08	39.11	41.11	39.98	40.91	39.49	40.91	39.28	40.93	39.09	40.76	39.89	40.62
11	41.26	40.92	39.23	41.09	39.79	41.11	39.96	40.92	39.37	40.91	39.2	40.91	39	40.78	39.75	40.55
12	41.26	40.91	39.77	41.09	39.51	41.11	39.95	40.92	39.23	40.89	39.13	40.9	39.92	40.76	39.6	40.51
13	41.25	40.91	39.55	41.09	39.46	41.11	39.98	40.92	39.56	40.89	39.99	40.9	39.82	40.76	39.53	40.51
14	41.26	40.91	39.53	41.09	39.2	40.11	39.95	40.92	39.58	40.89	39.88	40.9	39.7	40.76	39.46	40.51
15	41.26	40.93	39.5	41.09	39.12	40.11	39.98	40.92	39.56	40.88	39.97	40.9	39.69	40.76	39.34	40.41

APPENDIX B

Table 5.4: Gantt chart PSM I and PSM II

Activity	PSM I (Week)														PSM II (Week)											
	1	2	3	4	5	6	7	8	9	10	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12
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Literature review																										
Background study																										
Methodology																										
Experimental setup																										
Selection and formulation																										
Experimental setup																										
Experiment																										
Analysis																										
Testing																										
Report writing																										
Report submitting																										

APPENDIX C

Equipment used in formulation of nanofluid

Figure 5.1: Homogenizer machine

Figure 5.2:Controlling rotation of rpm

Figure 5.3: Ultrasonic machine

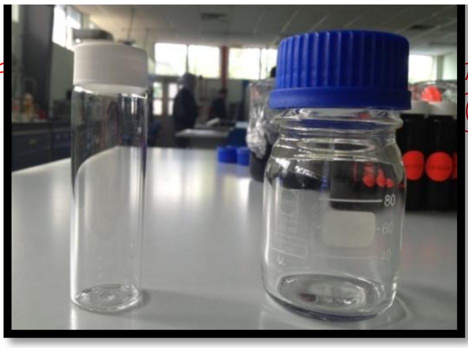

Figure 5.4 : 40mL and 100mL bottle

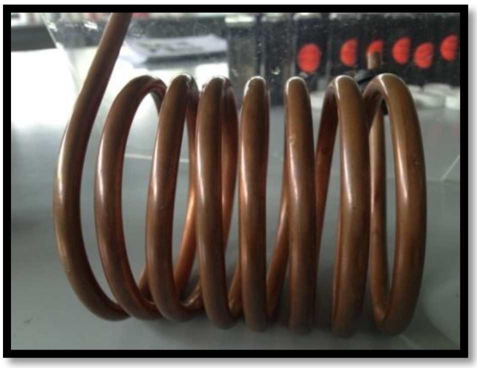

Figure 5.5: Copper coil

Figure 5.6: Thermal couple

APPENDIX D

Figure 5.7: Flow process formulating of nanofluid and heat transfer analysis test

APPENDIX E

Sample calculation heat transfer enhancement

Outlet temperature at 0.1wt% of CNT at 6°C = 8.71°C

Inlet temperature at 0.1wt% of CNT at 6°C = 13.73°C

Time difference at 0.1wt% CNT at 6°C

= inlet temperature – outlet temperature

= 13.73°C - 8.71°C

= 5.02 °C

Outlet temperature of H_2O at 6°C = 8.77°C

Inlet temperature of H_2O at 6°C = 10.12°C

Time difference of H_2O at 6°C

= inlet temperature – outlet temperature

= 10.12°C - 8.77°C

= 1.35 °C

Percentage of enhancement $= \dfrac{\textbf{experimental heat transfer}}{\textbf{base water heat transfer}}$ **X 100% - (100)**

= (5.02 °C / 1.35 °C) X 100%- (100)

= 271% of enhancement.