THE ENHANCEMENT OF COMPOSITE PHASE CHANGE MATERIAL TOWARDS THERMO-PHYSICAL PROPERTIES USING NANOPARTICLE FOR THERMAL ENERGY STORAGE

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DECLARATION

I declare that this project report entitled "The Enhancement of Composite Phase Change Material Towards Thermo-Physical Properties using Nanoparticle for Thermal Energy Storage" is the result of my own work except as cited in the references

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is enough in terms of scope and quality for the award of Bachelor of Mechanical Engineering with Honours.

Signature : ……………………………..

Supervisor's Name : ……………………………...

Date : ……………………………...

DEDICATION

I dedicated this project to all those respectful beings who have helped me in any way to become what I am today. Whose sacrifices seeded our success especially our parents who have felt my pain beyond me and never-ending prayers and support. I consider them as a divine of encouragement.

ABSTRACT

Nowadays, as global warming is becoming one of the world's most urgent problems, we need to find a better way to use energy, particularly in the energy storage are. Thermal energy storage is one of the recommended ways to improve energy recovery from solar energy, off-peak electricity and industrial waste heat recovery. In this paper, an overview of the Phase Change Material (PCM) experimental procedure is explored to improve its thermal conductivity. Enhancing PCM involves the use of nanoparticles that would influence the thermo-physical properties. Hence, the best candidate material as Nano fluids is preferred in order to maximize the thermal conductivity of the PCMs properties. The degree of super cooling of PCM affected by nanoparticle dispersion that can be regulated by the nanoparticle nucleation agent. In addition, the tiny structure can cause a large surface area of nanoparticles to correlate with their physical and chemical properties which lead with PCM's thermal-physical properties. Nanoparticles based on graphene are discussed in this study. The graphene surface area is the main characteristics used to determine the best thermal physical properties of material for Nano-enhanced phase change (NEPCM). Due to the best characteristics as base phase change material, inorganic salt hydrates material is reviewed in this paper. However, the use of graphene nanoparticles synthesis, characterization and modification process of nanoparticle itself to improve the thermal physical properties of inorganic PCM has been performed with limited research. The experiments in this paper are based on previous researchers by using different material of Nano fluids. The expected result of the study might be that the increasing percentage of thermal conductivity of the PCMs associated with its properties using systematic and numerical methods.

ABSTRAK

Pada masa kini, kerana pemanasan global menjadi salah satu masalah dunia yang paling mendesak, kita perlu mencari cara yang lebih baik untuk menggunakan tenaga, terutamanya dalam simpanan tenaga. Penyimpanan tenaga haba adalah salah satu cara yang disyorkan untuk meningkatkan pemulihan tenaga daripada tenaga suria, elektrik luar dan pemulihan haba sisa industri. Dalam makalah ini, gambaran keseluruhan proses eksperimen Bahan Perubahan Tahap (PCM) diuji untuk meningkatkan kekonduksian terma. Meningkatkan PCM melibatkan penggunaan nanopartikel yang akan mempengaruhi sifat fizikal terma. Oleh itu, bahan kandidat yang terbaik sebagai nanofluid adalah pilihan untuk memaksimumkan kekonduksian terma sifat-sifat PCM. Tahap Super cooling PCM dipengaruhi oleh penyebaran nanopartikel yang boleh dikawal oleh ejen nukleasi nanopartikel. Di samping itu, struktur kecil boleh menyebabkan luas permukaan nanopartikel yang besar untuk mengaitkan sifat-sifat fizikal dan kimia mereka yang membawa sifat-sifat fizikal haba PCM. Nanopartikel berdasarkan graphene dibincangkan dalam kajian ini. Kawasan permukaan graphene adalah ciri-ciri utama yang digunakan untuk menentukan sifat fizikal terma bahan terbaik untuk perubahan fasa nano yang dipertingkatkan (NEPCM). Oleh kerana ciri-ciri terbaik sebagai bahan perubahan fasa asas, bahan hidrat organik hidrat dikaji semula dalam kertas ini. Walau bagaimanapun, penggunaan sintesis nanopartikel graphene, pencirian dan pengubahsuaian nanopartikel itu sendiri untuk meningkatkan sifat fizikal terma PCM bukan organik telah dilakukan dengan penyelidikan yang terhad. Eksperimen-eksperimen dalam karya ini adalah berdasarkan penyelidik terdahulu dengan menggunakan bahan nanofluid yang berlainan. Hasil kajian yang diharapkan ialah peningkatan peratusan termal PCM yang dikaitkan dengan sifatnya menggunakan kaedah sistematik dan berangka.

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LIST OF ABBREVIATION

TES	Thermal Energy Storage
PCM	Phase Change Material
NPCM	Nano fluid Phase Change Material.
SSPCM	Shape Stabilized Phase Change Material
LHS	Latent Heat Storage
EG	Expanded Graphite
CN	Carbon Nano-additive
MWCNT	Multi-Walled Carbon Nanotubes
XGnP	Exfoliated Graphite Nano Platelets
R-GN	Random Graphite Nano sheets
0-GN	Oriented Distribution Graphite Nano sheets
T_m	Temperature Material
T_{mp}	Temperature Melting Point
T_{fp}	Temperature Freezing Point
DT	Temperature Difference
TEM	Transmission Electron Microscopy
SEM	Scanning Electron Microscopy

LIST OF ABBREVIATION

DSC	Differential Scanning Calorimetry
FT-IR	Fourier-Transform Infrared Spectroscopy
XRD	X-ray Powder Diffraction
PT100	Platinum Resistance Thermometers
$CaCl_2$	Anhydrous Calcium Chloride
γ-Al_2O_3	Gamma Aluminum Oxide
SiO_2	Silicon Dioxide
TiO_2	Titanium Dioxide
Cu	Copper
$CaCl_2H_2$O	Calcium Chloride Hexahydrate

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The energy crisis is the concern that as demand rises, the demands of the world on the limited natural resources used to power industrial society are declining. The availability of these natural resources is minimal. While they do occur naturally, replenishing the stores will take hundreds of thousands of years. Governments and individuals concerned are seeking to promote the use of renewable resources and to reduce the unsustainable use of natural assets through growing conservation. There are many international efforts working to resolve the energy crisis. One of the ways and solutions to reduce the energy crisis is by thermal energy storage (TES) in the daily life application.

Thermal energy is an ancient resource that is commonly used energy in the world. Thermal energy storage is one of the recommended ways to improve energy recovery from the solar energy, off-peak electricity and industrial waste heat recovery. This system has a variety of uses such as for renewable energy source and as sensible latent heat source. Thermal energy storage system is greatly dependent in the requirement for its storage time which is divided as long term storage and short term storage. In another way, it is divided as sensible heat storage and latent heat storage. Normally, water is used as a storage medium for their sensible heat storage system.

The conservation of thermal energy using phase-change materials (PCMs) is of great interest in many fields such as solar energy systems, floor heating and energy-efficient houses. (Cheng et al, 2010). Thanks to their desirable properties such as high latent fusion energy and low vapor pressure during melting, the fatty acids and paraffin wax can be described as the organic PCMs that can be used. However, the difficulty of this organic PCMs which is paraffin is due to its low thermal conductivity (with an average of 0.2W/(m·K). Low thermal conductivity will reduce the rate of heat transfer during melting and solidification cycles. In addition, during the solid-liquid transition, paraffin is suffering from leakage. Studies of paraffin's effective encapsulation and enhancement of thermal conductivity are therefore of great importance. In this study, significant efforts have been made to boost the thermal conductivity of PCM with the approaches, including the introduction of various high thermal conductive additives to PCM, such as carbon nano-additives (CNs) and graphene nano-additives, where CNs are considered to be the most promising additives. Until now, most previous studies have focused on the enhancement of PCM thermal conductivity by single CN, summarized and compared in our previous study by (Qu et al, 2020).

A new concept of the use of nano-sized particles called nanofluids in various metals and metal oxides such as carbon nano-additives, copper nano-additives and graphene nano-additives has become commercially available. Nanoparticles ' heat transfer is boosted as size decreases as the surface-to-volume ratio boosts. The rising prevalence of thermal conductivity of paraffin has been followed by an increase in the heat transfer rate which also increases the loading and unloading time for paraffin. Addition of PCMs nanoparticles will enhanced their thermal conductivity.

This project is focusing on the rising of thermal conductivity with and without using nanoparticles. The effects of nanofluids on the performance of a phase change material (PCM) for thermal energy storage system will be determine by comparing the data from previous literature.

1.2 Problem Statement

Phase change materials (PCM) has gain attention for years as a suitable medium in the thermal energy storage system. One of the most common approach to increase the thermal conductivity and improving the thermos physical properties of PCM is by adding nanoparticles making it as nano-enhanced PCM. On the other hand, some PCM has disadvantages such as Super cooling and combustible that needs to be considered for further improvement is determined**.** The effect of nanofluids on the performances of phase change material (PCM) for the thermal energy storage will be determine in this project. Thermal analysis method among the way of how to determine the thermal conductivity of the phase change material (PCM). This project will be engaging in term of comparison data and experimental from the previous researchers.

1.3 Objective

The objectives of the project are as follows:

1. To determine the suitable material of nanoparticles in enhancing the phase change material thermo-physical properties.
2. To investigate the effect of latent heat of PCM by using different nanoparticle.

1.4 Scope

The addition of nano-additives on the PCMs will influence the thermal conductivity of the thermal energy storage system. The aim of this project is to discover the effect of nanofluids on the performance of PCMs of the thermal energy storage. The data are then will be used to calculate the efficiency of the thermal conductivity and latent heat value significantly. This research is initially with design process and demonstrate by experimentally. Only comparison data and experimentation from previous literature are involve in this project.

1.5 Hypothesis

This experiment aimed to investigate the thermal performance of nanofluid PCMs for TES system. The concern of this project is to improve and increase the efficiency of the thermal conductivity and the effect of latent heat for the energy storage system. In order to achieve the higher thermal conductivity, by introducing nano-additives such as carbon and graphene with the paraffin wax will be conducted. The data will be used to calculate the efficiency of the thermal conductivity of the phase change material (PCM) by using thermal analysis method.

CHAPTER 2

LITERATURE REVIEW

2.1 Thermal Energy Storage (TES)

In general, thermal energy storage (TES) and phase-changing materials in particular, has been a major research subject for the past 20 years. TES provides solutions in very specific areas (Zalba et al, 2003) such as the time delays and power availability between energy generation (solar energy, cogeneration, etc.), energy security (hospitals, data centres, etc.) and thermal inertia and thermal protection.. In 2003, Zalba gave a useful classification of the substances used for TES, shown in Figure 21..

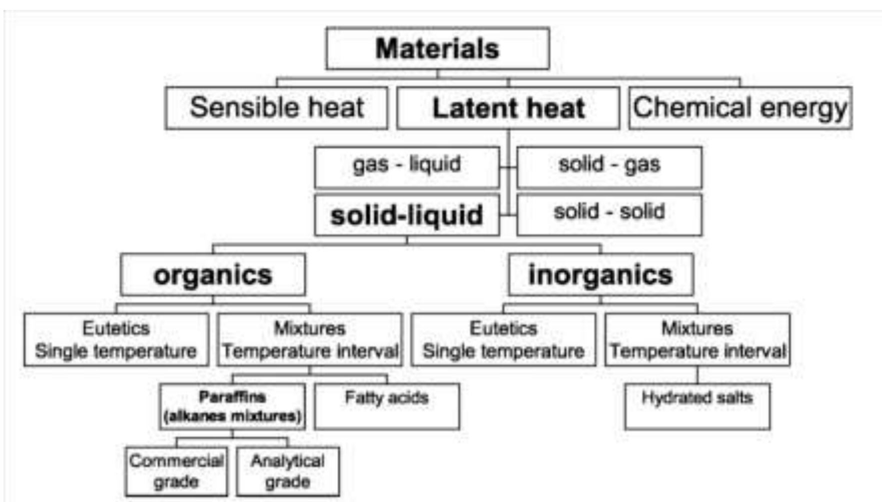

Figure 2.1 Classification of energy storage materials (Zalba et al., 2003).