UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE EFFECTIVENESS OF USING PHASE CHANGE MATERIAL (PCM) IN REDUCING CAR INTERIOR TEMPERATURE DURING DAY-TIME

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology (Automotive Technology) (Hons.)

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **THE EFFECTIVENESS OF USING PHASE CHANGE MATERIAL (PCM) IN REDUCING CAR INTERIOR TEMPERATURE DURING DAY-TIME**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

………………………………………….

(Project Supervisor)

ABSTRAK

Pada waktu siang, apabila kereta diletakkan menghadap sinar matahari, pemandu berasa sangat tidak selesa terutama selepas beberapa minit memasuki keretanya. Haba terperangkap dalam kereta menghasilkan suhu tinggi hingga boleh menyebabkan sesetengah orang mengalami sakit kepala dan pening. Langkah penyelesaian yang lebih mesra alam dan pengguna diambil dalam mempertimbangkan keselesaan haba bagi pemandu kereta dan penumpang. Oleh itu, kajian ini cuba mengurangkan suhu dalam kereta menggunakan bahan perubahan fasa (PCM). PCM adalah bahan yang boleh menyerap, menyimpan dan membebaskan haba pendam pelakuran apabila ia berubah fasa daripada pepejal kepada cecair atau sebaliknya. PCM berfungsi menyimpan tenaga sejuk pada waktu malam dan kemudian digunakan untuk menyerap haba pada waktu siang lantas menyejukkan ruang dalam kereta. Antara banyak jenis PCM, parafin mempunyai banyak kriteria yang diperlukan seperti haba pelakuran tinggi dan bersifat lengai menjadikan ia berpotensi dalam aplikasi penyejukan pasif. Kalorimeter Pengimbasan Perbezaan(DSC) mendapati suhu lebur dan haba pelakuran parafin adalah

bagi mengelakkan kebocoran semasa peleburan. Tiga pengkapsulan PCM iaitu menggunakan plastik, bekas aluminium dan keranjang aluminium telah dikaji. Keberkesanan pengkapsulan dalam mengurangkan suhu ditentukan dengan mengukur perubahan suhu pada model kereta. Ia didapati bahawa apabila bekas aluminium digunakan, suhu dalaman kereta meningkat kepada maks

C apabila tiada PCM digunakan. PCM dalam bekas aluminium mungkin mengalami proses perubahan fasa apabila suhu meningkat sambil menyerap haba. Dengan penambahbaikan selanjutnya, PCM mampu diaplikasikan dalam teknologi penyejukan dalaman kereta.

ABSTRACT

During day-time, when a car is parked facing the sun, the driver feels extremely discomfort especially in a few minutes after entering his or her car. Heat trap in car interior creates high temperature enviroment to certain extent some people experience headache and diziness. More enviromentally and user friendly solution must be taken in considerations concerning thermal comfort of car drivers and passengers. This study, therefore, attempted to reduce car interior temperature by using phase change materials (PCM). PCM is a material that can absorb, store and release latent heat of fusion when it change phase from solid to liquid or vice versa. PCM functions by storing cool energy which is available over-night within the PCM and later the stored energy is used to absorb the internal heat gains during day-time thus cooling the car interior space. Among various kind of PCM, paraffin possess many desirable properties such as high heat of fusion and chemically inert which make it promosing PCM for passive cooling applications. Differential Scanning Calorimeter (DSC) measurement determined that the melting temperature and heat of

C and 127.3kJ/kg, respectively. However, paraffin needs to be encapsulated in order to prevent leakage during melting process. Three encapsulation method for the PCMi,e,; by plastic capsule, by aluminum casing and aluminum foil, were investigated. The effectiveness of the encapsulation methods in reducing temperature was determined by measuring the temperature change in a car interior model. It was found that when aluminum casing

C when no PCM used. The PCM that encapsulated in aluminum casing most probably underwent phase change process when temperature rised while absorbing the heat. With futher improvement, PCM would technically viable in car interior cooling technology.

DEDICATION

T y N‟ b A gA g me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, Zuhrah binti Sidek who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my advisor En. Aludin bin Mohd Serah for the continuous support of my thesis study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my bachelor degree study.

I would like to thank my friends for accepting nothing less than excellence from me. Last but not least, I would like to thank my parents, my brothers and sister for supporting me spiritually throughout writing this thesis and my life in general.

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LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

PCM	-	Phase Change Material
LHTES	-	Latent heat thermal energy storage
DSC	-	Differential Scanning Calorimeter
PU	-	polyurethane

CHAPTER 1
INTRODUCTION

1.0 Introduction

The chapter starts with the background of this study then continues with the problem statement which is solid-liquid phase transition problem of phase change material (PCM). Finally this chapter highlights the objectives and the scope of this study.

1.1 Background

Global warming has already had observable effects worldwide. This phenomenon also affects to the car interior temperature and the passive cooling system was introduced.

1.1.1 Global Warming

Temperatures have risen during the last 30 years, and the period between and 2001 and 2010 was the warmest decade ever recorded. As the Earth warms up, temperature increases are becoming more common issue globally in many places. Temperature waves happen when a region experiences very high temperatures for several days and nights. This temperature rise may appear small, but small rises in temperature cause big changes for the world"s climate.

This is because the amount of extra energy needed to increase the world‟s temperature, even by a little, is vast. The graph of temperature trend during the last 250 years system is shown in Figure 1.1.

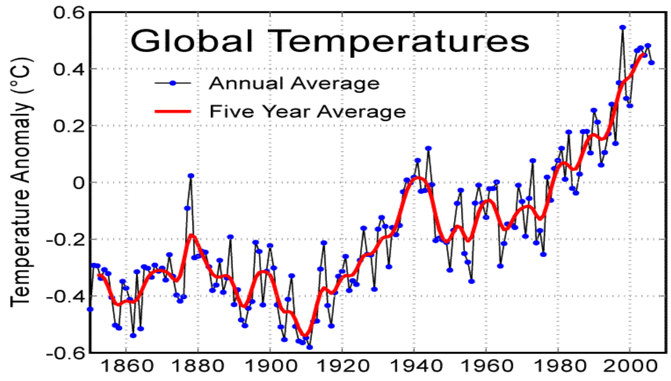

Figure 1.1: Global temperatures trend during the last 250 years

The global temperature has increased ever since the start of the industrial revolution. Current temperature level is probably higher than they have been anytime during the last 20 million years. This phenomenon triggers awareness to scientists, engineers, economists, and politician and the global citizens. The temperature is expected to increase at an accelerating pace during the next century.

1.1.2 Car Interior Temperature

Global warming affects to human lifestyle and environment. It also occurs to car interior. In the hot days, when the cars are parked in the parking facing the sun or even during the driving, drivers feel discomfort just after entering the vehicle. For those vehicles with air conditioning system, it usually takes minutes before the comfort temperature is reached. Temperature inside the vehicle cabin is very important to provide thermal comfort to the car passenger.

The temperature can be controlled by using air conditioning system that can be operated when the car engine is in operation. However, when the car is left or parked directly under the sunlight, temperature car interior will undoubtly increase. This may create interior temperature conditions that are extremely uncomfortable to the passengers.

1.1.3 Passive Cooling System using Phase Change Material

This study introduces the usage of Phase Change Material (PCM) as an alternative cooling system in automobile which is passive and energy-free. PCM functions by storing cool energy that is available over-night within the PCM and later the stored energy is used to absorb the internal and solar heat gains during the day-time thus cooling the car interior. The phase change processes between solid and liquid PCM is illustrated as in Figure 1.2.

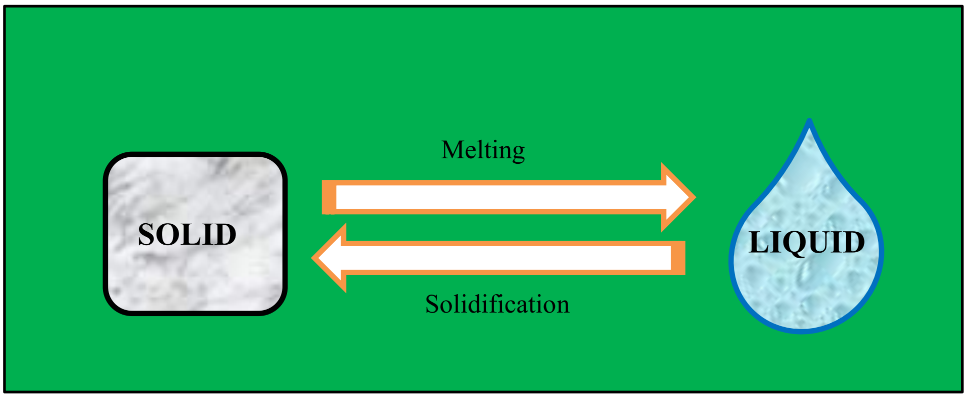

Figure 1.2: Phase Change of PCM

When a PCM freezes, it releases a large amount of energy in the form of latent heat at a relatively constant temperature. Conversely, when it melts, it absorbs a large amount of heat from the environment. PCMs recharge as ambient temperatures fluctuate, making them ideal for a variety of everyday applications that require temperature control.

This passive cooling does not require mechanical energy or any form of electricity to run the system. It also does not require any electronic device such as sensor. It is natural and also promotes potential energy saving p. This passive cooling system in car interior is illustrated in Figure 1.3.

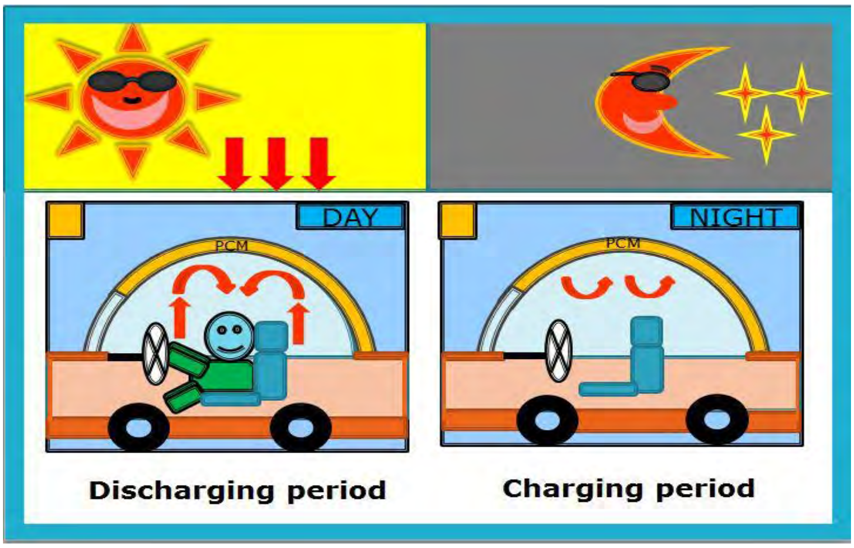

Figure 1.3: Passive cooling system in a car interior

When temperature rise, PCM melts and it absorbs heat, whereas when it changes to a solid (freezing), it releases the heat. Therefore, when PCM melts during day-time, it absorbs the car internal heat gains and use the stored energy capacity. As a result, the car interior temperature level decreases and become more comfortable to the driver and passenger.

1.2 Problem Statement

Global warming causes temperature rise day by day. This phenomenon also happens to car interior. When the cars are parked in the parking area facing the sun or even during the driving, the driver feels extremely thermal discomfort especially in a few minutes after entering his or her car.

Heat trap in the car interior creates high temperature environment to certain extent some people experience headache and dizziness. There has also been accidental death of young children or animals that had been left in the cars parked facing the sun in hot days. More concrete and practical actions need to be taken into considerations concerning thermal comfort of driver and passengers. Furthermore,

more environmentally and people friendly alternatives should be studied in order to reduce impact to the people and environment. This study, therefore, attempts to reduce car interior temperature by using paraffin PCM. This cooling method needs zero energy thus can be classified as passive cooling system. Among various kind of PCM, paraffin have been found to exhibit many desirable properties such as high heat of fusion, negligible supercooling, low vapor pressure in the melt, chemically inert and stable, self-nucleating, and many others. One of the major drawback paraffin is that they are solid-liquid PCM. They are reported to leak out during solid-liquid phase transition. Figure 1.4 illustrates the leakage of PCM when it is applied in a car interior.

Figure 1.4: The leakage of paraffin PCM in a car

Thus, PCM need to be encapsulated with a supporting material. In this study, the paraffin is encapsulated with various encapsulation materials. The effect of the encapsulated PCMs in reducing interior temperature by using a car interior model was investigated.

1.3 Project Objective

In order to ensure the project focus on its target, several objectives were established.

1.3.1 General Objective

This study aims to investigate the effectiveness of using Phase Change Material (PCM) in reducing car interior temperature especially during day-time.

1.3.2 Specific Objectives

- To investigate the best encapsulation material for paraffin PCM.
- To determine the effectiveness of using encapsulated PCMs in reducing interior temperature by using a car interior model.
- To calculate thermal efficiency of this passive cooling system.

1.4 Research Scope

- This project main focus on encapsulation material of paraffin PCM.
- This project focused especially on the method of encapsulation of PCMs with different parameters.
- A car interior temperature was simulated by using a small scale car interior model.
- Other factors such as humidity level, air flow rate and air filtration were not considered.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter mainly discusses on the concept of solid-liquid transition of PCM, the characteristics and classification of PCM which reviewed by several researchers. Some building and automotive applications of PCM are also introduced. This chapter then introduces the thermal properties measurement of paraffin as phase change material (PCM).

2.1 Phase Change Material

A phase-change material (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature. A PCM is capable of storing and releasing large amounts of energy at relatively constant temperature. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage material (Mostafa Kassem, 2007). The thermal energy transfer occurs when a material changes from solid to liquid, or liquid to solid. This is called a change in state, or phase. Initially, these solid–liquid PCMs perform like conventional storage material, their temperature rises as they absorb heat. Unlike sensible storage materials, however, PCM absorbs and release heat at a nearly constant temperature.

They store 5–14 times more heat per unit volume than sensible storage materials such as water, masonry, or rock (Sharma *et al.*, 2009). A large number of PCMs are known to melt with a heat of fusion in any required range. However, for their employment as latent heat storage materials these materials must exhibit certain desirable thermodynamic, kinetic and chemical properties

D. Juárez (2000) stated that PCM provides a solution to the increasing consumer demand for better energy efficiency and thermal regulation. The PCM substance is typically paraffin that absorbs and releases heat in order to maintain a required temperature. The PCM in response to temperature change is illustrated in Figure 2.1.

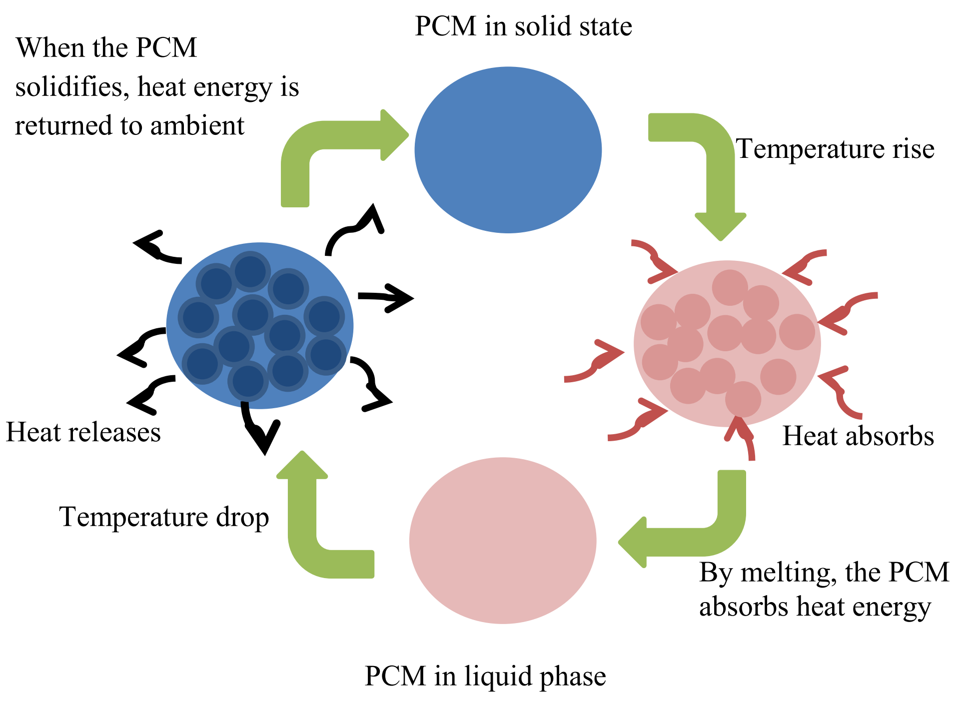

Figure 2.1: PCM in response to temperature change

When temperature rises, PCM absorbs heat and melts. Conversely, when temperature drops, PCM releases heat to surrounding and return to solid phase. This solid-liquid phase change cycles of PCM may repeated for hundreds or even few thousands time without undergoing significant change in its properties.

2.1.1 Classification of PCM

According to D. Buddhi (2009), a large number of PCM (organic, inorganic and eutectic) are available in any required temperature range. There are a large number of organic and inorganic chemical materials, which can be identified as PCM base on their melting temperature and latent heat of fusion. Figure 2.2 shows the general classifications of PCMs.

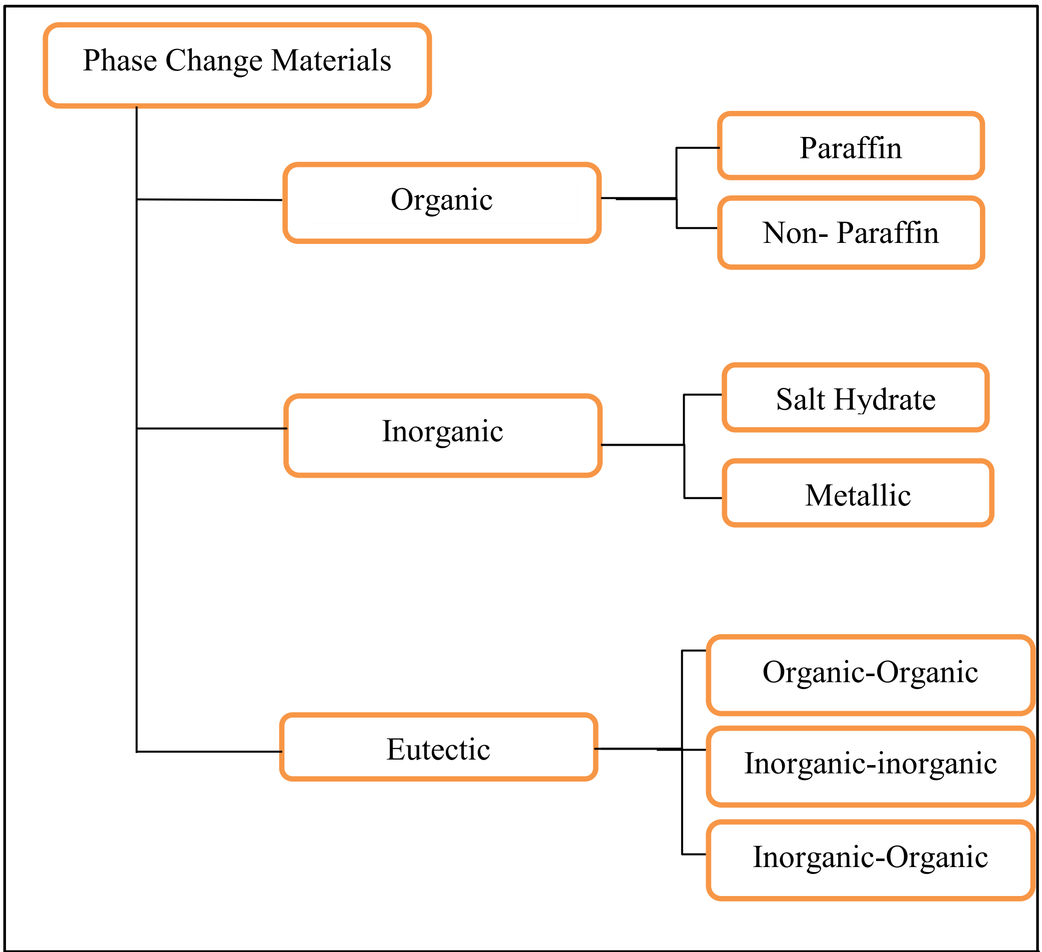

Figure 2.2: General Classifications of PCMs (Mostafa Kassem, 2012)

2.1.2 Organic PCMs

Organic materials are further divided into paraffin and non-paraffin. Paraffins exhibit congruent melting which means they melt and freeze repeatedly without phase segregation and consequent reduction of