UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THERMAL ENERGY STORAGE MEDIUM IN ABSORPTION REFRIGERATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Refrigeration and Air-conditioning system) with Honours.

by

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Supervisor: Madam Norain Binti Idris

ABSTRACT

In an era of modern and globalization, thermal energy storage is one of the good ways to get the heat storage to driven the system especially good to increase the efficiency system. Mostly, thermal energy storage is using to store the cold heat in HVAC system. Without the thermal energy storage, based on the problem in absorption refrigeration like the run out power of the systems cannot be solved. But the mediums for store the heat must be storing the large heat. So that, the objective to run this study is to preparation of test trig and to identify the best candidates for storing the heat from three medium that is paraffin wax, propylene glycol and organic oil (vegetable oil). Based on the objective of this project, the flow work of this study starting from the setup test trig and continue by the data collection to calculated the heating rate, cooling rate, and also heat transfer of mediums. The comparison of mediums is will be defined the best candidate for the selected mediums. Based on the properties of medium like high boiling point (370 °C) and low melting point (37 °C), the best candidate for thermal energy storage medium is paraffin wax (candle) while it is not affecting to the ODP and GWP. It is followed by propylene glycol and organic oil (vegetable oil). It shows the mediums suitable for criteria of the TES mediums. Thermal energy storage medium in absorption refrigeration is the title of this project where the topic discussing about the selected medium for absorption refrigeration.

ABSTRAK

Dalam era moden dan globalisasi, penyimpanan tenaga haba adalah salah satu cara yang baik untuk mendapatkan haba bagi memacu sistem ini terutama sekali baik kepada meningkatkan sistem kecekapan. Kebanyakannya, penyimpanan tenaga haba digunakan untuk menyimpan haba sejuk dalam sistem sistem pemanasan dan penyaman udara. Tanpa simpanan haba termal, berdasarkan masalah dalam sistem penyejukan penyerapan tidak dapat diselesaikan. Tetapi medium untuk menyimpan haba mesti menyimpan haba yang besar. Tujuan untuk menjalankan kajian ini ialah membuat rig ujian dan untuk mengenal pasti media terbaik dari tiga medium iaitu lilin parafin, propylene glycol dan minyak organik (minyak sayuran). Berdasarkan objektif projek ini, proses aliran kerja kajian ini bermula dari penyediaan rig ujian dan diteruskan dengan pengumpulan data untuk mengira kadar pemanasan, kadar penyejukan, dan juga pemindahan haba bagi media. Perbandingan bahan akan menentukan bahan terbaik untuk media yang dipilih. Berdasarkan sifat-sifat bahan seperti takat didih yang tinggi (370 °C) dan takat lebur rendah (37 °C) disamping tidak memeberi kesan kepada pemanasan global dan penipisan ozon, bahan terbaik untuk penyimpanan tenaga haba adalah lilin parafin (lilin). Media ini sesuai untuk kriteria media TES dan diikuti oleh propylene glycole dan minyak organik. Medium penyimpanan haba termal dalam penyejukan penyerapan adalah tajuk projek ini di mana topik membincangkan tentang medium yang dipilih untuk penyejukan penyerapan.

DEDICATION

I dedicate this project to Allah Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program. I also dedicate this project to my family who has encouraged me all the way and whose encouragement has made sure that I give it all it takes to finish this project which I have started. This project also is especially dedicated to my supervisor, for his willingness to guide me to the success of this project for my degree.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

TES	-	Thermal energy storage
PCMs	-	Phase change of materials
HTF	-	Heat transfer fluid
LHS	-	Latent heat sensible
LHTS	-	Latent thermal energy storage
LPA	-	Lower pressure absorber
HPA	-	High pressure absorber
LPG	-	Lower pressure generator
COP	-	Coefficient of performance
ODP	-	Ozone depletion potential
GWP	-	Global warming potential
CO_2	-	Carbon dioxide

CHAPTER 1

INTRODUCTION

1.0 Background of The Project

Thermal energy storage medium in absorption refrigeration is the title of this project where the topic discussing about the selected medium for absorption refrigeration. Absorption refrigeration system now using vapor absorption system. The absorption refrigeration system using source from electric, solar collector, and district heating. So that, another source can be used to give the heat in absorption refrigeration system is using Thermal Energy Storage Medium to store the heat.

Thermal energy storage used to store the cold and hot temperature. Recently, IT used to store the cold temperature that means to cooling process. It using medium glycol to convert glycol into ice. Now, the heating process are using into integrated the Absorption Refrigeration System and TES system. That means, the TES can store the large amount of heat mediums and supply to the absorption refrigeration system.

The selected of medium in TES are important to achieved the objective for this project. Based on the research by the properties of substances and the research, there are several mediums can be selected into this project. The first medium is paraffin wax (candle) followed by propylene glycol and organic oil (vegetable oil). Recently, propylene glycol is using in cooling system. But, because of the low freezing point of propylene, so it slowly to turn into cold. The comparison of data can be determined the best candidates of the three mediums can be apply in absorption refrigeration system.

1.1 Problem Statement

There are several problems based on recent thermal energy storage. First of all, the issue is the medium selected. The most medium that are using now is storing the lower heat based on the properties of medium. The medium selection must be storing the large heat and maintain the heat when it storing. Recently, the TES just used to store the cold heat for cooling system. To control the cold temperature is easy compared to the hot temperature because the heat losses to surrounding,

Secondly, the problem is no others backup heat when run out of power. For the absorption refrigeration, the source is from the chiller refrigeration. No other power can be used when the it runs out especially when during emergency. So that, the combination of thermal energy storage medium is suitable for this system. It can be used in time when needed. It also can be as a backup heat to give double heat in absorption refrigeration.

Last but not least, heat sources that are using now affect to the environment (ODP and GWP), the problems are not environmentally friendly and money saving. The recent medium is not suitable to be a medium storage because it can release the chemical to the environment. Besides, recent are using much money like a salt hydrated for a medium in TES.

1.2 Objectives

The main objectives for this project are to improve the function of thermal energy storage medium is integrated with absorption refrigeration become more effective and suitable to be used in any time that needed. The objective for this project study has been listed below:

a. To prepare/develop of the test rig (simplification for the medium selection) for medium selection based on the temperature duration of medium heat storage.

b. To identify the appropriate medium for thermal energy storage system which is integrated with absorption refrigeration system based on temperature change and heat storage duration where the medium is green and not effect to the environment.

1.3 Scope

The scope of this project is to study the thermal energy storage medium in absorption. The scope based on the experiment conducted to collect the data. The selection of medium must be suitable for TES to store the heat. This study is to identify the best candidates for selected medium. The preparation of test trig is using to collect data. The heating and cooling rate will be easily to determine the best candidates besides of the heat transfer. The other factor is the properties of medium that not give effect to environment. The heat storage of medium must be suitable when the TES is integrated with absorption refrigeration system. The hot temperature is most suitable for storing the heat. In this study, the comparison of medium is defined from the previous research.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will provide the evaluation from previous research that associated with this final year project. There are several previous researches related to the study on thermal energy storage medium for absorption refrigeration using different medium and methods to obtain the heat collector. The overall performance is depending on the size of collector, the change of temperature in phase, the supply temperature of heating appliances, and the storage volume in tank and thermal energy storage medium. This final year project integrated of absorption refrigeration system and thermal energy storage medium. The medium can be used when the main source of the system is exhausted. The medium from TES can replace the other source from heat collector besides can use for emergency.

2.1 Thermal energy storage medium

Thermal energy storage medium is the storage of heat or cold for periods of up to several months. The thermal energy can be collected whenever it is enough and be used whenever needed, such as in the opposing season. For example, heat from solar collectors or waste heat from air conditioning equipment can be gathered in hot months for space heating use when needed, including during winter months. Thermal energy storage can be realized through 3 ways of heat storage such as sensible, latent or thermochemical heat storage (Pereira da Cunha and Eames 2016). Sensible heat storage depends on the material's specific heat capacity and latent heat storage also depends on the material's phase change enthalpy within a narrow temperature to store heat.

Meanwhile, thermochemical heat storage it depends on adsorption/desorption or chemical reactions. Thermochemical heat storage is more than energetic than latent heat storage.

Thermal energy storage mostly using seasonal TES system, CSP plant system, domestic solar thermal, heat and cold storage of building HVAC system (G. Alva et al, 2018). There are two types TES system that is active system and passive system. Figure 2.1 below shows the passive and active system in TES. Passive system of TES is applied in buildings and active system of TES likes thermocline are analyzed. The system of TES gets heat sources energy from solar thermal, geothermal energy, fossil-fuel power, nuclear power plants, industrial waste and biomass. Thermal energy storage provides the environmentally friendly and economic to reduce the burning fuels and it also keep the heat storage in the system. Besides, the TES materials is suitable for application and be classified in 3 types. Firstly, sensible heat storage that means increasing the temperature but not change in phase. This type normally using water and thermal oils. Thermal oils are organic fluids and normally colorless clear liquids. Recently, there are many products thermal oil and can be seen in Appendix A. Thermal oil temperature range between 12 degree Celsius until 400 degree Celsius. It is showing the difference temperature is high ΔT in Equation 2.1 and can storing more heat compare to the water. The heat transfer coefficient range in between 1000 W/m^2K – 3500 W/m^2K. The advantages of the thermal oil are having low melting point and prevents to freeze compare to molten salt. It also has low toxicity because contain organic compound but it still must be kept under the operation because it can be burned in high temperature.

$$Q=mC_P\Delta T \quad \text{…… Equation 2.1}$$

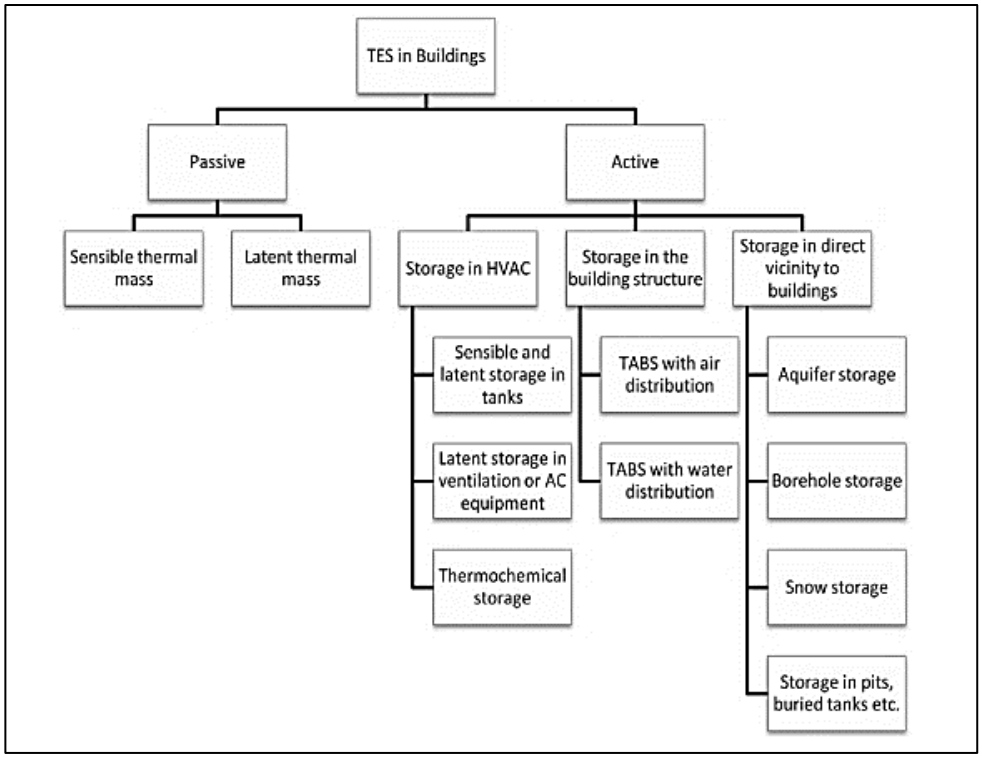

Figure 2.1 Passive and active system in TES (G. Alva et al, 2018)

Besides the thermal energy storage for latent heat storage is Paraffin. Organic TES using Paraffin is using in commercial application. Pure paraffin normally expensive so that the paraffin wax is suitable to replace the pure paraffin. It has 28 °C of melting point normally. It depends on the number of carbons. It raised when the value of carbon increases.

The thermal energy storage involving the collecting and heat transfer fluid (HTF) to the system. HTF can be assume as a thermal storage medium directly or using the other media something like HTF combine with other material in one packed system (Li and Lik Chan 2017). The factor of heat loss in transfer fluid when the temperature of hot thermal energy is reduces and make the efficiency of system decrease, the alternative design to storing the heat is using heat transfer fluid (HTF). The hot medium is stored and pumped out to the system. The tank is made by thick insulation. This design can store the heat like the same temperature when it heated. This system using two tanks to storing the cold or hot medium in a can be show in Figure 2.2.

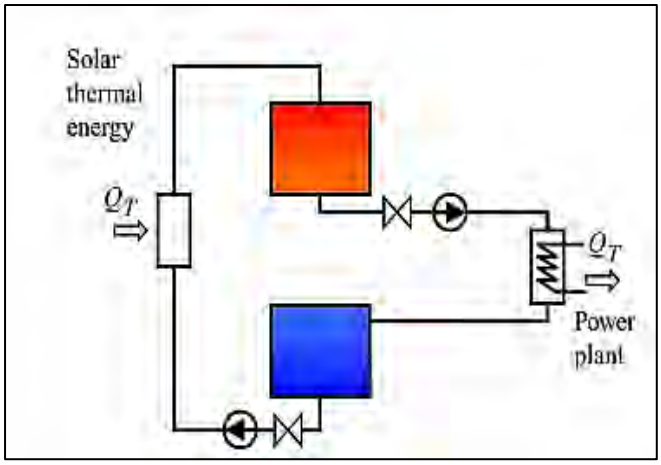

Figure 2.2 shows using heat transfer fluid (HTF) with two tanks (Li and Lik Chan 2017)

To keeps the high efficiency of the system, the two tanks must be combined in one tank to prevent from waste space. This called by thermocline thermal storage system. The system works needs the hot fluid into the top tank and the cold fluid into the tank from the bottom reversely and the hot fluid will exhaust from the top surface. This show the hot fluid kept on top and cold at the bottom tank. The separated of two fluid can be using by movable baffle. The Figure 2.3 below shows the thermocline thermal storage system separated with movable baffle.

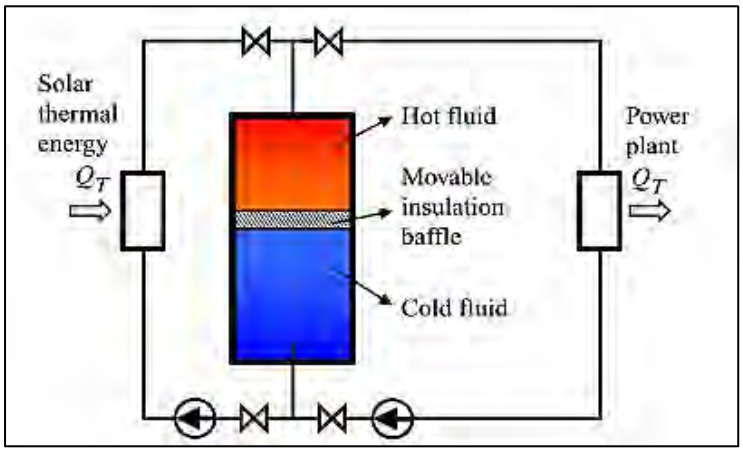

Figure 2.3 shows the thermocline thermal storage system separated with movable baffle (Li and Lik Chan 2017)

Based on the problem of heating and cooling conventional can produce the CO_2 emission. The alternative to solve the problem is using thermal energy storage by using solar thermal (Pereira da Cunha and Eames 2016). The thermal energy storage has 3 way that is sensible heat, latent heat and thermochemical. Thermochemical is not suitable for adsorption even it is energy compare to the latent heat. The sensible heat based on the specific heat capacity and latent heat by the phase of change enthalpy. The PCMs store is 2.5 until 6 times high than water. The figure 2.4 below shows the comparison of heat storage between 3 PCMs and water (Pereira da Cunha and Eames 2016). It shows the Paraffin Wax is higher to store the heat because the temperature difference higher.

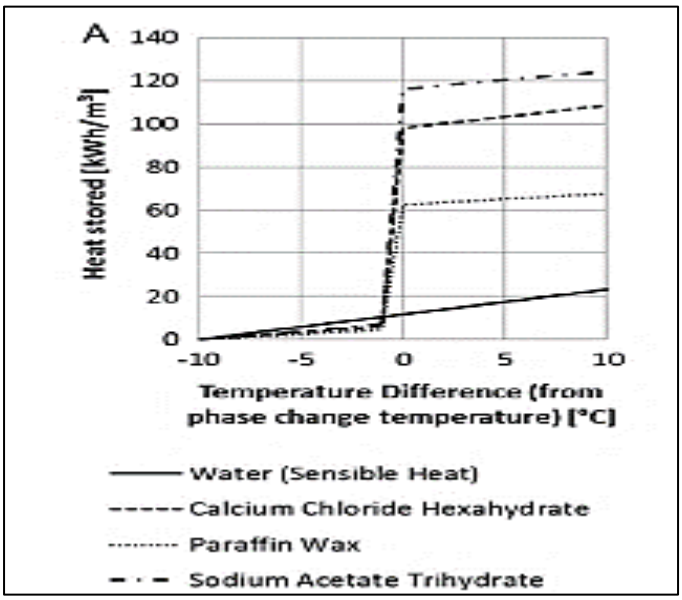

Figure 2.4 shows the comparison of heat storage between 3 PCMs and water (Pereira da Cunha and Eames 2016)

The thermal energy storage (TES) is using in short term and long-term storage. The majority of TES using sensible and latent heat (LHS) and for TES using latent thermal energy storage (LHTS). LHTS is using low temperature to get the high energy storage density (R.K. Sharma et al, 2015). Phase of change are divided in organic, inorganic and eutectic. Based on thermo physical properties, PCM can be improved the system. For