

Alternate Heat Energy Storage Using PCM

B. Meganathan¹, G.R.Vignesh², R.Giritharan², N.R.Vigneshwaran², K.Sasikumar²

Asst. Professor, Department of Mechanical Engineering, Velammal Institute of Technology, Chennai, India

B.E. Student, Department of Mechanical Engineering, Velammal Institute of Technology, Chennai, India.

ABSTRACT: The use of a latent heat storage system using phase change materials is an effective way of storing thermal energy. In this project, a PCM based tube in shell heat exchanger is designed and fabricated. The project focuses on the temperature distribution pattern of the phase change material during the process of charging and discharging the results are obtained by experimentally. Paraffin wax has been used as the phase change material. This type of thermal energy storage system can be used as a medium to store energy and can be used further. The research carried out aims is to analyze the melting and solidification processes of the PCM within the enclosures, and to evaluate the influence of the aspect ratio of the cavities on the heat transfer and to discuss which type of PCM is better for specific cases.

KEYWORDS: PCM – Phase Change Material, Solar Water Heater, Paraffin Wax, Latent Heat, Shell Tube, Charging and Discharging.

I. INTRODUCTION

The major issue faced by the current world is ‘Global warming’ which is the effect of releasing harmful gases termed ‘green-house gases’ into the atmosphere. Recent developments and researches are aimed to prevent the usage of fossil fuels to generate energy hence the renewable resources are used. In recent years, a lot of research work has been going on to overcome problems like low heat transfer rates between heat transfer fluid and phase change material (PCM) in both charging and discharging processes of the PCM-based Thermal Energy Storage (TES) System. The main types of TES are sensible and latent. Sensible TES system store energy by charging the temperature of the medium which can be water, brine, rock, soil, etc. latent TES system store energy through phase change, e.g., cold storage water/ice and heat storage by melting paraffin waxes. To provide a solution for this problem our project involves usage of solar energy. Alternatively thermal energy can be stored as latent heat in which energy is stored when the substance change from one phase to another by either melting or freezing. The temperature of the substance remains constant during phase change. It has the advantage of high-energy storage density and isothermal nature of storage process. In order to establish the effectiveness of using paraffin wax as a suitable phase change material.

II. LATENT HEAT STORAGE MATERIALS

Phase change materials (PCM) are ‘‘Latent’’ heat storage materials. 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 materials, their temperature rises as they absorb heat. Unlike conventional (sensible) storage materials, 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. 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. Moreover, economic considerations and easy availability of these materials has to be kept in mind.

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III.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, is capable of storing and releasing large amounts of energy. heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage (lhs) units.

IV. PCM CHARACTERISTICS

The most essential difference between PCMs and conventional heat storing mediums like water or rock is that the melting point of PCMs is within the working temperature range. Basically, even water is a PCM and probably it was the first material to be used as such, for example in connection with food cooling with ice. However, as the melting point of Water is 0°C, it cannot be used as a PCM for heat storage applications where the working temperature range usually is well above 0°C. Anyway, it is a good and everyday example to show how much heat can be absorbed in a phase change: Smelting ice to water requires approximately the same amount of energy as heating water from 0 to 80°C

V.PARAFFIN WAX

Paraffin wax is a white or colourless soft solid derivable from petroleum, coal or oil shale, that consists of a mixture of hydrocarbon molecules containing between twenty and forty carbon atoms. it is solid at room temperature and begins to melt above approximately 37 °c (99 °f). its boiling point is >370 °c (698 °f).common applications for paraffin wax include lubrication, electrical insulation, and candles. Dyed paraffin wax can be made into crayons. It is distinct from kerosene, another petroleum product that is sometimes called paraffin.



Fig.1 Paraffin wax

VI. PROPERTIES OF THE PARAFFIN WAX.

- Density, g/cm³ 0.91
- Melting temperature, K 331
- Thermal diffusivity, mm²/s 0.13
- Latent heat, J/g 143.70

VII. CHEMICAL PROPERTIES

- Long-term chemical stability.
- Compatibility with materials of construction.
- No toxicity.

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- No fire hazard.

PCM can suffer from degradation by loss of water of hydration, chemical decomposition or incompatibility with materials of construction. PCMs should be non-toxic, nonflammable and non-explosive for safety.

VIII. ASSUMPTIONS

For predicting the output air temperature due to discharge process in a pcm unit we assumed the following assumptions:

- a) Air behaves as an incompressible fluid.
- b) The Stefan number is very low.
- c) The heat loss assumed very low, and neglected.
- d) The heat transfer process in every cylinder is radially symmetric; the heat transfer in pcm is by conduction.

XI. LEARNING OBJECTIVES

1. After reading this module, students should be able to learn the general concept of Phase Change Materials (PCM).
2. Understand the applications of PCMs in sustainable energy.
3. Recognize the uses of PCM for heating and cooling systems.
4. Recognize the uses of PCM in buildings.
5. Recognize the uses of PCM in transportation.

X. EXPERIMENTAL SETUP

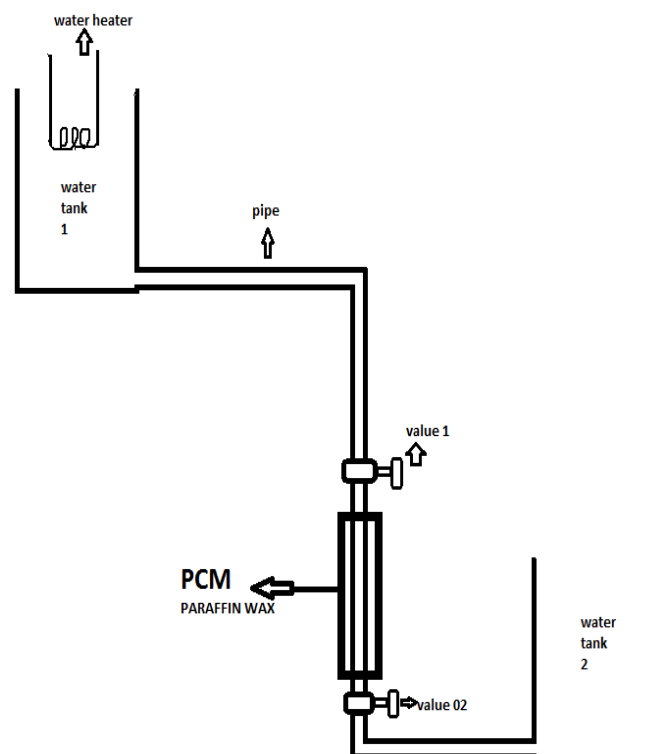


Fig.2 Experimental setup

XI. COMPONENTS

1. PCM CHAMBER:

Shell type chamber is used as PCM chamber, and it is made up of glass and it covered by insulating material.

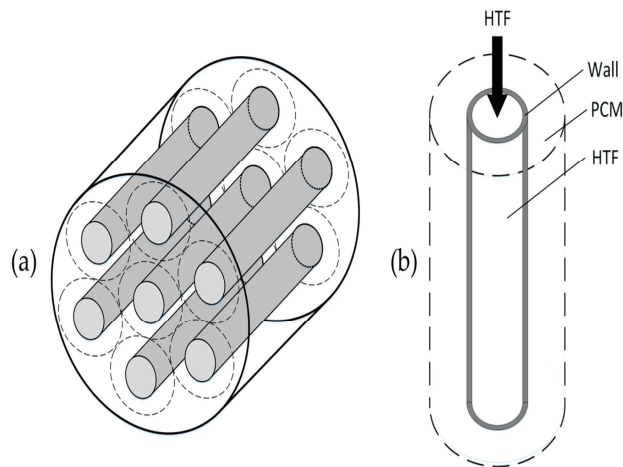


Fig.3 Heat exchanging chamber
(a) Multiple tubes, (b) Single tube.

2. STORAGE TANK:

The purpose of the storage tank is to act as a reservoir of water which will be circulated in the circuit. Ideally the storage tank should be insulated to prevent any exchange of heat through it.



Fig.4 Steel storage tank

3. HEATING COIL:

The purpose of the heating coil is to heat the water in the storage tank. The heating coil used in the setup is of 1500 W rating.

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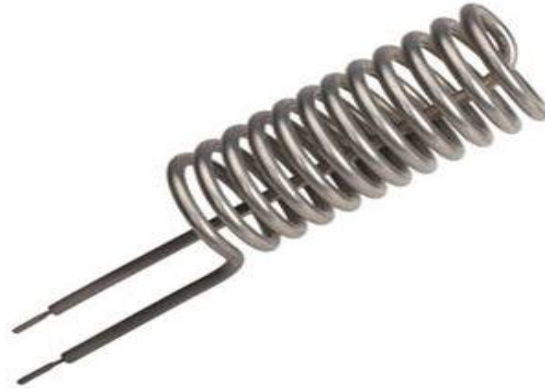


Fig.5 Heating coil

4. FLOW CONTROL VALVE:

The purpose of flow control valve is to regulate the mass flow rate of the heat transfer fluid through The circuit.



Fig.6 Control valves

5. TEMPERATURE INDICATOR:

The temperature indicator consists of 2 channels. Each channel receives input from different thermocouples which are incorporated in the energy storage unit.

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Fig.7 Temperature sensor

XII.WORKING

During sunshine period, valve 1 is kept open and valve 2 is kept closed .The cold water from the storage tank goes through the flat plate solar collector, absorbing heat energy from the solar radiations .It then passes through the PCM heat exchanger, where it loses its heat to the phase change material .It then goes back to the storage tank. In this way, the PCM gains heat energy which will then be used to heat water during non-sunshine period. During non-sunshine period, valve 1 is kept closed and valve 2 is kept open. The cold water from the storage tank goes through the PCM heat exchanger, absorbing heat energy from the heat stored in the phase change material .It then goes back to the storage tank. By this way cold water is heated with the help of heat stored in the PCM.

XIV. CONCLUSION

Paraffin wax is a good PCM for energy storage in latent heat storage system. It has a suitable transition latent heat of 210 kJ/kg. In addition, it does not exhibit any sub cooling .temperature range of 58-60°C and a relatively high .The given arrangement can be used to store thermal energy in solar water heating application. The cost to incorporate the system is also very economical. The primary objective of using paraffin wax as a PCM material has been successfully experimented. This project is highly feasible and more than the feasibility this project can overcome the energy crisis to greater extent.

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