HEAT TRANSFER ANALYSIS IN VARIOUS LAYERS OF PHASE CHANGE MATERIAL TANK WITH SPHERICAL ENCAPSULATION

[1]Prem Kumar M., [2]Ramachandram S.

[1,2]Department of Mechanical Engineering, Sathyabama University, Chennai, India

Email: [1]premhem2001@yahoo.com

[2]aishram_2006@yahoo.com

ABSTRACT

The thermal energy storage is considered to be one of the energy storage technologies. Thermal energy storage contains a thermal storage mass, and can store heat or cool. Basically, it can be classified as latent, sensible and thermo-chemical energy. Among these energy storage types, the most attractive form is latent heat storage in phase change material (PCM) because of the high storage capacity in a small volume and charging and discharging heat from the system at nearly constant temperature. In this project the heat transfer between the therminol oil and encapsulated PCM in various layers is analyzed using Computational Fluid Dynamics.

The PCM tank contains 3 layers of mesh structure in which spherical encapsulation are fixed. It is designed using ANSYS and the heat transfer between the heat transfer fluid and the various layers of encapsulation is analysed. During the charging mode the temperature of the therminol oil is given as 500°C as a input and the heat transferred to the various layers of the encapsulation is found using CFD. Similarly during the discharge mode the temperature of the therminol oil is noted taking PCM temperature as an input.

Keywords PCM; HTF; TES, Latent heat storage.

I. INTRODUCTION

Thermal energy storage can be defined as the temporary storage of thermal energy either at high or low temperatures. There are three methods of thermal storage system as sensible heat storage, latent heat storage and certain physiochemical reaction results in thermal storage. Heating or liquid or solid with out changing its phase is called sensible heat storage. A material which under goes a phase changes while heating is called latent heat storage. Generally, various heat transfer fluids are used for sensible heat storage. The fluids like water, molten salts, silicon oil, therminol oils, etc... are used for sensible heat storage based on their application. The phase change materials like paraffins, D-Mannitol, Sarbitol are used for latent heat storage system. In our project we have used silicon oil and D- monnitol as working fluids. The silicon oil is stored in a mild steel cylindrical container insulated with glass wool. The D-monnitol PCM is stored in a spherical stainless steel balls and it is placed inside the HTF tank in three layers as shown in figure.

The PCM tank is designed in such a way that it contains three layers of mesh structure placed in an equal interval in which the spherical enca[sulations containing PCM is fixed. There are two mode of experiment one is charging mode and another one is discharging mode. In charging mode the HTF is heated to its maximum boiling point and then it is allowed to cool during its discharge mode. In charging mode the input temperature of therminol oil is given as 500°C. And during discharge mode the heat transfer from PCM to HTF is noted.

A. Phase Change Material

A Phase Change Material (PCM) is a substance with a high heat of fusion which melts and solidifies at certain temperatures and capable of storing or releasing large amounts of energy [1]. The only phase change is used for storing energy is solid-liquid change. Liquid-gas PCMs are not practically suitable for thermal storage due to their large volumes or high pressure requirement to store the materials in gaseous phase.For this application D-Mannitol is used as PCM [4] .whose melting point is 165°C and boiling point is 295°C which will be more suitable for our application.

B. Heat Transfer Fluid

Any gas or liquid specifically manufactured for the purpose of transmitting heat from one system to another. There is variety of heat transfer fluids like air, water, glycol, hydrocarbon oils, silicon oil, and therminol etc…

In our CFD analysis therminol-66 oil is considered to be a HTF; the working range of this fluid is 40°C to 500°C.

II. MODELLING OF PCM TANK

The PCM tank is designed in a cylindrical manner and the material selected was mild steel. the thickness of the tank is taken as 5 mm. three layers of mesh structure with equal intervals is designed for the placement of spherical encapsulation. The diameter of the tank is considered to be 500 mm and height of the tank is taken as 600 mm.the spherical encapsulation is considered to be made of stainless steel. Solid modeling of the PCM tank is done in ANSYS and is shown in figure.1. Below

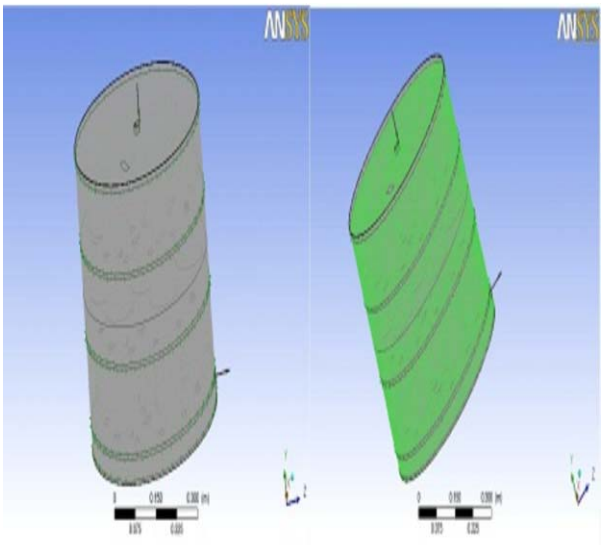

Fig. 1. Modelling of PCM tank

III. HEAT TRANSFER ANALYSIS IN VARIOUS LAYERS OF PCM TANK WITH SPHERICAL ENCAPSULATION

The analysis of heat transfer is carried out by giving the temperature the therminol oil as 500°C as an input. And the corresponding temperature transfer in each layer is analyzed as shown in figure.2.

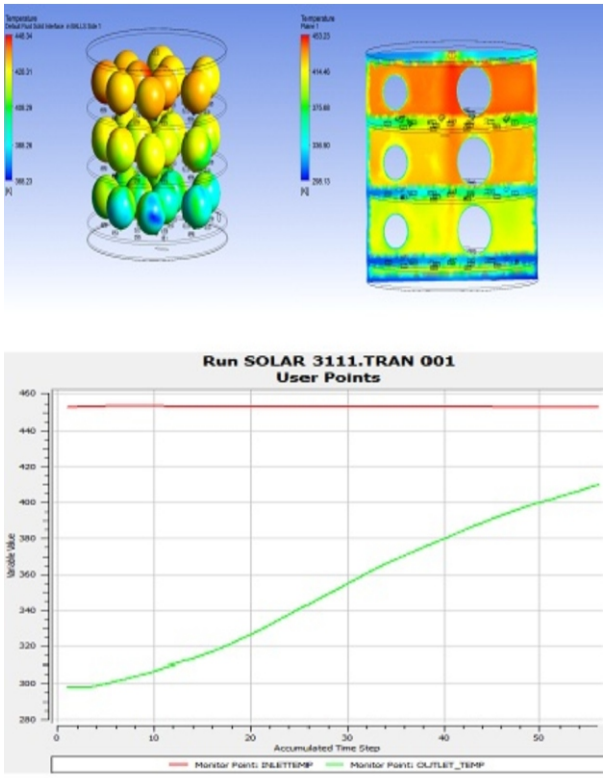

Fig. 2. Heat transfer analysis of PCM tank

Thus in the analysis it is understood that the heat transfer from the therminol oil to the encapsulated PCM balls is more in the first layer and it gradually reduces from top to bottom layer. Similarly the heat transfer from the PCM ball to therminol oil is more in the top layer and it gradually reduces from top to bottom layer.

IV. RESULTS AND DISCUSSIONS

The Results obtained from the heat transfer analysis shown in figure 2. It shows that the heat transfer between the therminol oil and the phase change material with spherical encapsulations is more in the top layer and it gradually reduses from the top to bottom layer.

During the charging mode the top layer of the encapsulation is around 400°C and in the second layer the temperature is around 350°C and the temperature in the last layer is around 300°C. It shows that the temperature of the PCM balls in various layers reduces from top to bottom layer gradually. And in the discharging mode the temperature of the HTF is noted in various layers. It shows the top layer of the HTF is

around 400°C and in the second layer the temperature is around 350°C and the temperature in the last layer is around 300°C.

V. CONCLUSION

The PCM tank contains 3 layers of mesh structure in which spherical encapsulation are fixed. It is designed using ANSYS and the heat transfer between the heat transfer fluid and the various layers of encapsulation is analysed. During the charging mode the temperature of the therminol oil is given as 500°C as a input and the heat transferred to the various layers of the encapsulation is found using CFD. Similarly during the discharge mode the temperature of the therminol oil is noted taking PCM temperature as an input. During the charging mode the top layer of the encapsulation is around 400°C and in the second layer the temperature is around 350°C and the temperature in the last layer is around 300°C. It shows that the temperature of the PCM balls in various layers reduces from top to bottom layer gradually. And in the discharging mode the temperature of the HTF is noted in various layers. It shows the top layer of the HTF is around 400°C and in the second layer the temperature is around 350°C and the temperature in the last layer is around 300°C. Finally we can conclude that the transfer of heat transfer between THF and PCM encapsulation and vice versa reduces gradually from top layer to the bottom layer.

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