International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 02 | Feb 2021 www.irjet.net p-ISSN: 2395-0072

HEAT TRANSFER ENHACEMENT OF PHASE CHANGE MATERIAL USING FINS

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Abstract - *Thermal energy storage system now have been recognized as one of the most efficient ways to enhance the energy efficiency and sustainability, and have received growing attention in recent years. During the phase change in a phase change material (PCM) storage system the solid – liquid interface moves away from the heat transfer surface and the surface heat flux decreases due to increase thermal resistance of the molten or solidified medium. Heat transfer enhancement technique such as fins have to be used to increase the heat transfer fraction in the store. The purpose of the review is to design the PCM module with or without fine, Finding the freezing temperature for different module and suggest best suitable module configuration. The storage is initially in a liquid state and it temperature is great the solidification temperature of the PCM. Experimentally finding the freezing temperature of PCM module with and with out fins using ice plant set up and the result are obtained are compare using the analytical method. The method can be improved by changing the PCM's, design of the PCM module and the material of module and fins.*

Key Words: **PCM Module, Fins, Heat Flux, Freezing Temperature.**

1. INTRODUCTION

Thermal energy can be stored as a change in the internal energy of particular material as sensible heat and latent heat or both. The most commonly used method thermal energy storage is the sensible heat method, all through PCM which effectively store and release latent heat energy have been studied for more than 15 years. Latent heat storage can be more efficient than sensible heat storage because it requires a small temperature difference between the storage and releasing function. PCM are an important and underused option for developing new type of energy storage device, which are as important as developing new source of renewable energy. Use of phase change material in developing and construction sustainable energy system is vital to the efficiency of these system based on PCM's capability to harness heat and cooling energies in an effective and convenient way. Thermal energy storage system employed in different application act as a thermal flywheel to store extra energy when the demand is less, and to deliver the same at other time. Latent heat thermal energy storage system (LHTES) with phase change material have cardinal the sensible heat storage system due to their large storage capacity and isothermal behavior. In recent year, PCM based thermal energy storage system have been received great research attention to store the cool energy available in the ambient during the early morning hours, and to use the storage cool energy for the space cooling of building during the daytime. Such LHTES during the phase change the solid liquid interface move away from the heat transfer surface. In this Process , thermal conductivity of the solidified PCM being very low, the surface heat flux decreases with respect to time, due to increase thermal resistance of the growing layer of the molten – solid medium. Hence, the study of various heat transfer enhance technique play important role in effective utilization of storage thermal energy.

2. PROBLEM STATEMENT

Design the PCM module with and without fins and investigate the freezing time required for phase change material, percentage reduction in time and suggest best effective configuration of PCM model.

2.1 Objective

1. Design of PCM module.

2. Performance of PCM with insertion of Fins.

3. The best configuration for PCM with fins.

2.2 Methodology

The phase change material is stored in a design module and tested in secondary refrigerant ethylene glycol. The freezing time required is measured for each module with and without fins and percentage reduction in freezing is determined.

3. DEVELOPMENT OF EXPERIMENTAL SETUP

3.1 The Setup Used For PCM Testing

1. Vapour compression refrigeration system as an ice plant test ring available at the college is used for testing the PCM. In the ice plant the primary refrigerant system use R-134a as a refrigerant and brine solution as secondary refrigerant.

2. PCM module consists of the rectangular bracket, which is manufactured by galvanized iron sheet. In the module the copper fins of designed dimension is attached to the module.

3. Manufacturing of the PCM module mounting and measuring system. In the measuring system the thermocouple is attached to the centre of module for temperature measurement.

4. The lid to cover the brine solution tank is manufactured.

3.2 Specification of Ice Plant aand Different Unit

- **Refrigerant**: R-134a.
- **System capacity**: 0.675 TR.
- **Ice production capacity**: 25kg of ice pre 24hrs.
- **Compressor type**: Hermetically sealed, 1/3H.
- **Condenser type**: Force convection air cooled.
- **Expansion device**: Thermostatic expansion valve.
- **Brine tank**: stainless steel -18 gauge.

Brine used is ethylene glycol.

- **No of ice can:** 6 Nos 700ml each.
- **Thermocouple:** Type K thermocouple range -200°C to +1350°C.

Fig -1: Ice Plant Test Ring

- **Data acquisition system**: Data Acquisition System is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numerical value that can be manipulated by a computer.

Here data acquisition system is uses to measure temperature variation in phase change material with respect to time.

Fig -2: Data Acquisition System

3.3 Selection of PCM

Sodium Chloride (NaCl\H_2O) is selected as PCM for testing because it has better latent heat and melting point.

Due to lesser solidification temperature the compressor work required to achieve the temperature is lesser.

Sodium Chloride has latent heat 289 KJ/Kg.

From reference solid temperature of phase change material is -5°C. To ensure this solidification temperature experiment was conducted and gets temperature -7°C.

4. DESIGN OF PCM MODULE

The storage volume of PCM module is 250ml.

v=l x h x w

Where,

l= length of module

w= width of module

h= height of module

The thickness of module is varied as 1, 1.2, 1.4, 1.6 and 2.0cm

We summarized following set of dimension of PCM modules for the 250ml storage capacity.

PCM Module No.	Thickness (cm)	Width (cm)	Length (cm)	Aspect Ratio (w/l)
1	1	10	25	0.4
2	1.2	10	20.85	0.48
3	1.4	10	17.85	0.56
4	1.6	10	15.65	0.63
5	2	10	12.50	0.8

Table -1: Dimension of PCM Module

4.1Fins Calculation

Fins diameter-2mm

Fin material- copper

4.1.1 Surface Area of Module

A=2(l x w)+2(w x h)+2(l x w)

where,

l= length of module

w= width of module

h= height of module

4.1.2 Surface Area of Fins

A=πDl1

Where,

D=Diameter of fins

I1=length of fins

For 5% the volume capacity of fin be *V1*

4.2 No of Fins

No of fins= v1/pieDl1

Module No.	No of Fins	Spacing of Fins
1	*9*	25
2	*8*	23
3	*7*	22
4	*6*	22.5
5	*5*	12.5

Table -2: Spacing and Quantity of Fins in Different Modules.

4.3 Module Manufacturing

For manufacturing of module, galvanized Iron sheet having low cost than other material and better thermal conductivity.

The module is prepared as per the dimension by cutting and hammering the sheet as per calculation.

The Fins is attached to the module at an equal space as shown in fig.

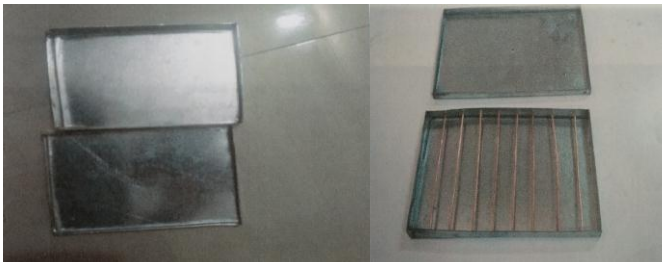

Fig -3: Module with Fins and Without Fins

5. TESTING OF PCM

5.1 Procedure of Experiment

- Phase change material as sodium chloride is mixed with water in the ratio of 90:10 on mass basis and PCM solution is prepared.
- The size of a modern 250 ml volume with varying the thickness are formed.
- Thermocouple is attached at a central of each PCM module.
- Operation solution is what into the module.
- It is no leakage of PC
- The teacher was allowed to cool in a prime time operating system the salt solution of PCM time and temperature are measured
- The process is repeated for different PCM module.
- The same process is followed for the PCM model with insertion of fins.
- Reduce in time of the solid picture of the PCM is determined.
- The module giving list and time of PCM is the best suitable configuration for the use in different application.

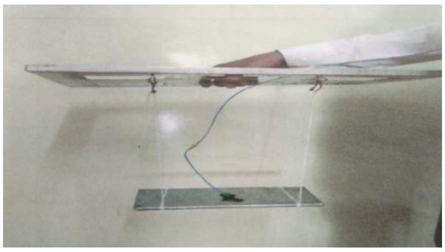

Fig -4: Actual Set of Testing

The experimental has been conducted for the different modules that we have manufacture for 10 minute with and without fins. The result is plotted as below.

Time (min)	Module 1 (Temp)	Module 2 (Temp)	Module 3 (Temp)	Module 4 (Temp)	Module 5 (Temp)
0	30	30	30	30	30
1	30	30	30	30	30
2	6	4	5	2	9
3	0	1	0	-2	3
4	-5	-2	-3	-6	-6
5	-6	-5	-5	-8	-9
6	-8	-7	-7	-9	-7
7	-8	-8	-9	-9	-7
8	-8	-8	-9	-9	-7
9	-8	-8	-9	-9	-7
10	-8	-8	-9	-9	-7

Table -3: Dimension of PCM Module Solidification Time Required For Module Without Fin.

Time (min)	Module 1 (Temp)	Module 2 (Temp)	Module 3 (Temp)	Module 4 (Temp)	Module 5 (Temp)
0	30	30	30	30	30
1	0	7	11	6	10
2	-7	4	5	0	-2
3	-7	-3	0	-4	-8
4	-7	-8	-3	-8	-9
5	-8	-8	-5	-8	-9
6	-9	-8	-6	-8	-9
7	-9	-8	-7	-8	-9
8	-9	-9	-7	-8	-9
9	-9	-9	-7	-9	-9
10	-9	-9	-7	-9	-9

Table -4: Solidification Time Required For Module with Fins

6. CALCULATION

The solidification time is measured for each model with and without fin. Reduction in percentage time for each model is determined.

%Reduction in time for solidification= $T_{without\ fins} - T_{with\ fins} / T_{without\ fins} \times 100$

Where,

T Without fin= Time required for solidification of PCM without Fins

T With fin= Time required for solidification of PCM with Fins

7. RESULT TABLE

Module No	Time required for solidification of PCM without fins(min)	Time required for solidification of PCM with fins(min)	% Reduction in time for solidification
1	8	4.5	43.75
2	10	7	30
3	11	9	18.18
4	12	8	33.33
5	18	15	16.66

Table -5: % Reduction in Time for Solidification

8. CONCLUSIONS

From the experiment and calculation, we have observed that the PCM modules with 25cmx10cmx1cm configuration i.e. Module-1 gives least solidification time. Fastest solidification occurs for the module of lesser aspect ratio (i.e. 0.4). Thickness increasing of module increases solidification time. From the experiment reading, it is observed that the best suitable PCM module is of size 25cmx10cmx1cm.

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