Thermal Optimisation Of Pcm Based Pin Fin Heat Sink Using Ansys

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Abstract— *Imbalance between energy demand and energy supply affects several kind of technologies. Such issue is especially relevant for energy systems; typical examples include solar energy utilization, thermal power generation, combined cooling, heating & power system and air conditioning. The idea to use phase change materials (PCM) for the purpose of storing thermal energy is to make use of the latent heat of a phase change, usually between the solid and the liquid state.*

Keywords . *Phase change materials,*

INTRODUCTION

Thermal energy storage (TES) is achieved with greatly differing technologies that collectively accommodate a wide range of needs. It allows excess thermal energy to be collected for later use, hours, days or many months later, at individual building, multi-user building, district, town or even regional scale depending on the specific technology. As examples: energy demand can be balanced between day time and night time; summer heat from solar collectors can be stored inter seasonally for use in winter; and cold obtained from winter air can be provided for summer air conditioning.

Storage mediums include: water or ice-slush tanks ranging from small to massive, masses of native earth or bedrock accessed with heat exchangers in clusters of small-diameter boreholes (sometimes quite deep); lined pits filled with gravel and water and top-insulated; and eutectic, phase-change materials. Other sources of thermal energy for storage include heat or cold produced with heat pumps from off-peak, lower cost electric power, heat from combined heat and power (CHP) power plants; heat produced by renewable electrical energy that exceeds grid demand and waste heat from industrial processes.

Phase change material possesses quality to store and release large amount of thermal energy while changing its phase, for example: from solid-liquid, liquid to vapour. Best example to describe phase change material is water and ice. When ice is heated, during its phase change from solid to liquid its temperature remains constant. The temperature does not change till two phases (solid – liquid) exist simultaneously. In addition the inflowing energy is used up in the phase transition.

MODELLING

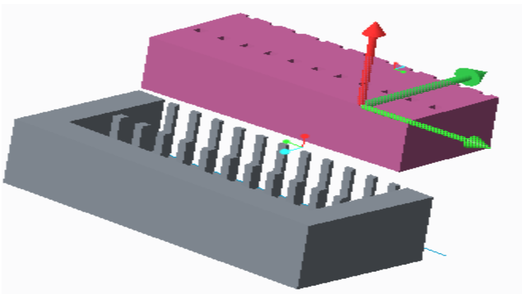


Fig1.1Model of pin fin apparatus

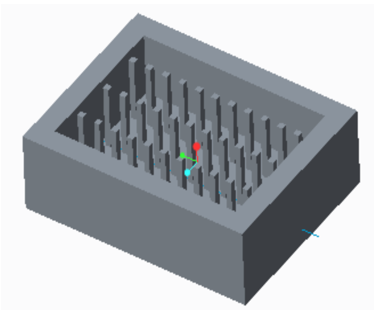


Fig 1.2 Pin fin apparatus with wax

Model of pin fin apparatus

DIMENSIONS:

External Length: 80 cm   Internal Length: 66 cm
External Width: 62 cm   Internal Width: 48 cm
Depth: 15 cm   Fin Size: 2x2 cm^2
Height of the Fin: 15cm   No. of Fins: 33

The above model was generated in CreO and was run in ANSYS with given input parameters and considering the block in 4 angles (0º, 15º, 30º, 45º) and the rate of heat rejection was observed for the above configurations

Properties of PCM:
Heat flux value: -10000
Thermal conductivity: 0.21
Specific heat: 2870

RESULTS AND DISCUSSION

At different time intervals the values for different orientations and values are tabulated below:

The heat contained in the PCM as well as the liqid fraction were given for each configuration at a regular interval of time

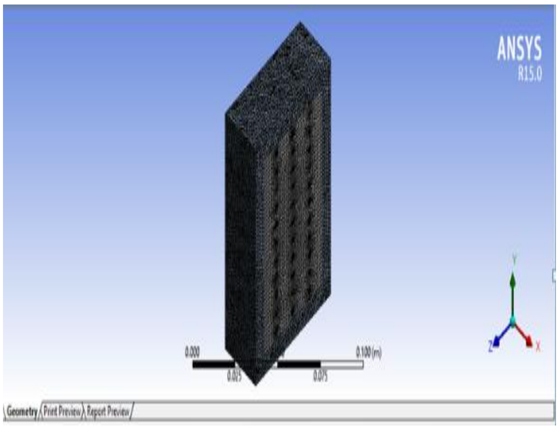


Fig 2.1Pin fin model imported to ANSYS

TOTAL ENERGY OF PCM AT 0 SECOND

Time(Sec)	Total Energy at **0º** (j)	Total Energy at **15°**(j)	Total energy at **30º**(j)	Total energy at **45º**(j)
0	8991.852	8991.852	8991.852	8991.852
20	8857.494	8857.586	8857.992	8858.141
40	8488.886	8491.883	8492.067	8492.111
60	8051.384	8053.415	8053.361	8051.606
80	7580.503	7582.071	7580.595	7571.291
100	7101.252	7107.578	7105.974	7094.582
120	6639.860	6650.883	6651.006	6641.414
140	6203.795	6219.055	6219.593	6210.461
160	5754.058	5770.611	5777.14	5768.719
180	5289.226	5307.332	5317.659	5317.974
200	4809.636	4836.347	4851.737	4857.297
220	4356.335	4372.099	4389.946	4398.997
240	3905.438	3920.379	3941.915	3954.347
260	3459.970	3474.397	3499.134	3514.689
280	3017.400	3031.373	3057.236	3076.357
300	2578.377	2591.765	2618.112	2640.488
320	2144.131	2156.98	2183.129	2209.125
340	1714.508	1726.872	1753.174	1782.708
360	1288.357	1305.213	1325.857	1358.65
380	865.371	877.456	901.584	935.752
400	446.822	458.664	481.484	516.278
420	34.523	45.994	67.442	102.348

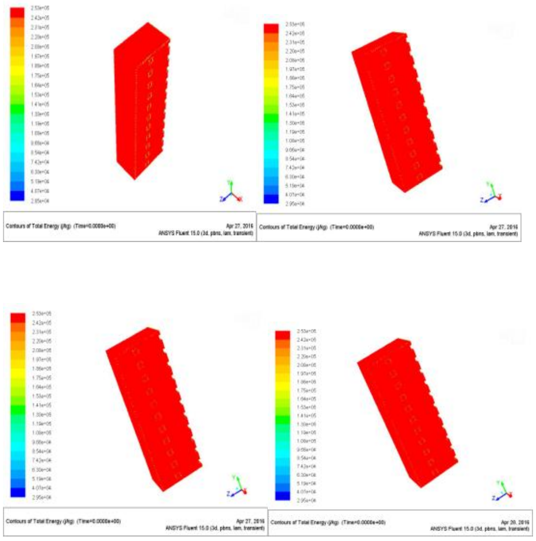


Fig 2.2 Fins at 0º,15º,30º,45º

Parameter	Total energy
TOTAL ENERGY at 0º	8991.852
TOTAL ENERGY at 15º	8991.852
TOTAL ENERGY at 30º	8991.852
TOTAL ENERGY at 45º	8991.852

TOTAL ENERGY OF PCM AT 100 SECONDS

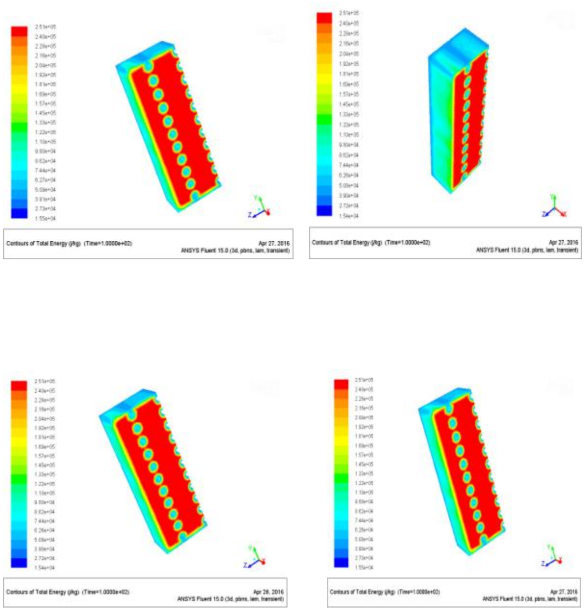


Fig 2.3 Fins at 0º,15º,30º,45º

Parameter	Total energy
TOTAL ENERGY at 0º	7101.25
TOTAL ENERGY at 15º	7107.578
TOTAL ENERGY at 30º	7109.983
TOTAL ENERGY at 45º	7094.582

TOTAL ENERGY OF PCM AT 300 SECONDS

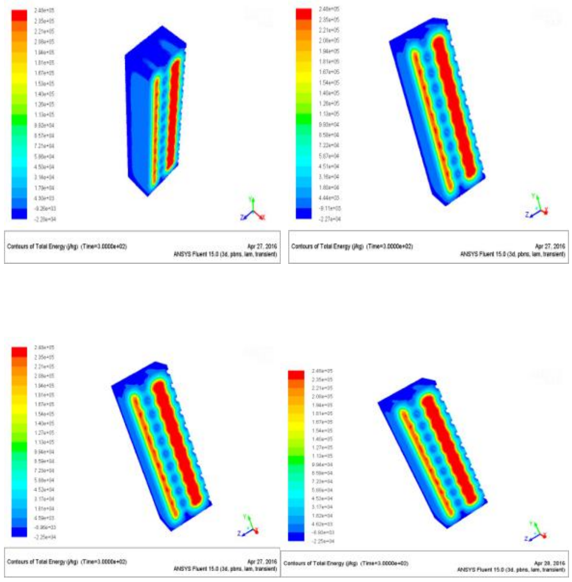


Fig 2.4 Fins at 0º,15º,30º,45º

Parameter	Total energy
TOTAL ENERGY at 0º	2578.378 j
TOTAL ENERGY at 15º	2591.765 j
TOTAL ENERGY at 30º	2618.113j
TOTAL ENERGY at 45º	2640.488 j

TOTAL ENERGY OF PCM AT COMPLETE SOLIDIFICATION

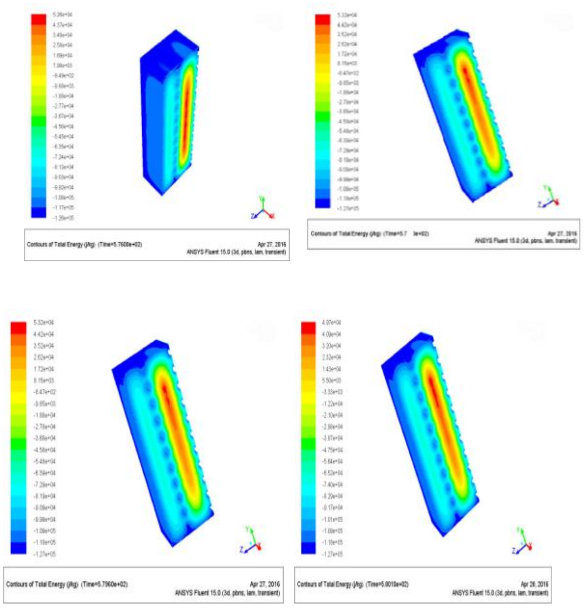


Fig 2.5 Fins at 0º,15º,30º,45º

LIQUID FRACTION OF PCM AT 0 SECONDS

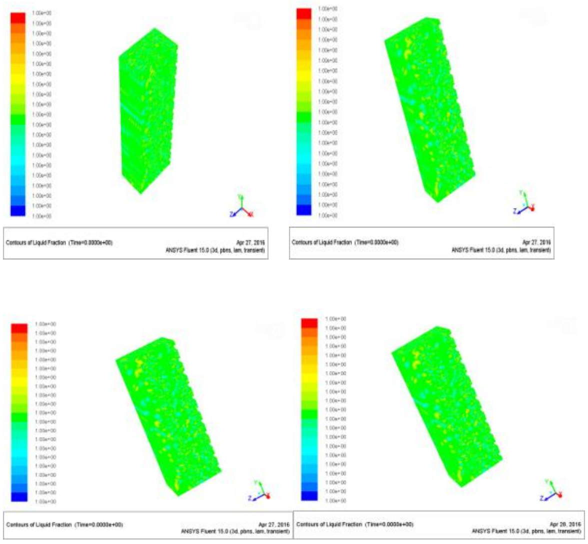


Fig 2.6 Fins at 0º,15º,30º,45º

Parameter	Percentage Of Liquid Fraction
Liquid fraction at 0º	100%
Liquid fraction at 15º	100%
Liquid fraction at 30º	100 %
Liquid fraction at 45º	100 %

LIQUID FRACTION OF PCM AT 200 SECONDS

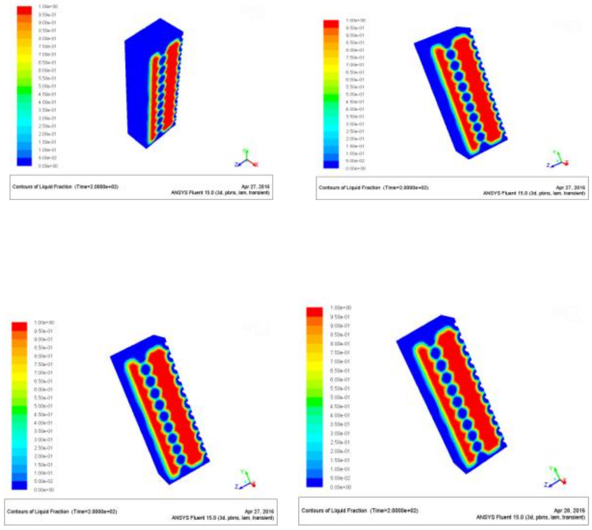
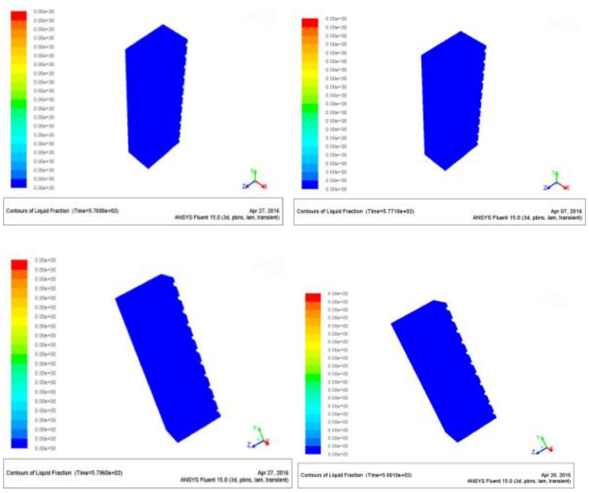


Fig 2.7 Fins at 0º,15º,30º,45º

Parameter	Percentage Of Liquid Fraction
Liquid fraction at 0º	45.11%
Liquid fraction at 15º	45.31%
Liquid fraction at 30º	45.51%
Liquid fraction at 45º	45.59%

LIQUID FRACTION OF PCM AT SOLIDIFICATION



Parameter	Percentage Of Liquid Fraction
Liquid fraction at 0º	0%
Liquid fraction at 15º	0%
Liquid fraction at 30º	0%
Liquid fraction at 45º	0%

For the analysis of phase change material paraffin wax as heat storage system with body provided with fins which is placed at various angular positions as 0 , 15 , 30 , 45 respectively .From this it was observed that 0° position is best for the removal of the heat from the heat sink as compared with others removal of heat from the storage from the sink is higher at 0° position. Other conclusion is that maximum amount of heat is removed at the point of contact of fin with paraffin wax which indicates faster solidification at fin when compared with other places.

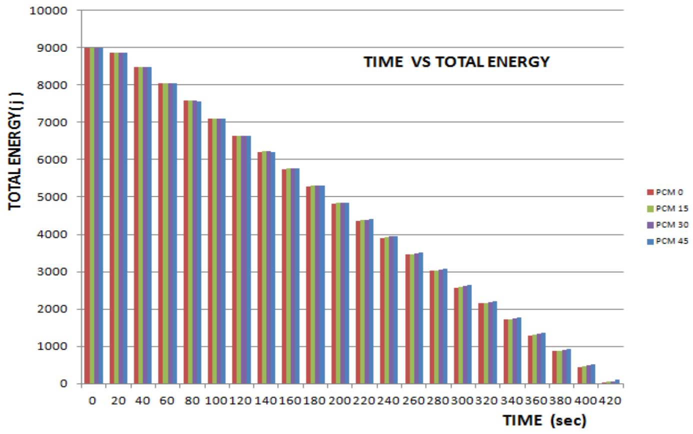


Fig 2.9TOTAL ENERGY VS TIME

Conclusions:

From the graph of Total energy Vs Time it can be inferred that till 120 seconds, the rate of heat rejection is same for all configurations (i.e Fins at 0º,15º,30º,45º) and from there the rate of heat rejection follows the increasing order of 0º,15º,30º,45º.

For a particular solidification time (say 400 sec) the total energy of a particular configuration is as follows

0º configuration- 446.82 J
15º configuration- 458.66 J
30º configuration- 481.48 J
45º configuration- 488052 J

The above values show that the heat rejection rate is maximum for 0º as the energy contained in the PCM was minimum of all other configurations

Also the liqid fraction of the PCM at an instant (say at time 200 sec) are as follows

0º configuration- 45.11%
15º configuration- 45.31%
30º configuration- 45.51%
45º configuration- 45.59%

From the above data it can be inferred that some heat is contained in the 45º configuration which is responsible for the excess liquid fraction of the PCM.

So, from the above tabulations the heat transfer rate is better in the case of 0º configuration of fin under the given input parameters.

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