Latent Heat Thermal Energy Storage using n-tetracosane in Copper Balls

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***Abstract*: The enormous utilisation of energy has led to the fact of saving it at large. To overcome the loss of energy, the present work initiates research in the field of Thermal Energy Storage in its latent form incorporating Phase Changing Material (PCM) in circular oriented copper Ball Structure. Heating of PCM (by an electric heater) inferred in these copper balls continues till 85˚C(well beyond the melting point of selected PCM), and then when disconnected, PCM discharges gradually giving off the heat accumulated within. Considering 30litres of water in Latent Heat Thermal Energy Storage Tank(LHTES), for a family of four, the research intends to investigate the prolonged duration of time required to keep the water warm. The consequence presents that the time required to charge(heat) water is 4.6 hours(270minutes) and discharge(heat is given off) is 29hours(1740 minutes). Thus proving significant potential in keeping water warm for better performance in a circular orientation.**

Keywords: Latent Heat Storage, Phase Changing Material (PCM), Thermal Energy

I. INTRODUCTION:

In the current century, the existing nature of energy has moved its presence abundantly. In the said Channel, there exists a need to modify energy sources into cleaner sources from mother nature. solar energy, comes with the detriment of its intermittent nature.LHTES, on the other hand, serves to be a popular storage system due to its advantageous history of high storage density[1]. Also, there occurs to be huge merchandise for PCM in the minds of researchers due to the need for investing in energy[1,2].

Studies deduce that TES charging with the help of air conditioning and discharging by electric heater benefits greater performance[3,4]. Also, the spherical shape of capsules offers maximum thermal conductivity with the largest energy density[5].

Solidification rates are depicted to give more amount of periodic time when compared with charging[6]. Though this scenario prevails, PCM poses a threat of low thermal conductivity. Not to compromise with thermal conductivity, the PCM can be incorporated into structures having higher thermal conductivity[7,8-10] like copper material, heat pipes, etc. some materials are posing better results than PCM like myristic acid[11], but cost limitation demands to choose PCM over any other. Various research regarding storing thermal energy in PCM is initiated mostly in the domestic domain of temperature between 0-60˚C[5], hence present study too, concentrates on the domestic application.

From the above characterization, current research work attains a spotlight on storing thermal energy in PCM for domestic application of trapping heat for long hours in other household purposes until it prevails to be warm, hoping to get the water warm for an entire day. for the said purpose, according to the survey, spherical capsules serve a better solution for incorporating PCM to negate the loss of low thermal conductivity.

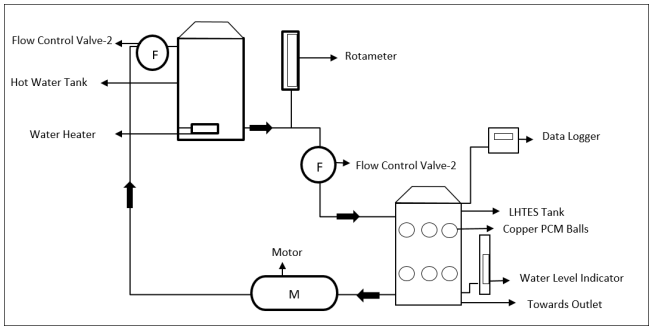

Fig. 1. Setup of LHTES

PCM selected is n-tetracosane having melting point as 48-50˚C. Thermocouples are inserted vertically inside each Spherical Copper Balls. When PCM is in charging condition it starts melting and reaches its temperature up to 85˚C, where it is partially in the vapor state. At this point, it stores latent heat and it stays in this condition for a long duration of time. Again it starts discharging when it gives its heat back to the water surrounding it.

II. RESULTS AND DISCUSSION:

No.of trials are considered to investigate the performance of PCM for circular orientation.charging and discharging cycle is employed and the results indicated in CFD are as under:

A. Charging for circular orientation

Fig. no. 2,3,4 depicts the temperature versus time graph in CFD for 3600,7200,12600 seconds of charging for circular orientation.

The temperature plots can be seen as 42.024 as lowest temperature in LHTES tank and 41.348 as highest temperature in LHTES tank at about 7200seconds; 56.371 as lowest temperature in LHTES tank and 57.047 as highest temperature in LHTES tank at 7200seconds,and78.907 as lowest temperature in LHTES tank and 79.583 as highest temperature in LHTES tank at 12600 seconds having temperature gradient of 0.67 , which means approximately 30 mins more will be required (approx) to reach the temperature of 85 (which is to be attained for charging). The total time to charge circular orientation is 4 hours.

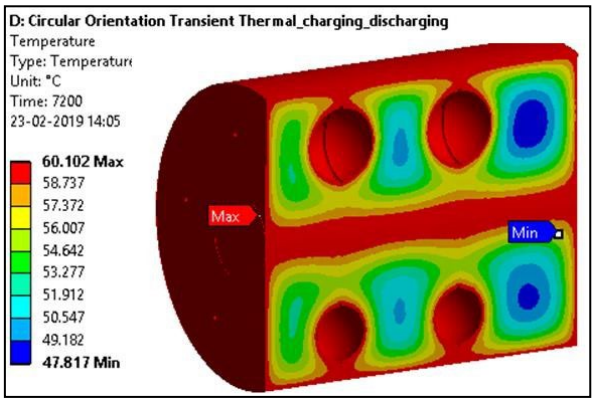

Fig. 2. Charging for Circular Orientation-PCM (7200sec)

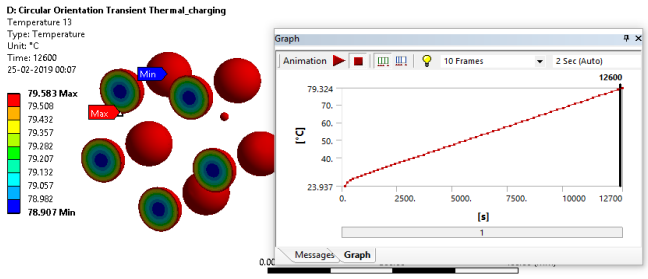

Fig. 3. Charging for Circular Orientation-PCM (12600sec)

B. *Discharging of Circular Orientation*

The temperature plots can be seen as 77.5 as lowest temperature in LHTES tank and 77.567 as highest temperature in LHTES tank at about 18000seconds; 70 as lowest temperature in LHTES tank and 70.067 as highest temperature in LHTES tank at 36000seconds,and40 as lowest temperature in LHTES tank and 40.067 as highest temperature in LHTES tank at 108000 seconds. Total time taken for discharging till 40 is about 30 hours

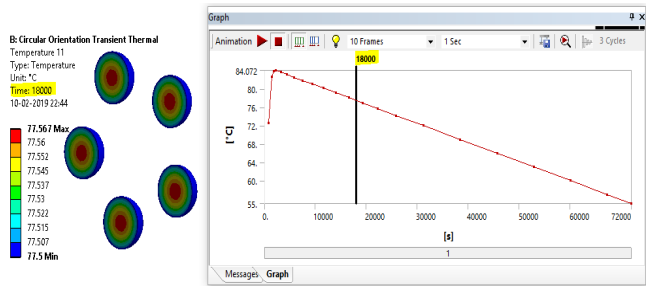

Fig. 4. Discharging of Circular Orientation-PCM (18000sec)

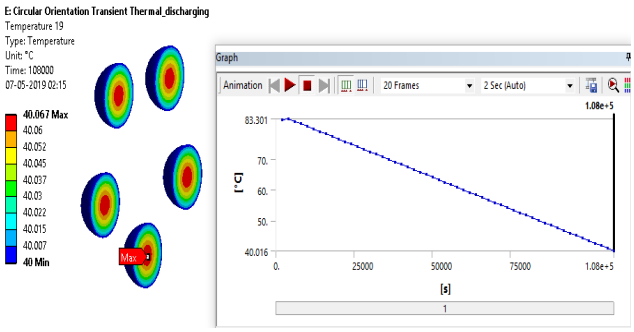

Fig. 5. Discharging of Circular Orientation-PCM (108000sec)

III. VALIDATION OF CFD WITH EXPERIMENTATION RESULTS

An experimental study is done by charging the PCM up to 85˚C (by an electric heater, which can be replaced by the solar heater) and then observing the discharging cycle till ambient temperature. The period attained for these cycles is noted down.

A. *Charging results for circular orientation*

Fig. no 6 shows the charging cycle readings. It took 4.6 hours to reach a temperature of 85 This indicates the similarity in CFD and experimental readings; wherein CFD results displayed 4.5 hours of expectation which is almost fulfilled by experimentation.

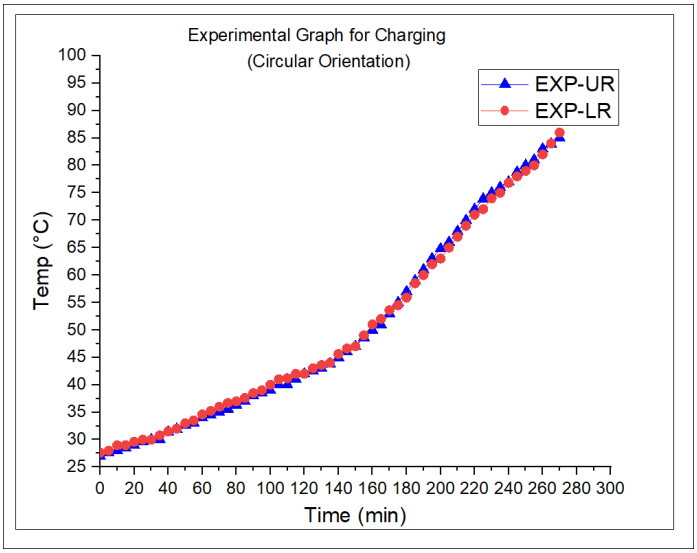

Fig. 6. :Experimental Charging Results -Circular Orientation

B. *Discharging results for circular orientation*

Fig. no 7 shows the total discharging cycle readings. It took 29 hours for PCM to reach an ambient temperature which is less by 1 hour than the CFD readings obtained for the discharging cycle. This 60 minutes time variation may be due to manual errors while experimenting.

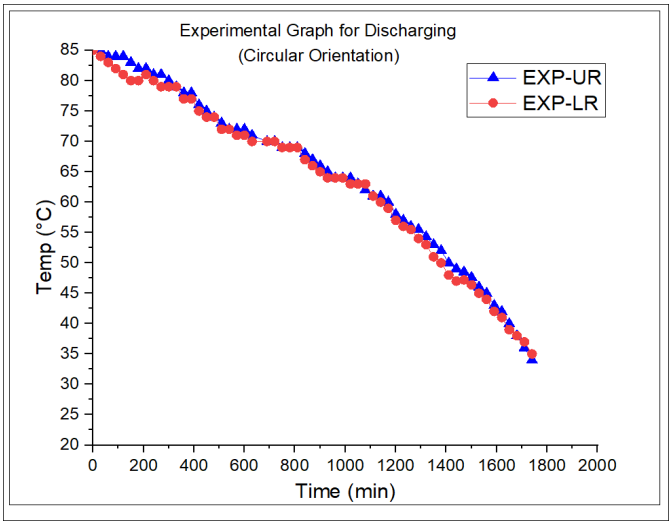

Fig. 7. :Experimental Discharging Results -Circular Orientation

IV. CONCLUSION

- An investigation on the performance of PCM in circularly placed Copper Balls is effectuated.
- Temperature dvariation on the behavior of circular oriented PCM balls gives fairly better appearance between the presented CFD and experimental results.
- 4.5 hours of charging(heating) and 20 hours of discharging(giving off heat) is the time taken to integrate the process of storing energy in water.
- circular orientation postulates advancement in storing heat for a longer duration of time but minor temperature fluctuations across the LHTES tank occur.
- These fluctuations may have occurred due to the absence of a PCM ball in the middle of the orientation, making the water of midway reaching to a different temperature.
- Hence, once charged, hot water continues to stay warm to about 29 hours which is more than a single day expectation without consuming much energy.

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