EXPERIMENTAL INVESTIGATION ON THERMAL PERFORMANCE OF LATENT HEAT STORAGE UNIT

Bhilore Ganesh[*1], Ahire Kiran[*2], Nikam Mayur[*3], Khairnar Sagar*[4], [*1,2,3,4] BE Mechanical From SND College Of Engineering & Research Centre, Yeola Dist. Nashik, India.
Prof. . Pathak G.J.[*5], Guide, Mechanical Department SND College Of Engineering & Research Centre, Yeola Dist. Nashik, India.
Prof. Baravkar P. S , Cordinator, Mechanical Department SND College Of Engineering & Research Centre, Yeola Dist. Nashik, India.

ABSTRACT
Macro-encapsulation is a common way of encapsulating the Phase Change Material (PCM) for thermal energy storage applications. The container shape may be spherical, tubular, cylindrical or rectangular. The study of melting phenomena of PCM needs to be understood for the design of thermal storage systems. The constrained melting of PCM inside rectangular and spherical capsule. Frontal area, volume is kept same in rectangular and spherical and square and equilateral triangle and plus geometry so in order to keep the mass of PCM same in both the cases. This ensures the effective comparison can be done for optimization of macro-encapsulated system.
Keywords: Thermal, latent heat, Pcm, Heater, Thermocouple, Conductivity

Introduction:
Energy plays a major role in the economic prosperity and the technological competitiveness of a nation. World energy outlook reported that the total energy demand in the countries like India and China is expected to increase from 55% in 2010 to 65% in 2035. The utilization of readily available energy of fossil fuels is increasing almost exponentially due to multiplying population, rapid urbanization and progressing economy. The resource augmentation and growth in energy supply have, however, failed to meet this increasing energy demand. Further, the energy demand in the commercial, industrial, public, residential and utility sectors varies on a daily, weekly and seasonal basis.
Energy storage will result in cutting down the energy waste which is cheaper, easier and faster way to solve many energy problems, improve the environment and enhance both energy security and economic development. The storage of energy in suitable forms is a present day challenge to the technologists. The requirement of thermal energy storage may also arise in several other cases such as in heat recovery systems where the waste heat availability and utilization periods are different. Therefore development of efficient and reliable thermal storage devices is one of the most important requirements for both conventional & non conventional. energy system. For developing country like ours, the usage of non-conventional energy sources especially solar energy is essential in wide range of applications both in urban and rural regions. same time. Our challenge is to make this robot adaptable to diameters varying from 260mm to 390mm based on two sliding mechanisms. In-pipe inspection robots are widely utilized in oil and gas industry, power plant industry and sewage system. These robots are applied to inspect defects, cracks and internal erosion which is due to many reasons such as degradation, creep, overheating, corrosion and others. Numerous in-pipe inspection robots have been built for the last two decades based on wheeled type, caterpillar type, snake type, legged type, inchworm type, screw type and PIG type. Each of the robots is developed according to distinct design requirements for specific environment and might be not suitable for other application. Therefore, by single locomotion system the inspection robot platform is only applicable for certain pipe configuration. Recently, combination of two or more locomotion system has been implemented to pipe inspection robot for more advantages in term of robustness and flexibility to their inventions.

By using hybrid locomotion system, the inspection robot is able to adapt and navigate in a various pipe configuration. Is generally used to inspect and measure surface cracks for metals. It is used toexcite induced current on metal surface. When there is no cracks on metal surface, the induced current is evenly.

Literature Reviews

Out of many heat transfer enhancement techniques, macro-encapsulation of PCM is a new and immersing technique . Macro-encapsulation is in some form of self-assembled structure or a package such as tubes, pouches, spheres, panels or other receptacle. These containers usually are larger than 1 cm in diameter and can be incorporated in building products as well. The main advantage of the macro-encapsulation is its applicability to both liquid and air as heat transfer fluids and easier to ship and handle. Macroencapsulation of the PCM helps to overcome the barrier of low thermal conductivity by increasing heat transfer rate. It is also helpful in forming a barrier and protecting the PCM from the outside environment and controlling the volume changes of the PCM. It has developed interest in several researchers especially because it can be cost effective comparative to other techniques. Spherical and rectangular shape for encapsulation of PCM is mostly used. Since the heat transfer is dependent on surface area there is need to investigate optimized shape for container.

Until now, the majority of cost-effective containers are plastic bottles (high density and low density polyethylene bottles, polypropylene bottles), mild steel cans and tin-plated metal cans . Some of the commercially manufactured macro-capsules used in LHSU are shown in Fig. 2.3 . In case of micro-encapsulation, except the matrix encapsulating the PCM has high thermal conductivity, the micro-encapsulation system suffers from low heat transfer rates. The inflexibility of the matrix prevents convective currents and forces all heat transfer to occur by conduction mainly. This can reduce the heat transfer rates, especially in the charging period. In addition to holding the liquid PCM and preventing changes of its composition through contact with the environment, macro-encapsulation also enhance the ease of handling PCM and its compatibility with the surrounding.

Fig Commercially manufactured macro -capsules.

Coating materials used in the macro-encapsulation of PCMs systems should meet the following distinctiveness :-

Possess high strength, flexibility and thermal stability.

Should be stable to UV exposure, barrier to moisture and air, etc.

Should be stable to environmental conditions.

Objective

The overall objectives of the proposed research are:

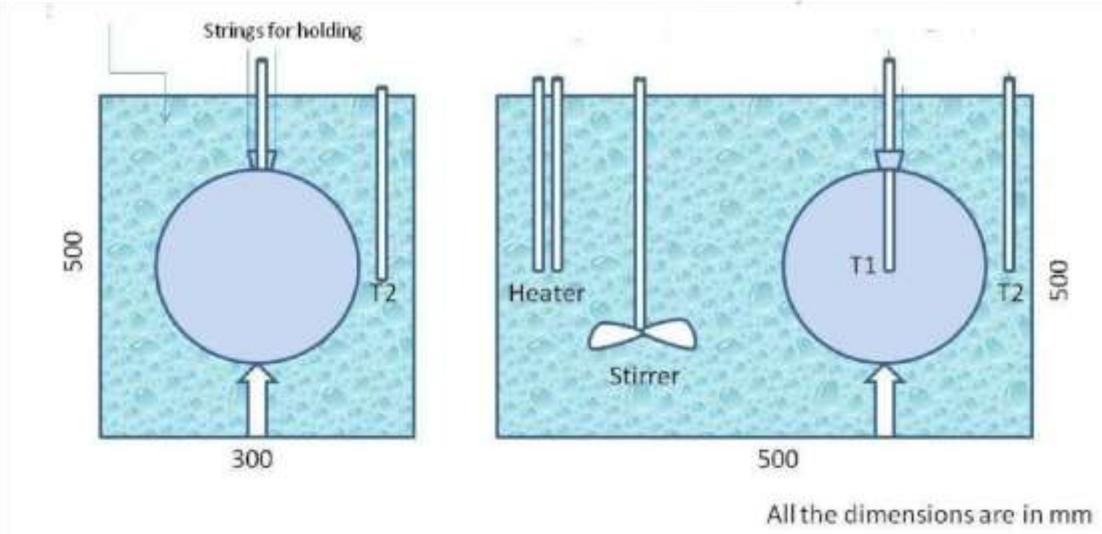
Select suitable PCM for the applications under consideration. The selection of the PCM depends on the operating temperature of the LHSU, stability of thermal properties of PCM over long term of cyclic operations, availability and economics.
Develop Experimental model for the thermal performance of macro-encapsulated LHSU using enthalpy-porosity model for proposed-shaped geometries.
Design and fabrication of an experimental setup for validating the model.
Examine thermal performance during charging and discharging process of macroencapsulated PCM incorporating proposed geometries experimentally.
Visualize solid -liquid interface during charging and discharging process.
Investigate constrained and unconstrained melting of PCM inside proposed geometries so as to create benchmark for such macro-encapsulations.
Propose a new shaped macro-encapsulated PCM for better thermal performance in terms of melting/solidification time.

Methodology

This study proposes a comprehensive and sysytematic methodology of phase change material assessment for latent heat thermal energy storage.
2. Performance assesment of phase change material wit the methodology is been carried out in an initial design phase of latent heat thermal storage unit.
3. We should select the different material for our experiment such as borosilcate glass paraffin wax and etc.
4. The different shape are made as per our setup diagram and set into the tank at specific distance.
5. Water is used as medium for surrounding to the shape and heat is given by the heater.
6. The performance of prescreened PCM's is evaluated and result provide a clear ranking list and quantitative performance indicators which give a confidence in selecting the best performing materials during design phase.
7. In order to improve the low thermal conductivity of pure PCM, two approaches are possible: i) the improvement of heat transfer using mass transfer, which is convection (only occurs in the liquid phase), and ii)the improvement of heat transfer through increasing the thermal conductivity (by adding objects with larger thermal conductivity to the pure PCM.

Working

In the present experimental investigation, paraffin wax is employed as phase change material and it is stored in borosilicate glass. These shapes are kept in tank and hot water is supplied into it



Conclusions and Future scope

Heat transfer in melting/solidification of PCM is greatly influenced by natural convection, top portion of encapsulated cavity is characterized by higher natural convection.

2. As the natural convection is more in uppermost part of cavity, there is need of heat transfer enhancement in lowermost part of cavity. Thus fins, multiple PCM method and nano-particle based PCM can be used as to enhance heat transfer characteristics.

3.It is also concluded that melting time required in case of macro-encapsulated PCM having rectangular shape is reduced by 18 % compared to spherical shape.

4.Melting of encapsulated PCM mainly depends on the geometry of encapsulation, thus there is need to optimize the shape and propose new geometries for enhanced characteristics.

5.Constrained melting is visualized, numerical model needs to be developed for the unconstrained melting.

6.Visualization of phase front is necessary to study actual heat transfer process in complicated geometries, experimentation needs to be carried out on constrained melting of encapsulated PCM.

7.Macro-encapsulated PCM can be effectively integrated with actual solar water heater to develop efficient water heating system.

References:

Khot S A, Sane N K and Gawali B S, "Experimental Investigation of Phase Change Phenomena of Paraffin Wax inside a Capsule", International Journal of Engineering Trends and Technology, Vol. 2(2), pp. 67-71, 2011 .

Regin A F, Solanki S C, Saini J S, "Experimental and numerical analysis of melting of PCM inside a spherical capsule", In: Proceedings of the 9th AIAA/ASME joint thermos physics and heat transfer conference, Paper AIAA 2006-3618, pp. 1-12, 2006.

Maheswari C U, Reddy R M, "Thermal Analysis of Thermal Energy Storage System with Phase Change Material", International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 4, pp.617-622, 2013 .

Lacroix M, "Contact melting of a phase change material inside a heated parallelepedic capsule", Energy Conversion and Management, Vol. 42, pp. 35–47, 2001.

Muhammed S K, Aikkara R and Kadengal A, "Analysis and Optimisation of Melting Rate of Solids PCM for Various Shapes and Configurations", International Journal of Emerging Engineering Research and Technology, Vol. 2(7), pp. 173-183, 2014.

Reddigari M R, Nallusamy N, Bappala A P and Konireddy H R, "Thermal energy storage system using phase change materials –constant heat source", International Scientific Journal: Thermal Science, Vol. 16(4), pp. 1097–1104, 2012.

Jellouli Y, Chouikh R, Guizani A and Belghith A, "Numerical Study of the Moving Boundary Problem During Melting Process in a Rectangular Cavity Heated from Below", American Journal of Applied Sciences, Vol. 4 (4), pp. 251-256, 2007 .

Ismail K A R, Henriquez J R, "Solidification of PCM inside a spherical capsule. Energy Conversion and Management, Vol. 41, pp. 173–87, 2000 .

Khodadadi J M, Zhang Y, "Effects of buoyancy-driven convection on melting within spherical containers", International Journal of Heat and Mass Transfer, Vol. 44, pp.1605–18, 2001.

DJ Malan, R.T Dobson, F.Dinter, "Solar thermal energy storage in power generation using phase change material with heat pipes and fins to enhance heat transfer ,"International on Concentrating Solar Power and Chemical Energy Systems, Solar PACES 2014 Conference, Energy Procedia 69 (2015) 925 – 936.

Ramalingam Senthil, Udhayakumar balaji, "Melting of pcm by elliptical and circular fins in the cylindrical thermal energy storage", Jr. of Industrial Pollution Control 33(2)(2017) pp 1663-1666, 22 December, 2017.120

Tomas Mauder, Pavel Charvat, Milan Ostry, "Experimental And Numerical Investigationof