

CFD Analysis of Phase Changing Material in Different Geometries-A Review

Md. Jamil Akhtar¹ Namraj Garhewal²

¹Research Scholar ²Assistant Professor

^{1,2}Department of Mechanical Engineering

^{1,2}Oriental College of Technology, Bhopal, Madhya Pradesh, India

Abstract— The melting behavior of a paraffin wax (A Phase Changing Material) in different geometries and configurations has been analyzed. The paraffin wax has been selected for the phase changing material. The various geometries are tapered vessel with hot wall outside, hemisphere section with hot wall outside and cylinder with hot wall outside. A 3-dimensional analysis of each geometry based on pressure a CFD analysis of model has been created in Fluent for simulating the Melting process. The most initial step in FEA is Pre-processing which is used to build and analyze a fluid flow model. It consists building of the models and then applying the mesh and entering the boundary conditions. Another software is CATIA, it is a mechanical design software which is used to create 3D modelling as it helps a designer to build and then mesh a model for computational fluid dynamics (CFD) and various scientific applications. FLUENT is a computer program for fluid flow modeling and transfer of heat in various types of complex geometries. It provides complete flexibility of meshing, including the ability of solving fluid flow problems using structured otherwise unstructured meshes those can be generated about complex geometries. The main aim of this study is to optimize the melting rate by changing the geometry of the object. Finally, the results calculated have been discussed in detail.

Keywords: Melting Time; Phase Change Material; Paraffin Wax; Heat Storage; Geometries Configuration; CFD Analysis

I. INTRODUCTION

A. Melting

An Efficient and economical storage of heat is an important way of the effective and vast scope of utilizing of solar energy for lower temperature thermal applications. Amongst the large number of heat storage techniques, Since latent heat storage is fundamentally one of the best and attractive way due to its capability of providing a highly energy storage density (kg/m³) and having characteristics of storing heat at constant temperature corresponds to standard saturation pressure and temperature of the heat storage substances.

Melting, or latent heat of fusion, is such a process that results in the phase transformation of a substances from one phase to another phase i.e, solid to a liquid. During phase transition both the phases remains at equilibrium conditions.

This happens when internal energy (u in kJ/kg) of the solid states increases, when the heat and pressure are applied, which increases temperature of the substance's to saturation temperature or at melting point. At the point of melting, the order of molecules or ions in the solid states breaks down into a lower ordered state, and the solid get melted to become a liquid.

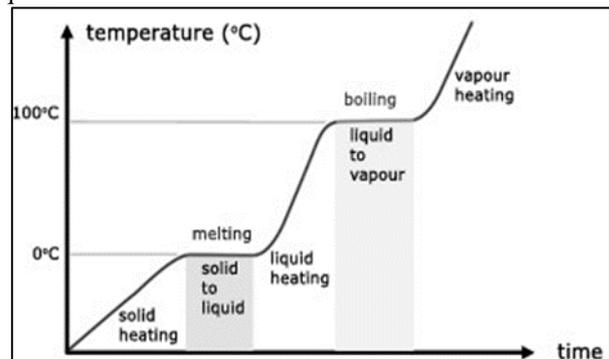


Fig. 1.1:

From the graph above,

- 0°C is the saturation temperature at which melting of the solid start.
- Temperature of fluid remains constant at 0°C as the solid starts melting.
- When the process of melting occurs, both the solid and liquid phases exist in equilibrium.

Generally, substances at molten state its viscosity decreases as the temperature increases. The only exception of this principle is in the element of sulfur, whose viscosity increases to some extent due to polymerization process and then decreases along with higher temperature in its liquid state. Energy available in any form is most precious and delicate. But, converting them in a usable form is undoubtedly an extremely important and valuable. Thus, from every perspective, its production and use in an efficient way is one of the ultimate goals behind any research and development work. Increasing demand for energy is an obvious reality, whereas the conventional resources are limited and exhausting at an alarming rate. Besides huge efforts on how more and more alternative energy resources can be mixed with the present use pattern, the rate of induction of renewable energies are significantly lagging.

II. LITERATURE REVIEW

Year	Name	Work	Outcomes
2017	Kai Yang, Jing Wang	They have presented a new boundary element method which has been developed to solve the nonlinear and linear heat conduction equations in which thermal conductivity of material depends on temperature. They also used radial integration method to deal with the domain	The most widely used iteration method is numerical, Newton–Raphson iteration method has been applied to solve the final nonlinear system of algebraic equations. They also developed the modal to find the correctness of the

		integral because of the varying thermal conductivity value along the length, and they have employed radial basis functions to approximate the unknown values in the domain integral.	numerical values those are being analyzed.
2016	Mohammad A. Bashar	He has done lots of experimental study in this filed such as he added PCM to thin rectangular chamber to investigate the performance of various thermo-physical properties/parameters. After study he compared All experimental results with a previous study by him with net PCM. From the concluded results, it may be generally observed that the thermal performance of PCM based on latent heat storage (LHS) may be improved by using thermal conductivity enhancers	But he found that the enhancement of heat transfer depends on many factors like, particle mass, density, volume concentration, thermal conductivity, specific heat, particle material, particle size, particles maintained at temperature and additives.
2016	Martin Koller, Heimo Walter	They have performed analysis on design of tube Heat exchanger consists of a steel tube and an aluminum wire matrix. In their numerical analysis, they used enthalpy-porosity formulation to get quantitative information related to the evolution time of the melting front within the phase change material.	After analyzing they found that when the solidification occurs the dominant heat transfer mechanism is heat conduction. The investigation has also shown that the discharging process has been slower than the charging process
2015	Nasser Mostafavini a	They depicted that melting of a NePCM in a square geometrical cavity various horizontal Source-Sink Positions and also on the vertical sidewalls has been numerically investigated.	In all the above cases discussed, the concentration volume of nanoparticles of 3% would result in the lowest melting time.
2013	Brian N. Turner	The main aim of presenting this paper is to numerically and effectively review the literature concerned to design process and analysis of fused deposition modeling (FDM) and corresponds to an additive manufacturing (AM) or rapid prototype processes (RP). A complete study of the literature related to process design and mathematical process modeling has been analyzed	In a modern industries application FDM and similar processes are non-conventional process of manufacturing among the wide variety of used rapid prototyping processes as increasing applications in finished parts manufacturing
2010	L. B. Ji	Considering thermal conduction depend on temperature and heat capacity, based on Acrylonitrile Butadiene Styrene (ABS), he developed a three-dimensional transient thermal finite element in Fused Deposition Modeling (FDM). By applying ANSYS parametric design language (APDL) and latent heat the moving material of ABS by the sprayer on the mold equipment is simulated has been considered.	His simulation result shows that the temperature field distribution likes an ellipse; secondly, he compared with the previous track, the latter one has larger heat affected region and larger inhomogeneous temperature distribution; the greatest temperature gradient takes place near the edges of deposited part where the sprayer scanning direction changes.
2015	Miqdam T Chaichan	The practical study depicted by them to analyze in improvement in single slope solar distiller productivity after adding some paraffin wax material to the steel base and sides. Aluminums powder has been mixed with paraffin wax so that its thermal conductivity can be enhanced. They fabricated three distillers; one without any changes, the second has taken the advantage of putting the PCM inside it	The practical shows that by adding paraffin wax can proved the distiller productivity of solar with almost 6.21% in the month of January and 10.88% in the month of February compared to that of simple solar distiller. When, paraffin wax is added with aluminium powder, it enhances its productivity by 21.91% in January as well as 25.51% in February as compared to simple solar distiller productivity.

1983	A. ABHAT	The study of which solidification takes place in vertical cylinder shell. This paper also includes the process of solidification of a phase change material (PCM) in cylindrical geometries have been numerically explored.	The effects of using mix air are investigated. The efficiency of the system is calculated. A correlation is developed, to predict the air room temperature from the ambient air temperature.
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A. Problem Identification

After study and analyzing the outcomes of various authors it can be interpreted that there is a need of optimizing the

geometry for thermal energy storing device and also there is need of simulation of already used geometry for validation and design of any new geometry to get comparatively better result.

Temperature 0 (C)	Density(kg/3m)	Specific Heat (J/kgK)	Thermal Conductivity (W/mK)	Viscosity (Ns/2m)	Solidus Temperature 0 (C)
40	750	28600	0.15	0.005	319

III. METHODOLOGY

I have taken three different geometry like hemisphere, cylindrical and tapered section using paraffin wax material for increase melting rate and compared the data with base paper having rectangular, cylindrical and spherical section.

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