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Analysis of "Latent Thermal Enenrgy Storage System" with RT35 (PCM)

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ABSTRACT

This work examines latent thermal energy storage in an exceedingly coaxal element, throughout each melting and solidification victimization PCM RT35. The examination could be a comparative study of a simplified, two-dimensional model of a horizontally oriented shell and tube device - versus - a vertically oriented one. The analysis is formed in CFD programme Ansys Fluent seventeen.1, through four totally different models. The results show that the vertical orientation performs higher in each cases, melting and solidification. The energy transfer quantity at intervals the natural action time is that the same, though the vertical orientation is roughly 2 hundredth quicker to complete soften and ninetieth to complete ninetieth. the most reason for this discrepancy is that the impact of gravity, that is additional distinguished within the vertical orientation.

Keywords: PCM, Heat Storage, RT35,CFD

1. Introduction

Latent heat storage depends on the phase changes of the materials , for example, from solid to liquid, that use latent heat energy to store energy. These materials usually embody

- Organic materials, paraffin- or non-paraffin-compound. they're largely used for heating and cooling applications in buildings as their temperature ranges around 20–32^0 C. they're with chemicals stable, non-corrosive and non-toxic with heat capability, however ar ignitable.
- Inorganic phase changing materials like metallic alloys and salt compositions, with the latter largely utilized in star thermal applications. they provide high heat capability, higher thermal conduction and rather low material price. In distinction, they're corrosive and funky down quickly.
- Eutectic mixtures will be of 3 types: organic–organic, organic–inorganic, and inorganic–inorganic. they're typically utilized in building applications. For alternative energy generation, largely inorganic materials ar used because of their temperature vary of 115–897^0 C.

1.1 Latent Heat Storage System With Phase Change Material

Energy storage systems can temporarily store renewable or cheap heat or cold respectively and make it available again later when it is needed. The time when energy is needed and when it is produced are often not the same, which is particularly relevant to regenerative heat production.

Conventional energy storage systems store heat or cold sensibly ("perceptible"). Each energy input or output causes an increase or decrease of the temperature. Latent heat storage systems additionally use the phase transition of the storage material from solid to liquid and the other way round. During the phase transition, the storage material can absorb or release large amounts of energy at almost constant temperature. The storage capacity can be significantly increased by taking advantage of this reversible process. The container size can be significantly reduced and result in a gain of space at constant energy storage capacity. The energy input / output takes place over a long period of time at an almost constant temperature. This means that the insulation of latent storage systems can be less sophisticated and expensive.

There are different forms in which the phase change materials can be brought into the storage tank, e.g. as granules, macro capsules (packs, panels, balls, etc.), or PCM fluids (Slurry) suitable for pumping. The available heat transfer area is crucial for the performance of the storage system.The exchange of energy in the LTES-system is made possible via a heat exchanger, Usually a shell and tube exchanger. The most common version is with the PCM on shell side, albeit the opposite occur. The heat transfer fluid, HTF, in most applications water, flow in the tube. There is a variety of different configurations of heat exchangers. A common setup of a simple shell and tube heat exchanger is illustrated in Figure.

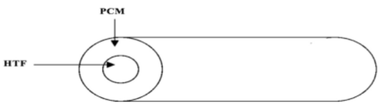


Fig 1 Simple Shell and Tube Heat Exchanger

2. Literature Review

1. **Design and performance of an off-grid solar combisystem using phase change materials by Aruna chala Kannan DarynRoan.2021**

An off-grid star combisystem with integral heat of transformation storage unit is intended and developed for active house and water heating throughout day and passive house heating throughout night. The solar combi-system performance shows that the typical energy saving quantitative relation and energy saving obtained for house heating were ~ ninety three and ~ a pair of.8 kWh, severally. it had been discovered that the air temperature within the state change material integrated house unit (area coverage ~60%; melting point: twenty three °C) stay ~ four to six °C cooler than corresponding while not state change material integrated house unit. The semi-permanent performance analysis of the solar combi-system shows that the off-grid system will with efficiency maintain the house temperature in a very comfortable zone throughout winter and summer season together with water heating for residential application. it's evident that the off-grid state change materials integrated star comb-isystem will result in vital energy saving in residential buildings each in colder and hotter climatic conditions.

2. **Applications and technological challenges for heat recovery, storage and utilisation with latent thermal energy storage By Zhi Li ,Yiji Lu,, Rui Huang et al. 2021**

This article provides a comprehensive state-of-the-art review of latent thermal energy storage (LTES) technology with a particular focus on medium-high temperature phase change materials for heat recovery, storage and utilization. This review aims to recognize potential methods to design and optimize LTES heat exchangers for heat recovery and storage, bridging the knowledge gap between the present studies and future technological developments. The key focuses of this work can be described as follows:

(1) Insight into moderate-high temperature phase change materials and thermal conductivity improvement methods.

(2) Various configurations of latent thermal energy storage heat exchangers and relevant heat transfer enhancement techniques

(3) Applications of latent thermal energy storage heat exchangers with different thermal sources, including solar energy, industrial waste heat and engine waste heat, are discussed in detail.

3. **Performance enhancement of PCM latent heat thermal energy storagesystem utilizing a modified webbed tube heat exchanger by Ahmed H.N. Al-Mudhafar et al. 2020**

In this work , a novel modified webbed tube heat exchanger was introduced and numerical investigation is made to make-out improvement in the thermal performance of phase change material (PCM) thermal energy storage (TES) system. To calculate the thermal performance for this heat exchanger its performance was compared with two types of heat exchanger. These heat exchangers included: the webbed tube heat exchanger and the triple tube heat exchanger. Two-dimensional numerical models were developed. The models enabled us to simulate conduction and natural convection heat transfer mechanisms. The processof solidification (discharging) was monitored during the simulation. The results showed that the PCM solidification process accelerates by 41% when applying the modified webbed tube heat exchanger compared to the webbed tube heat exchanger .

3. Objective

In a time of environmental issues and climate change, the search for more efficient energy systems is a constant process. More efficient usage of LTES could be one way to more efficiently utilise already harvested energy. In this thesis, LTES in a coaxial component is simulated and analysed in four different cases. The purpose is to see if there is a difference in performance between horizontal and vertical orientation of the heat exchanger, during charging and discharging.

4. Methodology

Analysing a transient heat transfer problems in multiple dimensions, with both convection and conduction, is almost impossible to do analytically. All though knowing what mechanisms involved is important to be able to setup the simulations correctly, with proper boundary conditions and meshing. It is also important to be able to interpret the obtained results. In the following paragraphs, governing equations and boundary conditions will be considered. Also methods used when simulating and the different cases considered, including PCM, will be presented.

4.1 Governing Equations

In the analysis of the phase-changing process, the enthalpy porosity method is used, which is described by Esapour et al. and from where the assumptions and equations in the following paragraph are derived from. When using this method, a few assumptions needs to be made; flow is considered laminar and the viscous dissipation term is considered negligible. These assumptions make it possible to write the continuity-equation as in equation 4.1.

$$\nabla \cdot \overline{V} = 0.$$

The momentum-equation can be written as equation 4.2

$$\frac{\partial V}{\partial t} + \overline{V} \cdot \nabla \overline{V} = \frac{1}{\rho}(-\nabla P + \mu \nabla^2 \overline{V} + \rho \overline{g} \beta (T - T_{ref})) + \overline{S}$$

The S-term is called the Darcy’s law damping term, the source term, which describes the effects of phase change on the convective heat transfer, i.e fluid flow in porous media with low Reynold’s number, defined in equation 4.3

$$\overline{S} = \frac{(1-\lambda)^2}{\lambda^3} A_{mush} \overline{V}$$

Amush is a constant describing the mushy zone. The thermal energy-equation can be written as in equation 4.4.

$$\frac{\partial h}{\partial t} + \frac{\partial H}{\partial t} + \nabla \cdot (\overline{V} h) = \nabla \cdot (\frac{K}{\rho C_p} \nabla h)$$

In equation 4.4. the enthalpy of the material is considered to be a combination of latent heat, i.e the enthalpy regarding the phase change, and the sensible enthalpy, h, the enthalpy regarding temperature change without phase change. This combination of enthalpies can be written as in equation 4.5 and 4.6

$$H = h + \Delta$$

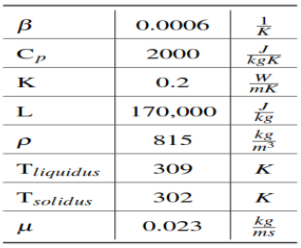
$$H = h_{ref} + \int_{T_{ref}}^{T} C_p dT.$$

The latent heat of the material L is a function of the fraction liquid or solid in a material described by equation 4.7.

$$\Delta H = \lambda L$$

4.2 Materials

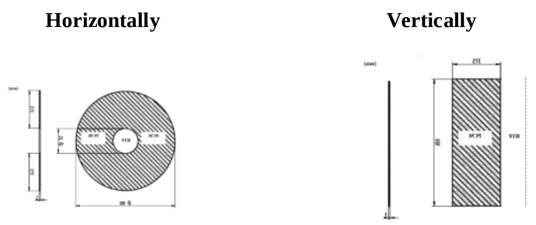
The PCM used in the numerical analyse is RT35, a paraffin-like organic substance. Its properties are presented in table 4.1



β	0.0006	$\frac{1}{K}$
C_p	2000	$\frac{J}{kgK}$
K	0.2	$\frac{W}{mK}$
L	170,000	$\frac{J}{kg}$
ρ	815	$\frac{kg}{m^3}$
$T_{liquidus}$	309	K
$T_{solidus}$	302	K
μ	0.023	$\frac{kg}{ms}$

4.3 Geometries

The number of geometries analysed are two. They are simplified models of a tube and heat exchanger, orientated horizontally and vertically. The first model is a thin geometry of a horizontal tube with a smaller diameter HTF tube co-centered inside. The second geometry is a thin half of a vertical tube, due to symmetry. This means one side is considered as the HTF side. The reason for modeling thin models rather than strict two dimensional models, is better convergence of the simulation. The models are illustrated in figure 4.1 and figure 4.2.



Horizontally **Vertically**

Fig 2 Geometries

5. Results & Discussion

In this chapter, the results of the numerical analysis are presented and from the processes examined and discussed. A comparison between the cases is made and analysed .

5.1 General Results

The purpose of the simulations is to see which of the orientations is best. As depicted in the vertical orientation is better in both cases, i.e. the time to complete melting and solidification is the shortest. In the case of melting, the vertical orientation is approximately 200% faster than the horizontal orientation. In the case of solidification, vertical orientation is approximately 90% faster than horizontal orientation.

The melting time for the horizontal orientation is approximately 33,000 seconds and the melting time for the vertical orientation is about 11,000 seconds. The solidification time for the horizontal orientation is approximately 55,000 seconds and the solidification time for the vertical orientation is about 29,000 seconds.

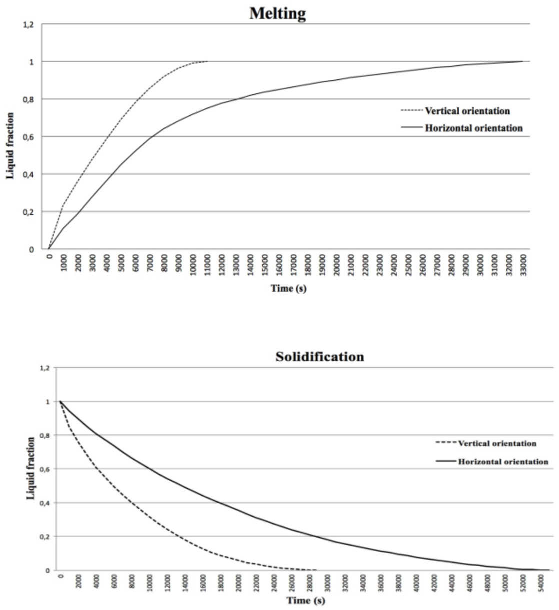


Fig 3 Results

6. Conclusion

A vertical orientation of the heat exchanger induce a melting time about 200% faster than the horizontal orientation. vertical orientation of the heat exchanger induce a solidification time about 90% faster than the horizontal orientation. The main reason for the difference of performance in time is the effect of gravity upon the heat exchanger, which induce a larger portion of natural convection.

REFERENCES

[1] Design and performance of an off-grid solar combisystem using phase change materials by ArunachalaKannan JyotiPrakashDarynRoan.2021

[2] Applications and technological challenges for heat recovery, storage and utilisation with latent thermal energy storage By Zhi Li ,Yiji Lu,, Rui Huang.et al 2021

[3] Applications and technological challenges for heat recovery, storage and utilisation with latent thermal energy storage By Zhi Li ,Yiji Lu,, Rui Huanget al 2021

[4] Performance enhancement of PCM latent heat thermal energy storagesystem utilizing a modified webbed tube heat exchanger by Ahmed H.N. Al-Mudhafar,et al 2020

[5] Latent thermal energy storage technologies and applications: A review Hussam Jouhara.et al 2020

[6] Synthesis and thermal properties of nanoencapsulation of paraffin as phase change material for latent heat thermal energy storage by NanZhangYanpingYuanet al 2020

[7] Numerical simulation and parametric analysis of latent heat thermal energy storage system by Manoj Kumar Soni, Nisha Tamar & Suvanjan bhattacharya et al 2020

[8] High temperature latent heat thermal energy storage: Phase change materials, design considerations and performance enhancement techniques by

BrunoCárdenasNoelLeónet al 2018

[9] Experimental analysis of thermal energy storage by phase change material system for cooling and heating applications by Jaykumar H.Patel M.N.Qureshi P.H.Darji et al 2018

[10] A comprehensive study of properties of paraffin phase change materials for solar thermal energy storage and thermal management applications by SamerKahwaji Michel B jonshon et al 2018

[11] Nanoencapsulation of phase change materials (PCMs) and their applications in various fields for energy storage and management

[12] Pilot-scale demonstration of advanced adiabatic compressed air energystorage, Part 2: Tests with combined sensible/latent thermal-energystorage bBecattiniL. GeissbühlerG. ZanganehA HaselbacherA. 2018

[13] Numerical analysis of latent heat thermal energy storage using encapsulated phase change material for solar thermal power plant by Kunal bhagat Sandip K.Saha et al 2016

[14] Numerical Analysis of Latent Thermal Energy Storage System With Embedded Thermosyphons by Karthik Nithyanandam , Ranga Pitchumani…..et al 2013

[15] Performance and Analysis of Thermal Energy Storage System using PCM By R. Meenakshi Reddyet al 2012