THERMAL ENERGY STORAGE THROUGH ENCAPSUALTED PHASE CHANGE MATERIAL AND ITS ENVIRONMETAL APPLICATION

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Abstract:Energy consumption in thermal application is significantly high around the world including India. Energy is also considered crucial part of any country which has to be managed according with the demand. Also with the increasing concern of environment shifting toward clean energy source like renewable energy source is practiced and as the conventional source of fuels are running out there is need of an alternative source. Increased population increases demand of energy and there is mismatch between demand and supply. To overcome this storing Waste heat recovery and solar energy for thermal application is a cleaner energy storage approach. Thermal energy storage collects the heat energy during the peak hours and it can be utilized to reduce the consumption of fuel and can also be used during the night time for thermal application. Phase change material is an emerging technology for storing thermal energy. Nitrate salt is used as phase change material and the storing enthalpy is checked of this salt. The present paper also focuses the environmental application of this phase change material.

***IndexTerms* – thermal energy storage, nitrate salt, phase change material.**

1 INTRODUCTION

Greenhouse gases (GHGs) like co_2 emissions increased exponentially with increase in the consumption of fossil fuel and result in to global increase in the temperature and it further result into global warming. Climate change is also due to increased concentration of co_2 and result in to the rising of sea level due to melting of the polar ice(Haripriya, 2002). As the fossil fuel are conventional source of energy and are limited for use there is need of an alternative source to match the demand of the population. Shifting toward the renewable energy source of the energy produces less secondary waste and it is also sustainable for any nation by mean of economic and social needs(Prieto, Cooper, Fernández, & Cabeza, 2016).
Solar radiation is intermediate by its nature; its total available value is a factor of time, weather conditions and latitude. There is a huge gap between energy demand and supply which creates energy crises. In world energy statistic report of International Energy Association (IEA) 2014 estimated that world's annual energy supply is 573 EJ and final consumption is 394 EJ(Ellabban, Abu-Rub, & Blaabjerg, 2014). From process of supply to consumption certain amount of energy loss is there which can be stored and used further. Among various energy storage system thermal energy storage(TES) is considered as one of the effective storage system. Energy storage not only connects the bridge between demand and supply but also improves the systems reliability and performance(Gabisa & Aman, 2016).
Thermal energy storage technologies are used since 20th century by one or other mean. Basically in ancient days' people use the soil, rock or water for storing the thermal energy which stores the sensible type of thermal energy. Sensible energy is change in the temperature of the material in which the energy is stored(Rohit, Devi, & Rangnekar, 2017). Basic principle of thermal energy storage is distributed in 3 steps and they are charging, storing and discharging as shown in fig 1. During day time the material gets heated from capturing the thermal energy from surrounding and during the off peak hours the energy which is been stored in material is released and the energy demand can be matched accordingly(Prieto et al., 2016). Materials over here store the energy by changing its phase or by just changing its temperature. Sometimes reacting with other compound and going for exothermic or endothermic reactions.

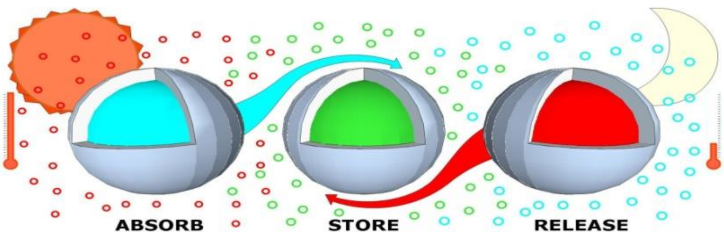

Figure 1: Principle of Thermal Energy Storage

Thermal energy storage is also classified further as latent heat storage, sensible heat storage and thermo chemical energy storage. Sensible is known for change in temperature, in latent there is change in phase of material and in thermo chemical there are association and dissociation reactions going on which is used for storing the thermal energy(Shilei, Guohui, Neng, & Li, 2007).

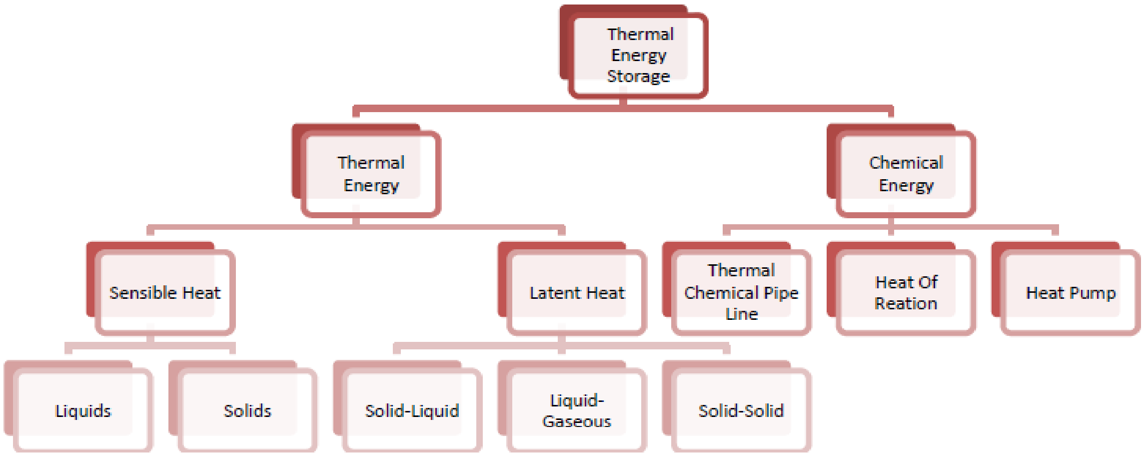

Figure 2: Classification of Thermal Energy Storage

This paper focus on latent heat storage which is done through phase change material, further there is a classification of phase change material which is like organic, inorganic and eutectic which is the mixture of organic and inorganic(Sharma, Tyagi, Chen, & Buddhi, 2009).

2.MATERIALS AND METHOD

2.1Materials

Sodium nitrate and potassium nitrate with purity 99% extra pure grade were taken from loba chemie (laboratory reagents and fine chemicals) which is used as phase change materials in this study. The properties of the materials like melting point, boiling point pH and density are given in Table 1. For encapsulation purpose TEOS (tetraethyl orthosilicate) was used as shell material, which was further mixed with ethanol, and distilled water as per stated procedure in(Tahan Latibari, Mehrali, Mehrali, Indra Mahlia, & Cornelis Metselaar, 2013). This process need to be done at specific pH ammonium hydroxide was mixed in the solvent for pH control(Zhang, Wang, & Wu, 2010).

Table 1: Basic parameter of the sample component

sample	Melting point	Boiling point	pH	Density	Percentage composition
$NaNo_3$	306 ^{O}C	380 ^{O}C	NA	2.26	≥99.0
KNO_3	334 ^{O}C	400 ^{O}C	5.5-8	2.109	≥99.0

2.2 Sample Purification

Purification of sample was done by specified process where the raw samples directly taken from the laboratory was firstly dissolved in a solvent and then filtered and dried in oven which was further melted above its melting point in muffle furnace this were the purified sample and the directly taken sample from laboratory were raw samples.

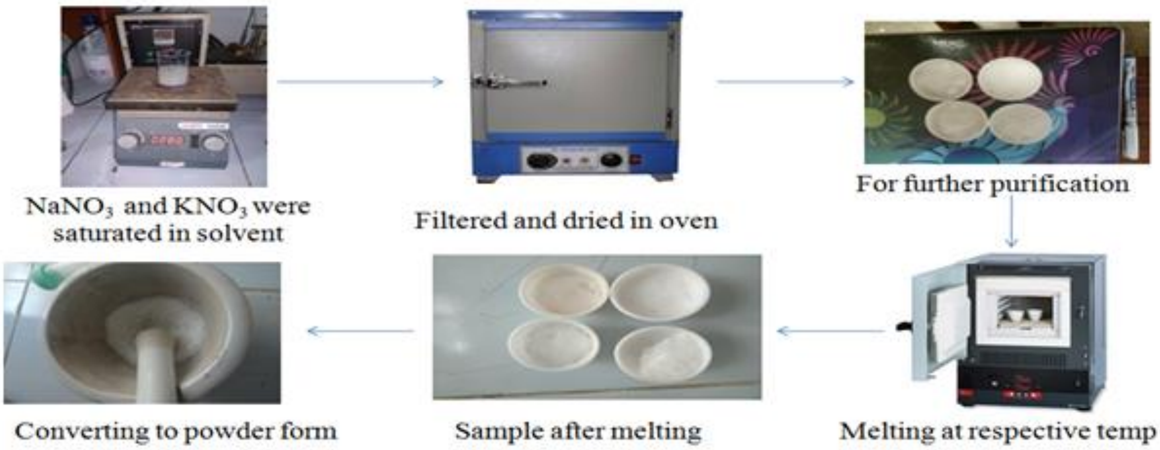

Figure 3: Sample purification process

2.3 Encapsulation method

Encapsulation is a process of applying a layer on the surface of phase change material and protecting the material from reacting with the surrounding. For encapsulation various process are available but in this study sol-gel method is used for the encapsulation. TEOS (tetraethyl orthosilicate)was used to prepare the sol solution and was added to the phase change material. Due to hydrolysis and condensation process there is a silica layer over the particle of phase change material.

This phase change material was tested in DSC (differential scanning calorimetric) for checking their melting behavior at constant supply of energy and also the storage capacity in form of enthalpy[10][11].

3 RESULT AND DISCUSSION

When the lab research work is taken to the field there is a different situation because many factors play its role and a result a vast deviation is observed. But for the analysis of the data from the field there is also a requirement of the lab experiment so the data can be compared and we can study the melting behavior of the material by testing in lab. In present study raw samples were taken and purified and tested under DSC. The nitrate samples were melted at their respective temperature and the difference of melted sample and raw sample was noted. In DSC sample was taken in the DSC aluminum container and the lid was also closed. The difference between raw sample and melted shows the present of impurities present in the raw sample as the enthalpy after 1st cycle of DSCis reduced and for melted sample it remains same.. Heating was given at rate of 20^{O}C from 30 to 300^{O}C range. Results indicate the impurities present as the difference between the control and purified sample is 1J/g of latent heat of fusion and both of the samples has melting point of 277.4^{O}C.

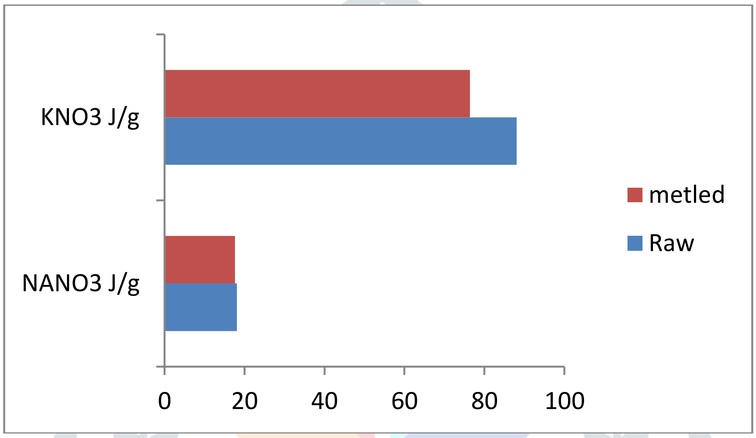

Figure 4: Comparison of Enthalpy

Mixture of this salts were also tested in DSC and compared with the encapsulated material. Proportion in the mixture was decided by performing various experiments using the different ratio and the highest enthalpy ratio was selected for the encapsulation purpose. Sodium nitrate 60% and potassium nitrate 40% shows the promising result for the storage of energy. Same ratio was selected for the encapsulation purposes and it was observed that the energy storage capacity of the encapsulated material decreases as the as there is silica shell on the particle surface which reduces the storing capacity but protect the material from reacting with the environment.

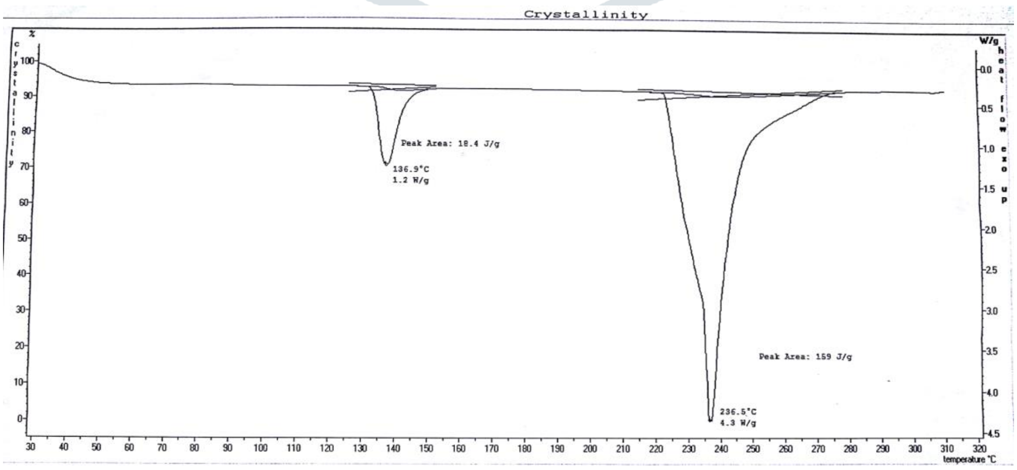

Figure 5: DSC curve of NA60K40

In fig. 6 we can observed the enthalpy was reduced compared to the enthalpy in the fig.5 which is the sample without encapsulation. To overcome some of the drawback of the phase change material there is also drawback after overcoming the other one. If the reactivity is control by providing the layer on particle it reduces the enthalpy of the material.

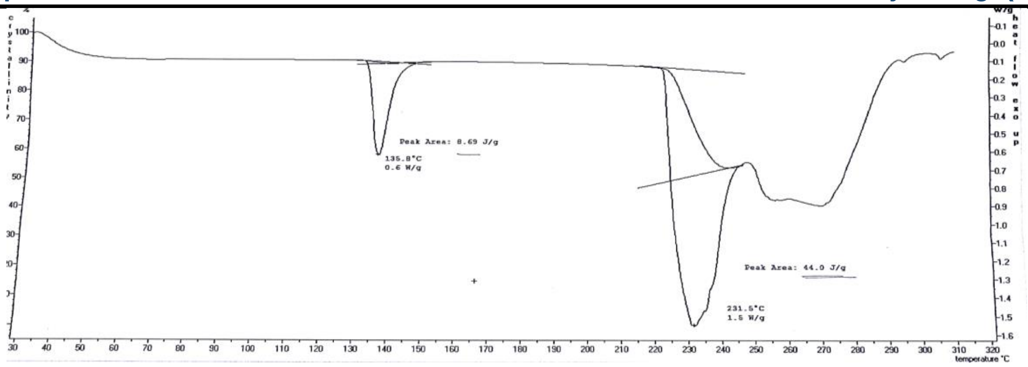

Figure 6: DSC curve of encapsulated material

4 CONCLUSIONS

Energy storage capacity of different sample were tested and compared. Due to presence of the impurities in the raw sample there was difference in the enthalpy of purified sample and raw sample. Comparative purified sample has less energy storage as the impurities are removed before testing and in raw sample the presence of impurities deviates the results and after 1st cycle the energy storage capacity is reduced in raw sample.Different ratios were tried and the promising ratio was found was sodium nitrate 60% and potassium nitrate 40%. This mixture shown the highest enthalpy comparative to different ratio tried. Further after applying the encapsulation to phase change material the energy storage capacity was reduced.

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