Performance Analysis of Energy Storage System with Hybrid Phase Changing Materials

Santosh Kumar Singh[1], Sujit Kumar Verma[2]

[1] GLA University, Institute of Engineering & Technology,
17km Stone, NH-2, Mathura-Delhi, Mathura, India
Santoshrajpoot78@gmail.com

[2] GLA University, Institute of Engineering & Technology,
17km Stone, NH-2, Mathura-Delhi, Mathura, India
sujit.verma@gla.ac.in

Abstract: ***Spurt in the enhancement of Green House Gasses emission and increasing fuel prizes are the main dragging force behind efforts to more effectively and economically utilize the various renewable energy resources. Almost everywhere in the world direct solar radiation is considered to be an alternative to lessen dependency on conventional energy. Mass scale utilization of this form of energy is only possible, if effective technology for its storage can be developed with low capital and running cost. One of the most effective techniques of solar energy harvesting is the use of phase changing materials (PCM). PCMs have wide ranging application areas in solar energy storage system due to their large thermal storage capacity the biggest disadvantages of PCM in the low thermal conductivity which results low heat transfer and low thermal storage at release rate which is a major drawback in this review various techniques are studies to enhance the the latent heat storage of the system it also focus on thermal conductivity enhancement by the introduction of nano material as fillers.***

Keywords: Phase changing material (PCM), Thermal energy storage (TES), Hybrid, Nano fluid

1. Introduction

The increasing demand of energy and limited stock of energy recourses such as fossils fuels forces the researchers to think about renewable energy recourses which is abundant and can be renewed at a significant rate it requires an efficient and effective energy storage devices which is low in cost and have positive impact on environment conventionally water was used as the energy storage medium but now a days PHASE CHANGING MATERIAL has become 1st choice of researchers as heat storage medium because of it high latent heat, high heat storage capacity and high energy density than water researchers evaluated that a pcm based THERMAL ENERGY STORAGE SYSTEM has 44.3% more energy storage density than water based storage devices similar investigation with PCM emulsion also achieve 34%increase in the energy storage capacity as against water based TES system The biggest disadvantage of PCM is it is low thermal conductivity which curtail the heat transfer rate during the charging and discharging process the best way resolve this problem is to use additives in PCM to increase the thermal conductive In this paper investigation is done by using nano materials as an additives in PCM to enhance the thermal conductive of HSS (heat storage system) nano-material acts as thermal Conductivity enhancer. Various samples are prepared to investigate the thermal property of nano-pcm composite result shows that efficiency was increased up to 46% with the increase in the weight of nano dispersed in nano-pcm composite apart from low thermal conductivity and hence poor thermal response factor other disadvantage of pcm is it instability in the melting temperature The current study deals with review of various techniques to improve the thermal conductivity latent heat storage of the thermal energy storage system like using single phase changing materials use of multiple phase changing materials encapsulations of pcm use of hybrid nano materials, use of NANO-PCM as thermal conductivity enhancers

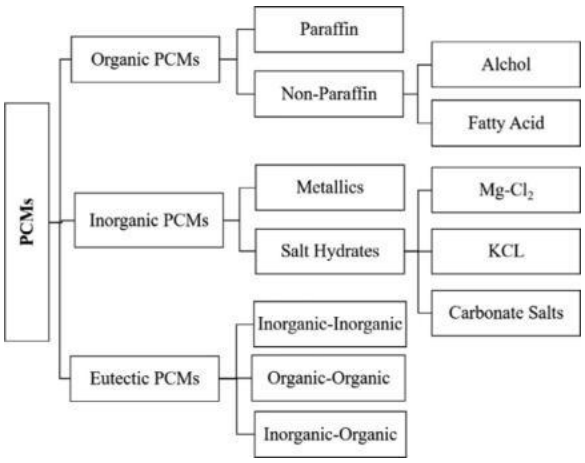

Fig1:- Classification Of Various Type of PCM

2. Methods to Enhance the Thermal Storage and Thermal Conductivity of Heat Storage System

2.1) Encapsulation

Encapsulation is one of the most important technique in LHTES systems experiment is performed using capsules of spherical shape total 180 capsules where used 60 each of various phase changing materials The storage system was charge with different flow rates the purpose of charging is to melt the encapsulated phase changing materials The diameter of each ball is 55mm approx leakage proof capsules are filled with 100 gm of pcm total 18 kg of pcm was used to fill the hollow steel capsules pcm having higher melting temperature is place on the upper side and pcm having lower melting

temperature are place in lower side the TES system was charged with different flow rates thus the heat storage takes place in the material as they change their phase from solid to liquid after the charging process discharging process takes place and the heat transfer fluid takes up the heat from pcm and solidifies pcm it was observed that discharging time varied from 200 min to 300 min for different flow rates of the circulated water through TES tank

2.2 Multiple PCM

Energy stored in TES unit in case of multi PCM is much greater than single PCM this is because in case of single PCM as the HTF rate is increased the melting of PCM starts and the HTF is stopped therefore the charging of the PCM is limited in case of single PCM in case of multiple PCM increase in the HTF causes the PCM to get charged at different time according to their melting temperature which allows them to store more heat as compare to the single PCM

Fig2: Comparision Of Single PCM With Multiple PCM

Efficiency of single PCM is grater than multiple PCM also reported by many researcher [19]

3. Hybrid Nano Fluids

Nano fluids has become one of the biggest research areas for the last decades as they are the most efficient heat transfer fluid recently researchers have tarried to make hybrid nano fluid by using different nano fluids together hybrid nano fluid enhance the thermal conductivity of the TES unit The main objective of preparing hybrid nano fluids is to enhance the thermal conductivity of the base fluid And also obtain the properties such as physical strength, chemical stability, mechanical resistance very high electrical and thermal conductivity of its constituent materials which cannot be obtain by single nano fluid.

Hybrid nano fluid are the combinations of two or more nano fluids is the present review the experimental review of the investigations is done and it was found that enhancement in the heat transfer coefficient was nearly 135% by the use of hybrid nano fluid in TES further result shows that mixture of AL_2O_3/CNT in base fluid water increases the convective heat transfer significantly Sunder [88] measured the convective heat transfer coefficient and friction factor of MWCNT-$Fe_2\ o_3$/water hybrid nano fluid flowing through constant heat flux circular tube there was an enhancement of 31.1% of nusselt number Shahsavar [5] investigated the concentration and temperature effect on thermal conductivity of hybrid nano fluid (Fe_3o_4-CNT/DI) Temperature volume concentration enhancement causes the increase in thermal conductivity of 34.43-44.6% with maximum concentration of CNTs (1.35%)+Fe_3o_4 (0.9%) at temperatutr range of (25-55)

Hussain [6] employed aluminium nitrate/EG hybrid nano fluid double pipe flow heat exchanger under a laminar flow condition shows a enhancement of 4% and temp. 50 asadi [7] shows the enhancement in thermal conductivity of hybrid nanao fluid (AL_2O_3/MWCNT/thermal oil) by 45% Wei [8] evaluated the the thermal property of diathermic oil by dispersing (SiC-TiO_2) nano particle the thermal conductivity of pure diathermic oil is decreased due to elevated temperature also the thermal conductivity also decreases due to single nano fluid (SiC/diathermic oil) or TiO_2/diathermic oil) also thermal conductivity and volume posses a linear relationship Madhesh and kalaiselvam [9] evaluated the thermal property of (Cu-TiO_2/water)it was found that that thermal conductivity of 0.69W/m.k was archived for concentration of 1% at 353K Hamid[10] suggested a equation to predict thermal conductivity of Tio_2-SiO_2/EG and water having fixed concentration of 1%while the nano particle was varied in a way of 20:80, 40:60, 50:50, 60:40, and 80:20 highest and lowest thermal conductivity was archived at 20:80 and 50:50 which

Shows that more the difference in the volume of nano fluid more is the thermal conductivity Yarmada [11] carried out experiment in which (Ag-graphene nano platelets /water) hybrid nano fluids where flowed through circular tube with constant heat flux result in the enhancement of in the heat conductivity

4. PCM-NANO Composite

Enhancing the thermal conductivity of PCM my adding thermally conductive nano size particle is one of the way to improve the PCM based TES system/

Tang [50] used carbon nano tubes to improve the thermal conductivity polyethylene glycol (PEG)/inorganic SiO_2 Composite PCM they added MWCNT with mass fraction 0.5, 1, 2 and 3% in composite PCM result shows that (PEG)/inorganic SiO_2 $-$ $MWCNT$ has the maximum thermal conductivity as 0.436W/m.k also PCM containing 3 wt% MWCNT increased by 53% Mehraili [62] investigated the effect of graphene nanoplatlets (GNPs) addition on the thermal conductivity of plasmatic acid (PA) thermal conductivity was increased by 8 times the pure (PA) Sheikh[12] prepared three nano composite by doping paraffin wax with SWCNT, MWCMNT, CNFS he found maximum thermal conductivity enhancement of13%, 10%, 7%for, wax/SWCNT, wax/MWCNT, wax/CNFs due maximum molecular density SWCNT has maximum latent hjeat capacity Kim and Drazal[13]used GNPs and paraffin to prepare the nano composite he found that with increase in 7% wt of GNPs the the latent heat capacity was increased by 200 % Chen[14] prepared nano composite with GNPs and paraffin's R-GNS graphite nano sheets and O-GNs oriented graphite sheets thermal conductivity of these nano composite where 20 and 7.5 times higher than that of prisintine paraffin for the wt of 5p of GNs thermal conductivity of O-GNS was more than R-GNS for same loadingWang [15] prepare the nano composite sample of paraffin wax and MWCNTs (.2, .5, 1, 2 wt%) thermal conductivity enhancement reached to 35% and 40% for solid and liquid state Ling [12] prepared PCM/EG nano composite experimental result shows that increase in the wt of EG increase the thermal conductivity but decrease the latent heat storage Zang [17] prepared shape stabilized phase changing material (paraffin/EG composite) paraffin was absorbed in EG EG acted as supporting material to stop leakage of melted paraffin there was 85% increase in th latent heat storage LI[18] prepare composite of NGS and

PCMs a nano layer of NG (1-10%wt) where dispersed in paraffin in a random orientation thermal conductivity was increased by 165% and latent heat was decreased Li et al (2014) synthesized and measured the thermal conductivity of grafted CNTs and paraffin's CNTs grafted with polyhydric alcohols it was observed that thermal conductivity CNT/paraffin's was increased graft treatment Mattawan and Assassin (2007) conducted and experimental study on thermal conductivity enhancement of paraffin wax by incorporating 0.1, 0.2, 0.3, 0.4 and 0.5% mass fraction aluminum particle their study shows 60% reduction in charging time with an aluminum mass fraction 0.5% compare to pure paraffin wax

5. Conclusion

Hybrid nano fluid is one of the biggest achievement of researcher in recent years but still more research has to be done before their industry implementation because of the synergistic effect through which they provide favourable properties all around of it constituents it has been found that improved thermal conductivity of nano fluids is one of the driving factor for the different application Selection of proper hybrid nano particle for the preparations of hybrid nano fluid is considered to be most important aspect in thermal conductivity enhancement. Most of the researchers suggested enhancement in thermal conductivity of hybrid nano fluid but some researcher found that due to impropriate selection hybrid nano fluid thermal conductivity may fall down. Thermal conductivity of hybrid nano fluid depends upon the base fluid Increase in temperature and concentration has upper limit after that thermal conductivity starts falling down Further work is needed to create a model that should take in account all the factors required for the thermal conductivity enhancement prediction Nano-Pcm composite is the biggest thermal conductivity enhancer

References

[1] Saw C.Lin, hussain H.AL-Kayiem evaluation of copper nanoparticle-paraffinwax compositions of solar thermal energy storage http://dx.doi.org/10.1016/j.solener.2016.03.004
[2] C.Amral, R.Vicente, P.A.A.P Marques, A.Barros-Timmons, phase change materials and carbon nanostructure of thermal energy storage: A literature Review http://dx.doi.org/10.1016/j.rser.2017.05.093
[3] Al-Kayiem, H.H., Alhamdo, M.H., 2012. Thermal behaviour of encap-sulated phase change material energy storage. J. Renew. Sust. Energy http://dx.doi.org/10.1063/1.3683532.
[4] Al-Kayiem, H.H., Lin, S.C., 2014. Performance evaluation of a solar water heater integrated with a PCM nano composite TES at various inclinations. http://dx.doi.org/10.1016/ j.solener.2014.08.021
[5] A.shasvar m.saghafian m.b shafli, effect of temperature and concentration on thermal conductivity and viscosity of ferrofluid loaded with carbon nano tubes heat mass tranfer52 (2016)2293-2301
[6] AM hussain thermal performance and thermal properties of hybrid nano fluid laminar flow in double pipe heat exchanger Exp.Term. fluid sci 88 (2017) 37-45
[7] A.Asadi, M.asadi heat transfer efficiency an experimental and theoretical investigations 117 (2018)474-486
[8] B.Weic.zou thermo physical property evaluation of diathermic oil based hybrid nanofluid for for heat transfer applications heat mass transfer heat and mass transfer107 (2017)281-287
[9] D.madhesh r. permeshwar exp. Analysis of hybrid nano fluid as a coolant 97 (2014)1667-1675
[10] K.A hamid, W.A azmi, M.F Nabil improved thermal conductivity Ti_{o_2}-Si_{o_2} hybrid nanofluid257 (2017)12067
[11] Shaikh S Lafdi K Carbon nanoadditives to enhance the latent energy storage of phase changing materialPhys 2008:103
[12] Kim S, Drzal LT High latent heat storage and high thermal conductive phase change materials using exfoliated graphite nanoplatlets solar energy matter solar cells 2009;93:136-42
[13] Chen Y Thermal characterization of graphite nanosheet reinforced paraffin phase change composite appl sci manuf 2013;44:40-6
[14] Wang jtermal properties of paraffin based composites containing multi walled carbon nanotubes2009;488:39-42
[15] Ling Z Chen j Xu t Fang X Zang Z thermal conductivity of an organic temperature range and novel thermal conductivity model 2015;102;202-8
[16] Zang Z study on paraffin expanded graphite composite phase change thermal energy storage materials energy conserve Manag 2006;47;303-10
[17] Li A nano graphite phase change material with high thermal conductivity Appl energy 2-013;106:25-30
[18] T.K. Aldoss, M.M. Rahman, Comparison between the single-PCM and multi-PCM thermal energy storage design, Energy Convers. Manag. 83 (2014) 79–87, http:// dx.doi.org/10.1016/j.enconman.2014.03.047.