THERMAL ENERGY STORAGE SYSTEM USING PCM CAPSULES WITH ALUMINIUM OXIDE

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Our aim is to increase the thermal conductivity of organic phase change material paraffin wax by adding additives .The thermal conductivity of paraffin wax can be enhanced by employing high conductivity materials such as alumina (Al2O3).An analysis has been carried out to study the performance and enhancement of paraffin wax with alumina (Al2O3) particles in capsules. Phase change materials (PCMs) with their phenomenal phase changing behaviour hold a key for many developments in renewable energy and engineering systems for sustainable future. PCM which can store and release heat energy over a temperature range has become an eminent candidate for many engineering applications that includes thermal, civil, electronics and textile.

Keywords*:* Paraffin wax, Alumina, Thermal conductivity ,latent heat, capsules

INTRODUCTION:

Scientists all over the world are in search of new and renewable energy sources to reduce the CO2 emissions from the combustion of fossil fuels, particularly in areas where low temperature applications are involved. Energy storage plays important roles in conserving available energy and improving its utilization, since many energy sources are intermittent in nature. Short term storage of only a few hours is essential in most applications; however, long term storage of a few days may be required in some applications. Solar energy is available only during the day, and hence, its application requires efficient thermal energy storage so that the excess heat collected during sunshine hours may be stored for later use during the night. Similar problems arise in heat recovery systems where the waste heat availability and utilization periods are different, requiring some thermal energy storage. Also, electrical energy consumption varies significantly during the day and night, especially in extremely cold and hot climate countries where the major part of the variation is due to domestic space heating and air conditioning. Such variation leads to an off peak period, usually after midnight until early morning. Accordingly, power stations have to be designed for capacities sufficient to meet the peak load. Otherwise, very efficient power distribution would be required. Better power generation management can be achieved if some of the peak load could be shifted to the off peak load period, which can be achieved by thermal storage of 2 heat or coolness. Hence, the successful application of load shifting and solar energy depends to a large extent on the method of energy storage used.

METHODS OF THERMAL ENERGY STORAGE:

Thermal energy can be stored as a change in internal energy of a material as sensible heat, latent heat, and thermo-chemical heat, or combination of these.

SENSIBLE HEAT STORAGE (SHS):

In Sensible Heat Storage (SHS), thermal energy is stored by raising the temperature of a solid or liquid. SHS systems utilize the heat capacity and the change in temperature of the material during the process of charging and discharging. The amount of stored heat depends on the specific heat of the medium, the temperature change, and the amount of storage material.

$$Q = \int_{Ti}^{Tf} mC_p dT = mC_p(T_f - T_i)$$

Where, m : mass

C p : The specific heat at constant pressure.

T i and T f : The lower and upper temperature levels between which the storage operates.

One major drawback of sensible heat storage is the large volume required, especially when the allowable temperature swing is small.

THERMO-CHEMICAL STORAGE:

Thermo-chemical systems rely on the energy absorbed and released in breaking and reforming molecular bonds in a completely reversible chemical reaction. In this case, the stored heat depends on the amount of storage material, the endothermic heat of reaction, and the extent of conversion.

$$Q=a_r \Delta m h_r$$

LATENT HEAT STORAGE:

Latent Heat Storage (LHS) is based on the heat absorption or release when a storage material undergoes a phase change from solid to liquid or liquid to gas or vice–versa. The storage capacity of the LHS system with a PCM medium is given by,

$$Q = m\ cp\ (Tm - Ti) + m\ L + m\ cp\ (Tf - Tm).$$

Amongst thermal heat storage techniques, latent heat thermal energy storage is particularly attractive due to its ability to provide high energy storage density typically 5 to 10 times higher can be reached and its characteristics to store heat at constant temperature corresponding to the phase transition temperature of the PCM. However, many practical problems are encountered with latent heat storage due to low thermal conductivity, variation in thermo physical properties under extended cycles, these problems have to be technically resolved before latent heat storage can be widely used.

OBJECTIVES:

In this project we aim to study means of improving the development of the constituent PCM, their encapsulation and use in a number of important applications in both the domestic and industrial sectors.

EXPERIMENTAL SETUP:

Our experiment consist of a heater, 5 thermocouples, 3 tanks, PCM capsules are kept in a tank by encapsulation method, a data logger which are interconnected each other as on experimental setup based on our knowledge and the detais from the reference paper we have studied. Which are shown in Fig 2.

FIG 1: PCM CAPSULES

FIG 2 : EXPERIMENTAL SETUP

RESULTS:

DURING CHARGING OF PARAFFIN:

Mass flow rate = 0.01 kg/sec

S.NO	TIME TAKEN IN(MIN)	TEMPERATURE T1°C	TEMPERATURE T2°C	TEMPERATURE T3°C	TEMPERATURE T4°C	TEMPERATURE T5°C
1	10	51	49	35	35	33
2	20	58	56	36	35	36
3	30	68	67	38	38	40
4	40	71	69	42	40	41
5	50	76	74	46	45	44

DESCRITION	10 MIN	20 MIN	30 MIN	40 MIN	50 MIN
HEAT ABSORBED BY PARAFFIN (KJ)	218.91	232.19	248.5	250	252.23
HEAT ABSORBED BY HOT WATER (KW)	0.0836	0.0836	0.0836	0.0836	0.0836

Mass flow rate = 0.03 kg/sec

S.NO	TIME TAKEN IN(MIN)	TEMPERATURE T1°C	TEMPERATURE T2°C	TEMPERATURE T3°C	TEMPERATURE T4°C	TEMPERATURE T5°C
1	10	55	53	33	33	34
2	20	58	56	34	34	36
3	30	68	66	39	38	39
4	40	71	68	41	41	43
5	50	75	74	46	47	52

DESCRITION	10 MIN	20 MIN	30 MIN	40 MIN	50 MIN
HEAT ABSORBED BY PARAFFIN (KJ)	227.53	232.19	248.59	250.49	252.59
HEAT ABSORBED BY HOT WATER (KW)	0.250	0.250	0.250	0.250	0.250

Mass flow rate = 0.06 kg/sec

S.NO	TIME TAKEN IN(MIN)	TEMPERATURE T1°C	TEMPERATURE T2°C	TEMPERATURE T3°C	TEMPERATURE T4°C	TEMPERATURE T5°C
1	10	54	51	33	34	35
2	20	59	58	35	36	37
3	30	68	66	39	39	40
4	40	70	71	43	42	43
5	50	76	74	46	47	51

DESCRITION	10 MIN	20 MIN	30 MIN	40 MIN	50 MIN
HEAT ABSORBED BY PARAFFIN (KJ)	226.61	233.59	244.5	245.63	246.49
HEAT ABSORBED BY HOT WATER(KW)	0.5016	0.5016	0.5016	0.5016	0.5016

DURING DISCHARGING OF PARAFFIN:

Mass flow rate = 0.01kg/sec

S.NO	TIME TAKEN IN(MIN)	TEMPERATURE T1°C	TEMPERATURE T2°C	TEMPERATURE T3°C	TEMPERATURE T4°C	TEMPERATURE T5°C
1	10	30	34	48	53	54
2	20	30	38	46	50	50
3	30	30	36	47	49	49
4	40	30	35	44	47	47
5	50	30	35	43	46	46

DESCRITION	10 MIN	20 MIN	30 MIN	40 MIN	50 MIN
HEAT ABSORBED BY PARAFFIN (KJ)	156.4	154.4	153.1	153.0	152.7
HEAT ABSORBED HOT WATER(KW)	0.1672	0.3344	0.256	0.209	0.208

Mass flow rate = 0.03 kg/sec

S.NO	TIME TAKEN IN(MIN)	TEMPERATURE T1°C	TEMPERATURE T2°C	TEMPERATURE T3°C	TEMPERATURE T4°C	TEMPERATURE T5°C
1	10	30	40	45	49	50
2	20	30	39	42	45	47
3	30	30	38	42	44	46
4	40	30	37	42	43	44
5	50	30	35	40	41	42

DESCRITION	10 MIN	20 MIN	30 MIN	40 MIN	50 MIN
HEAT ABSORBED BY PARAFFIN (KJ)	158.4	156.4	154.1	153.0	152.7
HEAT ABSORBED HOT WATER(KW)	1.254	1.128	1.003	0.874	0.752

Mass flow rate = 0.06 kg/sec

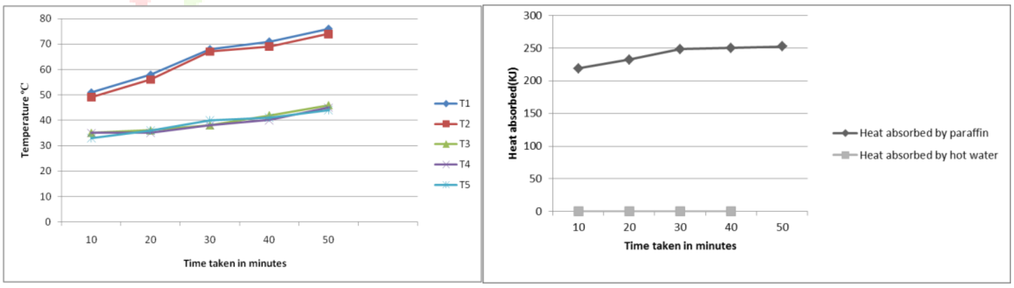
S.NO	TIME TAKEN IN(MIN)	TEMPERATURE T1°C	TEMPERATURE T2°C	TEMPERATURE T3°C	TEMPERATURE T4°C	TEMPERATURE T5°C
1	10	30	40	45	49	50
2	20	30	39	42	45	47
3	30	30	38	42	44	46
4	40	30	37	42	43	44
5	50	30	35	40	41	42

DESCRITION	10 MIN	20 MIN	30 MIN	40 MIN	50 MIN
HEAT ABSORBED BY PARAFFIN (KJ)	161.1	158.3	156.3	155.4	153.4
HEAT ABSORBED HOT WATER(KW)	3.009	2.257	1.755	1.254	1.254

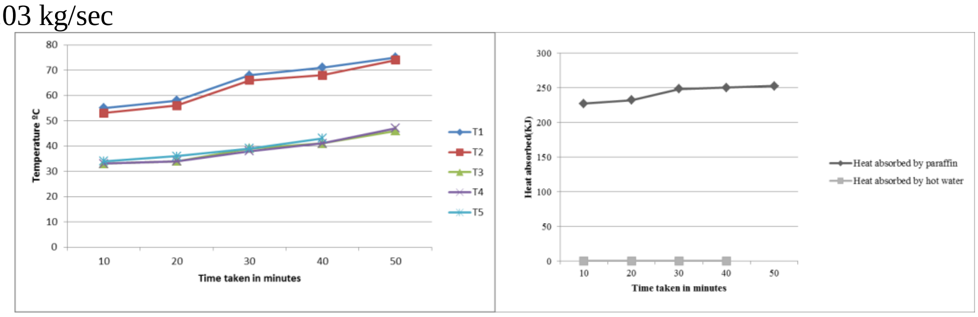
GRAPH:

DURING CHARGING OF PARAFFIN:

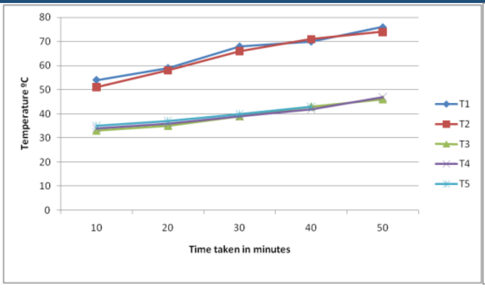
Mass flow rate= 0.01 kg/sec

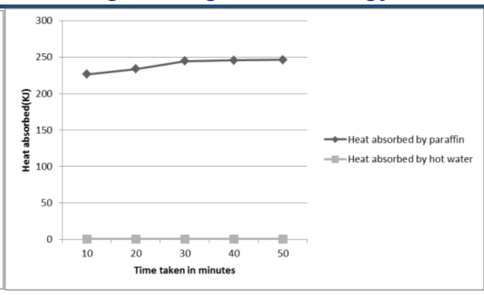


Mass flow rate= 0.03 kg/sec



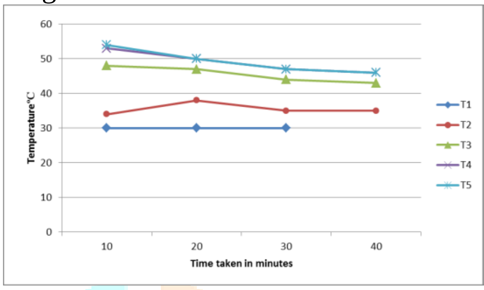
Mass flow rate =0.06 kg/sec

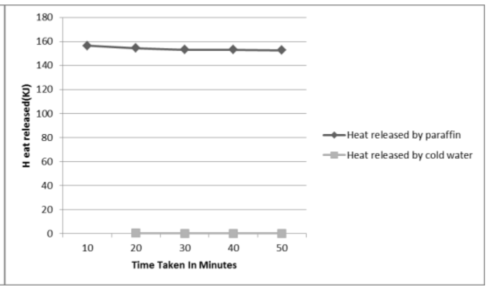




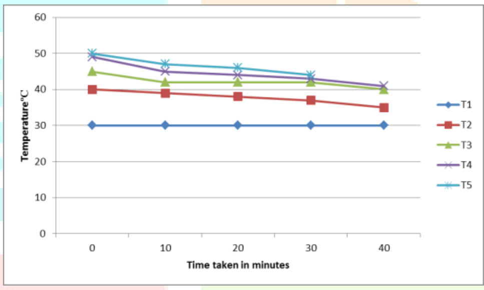
DURING DISCHARGING OF PARAFFIN:

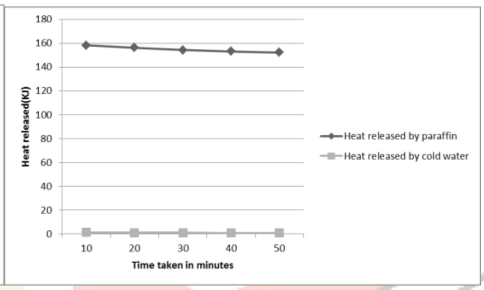
Mass flow rate= 0.01 kg/sec



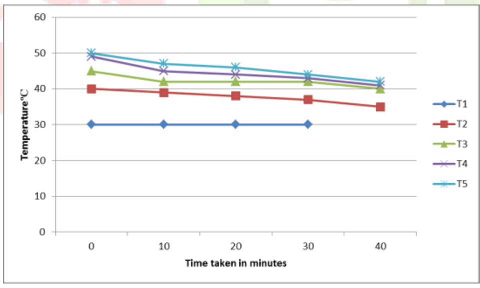


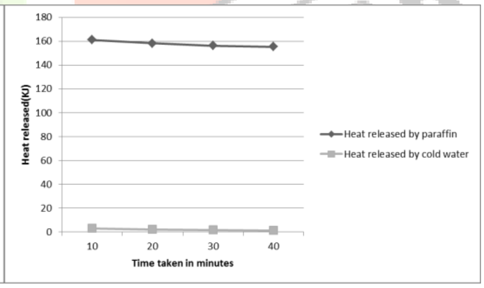
Mass flow rate = 0.03 kg/sec





Mass flow rate= 0.06 kg/sec





CONCLUSION:

In this project the thermal behavior of phase change material was improved by including Al2O3 nano particle with paraffin phase change material. An experimental setup was designed and fabricated to carry out the behavior of PCM. The improvement in the thermal property (thermal conductivity) is necessary to reduce the loading and unloading time of the PCM and also to have uniform melting of PCM, this is possible only if the thermal conductivity is more. Therefore it is mandatory to increase thermal conductivity of PCM. Initially the thermal conductivity of paraffin was 0.17W/mk supplied by purchaser and this also verified by us using transient hot wire method. After mixing the Al2O3 nanomaterial with the paraffin PCM, the thermal conductivity has increased to 0.3 W/mk (as per transient hot wire method) and 0.28W/mk (as per Maxwell Garnett equation). Thus there is an improvement in the thermal conductivity of PCM. The loading and unloading times of paraffin PCM were 5.4 hrs and 3.5 hrs for thermal energy storage of 313kJ. The results were phenomenal after adding Al2O3 nanoparticles, the loading and unloading time were 5 hrs and 3.2 hrs respectively for thermal energy storage 313kJ.further the thermal properties of the PCM can also be studied for various volume concentration and the optimum proportion can be determined.

REFERENCE:

1) Abhat, Low temperature latent heat thermal energy storage: heat storage materials, Solar Energy 30 (1983) 313–332.

2) Review on thermal energy storage with phase change: materials, heat transfer analysis and applications Bel_enZalba ,1, Jos_e Ma Mar_ın , Luisa F. Cabeza ,*, HaraldMehling
3) International Journal of Heat and Mass Transfer 48 (2005) 2561– 570 Improvement of a thermal energy storage using plates with paraffin–graphite composite Jose´ M. Marı´n ,*, Bele´nZalba , Luisa F. Cabeza , HaraldMehling
4) International Journal of Refrigeration 27 (2004) 839–849Free-cooling of buildings with phase change materials Bele´nZalbaa, Jose´ M. Marı´na, Luisa F. Cabezab, Harald Mehlingc,2
5) Applied Thermal Engineering 25 (2005) 1796–1807An approach to the simulation of PCMs in building applications using TRNSYS Manuel Iba´n˜ez ,Ana La´zaro ,Bele´nZalba ,Luisa F. Cabeza ,
6) Experimental study on thermal conductivity of lubricant containing nanoparticles Received: March 29, 2008
7) Experimental study on thermal properties ofBrines containing nanoparticles .Ching-Song Jwo1 and Tun-Ping Teng2
8) Experimental Determination of Thermal Conductivity of Fluid Containing OxideNanoparticles .L. SyamSundar and K.V. Sharma
9) The role of interfacial layers in the enhanced thermal conductivity of nanofluids: a renovated maxwell model w. Yu and s.u.s. Choi∗ energy technology division, argonne national laboratory, argonne, il 60439, usa;
10) Study of a PCM based energy storage system containing Ag nanoparticles j. L. Zeng, l. X. Sun, f. Xu1, z. C. Tan, z. H. Zhang, j. Zhang and t. Zhang.
11) An evaluation of PCM storage installed in air distribution systems Thermal characteristics of a storage tank with organic hydrate (PCM-13) and a simulation model.Motoi Yamaha, Shinya Misaki Dept. of Architecture, Chubu University, 1200 Matsumoto-cho, Kasugai, Aichi, Japan