COMPARATIVE STUDIES AND PERFORMANE ANALYSIS OF PHASE CHANGE MATERIALS AS MYRISTIC ACID & METHYL STEARATE BY USING THERMAL ENERGY STORAGE

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ABSRACT: *Solar energy is bountifully available in nature which can be utilized for household and industrial purposes however the harnessing of power is lot of less because of its sporadic nature. The thermal energy storage (TES) system utilized both sensible and latent heat has frequent favorable circumstances like high heat storage practicable in a unit extent and its isothermal conduct during the charging and discharging processes. Due to these advantages, in modern days years, lot of research work has been going on to conquer troubles like low heat transfer charges between heat transfer fluid and Phase Change material (PCM) in each charging and discharging techniques of the PCM-based TES system. In the existing experimental investigation consequences of a blended sensible and internal heat TES system with a varying (solar) heat furnish is supplied. Investigations are achieved inside the TES system for two exclusive phase change substances (myristc acid and methyl stearate) by different HTF flow rate (3,6 and 9 lit/min) by inserting the melted PCM in Mild Steel spherical capsules with diameter of 72mm. Experiments are carried out in each charging and discharging strategies (Batch wise and Continuous). The results exhibit that the myristic acid PCM attains higher temperature compared to methyl stearate in consider less time the distinction in charging rate is 16-19% foremost for myristic acid. The amount of energy released as boiling water is higher for myristic acid compared to methyl stearate and also in monetary factor of view the expense of myristic acid is lesser than methyl stearate in Indian market so the myristic acid PCM acts as optimal choice for Thermal Energy Storage system.*

Key words: Phase change Material (PCM); Heat Transfer Fluid (HTF); Lauric acid; Palmitic acid; Thermal energy storage (TES)

1.INTERDUCTION

In present day years, consideration has quickened to wane the expense of solar energy equipment and advance the availability of heat strength storage. To collect the warmth energy, basically two kinds of storage systems are developed. One is a sensible heat storage device and other is a latent heat storage system. To save a huge extent heat in a conservation unit volume, integrated sensible and latent heat storage systems developed. These systems have various advantages like giant warmness storage capacity in a unit degree and their isothermal conduct in the course of the charging and discharging processes. These systems are no longer in commercialized use like sensible heat storage (SHS) systems for the purpose of the inferior warmth transfer rate all through the charging and discharging methodologies and incredible preliminary cost. Some of the salient contributions in this route are considered in the development.

2 .OBJE CTIVE OF STUDY

A TES system is proposed and determined for its warm exhibition perception in that the system has able to supply hot water at a normal temperature of 45°± 1C for household use in general. The warm presentation of the system is inspected by utilized Myristic Acid and Palmitic Acid as a PCMs. Together charging and discharging experimentation are completed out for calculated the performance of the system by incorporating with variable inlet heat source.

In this process the consequence of subsequent variables is studied,

- Phase change materials
  a) Myristic acid
  b) Methyl stearate
- Mass flow rates of Heat Transfer fluid (HTF) :
  a) 3 lit/min
  b) 6 lit/min
  c) 9 lit/min

Above variables are studied in two diverse stages

1 . Charging process
2. Discharging process
   a) batch wise discharging process
   b) continuous discharging process

3. PROPERTIES OF PCM

PCM plays a prevailing position in the TES system. The determined of PCM is depend upon different parameters like latent warmness, melting factor, working temperature conditions, availability, cost and pressure so on. After consideration over these variables Lauric acid & Palmitic acid are chosen for present work. The capacity of PCM is to Absorb the heat energy from the heat source. After gaining the sufficient heat energy it changes its phase from solid to Liquid and again converts to solid phase after releasing the energy.

Property		value	Units
Melting point		55	°C
Latent Heat of Fusion		199	kJ/kg
Boiling point		326.2	°C
Flashing point		>110	°C
Density	solid	990	Kg/m^3
	liquid	861	
Specific heat capacity	solid	1700	J/kg K
	liquid	2400	
Thermal conductivity		0.171	W/m K

Table 3.1 properties of myristc acid

Property		Value	Units
Melting point		39	°C
Latent Heat of Fusion		189	kJ/kg
Boiling point		443	°C
Flash point		<110	°C
Density	Solid	849.2	Kg/m^3
	Liquid	836.02	
Specific Heat Capacity	Solid	1600	J/kg °C
	Liquid	2100	
Thermal Conductivity		0.165	W/m K

Table 3.2 Properties of methyl stearate

4. EXPERIMENTAL INVESTIGATION

4.1 EXPERIMENTAL SETUP :

ATES system is proposed and determined for its thermal overall performance or large execution in this the system has capable to supply warm water at a standard temperature of 45°±1C for household use in general. The thermal overall performance of the system is inspected by the usage of Myristic Acid and Methyl atearate as a PCMs. Together charging and discharging experimentation are done out for estimating the overall performance of the system. Through consolidating with variable inlet heat source. The experimental set up is created with a storage tank as the capability of 52 liters. This storage system is possibly to give around 200 liters of water at 45 °C±1temperature.

Figure 2illustrate the schematic diagram of investigation setup and Figure 3 show the investigation arrangement utilized in the study of thermal performance of TES system with the guide of capability of latent heat and sensible warmth of the PCMs (myristic Acid & methyl stearate). Investigation is done by via consolidating this storage device with variable warmth source (solar flat plate collector).

the above essential the TES tank specifications consists of 380 mm diameter and 500 mm height stainless metal TES tank which has a capacity of 52 liters of water storage is used. Shower plate is situated over the PCM circles to sprinkle the water consistently on the sphere. A spherical sphere of 72 mm outer diameter and 68mm inner diameter of 80 balls are positioned inside in the tank, the spherical capsules is placed in the storage tank in 5 layers each layer is separated by wire mesh. The storage tank is protected with glass fleece of 50 mm expensive to keep away from loss of heat. Anal round Aluminum cladding is furnished on apex of the fleece padding. For the precept of enrolling the temperature of heat transfer fluid (HTF) and phase change material (PCM) thermocouples (pt. 100) are positioned all along the pivot of tank. For this reason, 5 (dissimilar units of) temperature detectors contained with an accuracy of ±0.1°are situated at x/L=0.2,0.4,0.6,0.8,1.0 (L is length of the TES tank in mm; x is the axial distance from the top of the TES tank in mm; x/L is the dimension less axial distance from the pinnacle of TES tank) for identifying the temperature of heat transfer fluid.

Thermocouples are additionally positioned two inside the spherical capsules for deciding the temperature of the phase
Thermocouples are additionally positioned two inside the spherical capsules for deciding the temperature of the phase
change material. Before that solid PCM is to be melted and should be poured in to the spherical capsules. Figure 4 indicates the spherical capsules filled with PCM. And also, the thermocouples are connected to the wire mesh to indicate the water temperature interior the storage tank. Before that the Solid PCM must be melted and to be poured into the spherical capsules. Thermocouples are additionally positioned for measuring the inlet and outlet temperature of HTF. (The set up is sited in G. PULLAREDDY ENGINEERING COLLEGE, KURNOOL, LATITUDE 15°7 AND LONGITUDE 78°05, ANDHRAPRADESH, INDIA).

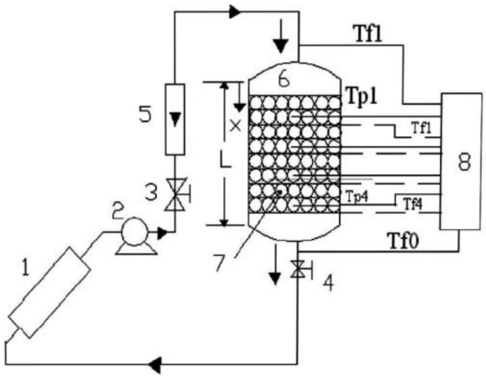
Assuming that 33% of heat ability is stored as sensible warmness (by using HTF) and 67% as latent warmth via PCM, the amount of PCM is imagined as 9.5kgs for filling the spherical capsules. The information of encapsulated spherical capsule is:

- 72 mm diameter spherical capsule made of mild steel is used for the filling of PCM.

The amount of HTF streaming inside the device is noted with the aid of a flow meter of a precision of 0.5 lph is incorporated in the device. Mass flow charges of HTF at 3, 6 and 9 lit/min are used in the experimentation performed. The flow rate is managed by using the control valves coordinated inside the flow line at inlet. A single stage regenerative centrifugal pump is engaged to circulate the HTF through the storage tank.

Fig : 4.1 (a) myristic acid

Fig : 4.2 (b) methyl stearate



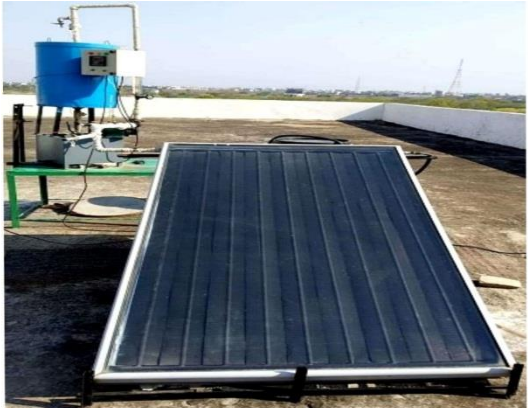


Fig 4.3 : schematic outliline Experimental set up

Fig 4.4 : photographic view of experimental setup

Fig 4.5 : Spherical capsules filled with the liquid PCM

Fig 4.6 : Photographic view of arrangement of PCM capsules

5.1 RESULT & DISCUSSIONS

The efficient heat storage of Thermal Energy Storage (TES) tank is concentrated through making utilized the Lauric acid and palmitic acid as Phase Change Materials (PCMs). Spherical capsules are utilized for storing the PCM with Mild steel as encapsulation material. Determination of best material for encapsulation of PCMs is depends upon the expense, toughness, simplicity of managing.

The Temperature dissemination of heat transfer fluid (HTF, water which acts as sensible heat storage material) and PCM at various levels of the TES tank for assorted mass flow rates and HTF inlet temperatures is reported during storage and recovery of energy from the TES tank. The historical backdrop of temperature of PCM during the process of charging and discharging are coordinated in the current investigation.

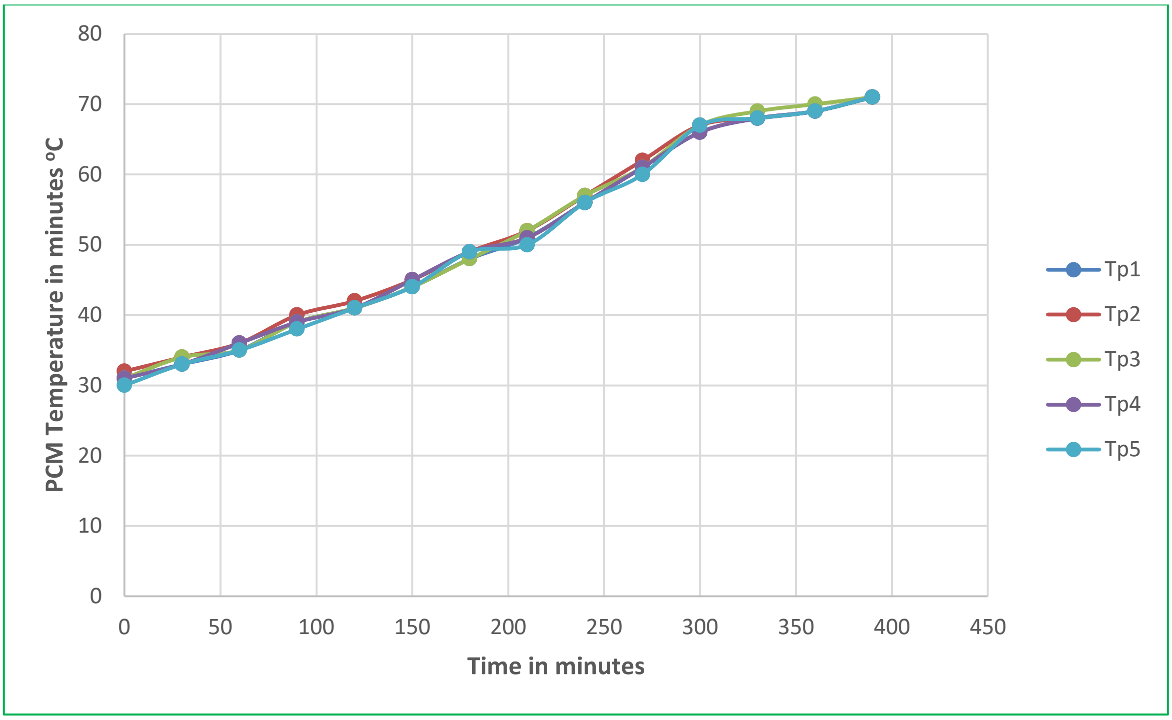


Fig 5.1 : Charging process of Myristic acid at 3 lit/min

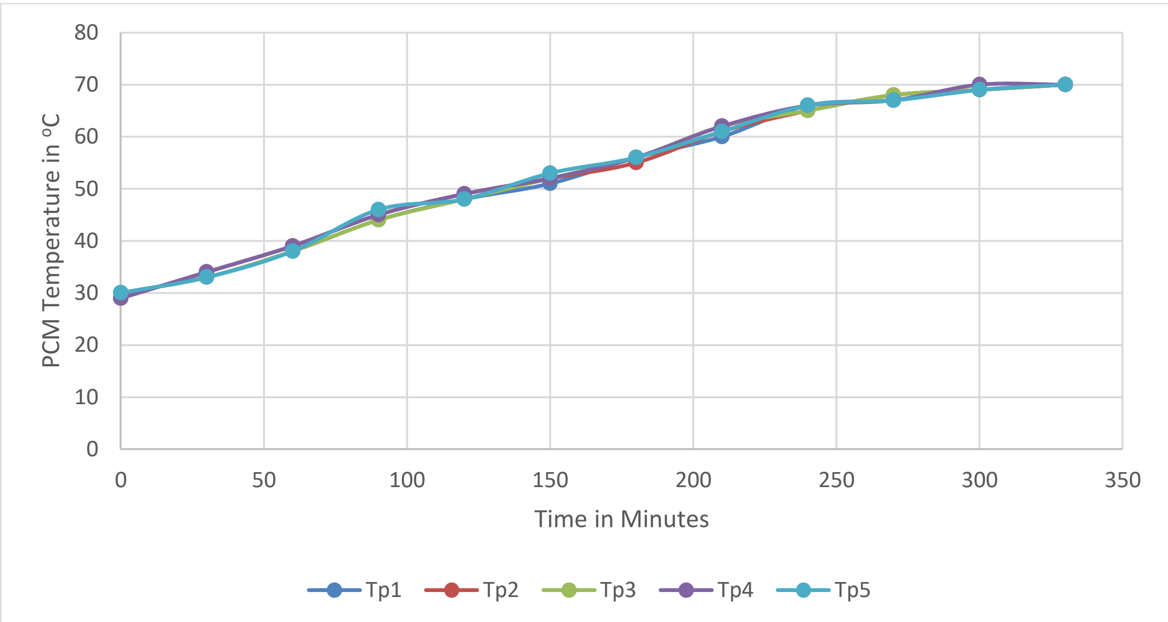


Fig 5.2 : Charging process of Methyl stearate at 3 lit/min

From the above graphs (5.1 &5.2) the top layers of PCM capsules will charge quicker than the beneath layers on the grounds that the hot water shower first and foremost contact with the top most layers and also the charging of Myristic acid takes as 390 minutes whereas the charging of Methyl stearate takes as 330 minutes. This is because of the issue that melting factor, Latent heat of Fusion and thermal conductivity of Myristic acid is high and additionally the time took for charging of both PCMs is higher due the low flow rate of 3 lit/ min due to the low flow rate the heat transfers from the HTF to PCM is low.

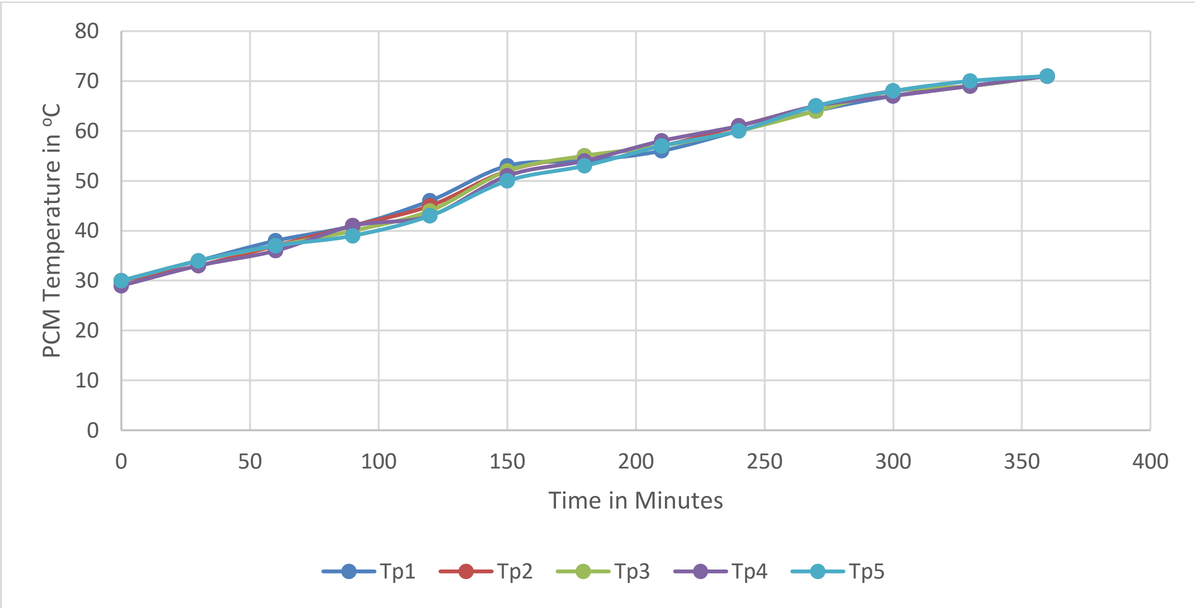


Fig 5.3 : Charging process of Myristic acid at 6 lit/min

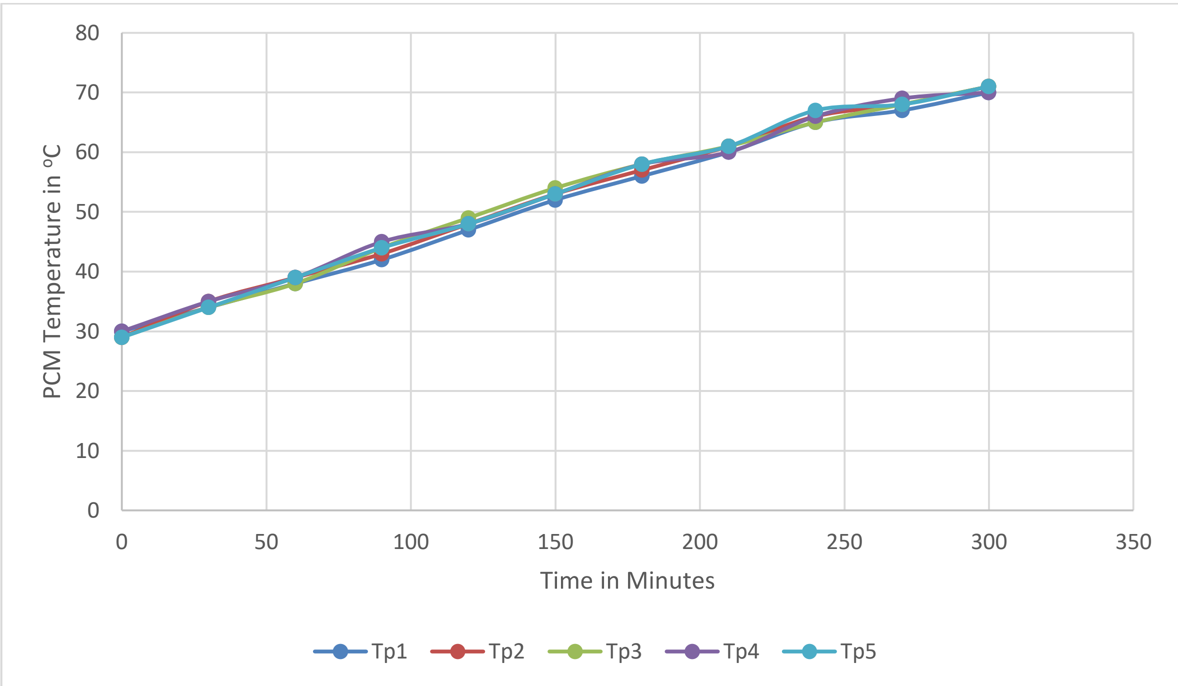


Fig 5.4 : Charging process of Methyl stearate at 6 lit/min

From the above graphs (5.3 &5.4) for charging of Myristic acid took 360 minutes while for charging of Methyl stearate it took 300 min that is practically half-hour variant exists between the charging time of both PCMs this is because to the variables that Latent heat of Fusion of Myristic Acid is superior to the Methyl stearate so Myristic acid takes additional energy to manage the phase. And also, the time variant took for charging of PCMs is significantly more. This is because of the way that flow charge is stepped forward from 3lit/ min to 6 lit /min due to the advanced flow charge the heat transfer from the HTF to PCM is more desirable.

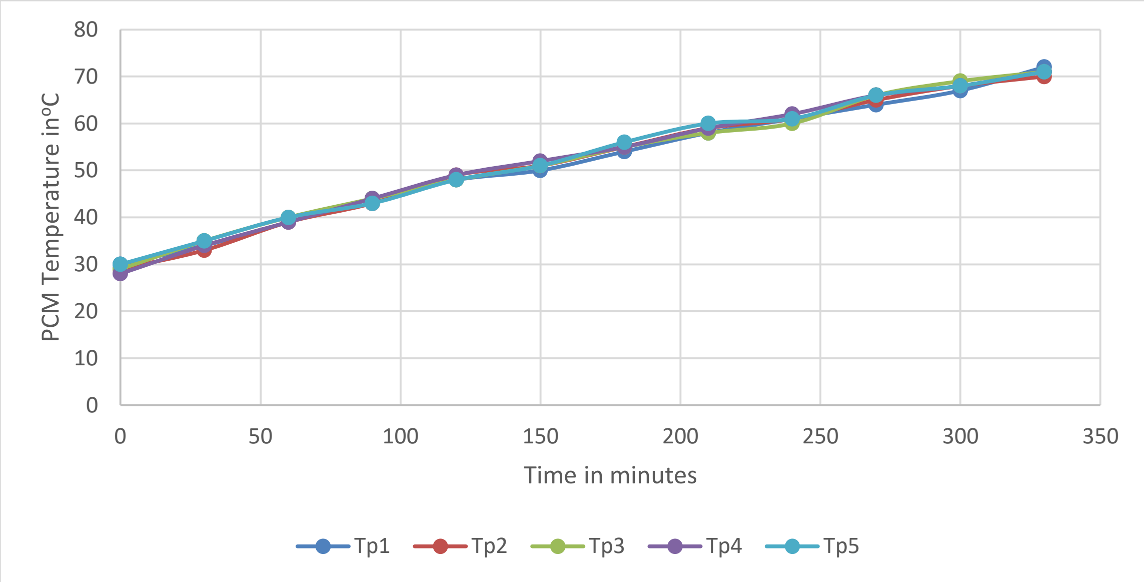


Fig 5.5 : Charging process of Myristic acid at 9 lit/min

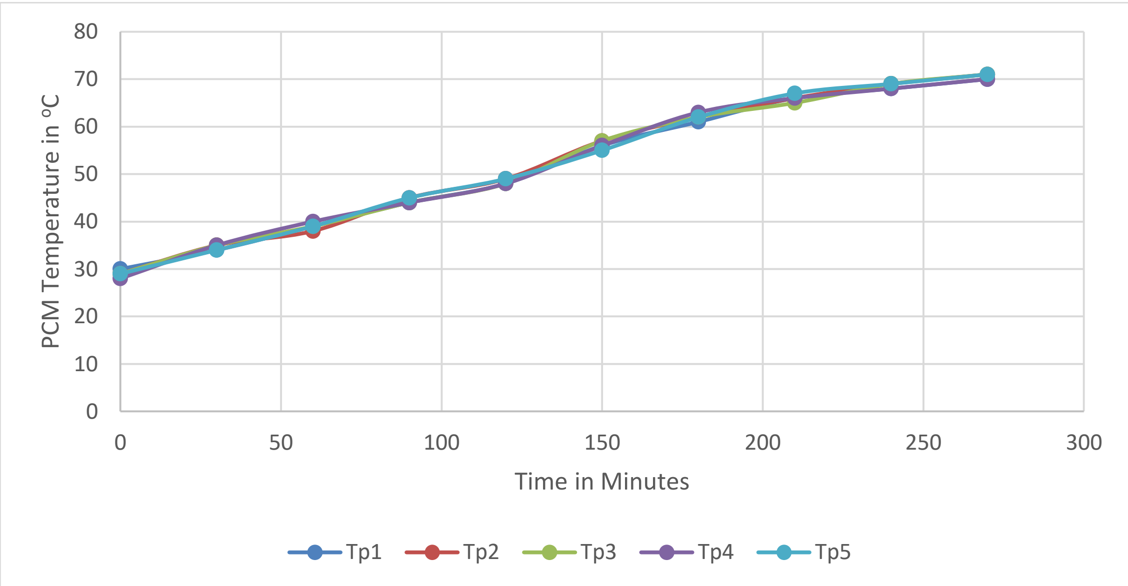


Fig 5.6 : Charging process of Methyl stearate at 9 lit/min

From the above graphs (5.5&5.6) for charging of Myristic acid took 330 minutes whereas for charging of Methyl stearate it nearly 270 minutes that is almost the hour (60) qualification exists between the charging time of both PCMs that is because of the fact that Latent heat of Fusion of Myristic Acid is superior than the Methyl stearate so Myristic acid takes greater energy to modify the phase. while in comparison with the 3, 6 lit/min the time took for charging of PCM is 16-21% much less for flow rate of 9lit/min. this is because of the reality the water temperature inside the storage tank increases consistently in accordance with inlet temperature of HTF provided from the solar collector and the PCM temperature additionally will increase steadily along with HTF temperature. Therefore, for the charging process the flow rate of 9 lit /min is high-quality for fast charging of PCMs.

Effect of Charging time :

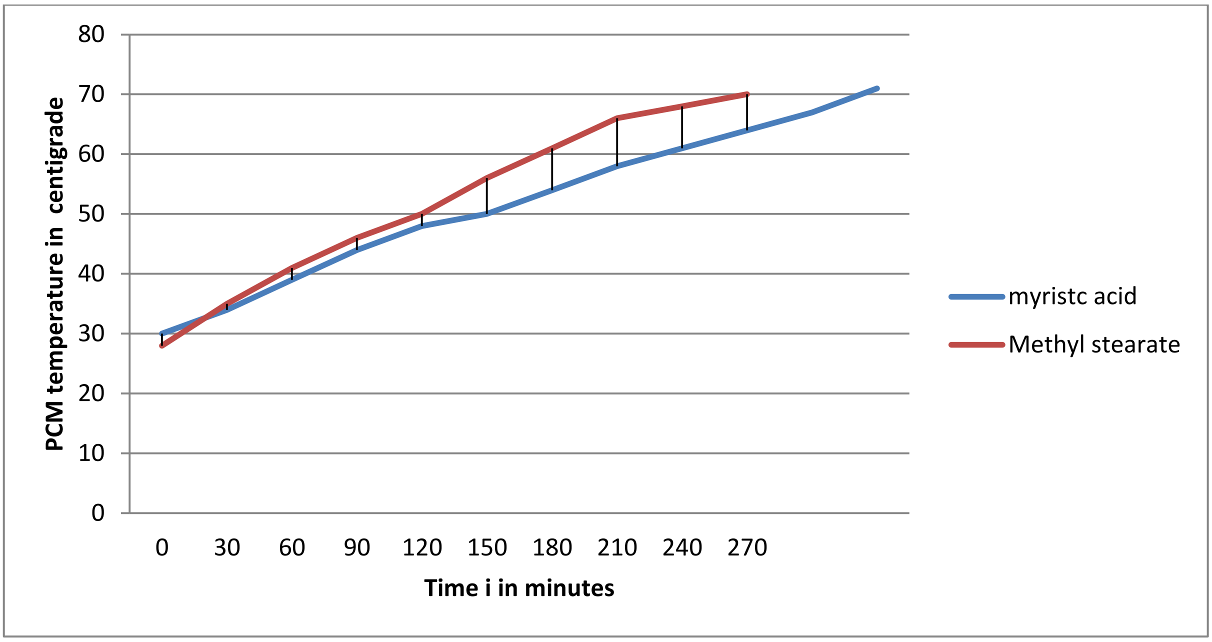


Fig 5.7 : Effect of Charging on PCM's at 9 lit/min

The above graphs recommend the heating curves for Myristic Acid and Methyl stearate. The charging time of Myristic Acid is 16- 21% more compared to that of Methyl stearate. This is because of latent heat, thermal conductivity and specific heat of Myristic Acid being more compared to Methyl stearate. Because of higher latent heat of Myristic acid, the energy took for the phase change is higher so that time took for complete the charging process is more compared to the Myristic acid from the above graph it is experiential that phase change temperature, and alter of phase are accomplished in advance by Methyl stearate.

Effect of PCM during Discharging :

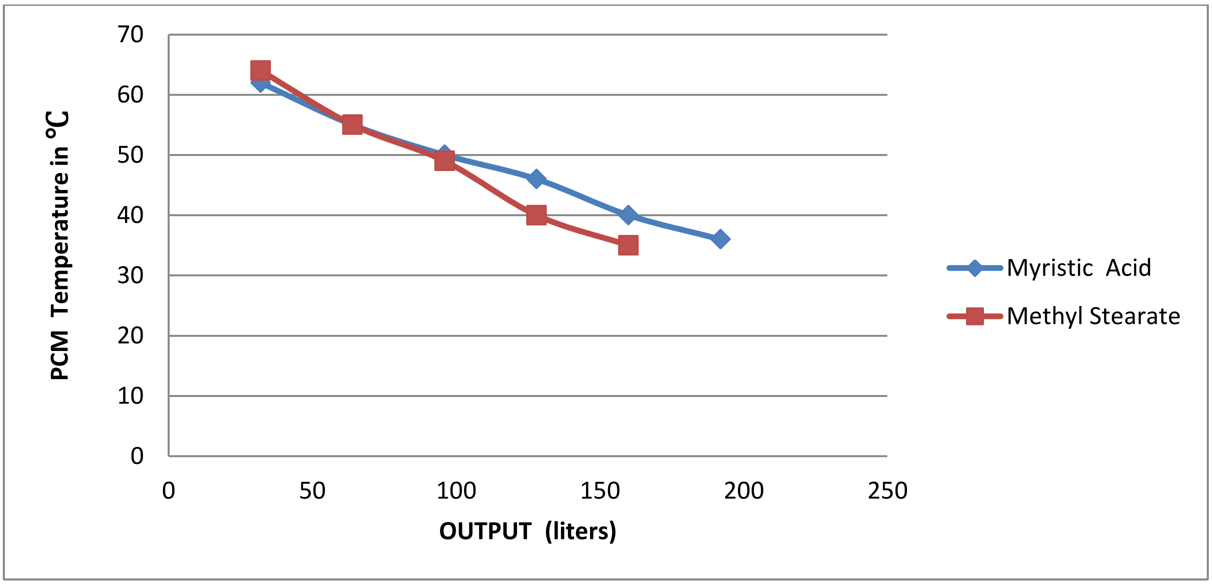


Fig 5.8 : : Batch wise discharging process of Myristic acid & Methyl stearate at 3 lit/min

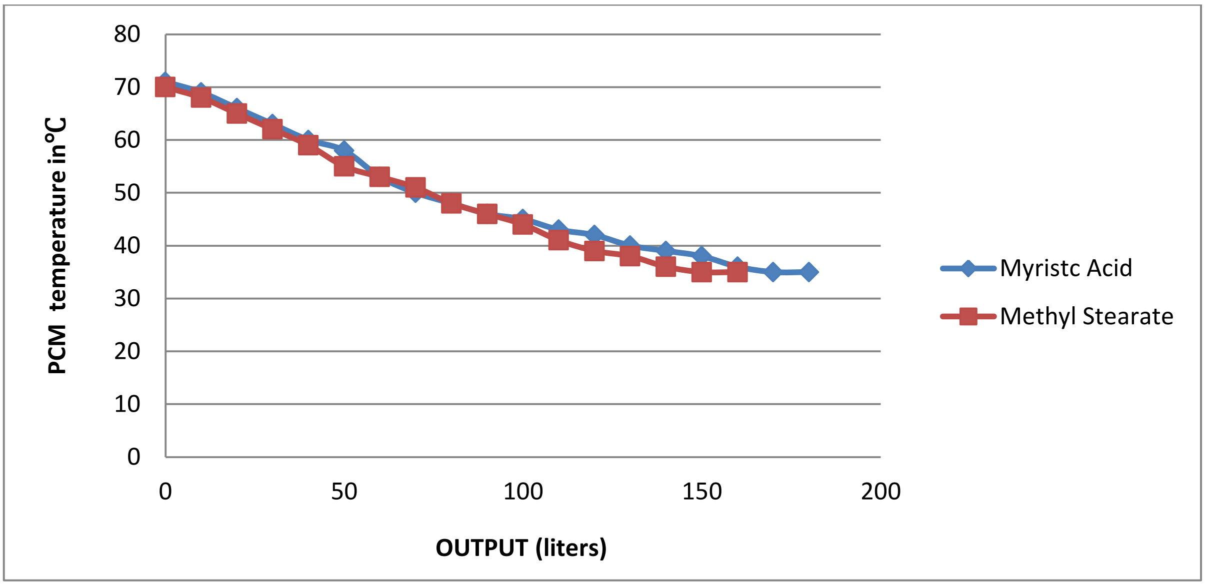


Fig 5.9 : Continuous discharging of Myristic acid & Methyl stearate at 3 lit/min

The above graphs specify the assessment of Batch sensible & continuous discharge of Myristic Acid and Methyl Stearate. From the consequences the volume of hot water received via batch wise discharge is 192 liters for Myristic Acid and for Methyl stearate is 160 liters. The extent of hot water is attained for myristic acid is 20% grander than Myristic acid and for continuous discharge the volume of warm water is got as for Myristic acid PCM is 180 liters and for Myristic acid it is received as 150 liters. The extent of warm water is got for Myristic acid is 10% grander than Methyl stearate. This is due to the fact that the latent heat of fusion, specific heat capacity of Myristic acid is foremost than the Methyl stearate so that for varying of phase of material it want superior energy which in turn stores more energy in the Myristic acid PCM due to that at some stage in the discharge the grander volume of hot water is obtained for each batch wise and continuous discharge of Myristic acid as in contrast to Methyl stearate PCM.

6. CONCLUSIONS

A thermal energy storage system using the conception of combined sensible and latent heat is developed for the supply of hot water at a usual temperature of 45°C±1 for a variety of applications. Mass flow rate has significant effect on charging time. It is seen from the figure that the charging time is decreased by 15-21% when the mass flow rate is increased from 3 to 9 Lit/min.

The extent of water discharged in case of Myristic acid PCM for batch wise discharge is 20% superior and for continuous discharge is 12.5% superior to Methyl stearate. This is because of latent heat, thermal conductivity and specific heat quantities of Myristic acid PCM is higher than Methyl stearate PCM. And also the cost of Myristic acid is 80 per kg and Methyl stearate is 110 per kg in the Indian market. In economical point of view Myristic acid gives the slightly higher output at less cost. Hence, Myristic acid is the finest substitute for TES system.

7. SCOPE OF FUTURE WORK

Experimentation may be designed to attain enhanced performance of TES tank by the following:

- ❖ In place of Flat plate collector, a parabolic dish collector may be considered for supplying HTF at higher In place of Flat plate collector, a parabolic dish collector may be considered for supplying HTF at higher.
- ❖ In place of single PCM used in spherical capsules, eutectic blend of dissimilar PCMs may be employed

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