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SolarWater Heater withPCM

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ABSTRACT

The one of the most important part of a solar collector system is the solar tank. The solar collectors work daytime only, and its power depends on the weather. The hot water consumption in family houses is generally bigger in the evening and in the morning, so it is necessary to store the utilized energy. The collectors transform but not store the solar energy. The storage is necessary to accomplish in a heat-insulated tank, placed in tempered space. According the current architectural tendencies the boiler rooms are smaller, so the putting of the currently available solar tanks is very difficult. It is necessary to store the energy in a little space. The solution of the problem is the solar tank particularly filled with phase change material. This tank has smaller dimensions and bigger heat capacity than the conventional tanks. The other important advantage of a PCM solar tank is the possibility of the operating of the collectors at lower temperature. It could result a higher efficiency of the solar collector system. The storage system consists of two simultaneously functioning heat-absorbing units. One of them is a solar water heater and the other a heat storage unit consists of PCM. The solar water heater functions normally and supplies hot water during the day. The storage unit stores the heat in PCM.s during the day and supplies hot water during the night and overcast periods. The storage unit utilizes small cylinders made of filled with paraffin (PCM) as the heat storage medium and integrated with a solar collector to absorb solar energy. The performance of this PCM based thermal energy storage system is compared with conventional sensible heat storage system and the conclusions drawn from them are presented.

Keywords— Solar Energy, Solar Water Heating System, Phase Change Material.

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I. INTRODUCTION

Energy is essential for the existence of human life and plays vital role in the progress of the nation. However the past few years have witnessed a rapid growth in global population putting a tremendous burden on energy resources .In the present scenario the importance of available energy can’t be underEstimated. Also due to fast growth of the India’s economy. The country’s energy demand has grown to an average of 3.65% per annum over the past 30 years.So it has become a need to harness alternate and renewable energy sources. Today India has one of the highest potential for the effective use of renewable energy sources .The country has also invested heavily in recent years in renewable energy utilization.Solar energy being simple to use, clean, non-polluting and inexhaustible has received wide spread attention in recent times. It provides well abundant energy source if utilized efficiently. But this energy is time dependent energy source with an intermittent character. Hence some form of thermal energy storage is necessary for more effective utilization of this energy source.

Phase Change Material (PCM) is one of the techniques to store this thermal energy in the form of latent heat. Inorganic phase change materials (PCM) are hydrated salts that have large amount of heat energy stored in the form latent heat which is absorbed or released when materials changes state from liquid to solid or solid to liquid .The PCM retains its latent heat without any change in physical or chemical properties over thousands of cycles. This PCM has wide range of applications; one of them is in the solar water heater.

Phase change materials can store energy by melting at a constant temperature. The selection of the PCM for a given application requires careful consideration of the properties of various substances. One of the most important aspect is the conformable melting point and the high latent heat of fusion. The choice of the substance depends upon the temperature level of the application. Residential, commercial and industrial buildings often have hot water requirement at around 60^0c and bathing, laundry and cleaning operations in domestic sector needs it at about 50^0c. The right melting point enables that the phase changing comes off during every usage cycle. Thereby the latent heat could be fully utilized.

The value of latent heat is very important, because the higher latent heat results in higher storable heat quantity. According these aspects we can choose several materials. We have to mind the chemical properties, the thermal expansion and the aspects of safety. PCMs in the range 50- 100^0c have been proposed for the water heating.

The inorganic compounds have the highest latent heat , but these materials are disposed to under cooling, so the phase changing do not come off in the melting point in every case. We cannot use the latent heat if the material remains in liquid state during discharging. So it cannot be used as our aim is to utilize the releasing latent heat during the solidification. The organic compounds (except paraffin) are expensive and toxic acids. Normally there is no contact of a water and PCM, but in case of failure PCM can mix with water, so we cannot use toxic materials.

Paraffin is the most suitable PCM by the physical and chemical properties. The paraffin is obtainable at a low price. This material has only one disadvantageous property: flammability. But in this case we will not mind because of the presence of water around the paraffin tubes.

There are various specific temperature PCMs (paraffin) commercially available in market.

TABLE I
PHYSICAL PROPERTIES OF PARAFFIN 5838

Melting point	50^0c
Latent heat	145 kJ/kg
Viscosity	1.9 mm^2/s
Density	1.412 g/cm^3
Specific heat capacity-solid	2.1 kJ/kgK
Specific heat capacity- liquid	2.4kJ/kgK
Coefficient of thermal	0.2 W/mK
Coefficient of thermal	0.15 W/mK

I. EXPERIMENTAL SET -UP

The photographic view of the experimental set- up is shown in Figure 1. The TES tank has a capacity of 48 liters, capable of supplying water for a family of four. Tank contains two plenum chambers on the top and the bottom of the tank and a flow distributor is provided on the top of the tank to maintain a uniform flow. It is considered that, on an average, the family would require 60 liters of heated water for their daily needs. This energy is stored as a mixture of sensible and latent heat of PCM, and sensible heat of water within the TES tank. We assume that the PCM store two-thirds of the energy while the remaining is stored as sensible heat of water. In the case of PCM less system, the same TES tank is used without having PCM shells.

Figure 1. Photographic View of Experimental Set- Up

II. EXPERIMENTAL TRIAL AND RESULT

In the system without PCM, the water in the tank gains the energy from the solar collector and stores it. Whereas in the system with PCM, the energy from the solar collector is gained by both the water and the PCM and stored it, in this case the PCM melts above its melting temperature.

In this situation, the heat energy stored in both the systems is compared and got the result as shown in figure 2.

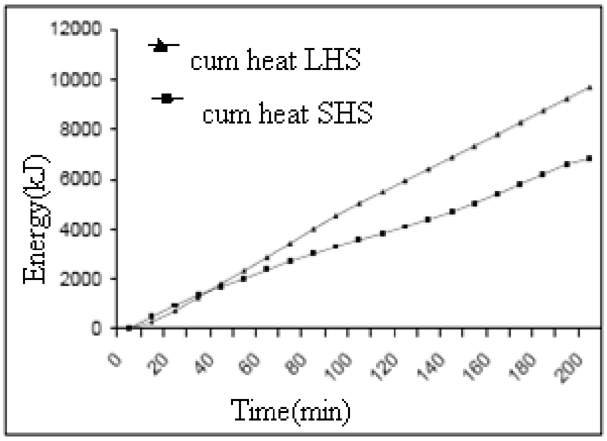

Figure 2.Comparison of Cumulative Heat In Both The System

Heat energy stored in the system with PCM far exceeds that stored in the system without PCM of the same size and volume of the storage tank. The heat stored per unit volume, when calculated, is 0.234 kJ/cc for the system with PCM and is 0.144 kJ/cc for the system without PCM. System with PCM can thus provide a substantial decrease in the storage volumes for the same heat stored, when compared to system without PCM.

To get the hot water in the absence of sun energy for maximum period, the time of solidification of PCM is also an important aspect to be considered. From experiment the calculated time of solidification is 172 min, for the temperature difference of the phase change temperature and the temperature of the outer wall of the tube of 2^0C (calculated for the tube with dia. 60mm and 1mm wall thickness). And 66 min for the temperature difference of the phase change temperature and the temperature of the outer wall of the tube of 2^0C (calculated for the tube with dia. 40mm and 1mm wall thickness).

The diagram shows the time of the solidification of PCM in function of diameter of tube. If the diameter of the tube is smaller, same amount of PCM requires more number of tubes. The specific heat exchange capacity is greater, the solidification is quicker, but the volume of the material of the tubes is greater too, so the heat capacity of the solar tank is lower.

During charging, in case of the system with PCM, the energy gained from the solar collector is taken by both the water and the PCM. But in case of the system without PCM, the energy is taken by the water only.

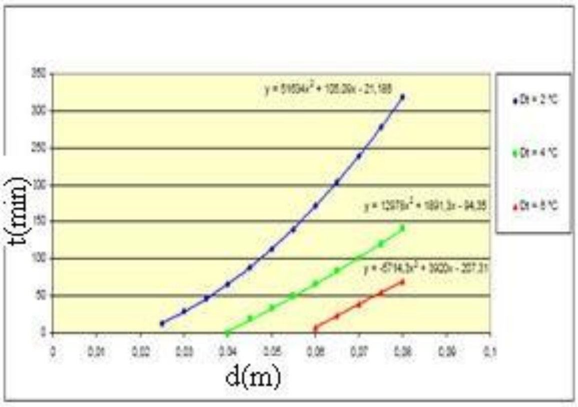

Figure 3.Solidifying Time in Function of Time and Temperature Difference

As a result we can say that, the particular temperature attained by the water in the system without PCM is quicker than the system with the PCM.

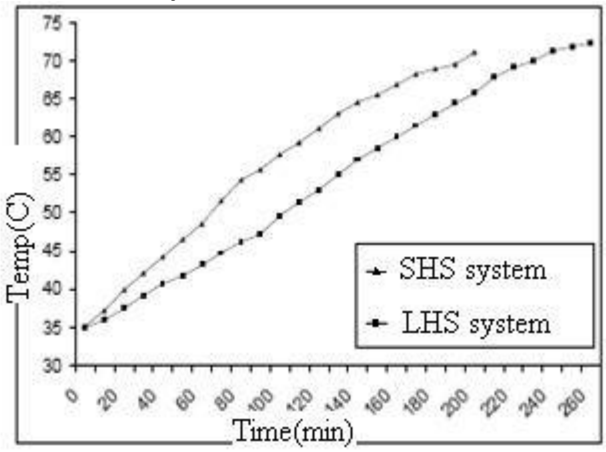

Figure 4.Temperature Histories of Both Systems during charging

We can observe that the system without PCM charges to the maximum temperature of 70^0C 40 minutes sooner than the system with PCM. On an average the charging time of the system without PCM is quicker than the system with PCM by 30- 60 minutes.

System efficiency is defined as the ratio of the amount of energy stored by the tank to the heat energy available from the solar radiation

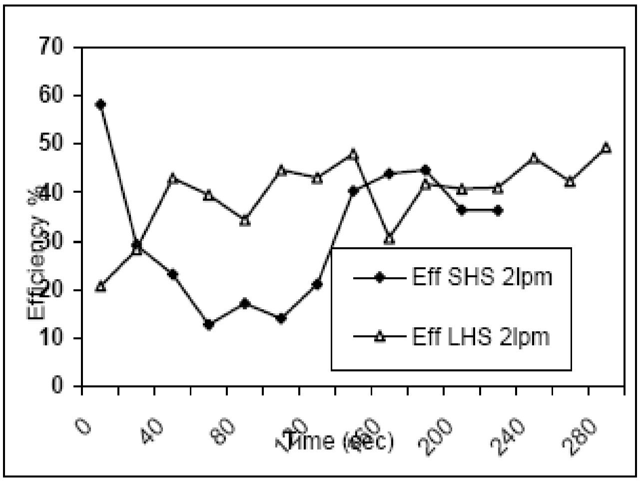

Figure 5.Comparison of System Efficiency

It is observed from the figure 5 that the efficiency of the system without PCM is fluctuating over various periods of time, while the efficiency of the system with PCM is constant over the phase transition temperature and that it also shows a higher efficiency. Hence the system with PCM is more efficient.

III. CONCLUSION

The thermal behaviour of the systems is investigated experimentally for various operating conditions. The effects of charging times, energy storage, time of solidification of PCM and efficiency of the systems are studied. These characteristics of both the systems are compared. At last it is concluded that:

The cost of the manufacturing of the tank is lower than the conventional tanks in trade with the same heat capacity and the space demand is much lower too. The other advantage of the PCM tank is the constant temperature during the heat accumulation. This constant temperature could be lower; it depends on the type of the PCM. The lower temperature of the heat accumulation permits the higher efficiency of the collectors at low external temperature.

Hence the systems with PCM are viable option for solar heat energy storage. Possessing considerable advantages over the systems without PCM, it can be used as an alternative to current domestic sensible solar water heating technologies.

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