ANALYSIS OF PCM BASED STORAGE SYSTEM IN AN IMPROVEMENT FOR WATER HEATING SYSTEMS

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ABSTRACT

The use of solar energy in solar water heater by using a phase change material (PCMs) in storage tank is the effective way of storing the thermal energy. Within the past decade uses of PCMs for heating and cooling applications for buildings, space heating and for water heating have been investigated. Experiment is carried out for the investigation and analysis of thermal energy storage incorporating with PCM for use in solar water heaters. Storing solar energy with the help of phase Change materials (PCMs) and utilizing this energy to heat water for domestic purposes during the night time. The system consist of two absorbing unit one of them is solar water heater other a heat storage unit consisting of PCM (calcium chloride hexahydrate).As this experiment is carried out for getting a hot water in night with help of phase change material. The storage unit consists of small cylinders which are made of aluminum filled with (calcium chloride hexahydrate) as a heat storage unit. During the day time the solar collector absorb the heat from sun and the water is heated with the help of solar radiation. The heated water transfer it heat to phase change material (PCMs). The phase change material absorbed the sensible heat and the excess heat is stored in the form of sensible heat. The water supply in the night is routed to the storage unit using a suitable control valve. Though it is time dependent but by using the PCM as phase change material as absorbing heat unit we can get the hot water during night, with increase in the performance of solar collector [11].

Keywords: Solar Energy, Thermal Energy Storage, Phase Change Material, Water Heating System.

I INTRODUCTION

Energy is the backbone of human activities. Historically fossil fuel in its solid phase, i.e. wood and coal, has been the prime source of energy. The increment in global energy demands due to population growth and 20th century industrial revolution leads fossil fuel through a transitional phase. The world saw a rapid growth of the use of solar warm water after 1960. Solar energy is an important alternative energy source that will more likely be utilized in the future. One main factor that limits the application of solar energy is that it is a cyclic, time dependent energy resource [5]. Therefore, solar energy systems requireenergy storage to provide during the night and overcast periods. In solar energy applications, TES can provide savings in systems involving either simultaneous heating and cooling. Most TES applications involve a diurnal storage cycle. PCMs absorb and emit heat while maintaining a nearly constant temperature within the human comfort range 20 to 30° C

The main objective of the paper is to improve the output of solar water heater so that we can get a hot water during the night time or in winter seasons for domestic purpose, industrial purpose or in hospitality. By using $CaCl_2$-$6H_2o$ salt hydrate inside the water storage tank which is an inorganic phase change material having melting point 29.8°C and latent heat 174KJ/Kg we can improve the performance of solar water heater.

The maximum development of these systems was not until 1970 due to the global oil crisis, leading to the search for alternative sources of energy such as wind, bio-fuels, solar energy, etc. There is a whole range of technological options designed to take advantage of the solar energy but only a few are popularly known, for example, the solar systems for hot water or photovoltaic systems to produce electricity. However, there are other technologies that are mature enough to be commercialized on a large scale that are unknown by most people. It is for this reason that parabolic solar concentrators are suitable for use in a wide variety of industrial processes which use thermal energy, such as dairy, processed waste, electricity, etc., replacing in this way the use of fossil fuels. It is well known that an effective solar furnace generally forms part of two categories. One is of type box; the other is with reflectors parabolic focusing.

1.1 Solar Energy Collectors

A solar collector is a device for collecting solar radiation and transfers the energy to a fluid passing in contact with it. Utilization of solar energy requires solar collectors. These are general of two types.

1) Non- concentrating or flat plate type solar collector

2) Concentrating (focusing) type solar collector

The solar energy collector, with its associated absorber, is the essential component of any system for the conversation of solar radiation energy into more usable form (e.g. heat or electricity).In the non- concentrating type, the collector area (i.e. area that intercepts the solar radiation) is the same as the absorber area (i.e. area absorbing the solar radiation) . On the other hand, in concentrating collectors, the area intercepting the solar radiation is greater, sometimes hundreds of times greater than the absorber area. By means of concentrating collectors, much higher temperature can be obtained than with the non-concentrating type. Concentrating collectors mat be used to generate medium pressure steam [9].

1.2 Applications of solar thermal collectors

1) Domestic water heating.

2) Industrial thermal process operations.

3) Electricity generation plants.

4) Solar water distillation plants. [9]

II THERMAL ENERGY STORAGE

Energy plays an important role in conserving the energy and improves the reliability and performance of the systems. Energy storage is all the more important where the source is the intermittent such as solar energy .Energy storage can reduce the time or mismatch between energy supply and energy demand, thereby playing a vital role in energy conservation. Energy demands in the commercial, industrial, and utility sectors vary on daily, weekly, and seasonal bases. These demands can be matched with the helpof thermal energy storage (TES) systems that operate synergistically. The use of TES for thermal applications such as space and water heating, cooling, air-conditioning, and so on has recentlyreceived much attention. A variety of TES techniques have developed over the past four or five decades as industrial countries have become highly electrified.Many types of energy storage play an important role in energy conservation [10].

2.1 Thermal energy storage is classified as

1) Sensible solid: i) Liquid ii) Solid

2) Latent heat: i) solid-solid ii) solid-liquid iii) liquid- gaseous.

The PCM to be used in the design of thermal-storage systems should passes desirable thermo, physical, kinetics and chemical properties which are as follows:

a) Thermal properties

1) Suitable phase-transition temperature
2) High latent heat of transition.
3) Good heat transfer.

b) Physical properties

1) High density.
2) Small volume change
3) Phase equilibrium

III EXPERIMENTAL SETUP

Fig. 2.1 shows the schematic diagram of the experimental set, Experimental set-up can be divided in three parts as follows.

1) Storage tank with PCM ($CaCl_2.6H_2O$) based Thermal Energy Storage
2) Parabolic Collector.
3) Main Water Supply tank.

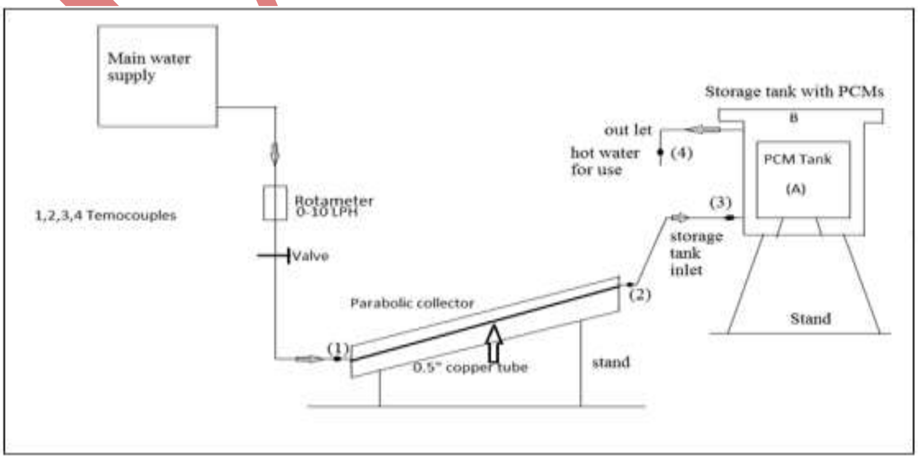

Fig. 2.1Experimental set up

IV EXPERIMENTAL INVESTIGATIONS

4.1 Experiment setup: Experimental setup shown with the solar collector connected to the TES tank [6]. Set-up consists of storage tank with PCM. The PCM aluminum tank of with the dimensions of 200 mm width and height 260mm is kept inside the storage tank with dimensions of 400mm width and height of 500 mm with the capacity of 50 liters. The aluminum storage tank of water is insulated by puff (Polyurethane puff).

The aluminum storage tank of water is connected with solar collector and the solar collector is connected with the main storage tank of water. The thermocouple is fixed at five different locations to note down the temperature of HTF during the intervals of one hour, temperature of PCM. Pyranometer is used to measure the intensity of solar radiation during the day time.

4.2 Experimental trial: During the charging process the HTF is circulated through solar parabolic collector and TES storage tank. During the day time face the collector towards the sun. Start the experimentation from 8 a.m. Start the flow of water with 10 LPH so that the water will flow through the rotameter through the collector. Not down the first temperature (T_1) of water at rotameter. Not down second temperature (T_2) of water / HTF after the collector. Not down the HTF temperature (T_3) inside the TES tank. Not down the PCM temperature (T_4) and note down the HTF temperature outside of the tank. Now during the day time PCM storage inside tank absorb the heat form the HTF. During the day up to certain limit the PCM will absorb the heat from HTF and during the night time i.e. after the sunset the PCM will start to give the heat to water inside the storage tank. Due to this the experimentation we can get the hot water during the night up to temperature of 45 °C. The experimentation was carried out with and without PCM.

V RESULTS

The temperature distributions of HTF with and without PCM in the TES tank for the constant mass flow rate are recorded during charging and discharging processes.

Fig: 5.1represent the curve of (HTF) with and without PCM. Experimental result shows that the temperature of HTF from time 6 to 9 p.m. without PCM is comparatively less than the temperature of HTF by using the (PCM).

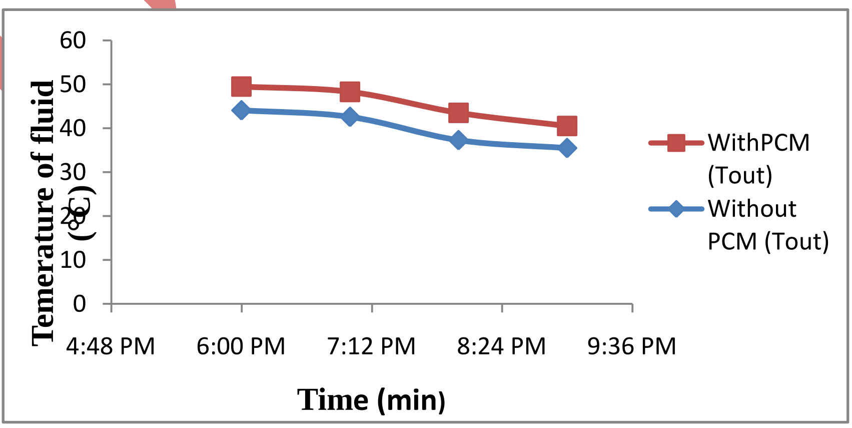

Fig: 5.1 Temperature of HTF Vs Time

Fig 5.2: represent the curve of temperature of (PCM) phase change material. As the tmperature of PCM start to increase upto certain limit can say that up to 4 p.m. As the PCM absorb the sensible heat of HTF stored in tank and release the heat during the night time. Due to this the temperature of water present in the tank get heated by sensibly up to 9 p.m or futher it ca also maintain the temperature of water for domestic use.

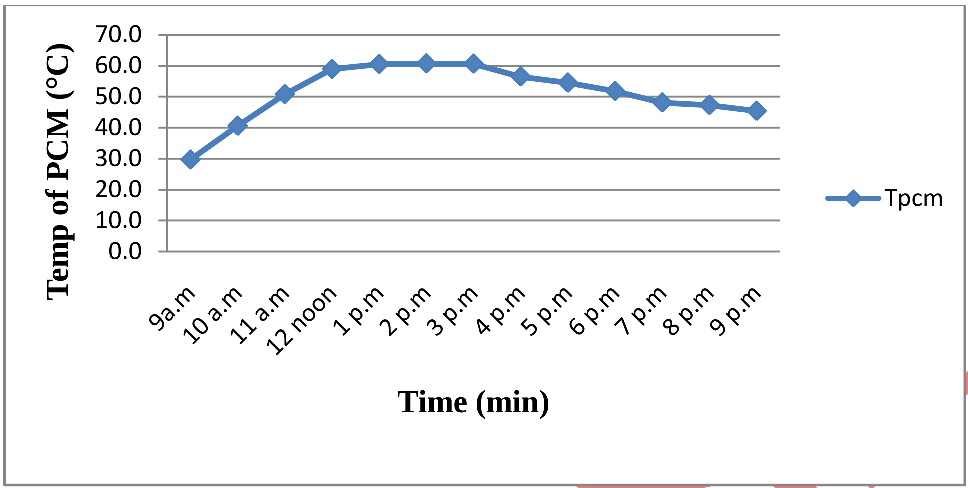

Fig: 5.2 Temperature of PCM Vs Time with & without PCM

Fig 5.3:represent the collector efficency of the system. Graphical represet shows that the collector efficieny can obtained up to 3 p.m or 4 p.m after than the intensithy of solar radiation goes on dreasing as it is dependent on solar radiation or time dependent, but by using the (PCM) we can maintain the temperaure of water up to desirable limit as it not possible without PCM in the winter seasons.

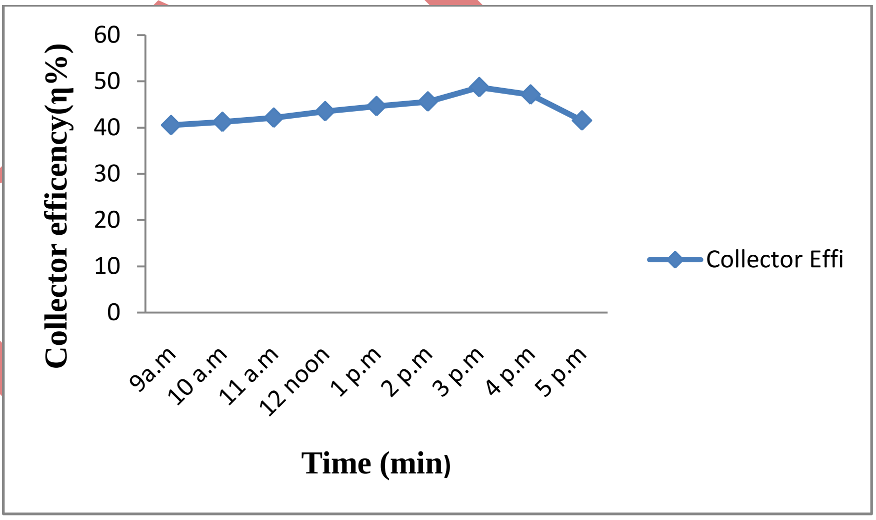

Fig: 5.3 Temperature of PCM Vs Time

VI CONCLUSION

Experimental set up have prepared to analysis the thermal performance of $CaCl2.6H2O$ (calcium chloride hexahydrate) by using as PCM based Thermal energy storage for heating the cold water on the concept of free or night heating, which have been carried out to save the energy cost by this system. As result were compare with and without PCM for the same capacity of solar parabolic collector. Results shows that it is feasible and advantageous to use this system for day as well as for the night working, for domestic purpose, industrial purpose or in hotels purpose rooms as it shows nearly 12-16 % increase in hot water by using PCM as compare with without PCM. Experimental analysis also shows that CaCl2.6H2O (calcium chloride hexahydrate) is best suitable for climatic conditions of Nagpur city, as its melting temperature is equal to the comfort temperature of hot day.

This system can be very useful in load shading affected areas of rural India where charging of thermal energy storage tank can be done when electricity is not available and same stored energy can be used later, i.e. this system can be used to balance the Power mismatch. It is got recorded that by using PCM we can get hot water during night for the domestic purpose.

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