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A REVIEW ON PERFORMANCE EVALUATION OF SOLAR WATER HEATER WITH PCM

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ABSTRACT

This review paper focuses on the use of Phase Change Material(PC098+6M).The solar tank is one of the most important part of solar collector system. The power of soler collectors depend on the weather. The solar collecter works day time only. In the evening and in the morning the hot water consumption in family houses is generally more ,so it is necessary to store the utilized energy. The collector do not store the solar energy but they can transform. The storage is necessary to accomplish in a heat-insulated tank, place in tempered space. According to the current architectural tendencies the boiler rooms are smaller, so the putting of the currently available solar tank is very difficult. It is necessary to store the energy in little space.So the solution of the problem is the solar tank particularly filled with phase change material. This tank has smaller dimention and bigger heat capacity than conventional tanks. Also the important advantages of solar tank is at lower temperature the possibility of operating of the collectors, result in a higher efficiency of the solar system. The storage system consist of solar water heater and heat storage unit PCM ,these are two heat absorbing units. The solar water heater supplies hot water during the day and storage unit store the heat in PCM 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 with ang integrated with a solar collector to absorb solar energy

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

I. INTRODUCTION

There is need of energy for the existence human life and placed important role in the development of the nation. however past few years have witnessed a rapid growth in global population putting a tremendous burden on energy resourses. In the present scenario the importance of available energy can't be underestimated. The energy demand of country has grown to an average of 3.65% per annum over the past 30 years, it is due to the fast growth of the india's economy. So it has become a need to harness alternate and renewable energy sources. In recent years India has also invested heavily in renewable energy utilization. Solar energy is simple to use, non-polluting, clean and inexhaustible. If utilize efficiently, the solar energy provides well abundant energy source. But this energy is time dependent energy source with an intermittent character. Hence for more effective utilization of this solar energy source, some form of thermal energy storage is necessary.

Over the last two decades a wide variety of solar energy technologies have been developed through research and development, Large-scale promotion and demonstration during the eighties and ninties. As a result, Some of this technologies are suitable for decentralized applications and have reached maturity and user-friendly status. India is blessded with good sunshine. The one of the most common uses of solar thermal technology is solar water heating. Our country receives solar radiation amounting to over $5x10^{15}$kWh per annum but daily average incident energy varying between 4 to 7 kWh per m^2 depending on the location. For more than sixty years SWH system have been used. In many countries like china, USA, Australia, Cyprus, Israel, Japan and South Africa, SWH system are very popular for their use in community, industrial and commercial application. The magnitude and importance of solar energy are well known. Solar energy is free, environmentaly clean, and therefore is recognized as one of the most promising alternatives energy resources options. Its total value is dependent on meteorological conditions of the location The utilization of solar energy can be more attractive and reliable if associated with a heat storage systems. All over the world, the scientists are in search of new and renewable energy sources. One of the option is to develop energy storage devices, which are as important as developing new sources of energy. Since the solar enegy supply is variable in daytime and is zero at night, considerable amount of solar energy being stored during day time to meet the demands at night. Therefore the energy storage is essential to any system depends largely on solar energy. The solar radiation can not be stored as such ,so first of all an energy conversion has to be brought and depending on this conversion a storage device is needed. For this purpose, the latent heat of fusion of phase change material is of great interest on account of its isothermal nature of the storage process and high storage density. This solar energy can be stored by using Thermal, mechanical, chemical, electrical methods. Due to the nature of solar energy the collector and storage unit these two components are required to have functional solar energy system. The collector simply collects the radiation that falls on it an converts a fraction of it to other form. The storage unit is required because of the non-constant nature of solar energy at certain times only a very small amount of radiations will be received. Due the high storage density and isothermal nature of storage process at melting temperature, the storage of thermal energy as latent heat of fusion has attractive features over the sensible heat. The operating pressure is lower than liquid to gas or solid to gas phase change therefore the phase change from solid to liquid or vice-versa is preferred.

II. PCM AND PCM TECHNOLOGY

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

By melting at a constant temperature PCM can store energy. The most important aspects of PCM are high latent heat of fusion and conformable meelting point. The choice of substance depends on the temperature level of application. The residential, commercial and industrial buildings often have hot water requirement at around 60^0C,and in domestic sector needs it at about 50^0C.The right melting point enables that the phase phase changing comes off during every usage cycle. Thereby the latent heat could be fully utilized. The higher latent heat results in higher storable heat quantity therefore the latent heat is very important. According to these aspects we can choose the several materials, We have to mind the chemical properties, the thermal expansion and aspects of safety. For water heating, PCMs is in the range of 50-100^0C have been proposed. 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. If the material remains in liquid state during discharging, we can not use th latent heat. So it can not 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 can not use toxic materials.

Paraffin is most suitable PCM by the physical and chemical properties which is obtainable at a low price. This material has only one disadvantageous property: Flammability. But in this case there is no matter of flammability because of the presence of water around the paraffin tubes.

Latent heat thermal energy storage(LHTES)system using PCMs is a process near isothermal that can provide significantly larger storage capacity compared to sensible heat thermal energy storages (SHTES)at the same temperature range. Isothermal storage is an important characteristics because of variation of fluid temperatures of solar field inlet and exit are constrained by the solar field equipment and also the thermal power Rankine cycles .As the storage capacity of a LHTES system is governed largely by the phase change latent heat which is typically several ten times B.Xuet al./Applied Energy 160 (2015)286-307287 bigger than the sensible heat, it is possible to have smaller and lower cost thermal storage system. To date, synthetic oils and molten salts are most widely used sensible heat storage materials in commercialized CSP systems. LHTE system using PCMs for CSP plants is still under active research and development. In the preent review ,discussions will focusbon LHTES systems. To better understand the state-of-the-art technology of LHTES systems in CSP plants, this paper presents surveys and discussions on five subjects:(1)Various PCMs for different thermal storage application;(2)Current status of research and application of LHTES system in CSP plant;(3)Mathematical modeling and numerical simulation to LHTES system;(4)Integration and seamless operation of CSP using thermocline LHTES system; and (5)Cost analysis of thermocline LHTES system.

III. INTRODUCTION TO PCMS FOR DIFFERENT THERMAL STORAGE APPLICATION

A number of studies have been reviewed on using different types of PCMs for LHTES. Those PCMs are generally known for thermal storage application include organic salts, inorganic salts and their eutectics. Parasffin waxes, esters, acids and alcohols these are organic compounds used for PCM ;inorganic compounds eutectics. PCMs from organic compounds generally have contains eutectics of inorganic salts, and their low melting point and can only be used for room-heating thermal storage. For high temperature thermal storage ,molten salts have been widely considered btresearchers.Since molten metals and alloys are considred as HTFs in nuclear power plants, they are also viewed as possible HTFs as well as PCMs for thermal energy storage in CSP systems. From the working temperature point of view ,Hoshi et al.categorized those materials with melting points below22^{0}C AS 'Low' temperature materials, and melting temperature upto 42^{0}C AS 'Medium'temperature materials and melting point greater than 42^{0}C as high temperature material suitable to CSP thermal storage.They collected the latent heat energy storage capacity of PCMs for various materials with meltings points in the range from 300K to 1200K.Applications of PCM are:It is used in solar power plants, Heating and hot water, spacecraft thermal system, thermal comfort in vehical, thermal storage of solar energy etc.

IV. RECENT DEVELOPMENT OF PCM ENCAPSULATION TECHNOLOGIES

It is difficult to ensure that the capsules having no leakages of liquid PCM when it is melt. Regin et al.,Nath and Nomura summarized the functions and requirements of materials to contain PCM(i)meeting the requirements of strength , flexibility , corrosion resistance , and thermal stability ;(ii)acting as a barrier to protect the PCM from harmful interactions with the heat transfer .PCM packaging configuration to enhance heat transfer. B.Xu et al./Applied Energy 160(2015)286-307 291 for fluid surrounding PCM capsules;(iii)capsules have relatively small to have large surface to volume ration, providing sufficient heat transfer surface area;(iv)providing structurak stability and easy handling. In order to make PCM capsules having the above characteristics, two different approaches can be adopted.

PCM pellet up of is made up of desired shape, either spherical or cylindrical and then apply a coating or a series of coatings which acts as a shell to hold the PCM inside. The other approach is to fabricate a shell(cylindrical or spherical)first and then fill with PCM. Due to recent development of in encapsulation technology, the size of PCM capsulescan cover the range from 1-2 cm(microsize)down to micrometers. Conventional PCM capsules are mostly in micro size. There are no. of published paper that reported various shell materials such as metal and plastics and various shape such as spherical and cylindrical. Micro-encapsulation of PCM is a technology getting significant attention recently for the advantages of getting larger surface area to volume ration and also better adaptation to themal expansion/contraction during phase change processes. The core PCM material, shell materials, thermo physical properties and capsule size of various micro capsule. Medium to high temperature PCM encapsulation usually needs metal shells. In summary, the technology of encapsulation of low temperature PCMs is getting a significant development, inparticular, the micro-encapsulated PCMs is becoming increasingly popular. The encapsulation of high temperarture PCMs is very challenging and thus is less popular despite its engineering importance. In the near future it is expected that that easy-producible encapsulation high-temperature PCMs with large thermal density for the purpose of CSP application will be developed. Advantages of PCM are as follows(i)Higher storage density than sensible heat, (ii)Smaller volume, (iii)Smaller temperature change between storing and releasing.And disadvantages oF PCM are density change, phaseseparartion and incongruent melting.

V. WOKING OF SOLAR WATER HEATER WITH PCM

The idea of solar water heater using the phase change material as a paraffin wax which is store the energy in the form of latent heat. In this review paper ,the solar water heater consist of copper tube which is the inlet water is entering and pass through the tube and outlet to the second end. Copper tube has thermal conductivity which is then covered with MS attachment, this is air tighten and filled with paraffin which is having a hole for to fill the paraffin also removing it. The foil collector is also used to reflect the ray which is incidence on the collector, it collects all the rays and concentrated on MS pipe. In between the gap paraffin wax will be placed so when solar solar energy incident the water which is flowing pipe gets heated, at that same time wax will heat. As the position of sun will change the solar intensity decreses and the melted wax will transfer its latent heat to the copper pipe and ultimately to the water.So in winter days the intensity of solar energy is low by using PCM material will increase the water heating and temperature of water heating and temperature of water. The thermocouple is plced in a inlet and outlet. One inside the wax zone and one with copper to measure various temperature by providing easy arrangement for adding and removing of wax and also providing partition in MS attachment so that wax does not concentrate on lower side angle.

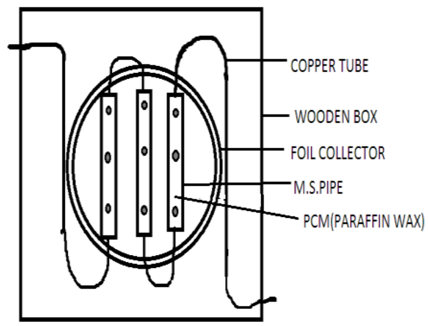

Fig:3.1 Experimental Set up of Solar Water Heater with PCM

VI. SOLAR ENERGY

Solar power is the world's largest renewable energy source the sun. it is 99% of the world's available renewable energy sources. Increasing environmental and climate awareness, the use of solar energy has been growing explosively the past few years. However it has some technological and economical developments issues, the huge research has to be done on the same. Sun light comes on earth in two components. One is direct beam of light another diffused sun light. Direct beam of sunlight brings about 90% of the solar energy, and the diffuse sunlight carries the remainder. The diffuse portion is the blue sky on a clear day and increases proportionately on cloudy days. The most of the solar energy carries direct beam, so maximum collection of energy should collected in this phase. In The proposed work of solar water heater with PCM having more than 60% efficiency.

VII. CONCLUSION

By using Phase Change Material the solar water heater helps to reduce cooling rate of water, thus it enhance the maximum utilization of solar energy and efficiency of system increases. The PCM based on solar water heater store the maximum solar energy.PCM Material Paraffin wax get melt at temperature 37 to 45^{0}C.When the radiation of sun get low, wax gives its latent heat to the water and obtain the better performance as compare to normal Solar water heater model. After 4PM in normal solar water heater outlet temperature get decreases but at same time higher efficiency is obtained due to PCM. By considering overall efficiency at that case the more efficiency is obtained as compare to the normal solar water heater .Also the efficiency between 2.00PM to 6.00PM is comparatively higher than normal solar water heater. On thermal energy storage with phase change material already the lot of work has

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done. As there is day by day need of solar energy thus this technique is more reliable and more inexpensive at the same time it is easy to implement. In the future this project will also helps to find the suitable PCM and provide the various design for solar water heating system to store the solar thermal energy.

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