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A Short Review On Solar Stills Using Nano Phase Change Materials And Their Enhanced Properties

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ABSTRACT
Water purification is one of the major natural requirements for humanity. A Solar still is a one of the low cost methods that produces pure and drinkable water from saline water by utilizing the solar radiation. For improving the efficiency of solar still numerous methods are being used in the recent years. Phase Change Material (PCM) is utilized in solar still which is discovered to be the most ideal alternative to expand the proficiency of solar still at daytime as well as during the evening. This kind of material has a higher advantage and attention, so that in this study, we are justifying the properties of PCM thermal energy during on distillation process and also we mentioned the reason behind why researchers chose paraffin as a PCM for Thermal Energy System. And also we are including the progress on improving the thermal conductivity property of PCM materials using nanoparticles. Nano materials played a very important role on PCM and which is enhancing the thermal conductivity behavior on thermal energy storage systems. In addition, the tiny structure will cause nanoparticles to have an enormous surface region that associates with their physical and chemical properties that respond to the thermal properties of PCM. Here the thermal conductivity of PCM can be improved by including exceptionally thermal conductive nanoparticles, for example, carbon nanotubes, graphene and metal oxide nanoparticles are used in PCM.

Keywords: Thermal energy storage system; phase-change materials; Nano materials, Solar still, Desalination.

1. INTRODUCTION

Water is the most important ingredient for sustaining life on Universe.71 percent of the surface of the planet is water covered and 96 percent of all salty water on earth is retained by the oceans and cannot be used directly. Water occurs in rivers, lakes and ponds which are fresh water resources on the planet and it can be made into use directly. The interest for water distillation rapidly increasing day by day and this is the best way of purifying drinking water from source of seawater [1]. Most of the sea water desalination systems are mostly based on thermal energy storage system and the use of solar energy. Because of its minor profitability, it was broadly utilized.

Numerous scientists have introduced streamlining or upgrading structures which have been tried hypothetically and tentatively. Utilization of desalination innovation is expanding to fulfill this need. Phase change material is the one of the inventions in the Thermal energy storage system (TES) which has been proven thermal physical properties in the various climatic conditions.PCM and nanocomposites are the promising materials for the solar desalination applications [2-4]. Among the different strategies for water desalination, solar stills have a few focal points including effortlessness, ease, simplicity of support, and low ecological effect [5]. The Latent heat storage systems are the main property of PCM for use in heating and cooling of the variety of applications including solar still, heat pump systems and solar power plant applications. Phase change energy material has a latent heat energy storage system; the energy is stored by phase change of the storage medium like solid-solid, liquid-solid or gas-liquid [6]. It has a property of sensible heat that shows the temperature difference between charge and discharging steps [7]. Dispersing nanoparticles into PCM is a new kind of technique which improves the thermal properties of PCM. It shows better performance in the Thermal energy storage systems. Many papers mention that nano phase change materials could play a vital role in heat storage capacity and thermal conductivity of solar still applications [8].In this review we discuss the solar still mechanism and techniques to improve the solar still productivity. In this paper we mentioned the advantages of using paraffin material as a PCM.

2. EXISTING TECHNIQUES OF SOLAR STILL

The world population and industrialization are hugely increasing day by day so the need for energy consumption is the matter for future generations. So that to replace the conventional energy system there is the alternative option for Consuming solar energy systems, it has good availability and free of cost [9]. Water purification process can be possible by the solar distillation method. There are many different types of solar systems mostly used based on the simplicity and efficiency of water production. Mainly solar stills are classified by active type and passive. These kinds of solar stills are classified upon their properties and functions. The recent research has found the major affecting factors of solar water productivity, the inclination angles of slope, depth of the basin, materials and solar radiation are the some of the reasons [10]. Temperature difference between water in the solar still basin and glass inner side temperature is the main factor which helps to increase the efficiency of water production. An active solar system gives higher production than passive type solar stills. To increase the temperature difference between the glass and basin water the air circulation of the inside still has slightly increased. It increases the heat transfer of both the medium of basin and the water cover. The cooling rate of the inner glass surface increases the rate of condensation. In addition there are many slight modifications which help to enhance their productions in various meteorological parameters and design such as the use of some modification in the internal and external sides of the solar water basin. Use of nano phase

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change materials is the better option for the improvement of solar desalination [11].

2.1 Mechanism Of Solar Still

The Solar still is working by the mechanism of evaporation and condensation, the fresh water is distilled by using a simple heat transfer mechanism. Figure 1 is showing the schematic diagram of concept and working method of the solar still. Active and passive solar still are the two types of solar still, both work on evaporation and condensation process. The solar still is mostly constructed by the basin, slope with glass cover and storage tank. The surface of the basin is filled with saline water and the solar radiation heats up the saline water to evaporate. The evaporating water is condensed through glass cover, then finally the flow of condensed water stored by the distillate collector. Basin temperature and condensation temperature and solar radiation is the major factor for solar water desalination, there are different types of approaches that help to increase the productivity of water like using the active components, external motors, pumps fans and absorption materials [12]. There has been much research already done in the modifications of solar still by using sponge cubes, absorption materials, wick, black paints, Fins, Insulations, condenser and evacuation tubes.

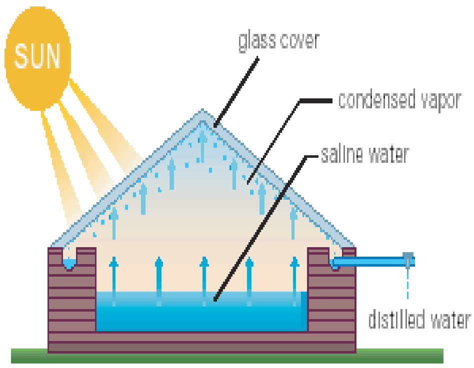

Figure 1**.** Mechanism of solar still

2.2 *Thermal Conductivity And Thermal Energy Storage System*

Energy storage plays vital roles in preserving available energy and improving its utilization, since many energy storage sources are mostly based on Solar Energy. But the Solar energy available only during the day time, so that researchers focused on the Phase change material which stores the heat collected during the day time and after using the night time. This kind of materials is called Latent heat storage material and it has consistent thermal conductivity. Common Heat storage medium equation of latent storage system (LHS) consist storage capacity as below equations. [6]

$$Q = m[C_{sp}(T_m - T_i) + a_m \Delta h_m + C_{1p}(T_f - T_m)] \quad (1)$$

$$Q = m[C_{sp}(T_m - T_i) + a_m \Delta h_m + C_{1p}(T_f - T_m)] \quad (2)$$

Eq. (3)-(6) states the prediction models of thermo physical properties used in the nano phase change material studies, including specific heat (Cp), density (ρ), latent heat of fusion (L), thermal expansion coefficient (β), [8]

$$(\rho Cp)qt = (1-\phi)(\rho Cp)q + \phi(\rho Cp)t \quad (3)$$

$$\rho qt = (1-\phi)\rho q + \phi\rho t \quad (4)$$

$$(\rho L)\mathrm{qt} = (1-\phi)(\rho L)q \quad (5)$$

$$(\rho\beta)\mathrm{qt} = (1-\phi)(\rho\beta)q + \phi(\rho\beta)t \quad (6)$$

3. PHASE CHANGE MATERIALS

The phase change material is the inevitable medium of enhancement of solar still applications and especially the organic PCM is the most consumed PCM in the recent publications [14].PCM provides a better thermal conductivity characteristic where it can absorb the latent heat and release the heat during the phase change process. The temperature of these materials remains constant, during the transition of the heating process. Mostly the Phase change materials for considering the thermal storage applications for their property of Latent heat and high thermal conductivity**.** Latent heat storage plays an important role in the PCM, latent heat is the heat absorbed or released by the thermodynamic system. The latent heat associated with the changes of phases in the thermodynamic system is called Latent heat of fusion. PCM is characterized into natural (paraffin, unsaturated fats) and inorganic (metallic salts) PCM. Because of the best attributes of phase change material, natural paraffin phase change material is our choice. Natural PCMs are more artificially stable than inorganic Phase change material which softens consistently without a super cooling. Yet, it gives a lower thermal conductivity contrasted with inorganic PCM. In this exploration, we will change the thermal trademark property of the PCM with the assistance of including the nanoparticles.

The latent heat thermal storage comparatively has better charging and discharging properties than sensible heat storage systems. It has more energy storage capacity and high heat of fusion. Organic and inorganic PCMs are the mainly used materials. Paraffin and fatty acids are well known organic phase change materials and hydrated salts is the main inorganic PCM. Melting temperature is the major difference in all kinds of Phase change materials depending o the applications PCM are widely used in the Energy sectors. In refrigerating applications the melting point should be above 90˚ C and while in the Air conditioning applications PCM melting temperature is below 15˚C. [15].

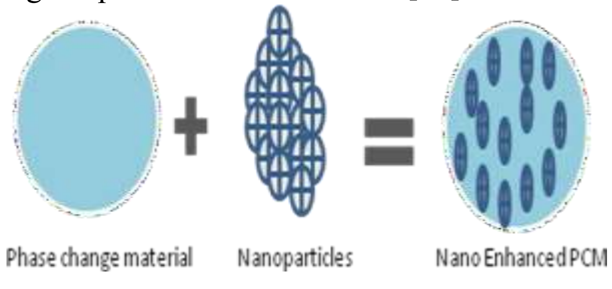

Figure 2 Concept diagram of Nano Enhanced PCM

Natural PCMs are more synthetically stable than inorganic PCMs and they liquefy consistently, and super cooling is definitely not a huge issue. In any case, the thermal conductivity of natural PCM is low. So the suitable nano material will be slightly dispersed into PCM, this process helps to improve the thermal conductivity of any kind of PCM.

3.1 Use Of Paraffin As A Pcm

Most of the research work was carried out on the improvement of PCM thermal properties such as paraffin and fatty acids. Paraffins are considering their low thermal conductivity, the most highly recommended materials for latent heat thermal energy systems compared to other PCM. For its desirable characteristics such as good heat storage density, melting or solidification with low sub cooling it was widely used in TES applications [16]. In addition they are available at a low cost; after a large number of thermal cycles, they are safe and thermally reliable and paraffin is readily available in a wide range of melting temperatures. Warzoha and Fleischer et al, proved that paraffin wax nano composites slightly increase the solar still production by the using the nanoparticles of graphene, carbon nanotubes, aluminium and titanium dioxide.

Properties of paraffin	
Phase	Solid
Color	White
Melting point Temperature	42-72 ◦C
Boiling point Temperature	4350 ◦C
Ignition Temperature	4300 ◦C
Density	0.9 g/cm3

Table 1 Properties of paraffin

3.2 Applications Of Nano Enhanced Pcm

In nano composite PCM thermal conductivity was found to be increased with dispersing nano materials into Phase change materials. Various nanoparticles already mentioned in the figure which help to enhance the properties of TES. Valan arasu et al., studied melting efficiency of paraffin wax filled with aluminum nanoparticles. They showed that heat transfer effect in the surface medium has increased and also examined the melting performance of paraffin with Al203 nanoparticles. Min Li et al, conducted the experiment and resulted in the higher thermal conductivity of PCM by using nano graphite paraffin composites. J.Wang et al, [5] prepared nanocomposites phase change materials by different copper nanoparticles and carbon nanotubes and experimentally mentioned that Nano PCM composites showed superior thermo physical properties than without Nano PCM.In the earlier, a lot of researches on nano particle mixed organic materials were conducted instead of inorganic nanoparticles.

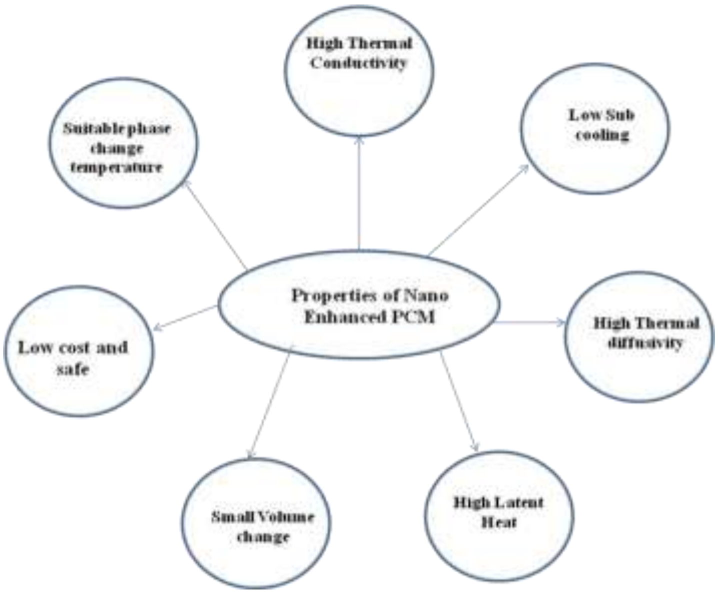

Figure 3 Excellent Characteristics of Nano PCM

4. PREPARATION OF NANO PCM

Water deepness's is inversely proportional to the still output. There are many researches already states that the large surface area of the solar still basin is leads to the high efficient water production. This kind of approach helps to improve the rate of evaporation and decrease the volume ratio of surface of the basin. Using the Phase change materials also slightly increase the production by their unique properties.PCM has a very high absorption phenomenon by comparing other energy storing materials. Kinga Pielichowska et al mentioned that the Thermal storage of the solar still production is comparatively increased by the using of Phase change materials [13].

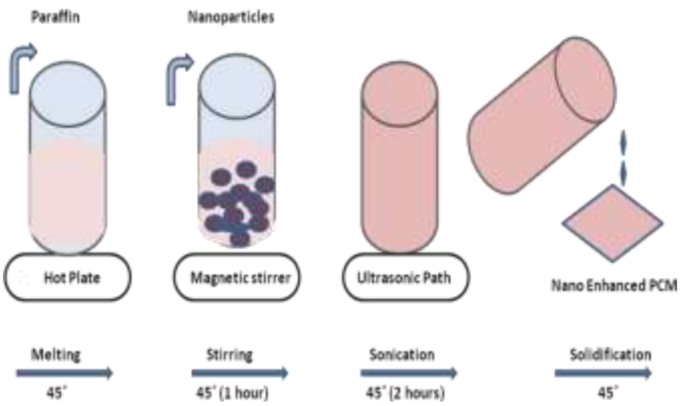

Figure 4 Steps of preparing Nano PCM

Figure.4 is showing the preparation technique of Nano PCM. Paraffin and nanoparticles are stirred around two hours until the segregation of both materials. The prepared material is used in the solar still applications. Mohammed Raza et al prepared the Graphene oxide/paraffin composites and produced the largest amount of fresh water at the day time. The results indicate that the thermal energy storage of PCM increased the distilled water productivity of the solar still. Most recently Omar Bait [20] et al, in their experimental work graphene and metal oxide nanoparticles was dispersed and they studied the changes in the thermal properties. Many experiments prove that the adding of nanoparticles into PCM helps to improve the thermal conductivity, latent heat capacity and phase change temperature[21-23]. Paraffin consists of low thermal conductivity, so the nanomaterials like graphene, ZnO, CuO, MgO and nanocomposites combined with the Paraffin and gives the high thermal conductive behavior to the paraffin Material.

5. CONCLUSION

The thermal conductivity has played a major role in the thermal property of the PCM; paraffin has a comparatively low thermal conductivity then other PCM. The dispersion of the nano composite materials increased the thermal conductivity. The amount of adding nanoparticles determines the efficiency of the fresh water production. The productivity and efficiency of the water desalination is strongly based on the climate conditions, solar radiation and the types of phase change materials. The study also provides properties of paraffin and explains the comparison with nano enhanced phase materials. The Nano PCM was in a stable state in the process of heat transition; there is no chemical reaction between the paraffin and nanoparticles.

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