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Review TMET

Double slope Solar Still by using Nano Embedded Binary Eutectic PCM: A Review

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Abstract

Solar distillation is an economical and eco-friendly technique. Concerns about the increasing need for clean drinking water for home and commercial uses are spreading around the world. In rural and tiny settlements with limited access to water and electricity, solar water distillation is a viable method for removing salty water from drinking water. The efficiency and performance of thermal energy storage materials based on phase change materials (PCM) and nanofluids (NF) are being enhanced by double slope solar stills (DSSS), which have been carefully examined and shown. Concerns about the increasing need for clean drinking water for home and commercial uses are spreading around the world. In rural and tiny settlements with limited access to water and electricity, solar water distillation is a viable method for removing salty water from drinking water. The efficiency and performance of thermal energy storage materials based on phase change materials (PCM) and nanofluids (NF) are being enhanced by double slope solar stills (DSSS), which have been carefully examined and shown. According to the researchers' published results, active solar still designs that use PCMs and nanoparticles could significantly increase production and provide a significant way to address the fresh water shortage. In order to compete with current and emerging technologies, the conclusions from this review will help future researchers choose and incorporate suitable adjustments in the configuration of solar stills using innovative phase change materials (PCMs) with nanomaterial's.

Keywords: Double slope solar still, performance, PCM, water, nano fluids

INTRODUCTION

Fresh drinking water can be produced via solar distillation. Its use is not limited to isolated, desert areas; small towns may also benefit from it. Water usage peaks during the warmer season due to increasing solar insolation. Solar stills are a practical and commonly used means of harnessing solar energy [1].

The blackened bottom of a solar still absorbs the majority of the incident sun energy, making it the hottest element of the system. Convection transfers some of the heat to the basin water, while conduction via the bottom and side insulation loses the remaining heat to the surrounding air. When a dye is added to the water, the water mass absorbs most of the incident radiation; just a little amount of the radiation reaches the basin's absorbing surface. The water in the basin heats up more as a result of this direct heating and the decreased bottom losses. Consequently, adding dye has two unique benefits and leads in a greater output from the still [2].

Two distinct advantages of adding dye to the water in a solar still are that it increases output and increases efficiency:

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1. *Direct Heating Effect:* A large amount of the incident solar radiation is absorbed by dye when it is added to water. The bottom of the basin, which is usually blackened to maximize absorption, receives less radiation as a result. This indicates that the water heats up more quickly because more solar energy is directly absorbed by the water.
2. *Decreased Bottom Losses:* A significant amount of solar radiation is still absorbed by the blackened bottom of the solar cell. Nonetheless, a portion of this energy is dissipated via conduction into the surrounding air and the layers of insulation underneath. Conduction losses are minimized by lowering the quantity of solar radiation that reaches the absorbing surface of the basin by adding dye. As a result, there is less heat loss from the still's bottom, retaining more heat in the system and transferring it to the water.

NANOFLUIDS AND ADVANTAGES

Nano fluids are a relatively new class of fluids made up of basic fluids mixed with nanoparticles (sizes ranging from 1 to 100 nm). Greater heat transmission out of the coolant is made possible by these particles, which are often made of metal or metal oxide. They also raise conduction and convection coefficients [3].

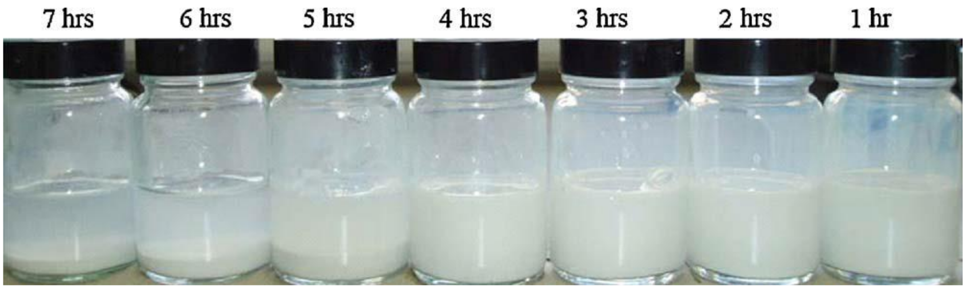

Figure 1. Samples of Al_2O_3 Nano fluids stability change with time [3].

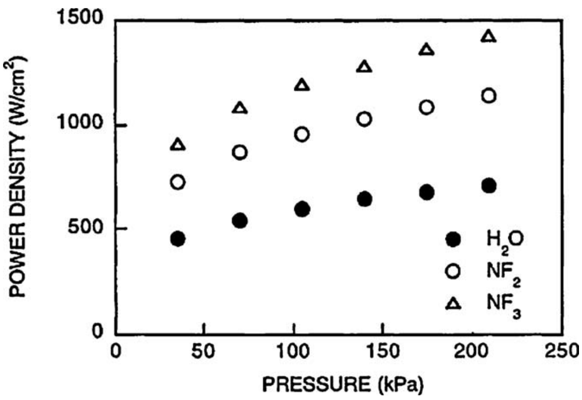

Figure 2. Power density with pressure for Nano fluids and water [3].

Rapid advancements in nanotechnology over the last several decades have given rise to a new class of coolants known as "nano fluids." A suspension of nanoparticles in a base fluid is referred to as a nano fluid. Dilute suspensions of functionalized nanoparticles composite materials were developed approximately ten years ago with the specific goal of increasing the thermal conductivity of heat transfer fluids (Figures 1,2). These fluids have now developed into a promising field of nanotechnology. Examples of common Nano fluids are water-based copper oxide Nano fluids and ethylene glycol-based copper Nano fluids. When it comes to heat transfer applications, these thermal Nano fluids are in a different class altogether from traditional colloids. Compared to conventional solid–liquid suspensions for heat transfer intensifications, nano fluids possess the following advantages [3].

a. Greater surface area for heat transfer between particles and fluids due to the high specific surface area.

b. Particles moving primarily in a Brownian motion with high dispersion stability.
c. Less pumping power needed to achieve the same intensification of heat transfer as compared to pure liquid.
d. Less particle clogging than with traditional slurries, which encourages system downsizing.
e. Modifiable characteristics that can be tailored to specific uses by altering particle concentrations, such as surface wettability and thermal conductivity (Figure 3).

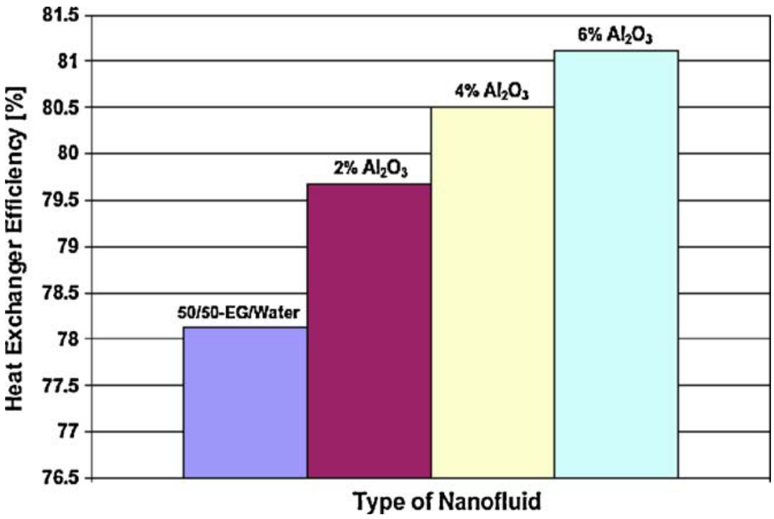

Figure 3. Heat exchanger efficiency of the heat recovery system with various concentrations of Al_2O_3 nanofluid [3].

Table 1. Thermo-physical properties of some nano enhanced PCMs [4].

S.N.	Methods	Purpose
1	XRD	X-ray diffraction techniques are a very useful characterization tool to study crystallographic structure, chemical composition and physical properties of materials and thin films. It can also be used to measure various structural properties of these crystalline phases such as strain, grain size, phase composition, and defect structure.
2	Transmission electron microscope (TEM) and Scanning electron microscope (SEM)	Operated at 20–200 kV was utilized to characterize size, shape and morphological aspects of the as-prepared AgNP
3	Particle Size analyser	It is used to observe the distribution of various sizes of the particles suspended in the base materials.
4	Thermo gravimetry and Fourier-transform infrared (FTIR)	Thermal and Chemical stabilities of PCM were studied.
5	Differential scanning calorimetry	Thermal property analysis including, Phase-change temperature and latent heat characteristics of base and SNOE PCMs was analysed
6	Sonication technique using Ultrasonic vibrator	To ensure the stability of solid NPs suspended in the PCMs.

Both a high specific heat and a high latent heat of fusion are beneficial for energy storage applications. This is due to the fact that a substantial quantity of energy can then be stored during the latent heating phase (during the melt transition) as well as during the sensible heating stage (as the PCM gets closer to the melt point). When choosing a PCM material, there are a few other factors to take into account. After repeated heat cycling with predictable and regular cycles of melting and freezing, the material should demonstrate stability on both a chemical and physical level. Important methods for describing the thermo physical characteristics of nano-enhanced PCMs shown in Tables 1,2.

APPLICATIONS OF PCMs

1. Thermal storage in buildings
2. Solar energy storage

3. Microelectronics cooling using Nano-PCMs in MCHS
4. Smart textiles
5. Medical applications
6. Solar water heating.
7. Thermal storage [5–8].

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Table 2. Application of Nano-Fluids in different temperature [11–12].

Types of Solar Collector	Types of Nano-Fluids	Result	Temperature
Flat-plate solar collector	SiO_2/ethylene glycol (EG)	An increase in Nano fluid concentration from 0 to 1% results in an efficiency enhancement approximately between 4 and 8%	Low Temperature
Direct solar collector	Al_2O_3/H_2O	Particle size has minimal influence on the optical properties of the Nano fluid within a 1% volume fraction. Collector efficiency increases partially with an increase in particle size	
Flat-plate solar collector	Al_2O_3/H_2O	The 0.2 wt% Al2O3 Nano fluid increases the efficiency of the solar collector in comparison with water as the working fluid by 28.3% and by using the surfactant the maximum enhanced efficiency is 15.63% [9–10]	
Parabolic solar collector	Al_2O_3/H_2O	Addition of trace amounts of the nanoparticle considerably improves the absorption characteristic. Improved thermal and optical properties and higher outlet temperature	Medium Temperature
Medium- to high temperature solar thermal collector	Ni/C ionanofluid	The absorbed energy fraction reaches up to almost 100% after the incident light only penetrates the ionanofluid for a distance of 1 cm	High temperature

CONCLUSION

Phase change materials (PCMs) are shown to have substantial advantages over sensible systems as a result of extensive research. These advantages include lower system mass and volume, increased storage density, and reduced energy losses to the environment. These materials have found many applications in various industrial sectors, despite the physical properties of most PCMs requiring the use of additional techniques like microencapsulation to increase the heat transfer area, reduce reactivity with the outside environment, and control volume changes during the phase transition. Due to the combined advantages of high thermal characteristics and latent heat storage of PCMs, nano-PCMs have found use in current energy systems to enhance system efficiency, reduce power consumption, and help reduce greenhouse gas emissions.

Nanofluids are sophisticated fluids that contain nanoscale metallic or non-metallic particles in a colloidal solution within another fluid. Nanofluids are utilized as working fluids in solar energy systems, as a coolant in electronic equipment microchannels, and as a storage medium in thermal storage systems. The addition of nanoparticles improves the thermophysical and thermal transport characteristics of nanofluids, such as thermal conductivity and heat capacity, according to experimental and computational research. A test should be conducted to determine the ideal volume fraction since the nanofluid concentration (volume%/weight%) also significantly affects the enhancement of heat transmission. It is also evident that the size of the nanoparticles affects the solar collector's effectiveness; thus, further research is necessary to determine how the size of the nanoparticles affects efficiency.The expense of nanoparticles, their synthesis, instability, and agglomeration problem—which could lead to an increase in pumping power—remain our biggest obstacle, though.

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