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A Review of Nano Fluid Role to Improve the Performance of the Heat pipe Solar Collectors

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Abstract

This paper gives a comprehensive review about the recent advances related with the application of the nano fluid in the heat pipe solar collectors. Papers reviewed including theoretical, numerical and experimental up to date works related with the nanotechnology applications in this type of the solar collectors. A lot of literature are reviewed and summarized carefully in a useful table (Table 1) to give a wide overview about the role of the nano fluid in improving the heat pipe solar collectors. It was found that the use of the nano fluid in the heat pipe solar collectors can play a significant role in increasing the efficiency of these devises.

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1. INTRODUCTION

Solar energy is considered nowadays as one of the most important sources of clean , free and renewable energy with minimum environmental effects. After industrial revolution (1970s) energy consumption increased sharply ,so threat of energy shortages led scientists to find new sources of energy. The solar energy is widely believed to be the most sustainable form of energy among another renewable energy sources. By mid of the 21st

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century, renewable sources of energy could account for 60% of the world's electricity market and 40% of this market are come for fossil fuels [1-2]. The solar energy can be defined as the energy which comes from the sun and can be converted into electricity and heat. Solar energy is a natural result of electromagnetic radiation released from the Sun by the thermonuclear reactions occurring inside its core. It has produced energy for billions of years, so the utilization of solar energy has received significant attention especially in the last ten years [3-4]. For example, some studies have indicated that about 1000 times from the global energy requirements can be achieved by using solar energy ; however, only 0.02% of this energy is currently utilized [5]. The main reasons of this huge attention in the solar energy applications are due to the increased demand of energy , limited availability of fossil fuels and environmental serious problems related with them especially the carbon dioxide emissions. From the other side , the huge increase in the human population can be considered as an extra serious problem [6]. In fact , the sun radiates every day , enormous amount of energy and the hourly solar flux incident on the earth's surface is greater than all of human consumption of energy in a year [7]. In spite of this huge amount of available solar energy, approximately 80% of energy used worldwide still significantly comes from fossil fuels [8]. Recently , one of the future projections is to reduce global carbon dioxide (CO_2) emissions by 2050 to 75% of its 1985 level if we can improve and use the solar energy equipments such as the solar collectors**.**

2. NANOFLUID : A GROWING FIELD.

Nanofluids can be defined as a solid-liquid composite materials consisting of nanometer sized solid particles, fibers, rods or tubes suspended in different base fluids. Some examples of nanoparticles are pure metals (Au, Ag, Cu, Fe), metal oxides (CuO, SiO_2, Al_2O_3 , TiO_2, ZnO, Fe_3O_4), Carbides (SiC, TiC), Nitrides (AlN, SiN) and different types of carbon (diamond, graphite, single/multi wall carbon nanotubes). Classical liquids, such as water, ethylene glycol and engine oil are some examples of base fluids. Choi [9] from Argonne National Laboratory in Unites States was the first person which was invented this fluid in 1995. He observed experimentally that the addition of high thermal conductivities metallic/non-metallic nano- particles into the base fluid was increased the thermal conductivity of these fluids dramatically and thus enhancing their overall heat transfer capability . For example, the thermal conductivity of copper at room temperature is about 700 times greater than that of water and about 3000 times greater than that of engine oil [10]. Nanofluid was used for various industrial applications. Some of these applications including nuclear reactors, transportation industry, electrical energy , solar absorption and biomedical fields [11-12]. Nanofluid have a good properties of radiation absorption and it has a high thermal conductivity. For example, the thermal conductivity at the room temperature of individual multi-walled carbon nanotubes (MWCNTs) were found to have values greater than 3000 W/ m.K [13]. Moreover , Assael et al. [14] indicated that about 1% volumetric fraction of MWCNT was enhanced the thermal conductivity of water by about 40%. In order to prepare nanofluids by dispersing nanoparticles in a base fluid, a proper mixing and stabilization of the particles is required. The size of nanoparticles is very small and in the range of 1–100 nm. It is highly recommended not to add large solid particles in the base fluids (more than 100 nm) due to the following main problems [15] :-

1-The classical millimeter or micrometer-sized particles sediment quickly in the fluid and forming a layer on the surface. This fouling layer reduces the heat transfer effectiveness of the fluid.

2- Existence of large solid particles require a large pumping power and this increases the cost.

3-The pressure drop in the fluid increases considerably due to the high increase in the viscosity.

4- The large size of the particles in the classical suspensions does not work with the emerging "miniaturized" devices because they can clog the tiny channels of these devices.

Therefore , nanofluid can be used efficiently to solve these drawbacks , since it has many features such as :-

1- High effective thermal conductivity.

2- It has a very small size , so it fluidizes easily inside the base fluids and can be moves faster inside solid blocks such as the porous media.

3- High specific surface area.

4- Small concentration of the particles helps the fluid to stay in its Newtonian behavior.

5-Viscosity, specific heat , thermal conductivity and density can be varied easily by changing particle concentrations to be suitable with different engineering applications [16].

6- Low pumping power [17].

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