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Review: Enhancing efficiency of solar thermal engineering systems by thermophysical properties of a promising nanofluids

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ABSTRACT

Unique properties of nanofluids as an absorber fluid, due to the smaller size of nanoparticles, which cover a larger surface area, make a bulkive evolution in heat transfer. Thermophysical properties of nanofluids are increased due to the potential of the nanoparticles surface area increased which is suspended in the conventional fluid. The initial parameter of thermophysical properties which is thermal conductivity (k) enhanced by some parameters like Brownian motion, interface resistance, morphology of suspended nanoparticles and aggregating in nanofluids are reviewed. In the present review paper, we have also mentioned the synthesis of nanofluids by various techniques; methods of stabilization, stability measurement techniques, and thermal conductivity and heat transfer properties, theoretical models of thermal conductivity and their applications are summarized.

1. Introduction

Renewable energy sources such as solar energy, reducible fossil fuel gas and oil reserves, which are turning out to be more cost effective and hard to discover. It likewise diminishes our support on imported fossil powers, enhancing our energy security. Solar energy is considered as a serious source of energy for many years because of the vast amounts of energy that is made freely available, if utilized by modern technology. Solar energy performs the earth is around $4{\times}10^{15}$ mW and it is 200 times more than the general use. At the point when the solar energy consumed by solar aggregator, it is converted into thermal energy [1,2].

The most efficient absorbers have a selective surface coating to reduce energy loss through heat emission of the solar radiation into heat and to converse of a high proportion, simultaneously reducing the emission of heat. Essential liquids, for instance, water, ethylene glycol, and thermal exchanger oil expect a fundamental part in various mechanical strategies such power era, heating or cooling forms, chemical processes and microelectronics. Be that as it may, these liquids have generally low thermal conductivity and in this manner can't achieve high thermal trade rates in building thermal engineering devices. A way to cross this barrier is using ultra fine solid particles suspended in common fluids to improve their thermal conductivity. The suspension of nano-sized particles (1–100 nm) in a conventional base liquid is known as a nanofluid. For example convectional fluid ethylene glycol has thermal conductivity 0.258 (W/m K) and Lee [3] reported that suspension of 4% volume CuO of 35 nm particles in base fluid ethylene glycol noted 20% increase in thermal conductivity.

Choi [3] made the principal calculated thermal conductivity of nanofluid Contrasted with ordinary fluid and traditional two-phase mixture, the nanofluid has higher thermal conductivity, relies on upon numerous variables, for example, particle volume fraction, particle material, particle size, particle shape, base fluid material and temperature [4]. Methods for increasing the heat transfer rate with respect to the temperature difference between the object and the environment, respective this the convection heat transfer coefficient increasing, or the surface area of the object increasing [5].

One of the methods to cross this barrier is to enhance the thermal conductivity and thermal features of coolants operators using nanofluid with higher thermal conductivity. Utilization of nanofluid to increase the thermal efficiency of a conventional solar powered engineering system is getting enormous consideration among mainstream researchers. Nanofluids are denoted as the dispersed of solid nanoparticles (metal or metal oxide) in the fluid and have vast attention recently because of the potential as high performance heat transfer fluids in electronics cooling and automotive [6]. This interest begins with the work of thermal conductivity enhancements of common heat transfer fluids such as ethylene glycol, water, oil, and small addition of solid nanoparticles. Solar collectors have been broadly used to enhance the

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operational fluid temperature within the range of 30–170 °C [7]. The performance of a solar collector depends on the absorption of solar radiation, which then in the form of absorbed energy and it is transferred to the working fluid inside the pipes of the solar collector and enhancing its efficiency [8]. The objective of the current research is mainly focused on theoretical and experimental studies to answer the following question, "How different parameters of nanofluid do affect thermal conductivity?" Many researchers are working to build a structural model or doing experiment that can help to explain the relation between thermal conductivity of nanofluids and co-related parameters. In our review, we will also discuss given below points in detailed.

1. The thermal conductivity enhancements for nanofluids will be impacted toward multi-faceted variables including that volume fraction of the suspended NPs, the tried temperature, that thermal conductivity of the base fluid, the size of the NPs and shape of particles, that pre-treatment process, and the additives of the liquids. The impacts from claiming these factors would exhibit in this survey.
2. Nanofluids have great potential for thermal management and heating transfer based on that variety of applications like micro-electronic mechanical systems (MEMS), electronic cooling and spacecraft thermal applications. And conjointly counselled for nanofluid design and engineering for industrial applications as a heat transfer fluid.
3. Mostly heat transfer usage in solar collectors is one of the key issues in energy saving, energy transfer, compact designs and different operational temperatures. However, the efficiency of solar thermal systems is limited by the absorption properties of the working fluid and heat transfer issue. This technology has been combined with the emerging nanofluids technologies prepared by liquid-nanoparticle suspensions as a nanofluid.

Therefore, it is necessary to enhance the strength and functions of the solar thermal engineering systems by heat transfer from solar collectors to storage tanks with the help of nanofluid. The energy applications point of view, two remarkable properties of nanofluids are characterised, one is the thermo-physical properties of nanofluids, enhancing the high temperature transfer by nanofluid and another is the application of nanofluids in solar collector as a well-established technology, and it lights up new way of applications. Nevertheless, the efficiency of these collectors is limited by the absorption and thermal properties of the operating fluid. This applied science has been blended with the emerging nanofluids technologies prepared by liquid-nanoparticle suspensions because of the size emerging and good heat transfer rate. This highlighted ways many thermal engineering systems are improved by using nanofluids and this can be applied to improve heat transfer rate of the fluid.

2. Nanofluids – promising absorber

Conventional fluid containing micro-meter sized particle and nanofluid containing nanometer sized particles. For nano-particles surface-area to volume ratio is 1000 times larger for particles with a 10 nm diameter than for particles with 10 µm diameters [9]. The larger surface areas of nanoparticles are relative to micro-meter particles increases heat transfer capabilities and increase stability of the suspension [10]. Nanoparticles have large total surface area and have great potential for heat transfer application. Nanofluid has distinctive characterization than conventional liquid in view of ultra-high thermal conductivity, ultra-fast heat transfer ability, the very high rise in viscosity of the base fluid, increased lubrication; reduce the friction coefficient, extreme stability and bulk transfer enhancement [11,12].

3. Methodology

Nanofluid synthesis is the main step in experimental studies of applying Nano phase particles to enhancing thermal conductivity of the Nanofluids. It is not only a mixture of liquid-solid suspension, but important factors are the long term stable suspension, low aggregation of particles, negligible or minimal change in the chemical properties of fluids and reproducibility. The change in pH suspension or the use of surface activator or dispersion are often done to change the surface properties of suspended particles and suppressing formation of particles cluster to obtain a stable suspension [13]. Nano fluids have been produced by two techniques, One-Step Method (Single step method) and Two-Step Method.

One-step method makes and disperses the nanoparticle directly into Base Fluid. Two-step method starts with nanoparticle synthesis by one of the physical or chemical techniques and then dispersing them into conventional fluid.

3.1. One-step method

A one-step technique is preferable to the two-step process to prevent oxidation of the particles. In this technique nanoparticles are synthesized and dispersed in a base fluid in a single process. This technique involves nanoparticle source evaporation and then deposition of the evaporation into a conventional fluid has been useful to produce non-agglomeration nanoparticles in uniformly dispersed and stably suspended in any base fluid [14]. With this method the nanoparticles are produced by heating the solid materials from an electrode of sparking and then condensing into liquid in a vacuum chamber to form nanofluids. In this method advantages are drying, storage, transportation and dispersion of nanoparticle neglected. So the agglomeration of nanoparticles is decreasing and the stability of fluid increases, but disadvantage of this method is that only low vapour pressure fluids are favourable with this process. These limits restrict application of the method [15]. The disadvantage to this method is that the volume concentration of suspended nanoparticles in fluid and quantities of nanofluids can be produced are much more limited than two-step method and producing nanofluids by this process is so expensive.

3.2. Two-step method

The two-step method for preparing Nanofluids is a the process started with nanoparticles, nano fibres or nanotubes is first produced as a dry powder by inert gas condensation, chemical vapor deposition, mechanical alloying or other suitable techniques of particles and then dispersed in a fluid in a second process step [16,17]. As the production of nanoparticles and its dispersion are two separate stages, the nanoparticles get agglomerated in both steps, especially in the process of drying, storage and transportation of nanofluids. This agglomeration is due to attractive van-der-Walls forces between nanoparticles and then Agglomerate particles tend to quickly settle out of liquid [19]. The agglomeration not only affects settlement and clogging of micro channels, but also decreases the thermal conductivity. Some techniques such as ultrasonic agitation or the addition of surfactants to the fluids are often used to minimize particle aggregation and improve dispersion behavior and stability [18]. But important problem is the stabilization of the suspension prepared and tonnage quantity production of nanofluids, if the agglomeration problem overcomes.

4. Stability of nanofluid

The agglomeration of nanoparticles influences the settlement and obstructing the micro channels. Furthermore, it diminishes the thermal conductivity if nanofluids [20]. Nanofluids lose their capability to exchange heat because of an inclination to coagulation. Stability of nanofluid can be