Proceedings of the 3rd Faculty of Industrial Technology International Congress
Bandung, Indonesia, October 28-29, 2021
ISSN

Performance Enhancement of PTSC by Using Mono and Hybdrid Nanofluids

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Abstract. The parabolic trough solar collector (PTSC) is one of the most reliable solar thermal technologies. Thermal energy is collected from solar radiation at a certain point. PTSC consists of a reflecting surface, an absorber tube, and working fluid. Solar radiation raises the enthalpy of the fluid inside the tube and increases the temperature of the tube wall. The aim of this study is to improve the thermal efficiency of PTSC by enhancing the working fluid. Furthermore, heat transfer analysis was used to investigate the performance of PTSC. The heat transfer performance is improved by using nanofluids (NFs) rather than convectional heat transfer fluids (oil, water, and ethylene glycol). Mixing nanoparticles into the fluid is an efficient way to improve the thermo-physical properties of NFs, such as thermal conductivity, density, and specific heat capacity. Therefore, the thermal conductivity increases with increasing solid volume fraction, which could raise the heat transfer coefficient. Furthermore, comparing the effects of using mono and hybrid NFs on thermal efficiency for better heat transfer.

INTRODUCTION

Energy efficiency is a major problem within our modern society due to recent environmental issues such as water pollution, air pollution, climate change, and global warming [1, 2]. Alternative energy sources such as solar, geothermal, [3, 4], wind, and biomass have been used recently to reduce pollution and inadequate fossil fuel supply [5]. Thus, developing and using renewable energy sources, such as solar energy, is critical [6]. In the past few years, solar energy research has demonstrated that it can be transformed into thermal energy using trough collector systems and solar concentrators, and subsequently into electrical energy using a steam turbine [7].

The advantages of new heat transfer fluids lead researchers to view them as a feasible choice for heat transfer enrichment in solar energy systems. Many researchers have studied solar energy, focusing on the ability to produce energy from solar radiation intensity and the benefits of solar energy synchronization with other direct and indirect applications such as heating [8]. The parabolic trough collector (ptc) is one of the most extensively used solar power systems to create high and medium temperatures with high efficiency. In 1870, johan ericsson invented a 3.25 m^2 parabolic collector called a "straight steam generator" to produce 373 w of electricity [9].

A solar collector is a device that converts solar energy into heat (fluid or air). It can then be used for hot water or to enhance heating systems. Solar collectors are heat exchangers that convert solar radiation into heat energy [10, 11]. The parabolic trough collector is ideal for generating power at temperatures as high as 400 °c [12].nfs are a new heat transfer fluid that can be used to improve heat exchanger performance in solar systems. One of the most significant technologies for improving the thermal performance of solar collectors is the use of nfs as working fluids [13]. Nfs are made by mixing working fluids such as water or thermal oil with nanoparticles. Some of the most common nanoparticles are cuo, al_2o_3, al, sio_2, cu and tio_2 [14].

Using these nanoparticles increases the flow thermal conductivity and thus the heat transfer rate from the hot tube to the working fluid. This article clarifies the use of nfs in ptc. To evaluate the use of nfs in solar systems, heat transfer and performance enhancement in solar thermal collectors must be precisely determined. Many studies have been done on nfs in heat transfer applications, especially solar collectors.

Metallic and nonmetallic nanoparticles were inserted into several base fluids at varying amounts. According to olia et al., 40% of the research used aluminum oxide (al_2o_3) nanoparticles to improve ptc thermal performance, while other nanoparticles (cuo, tio_2, fe_2o_3, etc.) Exhibited lower interest for the researchers. Hybrid nfs have many advantages for heat transfer applications. Hybrid nfs have shown good thermophysical characteristics, long-term stability, and heat transmission rate.

According to studies, using nfs in ptscs improves their thermal and optical properties. This review study investigates the effects of factors on performance, such as selection of mono and hybrid nanomaterials on base fluids, effect on thermophysical properties, and application of nfs inside ptsc technology.

PREPARAING OF NANOFLUIDS

NFs Preparation is the first step in doing nanofluid (NF) experiments. There are two primary methods for preparing nanofluids: the 1-step method preparation process and the 2-step method preparation process.

One-Step method

The one-step process involves creating and dispersing the particles in the fluid simultaneously. This approach avoids the dispersion, transportation, storage, and drying of nanoparticles, thereby minimizing nanoparticle agglomeration and increasing the stability of fluids [15]. So, this method can produce uniformly dispersed nanoparticles stable in the base fluid [16]. The various morphologies are affected and determined by the dielectric liquids' thermal conductivity properties.

Due to the inability of the one-step physical technique to synthesize NFs on a large scale and its expensive cost, the one-step chemical method is rapidly developing. The pulse wire evaporation technology is used to create NF. The apparatus includes capacitors, a high voltage DC power source, a gap switch, and a condensation chamber. By delivering a high voltage pulse (300 V) over a tiny wire, the wire evaporates and transforms into plasma in microseconds. The plasma is subsequently condensed into nanopowder by the inert gases Ar and N_2. The NF is then cascaded into the pulse wire evaporator's exploding container and combined with the nanosized powder to form a hybrid NF. This approach is ideal for making low-cost NFs [17].

Two-Step method

The first step in this process is to produce a dry nanoparticle powder. The two-step preparation approach involves combining base fluids with commercially available nanopowders generated by mechanical, physical, and chemical procedures such as grinding, milling, vapor phase methods, and sol-gel [18].

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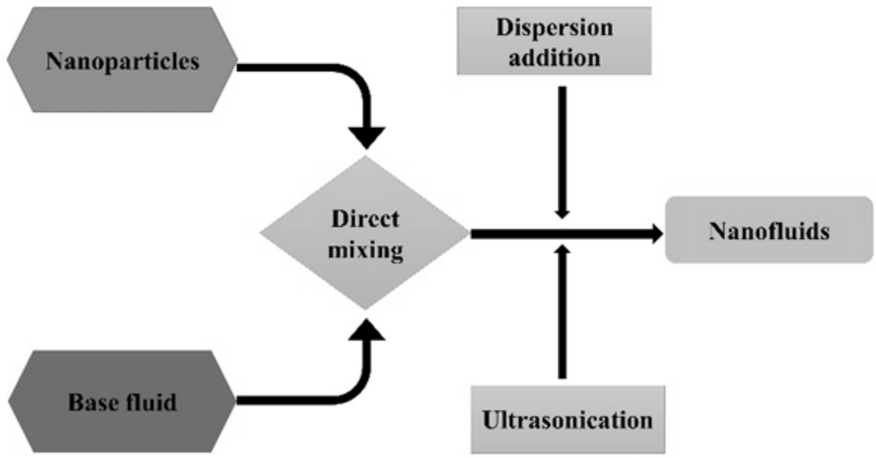

FIGURE 1. Two-step preparation process of NFs.

It is commonly done by compressing the solid sample, evaporating it with noble gases, and mixing it with the base fluid. Generally, nanopowders are stirred with host fluids using an ultrasonic vibrator or a higher shear mixing device. Ultrasonication or stirring on a frequent basis is essential to prevent particle agglomeration [19].

As strong Vander Wall forces limit particle attraction before complete diffusion in the fluid, this approach results in agglomeration and sedimentation. So, to resolve this issue, ultrasonic waves, NF exposure, pH adjustments, and surfactants were utilized. Figure 1 shows the two-step procedure that is most commonly used.

Thermophysical Properties

To analyze the thermal framework of mono and hybrid NFs, detailed thermophysical data is required. The amount of nanoparticles added to the base liquids affects their thermophysical properties. Considering the thermophysical properties of NFs, it is predicted that nanoparticles are continuously dispersed in the base fluids [20]. Their properties include thermal conductivity, viscosity, specific heat, and density [21]. However, the heat transfer coefficient and pressure drop are also important parameters to consider.

These properties depend on nanoparticle shape and size, volume concentration, surfactant, and so forth. The thermal conductivity of a liquid is directly connected to its heat transfer capacity without affecting the flow, pressure drop, or pumping power of nanoparticles in a fluid medium [22]. Fig. 2 shows several factors affecting NF thermophysical properties.

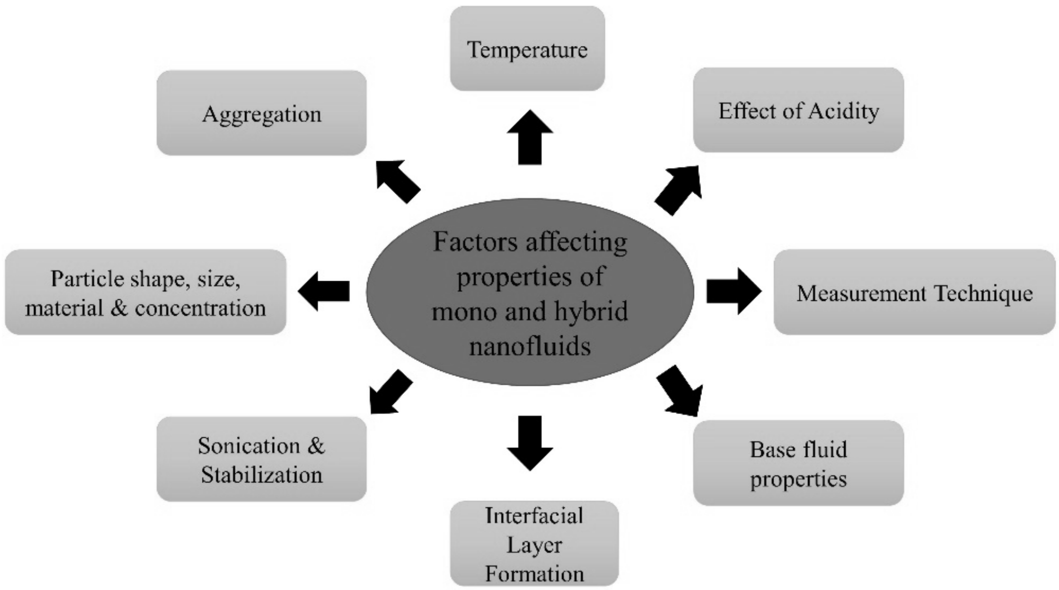

FIGURE 2. Factors affecting of the thermophysical properties of mono and hybrid NFs.

Thermal conductivity

NFs are produced by combining two or more types of nanoparticles into a base fluid to improve thermal conductivity [23]. The size of nanoparticles affects the thermal conductivity of NFs. The researchers studied the effect of particle size on NF thermal conductivity.

The results show that smaller particle size increases the thermal conductivity of NFs. The thermal conductivity of NF improves with increasing temperatures. However, to improve thermal conductivity, the NF must be enriched with chemicals like surfactants [24].

Viscosity

Viscosity is a fluid's resistance to shear or longitudinal deformation. Fluids are classified as Newtonian or non-Newtonian. A Newtonian fluid has a shear stress proportional to the deformation rate under constant pressure and temperature, but non-Newtonian fluids have a viscosity proportional to the shear rate [25]. Because of the NF suspension structure, viscosity plays an essential role in the NF framework's design, with major effects on the pressure drop of flow. In order to use NFs in various applications, their viscosity increase relative to their base fluid must be investigated and evaluated. NFs usually have a higher viscosity than their base fluids [26].

Furthermore, for NFs' use in various applications, the augmentation of the NFs' viscosity compared with their base fluid must be entirely explored and analyzed. NFs usually have enhanced viscosity compared with their basic fluids [27].

Specific heat capacity and Density

The size of nano particles affects the mono and hybrid NFs' specific heat and reduces their specific heat. In addition, smaller particles have more surface atoms than larger particles, implying greater specific heat [28]. Thus, the higher heat capacity of smaller particles can be explained by the bigger number of the surface atoms.

The density of NF improved with the volume concentration of nanoparticles in the base fluid and decreased with temperature. Agglomeration arises when the density of nanoparticles in the base fluid is not sufficient [29].

PERFORMANCE ANALYSIS OF PTSC

The PTSC is formed of several constituent parts and the fluid that flows through it, all of which influence the collector's performance. The PTSC consists of an absorber tube covered by a glass tube fitting at the trough's focal line [30]. Absorber tubes are made of copper or stainless steel and have high absorbance and low emittance. It is covered with a highly absorbent coating to improve performance [31].

The overall efficiency of the PTSC system is based upon two major factors, i.e., the thermal and optical efficiency of PTC, as shown in figures 3 and 4.

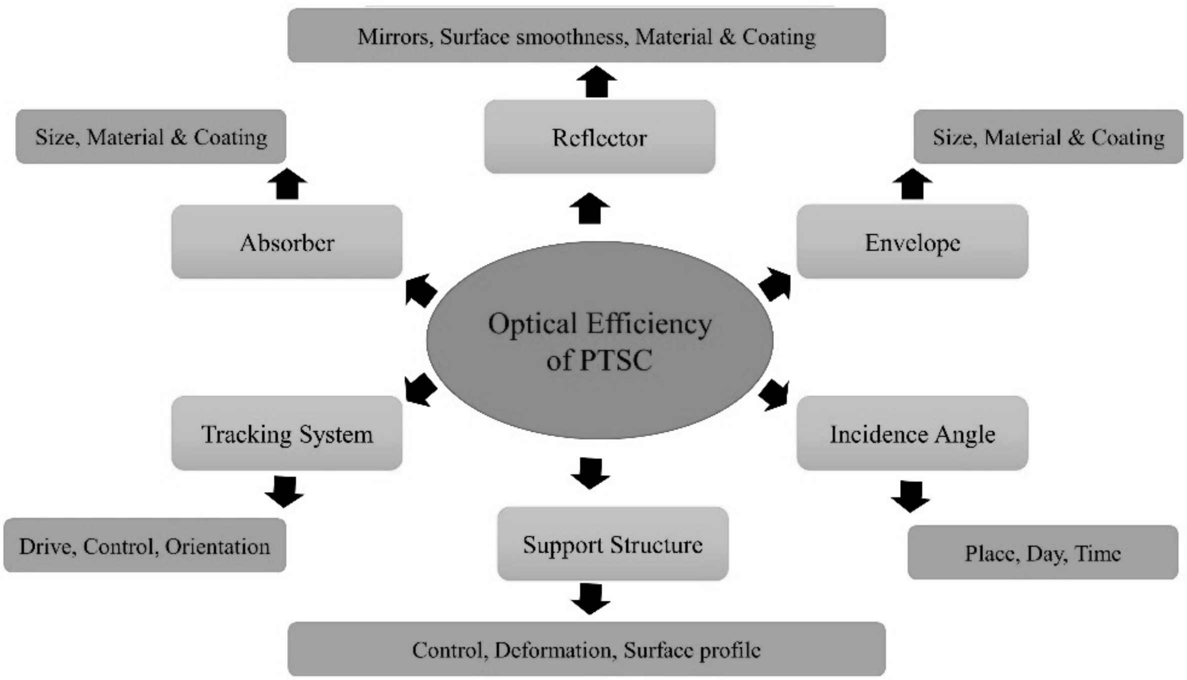

FIGURE 3. Factors affecting the optical efficiency of PTSC.

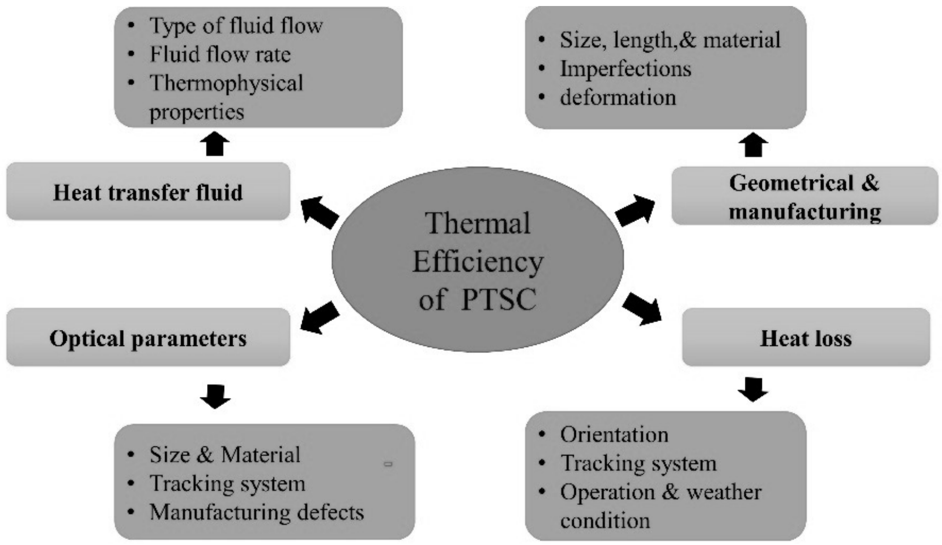

FIGURE 4. Factors affecting the thermal efficiency of PTSC.

CONCLUSIONS

The research reviewed the behavior of mono and hybrid nanofluids in PTSC. This review's findings are as follows:

- The arrangement of two ways, one-step strategy, is useful for creating advanced and stable NFs. A two-step technique is appropriate for mono and hybrid NFs.
- Agglomeration reduces nanofluid heat transfer. This affects the Brownian motion of nanoparticles, reducing their thermal performance.
- Hybrid nanofluid has better thermal conductivity than monofluid. The thermal conductivity of nanoparticles is affected by their morphology (size and shape). The concentration of nanoparticles in NFs with smaller particle sizes is greater than in those with larger ones at constant concentration.
- The viscosity of nanofluid increases with nanoparticle volume concentration and decreases with temperature. As the viscosity of the base fluid decreases, the thermal conductivity and heat transfer rate increase.

ACKNOWLEDGMENTS

This work was supported by the Stipendium Hungaricum Programme and by Doctoral School of Mechanical Engineering, Hungarian University of Agriculture and Life Sciences.

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