Dr. Nikhilesh Sil, 2025, 13:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

Enhancement of the Solar Energy System via Nano Fluid

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Abstract- Utilization of solar energy increased day by day due to the scarcity of natural resources such as fossil fuel (coal, oil, and natural gas) and the emission of Carbon dioxide (CO2)). Sun is the most important source of renewable energy on the earth as it is available free of cost and it is free of greenhouse gas such as carbon dioxide. Solar energy can be used for producing electricity, heating, cooling, and detoxification. It can be stored for future use also. But there is a problem in the proper utilization of solar energy and heat transfer process of the solar energy system. To overcome this situation the researcher designed the solar energy system in such a way that it can increase the heat transfer process. It is observed that solar energy system can be improved by the use of nano fluids. Nano fluid is nothing but the mixture nanoparticle together with the base fluid, which can store the solar energy and can be used in future. The major aim of this review article is to develop the renewable energy with the help of nano fluids and accelerate the production of renewable energy in several solar thermal systems.

Keywords- Renewable Energy; Nanoparticle; Nano Fluid; Solar Collector; Thermal System.

I. INTRODUCTION

Over the past several decades, the use of solar energy has grown steadily. Fossil fuels and other petroleum products are becoming more and more expensive due to the shortage of petroleum derivatives. The need for energy rose due to the world's population expansion and industrialization. The usage of petroleum products is growing in developing nations as their social and economic structures develop, but the amount of petroleum available is decreasing daily [1, 2, 3, 4, 5]. Furthermore, by 2040, energy consumption is predicted to rise by 33%, per the "Global Energy Report-2018" [6].In a single year, the amount of solar energy received by the earth's surface surpasses that of the sun. The amount of solar energy received by the earth's surface is enormous, and in a single year, it surpasses the combined energy from all known sources, including coal, oil, natural gas, and uranium. For a year, Earth receives around one hour more energy from the sun than the other planet. Therefore, renewable energy sources including solar, wind, hydro, geothermal, etc. are receiving increased attention from the government and researchers [7, 8, 9, 10, 11, 12]. Carbon dioxide (CO2) emissions and the use of fossil fuels (coal, oil, and natural gas) have grown significantly in the past few decades. Burning conventional fossil fuels (coal, oil, and natural gas) releases carbon dioxide (CO2), a heat-absorbing gas or greenhouse gas. Fossil fuel use rose from 3701.5 million tons in 1965 to more than 13511 million tons in 2017 [13]. In Figure1, consumption of fossil fuel is illustrated. Almost 84% of the energy is derived from fossil fuels. The use of fossil fuels has decreased recently (Figure 2), the overall amount consumed is around 128,550 terawatt-hours [14]. Between 1940 and 2020, carbon dioxide (CO2) emissions from industry and fossil fuels rose significantly, reaching a record high of 36.7 billion metric tons in 2019. In 2020, carbon dioxide (CO2) emissions fell 5% to 34.81 billion metric tons during the pandemic caused by the COVID-19 outbreak [15] (Figure 3). This contributes to global warming. These days, renewable energy is becoming increasingly significant due to the negative effects of greenhouse gases [16]. Solar, wind, hydro, tidal, geothermal, and biomass energy are just a few of the numerous renewable energy sources. By 2024, the International Energy Agency (IEA) projects that 30% of the world's electricity would come from renewable sources, up from 26% at the moment [17]. 60% of the global electricity market and 40% of the direct fuels market may come from renewable energy sources by the middle of the twenty-first century [18]. Furthermore, the advantages of sustainable growth that come with shifting to an economy that relies heavily on renewable energy cannot be quantified in conventional economic terms. Due to its free availability, the sun is the most dependable energy source on the planet. Electricity generation, heating, cooling, and purification are all possible with solar energy. Additionally, it can be saved for later use [19, 20, 21, 22, 23].The production of solar energy is expanding quickly as a result of its many uses.However, there is an issue with the solar energy system's heat transmission mechanism.High heat losses are occurring and the flux density of conventional solar collectors is limited. We must build the solar energy system to enhance the heat transfer mechanism in order to get over these problems.

Many researchers have spent the last few decades working to enhance the process of using solar energy. They have said that the application of nanofluids can enhance solar energy systems. Researchers suggested in 1970 that particle suspensions in liquids are required for direct absorption of solar energy [24, 25, 26]. Total solar energy is not absorbed by common solar fluids as water, ethyleneglycol, propyleneglycol (PG), etc. [27]. On the other hand, adding nanoparticles to the base fluid can improve the solar system's efficiency and heat transmission mechanism. The term "nano fluid" refers to a mixture of nanoparticles and base fluid [28].

A uniform mixture of nanoparticles in a basic fluid, ranging in size from 1 to 100 nm, is called a nano-fluid. In contrast to base fluids, they have improved thermo-physical characteristics [29]. When nanoparticles are added to a base fluid, the fluid's radioactive heat transfer properties [38] and thermo-physical [30, 31, 32, 33, 34, 35, 36, 37] mass diffusivity can be improved significantly.

A novel technology called a direct absorption sun collector (DASC) was created to overcome the drawbacks of conventional solar collectors, which transfer solar energy directly to a fluid medium, hence lowering the concentrated heat at the surface [39].

We attempt to give an overview of the advancements in renewable energy using nanofluids in this article. We also go over a number of techniques, including DASC, PCM, and ETSC, to increase the solar energy system's efficiency in the future.

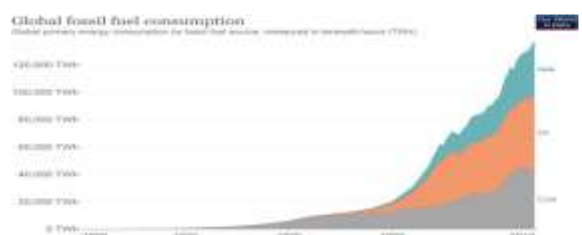

Figure 1: Consumption of fossil fuel worldwide from 1800-2019 [29]

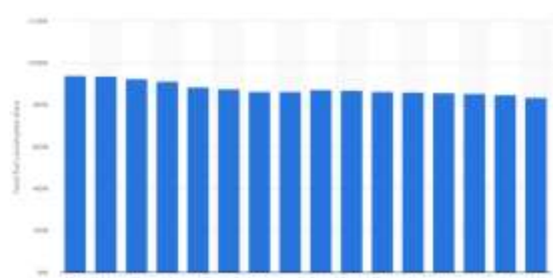
Figure 2: Consumption of fossil fuel worldwide from 1965 to 2020 [30]

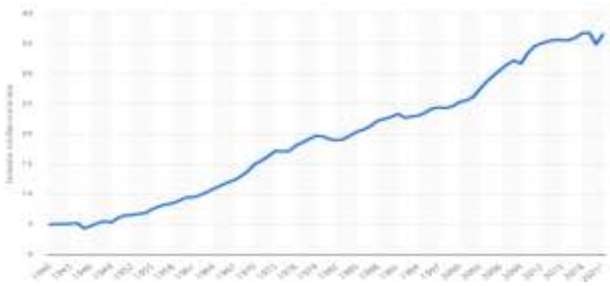

Figure 3: Annual CO2 emissions worldwide from 1940-2020 [32].

The Application of Nano Fluids

A novel technology is the use of nano fluids as a working medium for solar collectors. A detailed examination of radiation-based heat transfer of nano fluids is difficult due to their small size and physical characteristics. Numerous researchers devoted their time to address this intricate physics [40, 41]. In addition to increasing mass diffusivity and thermal conductivity [41, 42, 43, 44], adding nanoparticles to a base fluid also improves the fluid's other physical characteristics. The application of metallic nanoparticles greatly broadens the absorption spectrum and, while maintaining a distinct absorption peak, increases the absorption efficiency through the solar spectrum, which is one of the special advantages of nano fluids [45]. The efficiency of direct absorption solar collectors is restricted by the working fluid's absorption qualities, which are extremely low for typical fluids used in solar-collectors [45]. Direct absorption solar collectors have been proposed or suggested for a variety of applications, including water heating and electric power in inclement weather where conventional solar cells fail. Still, it is a weak absorber; it absorbs 13% of the energy. Our primary goal is to use this as a renewable energy source, so we add a few more characteristics. For example, adding tiny particles scatters incident radiation, increasing fluid absorption and improving collector efficiency [46]. The benefit of employing a particle-based fluid mechanism is that incident radiation is scattered by the tiny particles, which may result in greater radiative absorption. It is observed that when nanoparticles are present, incoming radiation increases more than nine times than that of pure water [47]. Similar to other recent innovations and study areas, nano fluids show improved heat-absorbing and heat-transport mechanisms. In light of earlier research, the functioning of nanofluids applied to the solar system is examined, along with the differences in performance and features between the solar system with and without nanofluid application. Recent findings and studies on the use of nanofluids in PV/T systems have also been coming together. Furthermore, it is reasonable to expect that it could improve the solar energy conversion process's overall performance [48]. A key component of the DASC method is the PV/T system, which uses the solar radiation system's light and heat to generate hot fluid and energy. PV/T systems are expanding quickly, and there are more ways to improve modeling, lower costs, boost overall efficiency, and keep the system operating for extended periods of time while using them for the right applications [49, 50].

Experimental Nano-fluids used

Their experiment has been studied in [1, 30, 45], and we can say with confidence that the findings are crucial for future study on renewable energy. We learned from this that for all nano fluid studies, a reflective aluminium tape was applied to the collector's rear surface. However, there was an experiment involving pure water that was reflecting. Additionally, the collector was tested by painting the copper plate a matte black colour. Additionally, the collector was tested by painting the copper plate a matte black colour. The fluid depth was regulated using a 150 m^1 thick metal spacer. A SuperPAR64 lamp was used to measure the sun spectrum at a height that allowed for the measurement of 1000 W/m2 of incoming radiative flux on the collector. A good approximation of the solar spectrum was obtained by measuring the lamp's spectrum at a colour temperature of 3158 K.A few fundamental procedures are needed, include mounting three T-type thermocouples to measure the fluid's input and exit temperatures and taking a temperature reading of the copper plate halfway between the inlet and outflow ports. To reduce heat loss from the collector's sides and back, the entire system was enclosed in a Styrofoam block. To prevent the Styrofoam block from absorbing any of the simulated sunshine, metal was used to protect it from incident radiation. Then, in accordance with the experiment described in the publication, nanoparticles of different sizes, shapes, and materials were suspended in de-ionized water to create nano fluids. It goes without saying that altering the optical characteristics has a significant impact on optimizing solar absorption. To do this, we must incorporate numerous additional ETSC, PCM, and other techniques into the system and develop a more effective collector.

II. RESULTS AND DISCUSSION

One of the greatest renewable energy sources with the least negative effects on the environment is solar energy. We aim to demonstrate the basic improvement suggested by the solar collector model under typical operating settings in the results of our review paper. The effects on the collector efficiency of changes in several operating parameters, such as the particle size, particle volume fraction, and others, are then examined. We compare the results of the current model's collector efficiency with those of a traditional flat-plate collector that uses pure water as its working fluid. A fraction of the radiant intensity is absorbed and scattered due to the specific optical characteristics of the nano fluid combination. Furthermore, the temperature change is not consistent. The upper layers experience the largest temperature increase, which diminishes with depth. Theoretically, the second term should eventually take over and the efficiency would rise considerably faster at much larger particle sizes [47]. The transmissible of the glass cover is another crucial factor that influences a solar collector's performance. For a known glass-protected material, the transmissivity of the glass cover is easily established and, under ideal working conditions, is a constant [as a function of wavelength]. However, in real-world situations, it is also impacted by things like dust build up and gradual wear and tear. It was found that when the transmissivity rises, the collection efficiency rises roughly linearly. For instance, at a glass-cover transmissivity of 0.7, the collector efficiency was approximately 55%, and at a glass-cover transmissivity of 0.9, the figure that most researchers use in their calculations, it reaches approximately 74% [45]. Since it is a renewable energy source and works well by raising collector efficiency with collector height, it achieves an asymptotic value of roughly 80%.This decrease results from the direct absorption of solar energy by the nanofluid, which heats it up. Even though the current findings indicate that the collector's overall length has a negligible impact on collector efficiency, an ideal collector length can still be determined. Furthermore, because of reduced heat losses, a nano fluid-based Direct Absorption Solar Collector (DASC) can reach comparatively greater temperatures than a flat-plate type collector in applications requiring high incident fluxes (such as those generated by large heliostat fields) [45]. Therefore, in order to meet energy demands, the solar thermal collector is an efficient renewable energy technique. Solar collectors can be broadly divided into two groups: concentrating collectors and flat plate collectors. In order to improve the efficiency of the DASC method, scientists and researchers worked to create the evacuated tubular solar collector (ETSC) method, which can convert thermal energy to electric energy at temperatures between 100 and 300 °C [51]. At different temperatures for different volume fractions, the optical and thermo physical properties of CuO nano fluid—the working fluid of a low temperature direct absorption solar collector—are discovered. This fluid is made by dispersing CuO nano particles into a mixture of distilled water and ethylene glycol (70%–30% in volume) as the base fluid [52, 53].

V. CONCLUSION

The application of nano fluid in solar collector systems has drawn the attention of numerous researchers in recent decades. We attempt to give a succinct overview of recent research on solar collector systems in this review paper. One can draw the following conclusions.

- The DASC, PCM, and ETSC techniques raise a solar thermal system's efficiency.
- By raising the base fluid's thermal potential, nano fluid is used to boost electrical efficiency.
- In addition to the DASC approach, the PCM and ETSC methods can improve the solar energy system's overall efficiency, electrical and

thermal potentiality, and solar cell material content.

- A solar water heater system has a very high initial cost but extremely low on-going costs.
- The usage of nano fluid raises the solar water heater's outer surface temperature and boosts system efficiency.

Future Scope of Nano Fluid in Solar Energy System

For the betterment of the solar thermal system by using nano fluid the following measure can be taken.

- Extensive theoretical and experimental study is necessary for the appropriate use of nano fluid.
- To develop the thermo physical properties of nano fluids, such as thermal conductivity, heat transfer rate, absorptivity, volume fraction, particle size, etc., a great deal of research is needed.
- To improve the efficiency of solar energy systems, hybrid nano fluid can be utilized in place of nano fluid.
- To maximize the financial and ecological advantages of the solar thermal system, economic and environmental research must be carried out.
- Nano fluid and hybrid nano fluid can be optimized to provide optimal performance in a solar thermal energy system.

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