Improvement of Solar Energy System with the Help of Nano Fluid

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ABSTRACT:

Utilization of solar energy increased day by day due to the scarcity of natural resources such as fosil fuel (coal, oil, and natural gas) and the emission of Carbon dioxide (CO_2)). 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:

In the last few decades, the utilization of solar energy increased day by day. Due to the deficiency of petroleum derivatives, the price of petroleum such as fossil fuels increases day by day. Rapid growth of population in the whole world and industrial growth increased the demand of energy.For the development of social and economic structure of the developing country, the use of petroleum products are increasing where as the availability of petroleum are decreased day by day [1,2,3,4,5]. And according to the "Global energy Report-2018" it is expected that the use of energy will be increased by 33% by the year 2040 [6].The earth's surface gets so much solar energy and in a single year the energy obtain by sunshine, exceeds comparing to the all known energy such as oil, coal, natural gas and uranium put together. Approximately earth is getting 1 h moreenergy from the sun than that of the other for1 year. So the government as well as researchers is paying more interest on renewable energy sources such as solar, wind, hydro, geothermal etc. [7, 8, 9, 10, 11, 12]. In the last few decades, the consumption of fossil fuels (such as coal, oil, and natural gas) and the emission of Carbon dioxide (CO_2) increased rapidly. Carbon dioxide

(CO_2) is a heat-catching gas or greenhouse gas that comes from the burning of traditional fossil fuels (such as coal, oil, and natural gas).The consumption of fossil fuels increased from 3701.5 Mt in 1965 to over 13511 Mt in 2017 [13]. The consumption of fossil fuel are shown in Figure 1. Nearly 84 percent of the energy comes from fossil fuel. Though it is shown that the uses of fossil fuel are decreases in the recent years (Figure 2) and the total consumption is roughly 128,550 terawatt-hours [14]. Carbon dioxide (CO2) emissions from fossil fuels and industry have increased considerably from 1940 to 2020 and in the year 2019 it reaches a record high of 36.7 billion metric tons of CO2. In 2020, in the pandemic situation due to the outbreak of COVID-19 the emission of carbon dioxide (CO2) decreased 5% and it reaches 34.81 billion metric tons [15] (See Figure 3), which causes global warming. Due to the harmfulness of greenhouse gas, renewable energy becomes more important nowadays [16]. There are so many sources of renewable energy solar energy, Wind energy, Hydro energy, Tidal energy, Geothermal energy, Biomass energy. Today 26% of the world's electricity are coming from renewable energy and according to the International Energy Agency (IEA) it is expected 30% by 2024 [17]. By mid of the 21st century, renewable sources of energy could account for 60% of the world's electricity market and 40% of the market for direct fuels [18]. Moreover, a transition to a renewable energy-intensive economy would provide benefits of sustainable growth that cannot be measured in standard economic terms. Sun is the most reliable source of energy on the earth as it is available free of cost. Solar energy can be used for producing electricity, heating, cooling, and detoxification. It can be stored for future use also [19, 20, 21, 22, 23]. Due to the various application of solar energy, the generation of solar energy is growing rapidly.But there is a problem in the heat transfer process of the solar energy system. There is a limitation in the conventional solar collectors on flux density and high heat losses are happening. To overcome these situations we have to design the solar energy system in such a way that it can increase the heat transfer process.

In the last few decade so many researcher have devoted their time to improve the solar energy utilization process. They have reported that solar energy system can be improved by the use of nano fluids. In 1970, researchers proposed that, for direct absorption of solar energy utilizing particle suspensions in liquids is necessary [24, 25, 26]. Common solar fluids such as water, ethyleneglycol, propyleneglycol (PG), etc., do not absorb total solar energy [27]. Whereas the use of nano particle in the base fluid can increase the performance and heat transfer process of the solar system. Nano particle together with the base fluid is called the nano fluid [28].

Nano-fluids is a homogeneous solution of nano particles of size 1 to 100 nm in basic fluid. They exhibit enhanced thermo-physical properties, compared to base fluids [29]. Addition of nanoparticles into base fluid can significantly enhance thermo-physical [30, 31, 32, 33, 34, 35, 36, 37] mass diffusivity and radioactive heat transfer properties of the fluid [38].

Direct absorption solar collector (DASC) is a new device which is developed to overcome the draw backs of conventional solar collector which directly transfer the solar energy to fluid medium, which successively reduce the concentrated heat at the surface [39].

In this article we try to provide a short review of the development of renewable energy with the help of nano fluids. We also discuss several methods such as DASC, PCM, ETSC to improve the efficiency of solar energy system in future aspects.

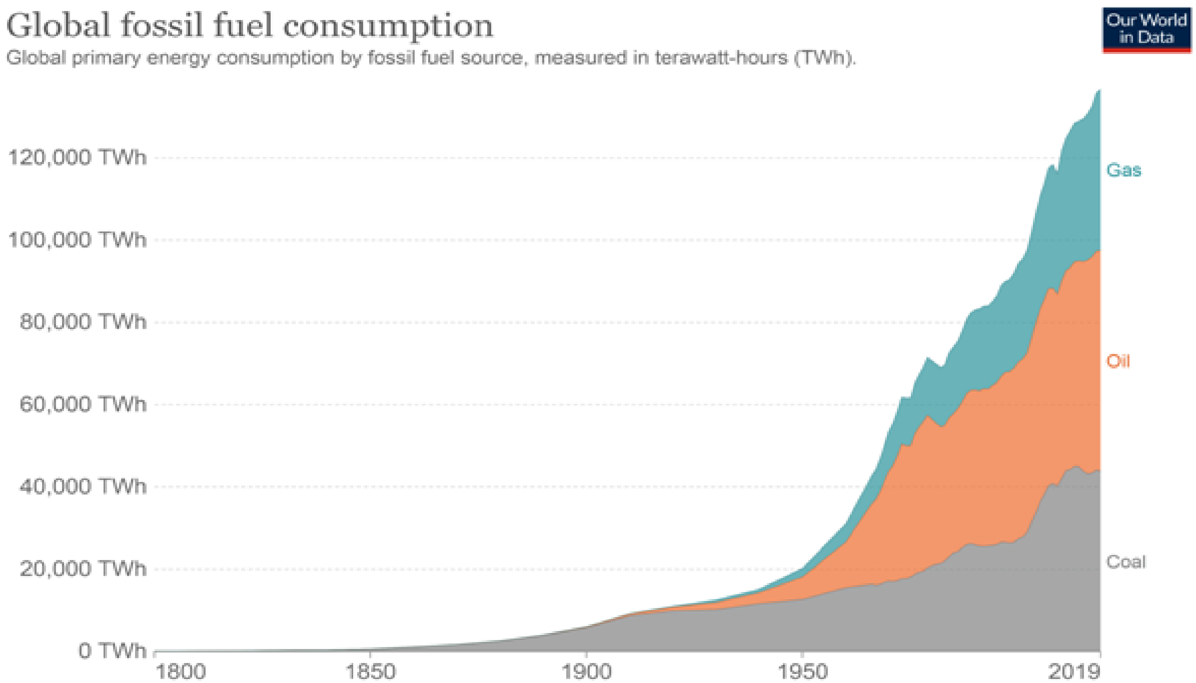

Figure 1: Consumption of fossil fuel worldwide from 1800-2019 [29]

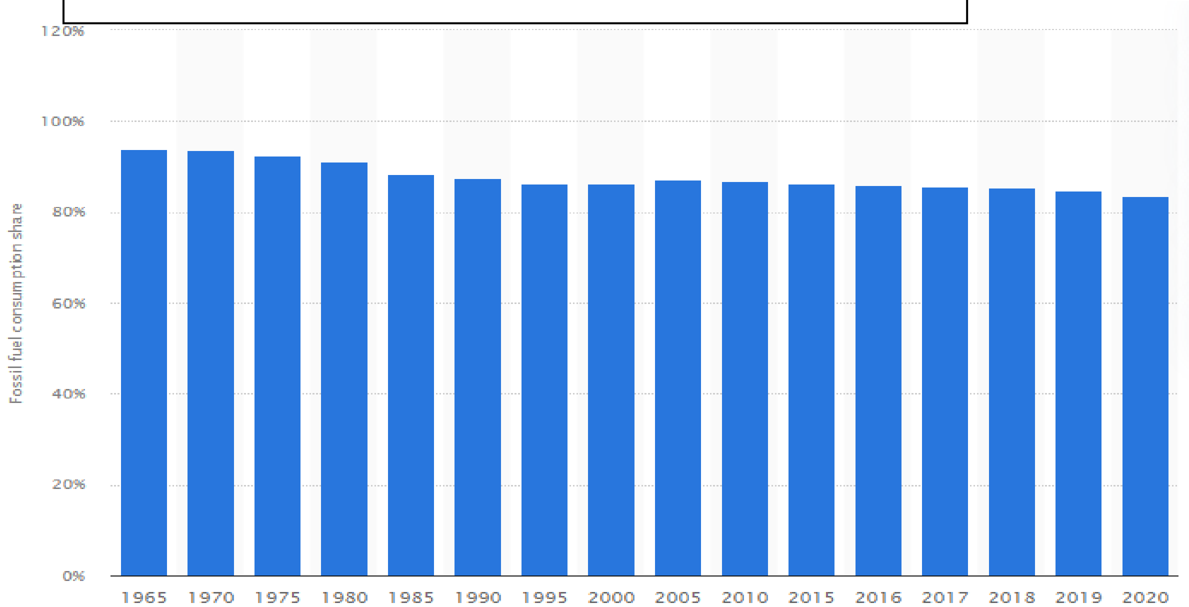

Figure 2: Consumption of fossil fuel worldwide from 1965 to 2020 [30]

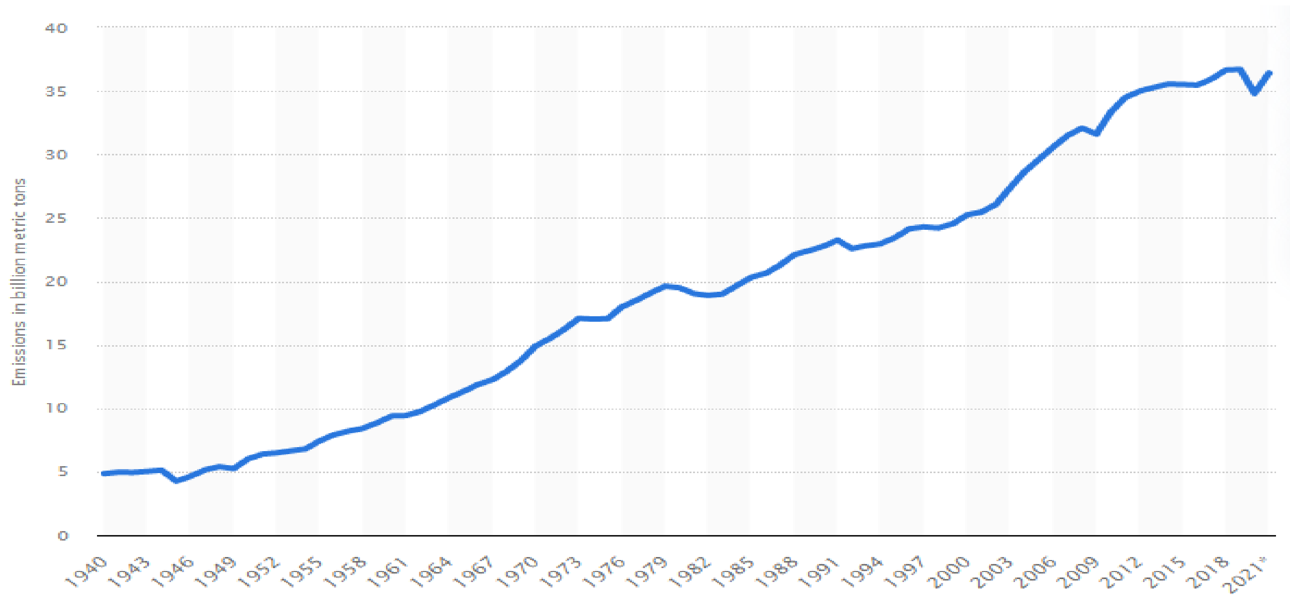

Figure 3: Annual CO2 emissions worldwide from 1940-2020 [31].

II. <u>The Application of Nano Fluids:</u>

The application of nano fluids as a working medium for solar collectors is a new technology. As of their small size and physical properties a thorough analysis of radiation based heat transfer of nano fluids is complex. So many researchers addressed this complex physics in their studies [40,41]. The addition of nanoparticles to a base fluid increases the other physical properties of the fluids as well as thermal conductivity [41, 42, 43, 44] and mass diffusivity. One of the unique benefits of the nano fluids is that when metallic nanoparticles are apply, the absorption spectrum is significantly expanded and while distinct absorption peak is maintained, the enhancement in the absorption efficiency through the solar spectrum is observed [45]. Direct absorption solar collectors have been suggested or proposed for a wide range of applications such as water heating, electric in bad weather where normal solar cell are failed; however the efficiency of these collectors is limited by the absorption properties of the working fluid, which is very poor for typical fluids used in solar-collectors[45]. However, it is still a weak absorber, only absorbing 13% of the energy. So our main moto is to use as a renewable energy for this, we add some extra features like, the addition of small particles causes scattering of the incident radiation allowing higher levels of absorption within the fluid, and hence an enhancement in collector efficiency [46]. The advantage of using a particle-based-fluid mechanism is that due to the presenceof the small particles, scattering of incident radiation takes place which can lead to increased radiative absorption. It was observed that the presence of nanoparticles increases the absorption of incident radiation by more than 9 times over that of pure water [47]. The nano fluids are analogously recent innovation and research area which exhibit enhanced of heat absorbing and heat transport mechanism.The working of nano fluids applied on solar system in the light of works done previously; it further also explores the variable performance and feature of the solar-system with and without application of nano-fluids. The recent results and reseach of the application on nano fluids in PV/T systems too have been consolidating. It can be safely assumed further that it might build up the overall performance of the solar energy conversion process [48]. The PV/T system is also a crucial factor in this DASC method, by this technique both light and heat of the solar radiation system to produce electricity and hot fluid. PV/T systems is fast growing with more methods/paths and techniques to increase the overall efficiency, reduce the cost, improve the modeling, and maintain the system for long periods of time and employing them for suitable application [49,50].

III. <u>Experimental nano-fluids used:</u>

It has been examined in [45,1, 30] by their experiment we can easily said that the experimental results are so important to research further in future on renewable energy. From this we came to know that The collector back surface was coated with a reflective aluminum tape for all experiments with nano fluids. But one of the experiments with reflective pure water. The collector was also tested with a matte black paint applied to the copper plate. The fluid depth was controlled with a metal spacer of thickness 150 -m¹.The solar spectrum a SuperPAR64 lamp was used at a height so that 1000 W/m2 of radiative flux was measured incident on the collector. The spectrum of the lamp was measured at a color temperature of 3158 K, provided a decent approximation of the solar spectrum .Some basic steps are required such as- Three T-type thermocouples were mounted to measure the inlet and outlet temperatures of the fluid, plus a measurement of the copper plate temperature midway between the inlet and outlet ports. The whole system was insulated within a Styrofoam block to limit heat loss from the back and sides of the collector. The Styrofoam block was shielded from incident radiation with aluminum so as to not absorb any of the simulated sunlight. Then a nano fluids were prepared by suspending various size, shape, and material nanoparticles in de-ionized water accordingly experiment as told in the paper. The effect of modifying the optical properties is obviously important in maximizing the amount of solar absorption. For this we have to design more efficient collector in this system and include many more method ETSC , PCM like that.

IV. RESULTS AND DISCUSSION

Solar energy is considered to be one of the best sources of renewable energy with the least environmental impact. In the results of our review article we want to show the fundamental improvement proposed from the solar collector model under normal operating conditions. After that the influences of variations in various operating parameters, like the particle size, particle volume fraction and others, on the collector efficiency are discussed. The collector efficiency by where we get the consequences for the present model are compared with those of a conventional flat-plate type collector using pure water as its working fluid. Since the Nano fluid mixture has selective optical properties, the radiant intensity is some portion absorbed and scattered. Moreover, the change in temperature is not uniform. The temperature increase is the highest for the top layers and decreases with depth. Theoretically, it may be expected that at much higher particle sizes, the second term would eventually dominate and the efficiency would perhaps increase much more rapidly [47]. Another important parameter which affects the performance of a solar collector is the transmissible of the glass cover. Under ideal operating conditions the transmissivity of the glass cover is a constant [as a function of wavelength] and is easily determined for a known glass-protected material. However, in actual practical conditions it is also affected by conditions such as dust accumulation, and wear-and-tear over time. It was observed that the collector efficiency increases almost linearly with an increase in the transmissivity. For example, the collector efficiency was about 55% for a glass-cover transmissivity of 0.7, and reaches about 74% for a glass-cover transmissivity of 0.9, which is the value used for most calculations of researchers [45]. As it is the energy source which is renewable and the thing which is effective by increasing the collector efficiency with collector height, and reaches an asymptotic value of about 80%.This diminution is caused because the solar energy is being absorbed directly by the nano fluid which causes it to heat up. Although the present results suggest that the influence of the overall length of the collector on the collector efficiency is relatively small, an optimum collector length can nevertheless be defined. Additionally, in applications where high incident fluxes are used (such as those produced by large heliostat fields), a nano fluid-based Direct Absorption Solar Collector (DASC) can achieve relatively higher temperatures, compared to a flat-plate type collector, due to lower heat losses [45]. So for that The solar thermal collector is an effective renewal energy process for solar energy harvesting to fulfil energy demands . The solar collector can be mainly categorized into two groups, one is flat plate collectors and the other is concentrating collectors. For the betterment of the solar collector by DASC method, the researcher and scientist devoted their time to develop the evacuated tubular solar collector (ETSC) method, which can convert the thermal energy to electric energy in between 100 and 300 °C, to maximize the efficiency of DASC method [53]. The optical and thermo-physical characteristics of CuO nano fluid as the working fluid of low temperature direct absorption solar collector which is prepared by dispersing the CuO nano particles into mixture of distilled water and ethylene glycol (70%-30% in volume) as the base fluid is found at the various temperatures for different volume fractions [51,52].

V. **CONCLUSION:**

In the last few decades so many researchers have been devoted there time for the use of nano fluid in solar collector systems. In this review article, we try to provide a brief analysis of recent work done on solar collector systems. The following conclusions can be made

(i) The efficiency of a solar thermal system is increased by DASC, PCM and ETSC methods.
(ii) Nano fluid is used to increase electrical efficiency by increasing the thermal potential of the base fluid.
(iii) Apart from DASC method PCM and ETSC method can increases the overall efficiency of the solar energy system, electrical and thermal potentiality also with a decreased amount of material of the solar cell.
(iv) Initially the cost of a solar water heater system is very high but its operating cost is negligible.
(v) The outer surface temperature of the solar water heater and the efficiency of the system is increased by the use of nano fluid.

VI. FUTURE SCOPE OF NANO FLUID IN SOLAR ENERGY SYSTEM

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

(i) For the proper utilization of nano fluid, extensive theoretical and experimental research work is required.
(ii) An extensive research work is required to develop the thermo physical properties of nano fluids such as thermal conductivity, heat transfer rate, absorptivity, volume fraction, particle size etc.
(iii) Hybrid nano fluid can be used in place of nanofluid to increase the better performance of solar energy system.
(iv) Economic and environmental studies must be conducted to optimize the economic and environmental benefits of the solar thermal system.
(v) Optimization techniques can be used to get the best possible results in a solar thermal energy system using nano fluid and hybrid nano fluid.

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