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Recent Review on Nanofluid/ Nanocomposites for Solar Energy Storage

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Abstract: Nanocomposites have huge applications for energy storage like solar energy storage. This reviewincludes the research on recent developments of nanofluid/ nanocomposites for solar energy storage which discussed the nanoparticles and nanofluids properties, solar thermal energy storage and nanocomposite application in solar energy utilization. From the previous studies, nanocomposites/ nanofluid may be considered as promising materials for energy storage fields.

Keywords-Nanocomposites, nanofluid, energy storage, solar energy, thermal energy.

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1.INTRODUCTION

Energy is an important entity for the economic development of any country. On the other hand, fossil fuels meeting a great portion of the energy demand are scarce and

their availability is decreasing continously. Nowadays, solar systems play an important role in the production of energy from renewable sources by converting solar

radiation into useful heat or electricity. Considering the environmental protection and great uncertainty over future energy supplies, solar energy is a better alternative energy form in spite of its slightly higher operation costs. Heat transfer enhancement in solar devices is one of the significant issues in energy saving and compact designs. One of the effictive methods is to replace the working fluid with nanofluids as a novel strategy to improve heat transfer characteristics of the fluid. More recently reserachershave become interested in the use of nanofluids in collectors, water heaters, solar cooling systems, solar cells, solar stills, solar absorption refrigeration systems, and a combination of different solar devicesdue to higher thermal conductivity of nanofluids and the radiative properties of nanoparticle. The effectiveness of nanofluids as absorber fluids in a solar device strongly depends on the type of nanoparticles and base fluid, volume fraction of nanoparticles, radiativeproperties of nanofluids, temperature of the liquid, size and shape of the nanoparticles, pH values, and stability of the nanofluids [1].Common fluids such as water, ethylene glycol, and heat transferoil play an important role in many industrial processes suchas power generation, heating or cooling processes, chemicalprocesses, and microelectronics. However, these fluids have relatively low thermal conductivity and thus cannot reach high heatexchange rates in thermal engineering devices. A way to overcomethis barrier is using ultra fine solid particles suspended incommon fluids to improve their thermal conductivity. Nanofluids, compared to suspensions withparticles of millimeter-or-micrometer size, show better stability,rheological properties, and considerably higher thermal conductivities.In recent years, many researchers have investigated the effectsof nanofluids on the enhancement of heat transfer in thermalengineering devices, both experimentally and theoretically.The enhanced thermal behavior of nanofluids could providea basis for an enormous innovation for heat transfer intensification,which is of major importance to a number of industrialsectors including transportation, power generation, micromanufacturing,thermal therapy for cancer treatment, chemicaland metallurgical sectors, as well as heating, cooling, ventilationand air-conditioning. Nanofluids are also important for the productionof nanostructured materials for the engineering of complexfluids as well as for cleaning oil from surfaces due to their excellentwetting and spreading behavior [2].In the present scenario when the demand is more than resources available, it's our necessity to develop an energy storage device to store energy at the time of availability and supply it whenever demand is more than available. Although Sensible heat storage is the most common method of thermal energy storage, but the recent research on advance material and system shows that density of stored energy is greater for latent heat storage than that of sensible heat storage. Phase change material is generally used in latent heat storage system and this type of system has been widely used for heat pumps, solar engineering, and spacecraft thermal control applications. Tremendous increase in the price of fossil fuel and continuous upgrading in the level of greenhouse gas emissions are the main driving forces behind the effective utilization non conventional energy resources. The storage of energy in suitable forms, conveniently converted into the required form, is a present day challenge to the technologists. Solar energy storage unit has the following characteristics (a) To conserve energy (b) To improve the performance and reliability of energy systems and (c) to reduce the mismatch between supply and demand. Scientists in many parts of the world are in search of new and renewable energy resources and stated that direct solar radiation is a prospective renewable source of energy and the solar energy

storage unit is the new source of energy. In other words solar energy storage unit can be called as the sub renewable sources of energy. There are various kinds of phase change materials but paraffin has been widely used for latent heat thermal energy storage system because of their large latent heat and proper thermal characteristics such as no super cooling, low vapour pressure, good thermal and chemical stability and self nucleatingbehaviour [3]. Solar energy can be harnessed to generate power by way of either solar photo voltaic route or by concentrating the sun's rays to generate high temperatures and high magnitude of heat (concentrated solar power or CSP). The concentrated heat generated by sun's energy can be transported using suitable heat transfer fluids to heat exchanger where this heat is transferred to convert water into steam and steam turbine is then driven to produce electricity. Out of the two options of solar energy, PV and CSP, CSP based thermal route offers distinct advantages in bringing down the least cost of electricity generated by way of providing storage and dispatch ability of solar power during off sun periods. Solar thermal energy is utilized by capturing the heat of the sun in devices, generally known as solar collectors, designed to maximize the heat absorption through their surfaces exposed to the sun. The heat that is absorbed on the surfaces of such solar collectors is then transferred through a heat transfer media, generally liquid in nature, which takes the collected heat to the point of use. In most of the concentrating solar power plants, sun's heat is captured by a receiver, transferred to a thermo fluid – also known as heat transfer fluid; and this heat from the thermo fluid is then used in a heat exchanger to convert steam from water [4]. Multifunctional materials combine different kinds of properties (structural, electrical, magnetic, thermal, etc.), which makes them suitable for performing multiple tasks simultaneously, and for being applied when stimuli of different nature are involved. The interest in multifunctional materials is increasing in both the scientific and industrial community, as demonstrated by the considerable growth of the number of publications. Among the different classes of materials, composites are particularly suitable to be designed as multifunctional materials. One of the main reasons to combine structural and non-structural properties in the same material is the need to save weight and volume, which is crucial, for example, in automotive/aerospace applications and in the portable electronics field. In this perspective, polymer matrix
composites are attractive because they combine the remarkable features of a polymeric matrix, such as the low density, ease of processability and relatively low cost, and the considerable stiffness and strength of fibrous reinforcing phases, thereby
allowing the production of composites with high specific mechanical properties. Multifunctional polymer composites find application in many different fields. An interesting field where the

multifunctionality could be exploited, although not yet thoroughly investigated, is that of the structural composites with thermal energy storage (TES) capability. TES can be defined as the storage of heat that can be released where and when needed, which considerably reduces the mismatch between thermal energy availability and request. TES technologies can be applied (1) to accumulate excess or waste heat for a later use, for example, in the solar thermal power plants, or to recover waste industrial heat, (2) to store heat for temperature control, for example, in the buildings industry or to produce smart textiles for body temperature regulation, or (3) to temporarily store heat that could damage a component, as in the cooling systems for electronic devices [5]. There are many studies on the properties of nanocomposites or composites and their applications which included the DC or AC electrical properties [6-20], optical properties [21-44], for environmental and biomedical applications[45-59], and heat transfer enhancement [60-106].

2.NANOPARTICLES AND NANOFLUIDS PROPERTIES

Nanoparticles are sized between 1 and 100 nanometers. Nanoparticles may or may not exhibit size related properties that differ significantly from those observed in fine particles or bulk materials. Nanoclusters have at least one dimension between 1 and 10 nanometers and a narrow size distribution. Nanopowders are agglomerates of ultra-fine particles, nanoparticles, or Nanoclusters. Nanometer-sized single crystals, or single-domain ultra-fine particles, are often referred to as nanocrystals. Nanoparticles are of great scientific interest as they effectively form a bridge between bulk materials and atomic or molecular structures. A bulk material should have constant physical property regardless of its size, but at the nano-scale size- dependent properties are often observed. Thus, the properties of materials change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant. Suspensions of nanoparticles are possible since the interaction of the particles surface with the solvent is strong enough to overcome density differences, which otherwise usually result in a material either sinking or floating in a liquid. Nanoparticles also often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum effects. For example, gold nanoparticles appear deep red to black in solution. Nanoparticles have a very high surface area to volume ratio, which provides a tremendous driving force for diffusion, especially at elevated temperatures. Sintering can take place at lower temperature, over shorter time scales than for larger particles. The fluids with nanosized solid particles suspended in them are called "nanofluids." The suspended metallic or nonmetallic nanoparticles change the transport properties and heat transfer characteristics of the base fluid. Heat transfer enhancement in solar devices is one of the key issues of energy saving and compact designs. Solar energy is widely used in applications such as electricity generation, chemical processing, and thermal heating due to its renewable and nonpolluting nature. Most solar water heating systems have two main parts: a solar collector and a storage tank. The most common collector is called flat-plate collector but this suffer from relatively low efficiency. There are so many methods introduced to increase the efficiency of the solar water heater. But the novel approach is to introduce the nanofluids in solar collector instead of conventional heat transfer fluids (like water) [107].

3.**SOLAR THERMAL ENERGY STORAGE Solar**

The performance of solar thermal energy systems is primarily controlled by the components that collect and store the energy. A solar collector is a type of energy exchanger that converts irradiation energy from the sun into thermal energy in a working fluid. The most important parameter in solar collector design and fabrication is good optical performance, to ensure that as much as possible of the incoming solar radiation is captured and directed to the receiver. As solar energy input is not constant, efficient thermal energy storage (TES) materials must then be employed to store any excess energy that is collected throughout the day for use at night . Different applications require different output temperatures, such as electrical power generation requiring a high-temperature (>175 □) TES system, whereas domestic space heating requiring a lowtemperature (<50 □) system. The properties of the storage materials generally pose a major effect on the TES performance. Many factors must be considered when designing a solar TES system, most of which fall under the subjects of cost-effectiveness, environmental impact and technical properties. Solar TES materials can be categorized into three main types depending on the storage mechanism: thermochemical (TCS), latent heat (LHS) and sensible heat (SHS) storage. As SHS is the most developed of the technologies, it has the benefit that numerous low-cost materials are available, but it also has the least storage capacity, thereby enhancing the dimensions of the system. Compared to other energy storage modes, SHS is commercialized largely, whereas LHS and TCS are still in the development phase. In addition, the durability of SHS system is around twenty years; whereas those of LHS (one-fourth of SHS) and TCS (one-tenth of SHS) were relatively low. Conversely, the capacity of LHS is much higher; but this is usually paired with poor heat transfer unless it is modified with heat transfer enhancement[108].

4.NANOCOMPOSITE APPLICATION IN SOLAR ENERGY UTILIZATION

The mechanical, electrical, thermal, optical, electrochemical and catalytic properties of the nanocomposite will differ markedly from that of the component materials. In solar concentrators, it is more important to use highly reflective nanocomposite coating on the concentrator for reflecting the solar radiation in the solar spectral region. Nanocomposites are also used as selective coating on the absorber surface to absorb the maximum amount of radiation reflected from the mirror. Ultimately, different nanocomposites can be used as thin film coatings on the reflector and the absorber to enhance the optical properties of the substrate material [109].

5.CONCLUSIONS

This review includes the applications of nanocomposites/ nanofluidfor solar energy storage. From the previous studies, the nanofluid of polymer with different concentrations of nanoparticles used thermal energy storage with good thermal and electrical properties. The (polymer/ nanoparticles) nanofluidhave characteristics such as: low cost, easy process ability good electrical and thermal properties make it suitable for heating and cooling systems.

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