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Nano Fluid-based Receivers for Increasing Efficiency of Solar Panels

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Abstract

Due to its renewable and non-polluting nature, solar energy is often used in applications such as electricity generation, thermal heating, and chemical processing. Solar power plants with surface receivers have low overall energy conversion efficiencies due to large emissive losses at high temperatures.

Nano fluids have recently found relevance in applications requiring quick and effective heat transfer such as industrial applications, cooling of microchips, microscopic fluidic applications, etc. Recent papers have indicated that the addition of nanoparticles to conventional working fluids (i.e., Nano fluids) can improve heat transfer and solar collection. The normal efficiency of the solar panels being used is recently found out to be 44.7% and by the use of Nano fluids it can be increased by 10-15% and by Plasmonic Nano fluids by 20% also. Dispersing trace amounts of nanoparticles into common base-fluids has a significant impact on the optical as well as thermo physical properties of the base-fluid. This characteristic can be utilized to effectively capture and transport solar radiation.

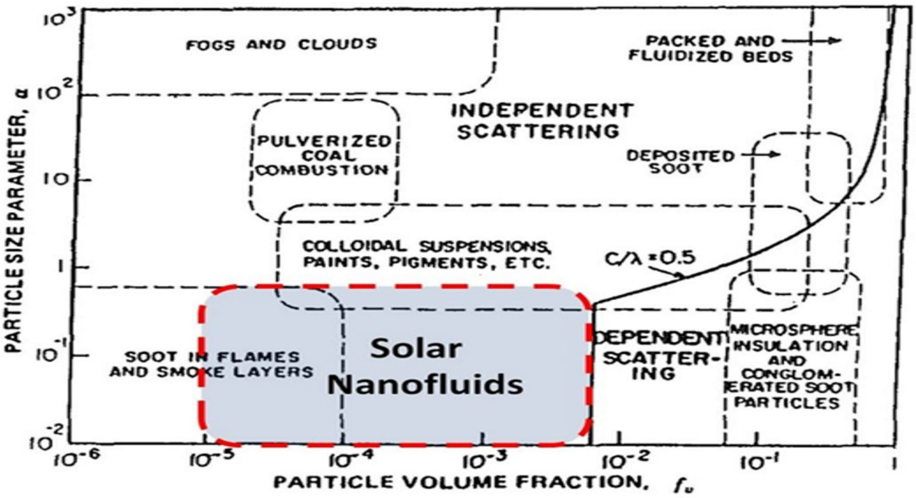
Keywords: Plasmonic Nano fluids, volumetric receivers, microchips, thermal efficiency.

1. Introduction

Nanofluids are a simple product of the emerging world of nanotechnology. Suspensions of nanoparticles (nominally 1 to 100nm in size) dispersed in fluids such as water, oils, glycols and even air and other gases can rightly be called nanofluids. The first decade of nano fluid research was primarily focused on measuring and modeling fundamental thermo physical properties of nanofluids (thermal conductivity, density, viscosity, heat transfer coefficient). Recent research conducted by our group and others, however, explores the performance of nanofluids in a wide variety of other applications.

2. Present Study

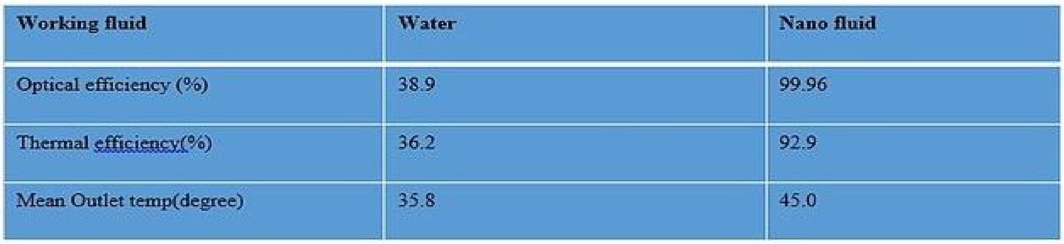
The present study reports a novel concept of a direct solar thermal collector that harnesses the localized surface Plasmon of metallic nanoparticles suspended in water. At the plasmon resonance frequency, the absorption and scattering from the nanoparticle can be greatly enhanced via the coupling of the incident radiation with the collective motion of electrons in metal. However, the surface plasmon induces strong absorption with a sharp peak due to its resonant nature, which is not desirable for broad-band solar absorption. In order to achieve the broad-band absorption, we propose a direct solar thermal collector that has four types of gold-nano shell particles blended in the aquatic solution. Numerical simulations and finite element analysis have shown that the use of blended Plasmonic nanofluids can significantly enhance the solar collector efficiency with an extremely low particle concentration (e.g., approximately 70% for a 0.05% particle volume fraction). The low particle concentration ensures that nanoparticles do not significantly alter the flow characteristics of nanofluids inside the solar collector. The results obtained from this study will facilitate the development of highly efficient solar thermal collectors using Plasmonic nanofluids.



Suspensions of nanoparticles (i.e., particles with diameters < 100 nm) in liquids, termed nanofluids, show remarkable thermal and optical property changes from the base liquid at low particle loadings. Recent studies also indicate that selected nanofluids may improve the efficiency of direct absorption solar thermal collectors. That is, their absorption of the solar spectrum must be established. Accordingly, this study compares model predictions to spectroscopic measurements of extinction coefficients over wavelengths that are important for solar energy (0.25 to 2.5 μm). A simple addition of the base fluid and nanoparticle extinction coefficients is applied as an approximation of the effective Nano fluid extinction coefficient. Comparisons with measured extinction coefficients reveal that the approximation works well with water-based nanofluids containing graphite nanoparticles but less well with metallic nanoparticles and/or oil-based fluids. For the materials used in this study, over 95% of incoming sunlight can be absorbed (in a nanofluid thickness ≥10 cm) with extremely low nanoparticle volume fractions - less than 1 × 10-5, or 10 parts per million. Thus, nanofluids could be used to absorb sunlight with a negligible amount of viscosity and/or density increase.

3. Thermal Conductivity of Nanofluids

We know that thermal conductivity of solids is greater than liquids commonly used fluids in heat transfer applications such as water ethylene have low conductivity.



Working fluid	Water	Nano fluid
Optical efficiency (%)	38.9	99.96
Thermal efficiency(%)	36.2	92.9
Mean Outlet temp(degree)	35.8	45.0

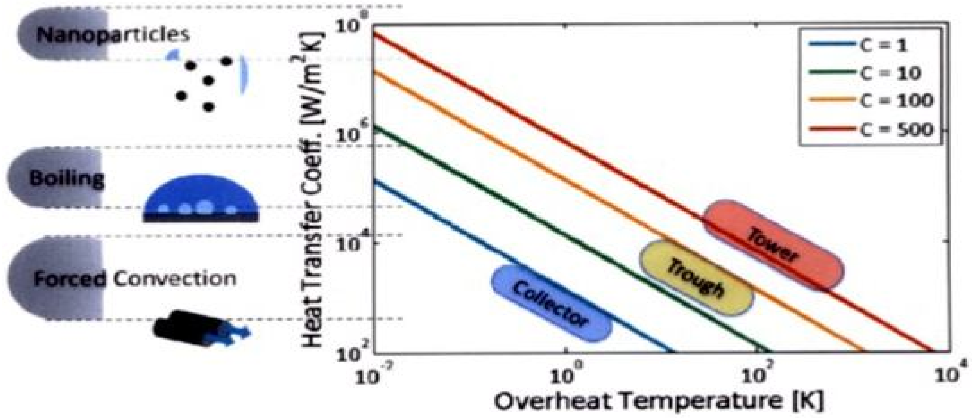
When compared to thermal conductivity of solids especially metals so addition of solid particles in a fluid can increase the conductivity of liquids. But we cannot add large solid particles due to main problems:

- Mixtures are unstable and hence sedimentation occurs.
- Presence of large solid particles also requires large pumping power and hence increases cost.
- Solid particles may also erode the channel walls.

Recent improvements in nanotechnology made it possible to introduce small solid particles with diameter smaller than 10nm.

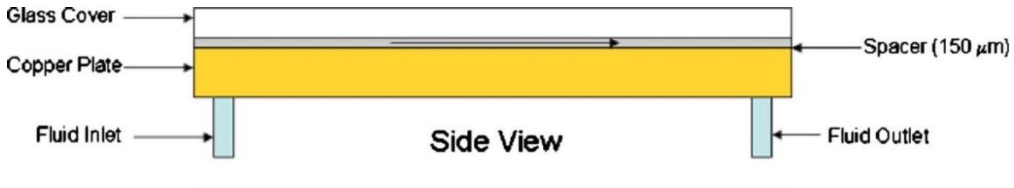
4. Heat Transfer

Theoretical studies of the possible heat transfer mechanisms have been initiated, but to date obtaining an atomic- and micro scale-level understanding of how heat is transferred in nanofluids remains the greatest challenge that must be overcome in order to realize the full potential of this new class of heat transfer.



5. Experimental Setup

The test apparatus was built around a micro-solar-thermal-collector that measures 35 cm^2, with a channel depth of 150 m. The micro channel geometry was selected to minimize the amount of nanofluids needed for each collector test. Furthermore the depth of the channel allowed for the measurement of appreciable temperature gain allowing a large range of nanofluids reaching the bottom of the channel would be nonzero. The collector glazing is a low-reflectance glass of thickness 3.3 mm for all experiments. Three different groups of nanofluids, with water as the base fluid, were considered: Graphite sphere-based 30 nm diameter, nominal, carbon nanotube-based 6–20 nm diameter, 1000–5000 nm length, and silver sphere-based 20 and 40 nm diameters. These fluids were either tested in varying volume fractions or varying particle sizes to understand how these variables impact solar thermal energy collection.



6. Benefits of Using Nano Fluids in Solar Collectors

A Nano fluid poses the following advantages as compared to conventional fluids which makes them suitable for use in solar collectors:

- Absorption of solar energy will be maximized with change of the size, shape, material and volume fraction of the nanoparticles.
- The suspended nanoparticles increase the surface area and the heat capacity of the fluid due to the very small particle size.
- The suspended nanoparticles enhance the thermal conductivity which results improvement in efficiency of heat transfer systems.
- Properties of fluid can be changed by varying concentration of nanoparticles.

- Extremely small size of nanoparticles ideally allows them to pass through pumps.
- Nano fluid can be optically selective (high absorption in the solar range and low emittance in the infrared.)

The fundamental difference between the conventional and nanofluids-based collector lies in the mode of heating of the working fluid. In the former case the sunlight is absorbed by a surface, where as in the latter case the sunlight is directly absorbed by the working fluid (through radiative transfer). On reaching the receiver the solar radiations transfer energy to the nanofluids via scattering and absorption.

7. Conclusion

The Purpose of this paper will focus on new preparation methods and stability mechanisms, especially the new application trends for Nano fluids in addition to the heat transfer properties of Nano fluids. We will try to find some challenging issues that need to be solved for future research based on the review on these aspects of Nano fluids.

References

[1] Todd P. Otanicar, Patrick E. Phelan, Ravi S. Prasher, Gary Rosengarten, and Robert A. Taylor

[2] Citation: J. Renewable Sustainable Energy 2, 033102 (2010); doi: 10.1063/1.3429737

[3] View online: http://dx.doi.org/10.1063/1.3429737

[4] Taylor et al.: Nanofluid optical property characterization: towards efficient direct absorption solar collectors. Nano scale Research Letters 2011 6:225.

[5] http://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1020&context=mech_fac

[6] http://thermalscienceapplication.asmedigitalcollection.asme.org/article.aspx?articleid=1690805

[7] P.keblinski, K.C.Leong, C.Yang. Investigations of thermal conductivity and viscosity of nanofluids,International Journal of Thermal Science(2006)