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# Performance Analysis of Thermal Conductivity And Volume Fraction Concentration of Various Nanofluid: Review

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***Abstract:*** *To enhancing the performance of solar thermal system, 1st increases the thermal conductivity of heat transfer fluid (HTF) and 2nd to increase the optical properties of absorber and their coating. Nanofluids plays vitalroleinvariousthermalapplicationssuchasautomotiveindustries,heatexchangers,solarpowergeneration etc.Thispapergivesareviewabouttherecentadvancesrelatedwiththeapplicationofthenanofluidinthesolar collectors.Alotofliteraturearesummarizedtogiveawideoverviewabouttheroleofthenanofluidinimproving the performance of solar system. It was found that the use of the nano fluid in the solar system can play a significant role in increasing the efficiency of thesesystem.*
***Keywords:*** *base fluid, nano-particles, solar thermal, thermal conductivity, volume fraction.*

## I. Introduction

Energyisaprimeinputtotheeconomyandsocialdevelopmentsofworld.Solarenergyisthemostcopiousofall energy forms. Sun release energy is about $63MW/m^2$ to the space, due to sun-earth geometry out of that $1350W/m^2$, generally $1kw/m^2$ energy reaches to earth surface. Renewable sources of energy from sun are fairly non-polluting and considered clean. Solar energy is environmental friendly energy has produced energy for billionsofyears.Nanotechnology,atermnormallyusedtodescribematerialsandphenomenaatanano scale,has been widely used in various engineering. Thermal conductivity of a liquid is an important physical property that decidesitsheattransferperformance.Conventionalheattransferfluidshaveinherentlypoorthermalconductivity which makes them inadequate for ultra high cooling applications. Enhancing heat transport properties of traditional heat transfer fluids has become a challenging topic for research and development. For developing energyefficientheattransferequipmenttheneedofnovelheattransferfluidshavinghigherthermalconductivity becomes mandatory. Nanofluids are well-dispersed nanoparticles suspended at low volume fractions in conventional liquids which enhance the mixture's thermal conductivity. Nanotechnology has been used in many applications intended to provide cleaner and more efficient energy supplies and uses. [1]Nanofluids are well-dispersed nanoparticles suspended at low volume fractions in conventional liquids which enhance the mixture's thermal conductivity. Nanofluids are well-dispersed nanoparticles suspended at low volume fractions in conventional liquids which enhance the mixture's thermalconductivity.

## II. Types Of Nano-Fluid

Adding small concentration of suspended nanometer particles into conventional fluid, to enhance their thermal conductivity forming mixture called as Nano-fluid. They are classified into following types,

a. Pure MetalNano-fluid
b. Metal oxideNano-fluid
c. Carbons basedNano-fluid

Types of nanoparticles investigated include pure metals (Au, Ag, Cu, Al, and Fe), metal oxides ($Al_2O_3$, CuO, $Fe_3O_4$, $SiO_2$, $TiO_2$, and ZnO), Carbides (SiC, TiC) and a variety of carbon materials (diamond, graphite, single/multi wall carbon nanotubes).

## III. Review Model (Metalnano-Fluid)

Amodelinvestigatethethermalconductivityandviscosityofsilver-deionizedwaternano-fluidbyL.Godson,B. Raja, D. Mohan Lal, S. Wongwises (2009),in this experiment silver de-ionized water fluid is used asworking fluid.Themixtureconsistofsilvernanoparticleshavingdifferentinvolumeconcentrationlike(0.3%,0.6%,0.9 %) at different temperature between 50˚c to 90˚c. The viscosity and thermal conductivity of working fluid is measured. When silver nano particles of 0.3% volume concentration that gives 27% enhancement in thermal efficiency,alsowhen0.9%volumeconcentrationthatgives80%enhancementat70˚caveragetemperature.Result showing related to viscosity, the viscosity of working fluid decreases with increase in temperature and increases with increase in particlesconcentration.[2] Enhancement of thermal conductivity of ethylene glycol based silver nanofluids, by Pankaj Sharma, Hyun Baek

, Taehyun Cho, Sangdo Park, Ki Bong Lee, (2011), in this experiment ethylene glycol with silver nano particles is used as working fluid. Different concentration of silver nano fluid (1000-10,000 ppm) were synthesized. The thermal conductivity as will as stability of a nano fluid is determined with the help of transient hot wire apparatus. After 30 days of preparation of these nanofluid, The thermal conductivity is decreased, details of reading is shown in below table.[3]

**Table1**. Silver/Ethylene glycol thermal conductivity reading

| Sr.No. | Nano-Fluid Concentration in ppm | % of thermal conductivity at the preparation time | % of thermal conductivity after 30 days of preparation |
|---|---|---|---|
| 1. | 1000 | 10 | 10-9 |
| 2. | 5000 | 16 | 15-14 |
| 3. | 10000 | 18 | 18-14 |

Enhancements of thermal conductivities with Cu/water nanofluid on a water chiller system by MinSheng Liu1, Mark ChingCheng Lin and ChiChuan Wang, (2011) ,in this study enhancement of thermal conductivity of water in the presence of copper (Cu) is investigated using two method. In physical mixing method ( two-step method), Cu-waternanofluidswithalowconcentrationofnanoparticleshaveconsiderablyhigherthermalconductivity.At aconstantvolumefraction,k/kbaseisthelargestatthestartingpointofmeasurementanddropsconsiderablywith elapsed time. Cu nanoparticles at 0.1 vol.%, thermal conductivity is enhanced by 23.8%. The ratio of k/kbase is almost unchanged when the elapsed time is above 10 min. The ratio of the thermal conductivity of the Cu-water nanofluidtothatofthebaseliquidvariesfrom1.24to1.78whenthevolumefractionofthenanoparticlesincreases from 2.5 to 7.5 vo1.%. Cu-water nanofluids are also synthesized using chemical method (One-Step method) but withoutsurfactant.TheagglomeratedparticlesizesoftheCunanoparticlesrangefrom50to100nmwithspherical and square shapes. The typical value of thermal conductivity is 0.25 W/m K for ethylene glycol, 0.6 W/m K for water.[4] Thermal conductivity of Fe nanofluids depending on the cluster size of nanoparticles by , K. S. Hong, Tae-Keun Hong, and Ho-Soon Yang, (2006), in this experiment focuses on the effect of the clustering of nanoparticles on the thermal conductivity of nanofluids. It is found from the variations of the nanocluster size and thermal conductivity that the reduction of the thermal conductivity of nanofluids is directly related to the agglomeration of nanoparticles. The thermal conductivity of Fe nanofluids increases nonlinearly as the volume fraction of nanoparticlesincreases.ThethermalconductivitiesofFenanofluidswiththethreelowestconcentrationsarefitted toalinearfunction.TheFenanofluidsshowamorerapidincreaseofthethermalconductivitythanCunanofluids as the volume fraction of the nanoparticles increases.[5]Au and Ag have high thermally conductivities and their addition to fluids for heat transfer applications would be interesting, but the specific absorption rate (SAR) was only discernable during initial heating, and at higher particle concentrations there was a significant reduction in performance. The reduced performance was the result of factors such as particle clustering nearthefluidsurface,whichinturnreducedsunlightenteringthenanofluid,alsothecostofnoblemetals,several researchers have investigated less noble metals and alternative materials[6].

## IV. Review Model (Metalnano-Fluid)

Temperature Dependent Thermal Conductivity Data of Water Based Nanofluids, by Honorine Angue Mintsa, Gilles Roy, Cong Tam Nguyen,(2007) ,Thermal conductivity values for three types of water-based nanofluids havebeenexperimentallydetermined forvarioustemperaturesrangingbetween20ºCand40ºC.Thespecification of nanofluids are shown in belowtable.

**Table2.** The specification of nanofluids.

| Sr.No. | Nano-fluid | Particles Size in (nm) | Temperature range |
|---|---|---|---|
| 1 | Cu | 29 | 20˚c to 40˚c |
| 2 | $Al_2O_3$ | 36 | |
| 3 | $Al_2O_3$ | 47 | |

An alumina/water based nanofluid containing 4% volume fraction of particles it shows an increase in thermal conductivityof25%andcopperoxide/waternanofuidwith5%volumefractionofparticlesshowntoincreasethe thermalconductivityof22.4%,soResultsclearlyshowtheincreaseineffectivethermalconductivityofnanofluids with particle volume fraction, with temperature and as well as with a reduction in particlesize.[7]

Thermalconductivityofnanoparticle–fluidmixturebyXinweiWangandXianfanXu(1999)proposedthework, two types of nanofluid ($Al_2O_3$,CuO) are dispersed in water, vacuum pump fluid, engine oil, ethylene glycol etc. $Al_2O_3$ and CuO particles measuring approximately 20 nm are dispersed in distilled (DI) water, ethylene glycol, engine oil, and vacuum pump fluid. Thermal conductivities of the fluids are measured by a steady-state parallel- plate technique. The average diameter of the $Al_2O_3$ powders is 28 nm, and the average diameter of the CuO powders is 23 nm. The received powders are sealed and are dry and loosely agglomerated. The powders are dispersedintoDIwater,vacuumpumpfluid,ethyleneglycol,andengineoil.Thepowdersareblendedinablender for one-half an hour and then are placed in an ultrasonic bath for another half an hour for breaking agglomerates. Resultsshowthatthethermalconductivitiesofnanoparticlefluidmixturesarehigherthanthoseofthebasefluids. The thermal conductivity of nanoparticle fluid mixtures increases with decreasing the particle size. The thermal conductivity increase also depends on the dispersion technique.[8]

Preparation techniques for nanofluids by A.Renuka Prasad, Dr.Sumer Singh and Dr.Harish Nagar (2017), This paper presents procedure for preparing a nanofluid which is a suspension consisting of nanophase powders and a base liquid and Mathematical expression for the nanofluid properties. The nanofluid shows great potential in enhancing the heat transfer process. One reason is that the suspended ultra-fine particles remarkably increase the thermal conductivity of the nanofuid. Nanofluids increase the Absorption of solar enegy will be maximized with change of the size, shape, material and volume fraction of the nanoparticles. The prepared nano-fluid shows the following properties,[9]

**Table3.** Properties of a Nanoparticles and base fluid.

| Nanoparticle | Thermal Conductivity (W/mk) | Density (kg/m3) | Specific Heat (J/kgK) | Volume Fraction |
|---|---|---|---|---|
| $Al_2O_3$ | 40 | 3970 | 765 | 0.9 |
| $TiO_2$ | 8095 | 4250 | 686.2 | 0.9 |
| Water (base fluid) | 0.613 | 997.2 | 4179 | 21 |

## V. Some Advantages Of Nano-Fluid

- Absorption of solar energy will be maximized with change of the size, shape, material and volume fraction of thenanoparticles.
- The suspended nanoparticles increase the surface area and the heat capacity of the fluid due to the very small particlesize.
- ThesuspendedNanoparticlesenhancethethermalconductivitywhichresultsimprovementinefficiency of heat transfersystems.
- Heatingwithinthefluidvolume,transfersheattoasmallareaoffluidandallowingthepeaktemperature to be located away from surfaces losing heat to theenvironment.
- The mixing fluctuation and turbulence of the fluid areintensified.
- The dispersion of nanoparticles flattens the transverse temperature gradient of thefluid.
- Tomakesuitablefordifferentapplications,propertiesoffluidcanbechangedbyvaryingconcentration ofnanoparticles.
- Nanofluids are efficiently used in Solar Thermalapplications.[9]

## VI. Limitations Ofnano-Fluid

- The major limitation in using nanofluid is poor long term stability of nano particle insuspension.
- Increased pressure drop and pumpingpower.
- Lower specificheat.
- High cost ofnanofluids.[9]

Theeffectivethermalconductivityandthermaldiffusivityofnanofluids,byX.Zhang,H.Gu,andM.Fujii(2005) were determined using the transient short-hot-wire technique. the effective thermal conductivities and thermal diffusivitiesofAl2O3/water,ZrO2/water,TiO2/water,andCuO/waternanofluidsaremeasuredandtheeffectsof the volume fractions and thermal conductivities of nanoparticles and temperature are clarified. The average diameters of $Al_2O_3$, $ZrO_2$, $TiO_2$, and CuO particles are 20, 20, 40, and 33 nm, respectively. The uncertainty of the present measurements is estimated to be within 1% for the thermal conductivity and 5% for the thermal diffusivity. The measured results show that the effective thermal conductivity and thermal diffusivity increase generally as the volume fraction of the particlesincreases.[10]

Heat transfer enhancement has been investigated in a square cavity subject to different side wall temperatures usingwater/SiO2nanofluidbyM.Jahanshahi,S.F.Hosseinizadeh,M.Alipanah,A.Dehghani,G.R.Vakilinejad, (2010). SiO2 particles with the average size of 12 nm were synthensized by plasma process and used for the preparation of nanofluids. SiO2 nanofluid has been prepared in a two-step procedure by dispersing nanoparticles in base fluid. Deionized water was used as a base fluid for the preparation of SiO2 nanofluids. An ultrasonic disruptorisusedtopreparenanofluids.thethermalconductivityofSiO2nanofluidare3.23%and23%atavolume fraction of 1 and 4percent.[11]

## VII. Review Model (Carbon Basednano-Fluid)

carbon black nanofluids were prepared by dispersing the pretreated carbon black powder into distilled water by Dongxiao Han, Zhaoguo Meng, Daxiong Wu, Canying Zhang and Haitao Zhu (2011), they also study The size and morphology of the nanoparticles. The photothermal properties, optical properties, rheological behaviors, and thermalconductivitiesofthenanofluidswerealsoinvestigated.Theoriginalcarbonblackpowderwaspretreated as follows: 15 g of original carbon black powder and 300 ml 30% H2O2 were added into a round-bottomedflask andheatedtoboilingundermagneticstirring.Thereactionwascarriedoutunderstirringandboilingfor5h.Then the mixture was filtrated at room temperature and dried at 100°C. Pretreated carbon black powder was obtained by repeating the process twice. Then the pretreated carbon black powder was ground and dispersed into distilled waterunderultrasonicvibrationfor1h.rties,opticalproperties,rheologicalbehaviors,andthermalconductivities ofthenanofluidswerealsoinvestigated.Theresultsshowedthatthenanofluidsofhigh-volumefractionhadbetter photothermalproperties.Bothcarbonblackpowderandnanofluidshadgoodabsorptioninthewholewavelength ranging from 200 to 2,500 nm. The nanofluids exhibited a shear thinning behavior. The thermal conductivity of carbonblacknanofluidsincreasedwiththeincreaseofvolumefractionandtemperature.Thethermalconductivity was measured on thermal Property Analyzer using a single-needle sensor for heating and monitoring of the temperature, which is based on the transient hot wire method. The instrument's probe (1.3 mm in diameter and 60-mmlong)wasverticallyimmersedinthecenterofnanofluids.hethermalconductivityrangeoftheprobewas

0.02 to approximately 2 W/mK.[12] Improving the Heat Transfer of Nanofluids and Nanolubricants with Carbon Nanotubes by F.D.S. Marquis and L.P.F. Chibante (2005) a new class of heat transfer fluids was developed by suspending nanoparticles and carbon nanotubes in these fluids. The resulting heat transfer nanofluids and nanolubricants possess significantly higher thermal conductivity. Thermal Conductivities of Various Solids and Liquids as shown in below table,[13]

**Table4.** Thermal Conductivities of Various Solids and Liquids.

| Sr.No. | Material | Form | Thermal Conductivity in (W/mK) |
|---|---|---|---|
| 1 | Carbon | Nanotubes | 1,800–2,000 |
| 2 | | Diamond | 2,300 |
| 3 | | Graphite | 110–190 |
| 4 | | Fullerenes (film) | 0.4 |

Thermal conductivity of CNT (Carbon Nanotubes) water based nanofluids, model developed by Patrice Estelle, Salma Halelfadl, Thierry Mare, (2015). Thermal conductivity measurement of carbon nanotubes water-based nanofluids is here reported. The experiments show that TC (Thermal Conductivity) enhancement of nanofluids produces at very low volume fraction. Three nanofluids, denoted N1, N2 and N3, are composed with the same nanotubes and differ from the surfactant used. The last nanofluid denoted N4 is obtained from nanotubes with

loweraspectratioandhigherdensitydispersedwiththesamesurfactantthattheoneusedwithN3.Theproperties of the different nanotubes and nanofluids are summarized in belowtable,

**Table6.** Properties of the different nanotubes and nanofluids.

| | N1 | N2 | N3 | N4 |
|---|---|---|---|---|
| Nanotube average diameter d(nm) | 9.2 | 9.2 | 9.2 | 11.4 |
| Nanotube average length l(μm) | 1.5 | 1.5 | 1.5 | 1 |
| Average aspect ratio (r=l/d) | 160 | 160 | 160 | 90 |
| Density (kg/m3) | 1800 | 1800 | 1800 | 2050 |
| Carbon purity (wt.%) | 90 | 90 | 90 | 90 |

Result shows the TC of base fluid decreases when the amount of surfactant is increased, and that the TC is lower thantheoneofdeionizedwateratthesametemperature.TCofNFincreaseswhenboththeCNTnanotubevolume fraction increases and temperature as well.[14]

## VIII. Conclusion

Thermal conductivity of conventional fluid is very low, so the heat absorbing rate is also small therefore need to increase the optical properties of the convention fluid. To overcome these problem new class fluid is developed i.e. Nanofluid. In the present study the nanofluid parameters such as base fluid properties, types of solid phase, nanoparticle size and concentration, synthesis techniques and nanofluid stabilization methods werediscussed.

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