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Computational analysis of intensive and extensive properties of Nano fluids

Rakesh Kumar[1] Mehak Hans[2] Rockey Tyagi[3]
Department of Materials Science and Nano Technology
Deen Bandhu Chhotu Ram University of Science and Technology Sonepat, Haryana

Abstract: A colloidal mixture of Nano-sized (<100 nm) particles in a base fluid called Nano-fluid, which is the new era of heat exchange fluid for different high temperature exchange applications where transport attributes are considerably higher than those of the base fluid. In the present study, the impacts because of volume fraction on thermo-physical properties (Thermal conductivity, Density, Specific Heat and Heat Capacity) for CuO,Al_2O_3,TiO_2,Fe_3O_4 with water and ethylene glycol based Nanofluids are tentatively explored. The present work concentrates on thermal conductivity and heat Capacity of Nano fluids using computational analysis. Results demonstrate that thermal conductivity increments with volume fraction for different Nano fluids with different percentage-of-increment
Keywords: Specific Heat, Thermal Conductivity, Heat Capacity, Density,

I. INTRODUCTION

Auto radiator is a basic bit of the engine cooling system. Due to confined space at the front of the engine, the degree of the radiator is constrained and can't be fundamentally stretched. Thusly, it is essential to grow the high temperature trade capacities of working fluids, for instance, water and ethylene glycol in radiators because of their low thermal conductivity. A late headway in Nanotechnology has been the presentation of Nano-fluids, i.e. colloidal suspensions of nanometer-sized strong particles rather than regular working liquids. Nanofluids are another class of liquids designed by Choi (**1995**)[1] scattering nanometer-sized materials (nanoparticles) in base liquids.Nanofluids are Nanoscale colloidal suspensions containing condensed Nano materials. They are two-stage frameworks with one stage (solid phase) in an alternate (fluid phase). Due to their phenomenal
Thermal execution, Nano- liquids have pulled in consideration as another era having diverse application in the field of Heat Exchangers, in Chemical Plants and in Auto-Cooling . Defense and Aerospace applications .The paper assesses different parameters of Heat exchange and relations between them.

A. Literature Review

Lee et al. (**1999**)[2] created model for measuring the thermal conductivity of liquids containing metals or metal oxides of conductivity higher than base liquids. Wang et al. (**1999**)[3] led probes the liquids having nanoparticles mixture and found that thermal conductivities of nanoparticle–fluid mixtures expand with respect to those of the base liquids. Li and Peterson (**2006**) investigate the nanofluids by differing the temperature of the liquid and additionally the volume fraction has been changed, and found that there is a viable increment in the thermal conductivity of the nanofluids. Xuan and Li (**2003**)[4] investigated experimentally heat transfer performance of Cu/water Nano fluid with concentration of 2% under turbulent flow conditions in a tube and observed more than 39% enhancement in the Nusselt number compared with pure water. Liu et al. (**2006**) and Murshed et al. (**2005**)[5] demonstrated the thermal conductivity improvement of Cuo Nano fluid and Titanium dioxide nanofluids respectively. Ollivier et al.[6] (**2006**) investigated the utilization of Nano fluids as a jacket water coolant in a gas spark ignition engine. They numerically simulated the unsteady heat exchange through the chamber and inside the coolant stream and reported that in light of higher thermal diffusivity of nanofluids, the thermal signal variations for knock detection expanded by 15% over the anticipated utilizing immaculate water. Nguyen et al. (**2007**) [7] used Al_2O_3/water Nano-fluid in an electronic cooling system and found a maximum of 40% Enhancement in convective heat transfer coefficient at an added particle concentration of 6.8 vol%. Gherasim et al.(**2011**)[8] displayed numerical recreations for an outspread stream cooling framework with an Al_2O_3/water Nano-fluid stream. The results show that the expansion of nanoparticles to the base liquid improves high temperature exchange execution. Likewise the numerical results demonstrate that the average Nusselt number and pumping force of Nano-fluid increment with expanding the

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molecule volume fixation. Mohammed et al.(**2011**) [9] numerically considered the impacts of utilizing Nano-fluid on the execution of a square molded micro-channel heat exchanger (MCHE). Their results exhibited that Al_2O_3 and Ag nanoparticles have the most noteworthy heat exchange coefficient and least Pressure drop among all nanoparticles tried, separately. They inferred that the profits of nanofluids, for example, upgrade in heat exchange coefficient are prevailing over the weaknesses, for example, increment in Pressure Drop. Peyghambarzadeh et al. (**2011**)[10] examined tentatively the convective high temperature exchange improvement of water and Ethylene Glycol based nanofluids.. The results demonstrate that the high temperature exchange improves around 40% compared with the base liquids in the best conditions. Shafahi et al.(**2012**) [11] utilized a two-dimensional investigation to study the heat exchange of a barrel shaped high temperature funnel using Al_2O_3,CuO and Tio_2 nanofluids. Their results affirmed that the heat exchange of a heat pipe is enhanced and thermal resistance across the heat pipe are reduced and maximum capillary heat transfer of the heat pipe is observed when nanofluids are utilized as the working fluid. The so improved properties of base fluids with nanoparticles dispersed in them need to be explored.

Table1. Thermo Physical Properties of various Nanoparticles in oxide Form

Particles	**Specific Heat (J/kg K)**	**Density(Kg/m3)**	**Thermal Conductivity (W/mK)**	**Diameter**
Al_2O_3	880	3700	46	20nm
CuO	540	6510	18	20nm
TiO_2	710	3840	11.7	10nm
Fe_3O_4	670	5180	80.4	36nm

Table2**.** Thermo Physical properties of base Fluids

Base Fluids	**Specific Heat (J/kg K)**	**Density (Kg/m^3)**	**Thermal Conductivity (W/mK)**	**Diameter (nm)**
Water	4197	971	0.669	0.384
Ethylene Glycol	2608.3	1081.4	0.261	0.415

II. METHODOLOGY

In order to examine the heat exchange of nanofluids and use them in practical applications, it is essential first to study their thermo-physical properties such as density, specific heat and thermal conductivity.

A. Specific Heat and Density

Utilizing traditional formulas determined for a two-phase mixture, the Specific Heat(Pak and Cho, 1998) [12]and density (Xuan and Roetzel, 2000)[13]of the nanofluid as an issue of the particle volume concentration and individual properties can be processed utilizing after Mathematical statements:

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$$\rho_{eff} = \left(\frac{m}{V}\right)_{eff} = \frac{m_b + m_p}{V_b + V_p} =$$

$$= \frac{\rho_b V_b + \rho_p V_p}{V_b + V_p} = (1-\phi_p)\rho_b + \phi_b \rho_p$$

$$(\rho C_p)_{eff} = \rho_{eff}\left(\frac{Q}{m\Delta T}\right)_{eff} = \rho_{eff}\frac{Q_b + Q_p}{(m_b + m_p)\Delta T} =$$

$$= \rho_{eff}\frac{(mC_p)_b \Delta T + (mC_p)_p \Delta T}{(m_b + m_p)\Delta T} =$$

$$= \rho_{eff}\frac{(\rho C_p)_b V_b + (\rho C_p)_p V_p}{\rho_b V_b + \rho_p V_p} =$$

$$= (1-\phi_p)(\rho C_p)_b + \phi_p(\rho C_p)_p$$

which can be rewritten as

$$C_{p,eff} = \frac{(1-\phi_p)(\rho C_p)_b + \phi_p(\rho C_p)_p}{(1-\phi_p)\rho_b + \phi_p \rho_p}$$

B. Thermal Capacity

It is the product of the density of nanofluids and the specific heat of nanofluids. It is a measurable physical quantity equal to the ratio of the heat added to (or subtracted from) an object to the resulting temperature change. Heat capacity is an extensive property of matter, meaning it is proportional to the size of the system.

$$Q = \rho_{nf\,X}\, C_{pnf}$$

C. Thermal Conductivity

The Thermal conductivity (knf) for Nano-fluid have been evaluated focused around two semi-empirical mathematical statements exhibited by Corcione [14] **(2011)** on the premise of a wide experimental data of trial information accessible in the writing as taking after comparisons:

$$\frac{k_{eff}}{k_{bf}} = 1 + 4.4\mathrm{Re}^{0.4}\mathrm{Pr}_{bf}^{0.66}\left(\frac{T}{T_{fr}}\right)^{10}\left(\frac{k_p}{k_{bf}}\right)^{0.03}\phi^{0.66}$$

III. RESULTS

Fig 1. Density of Nano Fluid with Base Fluid as Water and Ethylene Glycol

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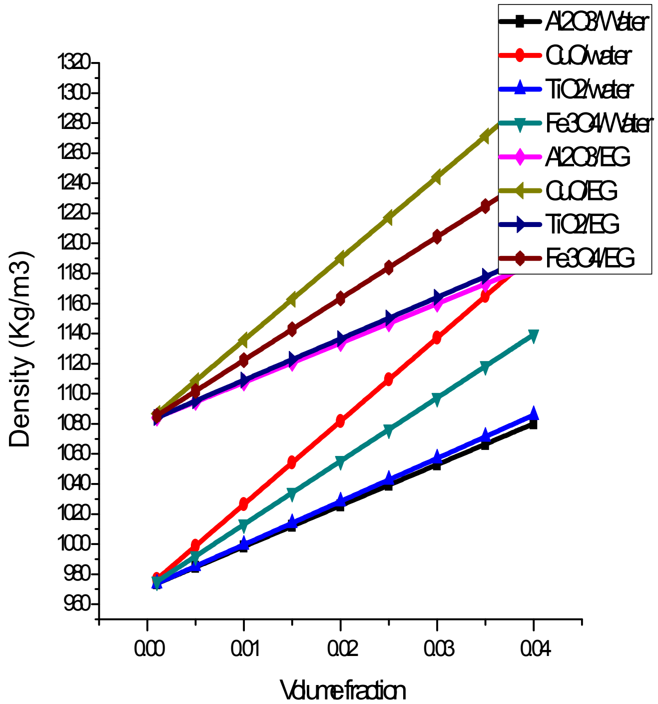
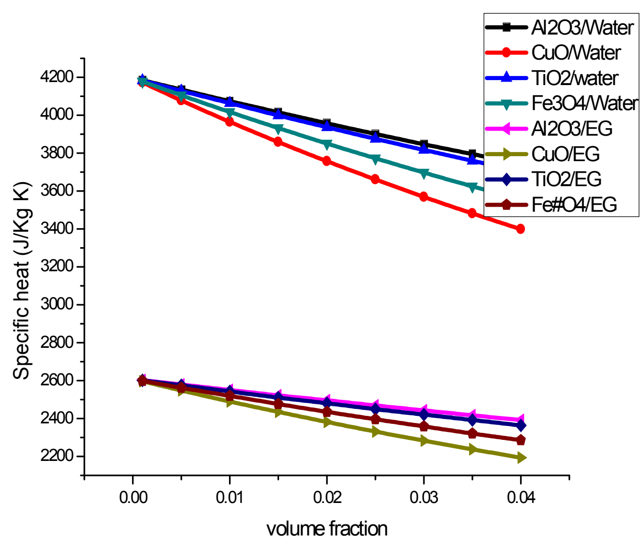


The density of Nano-fluids for volume fraction from 1% to 4% increases with water and ethylene glycol as base fluid.[15]

Fig2. Specific Heat of Nano fluid with Base Fluid as water and ethylene Glycol



The Specific Heat of Nano-fluids for volume fraction from 1% to 4% decreases with water and ethylene glycol as base fluid.[16-18]

Fig3. Thermal capacity of nanofluids with water as base fluid

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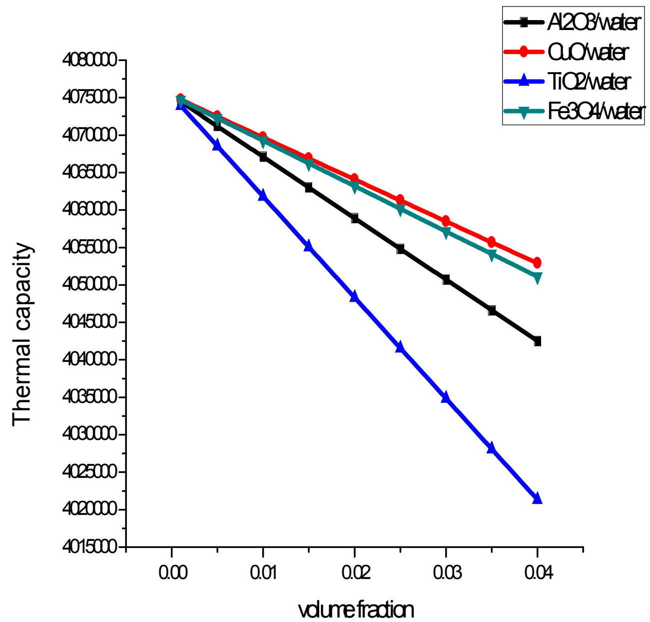
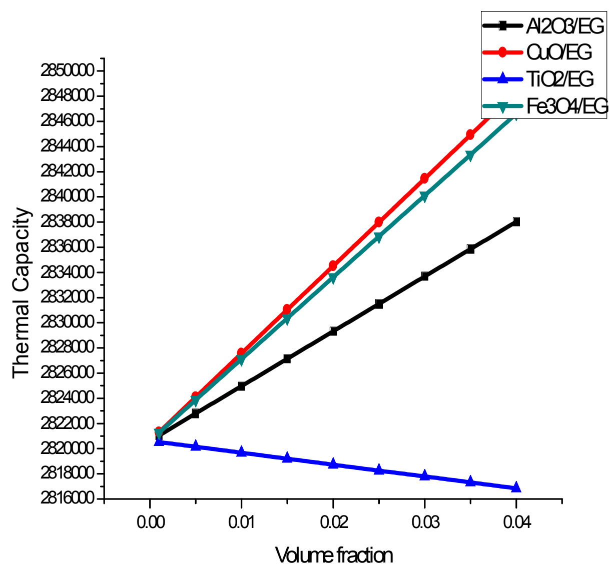


Fig4. Thermal Capacity of Nano fluids with Ethylene Glycol as base fluid



The thermal capacity of the Nano fluids decreases with increase in volume fraction with base fluid as water but in case of ethylene Glycol it increases for Al_2O_3, CuO, Fe_3O_4 nanoparticles with different volume fraction.

Fig5. Keff/ Kb for different nanofluids with water as base fluid at 343K.

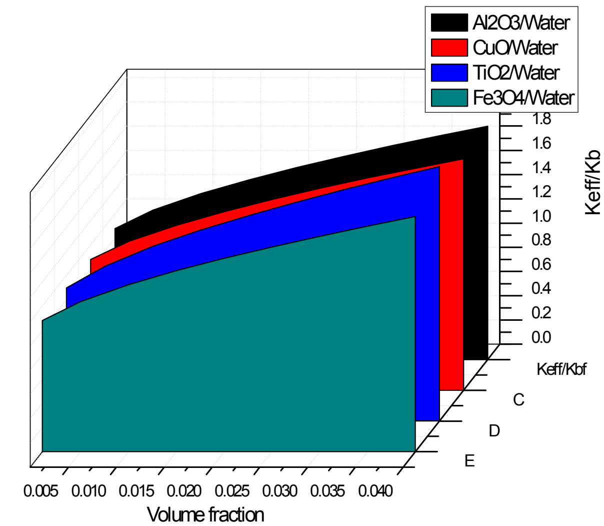
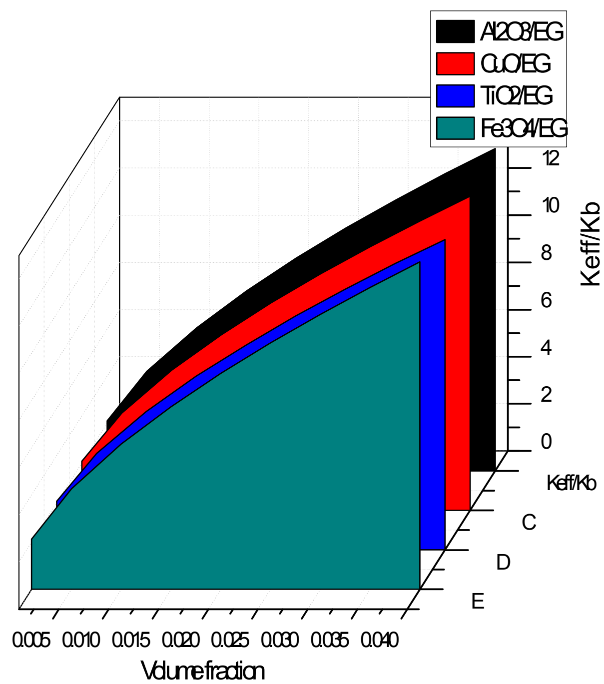


Fig6. Keff/Kb for different nanofluids with Ethylene Glycol as base fluid at 343K.



There is an increment in the effective thermal conductivity of the nanofluids as compared to the base fluids. (Ethylene Glycol and Water).The increment in the thermal conductivity is more in the ethylene Glycol as base fluid as compared to the water as base fluid[11,19-21]

IV. CONCLUSION

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In the present study, the effective thermal conductivity, Density, Specific Heat and Thermal Capacity of $CuO/Al_2O_3/TiO_2/Fe_3O_4$:Water/Ethylene Glycol based nanofluids with particle volume fraction were investigated at temperature 343K. The results show that the relative thermal conductivity of Nano fluid increases with particle volume fraction and . In contrast, the density of nanofluids significantly increases with particle volume fraction. The effect of temperature on the enhanced thermal conductivity of nanofluids is important for theoretical understanding and needs to be considered for further development. Finally, it is inferred from this study that the thermo-physical properties should be considered as important parameters with the use of nanofluids for high-temperature applications.

Nomenclature

ρ_{nf}= density of Nano fluid
ρ_p= density of particles (Kg/m^3)
C_p= specific heat of Nano particles
$C_{p\ nf}$=specific heat of Nanofluids (J/KgK)
M_b= mass of base fluids
M_p= mass of Particles (Kg)
V_b=volume of Base fluids
V_p=volume of Particles (m^3)
Q = Thermal Capacity (J)
Re= Reynolds Number
Pr= Pradantl Number
Kb =Thermal Conductivity of Base fluid
T=Temperature (K)
K_{eff}= Effective thermal Conductivity

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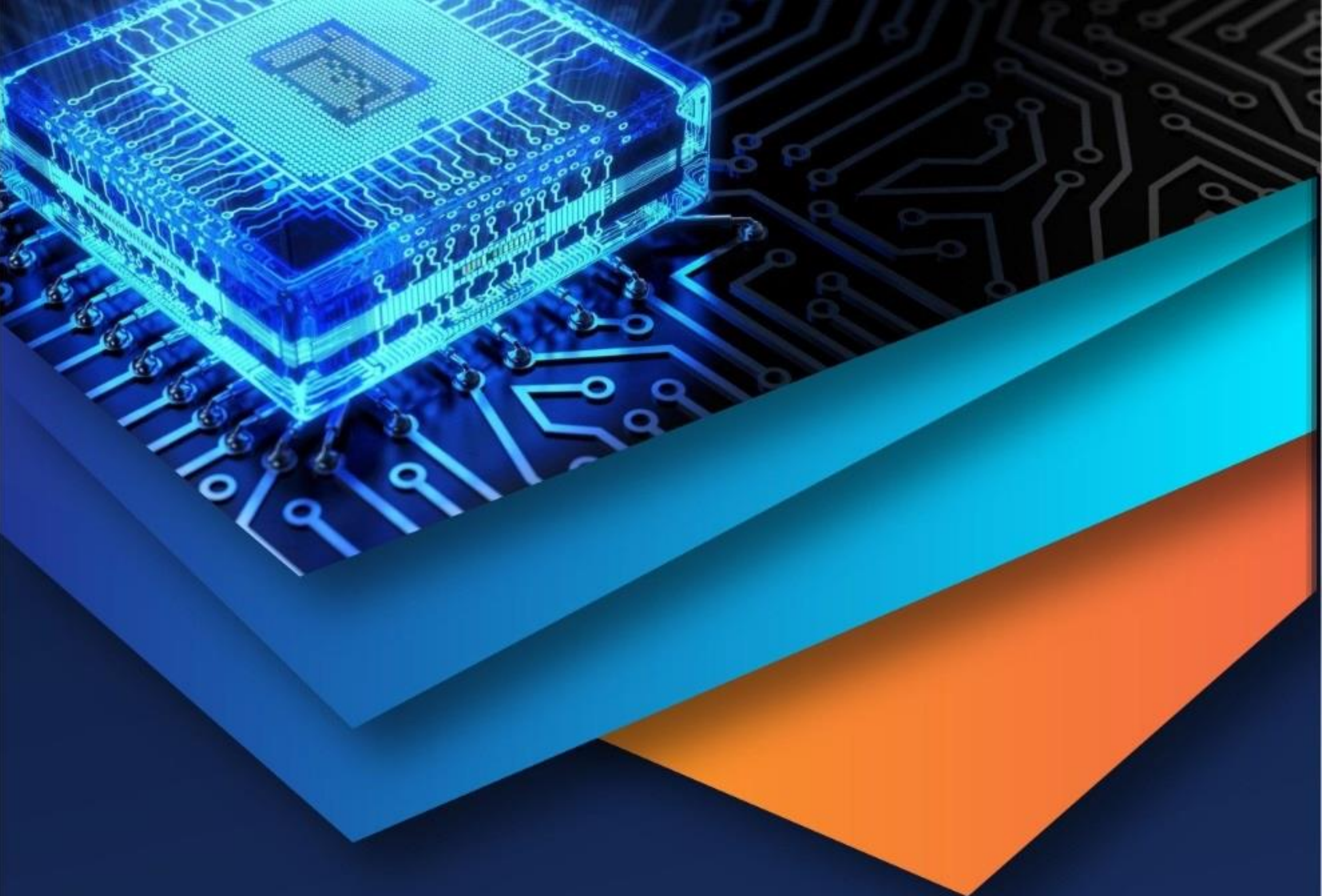

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