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Effect of Nanoparticle Concentration on Thermophysical Properties of Nanofluids

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ABSTRACT: Present study aims at comprehensive review of Thermo-physical properties of a nanofluid. Heat transfer in Nanofluids depends upon various factors like Particle Size, Brownian Motion, Molecular layering of liquid etc. In this work different thermos-physical properties like Thermal Conductivity, Viscosity, Specific Heat, Density are studied and the effect of particle concentration at different levels on these thermos-physical properties was reviewed. As Thermal Conductivity, Specific Heat and Density majorly effect on heat transfer capacity of Nanofluid, this work is concentrated on Study of these thermos-physical properties. Nanofluids' thermal conductivity and viscosity greatly depend on their size, volume concentration, shape and material. Nanofluid viscosity may increase or decrease depending upon the material of nanoparticle on lowering the size. Viscosity of nanofluid increases with increase in volume fraction of nanoparticle.

KEYWORDS: Nanoparticles, Nanofluid, Thermal Conductivity, Viscosity, Volume Concentration, Heat Transfer.

I. INTRODUCTION

The term "NANO FLUID" was first suggested by Sir Stefan Choi in the year 1995 at Argonne National Laboratory, USA. Since then various researches were carried out to explore their heat transfer characteristics. Since the last few decades, there has been an enormous growth in technologies ranging from electronics and communication, and computers. The need to attend to the thermal management problems in these areas gives the researchers a reason to find better, efficient cooling systems. Nano fluids with their superior thermal and electrical properties can find their applications in these areas. Nano fluids are quasi single phase medium which forms several colloidal dispersions of metallic, non-metallic ceramic or carbon nanotubes nanoparticles in a given base fluid. Nano fluids are characterized by an enrichment of base fluid like Water, Ethylene glycol, or oil with nanoparticles of various types mentioned above. When nanoparticles are suspended in a suitable base fluid, the Nano fluids thus prepared have superior thermal and electrical properties in comparison to their base fluids. The enormous heat transfer capacities of Nano fluids have motivated the researchers to explore the properties. Nano materials such as copper oxide, copper, aluminum oxide, silicon dioxide, carbon nanotubes etc., have been used for developing Nano fluids for the thermal properties that they offer. The boundary layer phenomenon and the Brownian motion of the particles play an important role in the rate of heat transfer enhancement. The Nusselt number rises considerably by increase in the volume concentration of the Nano fluid. Maximizing the heat transfer area, A is a common strategy to improve the heat transfer and many heat exchangers such as radiators and plate and frame heat exchanger designed to maximize the heat transfer area. This strategy cannot be applied to the microelectromechanical systems (MEMS).

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II. MEASUREMENT OF THERMO-PHYSICAL PROPERTIES AT DIFFERENT CONCENTRATION

The main thermo-physical properties of nanofluids are discussed in this section.

A) **Measurement of Thermal Conductivity:** Thermal conductivity is defined as amount of heat transferred through unit thickness of material in a direction normal to unit surface area. It is a measure of amount of heat transferred through material.

Thermal conductivity of nanofluid is determined by following equation,

$$k_{nf} = \frac{k_p + (2 * k_{water}) + (2 * (k_p - k_{water})) * \phi}{k_p + (2 * k_{water}) - ((k_p - k_{water})) * \phi}$$

Where, k_p = Thermal conductivity of nanoparticle

k_{water} = Thermal conductivity of water.

Thermal Conductivity measured using above equation at different concentration is given in following table,

Concentration (%)	Thermal conductivity (W/mK)
1	1.03
5	1.165
10	1.33
15	1.524
20	1.742

Table. 1 Thermal Conductivity of Nanofluid at Different Concentration Levels.

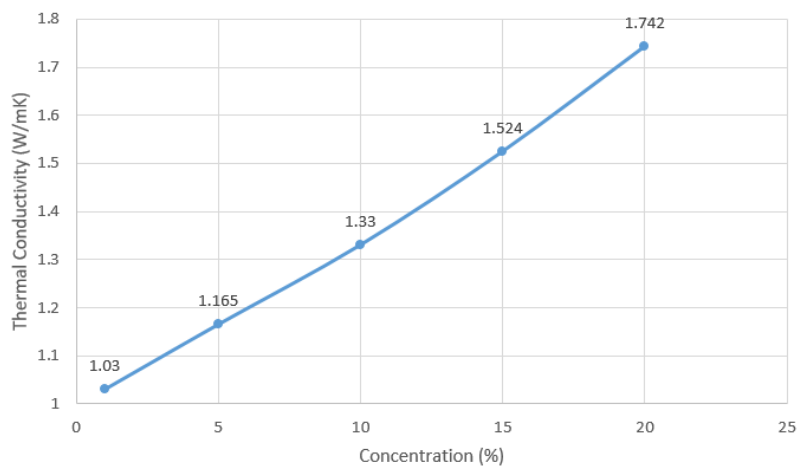


Fig.1 Graph of relationship between Thermal Conductivity and Concentration.

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Vol. 8, Issue 5, May 2019

B) **Measurement of Specific Heat:** The specific heat capacity is ratio of quantity of heat added or removed from an object to temperature change. The specific heat of nanofluids can be calculated by using mass balance equation as:

$$C_{nf} = \frac{(1-\phi_s)\rho_f C_f - \phi_s \rho_p C_p}{\rho_{nf}}$$

Where, ϕ = Nanoparticle Percentage,

ρ_f = Density of Base Fluid.

ρ_p = Density of Nanoparticle

Specific heat measured using above equation at different concentration is given in following table,

Concentration (%)	Specific Heat (J/kg K)
1	4146.2
5	4015.05
10	3851.12
15	3687.15
20	3523.21

Table 2 Values of Specific Heat at Different Concentration

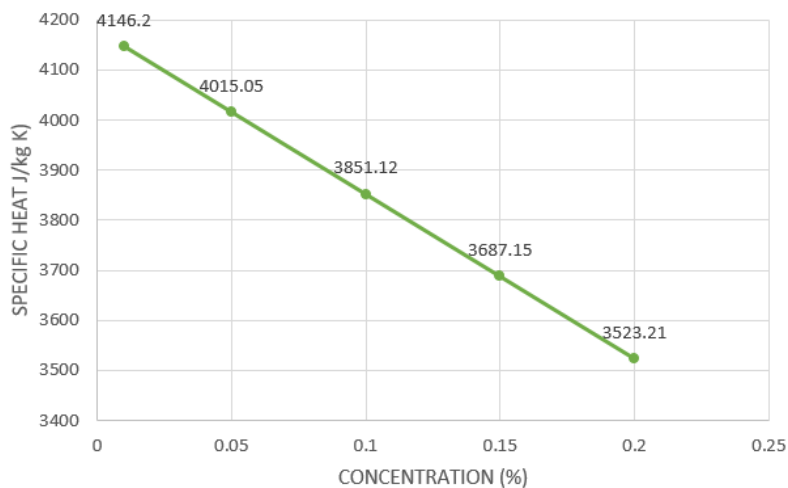


Fig.2 Graph Showing Relationship Between Specific Heat and Concentration

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Vol. 8, Issue 5, May 2019

C) Measurement of Density: The density of a substance is mass per unit volume. It can be numerically calculated by mass balance as follows,

$$\rho_{nf} = (1 - \phi_s)\rho_f + \phi_s \rho_p$$

Where, ρ_f = Density of Base Fluid,
 ϕ_s = Concentration of Nanoparticles,
 ρ_p = Density of Nanoparticles.

Density measured by above equation at different concentration levels is given in following table.

Concentration (%)	Density (kg/m ³)
1	1014.22
5	1082.74
10	1168.39
15	1254.03
20	1339.68

Table 3 Values of Density at different concentration

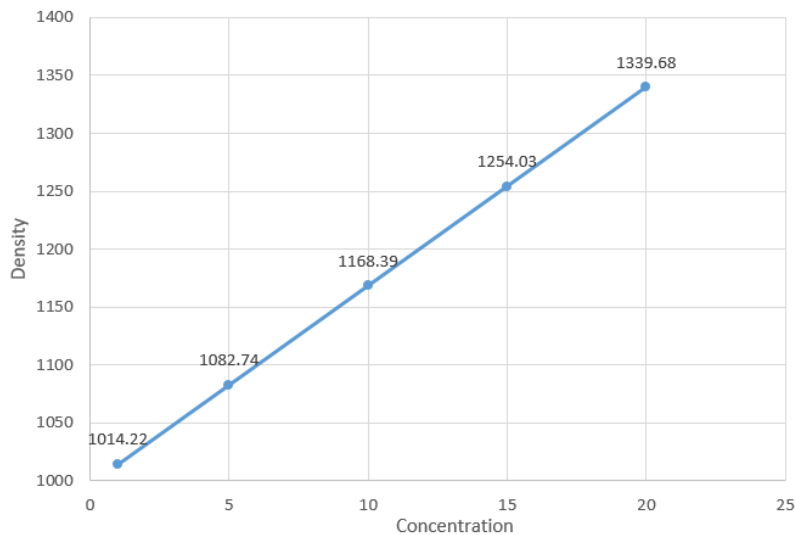


Fig. 3 Graph showing relationship between Density and Concentration

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III. CONCLUSION

From this study it can be concluded that,

- Nanofluids can show better heat transfer capacity which depends upon particle size Thermal Conductivity & Viscosity of the nanofluid.
- The increased concentration nanoparticles is will to raise the convective heat transferefficiency.
- The convective heat transfer coefficient depends on Axial Profile, Length andconcentration of nanoparticles.
- The nanofluids can be used efficiently in convective heat transfer applications..

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