Thermal Characterization Of Nanofluid –A Review

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Abstract- *Heat transfer characteristics of common fluid can be improved by suspending nano-sized (less than 100 nm) solid particle and given mixture is considered as a prospective working fluid for the applications like an electronic cooling system, car radiator, condenser etc. This paper encapsulates important aspects of nanofluid like Convective heat transfer characteristics, a Preparation method of nanofluid, factors affecting thermal conductivity. The article also suggests the direction for future research.*

Keywords- Heat transfer, Nanofluid, Thermal Conductivity etc.

I. INTRODUCTION

Augmentation of Heat transfer is one of the major issues of thermo-fluidic system owing to lack of energy resources. In lasts, certain decade miniaturization of the systems demands more compact cooling systems. To enhance heat transfer rate by reducing energy losses using new techniques, it is most important to deal with the energy wastage problems. Various techniques like the use of the extended surface, Surface vibrations, Additives etc. are resulted in the enhancement of heat transfer rate. But in last certain decades researcher were more focused on Nanofluid. The Commonly working base fluids like water, oil, ethylene glycol have a low thermal conductivity which hindrance in an improvement of performance of heat exchanger. The idea of suspending nanoparticle in a base fluid for improving thermal conductivity has been coined by Choi(1995) at Argonne National Laboratory to describe the new class of nanotechnology-based heat transfer fluids that exhibit thermal properties superior to those of their host fluids or conventional particle-fluid suspensions[1]. So nanofluid can be defined as a suspension which can be obtained by dispersing nanoparticles inside the base fluid. This added nano-particles can drastically improve the effective thermal conductivity of mixture and helps in improvement of thermal performance of heat exchanger.

II. PREPARATION METHOD

The first step in any experiment study is to prepare stabilized nanofluids. Preparation of stabilized nanofluid is major criterion for heat transfer because if particles are not properly stabilized than it may cause a formation of agglomeration and eliminate discussion related to the nanoscale. Different two techniques are available for preparation of nanofluid namely, 1) Two-step Method 2) One step method

1) Two-step Method:

The two-stage method is the most commonly utilized technique for preparation of nanofluid. In this method, the nanoparticle is firstly obtained in the form of dry powder by suitable methods & then these particles are dispersed in the base fluid directly. One can make a use of different surfactants or Dispersant to stabilize nanoparticles to avoid agglomerations & sedimentation of particles inside a base fluid. Making nanofluids using the two-step processes has remained a challenge because individual particles quickly agglomerate before dispersion, and nanoparticle agglomerates settle out in the liquids. Well-dispersed stable nanoparticle suspensions are produced by fully separating nanoparticle agglomerates into individual nanoparticles in a host liquid. [2] Ramtin barzegarian et.al (2017) prepared the suspension of AL_2O_3 nanoparticle with SDSB(Sodium Dodecyl Benzene Sulphonate) stabilizer and no sedimentation has been observed after 60 min of sonication. [3] Azmi et.al (2015) prepared the suspension of AL_2O_3 nanoparticle without dispersant followed by 2 hr of sonication.

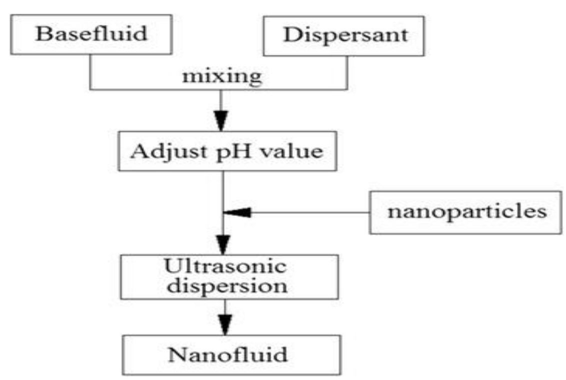

Fig.1-Two step Method

2) One step method:

With a specific end goal to reduce the agglomeration of nanoparticles, Choi developed a one-stage physical vapour build-up method to plan Cu/ethylene glycol nanofluid [1]. The one-stage process involves at the same time making and diffusing the particles in the fluid. In this system, the strategies of drying, stockpiling, transportation, and diffusing of nanoparticle are evaded, so the agglomeration of a nanoparticle is restricted and the solidness of fluids is extended. This method gives more stable suspension compared to two-step method. Zhu et al. (2004) developed a one-step chemical method for producing stable Cu-in-ethylene glycol nanofluids by reducing copper sulfate pentahydrate with sodium hypophosphite in ethylene glycol under microwave irradiation [1].

III.RESEARCH ON NANOFLUID CURRENT STATUS

1) Thermal conductivity:

The thermal conductivity of nanofluid received more attention in last certain decade because thermal conductivity is one of the main reasons for enhancement of heat transfer rate using nanofluids. There are several factors affects thermal properties of nanofluids are,

a) Particle volume Fraction: The volume concentration of nanofluids is one of the important characteristics of nanofluid which directly influences the thermal conductivity as well as the viscosity of nanofluids. Most of the research shown an increase in thermal conductivity and viscosity with an increment in particle volume fraction and the relation found is, all in all, linear. [4] Shriram et.al.(2017) measured the thermal conductivity of AL_2O_3-water nanofluid for different concentration and found enhancement ratio of 1.08 for 0.08% volume concentration at 50°C. And this ratio increased to 1.23 for the same concentration for AL_2O_3–ethylene glycol nanofluid. [2] Ramtin barzegarian et.al (2017) calculated thermal conductivity ratio using classical Maxwell Model and found an increase in thermal conductivity with respect to concentration level.[5]Saidur et.al found increment in thermal conductivity for all different shape of nanoparticle with an increase in concentration level.

b) Particle shape : For experimentation, spherical as well as cylindrically shaped nanoparticles are commonly used for nanofluid synthesis. The cylindrical particles have the larger aspect ratio (length to diameter ratio) than spherical particles. The wide differences in the dimensions of these particles do influence the enhancement of effective thermal properties of nanofluids. The major study found that there will be more heat transfer is associated with cylindrical particles. [5] Saidur et.al performed an experiment on five different shapes of γ-ALOOH nanoparticles (Spherical, cylindrical, platelets, Blades, Bricks) and found that the thermal conductivity of cylindrical particle is 2.47% more than spherical particle for given concentration of 0.010%.

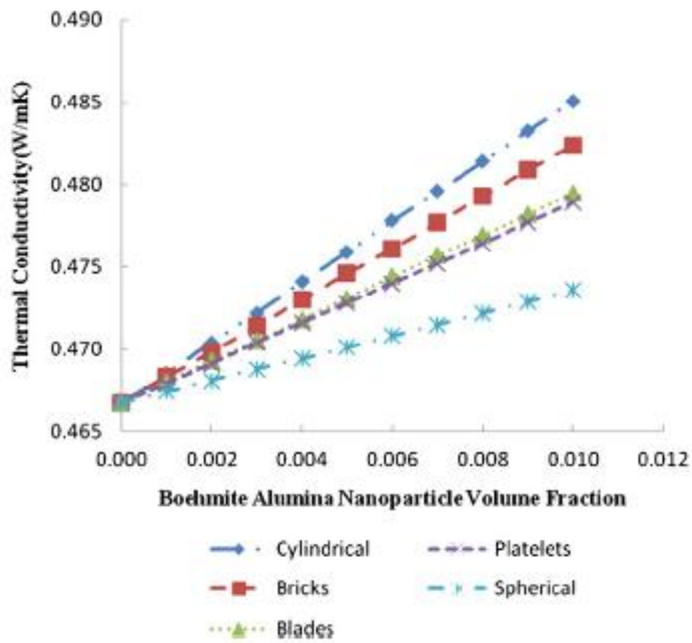

Fig.2 - Thermal conductivity ratio v/s Concentration level [5]

c) Temperature: The trend of majority experiment shows increased in thermal conductivity enhancement ratio with increased temperature. As the temperature of nanofluid increases the particle agglomeration, and viscosity decreases so that the decrement in the particle agglomeration and viscosity would improve the Brownian motion of nanoparticles in base fluid. [4] Shriram et.al.(2017) measured thermal conductivity of AL_2O_3-water nanofluid for different concentration at different temperature and found 7.40% increase in thermal conductivity ratio at 50°C compared to 30°C.

d) Surfactant : [6] Ran Liu et.al (2014) found that Compared with the anionic surfactant SDS(Sodium dodecyl sulphate) solutions, the thermal conductivity of non-ionic surfactant PVP (Polyvinylpyrrolidone) solutions decreases more quickly with the increase of mass fraction. And the thermal conductivity ratio of SDS solutions is higher than that of PVP solutions at the same concentration, but both lower than the thermal conductivity of deionized water, which means that surfactant has negative effects on the heat conduction of base fluid. The difference in the decrease of thermal conductivity ratio may be attributed to the difference in property and the length of the alkyl chain.So the selection of optimum concentration level of surfactant is an important criterion.

2) Overall heat transfer Coefficient & Convective heat transfer Coefficient

[7] Duangthongsuk et.al (2009) investigated thermal & Flow characteristics of $Ti\text{-}O_2$ Nanofluids (21nm cylindrical particles)

using a tube in tube heat exchanger and found that the convective heat transfer coefficient of nanofluid is slightly higher than that of the base liquid by about 6–11%.[8] Farajollahi et.al (2009) found optimum Concentration ratio of 0.3% and 0.5% for $Ti\text{-}O_2$ and AL_2O_3 at which nanofluid gives the maximum value of overall heat transfer coefficient.[9] Saidur et.al (2011) Found enhancement in overall heat transfer coefficient by 10.11 % for 2% volume fraction of copper nanoparticle and also found that the heat transfer enhancement is directly proportional to the mass flow rate of nanofluid.[10] Shriram et.al found that the nanofluids as coolant yields an overall heat transfer enhancement over the water about 16 % for both 1.5 LPM and 3.5 LPM of hot fluid flow rate.

3) Viscosity

Beside thermal conductivity, viscosity of nanofluids is another important thermal transport property in the application of heat transfer for energy engineering systems such as heat exchangers or cooling systems. Ray and Das [01] performed computational study of an automotive radiator using three different nanoparticles, Al_2O_3, CuO, and SiO_2 dispersed in the base fluid EG/W (60:40). Result reveals that by increasing the particle concentration increases viscosity which increased the Prandtl number but decreased the Reynolds number which affects the heat transfer and pumping power. [2] Ramtin barzegarian et.al (2017) found 0.0075% Enhancement in dynamic viscosity for 0.3% volume concentration.

Different Theoretical models has been used to calculate Viscosity of nanofluid but whenever Volumetric concentration ration is below 5% Einstein model is best for calculation of viscosity.

By reviewing and analysing the available literature about viscosity of nanofluid, it reveals that the viscosity of the nanofluid increased with increase in mass concentration and at higher particle volume fraction but decreased with the temperature.

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