Review on Application of Nano Fluid on Heat Exchangers

Dhanendra Sahu[1] D. N. Dewangan[2]
[2]Professor
[1,2]Department of Mechanical Engineering
[1,2]Rungta College of Engineering and Technology, Raipur, India

Abstract— The thermo physical properties of nano fluids and due to high heat transfer rates are highly demanded for heat exchanger applications. This paper presents a study on different types of nano fluids, nano particle concentrations and heat transfer improvement in various types of heat exchangers. Both experimental and numerical methods are used for analysis by various scholars and numerical results are validated with experimental results.

Keywords: Nano Fluids, Nano Particles, Thermal Conductivity

I. INTRODUCTION

Conventional fluids, such as deionized (DI) water or ethylene glycol (EG), used as the common working fluids in heat transfer applications have inherently low thermal conductivity relative to metals as well as metal oxides. Therefore, solid particles (Np) are added to these fluids to enhance their thermal conductivity. The product of this suspension is called a nanofluid, a term proposed by Choi in 1995 of the Argonne National Laboratory, U.S.A. A Nano fluid is a fluid contain Nano metre size metal particle, called Nanoparticles. These Nanofluids are engineering colloidal suspension of nanoparticle in base fluid by different methods. Nanoparticle used in Nano fluids are typically made of metals, oxides, carbides or carbon Nano tube. Common Nano particles are, Al_2O_3, CuO, TiO_2, CeO_2 and SiO_2. Base fluids include water, ethylene glycol and oil. Synthesis and stability of nanofluids are the two very primary requirements to study nanofluids.

II. CLASSIFICATION OF NANO PARTICLES

Nano particles are broadly divided into various categories depending on their morphology, size and chemical properties.[2]

A. *Carbon-based Nano particle*

Fullerenes and Carbon Nanotubes (CNTs) represent two major classes of carbon-based Nano particles Fullerenes contain nanomaterial that are made of globular hollow cage such as allotropic forms of carbon. These materials possess arranged pentagonal and hexagonal carbon units, while each carbon is sp2 hybridized. CNTs are elongated, tubular structure, 1–2 nm in diameter. These can be predicted as metallic or semiconducting reliant on their diameter telicity. These are structurally resembling to graphite sheet rolling upon itself. The rolled sheets can be single, double or many walls and therefore they named as single-walled (SWNTs), double-walled (DWNTs) or multi-walled carbon nanotubes (MWNTs)

B. *Metal Nano particles*

Metal Nano particles are purely made of the metals precursors. Due to well-known localized surface plasmon resonance (LSPR) characteristics, these Nano particles possess unique optoelectrical properties. Nano particles of the alkali and noble metals i.e. Cu, Ag and Au have a broad absorption band in the visible zone of the electromagnetic solar spectrum.

C. *Ceramics Nano particles*

Ceramics Nano particles are inorganic non-metallic solids, synthesized via heat and successive cooling. They can be found in amorphous, polycrystalline, dense, porous or hollow forms. Therefore, these Nano particles are getting great attention of researchers due to their use in applications such as catalysis, photocatalysis, photodegradation of dyes, and imaging applications.

D. *Semiconductor Nano particles*

Semiconductor materials possess properties between metals and non-metals and Semiconductor Nano particles possess wide bandgaps and therefore showed significant alteration in their properties with bandgap tuning. Therefore, they are very important materials in photocatalysis, photo optics and electronic devices.

E. *Polymeric Nano particles*

These are normally organic based Nano particles and, they are mostly nanospheres or noncapsular shaped. The former are matrix particles whose overall mass is generally solid and the other molecules are adsorbed at the outer boundary of the spherical surface.

III. LITERATURE REVIEW

Albadr et al. [1] experimentally studied horizontal shell and tube heat exchanger for forced convective heat transfer and flow characteristics of a counter flow under turbulent flow conditions for water as base fluid and different volume concentrations of Al_2O_3 nanofluid. They found that nanoparticles dissolved in distilled water not only increases thermal conductivity but also viscosity of the nanofluid. Friction factor increases with the increase in volume concentration of nanoparticle. Particle volume concentration of 2% the use of Aluminum oxide nanofluid gives significantly higher heat transfer characteristics.

Farajollahi et al. [2] Used shell and tube heat exchanger for comparative investigation of Al_2O_3 and TiO_2 water nanofluid. They studied that at different nanoparticle concentrations the heat transfer enhancements of both nanofluids are different. TiO_2/water and γAl_2O_3/water nanofluids has better heat transfer at higher volume concentrations, respectively.

Tiwari et al. [3] investigated experimentally to optimize particle volume fractions depends on a high heat transfer rate, convective heat transfer coefficient, also overall heat transfer coefficient, effectiveness and performance index. They gives result that the optimum volume conc. of Al_2O_3, CeO_2, SiO_2 and TiO_2 nanoparticles in water were 0.75, 1.0, 0.75 and 1.25 vol.%, for maximum heat transfer rate, overall heat transfer coefficient, convective heat transfer coefficient and effectiveness, respectively.

El-Maghlany et al. [4] experimentally investigated the thermal behavior of horizontal double tube heat exchanger having counter flow. Due to availability of high surface area for heat transfer, there is enhancement in overall heat transfer coefficient. They observed that availability of nanofluid and the rotation of inner pipe effectively increase the heat transfer rate however, On account of rotational speed of the inner pipe, pressure drop increases significantly.

Vermahmoudi et al. [5] experimentally investigated by considering laminar flow conditions, overall heat transfer coefficient of water-based iron oxide nanofluid has been measured in compact air-cooled heat exchanger. The concentrations range of 0.15%, 0.4% and 0.65 vol.% of stabilized Fe_2O_3/water nanofluid have been examined with different flow rates in the range of 0.2–0.5m3/h. The result shows that when nanofluid inlet temperature increases from 50 to 80 °C, the overall heat transfer coefficient reduced due to the large increase in the LMTD with gradually increasing nanofluid temperature difference.

Javadi et al. [6] studied SiO_2, TiO_2 and Al_2O_3 nanofluids were passed in a plate heat exchanger and the behaviour on thermo physical properties and heat transfer characteristics are compared with the base fluid. They concluded that the increasing nanoparticle's volume concentration, Prandtl number goes on decreasing. At 0.2% volume concentration maximum Prandtl number occurred which is equal to 0.406, 0.415, and 0.382 for Al_2O_3, SiO_2, and TiO_2 nanofluids, respectively.

Mare et al. [7] studied experimentally of two types of nanofluids for their thermal performances for comparison. The first nanoparticles used alumina oxide dispersed in water and the other one is aqueous suspensions of nanotubes of carbons. They found that for the same Reynolds number an improvement of convective heat transfer coefficient in laminar mode is about 42% and 50% for N1 and N2 respectively when compared with pure water.

Suresh et al. [8] investigated experimentally thermal characteristics of Al_2O_3/water and CuO/water nanofluids in transition flow in helical screw tape inserted in straight circular duct. Thermal performance analysis is mainly depends on the constant pumping power criteria, helical screw tape inserts give better thermal performance when used with CuO/water nanofluid than with Al_2O_3/water nanofluid. They concluded that CuO/water nanofluid is more efficient and gives better enhancement in heat transfer compared to Al_2O_3/water nanofluid.

Tiwari et al. [9] experimentally investigated the performance of the plate heat exchanger have been studied using different nanofluids (CeO_2, Al_2O_3, TiO_2 and SiO_2) for best overall heat transfer rate at different volume flow rates and specific range of concentrations. They give result that at the lower volume concentrations TiO_2 and CeO_2 nanoparticles possesses better heat transfer characteristics and at the higher volume concentrations Al_2O_3 and SiO_2 nanoparticles at the higher volume concentrations are more effective.

Sarafraz et al. [10] investigate experimentally the heat transfer coefficient and pressure drop characteristics of carbon nanotube water-based nanofluids inside the double pipe heat exchanger. They observed that presence of carbon nanotubes inside the deionized water can enhance the thermal conductivity of nanofluid up to 56% for wt.% = 0.3.

Labib et al. [11] studied numerically convective heat transfer of Aluminium oxide nanoparticle into two different base fluids. They give result that heat transfer coefficient enhancement appears to be more for using Ethylene Glycol as a base fluid than water.

Tiwari et al. [12] experimentally investigated the heat transfer and pressure drop characteristics in a chevron-type corrugated plate heat exchanger using CeO_2/water nanofluid as the coolant. Their result indicate that the convective heat transfer coefficient increases with increase in nanoparticle volume concentration (up to optimum value), volume flow rate of the heating fluid and coolant volume flow rate, and decrease in nanofluid temperature.

Aliabadi et al. [13] studied numerically convective heat transfer coefficient in the vortex-generator plate-fin channels copper-base deionized water nanofluid with laminar and steady-state flow, and validate their results by CFD method. They gives outcome that the better prediction of nanofluids flow inside the tested channel at the studied range. The average deviation between the experimental data and the CFD results based on this model for 0.1, 0.2, and 0.3% wt. nanofluids was about 4.2%, 3.1%, and 1.4%, respectively.

IV. Conclusion

Various researches are conducted in the augmentation of heat transfer using various types of nano fluids. Heat transfer is higher at laminar flow range of fluids. Furthermore, having stability and cost of nanofluid preparation and experimental rigs is a major issue in the nanofluid industry. Actual heat exchangers used in the industry are also increasing in price by the week due to the economy. Further commercialization and additions to theoretical and experimental research is suspected to solve these challenges while increasing the potential of nanofluids. The various methods of experimental research for thermal conductivity were summarized efficiently in this review paper. Heat transfer related experiments for nanofluids were analysed and the slight change in research objectives definitely changes in the setup of experimental rigs. Although the experimental methods were common and almost alike among most researchers, methods of nanofluid preparation are inconsistent between many researchers.

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