REVIEW ON APPLICATIONS OF METAL AND METAL OXIDE NANOPARTICLE IN HEAT AND MASS TRANSFER STUDIES

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Abstract – *Nanotechnology creates multiple oppurtunitities for the researchers involved in upgrading chemical processes. One of the significant advancement in this field is heat and mass transfer operations. Metal and metal oxide nanoparticle suspended nanomaterial was used by many researchers for enhancing heat and mass transfer rate. Hence in this article, the various applications of metal and metal oxide suspensions in base fluid with respect to heat and mass transfer studies were reviewed. From the reviewed literatures it was noticed that poor thermal conductivity is a primary drawback in the development of energy-efficient heat transfer fluids. Hence nanoparticle suspensions are expected to improve thermal conductivities compared to those of conventional fluids, and they are beneficial for improving rate of mass and heat transfer.*

Key Words: Metal, Metal oxide, Nanoparticle, Heat transfer, mass transfer

1. INTRODUCTION

Many research publications were found in the field of nanofluid because of its capability and utility, hence it is called as new engineering fluid. Researchers concentrate on the development of heat exchangers characterized by small size and volume of heat transfer fluids to reduce the pumping power as well as energy consumption. There are four Thermophysical properties of nanofluids such as viscosity, density, specific heat capacity and thermal conductivity (may be the most important one) are significant in altering the properties of conventional heat transfer fluids. The improved thermal properties of nanofluids help in the applications of thermal management systems. The potential benefits of nanofluids include electronics cooling, transportation, Chemical, nuclear, space and food industries. Noticeable developments have taken place in the miniaturization of heat exchanging equipment for enhancing the rate of heat transfer for the past two decades. Researchers focus on the development of heat exchangers characterized by small size and volume of heat transfer fluids to reduce the pumping power as well as energy consumption. Because of the potential benefits observed for the nanofluids, the various applications with respect to metal and metal oxide nanoparticle studies with respect to heat and mass transfer was reviewed in this paper.

2. LITERATURE ON HEAT TRANSFER STUDIES

In this section, the various literatures on heat transfer studies are presented. Pak & Cho [1] performed heat transfer and hydrodynamic behaviour of a submicron metallic nanoparticles of Al_2O_3 suspesion in a horizontal circular tube. They reported that the Nusselt number of the suspension increased with increasing nanoparticle concentration as well as the Reynolds number. They have proposed new correlation for the turbulent connective heat transfer. Xuan & Roetzel [2] analysed heat transfer behaviour of Aluminium oxide nanoparticle suspended water fluid and derived correlation to determine convective heat transfer coefficient . According to their study it was observed from their study that the rate of heat transfer improved significantly. Kebliski *et al.* [3] proposed the factors contributing for the heat transfer enhancement are the Brownian motion, molecular level layering of the liquid, the environment of the heat transport in the nanoparticles . Maiga *et al.* [4] studied the heat transfer effect on Al_2O_3 Suspended ethylene glycol and water fluids in a inside circular tubes. According to their results, Al_2O_3 suspended ethylene glycol base fluid shows higher heat transfer enhancement than Al_2O_3 suspended water base fluid.the experimental study was performed by srinivasan et al. [5] by dispersing TiO2 and ZnO nanoparticles in a base fluid of ethylene glycol and water. The Stusy was performed in a plate heat exchanger and observed 11.5% and 21.4% enhancement of heat transfer for ZnO and TiO2 nanoparticles respectively. Huminic *et al.* [6] performed Heat transfer studies with oxides of Aluminium and copper nanoparticles in water and reported that convective heat transfer coefficient enhances with nanoparticle volume fraction and Peclet number. The heat transfer studies performed by Huminic *et al.* [7] with Al2O3 / water nanofluid in circular tube with constant wall temperature boundary condition showed the rate of heat transfer increases with Peclet number. In a study conducted by Pantzali *et al.* [8] with copper oxide nanoparticle suspended water showed significant enhancement in heat transfer coefficient of base fluid. They have done the experiment in a Plate Heat Exchanger (PHE).They have used proposed models to validate their experimental results and obtained good agreement between theoretical results and correlations.

The heat transfer characteristics in the developing region were made by Anoop *et al.* [9]. They have used Al2O3 nanoparticles suspended water base fluid.. They also varied nanoparticle size of 45 and 150 nm and observed good enhancement in heat transfer by both the sizes.

Periasamy et al. [10] studied the the effect of hot fluid inlet temperature and graphene nanoparticle concentration on ethylene glycol-water fluid in a plate heat exchanger and observed the thermal conductivity was enhanced significantly.

Pandey *et al.* [11] performed heat transfer studies in a plate heat exchanger using Al_2O_3 suspended water nanofluids. The effects of nanofluid and water as coolants on heat transfer, frictional losses and exergy loss was analysed in their study. Their finding was the heat transfer rate improved with decrease in the nanoparticle concentration for water–nanofluid systems.

The pressure drop and heat transfer studies was performed by Tiwari *et al.* [12] by preparing CeO_2, and SiO_2 nanoparticles dispersed in water flowing in a Plate Heat Exchanger. They have varied nanoparticle volume fractions, flow rate and the temperature of the nanofluid.

The heat transfer study was performed by Vermahmoudi *et al.*[13] in a air cooled compact heat exchanger. They calculated the heat transfer and heat transfer coefficient of nanofluid by using Logarithmic Mean Temperature Difference (LMTD) method under laminar flow. They have observed that increasing the inlet temperature decreases the overall heat transfer coefficient (due to the large increase in the LMTD comparing with the less increase in the temperature difference of nanofluid). Barzegarian *et al.* [14] studied the heat transfer behaviour for TiO_2 suspended water base fluid in plate heat exchanger. Their finding was heat transfer rate of water increase gradually by adding nanoparticle.

Copper nanoparticles were prepared by Periasamy et al. [15] for studying the effect on thermo physical properties of different base fluids and observed that the nanoparticle has the potential benefit to enhance thermophysical properties of base fluids. Kole *et al[16]* conducted heat transfer studies in integral finned tube heat exchanger. They have suspended Zinc oxide nanoparticle and a base fluid of water. This study revealed that thermal conductivity and density of nanofluid increases, hence they showed heat transfer enhancement when using the nanofluid.

3. LITERATURE ON MASS TRANSFER STUDIES

The following literatures were collected with respect to mass transfer studies using nanoparticles. The study was conducted by Komati et al. [17] for the absorption of CO_2 in amine solutions using nanofluids of ferro fluids and reported approximately 93% improvement in the absorption of CO_2. The heat and mass transfer study conducted by Kim et al.[18] with SiO2 nanopaticle in a solvent of suspended water showed significant enhancement in the heat and mass transfer rate. Their observation was 18% and 47% increase of mass and heat transfer rate respectively. Periasamy et al.[19] conducted mass transfer with TiO2 nanoparticle suspension in water solvent for the absorption of CO2. Their experimental set up was packed bed absorption column. They have observed significant enhancement in the rate of absorption of CO2. Lee et al.[20], studied the mass transfer behavior of Al2O3 nanoparticle suspended in water solvent to absorb CO2 and reported that 5% improvement in absorption rate. Pang et al.[21] used Ag nanoparticle suspension in NH_3-water mixture and studied mass transfer performance in terms of CO_2 absorption. The study reveals there is a scope for utilizing nanoparticle in mass transfer studies and their result was 55% improvement in CO2 absorption. periasamy manikandan et al. [22] used the nanoparticle suspension of Al_2O_3 and water and studied the CO2 absorption rate. Their finding was nanoparticle addition increased the rate of absorption and obtained the highest enhancement at 0.6 volume fraction of nanoparticle. The mass transfer study performed by Torres Pineda et al.[23] in a tray column showed 10% increase in absorption rate for SiO_2 nanoparticle suspension.

4. CONCLUSION

In this paper the potential benefits of metal and metal oxide suspension in heat and mass transfer application was reviewed. From the collected literatures it was noted that the studies related with thermo physical properties, heat transfer, hydrodynamic studies, pressure drop studies were done with many researchers [24, 25]. However the study related with mass transfer was minimum [26]. The study reveals that the nanofluid has the significant contribution in enhancing the thermo physical behavior of base fluids, from which the heat transfer behavior also gets increased. The reasons for the enhacement are Brownian motion of nanoparticles, and grazing effect. Hence there will be a scope for evaluating the performance of nanofluid in simultaneous heat and mass transfer studies.

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