iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 Issue: III Month of publication: March 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Review: Enhancement of heat transfer by using Nano fluids

Deepak S Jani[1], Hitesh Patel[2], S.M.Patel[3]
[1]Mechanical, LDRP-ITR, India (P.G.Scholar)
[2]Mechanical, LDRP-ITR, India (Assistant Prof.)
[3]Mechanical, M.S.U, India (Assistant Prof.)

Abstract: This paper gives a detailed literature study and scrutiny into the results of the research and development, applications of nanofluids in heat transfer. Nanofluid is a comparatively new technology, the studies on nanofluid are not longer. Experimental data were reviewed in this study related to the enhancement of the thermal conductivity and convective heat transfer of nanofluids relative to conventional heat transfer fluids, and assessments were made as parameters of volume concentration, material, particle size, , base fluid material, temperature, particle shape, additive, and pH were taken into account, experimental results from so many researcher were used together when assessing data. The current state of knowledge is presented as well as areas where the data are presently inconclusive or conflicting. Heat transfer enhancement can be achieved using nanofluids is to be in the 15–40% range, with a few situations resulting in orders of magnitude enhancement

Keywords –Nano fluid, Heat Transfer, Radiator, Thermal conductivity, Viscosity.

I. INTRODUCTION

The Conventional fluids, such as water, engine oil, and ethylene glycol are normally used as heat transfer fluids. Although various techniques are applied to enhance the heat transfer, the low heat transfer performance of these conventional fluids obstructs the performance enhancement and the compactness of heat exchangers. The use of solid particles as an additive suspended into the base fluid is technique for the heat transfer enhancement. Improving the thermal conductivity is the key idea to improve the heat transfer characteristics of conventional fluids. Since a solid metal has a larger thermal conductivity than a base fluid, suspending metallic solid fine particles into the base fluid is expected to improve the thermal conductivity of that fluid. The enhancement of thermal conductivity of conventional fluids by the suspension of solid particles, such as millimeter- or micrometer- sized particles, has been well-known for many years [1]. However, they have not been of interest for practical applications due to problems such as sedimentation leading to increased pressure drop in the flow channel. The recent advance in material technology has made it possible to produce innovative heat transfer fluids by suspending nanometer-sized particles in base fluids which can change the transport and thermal properties of the base fluid. Nanofluids are solid-liquid composite materials consisting of solid nanoparticles or nano fibers with sizes typically of 1 to 100 nm suspended in liquid. The nanofluid is not a simple liquid-solid mixture; the most important criterion of nanofluid is agglomerate-free stable suspension for long durations without causing any chemical changes in the base fluid. This can be achieved by minimizing the density between solids and liquids or by increasing the viscosity of the liquid; by using nanometer- sized particles and by preventing particles from agglomeration, the settling of particles can be avoided. Nanofluids have attracted great interest recently because of reports of enhanced thermal properties [2-6].

II. PROPERTIES OF NANOFLUID

The flow properties of the base liquid (water) are well known and it is necessary to know the flow properties of nanofluid at different concentrations for theoretical analysis. Flow characters like density, specific heat, kinematic viscosity and pH value are estimated experimentally and theoretically. Temperature based flow properties are also estimated. All the flow characters are studied up to 0.8% volume fraction. The experimentally measured flow characters are good agreement with the available literature. Concentration based and temperature based regression equations are developed.

The maximum deviation of 6.44 % for density, 1.53 % of specific heat and 1.77 % of kinematic viscosity is obtained from the results of investigated and Pak and Cho at 0.8 % volume fraction. This deviation is acceptable range up to certain limit. If the percentage of the volume fraction increases the deviation is also increases [7].

The density of Al2O3/water nanofluid can be calculated using mass balance as [8] $\rho_{nf} = (1-\Phi)\rho_{bf} + \Phi\,\rho_p$ where ρ_p and ρ_{bf} are the densities of the nanoparticles and base fluid, respectively, and φ is volume concentration of nanoparticles. According to the concept of solid-liquid mixture, the specific heat of nanofluids is given by following [9]:

$$Cp_{nf} = \frac{(1-\Phi)\,\rho_{bf}\,Cp_{bf} + \Phi\,\rho_p Cp_p}{\rho_{nf}},$$

Volume 3 Issue III, March 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

where cp_p and cp_{bf}, are the heat specifics of the nanoparticles and base fluid, respectively. The viscosity of nanofluid can be calculated from the
following equation[10]:

$$\mu_{nf} = \mu_{bf}(1 + a\phi)$$

where a is the slope of the relative viscosity to the particle volume fraction. Value of a is a constant and calculated from the experimental results of Chun et al. [10]. In this work, it is equal to 15.4150. One well-known formula for computing the thermal conductivity of nanofluid is the Kang model which is expressed in the following form [11]:

$$K_{nf} = K_{bf} \times \frac{K_p + (n-1)K_{bf} - \Phi(n-1)(K_{bf} - K_p)}{K_p + (n-1)K_{bf} + \Phi(K_{bf} - K_p)}$$

III. EXPERIMENTAL INVESTIGATIONS

Khairul has done analysis of a helical coil heat exchanger using three different types of nanofluids (e.g. CuO/water, Al2O3/water and ZnO/water). Heat transfer coefficient and entropy generation rate of helical coil heat exchanger were analytically investigated considering the nanofluid volume fractions and volume flow rates in the range of 1–4% and 3–6 L/min, respectively. During the analyses, the entropy generation rate was expressed in terms of four parameters: particle volume concentration, heat exchanger duty parameter, coil to tube diameter ratio and Dean number. Amongst the three nanofluids, CuO/water nanofluid, the heat transfer enhancement and reduction of entropy generation rate were obtained about 7.14% and 6.14% respectively.[12]

Arunkumar investigated performance of the plate heat exchanger using different nanofluids (CeO2, Al2O3, TiO2 and SiO2) for various volume flow rates and wide range of concentrations. Optimum concentrations for different nanofluids have been determined as well and his Study showed that CeO2/water yields best performance (maximum performance index enhancement of 16%) with comparatively lower optimum concentration (0.75 vol.%) within studied nanofluids.[13]

Peyghambarzadeh investigated performance of radiator using Al_2O_3 nanofluid different concentrations of nanofluids in the range of 0.1e1 vol.% have been prepared by the addition of Al2O3 nanoparticles into the water. The test liquid flows through the radiator consisted of 34 vertical tubes with elliptical cross section and air makes a cross flow inside the tube bank with constant speed. Liquid flow rate has been changed in the range of 2e5 l/min to have the fully turbulent regime (9 _ 103< Re< 2.3_ 104). Additionally, the effect of fluid inlet temperature to the radiator on heat transfer coefficient has also been analyzed by varying the temperature in the range of 37e49 _C. Results demonstrate that increasing the fluid circulating rate can improve the heat transfer performance while the fluid inlet temperature to the radiator has trivial effects. Meanwhile, application of nanofluid with low concentrations can enhance heat transfer efficiency up to 45% in comparison with pure water.[14]

Adnan m hussain investigated SiO_2 nanofluid in car radiator for Four different concentrations of nanofluids in the range of 1–2.5 vol%. The flow rate changed in the range of 2–8 LPM to have Reynolds number with the range 500–1750. The results showed that the friction factor decreases with an increase in flow rate and increase with increasing in volume concentration. Further more, the inlet temperature to the radiator has insignificantly affected to the friction factor. On the other side, Nusselt number increases with increasing in flow rate, nanofluid volume concentration and inlet temperature.[15]

Jaafar Albadr experimentally studied on the forced convective heat transfer and flow characteristics of a nanofluid consisting of water and different volume concentrations of Al_2O_3 nanofluid (0.3–2)% flowing in a horizontal shell and tube heat exchanger counter flow under turbulent flow conditions are investigated The Al_2O_3 nanoparticles of about 30 nm diameter are used. The results show that the convective heat transfer coefficient of nanofluid is slightly higher than that of the base liquid at same mass flow rate and at same inlet temperature. The heat transfer coefficient of the nanofluid increases with an increase in the mass flow rate, also the heat transfer coefficient increases with the increase of the volume concentration of the Al_2O_3 increasing the volume concentration cause increase in the viscosity of the nanofluid leading to increase in friction factor[16]

Rahul bhogare carried out experiment with Al_2O_3 nanofluid and its effects on the heat transfer performance of the Automobile radiator have been determined experimentally. Air Reynolds number has been changed in the range of 84391-91290 and the fluid inlet temperature has been constant for all the experiments and mass flow rate of the coolant flowing through the radiator. The results demonstrate that nanofluids clearly enhance heat transfer compared to their own base fluid. In the best conditions, the heat transfer enhancement of about 70% compared to the base fluids has been recorded.[17]

M.ali has done Experimental investigation on forced convection heat transfer is applied to vehicles's radiator filled with AL2O3 water nanofluid with different concentrations: 0.1%, 0.5%, 1%, 1.5%, and 2% by volume. The experiments has been done for three cases, each case corresponds to different heat load, coolant flow rate, and air flow rate to simulate the vehicle engine cooling system at various loads relevant to the cooling system of Toyota Yaris 2007. The coolant and air heat transfer coefficients, Nusselt numbers, heat rate lost by the coolant and absorbed by the air, heat exchanger effectiveness, overall heat transfer coefficients, Reynolds number, and the pumping power are calculated. Log mean temperature difference (LMTD) and effectiveness-number of transfer units (ε-NTU) has been used to determine the outside air heat transfer coefficient. Results show gradual enhancement in the heat transfer with concentrations 0.1%, 0.5%, and 1% by volume (optimum at 1%); however deterioration occurs at concentrations 1.5% and 2%. The maximum percentage increase of the coolant heat transfer rate, coolant heat transfer coefficient, and coolant Nusselt number is 14.79, 14.72, and 9.51, respectively, which occurs at maximum load 1 and at ϕ = 0.01[18]

IV. CONCLUSION

This paper presents an overview of the recent developments in the study of heat transfer using nanofluids. Many important, complex and interesting phenomena involving nanofluids have been reported in the literature. Researchers have given much more attention to the thermal conductivity rather than the heat transfer characteristics. The use of nanofluids in a wide range of applications appears promising, but the development of the field faces several challenges: (i) the lack of agreement between experimental results from different groups; (ii) the often poor performance of suspensions; and lack of theoretical understanding of the mechanisms.

REFERENCES

[1]Lee S, Choi SUS, Li S, Eastman JA: Measuring thermal conductivity of fluids containing oxide nanoparticles. ASME J Heat Transfer 1999, 121:280-89.
[2]Wang XQ, Mujumdar AS: A review on nanofluids - part I: theoretical and numerical investigations. Braz J Chem Eng 2008, 25:613-630.
[3] Singh AK: Thermal conductivity of nanofluids. Defence Sci J 2008,58:600-607.
[4]Sridhara V, Gowrishankar BS, Snehalatha C, Satapathy LN: Nanofluids–a new promising fluid for cooling. Trans Ind Ceram Soc 2009, 68:1-17.
[5] Paul G, Chopkar M, Manna IA, Das PK: Techniques for measuring the thermal conductivity of nanofluids: a review. Renew Sust Energ Rev 2010, 14:1913-1924.
[6]Godson L, Raja B, Mohan Lal D, Wongwises S: Enhancement of heattransfer using nanofluids–an overview. Renew Sust Energ Rev 2010,14:629-641.
[7]Das SK, Putra N, Thiesen P, Roetzel W: Temperature dependence of thermal conductivity enhancement for nanofluids. ASME J Heat Transfer 2003, 125:567-574.
[8]B. C. Pak and Y. I. Cho, "Hydrodynamic and heat transfer study of dispersed fluids with submicron metallic oxide particles," *Experimental Heat Transfer*, vol. 11, no. 2, pp. 151–170, 1998.
[9]Y. Xuan and W. Roetzel, "Conceptions for heat transfer correlation of nanofluids," *International Journal of Heat and Mass Transfer*, vol. 43, no. 19, pp. 3701–3707, 2000.
[10]B. H. Chun, H. U. Kang, and S. H. Kim, "Effect of alumina nanoparticles in the fluid on heat transfer in double-pipe heat exchanger system," *Korean Journal of Chemical Engineering*, vol. 25, no. 5, pp. 966–971, 2008
[11]H. U. Kang, J. M. Oh, and S. H. Kim, "Estimation of thermal conductivity of nanofluid using experimental effective particle volume," *Experimental Heat Transfer*, vol. 19, no. 3, pp. 181– 191, 2006.
[12]M.A. Khairul , R. Saidur , M.M. Rahman , M.A. Alim , A. Hossain , Z. Abdin "Heat transfer and thermodynamic analyses of a helically coiled heat exchanger using different types of nanofluids" International Journal of Heat and Mass Transfer 67 (2013) 398–403
[13]Arun Kumar Tiwari, Pradyumna Ghosh, Jahar Sarkar "Performance comparison of the plate heat exchanger using different Nanofluids" Experimental Thermal and Fluid Science 49 (2013) 141–151
[14]S.M. Peyghambarzadeh, S.H. Hashemabadi , M. Seifi Jamnani , S.M. Hoseini. "Improving the cooling performance of automobile radiator with Al2O3/water Nanofluid" Applied Thermal Engineering 31 (2011) 1833e1838.
[15]Adnan M.Hussein,R.A.Bakara, K.Kadirgama." Study of forced convection nanofluid heat transfer in the automotive cooling system" Case StudiesinThermalEngineering2 (2014)50–61
[16]Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi "Heat transfer through heat exchanger using Al2O3 nanofluid at different concentrations" Case Studies in Thermal Engineering 1 (2013) 38–44.
[17]Rahul A.BhogareÀ, B.S.Kothawale, Priti Pramod Bodkhe and Amol Gawali. " Performance investigation of Automobile Radiator operated with Nanofluids Based Coolant".
International Journal of Thermal Technologies E-ISSN vol.4 ,No.2(2014) 2277 – 4114
[18] M. Ali, A. M. El-Leathy, and Z. Al-Sofyany, The Effect of Nanofluid Concentration on the Cooling System of Vehicles Radiator ,Hindawi Publishing Corporation ,Advances in Mechanical Engineering, Volume 2014, Article ID 962510, 13 pages, http://dx.doi.org/10.1155/2014/962510