ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 2, Issue 2, pp: (60-65), Month: October 2015 – March 2016, Available at: www.paperpublications.org

Analysis of Heat Transfer in Nanofluid- A Review

Mohite Y.R[1], Nalawade S.B[2], Ukirade P.V[3], Wagh M.R[4], Deshmukh.S.A[5]

Abstract: **Nanotechnology is concerned with the materials and systems whose structures and components reveal novel and significantly improved physical, chemical, and biological properties, phenomena, and processes due to their micro size. Workforce development is needed to achieve the benefits of nanotechnology development along with technology transfer. The intensity should be on hands-on educational experiences by developing nano-tech laboratory demonstration experiments that could be adaptable and combined into existing courses in engineering and engineering technology. Theoretical heat transfer rates were calculated using existing relationships in the literature for conventional fluids and nano fluids. Experiments were conducted to determine the actual heat transfer rates under operational conditions using nanofluids and the heat transfer enhancement determined compared to fluids without nanoparticles.**

Keywords: **Heat Transfer In Nanofluid, Developing Nano-Tech Laboratory.**

---

1. INTRODUCTION

A decade ago, with the rapid development of modern nanotechnology, particles of nanometre-size (normally less than 100 nm) are used instead of micrometre-size for dispersing in base liquids, and they are called nanofluids. This term was first suggested by Choi in 1995, and it has since gained in popularity. Many researchers have investigated the heat transfer performance and flow characteristics of various nanofluids with different nanoparticles and base fluid materials. In the dimensional scale a nanometer is a billionth of a meter. Nanoscale science and engineering has revolutionized the scientific and technological developments in nanoparticles, nonstructured materials, nanodevices and systems. National Science Foundation (2004) defines nanotechnology as the creation and utilization of functional materials, devices, and systems with novel properties and functions that are achieved through the control of matter, atom-by-atom, molecule by molecule or at the macro molecular level. A unique challenge exists in restructuring teaching at all levels to include nanoscale science and engineering concepts and nurturing the scientific and technical workforce of the future The advances in nanotechnology have resulted in the development of a category of fluids termed nanofluids, first used by a group at the Argonne National Laboratory in 1995 (Choi 19952).Nanofluids are suspensions containing particles that are significantly smaller than 100 nm (Wen and Ding 2004), and have a bulk solids thermal conductivity of orders of magnitudes higher than the base liquids. Experimental studies conducted have shown (Wang *et.al.*, 1999, Lee et.al 1999, Keblinski et.al 2002) that the effective thermal conductivity increases under macroscopically stationary conditions. Lee and Choi (1996), under laminar flow conditions, nanofluids in microchannels have shown a two fold reduction in thermal resistance (Lee and Choi, 1996) and dissipate heat power three times more than that of pure water. Studies conducted using water-Cu nanofluids (Xuan and Li, 2003) of concentrations approximately 2% by volume was shown to have a heat transfer coefficient 60% higher than when pure water was used. Such advances must have a broader impact culminating in promoting teaching, training and learning. Dissemination of research results will enhance the scientific and technological understanding of nanotechnology. This effort aims at bringing nanotechnology to the undergraduate level, especially at the applied level in engineering and technology curricula. The focus is to incorporate nanotechnology into existing course curricula such as heat transfer and fluid mechanics. The intention of the work described here is to introduce a simple experimental procedure in a heat transfer course to facilitate the understanding of the convective heat transfer behavior of nanofluids.

2. SCOPE

The nanoflulids will show great promise for use in cooling and related technologies such as waste heat recovery to make any plant efficient.

Transportation- Nanofluids have great potentials to improve automotive and heavy-duty engine cooling rates by increasing the efficiency, lowering the weight and reducing the complexity of thermal management systems for this reason nanofluids are use as coolant in radiators. As well as it is used in shock absorber, brake fluids, lubricators, fuel additives, coolants.

Space and Defence- A number of military devices and systems require high-heat flux cooling to the level of tens of MW/m2. At this level, the cooling of military devices and system is vital for the reliable operation. Nanofluids with high critical heat fluxes have the potential to provide the required cooling in such applications as well as in other military systems, including military vehicles, submarines, and high-power laser diodes. Therefore, nanofluids have wide application in space and defence fields, where power density is very high and the components should be smaller and weight less.

Nuclear Systems- For Cooling main reactor coolant for pressurized water reactors (PWRs). PWRs and boiling water reactors.for the emergency core cooling systems (ECCSs)

Electronic Applications - Due to higher density of chips, design of electronic components with more compact makes heat dissipation more difficult so nanofluids are used as cooling medium for different electroic devices eg. CPU

Water-based Al2O3 and diamond nanofluids were applied in the minimum quantity lubrication (MQL) grinding process of cast iron

3. EXPERIMENT

3.1 Experimental setup: A schematic of the experimental setup used to investigate heat transfer characteristics of nanofluid in a mini heat exchanger is shown in Fig.1.

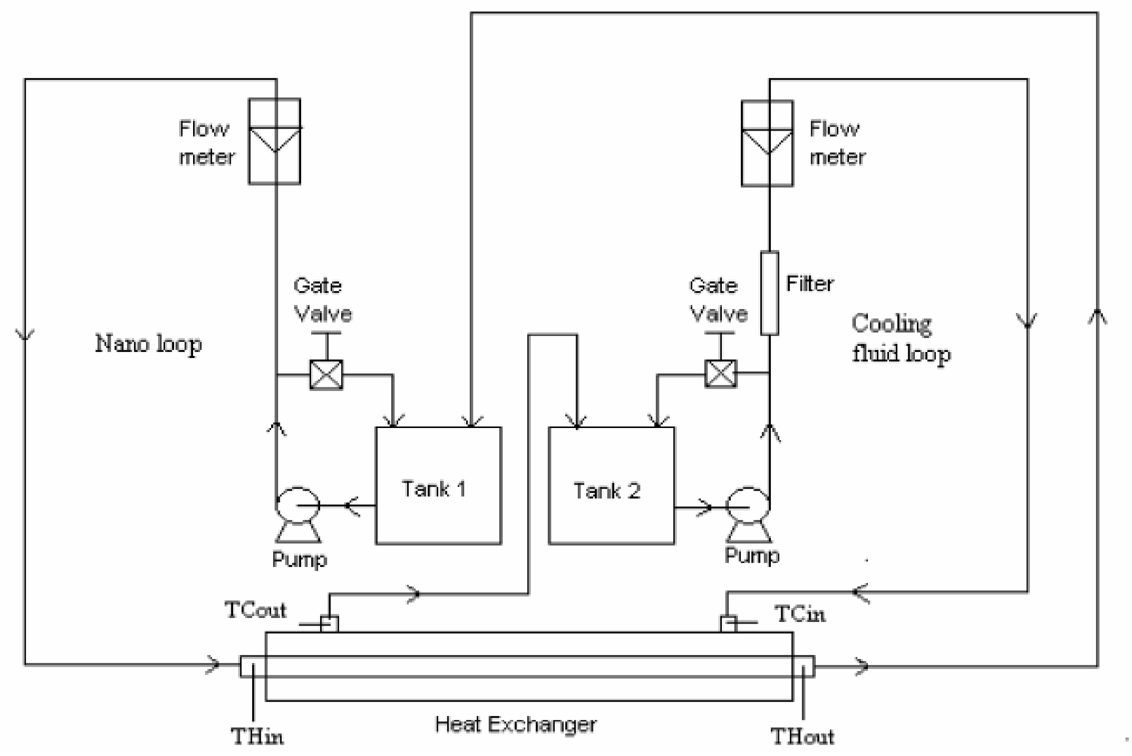

Figure 1: Mini heat exchanger

It consists of two flow loops, a heating unit to heat the nanofluid, and temperature measurement system. The two flow loops carried heated nanofluid and the other cooling water. Each flow loop included a pump with a flow meter, a reservoir and a bypass valve. The shell and tube heat exchanger is of stainless steel type 316L, 248 mm long consisting of 37 tubes. The tube diameter is 2.4 mm with a tube wall thickness of 0.25 mm, having a designed heat transfer area of 0.05 m2. Four J-type thermocouples were inserted on the heat exchanger to measure the bulk temperatures of inlet and exit fluid streams. An additional thermocouple was inserted in the nanofluid reservoir. All temperatures were recorded using a thermocouple scanner. The pumps used were magnetic drive centrifugal type with a maximum delivery rate of 11 l/min.

3.2 Determining properties:

The transport properties of the fluids, specific heat and viscosity were calculated using the mean fluid temperature between the inlet and outlet. As the pump performance was sensitive to the fluid viscosity at a specified speed, mass flow rate of the fluid streams were determined by weighing the volume collected over a 30 second time period.

3.3 Nanofluid preparation:

The nanofluid used in the experiment was 99.0+% pure copper oxide pre-dispersed in water,with an average particle size of 29nm, supplied by Nanophase Technologies Corporation, US. The nanofluid was mixed with de-ionized water to prepare experimental concentrations. It has been reported by Wen & Ding (2004) that nanofluids with less than 4% nanoparticles were found to be stable and the stability lasted over a week, no intermediate mixing was considered necessary.

4. EXPERIMENTAL RESULTS

Preliminary experiments with water were performed to gain experience in operating the set-up. The experiments were performed varying the nanofluid flow rate at a given concentration.

4.1 Base line experiment using water/water:

Using de-ionized water as the heating fluid in the tube side, and water as the cooling medium on the shell side, temperature measurements were taken at fluid inlet and exit positions after steady state has been reached. Steady state was determined when the temperatures remained constant with time for a 10 min. period. The mass flow rate (kg/s) of the fluid flowing inside the tube, and heat transfer rate (W) were plotted and the result shown in Fig.2

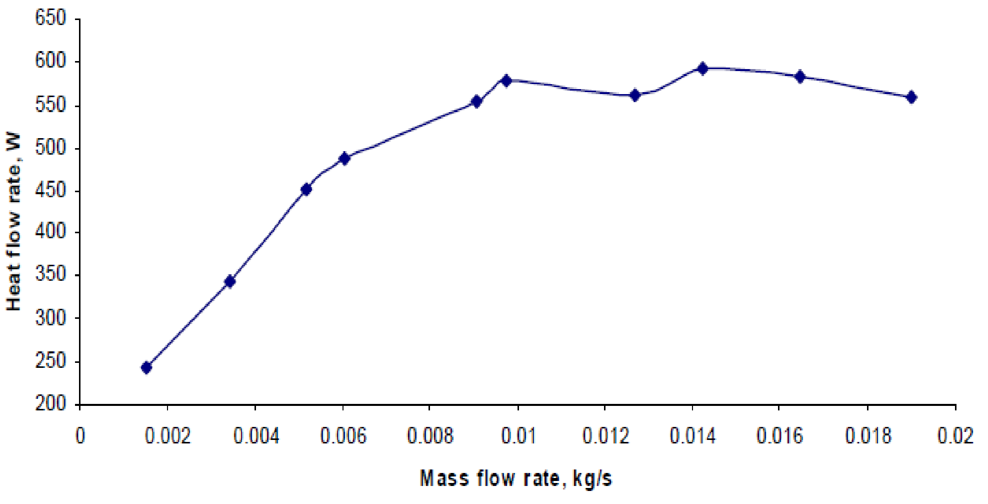

Figure 2: Heat transfer rate - water/water exchange.

4.2 Heat transfer between water/nanofluid with concentration of10x10-3%volume:

A very low nanofluid concentration was used as the first nano heat transfer experiment. An increase in heat transfer rate is observed at any given flow rate. The plot of mass flow rate vs. heat transfer rate is shown in Fig.3.

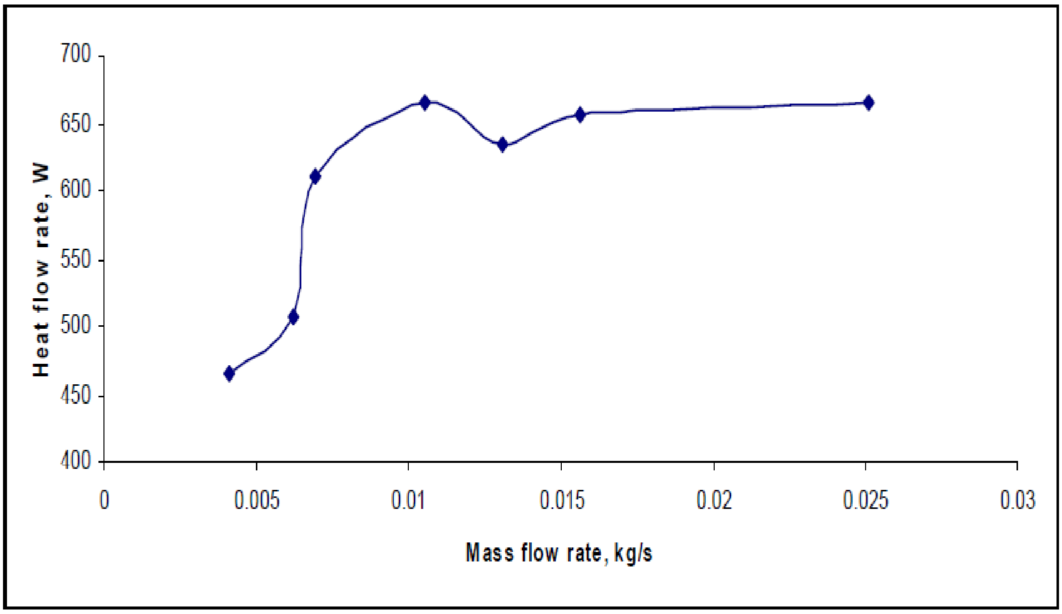

Figure 3: Heat transfer rate - water/nano concentration, 10x10-3 % by volume.

There is an improvement in heat flow rate due to the addition of nanoparticles even at very low concentrations. For example at a mass flow rate of 0.005 kg/s, a 5.5% increase in heat transfer rate is observed.

4.3 Heat transfer between water/nanofluid with concentration of 20x10-3%volume:

As the concentration of nanoparticles in the fluid increases, a further increase in the heat transfer rate is observed. The results for the higher concentration of nanofluid is shown in Fig.4

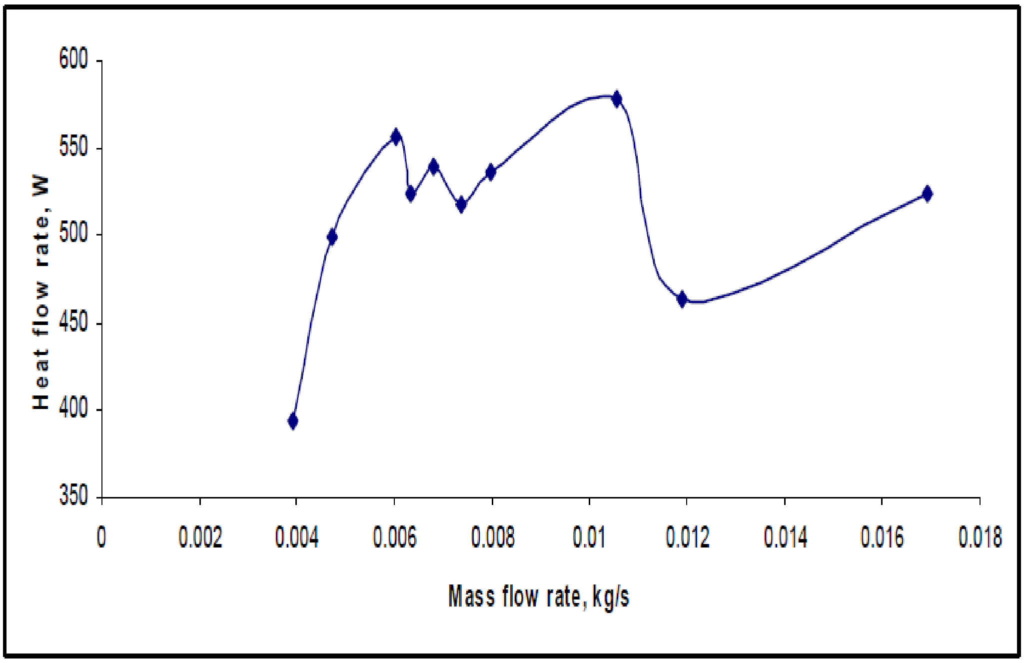

Figure 4: Heat transfer rate - water/nano concentration, 20x10-3 % by volume.

4.4 Heat transfer rate and Reynolds number:

The relationship between heat transfer rate and Reynolds number for the water/water exchange and water/nanofluid concentration of 10x10-3 are shown in Figure 5.

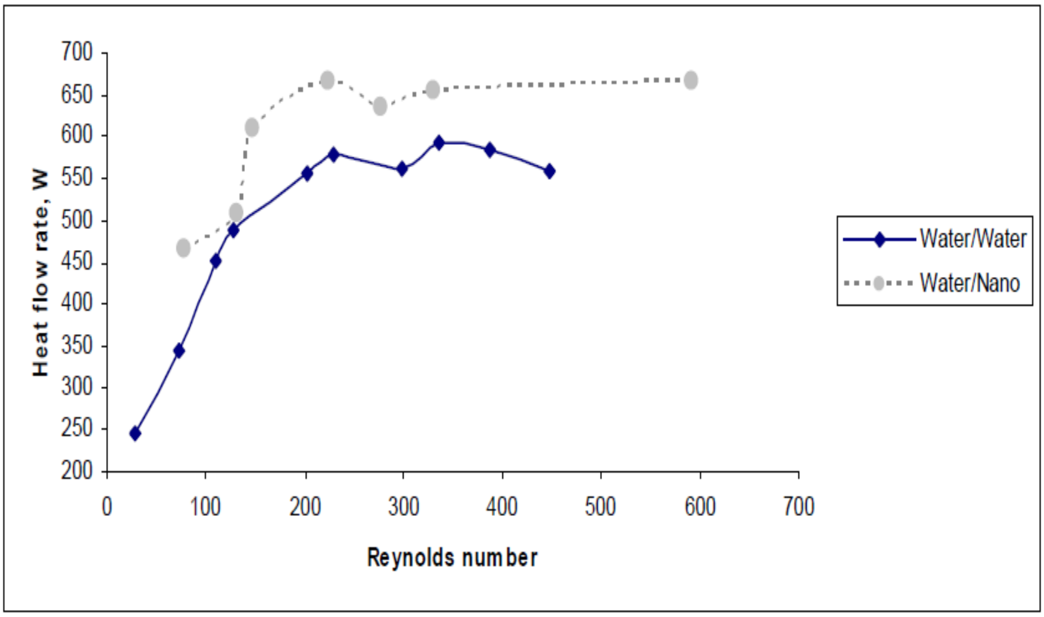

Figure 5: Reynolds number versus heat transfer rate.

5. FUTURE SCOPE

In Future, the next steps in the nanofluids research are to concentrate on the heat transfer enhancement and its physical mechanisms, taking into consideration such items as the optimum particle size and shape, particle volume concentration, fluid additives, particle coating and base fluid. Better characterization of nanofluids is also important for developing engineering designs based on the work of multiple research groups, and fundamental theory to guide this effort should be improved. Important features for commercialization must be addressed, including particle settling, particle agglomeration, surface erosion, and large scale nanofluid production at acceptable cost. Nanofluids offer challenges related to production, properties, heat transfer, and applications. In this section we highlight some future directions in each of these challenging areas.

1. Development of theoretical equations for thermo physical properties of Al2O3nanofluids is the grey area to be explored.

2. The effect of nanoparticles size on heat transfer and friction characteristics of nanofluids can be taken up for investigation.

3. Study on heat transfer investigation by changing the relative proportion in the base fluid constituents can be taken up as future work.

6. CONCLUSIONS

The following conclusions are stated:

a. Dispersion of the nanoparticles into the distilled water increases the thermal conductivity and viscosity of the nanofluid, this augmentation increases with the increase in particle concentrations.

b. The use of nanoparticles dispersed in de-ionized water enhances the heat transfer rate

c. At a particle volume concentration of 2% the use of Al2O3/water nanofluid gives significantly higher heat transfer characteristics.

For example at the particle volume concentration of 2% the overall heat transfer coefficient is 700.242 W/m2 K and for the water it is 399.15 W/m2 K d. Several factors increases the effective thermal conductivity of the nanofluid. The presence of nanoparticles reduces the thermal boundary layer thickness. Further research is necessary to explain non-idealities observed in the experiment

REFERENCES

[1] A.K.Singh “Thermal Conductivity of Nanofluids” Defence Science Journal, Vol. 58, No. 5, September 2008, pp. 600-607Ó 2008, DESIDOC.

[2] Prof. Alpesh Mehta, Dinesh k Tantia , Nilesh M Jha , Nimit M Patel “Heat Exchanger Using Nano Fluid” Mehta et al., International Journal of Advanced Engineering Technology E-ISSN 0976-3945 IJAET/Vol.III/ Issue IV/Oct.-Dec., 2012/49-54.

[3] Atul N. Pote, Pramod R. Pachghare “Experimental Analysis on Thermal Performance ofClosed Loop Pulsating Heat Pipe Using Zno/Water Nanofluid ” International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Volume 4 Issue 5, May 2015.

[4] Manal Hadi Saleh , Amina H. Dhaef “Heat Transfer in Horizontal Annulus Saturated with Copper Nanofluid under Various Boundary Conditions” International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Volume 4 Issue 4, April 2015 www.ijsr.net.

[5] M.H.U. Bhuiyana, R. Saidura,b, M.A. Amalinaa, R.M. Mostafizura, AKMS Islamc” Effect of nanoparticles concentration and their sizes on surface tension of nanofluids” 6th BSME International Conference on Thermal Engineering (ICTE 2014).

[6] M.Kh. Abdolbaqi , C.S.N.Azwadi , R.Mamat “Heat transfer augmentation in the straight channel by using nanofluids”Case StudiesinThermalEngineering3(2014)59–67.

[7] Rohit S. Khedkar,Shriram S. Sonawane ,Kailas L Wasewar “Water to Nanofluids heat transfer in concentric tube heat exchanger:Experimental study”Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference on Engineering(NUiCONE 2012).

[8] Y. Raja Sekhara, K.V.Sharmab, R.Thundil Karupparaja, C.Chiranjeevi “Heat Transfer Enhancement with Al2O3 Nanofluids and Twisted Tapes in a Pipe for Solar Thermal Applications” International Conference On Design And Manufacturing, IConDM 2013.

[9] Nanoscale Science and Engineering, (2004). Program Solicitation NSF 04-03.

[10] Choi, S.U.S, (1995).Enhancing thermal conductivity of fluids with nanoparticles, in: Siginer,D.A., Wang, H.P., Developments and Applications of Non-Newtonian Flows, FED-vol. 231/MD-vol. 66, *ASME, New York*, 1995 pp.99-105.

[11] Wen Dongsheng and Ding Yulong, (2004). Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions, *Int. J. Heat and Mass Transfer*, 47, 5181-5188.

[12] Wang, X.W., Xu, X.F., Choi, S.U.S., (1999).Thermal conductivity of nanoparticle-fluid mixture, J.Thermophys. *Heat Transfer*, 13 (1999) 474-480.

[13] Lee.S., Choi, S.U.S. et.al., (1999). Measuring thermal conductivity of fluids containing oxide nano particles, *J. Heat Transfer, Trans. ASME*, 121, 280-289.

[14] Keblinski,P., Philpot,S.R., et.al, (2002). Mechanisms of heat flow in suspensions of nano-sized particles (nanofluids), *Int. J. Heat Mass Transfer*, 45, 855-863.

[15] Lee, S., Choi, S.U.S., (1996). Applications of metallic nanoparticle suspensions in advanced cooling systems, *International Mechanical Engineering Congress and Exposition*, Atlanta,USA.

[16] Xuan, Y.M., Li, Q., (2003). Investigation on convective heat transfer and flow features of nanofluids, *ASME J. Heat Transfer*, 125, 151-155.