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Performance of Heat Sink for Electronic Cooling using (H_2O & Al_2O_3-H_2O) as a Coolant

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Abstract—*Mini channel heat exchangers are becoming successful in applications where small size objects are to be cooled such as electronic devices reason due to opportunities of reducing weight, size and cost of heat exchangers as compared to the orthodox methods. Due to high surface to volume ratio, mini channel heat exchangers are thermally efficient devices and can transfer more heat. Precise design for pressure drop and heat transfer is compulsory for the application of minichannel heat exchanger. This dissertation aims to study the basics of single phase and double phase heat transfer and pressure drop in mini channels using H_2O and Al_2O_3-H_2O nanofluids at different flow rates and different concentrations of nano particles. To increase thermal efficiency for better cooling and also for reducing the size of electronics. Experiments were done on the minichannel with dimensions 2.95 mm depth and 2.7 mm width which was made on the aluminum heat sink. A flat plate heater was used as a heat source and was attached to the bottom of the Aluminium heat sink. Temperature at the inlet and outlet of the sink was measured and analyzed at different flow rates using water and nano fluids containing aluminium oxide (Al_2O_3) at different concentrations. Pressure Drop was also measured simultaneously. Effect of Reynolds number on pressure drop, friction factor, temperature change and heat transfer was studied. Due to effective heat transfer, mini channel heat exchanger with nanofluids can be used for cooling purpose in electronics.*

1. INTRODUCTION

In modern years, need of electronic cooling in various electrical devices has been a major concern area. There is necessity of a system that is effective, compact as well as accomplished enough in maintaining the electronic equipment, communications, processors etc. that involves high heat flux and operating temperature to make them more efficient and life longing. In electric components, air cooling is most commonly used as it is easily available, economic and can be easily used in small components. Property of more heat carrying capacity of liquid makes liquid cooling more efficient than air cooling. As classified by Kandlikar and Grande [1], channels with hydraulic diameter ranging 10 μm-200 μm are microchannels and 200μm to 3mm are minichannels. Body organs such as liver, lung, kidney consists of micro and minichannels which provide high heat and mass transfer. Choi et al. [5] invented grade nanotechnology based on working fluids which had excellent thermophysical properties as compared to base fluids. Laura et al. [11] gave the information about stability, viscosity and thermal conductivity of water-based nanofluids containing TiO_2 nanoparticles. With increase in mass concentration and temperature, thermal conductivity of TiO_2-water nanofluids also increase. This study attempts to examine the effect of Reynolds number on pressure drop, friction factor temperature change and heat transfer for aluminium minichannel heat sink by using water and Al_2O_3-water nanofluids at different flow rates and concentrations.

2. LITERATURE REVIEW

William Grande et al. [2] studied thermophysical performance of minichannel flow and concluded that higher heat transfer rates are obtained by reducing dimensions of channels. X.N.Jiang et al. [3] experimentally studied the laminar flow through the small hydraulic diameter of different cross sections and concluded that conventional cooling techniques are not enough to meet future requirements. Sylvain Reynaud et al. [4] calculated the friction factor and heat transfer coefficients of minichannels. Deviation in experimental results with classical relations was due to imperfections of experimental apparatus. Das et al. [6] explained that attaining excellent thermophysical properties is main objective of nanotechnology at minimum concentration,. Ali Ijam et al. [7] used water and 2 nanofluids to flow in copper minichannel heat sink and found that thermal conductivity has increased when nanoparticles were added. Improvement in heat transfer was also obtained after adding nanoparticles. Ali Ijam et al. [8]. Maddah et al. [9] experimentally examined influence of Al_2O_3 and Ag nanoparticles on electrical conductivity, thermal conductivity and viscosity. It was found that thermal conductivity and viscosity enhanced when concentration of nanofluid is changed. Javedi et al. [10] examined analytically the consequences of Al_2O_3-liquid nitrogen,TiO_2-liquid nitrogen and SiO_2 liquid nitrogen based nanofluids on the plate fin heat exchanger and its results were compared with liquid nitrogen which was used as a base fluid. And it was found that the thermal conductivity, heat transfer rate and the heat transfer coefficient of the base fluid were enhanced by mixing the nanomaterials in it. Chein and Huang [12] inspected the performance of silicon microchannel heat sink by using Cu-water nanofluid and found that its performance has increased greatly by using nanofluid. Taylor et al. [13] used experimental and modelling results to measure optical properties of nanofluids with wavelength ranging 0.25-0.5 µm. It was also found that graphite-water based nanofluid and aluminum-water based nanofluid showed good response but other metals and base fluid that is oil showed less well response.

3. EXPERIMENTAL WORK

A schematic diagram of experimental setup is shown in Fig.1.

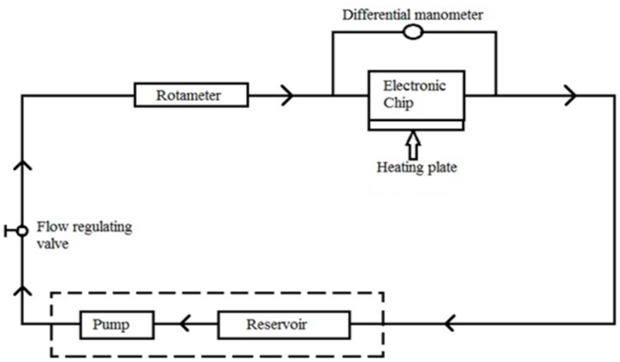

Fig. 1: Schematic of Experimental Setup

4. OPERATIONAL PROCEDURE

Set up consists of Aluminium test block with dimensions 85× 60×15 mm. Minichannel of particular dimensions was fabricated on aluminium block which was mounted by glass cover with the help of water tight adhesive to make it leak proof and to visualize the fluid flow. Flat plate heater of heat load 150 W and 60× 40×5 mm was attached at the bottom of the block to heat the fluid flow. Liquid contained by the fluid tank of 3L was driven by the pump of 1500 L/hr at different flow rates. After this flow rate was measured with rotameter and then flow was adjusted to the desired value with the help of flow regulating valve attached before the rotameter. Differential manometer and thermocouples were used to measure the pressure drop and temperature respectively, at the inlet and outlet of minichannel when steady state was reached. Coolants used in the experiment are Distilled water, nanofluid containing alumina nanoparticles at 0.01% vol. conc. and 0.05% vol. conc.

Table 1: Dimensions of Minichannel

Length	245mm
Area	7.965 mm^2
Perimeter	11.3 mm
Hydraulic Diameter	2.81 mm
Width	2.95 mm
Depth	2.7 mm

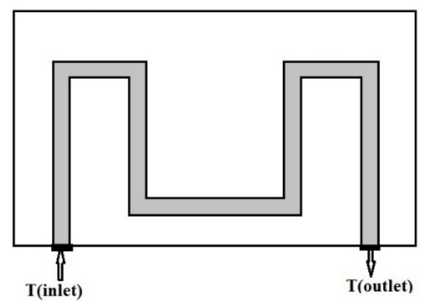

Fig. 2: Schematic of heat sink

5. PREPARATION OF NANOFLUIDS

For preparing a nanofluid of desired concentration, nanoparticles are dispersed into the base fluid i.e. water. Volume concentration of 0.01% was prepared by mixing nanoparticles 1.185 gm and 5.925 gm for 0.05% vol. conc. in 3 L of distilled water. To make the nanoparticles more stable and more dispersed in water, magnetic stirrer and ultra sonicator was used.

(a) (b) (c)

Fig. 3: Prepared samples: (a) distilled water, (b) 0.01% vol. conc.

Al_2O_3-H_2O (DI) nanofluid, (c) 0.05% vol. conc. Al_2O_3-H_2O (DI) nanofluid Sonication was done for 3 hours before testing density, thermal conductivity & viscosity of the nanofluids. Then these properties were measured at various temperatures by heating nanofluids over hot plate.

6. RESULTS AND DISCUSSIONS

All the readings obtained from the experiments have been represented graphically. Different graph showing the variation of pressure drop, friction factor and temperature change (inlet and outlet) with Reynolds number have been drawn depicting all the coolants.

From fig.4, it is clear that pressure drop has increased with increase in Reynolds Number. The trend of increasing is almost parabolic which also satisfies the theoretical aspect as per the Darcy Equation. According to which, Pressure drop is directly proportional to square of velocity, as Reynolds Number signifies the variation of velocity. Hence, this trend of Pressure Drop with Reynolds Number is justified for all concentrations. On addition of Nanoparticles, there is not much change in the pressure drop value. This is because nanoparticles are added at very small concentrations.

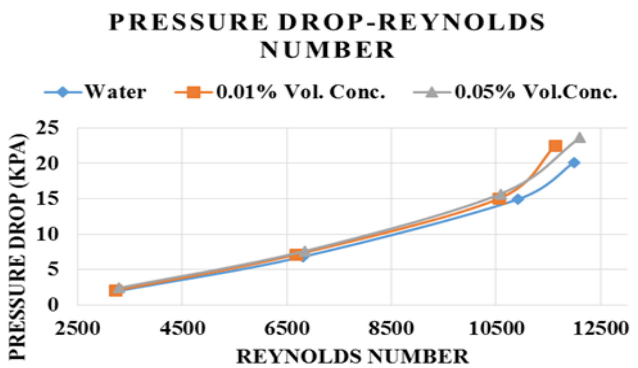

Fig. 4: Variation of Pressure Drop with Reynolds number.

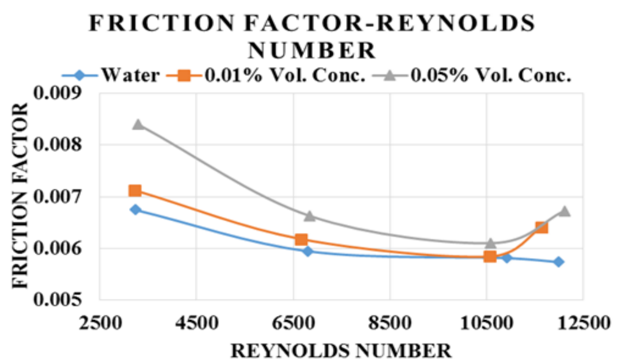

Fig. 5: Variation of Friction Factor versus Reynolds Number

Fig.5 shows that the friction factor has decreasing trend with increase in Reynolds Number. Variation of friction factor is very small for water. In case of 0.01% vol. conc., variation is slightly more as compared to water. Very large variation was recorded in the case of 0.05% vol. conc.

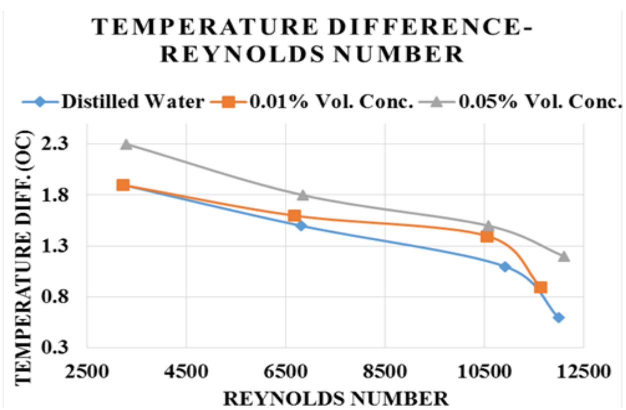

Fig. 6: Temperature Difference versus Reynolds Number

Fig. 6, shows that temperature difference decreases with increase in Reynolds Number for water. Similar trends were seen on addition of nano particles. Temperature difference for 0.01% Vol. Conc. is much similar to water whereas, temperature difference increases for all values of Reynolds number in case of 0.05% vol. conc. Fig.7 shows the variation of heat transfer rate with Reynolds number at different concentrations of nanoparticles. Rate of heat transfer has increase with increase in Reynolds number up to 10581 and after that it has decreased at all the concentrations. This is due to the fact that with increase in the Reynolds number, the time available for the heat transfer decreases which leads to decrease in heat transfer rate at high Reynolds number. Heat transfer rate has also increased on the addition of nanoparticles that is 0.05% vol. conc. nanofluids have max. heat transfer rate as compared to other lower concentration at all the Reynolds number.

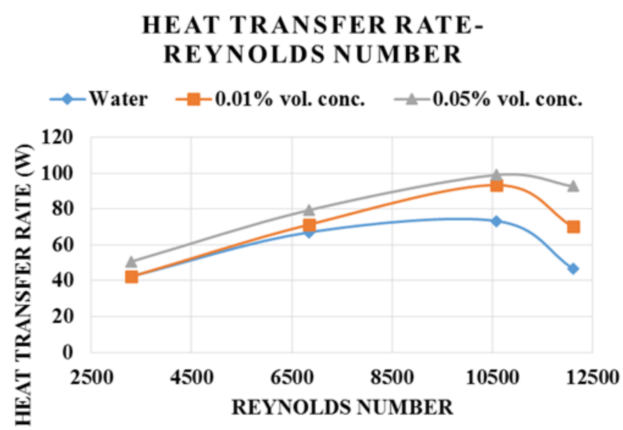

Fig. 7: Heat Transfer versus Reynolds Number

7. CONCLUSION

Experimental work has been carried out to study the cooling of aluminium heat sink using minichannel water as cooling medium. Nanoparticles were also added to water in order to enhance heat transfer rates. The following conclusions were made throughout the experimentation:

1) Pressure drop has shown parabolic increase with increase in the numbers. However pressure drop did not show any significant change on addition of nanoparticles because nanoparticles were added at very small concentrations.
2) With increase in Reynolds number, friction factor has decreased. Higher values of friction factor were obtained at 0.05% vol. conc. of nanoparticles, it has decreased with decrease in concentration at all the Reynold numbers.
3) Temperature difference between inlet and outlet of minichannel has decreased with increase in Reynolds number due to decrease in available time for heat transfer. Higher values of temperature difference were obtained for nanofluids at higher concentrations in comparison to water at all the Reynolds numbers.
4) On addition of nanoparticles, heat transfer rate has increased whereas at all the concentrations, it has

decreased at high Reynolds number due to decrease in the time available for heat transfer.

REFERENCES

[1] Kandlikar, S.G (2003). "Microchannels and minichannels – history, terminology, classification and current research needs paper" ICMM2003-1000 presented at First international conference on microchannels and minichannels, April 24-25, 2003, Rochester, New York, USA.

[2] William J. Grande (2002) "Evolution of microchannel flow passages-thermohydraulic performance and fabrication technology." ASME International Mechanical Engineering Congress & Exposition, November 17-22, 2002, New Orleans, Louisiana

[3] X.N.Jiang, Z.Y. Zhou, X.Y. Huang, and C.Y. Liu,(1997). "Laminar Flow Through Microchannels used for Microscale Cooling Systems" School of Mechanical and Production Engineering, nanyang TeTechnological University, Nanyang Avenue, Singapore 639798.

[4] Sylvain Reynaud, Francois Debray, Jean Pierre France, Thierry Maitre,(2005). "Hydrodynamics and heat transfer in two-dimensional minichannels" International journal of heat and mass transfer, Vol-48,pp-3197-3211, 2005.

[5] J. Eastman, U. Choi, S. Li, L. Thompson, S. Lee, "Enhanced Thermal Conductivity Through the Development of Nanofluids" Cambridge Univ Press, 1996

[6] S.K.Das, N. Putra, P. Thiesen and W. Roetzel., "Temperature dependence of thermal conductivity enhancement for nanofluids", -transactions of ASME. Journal of Heat Transfer Vol 125 pp 567-574.

[7] Ijam Ali, Saidur R, Ganesan.P. (2013) "Cooling of minichannel heat sink using nanofluids" International Communications in Heat and Mass Transfer 39 (2012) 1188–1194

[8] Ijam Ali, Saidur R,(2013) "Nanofluid as a coolant for electronic cooling(cooling of electronic devices)" Applied Thermal Engineering 32 (2012) 76-82

[9] Maddah H., Rezazadeh M., Maghsoudi M, Nasirkohdan S., (2013), "The effect of silver nd aluminium oxide nanoparticles on thermophysical properties of nanofluids". Journal of Nanostructure in Chemistry, vol. 3, pp.1-6.

[10] Javadi F.S., Sadeghipour S., Saidur R., Boroumandjazi G., Rahmati B., Elias M.M., Sohel M.R.,(2013),"The effect of nanofluid on thermophysical properties and heat transfer characteristics of a flat plate heat exchanger" International Communication in Heat and Mass Transfer, vol. 44, pp.58-63

[11] L Fedele, L Colla, S Bobbo,(2012) "Viscosity and thermal conductivity measurements of water based nanofluids containing titanium oxide nanoparticles" international journal of refrigeration, 35 (2012) 1359.

[12] Chein, G. Huang, "Analysis of microchannel heat sink performance using nanofluids" Applied Thermal Engineering 25 (17) (2005) 3104–3114.

[13] Taylor R.A., Phelan P.E., Otanicar T.P., Adrian R., Prasher R.P., (2011b), "Nanofluid optical property characterization towards efficient direct absorption solar collectors" Nanoscale Research Letters , vol. 6, issue 1, pp. 225.