Volume : 4 | Issue : 10 | Special Issue Oct- 2015 • ISSN No 2277 - 8179

FLOW THROUGH MICROCHANNELS-A REVIEW

Engineering

KEYWORDS: micochannels ,nanofluids ,thermal conductivity, convective heat flow, thermal resistance

Sagar Mittal	M.E Research Scholar,Department ,University Institute of Engineering & Technology, Panjab University, Chandigarh, India.
Amandeep Singh Wadhwa	Faculty, Mechanical Department, University Institute of Engineering & Technology, Panjab University, Chandigarh, India
Harry Garg	Scientist,CSIO,Sector-30,Chandigarh

ABSTRACT

The aim of this paper is to study heat transfer characteristics in a microchannel as it is an emerging trend from research point of view. With change in cross-section of the microchannel heat transfer characteristics varies and consequently there is change in pressure drop. Further the range of coolants used for microchannel heat transfer can vary from water ,ethyleneglycol,liquid metal to nanofluids. Heat transfer in microchannel with nanofluid is highly efficient wherasmicrochannel with liquid metal as coolant has higher heat dissipation capacity than water used as coolant. Microchannel cooling with liquid metal poses tough challenge with regard to corrosion and blocking problems in the cooling systems so better control methods have to be devised to prevent deterioration of the cooling system using liquid metal.

I. INTRODUCTION

Now a days, there is lot of advancement in new technologies e.gelectronics ,computer technologies , communication ,etc. The growth of these will lead to increasing power and large storage data in small size chips due to which the thermal management of these devices is a big problem .Therefore, heat transfer through microchannels using nanofluids is very efficient than the base fluid like water, ethylene glycol, de-ionized water, etc. Because microchannels have smaller size, higher convection coefficient, less coolant inventory and larger heat transfer area as compared to traditional heat transfer are widely used. Nanofluids are made by putting nanoparticles (size<100nm)such as copper, copper oxide,aluminium oxide in base fluid. These are very much efficient as these have high thermal conductivity, high heat transfer coefficient and more thermal capacity than ordinary coolants. In solid-liquid mixtures particles erode pipelines, clog flow channels, settle rapidly, cause severe pressure drop and also form layer on the surface which reduces thermal capacity of the fluid.

Viscosity of nanofluids are generally higher than that of base fluids. Therefore, frictional pressure drops of single phase flow of nanofluids are also higher. By flowing coolant with the help of micro pump through the microchannels will also increase heat dissipation rate. Microchannels are mainly used because of high heat transfer coefficient and as channel size reduce the pressure drop across the channel also reduces or low.

II.LITERATURE SURVEY

Microchannels were initially proposed for electronics cooling applications by Tuckerman and Pease [1], who used the direct circulation of water in microchannels fabricated in silicon chips. They were able to remove heat flux upto 790 W/cm2 using silicon microchannels but pressure drop was very high. Heat transfer was reported firstly by CHOI of the Argonne National Laboratories,USA in 1995.Choi and Eastman[2] developed a method and apparatus for increasing heat transfer in fluids like ethylene glycol, de-ionoized water and oil by dispersing nanocrystalline particles. Another major milestone was achieved by Phillips [3], who analyzed the heat transfer and fluid flow processes in microchannels and provided detailed equations for designing microchannel geometries.Mohammad Rahimi, Reza Mehryar [4] numerically investigated the effects of duct wall thermal conductivity and thickness on the local Nusselt number at the entrance and ending regions of a circular cross-section microchannel in a conjugate heat transfer problem.Y.Liu.et al.[5] studied forced convection heat transfer in microchannels using computational fluid dynamics.H.A. Mohammed [6] studied the effect of different microchannel geometries on thermal and hydrodynamic microchannel heat sinks.(MCHS). Reiyu Chein,Janghwa Chen [7] studied numerically, fluid flow and heat transfer in microchannel heat sinks by using numerically investigated FVM scheme.P. Gunnasegaran et.al. [8] investigated numerically on the pressure drop and friction factorof water flow in three different shapes of microchannel heat sinks which are rectangular,trapezoidal and triangular for Reynold number in range 100-1000 using finite volume method.

III. EXPERIMENTAL SETUP

The experimental and theoretical analysis shows that liquid metal coolant is a powerful way for heat dissipation of high heat flux density electronic devices. The experimental setup consisted of micro channel, peristaltic pump, radiator, weighing-measuring module, manometer, filter, and data acquisition system. Driven by the peristaltic pump, the fluid first went through the filter, test section of micro channel, and radiator successively, then passed through the weighing-measuring system for flow measurement, and finally entered the liquid collection for the next round of circulation.

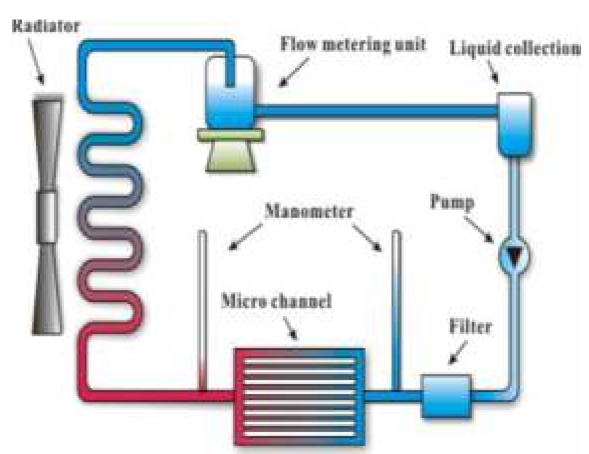
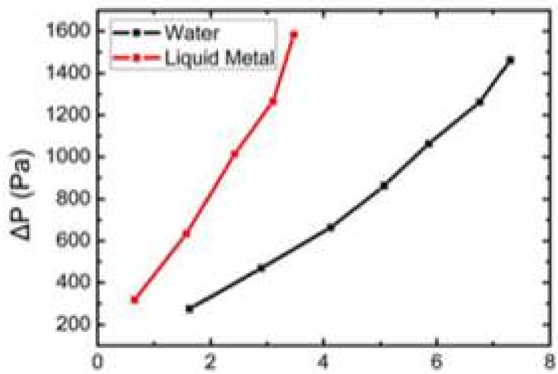


Fig.1 Microchannel flow:experimental set up

IV. RESULTS & DISCUSSION

In this experiment liquid metal was taken instead of water to evaluate the different flow and heat transfer characteristics in micro channel. Liquid metal has much higher thermal conductivity than water, so micro channel with liquid metal as the coolant could show superior heat dissipation capacity than that based on water. However, the density of liquid metal is nearly six times of water, so under the same flowing condition, the flow resistance of liquid metal in micro channel is greater and would consume more pump power. Therefore, the flowing characteristic and cooling capability of liquid metal based micro channel could be evaluated from the following three aspects:

1) The flow resistance (pressure difference between inlet and outlet) under different coolant volume flow.

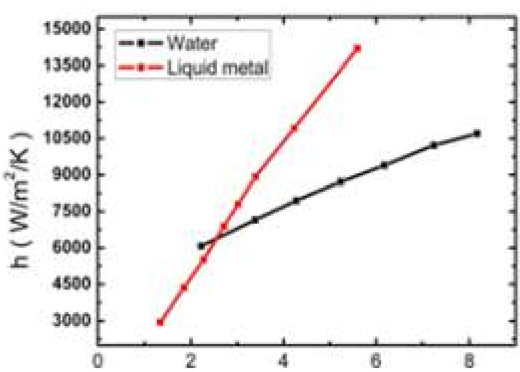


G(litres/hr)

Fig.2: Pressure difference Vs volume flow rate

Figure 2shows that the variation of both the curves has linear increasing trend as volume flow increases and as the velocity increases the slope of the curves get slightly larger.For same volume flow liquid metal has larger pressure difference between inlet and outlet than water when flowing through the microchannels.

2) Convective heat transfer coefficient under different coolant volume flow.

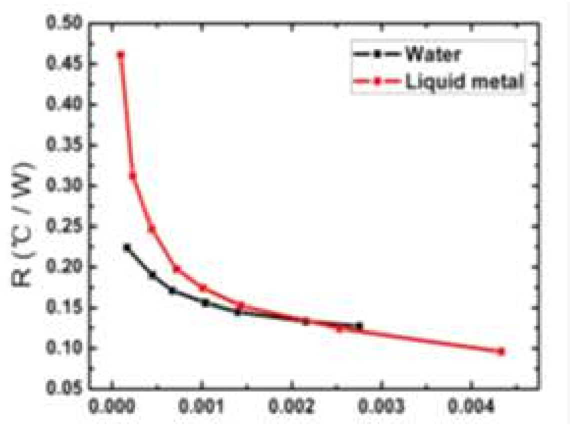


G(litres/hr)

Fig. 3: Heat transfer coefficient Vs volume flow rate

Figure 3 shows that in low velocity region, liquid metal has low convection heat transfer coefficient than water when flows in a microchannels. However, in high velocity region the convective heat transfer coefficient of liquid metal is higher than water. Liquid metal has much higher thermal conductivity than water but its thermal capacity is relatively smaller.In low velocity region heat transfer capability depends mainly upon coolant's heat capacity so liquid metal having low heat capacity has lower heat transfer coefficient. However, at high velocities thermal conductivity is the prime factor for heat transfer as coolant flows through the microchannels in a short time and temperature rise is not significant.

3) Convection thermal resistance under different pump power.



Power(W)

Fig.4: Convective thermal resistance Vs Pump power

From figure 4, it is seen that with increase of pump power the resistance of microchannels gets smaller and coolant flow increases. When pump power is small, thermal resistance of microchannel with liquid metal as coolant is larger than water because in low velocity region convective heat transfer coefficient of liquid metal is lower than that of water flowing through microchannel. However, with increase in pump power which means larger coolant flow, the thermal resistance of micro-channel with liquid metal as coolant would be smaller than that of water as convective heat transfer coefficient of liquid metal increases in high velocity region.

V. CONCLUSION

In the same volume flow and same flow geometric condition, the flow resistance of liquid metal flowing through micro channel would be higher than that of water. Liquid metal has much higher thermal conductivity than water, but its heat capacity is relatively smaller. Therefore in low velocity region the convective heat transfer coefficient of liquid metal is less than water as at low temperature heat capacity is an important factor for microchannel heat transfer whereas in high velocity region the heat transfer coefficient of liquid metal is higher than water as thermal conductivity has significant role in high velocity and temperature regions .Hence in low velocity region due to low convective heat transfer coefficient of liquid metal flowing through a microchannel as compared to water its thermal resistance is more at low power. With increase in coolant flow rate and hence power the convective heat transfer coefficient of liquid metal increases and therefore resistance decreases.

By using liquid metal as the coolant of micro channel cooling devices, the leakage and evaporation problems could be avoided much better. Also, the liquid metal can be driven efficiently by an electromagnetic pump without any moving parts. So the cooling system would run more stable. However, corrosion and blocking problems did exist in the liquid metal based micro channel, which would greatly affect the performance or even endanger the running of cooling system.

VI. FUTURE SCOPE

The present study of heat flow in microchannels is limited to single phase liquid flow. The study can be extended to formulate the computational model and experimental setup for two phase liquid flow. Further the effect of various fluids like ethylene glycol, water, nanofluids, etc for microchhannel heat flow can be studied and compared for various channel geometries. The optimum solution for corrosion and blocking problems in liquid based microchannels that effect the cooling system adversely have to be devised in future for better efficiency of the system.

VII. NOMENCLATURE

Δp : Pressure differernce between inlet and outlet, Pa
h : convective heat transfer coefficient, W/m2K
G : coolant volume flow rate, litres/hour

R : convective thermal resistance, °C/W
P : Power, Watt(W)

REFERENCE

[1] Tuckerman, D. B., and Pease, R. F. W., High Performance Heat Sink for VLSI, IEEE Electron Dev. Let., EDL-2, no. 5, pp. 126– 129, 1981. | [2] Cheng Lixin, School of Engineering,University of Aberdeem,King's college,Aberdeem,AB24 3FX,Scotland,UK(2008). | [3] Kandlikar, Satish G Thermal Analysis and Microfluidics Laboratory, Rochester Institute of Technology, Rochester, NY, USA | [4] Mohammad Rahimi, Reza Mehryar "Numerical study ofaxial heat conduction effects on the local Nusselt number at the entrance and ending regions of a circular microchannel" International Journal of Thermal Sciences 59 (2012) 87-94 | [5] Y. Liu, J. Cui, Y.X. Jiang, W.Z. Li "A numerical study on heat transfer performance of microchannels with different surface microstructures" International Journal of Applied Thermal Engineering 31(2011) 921-931. | [6] H.A. Mohammed, P. Gunnasegaran, N.H. Shuaib "Influence of channel shape on the thermal and hydraulic performance of microchannel heat sink"International Communications in Heat and Mass Transfer 38(2011) 474–480 | [7] ReiyuChein,Janghwa Chen "Numerical study of the inlet/outlet arrangement effect on microchannel heat sink performance" International Journal ofThermal Sciences 48 (2009) 1627–1638 | [8] P. Gunnasegaran, H. Mohammed, N. H. Shuaib "Pressure Drop and Friction Factor for Different Shapes of Microchannels" Proceedings of ICEE 2009 3rd International Conference on Energy and Environment, 7-8 December 2009, Malacca, Malaysia. | [9] Li Zhuo, Tao Wen-Quan, He Ya-Ling "A numerical study of laminar convective heat transfer in microchannel with non-circular cross-section "International Journal of Thermal Sciences 45 (2006) 1140–1148 | [10] Poh-senglee,sureshV.Garimella "Thermally developing flow and heat transfer in rectangular microchannels of different aspect ratios " International Journal of Heat and Mass Transfer 49(2006) 3060-3067. | [11] Yue-Guang Deng, Jing Liu, Yi-Xin Zhou, "Liquid metal based mini/micro channel cooling device", Proceedings of the ASME 2009 7thInternational Conference on Nanochannels, Microchannels and MinichannelsICNMM2009June 22-24, 2009, Pohang, South Korea