

IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 2 ISSUE : 4 Print / Issue Publication Date: 31-Mar-2017

ISSN : 2455-2143

Indexed In

Google SCHOLAR OPEN ACCESS doi Crossref

WWW.IJEAST.COM

editor@ijeast.com

International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 4, ISSN No. 2455-2143, Pages 190-194
Published Online February-March 2017 in IJEAST (http://www.ijeast.com)



COMPUTATIONAL HEAT TRANSFER ANALYSIS ON MICROCHANNEL HEAT SINK WITH RECTANGULAR & RECTANGLE WITH SEMI-CIRCULAR MANIFOLD ARRANGEMENTS

Anurag Dahiya
Department of ME
Gurukul Vidyapeeth Institute of Engineering and Technology, Banur, Punjab, India

Hardeep Singh
Department of ME
Gurukul Vidyapeeth Institute of Engineering and Technology, Banur, Punjab, India

***Abstract*— The overall performance of microchannel heat sink (MCHS) as a system is affected by the inlet and outlet manifold arrangements in addition to array of microcannel. In the present study the CFD analysis is performed w.r.t the heat transfer coefficient, and Nusselt number for two different manifold arrangements. In the present work two different arrangements: Rectangular (R) and Rectangle with semi-circular (RSC) of the inlet and outlet manifolds are selected. The result shows MCHS within the Reynolds number ranging from 342-857, the RSC type manifold has highest heat transfer coefficient (9%-10%) in comparison to R type manifold.**

Keywords— **Micro-channel heat sink; Manifold; Heat Transfer; Reynolds Number**

I. INTRODUCTION

Convection is the process of heat transfer seen in fluids or gases when it flows over the surface. When the gas or any fluid flows over the surfaces, it carries away the heat or gives its heat to the surface depending upon the difference in temperature. Microchannels are the mechanism used to enhance the convective heat transfer in various engineering applications. Tuckerman and Pease [1] have the first to propose the concept of microchannel heat sinks in 1981. It has been compared with conventional heat exchanger microchannel has a low to moderate pressure drop, lower coolant requirement smaller geometric size and lower operational cost with higher heat transfer performance. Mehendale et al. [2] described microchannel as based on hydraulic diameter are:

Micro heat exchanger: $1\ \mu m \le D_h \le 100\ \mu m$

Macro heat exchanger: $100\ \mu m \le D_h \le 1\ mm$

Compact heat exchanger: $1\ mm \le D_h \le 6\ mm$

Conventional heat exchanger: $D_h \ge 6\ mm$

Where D_h is a hydraulic diameter.

It has been provide the practical means to achieve a large total heat transfer surface area without the use of excessive amount of primary surface area. Various studies have been done to enhance the heat transfer either experimentally or analytically. However there is still need for more studies in this field so as to get maximum heat transfer from one surface to other using different types of MCHS. So, the system must be designed to get maximum heat transfer from the system so that it can perform its function well. This paper is presented in order to study some of the work done in this area.

Lee and Mudawar [3] have studied the effect of nanofluids for single-phase and two-phase heat transfer in micro sink. It has been found that the enhancement of heat transfer is due to the high thermal conductivity of the nanoparticles and required effect on thermal boundary layer. Wen and Ding [4] demonstrated the laminar flow of nanofluids of Al_2O_3 and de-ionized water through a copper tube. It has been observed the enhancement of connective heat transfer when the nanofluids were used and proposed that nanoparticle migration and the boundary layer disturbance were the main reasons for the enhancement. Koo and Kleinstreuer [5] proposed that the performance of microchannel could be improved by using fluids having high Prandtl numbers, high volume concentrations of nanoparticles and with high aspect ratios microchannels. Chein and Huang [6] investigated the heat transfer performance of nanofluid–cooled microchannels. It has been found better heat transfer performance than a water-cooled microchannel. Tsai and Chein [7] analyzed

International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 4, ISSN No. 2455-2143, Pages 190-194
Published Online February-March 2017 in IJEAST (http://www.ijeast.com)

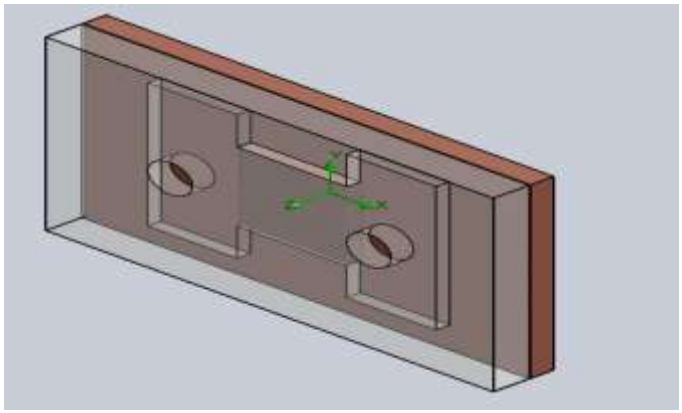


microchannel performance usimg carbon nanotube-H_2O and Cu-H_2O nanofluids and a porous media approach. It has been found that nanofluid have reduced the temperature difference between the bulk nanofluid and bottom-heated wall. Jang and Choi [8] numerically investigated a nanofluid-cooled microchannel. It has been found that the use of a water – diamond nanofluid enhanced the performance by about 11% as compared with pure water. Li and Kleinstreuer [9] have experimentally investigated the thermal performance in trapezoidal microchannel using pure water and a nanofluid. It has been found that the nanofluid have enhanced the thermal performance of microchannel flow with the expanse of more pumping power. Fard et al. [10] numerically analysed the laminar convective heat transfer of nanofluids in a circular tube under constant surface temperature. It has been found that increased in heat transfer coefficient with the nanofluids particle concentration and Peclet number. Mohammed et al. [11, 12] investigated the heat transfer of a trapezoidal microchannel using various nanofluids and substrate materials. It has been found that heat transfer performance of water-based nanofluids can be increased in a heat sink having a steel substrate.

From above study many interesting results indicating the potential of nanofluids to enhance the thermal performance of a microchannel. We can say that heat transfer increased using nanofluids for various channel geometry. The results show the effects of the type of nanoparticle, volume concentration and nanoparticle size on the heat transfer performance of a microchannel. . Anurag Dahiya et al. [13] have reviewed over a microchannel heat sink and they concluded that the various studies has been performed on MCHS. They found that enhancement of heat transfer rate is one of the major concerns in this area. Optimum temperature differences, spacing, width and depth are the most important factor affecting the performance of any device. The performances of the MCHS is also affected by the boundary layer formation. Several experiments have been done and relations were given in parliamentary procedure to count on these parameters. Most of the tests have been performed on aluminium and relations were developed for this. Different parametric studies have also been executed in order to interpret the elements involving the heat transfer process in a MCHS.

II. METHODLOGY

Design of micro channel heat sink showed in Figures1–2 shows the assembly of micro channel heat sink with different manifold arrangements. The material selected for micro channel is of copper while the Cover of Acrylic Sheet. The specification of the micro channel heat sink and Acrylic Cover is given in Table 1. The different parameters taken in consideration for the study have been shown in Table 2. CFD analysis on much have been executed with water as the working fluid. The readings obtained have been recorded. These readings have been used for the calculations so as to find the result.



(a)



(b)

Figure 1. (a) Assembly of MCHS (b) Micro channels.

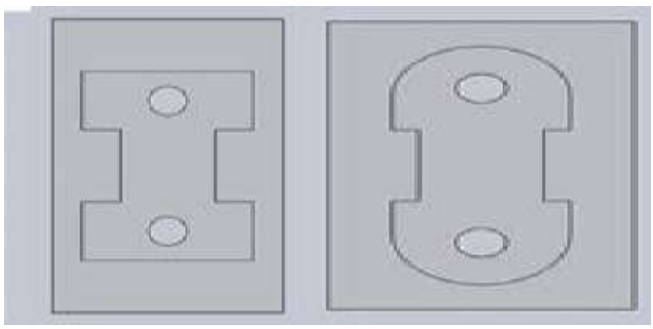


Figure 2. Acrylic cover plates with manifold arrangement.

Table 1. Specification of micro-channels

Width of Channels	500 µm
Spacing Between Channels	500 µm
base Plate Thickness	8000 µm

International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 4, ISSN No. 2455-2143, Pages 190-194
Published Online February-March 2017 in IJEAST (http://www.ijeast.com)

Length of Channels	24500 µm
Depth of channel	3000 µm
Thickness of Cover	6000 µm

Table 2. Thermo-hydraulic parameters considered

Flow rate (LPH)	**4, 6, 8, 10**
Wattages	50, 75, 100
Base fluid	Water
Design consideration	R, RSC
Number of Experiments Performed	36
Flow type	Perpendicular
Reynolds Number	342-857

The steps of calculation procedure followed are as:

1. Reynolds Number

$$Re = \frac{\rho v d_h}{\mu} \quad \text{(i)}$$

2. Average Temperature

$$T_{avg} = \frac{T_1 + T_2}{2} \quad \text{(ii)}$$

T
1 Temperature at inlet
1
2 Temperature at outlet

3. Temperature Difference

$$\Delta T = T_w - T_{avg} \quad \text{(iii)}$$

T_w is the wall temperature

Constant heat input is applied at the bottom of the MCHS. Other three wall assumed adiabatic. Thermocouple is located bottom of MCHS for observing the wall temperature.

4. Flow Discharge

$$q = mc_p \Delta t \quad \text{(iv)}$$

5. Heat Transfer Coefficient

$$h = \frac{q}{A_s \Delta t} \quad \text{(v)}$$

6. Nusselt Number

$$N_u = \frac{h d_h}{k} \quad \text{(vi)}$$

III. RESULTS AND DISCUSSIONS

3.1 Variation of Heat Transfer Coefficient with Reynolds Number

Through the experiments comparisons have been worked at three different Wattages (50, 75 and 100) and at different flow rates. From the result, it has been concluded the Heat transfer coefficient of the RSC is higher than the rectangular (figures 3-5).

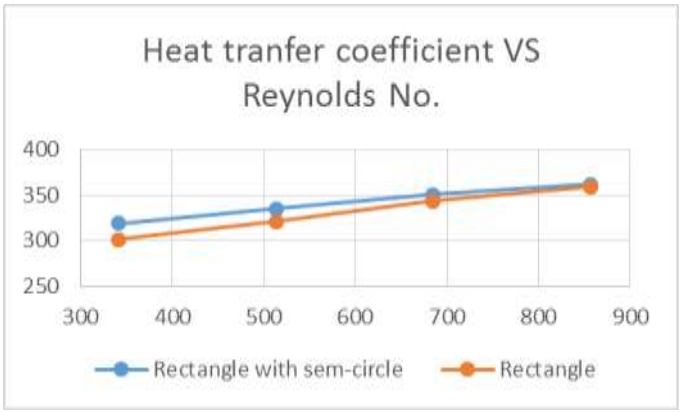


Figure 3. Reynolds Number vs. heat transfer coefficient at 50 W.

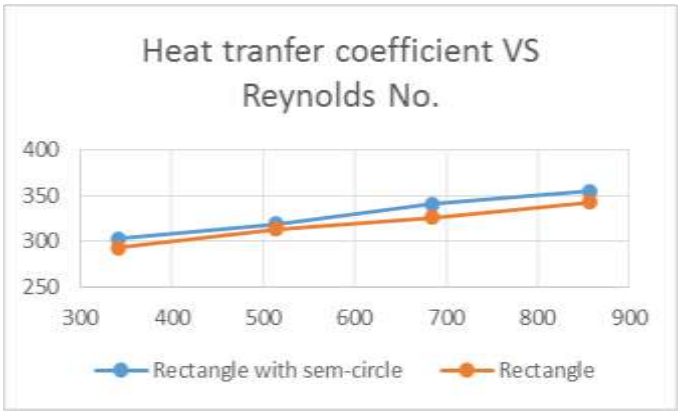


Figure 4. Reynolds Number vs. heat transfer coefficient at 75 W.

International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 4, ISSN No. 2455-2143, Pages 190-194
Published Online February-March 2017 in IJEAST (http://www.ijeast.com)

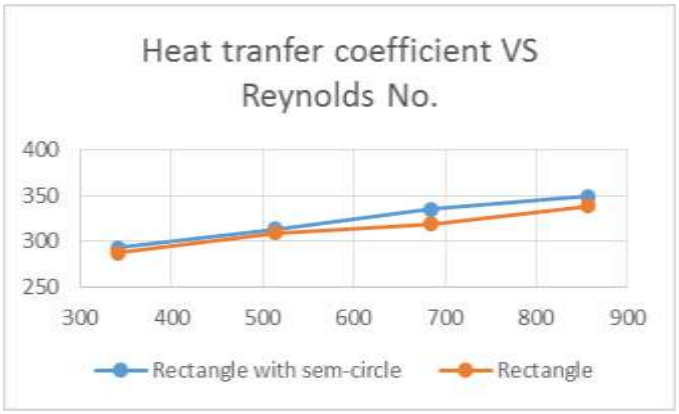


Figure 5. Reynolds Number vs. heat transfer coefficient at 100 W.

3.2 Variation of Nusselt Number with Reynolds Number

Through the experiments comparisons have been made at three different Wattages (50, 75, 100 and 125 W) and at different flow rates. From the result it has been concluded that the Nusselt Number of the RSC is higher than the rectangular Figures 6–8.

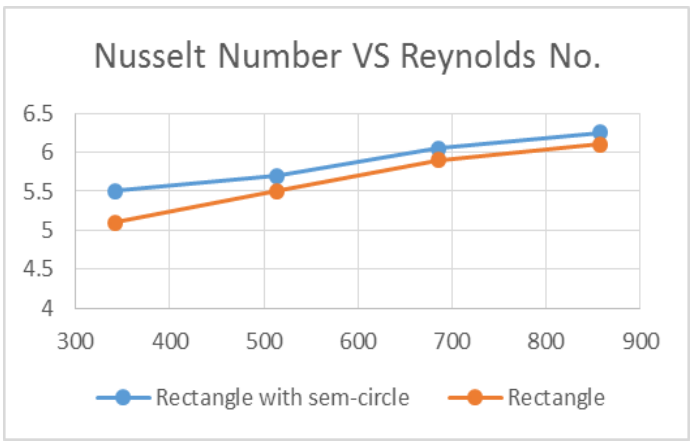


Figure 6. Reynolds Number vs. Nusselt Number at 50 W.

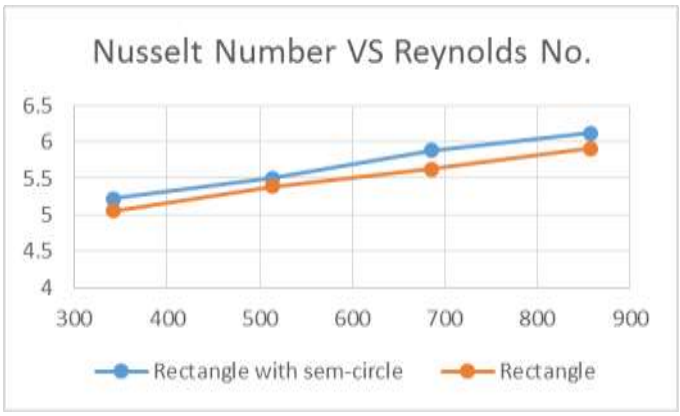


Figure 7. Reynolds Number vs. Nusselt Number at 75 W.

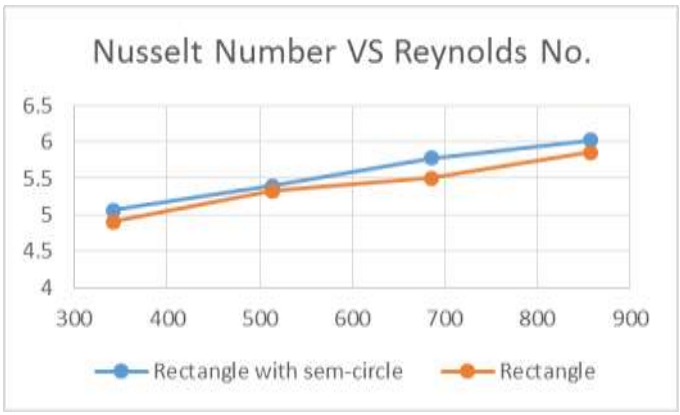


Figure 8. Reynolds Number vs. Nusselt Number at 100 W.

IV. CONCLUSION

In the present work computational analysis have been carried out to calculate heat transfer characteristics on Micro-channel heat sink using water as base fluid.

From the study following conclusions can be drawn:

It has been observed that heat transfer coefficient is increase in Rectangle with semi-circular manifold than that of rectangular manifold by 10 % at 50W, 9.8 % at 75W and 10.2% at 100W.

It has been observed that Nusselt number is more in rectangle with semi-circular manifold than that of rectangular manifold 3.21 % at 50W, 3.25 % at 75W and 2.87% at 100W.



V. REFERENCE

[1] D.B. Tuckerman, R.F. Pease, High performance heat sinking for VLSI, IEEE Electron. Dev. Lett. EDL 2 (1981) pp-126–129.

[2] S.S. Mehendale, A.M. Jacobi, R.K. Ahah, Fluid flow and heat transfer at micro and meso-scales with application to heat exchanger design, Appl. Mech. Rev. (53) (2000) pp-175–193
.

[3] J. Lee, I. Mudawar, Assessment of the effectiveness of nanofluids for singlephase and two-phase heat transfer in micro-channels, Int. J. Heat Mass Transfer 50 (2007) pp-452–463.

[4] D. Wen, Y. Ding, Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions, Int. J. Heat Mass Transfer 47 (2004) pp-5181–5188.

[5] J. Koo, C. Kleinstreuer, Laminar nanofluid flow in micro heat-sinks, Int. J. Heat Mass Transfer (2005) pp-2652–2661.

[6] R. Chein, G. Huang, Analysis of microchannel heat sink performance using nanofluids, Appl. Therm. Eng. 25 (2005) pp-3104–3114

[7] T.H. Tsai, R. Chein, Performance analysis of nanofluid-cooled microchannel heat sinks, Int. J. Heat Fluid Flow 28 (2007) pp-1013–1026.

[8] S.P. Jang, S. Choi, Cooling performance of a microchannel heat sink with nanofluids, Appl. Therm. Eng. 26 (2006) pp-2457–2463.

[9] J. Li, C. Kleinstreuer, Thermal performance of nanofluid flow in microchannels, Int. J. Heat Fluid Flow 29 (2008) pp-1221–1232.

[10] M.H. Fard, M.N. Esfahany, M.R. Talaie, Numerical study of convective heat transfer of nanofluids in a circular tube two-phase model versus single-phase model, Int. Commun. Heat Mass Transfer 37 (2010) pp-91–97.

[11] H.A. Mohammed, G. Bhaskaran, N.H. Shuaib, H.I. Abu-Mulaweh, Influence of nanofluids on parallel flow square microchannel heat exchanger performance, Int. Commun. Heat Mass Transfer 38 (2011) pp-1–9.

[12] H.A. Mohammed, P. Gunnasegaran, N.H. Shuaib, Influence of various base nanofluids and substrate materials on heat transfer in trapezoidal microchannel heat sinks, Int. Commun. Heat Mass Transfer 38 (2011) pp-194–201

[13] Anurag Dahiya and Harpreet Singh, "Review on microchannels heat sink to enhance the heat transfer coefficient," 2nd national conference on mechanical engineering 2015 ISBN no: - 978-81-930353-1-3 pp- 130-133.

IJEAST

INTERNATIONAL JOURNAL OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

AUTHORS

Anurag Dahiya

Hardeep Singh

ABOUT IJEAST

International journal of Engineering Applied Science and Technology (IJEAST) is a peer-reviewed, open access journal that publishes high - quality research paper in the field of Engineering, Applied Science and Technology.

IJEAST aims to provide a platform for researchers, academicians, and professionals to share their innovative ideas, research findings, and practical experiences with the global scientific community.

JOURNAL METRICS

H-INDEX	i10-INDEX	IJEAST CITATIONS	PEER-REVIEWED & OPEN ACCESS
33	154	9,647 (IJEAST CITATIONS)	PUBLISHED MONTHLY

PEER REVIEWED

All submission are rigorously peer reviewed to ensure quality.

AUTHORS ARE OUR PRIORITY

We value our authors and recognize their contribution to the advancement of research and knowledge.

OPEN ACCESS

Free and unrestricted access to research for all.

GLOBAL REACH

Connecting researchers and professionals worldwide.

TIMELY PUBLICATION

We ensure a swift and efficient publication process.

For more information, visit our website
www.ijeast.com

editor@ijeast.com

www.ijeast.com

India

2455-2143