Numerically Study on Heat Transfer Performance of Micro Channels Heat Sink with Different Shape by using N-Octane

Harpreet Singh
Assistant Professor
Department of Mechanical Engineering
Chandigarh university gharuan
India.

Harpreet Singh Randhawa
M. Tech Scholar
Department of Mechanical Engineering
Doaba group of colleges
India.

Abstract

The study of heat transfer characterstics in micro channel heat sinks is an emerging field from the research point of view. The variations in shapes and sizes of micro channel heat sink has led to the increase in heat transfer rate and reduction in pressure drop. Earlier work has been performed on different cross-sections of micro channel heat sink using water as a fluid for heat transfer. The numerical computation is carried out by solving the governing equations along with boundary conditions .The equations for fluid in single phase was solved by using a single domain conjugate problem. The governing equations is discretize in the fluid region using finite-volume method (FVM) with hybrid differencing scheme. The flow field is solved using the Simplex algorithm. The design of the micro-heat sink consists of an array of 11 holes cut in a channel of length 22mm, width 12mm and height 1.5mm. In this paper, we analytically designed a micro-channel heat sink for specific boundary conditions of inlet velocity of 0.1m/s, fluid temperature of 278K and temperature on the left side of 328 K and right side to be adiabatic. The analysis is performed numerically for its validation. The design was tested with different cross sections like rectangular, triangular, hexagonal ,circular and also compared the fluid for no. of channels 9,18 and 27 by using n-octane for heat transfer coefficient at reynold number range 100-1000.

Keywords: Micro Channel Heat Sink, Rectangular, Triangular, Hexagonal, Circular

I. INTRODUCTION

This study of fluid flow and heat transfer in heat sink is very important topic now a days in the field of research. The variations in shapes and sizes of microchannel heat sink has led to the increase in heat transfer rate and reduction in pressure drop in the microchannel heat sink. The application of microchannel heat sinks is used in the cooling of electronic devices, aerospace technology, automotive heat exchangers etc. Due to rapid increase in power density and miniaturization of electronic packages, very high heat flux chip cooling requires smaller hydraulic diameter and larger flow rate, which can lead to very high pressure drop. In allusion to this question, intense research has ensured and many investigations have been conducted to study the heat transfer and fluid flow characteristics of the newly proposed micro channel heat sink .In 1981,Tuckerman, D.B. and Pease, R.F.W[1] investigated the problem of achieving high-performance forced liquid cooling of planer integrated circuits..Gunnasegran et al.[2] studied the effect of geometrical parameters on water flow and heat transfer characteristics in microchannels is numerically investigated for Reynolds number range of 100–1000 and find out that smallest hydraulic diameter has better performance for heat transfer coefficient and pressure drop. Mohammad Rahimi, Reza Mehryar [3] 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.[4] numerically studied the Forced convection heat transfer occurring in microchannel is by using the computational fluid dynamics and lattice Botlzmann approaches. Simulation results of these two methods are compared and tested against available experimental correlation, and a good agreement is achieved. It suggests that both methods are suitable to describe the liquid flow in microchannels. H.A. Mohammed [5] studied the Microchannel heat sinks (MCHS) can be made with channels of various shapes. Their size and shape may have remarkable influence on the thermal and hydrodynamic performance of MCHS. The effect of shape of the channels on MCHS performance is studied for different channel shapes such as zigzag, curvy, and step microchannels, and it is compared with straight and wavy channels. The zigzag MCHS has the highest value of pressure drop, friction factor, and wall shear stress followed by the curvy and step MCHS, respectively.Reiyu Chein,Janghwa Chen [6] studied numerically, fluid flow and heat transfer in microchannel heat sinks aby using numerically investigated FVM scheme and study the inlet/outlet arrangement effects on the fluid flow and heat transfer inside the heat sinks. Using the averaged velocities and fluid temperatures in each channel to quantify the fluid flow and temperature distributions, it is found that better uniformities in velocity and temperature can be found in the heat sinks having coolant supply and collection vertically in inlet/outlet ports opened on the heat sink cover plate.. P. Gunnasegaran et.al. [7] investigated numerically on the pressure drop and friction factor of water flow in three different shapes of microchannel heat sinks which are rectangular, trapezoidal, and triangular for Reynolds number range of 100-1000 using the finite volume method. It is found that the values of Poiseuille number and friction factor depend greatly on different geometrical parameters. It is also inferred that the heat sink having the smallest hydraulic diameter for each type of shapes under consideration has better performance among the other heat sinks studied.

A lot of research has been done on micro channel but still a enough scope for researcher to do work in micro channel heat sink.

II. MICRO CHANNEL HEAT SINK GEOMETRY CONFIGURATION

In this work, a micro channel heat sink having 11 parallel channels of different cross sections like hexagonal(0.28mm), triangular(0.29), circular(0.28) and square(0.22) cross section by use a n -octane as a cooling fluid for specific boundary conditions. A numerical investigation has been performed on the pressure drop and friction factor of de-ionized water flow in the micro-fluidic devices for various types of fluid in micro channel heat sink for Reynolds number 1 to 2000.

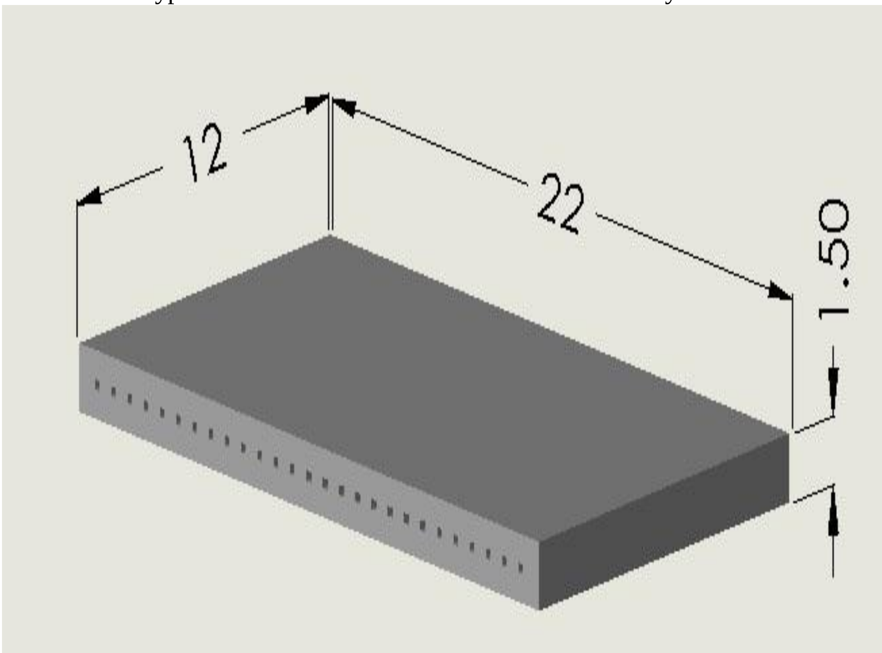

Fig. 2.1: Micro channel Heat sink Configuration

As in Fig.2.1 shows that the micro channel heat sink arrangement where N-octane fluid through these channels.the channels having different shapes i.e in rectangular, triangular and hexagonal shape as shows in fig 2.2,2.3,2.4.

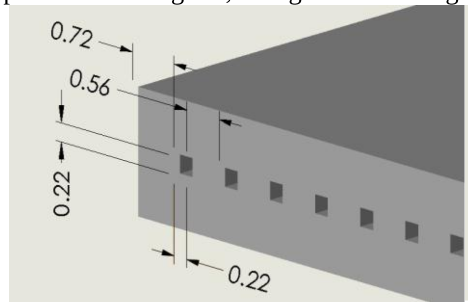

Fig. 2.2: Rectangular Section

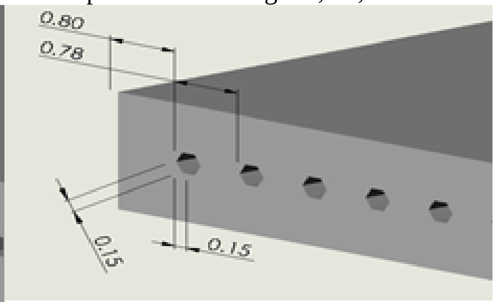

Fig. 2.3: Hexagonal Section

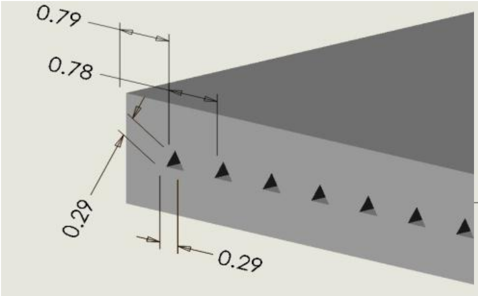

Fig. 2.4: Triangular Section

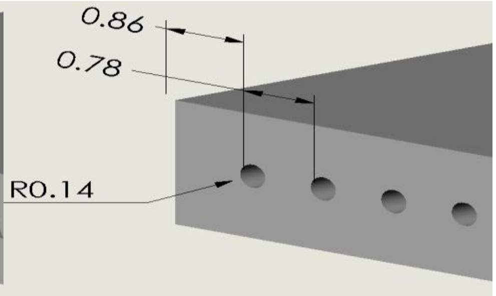

Fig. 2.5: Circular section

III. MATHEMATICAL FORMULATION

A. Governing Equations:

1) *Assumptions:*

Both fluid flow and heat transfer are in steady state and three dimensional. Fluid is in single phase, incompressible and the flow is laminar. Properties of both fluid and heat sink material are temperature independent.All the surfaces of heat sink exposed to the surroundings are assumed to be insulated except the top plate of heat sink where constant heat flux boundary condition simulating the heat generation from electronic chip is specified.The continuity, momentum and energy equations for the current problem can be written as,

Continuity Equation:

$$\partial U/\partial X + \partial V/\partial Y + \partial W/\partial Z = 0 \quad (1)$$

Momentum Equation:

X-Momentum:

$$(U\, \partial U/\partial X + V\, \partial U/\partial Y + W\, \partial U/\partial Z) = -\, dP/dX + 1/Re\, (\partial^2 U/\partial X^2 + \partial^2 U/\partial Y^2 + \partial^2 U/\partial Z^2) \quad (2A)$$

Y-Momentum:

$$(U\, \partial V/\partial X + V\, \partial V/\partial Y + W\, \partial V/\partial Z) = -\, dP/dY + 1/Re\, (\partial^2 V/\partial X^2 + \partial^2 V/\partial Y^2 + \partial^2 V/\partial Z^2) \quad (2B)$$

Z-Momentum:

$$(U\, \partial W/\partial X + V\, \partial W/\partial Y + W\, \partial W/\partial Z) = -\, dP/dZ + 1/Re\, (\partial^2 W/\partial X^2 + \partial^2 W/\partial Y^2 + \partial^2 W/\partial Z^2) \quad (2C)$$

Energy Equation:

$$(U\, \partial \theta/\partial X + V\, \partial \theta/\partial Y + W\, \partial \theta/\partial Z) = -\, 1/Re.Pr\, (\partial^2 \theta/\partial X^2 + \partial^2 \theta/\partial Y^2 + \partial^2 \theta/\partial Z^2) \quad (3)$$

B. Properties of N-Octane:

Table -1
N-Octane

Density	*720*	*kg/m3*
Viscosity	*0.00054*	*kg/ms*
Mean Velocity	*4.366*	*m/s*
Thermal Conductivity	*0.147*	*W/m.K*

C. Boundary Conditions:

Inlet velocity = 0.1 m/s
Fluid Temperature = 278K
Left Side Wall Temperature = 328 K

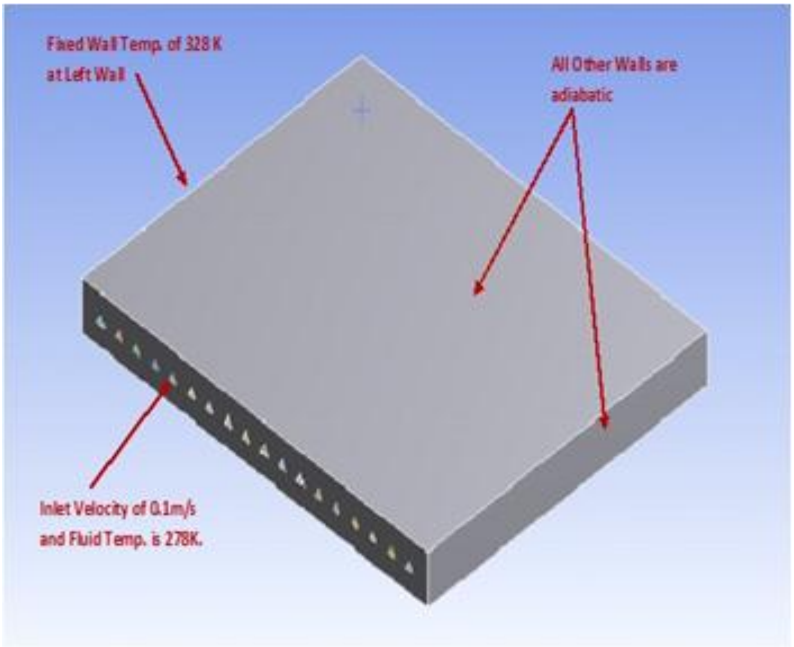

Fig. 3.1: Boundary Conditions

D. Numerical Simulation:

The numerical computation was carried by solving the governing conservation equations along with boundary conditions using FLUENT software .The equations for fluid phase were solved by using a single domain conjugate problem. The governing equations was discretized in the fluid region using finite-volume method(FVM) with hybrid differencing scheme. The flow field was solved using the SIMPLEX algorithm. Grid was generated using FLUENT software.

IV. Results and Discussion

The results has been shown on triangular ,rectangular and hexagonal section in fig 4.1,4.2 and 4.3.Compared these results by taking account 9,18,27 channels for each rectangular, triangular, hexagonal circular section..The N-octane fluid flow through these section and by applying a boundary condition we found that hexagonal section has more heat transfer coefficient followed by rectangular and triangular section.but in account of miniaturization devices a hexagonal channel with uniformities has difficult to manufacture as compared to rectangular and triangular section.

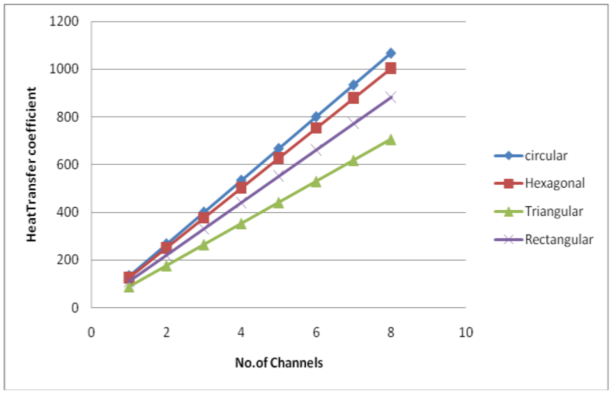

Fig. 4.1: Heat Transfer Coefficient vs No. of channels 9 by using N-octane

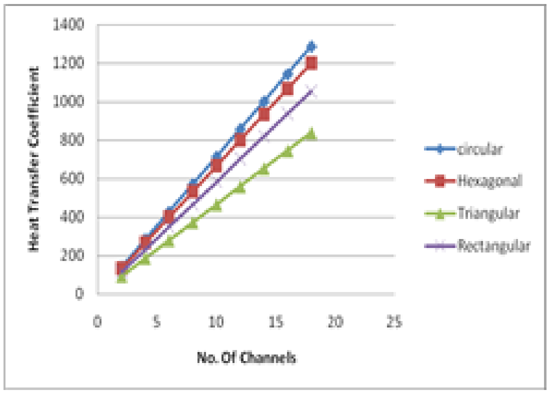

Fig. 4.2: Heat Transfer Coefficient vs No .of channels 18 by using N-octane

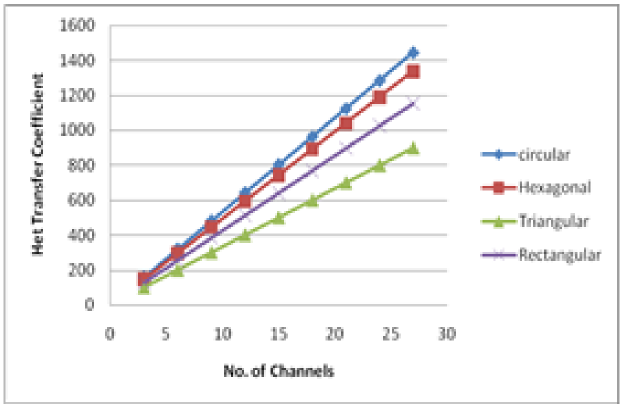

Fig. 4.3: Heat Transfer Coefficient vs No. of channels 27 By using N-octane

V. Conclusion and Future Scope

A. Conclusion:

The analytical study in Fluent software for the fluid flow and heat transfer in micro channel heat sink using different cross section and different number of channels and following conclusions were made:Heat transfer coefficient is the best in circular section, followed by hexagonal,rectangular, triangular .As we compared in 9,18 and 27 channels the trend is same accordingly the results.also we see this as the channel increases heat transfer coefficient is more.

B. Future Scope:

Present study deals with computational study of heat transfer and fluid flow in a micro channel heat sink for single phase liquid flow The study can be extended in future to experimental setup. The study can be extended to two phase fluid flow also. The effect of hydraulic diameter can be analyzed with the help of different cross sections like octagonal, heptagonal, etc. The effect of the fluids can also be studied by ethylene glycol, Water and other fluids etc. for cooling purpose of micro channel heat sink.

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