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Variation of Pressure Drop along the Straight and Bifurcated Channel: Experiment and Simulation

Vishal Bhuria, Gurjit Singh, S.S. Sehgal

***Abstract:** This paper derives an experimental and simulated investigation carried to analyze the performance of channel for calculating the pressure drop in laminar flow through rectangular shaped (straight and branched) microchannels. The microchannels taken ranged in variable aspect ratio from 0.75 to 1. Every check piece was made from copper and contained only one channel along a direction. The experiments were conducted with normal water, with Reynolds range starting from some 720 to 3500. Predictions obtained supported that with the variation in the aspect ratio the properties of the fluid also change. It is observed that the pressure drop changes with the change in the aspect ratio and flow rate and found that there is a correlation between the experimental and computational model results.*

***Keywords :** Aspect ratio, axial length bifurcated channel, pressure drop .*

I. INTRODUCTION

We studied in this experiment the heat transfer rate in microchanne. Microchannels have so many functions in a variety of industries, for example, in digital industry, cooling and refrigeration industry, food industry, and biomedical fields, and so on. These equipments provide more desirable heat transfer and fluid flow traits as in contrast to different traditional channels First of all Pease and Tuckerman use and suggested the microchannels to removal by the use of heat sink and heat exchanger.In which water following through the microchannels under the supervisions of laminar conditions. Lately study in this experiment the behavior of the microchannels same as the conventional channel. Other the study consider Hydroulic diameter of the microchannel 0.875 and0.5 In this experiment high pressure flow rate is considered. We are study the effect which are coming to increase the size of the channel shape, size and dimensions. For the study of pressure drop along a straight and branched microchannel with the aspect ratio and flow rate we have developed an experimental setup which includes the work piece made of copper.

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***** Correspondence Author
Vishal Bhuria*, Dept. of Mechanical Engineering, Chandigarh University, Chandigarh, India. Email:vishalbhuria143@gmail.com
Gurjit Singh , Dept. of Mechanical Engineering, Chandigarh University, Chandigarh, India. Email:gurjitpec@gmail.com
Dr. Satbie Singh Sehgal, Dept. of Mechanical Engineering, Chandigarh University, Chandigarh, India. Email:drsatbirsehgal@gmail.com

Pressure drop in microchannels has been studied in many investigation and has already been compared and contrasted with the behavior at "conventional"(i.e., larger-sized) length scales. However, there are wide discrepancies between completely different sets of printed results. A micro scale single strip microchannel is investigated in this study which shows results matching with the simulated model. The microchannel has the attributes of high surface area to volume ratio, large convective heat transfer coefficient, small mass, and volume, etc. the very small size of the microchannel make it possible to dissipate more heat at the limited space where as conventional cooling devices d not show much effect. As there is a large surface to volume ratio in the channel , so it has the capability to integrate the heat transfer rate and lower down the energy consumption. Now these days the energy consumption is the main criteria for any product design. Microchannel fulfills all the requirement of the recent trend. The range at which pressure behavior indicates a transition from laminar to flow has additionally differed wide in these studies. By creating a model for the properties response we directly determine the proportion of pressure drop along the channel for a fixed flow rate. the variables considered in this study are aspect ratio and axial length. By changing these two parameters it is found that pressure drop has a dominant dependence on the aspect ratio as well as flow parameters.

Sehgal et al.[1] carried the experiments and have experimentally investigated the effect of the channel aspect ratios along with the variation of different flow parameters P, U & S kind microchannel for different Reynolds number at variable heat inputs. The experiment is carried out for different range of Reynolds number and it is experimentally observed that the pressure drop is maximum in S type channel. It is found that the pressure drop is reduced as we go on increasing the aspect ratio. The pressure drop found minimum for P type channel. Weilin Qu et al. [2] have investigated both practically and mathematically the heat transfer properties. The Reynolds number range selected was between 139-1672, for different values of heat per unit area. It was observed by Weilin Qu et al. that at higher Reynolds number, the exit temperature of water reduces. Foli et al. [3] have reported two different approaches for obtaining the optimistic design dimension of microchannels for maximizing a heat dissipation rate. In the first approach analytical and computational model considered. The experiment was carried out to enhance the heat transfer rate by optimizing the aspect ratio. The another approach is based on genetic algorithm along with the computation model.

The experimental and computational result shows that the rate of heat dissipation depends on the different operating condition. Mushtaq et al. [4] have analyze the counter flow of microchannel heat exchanger with variable cross-sections such as rectangular, square,
Divergent-Convergent, circular and iso-triangular channels. They obtain that with the increase in number of channel for the same volume , the heat exchangers give remarkable pressure drop and heat transfer. Their experiment shows that the circular shape channel have the much effective performance(hydraulic and thermal) as compared to another cross-sectional channel.
Ngo et al. [5] have experimentally analyzed the pressure drop and heat transfer rate of micro channel heat exchanger with different shapes (*s*-shaped and zigzag) fins. They concluded that the microchannel with *s*-shaped give 5-6 times lower pressure drop and found that Prandtl number and the Reynolds number have the relation or can say dependence on the pressure drop and Nusselt number. The heat transfer characteristics dominantly depend on the Reynolds number and Prandle number.

II. EXPERIMENTAL SETUP

In this experimental setup a copper work piece is considered because of its high thermal conductivity and easy availability. A diagram of the whole experimental setup is given in figure 1.0. A manometer is used to read the pressure drop on inlet and outlet sections. It is experimentally found that the drop in pressure is different to the different. We take two channels (Straight and branched) of different aspect ratio. Both the work pieces are made up of copper. The fabricated model consists of only one channel. Pressure drop along a single microchannel is examined in this study. The branched channel is having the aspect ratio 0.75 and having a cross-section at inlet 0.75mm by 1.00mm. Table 1.2 shows the respective value of the channel. The channel is bifurcated at the middle into two equal parts in the branch shape. The outlet is made of the cross-section 0.515mm by 1.00mm. total axial length taken for this experiment is 15mm. The total thickness along with the channel is 2.00mm is taken for the experimentation. A thin acrylic sheet of thickness 3.00mm is attached for covering the top part of the channel. The given figure 1.1 shows the solid work model of the fabricated work piece.

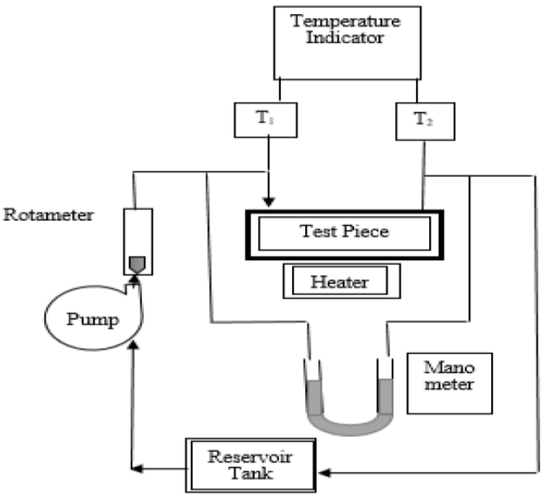

Fig. 1.0 Flow diagram of micro heat sink

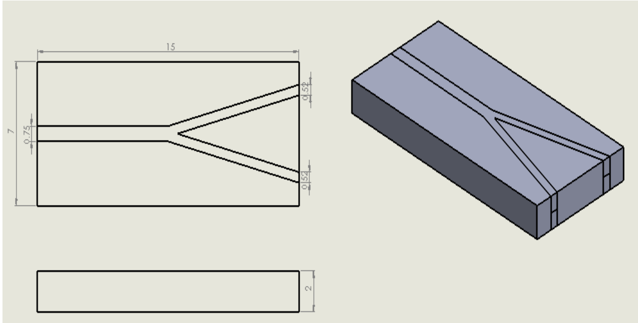

Fig. 1.1: Model of the fabricated workpiece (Branched)

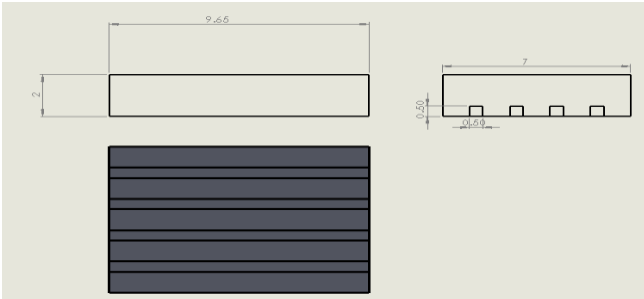

Fig. 1.2: Model of the fabricated work piece(straight)

On the other hand, a straight channel is having the axial length of 9.60mm is considered. The channel has the aspect ratio 1. The aspect ratio is the ratio of width to height. The channel is having the breadth and thickness as 0.5mm and 0.5mm respectively.Table 1.2 shows the respective dimension of the fabricated channel. An acrylic sheet of thickness 3mm is used to cover the outer part of the channel. For both the channel a rectangular manifold is used. The channel is made along a straight line. The thickness of both the channel is taken as 2 mm. in the given figure 1.2 the solid work model of the fabricated workpiece is shown.

Table 1.1: dimension of the various parameters of straight channel

S.No.	Dimension	Value
1	Width	0.5mm
2	Depth	0.5mm
3	Length	9.60mm
4	Thickness of workpiece	2mm
5	Aspect ratio	1
6	Area of cross section	0.25mm
7	Convective area	60mm^2
8	No. of channel	4

Table 1.2 : Dimension of parameters of Branched Channel

S. No.	Dimension	Value
1	Width	0.75mm
2	Depth	1mm
3	Length	15mm
4	Thickness of work piece	2mm
5	Aspect ratio	0.75

6	Area of cross section	0.75mm2
7	Convective area	60mm^2
8	Number of channel	1
9	Bifurcation angle	300

The experimental result is compared with the computer model. Another two designs of the same shaped channel are made for the validation process. It is observed that The result shows a reasonable resemblance to the fabricated model and the simulated model. the models are designed in solid work (0). The prepared model is simulated in Ansys fluent(). the simulated result is very much close to the pressure drop and heat transfer rate. Both the model are fabricated in such a way that both have equal convective area.

III. Result and Discussion Velocity with Axial Length

From the experimental data it is found that the velocity of the fluid flowing through the channel decreases with the axial length. Decreases in the velocity is somehow due to the roughness of the surface. Decrease in the velocity shows that there is pressure drop long the channel. The variation of the velocity with the axial length is shown in the figure x. from the given graph it is observed that there is acontinious decrease in the velocity for the straight channel. It is found that for the branched channel there is a remarkable drop in the velocity at the bifurcation point whereas the straight channel shows a linear drop in pressure. For the effective cooling and high heat transfer rate the velocity drop should be maximum. The fig 1.3 shows the variation of velocity against the axial length.

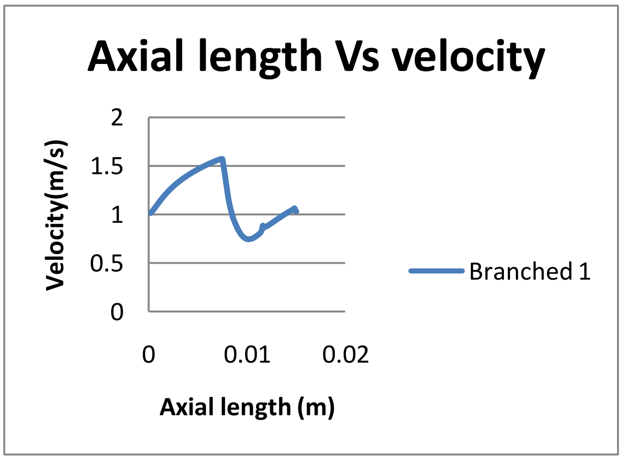

Fig. : 1.3 variation of velocity with the axial length

PRESSURE DROP WITH AXIAL LENGTH

Pressure drop along the two channel is investigated experimentally .there is a continuous pressure drop along the straight channel. Simulated result also shows the relevant result for the pressure drop. The variation of the pressure drop alonh the straight and branched channel is according to the figure 1.4. In the branched channel there is a drastic pressure drop at the point of bifurcation. Due to the drastic change in the velocity the pressure drop is maximum at the bifurcated point. The compression of pressure drop with the aspect ratio is shown in the fig.1.5

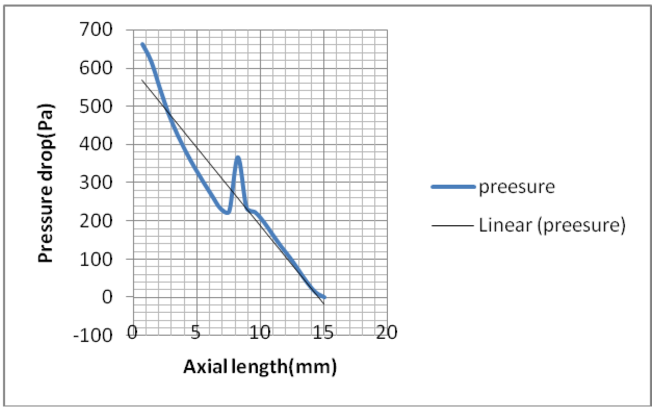

Fig. : 1.4 Pressure drop in the channel having aspect ratio 0.75

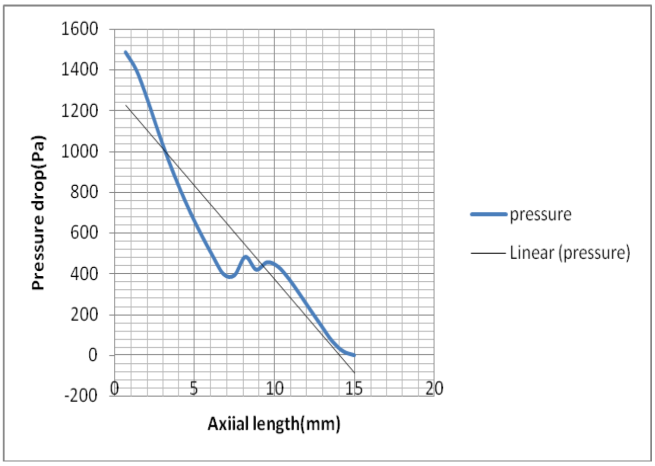

Fig.:1.5 variation of pressure along the axial length having aspect ratio 1

IV. Result and Discussion

Two model of microchannel having same convective area are studied experimentally and by modeling. From the observed data it can be concluded that pressure drop has the maximum impact on the heat transfer rate. It is found that due to the bifurcation in the branched channel there is a maximum pressure drop. Pressure drop also affected by the change in the aspect ratio. With the increase in the aspect ratio pressure drop is maximizes. The bifurcated model has the large drop in pressure.

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AUTHORS PROFILE

Vishal Bhuria, Researcher at Chandigarh University, Dept. of Mechanical Engineering,, Thermal Engineering. B. Tech from Gurukul Vidyapeeth Institute of engineering and technology, Ram Nagar, Banur. Research area Microchannel and compact heat exchangers

Gurjit Singh ME from GNDEC Ludhiana, Reserch area: CFD, Heat transfer in microchannels. Assistant Professor at Chandigarh University, Aerospace department.

Dr. Satbie Singh Sehgal, Dept. of Mechanical Engineering, Chandigarh University, Chandigarh, India. Reserch area heat transfer, solar energy