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DESIGN AND ANALYSIS OF VARIOUS FLOW HEADERS FOR UNIFORM FLOW DISTRIBUTION

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ABSTRACT

The flow distribution in headers is depend up on inlet velocity, inlet pressure, mass flow rate and mainly of header shapes. Therefore, it is important to design shape of the headers for our requirement. The flow distribution in headers is used in many engineering applications like civil, mechanical, electronics and chemical engineering field. In this study, headers shapes are used to study the uniformity of flow distribution .The header shape models such as rectangular, triangular and trapezoidal with twenty mini channels as outlet. Here, rectangular and triangular header shapes are considered as uniform manifold and trapezoidal header shape is considered as tapered manifold. The designing of shapes with help of GAMBIT and CFD .In rectangular and triangular header shapes flow of distribution is in non –uniform .So, here we focused only on trapezoidal header shape. From numerical results for trapezoidal header shape gives results as inlet velocity 1m/s, outlet velocity is 0.23m/s, inlet pressure (gauge pressure) is 103125 pa and outlet pressure is 311.78 pa for 20 mini-channel.

Keywords : CFD analysis, Fluid dynamics, Flow distribution, Header shapes, Uniformity flow.

I. INTRODUCTION

The uniform flow of header is important in many industrial applications where large storage tank is considered as one large pipe , then it is sub divided into small pipes and finally it will be collected in one large discharge tank. The flow of distribution in two types: U-type and Z-type. In U-type inlet flow direction is opposite to the outlet flow direction and in Z-type both the inlet and outlet flow directions are same. In other words it is classified into dividing and combining.

1.1 Types of Header Shapes

- Rectangular Header Shapes
- Triangular Header Shapes
- Trapezoidal Header Shapes

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1.1.1 Rectangular Header Shapes

The flow distribution in rectangular header is highly depending up on shape of the header. Here, shape of the header is uniform. The rectangle header structure has high velocity for the first five mini-channels, the velocity becomes constant for the next ten mini-channels and the velocity for the last five channels increases from the constant value but remains low when compared with the high velocity in the first five channels.

1.1.2. Triangular Header Shapes

The flow distribution in triangular header is highly depending up on shape of the header. Here, shape of the header is irregular in shape. The triangle structure for header has the high flow velocity initially and gradually decreases with the number of mini-channels.

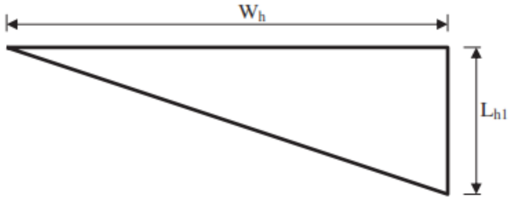

Fig. 1 Triangular Header Shape

1.1.3 Trapezoidal Header Shapes

The flow distribution in triangular header is highly depending up on shape of the header .Here, flow distribution mainly depend up on side back wall of the header shape. The trapezoidal structure for header has uniform velocity for maximum number of mini channels given in the header.

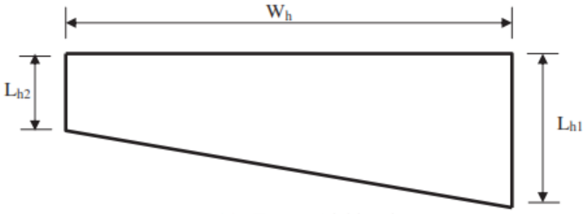

Fig. 2 Trapezoidal Header shape

II. PROBLEM DESCRIPTION

The non-uniform flow distribution causes a server problem in many industrial applications and it will reduce the life of the particular component in a system. Hence, objective of the study is to predict the uniform flow distribution in each mini channel outlet in uniform manifold i.e., to optimize the uniform manifold to get the better flow distribution in each mini channel outlet.

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2.1 Objective

The objective of this work is to design and analyze the various header models such as rectangle, trapezoidal and triangle to obtain uniform flow in multi-parallel port. The reason for uniform flow in mini channels is for reducing heat in micro fluidic devices.

III. MODEL FORMULATION

The different header shapes were designed by using the software GAMBIT and numerical results were obtained from CFD software. The designed header shapes with one common inlet and twenty mini channels outlet .In this software it cannot produce the correct value of outlet parameters.

With the trapezoidal header shape, the uniform flow distribution is possible but small ranges of mal distribution takes place. To avoid this mal distribution we have to optimize the header shapes to get correct values for corresponding outlet parameters.

From the optimized header shape we can get the uniform flow distribution in each mini channel outlet. Uniform flow distribution means ranges of velocity, pressure and total mass flow rate are equal in all twenty mini channel.

3.1 Methodology

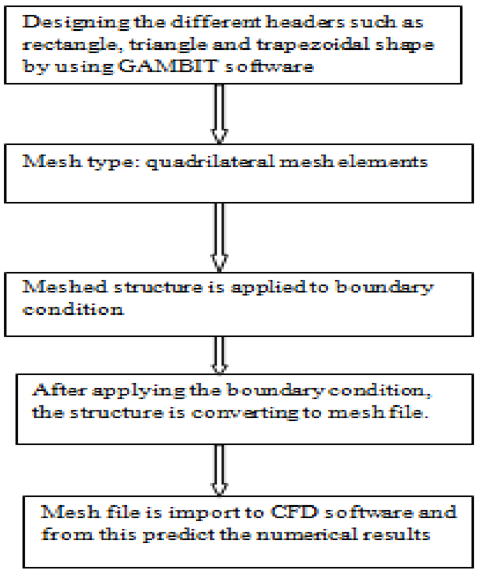

Fig. 3 Flow Chart for Methodology

3.2 Header Model

It design the model of Experimental tests for flow distributions from manifolds with different configurations have been conducted. The Numerical Model is created by using GAMBET Software show in figures.

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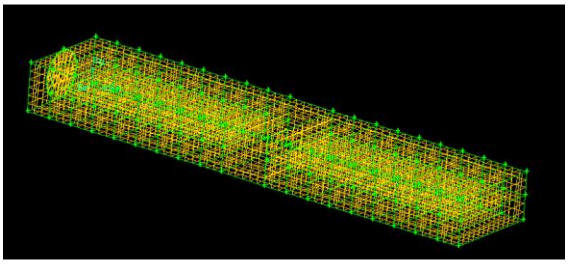

Fig. 4 Rectangular Header Model

Fig 4 shows that rectangular shape header, dimensions are D1=D2 (12.72), length 60mm, inlet and outlet diameter 3mm. It will be separated into two layer (i.e.,) one layer for header base and other for mini channels.

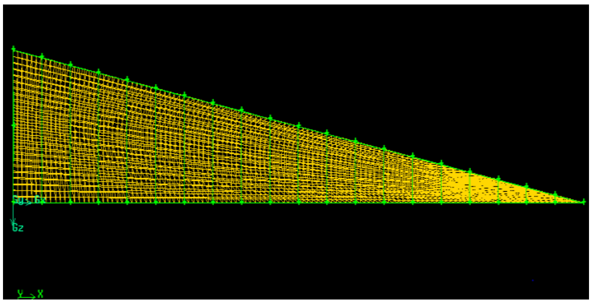

Fig. 5 Triangle Header Model

Fig 5 shows that triangle shape header, dimensions are D1 (12.72) and there is no D2, length 60mm, inlet and outlet diameter3mm. It will be separated into two layer (i.e.) one layer for header base and other for mini channels.

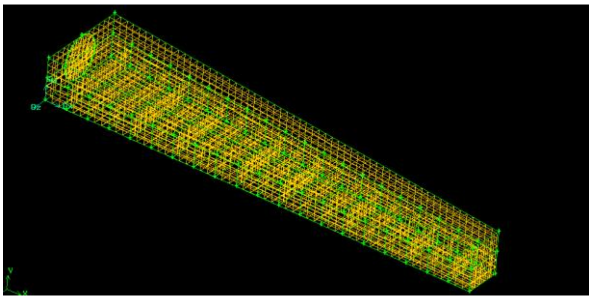

Fig. 6 Trapezoidal Header model

Fig 6 shows that trapezoidal shape header, dimensions are D1 (12.72), D2 (2.72), length 60mm, inlet and outlet diameter 3mm. It will be separated into two layer (i.e.) one layer for header base and other for mini channels.

IV. MEASUREMENT OF HEADER MODEL

The measurement of header model is the design of Trapezoidal Header shape of the uniform flow distribution headers. Measurement details were plotted in table 1 and table 2

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Table 1

Variations for manifold with Uniform longitudinal section

Length of manifold, mm	60
Diameter of inlet pipe , mm	5.8
Diameter of outlet pipe , mm	3
Height, mm	12.72

Table 2

Diameter of the Ratio of the manifold with Tapered longitudinal section

Case	**1**	**2**	**3**
D1(mm)	12.72	12.72	12.72
D2(mm)	2.72	6	5

4.1 Pressure range in flow distribution header

The below fluent diagram shows pressure range in mini channels,

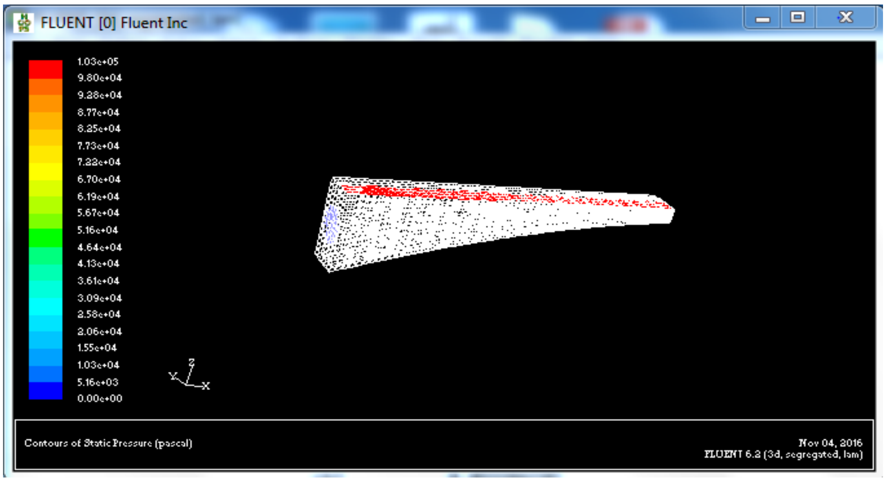

Fig. 7 Pressure Contour1

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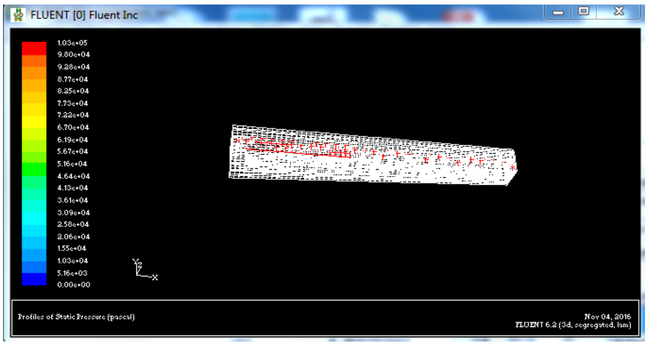

Fig. 8 Pressure Contour2

The above fig 7 and fig 8 shows that pressure ranges in all twenty mini channels. In fig 7 pressures will be high in all channels but in fig 8 pressures is high in first ten channels remaining channels have low.

4.2 Velocity range in flow distribution header

The below diagram shows velocity ranges in mini channels,

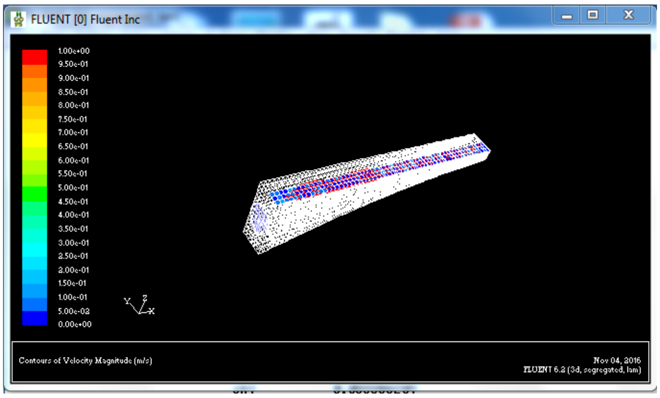

Fig. 9 Velocity Contour1

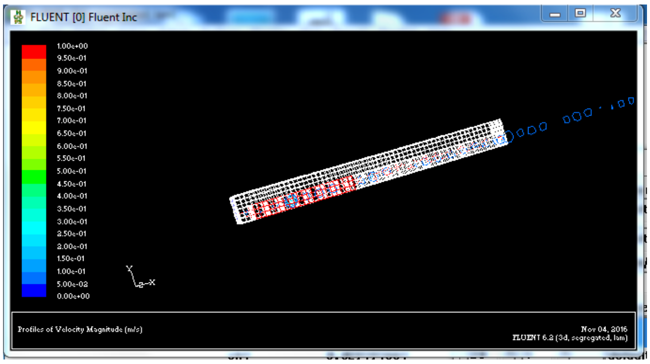

Fig. 10 Velocity Contour2

Fig 9 and fig 10 shows that different velocity ranges in all the twenty mini channels. In figure 5.3 in all twenty channels velocity ranges will be very low but in figure 5.4 in particular channels only velocity ranges will be very high remaining channels are in zero range.

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V. RESULTS ANALYSIS

Based on the flow analysis for header the inferences made in the different structures for header flow is as follows

1. The rectangular header structure has high velocity for the first five mini-channels, the velocity becomes constant for the next ten mini-channels and the velocity for the last five channels increases from the constant value but remains low when compared with the high velocity in the first five channels.
2. The triangular structure for header has the high flow velocity initially and gradually decreases with the number of mini-channels.
3. The trapezoidal structure for header has uniform velocity for maximum number of mini channels given in the header.

5.1 Waveform Results

The below waveforms shows that the different characteristics of three different header shapes,

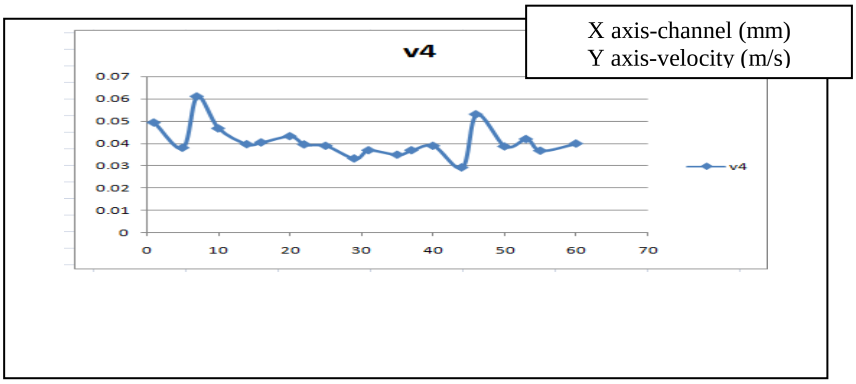

Fig. 11 Waveform for Rectangular Header

Fig 11 shows that the rectangle header structure has high velocity for the first five mini-channels, the velocity becomes constant for the next ten mini-channels and the velocity for the last five channels increases from the constant value but remains low when compared with the high velocity in the first five channels

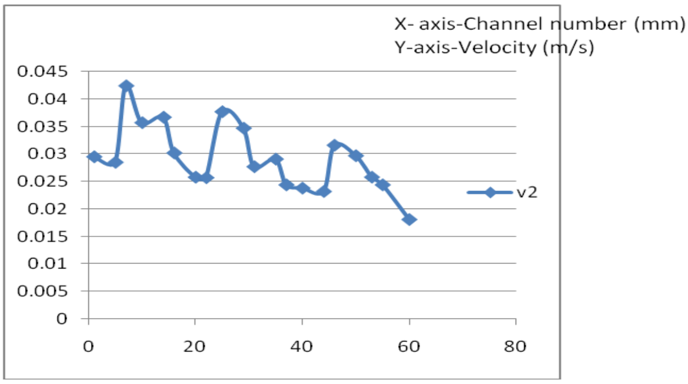

Fig. 12 Waveform for Triangular Header

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Fig 12 shows that the triangular structure for header has the high flow velocity initially and gradually decreases with the number of mini-channels.

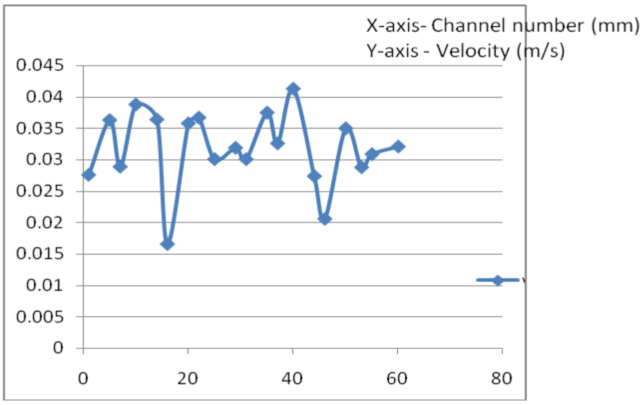

Fig. 13 Waveform for Trapezoidal Header

Fig 13 shows that the trapezoidal structure for header has uniform velocity for maximum number of mini channels given in the header.

5.2 Simulation result

1. Simulation results from CFD software show that inlet velocity is 1m/s and outlet velocity is 0.23m/s for 20 mini-channels.

2. Simulation results from CFD software show that inlet pressure (gauge pressure) is 103125 pa and outlet pressure is 311.78 pa for 20 mini-channel

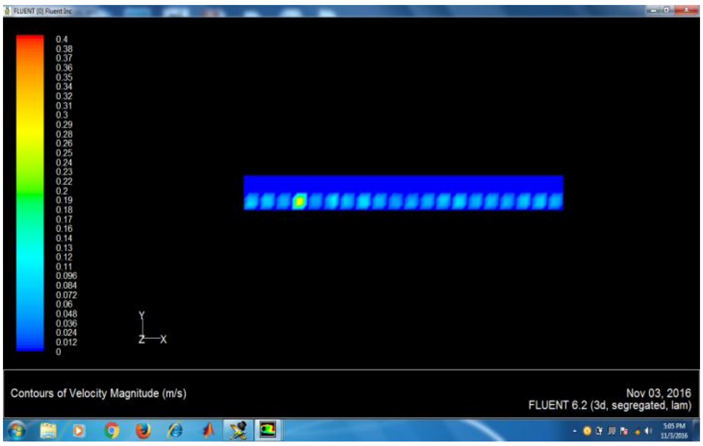

Fig. 14 Velocity contour

From fig 14, it is concluded that velocity will be uniform in all mini channels but in fourth channel velocity range is very high .Because recirculation of water action occur in 4^{th},5^{th},6^{th} channels.

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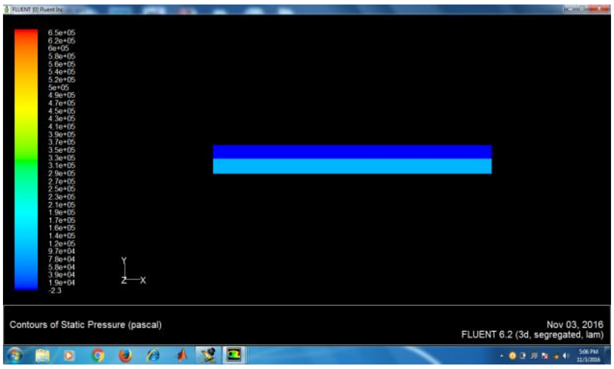

Fig. 15 Pressure Contour

From fig 15 it is concluded that pressure will be uniform in all mini channels.

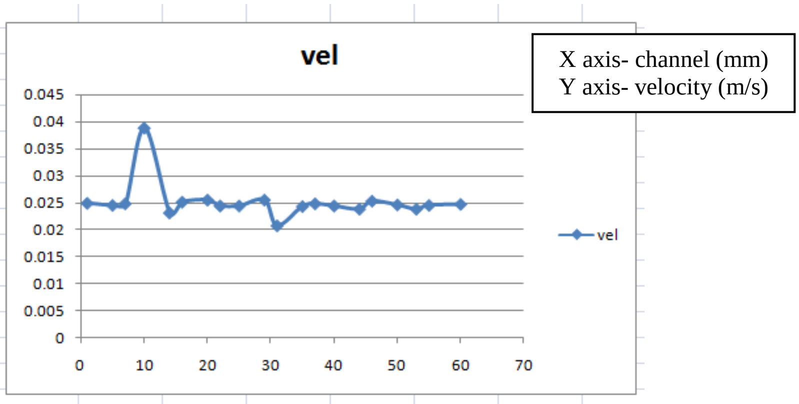

Fig. 16 Waveform for Trapezoidal Header

Fig 16 shows that the velocity ranges in each mini channels.

VI. CONCLUSION

The main aim of this analysis is to predict the non-uniform flow distribution in uniform manifold and optimize the header to get the uniform flow distribution in each mini channel outlet. The numerical and simulation result shows that rectangular header and triangular header is not suitable for uniform flow distribution. But depend up on their waveform characteristics it suitable other applications. Finally, trapezoidal header shape is used for uniform flow distribution and it is predicted from above waveform characteristics.

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