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Fabrication and Performance Analysis of Hybrid Configuration Micro-Mixers

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Abstract **- Mostly the micro channel parts are significant for lab on a chip device. Use of micro mixers is in biomedical devices and micro fluidic applications. The fabrication of micro mixers is quite tough by using conventional manufacturing. To characterize technology, different methods are used for the fabrication of micro channel. By using both conventional and non-conventional techniques, like micro milling, lithography, embossing processes and laser ablation processing. In the present days, Acrylic comes in a wide variety of standard. The fact that some of them are bullet resistant, it is now in highly demand. Acrylics come in various shapes. There are many ways of processing them, and the one discussed here is the process done by using laser cutter machines. The process is called laser-cutting process. In this paper, a study on the use of a commercial CO2 laser system for fabrication of micro-channel moulds using acrylic material. The accuracy of micro mixer mainly depends on the fabricated moulds. By using laser power and scanning speed we can control the depth of micro channel. To analyse the effect of Laser power and scanning speed on the depth of the Micro mixers mould primary experimentation is performed. According to analysis, it is observed that the depth of micro mixer mould increasing linearly with an increase in laser power and decreasing with increasing speed. The Y shape micro mixers hybrid configurations are designed and their experimental and numerical analysis is carried out using COMSOL Multiphysics software.**

Keywords **- CO-2 Laser, Micro-mixer, Moulds, Hybrid Configuration, COMSOL.**

I. Introduction

Now a day's micro total analysis systems (μTAS) plays significant role in many of the applications and Micro Channel is one of the prominent part of these systems. The Micro Channels are having applications in various fields like medical, diagnostics, chemical, biological, etc. [1][2]. The Micro Channels can be fabricated by using Acrylic material more economically and efficiently as compared to commercial materials like Silicon, Glass and Polymers, etc. Due to low cost and straight forward fabrication these Micro Channels are widely used in Medical and Engineering fields [3] [4]. There are various methods to fabricate the Micro Channels such as hot-embossing [5][6] injection molding [7] micro milling [8] infrared laser ablation [9] Photo chemical machining [10] [11] [12]. The CO2 laser machining is also a suitable option for fabrication of molds or direct Micro Channels. The use of CO2 laser machining not only speeds up the fabrication process but also the high flexibility of changing the design. Thus, the CO2 laser systems are very much useful for micromachining. In this paper, the Y shape micro mixers with hybrid configuration have been fabricated using the CO2 laser machining. The input parameters are also varied in order to achieve the different depths for the Micro mixers. The experimentation of fluid flow through micro-mixers of two geometries is carried out and Experimental results. Also numerical analysis is carried out using COMSOL Multiphysics software.

II. Design and Development of Micro-channels

Laser cutting is a technology that uses a laser to cut materials and is usually used in industrial manufacturing. Laser cutting works by directing the output of a high-power laser, by computer, at the material to be cut. The material then melts, burns, vaporizes away, or is blown away by a jet of gas, leaving an edge with a high-quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials. Industrial laser cutters are used to cut flat sheet material as well as structural and piping materials.

They are also quite efficient: the ratio of output power to pump power can be as large as 20%. This machine can cut through wood, acrylic, plastic, cloth, leather, matte board, melamine, paper, pressboard, rubber, wood veneer, fiberglass, cork and many other materials.

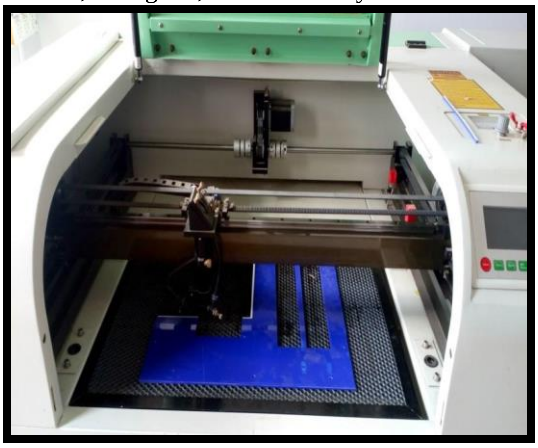

Fig. 1 CO-2 Laser Machine

A. *Design of Micro-Mixers:*

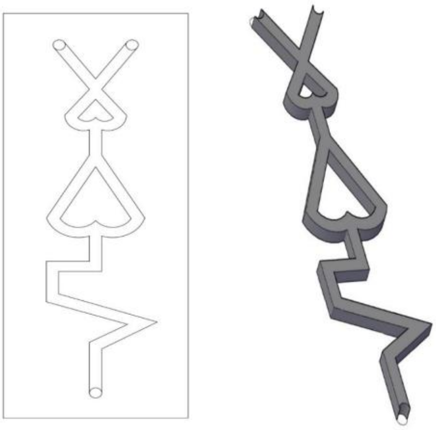

Fig. 2 Micro-Mixer-1 with hybrid Configuration

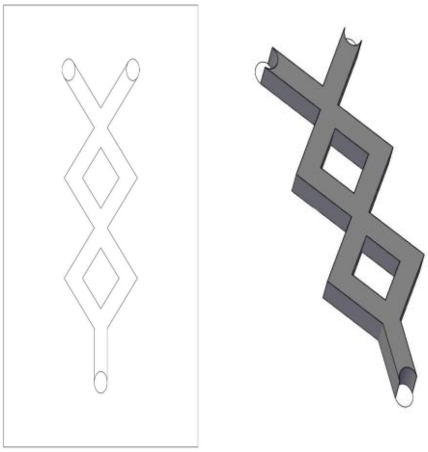

Fig. 3 Micro-Mixer-2 with hybrid Configuration

B. *Fabrication of Micro-Mixers using LASER Machine:*

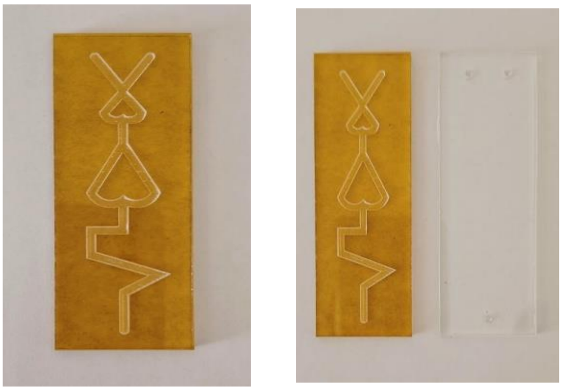

Fig. 4 Fabricated Micro-Mixer-1

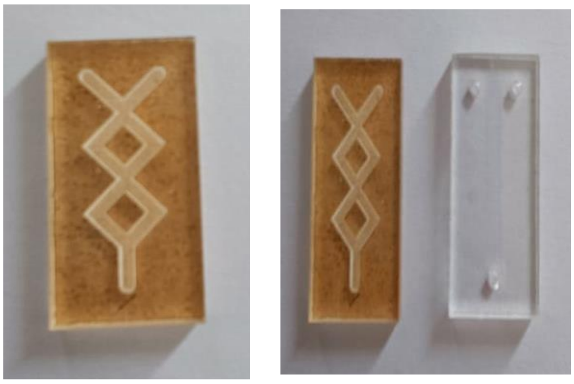

Fig. 5 Fabricated Micro-Mixer-2

The above micro mixers are fabricated using CO-2 LASER machining. The effect of laser power and speed will effect on the fabrication of micro mixers. The variation of laser power and speed will effect on the depth of micro mixers. The no. of reading is taken in this regard to finalize the depth of mixer.

III. Experimental Analysis

This study deals with the detailed experimentation of fluid flow through micro-mixers of various geometries. This section will present Experimental results obtained in micro fluidic laboratory at different Inlet velocities and flow rate in all mentioned micro-mixers. The visualization of fluid flow through fabricated micro mixer is shown in figure below. After that the experimental results are compared for flow pattern with simulation results

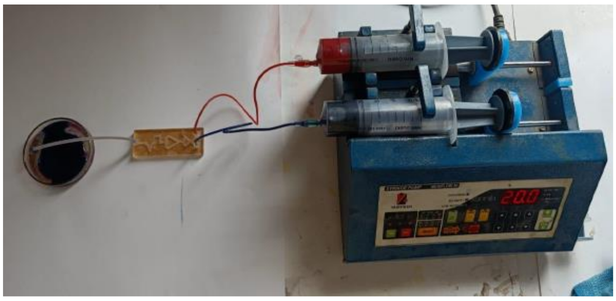

Fig. 6 Schematic of Experimental Setup

A. *Experimental Analysis of Fluid flow through Micro Mixers*

To conduct the experiment, Blue Ink and Water was taken as the sample. So, the property of the fluid was nothing but the property of the ink only.

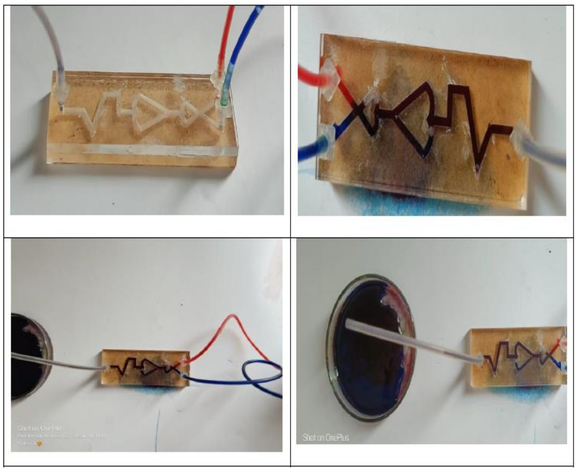

Fig. 7 Fluid flow through micro mixer-1

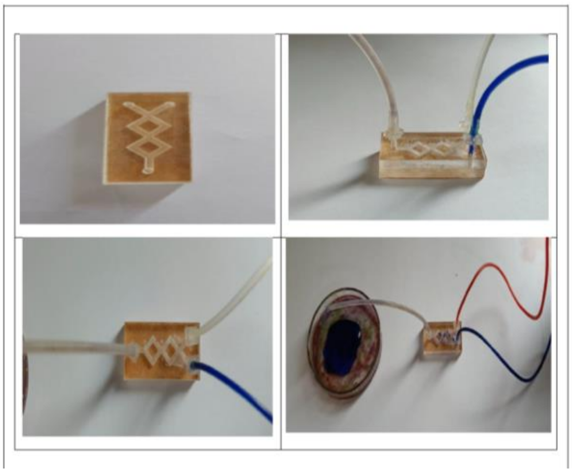

Fig. 8 Fluid flow through micro mixer-2

IV. NUMERICAL ANALYSIS OF CHANNELS USING COMSOL SOFTWARE

The numerical analysis channel is carried out using COMSOL Multiphysics software. The micro mixer is designed using AutoCAD and then imported in COMSOL software for the analysis purpose. Design of micro mixer in COMSOL

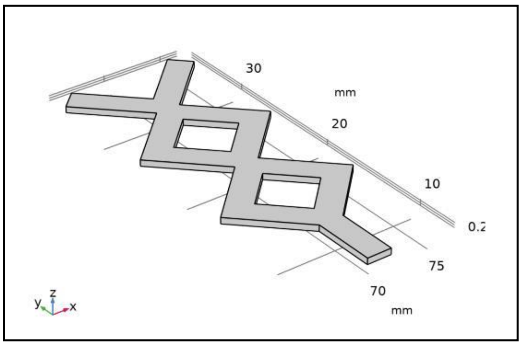

Fig. 9 Design of geometry

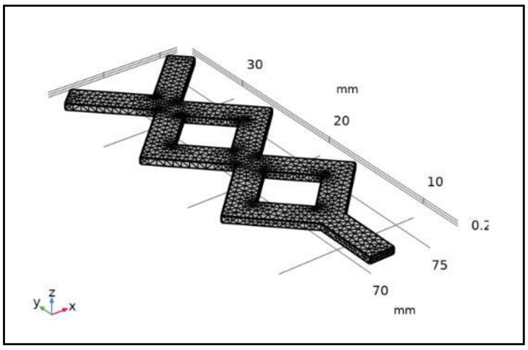

Fig. 10 Meshing of geometry

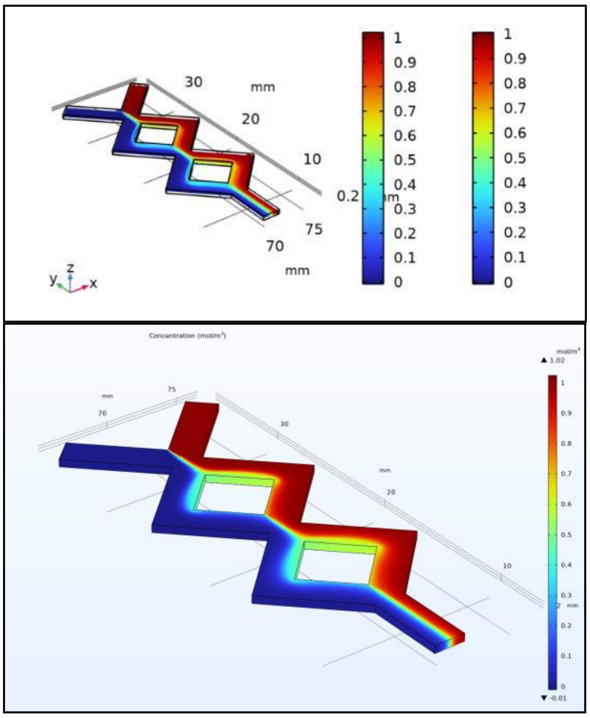

Fig. 11 Mixing analysis of micro mixer using COMSOL

V. CONCLUSION

Micro mixer is one of the essential components in integrated microfluidic systems for chemical, biological and medical applications. COMSOL Multiphysics software package is used for simulation of fluid flow and mixing through channels of different configurations. The micro MIXERS are major components required in Lab on a chip device. The fabrications of Y-shaped micro MIXERS with different configurations have been carried out using Laser cut machining. The molds are fabricated for three different widths and using two different parametric conditions. The depths recorded are as 0.5 mm and 0.52 mm. Y shape micro mixers with two different geometries have designed. CO2 Laser Machining is used for mold making of micro mixer. The fabricated Y shape channel is used for experiment analysis.

The following conclusions are drawn through this study.

1. Decrease in the inlet velocities of the incoming fluids gives minimum mixing length of Micro mixer.

2. Y Shape Micro mixer give better mixing length but slightly lesser pressure drop compared to others.
3. As the channel width decreases, mixing time and mixing length of Micro mixer decreases.
4. The micro mixers with hybrid configurations are more suitable for mixing the two fluids in minimum mixing length.

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