A Presentation on

Effect of geometry of the grooves on the mixing of Fluids in micro mixer channel

COMSOL CONFERENCE INDIA 2012

Ashok Kumar,
Ritesh Mandal,
Gulshan Prakash
& Vinayak Ranjan

Excerpt from the Proceedings of the 2012 COMSOL Conference in Bangalore

Contents

Introduction

- Microfluidics is the study of fluid flow in geometries with one of the channel dimensions being of the micrometer scale.
- These geometries are built-up into circuits known as microfluidic chips.
- One of the main challenges in microchannel is mixing where more than one fluid come together.
- Mixing fluids are used for micro-scale applications.
- This paper investigates flow characteristics and mixing behavior of fluids in micro channel due to three different geometries in micro-channel.

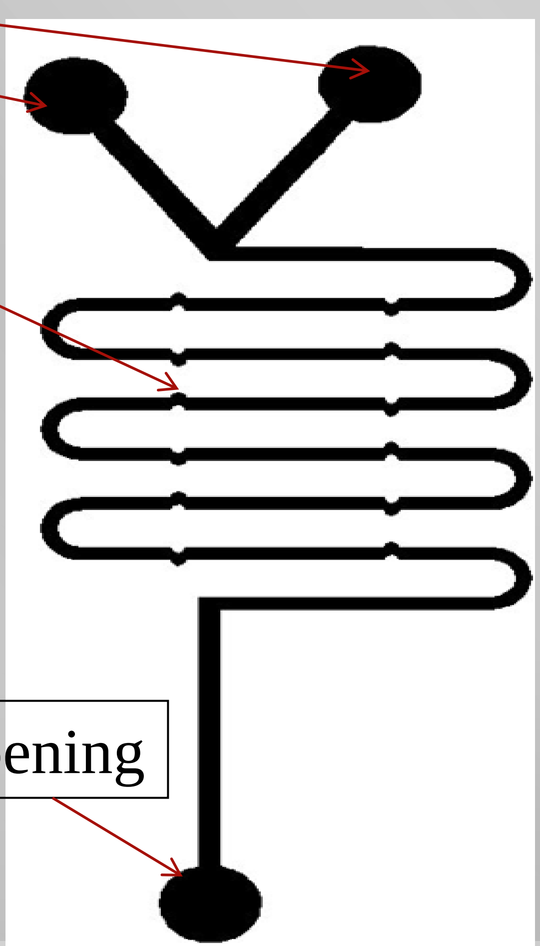
Applications

- Continuous-flow microfluidics.
- Digital (droplet-based) microfluidics.
- Molecular biology.
- Fuel cells.
- Microbial behavior.
- DNA chips (microarrays).
- Optics.
- A tool for cell biological research.
- Future directions.

Material and geometry

- Material of microchannel is **PDMS**.
- Geometry consists of various types of grooves (circular, triangular and rectangular) .
- Width of Channel = 200 µm.
- Depth of the channel = 200 µm.
- Length of the channel = 95 mm.
- Circular grooves has radius. of 100 µm.
- Rectangular and triangular grooves have also

  same cross section.
- Inner turning radius 550 µm.



- Outer turning radius = 750 μm.
- Angle between two inlets = 60°
- Two fluids are water and acrylene orange dye.
- In COMSOL, water and a fluid whose properties resembles with acrylene orange dye is taken.
- Inlet volume flow rate is 10μl/min.
- Input concentration of dye is 20 kg/m^3.
- Input concentration of water is 1 kg/m^3.
- Inlet velocity, viscosity and pressure of fluids were kept constant.

Analysis and Discussion

- Different cases are analyzed.
- Graphs in concentration vs length of the channel is plotted.
- The length of the channel for mixing of fluids is optimized.

❖ **Case 1: Channel with one triangular, one rectangular and one circular groove separately before each bend.**

- Optimum length for circular

  grooves: 55,000 µm.

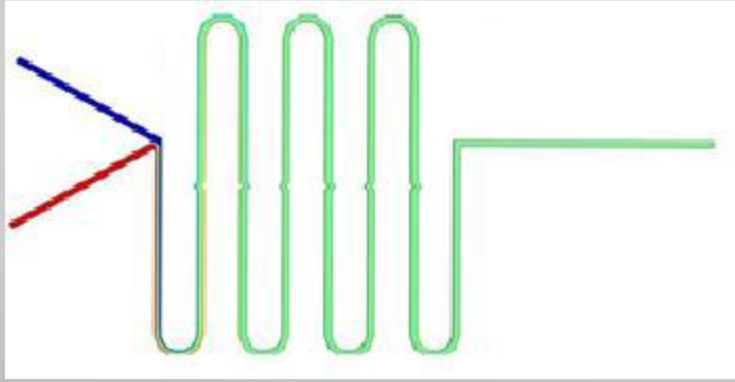
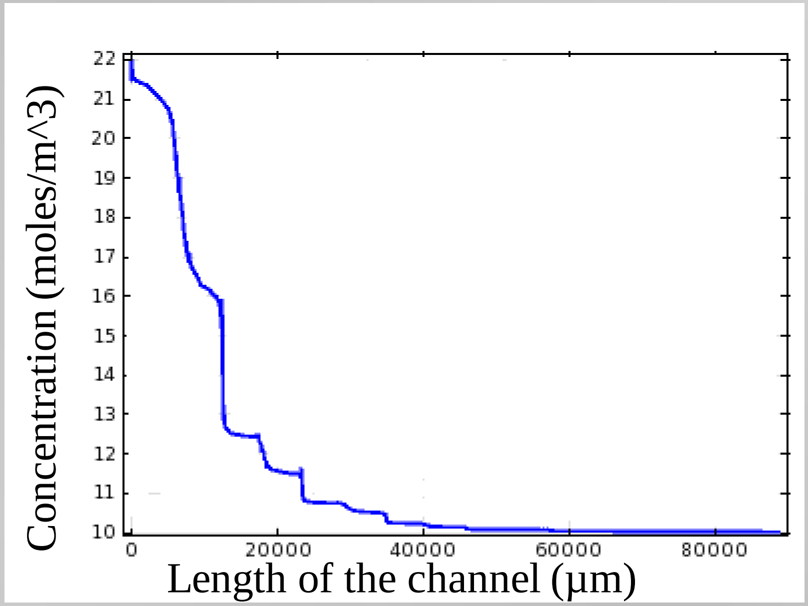


Fig. 2: Mixing behavior of two fluids in a microchannel having one circular groove.



Graph 1:- The effect of single circular groove on concentration of mixing in microchannel is having input velocity 20 µl/min along the channel length.

- For trianular grooves : 60,000 µm

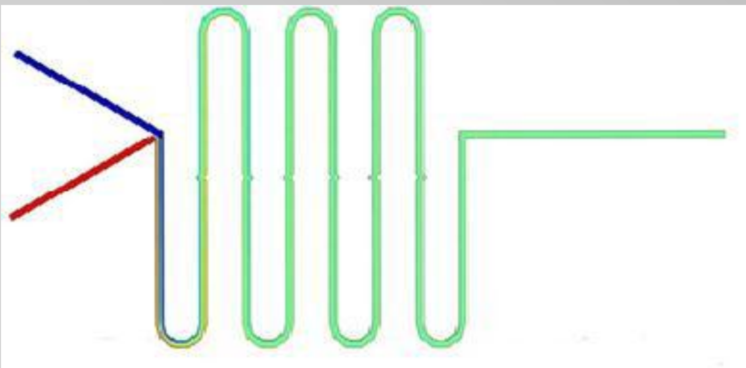
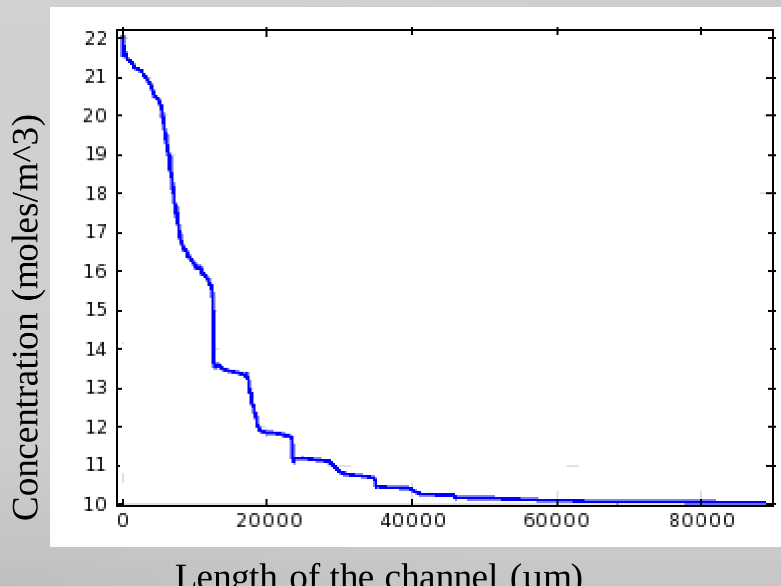


Fig. 3: Mixing behavior of two fluids in a microchannel having one triangular groove.



Graph 3:- The effect of single triangular groove on concentration of mixing in microchannel.

- For rectangular grooves: 57,500 µm

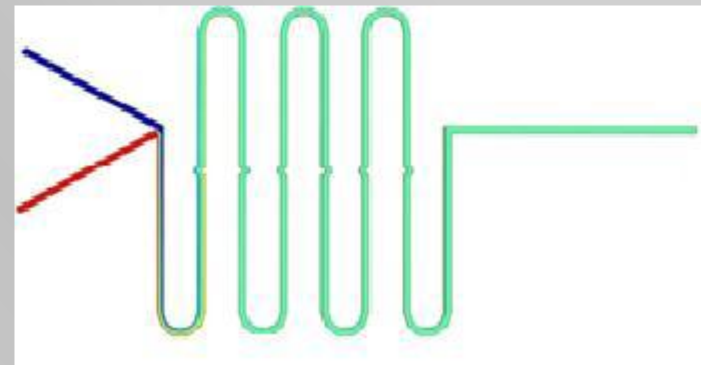
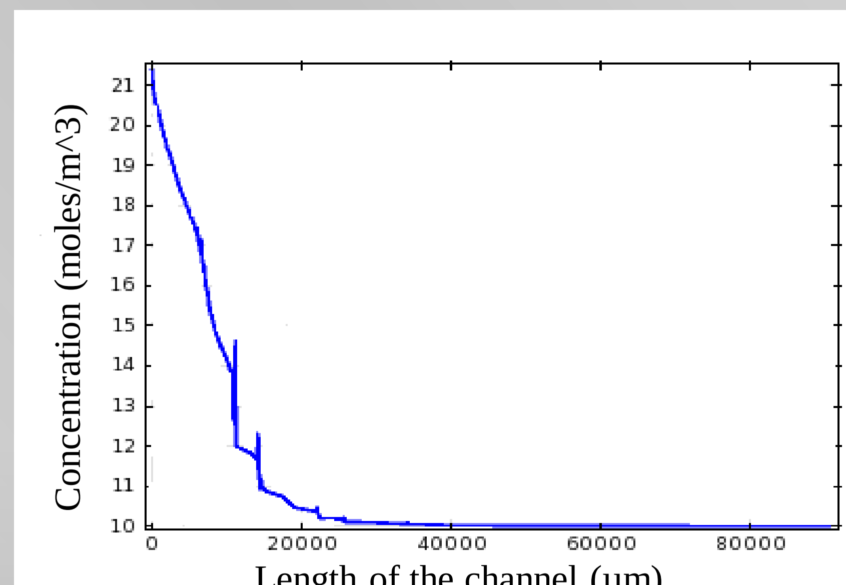


Fig. 4: Mixing behavior of two fluids in a microchannel having one rectangular groove.



Graph 3:– The effect of single rectangular groove on concentration of mixing in microchannel.

- **<u>Case 2:</u>** Channel with two rectangular, two circular & two circular grooves separately before each bend.
- Number of grooves increased, more proper mixing.
- For circular grooves : 40,000 µm.

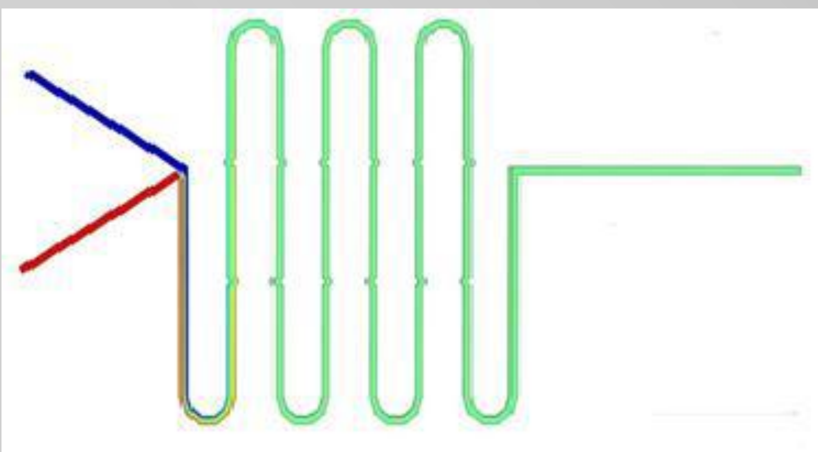
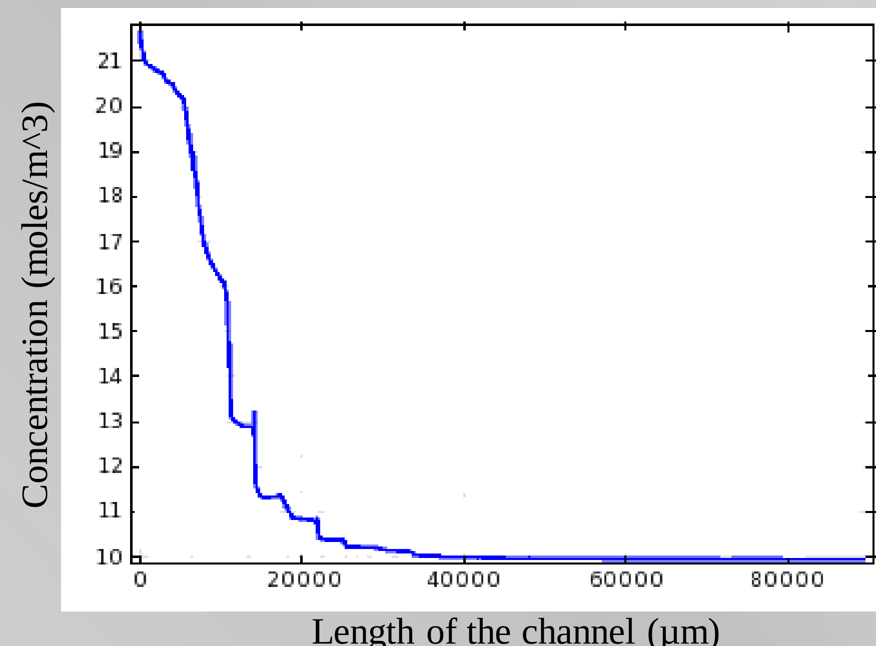


Fig. 5: Mixing behavior of two fluids in a micro channel having two circular grooves.



Graph 4:– The effect of two circular grooves on concentration of mixing in microchannel

- For rectangular grooves : 40,000 μm

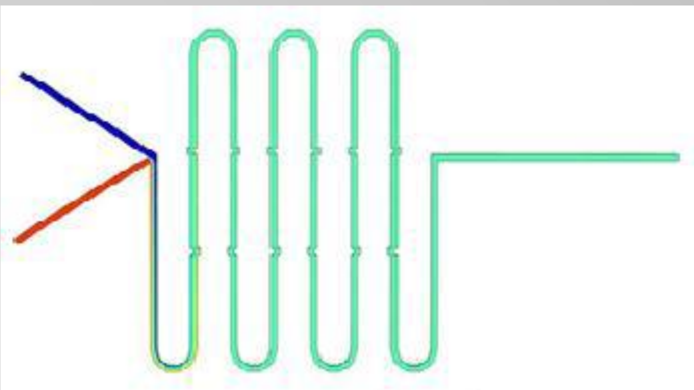
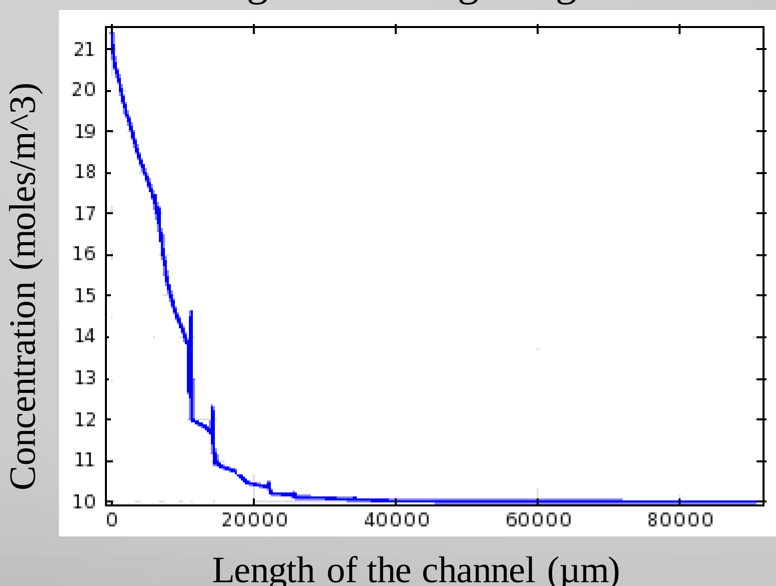


Fig. 6: Mixing behavior of two fluids in a micro channel having two rectangular grooves.



Graph 6:– The effect of two rectangular grooves on concentration of mixing in microchannel

- For triangular grooves: 45,000 μm

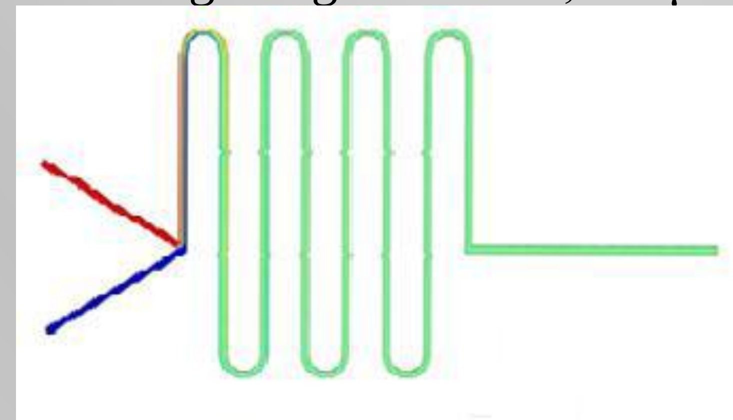
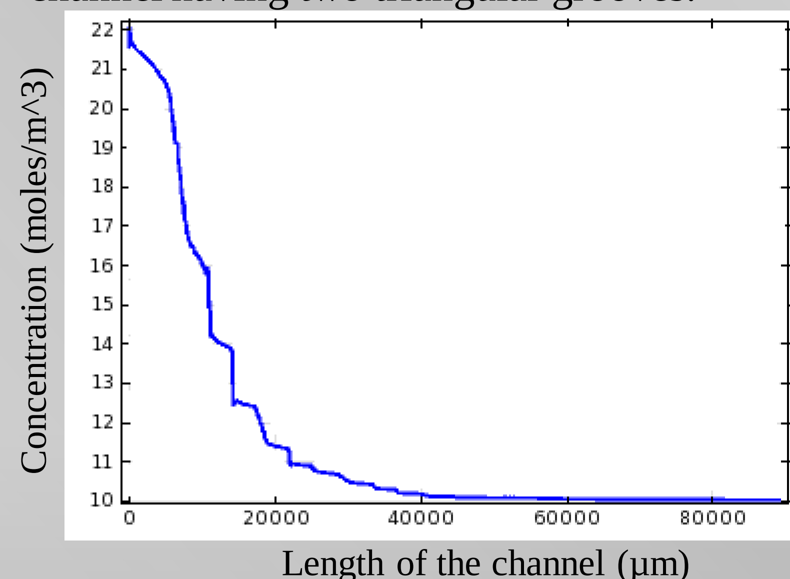


Fig. 7: Mixing behavior of two fluids in a micro channel having two triangular grooves.



Graph 5:– The effect of two triangular grooves on concentration of mixing in microchannel

- **Case 3: Channel with three circular grooves before each bend.**
- Optimized channel length is 35,000µm.

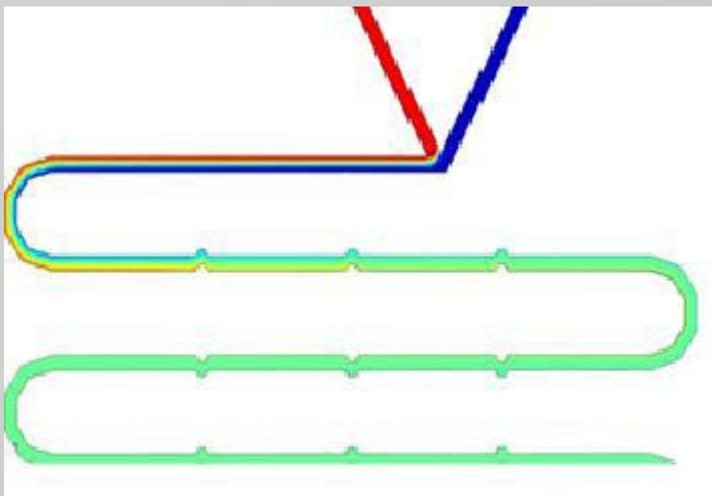
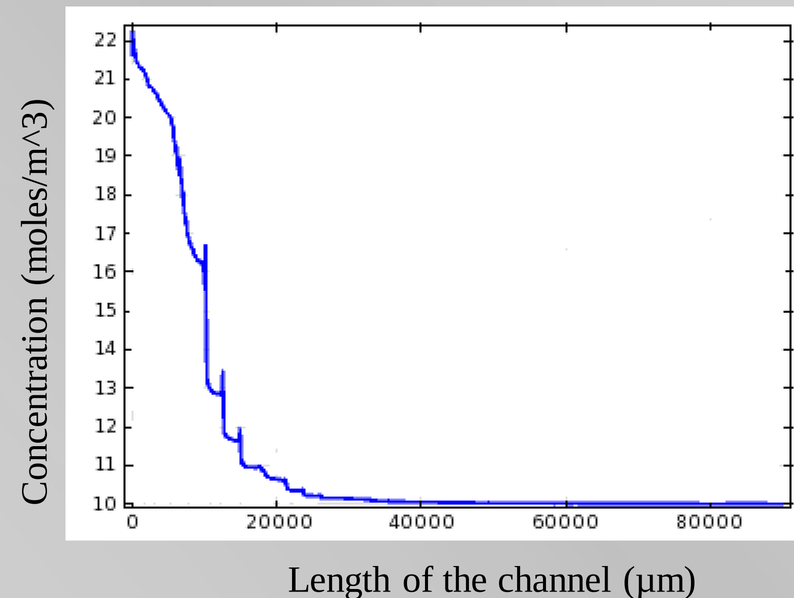


Fig. 8: Mixing behavior of two fluids in a micro channel having three circular grooves.



Graph 7:– The effect of three circular grooves on concentration of mixing in microchannel

- **Case 4: Channel with one circular, one rectangular and one triangular simultaneously before each bend**.
- Optimize length of the micro channel is 35,000µm.

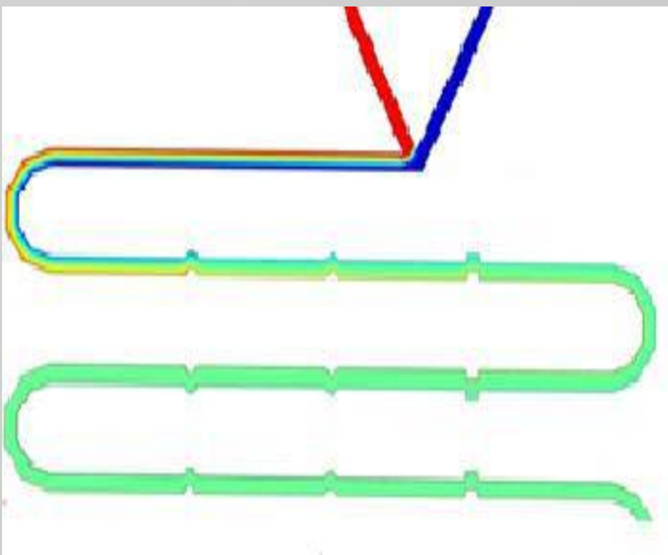
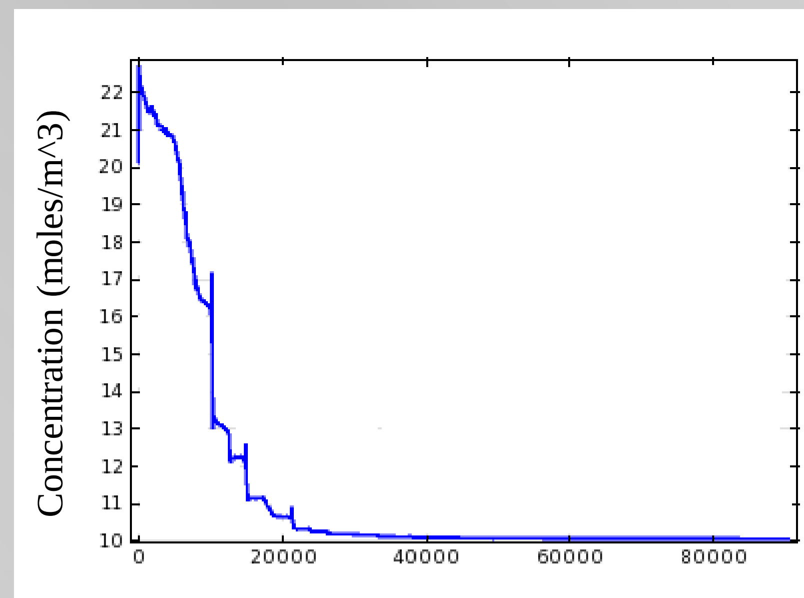


Fig. 9: Mixing behavior of two fluids in a micro channel having one triangular, rectangular and circular groove.



Graph 8:– The effect of one triangular, rectangular and circular groove simultaneously on concentration of mixing in microchannel

Conclusion

From the above study and simulation it has been concluded that:

- When we are increasing the number of grooves, the mixing length for proper mixing is decreasing.
- Mixing is affected by the geometry of grooves. Better mixing is obtained for circular groove case having three circular grooves before bend.
- The optimum length for mixing is found to be 35,000µm.

REFERENCES

- Shantanu Bhattacharya, Rahul Choudhary., Bilayer staggered herringbone micro-mixers with symmetric and asymmetric geometries. Micro-fluid Nano-fluid(2010).
- Su, Y.H., Zhao, Y.C., Chen, G.W., Yuan, Q., Liquid–liquid two-phase flow and mass transfer characteristics in packed microchannels. Chemical Engineering Science 65, 3947–3956. (2010).
- S.J. Tan, L. Yobas, G.Y.H. Lee, C.N. Ong, C.T. Lim, Microdevice forthe isolation and enumeration of cancer cells from blood. Biomed. Micro-devices 11, 883–892 (2009) .
- Soleymani, A., Kolehmainen, E., Turunen, I.. Numerical and experimental investigations of liquid mixing in T-type micro-mixers. Chemical Engineering Journal 135, S219–S228, (2008).
- K. Samuel, M. George, Whiteside, microfluidic devices fabricated in poly (dimethylsiloxane) for biological studies, Electrophoresis 24 (2003) 3563–3576.
- Nguyen, N.T., Wereley, S.T. Fundamentals and Applications of Microfluidics. Artech House, Boston, MA USA, (2002).
- Yang, J.T., Huang, K.J., Lin, Y.C. Geometric effects on fluid mixing in passive grooved micro-mixers. Lab on a Chip 5, 1140–1147, (2005).

THANKING YOU