**Numerical Study of Fluid Mixing at Different Inlet Flow Rate Ratio**

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**Highlights**

* A new Y-Y passive SAR mixer is designed and analyzed.
* Numerical simulation is done using Fluent for inlet flow rate ratio from 1 to 3.
* Mixing efficiency, flow pattern and pressure drop is calculated.
* Y-Y mixer shows the lowest pressure drop and have 90% mixing efficiency.

**1. Introduction**

Micromixer is a device which mix fluids regardless of their properties and nature such as density, viscosity, surface tension etc. in micro-scale. Micromixers and micro reactors are used in a wide range of chemical reactions, biochemical reactions, drug development and delivery, medical diagnosis, chemical synthesis and food industries [1] [2]. In micro scale the flow is typically laminar due to low Reynolds number [3]. In this paper, we designed a new SAR Y-Y mixer, and mixing performance and pressure drop is performed numerically by varying the inlet flow-rate ratio (1 to 3). In order to have a point of reference, the Y-Y micromixer was compared to the already established Chain, Tear drop and H-C micromixers.

**2. Micromixer Design**

The detailed geometrical configuration of Chain, Tear-drop, H-C and Y-Y micromixers is shown in Figure 1. All mixers are made of four identical elements which are connected with each other in various way to maximize mixing performance. The minimum dimension of all mixers is 4 mm. 

**Figure 1**. Design of the (a) Chain (b) Tear-drop and (c) H-C (d) Y-Y mixers with important parameters (unit in mm)

**3. Numerical Method**

ANSYS FLUENT 15, a commercial computational fluid dynamics software was employed to numerically determine mixing efficiency and pressure drop. The value of Reynolds numbers was used as one of the primary parameters for this study and is calculated as $Re= \frac{ρvd}{μ}$. Where ρ and μ are the fluid density and dynamic viscosity, respectively, v is the fluid velocity evaluated at the rectangular channel, and d is the characteristic length. A cut-cell Cartesian method was used to generate hexahedral cells suitable for the complex geometry used in computational fluid dynamics (CFD) simulations. Standard deviation of species concentration was calculated at a cross-section of the mixing channel to evaluate the mixing efficiency using the standard equations [4]. The grid dependency test for all mixers were performed varying numbers of grids.

**4. Result and Discussion**

Figure 2 revels the efficiency of all four mixers curves for different inlet flow-rate ratios and the curves show the same trend, the efficiency slightly increases for higher inlet flow-rate ratios, especially at 30 ≤ *Re* ≤ 100. The overall mixing efficiency is more than 90% at all Reynolds numbers, regardless of the inlet flow-rate ratios. The numerical data are in line with experimental values.



Figure 2. Numerical mixing efficiency of the mixers at the exit of the fourth element (Ratio 1 to 3)

As demonstrates in Figure 3, numerical curves of all mixers have the same trend, i.e. pressure-drop increases with the increase of flow rate. It is also clear that Y-Y has the lowest pressure drop.



Figure 3. Numerical pressure drop of the four micromixers, varying flow rate

**5. Conclusions**

Four passive mixers, which uses fluid folding, rotation, expansion and construction along with splitting and recombination to improve mixing, is presented. The numerical model was used to analyze the effect of different inlet flow-rate ratios (1 to 3) at 1 ≤ Re ≤ 100. The results showed that mixing efficiency depends on the Reynolds number as well as inlet flow rate ratio. The mixing efficiency of the Y-Y and H-C mixers is very good (greater than 90%) over the entire examined range of Reynolds numbers but Y-Y has the lowest pressure drop among the all presented micromixers.

**References**

1. V. Khaydarov, E. S. Borovinskaya, Appl. Sci. 8 (2018) 1-16
2. M. A. Ansari, K. Y. Kim, S. M. Kim, micromachine 9 (2018) 1-14
3. J. M. Park, D. S. Kim, T. H. Kang, Micro. And Nano. 4 (2008) 513-523
4. N. Solehati, J. Bae, A. P. Sasmito, Computers & Fluids 96 (2014) 10-19