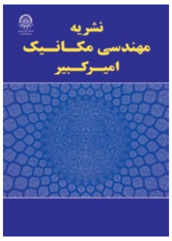

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Numerical Study of Mixing in Double and Multiple T-Shaped Micromixers with Aligned and Non-Aligned Inputs

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ABSTRACT: In this simulation mixing behavior of two fluids water and ethanol with various density and viscosity mixing in 5 types of T-micromixers numerically has been studied. The five Geometries under research are: 1 and 2 geometries are multiple T-micromixer with non-aligned inputs in one and two planes respectively, and the 3, 4 and 5 geometries are included multiple T-micromixer, double T-micromixer and T-micromixer. Simulation has been performed using computational fluid dynamics commerical code of ANSYS fluent 18 at Schmidt number of 752.26 for 6 different Reynolds number in range of 1 to 200. In creeping flow range, viscosity force and in laminar flow (non-creeping) the chaotic of flow was the main mixing factors for all studied geometries. For double T-micromixer and multiple T-micromixers two and three different types of placement for two fluids in the inputs respectively investigated and the most efficient mixing type has been specified.. Mixing results compared for specific flow types in double and multiple micromixers with single flow type in T-micromixer. The results show the mixing index and pressure drop are function of inputs' number and position. Also, for geometries with more than two inputs, types of input fluids have effects on these parameters. Maximum mixing index which was 0.4878 has been observed using flow 1 in multiple T-micromixer at Reynolds number equals 1.

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1. INTRODUCTION

Micromixers have a significant impact on the efficiency and sensitivity of microfluidic devices, that one of the most important components of these devices [1]. Mixing applications in micromixers can be used to combine the molten polymers, to tracking pollutants in large-scale rivers, and to combine atmospheric flows [2].

2. NUMERICAL INVESTIGATION USING FINITE VOLUME METHOD

In the present research, the mixing behavior of two fluids in five geometries in three dimensions is numerically studied. Also, when the number of micromixer inputs is more than two, can be studied that from which input the first fluid and which input second fluid to enter in order to achieve higher mixing rates. In the present study, for the geometries with six inputs, three different types for two fluids respectively in the inputs, and for the geometry double T micromixer with four inputs, two types for the placement of two fluids in the inputs have been investigated.

In this modeling, the second order upwind method is used to discretize the convection terms, whereas pressure and velocity fields are coupled by the SIMPLEC algorithm. The accuracy of the residual convergence is considered 10^{-5}

$$\vec{\nabla}.\left(\rho\vec{V}\right)=0 \tag{1}$$

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$$\vec{\nabla}.\left(\rho\vec{V}\vec{V}\right)=-\vec{\nabla}P+\vec{\nabla}.\left(\overline{\overline{\tau}}\right) \tag{2}$$

$$\vec{\nabla}.\left(\rho\vec{V}C_i\right)=-\vec{\nabla}.\vec{J}_i \quad , \quad \vec{J}_i=-\rho D_{i,m}\vec{\nabla}C_i \tag{3}$$

In the above equations ρ is the fluid density, P is the pressure, $\overline{\overline{\tau}}$ is the stress tensor, μ is the molecular viscosity, I is the unit stress tensor, C_i is the mass fraction of species, $D_{i,m}$ is the molecular diffusion coefficient.

In order to calculate the mixing rate obtained in the mixing channel, the mixing index is used which is defined as Eq. (3) [3].

$$Mi=1-\sqrt{\frac{\int_A (C-\overline{C})^2 dA}{A.\overline{C}(1-\overline{C})}} \tag{3}$$

In present work in order to ensure the accuracy of implemented numerical method, Cortes Quiroz et al [3] research has been used. In Fig. 1 the results of present research compared with their research and are in good agreement

In Fig. 2 geometry No. 1 is shown that has non-aligned inputs in one plane.

3. RESULTS AND DISCUSSION

In Fig. 3 a comparison is done between the geometries evaluated in the mixing index for the different Reynolds

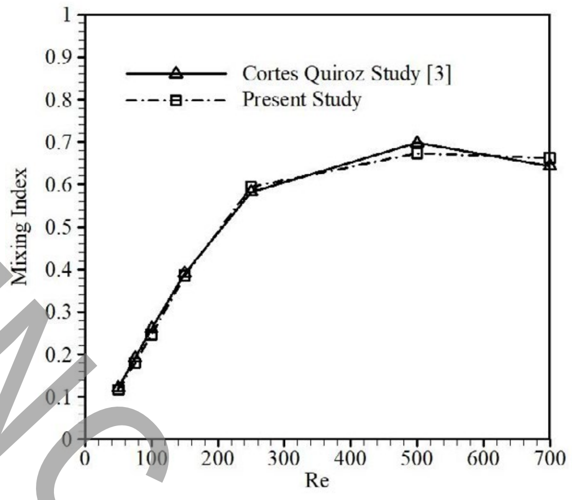

Fig. 1.Comparison of the mixing index versus different Reynolds numbers at the outlet mixing channel

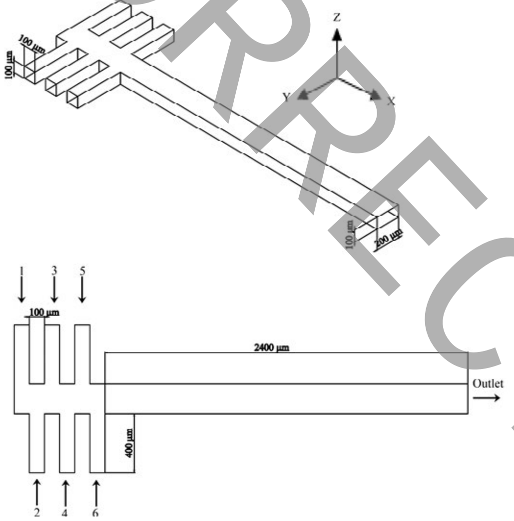

Fig. 2. Schematic of T-shaped micromixer, Geometry No. 1, multiple with non-aligned inputs in one plane

numbers, in flow1. In Comparing the performance of geometries that have aligned inputs for flow 1 which includes geometries No. 3, 4 and 5, the difference between these three geometries is in the number of inputs, geometry No. 3 has a higher mixing rate than the other geometries and geometry No. 4 also shows a higher mixing rate than geometry No. 5 .As shown in Fig. 3. In Re=200 comparing the mixing rate of two geometries No. 2 and 3, geometry No. 2 has higher mixing rate if it is examined in other Reynolds numbers geometry No. 3 has higher mixing rate and this mean that in Re=200 increase in velocity leads to more chaotic advection in geometry in comparison with geometry No. 3.

In fig. 4 comparison the pressure drop for flow type 1 in double and multiple geometries and the only type of flow in geometry No. 5 are given in different Reynolds numbers that the pressure drop directly proportional to the number of inputs and with increase in number of inputs, the pressure drop has increased.

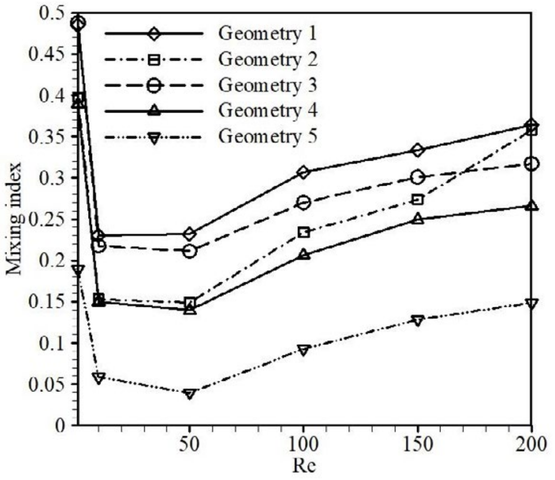

Fig. 3. Comparison of mixing index versus Reynolds numbers at outlet section (Flow 1 in double and multiple geometries)

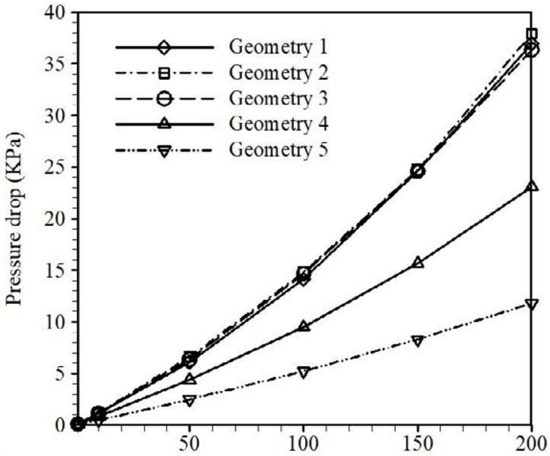

Fig. 4. Comparison of the pressure drop versus Reynolds numbers at the outlet section (Flow 1 in double and multiple geometries)

4. CONCLUSIONS

In this investigation mixing behavior of five geometries in three dimensions for two water and ethanol fluids in a wide range of Reynolds numbers has been implemented. For geometries with 6 inputs, the effect of placement position non-aligned inputs in one plane and non-aligned inputs in two pales, aligned inputs on the rate of mixing has been investigated. The results indicate that in geometries have more than two inputs types of two fluids placement in the inputs is effective in mixing rate.

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