Chapter 3
2D Numerical Study of a Micromixer Based on Blowing and Vortex Shedding Mechanisms

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ABSTRACT

In this chapter, a numerical study and assessment of the mixing efficiency of a novel microfluidic device for mixing two fluids are presented. The device under study consists of a two-dimensional straight microchannel with a square pillar centered across the channel. The main fluid flows through the microchannel from the main inlet to the outlet, while the second fluid is injected through the pillar as two small jets at its upstream corners. For different values of the Reynolds number, intensity ratio between the jets and the main channel stream and jets injection angle, the authors have conducted several numerical simulations to characterize both the mixing efficiency and the required input power to make the fluids flow. The optimum configuration has been revealed for high values of the Reynolds number, low intensity ratios, and high injection angles. Thanks to vortex shedding and the corresponding downstream oscillations, a mixing efficiency of around 90% can be reached. The worst mixing efficiency is obtained for a configuration without vortex shedding, having a mixing efficiency of only around 2%.

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NOMENCLATURE

$C_0$: Molar concentration of solute at channel inlet [mol/m$^3$].
$C_D$: Drag coefficient [-]
$C_L$: Lift coefficient [-]
$D$: Mass diffusion coefficient [m$^2$/s].
$F_x$: Streamwise, horizontal, force [N/m]
$F_y$: Spanwise, vertical, force [N/m]
$H$: Channel width [m].
$I$: Jet intensity ratio [-].
$L$: Channel length [m].
$n$: Number of grid nodes at the channel outlet.
$p$: Pressure [-].
$P$: Input power energy [-].
$Pe$: Péclet number [-].
$\bar{P}_i$: Average static pressure at channel inlet [-].
$\bar{P}_j$: Average static pressure at jet injections [-].
$q_i$: Channel inlet mass flow rate [-].
$q_j$: Jet injection mass flow rate [-].
$Re_i$: Reynolds number at inlet of the channel [-].
$Re_j$: Jet Reynolds number at the injections [-].
$Sc$: Schmidt number [-].
$St$: Strouhal number [-].
$t$: Time [-].
$U_i$: Mean velocity at channel inlet [m/s].
$U_j$: Mean velocity at jet injections [m/s].
$\vec{v}$: Velocity vector [-].
$W$: Side of the inner square pillar [m].
$W_j$: Jet injection width [m].
$Y$: Mass fraction of one fluid [-].
$Y_k$: Mass fraction at outlet $k$-grid cell [-].
$\bar{Y}$: Average mass fraction at the outlet [-].
$\eta$: Mixing efficiency [%].
$\rho$: Density [kg/m$^3$].
$\sigma$: Standard deviation of the mass fraction of one of the fluids [-].
$\sigma_{max}$: Maximum standard deviation in the system [-].
$v$: Kinematic viscosity [m$^2$/s].
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