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ASSESSING MIXING PERFORMANCE OF A STATIC MIXER USING COMPUTATIONAL FLUID DYNAMICS

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ABSTRACT

Static mixers are in-line motionless devices that can be placed into a pipe to promote the blending of miscible fluids or dispersion of immiscible liquids. These inserts are characterized by the mixing performance and the pressure drop they create. New designs of static mixers are continuously proposed to meet certain requirements of the final product. Instead of manufacturing numerous prototypes of different designs and conducting costly experiments to assess the characteristics of the inserts, it is suggested to use computational fluid dynamics (CFD) to visualize and quantify new insert designs. In this study, we demonstrate how CFD can be efficiently used to quantify the mixing performance of a six-element Kenics mixer. A system of two miscible liquids is numerically replicated by considering a single-phase incompressible flow coupled with the solution of a passive scalar equation that replicates the injection of similar fluid with dye in it. A commercial CFD package STAR-CCM+, Siemens PLM was used to perform simulations.

Three-dimensional, transient, incompressible, single-phase, turbulent flow across the Kenics mixer, corresponding to a Reynolds number of 12 000 is analyzed. Three turbulence models are considered: realizable k-ε, EB k- ε and Reynolds stress model. To ensure mesh independence, the problem is simulated on three successively refined structured grids with the finest mesh consisting of 10 million cells. The obtained numerical data agree well with the available experimental data: the deviation of the pressure drop estimate is below 10%. A weak dependence of mixing on the choice of turbulence model is also investigated.

The mixing performance is assessed by evaluating variation in concentration, mixing scales and the cause for their characteristic changes during the process. Novel definitions to quantify spatial or temporal segregation of scalar concentration are proposed to provide deeper insight into mixing. A strong correlation between the location of the passive scalar injection point and the mixing efficiency was also observed, which helped in predicting the injection location that yields the maximum mixing efficiency.