ANN-CFD Modelling

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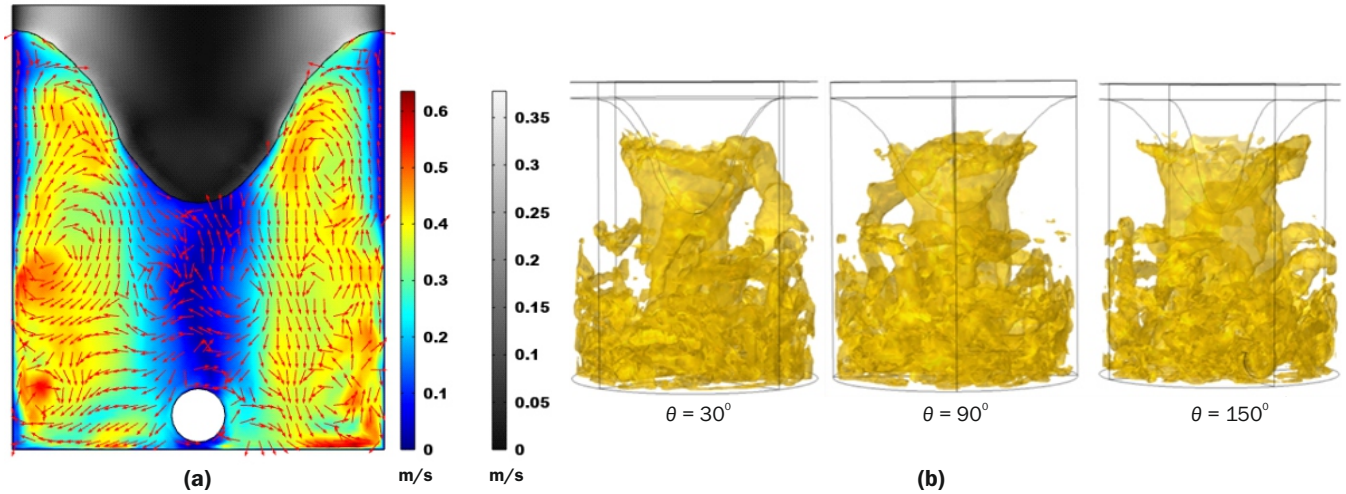
A Novel Computational Model to Simulate Flow in a Vortex Mixer



(a) Profiles of axial velocity magnitude and velocity vectors in a vertical central plane passing through the vortex mixer. (b) Snapshots of Q-criterion iso-surfaces for different angular positions of the stirrer.

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A novel ANN-CFD model for simulating flow in a vortex mixer is presented. Combining ANN and CFD model circumvents the need of computationally expensive interface-tracking simulations required to capture the vortex shape.

Liquid phase mixing is a very basic unit operation which is extensively used in chemical processes. Conventionally, liquid phase mixing is achieved by using impellers. However, for several applications passive mixing devices which do not require maintenance are indispensable. A vortex mixer, which is basically a vessel contents of which are mixed by a magnetic stirrer, is one such device and has several potential applications.

In a recent study (*Sarkar et al., A novel ANN-CFD model for simulating flow in a vortex mixer, Chem. Eng. Sci. 2023, 260: 117819*), a numerical model to simulate flow in a vortex mixer is reported. The presence of vortex makes the simulation of the vortex mixer very challenging and requires a model capable of capturing vortex shape (air-liquid interface). Such interface-tracking simulations are computationally expensive. In this work, a combination of Artificial Neural Network modelling and CFD modelling has been used to circumvent the need of interface-tracking simulations. An ANN is trained and validated using a large set of experimental data of vortex shape acquired using high-speed imaging for different parametric conditions. The trained and validated ANN is used to predict the vortex shape for the cases for which CFD simulations of the vortex mixer are required. The vortex shape predicted by the ANN is incorporated into the computational domain itself, obviating the need of interface-tracking simulations and thereby reducing a two-phase CFD problem to a single-phase CFD problem in which flow fields of the domain representing air and domain representing liquid are solved with appropriate boundary conditions specified at the air-liquid interface. The ANN-CFD model is validated with the reported PIV data. The validated model is used to have detailed insights into the flow physics, including turbulence structures in the vortex mixer.