Best Practice Guidance Seminar

CFD for Dispersed Multi-Phase Flows 2018

Lecture on:

Dilute and concentrated emulsions in agitated systems.

by Jerzy Bałdyga (Warsaw University of Technology, Faculty of Chemical and Process Engineering)

Methods of modeling of dispersion processes applied for manufacturing emulsions by mixing two immiscible liquids in the in-line high-shear rotor-stator mixers are considered in this lecture for diluted and dense emulsions.
In the case of diluted emulsions the RANS model of turbulence is applied in combination with the population balance equation. The population balance is expressed and solved using the quadrature method of moments (QMOM). The breakage kernel for drops whose diameter falls within the inertial subrange of turbulence is defined based on the mutifractal model of intermittent turbulence. Extension of the model to describe breakage of droplets smaller than the Kolmogorov microscale is presented as well. Comparison of model prediction with experimental data is shown for the in-line Silverson rotor stator mixers for 1% wt. silicone oils.
The model is further extended for dense oil-in-water emulsions of non-colloidal droplets to include effects of the droplet size distribution on the rheological behaviour of emulsions. The model includes effects of volume fraction of the dispersed phase, droplet size distribution, interfacial tension and shear rate on the relative emulsion viscosity. The model has universal character and can be combined with the population balance equation and CFD. Examples of modelling are presented for laminar and turbulent flows. In the case of laminar flow the Couette flow, the Taylor-Couette flow and the flow through a chamber are considered. In the case of turbulent flow in the high-shear rotor-stator mixer it is shown how the drop size distribution (effect of drop breakage), the flow pattern and emulsion rheology are interrelated (3-way coupling). Rheology of manufactured emulsions is expressed by the flow curves.
This lecture will thus show how intermittency of turbulence and the drop size dependent emulsion rheology can be coupled using CFD to simulate the process of product formulation.