Scaling up of Silverson rotor-stator mixers

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Abstract

In-line rotor-stator mixers are widely applied in industry for the formulation of a variety of emulsion products, however the current understanding of breakage/coalescence in such devices as well as literature information on their performance is limited. Prediction/control of droplet size as a function of process and formulation variables is important as droplet size strongly affects product performance. Understanding the mechanisms of droplet breakage allows identification of appropriate scale-up parameters to maintain consistent product quality.

Current literature relating to emulsification in in-line rotor-stator mixers is scarce and there are no validated drop size correlations to determine the most appropriate scaling term. One of the reasons for the lack of literature information on the performance of in-line mixers is due to the fact that continuous emulsification experiments using industrial pilot plant scale mixers are inherently difficult and expensive. A second reason is that few manufacturers offer small in-line mixers which may be used at the lab scale.

In this work the effect of scale of in-line MS type Silverson rotor-stator mixers was investigated, with double rotors and double concentric screens of different sizes, but with geometric similarity, shown in Fig. 1.

Fig. 1: Double rotor (left) and standard emulsor double screens (right) for the 150/250 MS Silverson

The large mixer is a 150/250 MS (outer and inner rotor diameters, 63.5 and 38.1 mm respectively; rotor-stator gap, 0.229 mm)) offered by Silverson in the catalogue as a pilot plant device whereas the smaller mixer, a 088/150 MS (outer and inner rotor diameters, 38.1 and 22.4 mm) was purposely designed and built for this research.

In both mixers silicone oils with viscosities of 9.4 and 339 mPas at a volume fraction of 1% were emulsified in water containing sodium laureth sulfate. The effect of rotor speed, total flow rate and viscosity of the dispersed phase on drop size distributions and average drop size has been investigated. The Sauter mean diameter was correlated with tip speed, mechanical energy dissipation rate, total energy dissipation and Weber number. It has been found that tip speed is the most appropriate scaling parameter for in-line rotor-stator mixers for low to intermediate dispersed phase viscosities.