Application Example: Optimization of Droplet Dispersion

Motivation

The interfacial surface area in liquid-liquid dispersions controls the mass transfer between phases. The surface area is determined by the droplet size of the dispersed phase. Various impeller and baffle designs and mixing speeds can be used to optimize droplet size.

Measurements

Test measurements were conducted to demonstrate the applicability and performance of the Pixact Droplet Monitoring (PDM) system to analyze the droplet size distribution in a mixing reactor. The expected droplet size ranges from 10 µm to 2 mm. The measurements were carried out in a 1L laboratory reactor equipped with a speed-controlled mixer. The impeller is a standard two-baffle propeller. The example dispersion consists of organic solvent (50 %) and water (50 %).

Results

The images of the droplets were acquired with a Pixscope imaging unit installed on the inlet port located on the side of the reactor. An example image of the dispersion captured by the measurement system is presented in Figure 1. The PDM system produces sharp high-contrast images of the droplets. The images are analyzed in real time by the Pixact software to detect each droplet and calculate their diameter. Typically, dozens or hundreds of droplets are detected in each image. Figure 2 shows an example image with the detected droplets encircled with red outlines.

The analysis is also able to distinguish gas bubbles from liquid droplets based on the differences in their refractive indices. The gas bubbles are then excluded from the analysis. Figure 3 presents the droplet size distribution at two agitation speeds: 300 and 400 rpm. The Sauter and volumetric mean diameters are 500 and 540 µm for 300 rpm and 380 and 410 µm for 400 rpm.

The PDM system has been shown to be a powerful tool for the diagnostics, optimization, control and troubleshooting of emulsion processes.

Benefits

The information on droplet size distribution can be used to select an optimal impeller design and mixing speed for the production-scale process. In production scale, PDM can be used to adjust droplet size distribution by controlling mixer speed, surfactant dosage and the component feed to the reactor.

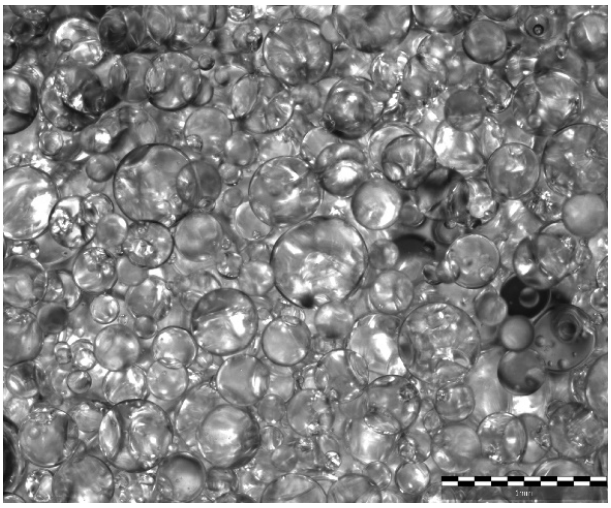

Figure 1. Example image of droplet dispersion

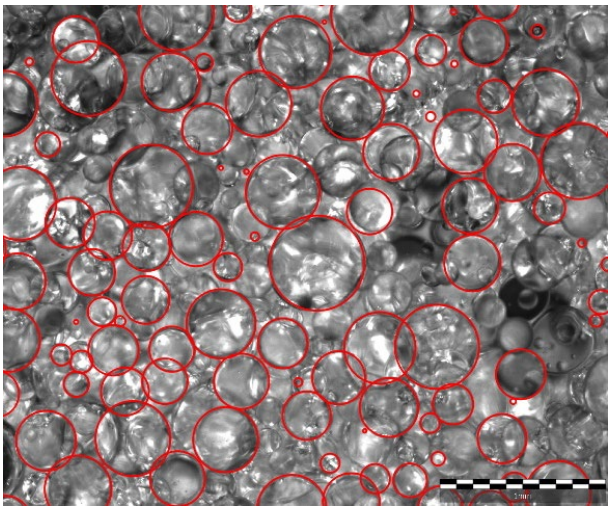

Figure 2. Droplet detections

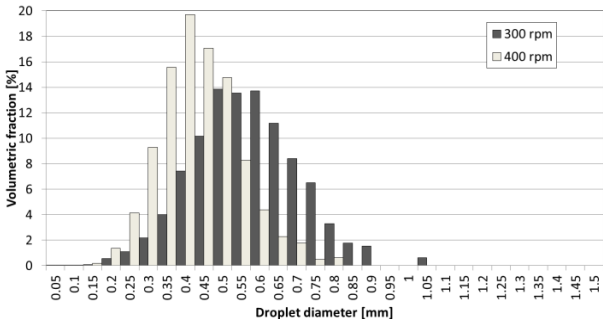

Figure 3. Droplet size distribution measured at two mixing speeds

Technical implementation

The PDM system is based on a Pixscope 32-100 imaging unit installed on a DN40p inlet of a 1L laboratory reactor. The droplet dispersion is imaged in the gap near the tip of the probe. The same measurement system can also be used in pilot-scale and production-scale reactors. A picture of the imaging unit is presented in Figure 4.

A picture of the measurement system in action is presented in Figure 5. The probe enters the dispersion just above the impeller level.

A summary of the specifications of the measurement system is presented in the table below.

Probe head	Pixscope 32-130 /DN40p
Material	Stainless steel AISI316L
Setup	Transillumination
Process interface	Sapphire window
Sealing	EPDM
Imaging resolution	3.4 µm/pix
Image area	8.8 mm x 6.5 mm
Optimal measurement range	20-1000 µm

Figure 4. Pixscope DN40p probe

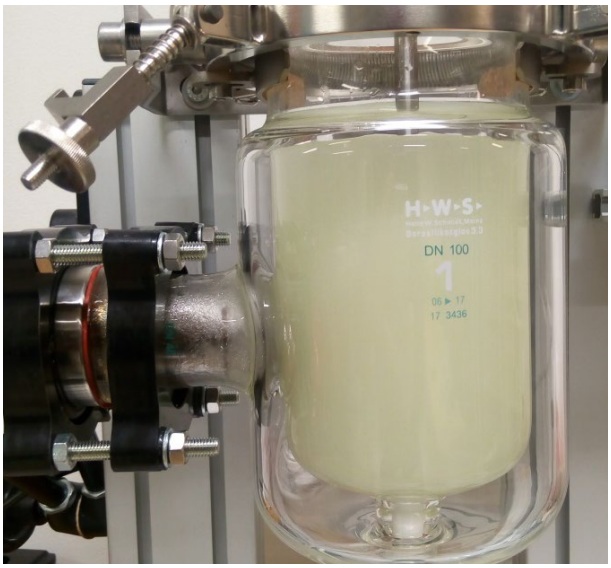

Figure 5. Droplet dispersion in a 1-liter laboratory reactor