Coalescence in a naturally stabilized liquid-liquid-solid dispersion: balancing rapid demulsifier dispersion with minimum drop breakup

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Abstract

This work explores the effects of mixing in a naturally stabilized water-in-oil system, specifically with respect to demulsifier dispersion and subsequent water drop coalescence in a mixer-settler stage of the oil sands extraction process. It is hypothesized that there are essentially two mixing steps relevant to the addition of demulsifier to the diluted bitumen. First, the demulsifier must be dispersed in order to counteract the effects of ashphaltenes and fine clays, which are both naturally occurring stabilizers. The second step involves maximizing drop coalescence while minimizing drop breakup through tight control of mixing parameters. Given that these two steps occur simultaneously, the mixing conditions must achieve adequate dispersion of the demulsifier while minimizing drop breakup in the system.

The concentrations of water, fines and bitumen in the final supernatent product are the variables which determine product quality. Prior to addition of demulsifier the dispersion is dilute, containing <5% by volume of water and naturally occurring surfactants in diluted bitumen. A dilute solution containing varying concentrations of demulsifier is injected above the impeller and the contents are stirred for varying amounts of time, at varying mixing intensity. The product is then allowed to settle for 1h in graduated cylinders. The supernatant product water content is measured using Karl-Fisher titration and the bitumen and solids content are evaluated using Dean-Stark OWS analysis. A three level factorial design is used to determine the relative effects of each variable and evaluate potential interactions and non-linear effects in the system. The drop size distribution of the dispersed phase is measured prior to demulsifier injection, immediately after mixing, and following 1h of batch gravity settling. The drop sizes are evaluated using microscopy and an adequately large sample of drop size measurements is used to construct the drop size distributions.

The results of this study provide the groundwork for a more rigorous exploration of pertinent variables, including a detailed study of the kinetics of the evolution of the drop size distribution with particular attention to drop coalescence.