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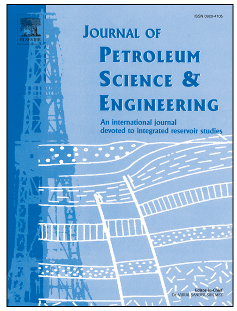

Oil-water dispersion formation, development and stability studied in a wheel-shaped flow loop

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Abstract

The work describes how a quasi-endless wheel flow loop can be used to study dispersion formation, development and stability at different pressures and temperatures. The so-called Wheel Flow Loop consists of a wheel-shaped closed pipe section that can be filled with gas, oil and water. By rotating the device in vertical orientation, a gravity driven flow is initiated. Several different flow conditions were simulated by varying the rotational speed. Onset of dispersion and the stability of emulsions formed was identified by interpreting torque profiles supported by visual observations. Two fluid systems, a realistic fluid system consisting of a light crude oil, synthetic natural gas and brine, and a model system consisting of a mineral oil, tap water and nitrogen as gas phase were investigated. Furthermore, the effect of temperature, pressure and water cut on dispersion properties was demonstrated. The sensitivity of the results indicated that the wheel qualifies as a characterization tool for dispersion properties. Furthermore, agreement in dispersion behaviour was found when straight pipe flow experiments were compared with the wheel matching the energy dissipation rate.

1. Introduction

Water is often co-produced during oil production, originating from formation water, water flooding or reinjection for pressure support. Although immiscible, oil and water can be dispersed as droplets of one phase in the other. Such dispersions can be formed during all stages of production like in the reservoir, production lines, in high shear pumps and valves. Factors affecting the dispersion process include relative phase fractions, interfacial tension, viscosity and shear rates. Moreover, interfacial active molecules and solids may play an important role in stabilizing dispersions, leading to what is defined as emulsions. Aged and stabilized emulsions may further affect break-up, coalescence and rheology of the droplets in the fluid system produced.

Dispersions are, during oil production, often deemed as unfavourable as they increase the effective viscosity of the fluid system resulting in increased pressure drop. Furthermore, emulsions lead to oil-water separation challenges. However, in some cases, like for highly viscous oils, pressure drop reductions can be achieved by dispersing the oil in water (Yang, Velthuis et al. 2013) leading to a mixture viscosity closer to water than oil. Oil continuous dispersions can be preferable as effective measures against corrosion keeping the steel pipe oil wetted during production.

However, correctly predicting dispersion behaviour in the production system is a challenge. Reliable dispersion models are not yet available for commercial flow simulators. This results in rather high uncertainties in predictions of the pressure drop. Experiments may be performed to provide detailed information about dispersion properties then used as input for simulations and further development of models. Previous experimental studies compared separated and dispersed flow at otherwise similar conditions, where inlet mixing was used to create dispersed flow (Angeli 1996, Soleimani 1999, Schümann, Tutkun et al. 2016). The results from these studies showed possible increases in the pressure gradient by up to factor three. This demonstrates the importance of correctly measuring, understanding and ultimately predicting dispersed flow behaviour.