Estimation of Unmeasured Oil and Water Purities for a Continuous Subsea Gravity Separator

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Controlling the quality of outlet streams in subsea oil-water gravity separators is currently difficult, because existing subsea sensors for oil and water purity are not sufficiently accurate. We address this issue by developing a dynamic model for a gravity separator that is used to predict and estimate the concentration of outgoing streams. We consider that the fluids inside the separator separate into layers of water, emulsion and oil, where the emulsion layer consists of two sections: sedimentation layer and dense-packed layer. The separator includes a weir that prevents the emulsion and the water from flowing over the weir leaving only oil to flow over the weir to the oil outlet section. The removal of the water takes place from the bottom of the separator from the water outlet.

Frising reviewed batch gravity separation models reported in the literature in [1] and classified them into sedimentation-based models and coalescence-based models. Sedimentation based models [2-6] are based on interfacial coalescence between droplets and interface, and sedimentation of droplets; whereas the coalescence based models [7,8] focus on binary as well as interfacial coalescence of the droplets of the dispersed phase. Sayda *et al.* [9] developed a model for a continuous gravity separation, however, their model ignores coalescence effects. A model for a horizontal pipe separator for continuous oil-water separation described in [10], combines principles from a sedimentation based model [11] and a coalescence-based model by Henschke [8]. Pipe separators, however, differ from gravity separators as gravity separators are not completely filled with liquids and often are designed with a weir.

Our model predicts oil content in outgoing oil and water streams based on lumped total and partial mass balances for each layer, including principles from sedimentation based models and Henschke's model for inter-layer mass transfer terms. It captures the effect of total inlet flow rate, inlet oil cut, and inlet droplet size on purities of outlet streams and thickness of each layer. We use the model in a Kalman-based non-linear estimator for estimating unmeasured variables, such as oil and water purities using level and density measurements.

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