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UNIFIED MODEL FOR PREDICTING FLOW PATTERNS AND PRESSURE GRADIENT IN HORIZONTAL OIL-WATER FLOW

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Abstract

The thesis presents theoretical investigations on flow behaviors for oil-water flow in horizontal pipes. It aims to develop a model that predicts the flow patterns and pressure gradient. The investigation is started by evaluating some of the available pressure gradient models against 10 pressure gradient data sources. Superficial oil velocity (Uso), superficial water velocity (Usw), and pressure gradient measurements corresponding to 774 experimental points collected from the open literature for oil-water flow in horizontal pipes are used for the evaluation. The collected database covers wide range conditions, pipe diameters and oil viscosities. Pressure gradient is normally predicted using flow pattern based models. These models (ex: two-fluid model) either assume full separation between the two liquid phases occupying the top and the bottom of the pipe respectively which is the case of stratified flow or assume uniform cross sectional distribution between the two phases (homogenous model) which is the case in dispersed flow. In this study, the performance of the two-fluid model and Al-Wahaibi correlation are evaluated for separated flow while the performance of the homogenous model is examined using different mixture viscosity correlations for dispersed flow. The prediction of the pressure gradient using the two-fluid model gives better results than Al-Wahaibi (2012) correlation for stratified flow while Al-Wahaibi correlation seems to have better agreement with dual continuous flow. For dispersed flow using the homogenous model, the best agreement with the data is obtained when Dukler (1964) mixture viscosity correlation was used.

Dual continuous pattern, where both phases retain their continuity at the top and bottom of the pipe respectively and drops of one phase appear into the continuum of the other, is common for a wide range of mixture velocities and phase fractions especially with low viscosity oils. However, two-fluid model cannot be directly used to predict the pressure gradient in the dual continuous regime as it contains features from both stratified and dispersed flow patterns. A new model is developed to predict the pressure gradient in dual continuous oil-water flow. The model takes into account the amount of entrainment that dispersed into the continuum of the other phase. Therefore, the two-fluid model is modified to account for the entrained drops of each phase and dispersed in the continuum of the other phase (entrained fraction). The entrained fractions are calculated using Al-Wahaibi and Angeli (2009) model. The prediction agreed reasonably well with the experimental pressure gradient data obtained from a number of studies for dual continuous flow.

Finally a new methodology is developed based on Al-Wahaibi and Angeli (2009) equations of entrained fractions to predict the flow patterns and pressure gradients in horizontal oil-water pipes. The performance of the model is tested against several experimental data. The model was able to predict reasonably well the flow patterns and pressure gradient.