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Two phase flow in a wavy core-annular configuration through a vertical pipe: Analytical model for pressure drop in upward flow

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A B S T R A C T

The vertical core-annular flow of two immiscible fluids with very different viscosities provides an attractive and low cost method for heavy and extra heavy crude oils lifting in vertical wells using water as a lubricant. Since the pressure gradient are balanced by wall-shear stresses in the water, the correspondent pressure drop is comparable to the flow of water only in the same pipe at the total volumetric flow rate since the oil tends to occupy the center of the tube and it does not come in contact with the pipe wall. Assuming that in this axisymmetric wavy flow the fluid in the center is much thicker than the annulus, a differential equation governing the velocity profile and then pressure gradient in the annulus is derived by using scaling analysis. An analytical solution is proposed for the prediction of the frictional pressure drop, which depends only on pipe geometry, physical properties and flow rates of the fluids. The comparison between the model predictions and recent experimental data shows a good agreement and great enhancement from "perfect core annular flow" model (PCAF). In the PCAF model the two Newtonian immiscible fluids flow axially inside a vertical pipe in a concentric configuration with a smooth circular interface.

Keywords: wavy core-annular flow; core flow; vertical upward flow; axisymmetric flow; frictional pressure drop; analytical solution.

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