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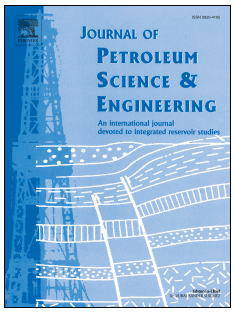

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RHEOLOGICAL STUDY OF TWO- AND THREE-PHASE HIGHLY VISCOUS FLUID FLOW IN PIPELINES

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Abstract

The study of highly viscous multiphase flow systems is of fundamental interest in the oil industry. Most of the Venezuelan oil fields produce heavy oil with other production fluids, such as water and gas, and sand particles flowing from the reservoir to the surface facilities. A fraction of these phases flows fully separated, while another one flows as a dispersed system composed by water/oil emulsion with gas bubbles dispersed as a foamed emulsion. With the objective to understand and characterize this latter complex system, new experiments have been performed in 0.0243-m and 0.0508-m horizontal pipelines, for air/highly-viscous oil of 0.430 Pa.s at 20°C, and water/air/oil mixture with a water-in-oil emulsion of 0.560 Pa.s at 20°C. The three-phase flow pressure gradient was found to be approximately 15% higher than for the two-phase system, at similar gas and liquid superficial velocities. The air/oil and air/oil/water foamed emulsion behaved as non-Newtonian fluids, when these are considered as pseudo-homogeneous systems.

A model to predict the flow pattern and pressure drop in horizontal pipelines was developed with an extensive database of 2167 experimental points, including new data and information collected and processed from different sources. A performance factor of 0.41 for Brito's three-phase (TM) model was consistently better than the performance factor obtained for other models commonly used by the oil and gas industry in similar multiphase flow systems.

Keywords: foam rheology, foamed emulsion, two-phase flow, three-phase flow, flow patterns, pressure drop model.

1. INTRODUCTION

In heavy oil production fields, *the transport of production fluids, i.e., oil, water and gas, commonly occurs as a "foamed emulsion" flow* (i.e., a water-in-oil emulsion with dispersed gas flowing as a foam). In Venezuela, the highly viscous oil and high volumes of gas and water produced impose technical challenges to handle these multiphase flow systems through pipelines.

Some flow characteristics such as the presence of slugging or stratified flow in pipes, and emulsion stability and foamability of heavy oils, can induce operational problems. In addition, corrosion and high pressures drop could occur, causing poor fluids separations. This may result in oils out of specifications, gas carried under and liquid carried over in the first separation