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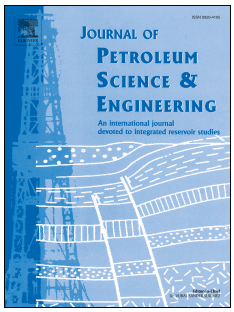

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Muili F. Fakoya, Ramadan M. Ahmed

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A Generalized Model for Apparent Viscosity of Oil-Based Muds

Muili F. Fakoya and Ramadan M. Ahmed, The University of Oklahoma, USA

Abstract

Oil-based drilling fluid, typically called oil-based mud (OBM), is an invert emulsion that finds application in drilling operations owing to its outstanding performance, especially in high pressure and high temperature (HPHT) wells. Besides, OBM promotes a better lubricity, ensures wellbore stability, increases the rate of penetration, and facilitates the achievement of low fluid loss and a thin filter-cake. Due to environmental concerns, the use of low-toxicity mineral oils as the base fluid or continuous phase for OBM is preferable. The flow behavior of OBM mainly depends on rheological properties of its continuous phase, and the volume fraction of the dispersed phase. Besides this, other imposed conditions like shear rate and temperature play a significant role. The availability of rheological models that show this connection is necessary for predicting rheology of OBM based on its formulation and borehole condition.

This work presents an experimental investigation of the apparent viscosity of OBM within a temperature range of 24 – 87^{o}C. The continuous phase was prepared with mineral oil, surfactants (emulsifier and wetting agent), organophilic clay, lime, and calcium chloride. Organophilic clay concentrations and oil/water ratio (OWR) were varied. Apparent viscosity measurements are gathered and analyzed. OBM displayed shear-thinning behavior that best fits the Herschel-Bulkley model. The results reveal notable trends of apparent viscosity and rheological parameters with increasing temperature, organophilic clay concentration, and OWR. Generalized empirical models that link the apparent viscosity of the continuous phase to that of OBM are developed by applying nonlinear regression analysis. The prediction of OBM rheological parameters requires the knowledge of continuous phase apparent viscosity at ambient temperature, dispersed phase volume fraction, and temperature. The models give a reasonable prediction of OBM apparent viscosity. The comparison of normalized or reduced rheological parameters and apparent viscosity of OBM and water-based mud (WBM) revealed the sensitivity of viscous properties of OBM to temperature as compared to that of WBM. This revelation shows why OBM is more susceptible to barite sag phenomenon than WBM.

Keywords: Invert-emulsion mud; shear thinning; temperature; oil-water ratio; clay content; apparent viscosity

1. Introduction

Emulsions are colloidal systems formed when two immiscible fluids are mixed (Jha et al., 2014). They find applications in the pharmaceutical, food, cosmetic, paint, oil and gas industry. Emulsions are categorized into oil-in-water (O/W) and water-in-oil (W/O) emulsions respectively. In O/W emulsions, the oil is the