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Study of the PVT Properties of Gas—Synthetic Drilling Fluid Mixtures Applied to Well Control

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Abstract

The study of the interaction between the formation gas and the drilling fluid during offshore operations as well as in HPHT environment is essential to safely and economically drill the pay zone of the well. The environmental regulatory issues and the peculiar technical aspects involved in deep and ultradeep waters require low toxicity synthetic drilling fluids. The main objective of this study was to understand the PVT behavior of those fluids by the experimental determination and modeling of thermodynamic properties such as: solubility, specific gravity and formation volume factor of the fluid. Those properties have a direct impact on kick detection and circulation out of the well and should be addressed in well control planning and execution. The experimental work was conducted in a PVT lab, using mixtures of methane and n paraffin based emulsions as unweighted drilling fluids, tested at the temperatures of 158, 194 and 302^{o} F. The pressure, temperature and fluid composition effects on those gas-liquid properties were analyzed and the experimental data for solubility and formation volume factor compared to predictions considering the additivity hypothesis and mathematical fittings based on the experimental data. A model for the methane and n paraffin system based on literature data and Peng-Robinson equation of state has also been fitted to the data in order to discuss the application of the additivity hypothesis for the emulsions. Pit gain evaluation based on the correlated experimental data for the synthetic drilling fluid has been performed and compared to the values expected for water based muds.

Introduction

One of the greatest challenges for the complex oil and gas exploration and exploitation scenarios such as deep waters and HPHT wells, is related to the drilling fluids, which must combine the technical requirements with the environmental regulatory issues. Synthetic based drilling fluids have been developed to provide the technical performance of the conventional oil based muds without their environmental damage, reducing the impact of cuttings discharge or eventual spill accidents. Among the synthetic oils available for drilling fluids, n paraffin is the most commonly used in Brazil and around the world.

An important aspect that should be addressed when drilling with a synthetic fluid is the peculiarities concerned with well control. Because of the solubility of formation gas in oil based fluids, it could be completely dissolved in the mud at bottomhole temperature and pressure conditions making kick detection very difficult. **Fig. 1** illustrates the difference between gas kick circulation in a water based mud, with the gas represented as a free phase, and in an oil based mud, with the gas initially dissolved and than being liberated as dispersed bubbles. Depending on the PVT behavior of the gas-oil mixture, the amount of gas in the well could be underestimated and the well control procedures affected. In the worst situation, an uncontrolled kick can turn into a blowout with all the inherent financial and environmental damage and possible casualties.

The study of the PVT properties of the synthetic fluids is essential for the complete knowledge of the gas-liquid mixture behavior in a kick situation. This includes the experimental determination and modeling of properties such as bubble pressure, gas solubility, formation volume factor and density of the gas-oil mixture. These properties can lead to the computation of the amount of dissolved gas in the mud and at which depth the gas influx would come out of solution. The thermodynamic model can also be applied to well control computer simulators for personnel training and study of the best procedures to reduce the associated problems and risks. It is important to emphasize that the thermodynamic properties and modeling are inherent of each formation and drilling fluid pair that will be in contact during the well control situation.

Considering the importance of the subject, the main objective of this work is to present experimental PVT data for methane - n paraffin based drilling fluid mixtures and models to predict their PVT behavior, considering both the additivity hypothesis and mathematical fittings based on the experimental data. The developed correlations were applied to illustrate pit gain