

Study on Polyvinyl Alcohol as Water-Based Drilling Mud Additive for Wellbore Isolation Strengthening and Reservoir Protection

ポウンギ, ダニエル

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氏 名 : Danielle POUNGUI (ダニエル ポウンギ)

論 文 名 : Study on Polyvinyl Alcohol as Water-Based Drilling Mud Additive for Wellbore Isolation Strengthening and Reservoir Protection (地層間隔離および貯留層保護のための水系掘削泥水添加剤としてのポリビニルアルコールに関する研究)

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論 文 内 容 の 要 旨

Drilling Mud is a viscous material used in drilling activity to facilitate the drilling process and isolate the wellbore from the surrounding formation. Adapting drilling mud design to meet the specific targeted formation conditions drives a meticulous selection of swelling clays, weighting materials, base fluid, and other additives that typically constitute the composition of the mud. However, the desired performance of the said designed mud is not always attained due to the unpredictability of formation conditions and the complexity of the drilling process, especially drilling wells increasing in depth, therefore challenging the drilling mud to higher temperatures and pressure (HTHP) conditions. One of the primal drilling mud features is the swelling index, which hosts equally important rheological parameters and naturally induced functions of the drilling mud. The vital function highlighted for this doctoral thesis is the drilling mud naturally induced phase separation (cake filtration), which provides a direct solid-liquid ratio quantitative assessment of the drilling mud. Moreover, Cake filtration ensures the protection of the borehole wall and the prevention of major drilling complications (Kicks, Blowout, etc.). In drilling mud optimization, Polyvinyl Alcohol (PVOH) is rising in interest as a potential weighting additive reported to show promising swelling ability via its hydrogel properties. Previous studies reported that water-based drilling mud significantly increases mud swelling compared with conventional drilling mud without PVOH.

This doctoral thesis proposes a water-based drilling formulation containing PVOH and examines the effectiveness of the PVOH-enhanced drilling mud through laboratory experiments. This study investigated the effectiveness of PVOH on rheological properties and well isolation. The affinity of PVOH to bentonite and an impact of the mud swelling mechanism through various experiments. The doctoral thesis consists of five chapters laid out as follows:

Chapter 1 explains the evolution of drilling mud in the oil and gas industry and describes its applicability in drilling operations. This chapter then highlights the functions of drilling mud and their practicality. The importance of mud balance in mud physicochemical properties and cake filtration and its implications for well isolation are discussed in this chapter. The final section of this chapter presents the limitations of those methods and introduces the consideration of chemicals as an effective potential cake filtration control, which is detailed in the following chapter.

Chapter 2 is a literature review of established filtration control polymers, including xanthum gum, polyanionic cellulose polymer, and betaine-type copolymer. Their proven influence on mud cake filtration is followed by a list of the limitations of each polymer. PVOH is then introduced and its promising influence

on mud balance and cake filtration is described based on its mechanical virtues and physicochemical properties. Recent research related to PVOH monitoring drilling mud was presented, showing the advantages of PVOH, the lenition that this doctoral thesis aims to address. The last section of this chapter shows the doctoral thesis construction and explains the objectives of this doctoral thesis based on the literature review.

Chapter 3 explains the experiments using the two basic materials: Bentonite and PVOH. Three types of PVOHs were investigated: Conventional polymer, nonionic polymer, and cationic polymer. The base fluids of the samples were prepared using a high speed homogenizer prior to the addition of bentonite to produce the slurries to be studied. Rheological tests according to American Petroleum Institute standards were performed as preliminary experiments. The effect of PVOH on drilling mud was evaluated by static cake filtration at ambient temperature. After static filtration, experiments revealing the mud swelling mechanism of the samples were carried out by measuring the polymer adsorption using UV spectroscopic reading at 450 nm wavelength. Through the experimental results and the adsorption model analysis, the solid-liquid equilibrium was selected as the best fit to describe the affinity of PVOH and bentonite particles.

Chapter 4 aims to investigate the thermal stability of PVOH enhanced drilling mud. The same experiments as above were performed at 25, 55 and 85°C. The experimental results show that both values decrease monotonically with increasing temperature, regardless of PVOH addition or concentration. A 30°C increase in temperature decreases the mud viscosity of WBM (without PVOH) by an average of 18% from its initial value. As little as 0.1% cationic and non-ionic polymers reduce viscosity by 10% and 0%, respectively. Experiments on 5-hour slurry samples showed that the addition of nonionic polymers improved slurry filtration by up to 34.7%, 1.25 times more than cationic polymers under the same filtration conditions. Increasing the filtration temperature moderately affects mud cake formation due to increased mud swelling index and preferential adsorption by the nonionic polymer. Thermogravimetric analysis of the filtrate of non-ionic and cationic show negligible similarities, although the base fluid with 0.28% cationic PVOH shows an onset of decomposition 5°C degrees lower than deionized water. The observed result led to the conclusion that PVOH appears to cause a significant downward shift in the thermal stability of the solutions compared to deionized water. Since water is made up of stronger and more stable bonds, the addition of PVOH causes these bonds to break down, weakening the stability of the solutions.

Chapter 5 presents some concluding remarks of the present study. As a final note, some plausible directions for future work are also provided.