



SPE 110638

An Innovative Manganese Tetra-Oxide/KCl Water-Based Drill-in Fluids for HT/HP Wells

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This paper was prepared for presentation at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11–14 November 2007.

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Abstract

Drilling Unayzah-B gas reservoir (shale and sandstone) in Saudi Arabia requires high mud density (± 95 pcf). To formulate this mud, calcium carbonate particles were used, because of their high acid solubility. However, when drilling the 5-7/8 inch hole, sticking occurred, which resulted in expensive fishing and/or sidetrack operations. To minimize these problems, barite was added with CaCO_3 to reduce the amount of solids needed to formulate the drill-in fluid. However, barite is acid in-soluble and may cause formation damage. Formate drill-in fluids with low CaCO_3 content were used to drill some wells in this reservoir, however these fluids are expensive and corrosive if their high pH values were not maintained in the field.

Saudi Aramco has developed drill-in fluids that are based on manganese tetra oxide particles to drill deep gas reservoirs. The properties of these ($D_{50} = 1$ micron), spherical shape, and high specific gravity (4.8 g/cm^3) make them good weighting material compared to CaCO_3 (2.78 g/cm^3 and $D_{50} = 10$ micron) and BaSO_4 (4.25 g/cm^3 and $D_{50} = 20$ micron).

The main objective of this study is to discuss lab work that was performed to design water-based drill-in fluids using $\text{KCl/Mn}_3\text{O}_4$ at 95 pcf. A second objective is to compare the properties of the new fluid with two typical fluids that are currently used to drill Unayzah-B reservoir. The first fluid is $\text{KCl/BaSO}_4/\text{CaCO}_3$ and the second one is potassium formate/ CaCO_3 . The experimental work included measuring the rheological properties, thermal stability, API and HT/HP filtration of the three drill-in fluids.

The results obtained showed that several polymers can be used to design $\text{KCl/Mn}_3\text{O}_4$ –drill-in fluids. The developed fluid had better thermal stability and filtration control compared to the drilling fluids that are currently used. This paper will discuss the results obtained and will demonstrate that the new fluid can save time and cost of drilling deep wells.

Introduction

Designing of drilling fluids for deep wells is challenging. Therefore, it has been the topic of many research studies. McCaskill and Bradford¹ mentioned the factors that we need to consider when designing drill-in fluids. For example, formation permeability determines filtration characteristics. Temperature or water-sensitive formation determines the type of polymer and type of drill-in fluids needed. The authors also suggested that there are goals in designing drill-in fluids that we need to consider such as rheological properties to provide good carrying capacity and minimum filtration control loss.

Carico and Bagshaw² showed how different polymers are used for filtration control, viscosity modification and shale stabilization. There are different types of polymers that can impact the rheological properties and filtration of drilling muds. Some polymers lose viscosity at high temperatures because of their degradation and instability at harsh conditions such as xanthan gum and starch. Some polymers are not effective in salt solutions because salt inhibits hydration of polymers affecting their functions. Polymer compatibility with drill-in fluids is important to achieve good suspension, rheology and filtration control to ensure good hole cleaning and less formation damage.

Abrams³ explained how designing drill-in fluids depends heavily on the selection of a suitable size of weighting materials that will work as bridging materials. Once the solids invade the formation, they cannot be removed by natural flow. Abram stated that “the medium particle size of the bridging material should be equal to or slightly greater than 1/3 the median pore size of the formation.” He also suggested using bridging materials at least 5 vol% of solids in the fluid.

Ezzat⁴ showed the requirements for water-based drill-in fluids for horizontal wells such as physical stability, cutting transport, lubricity and formation damage control. The hydrostatic pressure of the drill-in fluids must be high enough to control the formation pressure, but not too high to avoid fracturing the formation and losing circulation. Using bridging materials is important to minimize filtrate invasion, mitigate fines migration and improve hole stability. In deviated wells, cutting accumulation and settling while drill-in fluids are in static motion is a major concern. The drill-in fluids should have good rheological properties to prevent solids and cuttings settling. The author also stressed the importance of conducting core flood testing to evaluate formation damage at reservoir temperature and pressure.

Howard⁵ mentioned that the formate salts of the alkali metals are soluble in water and can form high density fluids.