Effect of Ferric Oxide Nanoparticles on the Properties of Filter Cake Formed by Calcium Bentonite-Based Drilling Muds

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Abstract

During the past few decades, nanoparticles (NPs) have been investigated as additives to address the challenges of drilling fluids and have shown potential for application. The present work focuses on introducing and investigating a calcium (Ca) bentonite-based drilling fluid with ferric oxide (Fe2O3) NPs.

Generating efficient filter cake is an important property of the drilling fluid and can affect the success of the whole drilling operation. This study aims at characterizing the filter cake produced by Ca bentonite-based drilling fluid modified using Fe2O3 NPs. Computed-tomography (CT) scan and scanning electron microscopy energy dispersive spectroscopy (SEM-EDS) were used for filter-cake characterization. The effects of NP concentration and filtration conditions on the filter-cake properties were investigated. A high-pressure/high-temperature (HP/HT) American Petroleum Institute (API) filter press was used to perform static and dynamic filtrations. Indiana limestone disks were used as filter media to simulate formation behavior.

The modified Fe2O3 NPs/Ca bentonite fluid showed improved filter-cake and filtration properties in the presence of polymers and other additives. A concentration of less than 1 wt% of NPs is preferred for generating a good-quality filter cake. The best characteristics were obtained when using an NP concentration of 0.3 to 0.5 wt %. The NPs/Ca bentonite-based drilling fluid can withstand conditions up to 500 psi and 350ÁF and generate filter-cake properties of 0.151-in. thickness, 6.9-cm3/30-min filtrate volume, and 0.449-md permeability. Fe2O3 NPs improved the filter-cake properties under both static and dynamic conditions. SEM-EDS showed a smoother/less-porous filter-cake morphology with less agglomeration when using NPs at optimal concentrations, which confirms that the NPs play a key role in forming a better filter-cake structure.

The present work provides an experimental evaluation of the filter cake generated by modified NPs/Ca bentonite-based drilling fluid at downhole conditions, which is an extension of our previous work using a simple NPs/Ca bentonite suspension (Mahmoud et al. 2018). The improved properties of the filter cake confirmed the effectiveness of using Ca bentonite modified with Fe2O3 NPs to formulate a drilling fluid that can effectively be used for drilling practices.

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