Using Ferric Oxide and Silica Nanoparticles To Develop Modified Calcium Bentonite Drilling Fluids

Omar Mahmoud , Hisham A Nasr-El-Din, Zisis Vryzas, Vassilios C Kelessidis

Abstract

One of the important functions of drilling fluids is to form a filter cake, which minimizes leakoff of drilling fluids into the formation. Drilling-fluid invasion can cause formation damage, but good-quality filter cake can reduce such damage. This research focuses on the laboratory techniques and performance results of testing innovative calcium-bentonite-based drilling fluids containing nanoparticles (NPs) for minimizing formation damage during drilling in harsh environments.

A rotational viscometer was used to measure the rheological properties of the tested fluids. Zeta-potential measurements were conducted at different NP concentrations to assess their stability and to investigate the role of charge potential. Indiana limestone outcrop disks were examined as the filter media for both static and dynamic filtration (up to 350ÁF and 500 psi) using a filter press. The filter cakes were examined using a computed-tomography (CT) scan and scanning-electron-microscopy energy-dispersive spectroscopy (SEM-EDS). Inductively coupled plasma optical-emission spectrometry (ICP-OES) was used to measure the concentrations of key ions in the filtrate fluids.

A reduction of 43% in the filtrate-fluid volume was achieved when adding 0.5 wt% of ferric oxide NPs compared with that of the base fluid. However, using silica NPs led to an increase in the filtrate volume and filter-cake thickness. Using 0.5 wt% of ferric oxide NPs provided less agglomeration and reduced the filter-cake permeability. In addition, the SEM-EDS and ICP-OES analysis showed a replacement of the cations dissociated from the bentonite by NPs, which promoted the formation of a rigid clay-platelet structure. The produced filter cakes consisted of two layers, as indicated by the CT-scan analysis. Increasing the concentration of NPs resulted in an increase in the fluid loss and filter-cake thickness. At a higher NP concentration (2.5 wt%), a third layer of NPs was observed, which adversely affected the filter-cake characteristics, as demonstrated by CT-scan analysis and SEM-EDS elemental mapping. Furthermore, the NP-bentonite fluids had stable rheological properties at different temperatures (up to 200ÁF) and NP concentrations. In addition, aging these fluids at 350ÁF for 16 hours showed minor changes in the rheological properties.

This research work provides an experimental evaluation of improved calcium-bentonite-based fluids using NPs under downhole conditions. The ferric oxide NPs have the potential to enhance the properties of calcium bentonite, as a low-cost alternative, to perform well in an application where the higher-value sodium bentonite is commonly used, which could provide more-efficient drilling operations and less formation damage.

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