Characterization of filter cake generated by nanoparticle-based drilling fluid for HP/HT applications

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

Faculty Member at the Department of Petroleum Engineering

Abstract

As high-pressure/high-temperature (HP/HT) drilling is inherently expensive, drilling fluids and technologies should be carefully selected to successfully handle the associated challenges. Over the past few years, nanoparticles (NPs), among other additives, have been investigated to address these challenges. The objective of this study is to investigate the potential of using ferric oxide NPs on the filter cake properties in downhole drilling environments.

Having an efficient filter cake is an important property of the drilling fluid and can affect the success of drilling operations. This research focuses on characterizing the filter cakes produced by Ca-bentonite-based drilling fluid contains ferric oxide NPs at downhole conditions. A combination of computed-tomography (CT) scan and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) was used in filter cake characterization. The effect of NP concentration, fluid preparation method, and filtration condition were studied. A HP/HT filter press was used to perform the filtration process at conditions up to 350°F and 500 psi. Indiana limestone core disks were used to simulate the filter media.

The experimental results showed that the ferric oxide NPs improve the filter cake and filtration properties of Ca-bentonite-based drilling fluid in the presence of polymer and other additives. Low NP concentration is preferred for obtaining a good cake quality with the best characteristics obtained at 0.3–0.5 wt% NPs. Furthermore, this drilling fluid can withstand conditions up to 500 psi and 350°F. Cake properties of 0.151 in. thickness, 6.9 ml filtrate volume, and 0.428 µd permeability was obtained at such conditions. The addition of NPs to the drilling fluid improved the filter cake properties under both static and dynamic filtration. SEM-EDS analysis confirmed the efficiency of using NPs to form a smoother/less porous filter cake morphology. Moreover, sonication for one hour and hydration for 16 hours are recommended for better preparation of these fluids.

This research provides an experimental evaluation of using ferric oxide NPs with Ca-bentonite-based drilling fluid to produce high-quality filter cake at downhole conditions. The characteristics of the filter cake generated confirmed the efficiency of such fluids.