Formation Damage Assessment and Filter Cake Characterization of NPs/Ca-Bentonite Fluids for Drilling Harsh Environments Using Computed-Tomography Scan

Omar Mahmoud ,Hisham Nasr-El-Din

Abstract

Invasion of mud filtrate while drilling is considered as one of the most common sources of formation damage. Minimizing formation damage, using appropriate drilling fluid additives that can generate good-quality filter cake, provides one of the key elements for the success of the drilling operation. This study focuses on assessing the effect of using different types of nanoparticles (NPs) with Ca-bentonite on the formation damage and filter cake properties under downhole conditions.

Four types of oxide NPs were added to a suspension of 7 wt% of Ca-bentonite with deionized water: ferric oxide (Fe2O3), magnetic iron oxide (Fe3O4), zinc oxide (ZnO), and silica (SiO2) NPs. The NPs/Ca-bentonite suspensions were then used to conduct the filtration process at a differential pressure of 300 psi and 250ǺF, using a standard filter press. Indiana limestone disks of 1 in. thickness were examined, as the filter medium, to simulate the formation in the filtration experiments. Computed-tomography (CT) scan technique was used to characterize the deposited filter cake and evaluate the formation damage that was caused by using different fluid samples.

The results of this study showed that the filtrate invasion is affected by the type of NPs, which is also affecting the disk-porosity. Using 0.5 wt% of Fe2O3 NPs with the 7 wt% Ca-bentonite fluid showed a higher potential to minimize the amount of damage. The average porosity of the disk was reduced by 1.0%. However, adding 0.5 wt% of Fe3O4, SiO2, and ZnO NPs yielded a disk-porosity decrease by 4.7, 13.7, and 30%, respectively. The decrease in the disk-porosity after the filtration is directly proportional to the volume of invaded filtrate. Compared to that of the base fluid, the best reduction in the filtrate invasion was achieved when adding 0.5 wt% of Fe2O3 and Fe3O4 NPs by 42.5 and 23%, respectively. The results revealed that Fe2O3 and Fe3O4 NPs can build better Ca-bentonite-platelet structure and thus, a good-quality filter cake. This is due to their positive surface charge and stability in suspensions, as demonstrated by zeta potential (ɕ-potential) measurements, which can minimize formation damage. Increasing the concentration of Fe3O4 NPs from 0.5 to 1.5 wt% showed an insignificant variation in the filtrate invasion, spurt loss, and filter cake permeability; however, an increase in the filter cake thickness as well as the amount of damage created was observed. The 1.5 wt% of ZnO NPs showed a better performance compared to the case having 0.5 wt% of ZnO NPs, but in the meanwhile it showed the lowest efficiency when compared to the other types of NPs. This could be due to their surface charge and suspensionsô instability.

Results of this work are useful in evaluating the drilling applications using Ca-bentonite based fluids modified with NPs as an alternative to the commonly used Na-bentonite. Additionally, it might help in understanding the NPs/Ca-bentonite interaction for providing more efficient drilling operations and less formation damage.

Future University In Egypt (http://www.fue.edu.eg)

Copyright É 2013 [Future University in Egypt]. All rights reserved.

Future University In Egypt (http://www.fue.edu.eg)

Copyright É 2013 [Future University in Egypt]. All rights reserved.