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Improvement in the transport capacity of drilled particles of aqueous-based drilling fluid using surface-enriched hydroxyapatite nanoparticles

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ABSTRACT

According to oilfield drilling records, improper transport of rock cuttings caused by eccentricity has led to some serious problems, such as mechanical pipe sticking, high fluid loss, and borehole expansion, which have reduced the total economic advantages associated with the well. These problems are common in directional drilling due to the substantial reduction of annular flow velocity from the narrow annulus, necessitating the need for high-functional drilling fluid components like nanoparticles (NPs). This study evaluated the performance of hydroxyapatite nanoparticles treated with sodium dodecyl sulphate (n-HAp) on the cuttings lifting ratio (CTR) of water-based mud (WBM). The rheological and filtration properties as well as the CTR performance of the designed n-HAp were compared with those of cupric oxide (CuO), nanosilica (SiO_2), alumina (Al_2O_3), and magnesium oxide (MgO) NPs. The fluid systems lifted 0.80–3.60 mm sandstone particles through pipe angles of 0°, 55°, and 90°. Other wellbore variables investigated include annular fluid velocities of 1.5, 2.5, and 3.5 m/s, pipe eccentricity ($e = 0$, 0.5, and 1.0), and 0.4, 0.8, 1.2, 1.6, and 2.0 g concentrations of n-HAp. At the same 2.0 g concentration, the findings demonstrate that n-HAp performed better in cuttings removal than each of the NPs. At a 1000 s^{-1} shear rate, the NPs-based fluid systems increased the viscosity of the WBM (0.166 Pa. s) by 10–87 %, while the n-HAp concentration increased it by 168 %. Also, using 2.0 g concentration, the n-HAp and the NPs decreased the fluid loss of the WBM from 9.4 mL to 5.4 mL and 8.2–4.8 mL, respectively. With n-HAp, the CTR of the WBM increased the most, by 28–38.6 %, and CuO-NP (14.6–23.5 %) came next, followed by Al_2O_3 (9.3–18.9 %), SiO_2 (5.0–13.4 %), and MgO-NP (2.8–7.7 %). Increasing eccentricity reduced the CTR of all the mud systems at all hole angles. Drilling through a 55°-pipe angle at 3.5 m/s resulted in the lowest CTR, and the obtained CTR related to this pipe angle is 58–75 % ($e = 0$), 53–70 % ($e = 0.5$), and 52–67 % ($e = 1.0$). These results are important for managing the drilling muds and optimizing drilling operations because they provide insight into the effect of pipe eccentricity on CTR.

1. Introduction

Drilling for oil and gas involves piercing the earth's surface to access a subterranean hydrocarbon resource via a borehole known as a well or wellbore. This process produces small rock pieces called cuttings, which increase as the hole deepens (Al-Azani et al., 2019; Shu and Ma, 2016). To prevent wellbore issues, rock cuttings must be removed optimally. The optimal performance of cuttings transport during drilling operations may be accomplished by enhancing the engineering elements or

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