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Tribology of drill bit material in deep oil drilling process: variation of weight on bit (WOB) and bit rotating speed

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Abstract

The oil and gas industry is faced with great challenges when it comes to the drilling process due to a shift in drilling shallow onshore layers, to deep and ultra-deep offshore layers. The depletion in the onshore oil and gas reserves has resulted in the need to explore alternative reserves, to meet the constantly increasing energy demand. Due to increased drilling depth, the drilling equipment faces challenges of increased torque and drag, which lead to friction and wear, as a result of complicated drilling environments. These challenges eventually lead to serious equipment failure, resulting in increased production costs. It is therefore of paramount importance to find different combinations of drilling parameters that will give the highest production rates at minimum costs while also paying attention to strict environmental and safety regulations. In this research, different drilling parameters such as weight-on-bit (WOB) and drill bit rotating speed, including different drilling environments such as dry and wet environments were studied, to determine how their different combinations affect the coefficient of friction (COF), when used in three different rock types; Fine-grained Arkose sandstone, Coarse-grained Arkose sandstone and Quartzite. In dry environments, varying the WOB and drill bit rotating speed greatly affects the COF. Higher speeds and low loads resulted in reduced COF while low speeds and high load portrayed increased COF. For wet environments, different nanoparticles were used in water-based and oil-based fluids. The oil used was environmentally friendly and biodegradable vegetable oil named castor oil. The nanoparticles (NPs) of bentonite, attapulgite, sepiolite and cellulose nanocrystals (CNC), were used as additives in drilling muds, to reduce the COF. These NPs were successful in the reduction of COF, but they performed better in the oil-based fluids than in the water-based fluids.