الكلية الدولية للهندسة والإدارة
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Title : Eco-Friendly Approach to Enhancing Drilling Fluids properties: A Study of Titanium Dioxide Nanoparticles.

The drilling fluid plays a vital role in the drilling operations, whereas an efficient drilling fluid can provide a very sufficient drilling operation, drilling fluid with appropriate rheological properties and a filtration rate can be used for various of sections of the drilled oil well. In this research Titanium Dioxide Nanoparticles will be added to the drilling mud used in the deep wells and experimentally tested on laboratory equipment's used in the current industry. This Research has been awarded MOHERI TRC 2023 Graduate Grant.

Introduction and Statement of the Problem / Project:

Nanoparticles (NPs) as a nanotechnologies unit have a huge potential for improving drilling fluids. However, the role of NPs in this field is still in its infancy and consequently has attracted much more attention in the last years. Despite the potential benefits of using TiO2 nanoparticles in drilling fluids, there is limited research on their effectiveness in enhancing the rheological properties of drilling fluids at elevated temperatures. Moreover, the effect of TiO2 nanoparticles on the filtration and fluid loss properties of drilling fluids is not well understood. Therefore, this study aims to investigate the impact of TiO2 nanoparticles on the rheological properties, filtration control, and fluid loss of drilling fluids at high temperatures. The findings of this study could contribute to the development of environmentally friendly drilling fluids that can withstand the high temperatures encountered in deep drilling operations while maintaining their rheological and filtration properties.

Objectives:

1- Assess the corrosion resistance: Determine how successfully drill pipe couplings protected against corrosion in challenging well drilling settings by carbon nanotube (CNT) nanocoatings.

2- Improve wear protection: Look into CNT nanocoatings' potential to offer drill pipe couplings improved wear protection, reducing wear and prolonging their lifespan.

3- Reduce friction: Evaluate CNT nanocoatings' ability to lessen the friction between drill pipe couplings, increasing the efficiency of such couplings and lowering the energy required for drilling operations.

4- Create the best nanocoating formulations possible by investigating several CNT nanocoating formulations and fine-tuning their chemical make-up to obtain the requisite corrosion resistance, wear protection, and friction reduction qualities.

5- Evaluate coating adhesion and durability: To assure the long-term efficacy of CNT nanocoatings on drill pipe couplings, evaluate the adhesion and durability of the coatings under simulated drilling conditions.

Synopsis and Plan of Work:

The American Petroleum Institute (API) has created a set of guidelines called API BUL 13D for characterizing the rheological properties of drilling fluids. These guidelines cover everything from fundamental rheological concepts to data collection and analysis. While non-Newtonian fluid models are well-covered, there is not enough attention paid to fluid models that exhibit Newtonian behavior at low shear rates. To formulate water-based mud, three main materials are typically used: CaCO3, barite, and salt. The presence of these chemicals can affect the overall volume of the mud, so it is important to calculate their volumes accurately to obtain a final volume of 350 ml, which is the standard volume based on API standards. The volumes of CaCO3, barite, and salt were calculated to be 6.5 ml, 4 ml, and 35 ml, respectively.

The total volume of water used was found to be 304.5 ml. The mixing of drilling fluids (WBM) follows standard procedures, beginning with adding 300 ml of fresh water and 0.25 g of caustic soda to the blender and allowing it to blend for 2 min. Next, 91 g of sodium chloride is added and mixed for 10 min. Xanthan gum (1g) is added and left to mix for 10 min, followed by the addition of starch (3.5 g), which is blended for another 10 min. Titanium dioxide nanoparticles are then added and left to mix for 10 min. Calcium carbonate (17.5 g) is added and allowed to mix, followed by the addition of barite (17.5 g), which is mixed in as well.
Design Expert is a robust software program that enables the creation of experiment designs and data analysis. It can be a valuable asset in testing the efficacy of Titanium di Oxide nanoparticles in drilling fluids for deep water applications by defining factors and responses such as concentration of additives, mixing speed and duration, viscosity, shear strength, and thermal stability. The software can then generate a randomized set of experimental runs to test the effects of each factor and analyze results to identify significant factors and interactions. By utilizing Design Expert, it is possible to save time and resources while optimizing formulations for maximum performance in deep water drilling applications.
A rotational viscometer is used to determine the drilling fluid's viscosity, yield point, and gel strength. The viscometer comprises a stainless-steel beaker connected to a flask and a rotating cylinder that rotates inside the sample at either 300 RPM or 600 RPM. A constant dial reading is achieved, and the value of Centipoise (cP) is used to calculate the viscosity and yield point according to universal laws. To determine the gel strength, the speed selection knob is set to 600 rpm and stirred for 10-20 seconds, then turned off, and paused for 10 seconds. After that, the speed selection knob is set to 3 rpm in the 10th second, and the maximum value that the disc reaches before the gel breaks is the gel strength value (10 s) in lbs/100 sq.ft. The process is repeated after waiting for 10 minutes to measure the gel strength (10 min) in lbs/100 sq.ft. Finally, to ensure safety, it is necessary to conduct a hazard identification and risk assessment of the product to identify potential hazards related to production, handling, transportation, and usage, taking into account the possible routes of exposure for workers and the public, as well as the environmental impact.

Research Outputs

A paper authored by Al Haitham and Dr. Girma, titled "A Comprehensive Review of Nanotechnology Applications in Oil and Gas Well Drilling Operations," has been published in the prestigious Q1 journal "Advances in Oil and Gas Well Engineering Science and Technology" section of Energies by MDPI.

Alkalbani, A.M. and Chala, G.T., 2024. A Comprehensive Review of Nanotechnology Applications in Oil and Gas Well Drilling Operations. Energies, 17(4), p.798.