Enhancement of Drilling Fluid Rheology by Nanoparticles

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ABSTRACT

A number of nanoparticles based water based drilling fluids (WBM) was formulated and their rheological properties were examined. The results show that the addition of nanoparticles increased the performance of WBM both at stationary and dynamic conditions. In addition, these nanoparticles increased the degree and the speed of the structural recovery.

INTRODUCTION

Rheology is about flow and deformation of materials under specified conditions[1]. Therefore, rheology is as much about the deformation of solid-like materials as it is about the flow of liquid-like materials, in particular the behavior of complex viscoelastic materials that show properties of both solids and liquids [2]. Rheology is an extremely important parameter of drilling-fluid performance. Modification of drilling fluid rheology can be a solution key to many drilling problems like pipe sticking, loss circulation and formation damage[3, 4]. Most of the drilling fluids behave as non-Newtonian fluids, time dependent known as shear thinning or pseudoplastic behavior, in which the fluid viscosity decreases with increasing shear.

There are a number of rheometric tests that can be performed on a rheometer to determine flow properties and viscoelastic properties of a material[5]. The focus of recent research has been on the general rheological behavior of drilling fluids without viscoelasticity and thixotropy[6-9]. Therefore, very few publications are available in the literature that discuss the influence of viscoelasticity and thixotropy properties[3, 10, 11]. As a viscoelastic material, drilling fluids display both viscous and elastic behavior, which requires detailed study. Identifying the differences in viscoelastic behavior could lead to better design of a drilling fluid recipe. The speed of the structural recovery (thixotropy) can imply how quickly a drilling fluid develops high gel strength to resist the settling of heavy particles out of suspension. Using nanoparticles to improve the performance of drilling fluids is a recent development. This work aims to study the influence of three different hybrid nanoparticles on the rheology, viscoelasticity and thixotropy properties of water based mud (WBM).

PRPARATION OF DRILLING FLUIDS

The preparation was started by scaling water to a specified amount. Bentonite was first added, which was mixed until the fluid. Then barite and other chemicals were added. The pH was adjusted by using 0.2ml of a base solution consisting of 0.1M of NaOH. Nanoparticles were then added to the mud. The nanoparticle mass concentration was determined based on the total mass the fluid mixture. The fluid was finally mixed by a Hamilton beach mixer for 20 minutes. The

laboratory analysis was initially preformed on the base mud to set a reference value.

RHEOLOGY MEASUREMENT

The Anton Paar Physica MCR301 rheometer was used to investigate the rheological properties of fluids. The flow behaviour of fluids was investigating by a rotational system. The oscillation amplitude sweep test was employed to find the linear portion of the viscoelasticity and to observe the structural characteristics of the fluids. While the combination of oscillation-rotation-oscillation tests was utilized to study the thixotropy behaviour.

RESULTS

As Figure 1 shows, the flow behaviour of nanoparticle seeded drilling fluid is similar to the base fluid (drilling fluid without nanoparticles). Both drilling fluids with and without nanoparticles followed the Herschel - Bulkley model and showed close curves relative to each other. The difference between them is that the addition of nanoparticles renders slightly higher viscosity, which could be linked with the effective dispersion ability of nanoparticles on the surface of bentonite.

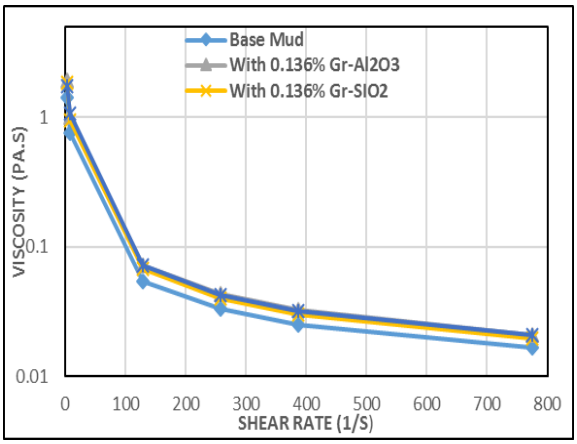

Figure 1 Measured Viscosity of prepared fluid samples as a function of shear rate

The addition of 0.136% of graphite and silicon dioxide is the best addition to develop the drilling fluid structure (Figure 2). As indicated in the Figure, this recipe gives more elastic properties at linear viscoelastic range LVE range and less shear stress at the flow point. This implies that nanoparticle hybrid Gr-SiO provides better gel structure, which can be broken with less shear stress.

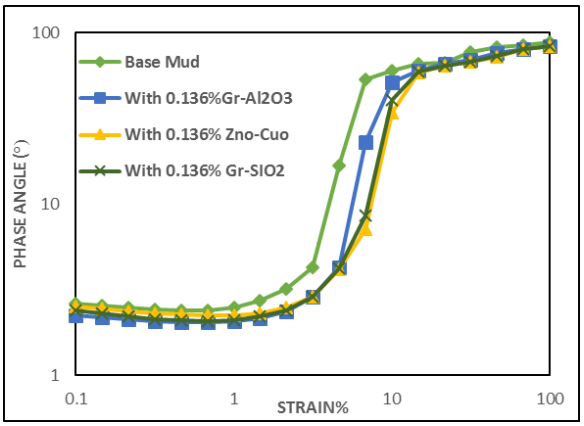

Figure 2 Measured phase angle of prepared fluid samples as deformation percentage

As clear from the Figure (3), the increase of nanoparticle concentration gains more elastic behaviour to the drilling fluid and increase the degree and the speed of the structural recovery through reducing the rebuilt time, which is beneficial to prevent the sedimentation of the cuttings and weighting materials.

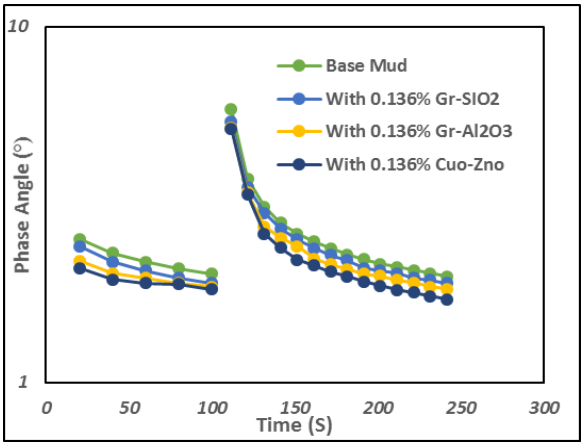

Figure 3 Measured Thixotropy of prepared fluid samples as a function of time

CONCLUSION

In this paper, the effect of nanoparticles on drilling fluid rheological properties was

experimentally investigated and the following conclusions could be drawn:
- The flow behaviour of nanoparticle seeded drilling fluid is similar to the base fluid, following the Herschel Bulkley model.
- The addition of nanoparticles to water based mud improves the viscoelasticity and thixotropy properties of water based mud.
-The improvement depends on the nanoparticles type and concentration.

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