ISSN: 2639-7536

Review Article

Petroleum and Chemical Industry International

Effects of Multi-Wall Carbon Nanotubes (MWCNT) on Performance of Water Based Mud (WBM)

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Submitted: 30 Dec 2021; **Accepted:** 05 Jan 2022; **Published:** 19 Jan 2022

Citation: *Abbas Sarkari., Koorosh Tookallo. (2022). Effects of Multi-Wall Carbon Nanotubes (MWCNT) on Performance of Water Based Mud (WBM). Petro Chem Indus Intern, 5(1), 05-06*

Abstract

The present review article expresses the effectiveness of different types of Multi-Wall Carbon Nanotube(s) (MWCNT) on the rheological properties of Water-Based Mud drilling fluid. Shale formations are troublesome according to their water sensitivity characteristic, low Nano-Darcy permeability with small nanometer-sized pore throats that are not effectively sealed by the solids in conventional drilling fluids. Water invasion into the shale formations causes different problems in the drilling industry. Nanoparticle additives have the potential to be used in drilling operations due to their large surface area and lower kinetic energy than micro-additives. The test results demonstrate that multi-wall carbon nanotube improves the rheological properties of the Water-Based Mud drilling fluid. Acidic-surface modified carbon nanotube in the presence of Polyethylene Glycol (PEG) increases the plastic viscosity and yield point of the sample more than unmodified carbon nanotube and hybrid multiwall carbon nanotube. Test results show that multi-wall carbon nanotubes (MWCNT) improve shale stability and shale recovery, finally leading to more well-bore stability in shale formations.

Keywords: Water Base Mud (Wbm), Rheological Properties, Nanoparticles, Multi-Wall Carbon Nanotube, Shale Stability, Shale Recovery.

Introduction

The maintenance of wellbore stability is important aspect of drilling operation. Water invasion to the shale formations is resulted due to weakening of the wellbore, and it causes many problems such as stuck pipe and hole-collapse. The problem of wellbore instability in the shale formation is well-known in the drilling industry, since over 75% of the drilled formations consist of shale rocks. Shale according to its water sensitivity characteristic causes 90% of wellbore instability problems, time spending and revenue in the petroleum explorations. Shales are also troublesome, since they have a very low Nano-Darcy permeability with very small nanometer- sized pore throats that are not effectively sealed by the solids in conventional drilling fluids. As shown in figure 1, when the shale formation is in contact with water, according to its components, it will brittle or swell [1].

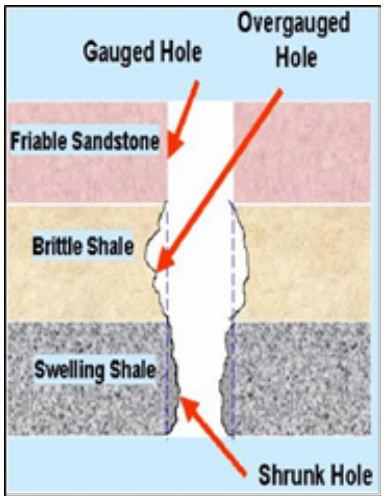

Figure 1: brittle and swelling shale

In the past, the balanced activity oil base muds (OBM) were used for drilling troublesome shale formations. OBM subject to its superior shale stabilization characteristic can solve such problems of wellbore instability. OBM is a key solution for maintaining the stability of the shale.

However, the use of OBM is limited largely due to its environmental restriction (particularly in offshore drilling), costliness and safety [2]. Water based mud (WBM) is rather more in contact with the clay than OBM. This contact may cause instability. In order to reduce the invasion of drilling fluids, the drilling fluids should form internal or external mud cake [3]. Normal additives cannot form good mud cake, because of small-sized pore throat and low shale permeability. Pore throat plugging may not be achieved in the shale, because of the large size of regularly used solid mud additives, which do not plug pore throat. Normal solid particles are approximately 100 times larger than pore throats. Slow flux of filtrate of WBM into the formation leads to a significant pore pressure zone near the wellbore wall and subsequently wellbore instability. Therefore, the physical plugging of Nanoscale pore throats in the shale formation by nanoparticles can be implemented to reach the several benefits, including pore pressure reduction owing to its feature of preventing the mud filtrate influx toward the shale, while the shale swelling is reduced owing to its feature avoiding the more interaction between the shale and mud filtrate, the high membrane efficiency is generated due to the shale permeability reduction and consequently the shale stability [4].

On the other hand, conventional macro and micro base fluids (chemicals and polymers) have limited thermal stability. Moreover, they would get thermal degradation above 125-130 °C. Due to degradation, these chemicals cannot perform their desired function effectively in the drilling mud systems. Therefore, in order to reach the desired viscous and gelling properties under high pressures and high temperatures, the drilling mud must comprise of the specific components, e.g. Nanoparticles, which have stability under extreme conditions. Excellent thermal conductivity of Nano base fluids associated with temperature and pressure tolerances, it can be a better choice. Nanoparticles have the potential to become a permanent constituent of all drilling mud systems, as they can be an efficient solution of many down-hole problems. Nanoparticles as a great alternative replace the traditional strategies and allow current drilling industry to go beyond the limits in order to reach those particular hydrocarbons regularly known as inaccessible [5].

Recently, Nano base drilling fluids have been formulated and resulted in the improvement of rheological properties, i.e. the stability and the gelling property, and the ultrathin mud cake. Nano base fluids reduce any damage during the formation by the elimination of spurt loss. Ultrathin mud cake dramatically decreases the differential pipe sticking and, as a result, Nano base fluid is applied in the formation with the high permeability [6]. Due to the following facts, the nanoparticle additives have the potential to be used in drilling operations; firstly, the huge surface area of NPs increases the interactions between Nanos and reactive shale and resolve borehole problems. Secondly, the less kinetic energy of NPs reduces the abrasive effect of Nanos on down-hole equipment [7].

The present invention reduces shale permeability by using multi-wall carbon nanotubes (MWCNT) to plug pore throats, build an internal and external filter cake and reduce the fluid invasion into the shale.

Conclusion

According to the specific properties of multi wall carbon nanotubes and test results multi wall carbon nanotubes (MWCNT) improve shale stability and rheological properties of water based mud. Unmodified carbon nanotube decreases the water loss and increases the cake thickness of the Mud (WBM). Not Modified Carbon Nanotube increases viscosity and yield point of the sample due to its greater diameter and length. By increasing the size (diameter and length) of MWCNT more viscosity, pH and yield point of the WBM is achieved. Acidic-surface modified carbon nanotube in the presence of Polyethylene Glycol (PEG) increases the plastic viscosity and yield point of the sample more than unmodified carbon nanotube and hybrid multiwall carbon nanotube. All in all, the presence of Multi- Wall Carbon Nanotubes increases the efficiency of polymers and improves the rheological properties and performance of the water base mud [1,6].

Acknowledgment

I would like to express my special thanks of gratitude to Mr. Babak Fooladi, CEO of Petro Gohar Farasahel Kish Co. who supported us in publishing this review article.

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