PERFORMANCE OF NANOPARTICLES AS FLUID LOSS ADDITIVES IN POLYMER-CLAY DRILLING FLUIDS

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To my beloved family especially my father and mother,

to lecturers and friends,

especially my supervisor and team mates,

million thank you for all your supports, encouragement and guidance.

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ABSTRACT

As oil discoveries become deeper and hostile, there is a need to improve the existing drilling fluids or to design a new ones which is more environmentally friendly with zero impact on the environment. Polymers and bentonite have been used as viscosifier and fluid loss control in drilling fluids and also can be used in almost any type of water and as a suspending agent. The applications of nanoparticles in drilling fluids is mainly to form a thin layer of non-erodible and impermeable nanoparticles membrane around the wellbore which prevents common problems like clay swelling, spurt loss and mud loss due to the circulation**.** The nanoparticles have high surface to volume ratio, therefore for any application the quantity of nanoparticles required will be less and hence there is cost advantage. In this study, the performance of nanosilica and multi walled carbon nanotubes (MWCNT) as fluid loss additives in polymer-clay mud were investigated at HPHT conditions with varying nanoparticles concentration and temperature. Before aging, plastic viscosity, yield point and gel strength of mud with nanoparticles shows an increasing trend as the concentration of nanoparticles increased from 0.01g to 1g. Mud with nanosilica gives the highest filtrate loss of 12ml and mudcake thickness of 10.24inch at 1g concentration and 300°F.Whereas, mud with MWCNT shows a decreasing trend in filtrate loss and mudcake thickness as nanoparticles concentration increased. However, filtrate loss for mud with nanoparticles is still high as compared to control mud. The finding shows that xanthan gum containing 1g MWCNT gives 4.9ml filtrate loss and mudcake thickness of 4.48inch at 200°F. After aging, plastic viscosity, yield point and gel strength of mud containing nanoparticles decrease significantly especially for 1g of nanosilica and 0.01g MWCNT. Filtrate loss and mudcake thickness also increased when the mud is exposed to temperature above 250°F. As a conclusion, xanthan gum with MWCNT gives a promising result in terms of rheological performance and form a thin, stable and uniform mudcake.

ABSTRAK

Eksplorasi minyak dan gas menjadi lebih mencabar terutamanya eksplorasi laut dalam. Oleh itu terdapat keperluan untuk memperbaiki lumpur penggerudian sedia ada atau menghasilkan lumpur penggerudian yang baru yang lebih mesra kepada alam sekitar. Polimer dan bentonit telah digunakan sebagai agen pelikat dan kawalan kehilangan cecair dalam lumpur penggerudian dan juga boleh digunakan dalam hampir semua jenis air dan sebagai agen penahan. Nanopartikel dalam lumpur penggerudian selalunya digunakan untuk membentuk lapisan nipis, tahan hakisan dan tidak telap membran nanopartikel sekitar lubang telaga yang boleh menghalang masalah seperti pengembangan tanah liat, dan kehilangan lumpur ke dalam formasi. Nanopartikel mempunyai nisbah permukaan yang luas,oleh itu penggunaan nanopartikel hanya memerlukan kuantiti yang sedikit dan ini dapat mengurangkan kos. Untuk kajian ini, prestasi nanosilika dan tiub nano karbon dinding berlapis (MWCNT) sebagai agenpengawal turasan dalam lumpur polimer-tanah liat telah dikaji pada keadaan tekanan dan suhu yang tinggi (HPHT) dengan kepekatan nanopartikel dan suhuberbeza. Kelikatan plastik, takat alah dan kekuatan gel lumpur dengan nanopartikel menunjukkan peningkatanapabila kepekatan nanopartikel meningkat daripada 0.01g untuk 1g. Polimer HEC dengan nanosilika memberikan kehilangan turasan dan ketebalan kek lumpuryang tinggi pada kepekatan 1g dan suhu 300°F. Manakala, Gum xanthan dengan MWCNT memberikan kehilangan turasan dan ketebalan kek lumpur yang rendah pada kepekatan 1g dan suhu 200°F. Walau bagaimanapun, kehilangan turasan untuk lumpur dengan nanopartikel masih tinggi berbanding dengan lumpur kawalan. Selepas proses penuaan lumpur, kelikatan plastik, takat alah dan kekuatan gel lumpur mengandungi nanopartikelmengalami penurunan. Kehilangan turasan dan ketebalan kek lumpur juga meningkat apabila lumpur terdedah kepada suhu melebihi 250°F. Secara keseluruhanya, gam xanthan dengan MWCNT memberikan hasil yang memberangsangkan dari segi reologi dan dapat menghasilkankek lumpur yang nipis, stabil dan seragam.

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bbl	-	Barrel
ml	-	Millilitre
cP	-	Centipoise
lb/bbl	-	Pound per barrel, ppb
lb/100 ft^2	-	Pound per 100 square ft
ppg	-	Pound per gallon
psi	-	Pound per square inch
^oC	-	Degree Celsius
^oF	-	Degree Fahrenheit
%	-	Percentage

LIST OFABBREVIATION

API	-	American Petroleum Institute
CBM	-	Coalbed Methane Mud
CCVD	-	Catalytic Chemical Vapour Deposition
CMC	-	Carboxyl Methyl Cellulose
EBM	-	Ester Based Mud
Fe	-	Iron
GO	-	Graphene Oxide
HEC	-	Hydroxyl Ethyl Cellulose
HPHT	-	High Pressure High Temperature
Ni	-	Nickle
OBM	-	Oil Based Mud
OPC	-	Organophilic Clay
PECVD	-	Chemical Vapour Deposition Systems
PHPA	-	Partially Hydrolyse Polyacrylamide
SiO_2	-	Silica Dioxide
SBM	-	Synthetic Based Mud
TG	-	Triglycerides
WBM	-	Water Based Mud
WMCNT	-	Multi Walled Carbon Nanotubes

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Increased challenges in operational depth, length of horizontal departure in extended reach wells, complexity of drilling operations, and the strict environmental regulations leads to the development and application of novel technologies. There are need to either improve on existing drilling fluids or design new ones in order to meet the technological demands for success especially in increasingly hostile drilling environments. Srivatsa *et al*., (2011) in their study stated that filtrate invasion is one of the most critical parameters that may cause a wellbore damage if not properly controlled. Filtrate not only will induced formation damage but also problems with filter cake removal adversely affect well productivity or injectivity.

Infield practise, a several type of fluid loss agent has been utilized in drilling fluid to reduce the drilling fluid loss. Amanullah *et al*., (2011) mentioned that it is often impossible to reduce fluid loss with micro and macro type fluid loss additives due to physio-chemical and mechanical characteristics. The normal fluid loss additives with range between 0.1-100 nm in diameter are not effective in reducing fluid loss in the formation with pore size less than 0.1 nm such as shale.

Other than fluid (water or oil or both) phase, the solids, chemicals and polymers that are used in designing a fluid play an important role in the functional behaviour of the fluids. Though the factors that guide the choice of a fluid base and the mud additives are complex, technical and environmental challenges must also be taken into consideration when selecting the drilling fluid additives (Gray *et al*., 1980). One of the new improvement in drilling technology is the used of nanotechnology. It has already contributed significantly to technological advances in the energy industries. Nanotechnology produces nanomaterials with many attractive properties, which can play an important role in intensifying mud cake quality, reducing friction, eliminate differential pipe sticking, maintaining borehole stability and protecting reservoir.

Qu *et al*., (2007) study focused on production of a type of polymer nanocomposites and their advantage when added in drilling fluids. The experimental result shows the properties of drilling fluids containing these nanocomposites had a superior filtrate reducing performance, excellent thermal stability and good inhibiting ability. They had concluded that polymer nanocomposites were an excellent fluid loss additives that could meet the requirement of drilling operation under extreme condition.

Due to its potential to form thin, non-erodible and impermeable mud cake with nano-enhanced, nano based fluids are expected to eliminate or reduced formation damage caused by filtrate loss in downhole condition. Water based nano fluids developed using several commercial nano materials to overcome the challenges associated with conventional drilling fluids. Compared with conventional drilling fluids, the water-based nanofluid could reduce formation damage in the oil and gas reservoirs significantly, control loss circulation well, and enhance the rate of penetration in hard rock formation greatly.

The cost of drilling fluid loss often represents one of the single peak capital expenditure during drilling. Novel study by Zakaria *et al*., (2012) shows that custom prepared nanoparticles drilling fluid system have higher ability to reduced fluid loss compared to commercial nanoparticles and drilling fluid system with lost circulation materials. The results also shows the engineered nanoparticles alone provided sufficient plugging as they sealed most of the holes in a typical mud cake or mud cake with typical lost circulation materials. They concluded that tailored made nanoparticles with specific characteristic is expected to play a promising role helping to solve the circulation loss and other technical challenges with commercial drilling fluid.

Nevertheless, the use of nanoparticles in drilling fluid must be at the right concentration and adoption of specific preparation method will led to a stable drilling fluid with desirable rheological behaviour. A new experimental study by Srivatsa *et al*., (2011) combines nanoparticles with surfactant-biopolymer based drilling fluid. They concluded that the system have better rheological and fluid loss properties than polymer or surfactant based fluid. This indicate that nanoparticles play an important role in reducing the fluid loss in fluid system. Furthermore, the results also show nanoparticles is effective for drilling through shale formation as it can penetrate the pores of the shale and act as bridging material and strengthen the wellbore. These combination of fluid system might be good for higher temperature as biopolymer are generally stable at 350°F.

1.2 Problem Statement

By applying nanoparticles as fluid additives in drilling mud system, it might help enhancing the rheological properties of drilling fluid and as a result, minimizing drilling problems especially in reducing fluid loss. Application of nano-based fluid additives in formulating high performance water based mud system has the potential to overcome the current and future technical challenges especially in HPHT condition (Amanullah *et al*., 2011). Thus, this research was conducted to examine the effectiveness of different concentration of nanoparticles as fluid loss additive in water base mud and their performance in HPHT condition.

1.2 Objectives of the Study

The objectives of this study are as follow:

1. To study the rheological performance of different polymer drilling fluids with different types of nanoparticles.
2. To determine the effectiveness of nanoparticles as fluid loss additives at high pressure high temperature (HPHT) conditions.

1.3 Scopes of Study

The scope of this study are as follows:

1. To prepare different Polymer-Clay mud system as a control mud formulation.
2. To employ nanoparticles as fluid loss additives in different Polymer-Clay mud system
3. To add different concentration of nanoparticles (0.01g, 0.1g and 1g) into the Polymer-Clay mud system.
4. To perform rheological properties test and HPHT filtrate loss test at different temperatures of 200°F, 250°F and 350°F and 500psi for non-aging and aging samples and measure the thickness of mud cake.

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