Advancement of high temperature and high pressure utilizing oil based drilling mud by using nanotubes

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ABSTRACT-It is imperative to comprehend the perspectives affecting oil based mud (OBM) rheology with a specific end goal to keep up a firm control over rheological properties of high temperature high pressure (HTHP) and high thickness oil based mud. This paper centers principally around the rheological properties of water-based boring liquid under high pressure and high temperature condition. This work centers around the outline, enhancement and plan of a HTHP water-based boring liquids as per the required determination, for example, rheological properties and liquid misfortune. To meet the previously mentioned boring liquid properties, the exploration was boundless to the utilization of dirt, polymers, and nanoparticles. Polymers give incredible rheological and liquid misfortune properties tooil base muds yet corrupt at high temperature. The test strategy utilized was by and large blending ofoil base mud with certain detailing and after that performing mud testing. The experimentation were led by "Suggested Practice on Standard Field Procedure for Testing Drilling Fluid" API RP 13B and "Prescribed Practice 13I Standard Field Procedure for Laboratory Testing Drilling Fluid" API 13I to meet the American Petroleum Institute (API) prerequisites and acquire dependable outcomes. The principle research facility tests associated with this task are mud arrangement, static rheology test, pH and HTHP static channel press. A bentonite mud and high temperature manufactured polymers have been effectively tried at 400-degree F with great rheological and filtration properties. The base mud definition comprises of the business synthetic concoctions given by ScomiOiltools, Malaysia. The base mud plan has a steady rheology and superb liquid misfortune properties at 400 F. A thin and impermeable channel cake has been acquired with least liquid misfortune at a temperature of 400 F. Specialists have effectively utilized nanoparticles for giving amazing rheology, warm strength and liquid misfortune control. Two nanoparticles to be specific, Polypeptide nanotubes (PNT) and Aluminum Oxide were tried on the base OBM framework to break down their impacts on HTHP rheology, liquid misfortune, and channel cake quality. An exceptionally positive outcome has been acquired utilizing Polypeptide nanotubes (PNT). The utilization of PNT in OBM expanded HTHP rheology by 14% and decreased liquid misfortune by 25%. Additionally, this exploration gives answers for the issues identified with HTHP OBM improvement like mud gelation, strong listing, and low-end rheology.

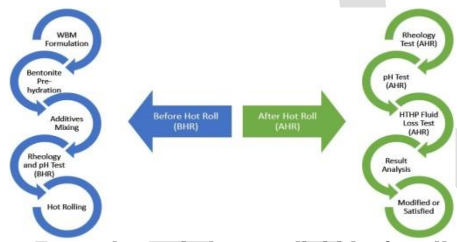
Keywords- HPHT,Oil based mud, polypeptide nanotubes, rheological properties.

I.INTRODUCTION

The most dominating issue that can influence boring liquids in HTHP conditions, is the warm corruption of the oil based mud framework, and prompting changes in its properties under HTHP conditions. Oil-based mud can oppose warm corruption and withstand serious downhole condition like HTHP. In any case, oil based mud forces a negative effect on nature and it isn't financially feasible contrast with the other sort of mud frameworks, for example, OBM. Henceforth, boring into arrangements with HTHP requires an eco-accommodating OBM penetrating liquid having stable rheological and improved liquid misfortune properties [8]. The principle capacity of bentonite in OBM is to hoist thickness and diminish filtration misfortune to wellbore dividers. Bentonite can be grouped into either Ca-bentonite with low swelling limit or Na-bentonite with high swelling limit [1]. As per Shan Wenjun et al., [3], the dirt property will be enormously influenced with expanding temperature because of hydration and mixture of Bentonite earth molecule in high temperature condition. Dirt gelation process in OBM requires exceptional consideration at temperatures higher than 300 F. Bentonite focus ought not be surpassed in excess of 3 lb/bbl while defining HTHP OBM [2]. An effective HTHP well boring requires a suitable control on penetrating mud rheology. As Johann [2] expressed that "if grouping of Bentonite or dirt materials surpasses satisfactory levels and results in consistency issues, polymeric deflocculants can be utilized if all else fails to control rheology." previously, high solids scattered penetrating liquid frameworks for HTHP boring contained lignosulfonate and lignite for rheology and liquid misfortune control. The customary lignite/lignosulfonate high-strong scattered muds work at alkalinity (pH 9) and require high measurements of lignite/lignosulfonate at temperature over 360 F in light of warm debasement. Chrome lignite debasement result is CO2 which flocculates earth and Bentonite, causing high return point and gel quality [2]. The ongoing advancement of manufactured short chain polymeric deflocculants enhanced the temperature solidness and low measurements contrasted with traditional lignite/lignosulfonates. They are temperature-stable over 400 F. Nanotechnology and surfactant has added to novel improvements in oil industry in the previous couple of decades. The rheology at HTHP condition is influenced by breaking bonds between mud particles at high temperature [6]. Nano based boring liquid extraordinarily lessens frictional obstruction between penetrate pipe and wellbore divider by framing a greasing up film at divider and pipe interface. Shale arrangement comprises of receptive dirts, which adhere to the bore and centralizer, causing balling impact. Nano based mud could be a superior decision in penetrating task in responsive shale in light of it hydrophobic film shaping trademark [12]. Because of the nearness of expansive amount of exact moment particles with high surface zone, warm conductivity, high temperature dependability, high versatility, and warm conductivity, compelling association with interior and outer surfaces of shake, nanoparticle-based penetrating liquids are foreseen to assume a key part in future and current high temperature and high pressure boring tasks [11]. Multiwall Carbon Nanotube (MWPNT) has been effectively utilized by Abduo et al., [8] to enhance HTHP rheological dependability and liquid misfortune.

II. EXPERIMENTAL PROCEDURE

The strategy is partitioned into a few stages, as appeared in Figure 1. The determinations of HTHP penetrating mud were set by the field understanding by boring liquid specialists of ScomiOiltoolsSdn. Bhd. The two stages included are before hot moving (BHR) and after hot moving (AHR). BHR comprises of Bentonite (Drill-Gel) pre-hydration for 16 hours, blending of freshoil base mud, rheology and pH test, and hot rolling. The tests required after hot moving (AHR) are same as BHR with an additional HTHP liquid misfortune test.



2.1 Drill-Gel Pre-Hydration

Pre-hydrated Drill-Gel was set up by including 35 lb/bbl of Drill-Gel and 1 lb/bbl of harsh pop to 0.97 bbl of water. The blend was mixed at fast for 30 minutes utilizing Hamilton shoreline blender. It was then kept for 16 hours at room temperature for better hydration.

2.2 Additive Mixing

The request of synthetic concoctions blended is appeared in table 1. The method for including synthetic concoctions and blending time for every substance is a vital perspective inoil base mud blending. The polymers were included gradually, and all the more blending time was given to every polymer for better hydration. A moderately higher blending time was additionally given to Drill-Bar and Drill-Gel.

2.3 Rheology Test

Rheology test speaks to the stream conduct and opening cleaning productivity of boring mud. This test is utilized to record rheology parameters like yield point (YP), plastic consistency (PV), and gel quality utilizing Fann viscometer-display 35SA. For HTHP mud the tests were done at 150 F as indicated by API models.

2.4 pH Test5

pH meter was utilized to discover the pH of boring liquid. pH assumes a vital part inoil base mud and influences mud properties. Water-base boring liquids are by and large kept up in the 8 to 12 pH run for enhanced synthetic dissolvability and execution, and also for hostile to consumption of penetrating and culmination devices (Scomi).

Table 1
Chemicals used and their function

Additive	Function	Base (lb/bbl)	Base + PNT (lb/bbl)	Base+Al_2O_3 (lb/bbl)
Drill fluid (bbl/bbl)	Base fluid	0.523	0.523	0.523
Caustic Soda	pH modifier	To pH 10	To pH 10	To pH 10
Soda Ash	control hardness	0.7	0.7	0.7
Hydro-Defoam HT	Foam remover	1	1	1
Hydro-Therm LV	HT Fluid Loss Polymer	6.2	6.2	6.2
Hydro-Therm R	HT Fluid Loss Polymer & Rheology modifier Polymer	1.8	1.8	1.8
Hydro-Zan	Rheology modifier	0.7	0.7	0.7
Sodium Chloride	Salinity	74.42	74.42	74.42
Hydro-Plast	HT fluid loss, shale stability	4	4	4

Hydro-Seal R	Bridging material, lubricity	4	4	4
Hydro-Sperse RS	HTHP Rheology stabilizer	2	2	2
Polypeptide nanotubes	Rheology & fluid loss improver	-	0.5	-
Aluminum Oxide	Rheology improver and H2S scavenger	-	-	0.5
Drill-Bar	Pressureing agent	Up to 14 ppg	Up to 14 ppg	Up to 14 ppg
Drill-Gel	Viscosifier and Fluid loss control	8	8	8
Magnesium Oxide	pH buffer	1.5	1.5	1.5
Ox-Scav L	Polymer extender	1	1	1
Hydro-Buff HT	Polymer extender, HT rheology Improver	1.5	1.5	1.5

2.5 Hot Rolling

Hot rolling is a procedure, which mimics a well bore mud dissemination in the research center utilizing a roller broiler and mud maturing cell. The reason for hot rolling is to check how the mud properties will change after a mud course at certain temperature. The mud tests were hot moved at 380 F and 400 F for 16 hours under 200 Psi pressure.

2.6 HTHP Fluid Loss Test

High temperature and high-pressure channel press is utilized at high temperatures and high pressures to locate the liquid misfortune. This test can be performed at unique down-gap temperature giving sensible estimations of liquid misfortune. All the HTHP liquid misfortune tests were performed utilizing Ofite HTHP channel press with strung cells (500 mL) at temperature 380 to 400 F and 500 Psi differential pressure. The paper speaks to an enhanced plan for HTHP dispersedoil base mud. The base detailing is an upgraded arrangement of polymers, earth, and dispersant with enhanced mud properties at lifted temperatures. The base is additionally enhanced by detailing with nanoparticles like Carbon Nanotube (PNT) and Aluminum oxide. The ordinary field particulars that were set up to depict the execution of the perfect liquid incorporated a Plastic Viscosity (PV) of under 50 cP, Yield Point (YP) in a scope of 18 to 30 lb/100ft2 and HTHP liquid loss of under 20 ml at 380-400 oF, and 500-psi differential pressure on solidified paper. The rheological properties were estimated by API norms utilizing fann 35SA viscometer at 150 F (66 oC).

III. RESULTS AND DISCUSSION

3.1 Formulation of Base

Theoil base mud was at first detailed with Drill-Gel as viscosifier and without Hydro-Sperse RS. The rheological properties after hot moving at 380 F for 16 hours expanded to high and unsatisfactory range (over 30 lb/100ft2). The plastic consistency (PV) and yield point (YP) were too high for down to earth application (PV over 50 cP). This expansion in rheology is caused by high temperature dirt gelation marvels. Shan Wenjun et al., [3] credited this to the mud property which is significantly influenced with expanding temperature because of hydration and mixture of dirt particles under high temperature condition.

A similar plan was then blended with a polymeric deflocculant known as Hydro-Sperse RS. Hydro-Sperse RS settled the rheology by scattering the earth at high temperature. The polymer uncoiled and accomplished a straight chain setup when broken down in water because of common shock of same charged gatherings along the chain. Hydro-Sperse RS effectively enhanced the activity by fortifying earth platelet disaggregation. Un-hydrated earth platelets are collected by edge to face and up close and personal electrostatic holding asshown in Figure 2.

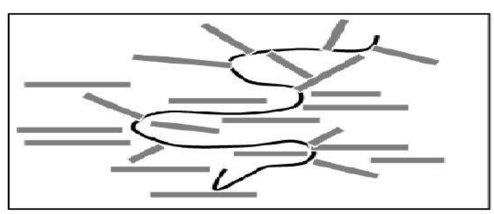
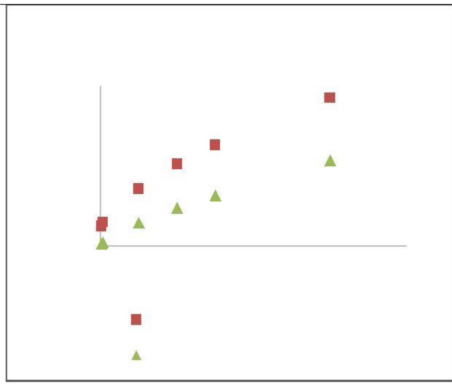


Fig. 1.Clay platelet aggregation before hydrationFig. 2.Short chain anionic polymers enhancesdisaggregation

At the point when water contacts polymer progresses toward becoming uncoil and adsorbs on dirt where polymer's negative charge kill positive charge of earth. This causes platelet disaggregation since polymer defeats the bond quality of the macrostructure as appeared in Figure 3. It turns out to be more powerful contrasted with untreated earth on the grounds that a bigger division of mud gets initiated for hydration [9]. The Figure 4 beneath demonstrates the rheology bends with and without Hydro-Sperse RS. Another examination in this exploration is the commitment of Hydro-Sperse RS to HTHP liquid misfortune. The ideal fixation for the most reduced liquid misfortune was derived to be 2 lb/bbl as appeared in Figure 5. This can be clarified as Hydro-Sperse RS disperse clay particles causing the formation of a thin.



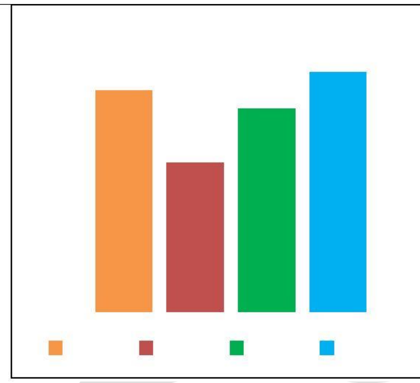


Fig. 3.Effect of Hydro-Sperse RS on Rheology afterFig. 4. Effect of Hydro-Sperse RS on Fluid losshot rolling

Fig. 5.Barite sagging due to low LSRV

The low end rheology or low shear rate consistency (LSRV) alludes to 3 and 6 rpm dial perusing of Fann viscometer. The low wellbore annular shear rate is best approximated by 6 rpm perusing, comparable to a shear rate of 10.2 sec-1. The 6 rpm perusing for boring liquids is imperative for cleaning the gap and suspend the cuttings. LSRV esteems are the primary inhibitive system for barite hanging at dynamic condition. These properties ought to be kept up inside the range for a specific arrangement of wellbore condition (Scomi). The utilization of Hydro-Sperse RS settled the rheology (PV and YP) at high temperature yet diminished the low end rheology (LSRV). The diminishing in LSRV brought about extreme drooping of solids as appeared in Figure 6. The LSRV was effectively raised by utilizing Hydro-Zan and Hydro-Buff HT. Hydro-Zan polymer is steady up to 250 F and corrupts at temperature higher than 250 F. The cooperative energy of hydro-zan and Hydro-Buff HT is clarified as Hydro-Zan proficiently balanced out LSRV until a temperature of 250 F, while over that, Hydro-Buff HT is in charge of adjustment of LSRV and generally rheology in view of its high temperature solidness. This methodology productively disposed of strong listing at high temperature. The general testing results are appeared in Table 2.

Table 2
Drilling fluid properties at 380-400 F

Drilling Fluid	Temperature (ºF)	Plastic viscosity (cP)	Yield point (lb/100 ft^2)	10 sec Gel (lb/100 ft^2)	10 min Gel (lb/100 ft^2)	HTHP Fluid loss (mL)	Cake thickness (1/32 inch)
Base	150 ºF (BHR)	58	45	8	32	-	-
	150 ºF (AHR 380 ºF)	42	17	5	6	8	3
	150 ºF (AHR 400 ºF)	42	21	3	6	9	4
Base + PNT*	150 ºF (BHR)	62	52	9	35	-	-
	150 ºF (AHR 380 ºF)	53	30	4	10	6	2
	150 ºF (AHR 400 ºF)	48	22	4	7	8	3
Base+ Al_2O_3	150 ºF (BHR)	56	46	8	35	-	-
	150 ºF (AHR 380 ºF)	46	21	4	10	9	4
	150 ºF (AHR 400 ºF)	42	20	4	7	9	4

3.1 *Rheological Properties*

Rheology of drilling fluid dictates successful drilling as well as hole cleaning. At HTHP conditions, the conventionaloil base mud system loses its rheology and results in major drilling problems. High temperature weakens or breaks the bonds among the mud particles and cause a severe drop in rheology. For this reason, the results after hot rolling (AHR) will be closer to reality and more meaningful at these conditions. It can be seen from Figure 7 that rheology is higher for mud sample with nanoparticles. The concentration of both Polypeptide nanotubes (PNT) and Aluminum Oxide nanoparticle is 0.15% by pressure. A small concentration of both nanoparticles improved the rheology of mud at 400 F. The rheology can be broadly explained in terms of PV, YP and gel strength.

3.2Plastic Viscosity (PV)

Drilling fluids usually consist of dispersed solids in continuous phase of fluid. PV (Plastic viscosity) is caused by mechanical friction of solids which constitute to total flow resistance. From Figure 8, it can be seen that PV increases for both samples containing nanoparticles compared to base sample. Many factors like increasing percent volume of solids, constant percent volume of solids, and decreasing particles size in drilling fluid increases plastic viscosity. Small particles size has high surface to volume ratio, which causes increased frictional drag (Scomi). The PV is higher for Carbon nanotube fluid compared to Al2O3 because its particle size is very small compared to Al2O3 and hence has a high surface to volume ratio.

3.3 Yield Point (YP)

The electrochemical attractive forces in the mud particles cause flow resistance and is termed as yield point. The surface of dispersed particles in mud can have positive, negative, or neutral charge. These charges cause electrochemical attractive or repulsive forces under dynamic condition, giving rise or drop to yield point respectively [7]. From Figure 8, it can be seen that YP of base sample is thermally stable up to 400 ºF. Table 2 shows the drop in YP for all the samples after hot rolling at 380 and 400 ºF. The YP or rheology for all the samples are in a stable range after hot rolling. Adding Polypeptide nanotubes and Aluminum Oxide nanoparticle further increased and stabilized the solid carrying capacity (YP). Polypeptide nanotubes efficiently increased and stabilized yield point of the base mud sample. This increase in YP is due to increasing quantity of solid particle and complex interactions among carbon nanoparticles and other additives. Al2O3 loses a proton in aqueous medium when pH is high and obtain a net negative surface charge [10]. This negative charge is responsible for interaction of Al2O3 with other charged particles and hence modify YP of the mud system. The most stable YP is given by polypeptide nanotubes compared to Aluminum Oxide and base.

3.4 Gel Strength

Gel strength is the power of forces of attraction in drilling mud at static condition. Figure 9 shows that gel strength for all the samples are in a range of 4 to 11 lb/100ft^2. These gels are considered as low gels and hence are desired in mud engineering perspective. High strength of attractive force cause high gelation, and vice versa. Flocculation of solids in the mud causes excessive gelation which results in high mud pump pressure to break the gel after a shutdown period. These gels are neither progressive nor high flat gels as these are undesired in the drilling industry (Scomi).

3.5 HTHP Filtration Properties

The combination of synthetic fluid loss polymers, dispersant, and clay enhanced the fluid loss properties of the base mud sample up to 400 ºF.Dispersant and fluid loss polymers are negatively charged low molecular pressure polymers of short chain length. These negatively charged polymer adsorbs on positively charged clay platelets causing neutralization of charges. This creates an overall negative charge and deflocculation occurs. The dispersion or deflocculation of clay particles result in the formation of a thin and impermeable filter cake. The formation of thin and impermeable filter cake resists excess fluid loss to wellbore formation. The synthetic fluid loss polymers used in thisoil base mud system also work as secondary viscosifier. The lower fluid loss can also be explained by the fact that a viscous base fluid of mud reduces fluid loss. This proves that the used polymers are stable up to or perhaps above 400 ºF. The addition of Polypeptide nanotubes to the base further enhanced the fluid loss properties. Polypeptide nanotubes not only reduced fluid loss but also filter cake thickness at high temperature and high pressure.Polypeptide nanotubes reduced the fluid loss by physically plugging the nano-sized pores of the filter cake (A.I. El-Diasty). This resulted in a thin impermeable filter cake with reduced fluid loss compared to other two samples. Aluminum Oxide did not show any improvement in fluid loss.

IV. CONCLUSION

In the present period, HTHP well boring is a standard and necessities a liquid with thermally stable rheology, liquid misfortune and other mud properties. This examination demonstrates that a traditionaloil base mud framework can be upgraded by utilizing built engineered polymers, dispersants, and dirt to proficiently withstand a high temperature up to or over 400 ºF. The base definition itself has streamlined rheological solidness and brilliant filtration properties at400 ºF. It is likewise reasoned that similarly helped in warm steadiness, rheological and filtration properties ofoil base mud at high temperature and high pressure. Aluminum Oxide nanoparticles demonstrated a little change in rheology with a restrictive advantage of being hydrogen sulfide forager.

V. RECOMMENDATION

The additional substances related with the base enumerating are ScomiOiltools business manufactured mixes with enhanced rheology reliability and transcendent filtration properties at ultra HTHP conditions. These novel engineered creations and itemizing can be instantly associated with by and by significant HTHP wells the world over. Thisoil base mud structure can be made prevalent inhibitive water base system like KCl/Polymer system, glycol or formate structure for entering responsive shale improvements. It is furthermore recommended to separate destructive or surfactant treated polypeptide nanotubes in oil base mud.

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