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Behaviour of Drilling Fluids on HPHT Well Conditions

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Abstract

Drilling a deep, High Pressure & High Temperature (HPHT) well is expensive, challenging with number of issues. Though Water based mud is cost effective and environmental friendly, its thermal stability is completely deteriorating because of water at elevated temperature starts to react with drill cuttings undesirably leads further drilling put into the trouble whereas oil based mud is suitable at this condition. Low Toxic Oil Based Muds (LTSOBM) such as refined crude oil/ mineral oil overcome all the challenges of water based mud stands by unreactive with the cuttings even the sudden increase in temperature and pressure Yet such as Mineral oil is environmental impact. This experimental study is elaborately discussing the efforts of both muds especially focussing on the major supports of Low Toxic Oil Based Mud under HPHT conditions such as its stability, yield point and various rheologies by bringing the field condition into lab.

Key words: *Oil Based Mud, Water Based Mud, Fluid loss, Yield point, Plastic viscosity.*

1. Introduction:

When the bottom hole of the drilling exceeds more than 150°C and 10,000 psi or the hydrostatic pressure gradient exceeds 0.8 psi/ ft where regular mud fails by degrading from its original composition ultimately reduces the flow of mud at dynamic condition. In water based mud increasing temperature causes to decrease viscosity, by the same time pressure is increased which results in increasing viscosity finally because hydroxide in water reaches above 94 °C starts react with clays in the formation which leads further problem.

1. Thinner can't work efficiently because of contamination which reduces the pH level of mud.
2. Bentonite also starts to flocculate the mud more causes poor hole cleaning, low drill cuttings carrying capacity, fill, stuck pipe etc.,
3. Owing to increasing temperature, the continuous reaction between electrolytes and inhibitors in the mud, the degree of dispersion & flocculation is also continuously changing which leads the mud unstable.
4. Once the mud is degraded, excessive fluid loss may happen which makes thicker mud cake and bore hole becomes much tight. So dragging becomes difficult.
5. Gel strength of the mud is increased uncomfortably which may lead to loss of circulation.
6. Water based mud is highly shale sensitive which leads to unstable the well condition by the form of sloughing. Because Water absorbs the clay and start to swell the well bore.

In oil based mud, Low Toxic Synthetic Oil is preferred as a base liquid for the continuous phase which withstands alone the rheological properties of other additives up to 150° C. By adding inhibitors and other additives for HPHT condition, the mud will tolerate up to 225° C. When encountering HPHT formation with oil based mud, oil won't lose its thermal stability because of its high boiling point elevation which carries other additives with proper function ahead. Mud stays at desirable gel strength by not allowing the drill cuttings to the mud together since wetting agents prevent further reaction of drill cuttings to the mud. The contamination can be controlled by adding primary emulsifiers which keeps the mud always alkaline. Due to clay and oil provides enough viscosity, mud will carry suspend and carry the drill cuttings makes the drilling success. Oil is not to shale sensitive hence no shale inhibitors required additionally. Fluid loss controllers allow the optimum fluid loss from the mud to formatting by forming the thinner mud cake in the side wall of bore where calcium carbonate involved by making bridge from formation to wellbore. The brine solution is added to the mud to keep the formation flux away from wellbore in the salt formation. Oil provides enough lubricity for the excellent drag even in a bit tight hole condition helps in preventing stuck pipe is a major advantage in the pre-eminent pressure zone.

2. The experimental procedure:

The samples are prepared with respective composition and specific time (mentioned in table 1 and table 2) in silversion mixer at 6000 RPM in 25 °C and both are prepared for 16 ppg because HPHT formation in deeper formation.

Table 1: Constituents of oil based mud and its respective functions

S No	Additives	Respective Function
1	Base oil	Provides thermal stability, kinematic viscosity
2	Primary emulsifier	Reduces interfacial tension between water and oil
3	Wetting agents	Reduces interfacial tension & contact angle between liquid and solid in the mud
4	Weighting material	Provides enough pressure to counter current the formation pressure
5	Filtration control additives	Helps to control the fluid loss at elevated temperature
6	Clay	Provides viscosity to carry the drill cuttings
7	Calcium chloride brine	Prevents the well bore from osmosis process
8	Lime	Detoxify the undesirable gases in the drilling
9	Calcium carbonate	Acts as bridging material to ensure the less formation damage
10	Oil/water ratio	Low ratio helps in greater flow of mud

The prepared mud is filled with aging cell and pressurized by 300 – 400 psia range. Now the aging cell is kept in the roller oven for 18 hours at 205 °C. The aged mud is carefully taken away from the oven and released pressure with caution. Further the sample is taken and mixed with heavy duty mixer at 6000 RPM at 25 °C for 30 minutes.

The drilling fluid rheologies such as yield point, API fluid loss, HPHT fluid loss are measured using various lab equipment such as Viscometer, API filter press, HPHT filter press respectively.

Table 2: The sample of water based mud formulation for HPHT condition

S. No	Additives /composition	Range /quantity	Mixing time (min)
1	Bentonite suspension	4 – 5 cp	---
2	Barite (in specific gravity)	2.05	20
3	pH (to be maintained)	10 – 10.5	20
4	Lignite powder	1.5%	30
5	Sufonated asphalt	2%	25
6	Fluid loss additive	1.5%	20
7	Thinner	0.5%	20

Table 3: The sample of oil based mud formulation for HPHT condition

S.No	Function of the additive	Quantity per 1 lab bbl (350 ml)	Mixing time (min)
1	Base oil	135 ml	-----
2	Emulsifier I	8.00 ml	10
3	Emulsifier II	2.00 ml	3
4	Alkalinty	7.0 ml	7
5	Brine (distilled water + (Calcium chloride)	45 ml, 17 gm	20
6	Viscosifier I	18 gm	15
7	Organophillic clay	8 gm	6
9	Fluid loss additive	5.0 gm	4
10	Bridging agent	34.0 gm	7
11	Weighting material	450 gm	20

3. Results & discussion:

Table 4: Results of water based mud and oil based mud formulated in table 1 & 2

S. No	Rheology	Value obtained For water based mud from table 1	Value obtained for oil based mud from table 2
1	Yield point (at 65 ±1 °C)	59	22
2	Plastic viscosity (at 65 ±1 °C)	57 cp	26 cp
2	API fluid loss (at room temperature & 100 psia)	6 ml	Not necessary
3	HPHT fluid loss (at room temperature & 100 psia)	41 ml	4.3 ml

Table 5: Desired specification of rheology value after hot roll as per API

S.No	Rheology	Values for HTHP fluid loss additive test
1	Yield point (at 65 ±1 °C)	20 – 45
2	Plastic viscosity in cp (at 65 ±1 °C)	ALAP
3	API fluid loss in ml (at room temperature & 100 psia)	≤ 6
4	HTHP fluid loss in ml loss (at room temperature & 100 psia)	≤ 30

3.1 Comparing yield points:

The yield point should be maintained in the range under HPHT condition, If the result is lower than the desired range, the drill cutting carrying capacity can be poor drill cuttings can't be transported from the wellbore and the mud cant suspend the released cuttings which leads to fall those into the well. Then the bore hole becomes unstable may cause to stuck pipe. If the result is too high, gelation of the mud becomes high which is the reason for flocculation or the drill cuttings even can't be cleaned inside the annulus or higher gelation may cause for even lost circulation. In the result the water based mud fails.

3.2 Comparing plastic viscosity:

If the plastic viscosity is high, the mud is contaminated with formation salt/ fluid. Either which leads to reduction of pH level of the mud or the drill cuttings started to react with drilling fluid then the hole becomes tighter. All the additives are working efficiently only in the higher pH level. So oil based mud is pretty lower than water based mud

3.3 Comparing API fluid loss:

It is the basic fluid loss and filter cake test to check the quality of mud cake. Generally it is done for water based mud and this test decides whether the mud will tolerate the temperature effect after the hot roll. The failed mud may lead to higher fluid loss and thicker mud cake. Oil is usually high temperature resistance. So this test is not performed for any additives to be added in the mud.

3.4 Comparing HPHT fluid loss:

The test decides quality of filtration control agents function at HPHT condition. If the fluid loss is optimum, the filter cake becomes thinner and desirable which avoids loss of circulation, stuck pipe etc., In the result oil based mud is more effective where water based mud fails.

4. Conclusions:

LTSOBM proves that it is capable of high thermal stability under HPHT condition up to 225°C. It provides the drilling progress more successful than any other muds. The contamination, fluid loss and yield point of the mud are very effective as it is clearly demonstrated in the experiment. Water based mud is completely undesirable and can't bear the condition. Though using LTSOBM is successful technically, the disposal is a major concern especially in the offshore. So Bio degradable – vegetable oils mainly palm methyl ester show the positive results in the experimental purpose, in the near future which will be implemented into the field to overcome the wastage concerns.

References:

[1] Aarrestad S, Blomberg, N.E., Boe, A., Jacobsen, E.A., Melberg B, Evaluation of Ilmenite as Weight Material in Drilling Fluid, SPE Journal of Petroleum Technology V 36(6), pp. 969-974, (1984).

[2] Adam T., Bourgoyne Jr., Keithk. F.S., Martin E.C., and Young Jr., Applied Drilling Engineering SPE Textbook Series, Vol 2, pp. 4082 (1991).

[3] Amani, M. The Rheological Properties of Oil- Based Mud Under High Pressure and High Temperature Conditions, Advances in Petroleum Exploration and Development, Vol 3(2), pp. 21-30. (2012).

[4] Amani M and Al-Jubouri M, The Effect of High Pressures and High Temperatures on the Properties of Water Based Drilling Fluids. Energy Science and Technology, Vol 4(1), pp. 27-33. (2012).

[5] Amani. M and Shadravan A, What Petroleum Engineers and Geoscientists Should Know About High Pressure High Temperature Wells Environment. Energy Science and Technology, Vol 4(2), pp. 36-60. (2012)

[6] Arash Shadravan, Mohammed Al-Jubouri and Mahmood Amani, Comparative Study of Using Oil-Based Mud Versus Water-Based Mud in HPHT Fields, Advances in Petroleum Exploration and Development Vol 4(2), pp. 18-27 (2012).

[7] Bacho J, Bruton J R, and Newcaster J.A, Drilling grade barites now and tomorrow, Industrial Minerals, Vol 472(1), pp. 52-55 (2007).

[8] Coffin G, Patel A.D, Thaemlitz, C.J, and Conn. L, New Environmentally Safe High-Temperature Water-Based Drilling-Fluid System. SPE Drilling & Completion, Vol 14(3), pp. 185-189, (1999).

[9] Ibeh C.S, Investigation on the Effect of Ultra-High Pressure and Temperature on the Rheological Properties of Oil-Based Drilling Fluids. MS Thesis, Texas A&M U., College Station, Texas, pp. 67 – 80 (2007).

[10] T. Hamida, E. Kuru, and M. Pickard, Filtration loss characteristics of aqueous waxy hull-less barley (WHB) solutions Petroleum Science and Engineering, vol. 72, issue 1-2. pp. 33-41(2010).

[11] Liang Dachuan and Ren Mao, Brief analysis of formation protection technology, West-China exploration engineering, Vol14 (7) pp.186-187 (2006).

[12] Tran A, Oil boom and baryte bust, Industrial Minerals, Vol 472(1), pp. 48-51 (2007).