Barite sagging: Polymer Integrated Drilling Mud Design Analysis

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Abstract - *Barite sagging is defined as separating and settling of weighing particles from the drilling fluids. Barite sagging occurs as a result of large density difference in drilling fluids or after the well is left uncirculated for a long time. This is a common problem in HPHT wells leading to wellbore instability; pipe stuck and well control problems. Hence, making corrections in the existing drilling fluids can be a solution to the problem which can save additional costs in case of failure to detect barite sagging. Hence, the study was done to add a new copolymer to invert emulsion drilling fluid in preventing sagging. The analysis of sag tests conducted by [5] B. Salem et. al. 2018 at 200°F to 350°F was done on a newly formulated drilling fluid for HPHT wells. The sag tests were performed with help of vertical and decline (45°) aging cells and were conducted for rheological characteristics and electric stability of the invert emulsion drilling fluid. The results of the tests on the drilling fluid conclude that the wells could be drilled without any sag issues reducing the overall drilling operation cost by reducing the non-productive time in resolving complications due to pipe sticking, wellbore instability or well control issues.*

Key Words: Sagging, Barite, Polymers, Drilling mud, Sag test, Mud design.

1. INTRODUCTION

The drilling fluids are made up of several chemicals and agents added for different purpose. The composition of drilling fluid generally comprises of base fluid, additives, density control agents (weighing agents), fluid-loss control agents, lost circulation material, corrosion and scale corrosion preventors, solvents and lubricants. Of these, the weighing agents play a major role in controlling the density of the drilling fluid that plays a crucial role in removing cuttings from the wellbore, suspending the cuttings, counteracting the formation pressures, formation of mud cake and maintaining wellbore stability. The common weighing agents used are barite, calcite and hematite. Other than these, soluble salts like NaCl, $CaCl_2$ and $CaBr_2$ can be added to drilling fluid in from of aqueous brine. The salts are rarely used as they accelerate the corrosion of the drilling equipment.

When Barite is used as a weighing agent, barite sagging is a common problem when the circulation is halted for a long time in vertical wells, and due to differential settling of barite in high angle wells. However, in dynamic conditions, it can occur due to low annular velocities. Barite sagging is a result of separation of weighing material, which is generally barite, from the liquid phase. This separation causes the low-density mud to move to the top of the borehole and the high-density mud to settle below the low-density mud. Sagging can cause pipe sticking if it is not addressed to for a long time and might result in high drilling costs due to sticking which will increase rig time.

Therefore, this paper aims to design a drilling fluid using several tests by use of polymers that can reduce barite sagging.

1.1 Barite and its Importance

Barite ($BaSO_4$) is insoluble and chemically inactive. Occurrence of barite is in the form vein and gangue mineral in ores of silver, zinc, copper, lead and nickel ([2] Abdou et al. 2018; Arcos, Zhu and Bickel 2008). Barite has a hardness of 2.3 to 3.5 and specific weight of 4.2 to 4.4 and it is known to be the most common weighing agent for drilling fluids till date. However, barite tends to sag, requiring gellants and viscosifiers to keep it in suspension. The drilled cuttings often tend to have the same size as API specified barite and hence, it is difficult to separate those cuttings from the drilling fluid in the solid separation system. ([2] Abdou et al. 2018)

Most of the barite that is mined is utilized in the oil and gas industry for preparation of drilling fluids. Barite causes increases the hydrostatic pressure of the drilling fluid which in turn will balance the formation pressures confronted during drilling. The hardness of barite is such that it will cause minimum damage the drilling tools.

1.2 Causes of and Problems Due to Barite Sagging

While the drilling operations are paused for some reasons, the drill pipes are commonly rotated at slow rates to avoid gelation of drilling fluids and pipe stuck. This low rotation leads to accelerated settling of barite resulting in severe barite sag ([5] Basfar et al. 2018; Bern et al. 2000). ([4] Nguyen et al. 2011, 2014) analyzed the parameters that effect the dynamic barite sag and found out that pipe rotation, annular velocity, eccentricity and inclined angle are the parameters that have an effect on barite sag. It was found by them that if the stress is greater than 12 lb./100 ft^2 under static condition, sagging is absent. They were successful in showing that pipe rotation and annular velocity contribute 21% and 60% respectively in prevention of sagging. Bern 2000; Dye et al. 2006 found that annular velocity of about 30 ft/min stimulates barite sagging.

Sagging can cause drilling and completion problems. Also, the differential hydrostatic pressure gradient can cause pressure control problems. Thick or tight barite beds can result in high torque and drag, pipe stuck, plugged borehole and even lost circulation in worst scenarios.

1.3 How To Overcome Sagging?

It was observed by several tests performed on various samples that the sagging can be minimized when polymers were used. ([5] Basfar et al. 2018) and Maxey 2007 both suggest that a sag factor greater than 0.53 suggests that the weighing material settles down in the drilling fluid.

The designed fluid must be evaluated for barite sag using:

1. Static sag test is helpful in determining the capability of a drilling fluid to keep the weighing material in suspension at specific temperature and time in a static condition.
2. Viscometer sag test (VST) gives a direct indication of sag tendency. It was first proposed by Jefferson 1991 as a well site test having relevance in both, field and laboratory.

Polymers are used to control the pH and to minimize the acidic nature of drilling fluid stabilizing the formation pressure. There are both natural and synthetic polymers where the property differs in each and every case of polymers. The polymers used in the following experiment are PAC, XG and CMC.

2. EXPERIMENTAL PROCEDURE

Table -1: Composition of Samples Used for Experiment

Sample No.	Composition
Sample 1	Water + Barite
Sample 2	Water + Barite + PAC
Sample 3	Water + Barite + XG
Sample 4	Water + Barite + CMC

Fig -1: Sample 1 and Sample 2

Fig -2: Sample 3 and Sample 4

Table 1: Quantity of Substances Used in the Samples

Sr No.	Substance	Quantity
1.	Water	350 ml
2.	PAC	1%
3.	XG	1%
4.	CMC	1%
5.	Barite	5%
6.	Bentonite	5%

Equipments used in the experiment were:

1. Remi stirrer;
2. 6-Speed Viscometer and;
3. Mud Balance.

Fig -2: Remi Stirrer

Fig -3: 6-Speed Viscometer

Fig -4: Mud Balance

1. The prepared samples were measured for their density in terms of specific gravity and ppg with the help of mud balance before and after mixing.
2. After one day, the density was recorded as ρtop before stirring and after the third day similar measurement was done for ρbottom. These two densities were taken into use in the following formula to calculate sag factor:

$$Sag\ Factor = \frac{\rho_{bottom}}{\rho_{top} + \rho_{bottom}} \qquad (1)$$

3. After calculation of sag factor, it was found that only sample 3 and sample 4 had the sag factor in range of 0.45 to 0.53, hence, only these two samples were considered for further test.
4. Also, barite samples with different polymers were observed for two days and allowed to settle without any disturbance.
5. After two days the results were taken as follows:
   - Sample 1 and Sample 2 were settled.
   - Sample 3 and Sample 4 were not settled.
6. To increase the effectiveness of the drilling fluid, 5% of bentonite was added in sample 3 and sample 4. Remi stirrer was used to mix bentonite in the drilling fluid for 10 minutes. For the bentonite containing fluid also, the densities ρtop and ρbottom were measured to calculate the sag factor of the same.
7. 6-speed viscometer was utilised for the measurement of gel strength. The viscometer was used at 600 RPM (θ_{600}) and readings were taken at 2 minutes interval to observe the gel strength. After the gel strength was measured, mud weight was again measured for both samples. The final sag factor calculation was done.

Fig -5: Sample 3 + Bentonite

Fig -6: Sample 4 + Bentonite

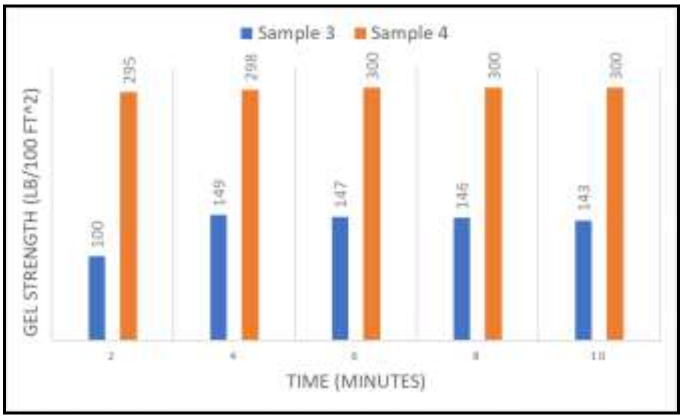

Chart -1: Comparison of Gel Strength

3. RESULTS AND DISCUSSION

i. The barite sag factor must be below 0.53 to control sagging. The sag factor is required to be between 0.45 to 0.53 for sagging to be under control.
ii. The sag test results after 2 days confirm that polymers, XG and CMC, when used in drilling fluid along with barite can help reduce or prevent barite sagging.
iii. After calculating the sag factor for drilling fluid with 5% bentonite, it was observed that sag factor was further reduced indicating good control over sagging. The final sag factor calculation with 5% bentonite reveals a reduced and stabilized sag factor.

4. CONCLUSION

The experimental results suggests that the addition of polymers in the drilling fluid leads to reduced and stabilized sag factor, which is indicative of controlled barite sagging. Hence, the well will be in stabilized condition and barite sagging will be reduced when polymers are added in the drilling fluid. Thus, sagging can be controlled.

NOMENCLATURE

1. XG = Xanthan Gum
2. CMC = Carboxy Methyl Cellulose
3. PAC = Poly Aluminum Chloride
4. ppg = Pounds per Gallon
5. ρ_{top} = Density of drilling fluid at the top of test cell/beaker
6. ρ_{bottom} = Density of drilling fluid at the bottom of test cell/beaker

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