

Effect of KCL on Rheological Properties of Shale Contaminated Water-Based MUD(WBM)

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Received: 12 December 2011 Accepted: 1 January 2012 Published: 15 January 2012

Abstract

Interests in the design of water-based muds(WBM) have escalated due to wellbore instability issues that arise from the abundance of problematic shales encountered while drilling. Conventional water-based muds(WBMs) that are used to drill through water sensitive shale formations cause a high degree of wellbore instability. Consequently, oil based muds(OBMs) were adopted to solve the wellbore instability problems due to their superior shale stabilization properties. Unfortunately, high costs, environmental restrictions, cuttings and used mud disposal difficulties and safety have largely limited the use of OBMs. As a result of these challenges with OBMs, WBMs that have the ability to effectively reduce shale instability problems have once again come under the lime light to replace the OBMs. Potassium-based (KCL)muds are used in areas where inhibition is required to limit chemical alteration of shales. This research study therefore was undertaken to evaluate the inhibition effects of different concentrations of KCL on the rheological properties of water-based mud(WBM) contaminated with shale. The rheological values using FANN viscometer with different concentrations of KCl(0.2

Index terms—

1 Introduction

The art and science of drilling wells require the use of drilling fluids for several reasons including cuttings carrying and maintenance of wellbore stability. Drilling fluid selection is dependent on the behaviour of the formation to be drilled. Shale, the most abundant rock type in the earth interacts variably with the fluids used. Shales are low-permeability sedimentary rocks with small pore radii that characterized by low permeability, medium to high clay content, and medium porosity in addition to other minerals, such as quartz, feldspar, and calcite. Shale types range from soft Gumbo shale in offshore Louisiana, Gulf of Mexico to hard brittle shale in South Louisiana with each type presenting its own set of problems. They account for over 75% of formations drilled all over the world and cause over 90% of wellbore instability problems. The distinguishing features of shale are its clay content and low permeability, which results in poor connectivity through narrow pore throats. Shales are also fairly porous and are normally saturated with formation water, with several factors affecting their properties, such as burial depth, water activity, and the amount and type of minerals present (Joel, et al).

Interests in the design of water-based muds (WBM) have escalated due to wellbore instability issues that arise from the abundance of problematic shales encountered while drilling. Conventional water-based muds (WBMs) that are used to drill through water sensitive shale formations cause a high degree of wellbore instability. Consequently, oil based muds (OBMs) were adopted to solve the wellbore instability problems due to their superior shale stabilization properties. Unfortunately, high costs, environmental restrictions, cuttings and used mud disposal difficulties, and safety have largely limited the use of Oil base muds. Consequently, WBMs that have the ability to effectively reduce shale instability problems have once again come under the lime light to

4 RESULTS AND DISCUSSION

43 replace the OBMs. The limited availability of models to adequately describe shale fluid interaction has hindered
44 the growth of inhibitive WBM development. Models based on chemical potential and hydraulic pressure had
45 been developed by Osisanya (1991), and further work by V Osisanya, et al (1996) have indicated the complexity
46 of theoretical analysis of driving forces and mechanisms that govern shale stability in the borehole.

47 The use of conventional WBMs in drilling shale formations results in the adsorption of water associated with
48 the drilling mud onto the surface of shale (Chenevert 1970). Depending on the shale type, water adsorption
49 may lead to various reactions such as swelling, cuttings dispersion, and increase in pore pressure (Chenevert
50 1973) creating wellbore instability to varying degrees. Common failures that occur from shale instability using
51 conventional WBMs include sloughing, caving, stuck pipe, bit balling and increased torque and drag. These
52 failures can grow into massive expenses due to lost non-productive time. In general, drilling fluid weight and
53 chemical compositions are the elements that are manipulated in order to control such instabilities. However,
54 instabilities in shale may be caused by a complex mechanism of shale drilling fluid interaction ranging from
55 mechanical to chemical reasons (Al-Bazali, 2005). Therefore proper selection of the drilling fluids to be used
56 on a particular well site is an essential phase of any carefully planned drilling operation. When this drilling is
57 expected to encounter shale zones, the selection of the fluid becomes even more important. To maintain a stable
58 borehole through such zones, a carefully designed mud will be required. The design of successful fluids for this
59 type of application depends largely on a knowledge of the physical and mineralogical characteristics of the shale
60 and its behavior when in contact with drilling mud.

61 Potassium-based muds are used in areas where inhibition is required to limit chemical alteration of shales.
62 Potassium performance is based on cationic exchange of potassium for sodium or calcium ions on smectites and
63 interlayered clays. The potassium ion compared to calcium ion or other inhibitive ions, fits more closely into
64 the clay lattice structure, thereby greatly reducing hydration of clays. Potassium-based muds perform best
65 on shales containing large quantities of smectite or interlayered clays in the total clay fraction. Shallow shales,
66 containing large amounts of montmorillonite, however, still swell in a potassium-based system. In recent years,
67 muds containing potassium chloride and a suitable polymer have been the subject of publications from several
68 areas. Laboratory studies of the effects of several salt solutions on the hardness of cores from water-sensitive
69 sands showed that 2% potassium chloride was a more effective stabilizing agent than was 2% calcium chloride or
70 10% sodium chloride.

71 In 1960, while drilling steeply dipping shales in the Cerro Pelado area of Venezuela, noted improved hole
72 stability when mud containing potassium ion replaced the commonly used sodium or calcium ions to inhibit clay
73 swelling. Hole enlargement in the shale section was significantly reduced a result attributed to the inhibitive
74 properties potassium ion and cited in a patent application filed in September 1963. The objective of this
75 work, therefore, is to evaluate experimentally the degree of inhibition of different concentrations of KCl on shale
76 contaminated WBM.

2 II.

3 Materials and Research Methodology

79 341grams of water was measured and poured into the Hamilton mixing cup. 4.0grams of bentonite was added
80 and prehydrated for 30 minutes under stirring condition. After 30 minutes, 0.2grams of xanthan gum, 0.4grams
81 of Pac-R, 0.6grams Pac-L respectively were added to the mixing cup. These with prehydrated bentonite was
82 stirred for 15 minutes before 0.25grams of Soda ash was added and stirred for another 10 minutes. Then 13.0
83 grams of barite was finally added and the mixture was stirred further for another 20 minutes for homogeneity
84 before taking the rheological readings and (10 seconds/minutes) gel strength using VG meter.

85 The mixing procedure was repeated using the grounded sample of shale. Different weights of the shale
86 (1%,2%,4%,7%,10%) respectively by weight of the formulated mud were added. Thereafter, the KCl(0.2%,
87 0.4%,1.0%, 2.0% and 4.0%) by weight of the formulated mud were added respectively. The rheological readings
88 and (10 seconds/minutes) gel strength values were recorded as well. The plastic viscosity and Yield Point values
89 were evaluated as applicable. III.

4 Results and Discussion

90 The results of the various tests are recorded in the tables below. 4.0%) by weight of the formulated mud sample
91 respectively, there was progressive reduction in the rheological values with increase in KCl concentration, no
92 increase for 0.2% KCl, (30cP to 22cP for 0.4%KCL), (32cP to 20cP for 1.0%KCL), (35cP to 18cP for 2% KCL)
93 and (45cP to 16cP for 4%KCL). Test results indicated that the KCl inhibited the swelling tendencies of the shale
94 and the rheological values reduced drastically and considering the 600rpm reading, the percentage reductions were
95 0%, 36%, 60%, 94% and 181% respectively compared to results without KCL in the mud as indicated above.
96 This agrees with previous studies that potassium chloride is very effective stabilizing agent in shale sensitive
97 formation. Fig- ?? shows the Plastic Viscosity result of the mud with different concentrations of the shale. The
98 test result indicated that as the concentration of shales increased, the plastic viscosity increases, however, there
99 was a noticeable reduction in the plastic viscosity values with introduction of KCl.

100 Fig- ?? shows the yield point results with the different concentrations of shale. The highest shale concentration
101 gave the least yield point value. This is an indication of dispersion and settling tendency of the solid particles
102

103 in the mixture. Depending on the shale type, water adsorption may lead to various reactions such as swelling,
104 cuttings dispersion, and increase in pore pressure ??Chenevert 1973) creating wellbore instability to varying
105 degrees. However, the introduction of KCL resulted to reduction in the yield point values.

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Figure 1: Fig 1 :Fig 2 :Fig 3 :Fig 6 :Fig 7 :

107 1

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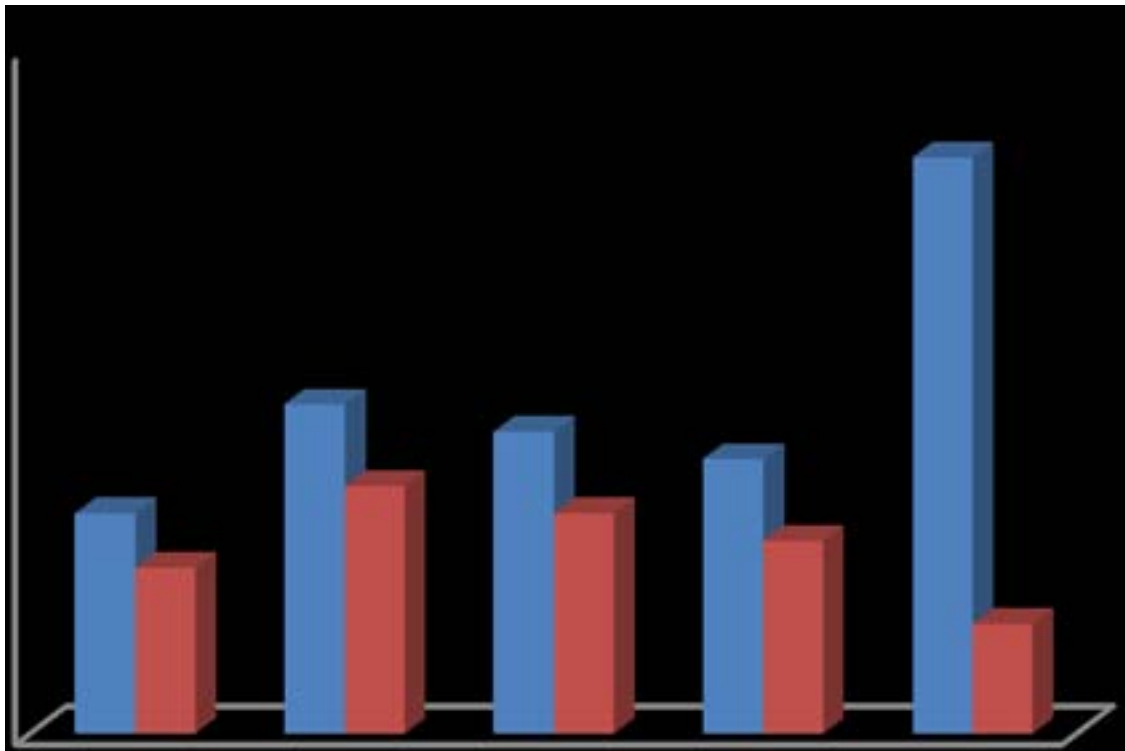


Figure 2:

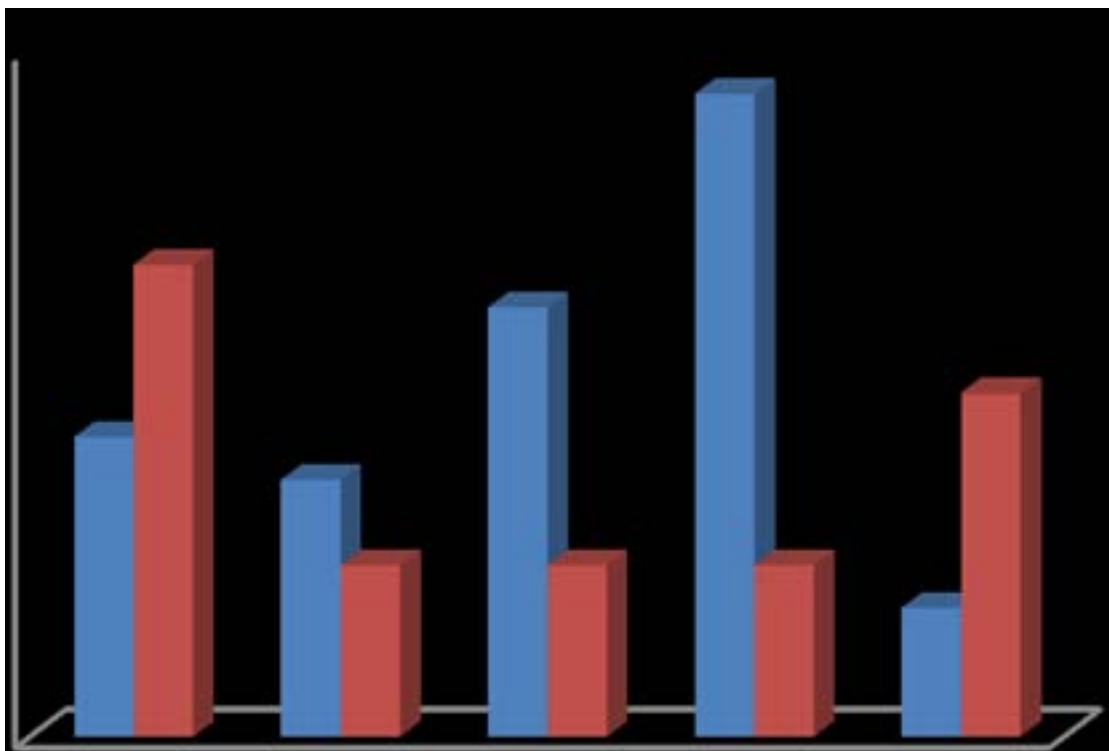


Figure 3: Volume

1

S/N	ADDITIVE(S)	FUNCTION(S)
1	Water	Base fluid
2	Soda Ash	Calcium precipitant and pH reducer in cement contaminated mud
3	Bentonite	Viscosity and Filtration control
4	XCD	Viscosity and Filtration control
5	Par R	Fluid loss control and Viscosifier
6	Par L	Fluid loss control and Viscosifier
9	Barite	Weighting agent
10	KCl	Clay inhibitor

Figure 4: Table 1 :

2

S/N	RPM	DIAL	READING
1	Ø600	21(Cp)	
2	Ø300	14(Cp)	
3	Ø6	2(Cp)	
4	Ø3	2(Cp)	
5	Plastic Viscosity(Cp)	7(Cp)	
6	Yield Point (lb/100Ft 2)	7(Cp)	
7	10Sec Gel strength(lb/100Ft 2)	1	
8	10Mins Gel strength(lb/100Ft 2)	2	

Table 3 : Shale Components

S/N	PARAMETER	RESULT
1	Native moisture content %	13.83
2	Cation Exchange Capacity Meq/100g	2.92

Figure 5: Table 2 :

4

MIXTURE	600 RPM (Cp)	300 RPM (Cp)	6RPM (Cp)	3RPM (Cp)	10sec gel(Cp)	10ming el(Cp)	PV (Cp)	YP (lb/100ft 2)
Mud+1.0% shale	23	15	2	1	1	1	8	7
Mud+2.0% shale	30	18	2	1	1	2	12	6
Mud+4.0% shale	32	21	5	3	4	7	11	10
Mud+7% shale	35	25	11	10	10	10	10	10
Mud+10% shale	45	24	12	11	11	13	21	3

Figure 6: Table 4 :

5

MIXTURE	600 RPM (Cp)	300 RPM (Cp)	6RPM (Cp)	3RPM (Cp)	10sec gel(Cp)	10min el(Cp)	PV (Cp)	YP (lb/100ft ²)
Mud+1.0% shale+0.2%KCl	23	17	2	1.5	2	3	6	1
Mud+2.0% shale+0.4% KCl	22	13	2	1	1.5	2	9	4
Mud+4.0% shale+1.0%KCl	20	12	2	1	1	2	8	4
Mud+7% shale+2.0% KCl	18	11	2	1	1	2	7	4
Mud+10% shale+4.0% KCl	16	12	3	2	2	3	4	8

Figure 7: Table 5 :

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13.83% and Cation exchange capacity of
2.92Meg/100g.

Figure 8: Table - 1

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