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Analyses of Fluids Used in Gravel Pack Placement in Sand Control Operations

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Abstract

Gravel pack fluids for proppant transport in sand control operations have been analyzed. The two fluids considered have been Xanthan and HEC. Laboratory experiment was conducted on the two fluids to determine their capabilities as carrier fluids. 30Lbs/Mgal and 40Lbs/Mgal of both fluids were considered using Trigonox A-W70 as breaker fluid. The result shows that Xanthan withstood more of the breaker fluid than HEC in terms of sand settling and breaker time. HEC broke at lesser time than Xanthan making Xanthan more capable to hold proppant at downhole conditions while transporting to target depth. The combined analyses of the breaking time, the sand settling capability, the plastic viscosity and pH makes Xanthan more preferable as a gravel pack fluid than Xanthan. However, HEC shows more ease of release of proppant once target depth is reached. Effect of proppant release and cost of proppant supports the choice of HEC as a gravel pack fluids. For optimized operation the combined use of HEC and Xanthan is recommended at calculated depth and downhole condition.

Key words: Gravel pack fluids; Sand control; Xanthan; Proppant

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INTRODUCTION

Sand production (or sanding) is the production of the formation sand alongside with the formation fluids (gas, oil and water) due to the unconsolidated nature of the formation. Produced sand has essentially no economic value. On the contrary, formation sand do not only plug wells to reduce recovery rates, it also erode equipment and settle in surface vessels. Controlling formation sand is costly and usually involves either slowing the production rate or using gravel packing or sand-consolidation techniques. As a result of this, sand production is a major issue during oil and gas production from unconsolidated reservoirs. This effect is a peculiar problem of the Niger Delta oil province which describes the Niger Delta very complex in its geology. Sand production is initiated when the formation stress exceed the strength of the formation (Carlson etal, 2002). The formation strength is derived mainly from the natural material that cements the sand grains, but the sand grains are also held together by cohesive forces resulting from immovable formation water (residual water). The stress on the formation sand grains is caused by many factors notably; tectonic actions, overburden pressures, pore-pressures, stress changes from drilling, and drag forces on producing fluids. (Appah, 2001). The methods/techniques that is being used to control sand in formations producing sand can be grouped as mechanical, chemical or combination methods.

Fitzsimons et al (2008) provides further evidence that the association does not require xanthan to be in the disordered form. These workers, how-ever, demonstrated that stronger gels are formed after heating to 95 ◦C.

The objective of the study is to analyze the effects of carrier fluids in the accurate placement of gravels in sand control operations. With physical properties as well as the chemical properties of several carrier fluids in sand control is analyzed in relation to the condition of the well and the reservoir and also the types of formation fluids. It is pertinent to note that these fluids may behave differently under these conditions and as such affects its rheology and its ability to ensure accurate placement of gravels in sand control operations.

1. METHODOLOGY-EXPERIMENTAL TEST

1.1 Gravel Pack Fluid Tests

The following tests are the fundamental test performed for gravel pack fluids

1.1.1 pH

It is necessary to perform pH test for gravel pack fluids. This is because some fluids function at special pH mediums, like the HEC gel is suited for acidic mediums while the Xanthan can actually be used for a variety of pH ranges. Most operators do not want an acidic pH which is while a pH range of near neutral or slightly alkaline is usually employed.

pH adjusters are usually implored to adjust the pH of gravel packing fluids. pH strips are used for a quick pH check. But a more accurate measurement is obtained by using pH meters.

1.1.2 Apparent Viscosity Test

The apparent viscosity of gels is determined using the Fann 35 viscometer. A direct viscosity reading in centipoise is obtained by taken the 300rpm reading of VG metres with F1 spring, B1 bob and R1 rotor.

1.1.3 Sand Settling Test

This is a test that monitors how well a fluid suspends sand. A significant challenge is the transportation of sand or proppant from surface to remote location downhole. Part of the criteria used to select good fracturing, gravel packing is their ability to transport and suspend solids. This test standardizes on preparing 10ppg gel/slurry sand.

1.1.4 Gel Break Test

This is to determine the breaker concentrations required to degrade the gravel packing gel. This can be done using the static or dynamic break test method. The gel is considered broken when viscosity of 10cp or less is obtained for dial reading of Fann 35. Fann 50 is usually used for tests with temperatures above 200oF.

Water analysis

Source water should be quality-tested, most especially before it is used for fracturing jobs. Typical water analyses performed in the laboratory may be grouped as follows:

- 3 part analyses: pH, chlorides and specific gravity
- 7 parts analyses: include the above plus potassium, Calcium, resistivity and total dissolved solids (TDS).
- Scaling tendency analyses: include the above plus iron, magnesium, Barium and sulphates.

Test for bacteria, reducing agent and phosphates may also be included.

1.2 Experimental Methods

Two gravel pack fluids were used for the experiments performed.

The experiments were performed for pH, apparent viscosity, Gel breaker test and sand settling test using 30lbs and 40lbs both for Xanthan gel and HEC gel respectively.

The experiment description on each fluid is divided into case one and case two cases one is for the 30lbs and the case two is for the 40lbs.

1.3 Materials/Equipment

- Water
- KCl
- Gelling agent (ie WG-37 commonly known as Xanthan biopolymer)
- Iron control agent (Fe-2)
- pH buffer (K-35)
- Gel breaker (Trignox)
- Biocides (BE-6 and BE-35)
- Water bath
- Blender
- Digital weighing scale
- Digital thermometer
- pH meter
- Timer
- Glass wares such as beakers, spatulars, measuring cylinders, weighing bowls
- Graduated jar
- Fann VG viscometer

1.4 Experimental Procedures

1.4.1 pH Test Procedure

- 1000gal of water was measured out and 2% KCl (20gal) was added to it. The pH of the water and the brine formed was measured.
- Then 0.15pptg of BE-6 and 0.15pptg (of BE-35 biocides were added to the brine
- Then 10pptg of Fe-2 (iron control agent was added) to the mixture
- Then the pH of the solution was taken
- Then the 40pptg of the gelling agent which is Xanthan was added
- Then the mixture was stirred and to a time it hydrated or viscosified
- Sodium carbonate was then added to increase the pH to a near neutral value
- The pH of the hydrate solution was taken as final gel pH

1.4.2 The Apparent Viscosity Test

- The hydrated gel was allowed to stand for one hour to allow all the fish eye to dissolve.
- Then the hydrated gel was taken to the VG viscometer and stirred at several RPMs.
- The values of the viscosities for the several rpm was recorded.

The above was done at room temperature. The procedure was repeated for reservoir temperature by placing the gel in a water bath and setting to the desired reservoir temperature

1.4.3 Gel Breaker Test

• 1ml of the Trignox gel breaker fluid was added to 200ml of hydrated gel

• Then the gel was put into the water bath

• The time at which gel was broken was measured

• The viscosity after the gel had be broken was also measured at several rpm

• Sand settling test 31

• I50ml of the gel was measured

• 180g of proppant sand(20-40 carbolyte) was used as the sand.

• The gel was then poured into the proppant and timed

• The sand settles in the gel and at different time the height of clear liquid was recorded.

The test was repeated for 40pptg Xanthan and also it was repeated for 30lbs and 40lbs using HEC gel as gelling fluid and other material remaining the same

The table below gives the material used for the experiment in their various concentrations.

Table 1
Chemicals Used for the Experiments and Their Concentrations

Function of chemical	30LBS/MGAL Xanthan		40LBS/MGAL Xanthan		30 LBS/MGAL HEC		40 LBS/MGAL HEC	
	Chemical	CONC.	Chemical	CONC.	Chemical	CONC.	Chemical	CONC.
Mix fluid	8.85% KCL	1000 GAL	2% KCL	1000 GAL	Fresh water	1000 GAL	8.88% KCL	1000 GAL
Biocide 1	BE-3S	0.15LBS	BE-3S	0.15LBS	BE-3S	NIL	BE-3S	0.15LBS
Biocide 2	BE-6	0.15LBS	BE-6	0.15LBS	BE-6	NIL	BE-6	0.15LBS
Iron control	FE-2	10LBS	FE-2	10LBS	FE-2	10LBS	FE-2	10LBS
Gelling fluid	WG-37	30LBS	WG-37	40LBS	WG-37	30LBS	WG-37	40LBS
pH buffer	K-34	pH 7-8	K-34	pH 7-8	K-34	pH 7.5-9	K-34	pH 8-9
Breaker fluid	Trigonox A-W70	10 -25gpt	Trigonox A-W70	10-25gpt	Trigonox A-W70	0.1-0.5gpt	Trigonox A-W70	0.1-2gpt

2. RESULTS AND DISCUSSIONS

For this paper, there are basically four parametres to be investigated in the choice of the best gravel packed fluid to be used. These parametres are given below

• pH of the fluid at reservoir temperature

• plastic viscosity of the fluid at reservoir temperature

• the sand settling capacities of the fluids with time

• the Gel break time of the various fluids (i.e. 300rpm)

2.1 pH and Plastic Viscoisty of the Fluid

The pH is necessary to determine the range of pH for the fluids to hydrate. For Xanthan pH has no effect on Xanthan because it can be used at any pH ranges. For the case of HEC, it is affected by pH. HEC can only hydrate in alkaline pH range.From the experimental result, the table below summarizes the information for the pH and plastic viscosity for the two gravel pack fluids used ie Xanthan (both 30lbs/Mgal and 40Lbs/Mgal) and HEC (both 30lbs/Mgal and 40Lbs/Mgal).

Table 2
Results for the pH and the Plastic Viscosities of the Fluids

Result description	30 PPG Xanthan	40 PPG Xanthan	30 LBS/MGAL HEC	40 LBS/MGAL HEC
pH of mix Fluid	5.5	5.5	4.81	5.5
pH after adding FE-2	2.18	2.18	2.85	2.39
pH after adding K-34	7.2	7.2	8.68	8.2
Apparent Viscosity	19cp @ 80oF	28cp @ 80oF	29cp @ 82oF	44cp @ 80oF

2.2 Sand Settling Test

The sand settling test gives the degree of proppant settling in the gravel pack fluid with time. This determines the length of clear liquid formed with time for the various gravel pack fluids. The fluid with higher length of clear liquids for the time investigated is less suitable to be used as gravel pack fluids. This is because the fluids has greater tendency to break and give up the proppant in the hole. The higher the clear liquid formed the weaker the fluid's capacity to retain and hold the proppant downhole to the target depth before breaking.

Table 3
Result for the Sand Settling Test

Time (min-utes)	Height of clear liquid above slurry (cm)			
	30 LBS/MGAL XANTHAN	40 LBS/MGAL XANTHAN	30 LBS/ MGAL HEC	40 LBS/ MGAL HEC
0	0	0	0	0
0.1	0	0	1	0.2
1	0.6	0	2.4	1.4
2	1.2	0.1	3.5	2.7
3	1.6	0.2	3.6	3.4
6	2.1	0.4	3.6	3.6

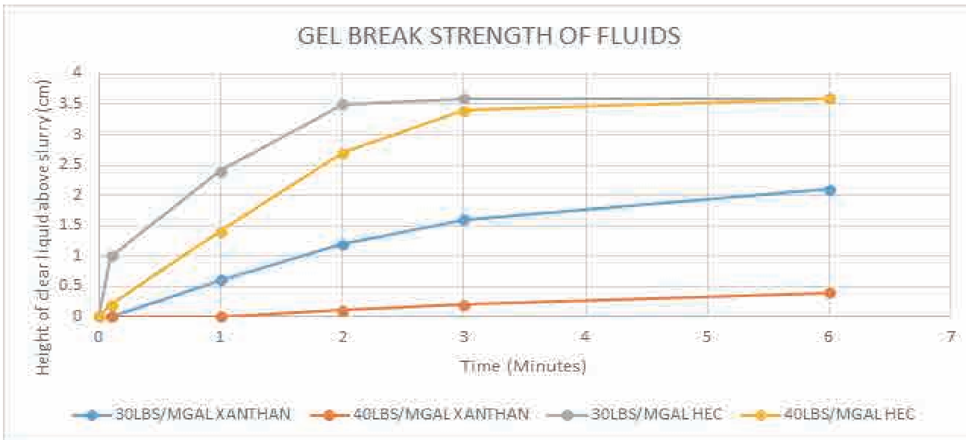

Figure 1
Graph showing fluid strength- height of clear fluid slurry in time

The graph above shows that more additions of Trigonox increases the depth of sand settling as more of the clear liquid is formed. Considering the two fluid, Xanthan has clear liquid appearance with time and thus will hold proppant for a longer time than the HEC during proppant transport.

2.3 Gel Break Time

The Gel break result is done to determine the conditions of speed and revolutions at which the gel will break (i.e. its viscosity will be identical to water viscosity). This is measured at different revolutions and the time for which each fluid breaks is recorded. The gel breaker is added at different concentrations to investigate the stability of the different fluids used with time at different revolutions of the viscosifier.

The table below gives the time at which the viscosity of the fluids is approximately the viscosity of water at 300rpm.

Table 4
Result for Gel Break Time for the Various Fluids

Composition	Break time
30Lbs/Mgal Xanthan and 20 gpt Trigonox	2 hours
30 Lbs/Mgal Xanthan and 20 gpt Trigonox	1 hour 30 minutes
40 Lbs/Mgal Xanthan and 20 gpt Trigonox	Not broken after 3 hours
40 Lbs/Mgal Xanthan and 25 gpt Trigonox	2 hours
30 Lbs/Mgal HEC and 0.1 gpt Trigonox	1 hour 30 minutes
30 Lbs/Mgal HEC and 0.5 gpt Trigonox	1 hour
40 Lbs/Mgal HEC and 0.1 gpt Trigonox	30 minutes
40 Lbs/Mgal HEC and 0.5 gpt Trigonox	30 minutes
40 Lbs/Mgal t HEC and 1.0 gpt Trigonox	30 minutes
40 Lbs/Mgal HEC and 2.0 gpt Trigonox	30 minutes

The table above shows that Xanthan has more resistance to the breaker fluid than HEC. Even at additions of higher concentration of breaker fluid Xanthan fluid broke at higher time than HEC for both quantities considered respectively. This shows that Xanthan will withstand the downhole forces more than HEC when used as gravel packed fluid.

DISCUSSIONS

Four parametres has been considered. For all the parametres Xanthan shows more useful characteristics than HEC for the following reason

- Xanthan is useful at any pH range
- Xanthan has more stability than HEC
- Xanthan has more time to Gel break than HEC.

CONCLUSION

For the research of the study conducted on gravel pack fluid used 30ppt and 40ppt the following conclusion can be drawn

- It is realized that HEC gel can only hydrate at a pH that is alkaline while the Xanthan gel does not have any specific pH rangeto hydrate.
- Xanthan gel breaks in more time than the HEC gel.
- Xanthan shows more useful characteristics as a gravel pack fluid than HEC in all the parametres considered
- HEC has more ability to give up fluid at the desire depth than Xanthan

The Xanthan gel is more recommended than the HEC gel for the following reasons:

- It holds the proppant sand more and does not break as readily as the HEC gel.
- It can be used for any range of pH
- The Xanthan offers more viscoelastic properties than the HEC gel.

But HEC has more capacity to release the proppant sand at the desired location than Xanthan. It becomes problematic also when xanthan is used to the target depth and the proppant is not released at depth with ease. This is where the characteristics of the HEC is require

Furthermore based on cost consideration Xanthan is more expensive than HEC gel. But the Xanthan offers better desirable characteristics and is therefore preferred. A formulation can be formulated using calculated quantities of both fluid o be useful at depth of interest.

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