COMPARISON ON THE FILTRATION PROPERTIES OF THE DRILLING MUD CONTAINING SYNTHETIC LATEX AND COMMERCIAL ADDITIVE

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Received: April 08, 2020; Revised: September 08, 2020; Accepted: November 04, 2020

Abstract

The objectives of this research were to study (1) the physical properties of drilling mud with Styrene-butadiene latex (SBL) as an additive, (2) the effect of SBL proportion and temperature for improving the filtration properties of drilling mud, and (3) compared the filtration properties and cost of drilling mud mixed with SBL, Xanthan gum, and Carboxymethyl cellulose (CMC). The research identified the effect on the rheological and filtration properties of the drilling mud mixed with 0.3, 0.5, 0.7, and 1 percent of weight by volume of SBL, Xanthan Gum, and CMC under ambiance condition at 30, 60, and 80°C, respectively. Physical properties of the mixed drilling mud included viscosity, gel strength, and filtration were investigated according to the API RP 13B-1 standard. The results of filtration properties test indicated that API fluid loss values of SBL, Xanthan gum, and CMC mixed with drilling mud were better than base bentonite mud about 20, 65, and 68% improvement, respectively.

Keywords: SBL, Carboxymethyl cellulose, Xanthan gum, API fluid lossI, Lost circulation additive.

Introduction

In petroleum drilling, the drilling mud is one of the important components in the drilling process due to its use for removing and suspending cutting during drilling well, cool the drill bit and clean during drilling and providing hydrostatic pressure to prevent formation fluids from entering into the wellbore. The drilling mud properties depend on the formation of rock which the drilling mud properties are different due to the ingredients added to drilling mud are called additives. For example, Xanthan gum is a viscosifier. Carboxymethyl Cellulose (CMC) is a filtration loss additive but these additives are a high cost so it is necessary to reduce the cost of additive.

Styrene-Butadiene Latex (SBL) is the most common type of styrene-butadiene emulsion polymer. it is made by the polymerization of different petroleum-based substances known as monomers, styrene, and butadiene. The SBL can be used to increase the filter loss control, gel strength, coating, viscosity, and good adhesion and elasticity property of drilling mud. The SBL has also the ability to provide a latex film or seal on at the surface of the filter cake (Stowe *et al.*, 2004) which the SBL may be capable to apply this new option instead of the expensive additive in petroleum drilling activity further. Therefore, this purpose of the study is to study physical properties of drilling mud with SBL

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as an additive base on the various SBL proportion and temperature, and also compare the filtration properties and cost of drilling mud mixed with SBL, Xanthan gum, and CMC.

Methodology

Drilling Mud Preparation

In this testing, the drilling mud is prepared using 60 g of bentonite, 120 g of barite and 1,000 ml of water were mixed together and various concentrations of SBL, Xanthan gum, and CMC with 0.3, 0.5, 0.7, and 1 percent of weight by volume. The drilling mud compositions are mixed for 10 min using Hamilton Beach. For mixing, these additives are added slowly to an agitated base bentonite mud to avoid a chunk occurring within the mud sample. The formulations of all drilling mud samples are shown in Table 1.

Testing

All of the drilling mud samples were tested in the Suranaree University of Technology laboratory according to the API RP13B-1 standard.

1) Viscosity Tests

Viscosity tests is a measure of internal resistance of drilling mud to flow. Generally, drilling mud has to high enough viscosity to transport the drill cuttings from the bottom hole to the surface. The viscosity is tested by using a Fann 35SA viscometer. The apparent viscosity, plastic viscosity, and yield point are calculated from 300 and 600 rpm readings (API Recommended Practice13B-1, 2003) by using respectively Equations (1), (2), and (3).

$$\text{Plastic viscosity } (\mu_p) = \theta_{600} - \theta_{300} \text{ (cP)} \quad (1)$$

$$\text{Apparent viscosity } (\mu_a) = \theta_{600}/2 \text{ (cP)} \quad (2)$$

$$\text{Yield point } (\tau_y) = \theta_{300} - \mu_p \text{ (lb/100 sq.ft)} \quad (3)$$

The gel strength of the drilling mud can be thought of as the strength of any internal structures which are formed in the mud when it is static. This property demonstrates the ability of the drilling mud to suspend drill solid and weighting material when circulation is ceased. (Benmounah *et al*., 2015). The gel strengths are reported in lb/100 Square foot and are measured by the rotational speed at 3 revolutions per minute (rpm). The first reading is noted after the mud is in a static condition for 10 seconds (Gel_{in}). The second reading will be 10 minutes (Gel_{10min}).

2) Filtration Test

Filtration is tested by using a Fann filter press series 821 which determines the API filtrate loss through standard filter paper and the filter cake thickness under static conditions. All mud samples are tested under 100 psi differential pressure of nitrogen. The purpose of the filtration test is to

Table 1. Compositions of drilling mud mixed with SBL, Xanthan gum, and CMC

Component of mud	Base mud	Base+0.3% *SBL*	Base+0.5% *SBL*	Base+0.7% *SBL*	Base+1.0% *SBL*
Water (ml)	1,000	1,000	1,000	1,000	1,000
Bentonite (g)	60	60	60	60	60
Barite (g)	120	120	120	120	120
SBL (g)	-	3	5	7	10
Xanthan gum (g)	-	3	5	7	10
CMC (g)	-	3	5	7	10

Table 2. The viscosity of drilling mud samples

Temperature (°C)	Mud composition	Apperent viscosity (μ_a)(cP)	Plastic viscosity (μ_p)(cP)	Yield point (τ_y) (Ib/100 sq.ft)	Gel_{in} (Ib/100 sq.ft)	Gel_{10min} (Ib/100 sq.ft)
30	Bentonite Base	14.8	7.3	15.0	9.0	12.0
	0.3%*SBL*	17.7	5.0	25.3	15.0	20.0
	0.5%*SBL*	19.2	7.7	23.0	16.0	23.0
	0.7%*SBL*	22.0	8.3	27.3	17.0	25.0
	1.0%*SBL*	26.0	8.7	34.7	22.0	29.0
60	Bentonite Base	16.8	6.7	20.3	12.0	15.0
	0.3%*SBL*	20.5	7.0	27.0	17.0	22.0
	0.5%*SBL*	22.0	7.7	28.7	18.0	26.0
	0.7%*SBL*	24.5	8.0	33.0	21.0	27.0
	1.0%*SBL*	28.0	8.3	39.3	24.0	29.0
80	Bentonite Base	21.5	5.3	32.3	16.0	19.0
	0.3%*SBL*	24.8	6.7	36.3	21.0	26.0
	0.5%*SBL*	28.3	7.3	42.0	22.0	31.0
	0.7%*SBL*	28.8	7.7	42.3	25.0	32.0
	1.0%*SBL*	29.7	8.3	42.7	30.0	37.0

simulate the fluid loss invaded through borehole formation.

Results and Discussion

Viscosity of Drilling mud

The apparent viscosity, yield point, gel strength, and plastic viscosity implied the drill cutting transportation ability of drilling mud. The viscosity results of drilling mud mixed with SBL are summarized in Table 2. The results revealed that drilling mud mixed with SBL increased the apparent viscosity, yield point, gel strength, and plastic viscosity. Therefore, the addition of SBL was concluded that can be enhanced the rheological properties. Analyze of the thermal effect indicated that the apparent viscosity, gel strength, and yield point increased as temperature increased while plastic viscosity tended to decrease when the temperature increased. The reason for the increase of the apparent viscosity, gel strength, and yield point was the higher temperature affected the clay particle was agglomerated (Luckham and Rossi, 1999).

The apparent viscosity was the measure of the resistance to flow caused by mechanical friction between solids in the drilling mud (Donald, 2020). The comparison of the apparent viscosity of drilling mud mixed with SBL, Xanthan gum, and CMC is shown in Figure 1. The results clearly showed that the drilling mud mixed with SBL, Xanthan gum, and CMC increased the apparent viscosity when compared to base bentonite mud. We can explain that the addition of SBL, Xanthan gum, and CMC increased the amount of solids particle and friction between solids particles. The comparison results for the apparent viscosity of drilling mud mixed with SBL, Xanthan gum, and CMC illustrated that the apparent viscosity value of drilling mud mixed with Xanthan gum was higher than drilling mud mixed SBL and CMC in all concentration.

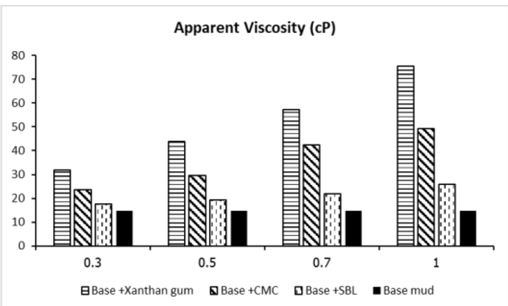

Figure 1. Comparison of the apparent viscosity of drilling mud mixed with SBL, Xanthan gum, and CMC

Figure 2 represents the comparison results for plastic viscosity of drilling mud mixed with SBL, Xanthan gum, and CMC. The results of plastic viscosity of the drilling mud increased as SBL, Xanthan gum, and CMC concentrations in the drilling mud increased. Nevertheless, it was remarked that plastic viscosity decreased with 0.3%SBL, behind 0.5% SBL concentration, plastic viscosity was an uptrend. The comparison results exhibited that the plastic viscosity value of drilling mud mixed with SBL was lower than drilling mud mixed with Xanthan gum and CMC in all concentrations. Previously, many researchers reported that the low plastic viscosity provided that the drilling mud can drill rapidly because of the low viscosity of drilling mud that was exiting the bit (Sukkatorn *et al*., 2017). Thus, drilling mud mixed with SBL can drill faster than drilling mud mixed with Xanthan gum and CMC.

The yield point implied the ability of the drilling mud to carry cuttings out of the annulus to the surface**.** The comparison of the yield point of drilling mud mixed with SBL, Xanthan gum, and CMC is shown in Figure 3. The results indicated that the yield point clearly increased as SBL, Xanthan gum, and CMC concentration increased. The drilling

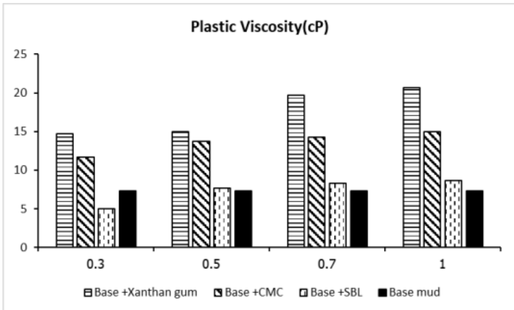

Figure 2. Comparison of the plastic viscosity of drilling mud mixed with SBL, Xanthan gum, and CMC

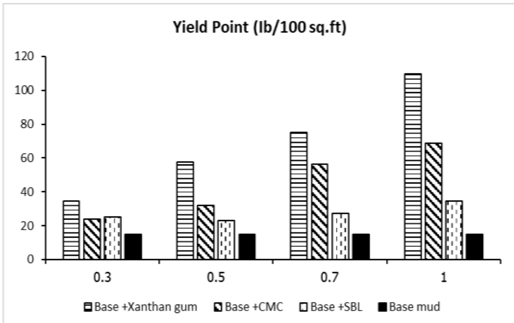

Figure 3. Comparison of the yield point of drilling mud mixed with SBL, Xanthan gum, and CMC

mud with a higher yield point carried cuttings better than a drilling mud of similar density but lower yield point (Rachain, 2016). Therefore, the drilling mud mixed with SBL, Xanthan gum, and CMC can be enhanced the carrying capacity of drilling mud. The comparison results with all three additives revealed that the yield point value of drilling mud mixed Xanthan gum was the highest in this research.

The comparison of the ten minutes gel strength of drilling mud mixed with SBL, Xanthan gum, and CMC is shown in Figure 4. The results showed that the ten minutes gel strength of the drilling mud mixed with Xanthan gum, SBL, and CMC respectively was high efficiency with more than base bentonite mud. As mentioned above, the gel strength of Xanthan gum demonstrated the high ability of the drilling mud to suspend drill solid and weighting material when circulation was ceased. Therefore, all three additives can be enhanced the suspending cutting efficiency of drilling mud.

Filtration Properties

The filtrated loss of base bentonite mud at the temperature of 30, 60, and 80°C is shown in Figure 5. The graphs showed the relationship between filtration loss behavior and the increasing time. The results exhibited that the filtrate loss increased as time and temperature increased. API filtrated loss of drilling mixed with SBL versus various concentrations of SBL at 30 min is shown in

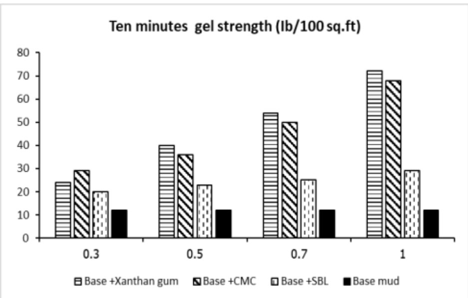

Figure 4. **Comparison of the ten minutes gel strength of drilling mud mixed with SBL, Xanthan gum, and CMC**

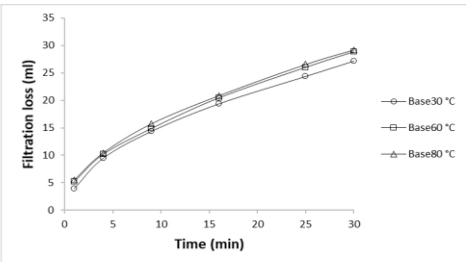

Figure 5. **API filtrated loss versus time of base bentonite mud**

Figure 6. The results indicated that filtrated loss increased according to increasing of temperature and represented that filtrated loss decreased as SBL concentration increased.

The filtrated loss of drilling mud mixed with various concentrations of SBL versus time at 30°C is shown in Figure 7. The results represented that all of the API fluid loss of drilling mud mixed with SBL reduced about 20 percent when compared to base bentonite mud. The particle of SBL distributed over the filter cake and SBL also can build up the thin latex film at filter paper. The filtrated loss of drilling mud mixed with various concentrations of CMC versus time at 30°C is shown in Figure 8. The results

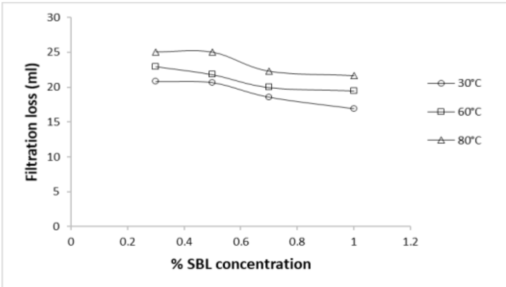

Figure 6. **API filtrated loss of drilling mixed with SBL versus various concentrations of SBL at 30 min**

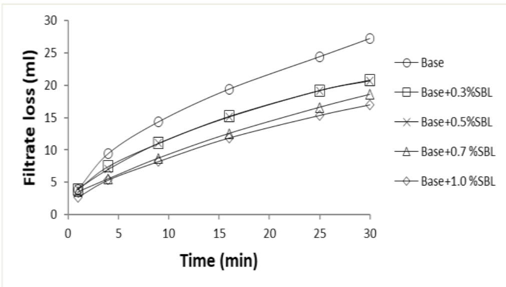

Figure 7. **API filtrated loss of drilling mud mixed with various concentrations of SBL versus time at 30°C**

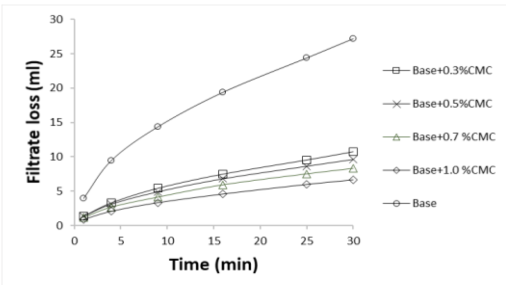

Figure 8. **API filtrated loss of drilling mud mixed with various concentrations of CMC versus time at 30°C**

clearly saw that the drilling mud mixed with CMC was better than based bentonite mud. The CMC showed excellent improvement in the filtration properties because CMC had excellent water retention properties. The drilling mud mixed with CMC reduced about 68% improvement. The filtrated loss of drilling mud mixed with various concentrations of Xanthan gum versus time at 30°C is shown in Figure 9. The graphs showed that the drilling mud mixed with Xanthan gum was also better than based bentonite mud**.** The drilling mud mixed with Xanthan gum reduced about 65% improvement which the reason for the decrease of filtrated loss because xanthan gum had a very high viscosity and it had the ability to make the drilling mud into the gel. The result of Figure 10 shows the comparison of the API filtrated loss of drilling mud mixed with 1.0% of SBL, Xanthan gum, and CMC versus temperature at 30 min. The graphs showed that the SBL, Xanthan gum, and CMC reduced filtrated loss. However, drilling mud mixed with 1.0% of CMC concentration at all temperatures was the best filtration loss additive in this study.

Mud cake thickness of drilling mud mixed with 1.0% of SBL, Xanthan gum, and CMC is shown in Figure 11. The filter cake properties of drilling mud mixed with additives were better than base bentonite mud such as toughness and slickness.

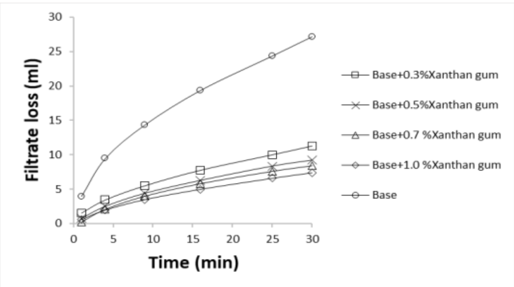

Figure 9. API filtrated loss of drilling mud mixed with various concentrations of Xanthan gum versus time at 30°C

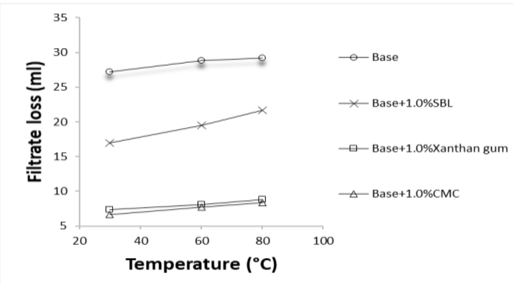

Figure 10. API filtrated loss of drilling mud mixed with 1.0% of SBL, Xanthan gum, and CMC versus temperature at 30 min

The graphs indicated that these additives also can decrease the filter mud cake thickness which they can protect the stuck pipe problem of the drill string. Usually, a good mud cake has to high enough thickness, and there is low permeability to prevent the formation of damage and fluid invasion into reservoir rocks.

Cost Analysis

In general, drilling muds are expensive, and the cost of drilling mud may represent about 15 percent of the total cost of petroleum well drilling. Therefore, the calculation and comparison of the costs of SBL with fluids commercially used in drilling systems are necessary. Table 3 exhibits the costs of chemicals used in drilling fluids to evaluate the cost of drilling fluid systems. The cost of drilling mud mixed with SBL is cheaper than base bentonite mud with another commercial additive. This will help to reduce the cost of additives in drilling activity further.

Conclusions

Based on the laboratory experiments and data analysis carried out in this study. In summary, the drilling mud mixed with various SBL, Xanthan gum, and CMC concentration can reduce the filtrated loss into the formation of 20, 65, and 68% improvement, respectively. The effect of temperature demonstrated that the increasing temperature resulted to increase filtrated loss of all drilling mud samples. The addition of SBL to

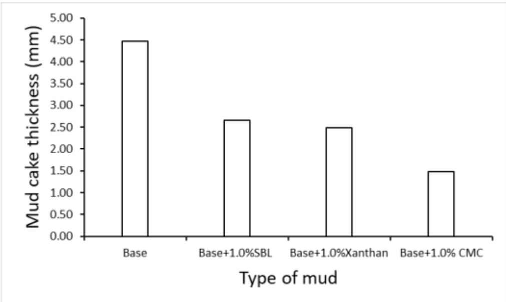

Figure 11. Mud cake thickness of drilling mud mixed with 1.0% of SBL, Xanthan gum and CMC at 30°C

Table 3. Cost of drilling mud chemicals

Chemicals	Cost (Baht)	Unit (kg)	Cost/kg (Baht/kg)
Xanthan gum	320	1	320
CMC	200,000	1,000	200
SBL	57	1	57

drilling mud improved rheological properties. The effect of the SBL proportion indicated that the increasing proportion improved the filtration properties which drilling mud mixed with 1% of SBL concentration at all temperatures represented good filtration properties for water-based mud in this study. Moreover, the cost of the SBL was cheaper than the cost of Xanthan gum and CMC about 82% and 72%. Therefore, the SBL can be another option for additives in drilling activity further. However, if compared to the filtration properties of the drilling mud mixed with SBL and the drilling mud mixed with Xanthan gum and CMC showed that the performance of Xanthan gum and CMC was still higher than SBL.

Acknowledgments

This research has been supported by the Kittibundit scholarship from Suranaree University of Technology (SUT). The author is also thankful to all of the staffs of the SUT laboratory for allowing using analysis equipment and advice.

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