International Journal of Science and Engineering (IJSE)

Home page: http://ejournal.undip.ac.id/index.php/ijse

Agarwood Waste as A New Fluid Loss Control Agent in Water-based Drilling Fluid

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Abstract - Agarwood has been used widely in various ways, including traditional medicine and art. The usage of agarwood has grown broader in modern times include in therapeutic medicines and perfumery. In this paper the agarwood waste has been explored to be used as a fluid loss control agent to control fluid loss without affecting the drilling fluid rheological properties which are density, pH, viscosity, yield point and gel strength. Agarwood waste was used as an additive in the drilling fluid system due to its unique characteristic. Rheological and filtration measurements were performed on the formulated water-based drilling fluid. Formulations of a base solution of fresh water, sodium hydroxide, bentonite, barite, and xanthan gum were presented. The performance of the agarwood waste as the fluid loss control agent was compared with based fluid formulation and water-based drilling fluid with treating with conventional fluid loss control agent (starch). The filtrate volume of drilling fluid with agarwood waste was about 13 ml while for drilling fluid with conventional fluid loss control agent, starch gave 12 ml of filtrate volume after undergoing filtration test by using LPLT filter press. The performance of drilling fluid with agarwood was efficient as drilling fluid with starch.

Key words - Fluid loss control agent, water-based drilling fluid, rheological test, filtration test and agarwood.

Submission : September 15, 2013 Corrected : October 10, 2013 Accepted: October 14, 2013

Doi: 10.12777/ijse.5.2.101-105

How to cite this article: Azizi, A., Ibrahim, M.S.N., Hamid, K.H.K., Sauki, A., Ghazali, N.A., Mohd, T.A.T. (2013). Agarwood Waste as A New Fluid Loss Control Agent in Water-based Drilling Fluid. *International Journal of Science and Engineering*, 5(2),101-105. Doi: 10.12777/ijse.5.2.101-105]

Introduction

Drilling fluid is a system that contains water, oil/gas and chemical additive. The drilling fluid can be divided into three type which are water-based drilling fluid, oil-based drilling fluid and gas-based drilling fluid [1]. Drilling fluid performs some critical function such as preserve wellbore stability and provides information of the wellbore. Another function of the drilling fluid is transport cutting to surface and normally act as cooler agent for drill bit [2]. The water based drilling fluid is used widely in the area where the oil-based is prohibited due to some reasons such as cost, environmental problem and logistics [3]. The drilling fluid may loss to formation the fluid encounter porous formation normally while drilling [4]. Fluid loss while drilling is a complex process where most of the fluid is lost underneath the bit [5] [6]. This loss is due to formation damage. Formation damage can happen anytime during well life and normally occur during drilling operations, well completion, production, stimulation, kill or workover operations. The main cause of this problem is external solid entrainment which is invasion of fluid into formation which is known as lost circulation.

The loss circulation problem can be defined as the partial or complete loss of drilling fluid or cement slurries into formation voids [7]. The condition when the problem considers as partially lost-circulation is when only some drilling fluid return to the surface while total loss-circulation is the drilling fluid totally loss to the formation which means no return to surface [2]. The loss circulation term also can be defined as the loss of fluid to the formation either drilling fluid or cement slurries [8]. The detrimental effects from the loss circulation problem are lost of rig time, stuck pipe, blowouts, and frequently, the potential well for high rate of production goes to abandonment stage without production [7]. One of the best practice in industry is introducing the fluid loss control agent in the drilling fluid system that help to accelerate the formation of filter cake and therefore control the overflow of drilling fluid into the formation pores [9]. An initiative is taken to prove the potential of agarwood waste as new fluid loss control agent in the formulation of water based drilling fluid rather than using the conventional fluid loss control agent which is starch. The drilling fluid with agarwood waste as fluid loss

additive shows the positive results since total fluid loss is less in comparison to the base fluid.

Materials and Methods

Materials

Laboratory testing had compared the performance of the agarwood waste product to base fluid system without using fluid loss control agent and the base fluid system with conventional fluid loss control agent. A formulation of a base solution of fresh water, sodium hydroxide, bentonite, xanthan gum and barite was performed (Formulation 1) [10]. Each test sample was prepared by using same based fluid composition and undergo rheology and filtration test as shown in Table 1.

Table 1: Formulation 1 - Base fluid composition

Additive	Quantity
Fresh Water	350 ml
Sodium Hydroxide (NaOH)	1.0 g
Bentonite	6.0 g
Xanthan Gum	0.7 g
Barite	130 g

Formulation 2 was done by adding conventional fluid loss control agent (starch) in order to see the performance of the drilling fluid on fluid loss aspect. In formulation 3, the starch was replaced by agarwood waste as a fluid loss control agent as an improvement of the drilling fluid system. The formulation 2 and formulation 3 were shown in Table 2 and Table 3.

Three other drilling fluid samples using formulation 3 (sample A, sample B and sample C) were prepared in order to analysis the effect of agarwood size distribution of fluid loss control. The weight percentage of the agarwood waste of 45 micron size and 90 micron size was shown in Table 4.

Table 2: Formulation 2 – Drilling fluid composition with starch

Additive	Quantity
Fresh Water	350 ml
Sodium Hydroxide (NaOH)	1.0 g
Bentonite	6.0 g
Starch	6.0 g
Xanthan Gum	0.7 g
Barite	130 g

Table 3: Formulation 3 – Drilling fluid composition with agarwood waste

Additive	Quantity
Fresh Water	350 ml
Sodium Hydroxide (NaOH)	1.0 g
Bentonite	6.0 g
Agarwood waste	6.0 g
Xanthan Gum	0.7 g
Barite	130 g

Table 4: Agarwood waste samples weight percentage for fluid formulation

Sample	Agarwood waste (45 micron size)	Agarwood waste (90 micron size)
A	25%	75%
B	50%	50%
C	75%	25%

Methodology

Preparation of Agarwood

The agarwood waste has gone through a few processes before adding into the drilling fluid system. The agarwood waste was ground into smaller pieces and then separated into 45 micron size and 90 micron by using a sieve shaker. The 45 micron size was classified as fine size while 90 micron was classified as medium size [11]. The sample of raw agarwood waste is shown in Figure 1(a) and Figure 1(b) shows the sample of the agarwood waste after grinded.

(a) **(b)**

Figure 1: The sample of agarwood waste (a) before and (b) after grinded

Mixing procedure

Each additive was added into fresh water steadily. The mixing procedure for water-based drilling fluid samples during the test was shown in Table 5. The mixture of fresh water and additives were stirred by using Mixer-Hamilton Beach Mixer. Six water-based drilling fluid samples were prepared with one laboratory barrel volume (350ml) each. The samples of drilling fluid with agarwood were shown in Figure 2.

Table 5: Mixing Procedure

Additive	Mixing Time	Mixing Speed	Property
Fresh Water	-	-	Base fluid
Sodium Hydroxide (NaOH)	3 minutes	low	Alkalinity
Bentonite	10 minutes	medium	Viscosifier
Xanthan Gum	10 minutes	medium	Viscosifier
Agarwood waste	10 minutes	medium	LPLT Filtration
Barite	12 minutes	high	Weighting agent

Figure 2: The sample of drilling fluid with agarwood waste

Rheological Test and Filtration Test procedure

Procedure for rheology and filtration test were based on API recommended standard (API-RP 13B-1 2009) [12]. The density of the drilling fluid samples was measured by using mud balance. The rheological properties of drilling fluid which are viscosity, gel strength and yield point were measured by using Viscometer. The pH of the drilling fluid was determined by using pH meter. For the filtration test, the LPLT filter press was used in order to determine the amount of filtrate loss of the drilling fluid samples.

Results and Discussion

The effect of agarwood waste on the rheological properties of water-based drilling fluid

The water-based drilling fluid rheological properties analyzed include density, pH, plastic viscosity (PV), yield point (YP), and gel strength. The results of the theological test were tabulated in Tables 6.

Density. The mud weight usually reporting in pound per gallon (ppg or lbs/gal) unit [13]. The standard mud weight should be 9.8 to 10.5 lbm/gal [14]. Other than that, the suggested mud weight for water-based drilling fluid was 11.0 ppg [15]. The result of the experiment shows that the density of the drilling fluid sample containing agarwood waste was the lowest, 9.5 ppg compared to a base fluid formulation, 10.3 ppg and base fluid with the addition of starch, 10.7 ppg. It reveals that the presence of the agarwood waste as the fluid loss control agent will reduce the density of the water-based drilling fluid. The important to control the mud weight within the range to avoid serious problem such as well kicks, formation fracturing and led to higher drilling cost [13].

Table 6: Rheological and Filtration properties

	Base fluid	Base fluid + starch	Base fluid + Agarwood waste
Mud Weight, ppg	10.3	10.7	9.5
pH	11.4	11.2	11.9
PV, cP	18	14	16
YP, lb/100ft^2	19	11	22
Gel, lb/100ft^2			
10'	9	6	9
10"	10	10	12

Drilling fluid pH. The optimum range pH is between 8.0 and 10.5 for water-based drilling fluid [16]. The pH should be in alkaline range in order to minimize the corrosion effect and will cause problems to drilling equipment [16]. The pH value of all the drilling fluid samples were within the ranges which is.

Rheological Test. Viscosity can be defined as the internal resistance of a fluid to flow. The viscosity of the drilling fluid containing starch shown the lowest reading which is 14 cP. The viscosity of base fluid and drilling fluid with agarwood waste samples does not vary in big value which is 16 cP for samples containing agarwood waste and 18 cP for base fluid sample. The presence of agarwood waste in the drilling fluid system had increased the yield point. Yield point can defined as the initial resistance to flow. The drilling fluid with high yield point gave a better performance in carrying cutting compared to the low yield point of drilling fluid of same mud weight [17]. The 10' and 10" gel strength result shows the presence of agarwood waste had increased its gel strength value. Gel strength shows the strength of attractive forces in the drilling fluid which is gelation properties under static condition. Excessive gelatin may be caused by high solids concentration [16].

The effect of agarwood waste as fluid loss control agent on the filtration properties of water-based drilling fluid

The filtration properties of water-based drilling fluid was tested by using LP-LT filter press. The filtration properties of drilling fluid were very important in determining the performance of the drilling fluid in prevention loss circulation problem. To manage the loss circulation problem, fluid loss additive had been introduced into the drilling fluid system. This additive will seal the permeable formations and prevent the fluid from drilling fluid loss to formation [15].

Filtration Test. The filtrate volume of the formulated drilling fluid samples (base fluid, base fluid + Starch and base fluid + agarwood) was shown Figure 3.

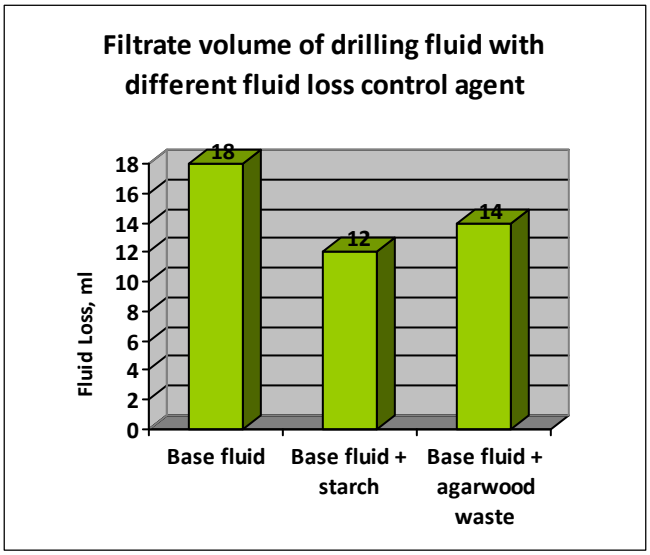

Figure 3: Fluid loss of both drilling fluid samples after the filtration process

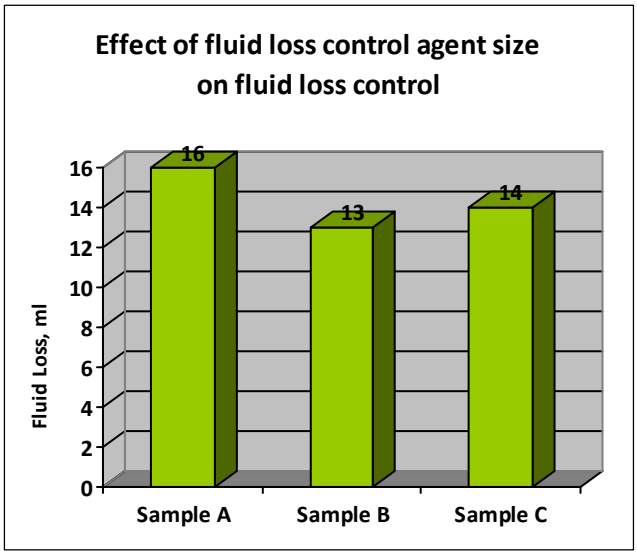

Figure 4: Filtration result of drilling fluid with agarwood waste as fluid loss control agent – Sample A (25% - 45 micron, 75% - 90 micron), sample B (50% - 45 micron, 50% -90 micron) and sample C (75% - 25 micron, 75% -90 micron).

The experimental results reveal that the fluid loss of Formulation 2 (Base fluid + starch) shows that the 12 ml and 18 ml fluid loss for base fluid formulation. The drilling fluid with agarwood waste show the result of 14 ml of filtrate volume when undergoes the filtration test. The potential of agarwood waste as a new fluid loss control agent is due to its physical characteristic which is fibrous. The fibrous is one of the fluid loss control agent characteristics [8].

The effect of agarwood waste sizes on filtration results

Further research on agarwood waste was performed. The size of the fluid loss control agent was being another variable. The combined size of the agarwood waste was made based on a weight percentage in Table 4. The sample with equal percentage of 45 micron and 90 micron agarwood gave the lowest filtrate volume when undergoes filtration test as shown in Figure 4. This performance was analysed to be close enough with the drilling fluid that using the conventional fluid loss control agent (starch).

Based on the result of this research, some recommendation were being proposed for future research. Firstly, new future research should proposed best water-based drilling fluid formulation with appropriate fluid loss volume. Based on the formulation, we can see the effect of adding fluid loss additive into the drilling fluid system. Secondly, the comparative performance of conventional fluid loss with new fluid loss control agent in preventing fluid loss should be performed in order to have good comparison data. For example, we can use synthesized modified starch such as Polyanionic Cellulose, carboxy methyl cellulose, and other polymers as fluid loss control additive [9] [18].

Thirdly, the variation agarwood size can be improved. The new researcher can use a smaller size of agarwood size like 25 microns or more bigger agarwood waste size more than 90 microns. This will give more understanding of the effect of fluid loss control agent size on fluid loss control. Apart from that, we can propose a drilling fluid sample with conventional fluid loss control agent and agarwood waste fluid loss control agent in a drilling fluid sample. This may give better results on filtration test. Finally, the scope of this research was only concentrated on low pressure and low temperature reservoir condition. We can propose this research to another extreme reservoir condition which high pressure and high temperature condition, HPHT which reflect to the actual reservoir condition.

Conclusions

Agarwood waste was compatible and can be used to formulate water-based drilling fluid and could be used as a substitute for the conventional fluid loss control agent to control fluid loss in water-based drilling fluid system. Other than that, by comparing the results of three water-based drilling fluid samples, the sample with the addition of agarwood waste as the fluid loss control agent gives high plastic viscosity, yield point and gel strength. Apart from that, drilling fluid sample with agarwood waste as a fluid loss control agent also shows the improvement for prevention of fluid loss. The usage of agarwood waste with different size distribution in the drilling fluid system had improved the fluid loss control. Lastly, the agarwood waste was suitable to use as a fluid loss control agent in water-based drilling fluid. It will be another alternative to the oil and gas industry in promoting safe environment and reduce the dependency on chemical additive and give more focus on biodegradable material such as agarwood waste. Apart from that, the availability of agarwood waste source is large and the cost for getting the waste is cheaper compared to the conventional fluid loss control agent.

Acknowledgements

Thank you to Universiti Teknologi Mara (UiTM) for giving me an opportunity and space to do this research project. I would also like to acknowledge with much appreciation the crucial role of the staff of Scomi Oiltools Sdn Bhd and SSTCM Chemicals Sdn. Bhd for giving permission to use their equipment during my research period and guiding toward the success of this research. A million thank to our sponsor, Research Intensive Faculty Fund (600-RMI/DANA 5/3/RIF (378/2012)) for the financial support throughout this research project.

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