ENHANCING THE RHEOLOGICAL PROPERTIES OF OIL-BASED MUD THROUGH THE INCORPORATION OF POTATO STARCH

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ABSTRACT

Oil-based drilling muds are effective in protecting formation integrity and resisting high temperatures, but additives are necessary to optimize their performance. This study proposes using potato starch as an additive to improve the performance of oil-based drilling mud. Potato starch was chosen because of its ability to act as a viscosifier or thickener that remains unaffected by water salinity. The research involved adding different concentrations of potato starch to a fresh oil-based drilling mud, with two Oil-to-Water Ratio (OWR) ratios, 75:25 and 80:20, employed for the two trials. Rheological testing was utilized to assess the influence of potato starch additives on the viscosity, gel strength, plastic viscosity, and yield point of drilling mud. The findings showed that the incorporation of potato starch in oil-based drilling mud can enhance its rheological values. Using potato starch as an additive offers the potential to tackle wells that have formation conditions that are brittle and sensitive to water and high temperatures. This research provides novel insights into the development of more effective and eco-friendly drilling mud formulations.

Keywords*: drilling mud, oil-based mud, potato starch, rheology, viscosifier*

ABSTRAK

Lumpur pemboran berbasis minyak telah terbukti efektif dalam melindungi integritas formasi dan memiliki ketahanan terhadap suhu tinggi. Namun, untuk mencapai lumpur pemboran yang ideal, diperlukan aditif yang sesuai dengan kebutuhan sumur agar dapat memaksimalkan kinerja lumpur pemboran. Penelitian ini bertujuan untuk meningkatkan kinerja lumpur pemboran berbasis minyak dengan menggunakan pati kentang sebagai aditif. Pemilihan pati kentang didasarkan pada sifatnya sebagai viskosifier atau pengental yang tidak terpengaruh oleh salinitas air. Metode penelitian melibatkan penambahan berbagai konsentrasi pati kentang ke dalam lumpur pemboran berbasis oil baru. Dua perbandingan Oil-to-Water Ratio (OWR) yang digunakan dalam dua kali uji coba adalah 75:25 dan 80:20. Penelitian ini dilakukan melalui pengujian rheologi untuk mengevaluasi pengaruh aditif pati kentang terhadap viskositas, gel strength, plastic viscosity, dan yield point lumpur pemboran. Selain itu, dilakukan perbandingan hasil dengan penelitian sebelumnya untuk memvalidasi hasil yang diperoleh. Hasil penelitian menunjukkan bahwa penambahan pati kentang dalam lumpur pemboran berbasis minyak dapat meningkatkan nilai rheologi. Penggunaan pati kentang sebagai aditif memberikan potensi untuk mengatasi sumur-sumur dengan kondisi formasi yang rapuh dan sensitif terhadap air dan suhu tinggi. Penelitian ini memberikan wawasan baru dalam pengembangan formulasi lumpur pemboran yang lebih efektif dan ramah lingkungan.

Kata kunci: lumpur pemboran, oil base mud, pati kentang, rheologi, viscosifiers

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INTRODUCTION

In a drilling operation, the drilling mud circulation system is an essential component. In the past, water was used as a medium to transport cuttings before the use of complex drilling muds (AT Bourgoyne, 1986). However, due to the increasing complexity of the geological formations, water is no longer acceptable as a drilling mud. This is because water is unable to counteract issues arising from drilling activities. The latter is utilized for formations that are highly sensitive to water due to the oil-based material of the mud. The latter is utilized for formations that are highly sensitive to water due to the oil-based material of the mud. The purpose of drilling mud is to lift cuttings to the surface, regulate the well pressure, and cool and lubricate the bit and drill string, among other functions (Hall et al., 1950)

Drilling mud is typically categorized as either water-based or oil-based. The latter is utilized for formations that are highly sensitive to water due to the oil-based material of the mud (Mike S, 2013). This mud type provides dependable protection against formation disintegration and is resistant to high temperatures. Furthermore, oil-based mud is employed in well completion and workover activities and to facilitate casing and liner installation, as well as pinched drill pipe release and minimization of damage to the drill pipe.

Several types of oil-based muds exist, including pertadex, diesel, new oil, and used oil. Over time, several new types, including saraline, smooth fluid, and coconut oil, have been utilized because they are considered more effective, efficient, and environmentally friendly. Traditionally, diesel was the base oil for conventional oil-based muds (Adewale & Ogunrinde, 2010).

The usage of oil-based mud, water-based mud, or other mud types is closely linked to the usage of additives. Additives have varying roles based on their composition, such as CMC and thinner. CMC acts as a viscosifier, increasing the viscosity of mud, while thinner is added to decrease its thickness. Therefore, the use of additives must match the well's conditions to ensure optimal functionality of basic ingredients and additives in improving drilling mud performance.

In this paper, we analyze the use of potato starch as an additive to improve the rheology of drilling fluid with new oil-based material. Technical term abbreviations will be explained when first used. In this paper, we analyze the use of potato starch as an additive to improve the rheology of drilling fluid with new oil-based material.

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Potato starch is chosen for its role as a viscosifier or thickener, as well as its unaffected properties by water salinity and ability to function as an efficient thickener. Additionally, it is a more economical and environmentally friendly option compared to other viscosifiers.

The selection of potato starch is based on its abundance and environmentally friendly nature. Indonesia produced 1.36 million tons of potatoes in 2021, a 6.1% increase from the previous year's 1.28 million tons according to the Central Bureau of Statistics (BPS) (Dihni, 2022).

For instance, a study titled "Drilling Mud Formulation Using Potato Starch (Ipomoea Batatas)" by Wami Emenike Nyeche et al. conducted in 2015 revealed the effectiveness of potato starch for such purposes. Previous studies have shown that potato starch is commonly used as a thickening agent and fluid loss reducer in drilling mud with a water-based base material. However, the addition of potato starch cannot completely replace viscosifier. It will cause the density value to drop when compared to using them both together. Therefore, further research is necessary to achieve a balanced ratio between potato starch and viscosifier.

Potato starch is a suitable viscosifying additive for drilling mud, as it can enhance its rheological properties (Assi, 2018). In this study, we will conduct a trial on drilling mud with new oil and with the addition of potato starch. This study will be conducted twice with variations in the ratio of new oil (75:25) and (80:20) and the addition of potato starch. The observed result will be the effect of the potato starch additive on the rheology of the drilling mud with the new oil-based material (Al-Hameedia, 2019)

METHODS

This study was carried out at the Laboratory, utilizing an experimental approach to address the problem. The experimental method involves manipulating the independent variables and comparing the outcomes to establish a cause-effect relationship between the variables.

The study involved direct observation of the rheological changes that resulted from manipulating independent variables. In this study, the independent variables include the ratio of new oil and water, specifically 75:25 and 80:20, as well as variations in the addition of potato starch.

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The rheological results obtained from the experiments will be used to compare the different independent variables and other factors, then compared against the given API standards. So, the purpose of the analysis was to determine the impact of adding potato starch to oil-based mud on the rheological properties of drilling fluid.

In this study, the results were compared with the API standards for drilling mud rheology, which is as follows for oil-based mud:

Plastic viscosity : less than 65 cp,
yield point (C300-PV) : 15-30 lb/100ft^2,
gel strength : 2/3-4/5 lbs/100ft^2.

Table 1. Tools and ingredients.

Tools	Ingredients	Size
Viscometer	New oil	112.5 ml and 120 ml
Measuring cup	Water	37.5 ml and 30 ml
Pippete	Primary emulsifier	4 ml
Multi mixer	Secondary emulsifier	1.9 ml
Stopwatch	Fluid loss control *1*st	1 gr
Digital balance	Fluid loss control *2*st	0.5 gr
Analytical balance	Viscosifiers	4 gr
Mud balance	Barite	24.8 gr
	CaCl2	17.615 gr
	CaCO3	5 gr
	Potato starch	4 gr and 6 gr

Research Procedure

1. Prepare the necessary tools and materials for the drilling mud manufacturing process.
2. Add new oil in the amount of 112.5 ml for the first experiment and 120 ml for the second experiment, along with 1 gr of Fluid Lost Control 1st, into the mixer cup. Mix thoroughly for 30 seconds.
3. After 30 seconds, add 4 millilitres of Primary Emulsifier first. Then add 1.9 millilitres

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of Secondary Emulsifier into the mixer cup and mix well for 2 minutes.

4. After 2 minutes, add the next mixture, CaCl2, in the amount of 17.615 grams into the mixer cup and mix well for 3 minutes.
5. After three minutes, add the next concoction of CaCO3, up to 5 grams, into the mixer cup and mix thoroughly for one minute.
6. Afterward, incorporate the subsequent blend of 4 grams of Viscosifier into the mixer cup and mix for four minutes until well combined.
7. After 4 minutes, add 0.5 g of Fluid Lost Control 2nd to the mixer cup. Mix well for 30 seconds.
8. After 30 seconds, add water (30 ml in the first experiment and 37.5 ml in the second experiment) and potato starch (6 grams in the first experiment and 4 grams in the second experiment) into the mixing cup. Mix well for 4 minutes.
9. After four minutes, add the final mixture, Barite, weighing approximately 24.8 grams to the cup mixer and mix well for 15 minutes until the mixture becomes thick. Then, turn off the device.
10. Next, conduct rheology.
11. Testing followed by data collection and processing.
12. Retrieve the results and draw research conclusions.

RESULTS AND DISCUSSIONS

Drilling mud to be used in a field must meet the specific requirements of that field. Therefore, production planning of drilling mud should carefully consider the materials used. While each field may have unique conditions, there are common standards that engineers can use as guidelines when designing drilling mud.

This study aims to enhance the rheological capabilities of drilling mud by introducing a new base oil and including potato starch as an additive. Two separate trials were conducted. The first utilized an oil-water ratio (OWR) of 75:25 and an addition of 4 grams of potato starch, while the second trial incorporated an OWR of 80:20 and 6 grams of potato starch.

In the first experiment, the plastic viscosity value of 40 cp met the standard of less than 65 cp. However, the yield point value, ranging from 15-30 lbs/100ft2, was not met on the first trial. Moreover, the gel strength value of 0.7 lbs/100ft met the API standard. Nonetheless, it is important to note that the oversizing of viscosifiers and potato starch led to the noted increase

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in yield point.

Experiment with OWR (75:25) and the addition of 4 grams of potato starch.

Table 2. First Trial Testing Results.

test type	testing standard	First trial testing results
C600	-	220
C300	-	180
Plastic Viscosity	< 65 cp	40 cp
(C600-C300)	15-30 lb/100ft2	140 lb/100ft2
Yield Point	2/3-4/5lbs/100 ft	0,7 lbs/100 ft
Maximum deviation 10 seconds	-	50
Maximum deviation 10 minutes	-	70

Experiment with OWR (80:20) and the addition of 6 grams of potato starch.

Table 3. Second Trial Testing Results.

test type	testing standard	Second trial testing results.
C600	-	320
C300	-	250
Plastic Viscosity	< 65 cp	70
(C600-C300)	15-30 lb/100ft2	180 lb/100ft2
Yield Point	2/3-4/5lbs/100 ft	0,9 lb/100ft
Maximum deviation 10 seconds	-	90
Maximum deviation 10 minutes	-	100

In the second experiment, objective measurements indicated a significant improvement in the rheological properties of the drilling mud. This represents a considerable improvement compared to the results of the first experiment.

The overall viscosity of the mud increased significantly, as did its Plastic Viscosity, which reached 70 cp. This increase in mud viscosity can be attributed to the addition of potato starch as an additive. Additionally, the different oil-water ratio (OWR) with a value of 80:20 also contributes to the increase. This increase indicates that the mud is better able to transport cuttings and prevent circulation loss. However, it is important to note whether this value meets the set API standard.

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The yield point in the second experiment reached 180 lbs/100ft2, indicating a significant increase compared to the first experiment. This increase can be attributed to the effect of potato starch addition and the difference in OWR (Imtiaz Ali, 2021).

Potato starch has a thickening property that increases the minimum pressure required for fluid movement. Furthermore, the increase in OWR may also contribute to the yield point increase, as a larger quantity of oil phase is involved in the blend.

The gel strength of 0.9 lbs/100 ft in the second experiment is still within the good category, according to API standards. It is noteworthy, however, that there was a difference in deviation between the 10-second gel strength and the 10-minute gel strength (Widodo, 2015). In the second experiment, the deviation was smaller compared to the first experiment, indicating better stability in sludge viscosity over a longer period.

Thus, adding potato starch and varying the OWR in the drilling mud significantly improved its rheological values. Although there were some inconsistencies with API standards, the second experiment demonstrated better rheological values compared to the first.

Analysis of the Use of Potato Starch in New Oil-Based Drilling Mud.

This study demonstrates that the inclusion of potato starch in drilling mud functions as a viscosifier, enhancing rheological qualities such as viscosity, plasticity, and gel strength. Potato starch as a drilling mud supplement has additional benefits, such as its biodegradable characteristics, capacity to regulate fluid loss, and compatibility with other additives.

Variations in Oil-to-Water Ratio (OWR) and potato starch amount were evaluated to determine their impact on drilling mud properties. Results indicated that the addition of potato starch with an OWR ratio of 80:20 and a 6-gram dosage significantly enhanced rheological values compared to the initial experiment's outcomes. However, potato starch can serve as an alternative viscosifier for drilling mud. However, the use of potato starch as a viscosifiers substitute does lead to a decrease in density compared to the use of the two together. Trials have shown that the first experiment resulted in a density of 8.1 ppg while the second experiment yielded a density of 7.8 ppg. Thus, further research is needed to find the optimal balance between potato starch and the viscosifiers to avoid any unwanted decrease in drilling mud density.

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The decrease was reportedly caused by insufficient water in the mud mix, which prevented the additives from functioning optimally. Therefore, it is important to ensure adequate water content in drilling mud to enable the additives to work effectively and achieve the desired attributes. However, a drawback of implementing potato starch is its inability to fully substitute the main viscosifier. Additionally, for the additive to attain maximum results, modifications to the water content in the drilling mud are necessary.

Moreover, the study confirmed the compatibility of potato starch with new oil-based drilling muds. Potato starch was able to effectively react with the components of the new oil-based mud, consequently enhancing the rheological value of the drilling mud. The successful use of potato starch in new oil-based drilling mud demonstrates the potential of using eco-friendly natural additives to enhance drilling mud performance.

CONCLUSION

In the first trial using OWR 75:25, the addition of 4 grams of potato starch yielded favourable results for the drilling mud, meeting the necessary standards of 40 cp and 0.7 for plastic viscosity and gel strength, respectively. It was concluded that a modification to the mud composition is necessary when the rheology value of the drilling mud falls outside the API standard. The use of oil-based mud with potato starch supplement is appropriate for wells that contain delicate formations prone to fragility and chemical damage. The mud regulates the movement of fluid and reduces the chances of formation damage. Oil-based drilling fluid supplemented with potato starch is suitable for use in wells located in regions with water-sensitive formations and high temperatures. This type of drilling fluid may reduce the interaction between water and formation while exhibiting excellent thermal properties. The findings of this study suggest that potato starch can enhance the rheological properties of oil-based drilling mud.

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