Scientific Contributions Oil & Gas, Vol. 47. No. 3, December: 205 - 213

SCIENTIFIC CONTRIBUTIONS OIL AND GAS
Testing Center for Oil and Gas
LEMIGAS

Journal Homepage:http://www.journal.lemigas.esdm.go.id
ISSN: 2089-3361, e-ISSN: 2541-0520

Laboratory Study on The Use of Local Additive of Clam Shell in Water Based Mud

Nur Suhascaryo and Farrel M. Dhaffa

Department of Petroleum Engineering, University of National Development Yogyakarta
Padjajaran street, Sleman, Yogyakarta, Indonesia.

Corresponding author: info@upnyk.ac.id.

Manuscript received: July 10th, 2024; Revised: August 06th, 2024
Approved: August 27th, 2024; Available online: December 06th, 2024.

ABSTRACT - The use of clam shells as additives in water-based mud has gained attention as a natural material in drilling fluids. This study tested the physical properties and rheology of water-based mud with varying amounts of clam shells. The density of the mud after adding clam shell additives was determined using a mud balance, and the rheology was tested using a viscometer. Filtration volume and mud cake thickness were also tested using an LPLT (Low-Pressure, Low-Temperature) filter press for 30 minutes. The pH measurement was performed from the filtrate volume. The results showed that adding varying amounts of clam shell additives increased the density by 8.7 ppg, 8.9 ppg, and 9 ppg, respectively. The filtration loss and mud cake produced were considered good, with filtration loss and mud cake being 13 mL and 1.6 mm, 12.2 mL and 1.4 mm, and 10.4 mL and 1.3 mm, respectively. Clam shell can be used as a fluid loss reducer because it can affect the viscosity value of the mud, resulting in a low filtration loss value. Proportional to filtration loss: if the filtrate comes out a little, the resulting mud cake is thinner.

Keywords: clam shell, drilling fluid, local additive, water based mud.

How to cite this article:

Nur Suhascaryo and Farrel M. Dhaffa, 2024, Laboratory Study on The Use of Local Additive of Clam Shell in Water Based Mud, Scientific Contributions Oil and Gas, 47 (3) pp. 205-213. DOI.org/10.29017/SCOG.47.3.1635.

INTRODUCTION

Drilling fluid plays a vital role in the success of drilling operations. It represents 15–18% of the total cost of an oil well drilling (Khodja et al. 2010a, b) and is generally classified as water-based mud and oil-based mud according to their phase type and chemical properties (Melbouci & Sau 2008). The drilling fluid performs many critical tasks essential for an efficient drilling process. The main functions fulfilled by drilling fluids include removing drilled cuttings from the hole, controlling subsurface pressure, cooling and lubricating drilling tools, maintaining the stability of the wellbore, controlling corrosion, and suspending drilled cuttings when drilling is paused (Aboulrous et al. 2016 – Khodja et al. 2010a, b). The type of drilling fluid following the well's characteristics will support the success of the drilling operations, especially in terms of flow pattern and drilling speed and the cutting removal's success (Suhascaryo et al. 2021). The main factors governing the selection of drilling fluids are the types of the formation to be drilled; the range of temperature, strength, permeability, and pore fluid pressure exhibited by the formations; the formation evaluation procedure; the water quality available; and ecological and environmental considerations (Bourgoyne et al. 1986). Hole enlargement, drilling fluid a great loss to the formation, poor hole cleaning as well as severe shale collapse were inevitably encountered. The difficulties resulted in drilling accidents occurred frequently, thereby drilling costs soared upwards (Peng et al. 2009). Therefore, various chemicals, different additives, and polymers have been mixed into the drilling mud to maintain the flow properties such as mud weight, gel strength, viscosity, and filtration at desired levels (Moghaddam & Saadatabadi 2020; Skalle 2011; Khodja et al. 2010a, b). Compared to the total cost of a well, mud costs are only around 8–10%. Other costs include drilling rig rental, bit cost, casing and tubing cost, cementing cost, logging cost, etc. However, mud can affect up to 60–70% of these costs (Kartini 2014). As conventional drilling mud additives increase the drilling cost, there has recently been growing interest in applying cheap, readily available, and environmentally friendly additives that could be an alternative to existing conventional ones (Aboulrous et al. 2019 – Avci et al. 2016). To reduce the harmful effects of synthetic chemicals, research into using natural materials as additives in drilling muds has become an essential focus in recent years.

Clam shells are one of the attractive natural materials to be used as additives. The clam shell is a by-product of the fishing industry, and its physical and chemical properties make it a viable additive for drilling fluids. Clam shells are rich in mineral content, especially calcium carbonate (Lertwattanaruk et al. 2012), which can exert binding and strengthening effects on drilling mud. This clam shell, also known as a sea shell, is the common name for a hard, protective outer layer, or in some cases a "test", created by a sea creature or a marine organism. Clam shells are most often found washed up empty on beaches or other parts of the coastline after the soft parts of the animal have either been eaten by another animal that attacked it (predation), human beings as seafood or after the animal has died. Scavengers have eaten the soft parts or have rotted out (Akeja et al. 2014). A clam's body is protected by its shell, a hard outer layer. The shell is part of the body of a marine animal. In most cases, this shell is an exoskeleton, usually that of an animal without a backbone, an invertebrate. Depending on the species, clam shells can be round, oval, flat, or triangular. The shell is composed of calcium carbonate and consists of two symmetrical halves: an upper shell and a hinged lower shell. Calcium carbonate is the main constituent of clam shells and is usually found as aragonite or calcite crystals (Lertwattanaruk et al. 2012). Clam shells have a specific gravity value of 2.82 (Lertwattanaruk et al. 2012). The chemical composition of clam shells can be seen in Table 1. (Lertwattanaruk et al. 2012).

Table 1
Chemical composition of clam shells

Chemical Composition (%)	Type of Clam Shells			
	Oyster	Mussel	Cockle	Clam
SiO_2	1.01	0.73	0.98	0.84
Al_2O3	0.14	0.13	0.17	0.14
Fe_2O_3	0.07	0.05	0.06	0.06
Cao	53.59	53.38	54.24	53.99
MgO	0.46	0.03	0.02	0.08
K_2O	0.02	0.02	0.03	0.03
Na_2O	0.23	0.44	0.37	0.39
SO_3	0.75	0.34	0.13	0.16
Cl	0.01	0.02	0.01	0.02
SO_4	0.43	0.11	0.07	0.06
$CaCO_3$	96.8	95.6	97.13	96.8

Using clam shells as additives in water-based mud can also help reduce dependence on imported additives and encourage the development of local industries. Therefore, laboratory research on clam shells as additives in water-based mud is very relevant and necessary. This research is expected to contribute to developing environmentally friendly and sustainable technologies in the oil and gas industry and provide a better understanding of the potential of clam shells as additives in water-based mud.

METHODOLOGY

This section explains the preparation of tools and materials for use and mud testing from clam shells in water-based mud. Preparation of tools and materials to be used in this drilling mud research using water-based mud with additional additives in the form of clam shells as samples to be studied. Clam shells are one of the shellfish wastes that can be utilized as drilling mud additives because they are rich in calcium carbonate content (Lertwattanaruk et al. 2012 – Agwu et al. 2020). Clam shells are expected to be used as additives (Agwu et al. 2020).

For the preparation of tools, several tools are needed to help the course of research on the physical and rheological properties of mud, ranging from ovens, mortars, sieve shakers, measuring cups, digital scales, mud mixers and cups, mud balances, viscometers, LPLT filter presses, filter paper, pH test paper strips, and vernier calliper.

Clam shells will be used in this research to separate materials. Clam shells must undergo several processing steps before becoming a drilling mud additive as presented in Figure 1 (Agwu et al. 2020).

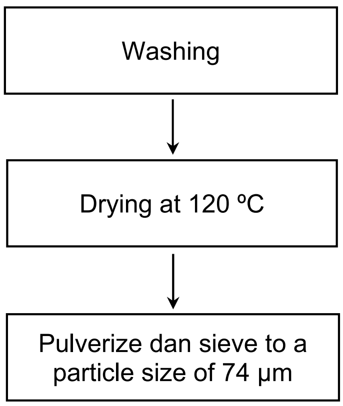

Figure 1
Flowchart for the process of clam shell to becoming additive

Before testing the physical properties and rheology of the mud, the first thing to do is to make the basic mud and the mud that has been added with clam shells. After that, we can test the physical and rheological properties of the mud.

Density: Density testing is carried out to determine the density of mud to adjust the formation pressure and formation fracturing pressure so that no problems arise during drilling operations (Buorgoyne et al. 1986 – Bridges & Robinson 2020). The test was conducted using a mud balance.

Rheology: Mud rheology testing aims to determine the ability of mud to withstand cutting during dynamic and static conditions (Buorgoyne et al. 1986 – Bridges & Robinson 2020). Rheology that will be tested here includes measurements of plastic viscosity (PV), yield point (YP), and gel strength. The test was conducted using a viscometer. To find the value of plastic viscosity on a laboratory scale, the following equation (1) is used (American Petroleum Institute 2010):

$$PV = C_{600} - C_{300} \quad (1)$$

PV = Plastic Viscosity (cp)
C_{600} = Dial reading at 600 rpm
C_{300} = Dial reading at 300 rpm

The following is an empirical correlation to calculate the recommended upper and lower limits for plastic viscosity (Ing & Prassl 2003):

Table 2
Empirical correlation of plastic viscosity limits

Plastic Viscosity Range		
Mud Weight* (ppg) *Range	***High Range* (cp)**	***Low Range* (cp)**
MW < 14	3.40MW – 18.6	2MW – 14
14 ≤ MW < 17	5MW – 40	4.33MW – 46.95
17 ≤ MW < 18.4	8.57MW – 100.25	8.57MW – 118.25
MW ≥ 18.4	16.68MW – 248.73	16.67MW – 266.73

To find the value of the yield point on a laboratory scale, the following equation (2) is used (American Petroleum Institute 2010):

$$YP = C_{300} - PV \quad (2)$$

YP = Yield Point (lb/100ft^2)
C_{300} = Dial reading at 300 rpm
PV = Plastic Viscosity (cp)

The following is an empirical correlation to calculate the recommended upper and lower limits for yield point (Ing & Prassl 2003):

Table 3
Empirical correlation of yield point limits

Yield Point Range		
Mud Weight* (ppg) *Range	***High Range* (lb/100ft^2)**	***Low Range* (lb/100ft^2)**
MW < 11	-4MW + 66	0.4MW – 0.6
11 ≤ MW < 14	-1.67MW + 40.04	0.4MW – 0.6
MW ≥ 18.4	-0.6MW + 25.4	0.4MW – 0.6

Filtration Loss and Mud Cake: Filtration loss testing is done to see how much filtrate volume comes out of the mud because if the filtrate volume comes out too much, it can cause problems (Buorgoyne et al. 1986 – Bridges & Robinson 2020). Meanwhile, the mud cake test aims to determine the thickness of the mud cake formed from the volume of filtrate that comes out of the mud (Buorgoyne et al. 1986 – Bridges & Robinson 2020). The test was conducted using a filter press LPLT.

pH: The pH test on the mud is carried out to determine the mud's pH, where the mud's condition must be in an alkaline pH condition so that the additives in the mud can work adequately (Buorgoyne et al. 1986 – Bridges & Robinson 2020). The test was conducted using a pH test paper strip.

RESULT AND DISCUSSION

The following are the results and analysis of the research that has been done previously on water-based mud with additional shell additives that are expected to become commercial additives.

Density Testing

The results in Figure 2, show that adding of clam shell additives to the mud sample increases the density of the mud. In WBM 1, the density value is 8.6 ppg; in WBM 2, the density value is 8.7 ppg; in WBM 3, the density value is 8.9 ppg; and in WBM 1, the density value is 9 ppg. This can occur because the specific gravity of the shell is almost equivalent to that of carbonate, which is 2.82, which is included in the weighting agent category whose function is to increase the density of the mud. Density must be considered in drilling operations to avoid problems when passing through diverse formations. However, the density of the mud should not be less than the formation pressure and not exceed the formation fracture pressure (Buorgoyne et al. 1986 – Bridges & Robinson 2020).

Table 4
Mud sample testing results

Mud Sample	WBM 1	WBM 2	WBM 3	WBM 4
Clam Shell (gr)	0	8	15	25
Density (ppg)	8.6	8.7	8.9	9
Plastic Viscosity (cp)	5	7	9	11
Yield Point ($lb/100ft^2$)	9	12	17	21
GS 10" ($lb/100ft^2$)	2	8	15	18
GS 10' ($lb/100ft^2$)	4	12	18	22
Filtration Loss 30 minute (mL)	14.1	13	12.2	10.4
Mud cake (mm)	1.7	1.6	1.4	1.3
pH	10	10	10	10

Rheology Testing

In Figure 3, the plastic viscosity value of the four muds increases. In WBM 1, the plastic viscosity value is 5 cp; in WBM 2, the plastic viscosity value is 7 cp; in WBM 3, the plastic viscosity value is 9 cp; and in WBM 4, the plastic viscosity value is 11 cp.

The significant value of plastic viscosity in WBM 4 is due to the content of solids used in WBM 4 is the largest, which can be seen in Table 1. where the solids added are 25 grams of clam shells, where the more significant the solids added, the greater the plastic viscosity value due to friction between

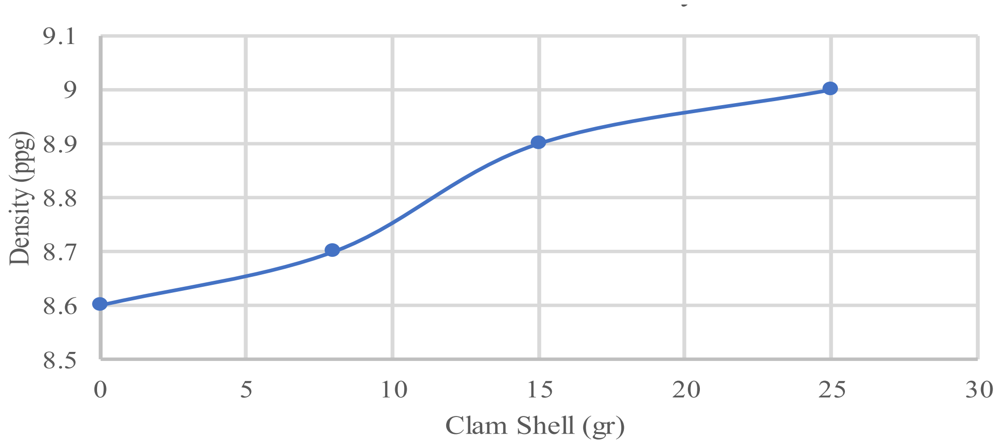

Figure 2
Effect of clam shell addition on density

particles in the mud sample (Bridges & Robinson 2020). The expected plastic viscosity value is as low as possible because the lower the plastic viscosity, the lower the pump horsepower, and the bit hydraulics and penetration rate can be optimized (Bridges & Robinson 2020).

In Figure 4, the yield point value increases as the clam shell additive are added to the mud sample. In WBM 1, the yield point value is 9 lb/100ft2; in WBM 2, the yield point value is 12 lb/100ft2; in WBM 3, the yield point value is 17 lb/100ft2; and in WBM 4, the yield point value is 21 lb/100ft2. This is because the yield point can be influenced by the content of solids added to the drilling fluid, so the effect caused by adding additives can differ depending on the additive type (Adams & Adams 1985). There is a relationship between plastic viscosity and yield point; an increase in yield point followed by little or no change in plastic viscosity indicates a chemistry problem; an increase in plastic viscosity followed by little or no increase in yield point indicates a solids problem (Bridges & Robinson 2020).

In Figure 5, the gel strength value has increased but not significantly; due to the low viscosity of the mud in the study. In WBM 1, the gel strength values at 10 seconds and 10 minutes are 2 and 4 lb/100ft2, respectively; WBM 2, the gel strength values at 10 seconds and 10 minutes are 8 and 12 lb/100ft2 respectively; WBM 3, the gel strength values at 10 seconds and 10 minutes are 15 and 18 lb/100ft2 respectively; and WBM 4, the gel strength values at 10 seconds and 10 minutes are 18 and 22 lb/100ft2 respectively.

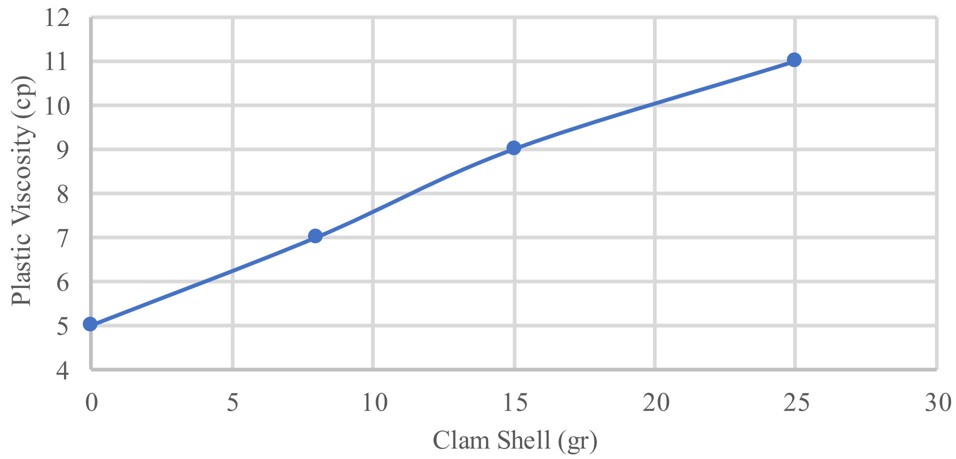

Figure 3
Effect of clam shell addition on plastic viscosity

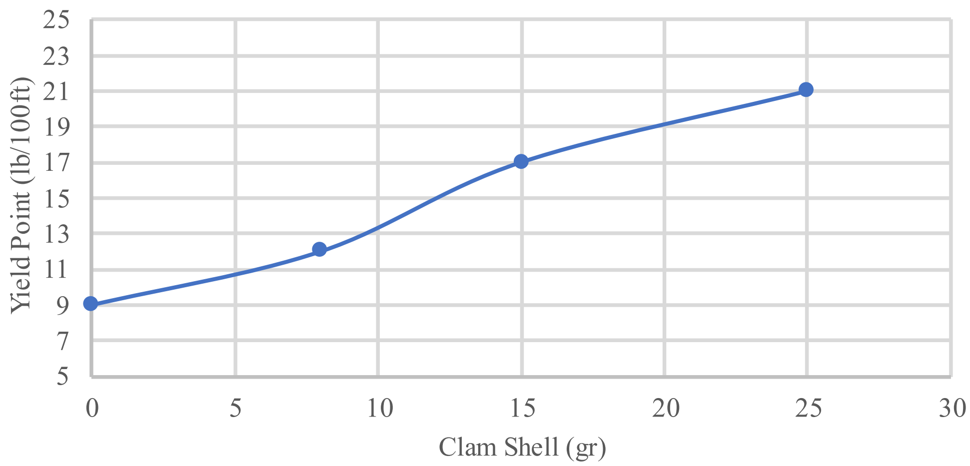

Figure 4
Effect of clam shell addition on yield point

The gel strength values of the four mud samples are also cate ized as suitable parameters because the gel strength values at 10 seconds and 10 minutes of the four mud samples are stable. A good gel strength is a gel strength whose value is low, and there is no significant difference between the gel strength at 10 seconds and 10 minutes (Chevron Texaco & BP 2002).

Filtration Loss and Mud Cake Testing

In Figure 6, the filtration loss of the four mud samples has a smaller volume along with the addition of clam shell additives to the mud samples. WBM 1 produces 14.1 mL of filtrate, WBM 2 produces 13 mL of filtrate, WBM 3 produces 12.2 mL of filtrate, and WBM 4 produces 10.4 mL of filtrate.

Almost all mud samples meet the API standard, which is 13.5 mL/30 minutes, but only WBM 1 does not meet it. Clam shell additives can affect the viscosity value of the mud, which increases the viscosity of the mud so that it can bind free water, and the resulting filtration loss value is less (Halliburton Fluid Systems 2006). As a result of the large amount of filtrate entering the rock pore, it will cause formation damage, such as blockage of porosity around the borehole, reducing the price of permeability and clay development (swelling) (Bridges & Robinson 2020). The expected filtration loss is a slight filtration loss, which avoids clogging the rock pores and thickening the mud cake in the borehole (Chevron Texaco & BP 2002 – Halliburton Fluid Systems 2006).

In Figure 7, the resulting mud cake is getting thinner, along with the addition of clam shell additives to the mud sample. WBM 1 produced a mud cake 1.7 mm thick, WBM 2 produced a mud cake 1.6 mm thick, WBM 3 produced a mud cake 1.4 mm thick, and WBM 4 produced a mud cake 1.3 mm thick. Mud cake is directly proportional to filtration loss; if the filtrate comes out a lot, the mud cake produced is even thicker. Conversely, the resulting mud cake is thinner if the filtrate comes out a little. As a result of thick mud cake, the stability of the borehole is compromised, which can hinder the drilling process due to problems such as pipe sticking (Bridges & Robinson 2020 – Ing & Prassl 2003). The expected mud cake thickness is a thin mud cake that can help the drilling process, which serves as a cushion for the drill string and prevents the collapse of the borehole wall. API standards also suggest that mud cake thickness should not exceed 2 mm (American Petroleum Institute 2010).

pH Testing

In Figure 8. the pH value of the four mud samples is constant. WBM 1 shows a pH value of 10, WBM 2 shows a pH value of 10, WBM 3 shows a pH value of 10, and WBM 4 shows a pH value of 10.

So, based on these results, it can be categorized that the four mud samples are alkaline because the pH value is above 7. The expected pH ranges from 9 - 11 to get good borehole stability and control the properties of drilling mud (American Petroleum Institute 2010). However, if there is an H2S problem, the pH value must be kept above 10. The pH must be alkaline not to cause corrosion of drilling equipment; a pH that is too alkaline can also cause flocculation problems (Bridges & Robinson 2020 – Ing & Prassl 2003).

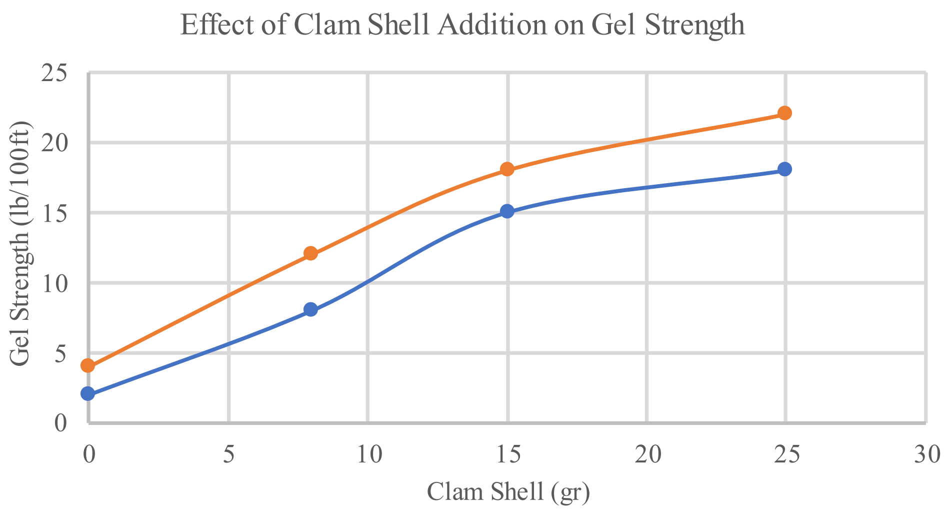

Figure 5
Effect of clam shell addition on gel strength

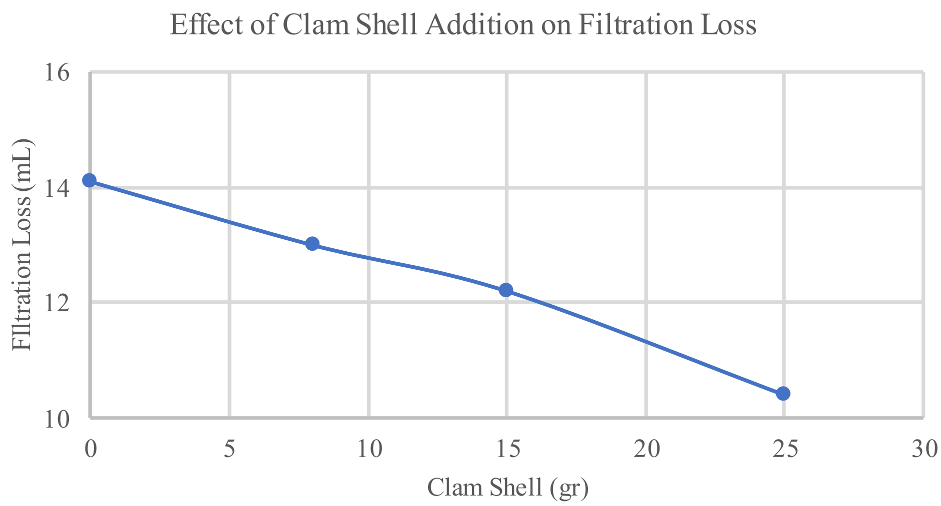

Figure 6
Effect of clam shell addition on filtration loss

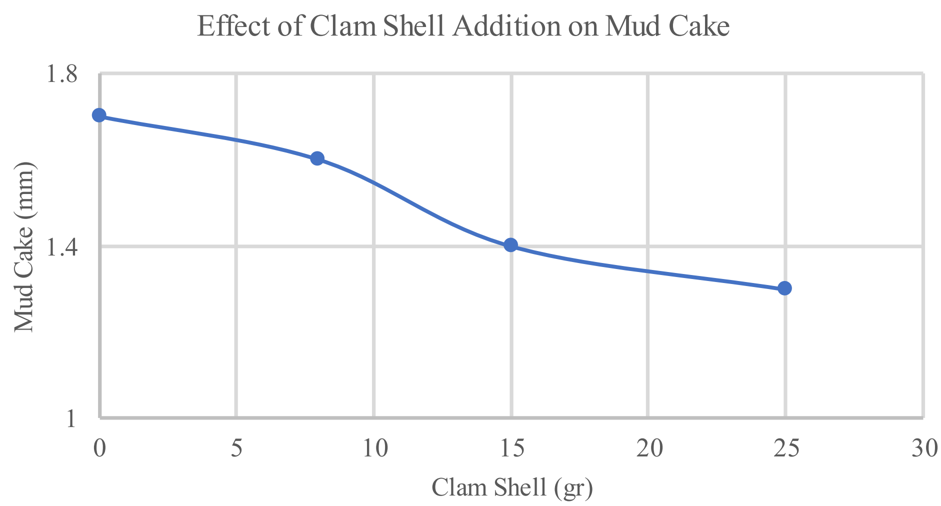

Figure 7
Effect of clam shell addition on mud cake

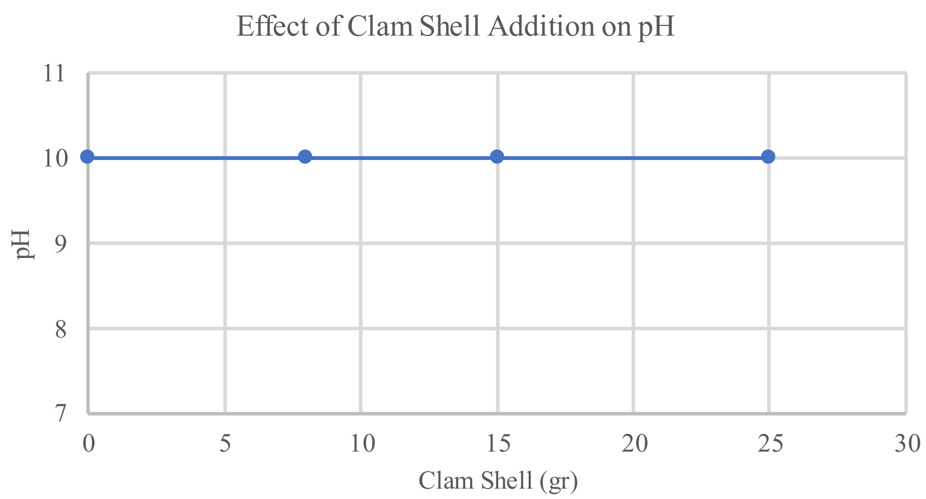

Figure 8
Effect of clam shell addition on pH

CONCLUSION

Based on the results of the discussion, it can be concluded that the addition of 25 g clam shells to the mud gave density, PV, YP, filtration loss, and mud cake values of 9 ppg, 11 cp, 21 lb/100ft2, 10.4 mL/30min, and 1.3 mm, respectively and the results of physical properties and rheology testing for the three mud samples added with clam shells show that clam shell extract can be used as a fluid loss reducer.

The clam shell can be used as a fluid loss reducer because clam shell additives can affect the viscosity value of the mud, which increases the viscosity of the mud so that it can bind free water. The resulting filtration loss value is less. Mud cake is directly proportional to filtration loss; if the filtrate comes out a little, the resulting mud cake becomes thinner.

ACKNOWLEDGEMENT

The authors thank the drilling fluid laboratory Petroleum Engineering Department, “Veteran” University of National Development Yogyakarta, for the publication permission.

GLOSSARY OF TERMS

Symbol	Definition	Unit
Density	Mass of a unit volume of a material substance	kg/m^3
Filtration Loss	The escape of the liquid part of a drilling mud into permeable formations.	ml/30 minutes
Gel Strength	A measure of the ability of a colloidal dispersion to develop and retain a gel form based on its resistance to shear	lb/100ft^2
Mud	A heavy viscous fluid mixture that is used in oil and gas drilling operations to carry rock cuttings to the surface and to lubricate and cool the drill bit	
Mud Cake	Compacted solid or semisolid material remaining on a filter after pressure filtration of mud with a standard filter press	mm
pH	A value representing the hydrogen ion concentration in liquid, and it is used to indicate the acidity or alkalinity of drilling mud	
Plastic Viscosity	The resistance to the flow of a fluid in bores	CP
Rheology	The study relationship between force (stress) and deformation (strain) of engineering materials under a set of loading and environmental conditions	Rheology
Water Based Mud	A drilling fluid composed of water and bentonite and heavy minerals which are also added for weight	

REFERENCES

Aboulrous A.A., Mahmoud, T., Alsabagh, A.M. & Abdou, M.I., 2016, Application of nature polymers in engineering. In: Natural Polymers, pp 185 – 218.

Adams, N.J. & Adams, N., 1985, Drilling engineering: a complete well planning approach. Pennwell Corporation.

Agwu, O.E., Akpabio, J.U. & Akpabio, M.G., 2020, Potentials of waste seashells as additives in drilling muds and in oil well cements. Cleaner Engineering and Technology, 1, 100008.

Akeja, O.A., Akintola, S.A. & Akpabio, J.U., 2014, The Use of Crassostrea Virginica as Lost Circulation Material in Water-Based Drilling Mud.

American Petroleum Institute, 2010, Specification For Drilling Fluid Material.

Avci, E., Szabo, T. & Federer, G., 2019, Rheological performance of fly ash in inhibitive water-based drilling fluids. Petroleum & Coal 67, 1307 – 1313.

Bourgoyne, A.T., Millheim, K.K., Chenevert, M.E. & Young, F.S., 1986, Applied drilling engineering.

Bridges, S. & Robinson, L., 2020, A practical handbook for drilling fluids processing. Gulf Professional Publishing.

Chevron Texaco & BP., 2002, Drilling Fluid Manual.

Dhaffa & Farrel M., 2023, Studi Laboratorium Penggunaan Aditif Lokal Cangkang Kerang pada Water Based Mud. FTM UPN "Veteran" Yogyakarta.

Halliburton Fluid Systems 2006, Baroid Fluid Services Fluids Handbook.

Ing, D. & Prassl, W. F., 2003, Drilling Engineering. Curtin University of Technology, Kensington.

Kartini, R., 2014, Lumpur Berbasis Air Rendah Padatan dan Tahan Temperatur Tinggi Bagi Pemboran di Formasi Serpih. LPMGB, Vol. 48, No. 2, 111 – 118.

Khodja, M., Canselier, J.P., Bergaya, F., Fourar, K., Khodja, M., Cohaut, N., Benmounah, A., 2010a, Shale problems and water-based drilling fluid optimisation in the Hassi Messaoud Algerian oil field. Appl. Clay Sci. 49, 383 – 393.

Khodja, M., Khodja-Saber, M., Canselier, J. P., Cohaut, N. & Bergaya, F., 2010b, Drilling Fluid Technology: Performances and Environmental Considerations. Products and Services; from R&D to Final Solutions, pp. 227 – 256.

Lertwattanaruk, P., Makul, N. & Siripattarapravat, C., 2012, Utilization of ground waste seashells in cement mortars for masonry and plastering. Journal of environmental management, 111, 133-141.

Melbouci, M., Sau, & A.C., 2008, Washington, DC: U.S. Patent and trademark office. U.S. Patent No. 7, 384 – 892.

Moghaddam A.K. & Saadatabadi, A.R., 2020, Rheological modelling of water-based drilling fluids containing polymer/bentonite using generalized bracket formalism. J. Petrol. Sci. Eng. 189, 1 – 16.

Peng, C., Feng, W., Luo X., Li, S. & Riji, C., 2009, An Environmentally Friendly Wbm System Can Prevent Hard Brittle Shale Instability. Scientific Contributions Oil & Gas, Vol. 32, No. 2, 133 – 142.

Suhascaryo, N., Wahyurini, E. & Guntoro, Y.C., 2021, Utilization of Crude Oil as an Alternative Oil Base Mud Drilling Operation by "VICOIL" Standard Drilling Simulation Rig in MGTM Well UPN "Veteran" Yogyakarta Education Park Mineral Geotechnology Museum Field. Scientific Contributions Oil & Gas, Vol. 44, No. 2, 123 – 139.