STM JOURNALS

International Journal of
Pollution: Prevention & Control

Volume 1, Issue 2, 2023
DOI (Journal):10.37591/IJPPC
(July-December)

https://journals.stmjournals.com/ijppc

Review IJPPC

A Ponder & Sedulousness of Legion Shale Stabilizing Materials in Aqueous Based Drilling Fluid During the Process of Borehole Strengthening

M. Panbarasan[1,*], S.Venkateshbabu[2], R. Karthikeswaran[3], J.Sudharsan[4]

Abstract

Drilling fluid used while drilling the layers of shale will have the potential of reacting with water which tends to increase stickiness, induce swelling and promote sloughing of the borehole. This results in the reduction of drilling fluid circulation, increased mud loss, increase in torque and drag, reduction in lubricity. This will ultimately result in the increase of Non-Productive Time (NPT) during drilling which in turn increases Capital Expenditure (CAPEX) to the operators thus leads to the longer return on investment (ROI) thereby directly impact the project economics. The drilling fluids which also mixes with the aquifers and it leads to subsurface deformation and environment pollution. Now the pollution control boards are using stringent measures to curb the pollution either on or below the surface, any driller fail to comply has to pay a hefty sum as penalty or else leads to banning in operation. This can be overcome by adding shale stabilizing agents to the drilling fluid. But shale stabilizing agents can reacts differently with the type of formations and depth at which it is used. Various physical properties such as appearance, bulk density, pH, moisture content, water solubility, solubility in oil, sulphonate group, thermal stability, particle size, fluid loss, strain has to be considered and their reactivity with numerous types of shale rock with its different petrophysical properties such as permeability, water saturation, shale volume, wettability, porosity, pore volume compressibility, relative permeability, capillary pressure, oil saturation and water saturation has to be taken into account. In this paper, various shale stabilizing agents are added with water-based drilling muds which was employed in different subsurface formations and its' behaviour was studied.

Keywords*:* Borehole, Drill Cuttings, Drilling Fluid, Filter Press, Fluid Loss, Mud Loss, Shale Stabilizer

***Author for Correspondence**
M. Panbarasan
E-mail: panbarasanpc@gmail.com

[1]Assistant Professor & SPE Ambassador Lecturer, AMET University, Chennai, Tamil Nadu, India
[2]Professor & Head, Department of Petroleum Engineering, JCTCET, Coimbatore, Tamil Nadu, India
[3]Assistant Professor, VELS Institute of Science, Technology & Advanced Studies (VISTAS), Chennai, Tamil Nadu, India
[4]Doctral Research Scholar, University of Petroleum and Energy Studies, Dehradun, Uttarakhand, IndiaReceived

Received Date: December 07, 2023
Accepted Date: February 09, 2024
Published Date: March 07, 2024

Citation: M. Panbarasan, S.Venkateshbabu, R. Karthikeswaran, J.Sudharsan. A Ponder & Sedulousness of Legion Shale Stabilizing Materials in Aqueous Based Drilling Fluid Duringthe Process of Borehole Strengthening. International Journal of Pollution: Prevention and Control. 2023; 1(2): 35–40p

INTRODUCTION

Drilling fluid is the major constituent in the process of drilling. Drilling fluid circulation system is similar to that of the blood circulation system of the human body. It carries the necessary materials throughout the wellbore during drilling process and maintain its' stability.

Shale is a rock type which commonly encountered in drilling operation. It is a fine-grained, fissile, detrital sedimentary rock formed by agglomeration of clay and silt-sized particles into thin & relatively impermeable layers.

Drilling fluid is a mixture of water as a main constituent and various types of chemicals as additives to maintain different physical & chemical

properties. During drilling, the water present in the drilling fluid reacts with shale results in swelling of the wellbore. It inhibits the transportation of drill cuttings to the surface, which leads to settling of drill cuttings thereby reducing the rate of penetration (ROP) [1,10]. This can be prevented by adding shale stabilizing materials along with the drilling fluid. Various shale stabilizing materials are to be discussed with its' physical properties, applications, usage & advantages.

PHYSICAL PROPERTIES

The physical properties are appearance, bulk density, pH, moisture content (% by weight), Solubility in water (%), Solubility in oil (%), Solubility in distilled water (%), Sulphonate group, Thermal stability, Particle size, HPHT fluid loss (ml/30 min), Lubricity coefficient [5, 9].

The physical properties are calculated using the standard procedures. For calculation of HPHT fluid loss, API filter press (#170-01:230 V) is used [8].

SHALE STABILIZING MATERIALS

The following are the shale stabilizing materials for WBM:

Sulphonated Shale Stabilizer

a. Sulphonate asphalt
   i. Sulphonated asphalt
   ii. Sulphonated asphalt
   High Pressure High Temperature [8]
b. Kalium sulphonated asphalt
c. Asphaltic shale stabilizer
d. Shale inhibition polymer
e. Fractionally Hydraulised Poly Acrylamide (FHPA - Powder)

Shale Stabilizing Materials for WBM

Sulphonated Shale Stabilizer

It is a restructured sodium sulphonated asphaltic compound. Its' diversified mud conditioner bestows to the stability of drilling mud & shale, subdue dispersion of drill cuttings, reduces torque and drag, [7] controls water loss at elevated temperatures Table 1.

Table 1: Comparison of physical properties of sulphonated asphalt & sulphonated asphalt high pressure high temperature.

Properties	**Range**	
	Sulphonated Asphalt	***Sulphonated Asphalt High Pressure High Temperature***
Appearance	*Blackish brown powder*	*Blackish brown powder*
Bulk density (kg/m^3)	850-950	850-950
pH (1% solution)	>8.5	>8.5
Moisture content (% by wt)	<10	<10
Solubility in water (%)	Min 75	Min 70
Solubility in oil (%)	Min 25	Min 20
Sulphonate group	Positive	Positive
Thermal stability	250°C	200°C
Particle size	>90% through BSS 40	>90% through BSS 40
HPHT fluid loss (ml/30 min)	25-30	<25

Applications

It is used for minimizing fluid loss, torque and drag reduction, suppression of clay swelling.

Advantages

- Enhances lubricity by reducing torque and drag of the drill string [5]
- Improves the quality of filter cake
- Seal off micro fractures in shale
- Control water loss at high temperature
- Prevents corrosion
- Reduces HPHT fluid loss [8]

Kalium Sulphonated Asphalt

It is a modified kalium sulphonated asphaltic compound. It is highly effective in potassium environment, as it yields water soluble potassium (K^+ ions) into the drilling system [2] Table 2.

Table 2. Physical properties of kalium sulphonated asphalt.

Properties	**Range**
	Kalium Sulphonated Asphalt
Appearance	Blackish brown grey powder
Bulk density (kg/m^3)	850 – 950
pH (2% solution)	>8.0
Moisture content (% by wt)	<10
Solubility in water (%)	65 – 75
Solubility in oil (%)	> 25
Potassium content	>10
Thermal stability	>160°C
Softening Point	>260°C
Particle size	>90% through BSS 40
HPHT fluid loss (ml/30 min)	>25

Applications

It is used for fluid loss control, improving lubricity of all water systems at high temperature.

Advantages

- Inhibits dispersion of drilled solids
- Produces thin and strong wall cake
- Controls shear strength
- Control water loss at high temperature
- It stabilizes shale formation

Asphaltic Shale Stabilizer

It is a restructured sodium sulphonated asphaltic compound [2]. It contributes to the control of high temperature water loss and aids emulsification of oil Table 3.

Table 3. Physical properties of asphaltic shale stabilizer.

Properties	**Range**
	Asphaltic Shale Stabilizer
Appearance	Blackish brown powder
Bulk density (kg/m^3)	850 – 950

pH (1% solution)	>8.5
Moisture content (% by wt)	<10
Solubility in water (%)	Min 70
Solubility in oil (%)	Min 20
Sulphonate group	Positive
Thermal stability	200°C
Particle size	>90% through BSS 40

Applications

It is used for fluid loss control, reduction of torque and drag, inhibition of clay swelling of all WBM.

Advantages

- Compatible with all WBM
- Prevents drill bit and bottom hole assembly freeing by preferentially oil wetting the drill string [7].
- Improves filter cake quality
- Prevents swelling of clay
- It inhibits corrosion

Shale Inhibition Polymer

It is a high molecular weight anionic polymer viscosifier [3]. It is ample enough to dissolves in aqueous medium and is mainly utilized as an efficient fluid loss reducing agent, thickening polymer and prophylactic suspension mixture for shale formation and drill fragments in low salinity water, natrium saltwater and potassium chloride water-based mud systems [4]. It is simpatico with almost all the drilling mud products, biopolymers, Poly-Aluminium Chloride and CarboxyMethyl Cellulose Table 4.

Table 4. Physical properties of shale inhibition polymer.

Properties	**Range**
	Shale Inhibition Polymer
Appearance	Creamish white viscous liquid
Bulk density (kg/m^3)	1000 – 1100
pH	7 – 9
Thermal stability	>160°C
Ionic character	Anionic

Applications

It is employed as a stabilizer in shale formation, thickening medium and detrition minimizer in hard phase nullified drilling mud [6]. It renders suppression, slipperiness, minimizes detrition in low saline water.

Advantages

- It improves lubricity
- Easily dissolves with water
- Helps in better removal of drill cuttings
- Used as a flocculent
- Viscosity developing agent

Fractionally Hydraulised Poly Acrylamide

It is a co-polymer of anionic character and have high molecular weight [4]. It upholds the stability of borehole surface by precluding swelling of shale layer and degradation of shale formation Table 5.

Applications

It maintains viscosity. It can be used along with bentonite to increase the gel strength [5] which aids to suspend drill cuttings when circulation stops.

Table 5. Physical properties of fractionally hydraulised poly acrylamide.

Properties	**Range**
	Fractionally Hydraulised Poly Acrylamide
Appearance	White free flowing powder
Bulk density (kg/m^3)	850 - 950
pH (2%)	8 - 9
Moisture	<8%
Solubility	Water soluble

Advantages

- It restricts the reaction of water with shale
- It resists the microbial activity
- It yields high viscosity which results in better removal of drill cuttings [6]
- Used as a flocculent

RESULTS AND DISCUSSION

Five different types of shale stabilizing agents were taken and its' physical properties were studied. The study reveals that depending upon the chemical constituents & physical parameter of the subsurface environment, the shale stabilizers are to be used.

The results are incurred as follows:

1. For the environment with unionized potassium, potassium sulphonated asphalt is used.
2. If the drill string has increased torque and drag, Sulphonated asphalt is to be employed.
3. The subsurface is contaminated with microbial activity, Partially Hydraulised Poly Acrylamide is to be applied.
4. While drilling in the fresh water zone, Shale control polymer is deployed.
5. In case of high fluid loss, Asphaltic shale stabilizer is used to mitigate it.

Usage of these chemicals need high precaution as they are highly corrosive. Care must be taken as an industrial chemical by wearing personal protective equipment (PPE) and follow the precautions mentioned in Material Safety Data Sheet (MSDS).

REFERENCES

1. Shu He, Lixi Liang, et.al., "The influence of water-based drilling fluid on mechanical property of shale and the wellbore stability" KeAi Advanced Research Evolving Science Petroleum 2016(2): 61–66
2. Abdul Razak Ismail, et.al., "Shale Swelling Mitigation in Water-based Drilling Fluids with Amine Additives" IC-GeoE-SIMPOMIN, 2015: 24 –29
3. Ezekeil H. Hudson and Antoine Thuriere, "Survey of Polyamines as Prospective Shale Stabilizers" American Association of Drilling Engineers, April 2016: 1–9

4. D.N. Schulz, G. Allan Stahl, “Applications of Water-Soluble Polymers as Shale Stabilizers in Drilling Fluids” Water Soluble Polymers, Edition 1986 Chapter 10: 171–181
5. Eric van Oort, “On the physical and chemical stability of shales” Elsevier: Journal of Petroleum Science and Engineering 2003 (38): 213–235
6. Jiangen Xu, Zhengsong Qiu, et.al., “A polymer microsphere emulsion as a high-performance shale stabilizer for water-based drilling fluids” The Royal Society of Chemistry 2018(8): 20852–20861
7. Mohammad Amin Albooyeh, Iman Rahimzadeh & Mohammad Javad Ameri, “Promoting wellbore stability in active shale formations by water-based muds: A case study in Pabdeh shale, Southwestern Iran” Journal of Natural Gas and Engineering, June 2018(2): 56–64
8. J.Sudharsan, “Behaviour of Drilling Fluids on HPHT Well Conditions”, International Journal of Advanced Scientific Research and Management, Volume 3, Issue 7, July 2018: 280–282
9. M.J.A.Prince, “A Review on Planning for An Exploratory Well”, International Journal for Research in Applied Science & Engineering Technology, Volume 5, Issue 6, June 2017: 1450–1463
10. Sudharsan.J, “An Outlook on Predictions of Crude oil Price near Future”, Journal of Emerging Technologies and Innovative Research, Volume 5, Issue 8, August 2018: 779–781

