NANO-ENHANCED DRILLING FLUIDS: CAPABLE SOLUTION FOR REDUCING HIGH TORQUE AND DRAG IN DRILLING OPERATION

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Abstract:
A new material milled to nano size has been tested for use in drilling mud and experimental results showing significant improvements in viscosity and density of the drilling fluids are reported. Experiments were performed with different size distributions and compositions and drastic changes in rheological properties are observed. Comparison of the material with existing additives is presented and the benefits of reducing size to nano scale are also reported in the experimental results.

Abbreviations:
BR = Bentonite regular (used in industry)
ATR = New material
BF = Barafos (viscofier used in industry)
BT = Barite (used in industry)
HM = Haematite (Used in industry)
P.V = Plastic viscosity
Cp = Centipoise
CTD = Coiled tubing drilling
HDD = Horizontal and directional drilling

1. Background:

Due to fine & very thin film forming capability of nanomaterials, nano-based fluids can provide a significant reduction of the frictional resistance between the pipe & the borehole wall due to the formation of a thin lubricating film [1]. Initial studies revealed that a material (called ATR in this paper) which is abundant in Oman, have good Fann viscosity for use in drilling mud & is a prospective material to use in nano form to improve rheological properties. XRD tests were carried out and the material was found to be consisting mainly of Montmorillonite [Nax (Al,Mg) $2Si_4O_{10}$ (OH), Quartz low (SiO_2) and Clinochlore-IIb [Mg_5Al (Si_3Al) O_{10} $(OH)_8$].

2. Experimental procedure:

ATR was tested by X-ray diffraction technique followed by milling to nano size by using a Fritsch attrition milling machine. Different samples were milled to different number of hours to have various sizes of the particles. The particles collected after 5 hours of milling had a size distribution ranging from 30-50 µm. The remaining material was put for further milling till they were milled to nano size (70-90 nm). The viscosity and density tests were performed in a scheme so as to highlight the usefulness of the material as compared to regular additives and then investigate the effects of size by using first micro and then nano scaled particles of the same material. All the drilling mud samples were made in 500 ml of water. Different materials and size distributions were tested for their impact on viscosity and density of the drilling fluid samples. A Fann 35 Viscometer was used to find the viscosities of the samples and a regular drilling mud balance for measuring the densities was employed

Fig-5.1: *Fritsch milling machine (left) and Fann 35 Viscometer (Right)*

3. Results and discussion:

3.1: Viscosity tests for material effectiveness:

Reducing the quantity of BR and increasing the quantity of ATR by same amount resulted in apparent reduction in plastic viscosity.

S No	BR (gms)	ATR (gms)	Plastic Viscosity (cp)
1	40	0	12.2
2	30	10	6.5
3	20	20	4
4	10	30	3.5
5	0	40	2.1

Table–3.1.1: *Viscosity with reducing BR and Increasing ATR (micro)*

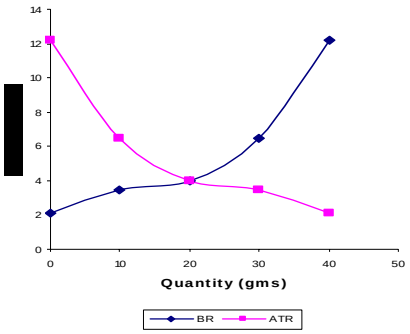

Fig-3.1.1: *Viscosity with reducing BR and Increasing ATR (micro)*

3.2: Use of Nano particles of tested material:

In presence of 40 gms of BR, smaller size of ATR particles (nano size) was tested and compared with regular drilling mud additive Barafos (BF). Significant reduction in viscosity from 14 cp to 8 cp was observed.

Size level	BR	ATR (micro)	BF	ATR (Nano)	PV
Micro	40	2	0	0	14
Nano	40	0	0	2	8
Micro	40	0	5	0	9

Table – 3.2.1: *Viscosity with barafos and ATR (micro and nano)*

3.3: Density tests for material effectiveness:

In a sample of drilling mud containing 40 gms of BR the following materials were tested:

BR (gms)	HM (gms)	Density (gm/cm³)	BT (gms)	Density (gm/cm³)
40	40	1.065	40	1.091
40	80	1.162	80	1.18
40	120	1.266	120	1.225

Table -3.3.1: *Density with regular additives*

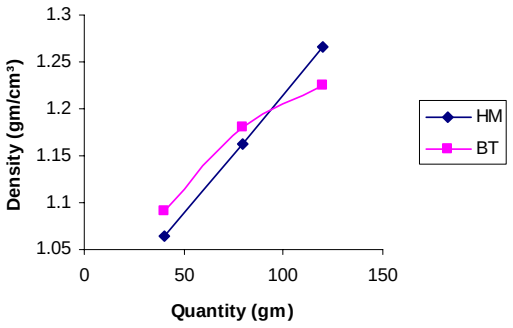

Fig – 3.3.1: *Density increment with additives*

Later on the tested material was used to make samples in different quantities while reducing the quantity of BR by same amount.

S No	BR (gms)	ATR (micro) (gms)	Density (gm/cm³)
1	40	0	1.022
2	30	10	1.062
3	20	20	1.043

Table-3.3.2: *Density with reducing BR & Increasing ATR (micro)*

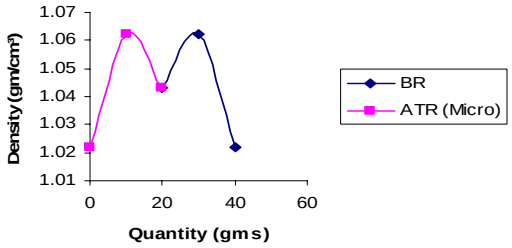

Fig-3.3.2: *Density reducing BR & Increasing ATR*

3.4: Micro to Nano:

Experiments were repeated with same scheme but using ATR (nano) to investigate the effect of reducing the size to nano scale of the tested material. The following results were noted:

S No	BR (gms)	ATR (gms)	Density (gm/cm³)	Plastic Viscosity (cp)
1	40	10 (micro)	1.055	11.5
2	40	10 (nano)	1.095	6.2

Fig-3.3.1: *Comparison of ATR (Micro) & ATR (nano)*

4. Conclusion:

The tested material (ATR) was found to be suitable for use in drilling mud due to its functional characteristic of maintaining low viscosity without compromising the density requirement and thus expected to minimize drilling problems. The material even in the micro size was effective in low additive concentrations as compared to regular additives, barafos, barite and haematite, and much lower concentration of the material in nano size was found to be more effective.

5. References:

[1] Md. Amanullah, M. Ashraf, Nano-Technology-its significance in smart fluid development for oil and gas field application, SPE Technical symposium, Saudi Arabia, 2009.