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IMPACT OF NANO-PARTICLES ON THE RHEOLOGICAL PROPERTIES OF DRILLING FLUIDS

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Abstract - *In geotechnical engineering, drilling fluid is used to aid of borehole into earth. Liquid drilling fluid is often called drilling mud. The main functions of drilling fluid is providing hydrostatic pressure to prevent formation fluids entering into the well bore, keeping the drill bit cool and clean during drilling, etc. These days bentonite a natural occurring material is used in drilling fluid. In this work we have synthesis three samples of bentonite with varying sizes, ranging from micro to Nano sizes by grinding them with Planetary Ball Mill. With the help of FTRI and XRD the functional group and the nature of particles have been determined. Here our work mainly focuses on the reactivity between the particle and the fluid, as due to Nano size the surface contact area increases. Here we have prepared a water based mud (WBM) and other polymers have also been used during the process. Here we have reduced bentonite to Nano size and then examined it while using it in the water based drilling mud. Therefore we will develop a mud made up of Bentonite Nano particles that should be mechanically strong, physically small and thermally stable in comparison to the micro sizes. After all we'll be concluding that as the surface contact area increases the reactivity also increases and hence there is a significant change in the physical properties of drilling fluid.*

Index Terms- Drilling fluid, Bentonite, Nano particle, XRD, FTRI, Planetary Ball mill

I. INTRODUCTION

Drilling fluid is used to aid of borehole into earth Liquid drilling fluid is often called drilling mud. Bentonite based drilling fluids are used for drilling borehole for wells Bentonite act as the reactive phase in the Drilling fluid.

The main functions of drilling fluid are:

Providing hydrostatic pressure to prevent formation fluids entering into the well bore, Carry the drill cutting to the surface, keeping the drill bit cool and clean during drilling, etc.

Depending on the composition, drilling fluids are mainly classified into three types, i.e., water-based drilling fluids (WDFs), oil-based drilling fluids (ODFs), and synthetic drilling fluids (SDFs). Although ODFs and SDFs have better capacity to maintain the stability of wellbore and to lubricate the drilling pipe and bit, the development of WDFs is the future considering environmental and economic effect.[1,2] Furthermore, the advantages of WDFs also include good cooling and cutting removal ability, and fast formation breaking-down rate.

WDFs are usually composed of water, clay, and rheology modifier, and fluid loss controller. Among many types of clays, bentonite (BT) is commonly used in WDFs due to its outstanding swelling capacity and superior rheological properties.[3] In WDFs, the presence of BT improves the viscosity via edge-to-face attraction, and forms a compact filter cake, which helps prevent the fluid invasion into the formation.

Selection of the proper drilling fluid is important to the success of a drilling operation. No fluid is suitable for all situations. Fluids with different base liquids, different dominating cations in the aqueous phase, different chemical additives, or broadly diverse physical characteristics have different behaviors, making for a large menu of choices.

In general, a large amount of BT is required to obtain the desired rheological and filtration properties. Meanwhile, the incorporation of too much BT also creates much thicker filter cakes, which could cause serious formation damage and pipe sticking problems, and hence reduce the drilling productivity.[4, 5] To overcome these drawbacks, polymer-based rheological modifier and fluid loss reducer are normally applied. Currently, nanotechnology is recognized as "the next Industrial revolution", which has a far-reaching effect on almost every industry and even all aspects of our daily life. The extra-large surface area to volume ratio results in superior or even unexpected performances for surface-dependent nanomaterial.

Nanotechnology has shown great potential in wide ranging application and can provide solution for a wide range of problems both in upstream and downstream industry. There is a increasing interest in evaluating the use of nanotechnologies in various drilling operation to improve the performance in various situations.

2. EXPERIMENT

2.1. Synthesis of Nanoparticles

There are several methods for creating nanoparticles, including both attrition and pyrolysis. The synthesis and application of nanoparticles is one of the most interesting filed of research from basic and applied point of views. In this work for the synthesis of smaller size particles we have used planetary ball mill, which works on the principle of attrition (the process of reducing something's strength or effectiveness through sustained attack or pressure) size reduction is done by impact as the zirconium balls drop from near the top of the shell.

For this work we've taken three samples of bentonite from the ball mill. Initially 180 grams of bentonite was introduced into the ball mill and then at the period of every four hours 60 grams of sample was taken out. In this way we got three samples those are, 0-4 hours' samples, 4-8 hours sample and 8-12 hours sample. Hence the last sample was grinded in the ball mill continuously for 12 hours. So all three samples were of varying sizes and so with different sizes we can compare the rheological properties of those particles.

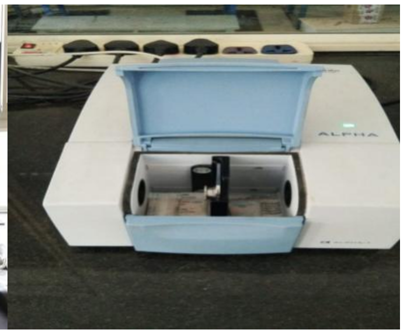
2.2. Characterization of the Nanoparticles:

2.2.1. Mineralogical studies:

Mineralogical composition for both the local bentonite and Nano-bentonite was determined by X-ray diffraction (XRD) using X-ray diffraction equipment shown in the figure at 40 kV, 35 mA. And scanning speed 0.02°/s. The reflection peaks between 2ø = 2° and 60°, corresponding spacing (d, A°) and the relative intensities (I/I°) were obtained, With the help of XRD we can come to know that the bentonite particles have changed from the crystalline to amorphous.

2.2.2. FT-IR spectrum analysis:

FT-IR Spectrum analysis for the studied local bentonite and Nano-bentonite was carried out using equipment sown in the figure. Through FTIR we came to know that there is a negotiable change in the functional groups associated with bentonite particles.



Figures 1 and 2 shows the equipment used for XRD and FT-IR respectively

2.3 Synthesis of drilling fluids with Nano bentonite as main constituent:

In total 9 samples were prepared with Nano bentonite as a main constituent and guar gum as a viscosifier in different proportions. After taking these samples they were thoroughly mixed with help of Hamilton beach mixer.

(Figure-3 shows the Hamilton beach mixer)

2.4. Determination of Mud Density:

The Mud Balance is used to determine density of the drilling fluid. The Instrument consists of a constant volume cup with a lever arm and rider calibrated to read directly the density of the fluid. Before testing densities of drilling fluid samples, mud balance must first be calibrated by using water as the sample. The density of water is 1 gm. /cc. After measuring density of mud sample and mud synthesized from A Nano bentonite, the true density is calculated.

2.5. Determination of Viscosity:

The viscosity of a fluid is defined Rheology refers to the deformation and flow behavior of all forms of matter. Certain rheological measurements made on fluids, such as viscosity, gel strength, etc. help determine how this fluid will flow under a variety of different conditions. This information is important in the design of circulating systems required to accomplish certain desired objectives in drilling operations as its resistance to flow. The desired viscosity for a particular drilling operation is influenced by several factors, including mud density, hole size, pumping rate, drilling rate, pressure system and requirements, and hold problems. The indicated viscosity as obtained by instrument OFITE M 900 viscometer (Figure-4). Apparent viscosities (AV), plastic viscosity (PV), yield point (YP) and gel strength were measured according to API specifications. With the help of viscometer ϴ--600, ϴ-300, 10 sec gel strength and 10 minutes gel strength are found out.

Figure-4: OFITE M 900 Viscometer

2.6 Determination of reactive particles present in the clay:

A test to determine the amount of clay-like materials in a water-base drilling fluid based on the amount of methylene blue dye absorbed by the sample. Results are reported as "MBT" and also as "lb. /bbl., bentonite equivalent" when performed to API specifications.

With the help of this test we can come to know how many reactive clay particles are present in the drilling fluid.

Figure-5 Apparatus of methylene blue test (MBT).

2.7. Determination of pH:

The Ph of drilling mud is used to measure with the help of fann digital Ph meter. A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH.

Figure-6: Digital pH meter

3. Results and Discussion

3.1 Determination of viscosity:

The graph (figure-7) below shows different viscosity on different sizes of particles. The viscosity of Nano mud is higher than the normal drilling mud at a room temperature.

Further discussion has been done below on PLASTIC VISCOSITY, APPARENT VISCOSITY, YIELD POINT and GEL STRENGTH.

3.1.1 Determination of Plastic viscosity:

Plastic viscosity is the resistance to the flow of a fluid. In wells it is caused by the mechanical friction within the drilling mud due to interaction between solids, the liquids and the deformation of liquid that is under shear stress.

The (graph-3) below shows the difference between the plastic viscosities of micro and Nano size bentonite.

From the /9graph-3) it is clearly evident that Nano size bentonite is more susceptible to the stress applied.

3.1.2 Determination of Apparent viscosity:

The apparent viscosity depends on the shear rate, apparent viscosity is the shear stress applied to a fluid divided by the shear rate.

The (graph-2) below shows the apparent viscosities for different size have been plotted and from that we have concluded that with the increase in the size of particles the apparent viscosity also increases.

3.1.3 Determination of yield point:

Yield Point (YP) is resistance of initial flow of fluid or the stress required in order to move the fluid. It can be simply stated that the Yield Point (YP) is the attractive force among colloidal particles in drilling fluid. Basically yield point is the point from where the particle starts to deform.

Here we've shown the (graph-1) the yield points for all the sample sizes of bentonite and it can be clearly seen that yield point of Nano bentonite is higher than the other two greater size samples.

3.1.4 Determination of gel strength:

The shear stress measured at low shear rate after a mud has set quiescently for a period of time (10 seconds and 10 minutes in the standard API procedure).

Here 10 sec and 10 minutes gel strength was found out with help of viscometer and graphs were plotted.

We've shown the (graph-4) and from that we can conclude that the gel strength for Nano sized bentonite is more than the micro sizes.

3.2 Determination of reactive clay particles:

For the determination of reactive clay particles methylene blue test was performed (MBT). With the help of this test we have come to know that percentage of reactive clay particles in the Nano sized bentonite is more than the micro size particles.

It is calculated in terms of methylene blue capacity (MBC) of the drilling fluid as follows:

MBC = *methylene blue, ml /drilling fluid, ml*

Where drilling fluid is always taken as 2 ml.

The (graph-5) has been shown below for the MBC test.

4. Conclusion

1) It has been observed that after keeping the sample for 12 hour in Ball mill there are almost negotiable change in the chemical composition of Bentonite.
2) Particle size is changing after keeping the sample for 12 hour in the ball mill
3) After performing the rheological test, it is observed that PLASTIC VISCOSITY (PV), APPARENT VISCOSITY (AV), YIELD POINT (YP) values are changing.
4) For sample which was kept for 8 to 12 hour all the values were higher comparatively other two samples (0 to 4 hour & 4 to 8 hour)
5) Gel strength values are also more for the sample which was kept for 8 to 12 hour as compare to other two samples (0 to 4 hour & 4 to 8 hour)
6) It is a clearly evident that rheological properties of drilling fluid are changing with the change of particle size distribution.

7) It has been observed from the Methylene Blue Test that reactive Bentonite amount is more in case of the sample which was kept for 8 to 12 hours inside the ball mill compared to the other two sample. So we can conclude that with the milling of Bentonite sample (reduction of particle size), particles are becoming more reactive.

8) Overall it can be concluded that Nano bentonite can give us better rheological properties than the regular one.

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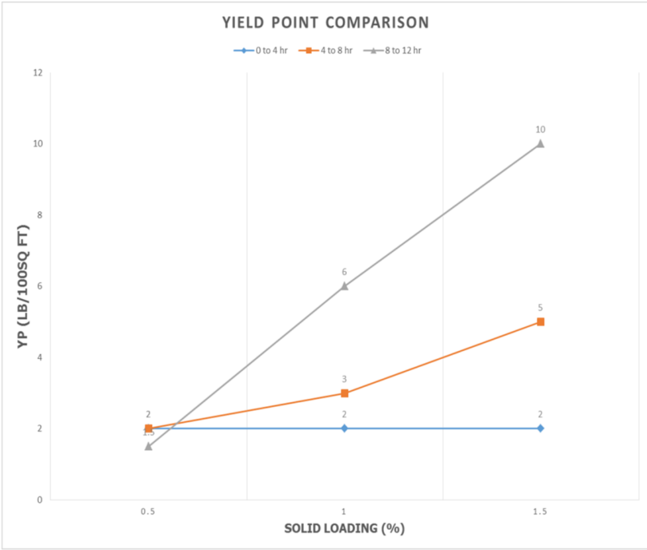
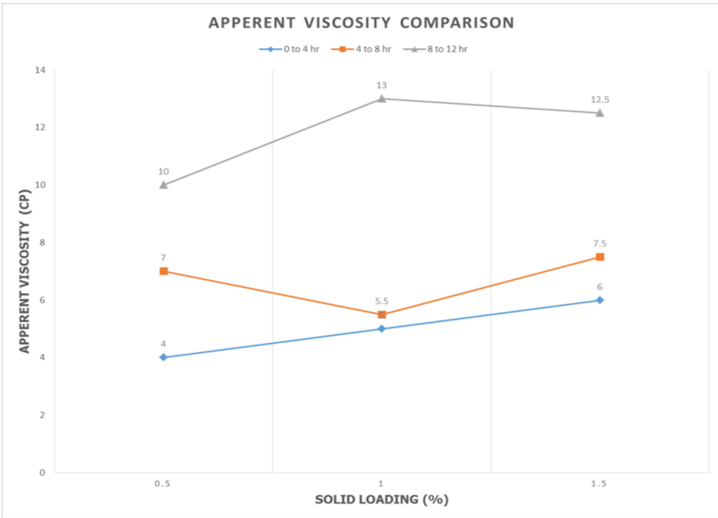
GRAPH-1



GRAPH-2



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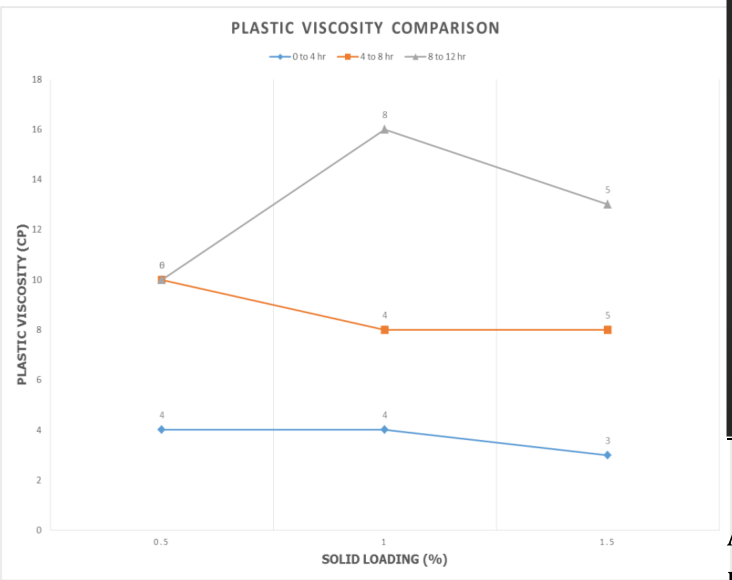
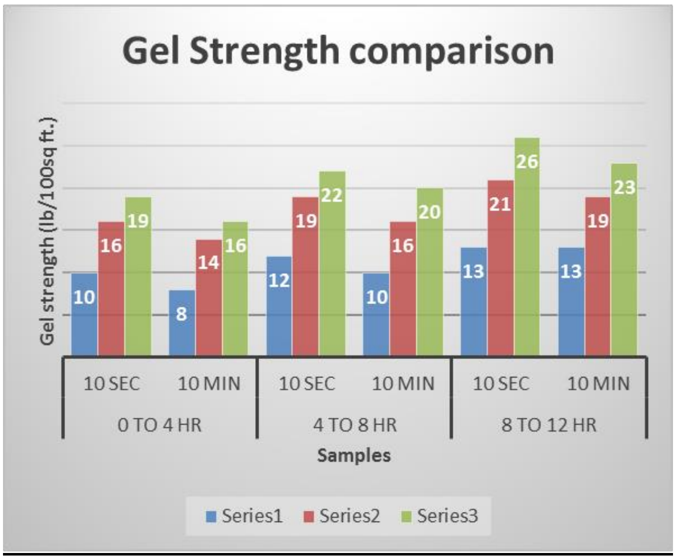
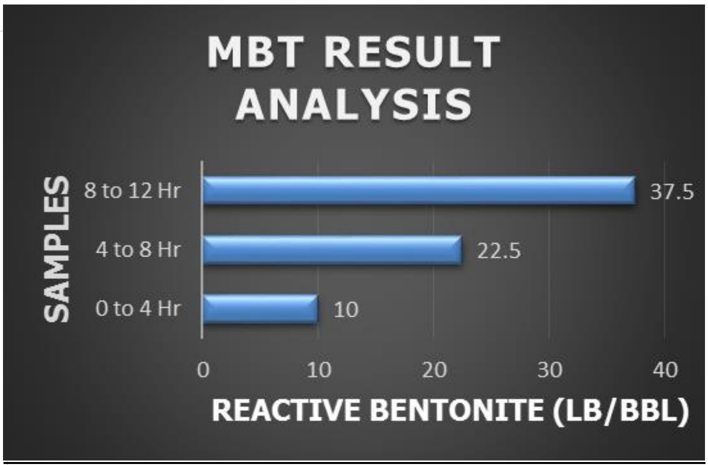
GRAPH-3



Graph-4



GRAPH-5



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