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FURTHER RESEARCH ON THE EXPERIMENTAL DETERMINATION OF THE EFFECT OF DRILL CUTTINGS ON OIL BASED MUD

Chiedu L. Ezenweichu

Department of Mining Engineering, Federal University of Technology, Akure, Ondo State Nigeria. lindaezenweichu@gmail.com

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Abstract

The research work evaluates the effect of drill cuttings on oil based mud and in the entire drilling process. The objective of the result was obtained through the collection of drill cuttings sample in Addax well, ADNH – 12, 8.5inch section at 8540feet. The cuttings were processed using a verti – g dryer and used to contaminate mud samples. These are sample I with 0% v/v concentration, sample II with 10 % v/v concentration and sample III with 30 % v/v concentration of drilled cuttings. The results were discussed in terms of electrical stability, high pressure – high temperature (HPHT) fluid loss including the resultant filter cake, density, and the rheological properties of the active fluids. Experiment shows that the electrical stability drops in half as drilled solids concentration increases from 0 – 105 lb/bbl. The HPHT fluid loss test produced thicker filter cake and the HPHT fluid loss doubles while the yield point also doubles as drilled cuttings concentration increases, implication of which could result to some drilling problem such as differential sticking of pipe, wellbore instability, lost circulation, poor cement bonding to the formation.

Keywords: density; differential sticking of pipe; viscosity; drill cuttings; drilling mud; yield point; filter cake.

1. Introduction

A contaminant is any type of material (solid, liquid or gas) that has a detrimental effect on the physical or chemical characteristics of a drilling fluid. The coarser solids, though they can be troublesome, are ordinarily the least injurious to drilling-fluid performance and are the most easily separated. The solids particles that cause solids problems in oil well drilling are those that create viscosity problems and contribute to poor hole conditions. These are the finest solids, the colloids and ultra-fine solids that, because of their small size and great number at any given solids concentration, have a disproportionate amount of surface area per unit of volume. These solids, which are generally considered to be the most detrimental to drilling-fluid performance, are too fine to be separated by screens or hydrocyclones. Their concentration can be reduced only by dilution or centrifuging. Note that solids surface area and the concentration of solids particles per unit of liquid volume, rather than the solids volume itself, are the usual sources of solids problems. Consequently, while retort solids can provide clues to the possible causes of drilling-fluid problems, solids problems can arise due to decreasing particle size even though the concentration of solids in the fluid remains unchanged.

During drilling operations, drill cuttings consisting of rock and low-yielding clays are incorporated into the mud. The types and quantity of these cuttings present in drilling mud systems affect many mud properties adversely – fluids density, viscosity, gel strength, filter cake quality and filtration control and other chemical and mechanical properties. These cuttings and their volumes also influence mud and well costs, including factors such as rate of penetration (ROP), hydraulics, dilution rate, torque and drag, surge and swab pressure, differential sticking, lost circulation, hole stability, and balling of the bit and bottom-hole assembly. These in turn, influence the service life of bits, pumps and other mechanical equipment. The properties of oil base mud are also influenced by the time and severity of agitation and the oil-water ratio since most oil base drilling fluid maintain a fixed oil-water ratio.

2. Collection of samples and laboratory analysis of samples

The sample used was already prepared by MI SWACO which was obtained in Addax well, ADNH-12, 8.5 inch section at 8540feet. The sample (cuttings) obtained was actually used to contaminate mud samples at concentrations of 10% v/v and 30%v/v.

The samples were analyzed at Mud Laboratory of MI SWACO Port Harcourt, River state. All readings were taken @120°F and @150°F both for before and after hot rolling. Three type of mud samples were prepared ranging from sample I (0% of drill cuttings), sample II (10% of drill cuttings) and sample III (30% of drill cuttings). The muds are mixed according to the procedures recommended by API. The analysis was carried out to determine some of the mud properties such as mud density, plastic viscosity, yield point, gel strength, electrical stability, sand content, HPHT filtration, oil-water ratio, salinity, whole mud alkalinity and lime content etc.

High-Pressure High-Temperature Filter Press was used to measure the amount of fluid loss. It is designed for testing fluids at elevated temperatures and pressures. Mud was placed into a 250 ml filter cell and was heated to 250°F. Pressure was increased by 500 psi by pressurized nitrogen gas. A back pressure receiver was maintained at 100 psi as filtrate was collected. The filtrate test ran for 30 minutes, upon which the volume of filtrate was recorded and the filter cake thickness was measured and reported in 30 seconds of an inch. Electrical Stability Meter was used to measure the electrical stability of oil based fluid. The relative stability of a water-in-oil emulsion mud was indicated by the breakdown voltage at which the emulsion becomes conductive. The ES test utilizes a probe with a pair of electrodes which were placed in the oil mud. A voltage was applied until the mud conducted a current. Retort kit was used to determine the quantity of liquids and solids in the drilling fluid. Mud was placed in a steel container and heated until the liquid components have been vaporized. The vapors were passed through a condenser and collected in a graduated cylinder, and the volume of liquid was measured. Solids, both suspended and dissolved were determined by difference.

3. Results and discussion

The various samples were subjected to different test to determine their properties and compared with the acceptable range for optimum drilling performance. Results of the various analyses indicate the characteristic properties of the drilling fluid samples.

Figures 1a, 1b indicate that filtrate loss decreased as drilled cuttings concentration increases from 0 – 105 lb/bbl.

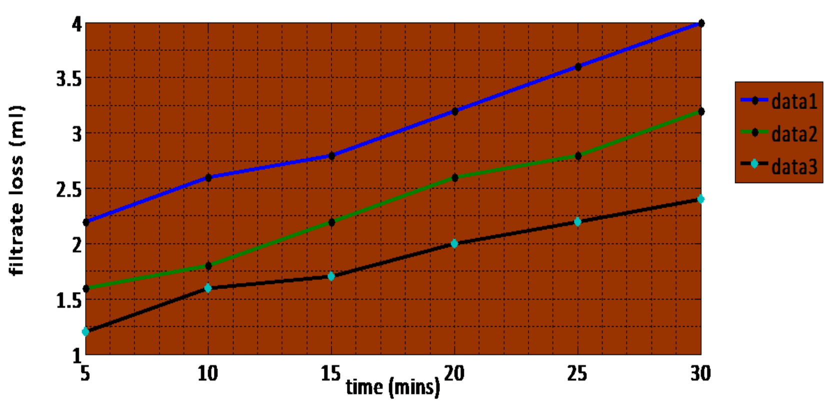

Figure 1a Plot of filtrate loss versus time before hot rolling

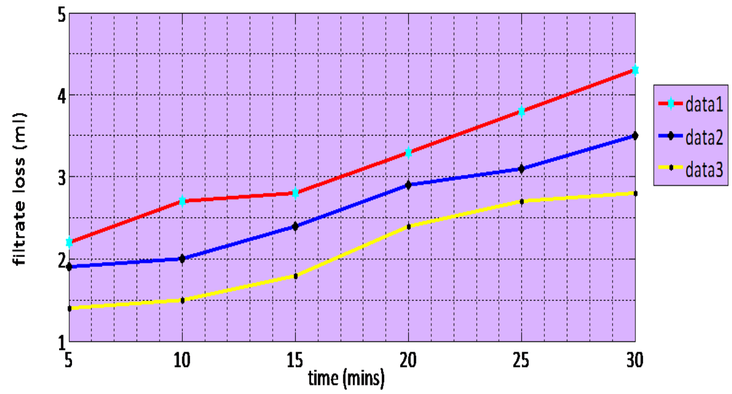

Figure 1b Plot of filtrate loss versus time after hot rolling

The mud cakes for Sample I is thin, hard and impermeable as a result of the polymers, while samples II and III is thick, permeable and fluffy, this is as a result of the increased concentration of drill cuttings. The values for samples I and II are thin enough for safe drilling operation. Sample III is too thick, this may cause an increasing potential for differential sticking of the drill string.

Figure 2(a-f) shows that an increase in the values was indicated by the increase in the concentration of drill cuttings in samples II and III and this will cause gel structure to develop when the samples are allowed to rest. The high plastic viscosity values can also be said to be a function of increasing drilling fluid density. Figure 2a, shows that the maximum yield point decreases as mud density because of the larger quantities of weighting materials (cuttings build up) that must be suspended to obtain higher mud densities.

Gel strength as a reflection of the low shear rheology values act as a measure of the attractive forces operative in a static condition, the initial 10 seconds and final 10 minutes values is observed to increase as cuttings concentration increases from 0 – 105 lb/bbl. This implies that the minimum shearing stress necessary to cause slip wise movement for drilling operation will increase at the beginning and start of drilling after drilling break. The high gel strength is an indication of high suspension ability of the mud samples and also desirable for preventing barite settlement under static down hole conditions.

The results of the apparent viscosities for the samples I, II and III indicate the high suspension ability of the mud samples during drilling break but with an overall detrimental effect on the drilling process.

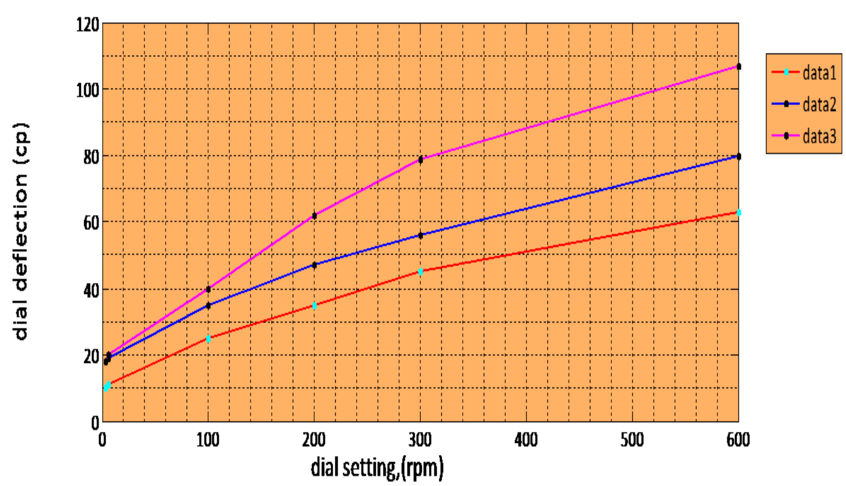

Figure 2a A Plot of Dial deflection Vs Dial Setting before hot rolling @120°F

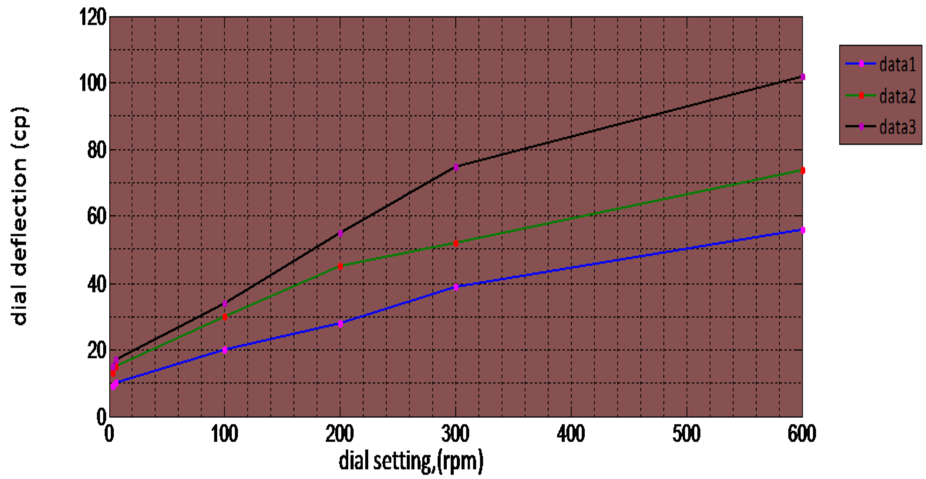

Figure 2b A Plot of Dial deflection Vs Dial Setting before hot rolling @150°F

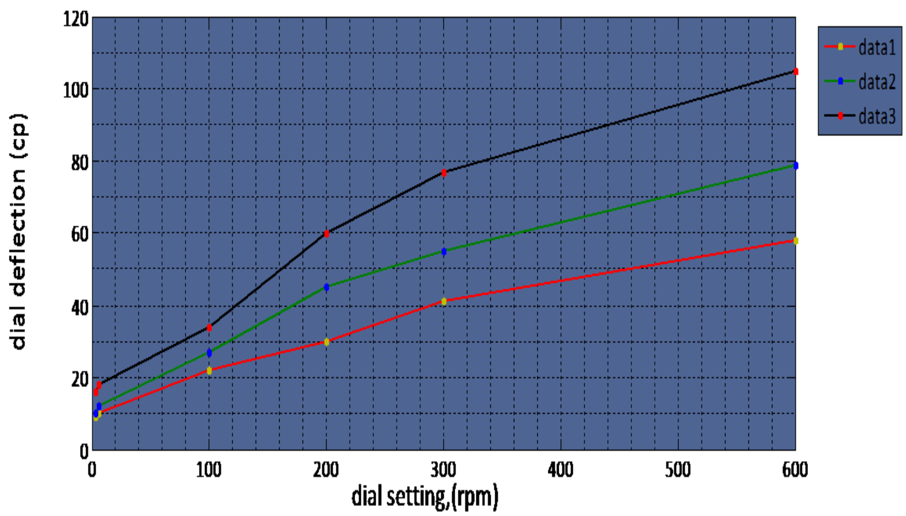

Figure 2c A Plot of Dial deflection Vs Dial Setting after hot rolling @120°F

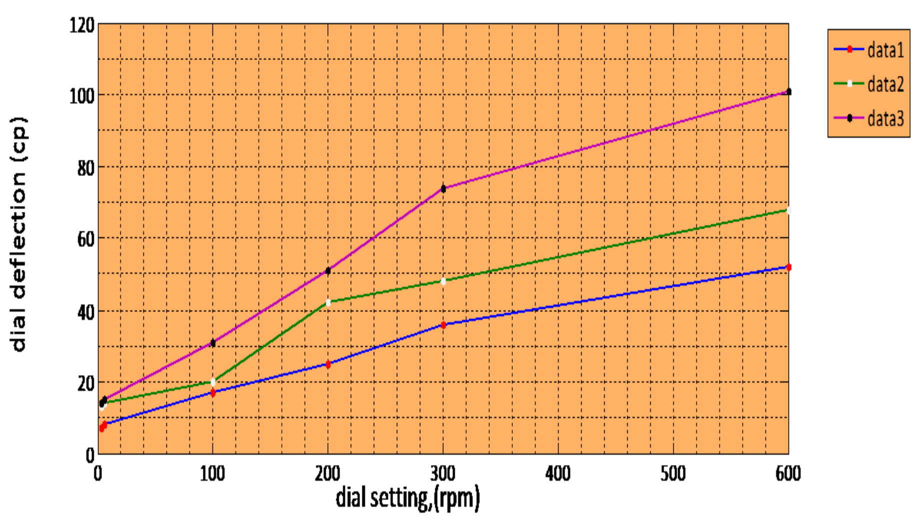

Figure 2d A Plot of Dial deflection Vs Dial Setting after hot rolling @150°F

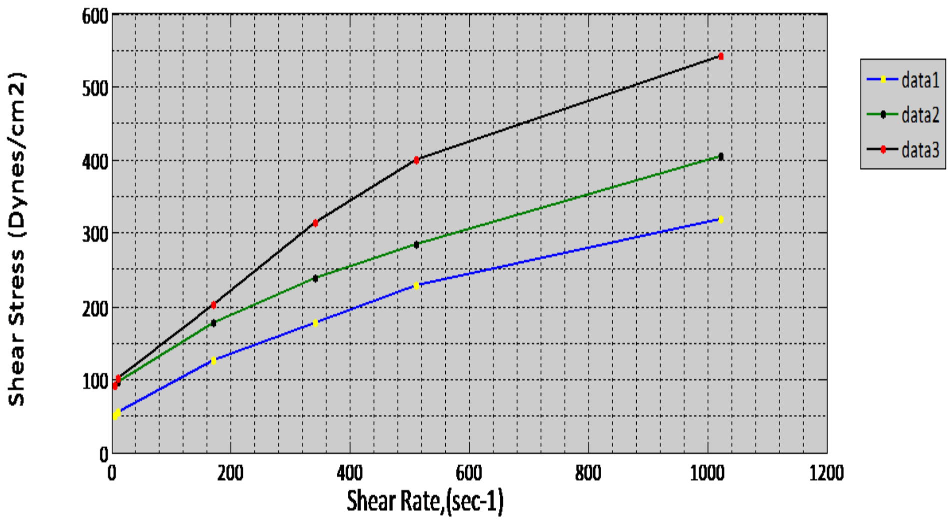

Figure 2e Shear stress Vs Shear Rates for mud Samples before hot rolling @ 120°F

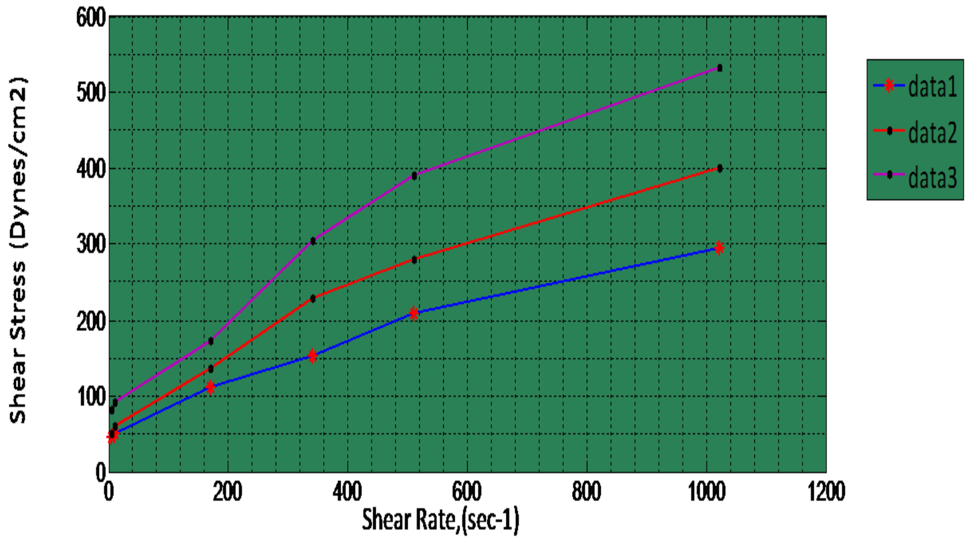

Figure 2f Shear stress Vs Shear Rates for mud Samples after hot rolling @ 120°F

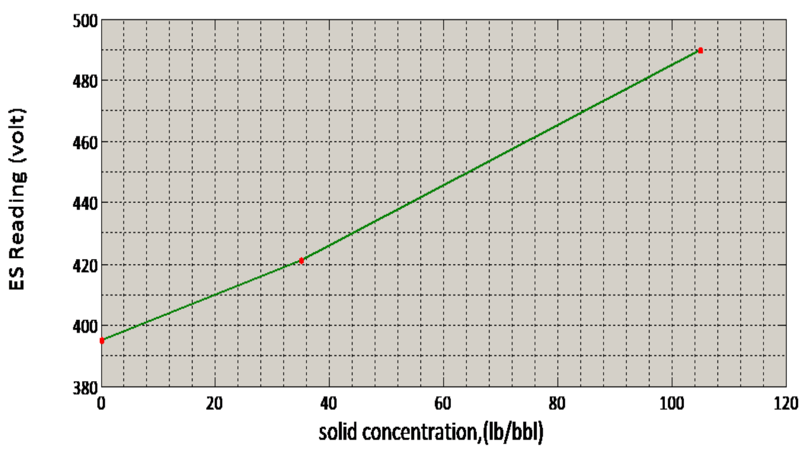

Figure 3a Plot of Electrical Stability Vs Solids Concentration before hot rolling @120°F

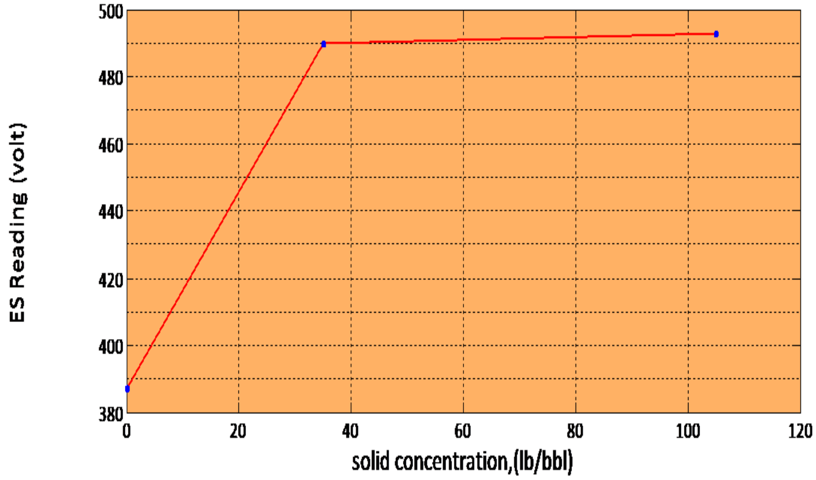

Figure 3c Plot of Electrical Stability Vs Solids Concentration after hot rolling @120^{o}F

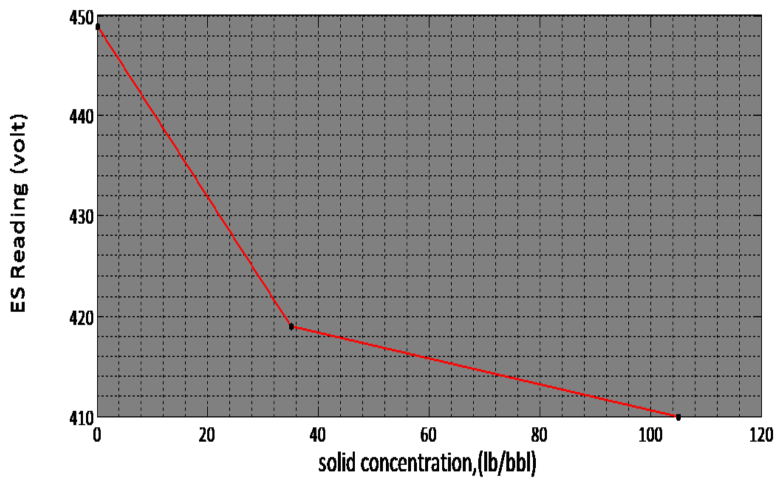

Figure 3b Plot of Electrical Stability Vs Solids Concentration before hot rolling @150^{o}F

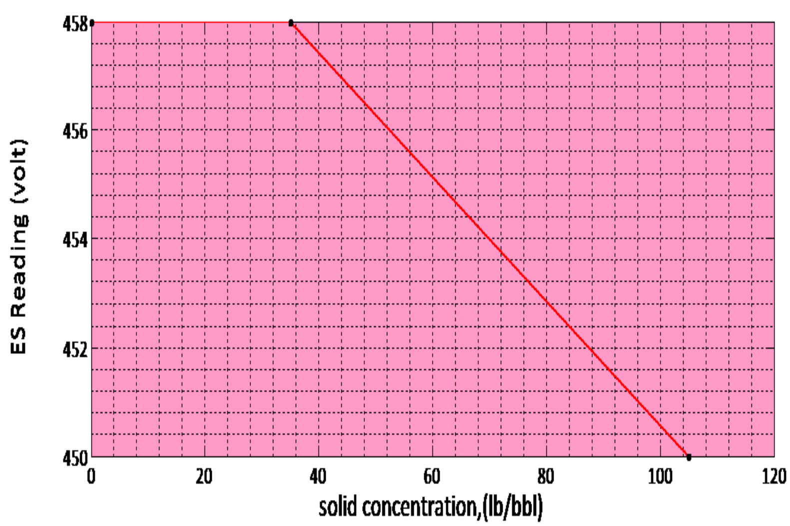

Figure 3d Plot of Electrical Stability Vs Solids Concentration after hot rolling @150^{o}F

Figure 3(a-d) indicates that sample III has a very low ES value while samples I and II falls within an acceptable range and this is as a result of the increase in the percentage water content of the mud as seen in the retort analysis. This result implies that the mud is not stable as a result of emulsion weakening and this will also have filtrate and rheological indications

4. Conclusion

Evaluation of the mud samples showed varying characteristics as the concentration of drilled cuttings increases from 0 – 105 lb/bbl.

The mud weight increase was as a result of drill cuttings incorporation as drilling progressed. This should however be controlled to avoid formation damages.

Poor filter cake quality (more coarse drilled solids) results in a more-permeable, more-porous cake. Poor cake quality (thicker and brittle) can maximize wall sticking and reduce frictional forces between drill string and wellbore, loss circulation, and poor cement bonding to the formation.

Solids decrease the frictional pressure drop causing too high viscosities in the oil mud system but do greatly increase the ability to carry the rock cuttings to the surface. An ever increasing concentration of drilled cuttings contributes to poor rheological properties and increase fluid maintenance cost.

High gel strength was indicated by increasing concentration of drilled cuttings in the oil base mud.

The results obtained from the retort analysis agree with the water content obtained from highly weighted mud. This results in low electrical stability values due to emulsion weakening

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