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Parametric Study of Dynamic Manner of Drilling Fluid; the New Aspect

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Abstract

The experiments are held to investigate the effect of aging time and temperature on a prepared oil based drilling mud which contains nano aluminium oxide particle. The rheological specifications of drilling mud in high temperature – high pressure viscometer are considered in this work to simulate the drilling conditions occurred in deep wells. Also, the effect of using nano particle is investigated comparing the Rheological behaviour of simple oil based drilling mud with that is obtained from nano-oil based drilling mud. So, shear stress, shear rate, effective viscosity, plastic viscosity and gel strength are measured versus temperature and working time for two types of drilling mud. Results represent the rheological treatment of drilling mud in a range of temperature and aging time so are applicable and useful in prediction of the amount of required shear force or shear stress at a defined temperature and time to reach a defined shear rate.

Keywords

Rheological Specifications, Oil Based Drilling Mud, Strength, Yield Point, Viscosity

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1. Introduction

The key to making the rotary drilling system work is the ability to circulate a fluid continuously down through the drill pipe, out through the bit nozzles and back to the surface. The drilling fluid can be air, foam (a combination of air and liquid or a liquid. Liquid drilling fluids are commonly called drilling mud. All drilling fluids, especially drilling mud, can have a wide range of chemical and physical properties. These properties are specifically designed for drilling conditions and the special problems that must be handled in drilling a well.

1.1. Purpose of Drilling Fluids

Cooling and lubrication: As the bit drills into the rock formation, the friction caused by the rotating bit against the rock generate heat. The heat is dissipated by the circulating drilling fluid. The fluid also lubricates the bit.

Cuttings removal: An important function of the drilling fluid is to carry rock cuttings removed by the bit to the surface. The drilling flows through treating equipment where the cuttings are removed and the clean fluid is again pumped down through the drill pipe string.

Suspend cuttings: There are times when circulation has to be stopped. The drilling fluid must have those gelling characteristics that will prevent drill cuttings from settling down at the bit. This may cause the drill pipe to be stuck.

Pressure control: The drilling mud can be the first line of defence against a blowout or loss of well control caused by formation pressures.

1.2. Lost Circulation

The lost circulation can occur in several types of formations,

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including high permeable formations, fractured formations and cavernous zones. The lost circulation materials can be added to the mud to bridge or deposit a mat where the drilling fluid being lost to the formation. These materials include cane and wood fibers, cellophane flakes and even padi husks were used in oil drilling in Sumatra.

1.3. Stuck Pipe

Stuck pipe can occur after drilling has been halted for a rig breakdown, while running a directional survey or when conducting other no drilling operation. The drill pipe may stick to the wall of the hole due to the formation of filter cake or a layer of wet mud solids on the wall of the hole in the formation.

1.4. Heaving or Sloughing Hole

This occurs when shale's enter the well bore after the section has been penetrated by the bit. To solve this problem, drilling is suspended the hole is conditioned (by letting the mud in circulation for a period of time)

1.5. Types of Drilling Fluids

1.5.1. Water-Base Mud

This fluid is the mud in which water is the continuous phase. This is the most common drilling mud used in oil drilling.

1.5.2. Oil-Based Mud

This drilling mud is made up of oil as the continuous phase. Diesel oil is widely used to provide the oil phase. This type of mud is commonly used in swelling shale formation. With water-based mud the shale will absorb the water and it swells that may cause stuck pipe.

1.5.3. Air and Foam

There are drilling conditions under which a liquid drilling fluid is not eh most desirable circulating medium. Air or foam is used in drilling some wells when these special conditions exist.

1.6. Mud Properties

1.6.1. Mud Density or Mud Weight

The mud weight is measured by means of a mud balance. The weight of water is 8.33 ppg. The mud weight can be increased by adding barite (barium sulphate). Barite has a specific gravity of between 4.2 – 4.3. Other materials can be used to increase mud weight such as ilmenite (S.G of 4.58)

1.6.2. Mud Viscosity

The mud viscosity is difficult to measure but in the field the Marsh funnel and the Fann V-G meter is commonly used. The Marsh Funnel is filled with mud, the operator then notes the time, removes his finger from the discharge and measures the time for one quart (946 cm^3) to flow out. Marsh funnels are manufactured to precise dimensional standards and may be calibrated with water which has a funnel viscosity of 26 ± 0.5 sec. In using Fann V-G (Viscosity-gel) meter, readings are taken at 600 rpm and 300 rpm. The Yield point is influenced by the concentration of solids, their electrical charge, and other factors. If not at the proper value, it can also reduce drilling efficiency by cutting penetration rate, increasing circulating pressure, and posing the danger of lost circulation.

2. Materials and Methods

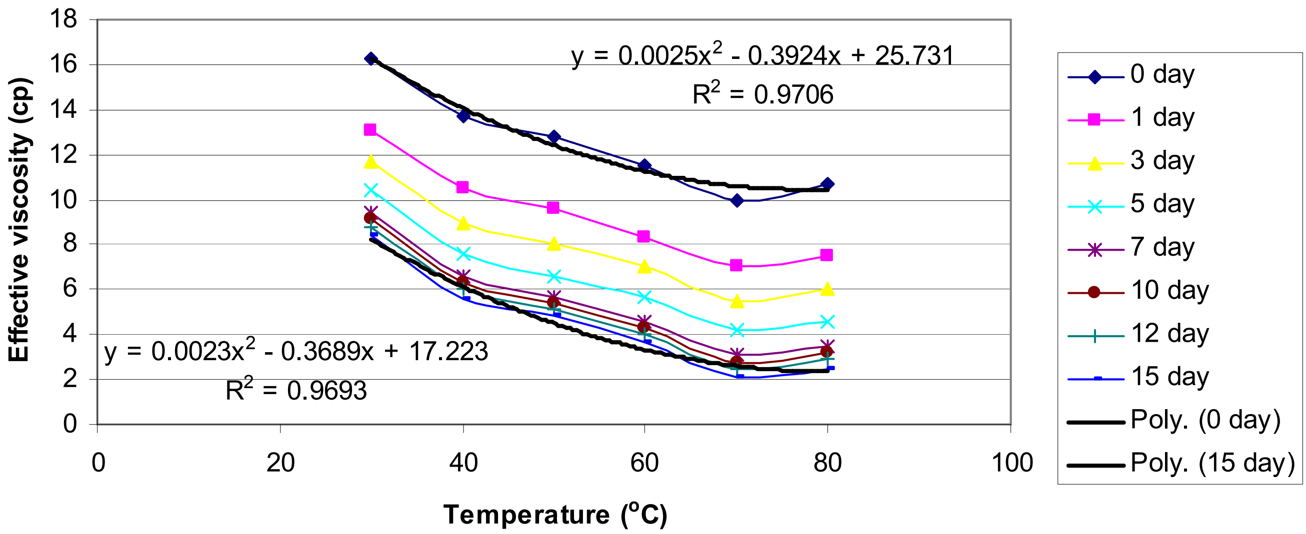

Figure 1. The effect of temperature on effective viscosity as a function of aging.

Oil drilling mud contains emulsifier, viscosifyer, wetting agent, brine, lime and other components.

The operating temperature affects the properties of fluids due to researches. The effect of operation temperature which varies from 30 C to 80 C is investigated. The results are measured after 0, 1, 3, 5, 7, 10, 12 and 15 days, respectively. Also, a comparison in behaviour of nano drilling fluid (NDF) and simple drilling fluid (DF) is shown. Also, all curves which are related to the Rheological behaviour of DF are at the higher range of shear rate value than those are related to the NDF, at the constant temperature and the constant amount of shear stress. This can indicate on the less amount of required pump power to recycle the oil based drilling fluid which contains nano particle after a static state than that is needed for simple oil based drilling fluid. This may show the improvement in properties of oil based drilling fluid by addition of nano particles. Figure 1 shows the effect of operating temperature on the effective viscosity values.

Temperature influence on the effective viscosity through time is shown in Figure 1. The increase in temperature decreases the amount of effective viscosity. Also, aging decreases the amount of effective viscosity. The high temperature increases flocculation in mud and decreases viscosity however can be modified by adding bentonite and lignosulphate. Temperature increase eliminates the effect of temperature in reduction of viscosity. There are two second order polynomials to predict the trend of changes in effective viscosity of nano drilling fluid after 1 day and also 15 days of aging time.

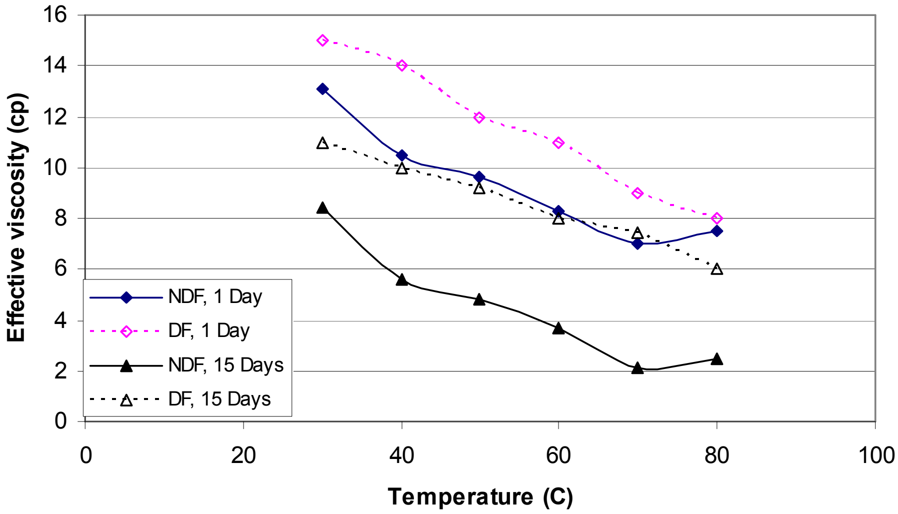

Figure 2. Comparison between values of effective viscosity of DF and NDF.

The effect of increasing the temperature values is considered in the Figure 2 for both simple and nano types of drilling mud after working time of 1 ay and 15 days. According to the Figure 2, passing days doesn't have any considerable decreasing effect on values of effective viscosity of simple drilling fluid. After 1 day and 15 days, the amount of effective viscosity of nano- drilling mud is averagely 18% and 50% lower than those are for simple drilling fluid, respectively.

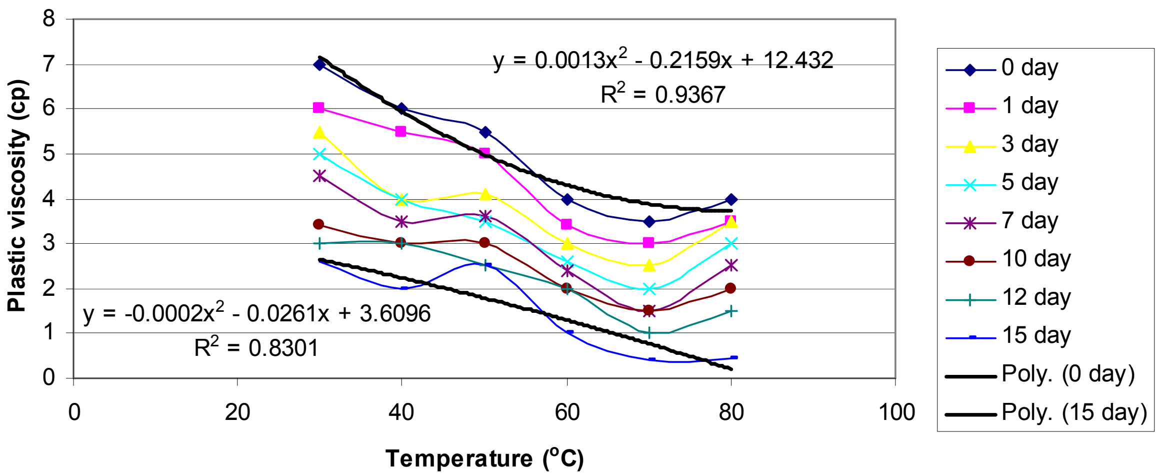

Figure 3. The effect of temperature on the values of plastic viscosity.

Two predictive correlations as second order polynomials are presented in the Figure 3. The accuracy of correlation seems to be decreased after 15 days.

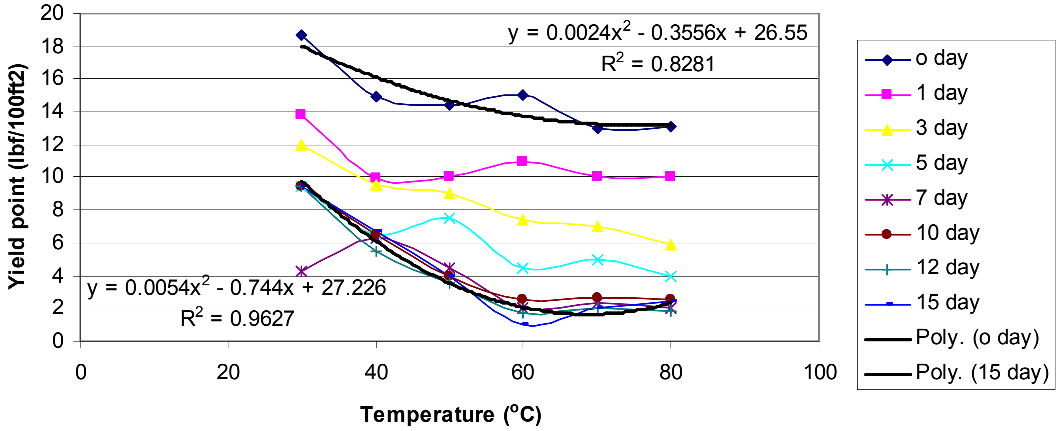

Figure 4. The effect of temperature on yield point.

Figure 4 shows the yield point as a function of temperature from initial working day to 15 days aging. The amount of yield point can predict the cutting slip velocity in drilling performance. The increase in working temperature decreases the amount of yield point. Also, regular shear stress during days decreases the amount of yield point. Two predictive correlations for amounts of yield point of nano drilling mud are presented in Figure 4 for this value, the accuracy of the correlation is not high (R^2= 0.83).

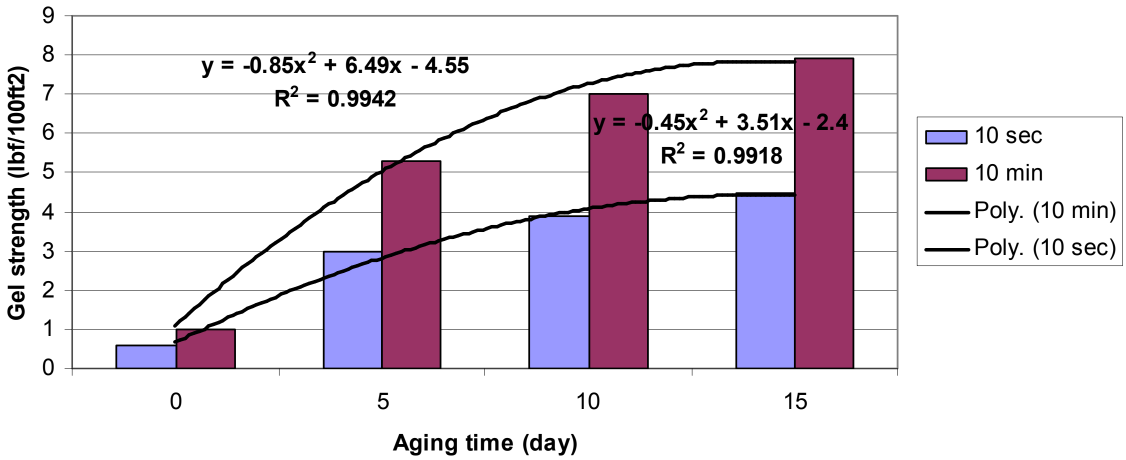

Figure 5. The influence of aging time on the amounts of gel strength.

The Figure 5 presents the dependency of gel strength of mud on aging time. Through four different 0, 5, 10 and 15 days and at each time both initial time of working (10 second) and 10 minute working time are considered. Higher aging time results higher gel strength even though the intensity of 10 min aging is decreased in higher aging. Comparing the strength values resulting in 10 min and 10 s. shows 1.7-1.8 ratios which are 1.66, 1.76, 1.79 and 1.75 at 5, 10 and 15 days, respectively. These trends may be analysed by the increase in the particle numbers and the increase in large intermolecular forces. Flocculation of bentonite clays occurs at high temperatures. So, high viscosities are obtained at low shear rates and high gel strengths are obtained at high temperatures due to the experiments mentioned above.

3. Conclusion

In this work, experimental data of the amount of viscosity, gel strength and yield point are presented which introduce the treatment of oil based drill mud versus aging time (1, 3, 5, 7, 10, 12 and 15 days) and temperature (30, 40, 50, 60, 70 and 80 C). Comparison of values of effective viscosity and plastic viscosity of simple drilling fluid with nano drilling fluid shows the considerable effect of nano particle on decreasing of these parameters (56% in effective viscosity and 50% in plastic viscosity) after 15 days with increasing in temperature.

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