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Temperature Effects on the pH of Water Based Drilling Mud and Mud Ph Concerns on the Environment

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Abstract
Drilling mud is a complex mixture of clay, water, and additives used primarily for bringing out cuttings from the well. Toensure the drill mud functions properly to achieve the desired result; a suitable drilling mud must be selected. Drilling through high temperature zones with water-based mud can be very problematic in the petroleum industry. The mud pH is a very significant rheological property, wherefore; this paper investigates the effects of temperature on the pH of water-based drilling mud. Water based mud was prepared with resistant additives and weighing materials for different temperature variation in degree Celsius, ranging from 28ºc, 30ºc, 40ºc, 50ºc, 60ºc to 70ºc which was the highest temperature in the experiment. Result from the experiment shows that the pH of the mud decreases with an increase in temperature. The decrease in the pH value makes the performance of the drilling fluid deteriorate and creates a corrosive environment that impacts both on production facilities and contaminate ground water as well as the environment.

Keywords: Water; Additives; Concentration; Drilling mud

1. Introduction

Drilling mud's area combination of clay, water, and additives used in a drilling well operation to lubricate bit, carry out rock cuttings, and to maintain pressure. Drill muds are very significant for a drilling operation and therefore needs to be properly designed to avoid unnecessary economically implied losses such as fluid lost circulation(Alkinani, et al., 2019) and problems associated with stuck pipe(Al-Hameedi, et al., 2018).

To make sure that proper functionality of drilling mud is achieved; suitable drilling mud is selected for specific drilling operation with the most favourable properties for the job. Most of the drilling mud functions are controlled by its rheological properties (Dhiman, 2012). Drilling process problems such as high

temperature conditions are usually encountered during a drilling progress. The American Petroleum Institute (API)has a recommended practice for testing drilling mud properties at regular interval to help mud engineers determine proper functioning of drilling fluid.
There is an increase in temperature when drilling deep into formations.Therefore, in producing for high temperature zones, petroleum engineers encounter a number of challenges in a drilling operation which can be caused by factors such as reduction in viscosity of the mud, decreased alkalinity, reduction in the degree of hydration, increase in the degradation rate of additives and an increase in the dispersion of clay particles(Al-Hameedi, et al., 2020).

The pH indicates the degree of acidity or alkalinity of the drilling mud which is obtainable in a numerical value of 0 to 14, this means an inverse measurement of hydrogen concentration in the fluid (Bakhtiar, 2015).

Azar and Lummus(1975) performed an experiment to determine the effect of drill fluid pH on the corrosion-fatigue performance of Grades D and E drill pipe materials. Results show that the drill mud pH between 8.0 and 10.0 for non-dispersed bentonite mud and 9.0 to 11.0 for dispersed lignosulfonate mud is not a valid measurement for corrosion control.

1.1 Mud pH and Environmental Concerns

In petroleum exploration and drilling, drill wastes in the form of drill mud and drill cuttings are produced. These wastes cuttings and fluids are usually in large volumesand have been agreed to have an impact on the environment (Al-Hameedi, et al., 2019).Initially, these drill wastes were either dumped in a storage facility or disposed of at sea (Albeshr, et al., 2016).Saasen et al. (2014) noted that these drilled wastes are sometimes disposed in a "junk" well. Current disposal and management practices for drill mud and cuttings in the petroleum industry has become a growing and serious challenge (Nahim, et al., 1993).Drilling mud waste disposal in an environmentally friendly manner is a costly and a difficult task because of the compound nature of the drilled mud waste (Albeshr, et al., 2016). It is reported that wastes such as muds and formation solids from water-based drill muds may contain biocides, heavy metals and inorganic salts which may have significant effect on the environment (Simiyu, et al., 2016). Consequently, the level of pH and a combination of other dissolved gases present in the drilling environment can significantly impact on oil well facilities as well as the environment when these drilled wastes are not properly treated before disposal (Azer & Lummus, 1975).

It is important to maintain the mud pH level as more drilling additives which will be more costly in the long run will be required to achieve the correct viscosity if the pH level is too low. A pH of 7.0 is a neutral solution, it is acidic if the pH is lower than 7.0 and alkaline if the pH is higher than 7.0.Drilling fluid additives are developed to mix with water to give a pH level ranging from 8.5 to 10 so as to give the required chemical result and to provide a proper yield.

This work, through experimental study was conducted to determine the effect of this high temperature effect on the mud pH property when drilling within deep formations.

The performance of the drilling mud under high temperature is extremely significant for drilling geothermal and deep wells.

2. Materials and Method

In this work focused on investigation by way of laboratory experiment, the effect of temperature on mud pH. The methodology adopted for this work is based on the API recommended practice for field testing of water-based mud.

2.1 Materials:

Bentonite clay (sodium montmorillonite clay), barite, carboxyl methyl cellulose (cmc), distilled water (350ml)

Apparatus:

Measuring cylinder (EX20ºc 500ML ± 5ml), digital weighing balance, mixer cup, mud mixer machine (REG no 402260 VICCO), drier box (DHG- 9053), thermometer (-20 to 100ºc), mud balance (model 140 Baroid testing equipment), pH meter (digital pH meter), digital stopwatch, beaker, fann filter press (series 300).

2.2 Mud Preparation and Experimental Procedures

This involves the laboratory preparation of water-based mud (mud composition) that is necessary to obtain a level of resistant additives and weighing materials of high temperature (HT) condition, so as to determine the characteristics of the mud at different temperature range. Here, a digital weighing balance is used to weigh the bentonite (sodium montmorillonite) clay (21g), barite (5g), Carboxyl methyl cellulose (cmc) (6g) and poured in a mixer cup, and then 350ml of distilled water was measured with a measuring cylinder (ml) and added to the mixture in the mixer cup. The mixer cup was attached to a mixer machine with the aid of a clip and the mixer machine was connected to a power source for powering. The powered mixer machine helped to properly mix or blend the mixture to obtain a smooth mixture of the mud. The prepared mud was then placed inside a drier box and heated for some hours to obtain the highest required temperature for the test.

2.3 Procedures for pH Determination using pH Meter:

In carrying out this experiment, the instrument is turned on according to the required standard. The electrode tips were washed under a stream of running water and gently wiped dry with a piece of tissue. The electrode protective cap was removed.Insert the electrode and the temperature probe into the sample (prepared mud) to be tested. The sample is stirred gently and waited for it to stabilize. After the sample was stabilized, readings were taken and recorded. This was done for a maximum temperature of 70ºc and repeated for a temperature drop of range: 70º, 60,50,40,30, and 28ºc. After the experiment, the electrode was rinsed with clean water and replaced the electrode protective cap.

Here it was also noted that prior to each measurement recorded; during the experiment, the tested mud was stirred gently and waited for the stability symbol to obtain accurate results.

Mathematically, mud p^H can be determined by:

$P^H = - \log [H^+]$(1)

Where $[H^+]$ is the hydrogen ion concentration in moles per liter. At room temperature, the ion product constant of water, K_w, has a value of $1x10^{-14}$ mol/L.

$K_w = [H^+] [OH^-] = 1.0 \times 10^{-14}$ (2)

For pure water, $[H^+] = [OH^-] = 1.0 \times 10^{-7}$ and hence, pH = 7(3)

According to the p^H formula, the more hydrogen atoms present, the more acidity of substance is but the p^H value decreases.

3. Results and Discussion

The readings of the mud pH were determined using a digital pH meter and the corresponding temperature readings gotten were recorded in a tabulated format. The readings were recorded in moles per liter (mol/L) and at the corresponding temperature readings are given as tabulated in Tables 1.

Temperature (ºC)	P^H (mol/l)
28	9.4
30	9.4
40	9.3
50	9.2
60	9.1
70	9.0

Table 1. Readings of mud pH with temperatures.

The mud P^H readings recorded from the digital P^H meter were subsequently plotted against the corresponding temperatures, and this is shown in figure 1 below.

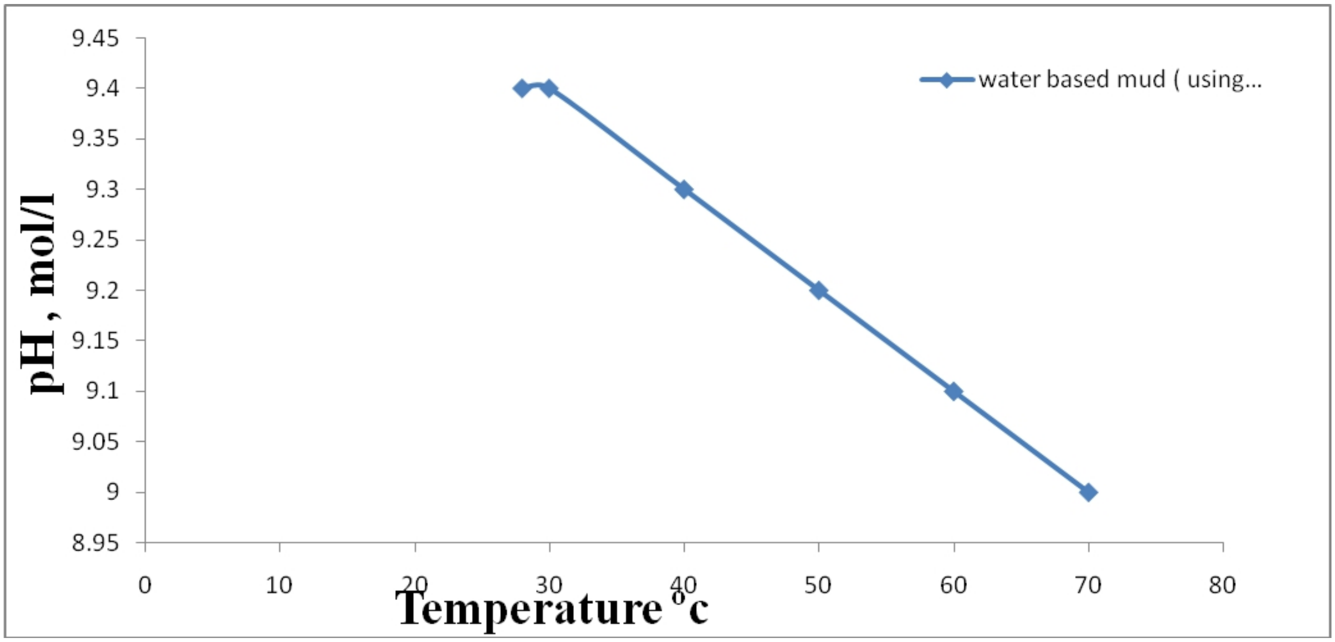

Fig. 1 Plot of pH against temperature (water-based mud, using bentonite clay).

practical test was performed to determine the characteristics of the pH of mud at different temperature in degree Celsius, ranging from 28ºC, 30ºC, 40ºC, 50ºC, 60ºC to 70ºC as the maximum temperature obtained.

From the results of the experiments carried out on the four different properties of the mud, temperature was found to have undoubtedly huge effect on the properties, and this was obvious at higher temperatures in all the four properties tested for. As shown in Figure 1, at temperatures of 28ºC and 30ºC, the P^H values are 9.4 and 9.4 mol/l which was constant since there was not much temperature difference. At temperatures above 30ºC to the maximum temperature obtained at 70ºC, there was a decrease in the mud pH.

Conclusion

With the evidence on the results obtained, drilling through high temperature zones in the formation with water-based drilling mud is a major problem in the petroleum industry. From the result of the experiment carried out on the pH of the mud, the pH of the mud decreases during exposure to high temperature; therefore, the mud pH must be made to be high enough for the entire time the mud will be left in bottom of the well at high temperature. High temperature will lead to the decrease of p^H value, this will make the performance of drilling fluid deteriorate. It is of importance to monitor and keep the pH high as a decrease below the value of 7 will increase the acidity of the mud thereby aiding to increase the corrosion rate of down hole equipment's.

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