The Additives Impact the Gel Strength of the Water Based Drilling Mud

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Abstract

One of the most important functions of drilling mud is its ability to suspend the rock cuttings during drilling cease, this ability is related mainly to gel strength. Gel strength is caused by the attractive forces between the active particles of bentonite (clay) during the static period. Sodium-based bentonite concentration has a direct effect on the gel strength. In addition, cement contaminants may encounter drilling mud as a result of casing string cementation which in turn also leads to a noticeable impact on gel strength. As consequence, it is vital to observe drilling mud gel strength continuously to identify efficient drilling mud functions. In this paper, an experimental study was performed via a shearometer, the aim of this study is to investigate the effect of the variety of the weights of sodium-based bentonite and cement slurries on the gel strength of water based mud. To analyze the influence of bentonite additives, four drilling mud samples were prepared with bentonite weights; 40, 60, 70, and 80 gm respectively, and gel strength was measured at each weight. While cement contamination had been examined by preparing three drilling mud samples contaminated with 2 gm, 3 gm, and 5 gm of class G cement. The results showed that an increase in bentonite quantities leads to rising in gel strength directly. The findings also showed that gel strength increased as the level of cement slurries raised. Furtherer increase appeared from 20.2 to 42 lb/100 ft^2 when cement weight increased from 2 to 5 gm respectively.

Keywords: *drilling mud, rock cuttings, cement, gel strength, water based muds.*

1. Introduction

The ability of drilling mud to suspend cuttings and weighting material at the moment of ceasing circulation is one of its most important functions. This ability is caused by gel strength property, while the drilling muds of low gel strength cannot suspend cuttings efficiently, in this case, severe problems may occur, for example cutting accumulation, pipes sticking, and unleveled hydrostatic pressure. Drilling mud with a high gel strength requires more pumping energy to recirculate after stopping. Due to the high pumping pressure, the formation pressure can be exceeded and damage can occur [1]. Gel strength is a crucial property of drilling mud to suspend the rocks cuttings during circulation and when the pump is ceased by ensuring proper rheological properties, hole cleaning and carrying drilled cuttings from the downhole can be improved. [2]. In comparison, the yield point can be regarded as the tendency for drilling mud to carry cuttings from the borehole towards the surface, where a cuttings control system can be used to remove them from the surface [3]. Gel strength can be referred to as the amount of attraction between the particles in a drilling fluid when the conditions are static. It is common practice in the upstream petroleum industry to use certain additives to increase the gel strength of calcium carbonate drilling fluids

used in drilling [4]. Importantly, It is recommended that gel strength rise rapidly to a level where drilled cuttings can be suspended, and then be "flat," meaning there should be little or no further gel strength development with time.

J. Sun, et al. indicate that when the drilling operation is paused, drilling mud's gel strength is determined by its ability to enhance and maintain a gel structure. In addition, an efficient gel strength is one of the major requirements to maintain the pressure of circulation required for retrieval of main drilling activities [5].

Eric and Richard presented an experimental study including the influence of cement contamination at various concentrations on four samples of water based drilling mud. Three of them were exposed to 10, 20, 30 gm of class G cement at wide temperature range. The study had been showed the grading of the rheological properties under various conditions presenting that gel strength and yield point had been increased obviously with cement quantities at along the whole temperature range. In contrast, plastic viscosity dropped gradually with cement slurry at 40 and 60◦C [6].

Fahd *et al.* stated that calcium carbonate water based mud showed no response in gel strength with the time at 85°F, while at high temperature range, gel strength decreased with the time reaching zero lb/100 ft^2 at 200°F, this state was solved by adding various quantities of bentonite [7].

2. Drilling Mud Contamination

Any material that alters the properties of drilling mud as it is encountered, is considered a major cause of drilling mud contamination, such properties as filtration, viscosity, and gel strength.
Depending on the drilling fluid type, the type of contaminant, and the level of contamination, drilling mud contamination varies in severity [6].

Mud systems are adversely affected by these contaminants, which reduce their performance and quality. One of the main contaminants is the cement which has been investigated in this study. The results of initial gel strength and gel at 10 minutes of water based mud with different cement quantities would be shown later in this study.

3. Experimental Work

In this study, procedurally, the gel strength is measured after 10 seconds, 5, and 10 minutes, by adding alternatively affected materials in different quantities, namely, bentonite and cement (class G) which have played a key role in the gel strength property of drilling mud.

3.1 Materials and Instruments

-hollow tube weighing 5 gm.

A stainless steel cup of 600 ml with a graduated ruler maintained on its center, the ruler is subdivided into log subdivisions representing the gel strength value in lb/ 100 ft^2.

- Hamilton Beach Mixer.

3.2 Methodology

In this study, water based mud has been prepared which is commonly used in Iraqi oil fields. Firstly, drilling mud is prepared by mixing 600 ml of fresh water with 40 g, 60 gm, 70, and 80 gm of sodium-based bentonite in an electrical mixer for 1 minute to measure the gel strength under different situations.

3.2.1 Measurement of Initial Gel Strength

The mud sample is poured into a cub of the shearometer to be leveled with the lowest line of the scale, namely 3 lb/ 100 ft^2, secondly, the wet tube is freely released into the cub for one minute to penetrate the drilling mud sample,

after that the initial gel strength is recorded from the log- graduated ruler in units lb/ 100 ft^2.

3.2.2 Measurement of Five and Ten-Minute Gel Strength

The mud sample was returned to the mixer for one minute to break the initial gel structure that developed. Then, it was poured into the cup of shearomter to the lowest line, after that, the mud sample is left in the cup for 5 minutes under static conditions in order to reconstruct the gel structure. After 5 minutes have elapsed, it is the time to record the gel strength of five minutes by releasing the tube freely into the mud sample and reading gel strength after 1 minute. Lastly, the steps are repeated to record the gel for ten minutes in the same procedure except for the time of static to be 10 minutes.

4. Results and Discussions

Firstly, the experimental work began with the investigation of bentonite added to the drilling mud in different quantities. Secondly, cement (class G) was also analyzed as a drilling mud contaminated, by adding it at different weights at constant bentonite quantities.

4.1 Investigation of Bentonite Additives

Table 1 shows the results of gel strength at 10, 5 minutes, and initial gel for drilling mud samples composed of 600 ml of water mixed with bentonite weighing 40, 60, and 70, 80 gm respectively.

Table 1. Gel strength of water based mud at various periods and different quantities of bentonite.

Weight of bentonite (gm)	Initial gel strength (lb/ 100 ft^2)	Gel strength at 5 minutes (lb/ 100 ft^2)	Gel strength at 10 minutes (lb/ 100 ft^2)
40	3	3.3	6
60	7.4	8.6	17
70	13	14.7	22.3
80	17.4	19	40.4

Figure 1 shows that adding various bentonite weights to the drilling mud leads to an increase in the gel strength of drilling mud at all investigated time periods. It can be clearly seen that there is a noticeable effect of bentonite quantities on the gel strength. the peak value of gel strength was associated with 80 gm of bentonite at 10 minutes of static conditions which in turn leads to high hydrostatic pressure and may cause formation damage and excessive pump pressure to initiate the circulation.

Gel strength of the prepared drilling muds is tested for a short time of 10 seconds (initial gel), 5 minutes, and a long time of 10 minutes. In each static period, gel strength has increased sharply as the bentonite weight has raised. initial gel strength increased from 3 lb./100ft^2 which is considered the lowest shear stress required to break the gel structure to 17.4 as a peak point. While during long static times, namely, at 10 minutes, gel strength recorded a very high gel strength reaching 40.4 lb/100 ft^2, indicating that there would be difficult drilling conditions.

Figure 2 shows the gel strength as a function of time for bentonite quantities 40, 60, 70, and 80 gm respectively. It was obvious that as the bentonite quantities increased, time shows more effect than those lower quantities, increasing dramatically from 17.4 to 40.4 lb/ 100 ft^2 corresponding to 80 gm of bentonite.

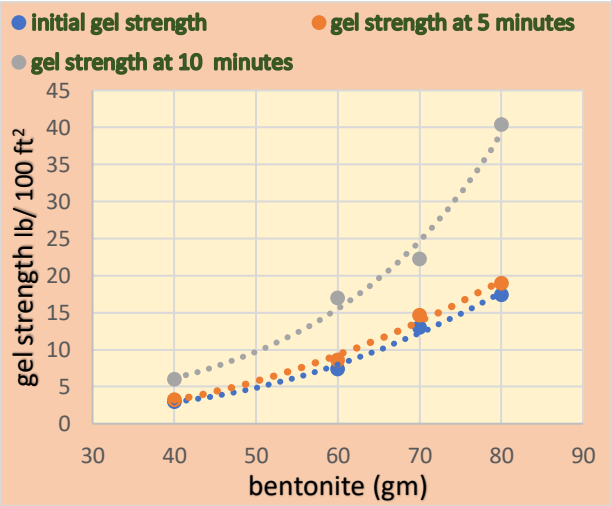

Fig 1. Gel strength at various additives of bentonite.

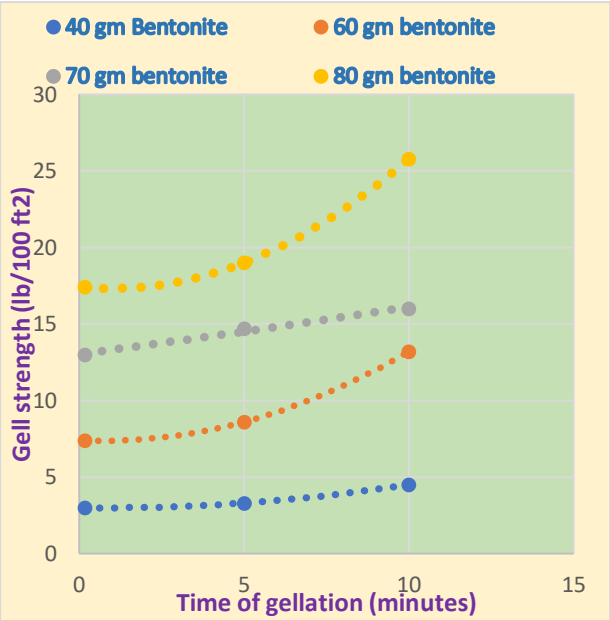

Fig 2. Gel strength corresponding to different static periods.

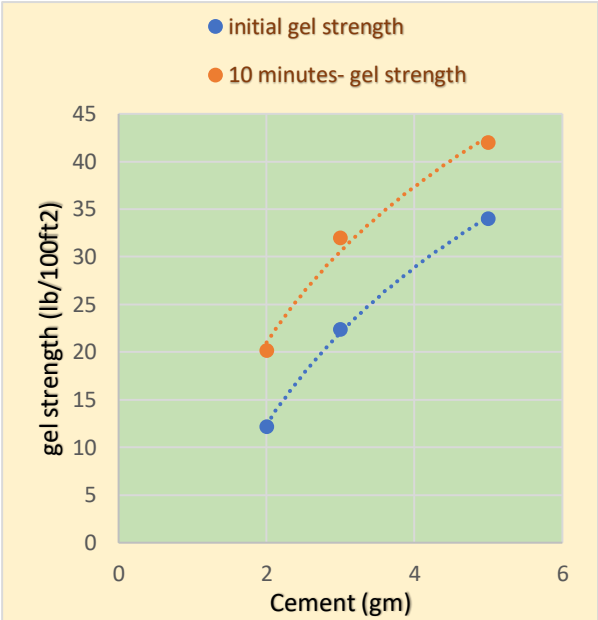

Fig 3. Gel strength of drilling mud with additives of 60 gm of bentonite and various grams of cement contaminant.

4.2 Investigation of Cement Additives

Table (2) presents the results of the initial gel strength and 10 min gel strength of water based mud of 60 gm bentonite with different quantities of cement (class G). From figure 3, the initial gel strength and 10 minutes- gel strength increased progressively as cement quantities raised, this was caused by the bonding trend of the cement and the increase in the pH of drilling mud.

Table 2. Gel strength of drilling mud composed of 60 gm bentonite corresponding to different cement quantities.

Weight of cement (gm)	Initial gel strength (lb/ 100 ft^2)	10 min-gel strength (lb/ 100 ft^2)
2	12.2	20.2
3	22.4	32
5	34	42

5. Conclusions

The results showed that the amount of bentonite had the dominant effect on the gel strength comparing to the cement additives and time of gelation.

This study stated that the influence of static time had a key fingerprint as the bentonite concentration increased to 80 gm, while at lower weights (40 gm) there was a steady an increase in the gel strength.

Cement contamination introduced a constant effect over initial and 10 minutes static period indicating a steady trend of the time.

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