Effect of Temperature on Drilling Mud

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Abstract: The main functions of drilling fluids include providing hydrostatic pressure to prevent formation fluids from entering into the well bore, cooling drilling bit, cleaning borehole while drilling and Stability of borehole. While drilling, the drilling mud transport drilling cuttings to surface and suspending the cuttings while drilling stop. There are many factors that effect on drilling mud, including the borehole temperature. Therefore, with increasing in drilling depth the wellbore temperature increases that effect on drilling mud properties (viscosity include yield point (YP) and plastic viscosity (PV)). This experimental work conducted at rig IDC 41, NS-39 in the Nasiriyah oil field by using real field data. The devices for this work are fan V-G meter (Model 286), heat source and temperature measurement (IR Thermometer). In this experiment using two types of drilling mud density (1.35 gm/cc and 1.21 gm/cc), with increasing temperature the value of PV and YP increase. Also, YP/PV ratio increasing means more drilling cuttings transport.

1 Introduction

There are three key technical problems about drilling fluid for ultra-deep well drilling stability of additives against high temperature (aging); control of rheology and filtration loss with high solids content; narrow safe density window and poor stratum pressure-bearing capacity lead to borehole collapsing, leakage of drilling fluid and stick slip of a drill bit. Increase temperature of water base mud, bentonite will be hydrated and passivated in high temperature condition, and thus high effect on clay property. Therefore, main problem is a clay hydration in highest temperature drilling mud [1].

The main function of drilling mud carry drill cutting to surface while drilling. Also, drilling fluid serves to cool the bit, provide power to the mud motor and measuring-while-drilling (MWD) tool, support the walls of the hole and control the well pressure (prevent the well from flowing). An alternative method is called reverse circulation, where the flow of the fluid is reversed from the previously mentioned one [1]. Determination of the mud properties requires the experimental examination of the mud system at both the standard API and the high temperature, high pressure conditions at intervals throughout the duration of the drilling process [2]. It is quite easy to determine the mud properties at the surface conditions. Moreover, maintaining bottom-hole conditions at the surface for experimental reasons is difficult and risky. In order to investigate the properties of a drilling fluid at bottom-hole conditions from the surface conditions, the concept of aging is used Aging of drilling fluid is the process in which a drilling fluid sample previously subjected to a period of shear is allowed to more fully develop its rheological and filtration properties [3]. Aging takes place when mud is left inactive for example during tripping. Aging is done under conditions which vary from static to dynamic and from ambient to highly evaluated [4].

2 Experimental work

For this paper used many a device such as:
2.1 FANN V-G METER
Figure (1) fann V-G meter (Model 35 A) is used to measure two constant speeds, 600 and 300 rpm. The plastic viscosity (Pν), in centipoises, is calculated by the following equation:

\[ Pν = \frac{Ø600 - Ø300}{600} \]

Where:
- \( Pν \) = Plastic viscosity in centipoises, cp, Ø600 and Ø300 = Dial reading at speeds of 600 and 300 rpm respectively
- The yield point (Yp) in (lb/100ft²) is calculated from the following equation:

\[ Yp = Ø300 - Pν \]

Figure 1: fann V-G meter.

2.2 IR Thermometer
An electronic infrared thermometer is comprising a housing forming an interior chamber, a pyro electric sensor mounted within the chamber for sensing temperature change and generating an indicative electrical signal, means for directing infrared radiation from the object to be measured to the pyro electric sensor, a shutter assembly for controlling the passing of infrared radiation to the pyro electric sensor, an ambient temperature sensor for sensing ambient temperature within the interior chamber and generating an electrical signal indicative thereof, an electrical circuit for processing the electrical signals to calculate the temperature of the object to be measured, and an indicator for indicating the calculated temperature as show in figure (2).

Figure 2: Shows the shape of the IR-Torsometer device.

Despite the accuracy of the device and the quality of sensor sensors, but there is a ratio of error in reading the device depends on the wavelength and temperature, so it takes into account the proportion of error in the measurement of temperature and we relied on a scheme through which the error rate based on the wavelength of infrared radiation and temperature measured.
Figure 3: Measurement error in the case of 10% error in setting emissivity depend on wavelength and target temperature.

2.3 experimental procedure
In this experiment we took a sample of drilling fluid at a depth of 1870 m, fluid density = 1.35 gm / cc. We place the drilling fluid into a simple cup and then use an IR Thermometer to measure the temperature of the liquid, which is equal to 34°C, which represents the temperature of the surface. Then we take the sample and insert it into the viscometer. In order to know the viscosity values and the yield point, the bottom of the device with the base of the device and then descend the rotor until it reaches the line in the cup simple so that the rotor part immersed in the drilling fluid, and then start the machine on the rotation speed of RPM 600 and wait from 5-10 sec to prove readability and then record reading.

\[ \text{Plastic viscosity} = \Omega_{600} - \Omega_{300} \]

\[ \text{Yield Point} = \Omega_{300} - \text{P.V} \]

Then put the sample in a container and place it on the electric heater to heat the drilling fluid. The machine starts by heating the sample and moving the liquid continuously by means of a glass instrument so as not to mix the liquid with the surface by gelatin and high wife and to spread the heat in all parts The sample is equal, for a temperature controlled measurement. We wait a short period of time until the sample temperature reaches 44°C (we measure the temperature by the IR-Thermometer) and then put the sample into the simple cup of the viscometer and place it in the device. We record readings for both 300RPM rotation speed and 600RPM rotation speed.

\[ \Omega_{600}=62 \text{ RPM} , \quad \Omega_{300}=37 \text{ RPM} \]

\[ \text{Plastic viscosity} = \Omega_{600} - \Omega_{300} \]

\[ \text{Yield Point} = \Omega_{300} - \text{P.V} \]

As in the previous step, we heat the drilling fluid to a temperature of 54°C and put it into the machine and record

\[ \Omega_{600}=55 \text{ RPM} , \quad \Omega_{300}=34 \text{ RPM} \]

\[ \text{Plastic viscosity} = \Omega_{600} - \Omega_{300} \]

\[ \text{Yield Point} = \Omega_{300} - \text{P.V} \]

Then we drill the drilling fluid to a temperature of 64°C and put the sample into the device and record

\[ \Omega_{600}=54 \text{ RPM} , \quad \Omega_{300}=35 \text{ RPM} \]

\[ \text{Plastic viscosity} = \Omega_{600} - \Omega_{300} \]

\[ \text{Yield Point} = \Omega_{300} - \text{P.V} \]

Then we heat the drilling fluid to a temperature of 74°C and put it into the machine and record

\[ \Omega_{600}=60 \text{ RPM} , \quad \Omega_{300}=36 \text{ RPM} \]

\[ \text{Plastic viscosity} = \Omega_{600} - \Omega_{300} \]

\[ \text{Yield Point} = \Omega_{300} - \text{P.V} \]
Rotation Speed 600 RPM, Rotation Speed 300 RPM.
$\Omega_{600}=65$ RPM, $\Omega_{300}=41$ RPM
Plastic viscosity = $\Omega_{600} - \Omega_{300}$
P.V=65-41=24
Yield Point = $\Omega_{300}$ - P.V
Y.P=41-24=17
Taking into consideration each measurement process, the simple cup of the viscometer should be washed, dried, and the rotor of the viscometer must be cleaned in order to obtain accurate readings. We reached the temperature that represents the temperature of the production class (containing the oil) in the fields of Nasiriyah, so we stop at this value of the temperature.
We take another sample of the drilling fluid at a depth of 1700 m, fluid density = 1.21 gm/cc.

3 Results and Discussion
We carry out all the previous steps for the first sample figure (1) and second sample figure (2) and get the following results:

Table 1: first sample

| T(°c) | $\Omega_{600}$ | $\Omega_{300}$ | PV | YP | YP/PV |
|-------|---------------|----------------|----|----|--------|
| 34    | 57            | 35             | 22 | 13 | 0.59   |
| 44    | 62            | 37             | 25 | 12 | 0.48   |
| 54    | 55            | 34             | 21 | 13 | 0.62   |
| 64    | 54            | 35             | 19 | 16 | 0.84   |
| 74    | 65            | 41             | 24 | 17 | 0.71   |

Table 2: second sample

| T(°c) | $\Omega_{600}$ | $\Omega_{300}$ | PV | YP | YP/PV |
|-------|---------------|----------------|----|----|--------|
| 34    | 56            | 34             | 22 | 12 | 0.54   |
| 44    | 53            | 33             | 20 | 13 | 0.65   |
| 54    | 51            | 31             | 20 | 11 | 0.55   |
| 64    | 55            | 35             | 20 | 15 | 0.75   |
| 74    | 57            | 38             | 19 | 19 | 1      |

From the all result plot temperature vs PV and YP. So, from sample one (Density=1.35 gm / cc) the figure (4), the PV increased from 34 C° to 44 C° and the maximum value for PV at 44 C°. Moreover, the PV decreased from 44 C° to 64 C° and minimum value for PV at 64 and then began increased from 64 C° to 74 C°. So, the best value for PV at 64 C° because the carry capacity become best and then good hole cleaning. Also, the YP decreased slightly from 34 C° to 44 C° and then it will be increased from 44 C° to 74 C°. The best value for YP at 74 C° and the carry capacity became best at this value then good hole cleaning.

From sample two (Density=1.21 gm / cc) the figure (5), the PV decreased from 34 C° to 44 C° and then became constant until 64 C° and it decreased at 74 C°. So, the best value for PV at 74 C° because the carry capacity become best and then good hole cleaning. Also, the YP increased from 34 C° to 44 C° and then it will be decreased from 44 C° to 54 C°. Finally, YP increased from 54 C° to 74 C°. The best value for YP at 74 C° and the carry capacity became best at this value then good hole cleaning.
From the figure (6) the best drilling fluid is simple two because of the YP/PV ratio will be increased with increased temperature and the beast value at 74°C. So, the carry capacity become good then beast hole cleaning. Moreover, the hole cleaning become good with increase value of YP/PNV ratio. Also, the sample two after 64°C the YP/PV ratio will be decrease and then bad hole cleaning.

Figure 6: YP/PV ratio.

4 Discussion
The most points noticed summered as:
1- For heavy weight fluid (high density) the PV value increased with increased in temperature especial in 74°C but in light fluid (low density) the PV value decreased with increased in temperature.
2- With high density must be add some additional chemical material for improved the fluid mud with high temperature.
3- For heavy weight fluid (high density) the YP value less than in light fluid (low density) and that’s mean all light fluid (low density) with increased in temperature that improve carry capacity and good hole cleaning.

References

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