MODELING AND RHEOLOGICAL CHARACTERIZATION OF SLUDGE BASED DRILLING OIL

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Abstract: When the drilling mud is in contact with more or less permeable walls of the well, the liquid filter part in the formation by depositing on the walls of the solid part is called the cake (silty clay film). Among the main functions of drilling fluid include keeping the walls of the well due to the hydrostatic pressure exerted by the flowing fluid. Also, the mastery of the rheological properties of the mud used is required.
The rheological characterization focus on the drilling mud used for drilling the 121/4 phase in the well AY (Hassi Messaoud) is an invert emulsion mud with oil report / water 85/15 and its density is 2.04, consisting essentially of gas oil, organophilic clay, two emulsions, sodium chloride and barite. It would define the rheological model of drilling fluid used and seek the most suitable rheological model. The rheological tests were carried out using a Fann viscometer 6-speed (3, 6, 100, 200,300 and 600 rpm) to determine the rheological properties of the mud as the yield value or yield stress, the plastic viscosity and apparent viscosity. Other rheological parameters such as the consistency index (k) and the behavior index (n) of the mud were estimated. The results show that the Herschel-Bulkley model is a minimal deviation from other models (model Bingham and Ostwald de Waele or Power).

Keywords: drilling mud, rheology, plastic viscosity, yield value.

Introduction

Originally drilling "Rotary," the essential role of the mud was to evacuate cuttings (cuttings) from the bottom of the well to the surface. Today, the drilling mud is of paramount importance for the realization of a survey because it has important functions that can be grouped in three main functions, namely participation in the advancement of the tool, the hole cleaning and proper maintenance of the walls of the hole.

There are three types of sludge, sludge whose continuous phase is water, sludge whose continuous phase is oil and sludge air (rarely used because of the expensive equipment, security problems and inefficiency if rash of fluid from the formations traversed). Sludge from the oil, there are the direct and inverse sludge sludge direct (oil) contain 5 to 15% water and a maximum inverse sludge may contain up to 60% water. Sludge oil is complex fluids threshold (Osisanya, 2001; Coussot, 2009). The oil-based mud's are mainly used in all phases of drilling (except phase surface, shallow and where the land is poorly consolidated, the bentonite slurry is used). Sludge oil are mainly used for drilling and core producer levels to solve problems or swelling clays high dispersant, drilling deep wells and high temperature as well as the recovery and maintenance of producing wells (workover) (Thai-Son et al., 2009; Clain X et al., 2009) power.

This research is to characterize the most suitable for the drilling mud used rheological model, acting on the rheological parameters of the drilling mud (Fadairo et al., 2012; Maglione et al., 2000) while keeping the optimal characteristics of the drilling mud used so that it plays its role. The determination of the rheological model of the mud is made, according to the test program described in the experimental part of study.

Formulation of the drilling mud used

Mud used: The mud used to drill the $12^{1/4}$ phase in the slurry is well HY invert emulsion with an oil/water (O/W) 85/15 and a relative Specific Gravity (SG) of 2.04. The formulation of a cubic meter of this mud is shown in Table 1.

Table 1. The formulation of drilling mud used

Produits	Quantité (l/m3 ou en Kg/m3)
Gas Oil	516.00
Saumure (NaCl)	108.00
Lime (fatty based emulsifier activor)	30.00
Primary emulsifier	12.00
Secondary emulsifier and wetting agent	12.00
Lignite based fluid loss additive	8.00
Wetting agent	2.00
Barite (BaSO4)	1420.00

Equipment used: Rheometer was used Fann 35 A 6-speed (Fig.1). Speeds were 600, 300, 100, 6 and 3 rpm (rotation per minute). The measured parameters are the plastic viscosity and yield value.

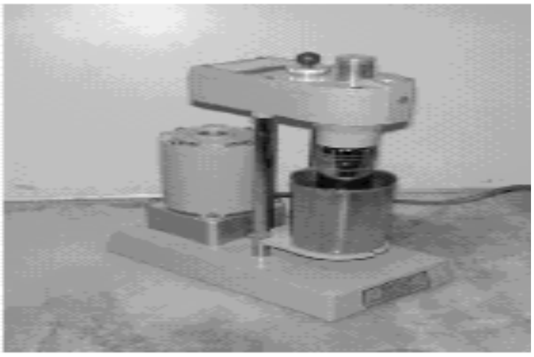

Fig. 1. Fann viscosimeter 35A.

The principle of determination of these parameters is to take readings at rotational speeds of 600 to 300 rpm.

The Fann viscometer is calibrated to give directly:

- The plastic viscosity (PV) PV = L 600 - L 300
- The apparent viscosity (AV) AV = L 600/2
- Yield value (YV) YV = (L300 – PV) = 2 (AV-PV).

Experimental Protocol

The determination of the rheological model of the mud was as follows:

- Using a Fann viscometer was performed four tests and took the arithmetic mean of a sample of the mud used;
- Using the readings obtained, the actual curve $\tau = f(\gamma)$ is plotted;
- Draw on the same graph the curve $\tau = f(\gamma)$ following the approach of Bingham;
- On the same graph Tracer the curve $\tau = f(\gamma)$ according to Ostwald approach;
- Make a comparative interpretation to define the rheological model is best used with mud.

The results obtained during tests conducted with the Fann viscometer shown in table2.

Table 2. The results obtained during tests conducted with the Fann viscometer.

Rate of rotation Ω (tr/min)	600	300	200	100	6	3
Rate of deformation γ (sec^{-1})	1021.8	510.9	340.6	170.3	10.218	5.109
lectures θ (cadran)	86	50	37	23	13	11
	86	50	37	23	13	11
	85	49	35	21	12	10
	88	52	37	22	13	11
the average (cadran)	86.25	50.25	36.5	22.25	12.75	10.75
Shear stress τ ($dynes/cm^2$)	440.73	256.77	186.515	113.69	65.15	54.93
Shear stress τ ($Lb/100ft^2$)	92.08	53.64	38.96	23.75	13.66	11.47

Rheological modeling mud

To set the rheological model of the mud used, it assimilates every time a known rheological model, namely, the Bingham model, the Ostwald model and Herschel Bulkley model and is subsequently a comparative interpretation.

Approach following the Bingham model

Bingham model is given by the following equation:

$$\tau = \tau_0 + \mu_P * \gamma \quad (1)$$

where :
τ: Shear stress (Pa)
γ : Gradient de vitesse de cisaillement (sec^{-1})
τ_0: Yield value ($lb/100ft^2$)
μ_P: plastic viscosity (Pa. s).
Was obtained :
$\mu_P = \theta_{600} - \theta_{300}$ =86.25-50.25

$$\mu_P = 36\ cp$$

$\tau_0 = 2\theta_{300} - \theta_{600}$ = (2*50.25)-86.25

$$\tau_0 = 14.25\ lb/100\ ft^2$$

For different values of "γ" are the values of "τ", the results are shown in table 3.

Table 3. Approximate results following the approach of Bingham.

Rate of rotation Ω (tr/min)	600	300	200	100	6	3
Rate of deformation γ (sec^{-1})	1021.8	510.9	340.6	170.3	10.218	5.109
Shear stress τ ($lb/100ft^2$)	91.20	52.72	39.90	27.07	17.92	14.63

Approach following the model of Ostwald Weall:

This model power is characterized by the following equation:

$$\tau = k * \gamma^n \quad (2)$$

Where:

k and n: rheology factors
k = consistance indice et n = Comportment indice.

Was obtained :

$$n = 3.32 * log\left[\frac{\theta_{600}}{\theta_{300}}\right] = 3.32 * log\left[\frac{440.73}{256.77}\right]$$

$$n = 0.78$$

$$k = \frac{\theta_{300}}{511^n} \qquad \text{d'où}: \; k = \frac{50.25}{511^{0.78}}$$

$$k = 0.38 \; lb.sec^{-n}/100ft^2$$

For different values of "γ" are the values of "τ", the results are shown in Table 4.

Table 4. Results obtained using the approach of Ostwald.

Rate of rotation Ω (tr/min)	600	300	200	100	6	3
Rate of deformation γ (sec^{-1})	1021.8	510.9	340.6	170.3	10.218	5.109
Shear stress τ ($lb/100ft^2$)	84.54	49.23	35.88	20.89	2.32	1.35

Comparative study:

Is plotted on the same graph of the rheogram curve τ = f (γ) of each model 02 provided with the real curve (Fig. 2).

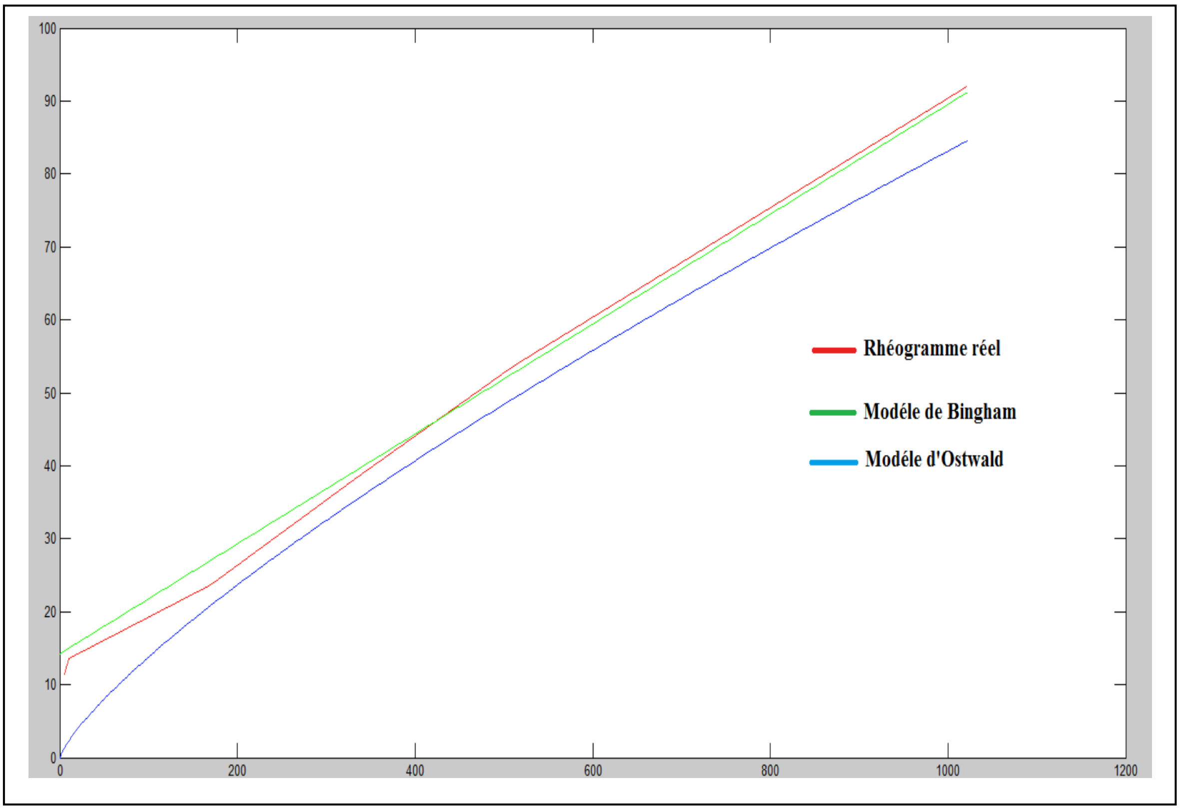

Fig. 2. Rheologicals models and the actual flow chart of drilling mud used.

The graph above shows the curves rheograms 02 rheologicals models and the actual flow chart of drilling mud used. According to the graph, we see that for the model of Ostwald, there is a large gap between the curve and the real flow chart, which to exclude this model to be the most suitable model drilling mud used. Regarding the Bingham model, we see that is a very small gap for large values of strain rate "γ" by against a standard that can not be neglected for small values of "γ ". For this we propose a different model is the Herschel-Bulkley model.

Approach following the Herschel-Bulkley model:

This model is most common in the case of drilling muds, it is characterized by the equation:

$$\tau = \tau_0 + k * \gamma^n \quad (3)$$

With: $\tau_0 = \theta_3 = 10.75$

$$\tau_0 = 10.75 \quad lb/100ft^2$$

$$n = 3.32 * log\left[\frac{\theta_{600} - \tau_0}{\theta_{300} - \tau_0}\right] = 3.32 * log\left[\frac{86.25 - 10.75}{50.25 - 10.75}\right]$$

$$k = \frac{\theta_{300}}{511^n} = \frac{50.25}{511^{0.91}}$$

$$n = 0.91$$

$$k = 0.15 \quad lb.sec^{-n}/100ft^2$$

For different values of "γ" are the values of "τ", the results are shown in table 6.

Table 6. Results obtained using the approach of Herschel-Bulkley.

Rate of rotation Ω (tr/min)	600	300	200	100	6	3
Rate of deformation γ (sec^{-1})	1021.8	510.9	340.6	170.3	10.218	5.109
Shear stress τ ($lb/100ft^2$)	92.90	54.46	30.22	26.83	11.99	11.41

The results are shown in Figure 3.

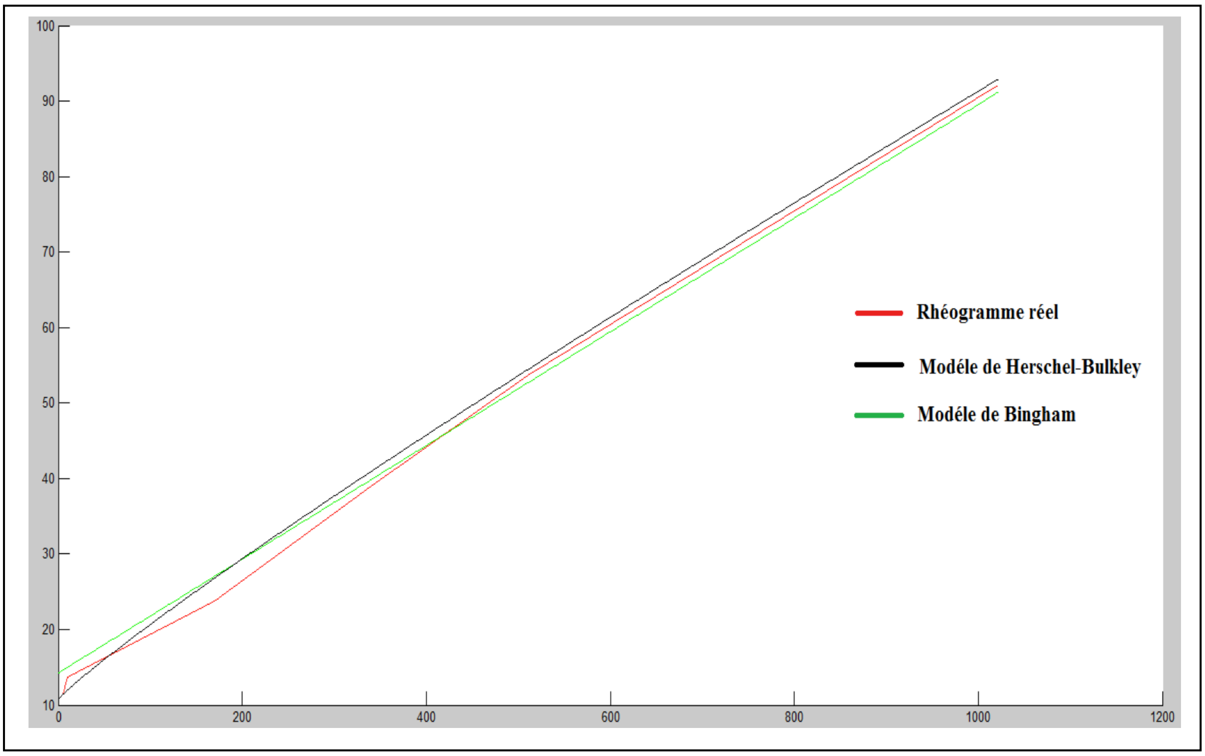

Fig. 3. Approach of Rheologicals models Herschel-Bulkley's and Bingham's

The graph above shows the curves of the flow chart of drilling mud used following the approach of Herschel-Bulkley and Bingham's approach with that of real rheogram. On notes that the Herschel-Bulkley model, represented in this case, by the state equation:

$$\tau = 10.75 + 0.15 * [\gamma]^{0.91}$$

According to the flow chart layout, we see a gap between the model and the Herschel Bulkly real rheogram for small values of strain rate "γ", but represent a minimum standard for large values of strain rate.

Conclusion

Modeling of complex fluid flows threshold is a field of research in its own right, particularly because of the difficulties in the coexistence of a solid diet and liquid diet. On the complex as drilling mud's used in oil well fluids, it is noteworthy that whatever the geometry (mud flow into a well and often in a porous medium) force or pressure gradient to provide according to the mean flow velocity follows a similar law in Herschel-Bulkley model (with the distinction of having a τ_0 threshold flow and a change of shear rate γ as a function of stress τ imposed).

The results thus show that the Herschel-Bulkley model is a minimum distance in relation to the mud studied (and compared to other models, namely the Bingham model or the Ostwald model), which confirms that the Herschel-Bulkley model best characterizes the drilling mud used.

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