Effect of Salt Contamination on the Rheological Properties and Electrical Resistivity of Bentonite and Kaolinite Drilling Muds

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Abstract: In this study, both shear stress-shear strain rate relationship and the changes in the electrical resistivity of 8% bentonite and 8% kaolinite drilling muds contaminated with up to 3% salt have been investigated. Both shear stress and electrical resistivity decreased as the salt contamination increased. Hyperbolic model better predicted the shear stress-shear strain rate relationship for the drilling muds. As the mud contaminated by 3% salt, the maximum shear stress and electrical resistivity decreased by 73% and 49% for 8% bentonite and by 18% and 99% for 8% kaolinite drilling mud respectively.

1. Introduction: Drilling fluids are essential in the oil and gas industry as they provide a conducive environment for carrying out effective and efficient drilling operations as well as enhance completion and productivity of wells. Drilling fluids are classified as water based, oil based and aerated drilling fluids (Vikas and Sharma 2004, and Kelessidis et al. 2007). Kaolin is important industrial clay for economic benefit, which is wide spread with fine particle size, inertness, non-toxicity and has a high proportion of alumino-silicate like the bentonite clay although unlike the bentonite clay, it does not have a good swelling ability (Badmus and Olatinsu 2009).

2. Objective: The objective of this study was to quantify the shear stress-shear strain rate relationship and the changes in the electrical resistivity of 8% bentonite and 8% kaolinite drilling mud contaminated with up to 3% salt. In addition, the shear stress-shear strain rate relationship was modeled using the Herschel- Buckley (H-B) and hyperbolic models.

3. Materials and Methods: Shear stress-shear strain rate relationship was determined using the electrical viscometer with high speed range up to 600 rpm (1024 s-1) while the changes in the electrical resistivity were quantified using the conductivity meter.

4. Models: The Herschel-Bulkley model (Eq. (1)) defines a fluid with three parameters and can be represented mathematically as follows:

$$\tau = \tau_{o1} + k_1\dot{\gamma}^n \qquad (1)$$

where τ, $\dot{\gamma}$, k_1 and n represent the shear stress, yield stress, shear strain rate, correction parameter and flow behavior index respectively.

Based on the inspection of the test data, following hyperbolic relationship is proposed:

$$\tau - \tau_{o2} = \frac{\dot{\gamma}}{A+B*\dot{\gamma}}$$
(2)

where τ, τ_{o2}, $\dot{\gamma}$, A and B represent the shear stress (Pa), yield stress (Pa), shear strain rate (s^{-1}), and A $(Pa\ s)^{-1}$ & B $(Pa)^{-1}$ model parameters respectively.

5. Results: The effect of salt contamination on shear stress-shear strain rate relationship of 8% bentonite and kaolinite drilling mud with H-B and hyperbolic model predications is shown in Fig.1 (a and b). Table 1 identified Herschel-Buckley & hyperbolic rheological model parameters with electrical resistivity of bentonite and kaolinite drilling mud contaminated with salt.

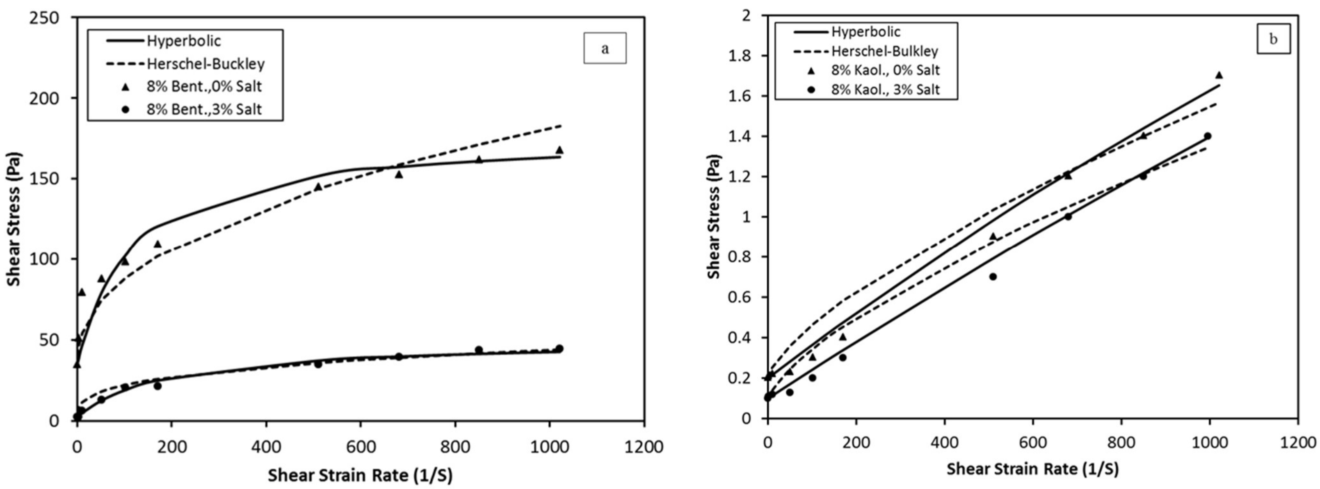

Figure 1. Shear stress-shear strain rate modeling of different drilling mud tested at room temperature with salt contamination up to 3%, (a) 8% bentonite, and (b) 8% kaolinite.

Table 1. Herschel-Buckley & hyperbolic rheological model parameters with electrical resistivity of different drilling mud contaminated with salt.

Comp. (%)	Salt (%)	Herschel-Bulkley model Eq. (1)					Hyperbolic model Eq. (2)					Electrical resistivity ρ (Ohm.m)
		τ_{o1}(Pa)	k_1(Pa.s)	n	RMSE (Pa)	R^2	τ_{o2}(Pa)	A(Pa.s)$^{-1}$	B(Pa)$^{-1}$	RMSE (Pa)	R^2	
8 B	0	35	7	0.44	11.62	0.93	35	0.8	0.007	12.42	0.93	2.3
8 B	3	1.2	5	0.31	3.51	0.95	2.5	4	0.021	1.77	0.99	1.17
8 K	0	0.2	0.01	0.71	0.108	0.96	0.2	600	0.1	0.049	0.99	16
8 K	3	0.09	0.01	0.7	0.098	0.96	0.1	700	0.07	0.038	0.99	0.18

Note: B= bentonite, K =kaolinite.

6. Conclusion:

Both shear stress-shear strain rate relationship and electrical resistivity of bentonite and kaolinite drilling mud decreased as the salt contamination increased. Hyperbolic rheological model prediction was better than H-B model

7. Acknowledgement:

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8. References:

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