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

A. Raheem[1] and C. Vipulanandan[1], Ph.D., P.E.
[1] Texas Hurricane Center for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
E-mail: amraheem@uh.edu, cvipulanandan@uh.edu Phone: (713) 743-4278

Abstract: In this study, the effect of temperature and salt contaminant on both shear stress-shear strain rate relationship and the changes in the electrical resistivity of 8% bentonite and 8% kaolinite drilling muds have been investigated. Both shear stress and electrical resistivity decreased as the temperature increased. Hyperbolic model better predicted the shear stress-shear strain rate relationship of the drilling mud. As the temperature increased from 25o C to 75o C, the maximum shear stress and electrical resistivity decreased by 44% and 93% for 8% bentonite and by 42% and 51% for 8% kaolinite drilling muds respectively.

1. Introduction: The rheological properties of drilling muds are affected by the temperatures and many other factors based on the application and environment. The temperature changes are not so large in shallow wells, and hence the rheological variations with temperature may be small based on the composition of drilling muds. Nevertheless, the temperature changes are tremendous in deep wells; therefore, it is vital to study the behavior of drilling mud in such conditions (Rommetveit and Bjqrkevoll 1997). Kaolinite clay is an important industrial clay for economic benefit and is present widely in Africa and has a high proportion of aluminium-silicate like the bentonite clay with lower swelling ability (Abdulkadir et al. 2013). Hence, it is of point of interest to study the effect of different temperatures on the rheological behavior of bentonite and kaolinite drilling muds.

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

3. Materials and Methods: In this study, 8% bentonite and 8% kaolinite drilling muds were contaminated with 3% salt were studied under the effect of different temperatures. Shear stress-shear strain rate relationship was computed using electrical viscometer with high speed range up to 600 rpm (1024 s-1) while the changes in the electrical resistivity were quantified using conductivity meter.

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

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

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 suggested:

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

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 temperature on shear stress-shear strain rate relationship of 8% highly contaminated bentonite and kaolinite drilling muds 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 highly contaminated bentonite and kaolinite drilling mud tested at different temperatures.

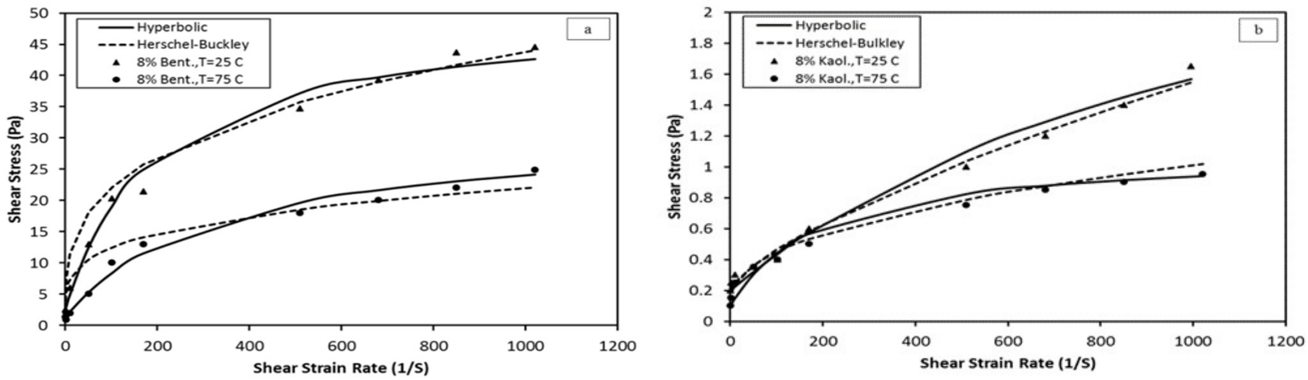

Figure 1. Shear stress-shear strain rate modeling of 3% salt contaminated different drilling mud tested at two different temperatures 25o C and 75o C, (a) 8% bentonite, and (b) 8% kaolinite.

Table 1. Herschel-Buckley & hyperbolic rheological model parameters with electrical resistivity of 3% salt contaminated different drilling mud tested at different temperatures.

Comp. (%)	Temp. (C°)	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	25	1.2	5	0.31	3.51	0.95	2.5	4	0.021	1.77	0.99	1.17
8 B	75	1.3	3.2	0.77	3.22	0.86	1.3	11	0.033	1.11	0.98	0.083
8 K	25	0.2	0.01	0.71	0.046	0.99	0.2	400	0.33	0.061	0.99	16
8 K	75	0.1	0.05	0.42	0.038	0.98	0.1	195	1	0.050	0.97	7.9

Note: B= bentonite, K=kaolinite.

6. Conclusion: Both shear stress-shear strain rate relationship and electrical resistivity of the highly contaminated bentonite and kaolinite drilling mud decreased as the temperature increased. Hyperbolic rheological model prediction was better than H-B model.

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8. References:

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