Effect of Oil Contamination on the Electrical Resistivity and Rheological Properties of Smart Spacer Fluid

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Abstract: In this study, the spacer fluids were tested for rheological properties with Oil contamination varying from 0 to 5%. The spacer rheology was modelled using Bingham-plastic model, Herchel Burlkey model and Vipulanandan model. The spacer fluid with 1% nanoFe_2O_3 showed increase in rheological properties with the increase in Oil contamination from 0 to 5%. The Plastics viscosity increased from 26 to 47cP, a 81% increase and yield point from 6 Pa to 12.7 Pa, a 112% increase. The electrical resistivity changed from 0.19 Ω-m to 7.8 Ω-m, a 400% increase with 5% Oil contamination.

1. Introduction:

Spacers or Flushes are used to thin and disperse drilling-fluid particles, and are used to separate drilling fluids and cementing slurries. These spacers can be used with either water based or oil based drilling fluids. Use of this spacer fluid prepares the casing and the formation for cementing process. Recent studies have shown that when nanomaterials are added to the drilling muds it can be used as a sensing material downhole for temperature and pressure[1]. Use of nanomaterials in spacer fluids enhances cleaning ability and can make it sensing. There is no current method to monitor the contamination of spacer fluid in real time. Electrical resistivity can be used as sensing parameter for monitoring the extent of contamination in the spacer fluids[2].

2. Objective: The main objective was to quantify the effect of oil contamination on electrical resistivity and rheological properties of smart spacer fluid.

3. Materials and Method:

The spacer fluid was prepared by using water as base fluid, Rheology Modifier as 0.75% Guargum, Surfactant: 0.4% UHBS, Inhibitor: 3% KCl, with a Modification: Nano Iron (Fe_2O_3): 1%. KCl was mixed in base fluid water and mixed thoroughly until dissolved. Then rheology modifier Guargum was added followed by UH Bio-surfactant and mixed until uniform solution is obtained. Nano iron is then added as a modification.

Modeling:

Bingham plastic Model:

Two parameters model which can be presented as followed:

$\tau = \tau_y + \eta_p \dot{\gamma}$, in which τ_y is yield stress and η_p is plastic viscosity of the fluid.

Herschel-Bulkley Model:

This is a three parameters model represented as followed:

$\tau = \tau_{0_1} + k\dot{\gamma}^n$, Where τ_0 is yield stress and k and n are experimentally fit parameters.

Vipulanandan Model:

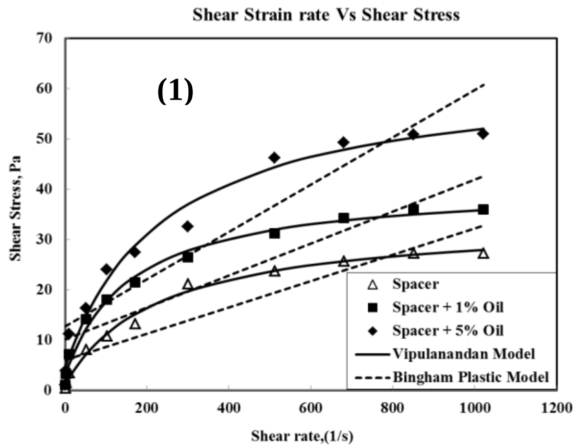
$$\tau = \tau_{0_2} + \frac{\dot{\gamma}}{A + B\dot{\gamma}},$$

in which τ_0 is yield stress and k and n are experimentally fit parameters.

If we calculate the ultimate shear stress from this model we will have:

$\lim_{\dot{\gamma}\to\infty} \tau = \tau_{0_2} + \frac{1}{B}$

4. Results and Discussion:



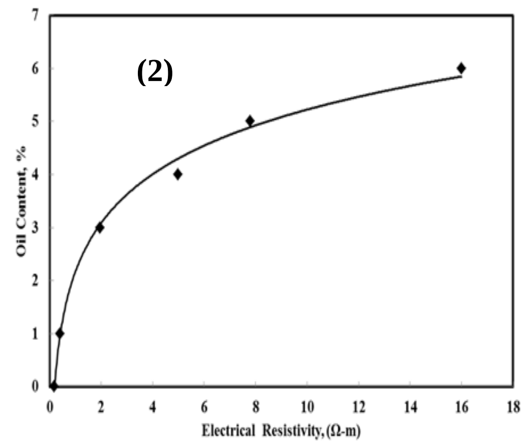


Figure 1- Effect of Oil Contamination on Rheology of spacer with NanoFe$_2$O$_3$
Figure 2- Effect of Oil Contamination on Electrical Resistivity

Table 1:Rheological Model parameters for effect of Oil Contamination

	Bingham Plastic Model			Hershel Burkely Model			Vipulanandan Model				
Model Parameters	PV	PV(cP)	YP(Pa)	n	k	τ (yield)	A(Pa. s)$^{-1}$	B (Pa)$^{-1}$	τ (yield)(Pa)	τ (max)(Pa)	Δτ(max)(Pa)
Spacer + NanoFe	0.026	26	6	0.41	1.72	0	7.1	0.03	1.25	34.6	0
1% Oil	0.031	31	10.1	0.34	3.62	0	4.21	0.026	3.01	41.5	19.9
5% Oil	0.047	47	12.7	0.37	4.02	0	4.15	0.017	4.57	63.4	52.9

Bingham model (1919)

The spacer fluid with 1% nanoFe$_2$O$_3$ showed increase in rheological properties with the increase in Oil contamination from 0 to 5%. The Plastics viscosity increased from 26 to 47 cP and yield point from 6 Pa to 12.7 Pa. (Fig. 1 and Table 1)

Vipulanandan model (2014)

Increasing the percentage of oil contamination increased the τmax values by 50%. For upto 5% contamination the τmax values were found to increase linearly. The yield stress also increased from 1.25 Pa to 4.57 Pa with 5% Oil contamination.

Resistivity: The electrical resistivity was found to increase with the increase in the oil content. The resistivity increased from 0.19 Ω-m to 7.8 Ω-m for 5% oil contamination. It tends to reach a maximum value which after which any further addition of oil does not change the resistivity. This can be termed as the maximum oil limit taken by the Spacer solution (Fig. 2).

5. Conclusion:

Electrical resistivity can be used to monitor the percentage of contamination in the spacer fluid which changes by 400% for 5% contamination. The maximum shear stress also increased from 34.6 pa to 63.4 Pa, a 53 % increase with 5% oil contamination.

6. Acknowledgements:

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7. References:

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