Effect of Nano Iron Oxide Particles on the Electrical Resistivity and Rheological Properties of Smart Spacer Fluid under Varying Temperatures

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Abstract: In this study, the effects of nano iron oxide (nanoFe_2O_3) particles on the electrical resistivity and rheological properties of a sensing smart spacer fluid under varying temperatures were investigated. The temperature was varied from 25°C to 85°C. The nanoFe_2O_3 contents (particle size of 30 nm and surface area of 38 m^2/gm) in the spacer fluid were varied up to 1% by the weight of spacer fluid to enhance the sensing electrical resistivity and the rheological properties of the spacer fluid. The initial resistivity of the spacer fluid without and with 1% nanoFe_2O_3 at room temperature were 0.18 Ωm and 0.19 Ωm, a 6% increase in resistivity, a good sensing property. The electrical resistivity changed from 0.19 Ωm at 25°C to 0.07 Ωm at 85°C, 63% decrease. The rheological properties decreased with increase in the temperature.

1. Introduction:

Spacer fluids have been primarily developed to separate the cement slurry from the drilling fluid as they are not normally compatible. Incompatibility in the fluids can cause significant increase in the viscosity, and thus hydraulic resistance inside the wellbore. Efficient displacement and effective removal of the drilling fluids and associated residues from the wellbore prior to the completion of a well is critical for optimized hydrocarbon recovery[1].Spacer systems play a crucial role in proper cementing job by complete displacement of the drilling mud and removal of the filter cake developed along the formation. Various designs of spacer systems are available in the oil and gas industry, but they may not be suitable for all conditions. Generally a spacer fluid is composed of the following components: Water/Oil as the base fluid of spacer system, weighting materials to increase the density of the spacer system, rheological modification agent or polymers and a proper surfactant Package[2].

2. Objective: The main objective was to quantify the changes in the electrical resistivity and rheological properties of smart spacer fluid modified with upto 1% NanoFe_2O_3under varying temperatures.

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 was obtained. Nano iron is then added as a modification.

Modeling

Vipulanandan Rheological relationship between shear stress and shear strain rate for the smart spacer fluids was investigated (Vipulanandan and Mohammed 2014).

$\tau - \tau_{o2} = \frac{\dot{\gamma}}{C + D * \dot{\gamma}}$, where τ: shear stress (Pa); C $(Pa.\ s)^{-1}$ and D $(Pa)^{-1}$: are model parameters;

4. Results and Discussion:

The resistivity increased from 0.18 to 0.19 Ωm with the addition of 1% NanoFe_2O_3. In the spacer with 1% nanoFe_2O_3 resistivity decreased from 0.19 to 0.07 Ωm with increase in temperature from 25 to 85°C. (Fig-1&2)

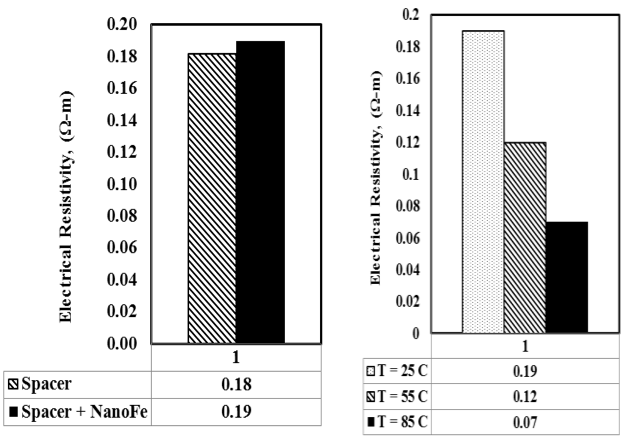

Figure 1,2: Effect of temperature of electrical resistivity of spacer fluid without and with

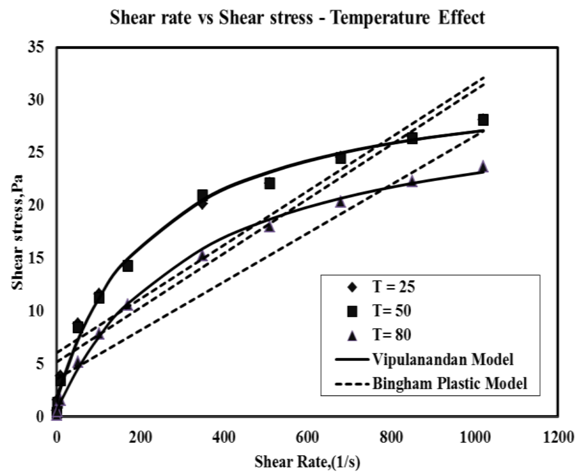

Figure 3:Shear Stress- Shear Strain rate variation with Temperature on Spacer Fluid with NanoFe

Table 1: Model Parameters for effect of temperature on Spacer fluid with NanoFe

Temperature	Bingham Plastic Model			Vipulanandan Model			
Model Parameters	PV	PV(cP)	YP	$A(Pa.\ s)^{-1}$	$B\ (Pa)^{-1}$	τ (yield)(Pa)	τ (max)(Pa)
T = 25	0.025	25	6.05	7.4	0.032	1.70	33.0
T = 50	0.025	25	5.17	7.01	0.033	1.30	31.6
T = 80	0.022	22	3.59	11.08	0.033	0.55	30.9

Bingham model (1919): The spacer fluid with 1% nanoFe_2O_3 showed decrease in rheological properties with the increase in temperature from 25 to 85°C. The Plastics viscosity reduced from 23 to 5.2 cP and yield point from 4.8 Pa to 0.25 Pa.(Fig -3 and Table-1)

Vipulanandan model (2014): The maximum shear stress reduced by 53% for increasing the temperature to 85°C showing how sensitive τmax was to temperature and magnetic field.(Fig -3 and Table-1)

5. Conclusion:

The electrical resistivity of the spacer fluid increased with NanoFe_2O_3 addition and decreased with increasing temperature. The spacer fluid rheological properties, yield point and plastic viscosity were found to decrease with increase in the temperature.

6. Acknowledgements:

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7. References:

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[2] Ryan Zanten, Larry Deen,et al, "Succesful Field Applications of Surfactant Nanotechnology to Displace Oil- based Drilling Fluids for Completions Operations". AADE,2011.