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Anaerobic Monitoring of Polymer Viscosity Derived from Radioactive Tracer—Tool Well Logs and Detailed CFD Wellbore Model

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Abstract

Viscosity monitoring is one of the critical parameters in polymer flooding. However, the use of oxygen scavenger in water flooding and polymer flooding operation undermines simple aerobic viscosity measurements.

When very low quantities of oxygen are added to a polymer solution containing oxygen scavenger a reaction involving free radicals breaks polymer molecules apart leading to very high viscosity loss (degradation). This problem makes it difficult to take fluid samples and make viscosity measurements of the injection stream with a field viscometer in aerobic conditions.

In this study we have used tracer ejector tool (routine nuclear flolog). When the tracer tool is located and held stationary above the perforations a "shot" of radioactive fluid is ejected. The two gamma ray detectors beneath ejector port record gamma ray intensity as a function of time. The gamma ray signature depends on the fluid profile in the casing. The fluid profile in the casing is governed by fluid flow rheology.

The rheology of a polymer solution is non-Newtonian and is modelled with the Carreau equation. For a given water composition and in absence of any degradation the non-Newtonian exponent in the Carreau equation depends on polymer concentration. If the polymer solution suffers any type of degradation the non-Newtonian exponent will shift closer to the water exponent regardless the concentration.

This work proposes to history matching the Carreau equation to reproduce the gamma ray peaks in the casing using a detailed CFD (Computational Fluid Dynamics) well model. Then, Carreau equation is used to estimate indirectly the viscosity in anaerobic conditions.

We validated the method using sophisticated anaerobic inline viscometer upstream the well head which allows us to determine with good accuracy the non-Newtonian exponent.

The method described in this work uses routine simple monitoring measurements coupled to a detailed CFD well bore model that reproduces exactly the fluid flow along the casing to monitor the polymer solution viscosity. The integration between the operation, reservoir engineering and researchers of different disciplines has been key factor in the success of this simple but innovative application.