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Methodologies Used to Estimate Swept Fracture Volume and to Design Gel Polymer Treatments for Profile Modification, Sweep Improvement, and Water Shut--off in Prolific Natural Waterdrive

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SUMMARY

This paper will describe new and unique methods that are being developed and used to more accurately size and design gel polymer treatments at injectors and producer wells. These techniques include novel diagnostic plots and mathematical predictive models used to forecast results and economics, and the predictive accuracy of the model is confirmed against field case studies. The paper will also present a statistical evaluation of nearly 100 treatments, comparing water reduction and incremental oil recovery to variables like gel polymer volume, oil gravity, formation thickness and lithology, depth, and injection pressure, to name a few.

Abstract

Premature water breakthrough from injection wells or from naturally occurring aquifers increases lease operating expense, limits sweep efficiency, and reduces oil recovery. In heterogeneous, naturally fractured carbonate reservoirs, a disproportionately large percentage of the drive fluids preferentially sweep only the largest fractures that exist in a relatively small percentage of the reservoir. Consequently, mobile oil, that would otherwise be recovered, remains stranded in the smaller fractures and in the porous and permeable rock matrix. Further, premature water breakthrough routinely leads to extremely high water producing rate and high pressure gradient, which suppresses oil flow, particularly when oil viscosity is high. It has been previously reported over the years that cross-linked polymer gel has been successfully used on numerous occasions to plug swept fractures in order to reduce water production and redistribute drive fluids into previously by-passed areas of many fields in the US e.g. Big Horn Basin, Wyoming and Arbuckle reservoirs that contain large volumes of unrecovered mobile oil. However, no serious attempts have been made to estimate the volume of the swept fractures so that gel polymer treatments can be more accurately sized. Further, very few, if any studies exist to assess the variables that appear to have the greatest impact on treatment performance. Selection of candidates among a multitude of possible injectors or producers, estimation of optimal treatment volume, and prediction of incremental barrels of oil produced, are some questions encountered both by the operators and service companies during the planning and design stage.

This paper will describe new and unique methods that are being developed and used to more accurately size and design gel polymer treatments at injectors and producer wells. These techniques include novel diagnostic plots and mathematical predictive models used to forecast results and economics, and the predictive accuracy of the model is confirmed against field case studies. The paper will also present a statistical evaluation of nearly 100 treatments, comparing water reduction and incremental oil recovery to variables like gel polymer volume, oil gravity, formation thickness and lithology, depth, and injection pressure, to name a few.

The paper contributes in the following ways:

1. Presents a systematic approach to select candidates, accurately design treatments, and predict performance utilizing common and readily available data.
2. Presents a first-ever statistical analysis of results of numerous Big Horn Basin, Wyoming and Arbuckle, Kanasa treatments that can be used to verify performance expectations.
3. Presents a methodology that can be easily adjusted for use in any naturally fractured, natural waterdrive, or waterflood reservoir in the world.