SPE 124001

Oil-Recovery Predictions for Surfactant Polymer Flooding

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This paper was prepared for presentation at the 2009 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4–7 October 2009.

Summary

There is increasing interest in surfactant-polymer (SP) and alkali-surfactant-polymer (ASP) flooding because of the need to increase oil production from depleted and water flooded reservoirs. Prediction of oil recovery from SP flooding, however, is complex and time consuming. Thus, a quick and easy method is needed to screen reservoirs for potential SP floods. This paper presents a scaling model that is capable of producing reliable estimates of oil recovery for an SP flood using a simple spreadsheet calculation. The model is also useful for initial SP design.

We present key dimensionless groups that control recovery for a SP flood. The proper physics for SP floods including the optimal salinity in the three-phase region and the trapping number for residual oil saturation determination has been incorporated. Based on these groups, a Box-Behnken experimental design is performed to generate response surface fits for oil recovery prediction at dimensionless times. The response surfaces derived can be used to estimate the oil recovery potential for any given reservoir and are ideal for screening large databases of reservoirs to identify the most attractive chemical flooding candidates. The response function can also be used for proper design of key parameters for SP and ASP flooding. Our model will aid engineers to understand how key parameters affect oil recovery without performing time consuming chemical simulations.

This is the first time that dimensionless groups for SP flooding have been derived comprehensively to obtain a response function of oil recovery as a function of dimensionless groups.

Introduction

Surfactant-polymer (SP) and alkali-surfactant-polymer (ASP) flooding processes involve the injection of a surfactant-polymer slug followed by a polymer buffer and chase water injection. If designed correctly, the surfactant increases the capillary number, which is crucial for the mobilization and recovery of tertiary oil. Polymer increases the sweep efficiency by lowering the mobility ratio. If the reservoir crude oil has sufficient saponifiable components, soap is generated *in situ* by the reaction of these components with the injected alkali.

Past screening models such as that of Paul *et al*. (1982) did not consider gravity and salinity effects. Wang *et al.* (1979) and Shook *et al.* (1988) carried out sensitivity studies on SP floods, but did not attempt to correlate oil recovery to the parameters studied. Thomas *et al.* (2000) described scaling criteria for the micellar flooding process from the basic mass balance equations using inspectional and dimensional analysis. Micellar flooding experiments were carried out in sandstone cores of two different sizes, and the scaled up recovery curves were compared. The agreement between the predicted and actual recoveries was good in some cases, but poor in others. Poor agreement is likely because they did not consider effects like heterogeneity.

This paper presents a screening model that is capable of quickly producing quantitative estimates of oil recovery for a given surfactant-polymer flood including the effects of heterogeneity and salinity. It also develops the important dimensionless groups necessary to scale SP floods using inspectional analysis. The derived groups are used in a Box-Behnken experimental design to produce response surfaces for dimensionless oil recovery during SP flooding. We also give an approximate method to correct the scaling groups for the addition of alkali in the SP process.

Procedure

The first step in creating a screening model is to determine the important dimensionless groups that govern recovery for SP floods. Inspectional analysis was carried out on the mass balance equations and boundary conditions for SP flooding, and auxiliary rela-