Effects of Dispersion and Dead-End Pore Volume in Miscible Flooding

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Abstract

The design of the solvent slug size for a miscible flood process can be improved with data on holdup (or capacitance process can be improved with data on holdup (or capacitance effects) and dispersion of the solvent slug in the reservoir. A modified version of the Coats-Smith dispersion-capacitance model and an improved solution method for the model were used to study dispersion and capacitance effects in cores. The velocity dependence of the model parameters is shown. A correlation is developed for estimating effective dispersion coefficients for field application. The method described provides a means for characterizing the properties of dispersive mixing and microheterogeneity of reservoir properties of dispersive mixing and microheterogeneity of reservoir cores and aids in the design of the volume of solvent for miscible floods.

Introduction

The amount of solvent that must be injected is a critical factor in the success of a miscible flood. Because of the cost of miscible solvents such as carbon dioxide or rich gas, slug processes generally are used. If the solvent slug used is larger processes generally are used. If the solvent slug used is larger than necessary, the solvent cost will be increased without compensatory increases in oil recovery. If too small a slug is used, some of the oil that could have been moved will be left behind. The slug size required is affected by many variables, including reservoir geometry, interwell spacing, gravity effects, mobility ratios, etc. Slug degradation is caused by mixing (by dispersion) of solvent with oil at the leading edge of the solvent bank and with chase fluid (for example, dry gas) at the trailing edge. Trapping of oil and solvent in microscopic heterogeneities (regions of dead-end pore volume or relatively stagnant flow) also contributes to the mixing-zone growth. This trapping, known as capacitance may be caused by rock heterogeneities or by shielding of oil and solvent by water films. This paper is concerned with predicting solvent slug requirements in an idealized linear system where gravity, mobility ratio, and areal sweep effects are unimportant, but where longitudinal dispersion (mixing at the leading and trailing edges of the bank) and capacitance effects are significant. An example might be a miscible displacement in the pinnacle reef formations of Alberta. A prediction of the effects of dispersion and capacitance was needed for the design of a miscible flood of this type. The oil-column height was about 350 ft, and the flood advance rate was to be downward at 0.0384 ft/D. The oil/solvent viscosity ratio of 10 was unfavorable; however, it was expected that the unfavorable mobility effects would be largely compensated for by the stability effects of gravity at the low flow rate. Published data relating to similar reservoirs indicated that "stagnant volume" that could cause trapping and degradation of the solvent slug might be as much as 10 percent of the reservoir volume. Based on these data, preliminary calculations were made using the Coats-Smith dispersion-capacitance model to predict the mixing-zone profiles. The results indicated that this level of stagnant volume might cause the solvent requirement to be increased by 30 to 90 percent over the amount predicted by a simple dispersion model without capacitance effects if the peak solvent concentration in the enriched gas bank did not drop below 99 percent throughout the life of the flood. Coats and Smith indicated that tests in short cores would show extended mixing zones if capacitance effects were present, but that if the magnitude of the transfer group $M(D) = M(L)/u$ was large (as it would be in a field situation, where L may be very large), the influence of capacitance would be minimized. The prediction of a 30- to 90-percent increase in solvent requirements for the case described above prompted a review of methods for measuring capacitance effects and a search for a more convenient method for predicting the severity of capacitance effects in field application. predicting the severity of capacitance effects in field application. An improved method for modeling data from short core tests was developed, and experimental work was performed to investigate the factors influencing the capacitance-model parameters.

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