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Potential Microbial Enhanced Oil Recovery Processes: A Critical Analysis

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Abstract

This paper summarizes a critical review of possible microbially enhanced oil recovery (MEOR) methods and mechanisms to identify the most plausible utilization of microbial technology to enhance oil recovery. This paper is intended to stimulate discussion about broad applications of MEOR to field-wide improvement of oil displacement and recovery.

The potential benefits of different MEOR mechanisms were examined for a representative North Sea reservoir of sandstone containing a light crude oil. In each case, the material input requirements for nutrients and inoculum were calculated in relation to the projected incremental oil production, assuming that the key components (bacteria, nutrients, or bacterial products) were uniformly distributed in the swept zone of the reservoir.

The capillary number for the reservoir suggested that incremental oil recovery by biosurfactant production in situ would be modest under ideal conditions. The achievable yields would be lower because the Microbiol. in the reservoir would not be controllable to achieve sustained surfactant production. Losses of biosurfactants by adsorption to reservoir rocks and in situ biodegradation would further limit performance. The stimulation of surface active bacteria in the reservoir may affect the flow of fluids by producing emulsion droplets of oil coated with bacteria. The formation of a biofilm at the oil water interface changes the rheology of the interface, and may provide a useful mechanism to control mobility and areal sweep in reservoirs. Any mechanisms that required changes to large volumes of reservoir material, to produce gases, solvents, acids, or to significantly alter permeability, were not considered to be feasible. The limiting case of plugging fractures with bacteria and their polymeric byproducts does have considerable potential, but only for reservoirs which offer significant improvements in production with minimal injected volumes. The biological deposits must retain longer term resistance in situ to ensure that the anticipated production increase is achieved.

This study provides a methodology for the systematic assessment of MEOR proposals using well-established reservoir engineering principles.

Introduction

The objective of this study is to determine which mechanisms of microbial enhanced oil recovery (MEOR) have potential for successful application to a typical sandstone North Sea petroleum reservoir with light crude oil. The scope is to examine *in situ* processes by which microbial activity in a petroleum reservoir can be modified, augmented or introduced to benefit oil recovery. Possible inputs to the reservoir for these processes include addition of specific bacterial strains and addition of nutrients. The emphasis throughout the study is to provide quantitative estimates of the potential increase in crude oil recovery by MEOR.

A number of mechanisms have been proposed for MEOR that fall into two broad categories: A. Alteration of oil/water/rock interfacial properties, and B. Changes in flow behavior. Each biological mechanism was assumed to change the initial conditions in the reservoir by altering one or more fluid, rock, or interfacial properties. In each case, the incremental oil recovery arising from the change in properties was determined using simple and well-established methods for reservoir analysis. Transport of bacteria and nutrients into the reservoir was assumed to be uniform and complete at the start of the MEOR process. The analysis only considered reservoir-wide displacement mechanisms that could be used to change crude