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Flooding Thin Low-Permeability Layers With a New Salt-Resistant, Medium-Molecular-Weight Polymer

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Abstract

Our interest is the enhancement of conventional oil recovery factors from thin low-permeability layers in a sandstone-shale sequence containing dozens of oil-saturated beds. Polymer flood is an option we have been using for many years in the Daqing Oilfield[1].

The physical chemistry performance, salt resistance performance, shearing resistance performance and aging stability of a new salt-resistant, medium molecular weight polymer (KY700) were evaluated by laboratory experiments. Results showed that the KY700 performs well and that its properties are particularly suited for thin, low-permeability layers, therefore field testing was undertaken. We present details of two full-scale field applications of the new polymer in two experimental areas in the Daqing Oilfield. In both cases, the injection and production profiles were significantly improved, oil production rates increased, and water production ratios decreased. The polymer appears to be a new and valuable product that can increase conventional oil recovery through polymer flooding of appropriate thin sandstone strata of moderate to low permeability.

Key words:

Low permeability reservoir, polymer flooding, salt resistant polymer, EOR, sandstone

Introduction

Daqing Oilfield Company Ltd. was one of the pioneering corporations in developing polymer flooding techniques for layered sand-shale sequences. These were applied mainly to some of the dozens of layers in the Daqing oilfield, a supergiant field in the center of the northern Songliao Basin, Heilongjiang Province, PRC.[i]

Good results have been achieved in polymer flooding the thicker and higher permeability zones in this sequence, mainly through use of the product PT1200[2], which is a high molecular weight hydrolyzed polyacrylamide whose molecular weight is about 12 – 16×10^6 atomic units. However, no suitable polymer has been located or developed for conventional oil sandstone formations with a lower permeability range (e.g. 10 - 100 mD).

An evaluation program was initiated to assess a new salt-resistant polymer with medium molecular weight (MW) for application to the many thin, low-permeability sandstone layers that characterize the Daqing Oilfield. This polymer is called KY700 for brevity. Specifically, the following characteristics were explored: the physical chemistry attributes, the resistance to salt (and in general the resistance to cations), the shearing resistance, and the stability of the mixed upon prolonged aging.

The KY700 polymer with its medium-range molecular weight seems to be much more suitable for thin, low permeability layers than higher molecular weight commercial polymer products; therefore, it was applied in field trials in sandstones under realistic full-scale conditions. Apparently because its MW is lower than previously used products, KY700 can be injected more easily into the low to moderate permeability layers of interest. It therefore allowed EOR activity to take place in a number of thin conventional oil zones in the Daqing Oilfield that could not be easily accessed with the previous generation of polymers.

Physical Chemistry

Conventional physical chemistry analyses have been performed on KY700[3] and compared to PT1200, a polyacrylamide formulation for EOR that is common in oilfield applications. The comparative results are presented in Table 1. (Many of the terms are defined in the polymer literature and will not be re-defined here.)

The physical properties of polyacrylamide formulations depend on the degree of hydrolysis[4]. Physical chemistry analyses indicate that KY700 has a low relative MW, compared to that of the PT1200 (less than half the MW). Nevertheless, it has a reasonably high viscosity for that MW, as it achieves a higher degree of hydrolysis. The viscosity is sufficient to allow the hydrolysed polymer to act as a pore displacement agent in a flooding mode, driven by high