Numerical Modeling of Solvent Enhanced Water Flooding

M. Chahardowli[1], R. Farajzadeh[2], H. Bruining[1]

[1]Delft University of Technology, Delft, The Netherlands
[2]Shell Global International Solutions, Den Haag, The Netherlands

Abstract

Mutually soluble-solvents can improve the ultimate recovery in conventional reservoirs. Initially, the solvent moves with the imbibing aqueous phase into the reservoir. However, upon contact with oil, diffusion occurs and the solvent is transported in the oleic phase. Through the migration of the mutually soluble component from the aqueous phase into the oleic phase, oil properties and/or rock-fluid interactions are modified. Our hypothesis in this work is that the mutually soluble solvent increases the oil recovery via enhancement of water flooding. The main recovery mechanisms are the oil swelling and oil viscosity reduction by MSS.

Mass conservation equation has been written for all components. The system contains equation for two immiscible aqueous phase and oleic phase. For instance, the main parameters are saturation, pressure of the aqueous phase and relative volume of water and polymer in the aqueous phase. The process is firstly governed by solvent partitioning between the aqueous phase and the oleic phase. The model is suitable to estimate the density, the viscosity, the pressure and the saturation of the phases and the relative volume of all components in each time step. The initial condition at each sequence of the flooding depends is obtained from the distribution of the main model parameters at the end of last sequence that depending on the flooded fluid. Boundary conditions are also governed by the injection fluid condition.
The experimental results were interpreted successfully and a good match has obtained between experimental and numerical results. According to our numerical study, It appears that the most effective contributing mechanisms in the solvent-enhanced water flooding are: (1) swelling of the residual oil and increasing the saturation of the oleic phase (as a result increasing the oil relative permeability), (2) reducing the oil viscosity and as a result increase in the oil mobility. The contribution of other mechanisms like interfacial tension reduction, oil density reduction, etc. in the oil recovery are less effective.

Reference

M. Chahardowli, R. Farajzadeh, J. Bruining "Numerical Simulation of Mutually Soluble Solvent-aided Spontaneous Imbibition in Fractured Reservoirs", 14th European Conference on the Mathematics of Oil Recovery, ECMOR XIV, 8th-11th September 2014, Catania, Sicily, Italy.

M. Chahardowli, J. Bruining "Modeling of Wettability Alteration during Spontaneous Imbibition of Mutually Soluble Solvents in Mixed-Wet Fractured Reservoirs", COMSOL Multiphysics Conference, September 17 – 19th 2014, Churchill College, Cambridge, UK.

M. Chahardowli, R. Farajzadeh, R. Krastev "Measurement of Partition Coefficient of a Mutually Soluble Solvent between Oil and Mixture of Polymer + Salt + Water", in the Booklet of the International Colloid and Surface Science Symposium, UK Colloids 2014, p. 225, abstract no. P12, 6 – 9th July 2014, London, United Kingdom.

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M. Chahardowli, A. Zholdybayeva, R. Farajzadeh, J. Bruining "Solvent Enhanced Spontaneous Imbibition in Fractured Reservoirs", SPE 164908, 13th EuroPEC Conference and Exhibition, 10-13th June 2013, London, UK.

M. Chahardowli, J. Bruining "Modelling of Non-equilibrium Effects in the Gravity Driven Countercurrent Imbibition", COMSOL Multiphysics Conference, 11-13th October 2012, Milan, Italy.

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4