Mathematical Modeling of Low-Salinity Waterflooding

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One of the concerns about producing a petroleum field is the oil recovery capacity of a determined reservoir. Primary recovery, depending only of the reservoir natural pressure - are very low (about 35% of the original oil in place (OOIP)), so it is necessary aditional methods to optimize oil recovery. Waterflooding is the most basic process and it is able to improve recovery by approximately only 50% of OOIP. Since most part of oil still remains without be produced when using secondary recovery, other methods, known as Enhanced Oil Recovery (EOR), have been developed in order to extract maximum oil volume from a reservoir. It can involve chemical methods, which includes the injection of polymers, miscible flooding, foams and surfactants; and thermals methods, as hot water injection, in situ combustion. These methods must be evaluated and is chosen according to the rock formation and oil properties.

As a recent alternative, laboratory experiments have pointed out the Low-Salinity Waterflooding (LSW) as a method for EOR. One of the possible reasons proposed to explain the additional oil recovered by LSW is the wettability alteration that leads to an improvement of displacement efficiency by changing formation wettability to oil-wet to more water-wet. Other mechanisms attempt to describe the process related with LSW, among which permeability reduction due to fine migration, increased pH effect and reduced interfacial tension (IFT) and multicomponent ion exchange (MIE) (SHENG, 2014). Most of these hypotheses are interconnected and remain a key to understand how the LS effect works.

So with the view to choose the best method of EOR, analytical and numerical mathematical solutions plays an important role in the development of a theory able to forecast the production histories and profiles of a reservoir. After determined the equations which rules the behavior of the two-phase flow in the porous media - in general, a system of partial differential equations based in the material balance - it is necessary to establish the technique to be utilized. Initial and boundary conditions should be set up according with the physical nature of the problem and its assumptions. Some of these techniques includes the solution of hyperbolic systems through characteristic methods, adopting devices as the entropy (Lax) and Hugoniot conditions to construct the curves.

We will focus in the ion exchange theory to develop an analytical solution for a multicomponent system in water-oil phases. It will be considered four components diluted - three cations and one anion - which can adsorb in the porous medium. This adsorption follows a singular isotherm and the problem equations will be modelled through an isothermal one-dimensional flow.

Palavras-chave: EOR, Low Salinity Waterflooding, Hyperbolic Systems

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