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Development of a tool for fundamental undersating of multipahse non-newtonain flow in annulli

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Abstract

Polymer flooding is a most important chemical EOR methods that uses to increase oil recovery by decreasing the water/oil mobility ratio by increasing the viscosity of the displacing water. Polymer flooding can be as a secondary oil recovery method, but more often it is used as a tertiary oil recovery method based on classical flooding. Polymer flooding consist of adding polymer to the injected water to increase the viscosity and also a decrease of aqueous phase permeability that occurs with some polymers, led to a lower mobility ratio. This lowering increases the efficiency of the water flood through greater volumetric sweep efficiency and a lower swept zone oil saturation. Generally, a polymer flood will be economic only if the water flood mobility ratio is high, the reservoir heterogeneity is high, or a combination of these two occurs. This study evaluated using of polymer flooding in one of the Iranian heavy oil reservoirs and compared between obtained results of polymer flooding simulated with and water flooding process in different scenarios.

Results also show that the polymer flooding scenario has higher oil recovery in comparison to other displacement methods such as natural depletion and water flooding. In addition, In this study, it was investigated that solving the problem of determining the viscosity of polymer solutions in the case of polymer flooding in one of the Iranian heavy oil reservoir. Primary and secondary recovery methods do not give the maximum oil recovery in certain oil fields, and have a high water cut. Enhanced oil recovery (EOR) methods can solve these issues. CO_2 has been used to recover oil for more than 40 years. Currently, about 43% of EOR production in U.S. is from CO_2 flooding. CO_2 flooding is a well-established EOR technique, but its density and viscosity nature are challenges for CO_2 projects. Polymer flooding that falls under chemical EOR is one of these methods.

The mechanisms of polymer flooding leads to increasing the viscosity of the displacing fluid, water, and reduces the mobility to be lower than the displaced fluid, oil. This gives a better sweeping efficiency, which translates into higher oil recovery and lower water cut because of the delay of viscous fingering and water breakthrough. To select a suitable polymer for a particular field, parameters such as; polymer viscosity, concentration, slug size should be studied carefully. The EOR techniques are employed to recover more oil from mature reservoirs after the primary and secondary oil production stages. Polymer flooding as a chemical EOR method involves adding polymer molecules in order to increase water viscosity. Low density (0.5 to 0.8 g/cm3) causes gas to rise upward in reservoirs and bypass many lower portions of the reservoir. Low viscosity (0.02 to 0.08 cp) leads to poor volumetric sweep efficiency. So water-alternating-gas (WAG) method was used to control the mobility of CO_2 and improve sweep efficiency. However, WAG process has some other problems in heavy oil reservoir, such as poor mobility ratio and gravity overriding. To examine the applicability of carbon dioxide to recover viscous oil from highly heterogeneous reservoirs, this study suggests a new EOR method--polymer-alternating gas (PAG) process.

The process involves a combination of polymer flooding and CO_2 injection. To confirm the effectiveness of PAG process in heavy oils, a reservoir model from Liaohe Oilfield is used to compare the technical and economic performance among PAG, WAG and polymer flooding. Simulation results show that PAG method would increase oil recovery over 10% compared with other EOR methods and PAG would be economically success based on assumption in this study. This study is the first to apply PAG to enhance oil recovery in heavy oil reservoir with highly heterogeneous. Besides, this paper provides detailed discussions and comparison about PAG with other EOR methods in this heavy oil reservoir. Increasing water viscosity will improve the mobility ratio of injected fluid to reservoir fluid toward a more favorable value. Therefore, vertical and areal sweep efficiencies are increased compared to typical water flooding. Polymer flooding will be most effective if applied in the early stages of a water flood while the mobile oil saturation is still high. Polymer is also a critical component when considering other chemical EOR technologies such as alkaline-polymer or alkaline-surfactant-polymer.

The presence of a polymer in water increases the viscosity of the injected fluid, which upon injection reduces the water-to-oil mobility ratio and the permeability of the porous media, thereby improving oil recovery. The objective of this work is to investigate strategies that would help increase oil recovery. For that purpose, we have studied the effect of injection pressure and increasing polymer concentration on flooding performance.

This work emphasizes on the development of a detailed mathematical model describing fluid saturations, pressure, and polymer concentration during the injection experiments and predicts oil recovery. The mathematical model developed for simulations is a black oil model consisting of a two-phase flow (aqueous and oleic) of polymeric solutions in one-dimensional porous media as a function of time and z-coordinate. The mathematical model consisting of heterogeneous, nonlinear, and simultaneous partial differential equations efficiently describes the physical process and consists of various parameters and variables that are involved in our lab-scale process to quantify and analyze them. A dimensionless numerical solution is achieved using the finite difference method.