Abstract

Wettability of a porous reservoir rock is an important factor that affects oil recovery during waterflooding. It is recognized as being important for multiphase properties. Understanding the variation of these properties in the field, due to wettability trends and different pore structures, is very critical for designing efficient and reliable processes and projects for enhanced hydrocarbon recovery. After primary drainage the reservoir wettability changes: if it was oil-wet initially, it gradually changes to water-wet during waterflooding. This change in reservoir wettability towards water-wet will reduce the residual oil saturation and improve the oil displacement efficiency. However, knowledge of the constitutive relationship between the pore scale descriptors of transport in the porous system is required to adequately describe wettability trend and its impact on oil recovery, particularly during waterflooding. In this work, the petrophysical properties that define fluid flow in the Agbada, Nigeria sandstone reservoir were determined using conventional experimental and x-ray CT scanning methods. Experimentally measured average porosity is 0.28, average permeability is 1699 mD, while the initial and irreducible water saturation is 0.22. Permeability in the *x*, *y* and *z* directions, ranging from 50 to 200 mD, were calculated from the pore network extracted from the Agbada sandstone rock. Results obtained from the Amott-Harvey wettability measurement method indicate that the reservoir is strongly water-wet, with Amott-Harvey index of about 0.9. The cross-over between the water and oil relative permeabilities occurred at saturations of the samples above 0.5, giving an indication of strong water-wetness. The work summarizes the mechanism of wettability alteration and characterizes the performance of the reservoir during waterflooding from injecting water, and relates the residual oil saturation, relative permeability and volumes of water injected to wettability and its effects on oil recovery. Waterflood oil recovery is computed using the Buckley-Leverett method based on the

reservoir rock and fluid properties. Computed waterflood oil recovery using this method was about 60% of the oil initially in place. Plots of spontaneous imbibition rate show that the injection rate for optimal oil recovery is 40 bbls of injected water per day. At this rate, both the mobility and shock front mobility ratios are less than 1, leading to a stable flood front and absence of viscous fingering. Waterflooding is by far the most widely applied method of improved oil recovery over the years with good results in conventional and unconventional (tight oil) reservoirs It is relatively simple and cost effective: abundance and availability of water. Waterflood oil recovery factor is affected by internal and external factors. The placement of the injection and production wells, for example, impacts on the effectiveness of the waterflooding process. I considered the placement of the wells in a five-spot pattern as elements of an unbounded double periodic array of wells and assumed the reservoir to be homogeneous, infinite and isotropic, with constant porosity and permeability. Both fluids are treated as having slight but constant compressibility and their flow governed by Darcy’s law. The average pressure in the reservoir satisfies quasi-static flow or diffusion equation. I then assumed piston-like displacement of oil by injected water that takes account of viscosity diffence between both fluids and proposed a model based on the theory of elliptic functions, in particular Weierstrass p-functions functions. Oil-water contact movement, dimensionless time for water breakthrough at the production well, areal sweep and average reservoir pressures were modeled. The model was tested using Wolfram Mathematica 10 software and the results are promising. The thesis has therefore established that the Agbada sandstone reservoir is strongly water-wet and that waterflooding is a viable option for enhanced oil recovery from the reservoir.