A Power-Law Mixing Rule for Predicting Apparent Diffusion Coefficients of Binary Gas Mixtures in Heavy Oil

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Abstract

Non-thermal gas injection approaches are promising to recover the vast heavy oil resources where thermal methods are inapplicable. When a gas is made in contact with heavy oil, mass transfer between gas and heavy oil is mainly dominated by diffusion and dispersion, and thus affecting oil production response. Due to the time-consuming and complicated measurement procedures, simple correlations are necessary to accurately predict diffusion coefficient of a gas or gases in heavy oil. In this study, a power-law mixing rule has been developed to determine apparent diffusion coefficient of a binary gas mixture on the basis of diffusion coefficients for pure gases in heavy oil. Diffusion coefficients of pure gases under different pressures and different temperatures are predicted by incorporating the principle of corresponding states for one-dimensional gas diffusion, and adding the specific surface area for three-dimensional gas diffusion, respectively. Then, the developed correlations are used to reproduce the measured diffusion coefficients for pure gases diffusing in three different heavy oils, i.e., two Lloydminster heavy oils and a Cactus Lake heavy oil. Accordingly, such predicted pure gas diffusion coefficients are adjusted based on the reduced pressure, reduced temperature, and equilibrium ratio to determine apparent diffusion coefficient for a gas mixture in heavy oil, where the equilibrium ratios for hydrocarbon gases and CO_2 *are determined by using the equilibrium ratio charts and Standing's equations, respectively. It has been found for various gas mixtures in two different Lloydminster heavy oils that the newly developed mixing rule can reproduce the apparent diffusion coefficient for binary gas mixtures in heavy oil with a good accuracy. For the pure gas diffusion in heavy oil, the AARDs for diffusion systems with two different Lloydminster heavy oils and a Cactus Lake heavy oil are calculated to be 2.54%, 14.79%, and 6.36%, respectively. Meanwhile, for the binary gas mixture diffusion in heavy oil, the AARDs for diffusion systems with two different Lloydminster heavy oils are found to be 3.56% and 6.86%, respectively.*

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