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Feasibility of injecting CO2 into low-permeability gas reservoirs to enhance gas recovery

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Natural gas resources in tight sandstone are huge, but the gas production rate decreases rapidly and the gas recovery rate is low due to poor reservoir physical properties. Injecting CO2 when the gas reservoir is depleted can enhance gas recovery and simultaneously sequestering a large amount of greenhouse gases, which has significant economic and environmental benefits. To fully understand the production mechanism of the CO2 flooding process at the field scale and evaluate the technical feasibility, a mathematical model is established to study the dynamic behavior of the method in this work. Based on the geological data of the Sulige gas field in the Ordos Basin, a 3D numerical simulation model of CO2 flooding in tight gas reservoirs under the five-point well pattern is established. The production dynamic behavior of enhanced gas recovery and CO2 storage processes is studied through numerical simulation approach. Moreover, the impact of engineering and geological parameters on production performance is discussed, such as perforation strategy, CO2 injection rate, permeability, porosity, diffusion coefficient, residual water saturation, reservoir thickness, etc.
Results indicate that the CH4 production rate is significantly increased after CO2 flooding, and the gas recovery can be increased by up to 19.2%, confirming the feasibility of CO2 injection technology to enhance CH4 production in depleted tight gas reservoirs. According to the spatial distribution characteristics of the components, the reservoir can be divided into CO2 zone, CH4-CO2 mixed zone, and CH4 zone. Although a CO2-CH4 mixing zone is formed due to diffusion, there was no significant mixing in the reservoir, ensuring the purity of natural gas in the production wells. Once the CO2 breakthrough occurs, the CH4 production rate decreases rapidly, and the spatial distribution of CO2 is only slightly affected by the gravity difference of the components. These characteristics are significantly different from those of high-permeability gas reservoirs. The CO2 front in the early stage of flooding is proportional to the square root or cube root of time, depending on the perforation location and reservoir thickness. However, the CO2 front in the late flood stage shows a linear relationship with the square of time. It is recommended that injection well and production well be fully perforated in the gas interval because the enhanced gas recovery is higher than other perforation options and excessive bottom-hole pressure in the injection well can be avoided. As the permeability increases, the CO2 breakthrough time becomes shorter, and the CH4 recovery increases, resulting in less CO2 buried in the reservoir. The diffusion coefficient has a significant impact on production dynamics. The larger the diffusion coefficient, the wider the mixing range of CH4 and CO2, which accelerates the CO2 breakthrough and leads to low CH4 recovery.

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