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Microscopic production characteristics and influencing factors of micro-nano pores in shale oil enhanced oil recovery by air injection

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Abstract: In order to explore how to improve the development effect of air flooding in shale oil, an online physical simulation method for shale oil air injection enhanced oil recovery was established by high-temperature and high-pressure CT scanning and nuclear magnetic resonance (NMR) technology, the development effect of air flooding of shale oil under different depletion pressures and the micro-production characteristics of different pore throats were analyzed, and the oil recovery mechanism of shale oil air flooding was given. On the basis, the effects of air oxygen content, permeability, capillary number, and gas injection pressure on the shale air flooding effect and pore crude oil production were analyzed. Subsequently, the shale digital core pore-fracture network model was reconstructed by high-resolution CT combined with advanced algorithms of AVIZO visualization software, and the influence of fracture development degree on enhanced oil recovery was analyzed by combined with magnetic resonance imaging (MRI). The results show that the development effect of shale oil could be greatly improved by injecting air after the shale reservoir was depleted, but the oil displacement efficiency and the production degree of different levels of pore throats under different injection timing were different. At the initial state, the crude oil in the shale core was mainly distributed in nanopores, sub-micropores, and micropores, where the oil content exceeded at least 75% in these pores. The oil discharge rate of macropores was fast at first and then slows down, but the oil discharge rate of nanopores increased almost linearly during air flooding. The higher the air oxygen content, the stronger the low temperature oxidation, the more obvious the thermal effect and the viscosity reduction effect, the higher the production degree of pores at different levels, and the recovery factor gradually increases. The higher the permeability, the better the pore throat connectivity, the stronger the fluid flow capacity, and the higher the recovery degree of shale oil. With the injection pressure increases, the lower limit of the minimum pore throat production increases, but it is easy to produce gas channeling, which leads to the breakthrough in advance, and the recovery increases first and then decreases. Notable, fractures can effectively increase the contact area between gas and crude oil, promote the mass and heat transfer between matrix fractures, and increase the air sweep coefficient and matrix oil drainage area by supplying oil to fractures through the matrix; the utilization of submicron pores and micron pores increased to 34.3% and 42.7%, respectively, which means that the proper fracturing before air injection can help to improve the oil displacement effect of air injection.

Key words: NMR; shale oil; heat and mass transfer; air flooding; CT scanning; EOR; microscopic production; factor

Participation

In-Person

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