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Simulation Study on Polymer Flooding with Thermal Degradation in Elevated-Temperature Reservoirs

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Abstract : Polymers injected into elevated-temperature reservoirs inevitably suffer from thermal degradation, resulting in severe viscosity loss and poor flooding performance. However, for polymer flooding in such reservoirs, present simulators fail to provide accurate results for lack of description on thermal degradation. In light of this, the objectives of this paper are to provide a simulation model for polymer flooding with thermal degradation and study the effect of thermal degradation on polymer flooding in elevated-temperature reservoirs. Firstly, a thermal degradation experiment was conducted to obtain the degradation law of polymer concentration and viscosity. Different types of polymers degraded in the Thermo tank with elevated temperatures. Afterward, based on the obtained law, a streamline-assistant model was proposed to simulate the degradation process under in-situ flow conditions. Model validation was performed with field data from a well group of an offshore oilfield. Finally, the effect of thermal degradation on polymer flooding was studied using the proposed model. Experimental results showed that the polymer concentration remained unchanged, while the viscosity degraded exponentially with time after degradation. The polymer viscosity was functionally dependent on the polymer degradation time (PDT), which represented the elapsed time started from the polymer particle injection. Tracing the real flow path of polymer particle was required. Therefore, the presented simulation model was streamline-assistant. Equation of PDT vs. time of flight (TOF) along streamline was built by the law of polymer particle transport. Based on the field polymer sample and dynamic data, the new model proved its accuracy. Study of degradation effect on polymer flooding indicated: (1) the viscosity loss increased with TOF exponentially in the main body of polymer-slug and remained constant in the slug front; (2) the responding time of polymer flooding was delayed, but the effective time was prolonged; (3) the breakthrough of subsequent water was eased; (4) the capacity of polymer adjusting injection profile was diminished; (5) the incremental recovery was reduced significantly. In general, the effect of thermal degradation on polymer flooding performance was rather negative. This paper provides a more comprehensive insight into polymer thermal degradation in both the physical process and field application. The proposed simulation model offers an effective means for simulating the polymer flooding process with thermal degradation. The negative effect of thermal degradation suggests that the polymer thermal stability should be given full consideration when designing polymer flooding project in elevated-temperature reservoirs.

Keywords : polymer flooding, elevated-temperature reservoir, thermal degradation, numerical simulation
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