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Mechanism Research on Rapid Expansion of Steam Chamber Based on Nitrogen Inducing

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For heavy oil reservoirs buried over 3000 ft, the high pressure would lead to low dryness and expansion difficulty for injected steam. Therefore, they are mostly developed by steam huff and puff, and the EOR methods such as steam flooding and SAGD cannot be used. As a results, the oil recovery could hardly reach 25%.

In order to solve this problem, a method of rapid expansion of steam chamber using nitrogen inducing is proposed based on nitrogen assisted flow experiment and reservoir numerical simulation study. Firstly, the effects of nitrogen concentration on partial pressure and dryness of steam under high temperature and high pressure were obtained by phase behavior experiment, which indicated that additive nitrogen amount of 20~40% would decrease the steam saturated vapor temperature over 54°F. Secondly, the phase distribution during the fluid flow and heat dissipation process were analyzed by pore-scale multiphase flow simulation, and the nitrogen would restrain the steam condensation process and increase the gas saturation along the flow direction. In the meantime, the core flow experiment shows that the nitrogen gas could decrease the multi-component fluid flow resistance over 84%, which can be considered as strong flow conductivity in porous media. Taking advantage of nitrogen gas inducing ability, the nitrogen pre-injection would build a fast flow channel in relatively higher permeability layer. It could also reduce the injection pressure over 260 psi and enhance the steam dryness about 0.15. Inside the fast flow channel, the follow-injected steam would reach a longer flow distance and higher saturation horizontal plane. As a results, the steam overlap around the injection well would get relatively slower due to the high flow velocity on horizontal plane. Then the gravity drainage process can heat and displace the heavy oil above the fast flow channel, and partial nitrogen gas would gather at the top of the reservoir and reduce the heat loss to the cap rock by 11% by reservoir numerical simulation evaluation.

Overall, this method can improve the thermal recovery over 19% and reduce the oil-steam ratio about 0.05, which provides a new way for economical thermal EOR in deep heavy oil reservoirs.

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