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Quantitative characterization method for residual oil distribution in heavy oil after multi-cycle steam huff and puff based on CT scanning

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1. Objectives/Scope Steam huff and puff is an important development method for heavy oil reservoirs. An accurate description of the remaining oil distribution after steam huff and puff is crucial for guiding subsequent reservoir development. In this study, a new experimental apparatus was used to simulate the multiple cycles of steam huff and puff process more realistically. The occurrence state and distribution of remaining oil after different cycles of steam huff and puff were investigated.
2. Methods, Procedures, Process Laboratory experiments usually employ displacement to simulate steam huff and puff. In this study, a low-density and temperature-resistant material was used innovatively as the sand pack model, enabling multi-cycle steam huff and puff and in-situ CT scanning. The experimental procedures include steam injection, soaking, and recovery, with CT scanning of the sand pack model after each cycle. Based on characterization parameters such as shape factor and Euler number, the microscopic remaining oil is classified into network-like, cluster-like, film-like, and isolated droplet-like remaining oil. The proportions of these different types of remaining oil are compared after each cycle.
3. Results, Observations, Conclusion The viscosity of the heavy oil used in the experiment is 800 mPa·s (25℃). The statistical results indicate that as the number of cycles increases, the proportion of network-like remaining oil decreases, while the proportions of cluster-like, film-like, and isolated droplet-like remaining oil increase. From the first to the seventh cycle, the proportion of network-like remaining oil decreases by 34.11%, while the proportions of cluster-like, film-like, and isolated droplet-like remaining oil increase by 12.84%, 14.48%, and 6.76% respectively. The remaining oil transitions from a continuous distribution to a discontinuous distribution. This is because during steam injection, steam and heavy oil enter the intermediate container. During the soaking phase, steam is converted into hot water, forming an oil-water mixture with the oil. In the production phase, the oil-water mixture enters the sand pack, causing the network-like remaining oil to transform into cluster-like, film-like, and isolated droplet-like remaining oil, resulting in the discontinuous distribution of remaining oil. With an increase in the number of cycles, the water saturation increases, and the distribution of remaining oil becomes more dispersed.
4. Novel/Additive Information In this study, a new physical experimental model was developed to simulate the multi-cycle steam huff and puff process of heavy oil realistically. In-situ CT scanning technology was employed to quantitatively characterize the distribution of microscopic residual oil. This research guides the subsequent cold production of heavy oil.

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Primary authors: ZHENG, Haoyu (China University of Petroleum (East China)); Prof. HOU, Jian (China University of Petroleum (East China))

Presenter: ZHENG, Haoyu (China University of Petroleum (East China))

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