Slight insights and perspectives of future heavy oil recovery

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Abstract
In this paper, we put forward critical future prospects based on the paper that was published on International Journal of Heat and Mass Transfer. At present, engineers are familiar with the advantages and disadvantages of different working fluids in thermal recovery of heavy oil. For all the oil displacement mechanism, they can be summarized into only three aspects: (a) physical heat conduction, (b) chemical reactions, and (c) the differences in hydrodynamic properties between fluids. This is already well known in the existing body of knowledge. However, how much will each of these three mechanisms contribute to the total oil recovery efficiency is quite interesting and important to the industry. Based on the commented paper and some related references, we pointed out the future research directions in this area.

Keywords Heavy oil · Different working fluids · Three main displacement mechanisms · Contribution degree · Quantitative characterization

Insights and perspectives

The paper entitled “Experimental study on the mechanism of enhanced oil recovery by multi-thermal fluid in offshore heavy oil” published on International Journal of Heat and Mass Transfer presented important additives to the existing knowledge on the oil displacement mechanisms under different thermal fluid flooding condition. At present, the study on heavy oil displacement mechanisms can be divided into three branches: (a) the physical heating mechanism (Sun et al. 2018a, b, c; Zhao et al. 2018), (b) the chemical reaction mechanism (Tiyao et al. 2010; Huang et al. 2018; Xu et al. 2013), and (c) the hydrodynamic mechanism (Bao et al. 2016; Wu et al. 2018).

For the first mechanism, the heavy oil will be heated to a higher temperature under thermal fluid injection, and the corresponding oil viscosity will be reduced. As a result, the mobility of heavy oil is increased. This oil displacement mechanism is caused by heat conduction. It has been pointed out that the contribution of heat conduction on oil recovery efficiency increases rapidly with the increase of steam quality, and the effect of steam temperature on physical heat conduction can be neglected when it is superheated steam (Sun et al. 2018b). This study revealed that physical heating is not the dominant factor in controlling oil recovery efficiency when it is superheated steam. However, it has been reported that the oil recovery efficiency is greatly increased when saturated steam is replaced with superheated steam (Xu et al. 2018b). This study revealed that physical heating is not the dominant factor in controlling oil recovery efficiency when it is superheated steam. However, it has been reported that the oil recovery efficiency is greatly increased when saturated steam is replaced with superheated steam (Xu et al. 2013). This finding showed that either chemical reactions or the hydrodynamic mechanism is the dominant controlling factor in increasing heavy oil displacement efficiency.

For the second mechanism, the components in heavy oil or compositions from rock mineral react with water under high-temperature condition (Xu et al. 2013). The heavy components in heavy oil can be reduced to lighter ones after hydrothermal pyrolysis reactions between oil components and water, and the permeability of rock matrix can be increased due to high-temperature steam flooding (Xu et al. 2013). One may find that the above-mentioned two
mechanisms can be achieved under static conditions. Note that the physical heating and chemical reactions are the basics of all mechanisms. This is because the decrease in oil viscosity and increase in rock permeability must be the fundamental objectives to achieve if the heavy oil displacement efficiency is wanted to be increased.

For the third mechanism, the fluid mobility varies according to relative permeability of fluid phase. The heated radius will be larger if the thermal fluid is injected to a farther place in reservoir, so that physical heating and chemical reactions can take place in a farther place. Consequently, the oil displacement efficiency is increased.

The results from the commented paper are well known before reading. As a result, quantitative characterization of contribution degree of the mentioned three mechanisms can have practical value. We expect the authors to conduct CMG simulations to find out the contribution degree of physical heating, chemical reaction and hydrodynamics on heavy oil recovery efficiency under different working fluids, so that engineers are able to quantitatively master different recovery mechanisms in practice.

The authors have conducted a series of studies on thermal recovery of heavy oil, geothermal energy recovery and shale oil and gas development (Sun et al. 2017a, b, c, d, e, f, g; Sun et al. 2018d, e, f, g, h, i, j, k, l, m, n, o, p, q), and the further readings of these articles are listed below and recommended (Sun et al. 2017h, 2018r, s, t, u, v, w, x, y, z, aa, ab, 2019a, b; Yu et al. 2019).

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References


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