



Contribution ID: 146

Type: Oral Presentation

Simulation Study of In-situ Conversion Process in Low-mid Maturity Shale Oil Reservoir

Monday, 22 May 2023 10:50 (15 minutes)

Continental shale oil in China is mainly of low-medium maturity, filled with heavy oil of low mobility and organic matter that unconverted. Horizontal drilling and hydraulic fracturing are insufficient to obtain economic production in such reservoir, thus in-situ heating and transform technology should be applied. A multiphase multicomponent hydro-thermal coupled numerical model considering multistage kinetic reactions is developed to describe the decomposition of solid organic matter, cracking of heavy hydrocarbon, phase behavior and rock property evolution.

During the in-situ process, organic matter (kerogen) decomposition and heavy oil cracking happens, enhancing hydrocarbon mobility. The research focuses on the development of multiphase multicomponent hydro-thermal coupled numerical model, with the evolution of porosity and permeability considered. The finite volume method is used for the space discretization of flow and heat transfer equation, and solved by the fully coupling method. Finally, the impact of important parameters on cumulative production are analyzed.

The compositional flow model is validated by comparing the results with those of CMG, and the coupled hydro-thermal model is validated against COMSOL Multiphysics. The impact of parameters including heating temperature, kerogen concentration, well bottom hole pressure, heater pattern and initial water saturation on cumulative production is analyzed. The results are summarized as: kinetic reaction rate is controlled by temperature and different reactions take place at variety heating temperature, influencing the fluid composition; higher kerogen concentration can enhance cumulative hydrocarbon production after in-situ conversion, making it an important parameter to evaluate before production; low bottom hole pressure can extract hydrocarbon products in time to prevent from further cracking and coking; different heater pattern has impact on the ratio of energy output to energy input, and hexagon heater is the most benefit; high water saturation will enhance energy consumption to heat water and reduce the utility ratio of energy, thus dewater process is required to reduce water saturation. It can be concluded that the in-situ conversion process is feasible in low-mid maturity shale oil reservoir, during which kerogen decomposition and hydrocarbon cracking happens. Besides, the operating parameters should be investigated to make the heating process economical.

The proposed model provides an efficient tool for modeling the in-situ conversion process of low-mid maturity shale oil reservoirs. In this paper, the reservoir fluid property variation, in-situ porosity and permeability evolution, and production characteristics are illustrated, which could provide insights on heater design and well operational management. With multiple transport mechanisms and multi stage kinetic reactions incorporated, the hydrocarbon production characteristics and formation property evolution of shale reservoirs can be both accurately captured.

Participation

In-Person

References

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Session Classification: MS17

Track Classification: (MS17) Thermal Processes, Thermal Coupling and Thermal Properties of Porous Media: modeling and experiments at different scales