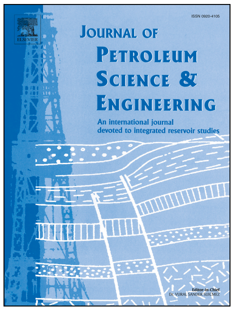

Calculation of proppant-carrying flow in supercritical carbon dioxide fracturing fluid

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Calculation of proppant-carrying flow in supercritical carbon dioxide fracturing fluid

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Abstract: As a new clear and efficient fracturing fluid, supercritical carbon dioxide (SC-CO_2) has many advantages in the development of unconventional oil and gas resources, such as no harm to the reservoir, improving the reservoir permeability and fluid flow resistance, quickly completely flowing back after fracturing. Based on the principle of suspension energy balance, an equilibrium flow rate model of proppant-carrying flow of SC-CO_2 is derived, and calculation errors are 3.32% and 4.54%, respectively, compared with equilibrium flow rates obtained from experiments under different density and particle sizes. By considering the change of fluid internal energy and flow work, filtration characteristics, physical parameters, and SC-CO_2–rock adsorption in the SC-CO_2 fracturing process, a proppant-carrying flow calculation model of the SC-CO_2 fracturing fluid is established based on temperature–pressure field coupling, fracture and filtration zone coupling, and SC-CO_2 fluid and proppant coupling. In the experiment, the heights of nine groups of proppant embankments were measured, and the average model prediction error value is 3.43%. SC-CO_2 has a similar proppant-carrying capacity to that of clear water under the high Reynolds number condition. Based on the proppant-embankment prediction model of SC-CO_2 fracturing, through analyzing proppant-carrying characteristics of the SC-CO_2 fracturing fluid, the proppant concentration distribution and proppant embankment section are obtained at different fracturing times. According to the calculation, as the fracturing fluid pumping rate increases, proppant density and proppant particle size will decrease, the viscosity of the SC-CO_2 fracturing fluid system will increase, and proppant accumulation height can be reduced over a small range, while proppant accumulation length will experience a greater increase along the fracture length direction. During field operation of SC-CO_2 fracturing, the proppant pumping process should be optimized according to the proppant embankment section and proppant concentration should be choose increased in small steps to meet fracture propping requirements.

Key words: Supercritical carbon dioxide fracturing; Fracture; Proppant-carrying flow; Equilibrium flow rate; Proppant embankment

1. Introduction

Unconventional gas (tight gas and shale gas) reservoirs generally show low porosity, low permeability, low pore-throat radius, and high gas-flow resistance. Hydraulic fracturing is a common employed technique to realize commercial exploitation. Currently, clear water fracturing and slippery water fracturing are widely adopted and have successfully promoted the commercial development of shale gas in North America, but this technology is not suitable for water-sensitive formations (Zhao, 2017). Moreover, large-scale fracturing operations can create water waste and pollute underground water sources. Supercritical carbon dioxide (SC-CO_2) fluid refers to a CO_2