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Evaluating and enhancing the fracture conductivity by an optimised carrier fluid and proppant design

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Despite the fact that China has become one of few countries that can achieve economic exploitation of continental shale oil and gas, we are still confront of tricky challenges in further enhancing the recovery of hydrocarbon. Among the influencing factors, the long-term fracture conductivity after hydraulic fracturing plays a crucial role in the overall productivity of the well. Meanwhile, the stimulation of natural fissures, which are expected to collaborate with the artificial fractures, is also of great significance to an improved reservoir permeability. This requires a well-projected design and injection scheme of fracturing fluids and proppant. On top of that, a better understanding of the transport mechanism of such a fluid-particle-based system at the particle-scale can promote an optimised combination of fracturing fluid and proppant.

Hence, the aims of the current research include a parametric study of the particle-laden flow in the fractures and a systematic evaluation of the conductivity of the propped fractures. The study on proppant transport is accomplished by means of numerical simulation. The implemented numerical framework consists of the lattice Boltzmann method (LBM) for the fluid and the discrete element method (DEM) for the large number of moving particles. A partially saturated boundary condition is applied to provide an accurate characterisation of the fluid-solid boundaries. The transport mechanism of the proppant at the artificial-natural fracture intersection as well as the flowback mechanism of the proppant are studied. Factors including proppant size and concentration, aperture-to-diameter ratio, injection rate and fracture inclination are investigated in detail. Specifically, the shear-thinning rheology of the immersed proppant bed is observed, which results in a nonlinear variation of proppant bedload transport with the fluid. The fracture conductivity is experimentally evaluated using the shale cores and sand proppant at the reservoir pressure. By adjusting the proppant aspect ratio, we find an optimised proppant concentration for each overburden pressure, under which the fracture conductivity reaches the maximum.

The present study can provide a powerful numerical approach towards a particle-scale characterisation of proppant transport. Besides, it also formulates an efficient workflow to evaluate and optimise both short- and long-term fracture conductivity. The outcome of the current research contributes to a better design of the fracturing fluid comprising of the carrier fluid and proppant. It also provides a theoretical basis for an optimised proppant selection for future hydraulic fracturing operations, which benefits the exploitation of the continental shale oil in China.

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