Mao, Shaowen; Wu, Kan; Moridis, George


Summary: The numerical simulation of hydraulic fractures is a critical yet challenging computational problem due to its multi-physics nature. This paper develops an integrated hydraulic fracturing simulator by coupling a planar three-dimensional (PL3D) fracture propagation model with an efficient Eulerian-Lagrangian (E-L) proppant transport model. The fracture propagation model uses the finite volume method (FVM) and displacement discontinuity method (DDM) to solve the fluid flow and rock deformation, respectively. For proppant transport, we develop a pseudo-3D multiphase particle-in-cell (P3D MP-PIC) model, in which the fluid flow is addressed by FVM as a continuum, but the particles are tracked in a Lagrangian fashion as discrete phases. In contrast to Eulerian-Eulerian (E-E) proppant transport models, the P3D MP-PIC can efficiently deal with multi-modal particle simulations (i.e., particles of different sizes or materials) and avoid the problem of numerical diffusion. The fracture propagation and proppant transport models are validated by analytical solutions and laboratory experiments. We adopt a one-way coupling strategy to consider the effect of complex fracture propagation and fluid leak-off on slurry transport, in which the dynamic fracture geometry and fluid leak-off is first computed via the fracture propagation model, followed by the fully coupled fluid-particle simulation using the P3D MP-PIC. The integrated model can simulate the fracturing treatments in multilayered reservoirs with varying confining stresses at an industrial field scale. The simulation results can improve the prediction of effective/propped fracture geometries and better the fracturing designs.

MSC:
76-XX Fluid mechanics
74-XX Mechanics of deformable solids

Keywords:
hydraulic fracturing; hydraulic fracture propagation; proppant transport; Eulerian-Lagrangian method; Numerical simulation

Full Text: DOI

References:
[8] Zimmermann, G.; Blöcher, G.; Reinicke, A.; Brandt, W., Rock specific hydraulic fracturing and matrix acidizing to enhance a geothermal system—concepts and field results, Tectonophysics, 503, 1-2, 146-154 (2011)


Jeffrey, R. G.; Chen, Z.; Mills, K. W.; Pegg, S., Monitoring and measuring hydraulic fracturing growth during preconditioning of a roof rock over a coal longwall panel, (ISRM International Conference for Effective and Sustainable Hydraulic Fracturing (2013), OnePetro)


Zeng, J.; Li, H.; Li, S.; Zhang, D., Evaluating the transport performance of novel-shaped proppant in slickwater fracturing with the multiscale modeling framework, SPE J., 1-16 (2022)


Kou, R.; Moridis, G.; Blasingame, T., Bridging criteria and distribution correlation for proppant transport in primary and secondary fracture, SPE Hydraulic Fracturing Technology Conference and Exhibition (2019), OnePetro


Zhang, Z.; Mao, S.; Zhao, H.; Wu, K., Simulation of proppant transport in field-scale curved fractures, (SPE/AAPG/SEG Unconventional Resources Technology Conference (2020), OnePetro)


Mao, S.; Siddhanshetty, P.; Zhang, Z.; Yu, W.; Chun, T.; Kwon, J. S.I.; Wu, K., Impact of proppant pumping schedule on well production for slickwater fracturing, SPE J., 26, 01, 342-358 (2021)

Mao, S.; Zeng, J.; Wu, K.; Zhang, D., Lagrangian numerical simulation of proppant transport in channel fracturing, SPE J., 26, 01, 342-358 (2022)


Tsai, K.; Fonseca, E.; Degaleesan, S.; Lake, E., Advanced computational modeling of proppant settling in water fractures for shale gas production, Spe J., 18, 01, 50-56 (2013)


Tong, S.; Mohanty, K. K., Proppant transport study in fractures with intersections, Fuel, 181, 463-477 (2016)


[92] Olson, J. E., Fracture aperture, length and pattern geometry development under biaxial loading; a numerical study with applications to natural, cross-jointed systems, Geological Society, London, Special Publications, 289, 1, 123-142 (2007)


[96] Barree, R. D., A practical numerical simulator for three-dimensional fracture propagation in heterogeneous media, (SPE Reservoir Simulation Symposium (1983), OnePetro)


growth into a zone of lower confining stress, (The 42nd US Rock Mechanics Symposium (2008), OnePetro)


This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.