Effects of dense granular suspension rheology and dynamic bridging on proppant transport in hydraulic fractures

S. A. Boronin[1], *E. V. Dontsov*[1,2], *D. Yu.Derbyshev*[1], *I.A. Garagash*[1,3], *A. A. Osiptsov*[1]

[1]*Multiphase Systems Lab, Skolkovo Institute of Science and Technology, Moscow, Russia*

[2]*W.D. Von Gonten Laboratories, Houston, USA*

[3]*Institute of Physics of the Earth, Russian Academy of Science, Moscow, Russia*

Proppant transport models implemented into existing commercial hydraulic fracturing simulators are formulated on the basis of simplification assumptions, which limit their application to hydraulic fracturing technology [1] including the uniform particle concetration across the fracture aperture and static proppant bridging condition [2]. Modeling the proppant transport in the whole range of particle concentration (from dilute limit up to the close pack of proppant particles) requires to consider the effect of inter-particle interactions for arbitrary particle volume concentrations, which leads, in particular, to particle migration away from the fracture walls [3]. In addition, it is shown in [4] that proppant bridging in the fracture is affected by local fluid velocities. At low velocities, proppant arches are able to move due to insufficient friction force between the particles and the walls. At large velocities, deformation of proppant particles due to hydrodynamic drag leads to disintegration of the bridge. Our aim is to develop an advanced proppant transport model that accounts for the effects described above.

We consider transport of proppant particles carried by Newtonian incompressible fluid in a narrow hydraulic fracture in the framework of dense suspension model proposed in [3]. Reduced system of the two-dimensional governing equations for proppant transport is coupled with the dynamic proppant bridging condition proposed in [4]. Governing equations are solved numerically using the second-order accurate finite difference method. Parameteric study of proppant placement in a steady channel and in a propagating hydraulic fracture is carried out. We demonstrate significant difference between the standard suspension model and dense granular rheology model supplemented with the dynamic proppant dridging condition. It is found that the simulations run in the framework of novel model predict larger proppant transport length as compred to the existing proppant models.

References

[1] Osiptsov, A. A. (2017). Fluid mechanics of hydraulic fracturing: a review. *Journal of petroleum science and engineering*, 156, 513-535.

[2] Mack, M. G., & Warpinski, N. R. (2000). Mechanics of hydraulic fracturing. *Reservoir stimulation*, 6-1.

[3] Dontsov, E. V., & Peirce, A. P. (2014). Slurry flow, gravitational settling and a proppant transport model for hydraulic fractures. *Journal of Fluid Mechanics*, 760, 567-590.

[4] Garagash, I. A., Osiptsov, A. A., & Boronin, S. A. (2019). Dynamic bridging of proppant particles in a hydraulic fracture. *International Journal of Engineering Science*, 135, 86-101.