Contribution ID: **575** Type: **Oral 20 Minutes**

A Discrete Element Approach in Modeling Proppant Transport in 3D Fracture Networks

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Objectives/Scope:
The understanding of proppant transport plays a critical role in estimating propped fracture dimensions and performance. Existing models generally assume a vertical planar geometry, whereas the reality in the subsurface may be much more complex. We use the discrete element method to simulate field scale proppant transport in complex fracture networks. Our results show that sharply-angled fracture networks reduce fluid velocity and increase the particle-wall interaction. The combined effects can cause early settling of proppants, thus limiting their efficient placement and the fracture effectiveness.

Methods, Procedures, Process:
To calibrate our numerical model, we conducted two validation simulations that describe particle settling tests and laboratory proppant transport experiments. Through scoping calculations, we determined the correct drag force model and matched both analytical solutions and experimental data for a wide range of flow regimes that included three proppant sizes (20-30 mesh, 30-40 mesh and 50-70 mesh) in two types of fluids (water and oil).
For the main component of our study, we simulated proppant transport in a 3 dimensional, field-scale fracture network using our benchmarked models. In our search for an optimal stimulation strategy, we also experimented with various perforation and pumping strategies, and then compared the proppant distribution results.

Results, Observations, Conclusions:
By analyzing the velocity and trajectory of proppant particles during transport, we identified two different stages of the proppant transport process —a "suspension" stage and a "settling" stage. During the suspension stage, the fluid drag and the gravitational forces dominate, driving proppants further into the fracture. When the proppants reach a flow stagnation area, or if/when the proppants collide with the fracture boundaries (side walls or bottom of fracture), the proppant particles lose momentum and then accumulate into "dunes" and become "settled." Finally, we observed that proppant transport in a sharply-angled fracture network leads to local flow velocity reduction and stronger particle collision interactions, leading to dramatic reductions in the transport efficiency.

Application/Significance/Novelty:
This work provides a better understanding of proppant transport behavior in sharply angled fracture networks. A significant difference from prior (laboratory) experiments is the capability of our model to simulate proppant transport at field-scale flowrates. Such a capability is critical for understanding the proppant transport behavior by ensuring that the correct Reynolds number and flow regime are used in the calculations. To the best of our knowledge, this is the first study that emphasizes the importance of particle Reynolds number to proppant transport process.

Lastly, using the discrete element method and high-performance (parallel) computing, we were able to represent various perforation and pumping schemes, which is essential for developing an optimized stimulation strategy.

References

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