Computational Modeling of Proppants Transport in Rock Fractures

Farid Rousta[1], Dustin Crandall[2], and Goodarz Ahmadi[1]

[1] Department of Mechanical and Aerospace Engineering
Clarkson University, Potsdam, NY

[2] National Energy Technology Laboratory
US Department of Energy, Morgantown, WV

Outline

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  - ❑CFD-DEM Codes
  - ❑Rough-Wall Fractures
- **Results**

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  - ❑Smooth channel fracture
  - ❑Rough-Wall Fractures
  - ❑Fracture coverage and permeability
  - ❑Neural Network capability
- **Conclusions and future work**

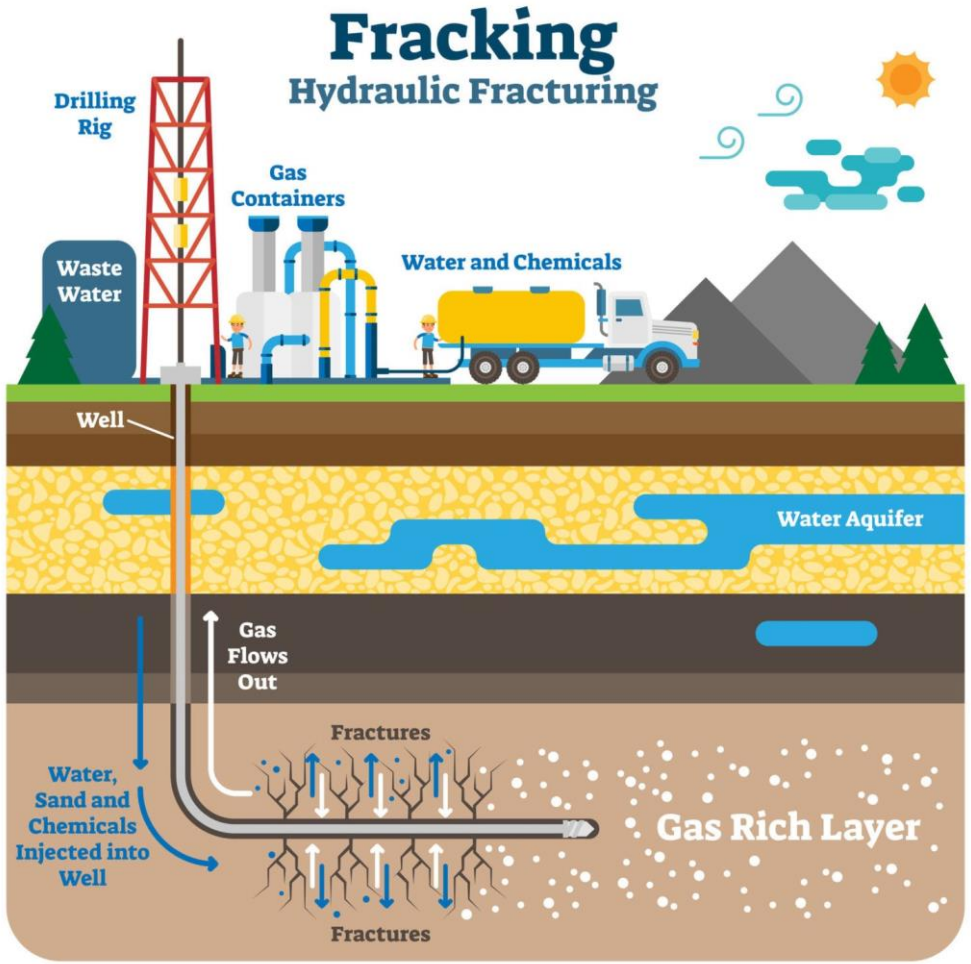
Motivation

- Experimental fracture field studies are expensive.
- Numerical studies with a realistic fracture geometry are scarce.
- The effect of proppant's properties on the fracture coverage is not fully understood.

Objectives

- Develop a computational model for proppant flows in rock fractures.
- Assess the facture coverage under different conditions.
- Access the capability of the neural network on fracture coverage prediction.

Hydraulic Fracturing



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Purpose

- Releases petroleum or natural gas trapped in shale rock formations.
- Develop more efficient geothermal energy systems.

Fracturing Procedure

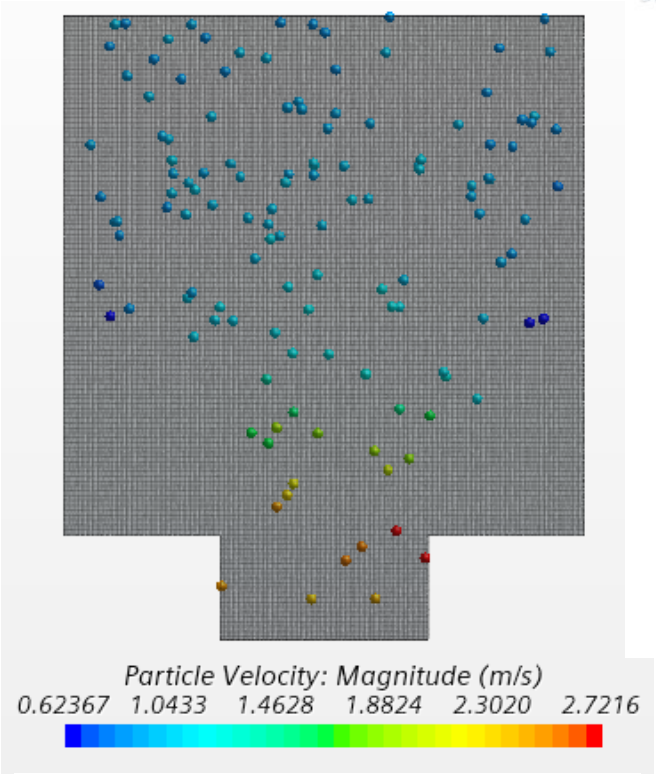
- Drilling a horizontal well in the targeted formation and inserting a steel pipe with holes into the wellbore.
- Pressurized liquid and proppants are injected into wellbores.
- The targeted formation fractures and small fractures opens up.
- Injection process is ceased, and the fracking liquids is drained.
- Proppant keep the rock fractures open and allows gas/oil production, or efficient heat transfer in geothermal systems.

Smooth channel fracture

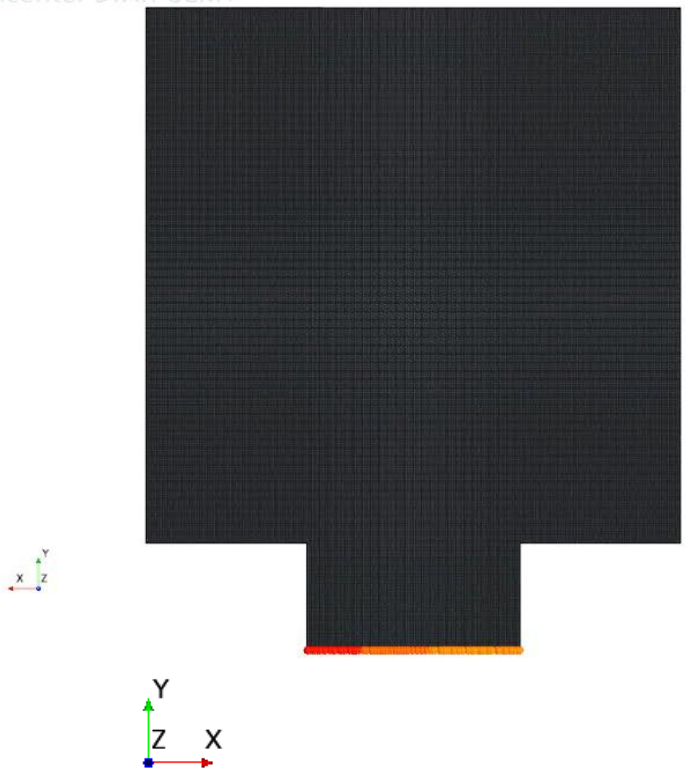
- Smooth walls
- Fracture Dimension = 100 × 100 × 0.4 mm
- Slick water + sand
- Gravity in –Z direction
- 1000 Particle per second
- Inlet pressure = 10 m^2/s^2 normalized by the fluid density

Particle Distribution

Particle distribution after 5s

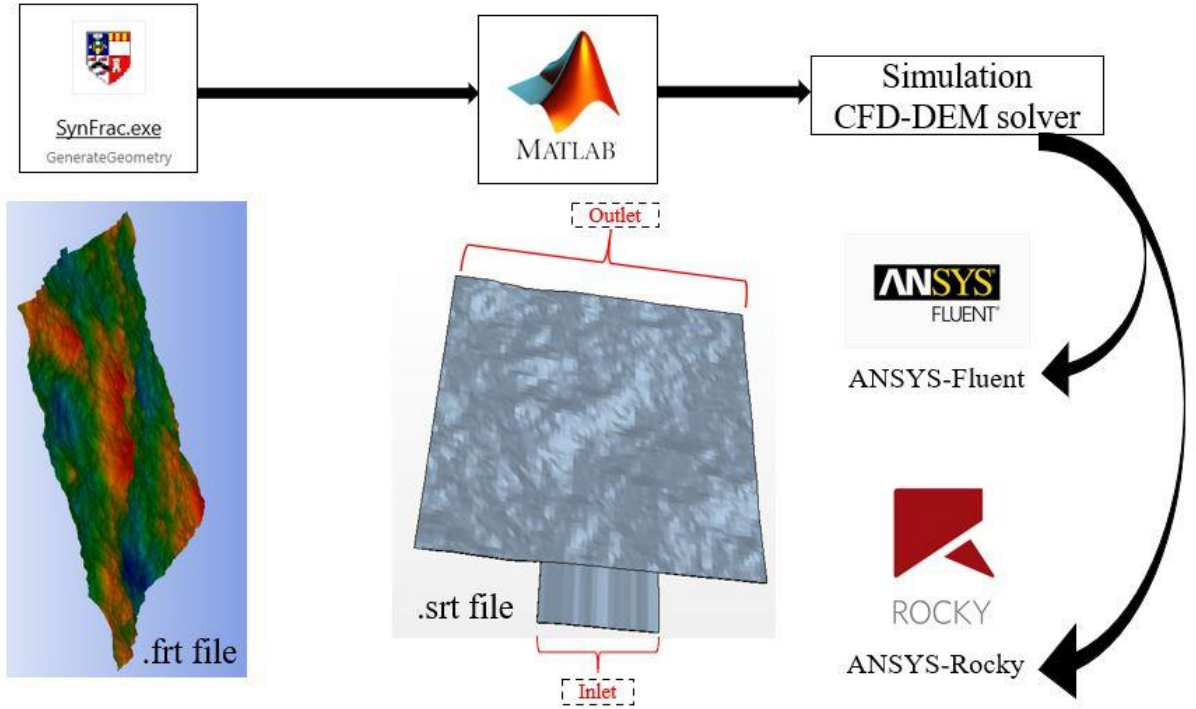


Movie of particles displacement



Rough wall Fracture, CFD-DEM Code

A schematic of the numerical solvers

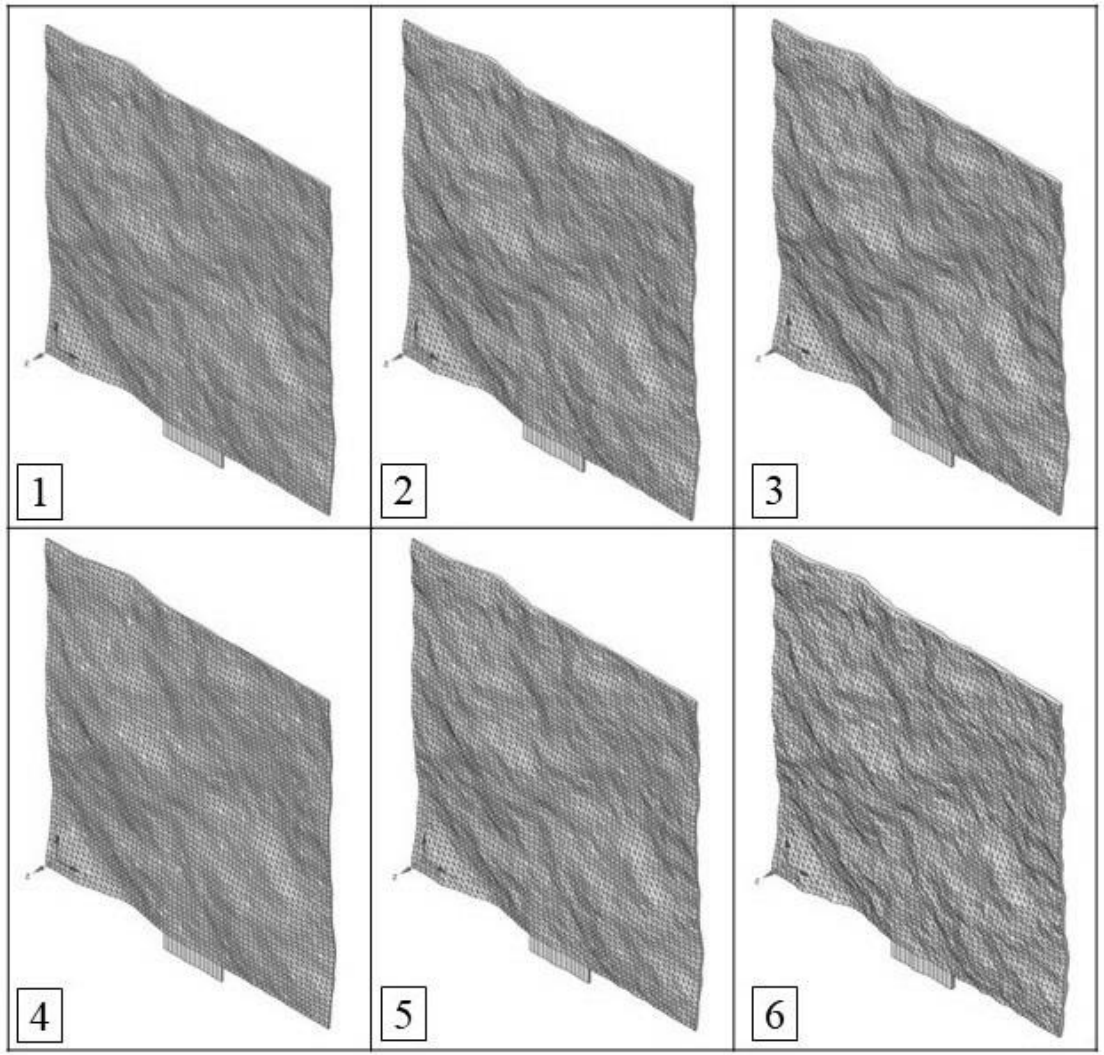


Parameter	Value	Parameter	Value
Fracture dimension	$100 \times 100\ mm$	Particles density	$2650\ kg/m^3$
Injection velocity	$0.5\ m/s$	Proppant injection rate	$3300\ N/s$
Fluid density	$1000\ kg/m^3$	Young's Modulus	$5 \times 10^6\ Pa$
Fluid dynamic viscosity	$0.001\ Pa.s$	Poisson's ratio	0.5

Test cases of various fracture and proppant diameter

Changing standard deviation

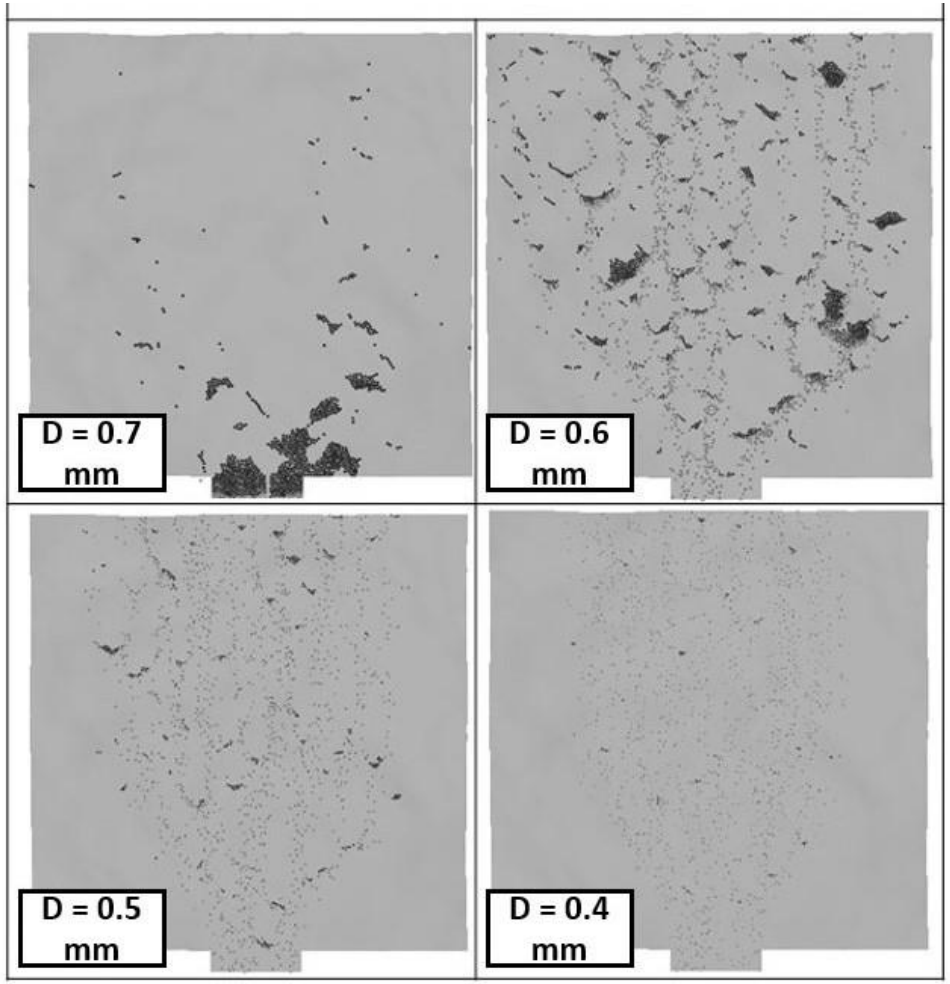
Changing fractal dimensions



Various fracture geometry

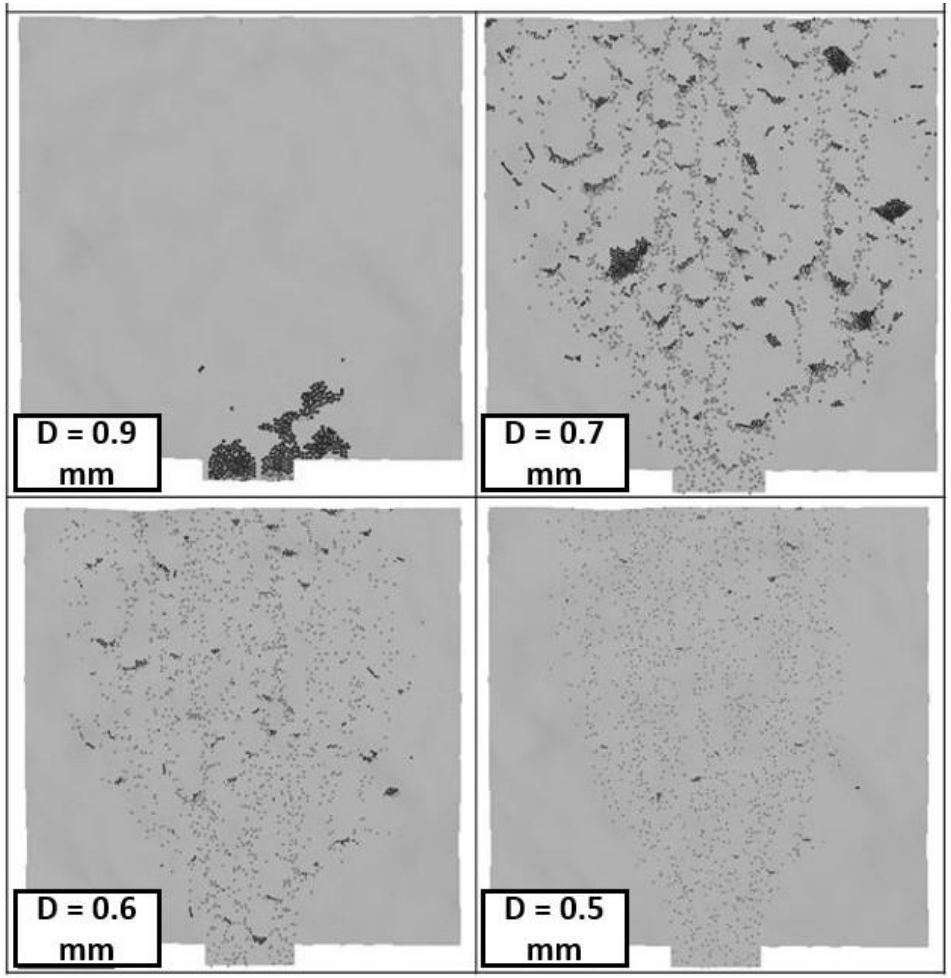
Fracture Coverage

Mean aperture size of 0.81 mm



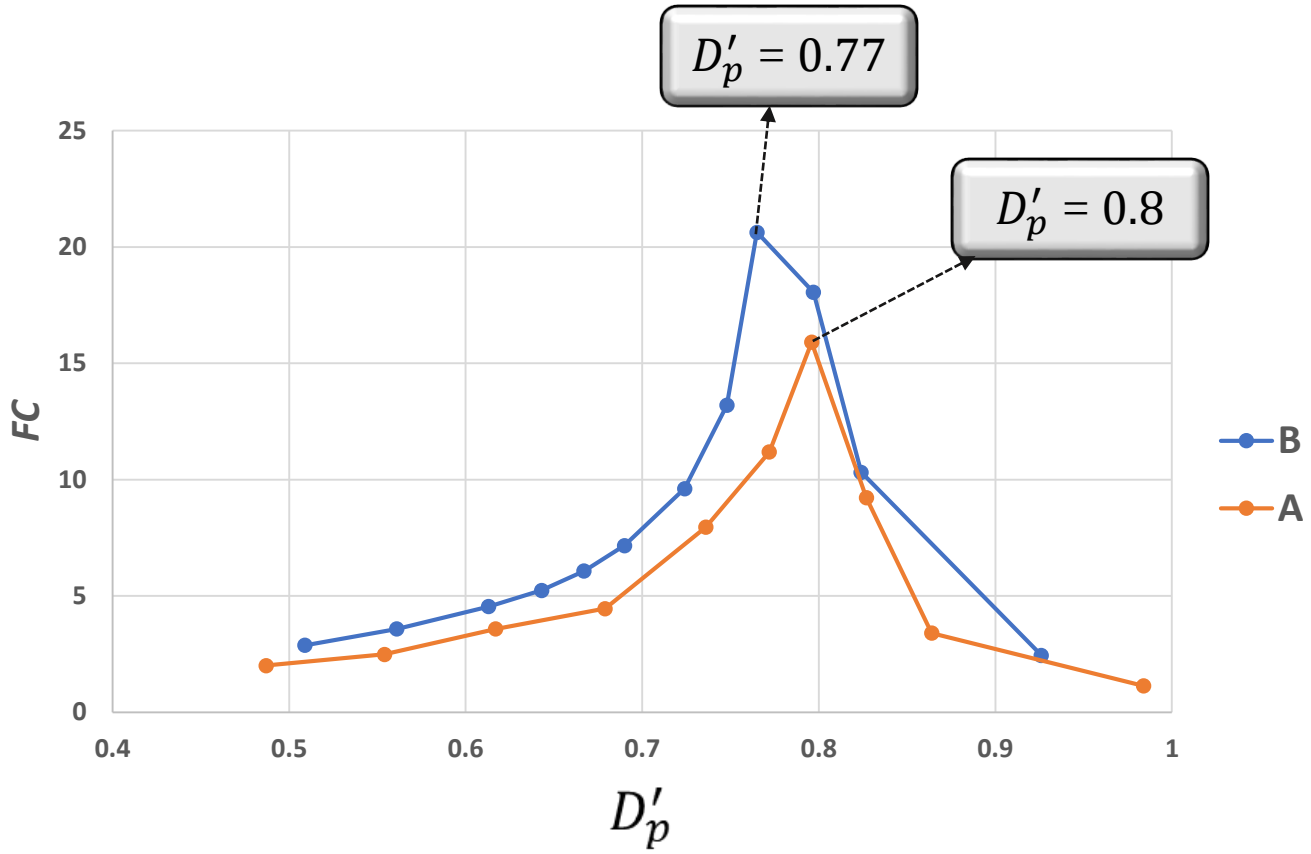
A

Mean aperture size of 0.97 mm



B

Fracture Coverage

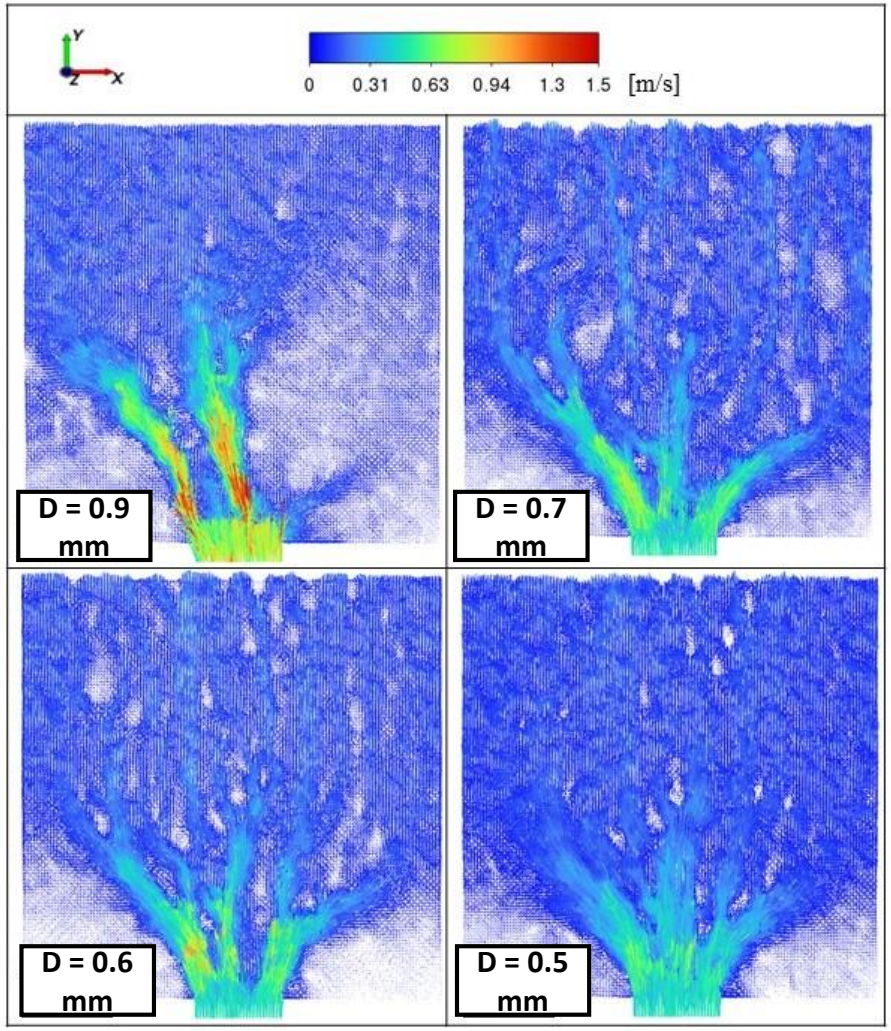


$D'_p = D_p$ / Mean aperture size

The fracture surface coverage as a function of non-dimensional proppant diameter.

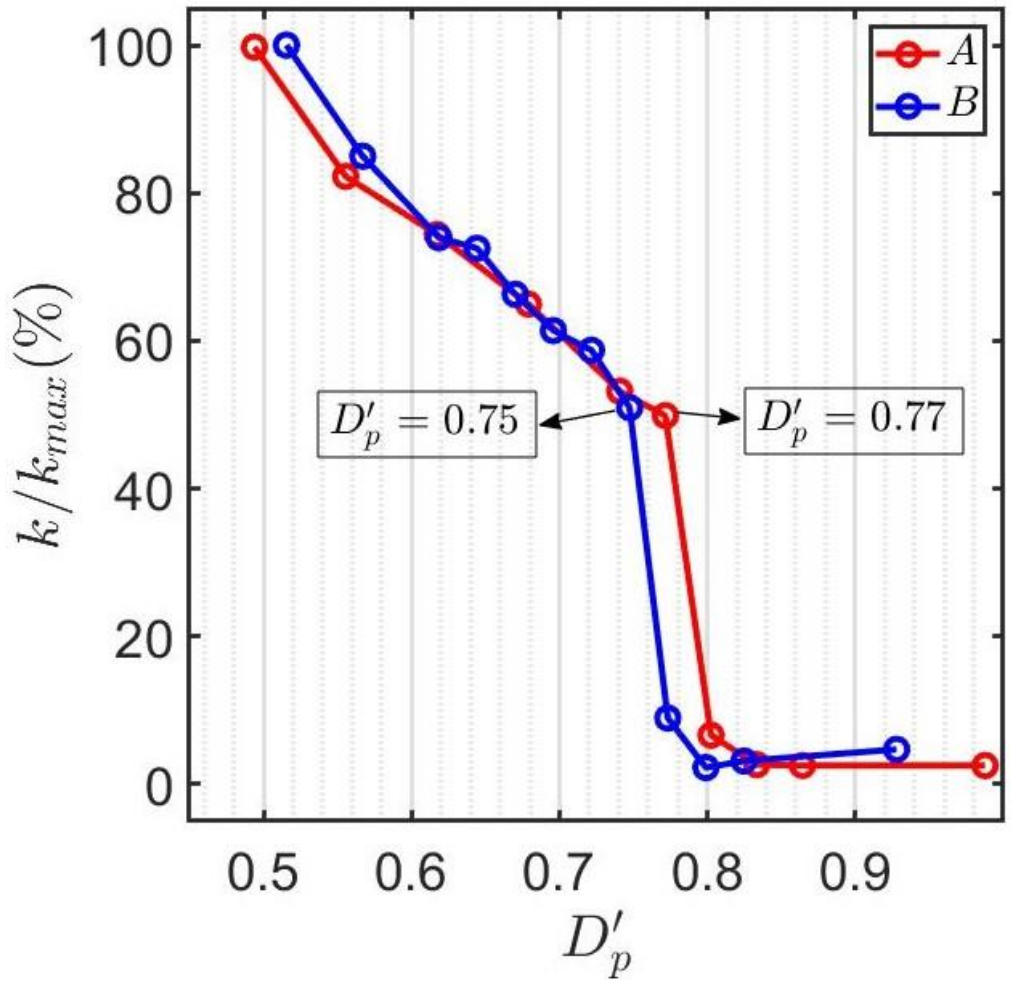
Fracture blockage

Fluid velocity vector colored by velocity magnitude in fracture with a mean aperture size of 0.97 mm.



B

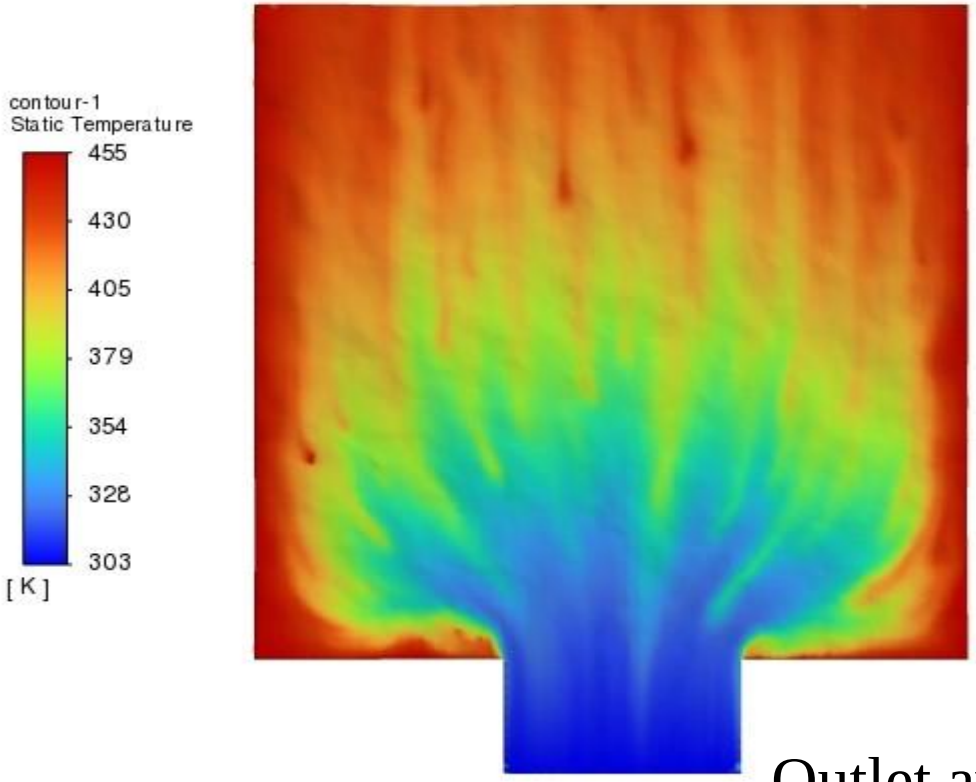
Fracture permeability



When D'_p exceeds 0.75, the permeability almost drops to zero.

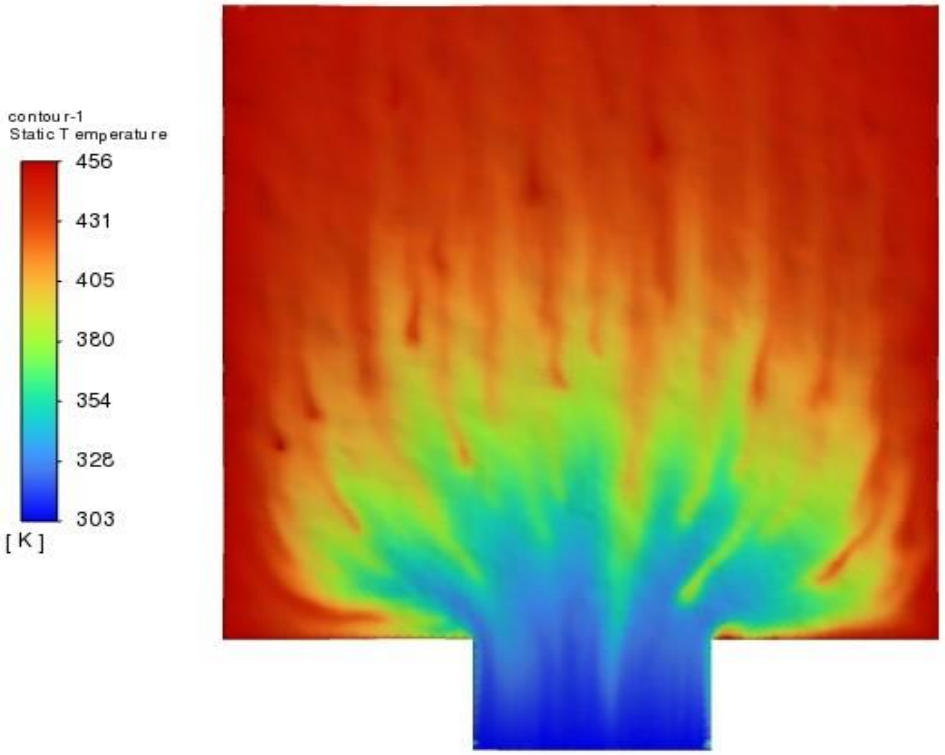
Heat transfer

- Water flow
- Pressure = 25 MPa
- Wall temperature = 182 C
- Inlet temperature = 30 C



Outlet average temperature = 431.8

- Nano-fluid (water + Al_2O_3)
- Pressure = 25 MPa
- Wall temperature = 182 C
- Inlet temperature = 30 C



Outlet average temperature = 446.5

Conclusions

- A novel procedure to numerically study the proppant transport in fractures with realistic surface roughness was introduced.
- Sample results on effect of rough fracture characteristic and particle diameter on the coverage of the fracture were presented.
- For considered cases the non dimension proppant diameter of $D_p' = 0.75$ leads to the highest coverage.

Future Study

- For the future study, the effect of fracturing fluid characteristics including the viscosity and pressure on fracture coverage will be investigated.

Thanks for your attention!

Questions?