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Navigating the Future of Unconventional Resources

EXPERIMENTAL STUDY OF PROPPANT TRANSPORT BY FOAM FRACTURING FLUIDS

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DELAWARE RESEARCH & TECHNOLOGY CENTER

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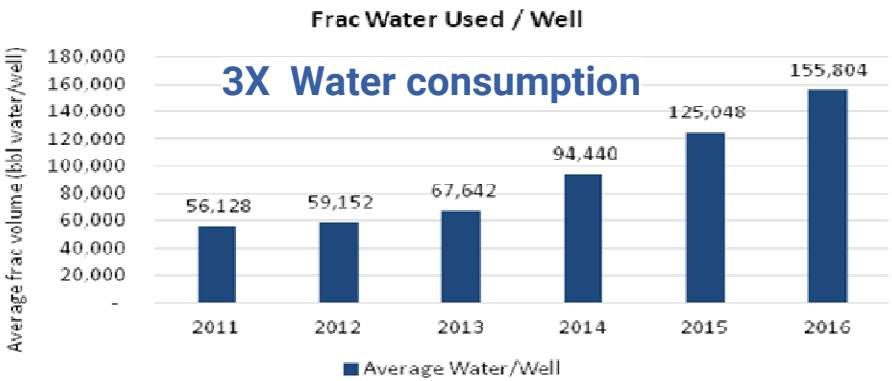
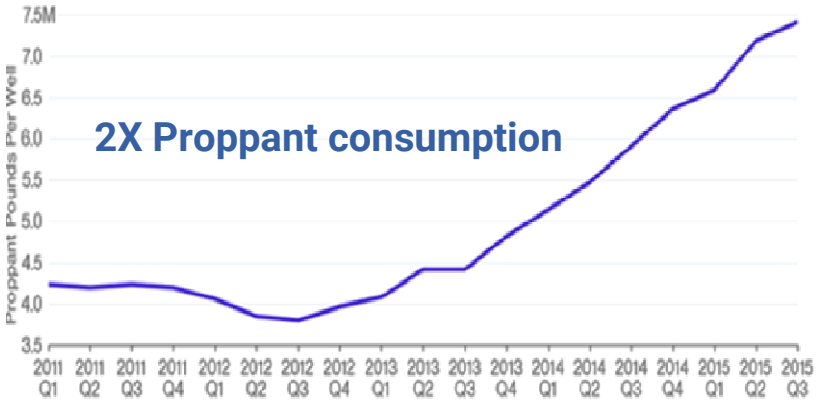
Objectives

- Improve understanding of **foam** properties and proppant transportation using different **fracturing fluids**
  - Study of **foam behavior** under different conditions
  - Quantification of proppant transported and **comparison with other fluids**
- Translate improved understanding into increased recovery

Hydraulic Fracturing

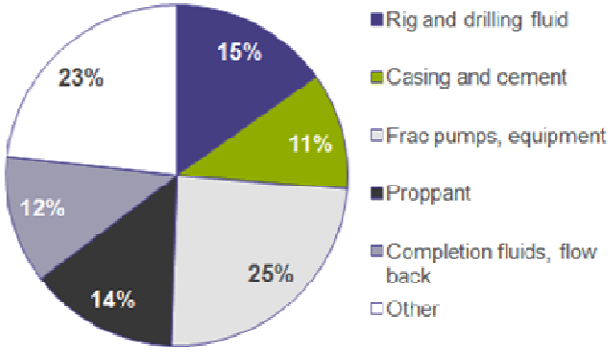


FracKnowledge Frac Database.



Primary Vision Inc.

- Water 2016: 3MM to 8MM gal/well
  - Disposal and sourcing issues
- Proppant 2016: 1700 lbs/ft
  - Proppant Consumption is indicative of the importance of proppant placement



IHS Oil and Gas Upstream Cost

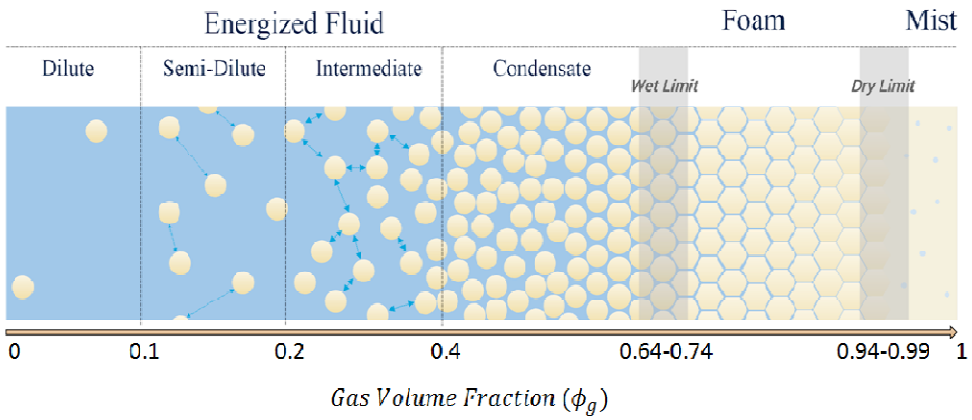
Laboratory Apparatus - Experimental Approach

- Proppant Transport Test Bench (**PTTB**)
- 2,400psi (**160 bar**) operating pressure (N_2 only)
- Foam **Rheology** and Stability Measurements are also possible
- **Benchmark** different types of fluids and proppants

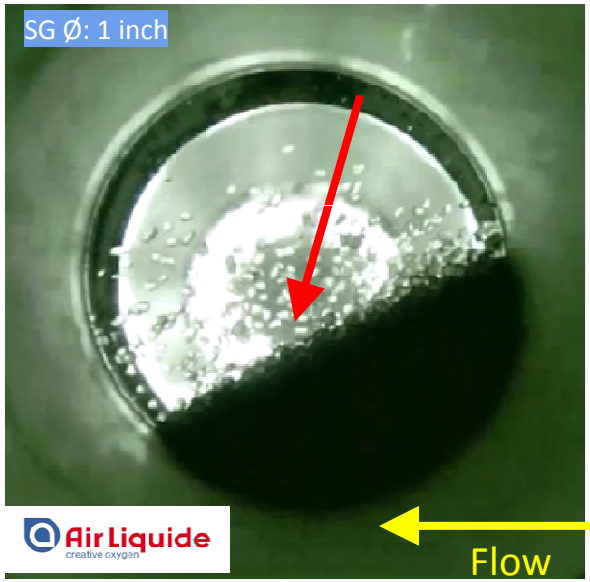
Sight glass image

Proppant Transport: Variables and Parameters to Consider

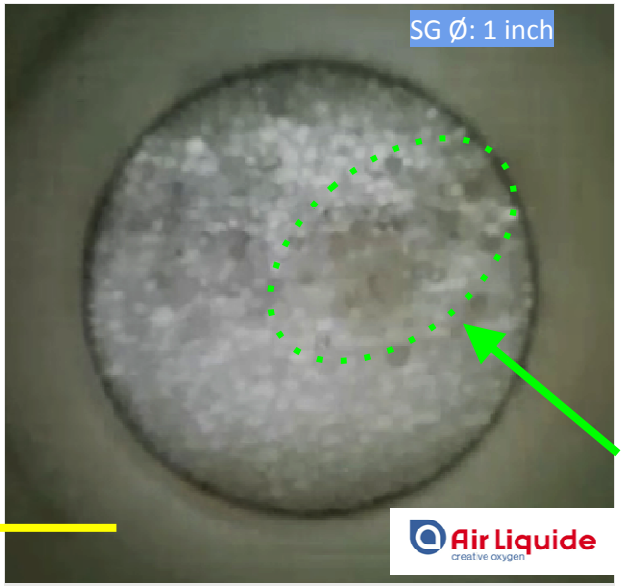
- Total Flow & Gas %
  - **Water, Energized Fluid and Foam**
  - **Flow and Pressure**
- Sand Addition Rate (2 hoppers in line)
  - Sand Loading - SAV position
  - Total Quantity
  - Run time
- Proppant
  - Size and shape
  - Material
- Surfactant & Thickener
  - **Concentration**
  - **Properties (type)**



Proppant Transport Water vs. N2 foam



Water – Proppant

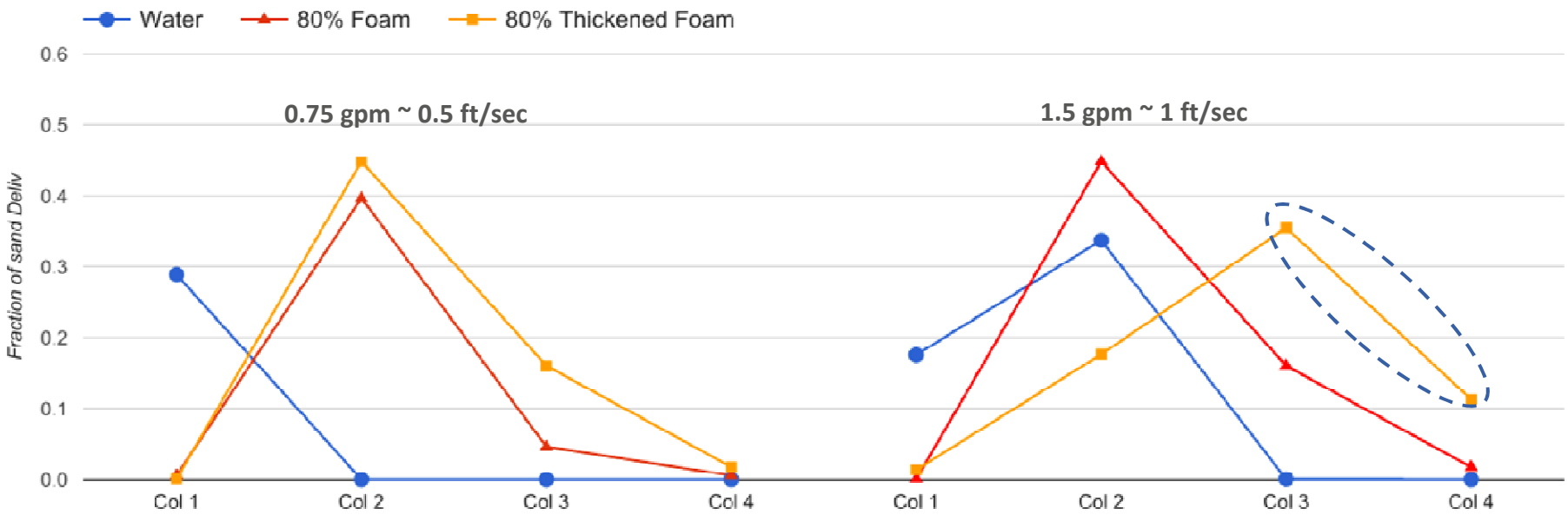


80% Foam – Proppant

- **Water:** Mainly **translational** transport
- **Foam:** Mainly **suspended** transport

Proppant Transportation - Fluid Comparison

Water, Foam and Thickened Foam: % flows, sand load 5.4 g/sec



*Results: average from multiple tests

* 0.75 gpm, sand loading = 1 lb/gal
* 1.5 gpm, sand loading = 0.5 lb/gal

Transport Performance:

1.5 gpm > 0.75 gpm

Thickened Foam > Foam without thickener > Water

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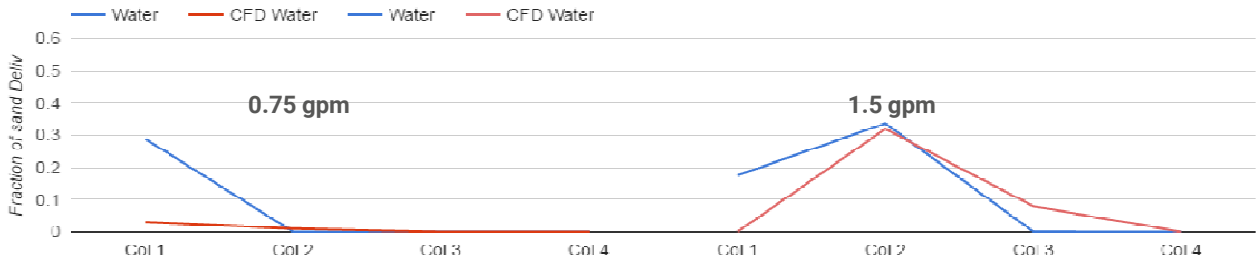
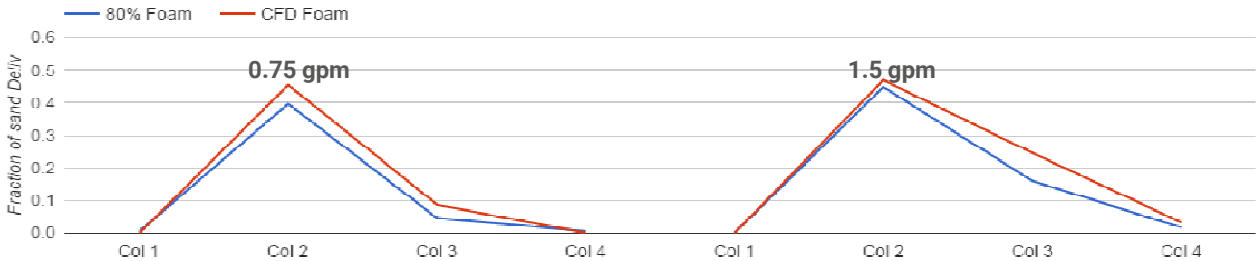
Proppant Transportation
Lab Results and CFD Comparison

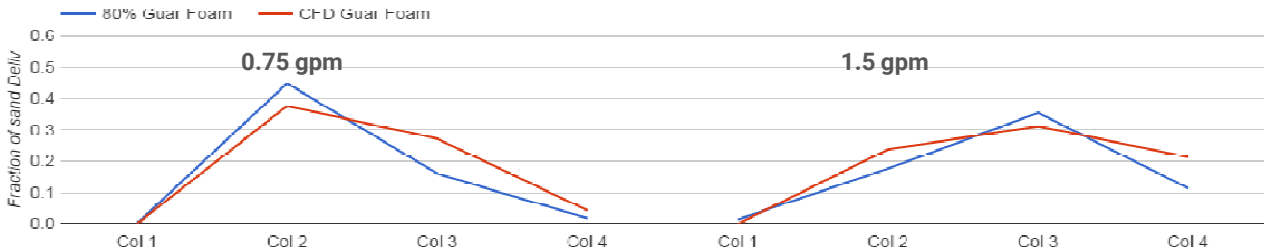
Water



80% Foam

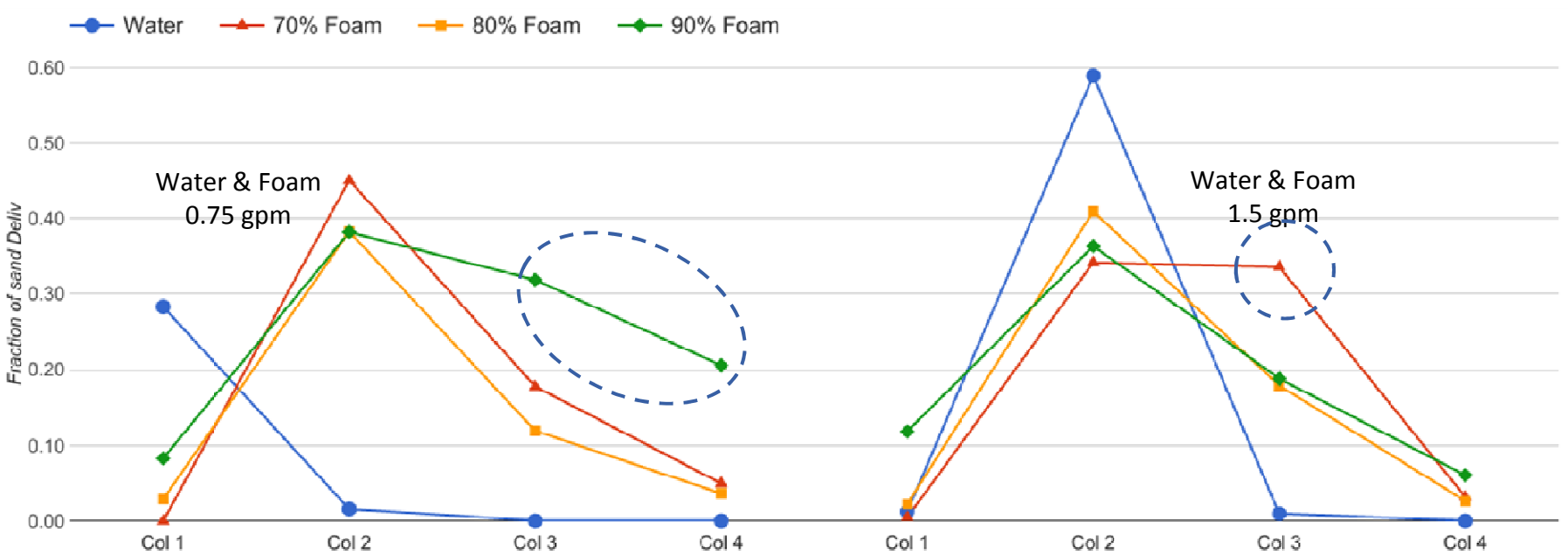


80% Thickened Foam



Experimental Results - Varying Foam Quality

Water & Foam: different % and flow. Sand load **8.6 g/sec**

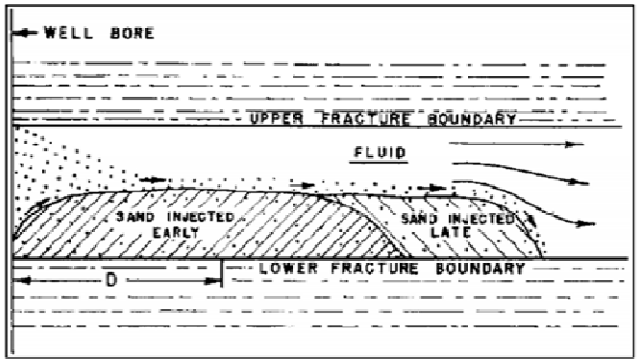


*Results: average from multiple tests

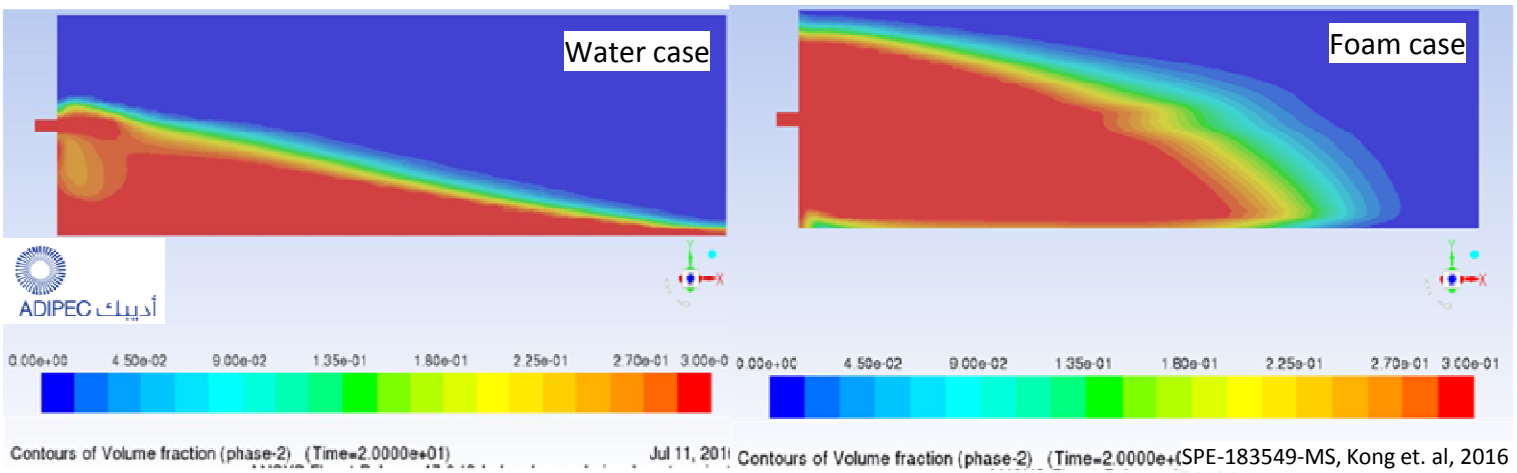
90% gives the best performance at 0.75gpm, though not at 1.5 gpm

Extending to fracture geometry with Computational Fluid Dynamics

- A CFD (ANSYS - Fluent) model for proppant transport has been developed (Kong et al.)
- CFD parameters tuned to match lab data
- CFD model used to predict proppant behavior at fracture dimensions



Kern et al., 1959



(SPE-183549-MS, Kong et. al, 2016

Conclusions

- We have a working Proppant Transport Test Bench **(PTTB)**, new tool to explore the operating space.
  - High pressure (supercritical) foams
  - Quantification and visualization of proppant transport
- Tuning a Fluent model to model the proppant transport shows promising first results.
  - Simulation results correlate with the weight of material per collection point of test bench
  - Using the model for realistic fracture dimensions shows potential for foams.

Path Forward

- Use laboratory proppant transport tests to optimize surfactant, thickener and foam quality selection
- Use CFD to extend to fracture dimensions
- Optimized proppant transport increases propped area
  - ~ 50% increase appears feasible
  - Is equivalent productivity increase achievable?
  - Field confirmation of laboratory results required

THANK YOU FOR YOUR ATTENTION

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