GeoWell: Primary cementing of geothermal wells

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NORCE Norwegian Research Centre AS

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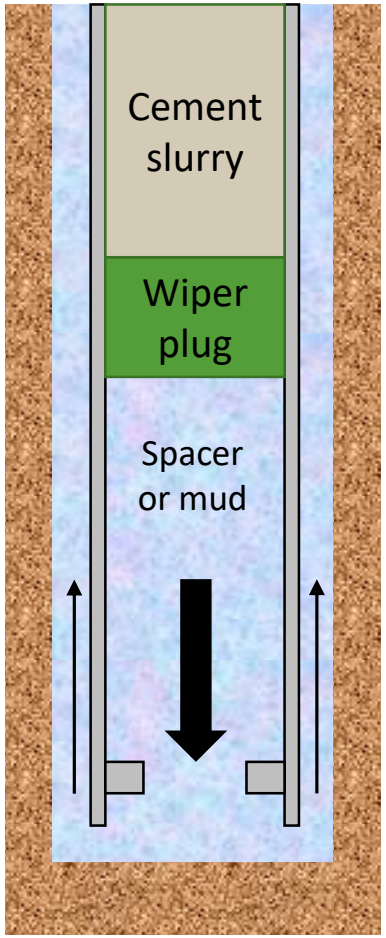
Primary cementing

- Purposes of primary cementing:
  - Zonal isolation
  - Casing support and protection



- Mud displacement recognized as important step for successful primary cementing

- O&G wells typically not cemented all the way to surface
  - Control the risk of formation fracturing by limiting the pressure behind casing during placement
  - Cementing usually performed by conventional circulation

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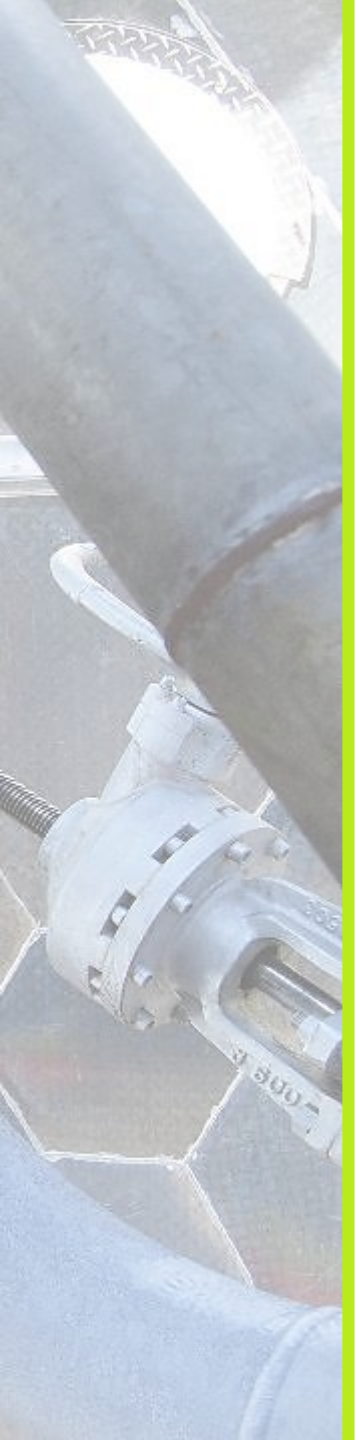
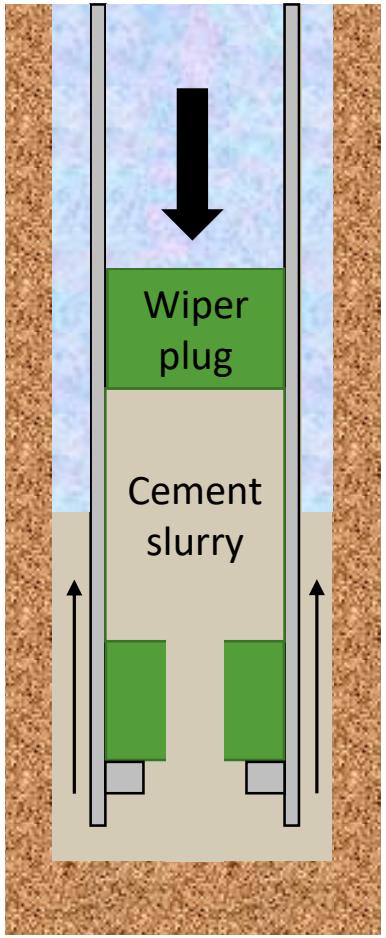


Primary cementing

- Conventional circulation: Fluids pumped down casing and up annulus
  - Mechanical plug separates fluids inside casing
  - Density-stable fluid configuration in annulus
- O&G industry-accepted guidelines for effective displacement:
  1. Density hierarchy
  2. Viscosity hierarchy
  3. Mobilization requirement on narrow side
  4. Interface velocity on wide side less or equal to that on the narrow side of the annulus
- Formulated to promote steady conventional circulation displacements in eccentric annuli



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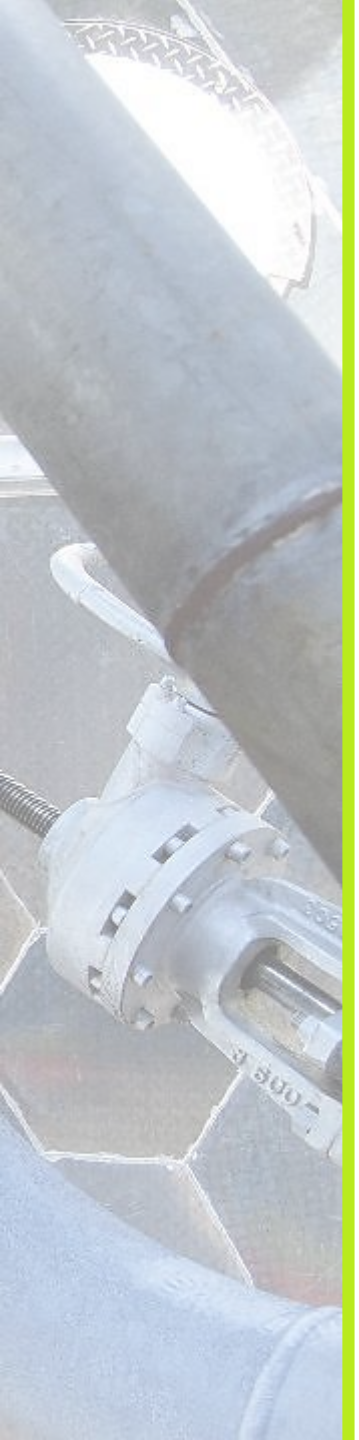
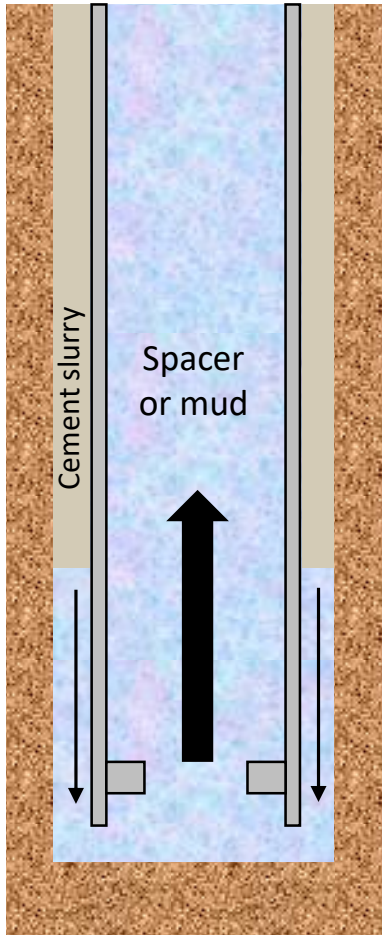


Reverse circulation cementing

- Geothermal wells are typically cemented to surface
  - Results in high bottom-hole pressures
- Cement placement by *reverse circulation* can be used to reduce circulating pressures
  - Fluids pumped directly into the annulus
  - No mechanical fluid separation
- Will normally lead to a **density-unstable** displacement in annulus
  - How will this affect displacement effectiveness?



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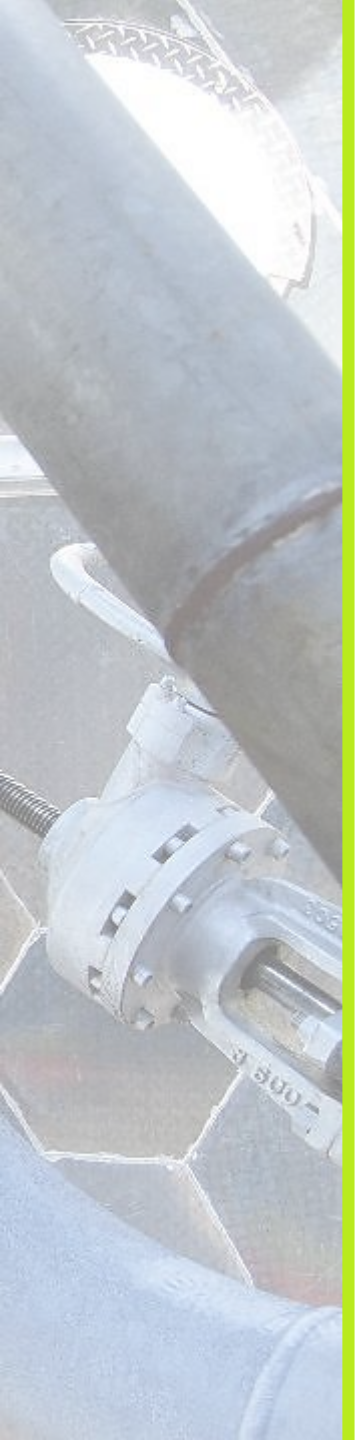
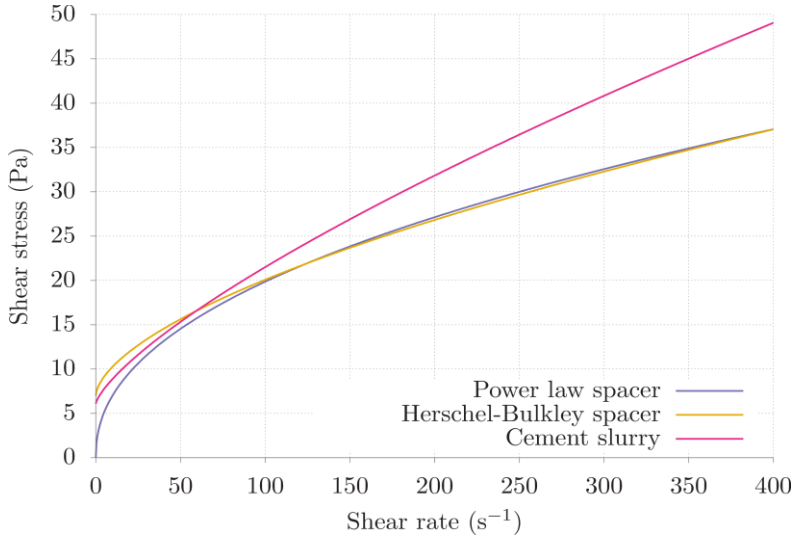
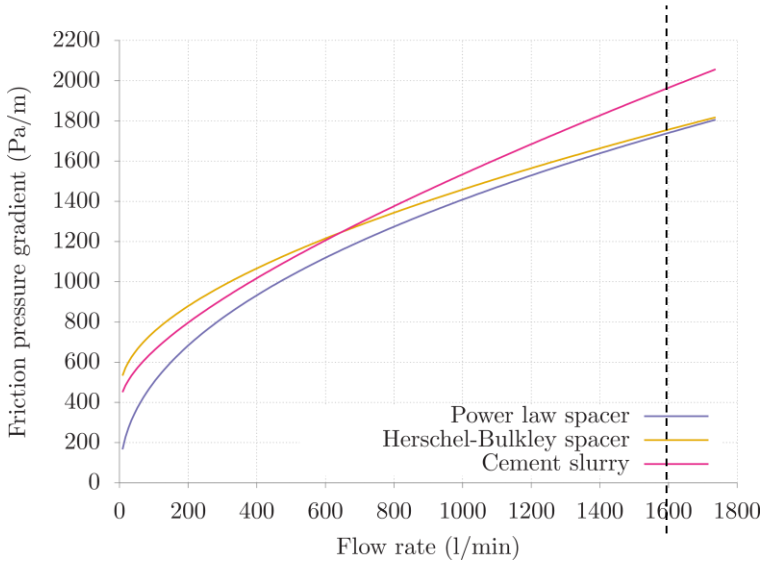


Study of reverse circulation displacements

- We have performed 3D simulations to compare conventional and reverse circulation displacement flows
  - Displacements designed in accordance with industry guidelines for **conventional displacement**
  - Consider two different spacer fluids: i) Power law and ii) Herschel-Bulkley





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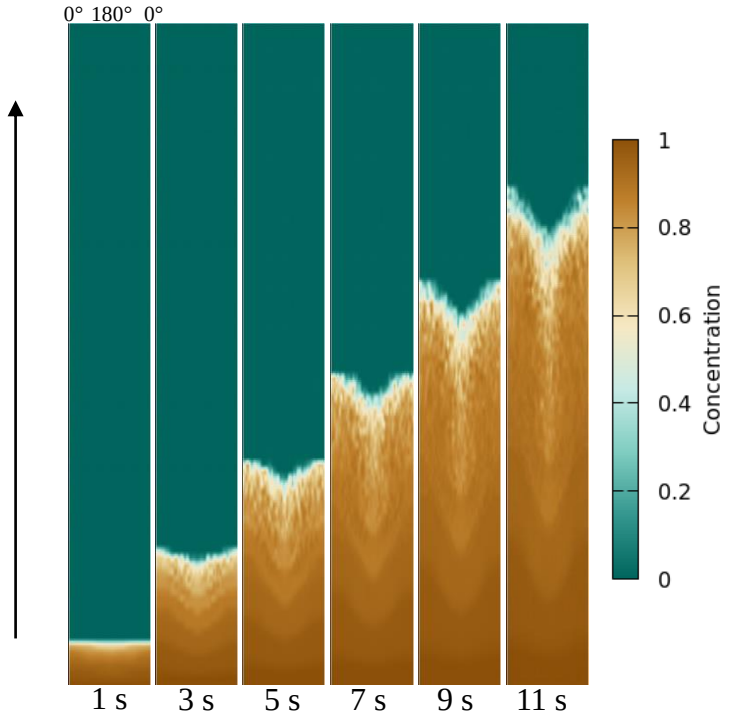
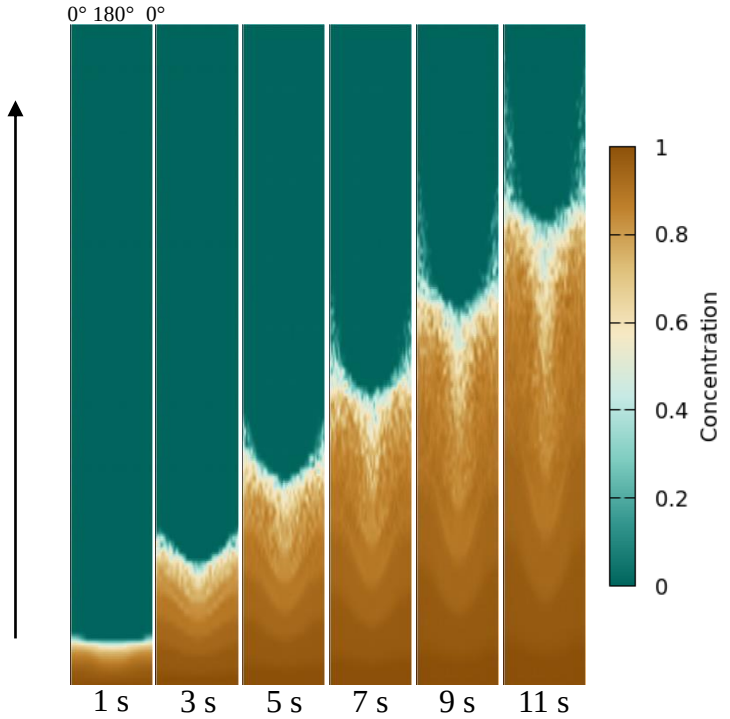
Conventional circulation

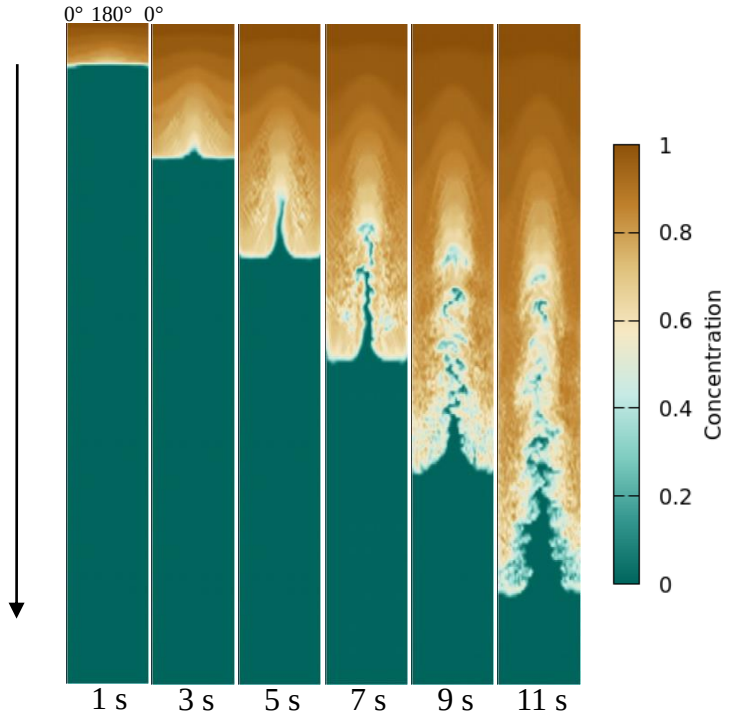


Herschel-Bulkley spacer – Cement slurry

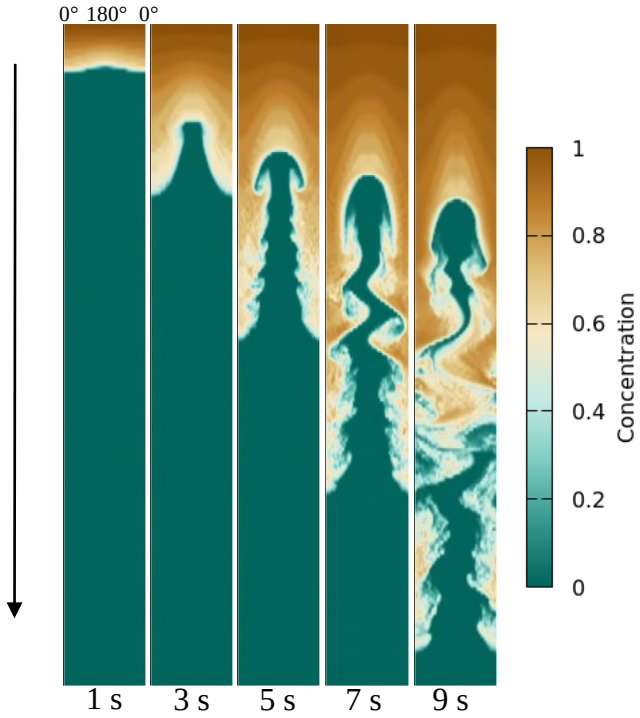


Power law spacer – Cement slurry

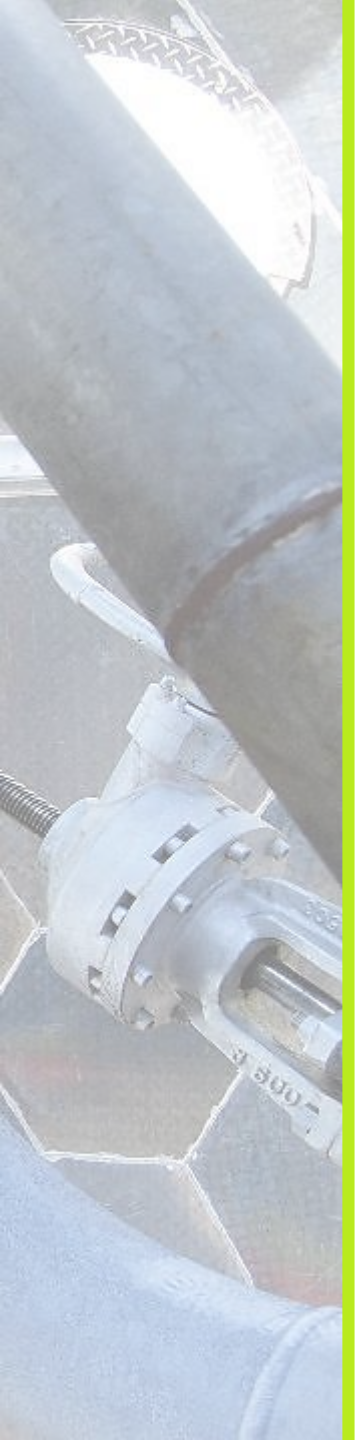
Reverse circulation



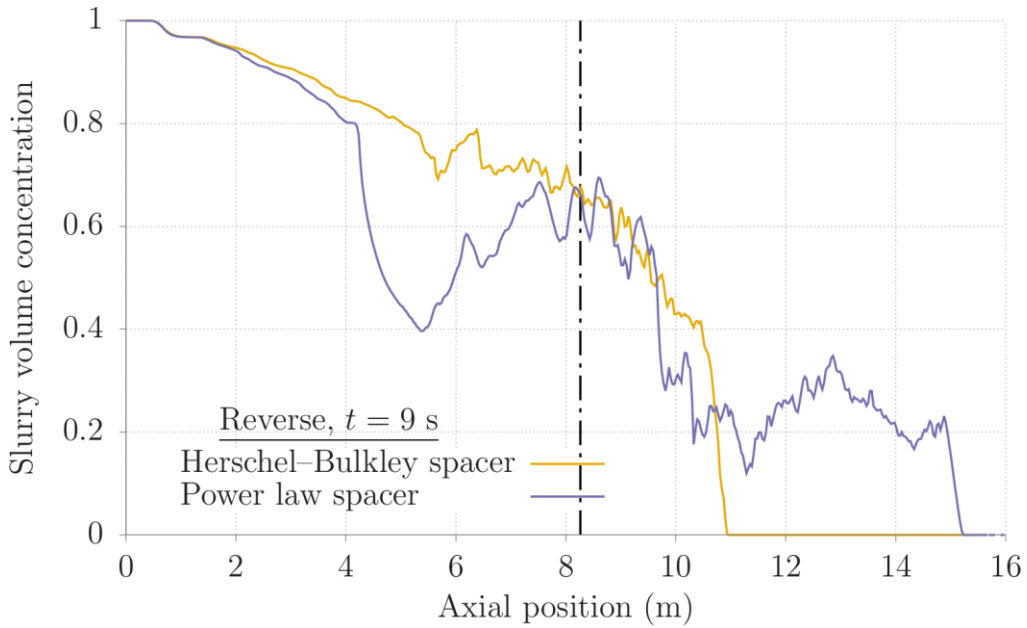
Herschel-Bulkley spacer – Cement slurry



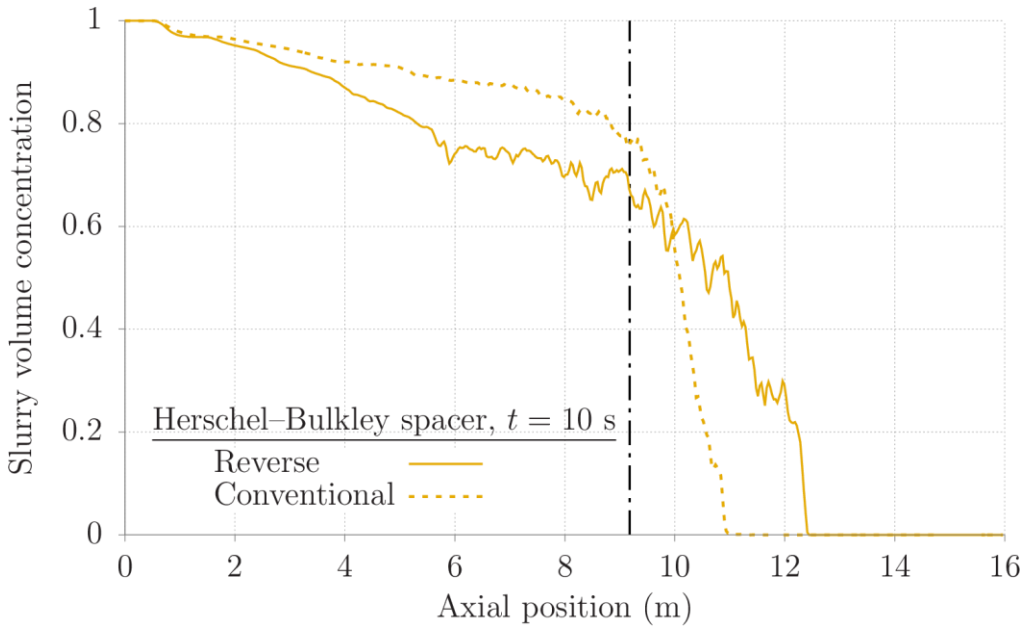
Power law spacer – Cement slurry



Comparison of displacement effectiveness



- The Herschel-Bulkley spacer gives a more stable displacement than the power law spacer under these conditions



- Although reverse displacement is unstable, the Herschel-Bulkley spacer performs surprisingly well compared to conventional circulation

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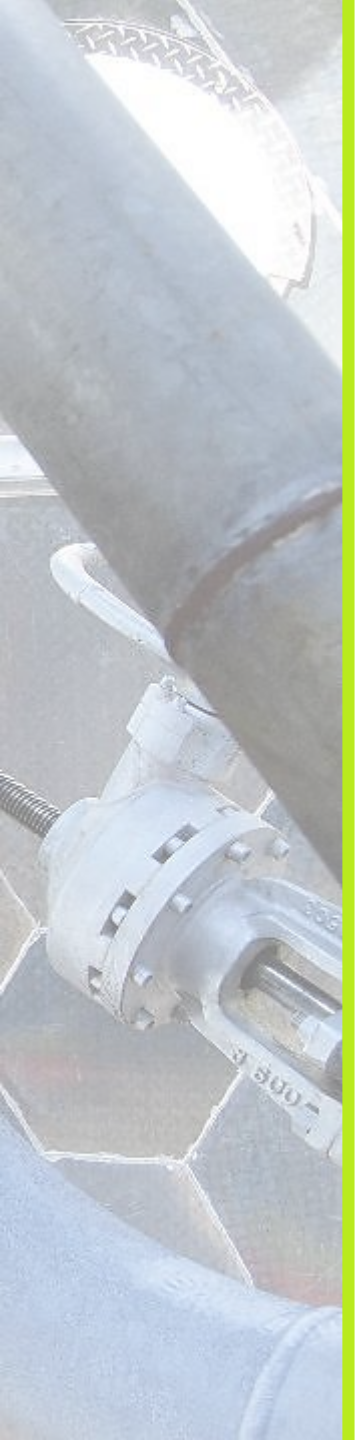

Conclusions

- We have performed a first investigation of reverse circulation displacements in eccentric annuli involving non-Newtonian fluids
- Pairs of spacer fluid and cement slurry that exhibit qualitatively similar conventional circulation displacements may display qualitatively different behavior in reverse circulation
- Reverse circulation displacement of yield stress spacer appears more effective than displacement of purely viscous power law spacer
  - Yield stress spacer effectively more viscous at low shear rates
- Need controlled experiments for validating simulation results

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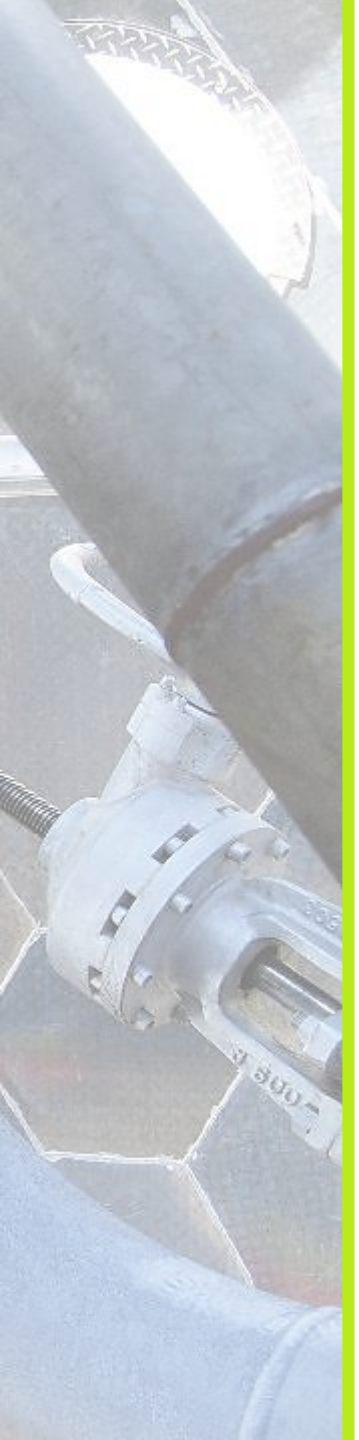

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