

The balanced plug:

Quality Improvement Project

October 2019



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Agenda

- Use of balanced plugs in drilling and P&A operations
- Refresher
 - CFD work
 - Rheology models
- Overview of ongoing improvement project
 - CFD model for the balanced plug
 - Fluids work
 - Potential field routine
- What we need
 - BHA

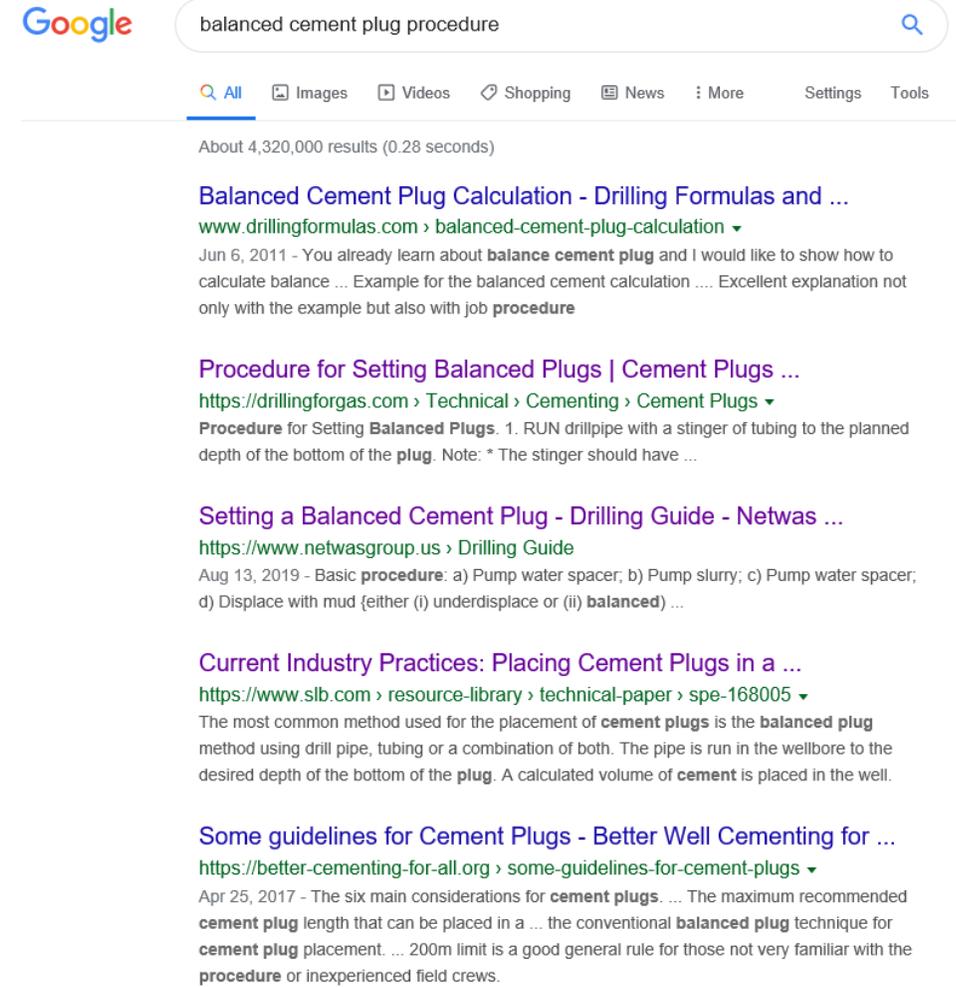
Introduction and refresher

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Use of balanced plugs

- Fill a dry hole
- Set a kick off plug
- Fundament (for something else)
- P&A of a casing where the casing by open hole has a existing Well Barrier Element
- Well known technique in the industry (illustrated right)
- **Project goal:** Set kick off plugs which require +/- 15 klbs average weight on bit to drill out (top part)



Google

balanced cement plug procedure

All Images Videos Shopping News More Settings Tools

About 4,320,000 results (0.28 seconds)

Balanced Cement Plug Calculation - Drilling Formulas and ...
[www.drillingformulas.com > balanced-cement-plug-calculation](http://www.drillingformulas.com/balanced-cement-plug-calculation)
Jun 6, 2011 - You already learn about **balance cement plug** and I would like to show how to calculate balance ... Example for the balanced cement calculation Excellent explanation not only with the example but also with job **procedure**

Procedure for Setting Balanced Plugs | Cement Plugs ...
[https://drillingforgas.com > Technical > Cementing > Cement Plugs](https://drillingforgas.com/Technical/Cementing/Cement-Plugs)
Procedure for Setting Balanced Plugs. 1. RUN drillpipe with a stinger of tubing to the planned depth of the bottom of the **plug**. Note: * The stinger should have ...

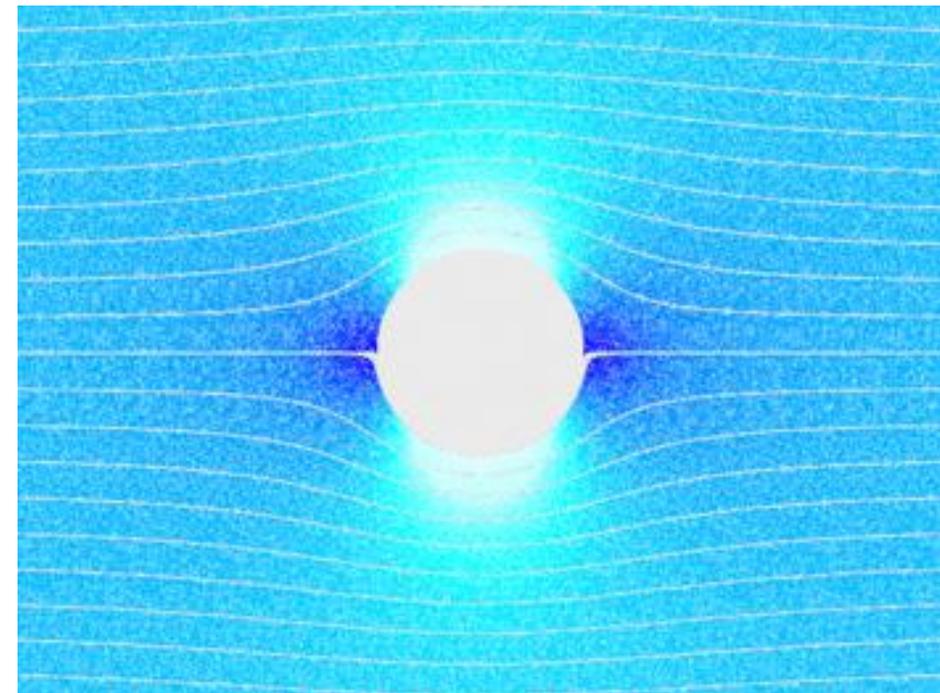
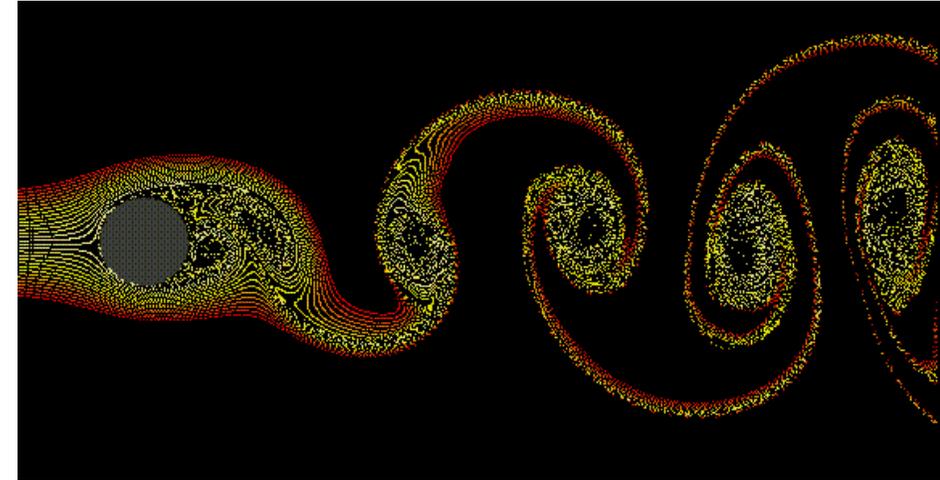
Setting a Balanced Cement Plug - Drilling Guide - Netwas ...
[https://www.netwasgroup.us > Drilling Guide](https://www.netwasgroup.us/Drilling-Guide)
Aug 13, 2019 - Basic **procedure**: a) Pump water spacer; b) Pump slurry; c) Pump water spacer; d) Displace with mud (either (i) underdisplace or (ii) **balanced**) ...

Current Industry Practices: Placing Cement Plugs in a ...
[https://www.slb.com > resource-library > technical-paper > spe-168005](https://www.slb.com/resource-library/technical-paper/spe-168005)
The most common method used for the placement of **cement plugs** is the **balanced plug** method using drill pipe, tubing or a combination of both. The pipe is run in the wellbore to the desired depth of the bottom of the **plug**. A calculated volume of **cement** is placed in the well.

Some guidelines for Cement Plugs - Better Well Cementing for ...
[https://better-cementing-for-all.org > some-guidelines-for-cement-plugs](https://better-cementing-for-all.org/some-guidelines-for-cement-plugs)
Apr 25, 2017 - The six main considerations for **cement plugs**. ... The maximum recommended **cement plug** length that can be placed in a ... the conventional **balanced plug** technique for **cement plug** placement. ... 200m limit is a good general rule for those not very familiar with the **procedure** or inexperienced field crews.

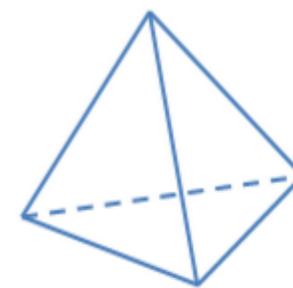
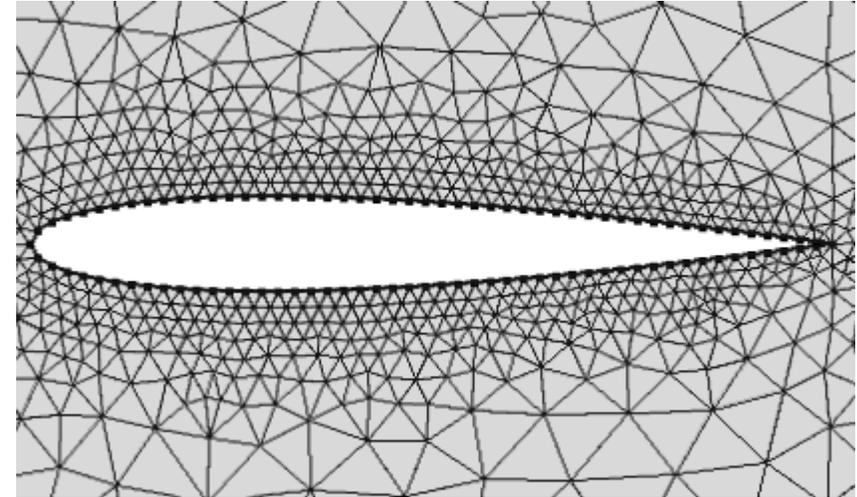
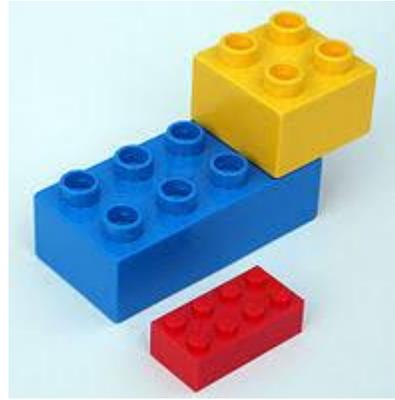
Refresher – intro to CFD

- Computational Fluid Dynamics = Numerical solution of fundamental equations of fluid motion to calculate velocity, pressure and other flow parameters of interest
- It is possible to consider multiple phases (e.g. gas and liquid), compressibility, non-Newtonian fluids, and other complex fluid properties
- Fundamental equations that CFD solves:
 - Continuity Equation (Conservation of Mass)
 - Navier-Stokes Equation (Conservation of Momentum)
 - Equation of State (Conservation of Energy)

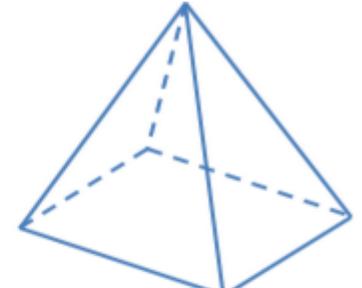


Refresher: Discretization Methods and Meshing used in CFD

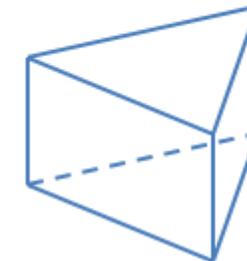
- Domain Discretization: Fluid domain is divided into a number of “cells” like pieces of Lego. They could range from thousands of cells to millions
- Finer mesh (cells) in critical areas and coarser mesh in non-critical areas greatly improve computational efficiency
- There several discretization methods available
 - Finite Volume Method
 - Finite Element Method
 - Boundary element Method
 - Finite Difference Method
- Finite Volume Method is commonly used in CFD
 - Popular cell shapes are tetrahedron, hexahedron, Pyramid or similar



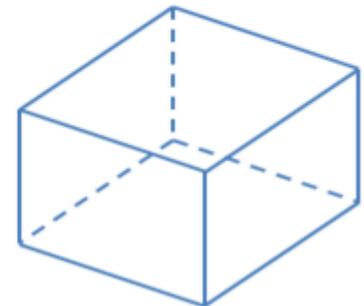
Tetrahedron



Pyramid

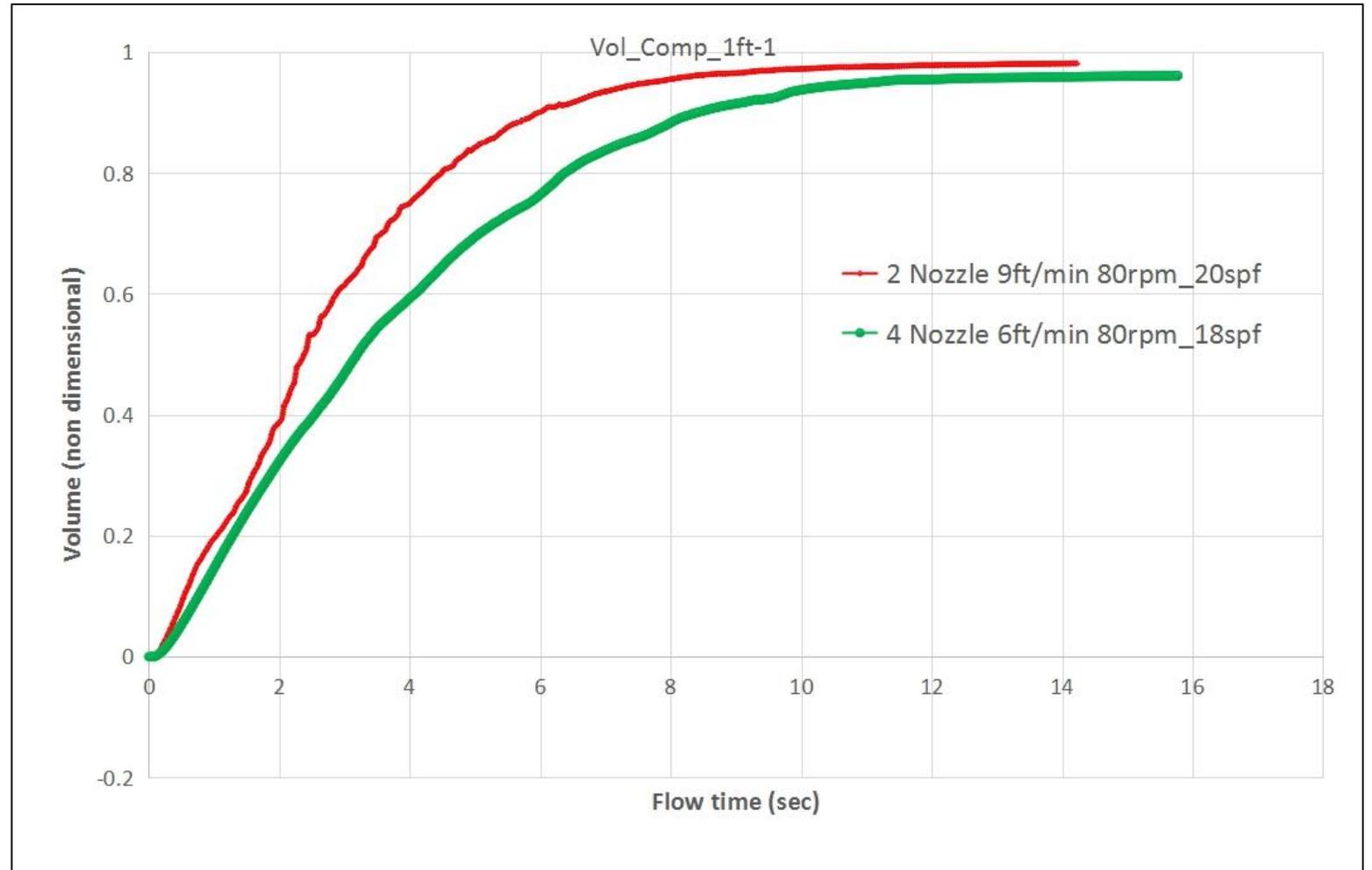
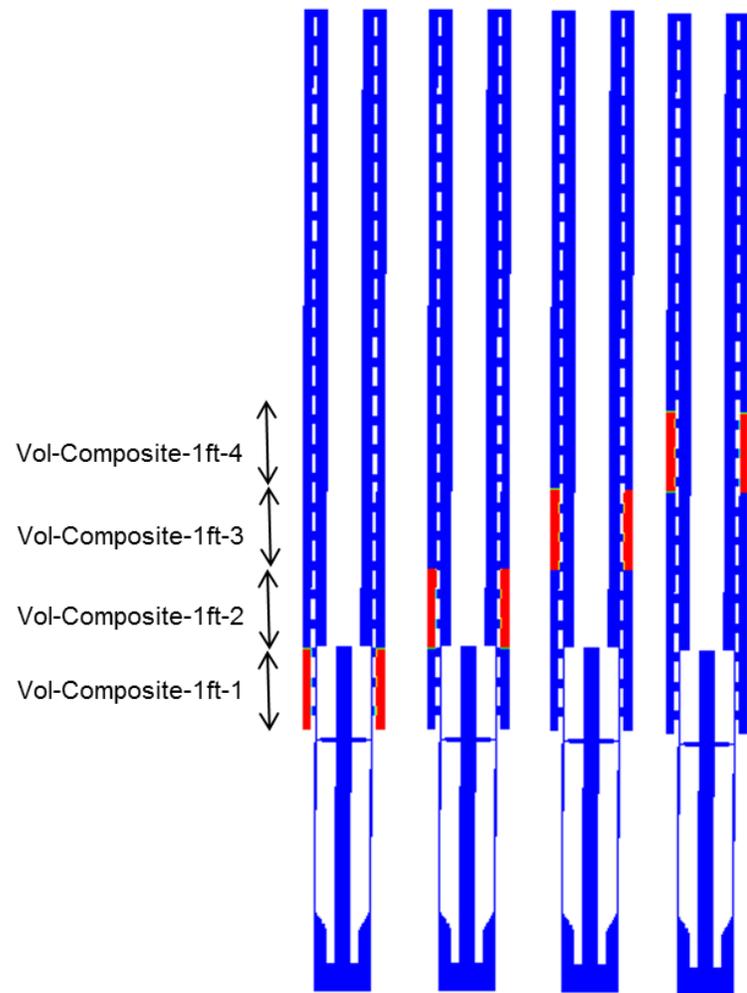


Triangular Prism

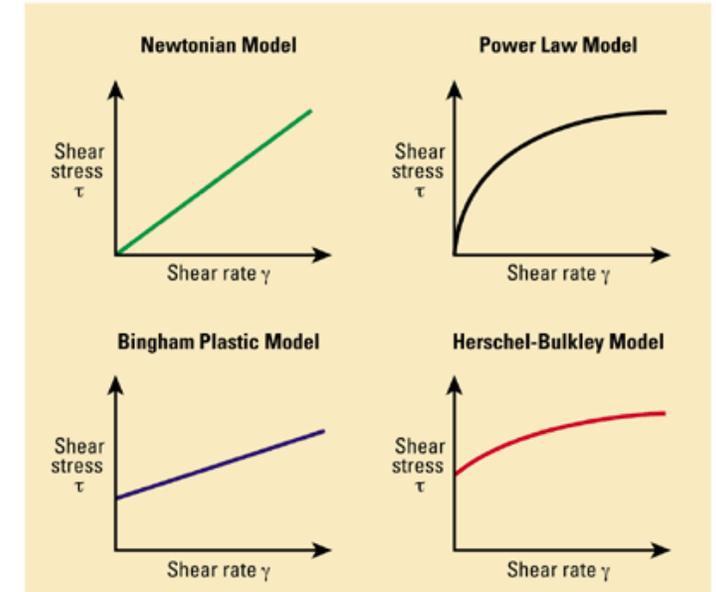
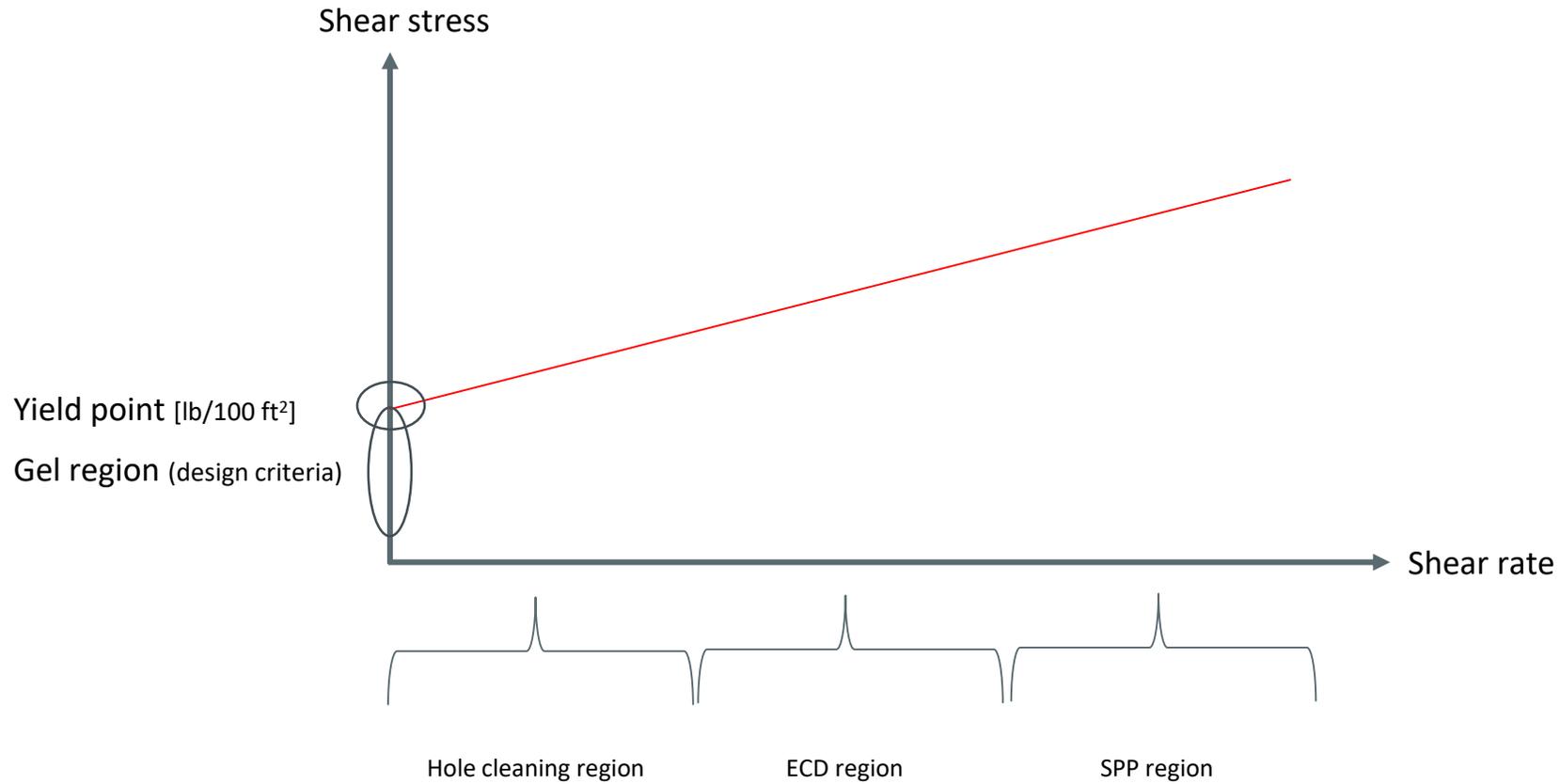


Hexahedron

Refresher: Cementing in a P/W/C operation, pump/pull/rotate



Refresher – rheology models



https://www.glossary.oilfield.slb.com/en/Terms/h/herschel-bulkley_fluid.aspx

An aerial photograph of a large offshore oil and gas platform under construction in the middle of the ocean. The platform is a complex of yellow and grey steel structures, including a central processing area, several cranes, and a helipad. A red supply vessel is docked at the platform's side, and a smaller boat is visible in the water nearby. The sky is overcast with grey clouds.

Ongoing project

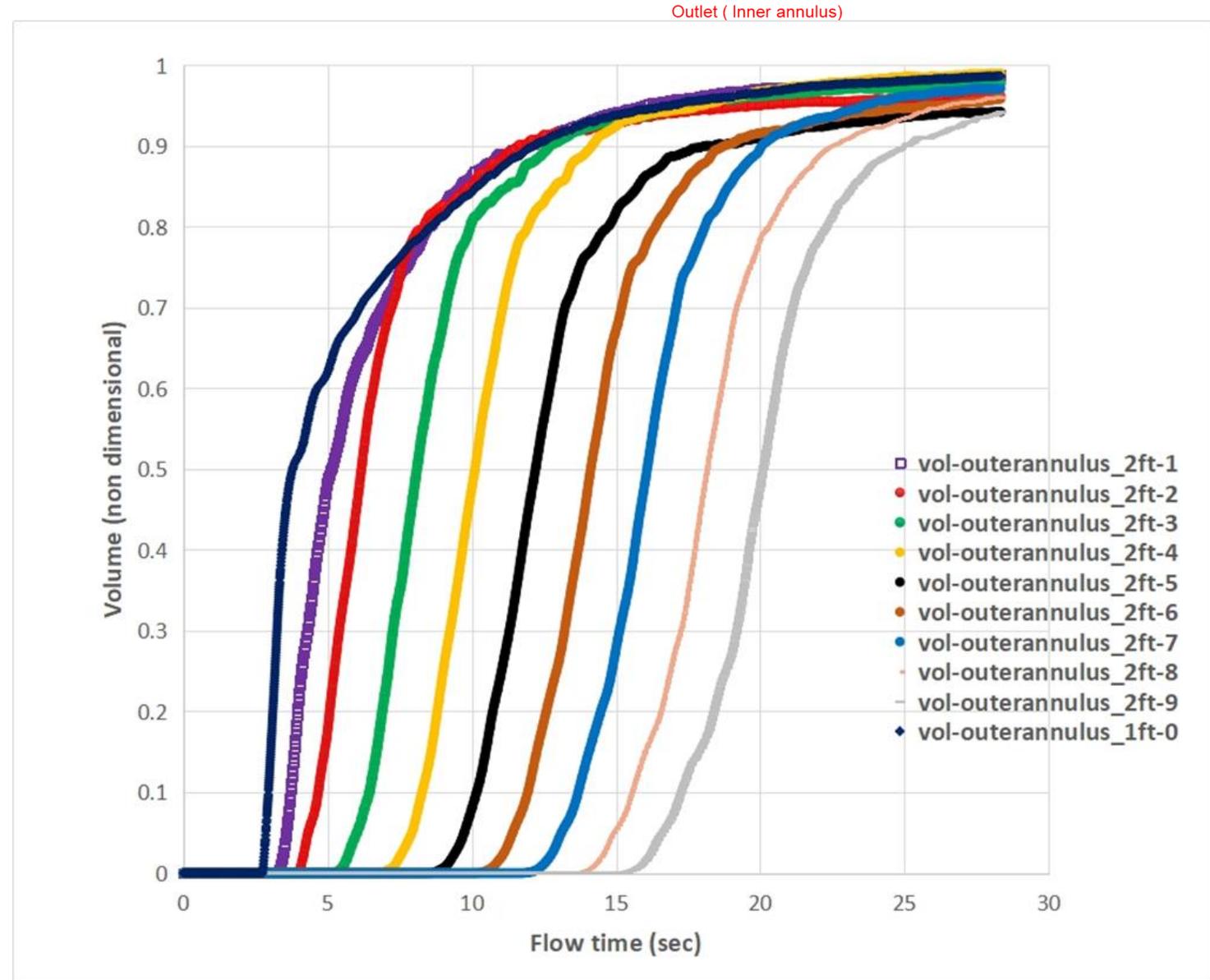
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Project outline

- Done:
 - Pull and review best practice from COP globally
 - Ensured we worked accordingly and mapped GEA balanced plug operations from mid 2018
 - Outlined CFD model
 - Done initial CFD work
 - Modified CFD model – fluids input
 - Done a cross check to drilling based hole cleaning models
- Ongoing or to do
 - CFD based parametric optimization with open ended drillpipe
 - Select BHA
 - Input BHA into CFD model and do final parametric optimization

First case which was modelled in CFD

- 20 ft long
- Investigated first 18 ft, segmented into 9 x 2 ft
- Fluids:
 - 15 ppg water based spacer
 - 14.5 ppg OBM
- Displacement rate
 - 420 gpm
- 5 7/8" pipe, static and low side, inside a 14 2/9" slick hole
- **Conclusion:**
 - Simulation result or experience data is wrong

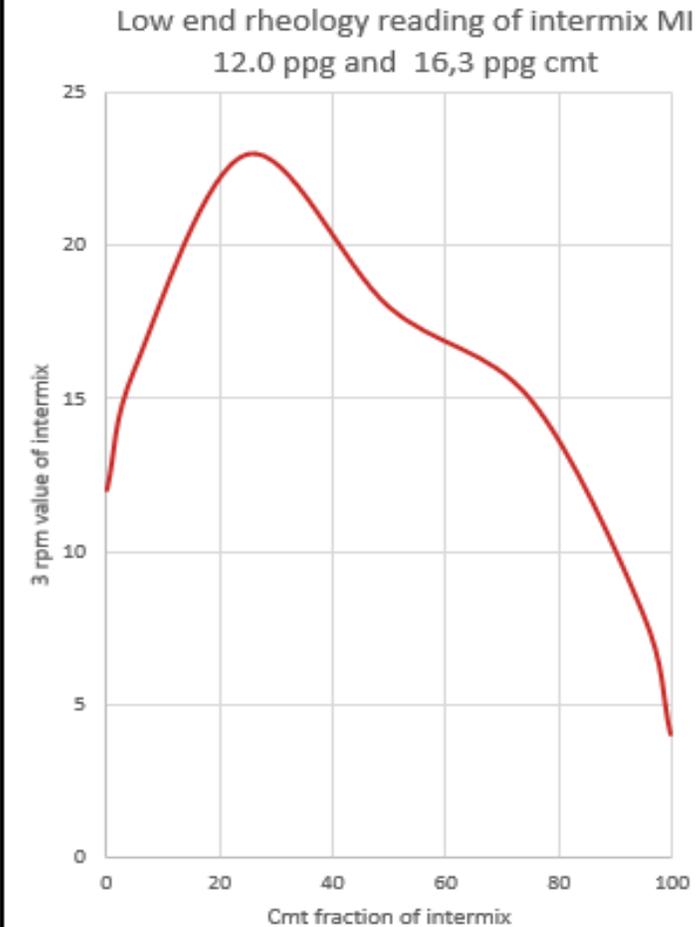
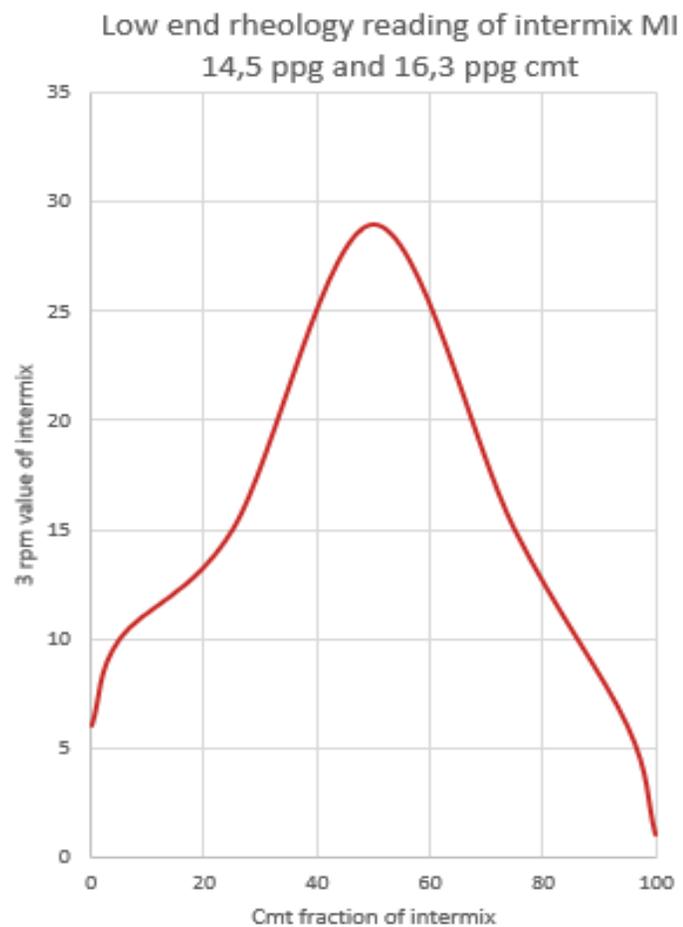
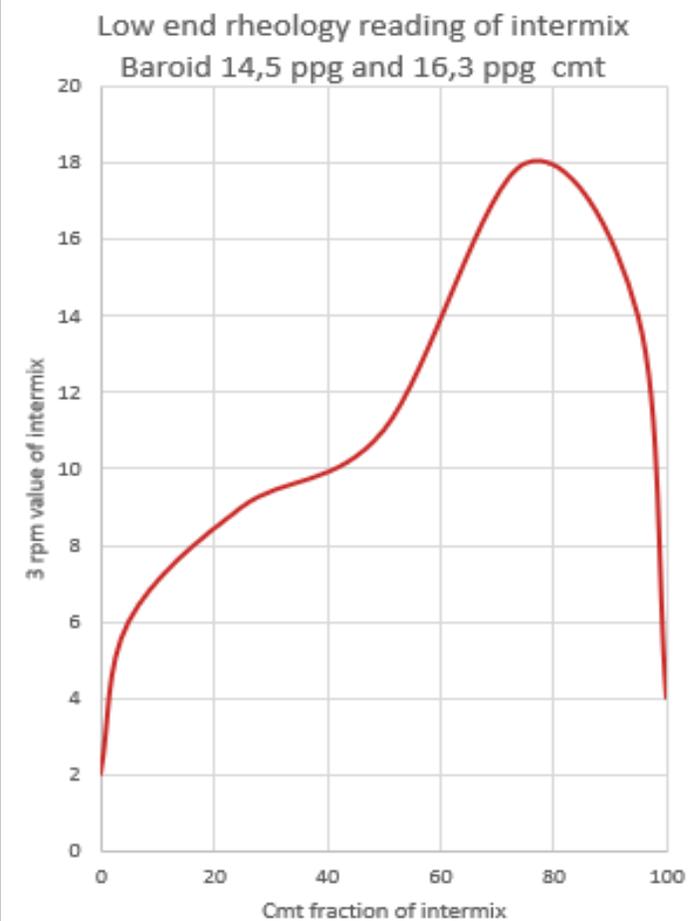


Balanced Plug CFD model – introduced intermix viscosity (WBM vs cmt)

Bingham Plastic model - Baroid 14,5 ppg

Bingham Plastic model - MI 14,5 ppg

Bingham Plastic model - MI 12.0 ppg



PV value of intermix

PV value of intermix

3 rpm value of intermix

3 rpm value of intermix

3 rpm value of intermix

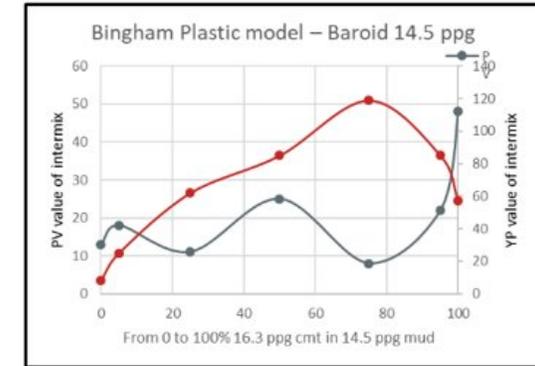
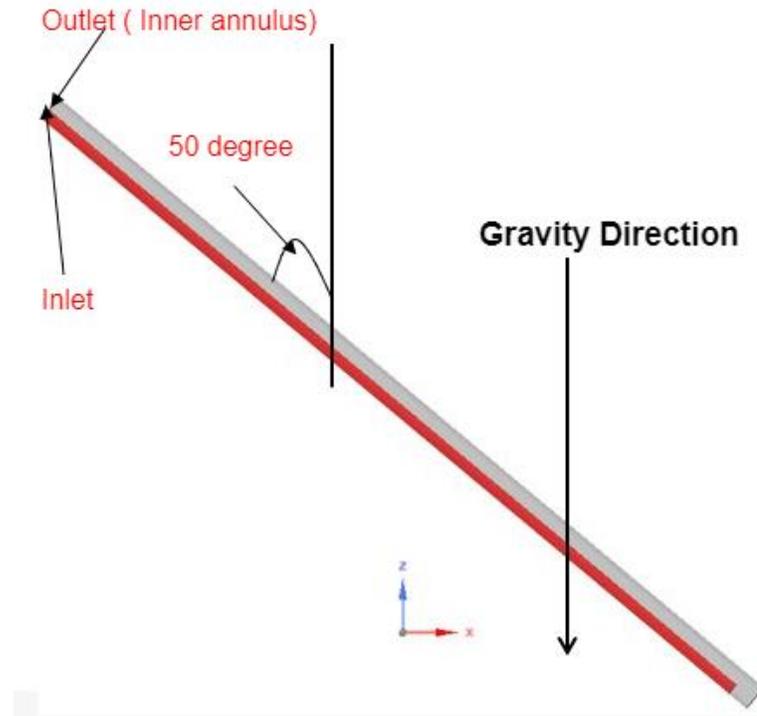
Cmt fraction of intermix

Cmt fraction of intermix

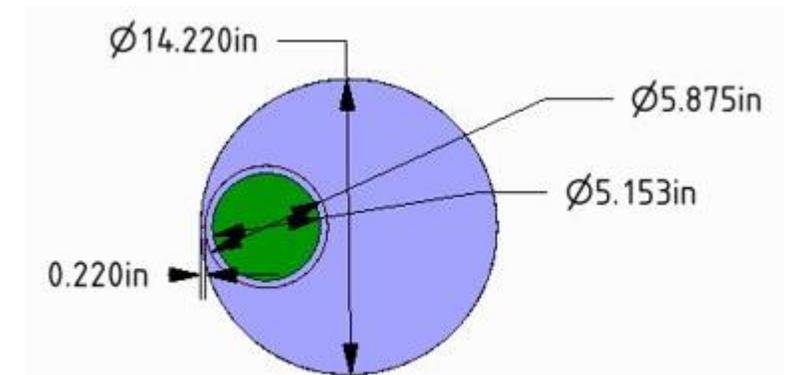
Cmt fraction of intermix

Input cmt/WBM intermix YP

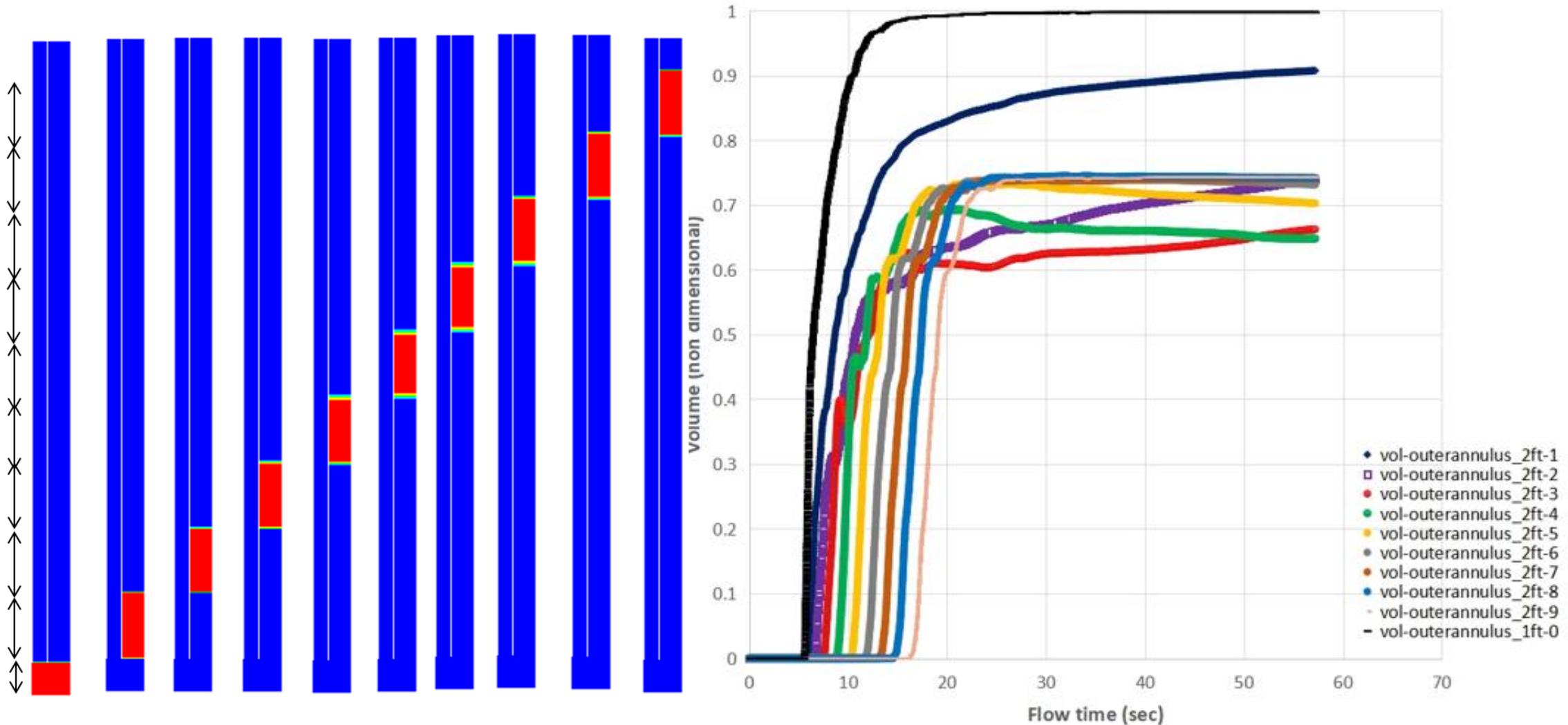
- Model is 60 ft long
- Investigated first 40 ft, segmented into 20 x 2 ft
- Starting point: pipe static and low side
- Hole
 - 13 1/2" washed out to 14 2/9" (reflects 30% excess)
- Fluids:
 - 16.1 ppg cement
 - 14.5 ppg WBM
 - **Intermix of cmt and WBM**
- Displacement rate
 - 420 gpm



Fluids	MW	Viscosity (Bingham Plastic)	
	Density (ppg)	PV (cp)	YP (lb/100ft ²)
Cement	16.30	48.00	59.00
High viscosity intermix (75%C and 25%M)	15.85	9.00	119.00



Use of cmt/WBM intermix YP in the CFD model changed the picture



5 7/8" DP, 1 ft standoff, looking at first 9 x 2 ft – which indicates 420 gpm is sub optimal, we get channeling

Time out:

- Decided to do a “drilling check”
- Does current model reflect drilling experience?

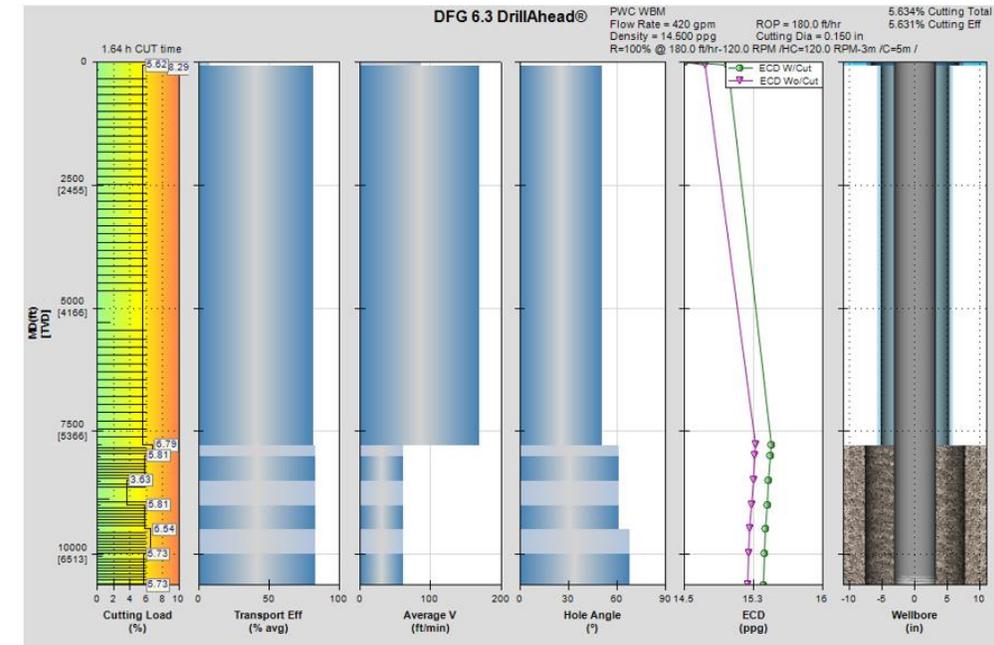
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The Drilling Check, standard hole cleaning simulation

- Case – September 2019 drilling operation
 - Drilling 9 1/2" x 10 3/4 hole under 10 3/4" liner
 - Assumed hole size 10 8/9" (reflects 30% excess cmt) to cover for washout
 - Assumed 180 ft/hr ROP
 - Used standard P&A WBM (this is what we have intermix data on)
 - Assumed no chemical interaction (viscosity effects) between mud and cuttings
 - Cuttings density set to 2.1 SG, for reference cmt is +/- 1,9 SG
 - Checked w/ various DP sizes, open ended
- Output
 - Illustrations
 - "Transport efficiency" (TE) and annular velocity
 - Selected a target criteria
 - Transport efficiency > 80%
 - Annular velocity > 180 ft/min
- **Conclusion from "hole cleaning simulation"**
 - We should challenge the use of stinger in our parametric optimization work
- **CFD model indicates string out/channeling**
 - Observed? (yes)
- **Discussed gels**
 - model? (not)
- **Discussed based on reference operations**
 - Reference operation 1 in a 7,25" hole, 850 ft long
 - Reference operation 2 in a 13 1/2" open hole and into 13 5/8 csg, 1160 ft long
 - Required plug length?
 - Maximum cement volume?

Flow rate 420, RPM 120



DP size	Transport efficiency criteria	Annular velocity criteria, flow rates < 170 – 420> gpm
6 5/8"	OK for > 120 rpm	Approach criteria for 420 gpm
5 7/8"	OK for > 120 rpm	Below criteria
5"	OK for > 120 rpm	Significantly below criteria
3 1/2"	OK for > 120 rpm	Significantly below criteria

Time in:

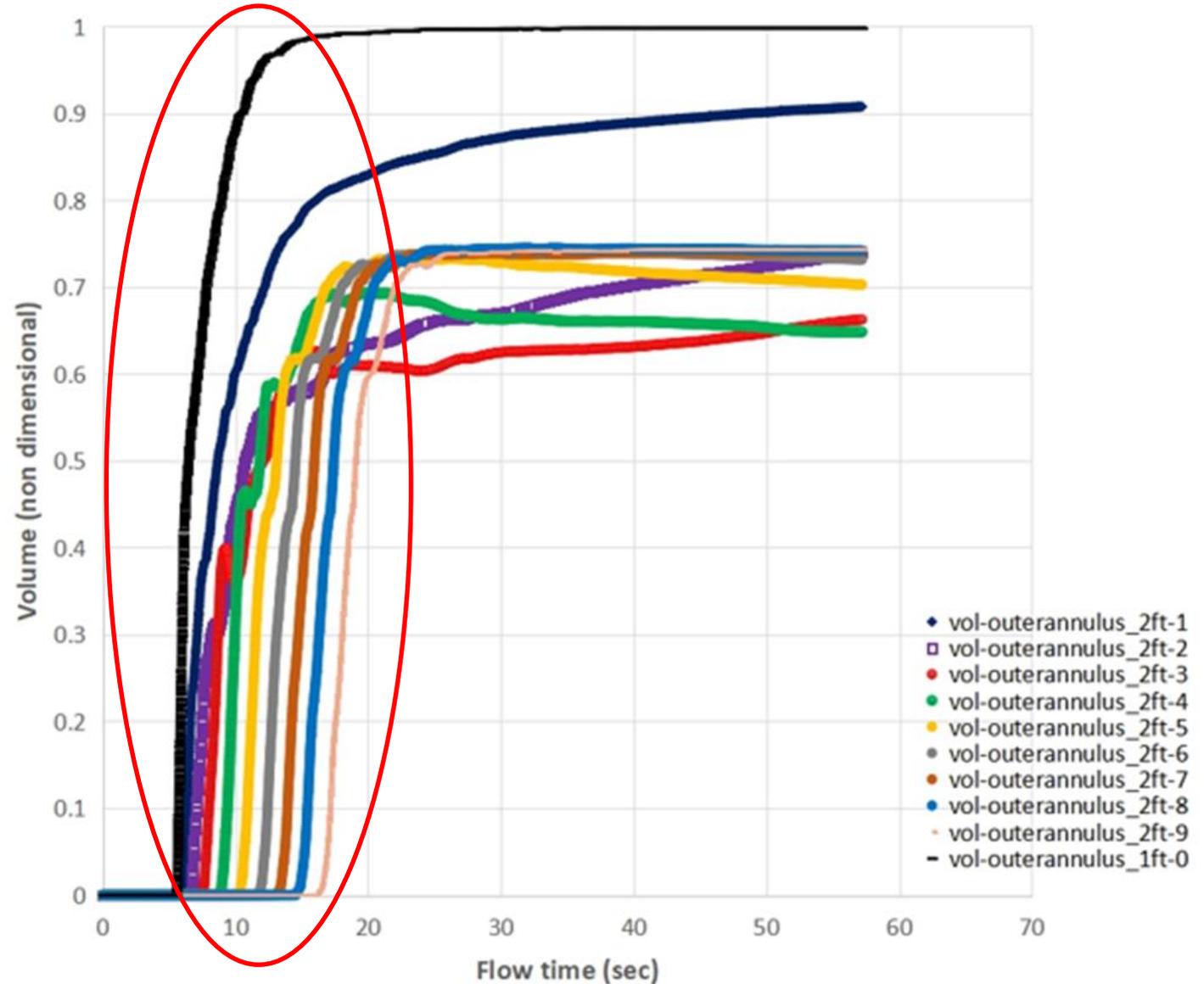
- What can we do?

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Potential field routine

- Pump, pull and rotate
- Parametric optimization ongoing
 - Fluids
 - WBM case
 - OBM case
 - Pump rates
 - String rotation
 - Cmt volume/translation speed
 - String size
 - Use of string mill/centralizer/similar
- Need displacement rate in the outlet region to be $>$ pulling rate for this to be successful
- Hope to try this sometime 2020



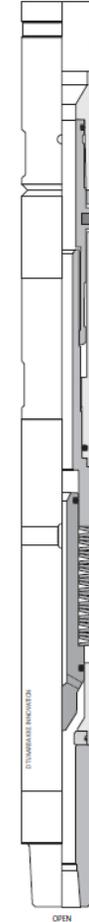
Need

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Need

- BHA
 - Bull nose
 - Spring loaded float (anti U-tube)
 - Float
 - Stabilizer/centralizer/scrape
- Practical
 - BHA is plug and play and will go offshore in 1 basket
 - Most likely assembled from existing components
 - Standard DP connection
 - On stand by, or stored offshore
 - Sturdy
 - Re-dress routine/service
- Suggested reading
 - Published Best Practice for balanced plug (google it)
 - SPE 184702 (cmt displacement and CFD work)
 - COP 2014/2017 presentation (P/W/C)
 - Halliburton/Baroid 2018 PAF presentation (cmt vs WBM)



<http://www.aarbakeinnovation.com/home>



<http://www.mustang-oil-services.com/product/>



<https://www.sub-drill.com/>

Q&A

