Hole Cleaning
AADE – Houston Chapter

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February 27, 2014

Topics

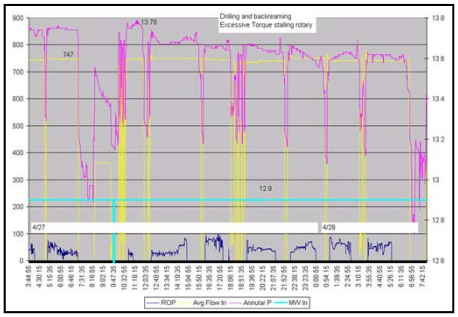
- Definition
- Ramifications
- Hole Cleaning / Hydraulics Modeling
- Advantage Hole Cleaning Model
- Example Output
- Advantage System Usage

What is Hole Cleaning?

- Simply put, hole cleaning is the ability to remove sufficient drilled formation allowing uninterrupted operations due to insufficient cuttings removal.
  - This does not mean 100 percent cuttings removal
  - The intention is to remove enough cuttings to prevent NPT due to poor hole cleaning

Poor Hole Cleaning - Ramifications

- Increased NPT (non productive time), increased costs.
- Can lead to loss of drill string or even the well itself.
- Can damage reservoir and reduce wellbore productivity.



Hole Cleaning / Hydraulics Models

- First and foremost, the model is as good as the user
  - It's easy, just select run
  - WRONG
  - Emphasis on understanding and interpretation by the user
- Second why the need for a model?
  - Pressure tools tell the story
  - Torque / drag trends tell the story
  - Observations at shakers tell the story
  - Sweeps may or may not tell the story
  - Measure; volume drilled vs volume over shakers
- To be **proactive** in the pre-planning stage vs **reactive** while drilling

Advantage Hole Cleaning Model

- SPE 28306 - Clark, Bickham, "A mechanistic model for Cuttings Transport"
- The model is based on the balance of the forces acting on a cutting in the annulus.
  - **Settling** - ~30° The cuttings moving downwards due to the gravitational force against the buoyancy and the drag force
  - **Lifting** - ~30-60° A cyclic motion of moving the particle in the area of higher fluid velocity due to lift and buoyancy forces, moving the particle suspended in the fluid and continuously settling down again
  - **Rolling** - ~60-90° Particles roll on the low side of the annulus when the Lift and Drag force exceed the gravitational force and the plastic force.

What does this mean?

- The Advantage Hole Cleaning model provides a means of analyzing cuttings transport as a function of:
  - Operating conditions (flow rate, ROP)
  - Mud properties (density, rheology)
  - Well configuration (angle, hole size, pipe size)
  - Cuttings properties (density, size, angle of repose, bed porosity)

In other words, it is an engineered approach to calculating hole cleaning.

7

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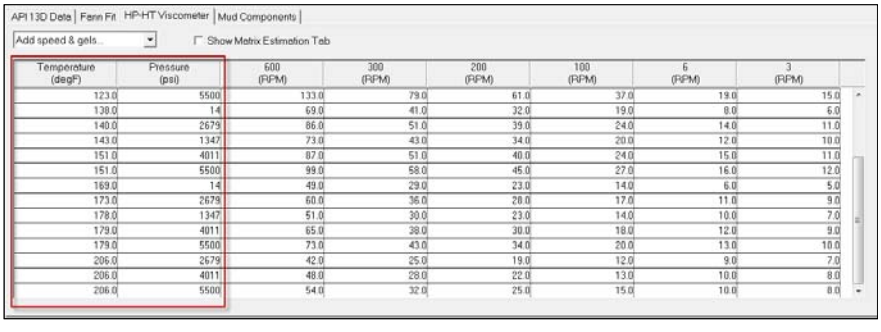
Advantage Hydraulics Model – Characteristics

- Advantage requires 8 sets of FANN data, at different T and P, to model HPHT effects.
- Accurately represent the drilling fluid under down hole conditions.
- Interpolation, not extrapolation.



Temperature (degF)	Pressure (psi)	600 (RPM)	300 (RPM)	200 (RPM)	100 (RPM)	6 (RPM)	3 (RPM)
123.0	5500	133.0	79.0	61.0	37.0	19.0	15.0
138.0	14	69.0	41.0	32.0	19.0	8.0	6.0
140.0	2679	86.0	51.0	39.0	24.0	14.0	11.0
143.0	1347	73.0	43.0	34.0	20.0	12.0	10.0
151.0	4011	87.0	51.0	40.0	24.0	15.0	11.0
151.0	5500	99.0	58.0	45.0	27.0	16.0	12.0
169.0	14	49.0	29.0	23.0	14.0	6.0	5.0
173.0	2679	60.0	36.0	28.0	17.0	11.0	9.0
178.0	1347	51.0	30.0	23.0	14.0	10.0	7.0
179.0	4011	65.0	38.0	30.0	18.0	12.0	9.0
179.0	5500	73.0	43.0	34.0	20.0	13.0	10.0
206.0	2679	42.0	25.0	19.0	12.0	9.0	7.0
206.0	4011	48.0	28.0	22.0	13.0	10.0	8.0
206.0	5500	54.0	32.0	25.0	15.0	10.0	8.0

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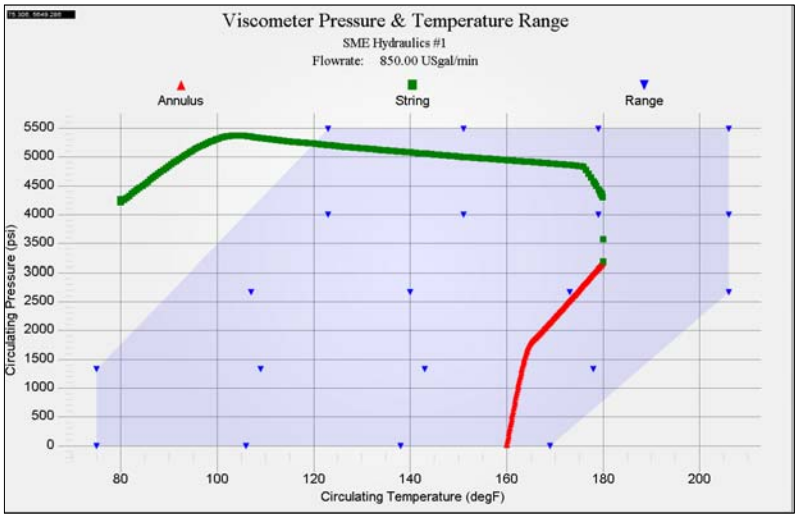
Advantage Hole Cleaning Model – Characteristics



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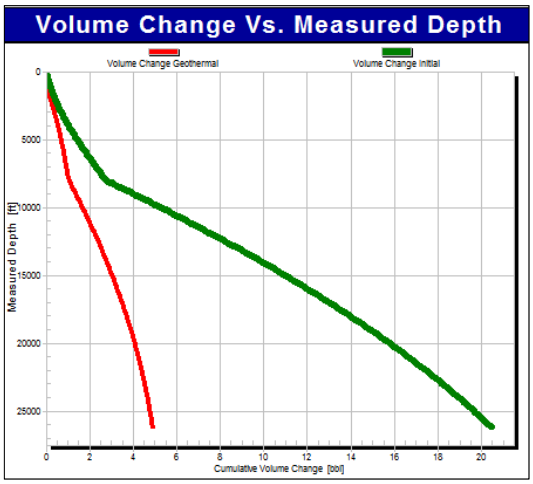
Advantage Hydraulics Model – Characteristics

PVT data for common base fluids (Compressibility)



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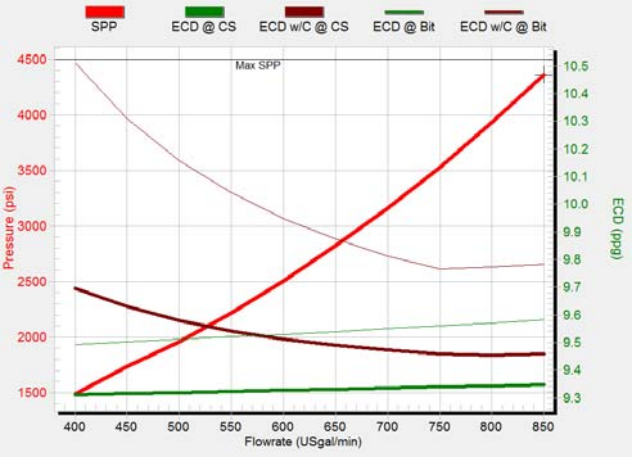
Advantage Hydraulics Model – Characteristics

Flowrate optimization - analyze the cuttings transport capabilities of a given flowrate and to predict the required flowrate to clean the well.



11

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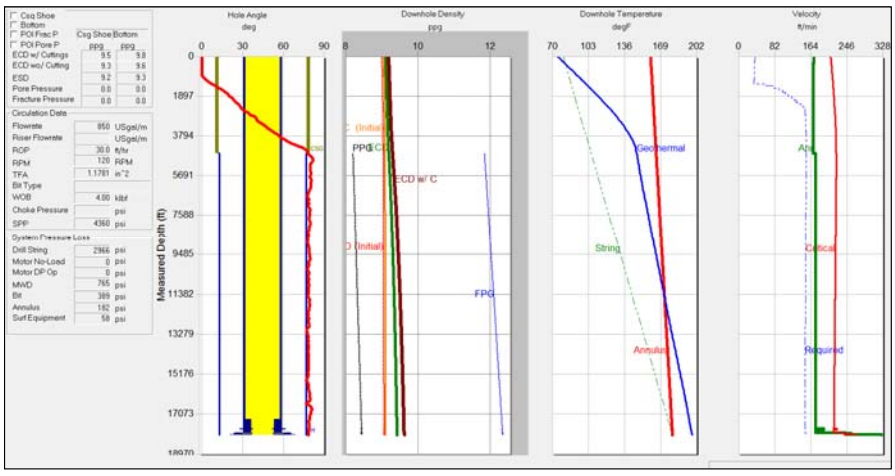
Advantage - FreezeFrame



12

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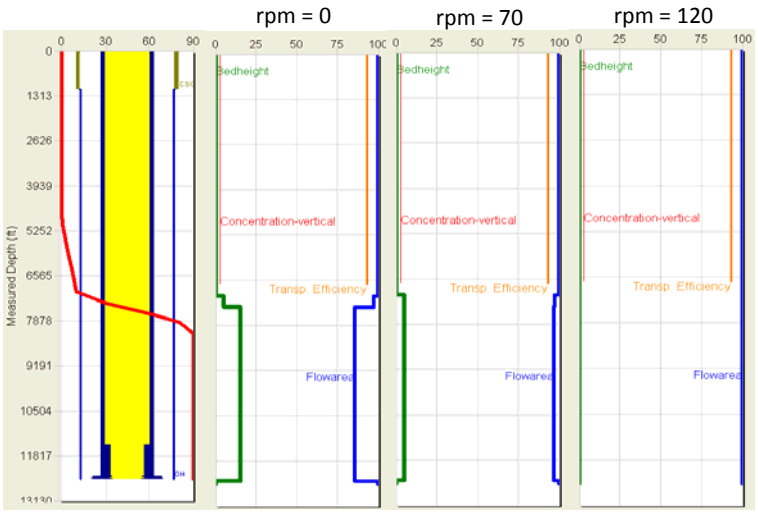
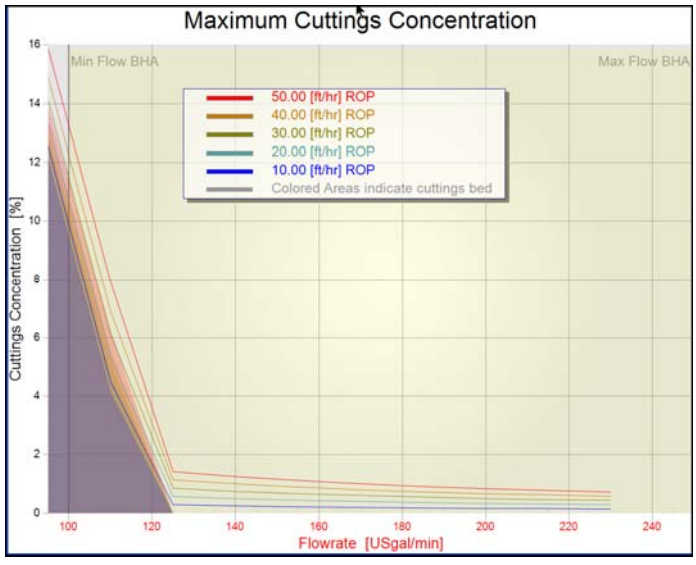
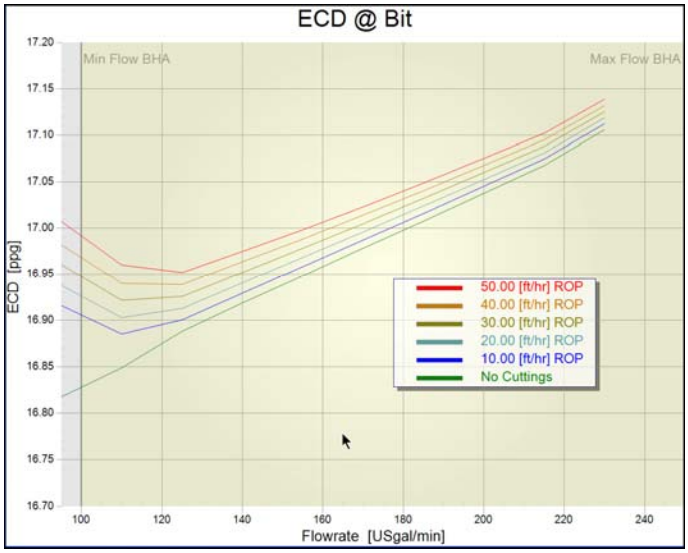
RPM Effect on Hole Cleaning



ROP Effect on Hole Cleaning



ROP Effect on ECD at Bit



15

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Pre-Well Planning

- Hole cleaning / system pressure losses
  - Casing program
  - Detailed BHA with tool psi loss and bit TFA's
  - Wellbore trajectory
  - Mud weights with appropriate viscosity profiles (HPHT)
  - Planned ROP
  - Geothermal temperature profile
  - Fracture / pore pressure gradients
  - Rig limits (SPP)

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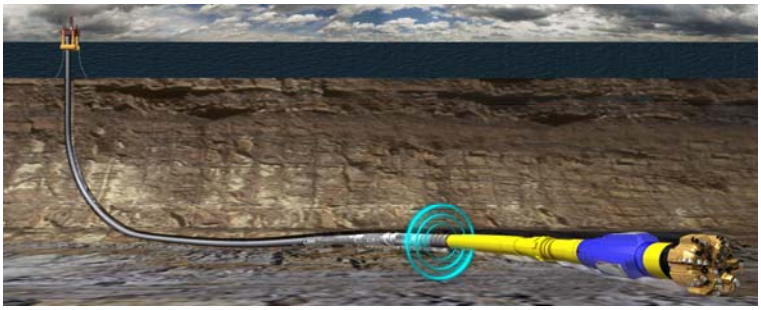
In Situ Drilling

- Monitor trends – are we seeing expected SPP, ECD down hole?
- If not, can we use the model to determine the discrepancy?
- Prepare for next day's drilling, look ahead.



17

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Post Well Analysis

- Review operation focused on specific problems
  - Hydraulics / hole cleaning modeling on actual operation
  - Daily Drilling Fluid Reports (fluid provider)
  - Daily Drilling Reports (operator)
  - Down hole tool data (essential for a detailed review of problems encountered)
    - Flow rates
    - ROP (instantaneous)
    - Sliding / rotation ratio
    - Torque
    - Pressure
    - ECD (pumps on) / ESD (pumps off)

18

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Conclusions

- Modeling hole cleaning does not simply involve a single equation.
- Involves many inputs, calculations, drilling parameters, and most of all, *experience and common sense on the part of the user.*
- It can take many years to master the concept of hole cleaning, and requires modeling of the entire wellbore to calculate accurately.
- Optimized hole cleaning does not necessarily equal best drilling practices.
- With a properly trained engineer, Advantage Hydraulics modeling can accurately simulate both the hydraulics and the hole cleaning of a given well.

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Thank You for Attending – Questions?

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