American Association of Drilling Engineers

Rigsite Monitoring and Control of the size of Drilling Fluid Particulates:

“Imaging Analysis of Drilling Mud Particles for Real Time Control”

Tod Canty Sr., PE
JM Canty Inc
Particle Size Analysis of Drilling Fluids

• Introduction
  – Drilling muds or fluids are complex aqueous or oil-based suspensions designed to fulfill a number of important functions during the oil extraction process.
  – Main Functions
    – Provide hydrostatic pressure to prevent formation fluids from entering the well bore
    – Keep the drill bit cool and clean during drilling
    – Carry out drill cuttings
    – Suspending drill cuttings while drilling is paused and while drilling assembly is brought in and out of the hole
    – Avoid formation damage and limit corrosion
Why Drilling Fluid Particle Size Distribution is Important

• Mud performance controlled by manipulating the mud composition and the properties of the constituents through the addition of different additives.
• Particle size significantly affects the way in which the mud interacts with the surrounding geology.
• Particle size measurements play an important role in the formulation of high performance drilling muds.
• Particles smaller than the pore size of the surrounding geological formation will bridge rock pores during mud circulation, leading to the formation of a filter cake that prevents the egress of fluids from the well during drilling.
• This “filter cake” protects the surrounding rock from damage while simultaneously preventing fluid loss and achieving well stabilization.
Industry Techniques for Particle Size Analysis of Drilling Fluid

• History of various techniques
  – Sieves
  – Laser
  – Imaging
Industry Techniques for Particle Size Analysis of Drilling Fluid

• Sieve Analysis
  – Used for many years, simple & inexpensive
  • Disadvantages:
    – Time (Sedimentation and Sieving are both slow and time consuming processes)
    – Particle Size (Particles too small for separation by sieving to be practical)
    – Error (Over-energetic sieving causes attrition of the particles and thus changes the calculated particle size distribution)
Industry Techniques for Particle Size Analysis of Drilling Fluid

- Laser Diffraction
  - Quickness and ease of use
  - Disadvantages:
    - Water droplets (in oil based) Oil droplets (in water based) mud measured as particles.
    - Non-spherical objects (large discrepancy between laser measurements)
    - Laser 1D (equivalent sphere) and not recommended for large aspect ratio.
    - Distortion of Measurements (existence of “ghost” particles caused by sharp edges on the objects which produce high angle diffraction
    - Acicular particles (shows much larger sizes compared to laser diffraction, undercounts events generated by major chord
    - Laser diffraction intrinsically biased towards the smaller edge of spectrum.
Laser Sampling Problems

Laser diffraction typically only uses a sample size of around 1mL to 2mL. The problem with this is the steps necessary to break down a sample small enough for laser diffraction from the original sample gathered at the process line. Some possible issues are:

- Does the sample container harbor particles not wanted within the sample?
- By the time the sample is drawn have particles began to settle out of solution?
- Is there a large difference in particle density between a sample drawn from the top of the container to the bottom?
- Is a few mL sufficient for proper particle analysis?

- With the Canty Cross-Cut Sampling Valve none of these potential sampling issues come into play.
Imaging Advantage

Drilling Mud System
- Canty’s Drilling Mud particle Analysis system has many distinct advantages over Laser Diffraction systems and sieve
  - Real time 2Dimensional particle shape analysis.
  - The particles are oriented in the fluid dynamically designed flow cell to measure the largest length and widest section of the particles. All aspect ratios are measured correctly
  - Direct measure of particle area – a two dimensional measurement.
  - Direct measurement of particle perimeter – a two dimensional measurement.
  - Direct measure of major axis and minor axis – a two dimensional measurement.
  - Able to separately measure various particles separately water, barite, polymer using size shape and color data
  - Direct measurement of particle color.
  - Large particle range – 2” down to .7 micron
How it Works

- Fiber optic lighting
- Fused glass safety barrier
- EXP & ATEX available
- High pressure / temperature ratings
- Auto-dilution

Figure 4: Figure 1 above displays both mud particulate and emulsified water droplets
How it Works

- Lighting is critical for any vision based system.
- Canty have been doing process lighting for well over 30 years – part of our core business.
- Would not be so confident in our vision based technique without our lighting expertise.
Canty’s Fused Glass Technology

- Fusion of glass to metal – one piece construction
- Critical to our vision based technique
- Pressures to 10,000 PSI, Temp -450 to 800ºF
Importance of fused glass technology

- Hermetically sealed one piece construction means no recesses or gaps where product can adhere to and start to build up
- Self cleaning unit
CANTY MICROFLOW
Portable / Lab System

“How it works”
Canty Laboratory Drilling Fluid System
Lab = Online
Canty In-Line Drilling Fluid System

- The Canty In-Line Drilling Fluid System allows for the analysis of drilling fluids by a direct in-line process connection.
Canty Cross-Cut Sampling Valve

- Canty’s cross-cut sampling valve system allows for quick consistent and repeatable sampling of a drilling fluid process line.
- The valve system directly samples a cut of fluid from the center of a process line.
- That full “cut” is then diluted in water and directly run through the analysis equipment.
- This method allows for direct testing of a representative “cut” of drilling fluid.
Sample Extraction Comparison

Laser Sample Extraction

1. Drilling Mud Process Line
   - Sample Container

2. Subject to user error/contamination
   - Pipet
   - Sample Container

3. Subject to user error/contamination
   - Laser Sample 2mL - 3mL

Canty Cross-Cut Sampling Valve System

- Water Line flushes valve system out each time
- Measured "cut" sample with no potential contamination. Sample size is exactly the same every time
Figure 8 – Canty Results for SAM2529-A1 – Run x3 showing repeatability

Figure 9 – Canty Results for SAM2529-A2 – Run x3 showing repeatability

A1

Dv10: 4.30248
Dv20: 5.22998
Dv30: 5.9224
Dv40: 6.61973
Dv50: 7.31678
Dv60: 8.12143
Dv70: 9.04212
Dv80: 10.3373
Dv90: 12.6688
Dv100: 27.5662

A2

Dv10: 32.3875
Dv20: 46.3585
Dv30: 57.8698
Dv40: 68.5946
Dv50: 79.2649
Dv60: 90.1894
Dv70: 102.944
Dv80: 118.996
Dv90: 143.287
Dv100: 305.163
Figure 10 – Canty Results for SAM2529-A3 – Run x3 showing repeatability

<table>
<thead>
<tr>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dv10:</td>
</tr>
<tr>
<td>Dv20:</td>
</tr>
<tr>
<td>Dv30:</td>
</tr>
<tr>
<td>Dv40:</td>
</tr>
<tr>
<td>Dv50:</td>
</tr>
<tr>
<td>Dv60:</td>
</tr>
<tr>
<td>Dv70:</td>
</tr>
<tr>
<td>Dv80:</td>
</tr>
<tr>
<td>Dv90:</td>
</tr>
<tr>
<td>Dv100:</td>
</tr>
</tbody>
</table>

Figure 11 – Canty Results for SAM2529-A4 – Run x3 showing repeatability

<table>
<thead>
<tr>
<th>A4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dv10:</td>
</tr>
<tr>
<td>Dv20:</td>
</tr>
<tr>
<td>Dv30:</td>
</tr>
<tr>
<td>Dv40:</td>
</tr>
<tr>
<td>Dv50:</td>
</tr>
<tr>
<td>Dv60:</td>
</tr>
<tr>
<td>Dv70:</td>
</tr>
<tr>
<td>Dv80:</td>
</tr>
<tr>
<td>Dv90:</td>
</tr>
<tr>
<td>Dv100:</td>
</tr>
</tbody>
</table>
Figure 12 – Canty Results for SAM2529-A5 – Run x3 showing repeatability

Sample A5 - PSD

<table>
<thead>
<tr>
<th>Dv 10</th>
<th>Dv 20</th>
<th>Dv 30</th>
<th>Dv 40</th>
<th>Dv 50</th>
<th>Dv 60</th>
<th>Dv 70</th>
<th>Dv 80</th>
<th>Dv 90</th>
<th>Dv 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>1114.83</td>
<td>1389.18</td>
<td>1644.05</td>
<td>1875.7</td>
<td>2125.38</td>
<td>2411.56</td>
<td>2750.31</td>
<td>3157.38</td>
<td>3879.91</td>
<td>6380.82</td>
</tr>
</tbody>
</table>

Figure 13 – Canty Results for SAM2529-A6 – Run x3 showing repeatability

Sample A6 - PSD

<table>
<thead>
<tr>
<th>Dv 10</th>
<th>Dv 20</th>
<th>Dv 30</th>
<th>Dv 40</th>
<th>Dv 50</th>
<th>Dv 60</th>
<th>Dv 70</th>
<th>Dv 80</th>
<th>Dv 90</th>
<th>Dv 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>112.012</td>
<td>140.227</td>
<td>167.317</td>
<td>196.686</td>
<td>228.406</td>
<td>268.017</td>
<td>319.521</td>
<td>399.095</td>
<td>558.778</td>
<td>1466.51</td>
</tr>
</tbody>
</table>
Figure 14 – Canty Results for SAM2529-A7 – Run x3 showing repeatability

<table>
<thead>
<tr>
<th>A7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dv10</td>
<td>80.797</td>
</tr>
<tr>
<td>Dv20</td>
<td>143.156</td>
</tr>
<tr>
<td>Dv30</td>
<td>210.942</td>
</tr>
<tr>
<td>Dv40</td>
<td>283.319</td>
</tr>
<tr>
<td>Dv50</td>
<td>347.314</td>
</tr>
<tr>
<td>Dv60</td>
<td>404.698</td>
</tr>
<tr>
<td>Dv70</td>
<td>479.288</td>
</tr>
<tr>
<td>Dv80</td>
<td>554.591</td>
</tr>
<tr>
<td>Dv90</td>
<td>646.791</td>
</tr>
<tr>
<td>Dv100</td>
<td>906.67</td>
</tr>
</tbody>
</table>
LCM Data

<table>
<thead>
<tr>
<th>Sample</th>
<th>Circularity</th>
<th>Aspect Ratio</th>
<th>DV50</th>
<th>Average Length</th>
<th>Average Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.645118</td>
<td>1.54769</td>
<td>7.51416</td>
<td>5.33018</td>
<td>4.38413</td>
</tr>
<tr>
<td>A2</td>
<td>0.765093</td>
<td>1.58019</td>
<td>79.2649</td>
<td>24.8171</td>
<td>19.807</td>
</tr>
<tr>
<td>A3</td>
<td>0.845846</td>
<td>1.56903</td>
<td>239.155</td>
<td>199.259</td>
<td>158.837</td>
</tr>
<tr>
<td>A4</td>
<td>0.850825</td>
<td>1.53341</td>
<td>2189.72</td>
<td>2028.52</td>
<td>1707.78</td>
</tr>
<tr>
<td>A5</td>
<td>0.783272</td>
<td>1.74953</td>
<td>2125.38</td>
<td>1122.23</td>
<td>838.133</td>
</tr>
<tr>
<td>A6</td>
<td>0.822686</td>
<td>1.60664</td>
<td>228.406</td>
<td>143.751</td>
<td>110.268</td>
</tr>
<tr>
<td>A7</td>
<td>0.79645</td>
<td>1.54956</td>
<td>347.314</td>
<td>26.0251</td>
<td>21.0355</td>
</tr>
</tbody>
</table>

**Figure 15 – Circularity vs. Aspect Ratio, Samples A1 – A7**
LCM Data

**DV50**

![DV50 Graph](image1)

*Figure 10 – DV50, Samples A1 – A7*

**Average Particle Length & Width**

![Average Particle Length & Width Chart](image2)

*Figure 17 – Average Particle Length (mean fiber length) & Width (mean minor axis)*
Figure 9 Live Image of VK50 + Baracarb 150. PSF = 1.4μm per pixel. FOV = 2.27mm in Horizontal Direction
Figure 10: Bimodal distribution observed for sample VK50 and Baracarb 150, which have two distinct particle size distribution.
Drilling Mud Testing

Drilling mud spiked with Barite + Mica + Gseal + LCF + Carb + Poly
(Cross-polarized lighting used to optimize difference in particles types)
Drilling Mud Testing

640 x 480 color image oil based drilling mud
(Cross-polarized lighting used to optimize difference in particles types)
Drilling Mud Testing

Water based mud

Water based mud spiked with – carb
Notice increase in “white” particles
Canty Software Analysis

Canty Vision Software Package Individually analyzes particles (water based drilling mud / polarized lighting)
Conclusion

• Canty’s Drilling Fluid Particle Analyzer is a system capable of high precision drilling fluid analysis. Our analyzers offers many unique advantages over laser diffraction technology.
• With the ability for high resolution color analysis the Canty Drilling Mud System can be a unique tool for drilling fluid engineers to aide in the microscopic examination of drill cuttings.

Questions?