PARTICLE SIZE ANALYSIS OF DRILLING FLUID

The particle size distribution of drilling fluid is an important physical parameter along with other properties such as density and rheology. Although particle size is recognized as being a critical parameter, older techniques such as sieving and sedimentation have long been used in this industry. Laser diffraction is now becoming more popular due to the increased amount of information generated by this analysis technique which is quick and easy to use. This application note explains why particle size distribution is critical and how HORIBA laser diffraction analyzers can be used to measure the particle size distribution of drilling fluids. Two diffraction analyzers were used in the study, the LA-950 and the more portable LA-300. Both models offer unique advantages for these samples.

Introduction

Drilling fluids (or muds) are often used when drilling oil and natural gas wells. The drilling fluid is pumped from the mud pit through the drill string and out of the nozzle of the drill bit. The fluid is continuously re-circulated wetting the drill bit interaction with the formation and carrying the cuttings up the annular space between the drill string and hole being drilled. Drilling fluids fulfill many functions including:

- Remove cuttings from the well
- Control formation pressures
- Maintain wellbore stability
- Seal permeable formations
- Lubricate, cool, and support the drill bit and drilling assembly

Typical water based drilling fluids are often suspensions of bentonite clay (gel) with additives such as barium sulfate (barite), calcium carbonate (chalk) or hematite. Thickeners such as xanthan gum can be added to increase the viscosity of the fluid. The particle size distribution of the solids in the drilling fluid is an important physical characteristic affecting the interaction with the well formation and the rheological properties of the fluid itself.

Testing the Particle Size of Drilling Fluids

One historic approach for specifying the particle size of drilling fluids is described in ISO 13500 "Petroleum and natural gas industries - Drilling fluid materials – Specifications and tests". This standard includes two tests for particle size:

- Using a 200 mesh sieve to determine the sample residue greater than 75 μm where the maximum allowable mass fraction is 3.0%.
- Measuring particles less than 6 μm using sedimentation where the maximum allowable mass fraction is 30%.

These two tests provide single point results without any information on the full
Particle size distribution of the sample. Laser diffraction is an easy to use, quick and reproducible technique capable of measuring the entire distribution of particles in almost any drilling fluid. For this reason laser diffraction is becoming a more popular technique for drilling fluids both in the laboratory and in the field. The API, TG03 group has investigated the laser diffraction method through committee work and round-robin tests of typical samples. The samples analyzed in this study were performed following the guidelines published by the API group.

Experimental

The composition of the drilling fluid sample used for this study is shown below:

- Bentonite 29 g/l
- Xanthan gum 2.9 g/l
- P.A.C. (polymer additive) 2.9 g/l
- Barite 15 g/l
- NaOH 0.7 g/l

The sample preparation and instrument settings for the measurements made on the laser diffraction analyzers LA-950 and LA-300 are shown below:

- Refractive Index for barite = 1.64, 0.1
- 5 g of barite was added to a beaker.
- Dispersant* was added to the barite drop wise until a smooth paste was created.

*Dispersant solution: 1 g of sodium pyrophosphate/1000 cm³ of solution.

- Sampler was filled with DI water.
- The barite sample was added to the sampler using a clean spatula to a desired concentration:
  - Light Transmittance = 80-90%
- Sampler circulation setting = 5
- Ultrasound at level 7 (full power) applied to sample for 60 seconds
- Wait 30 seconds after turning off the ultrasound
- Perform particle size measurement
- Repeat these steps for a total of 3 subsamples from the original paste

Record:

- The cumulative volume % less than 6 μm values.
- The cumulative volume % above 75 μm values.
- The d10, d50 and d90 μm values.

When using the LA-950 the software automatically calculates the mean (average), standard deviation and coefficient of variation (COV, CV) for the d10, d50 & d90 of multiple analyses with the same sample. A good result set will produce a coefficient of variation for the d50 μm values less than 3%. Likewise, the coefficient of variation for the d10 and d90 μm values should be less than 5%. For particle diameters below 10 μm, the maximum coefficient of variation for each may be doubled.

Note: These reproducibility levels are as described in ISO 13320 (2).

Results

The results from the LA-950 are shown in Figure 2 and Table 1:

![Figure 2: Particle size distributions of three drilling fluid measurements using the LA-950](image)

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>D (v, 0.1)</th>
<th>D (v, 0.5)</th>
<th>D (v, 0.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Mud</td>
<td>1.211</td>
<td>9.568</td>
<td>38.269</td>
</tr>
<tr>
<td>Sampling 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling Mud</td>
<td>1.212</td>
<td>9.602</td>
<td>38.490</td>
</tr>
<tr>
<td>Sampling 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling Mud</td>
<td>1.211</td>
<td>9.567</td>
<td>39.830</td>
</tr>
<tr>
<td>Sampling 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1.211</td>
<td>9.579</td>
<td>38.863</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.001</td>
<td>0.020</td>
<td>0.845</td>
</tr>
<tr>
<td>CV (%)</td>
<td>0.048</td>
<td>0.208</td>
<td>2.174</td>
</tr>
</tbody>
</table>

| ISO 13320-1 (20.0, 15.0, 20.0) | PASSED | PASSED | PASSED |

Table 1: Reproducibility (COV) results from the LA-950
The averaged results from the LA-300 are shown in Figure 3 and Table 2.

**Figure 3**: Averaged particle size distribution of drilling fluid measurements using the LA-300

<table>
<thead>
<tr>
<th>Diameter on %</th>
<th>Value (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00 (%)</td>
<td>0.875</td>
</tr>
<tr>
<td>50.00 (%)</td>
<td>8.999</td>
</tr>
<tr>
<td>90.00 (%)</td>
<td>40.147</td>
</tr>
</tbody>
</table>

**Table 2**: d10, d50, and d90 values from the averaged LA-300 measurements.

It was easy to perform these measurements and achieve the desired COV values using either the LA-950 or LA-300. The two systems gave slightly different results for the same sample. This is not uncommon in the field of particle characterization. Two different models systems will not typically generate the exact same results. The LA-950 is a newer design and is more automated. The LA-950 is the instrument of choice in the laboratory setting when the broadest possible size range and capability is required. The LA-300 is a smaller, more portable system, making it the ideal system when these measurements are made in the field.

**Conclusions**

HORIBA Instruments delivers the advanced measurement technologies and world wide expertise and support required by the drilling fluids and exploration industries.
Interaction of laser light with particles leads to characteristic scattering patterns. These patterns depend on particle size, the optical properties of the particles and the dispersion medium and the wavelength of the incident light. Large particles are scattering light predominantly at small angles. A particle analyzer therefore needs high angular resolution in forward direction as well as high angle detectors for lateral and backscattered light. The HORIBA LA-950 meets both demands using a 64 element ring detector in forward direction and 23 side and backward detectors giving a high sensitivity for the complete measuring range, from 10nm to 3mm. In addition, the use of two light sources with different wavelengths increases the sensitivity for nanoparticles.

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