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.

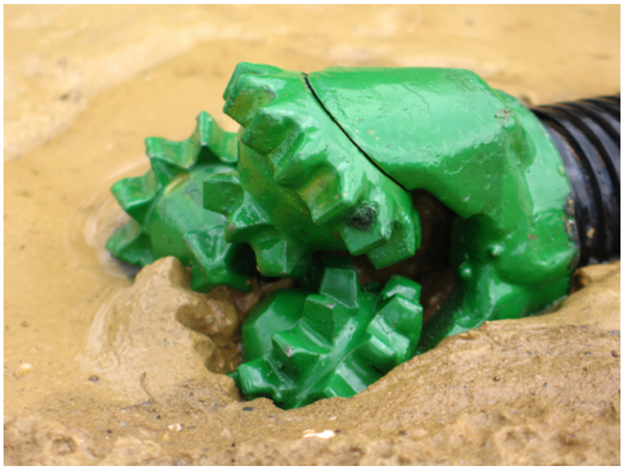

Figure 1: Drill bit in drilling fluid

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" (1). 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 cm^3 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 sub-samples 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.

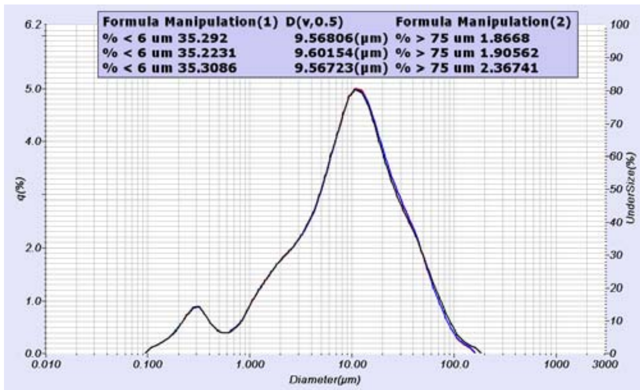

Figure 2: Particle size distributions of three drilling fluid measurements using the LA-950

Sample Name	File Name	D(v,0.1)	D(v,0.5)	D(v,0.9)
Drilling Mud Sampling 2	200911301126035.NGB	1.211	9.568	38.269
Drilling Mud Sampling 2	200911301126036.NGB	1.212	9.602	38.490
Drilling Mud Sampling 2	200911301127037.NGB	1.211	9.567	39.830
Average		1.211	9.579	38.863
Std. Dev.		0.001	0.020	0.845
CV (%)		0.048	0.208	2.174
ISO 13320-1 (20.0, 15.0, 20.(		PASSED	PASSED	PASSED

Table 1: Reproducibility (COV) results from the HORIBA LA-950

Figure 3: The LA-950 laser diffraction analyzer

The averaged results from the LA-300 are shown in Figure 4 and Table 2.

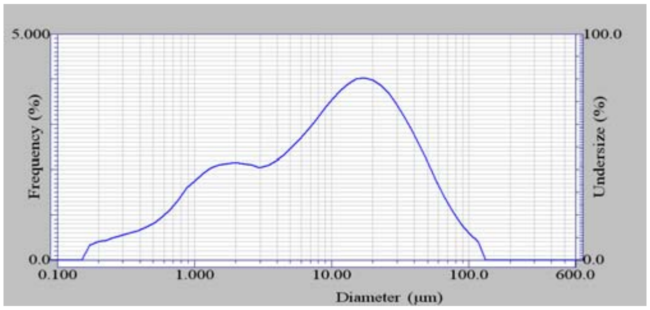

Figure 4: Averaged particle size distribution of drilling fluid measurements using the LA-300

Diameter on % :	(1)10.00 (%)-	0.875(µm)
	(2)50.00 (%)-	8.999(µm)
	(3)90.00 (%)-	40.147(µm)

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

Figure 5: The HORIBA LA-300 laser diffraction particle size analyzer

Conclusions

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. HORIBA Instruments delivers the advanced measurement technologies and world wide expertise and support required by the drilling fluids and exploration industries.

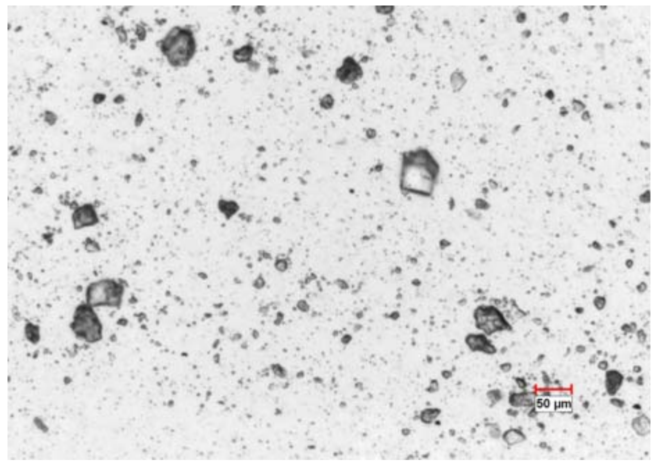

Figure 6: Photomicrograph of drilling fluid using the HORIBA PSA300 image analyzer

References

1. ISO 13500, Petroleum and natural gas industries - Drilling fluid materials – Specifications and tests

2. ISO 13320, Particle size analysis- Laser diffraction methods -Part 1: General principles

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