In order to drill a successful oil well, most drilling operators will use a good drilling fluid or mud. Mud cools and lubricates the drilling tool, helps to attack the rock by injection under pressure, and cleans out the hole, carrying away the pieces of crushed rock [1]. These mud systems are usually WBM (Water-Based Mud), OBM (Oil-Based Mud) or SOBM (Synthetic Oil-Based Mud). One of the major problems with these systems, particularly when reused on different wells, is the build-up of very fine micron solids (less than 5 microns) known as Low Gravity Solids (LGS).

The generation of LGS in the mud creates, slower penetration rates, high pump pressures and increased solids surface area or plastic viscosity. The main risk is the mud becomes stuck and to loose the hole drilled.

Particle shape determination permits also to quantify the shape anisotropy of particles or to provide information relating to surface area regularly.

In this article we show the importance of morphological analysis and show the benefits of combining laser diffraction size measurements with simultaneous shape analysis using the same sample.

The use of Particle Size Analysis (PSA) for Drilling in the Petroleum Industry

Particle Size Analysis (PSA) based on laser diffraction is an easy-to-use technique to measure liquids and dry products. All mud systems with their different carry liquids can be tested, from WBM and OBM to SOBM.

In the figure 1, we can observe that the particle size distribution decreases during drilling process from 35 µm to 2.6 µm.

This analysis makes it possible to detect the presence of 5 µm particles in drilling fluids in order to avoid the cementing process in the well.

Along with drilling mud, the particle size measurement of LCM (Lost Circulation Material), such as calcium carbonate (CaCO₃) and barite (BaSO₄) (figure 2), is significant.

The latter are used as a weighting material to increase the apparent density of the mud and can be measured with adapted dispersion protocols.

By adjusting the viscosity of the carrying liquid, the stabilisation of weighting materials makes it possible to take the particle size measurement without sedimentation.

Dispersing agents are usually added to provide steric stabilisation. This mechanism is usually based on adsorption of polymers onto particle surfaces to reduce the Van der Waals attractive forces.

The Desagglomeration is obtained by airflow turbulence combined with particle-particle and particle-wall collisions. The resulting two phases flow is then directed to the laser path through a succession of venturi sections and a special nozzle.

The Influence of Shape Factor in Drilling Efficiency

In addition to particle size distribution, shape parameters provide much information on the drilling fluid's properties. In the figure 3 a), we have reported the influence of particle's morphology on the two main shape parameters. The aspect ratio defined as the ratio of Feret diameters corresponding to the length represented in figure 3 b) and the circularity ratio, proportional to the ratio of the area of the particle to its perimeter squared.

For example, the intrinsic viscosity [η] of particles with the same volume is directly related to their aspect ratio (figure 4) [1–2]. Furthermore, the rheological properties of some materials used in petroleum industry are of great importance in structural and geotechnical engineering.
Figure 5 shows an improvement in the state of dispersion due to optimisation of the period of ultrasound treatment. The modification of the state of dispersion can also be seen through the change in the particle size distribution.

Particle size Distribution and Observations using Optical Microscopy

A second benefit lies in the quantification of the state of agglomeration, for example through the circularity or degree of sphericity of particles or of agglomerates of particles.

The photographs in figure 6 show that the production sequence for the glass beads has either produced particles with a high degree of shape anisotropy (a), adhering particles of very variable sizes (b), or that contaminants have been introduced into the production batch (c). In this last case, the difference in morphology and the transparency of the material provide information about its chemistry.

This specific design makes it possible to perform a shape analysis with the same sample analysed by laser diffraction and to compare these two techniques.

Laser diffraction measurement of particle sizes can be carried out both via a dry process and via a wet process. After optimisation of the sample dispersion conditions, the results obtained can be correlated with those obtained by optical microscopy (figure 7). For the three modes of measurement, the particle size distributions are similar and median diameters of 50 µm are obtained.

With their robust design, they enable testing and analysis to be performed in the field without being affected by dust or vibration, and provide reliable analysis even under adverse industrial conditions for routine analysis.

From this information, the condition of the drilling fluid can be quickly and accurately assessed. Shape analysis makes it possible to control the particle morphology to complete knowledge of the material’s properties.

Decisions can be made based on this accurate data to correct the problem in the most efficient way before a serious incident occurs.

By employing robust analytical methodologies, formulators can use this tool to generate reproducible particle size data rapidly, which in turn facilitates the development of formulations suitable for drilling in diverse geologies.

Conclusions

The measurement of particle size is a key point for drilling fluid formulation, which itself plays an important role in the efficiency of drilling wells. CILAS Particle Size Analysers are easy to use, fast, accurate and very reliable with liquid and dry formulations.

References