HORIBA Scientific

Application Note

Size and Shape of Proppants

AN205

Hydraulic fracturing is used in the oil and gas industry to increase the flow of oil and/or gas from a well. The producing formation is fractured open using hydraulic pressure and then proppants (propping agents) are pumped into the oil well with fracturing fluid to hold the fissures open so that the natural gas or crude oil can flow up the well. The proppant size, shape, and mechanical strength influences the integrity of the newly created fractures, and therefore the flow of oil and gas out of the well.

Proppant Characteristics

The material used for proppants can range from naturally occurring sand grains called frac sand (top left), resin coated sand (top right), to high-strength ceramic materials (bottom left), and resin coated ceramic materials (bottom right).

Figure 1: Different types and grades of proppants

Quality Control

The quality control of the proppants is described mainly in ISO 13503-2 (1), which replaces the earlier API standards RP 56, 58 and 60. Among other tests, the standards demand the test of size, shape and crush resistance.

Size

The size range of the proppant is very important. Typical proppant sizes are generally between 8 and 140 mesh (106 µm - 2.36 mm), for example 16-30 mesh (600 µm – 1180 µm), 20-40 mesh (420 µm - 840 µm), 30-50 mesh (300 µm – 600 µm), 40-70 mesh (212 µm -420 µm) or 70-140 mesh (106 µm - 212 µm). When describing frac sand, the product is frequently referred to as simply the sieve cut, i.e. 20/40 sand.

Shape

The shape of the proppant is important because shape and size influence the final permeability through the fracture. A wide range of particle sizes and shapes will lead to a tight packing arrangement, reducing conductivity. A controlled range of sizes and preferential spherical shape will lead to greater conductivity. The roundness has been historically analyzed (2) using a visual, manual method based on the chart shown in the figure below, originally developed by Krumbein and Sloss. This method results in large subjective differences from operator to operator.

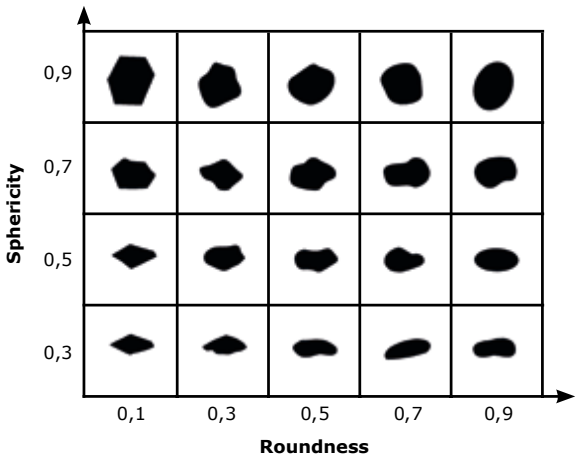

Figure 2: Chart for visual estimation of sphericity (y-axis) and roundness (x-axis)

Proppant	Shape	Strength	Conductivity
Frac sand	Irregular, dependent on source	Low	Low
Resin-coated sand	Irregular, smooth, rounded	Medium	Medium
Ceramic	Uniform round	High	High

How the CAMSIZER Works

The CAMSIZER uses dynamic image analysis technology to provide a fast and reproducible technique for the particle size analysis of proppants. The results are extremely reproducible and identical to the sieve data thanks to an intelligent sieve correlation function in the software. Up to 40,000 particles can be analyzed per second, thus after typically 1 to 3 minutes a statistically sufficient amount of sample has been analyzed. The wide dynamic range from 30 µm to 30 mm enables the analysis of the entire dynamic range of any frac sand or other proppant. In addition to the size distribution, the CAMSIZER analyzes the shape of the particles at the same time, providing accurate morphology data that is totally independent of the operator.

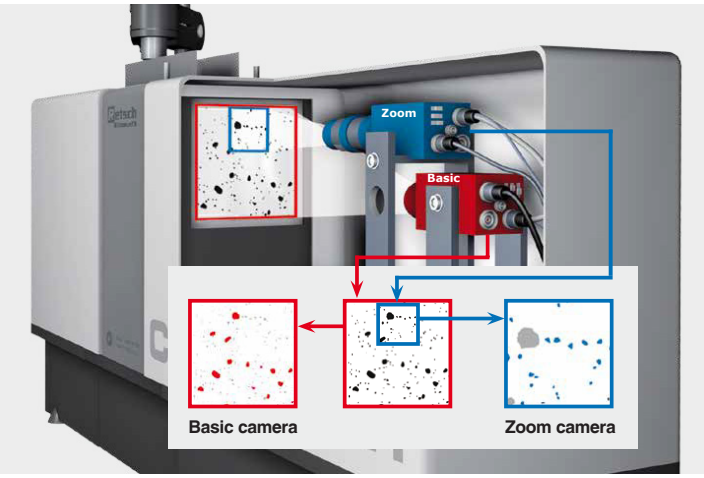

Figure 3: The CAMSIZER Dual Camera Technique

Typical Results from the CAMSIZER

Several commercially available proppants were analyzed by the CAMSIZER to demonstrate the results that can be generated using this technique. A series of five different proppants were analyzed for size and shape distribution using the CAMSIZER. Figure 4 shows the size distribution using the xCmin (3) descriptor (minimum of maximum chords, typically the particle width) which best correlates to sieve results. Each sample was measured twice in order to show the reproducibility.

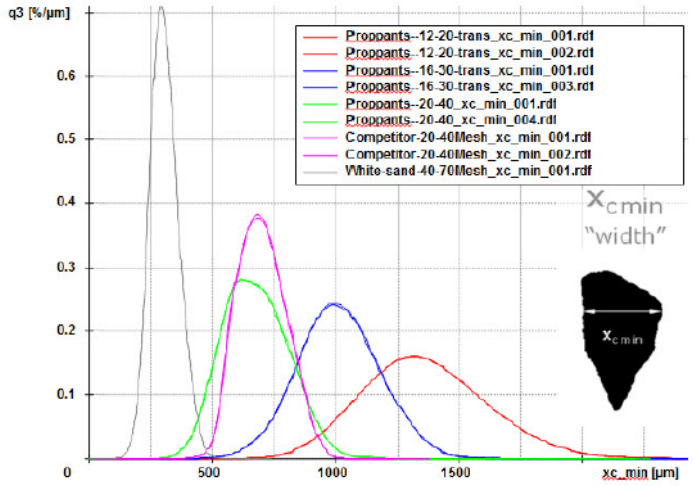

Figure 4: Size analysis of five different proppant samples

The same five samples were simultaneously analyzed for shape distribution using aspect ratio as the morphological descriptor. Note that the violet colored result in the figure below is the most round while the frac sand samples are the most irregularly shaped.

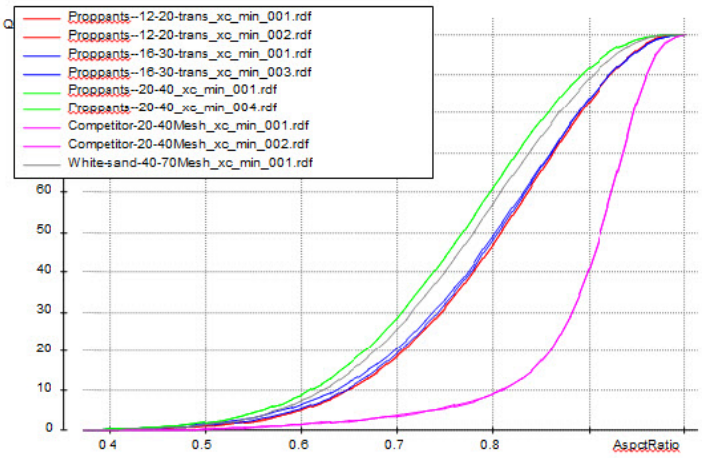

Figure 5: Aspect ratio of the same proppants from the previous figure's size results.

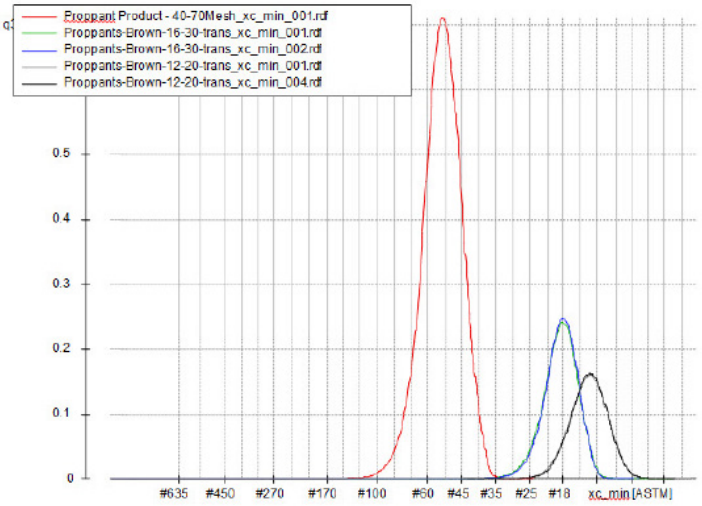

Figure 6: Size analysis of three different products from different suppliers.

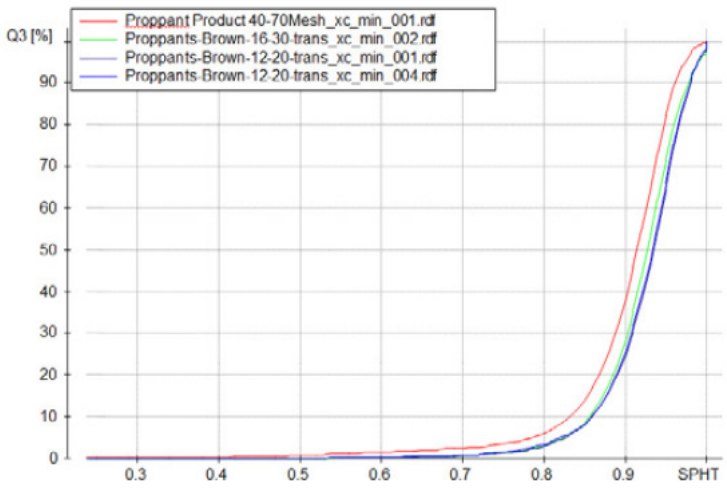

Figure 7: Shape analysis of the same samples. The blue curve shows the roundest material

Summary of Benefits

The CAMSIZER is much faster than that of traditional analysis. It saves time and money in the lab by reducing the work load and increasing the effectiveness of lab personnel. The tool also saves money and improves product quality by allowing for more frequent and faster testing. The shape analysis information is objective, accurate, and far more complete than manual visual inspection.

- Combined size and shape analysis
- Fast: 3 minutes for size and shape analysis
- Objective: Fully automated, reproducible, computer controlled analysis
- Reproducible, statistically significant results from millions of particles per sample
- Identical, repeatable results in all production sites, worldwide
- High resolution: up to 3,000 size classes
- Results directly comparable with sieving

References

1. ISO 13503-2:2006 Petroleum and natural gas industries -- Completion fluids and materials -- Part 2: Measurement of properties of proppants used in hydraulic fracturing and gravel-packing operations

2. "Measurement and Geological Significance of Shape and Roundness of Sedimentary Particles" Krumbein, Journal of Sedimentary Petrology, vol 11, no 2, pp 64-72, plate 1, August, 1941

3. See http://www.horiba.com/fileadmin/u ploads/Scientific/Documents/PSA/Manuals/CAMSIZER_Characteristics_No v2009.pdf