Choose the Right Proppant for your Application

PART 1: PHYSICAL PROPERTIES

The American Petroleum Institute (API) standards 19C and 19D and the International Organization for Standardization (ISO) standards 13503-2 and 13503-5 rule the guidelines for evaluating the quality of the different proppant types. The procedures therein described are used to determine some properties which directly impact the performance of the sustaining agents in the hydraulic fracturing and gravel-packing operations, allowing the establishment of standard comparisons among different proppant sources, technically supporting the selection of the ideal proppant for a specific application.

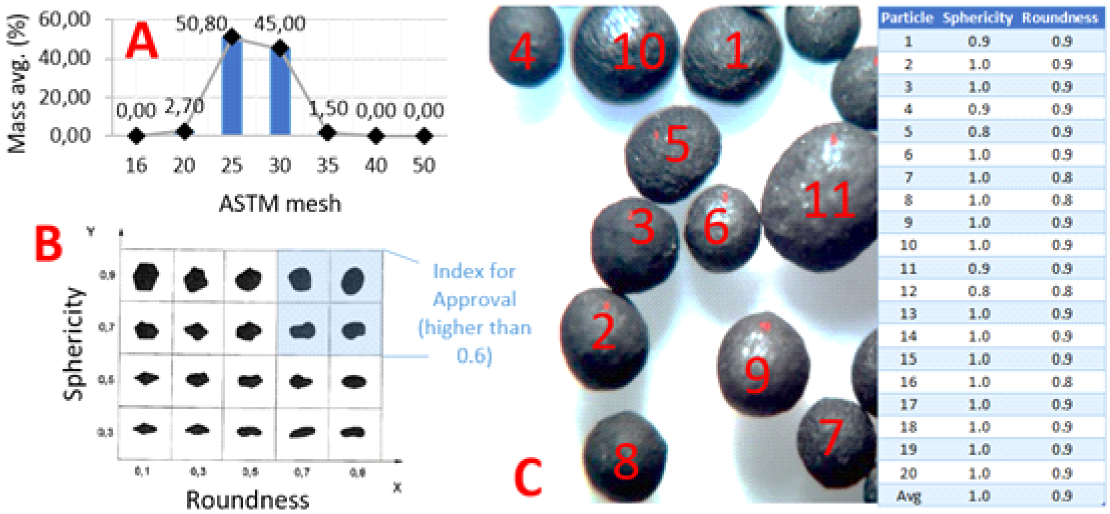
In this first of a four-paper series, the target is to highlight the importance of the main physical proppant properties. Size distribution, sphericity and roundness, densities and crush resistance are the focus of this present paper and should guide end users to choose the right proppant for their application, aiming the maximum performance of the wells.

Size Distribution

Both API and ISO sieve size distribution standards for fracturing proppants (Figure 1.A) determine that at least 90% of the proppant weight shall pass through the coarse nominal sieve and remain retained on the fine nominal sieve. The typical proppant size designations range from 6/12 mesh to 70/140 mesh and the most common proppant sizes are 20/40, 30/50 and 40/70 mesh size distributions. Proppant size influences the proppant range distribution inside the reservoir during placement. The tendency is that coarser proppants present higher conductivity at low closure stresses although having shorter range for their placement, which occurs when the largest particle of the proppant is greater than one-third of the fracture width, whereas thin proppants have longer range and higher crush resistance due to their size and load distribution.

Sphericity and Roundness

Based on the chart developed by Krumbein and Sloss (K&S, Figure 1.B) in 1963, the API and ISO sphericity and roundness standards evaluate the proppant shape by visual comparison (Figure 1.B and C). The higher the K&S number, the closer is the proppant shaped-like a perfect sphere. Normally, high K&S number is related to high crush resistance and fluid conductivity at high closure stresses. Generally, low sphericity and roundness proppants present a faster fall off in conductivity at the higher stresses as they will give rise to higher contact and shear stresses that can prematurely break off the irregularities of the proppant surface.



Particle	Sphericity	Roundness
1	0.9	0.9
2	1.0	0.9
3	1.0	0.9
4	0.9	0.9
5	0.8	0.9
6	1.0	0.9
7	1.0	0.8
8	1.0	0.8
9	1.0	0.9
10	1.0	0.9
11	0.9	0.9
12	0.8	0.8
13	1.0	0.9
14	1.0	0.9
15	1.0	0.9
16	1.0	0.8
17	1.0	0.9
18	1.0	0.9
19	1.0	0.9
20	1.0	0.9
Avg	1.0	0.9

Figure 1. Sieve analysis (A), Krumbein and Sloss chart (B) and a ceramic proppant micrograph with sphericity and roundness average attribution for each particle (C).

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Densities

In a few words, there are three types of densities evaluated as per API and ISO standards for proppants evaluation: bulk density - related to the mass which fill a known volume; apparent density that comprehend the mass of the material excluding the external volume and absolute density associated to the material mass excluding external volume and connected porous.

Usually, Bulk Density (BD) is applied to determine the mass of a proppant needed to fill a fracture, an annulus for gravel packing, or storage tank. Besides that, to provide fill tendency of the proppants in the reservoir and hydraulic fluid behaviour for the proppant delivery, apparent density is used. The apparent density also known as Apparent Specific Gravity (ASG) is determined by using a low-viscosity fluid that soak the proppant particle surface and can penetrate the open pores. Notwithstanding absolute density exclude open pores that may exist in the proppant as well as void spaces among them.

Crush resistance

The API and ISO crush resistance standards provide the amount of fines generated after crushing a proppant sample at a specified stress. Considering the proppant performance inside the fracture, these fines can clog the hydrocarbon recovery pathway, dramatically impairing the well conductivity. Previous studies showed that only 5% fines can decrease the proppant pack conductivity by 62%. These studies also concluded that the size of these fines influences this conductivity reduction. For a 20/40 mesh proppant, for instance, fines between 100 and 200 mesh are those capable of clogging the space between the proppant particles and impair the conductivity of the pack.

In face of the four topics presented, a good understanding about the physical properties of the proppants can drive to a proppant selection which allows a better well performance, economic feasibility increase, and maximization of the return on investment. In this regard, Mineração Curimbaba stands out as one of the most traditional ceramic proppant manufacturers, with thousands of tonnes of proppants produced, delivered and used worldwide in the last 3 decades, being able to help its partners selecting the best ceramic proppant for hydraulic fracturing and gravel-packing operations. Under the well-known brand names SinterMax (UHSP), SinterBall (HSP) and SinterLite (ISP), Mineração Curimbaba offers a wide range of products for different closure stresses, granting service companies and operators high and long-term productivity of the wells.