

Knowing how to select the right free cutting abrasives for a ceramic or glass grinding or polishing operation can help ensure high-quality results.

# SELECTING Free Abrasives

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**M**any glass and ceramic manufacturers use “free cutting abrasives”—i.e., abrasive materials that are not placed in a bond or otherwise fixed by another process, such as film, tape or a resin/glass matrix—to grind and polish their products. As with any manufacturing operation, a number of variables can affect how well the abrasive performs its task. The particle size distribution, coarse channel, aspect ratio and particle morphology of the abrasive can all affect the finished quality of the glass or ceramic product. Knowing what to look for in an abrasive material can help manufacturers choose the right abrasive for their particular applications.

## Particle Size Distribution

The particle size distribution of an abrasive material is an important factor in determining how the abrasive will behave in a grinding or polishing process. This characteristic is often graded according to what is called a Gaussian distribution, or bell curve, where the boundaries are defined as d10, which is the fine end of the distribution; d50, which is the median or middle range; and d90, which is the coarser end.

Mean volume can be another useful way of describing a particle size distribution if the standard distribution holds a

tolerance that is centered around the mean of the distribution. Mean volume is a calculated algorithm based on the volume that a particle occupies in the measuring medium—i.e., a particle will displace its own volume if it is submerged in a liquid, and that volume can then be calculated by measuring the height of displaced liquid.

Even if no other variables about the abrasive material are known, basic predictions about the behavior of the abrasive can be made based on its particle size distribution. For example, a d50 of one 15-micron ( $\mu$ ) material will not be as aggressive as a d50 of another 15- $\mu$  material if one of the distributions contains a higher value at the d10 mark in the same species of abrasive.

For submicron abrasive applications, the “span” of the particle size distribution is also important. This characteristic is defined as the  $d90-d10/d50$ —the lower the value, the tighter the distribution. The span provides a relative measure between the points of distribution and therefore signals the quality of the distribution. For example, if we specified a mean of 0.17  $\mu$  with a standard deviation of  $\leq 0.050 \mu$  on a 0-0.25- $\mu$  material, we could receive a material with a d50 = 0.167  $\mu$ , a d90 = 0.237  $\mu$  and a d10 = 0.119  $\mu$ . If we add span control to the same specified material at

$\leq 0.068$ , we might receive a d50 = 0.164  $\mu$ , d10 = 0.118  $\mu$  and a d90 = 0.230  $\mu$ . While the differences may seem trivial, the tighter specification can generate a higher quality finished part.

It should be noted that a number of different devices can be used to calculate these distributions, and all devices are not equal. Abrasive users should insist that the particle size analysis conform to the accepted norms of the gage reproducibility and repeatability (R&R) studies developed for use in the automotive industry.

## Coarse Channel

The coarse channel is the largest particle discerned by the measuring device and is an important measure of coarse particle control. (Coarse particles are outliers of the distribution and can be a destructive force in grinding and polishing operations.) Abrasive users should look at the percentile in the largest channel—a value of 0.15% or less is usually desirable.

As with particle size distribution, the instrumentation used by the abrasive supplier can affect the reported coarse channel measurements and should conform to the appropriate industry standards.

## Aspect Ratio

An abrasive material’s aspect ratio describes its particle shape, which can be

an important factor in some ceramic and glass polishing operations. The simplest way to determine aspect ratio is to divide a particle's length by its width, and this type of measurement is typically suitable for most applications. However, for applications that require a more exact measurement of aspect ratio, the "centroid calculation" method should be used. This method uses the ratio of the longest length to the longest width and provides a higher degree of accuracy of actual particle shape to the calculated ratio.

### Particle Morphology

Particle morphology is the external study of structure or form and is usually conducted with a scanning electron microscope (SEM) (see Figure 1). This characteristic can be crucial for free abrasives used in polishing operations because particles with high-protruding striations on the surface can gouge the work piece. With superabrasives, the particle morphology can be tightly controlled through mechanical and chemical methodologies. A particle morphology analysis conducted by either the supplier or end user can ensure that the abrasives have been processed appropriately.

### Putting it All Together

The abrasive selection for a given ceramic or glass application depends on the type of product, the number of steps involved and the desired end result. In most high-tech ceramic applications, the initial material removal rate and subsequent finishing of the part are the most important stages.

For example, let's say we're producing aluminum oxide faucet seals and we want to lap for flatness as the first step. We would probably want a fairly coarse particle size distribution—i.e., the d10 of the distribution will not be as critical as the d50 or d90, because the coarse end of the distribution does most of the material removal work. However, this does not mean that the distribution should primarily be on the coarse end. While an abrasive with a higher level of coarse particles will provide a higher material removal

rate, using too many coarse particles will take material off in such large quantities with such deep valleys that a secondary polishing operation might not be able to remove these valleys to an acceptable finish. For our rough lapping operation of the ceramic seal, the specification might be a d50 range of 10 to 20  $\mu$ , with a d90 of less than or equal to 20.5  $\mu$  and a hard stop on the coarse channel of 32.5  $\mu$ , meaning that the largest particle should not exceed this value.

In the second step of the operation, we'll want to polish the part. To select the appropriate abrasive characteristics for this step, we must first define the ideal level of polishing required for the final application. For example, when polishing ceramic seals, the material removal rate (Ra) and root mean square (RMS) of the peaks and valleys of the polishing process

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are the important considerations. If these values are too low (i.e., a highly polished surface), the seal will have a tendency to "stick" to the mating surface. In faucet seal applications, an extremely low Ra/RMS will cause excessive strain on the mechanical holding mechanism, while in mechanical pump applications, it might cause the spring tension device holding the seal to fail. In either case, the product will probably fail to perform as designed.

In our example of aluminum oxide faucet seals, we would want a surface roughness that is high enough to provide a positive seal against liquid seepage while still being low enough to ensure useful operation. We would probably select a 2 to 4  $\mu$  material with a high aspect ratio (1.4 to

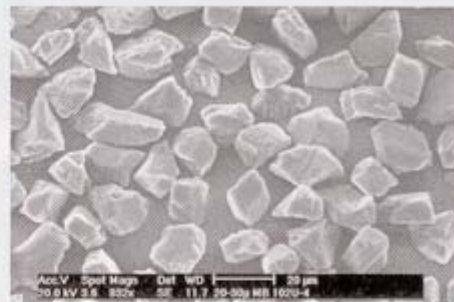


Figure 1. An SEM showing the particle morphology of a blocky abrasive material.

1.0) and a particle morphology in which the surface characteristics exhibit a certain degree of surface striations on the particle.

In glass texturing operations, the abrasive requirements would be quite different. For instance, in automotive glass edging, the surface needs to be rough to the edge of the glass to ensure a tight fit against the elastomeric window frame seal. The edge of the glass also needs to have a uniform roughness to ensure a good seal and an aesthetically pleasing finish. For this type of application, we would select a narrow particle size distribution, such as 15-25  $\mu$  with a mean of 19.5  $\mu$  and a standard deviation of less than or equal to 2.6  $\mu$ , with a tight standard deviation and a low aspect ratio (1.3 to 1.0 or less).

### High-Quality Results

Every ceramic or glass grinding or polishing operation will require a unique combination of abrasive characteristics to achieve the desired results, and suppliers can help users optimize their selection. However, being able to specify characteristics such as coarse channel, aspect ratio and particle morphology in addition to particle size distribution can help ceramic and glass manufacturers ensure that the abrasives they choose will be tailored to their specific applications. ☉

For more information about selecting free abrasives for grinding and polishing operations, contact Warren/Amplex Superabrasives, 1401 E. Lackawanna St., Olyphant PA 18447; (800) 368-5155 or (570) 383-3261; fax (570) 383-3218; e-mail info@warrendiamond.com; or visit [www.warrendiamond.com](http://www.warrendiamond.com).