Value of Controlling Abrasive Particle Size

This Month’s Question:

How important is it to have tight control of particle size distribution of abrasives for blast cleaning? Does industry need an effective method of designating abrasive gradations?

From John Peart, Federal Highway Administration, McLean, VA:

First, the control of the particle size distribution of blast cleaning abrasives is extremely important because it significantly affects both cleaning rate and coating performance. Second, the screening analysis now used is an effective method to characterize particle size distribution.

The economy and performance of a blast cleaning operation are a primary function of the abrasive selected. For maximum economy and efficiency, it is important to select the proper size distribution and type. This is particularly true with non-recyclable abrasives. To be truly efficient, an abrasive must clean rapidly and yield a quality surface that will enhance the performance of the coating system applied.

Two factors must be considered when choosing the size distribution of the operating mixture to maximize cleaning rates: the high impact energy provided by the mass of the larger particles and area covered by the working mixture. The latter is determined by the number of particles available for impact. Impact energy and area impacted vary inversely with respect to abrasive size. Larger abrasive particles have higher impact energies but provide fewer impacts per unit area than smaller ones. Hence, the most productive cleaning mixture must contain varying particle sizes. The larger sizes with the greater impact energy loosen the more tightly adhering, heavier contaminants. The midsize and finer sizes provide large area coverage, and their “scouring action” greatly increases the cleaning speed. The finer sizes also provide the necessary action to clean the bottoms of pits and crevices.

The type, density, and adhesion of the contaminant to be removed significantly affect the design of a productive abrasive mixture. Mill scale removal requires the high impact energy of numerous large particles, as opposed to paint and powder rust removal, which requires increased numbers of midsize and finer particles for increased removal rates. The latter sizes also impart a denser, more uniform finish with a reduced profile.
The requirement for such profiles is increasing because of the expanded use of lower build coatings such as water-borne.

Good abrasive mixes should contain significantly higher weight percents of midsize particles than the sum of the fines and oversize particles. Where paint and rust are the primary materials to be removed, the preferred midsize particle range would equate to the particles that would pass through a No. 20 U.S. standard sieve and be retained on a No. 40 sieve.

Recognizing the value of a well balanced abrasive mix, military and industry organizations developed specifications to limit the range of size extremes and to insure that midsize particles are predominant. These restrictions depend on the grade defined. One such standard published by the U.S. Commerce Department, CS 271-65, “Grading of Abrasive Grain for Grinding Wheels,” also established size distribution limits for pressure blasting abrasive on sizes defined by U.S. standard sieve numbers. It is a recorded voluntary standard of the abrasive trade and is concurred with by many abrasive trade associations.

The demand for abrasives has increased as new uses have been developed (e.g., filter media, roofing granules, bonded abrasives, airport deicers). Many of these new uses have stringent size distribution limits. Screen sizes No. 18-No. 30 are in demand to satisfy these requirements. This causes an excess supply of oversize and fine material, created because of normal size distribution during crushing.

A widening of the size distribution limits, a reduction of the number of midsize particles, and an increase of oversized particles have been noted on the commercial blasting grade of abrasives being delivered by some suppliers. This has been confirmed by screen analysis of abrasive delivered to a shipyard and to 3 bridge maintenance sites. The excessive profiles obtained with these materials alerted the users to the problem.

The painting industry needs a standard that defines the particle size distribution by sieve analysis of abrasive mixes designed for the efficient removal of a limited combination of contaminants. Such a standard would result in improved abrasive quality, more uniform production rates, and reproduction of the profiles obtained.

The SSPC Specification SSPC-AB 1 does not completely fulfill this need. It leaves the specification and size distribution characterization of the abrasive to the specifier. Most users do not have the necessary technical support and resources to define the parameters and to insure that the delivered product complies with the requirement.

ISO/TC 35/SC 12 Committee of the International Standard Organization has recognized the need and the supplier’s ability to meet such standards. The committee has specified size distribution limits by sieve analysis in its proposed abrasive specifications, but much time will be required by the consensus process before publication of the specifications. The need for such a standard is well documented.
From Bill Hitzrot, Chesapeake Specialty Products, Baltimore, MD:

During blast cleaning, cleaning rate and profile are in part controlled by the particle size distribution of the blast cleaning abrasive. If the abrasive particle size varies greatly, then cleaning rate and profile vary.

Furthermore, the current trend toward tight profile control to minimize paint consumption, lower VOCs, and improve coating life demands that there also be tight control over abrasive particle size to assure proper cleaning rate and prevent excessive profile. The answer, therefore, to the first part of the question is “yes”; particle size control is critical to assure uniform cleaning rate and profile control.

The second part of the question can best be answered by referring to the new SSPC Mineral Slag and Abrasive Specification. Paragraph 4.4.1 states, “the abrasive supplier shall designate range(s) for maximum and minimum retention of each size to meet the profile range(s) specified...”; and paragraph 4.4.2 states “The designed sieve size distribution and ranges will become the acceptance standard for the specific abrasive submitted.”

The wide variety and sizing of abrasive covered by the Mineral and Slag abrasive specification precluded the SSPC abrasive committee from incorporating a single, overall size distribution to cover all abrasives. Once an abrasive has been selected for a job and a size distribution agreed upon to provide the required cleaning and profile, then periodic checking should be done to assure compliance.

Steel abrasives also have a standard, the SAE size designation for standard abrasive sizes. This has been an effective standard for steel abrasives. For recyclable steel abrasive applications, conducting periodic screen analyses of the working mix is necessary. Maintaining a uniform size distribution of a recyclable working mix assures proper cleaning and profile control.

The industry standards are in place. The owners and contractors have to work together to make the standards effective.

From Bill Hall, Jet Edge, Minneapolis, MN:

My company is an equipment vendor involved with many applications requiring high quality abrasives. These applications range from ultra high pressure water/abrasive blasting to high performance abrasive/jet metal cutting. We are concerned about the inconsistency in the marketplace when comparing supposedly equal abrasives from various vendors.

Many applications require tight, well defined process control during the manufacture of the abrasive to maximize performance and achieve specific end results. Many factors and parameters exist affecting blast cleaning performance, the end results, and cost factors associated with the blasting process. In addition, these variables and parameters can change.
dramatically from application to application, even when applications appear to be similar.

These applications require the control of many variables, including abrasive particle size distribution, purity, specific gravity, angularity, shape, and hardness.

Particle size distribution is usually a more important parameter when the focus is in minimizing the abrasive requirement at higher abrasive particle velocities. For instance, certain abrasive particle sizes withstand the stress associated with the integration of the abrasive particles into the high velocity air or water stream better than other abrasive particle sizes. Cleaning or cutting performance decreases in proportion to the amount of abrasive pulverized during the integration process.

Particle size distribution is also important when the abrasive particle distribution must contain a certain range of particle sizes to accomplish a specific blasting task, and when an attempt is made to maximize the re-use of a recyclable abrasive.

Many applications, however, do not require tight specification control of the abrasive. “Restrictive” abrasive specifications will add unnecessary expense to the operation when the end result specification is vague, when the end result can be accomplished utilizing a variety of processes (e.g., power tool cleaning or pure water-jet blasting), when the end result can be accomplished by utilizing a variety of abrasive types, or when the cost of operations is the most critical element to control.

We would like to assume that the abrasive products from the individual abrasive manufacturers or processors are consistent from bag to bag or batch to batch. Based on our observation of abrasive we have been exposed to, we are disappointed in the comparative quality of abrasive available from vendor to vendor. The marketplace deserves better control, when necessary, when specifying a specific size and type of abrasive from the various vendors.

Abrasive standards can provide a quality control parameter for project specifiers, abrasive producers, and users. While there does exist a quasi nomenclature standard for abrasives, no consistent material specification exists. Abrasive specifications complying with an industry standard should be available when necessary. These specifications should not be created to restrict competition, eliminate competition among different technologies, or add unnecessary expense to abrasive blast applications.

From John M. Lunardini, Lunardini Industries, Bridgeville, PA:

I will address the second part of the question first.

The Society of Automotive Engineers (SAE) and the American Foundry Society (AFS) have specifications for grading new shot and grit.
For aluminum oxide, there are guidelines available from the Abrasive Grain Association (AGA). When no other specification is available, the federal government has a military specification for grading most abrasives, including sand and coal slag.

For the most part, all specifications refer to the amount of material that passes through and/or is retained on a specific U.S. Standard Sieve. The U.S. Standard Sieve is available in several mesh or micron opening sizes. When material is sized, several screens in ascending screen size order are stacked together and placed in a machine that will shake the abrasive tested through the screens for a given period of time. The percentage of material retained on the screens is calculated and recorded.

Each manufacturer may use different retained percentages on screen sizes to determine the abrasive mix. Most abrasives include 2 or as many as 5 screen sizes. Most specifications say that the abrasive will “all pass” a specific size and be retained on another size. In between the 2 limiting sizes, there may be 2 or more gradations.

As for the first part of the question, the manufacturer decides what combination of screen sizes include in 1 specific, sized product. There are 2 important reasons for controlling particle size distribution.

The first reason is economics. When an abrasive is manufactured or mined, there are many screen sizes. The screens can be as coarse as #2 and finer than #1000.

Extremely fine material is collected in dust collectors. The other material is blended into different sizes. This way, the majority of the material can be utilized for blasting purposes.

The second reason, efficiency of cleaning, is the major reason abrasive is sized using differing particle sizes. An abrasive of all one screen size may not be very efficient for blast cleaning until it breaks down into smaller sizes. For non-recoverable abrasives, a very close screen size is not advisable because although it may remove the coating, the substrate will not look clean. For recoverable abrasives, it takes longer to achieve a “working mix.”

Due to the increased use of metal abrasives, there are some points to consider. The sizing of metal abrasive according to SAE standards originated many years ago for using this material in wheel blast machines.

Now that we are using a lot of air blast, the initial grading of new material may have to be blended. For instance, if a 25 grit material is needed to remove many layers of coating and rust, it may not have the metal looking “white.” Therefore, some 50 (or even 80) mesh material should be mixed in initially. Then, as all the material gets recycled, the 25 grit material will eventually develop its even work mix.
All recyclable abrasives should be graded closer to specific screen sizes than non-recoverables so that they can develop the necessary work mix.

For this ever-changing industry, the only control I would consider worthwhile would be that for each given size of recyclable abrasive, there is a limitation on the amount of extreme fines. This limitation would permit better control over material that has not been well reclaimed or cleaned in one operation and is then moved to another blast operation. The extreme fines cause more dusty conditions. They also require more maintenance on the blasting equipment. Fine abrasive, even dust, causes excessive wear to equipment.

I do not think it is possible to develop more specific guidelines for non-recoverable abrasives.

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