MAKING THE RIGHT WATERJET ABRASIVE CHOICE

Hardness, density, toughness, and particle shape help determine the best material for the job

By R. Randolph Rapple

Selecting the right abrasive type and size for a waterjet cutting application (see **Figure 1**) can make a significant difference in the performance and profitability of equipment.

Abrasive selection begins with an examination of the material and the cutting specifications. The difficulty involved in cutting the material and the desired surface finish help the fabricator to determine the proper abrasive to use. The abrasive product needs to have hardness, density, toughness, and a particular shape. Additionally, the industry has had to develop sources that can produce abrasives with high purity, tight particle size distributions, and a high degree of cleanliness.

Virtually every abrasive known to man—both natural and synthetic—has been considered for use as an abrasive in waterjet cutting. Almandine garnet has emerged as a mineral with the best characteristics for waterjet cutting. Other minerals may be harder, heavier, or lower in cost, but almandine garnet emerges as the one material with the best combination of characteristics for abrasive waterjet cutting. The naturally occurring material is mined and processed for numerous industrial applications in addition to waterjet cutting, such as blasting media and water filtration granules. (The common almandine garnet is brownish-red in color and opaque. The much rarer, gem-stone-quality almandine garnet is marked by a deep red color and is transparent.)

Figure 1
Waterjet abrasive typically accounts for about one-third of the hourly operating expenses of a waterjet cutting operation.

A Closer Look at Abrasive Makeup

Natural attributes and mineral processing have a direct effect on how the abrasive material will perform as a waterjet abrasive. A fabricator should be aware of how these attributes affect the performance of the abrasive.

Attributes inherent to the natural mineral include the following.

Hardness. Waterjet cutters need to balance cutting speed and component wear. Using a soft abrasive extends nozzle life, but slows down cutting. Using an abrasive that is very hard offers fast cutting but erodes the nozzle too quickly. This decreases accuracy in the cutting process and results in recurring downtime and the added expense of frequent nozzle replacement. Almandine garnet falls between 7 and 8 on the Mohs scale, which effectively balances the need to cut quickly and provide reasonable cutting tool life.

Density. The principal cutting force of a waterjet is a function of mass multiplied by velocity. The ideal abrasive therefore has the heaviest particle that the water stream can accelerate to maximum velocity. This generates the maximum cutting force.

An abrasive that is too light won't pack much of a punch, and an abrasive that is too heavy won't accelerate to maximum velocity, sapping the waterjet stream of its power. As with hardness, the key is to find an abrasive that hits the sweet spot. Almandine garnet has a specific gravity of 4.0 (four times the weight of water) and falls right into the ideal range for both punch and acceleration.

Toughness. Sometimes referred to as *friability*, toughness plays a direct role in how well a waterjet abrasive performs. Material that is too friable breaks down in the focusing tube and ends up too fine to cut effectively. Abrasive that is too tough (think malleable like lead) rounds during the mixing process and is too dull to cut well. The ideal abrasive has a measured rate of breakdown and produces sharp, angular cutting edges. Once again, almandine garnet with its semifriable nature and conchoidal fracture fills the need.

Figure 2
Magnetic separation is used to separate magnetite and ilmenite from the almandine garnet.

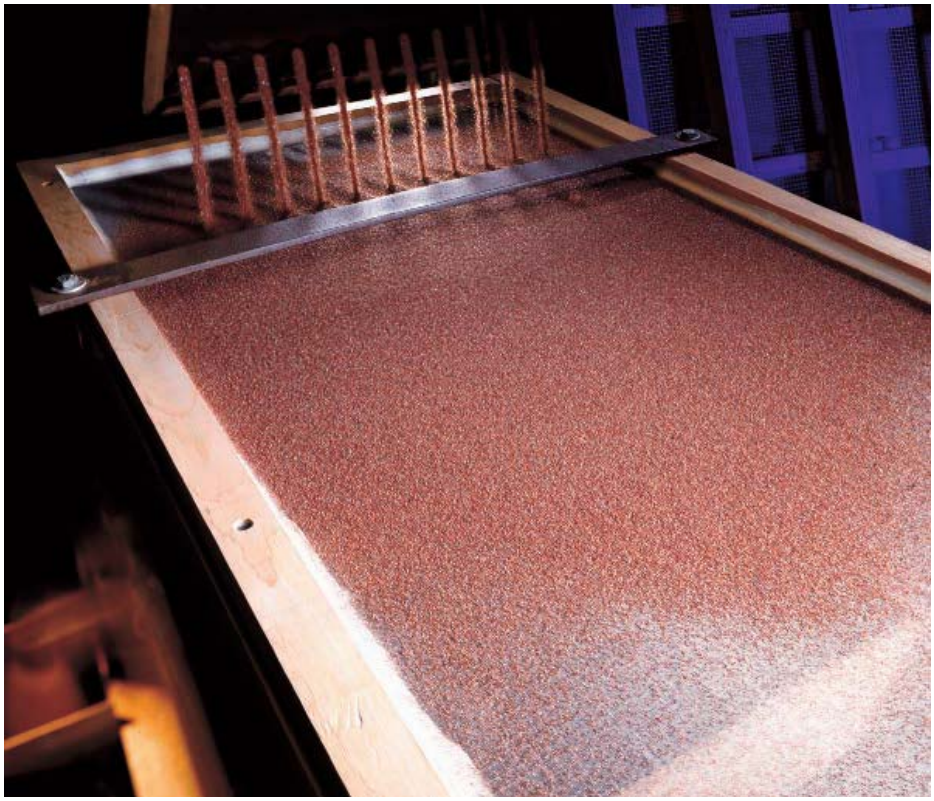

Figure 3
Product screening is a critical step in maintaining consistent particle size distribution.

Particle Shape. Abrasives are available in every particle shape imaginable, from perfect beads, like steel shot, to razor-sharp, needle-like crystals found in silicon carbide, a synthetic abrasive used in high-tech applications. Recognizing that a sphere is the ideal carrier of mass projected in a high-powered water stream, a fabricator might assume that the waterjet manufacturers would look for spherical particles. However, they must keep in mind the constant balancing act involving acceleration, wear, and cutting.

After conducting extensive trials on numerous waterjet platforms in the world, waterjet experts have determined that the most suitable particle shape depends on the material being cut and edge finish requirements. Sharp, angular grains cut more quickly and offer superior edge finishes. Subrounded grains are used in more general-purpose, standard cutting applications.

A waterjet cutting machine manufacturer or an abrasive supplier can provide more information on both types and assist in trials to determine which particle shape is best for an application.

The following attributes are controlled during mineral processing.

Purity. As a natural mineral, almandine garnet is mined, milled, and processed to meet the producer's final specifications. High-purity materials typically involve added processing stages and call for greater attention to detail during the refining process when compared to processing low-purity products. As a result, high-purity materials cost more, but they also deliver superior cutting results (see **Figure 2**). Low-purity products may contain materials other than the garnet that rob a waterjet cutting machine of its ability to cut well.

Particle Size Distribution. Tight, consistent control of the particle size distribution is extremely important to maximize the performance of a waterjet (see **Figure 3**). Coarse or oversize particles pose a real risk of clogging the nozzle, which can bring the machining process to a standstill and potentially damage the workpiece. Conversely, excessive fines can collect in the feed line or the cutting head, causing irregular feed or sputtering in the cutting stream. Inconsistent distribution can create a nightmare for operators as they have to adjust the abrasive feed rate to maintain cutting speeds.

Cleanliness. While similar to particle size distribution, abrasive cleanliness stands on its own as the final important attribute for a waterjet cutting abrasive. Cleanliness refers to the amount of superfines present in the abrasive product. These fines are so small that they often adhere to larger particles. From a technical perspective, the producers of quality garnet abrasives use a measurement called *suspended solids* to quantify how clean the product is. Using a product that has not been properly processed generates nuisance dust while loading the abrasive hopper, which over time may cause poor feeding or cutting.

Finding the Right Abrasive Source

Choosing the right supply partner is an important action for a metal fabricator. A waterjet manufacturer or the abrasive supplier can assist the business to determine the right abrasive type and grade. This results in an abrasive selection that will maximize the performance of the waterjet cutting machine.

This type of consultation may include the evaluation of several different products to determine which abrasive is best for the job:

- **Should the abrasive be hard rock or alluvial?** The material being cut, its thickness, and the desired surface finish requirements influence the choice of hard rock (see **Figure 4**) or alluvial (see **Figure 5**) abrasives.
- **What grade should the abrasive be?** Both hard rock and alluvial products are available in a variety of grades ranging from coarse (50 mesh) to very fine (230 mesh). Most waterjets use grades between 50 and 120 mesh, with 80 mesh being the most widely used.

The supply partner should be capable of delivering garnet in paper bags, bulk bags, or even in straight bulk. It also helps if the abrasive supplier can ship within 24 hours of receiving an order and has a warehouse nearby for one- to two-day shipping. This ensures timely deliveries and keeps freight costs as low as possible. **FAB**

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Figure 4
This is a closer view of hard rock garnet abrasive.

Figure 5
This is a closer view of alluvial garnet abrasive.