BARTON

White Paper

How to Choose the Right Abrasive for a Waterjet Application

Introduction

Selecting the right abrasive type and grade for a waterjet cutting application can make a significant difference in the performance and profitability of your waterjet operation.

Abrasive selection begins with an examination of the material and the cutting specifications. The difficulty of cutting the material as well as the desired edge quality are two important factors in determining the proper abrasive to use.

In addition, the waterjet machine needs to be set up to match the cutting specifications to ensure that the abrasive is delivered effectively and efficiently.

A wide variety of factors impact the performance of waterjet abrasives. Addressing a few considerations up front will help the operator choose the ideal abrasive for a waterjet cutting operation.

Of course, different abrasive materials have different performance characteristics. It is important to understand these characteristics when matching an abrasive to a particular application.

Performance characteristics of different abrasives

How do hardness, density, toughness and particle shape affect the performance of a waterjet abrasive?

Virtually every abrasive known to man — both natural and synthetic — has been considered for use in waterjet cutting. Almandine garnet has emerged as the mineral with the best characteristics for abrasive waterjet. Other minerals may be harder, heavier or lower in cost, but almandine garnet is the abrasive with the best combination of characteristics for 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 applications. The common almandine garnet is brownish-red in color and opaque. The much rarer, gemstone-quality almandine garnet is marked by a deep red color and is transparent.

Other abrasives can be used in waterjet cutting. Aluminum oxide is harder than garnet and is sometimes used for cutting very hard materials such as ceramic. One drawback, however, is that using aluminum oxide dramatically shortens mixing tube life, increasing the cost of the operation. Staurolite is a naturally occurring mineral with a density and hardness similar to garnet and is an economical general-purpose waterjet abrasive. Softer abrasives like olivine can be used for cutting less-demanding materials such as aluminum.

A closer look at abrasive characteristics

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 the following four key attributes affect the performance of the abrasive.

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. Nozzle erosion decreases accuracy in the cutting process, results in recurring downtime and adds the expense of frequent nozzle replacement. Almandine garnet falls between 7 and 8 on the Mohs hardness scale, which effectively balances the need to cut quickly and provide reasonable cutting tool life.

MOHS HARDNESS SCALE

Diamond	10
Corundum	9
Topaz	8
Quartz	7
Feldspar	6
Apatite	5
Fluorite	4
Calcite	3
Gypsum	2
Talc	1

The Mohs scale of mineral hardness characterizes the scratch resistance of various minerals by rating the ability of a harder material to scratch a softer material. As the hardest known naturally occurring substance, diamond is at the top of the scale.

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 in 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 semi-friable nature and conchoidal fracture, fills the need.

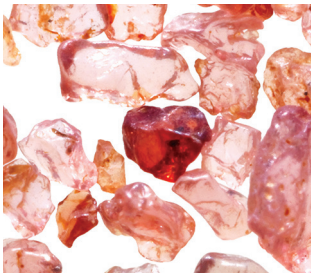
PARTICLE SHAPE

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 efficiency.

Through extensive trials on numerous waterjet platforms around the world, waterjet experts have determined that the most suitable particle shape depends on two factors: the material being cut and the edge finish required. Grains with sharp, angular edges cut more quickly and offer superior edge finishes. Subrounded grains are used in more general-purpose, standard cutting applications.

A waterjet equipment 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.

ADIRONDACK® HPX® hard rock garnet abrasive



ALLTEK® HPA® alluvial garnet abrasive

How do purity, particle size and cleanliness affect the performance of a waterjet abrasive?

The waterjet cutting industry depends on sources that can produce abrasives with high purity, tight particle size distributions and a high degree of cleanliness, which are all attributes that 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 low-purity products. As a result, high-purity materials cost more, but they also deliver superior cutting results. Low-purity products may contain materials other than garnet that rob a waterjet cutting machine of its ability to cut well. When produced for use as a waterjet abrasive, other minerals must be processed to meet the high purity level required for waterjet cutting.

PARTICLE SIZE DISTRIBUTION

Tight, consistent control of the particle size distribution (PSD) is extremely important to maximize the performance of a waterjet. Coarse or oversized 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 particle size distribution can create a nightmare for operators that 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 the cleanliness of the product. Using a product that has not been properly processed generates nuisance dust while loading the abrasive hopper, which may cause poor feeding and cutting over time.

Achieving optimum abrasive performance

Optimum abrasive performance can only be achieved when the equipment is properly set up according to the OEM specifications for the material being cut and desired edge quality of the finished part. Other factors that can influence cutting performance include:

- Nozzle/orifice combination
- Machine pressure
- Pump horsepower
- Machine controls setup

It is advisable to consult with the manufacturer of the waterjet equipment for the proper setup for a particular application.

Performance characteristics of BARTON waterjet abrasives

In the 1980s BARTON collaborated with the pioneers of abrasive waterjet technology to develop a garnet abrasive specifically designed to meet the needs of waterjet cutting. This collaboration led to the production of ADIRONDACK® HPX® garnet. Since that time, BARTON has expanded and enhanced its product line to offer four levels of performance in many grades ranging from 50 to 230 and two designed specifically for micro waterjet cutting: 62µ and 75µ.

ADIRONDACK® HPX®

The premier hard rock garnet for waterjet cutting, ADIRONDACK HPX is the original waterjet abrasive. A sharp, angular garnet, HPX is ideal for the most demanding applications.

- Cuts faster, deeper and straighter with better edge quality

ALLTEK® HPA®

A highly versatile, alluvial garnet abrasive, HPA is the most widely used abrasive in the industry.

- A workhorse garnet for any application

ECOTEK® HPR

General-purpose ECOTEK waterjet abrasives deliver reliable and economical waterjet cutting.

. Economical waterjet cutting

If you are new to the waterjet industry or have questions about a new application, an experienced, qualified waterjet abrasives expert at BARTON can help determine the right abrasive type and grade for your application.

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