Custom Considerations

▶ BY DR. JEFFREY A. BADGER

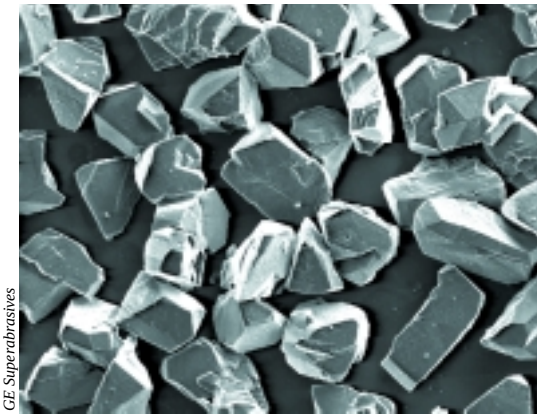
What you need to know before buying a custom superabrasive grinding wheel.

The grinding operations your shop performs with diamond or cubic-boron-nitride wheels are probably the ones that cause you the least trouble. After all, these hard abrasives are the most potent, so they tend to consistently work well.

And because a superabrasive wheel causes so few problems, it's unlikely you spend much time experimenting with different wheel types. The one you're grinding with does the job, and you have other matters on your mind.

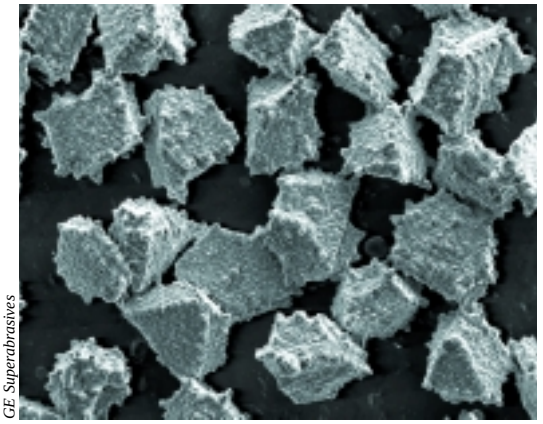
Sometimes, though, you might wonder if a custom wheel tailored to your specific application would give you the extra edge that would allow you to bump up speeds and feeds, improve surface finish, reduce wheel wear and save money.

As with most things, there's no pat answer—but several things to consider. This article describes what you need to know when deciding if you should try a custom wheel and, just as importantly, how to judge if switching would or would not be worth the bother.



GE Superabrasives

Angular-shaped CBN grits cut efficiently and regenerate sharp edges, but are easily fractured, resulting in greater wheel wear.



GE Superabrasives

When resin bonds are used, coatings are needed to help hold the grits firmly in place.

Variety is the Key

A conventional-abrasive wheel usually comes in a standard shape and is dressed to form by the end user. This allows wheel manufacturers to produce a variety of types, secure in the knowledge that there is a market for them. For this reason, there's a large selection of grit types, bond types, sizes and grades available.

Superabrasive wheels, on the other hand, must be produced to the required form. (It's not a good idea to dress superabrasive wheels to form, as the dressing process removes a costly product.) As a result, there is little variety among off-the-shelf superabrasive wheels. The types of bond usually are restricted to either resin bond or electroplated.

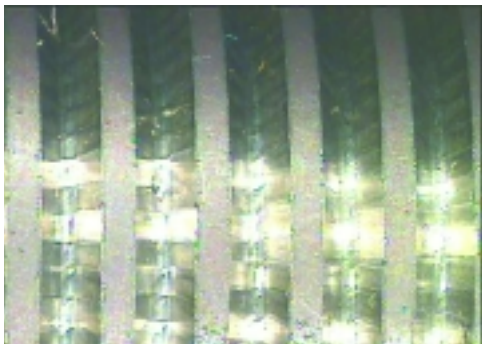
The benefit of a custom wheel is that you aren't limited to what's available in stock. You can specify what you want. For example, you could specify an angular-grit type instead of a blocky one, a different concentration, a softer or harder grade, or a different bond material.

Those who choose the custom route often change from an off-the-shelf electroplated or resin-bond wheel to a vitrified-bond wheel. In many applications, vitrified wheels yield more consistent results, reduce cycle times and last longer.

This is because vitrified wheels act quite differently than resin-bond ones. A resin bond is softer, so wheels wear quickly and self-sharpen. A vitrified bond is much stronger, so the sharpening is done during dressing. Such wheels are designed to act "hard" and, consequently, tend to last up to 10 times

longer. Also, because the bond material is stronger, a vitrified wheel can incorporate more abrasive.

Resin-bond wheels can hold a maximum of about 25 percent abrasive (100 concentration), whereas vitrified wheels can hold a maximum of about 50 percent abrasive (200 concentration). In addition, a vitrified bond holds the grits more firmly. As a result, a vitrified wheel doesn't require a coating, as is the case with a resin-bond wheel. A vitrified-bond wheel also can be dressed automatically; it requires no subsequent conditioning with an abrasive tool—such as a stick—or a "run-in" period to open up the wheel.



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Chatter marks after the first pass of a three-pass thread-grinding operation. Increasing the material-removal rate on a machine lacking sufficient stiffness causes vibration and chatter marks.

When to Switch

Customizing a wheel specification—grit size or type, grade, etc.—adds about 20 to 40 percent to the price, assuming you stay within the same bond family. The cost of jumping from resin to vitrified, which is more expensive to produce, adds an additional 50 to 300 percent to the price.

The key factor in deciding whether or not to go custom is batch size. If you make a specific part out of a specific material to a specific size, and produce thousands of them in a single run, then it would be worthwhile to take time to optimize the process. Optimizing the wheel is a big part of process optimization.

By contrast, if you are the type who grinds a bit of this today and a bit of that tomorrow, with small batch sizes and varying part geometry, then your parameters change so much that process optimization would not be possible. Therefore, you should grind with an off-the-shelf wheel.

If batch size dictates that you should buy a customized superabrasive wheel, what kind of improvements can you expect? If you stay within the same bond family and simply change wheel composition, you can improve performance by 10 to 20 percent. And if you move to a different family—from resin to vitrified, for example—expect an additional 20 to 100 percent jump.

Be aware, however, that trying to quantify performance beforehand is notoriously difficult, because it depends on what you are trying to achieve, e.g., longer wheel life, greater consistency, a finer surface finish or shorter cycle times. Be aware, too, that improvements in performance will largely depend on the quality of your machine. This is especially true when trying to reduce cycle times.

Limitations of Old Machines

It's hard to "teach" an old grinding machine new tricks. You can't just slap

Know the lingo

If you are going to discuss a custom superabrasive wheel with your wheel supplier, it's a good idea to learn how to speak his language. Superabrasive jargon can be cryptic, so here are some definitions of the key terms. Knowing these will help you keep the salesman on his toes.

Angular vs. blocky: Angular grits have high aspect ratios (the ratio of their longest length to their shortest length), whereas blocky grits are somewhat round. During grinding, an angular shape is more efficient, since the grit is more likely to attack the workpiece at an angle that is conducive to cutting. However, because they extrude out, they also are exposed to larger stresses and are likelier to fracture.

Blocky grits, on the other hand, tend to attack at inferior angles and, consequently, do not cut as efficiently. However, because their shape is somewhat round, they can absorb larger forces and stresses and, therefore, are less likely to fracture. Wheels with angular grits tend to stay sharper—but wear more. Wheels with blocky grits are more prone to dulling, but they wear less.

Bond type: There are four basic bond types for superabrasive wheels: metal, vitrified, resin and electroplated. Each bond family, though, contains many different bond variations. This is a result of wheel manufacturers formulating different bonds for different applications. They usually keep these recipes under wraps, but don't hesitate to ask about them. Even if they won't divulge their secrets, they can tell you which bonds work better for specific applications. A simple change of bond material can improve an operation significantly.

Microfracture vs. macrofracture: Grits fracture along their crystallographic fracture planes. Microfracturing grits tend to fracture into small pieces, whereas macrofracturing grits tend to fracture in large chunks.

Tough vs. friable: Tough abrasives can absorb a beating without cracking, meaning they wear less. However, the grits are not released upon dulling. Friable (or brittle) materials tend to fracture more easily. This results in better self-sharpening but greater wheel wear.

Wheel grade: This term refers to the wheel's strength, or how tightly the bond material holds the grits. The harder the grade, the slower the wheel wear. However, when the grade is hard, grits don't release as readily as the wheel wears. This can lead to higher forces being generated and excessive heat generation.

The wheel grade should strike a balance between strength and sharpness. It should be hard enough to maintain form but soft enough to release dull grits.

—J. Badger

a state-of-the-art, custom superabrasive wheel on any old machine and expect major improvements.

When you increase the material-removal rate by bumping up the speeds and feeds, radial and tangential forces increase proportionately. When these forces increase, the propensity for vibration also increases. If the machine isn't sufficiently rigid, vibration occurs, chatter marks appear on the workpiece and the wheel wears excessively.

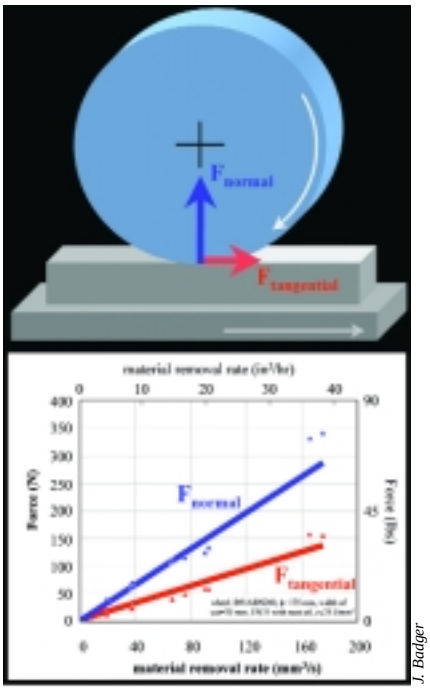
Older machines designed for the low mrr of conventional abrasives usually lack the rigidity necessary for superabrasive grinding. In addition, an increase in normal grinding forces means greater deflection, making tight tolerances more difficult to achieve. However, some machines can be modified so that they are stiffer by replacing components such as the spindle, bearings and toolholder.

Wheel speed is another factor affecting performance. Superabrasives tend to grind best when wheel speed is high. Older machines that were designed for grinding with conventional-abrasive wheels often cannot run at a high rpm. (High speeds produce high centrifugal forces that cause conventional wheels to burst.) That's unfortunate because, for a fixed set of conditions, a higher wheel speed means a "harder-acting" wheel, resulting in less wheel wear. This also means a higher grinding (G) ratio, which is calculated by dividing the cubic inches of material removed by the cubic inches of wheel wear.

Nevertheless, some old machines can be modified to run safely at higher speeds and feeds without shortening wheel life. Consult your wheel manufacturer and machine builder for specific limitations and safety precautions.

Increasing performance also requires controlling the excess heat that will be generated because of the higher speeds. Heat generation rises proportionately with a rise in the mrr. Make sure that coolant velocity matches wheel velocity.

A stiff, accurate, repeatable dresser is also important. Old dressers often end up taking off 0.0010" instead of 0.0001", wasting costly material.



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Increasing the material-removal rate means a proportionate increase in forces acting on the wheelhead. A stiff machine is needed to handle the larger forces.

Another thing to remember when upgrading equipment is the person operating it. A grinding-machine operator often spends years tweaking the speeds and feeds to optimize a process. So once you put on the new superabrasive wheel, give him time to tweak.

Lastly, when discussing the custom issue, there is always an enthusiast who says that if you're not using a customized grinding stone you're living in the Stone Age. But that's not fair. There are times when a standard stone just makes more sense.

You know what's best for your shop. Acquire all the information that you can—then go with what feels right.

About the Author

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Grinding in the real world

Changing from a standard to a custom superabrasive wheel often pays off handsomely—even if the parameter changed seems minor. That proved to be the case for one company that uses resin-bond CBN wheels to grind parts made from high-vanadium-powder steel.

The company changed from a medium-strength, blocky-shaped, microfracturing grit to a high-strength, angular-shaped, fracture-resistant macrofracturing grit.

An angular grit penetrates at a more aggressive angle. That improves the cutting action but results in greater forces being generated and increases wheel wear. However, the new grit is fracture-resistant, or tougher. This means that it's less likely to break in two, which reduces wheel wear. And when the new grit does fracture, it does so on a macro scale, meaning it fractures more sharply.

Keeping track of how all these opposing parameters work in conjunction with one another might have been daunting, but the wheel salesman must have known what he was doing. The company's wheel life increased 450 percent, with only a 13 percent increase in power consumption. And the financial savings, as well as the reduced time in dressing and changing out wheels, has more than covered the extra expense of applying a custom wheel.

—J. Badger

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