Ask The Grinding Doc

Shedding light on cryptic nomenclature

BY DR. JEFFREY A. BADGER

The Doctor is in. Starting with this issue, CTE begins a semi regular column aimed at answering readers' questions about grinding and dispensing grinding – related advice. The author is Dr. Jeffrey Badger – The Grinding Doc. Badger is an independent consultant currently working for Erasteel in Sweden. If you have a question about grinding, e-mail it, along with your name and contact information, to badgerjeffrey@hotmail.com. Or, send it to CUTTING TOOL ENGINEERING, 400 Skokie Blvd., Suite 395, Northbrook, IL 60062; e-mail: alanr@jwr.com.

Dear Doc,

Printed on every grinding wheel is a series of numbers, but the only person who claims to understand them is our local abrasives salesman. I can't help wondering if it is some sort of conspiracy to keep end users in the dark about what's really going on. Every time I inquire about the numbers, the salesman mumbles something about hardness, grade, "open structures" and "free-cutting" wheels.

After some recent grinding –burn problems, he suggested switching from "72A 60K5 VB" to "24A 46L7 VB." I've been grinding for 40 years and these numbers and letters are still a mystery to me. Do you think he is purposely withholding information for me? Can you shed some light on the subject?

The Doc's Diagnosis:

Cryptic wheel designations can be intimidating. I used to wonder if abrasives salesmen spoke with such ambiguity because they were not quite sure what all the letters and numbers meant themselves. But that's usually not the case. Your salesman knows his subject and he wants to help you achieve the best results possible. It's just that all those digits can be tricky-even for the most experienced grinder. There is no reason to be wary.

I can assure you that deciphering this code is not as difficult as it may seem. It's just a matter of learning the lingo and taking one parameter at a time. Let's start by looking at what's in a conventional grinding wheel.

The three basic constituents of a grinding wheel are the abrasive, the bond material and its porosity. The abrasive is the hard material that does the cutting. It is held in place by the bond material. The porosity simply refers to the air pockets trapped within the wheel.

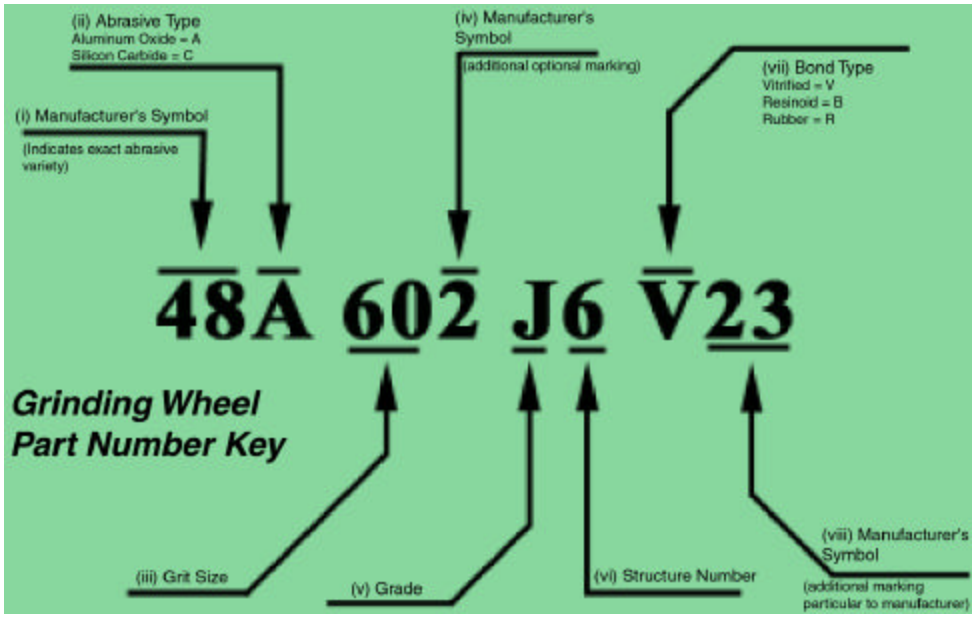
These pockets are important because they deliver coolant to the wheel/work piece interface and provide space for chip formation. A typical vitrified wheel might consist of 50 percent abrasive, 30 percent air and 20 percent bond material. The relative percentage of each component is very important in terms of wheel behavior during grinding. For example, a wheel with more bond and less porosity will act "harder." In other words, the extra bond material holds the grits more firmly, making them less likely to release upon dulling (blunting and attritions wear in grinding lingo.) A wheel with extra bond maintains form well but is prone to burning the work-piece, which is caused by the stubborn, intractable, inefficient dull grits.

In contrast, a wheel with less bond material and greater porosity will act "softer." This means the grits are held less firmly and are more likely to release upon dulling. The wheel stay sharp (free-cutting or self-sharpening), but it's more prone to losing form.

Knowledge of the wheel marking system is an invaluable tool for the experienced grinder. Let's look at what the digits and letters mean. (The symbols explained in the following only apply to conventional abrasives; cubic boron nitride and diamond grinding wheels have a different marking system).

(i), (iv) and (viii) Manufacturer's Numbers. (i) denotes the exact abrasive varietal, for which each manufacturer had a different number; (iv) optional digit that indicates a mixture of grain sizes; and (viii) further specifies the bond variety and/or additional details about the wheel.

(ii) Abrasive Type. It's either "A" for aluminum oxide or "C" for silicon carbide. There are numerous varieties of each type, so the specific varietal abrasive is indicated in (i). A few examples are friable white Al_2O_3, for precision grinding (it fractures or crumbles during grinding, generating



sharp edges); brown Al_2O_3, for heavy-duty grinding (it's tough but less friable); monocrystaline Al_2O_3, for finish grinding (it has a high purity and sharp crystal structure); and microfracturing seeded-gel (SG) Al_2O_3.

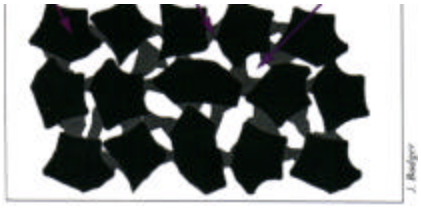
(iii) Grain Size. Denotes the size of the grits. The number relates to the number of screen wires used during sieving; a larger number corresponds to a smaller-sized grit. For the practical engineer, the mean "grit diameter" is useful and is determined by the following calculation: grit diameter (mm)=15.2/grit number, or grit diameter (inches)=0.6/grit number.

Coarser grits allow higher stock-removal rates and tend to fracture more easily. This helps maintain their sharpness but produces a rougher finish. Finer grains are for higher-precision grinding and provide a finer finish.

(v) Grade. The grade indicates the "strength" of the wheel, or how tightly the bond material holds the grits. It's sometimes referred to as the wheel hardness, which can be misleading as it has nothing to do with the hardness of the abrasive. One common designation is the relative percentages of bond material and porosity for a fixed abrasive percentage. An increase in grade (for example, moving from J to K) corresponds to a 2 percent increase in bond material and a 2 percent decrease in porosity. However, hardness scales are not universal. Percentages and effective hardnesses differ from one manufacturer to the next. In addition, resin-bond wheels have virtually no porosity; the grade is achieved by changing the bond formulation.

(vi) Structure Number. This number indicates the amount of abrasive in the wheel. A larger number means that there's a smaller percentage of abrasive in the wheel-an open structure. One method of designating structure relies on a 2 percent decrease in abrasive for every increase in structure number, with a corresponding increase in both bond and porosity.

Open wheels have fewer grits, so they tend to penetrate deeper. This results in a poorer surface finish less heat generation and more wheel wear. Closed wheels have more grits, so they tend to penetrate less deeply than open wheels. Closed wheels produce better surface finishes.



(vii) Bond Type. This letter denotes the bond material, with "V" for vitrified, "B" for resinoid and "R" for rubber ("M" is the standard designation for metal bonds, which are for superabrasive wheels). Vitrified bonds are porous (good for cooling), less sensitive to temperature and stiffer (good for precision grinding). Resinoid bonds are non-porous, temperature-sensitive, tougher (good for heavy-duty operations and handling side-forces) and less stiff (good for surface finish). Rubber bonded wheels can be made as thin as 0.002'' (good for slitting fountain pen nibs) or very thick (good for centerless grinding control wheels), and can produce extremely fine surface finishes.

Multiple Interdependent Variables

Now that we know how to read grinding wheel designations and have a basic idea of how changes affect grinding performance, let's try to figure out why your abrasive salesman suggested the changes he did.

First, the grinding wheel manufacturer's "72A" designation is for tough brown Al_2O_3, and "24A" stands for an equal mixture of brown Al_2O_3 and white Al_2O_3. White Al_2O_3 is friable, so it tends to self-sharpen, which is good for decreasing burn but bad for surface finish and keeping form.

Second, the proposed grit size increased from 60 (0.25mm) to 46 (0.33mm). Larger grits are better for high stock removal and tend to self-sharpen. Again, this is good for decreasing burn but bad for surface finish and keeping form. On the other hand, larger grits tend to make the wheel act harder, which is good for keeping form but, possibly, bad for inhibiting grinding burn.

Third, he suggested a grade increase from K to L, which represents a harder wheel. This change is good for surface finish and keeping form, but it's likelier part burning will occur.

Fourth, the structure number increases from 5 to 7, creating a more open wheel. This means fewer grits and greater porosity, which Is good for cooling and decreasing burn but bad for surface finish and keeping form.

Therefore, the salesman suggested a new grit that is good for decreasing part burn but bad for finish and form. Yet the new wheel could act too hard, making it likelier to burn the part while supplying a good finish and maintaining form well.

Although a passionate tribologist, The Doc is not a masochist. Trying to figure out which parameters dominate in this situation can be a mind-boggling exercise in futility.

In light of this, perhaps the abrasive salesman is less devious than we give him credit for. Changing only one parameter at a time can be a long process. And, changing just one parameter could produce some very negative side effects. He is trying to decrease burn while anxiously keeping an eye on the other parameters. But with all of these variables seemingly working against each other in different ways, multiple changes mean that the final effect is notoriously difficult—if not impossible—to predict.

So the next time your abrasive salesman suggests a change, the refrain from becoming annoyed by his response. Instead, have faith in his experience and intuition. The Doc has always believed that grinding is a combination of science and mysticism. The wise grinder is able to successfully fuse the two realms. Utilizing the technical knowledge of the theoretical grinder and the intuitive skills of the practical grinder, he relies on scientific principles and spiritual inspiration to choose the ideal wheel for the job.

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