Sharpening Your Turning Tools

History

In the 1800s there was much experimentation with methods of bonding corundum to make grinding wheels. Shellac, animal glue and vulcanized rubber were all being used, but the most popular for a brief period was a silicate of soda bond developed by Gilbert Hart in Detroit in 1872. Shortly thereafter, Frank Norton, a potter in Worcester, Massachusetts, encouraged two of his potters to try grinding-wheel manufacturing to augment the company product line. Legend has it that Norton bet a bucket of beer that Sven Poulson, one of his Swedish immigrant potters, could not duplicate the Hart wheel. Poulson mixed emery with some pottery slip clay and fired three emery wheels; one was good. This is credited as being the first vitrified-bond (*convert (something) into glass or a glasslike substance, typically by exposure to heat*) wheel. After a number of false starts, serious production of the wheels began in 1878. Poulson had meanwhile become frustrated and left Norton, but his brother-in-law, John Jeppson, who had learned wheel making from Poulson, almost single-handedly brought Norton to industry dominance by 1890. Within 25 years, 75% of all grinding wheels sold in the United States were vitrified bond.

GRINDSTONE CODES

38 A 80 - H 8 V BE

38 A 80 - H 8 V BE

Norton symbol

The first number indicates the type of aluminum oxide that Norton used in this stone. Norton uses a number of other types as well but is reluctant to explain them to consumers.

38 **A** 80 - H 8 V BE

Abrasive

A = Aluminum oxide
C = Silicon carbide
D = Diamond
There are many codes for abrasives, but these are the ones of interest to woodworkers.

38 A **80** - H 8 V BE

Grit size

Grit size can range from 8 to 500. The band from 60 to 120 is used in basic tool grinding.

38 A 80 - **H** 8 V BE

Grade

Wheel grade is indicated by a letter from the following ranges:

ABCDEFG	HIJK	KMNO	PQRS	TUVWXYZ
Very soft	Soft	Medium	Hard	Very hard

A wheel is make harder by increasing the amount of bonding material. This reduces the volume of the pores and makes the abrasive particles more resistant to release. The wheel lasts longer but tends to grind hotter because it retains more worn particles than a softer wheel; this reduces the cutting rate and increases friction when grinding tool steel.

38 A 80 - H **8** V BE

Structure

Structure describes the grain spacing.
0 1 2 3 4 5 6 7 8 9 10 11 12
Dense ——————————> Open
In general, an open structure is cooler cutting because of entrained air and reduced friction. It also has reduced tendency to glaze. A dense structure is more durable but is hotter in use and more subject to glazing.

38 A 80 - H 8 **V** BE

Bond

The most common bonds are:
V - Vitrified (tool grinding)
B - Resinoid (high speed, rapid metal removal)
R - Rubber (high-pressure grinding)
E - Shellac (where an elastic bond is needed)
M - Metal (used with diamond and boron nitride)

38 A 80 - H 8 V **BE**

Bond modification

An optional manufacturer's designation for some modification to the basic bond; in this case it indicates a modification to the basic vitrified bond.

GRIT TYPE AND COLOR

Grit type is generally aluminum oxide (white, pink, ruby red, brown, grey, etc.) silicon carbide (black or green), ceramic (blue and pink) or any combination of these. Aluminum oxide is by far the most popular. It is available in the following colors: White, pink, red, ruby red, brown, and grey. Each color has its own grinding characteristics. Grey and brown grit are the workhorse grits used in bench grinding and production grinding. Tough and inexpensive they are the most 'general purpose' grit found. These can be used on low to high carbon steels. The pink and white grits are typically used on your harder steels which need a cool, friable cutting action to avoid burns. The ruby red grit is a special tough grit also used on tool steels. These grits are a little bit more expensive than the grey/brown. Ruby red is very expensive. Silicon Carbide grits are commonly either black or green. Black silicon carbide is used to grind non-ferrous metals such as aluminum and brass and on plastics, rubber, and stone products such as marble and granite. Black silicon carbide is a very sharp grit. Green silicon carbide is an even sharper grit than black and is used primarily for carbides, titanium and plasma sprayed materials. One interesting characteristic of silicon carbides is the effect they have on steels. Due to the sharpness of these grits, one would think that they would be too aggressive and not provide a good finish. In fact, on steels, silicon carbide is used as a sort of polishing/finishing grit. It is used in tumbling processes as a surface finishing product. Also, manufacturers will often blend a small percentage of silicon carbide in with aluminum oxide grit in grinding wheels and honing stones to achieve a better work piece surface finish on steels. The grit will dull and provide a rubbing action on steels which produces a better surface finish.

A newer grit that is available is ceramic (also referred to as SolGel® or SG®). Ceramic grit has the characteristic of not dulling -- It will break down or fracture into sharp corners rather than dull and pull out of the bond. This makes the wheel typically last longer and it will also provide excellent aggressive stock removal without heat buildup. This grit is only made by a couple of producers and is very expensive, typically two or three times as expensive as aluminum oxide. You will normally not see a 100% ceramic grit wheel. The grit is typically mixed with aluminum oxide in various percentages from 10% up to 50%. Ceramic is used in tool steels and lower carbon steels equally well. These grinding wheels typically require a good bit of custom engineering for your specific application and process to achieve profitable results.

Grit types are sometimes mixed in combination for achieving certain cutting characteristics. Grits are also called friable (white) or semi-friable (pink, brown and grey, red, etc.). Friable grit breaks down more easily and is useful for cutting harder materials.

Spark Test

When there were few alloys on the market, a spark test was a quick and accurate way to identify iron and basic steel types. With the hundreds of alloys now used in tools it is much less reliable, but it can still be used for rough classifications in many instances. It is still an effective testing process with older tools and plane blades. The spark patterns shown (next page) are those that would be generated by grinding a tool on a powered dry wheel. This test does not work well or at all on CBN or Diamond wheels, just FYI.

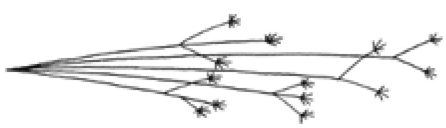
Wrought iron
Long yellow streaks, becoming leaflike in shape before expiring

Mild steel
More variety in streak length, with smaller leaves and some sparking

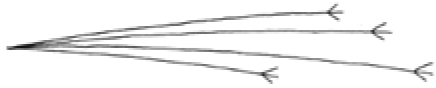
Medium-carbon steel
Almost no leaf, some forking, great variety of streak length, sparking nearer the wheel

High-carbon steel
No leaf, bushy spark pattern, forking and sparking starting very close to the wheel; less bright than medium-carbon steel

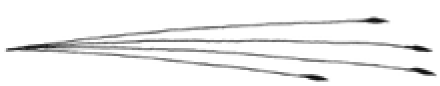
---



Manganese steel
Small leaf before streaks fork to form sparks



High-speed steel
Faint red streaks forking at the tip



Stainless steel
Bright yellow streaks with a small leaf end

Norton grinding wheel, code 38A80-H8VBE. (Photo by Susan Kahn)

The stone used as an example (38A80-H8VBE) is the best all-purpose stone for dry grinding in a woodworking shop. It cuts quickly with minimal friction but excellent abrasion. For very light grinding where a fine finish is important, such as with carving tools, a 100x or 120x stone can be used but the rest of the code should be the same. It is important to have a relatively soft bond and open structure.

SEEDED-GEL STONES

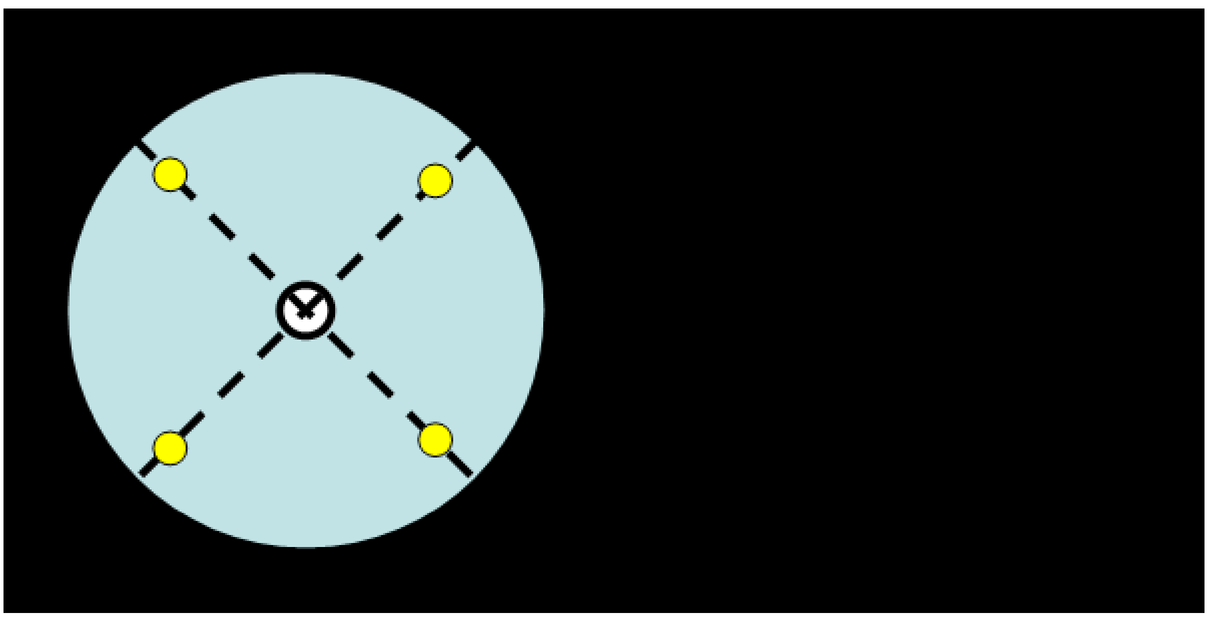
For more aggressive grinding, such as reshaping of high-speed-steel turning tools, the new SG (seeded gel) stones from Norton work well. The grit in these is an aggregation of submicron particles. The sieved grits are actually made up of many small particles much like polycrystalline diamond versus monocrystalline diamond. They, too, are self-dressing wheels in that particles will fracture under pressure rather than load up, but they are designed for greater grinding pressures than would be normal in grinding chisels and plane blades. These wheels also grind hotter because they are not available in a bond softer than "I." But this is less of a problem with high-speed steel, which has excellent red-heat hardness and can take higher grinding temperatures than regular tool steels without deteriorating.

The polycrystalline particles in the SG wheels are available in four concentrations: 100%, 50%, 30% and 10%. The balance would be standard 38A grit. The recommended concentrations for HSS turning tool grinding would be 50% or 30%. The codes for these would be, respectively, 5SG80IVS and 3SG80IVS in 80x and 5SG100IVS and 35SG100IVS in loox.

GRINDING WHEEL RING TEST:

Before installing a new wheel on your grinder, you should perform the “ring test”. To do this, support the wheel on a dowel, or pencil through the mounting hole. Your finger will work too. Then tap the wheel in four places at the 1:30, 4:30, 7:30 and 10:30 positions (45 degrees each side of vertical through the hub, both below and above the center line), about 1” in from the edge of the wheel. Then rotate the wheel 45 degrees and repeat the test again for a total of eight taps. To perform the ring test, wheels should be tapped gently with a light nonmetallic implement, such as the handle of a screw driver for light wheels, or a wooden mallet for heavier wheels.

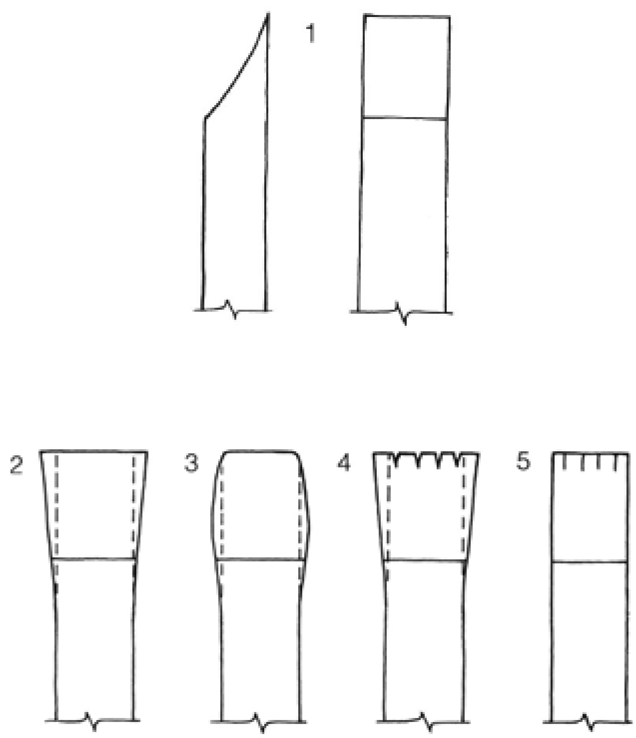
A sound and undamaged wheel will give a clear tone. If cracked, there will be a dead sound and not a clear ring and the wheel should not be used. Wheels must be dry and free of sawdust when applying the ring test; otherwise the sound may be deadened.



For additional information on this topic or any other grinding wheel safety information, please review ANSI (ANSI B7.1), OSHA and literature provided by the grinding wheel and machine manufacturer. You may also contact the Saint Gobain Product Safety Department at Tel. (508) 795-2690 or Fax. (508) 795-5120 for additional product safety information.

To Quench Or Not To Quench?

As a general principle, quenching tools during grinding is a substitute for good technique. The drawing below shows what happens to a quenched tool. 1. Tool at room temperature before grinding. The thin edge heats and cools very rapidly in comparison to the main blade body.



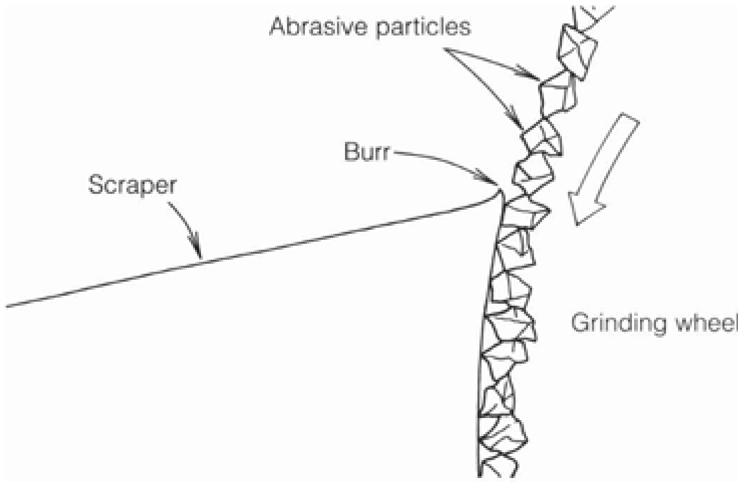
Dotted lines show normal width at room temperature.

2. As the tool heats up during grinding, it expands. 3. If the metal were perfectly elastic, this is what the tip would look like as it first hit the water and the thin tip cooled more rapidly than the rest of the blade. 4. But metal is not perfectly elastic, and as it shrinks, tiny cracks are created in the edge.

3. When the entire blade has cooled, the cracks may become invisible but they will be there.

How A Burr Forms During Grinding

At various times in woodworking literature you will see comments that the burr forms on the top of the scraper by a deposit process; hot chips of steel removed by the wheel are carried around a full rotation and deposited on the top of the scraper, sort of tack welded into position. This is not what happens. The burr forms on the top of the scraper because a large number of the abrasive particles in a wheel at any one time have negative rake angles. Such particles tend to plow a groove in the steel without removing much material. When the particles first encounter the top edge of the scraper, they deform the steel at that point, raising a lip that is the burr that turners depend on for cutting. Only a fairly small percentage of particles in a grinding wheel are actually cutting, taking out chips. Many are just scraping or plowing their way through. Scraping or plowing removes material but also generates a lot of heatby deforming the steel. For this reason, you always want a clean unglazed wheel with the maximum number of sharp particles exposed.



Abrasive particles
Burr
Scraper
Grinding wheel

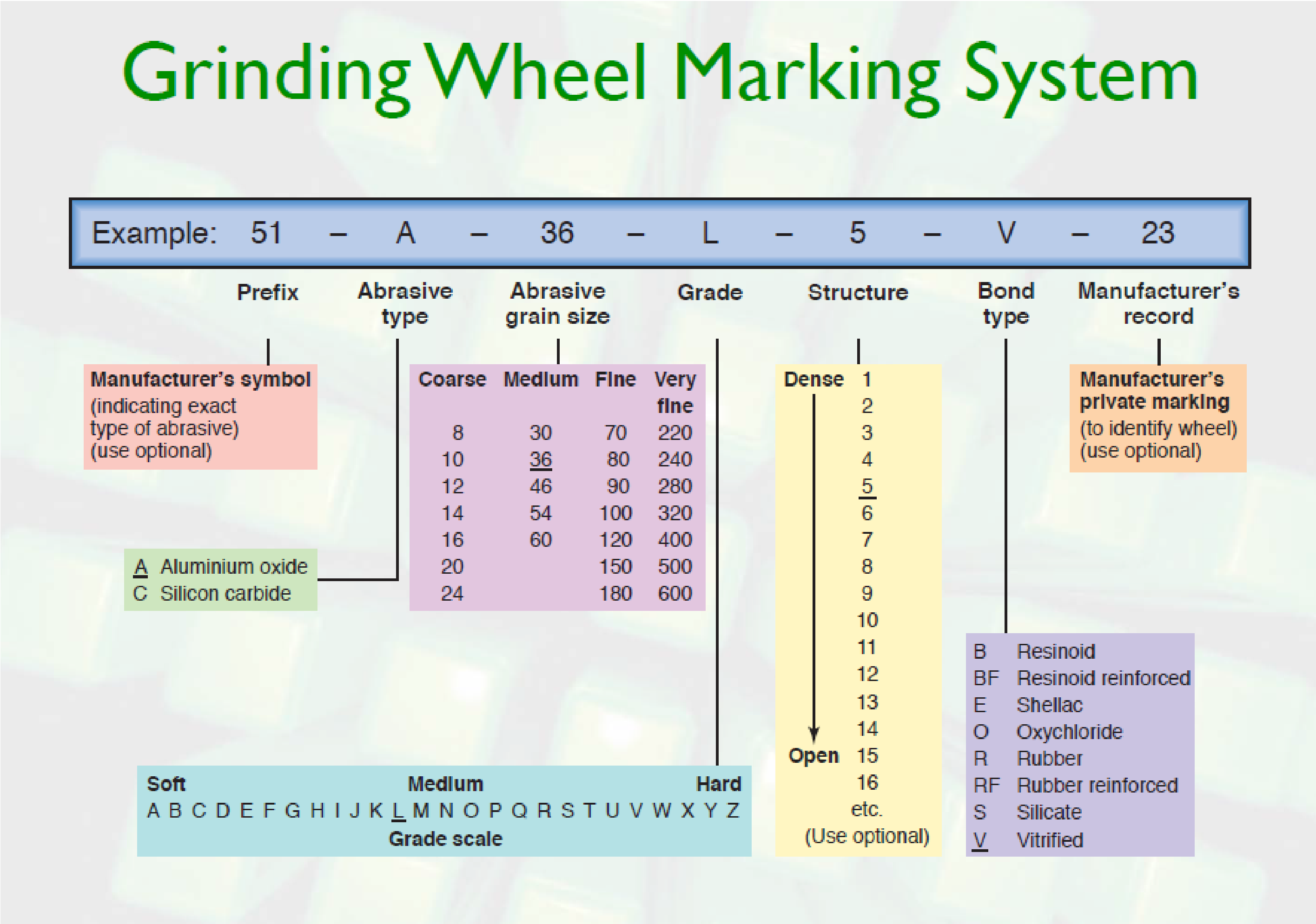
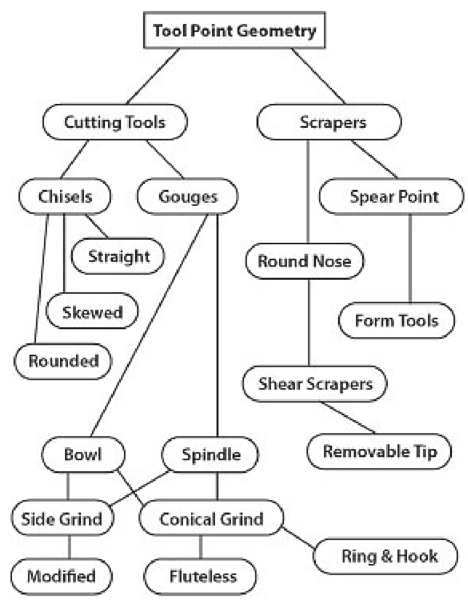
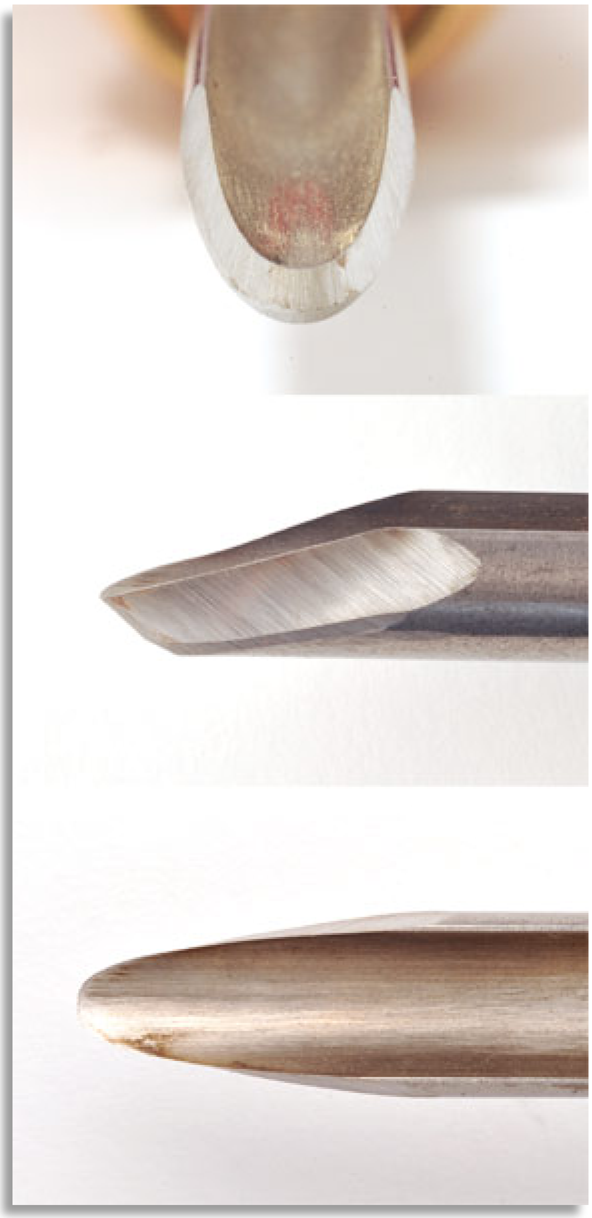
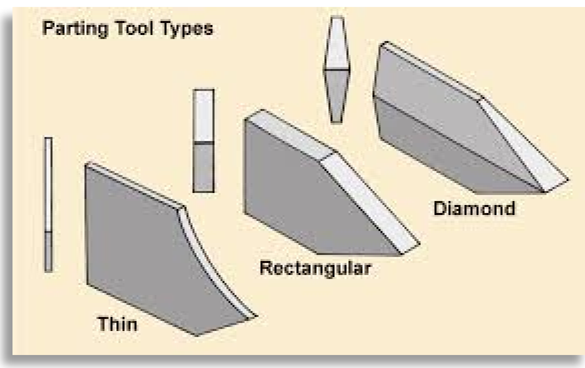
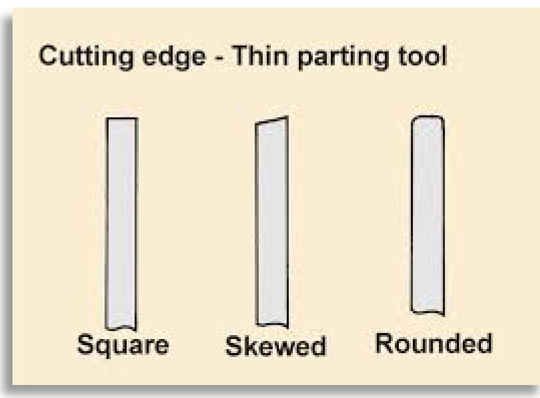


Fig 2 – Measuring edge angle



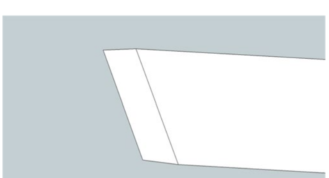




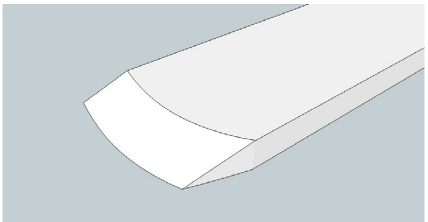


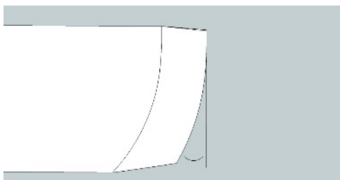
Straight Skew

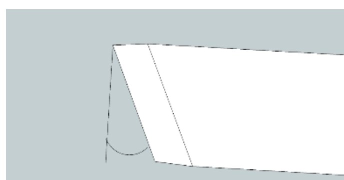
*Curved skew: beginning with the **toe** (long point) grind a fairly straight section, then increase the curve to the **heel** (the short point).*

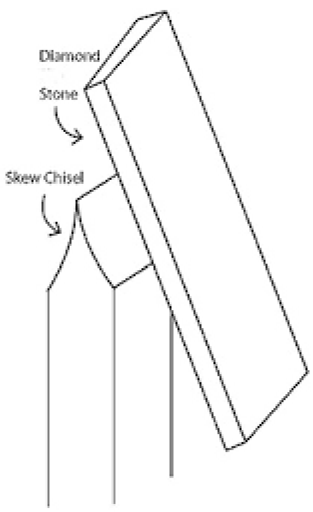


A Straight Skew


Curved skew: beginning with the **toe** (long point) grind a fairly straight section, then increase the curve to the **heel** Straight Skew (the short point).


The skew angle is 20 degrees


The skew angle is 30degrees.



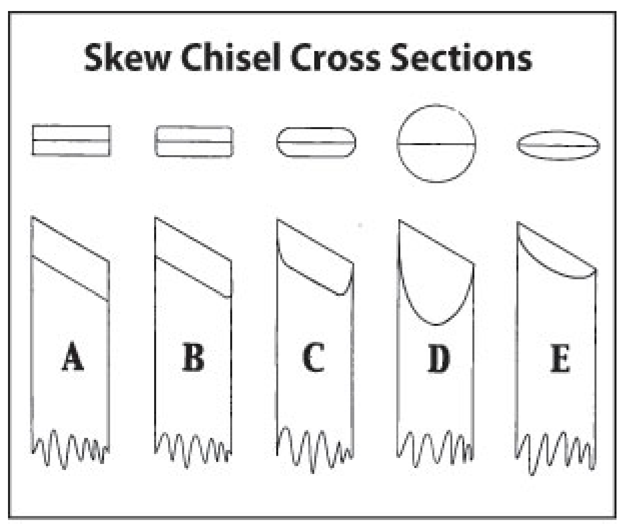


Fig 8 – Skew chisels are ground on both sides

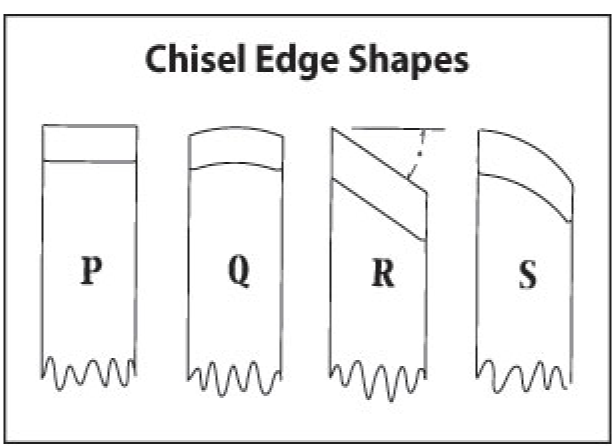


Fig 9 – Chisel shape can be straight, curved or angled

Examples of jigs

Bottom line why do you need to learn to sharpen your tools? What are you cutting how much are you cutting? An 8” diameter bowl blank is 25.12 inches in circumference so that means at 1000 RPM you have cut 2,093.33 ft. or 25,120 inches in one minute… So, a mile is 5280 ft. so every 2.53 minutes your tool cuts 1 mile of wood, and you wonder why you must sharpen your tools.

Symptoms of Dullness

1. More force is required to keep the tool stable
2. A rougher surface is produced with more tear-out
3. More Dust and less Shavings emerge from the tool.
4. More heat is produced especially with dry wood

Rules:

1. Remove the least amount of metal possible
2. Convivence – if it's not easy to get to and use you will procrastinate and use a dull tool
3. Accuracy or Repeatability – Important in a sharpening system
    a. Prolong tool life
    b. Reduce Sharpening time
    c. Reduce heat buildup (Not an issue with CBN)
    d. Satisfy Rule one
4. Tool Point Geometry and Sharpening are two different subjects
5. You need two different sharpening systems – Calm down that means to different grits of wheels. One for shaping tool geometry on new or damaged tools and a fine grit wheel for maintaining the cutting edge
6. Put your fear away! You are not going to hurt anything.

Tool Point Geometry

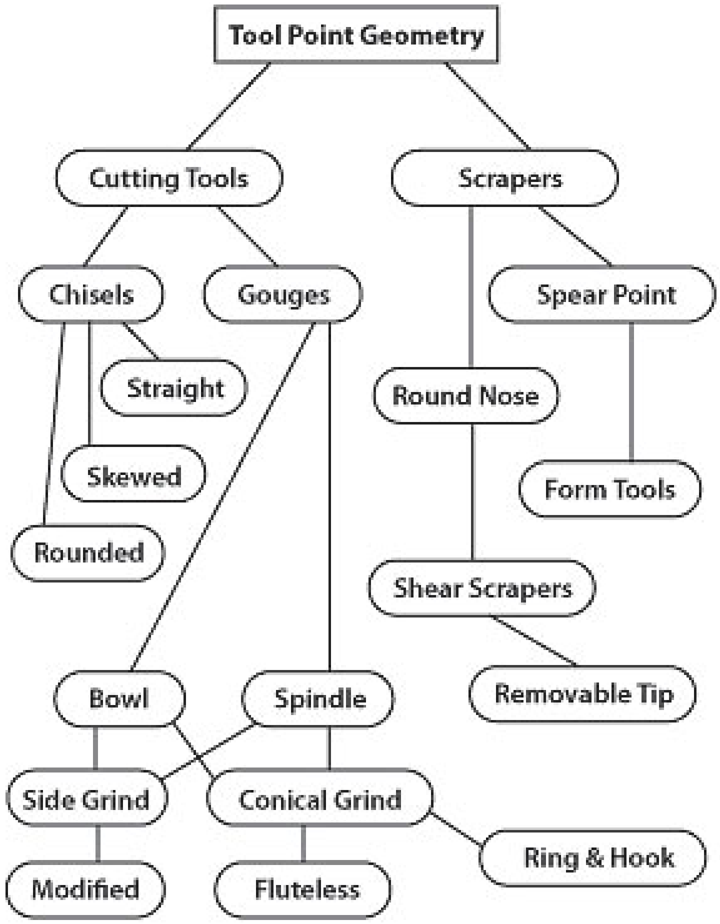
Woodturning tools are subjected to more wear and tear than any other kind of hand held tools used in woodworking. Just look at the pile of chips that accumulate around your lathe and you will be convinced of this fact.

Sharpening is not covered in detail in most of the turning books I have read. Let's divide the subject into two distinct parts.

Tool Point Geometry describes the shape of the tool. To understand this topic thoroughly, we need to explore why the tool is shaped the way it is, and how the shape affects the way it behaves.
Sharpening is the routine maintenance of the perfect edge. This operation assumes the correct geometry has previously been achieved, and we aim to keep it that way as we sharpen the tool hundreds or even thousands of times.

Basics of Tool Point Geometry

An edge is formed at the intersection of two planes – these planes may be flat, curved or a complex conical surface. The angle of intersection is called the dihedral angle, usually referred to as the edge angle. It is measured as the angle between two lines which are perpendicular to the edge at their point of intersection and lie on the respective planes.



Looking at the chart (Fig. 1), you see two main groups of woodturning tools — cutting tools and scrapers. Cutting tools are divided into two main groups — gouges and tools. As we discuss these types, we will examine two aspects of tool point geometry — the edge angle and the shape of the line which forms the edge.

Fig 2 – Measuring edge angle

The best edge angle for woodturning tools is 35 to 40 degrees (Fig. 2) although turners differ greatly in working practices. I have seen angles between 25 and 55 degrees used. Many people think that since their cabinet tools and carving tools are ground at 25 to 30 degrees, that this must be good for turning tools also. However, turning tools are subjected to much more brutal conditions than hand tools. For this reason, a blunter angle is preferred because it produces an edge which is more robust, stays sharp longer, and is less likely to overheat.

Also, unlike carving tools, turning tools are usually used at a shear angle. This means that the edge is not perpendicular to the direction of travel. This produces an effective cutting angle which is much less than the measured edge angle. To understand this concept, think about a switch-back road which ascends a mountain. The effective angle of climb is reduced because the road does not go straight up the mountain, but angles across the face of the slope. So, when we use a turning tool at a shear angle, the actual cutting angle of the edge is much less than the angle at which we ground the bevel on the tool. For these reasons, I do not think it is necessary to grind turning tools to a more acute angle than 35 to 40 degrees.

But decisions of tool point geometry should be based on how they affect the behavior of the tool in actual use. Tools which are too acute, I find, are harder to control than those ground at about 40+ degrees.

Flat Grind Versus Hollow Grind

Most wood turning tools are hollow ground. Flat grind defines the bevel as a straight line — at least in the longitudinal plane. This allows better control of the tool. If you want your tool to go in a straight line, you need a straight bevel. If the bevel is curved in a hollow shape (concave), then the tool is always trying to follow this curve, and it is a struggle to keep it going straight. That is the theory. I have not, and probably will not go to a flat grind system. While I have tried it I didn't find a vast improvement, but others have.

Nose Radius of Gouges

No factor of tool point geometry affects the behavior of a gouge more than nose radius because a smaller radius produces a narrower chip and results in a smaller cutting force. Figure 3 shows five different shapes possible from the same tool profile (or cross section). These differ only in their nose radius. The first example is a "straight across" grind (radius = infinity). This is the way we grind a roughing gouge for spindle work; it has no nose and has sharp outside corners. Until recently this is the way most English turners ground their bowl gouges too. (See Frank Paine – The Practical Woodturner, or Peter Child, – The Craftsman Woodturner) The remaining four examples in the illustration show a decreasing nose radius from about one inch down to 1/16 inch.

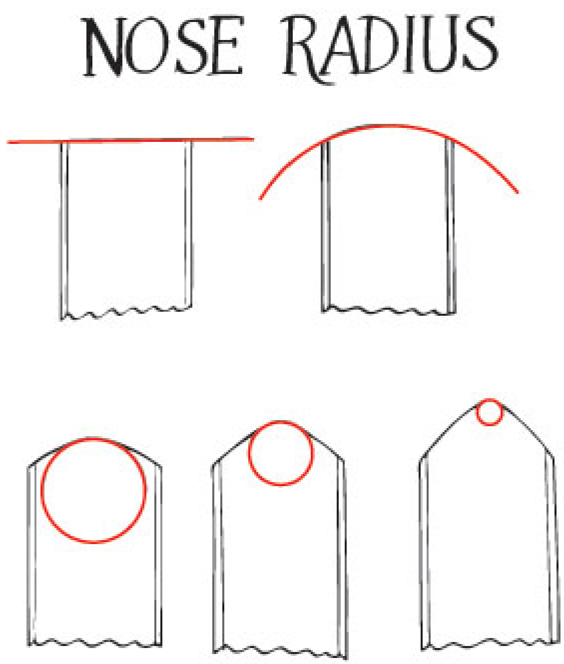


Fig 3 – Different nose radii are possible from the same chisel profile

Besides the straight across gouge already mentioned for roughing and working into corners, each of these variations has certain strengths and weakness for applications of various kinds. For example, the smaller nose radius allows for easier piercing of the surface for initiating cuts (coves) at very high vertical angles, while the wider nose tools generally make it easier to produce a smooth cut on flat surfaces or the bottom of coves.

During sharpening it is important to maintain the nose radius to the shape you prefer. Note that there are two distinct types of gouges — those forged from a flat piece of steel which has be bent into the "U" shape common to all gouges, and those created by milling a groove into a piece of round steel (Fig. 4). The milled gouge is the modern convention. Gouges made from round steel present a cross section which is thicker in the middle than at the edges. Because there is more material in the middle, this part resists the grinding process more. As a result, there is a tendency for these tools to become more pointed (toward a smaller nose radius) as they are sharpened. You must be conscious of this and slow the swing on the grinder in the middle to counteract this tendency, and thus maintain the correct nose radius.

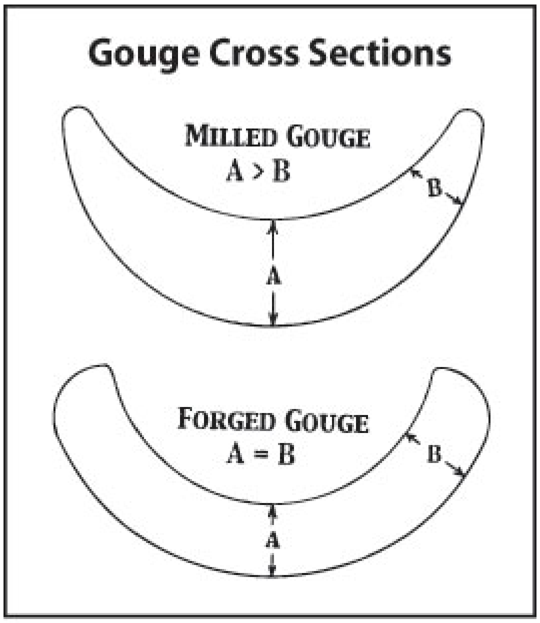


Fig 4 – Two distinct types of gouges

SCRAPERS

Scrapers are used in bowl turning, chuck, and faceplate work, where the grain of the wood is perpendicular to the axis. In this kind of work, the grain is constantly changing from end grain, to cross grain, to long grain, and a scraper is well suited to the task. Scrapers are almost never used in spindle turning.

<u>A scraper does not stay sharp very long even under the best conditions</u>, but this disadvantage is outweighed by its ability to handle variable grain direction without lifting or tearing-out the grain.

A gouge (cutting tool) is the best choice for roughing because it has positive rake, which removes wood more quickly with less friction, and the tool stays sharp longer. However, there are many situations where scrapers are necessary — smoothing and blending curves, fine details, and awkward situations where a gouge or other cutting tool cannot be presented at the correct angle.

A scraper is used in a very different manner than a cutting tool because the bevel of a scraper does not rub the work. Instead a scraper is controlled by pressure only, and the handle is held higher than the edge, giving the tool a negative rake. It is this negative rake and the ability of the scraper to take microscopically fine shavings that reduces tear-out and makes it the best finishing tool for difficult varying grain situations.

Because the bevel of a scraper does not rub, the exact angle or shape of the grind (flat or hollow) does not make much difference. Usually, scrapers are ground at a very blunt angle, corresponding to an included angle of 70 to 80 degrees. When the tool is used with a negative rake angle of 10 degrees, then the resulting clearance angle is 20 to 30 degrees.

Gouges — Axial vs. Oblique Grind

There has been a revolution in the way most turners sharpen their bowl gouges in the last 15 years. To some degree this has changed for spindle gouges too. The new geometry is usually referred to as side grind and is achieved by swinging the handle from side to side during grinding, instead of simply rotating it. What this produces is a beveled surface which is not referenced to the axis of the tool, but oblique to it. The obvious effect of this is that the gouge has longer edges on the sides (or wings) than a conventional grind (Fig 7).

Fig 7 – Side grind produces a conical bevel

These long side edges are useful in many bowl turning situations, especially reaching into end grain boxes or goblets where the cut must be made in a pulling motion (working toward the mouth).

The disadvantage of side grind is that the angle of the bevel changes whenever you rotate the tool. This means that if you rotate the gouge during the cut (to alter the shear angle), the gouge reacts by changing its direction. On a conventionally ground gouge, the angle of the bevel is constant with respect to the handle, and you can rotate the gouge any way you like during the cut (to alter the shear angle) without changing its direction of cut. Also, it is much easier to start a cut when you know that its angle is not dependent on the rotation of the tool.

SKEW TOOLS

Skew tools are part of a whole class of spindle turning tools which are ground on both sides. Most skews are made from rectangular stock, and the corners are extremely sharp (Fig 8-A). The tool cannot successfully be used in this condition because the corners dig into the

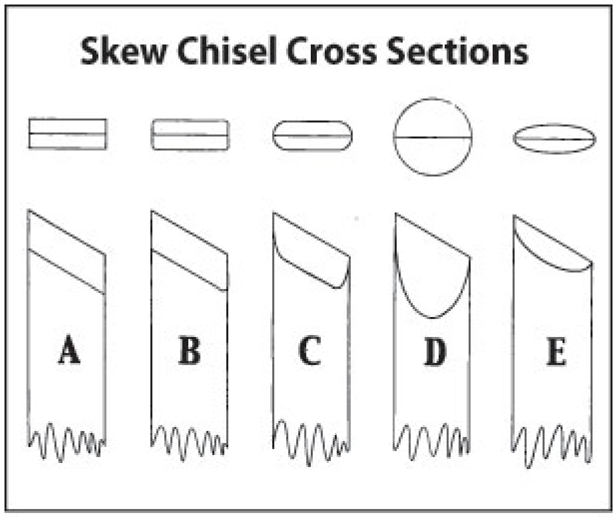


Fig 8 – Skew chisels are ground on both sides

tool rest (not to mention your fingers). This will prevent the tool from sliding along the tool rest smoothly, and eventually will damage the surface of the tool rest.

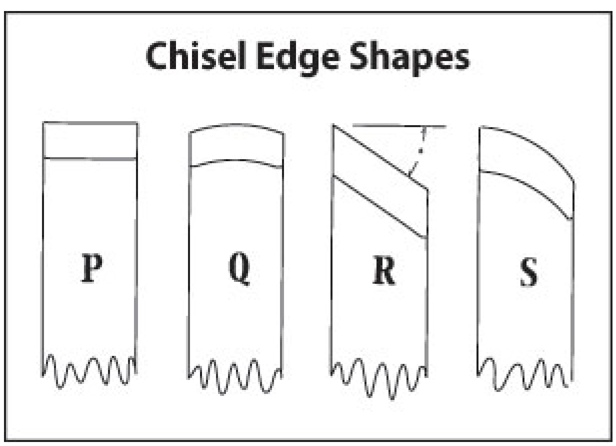


Fig 9 – Chisel shape can be straight, curved or angled

Such a skew tool can be put right by rounding over the corners (Fig 8-B). A new type of skew is now available which has its short sides completely rounded over; so, the cross section takes the shape of a race track (Fig 8-C). These are called the “rolled edge” skews, and I highly recommend them. Also, some of the new skew tools are made from round stock (Fig 8-D), and these are excellent in the small sizes. Avoid the “oval skew” (Fig 8-E) with the long sides rounded.

The shape of the edge of the tool can vary. It may be a straight line which is square across (Fig 9-P) or slightly rounded (Fig 9-Q).

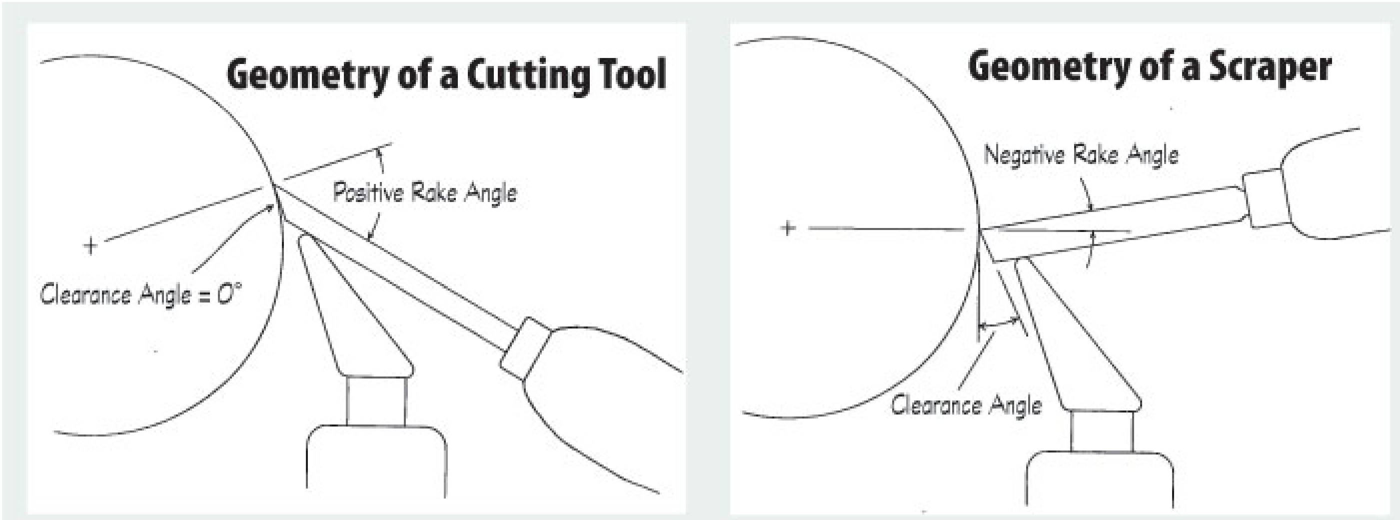
The standard skew (Fig 9-R) has a straight edge which is ground to an angle — usually 20 to 40 degrees. This is an extremely versatile tool which offers the choice of using the heel or the toe in different situations.

The edge may be a curve (Fig 9-S) which creates a narrower chip and behaves more like a gouge since it has a nose radius. Note however that a skew which is shaped to a curve does not have a distinct sharp point (the toe of the skew) and this is a limitation.

The Myth of the Original Grind

Many beginners think that they should maintain the geometry that the tool had when they bought it. While this may be true of the Ellsworth signature gouge and a few others, in general this is a dangerous assumption. The person who ground the tool at the factory probably never turned a piece of wood in his life. He is just grinding it the quickest possible way so it looks like it has been sharpened; and this is OK because it gives you a head start in regrinding the tool the way you want it.

With all the tools available and all the possible ways to grind them, there are too many variations for anyone to master in one lifetime. So, I will leave you with this final thought — Take time to experiment. If you do, you will soon realize that this article has barely scratched the surface of this subject.



Application of cutting tool results in high positive rake *Application of scraper results in negative rake*

This document was put together from my own thoughts and the from articles by Stuart and Allen Batty, Jon Siegel, Trent Bosch and a few others.