BACKGROUND FOR SHARPENING

By Larry Gould

These thoughts were engendered by the sharpening session at a recent club meeting.

Cutting

Cutting, for example what we do to wood on a lathe, involves an edged tool. A sharp edge causes extreme pressures to be generated when it is pushed into the work. The strength of the material is exceeded and the wood ruptures just in front of the cutting edge. If the tool is being pushed straight into the work, that is at 90° to the surface, the tool's bevels wedge the broken surfaces aside until the forces on these bevels equals the force pushing the tool and the action stops. However, if the tool is directed into the work but parallel to the surface, it severs a chip from the work. If the chip is thin enough, it is bent aside by the bevel and the severing continues. On the other hand, if the chip becomes too thick bending it exceeds the capacity of the machine, stopping the lathe.

If the material is frangible, like stone, it comes off as small pieces.

A tool can have multiple edges, like a file. In this case the downward force is taken on many small teeth, the individual edges sinking into the work until all the force is balanced. Then forward motion causes these teeth to cut until the gullets fill up with chips, which hold the teeth out of the work.

Saws are very narrow files and have the same characteristics. A few teeth should be in contact with the work at all times.

Grinding

Grinding is a form of cutting using abrasives. Particles of a substance harder than the work are rubbed across the surface. If the abrasive has sharp, angular facets, each particle cuts or scratches a bit of the workpiece off the surface, exposing fresh material and leaving a striated surface behind. If the particles are rounded or the edge is trailing they depress the workpiece material without removing it and leave a burnished surface behind.

Grinding, honing, and polishing are all the same operation; only the particle size is different.

There are many ways to hold abrasive particles against the work. The holding means is called the matrix.

Examples

- A lap is used to grind valve seats with the abrasive particles suspended in oil.
- A lapidary (one who uses laps) grinds facets onto gem stones using diamond powder suspended in oil.
- Abrasive in a vehicle like oil, water, wax, etc. is put on a rag to rub down a surface, such as a paint film.
- Milder abrasives are used to polish a car, silverware, your teeth....
- Similarly, a cloth buffing wheel holds the compounds used to ‘color’ metals.
- Rubber is impregnated with abrasives to make pencil erasers. Coarser grains make an ink eraser

- Rubber wheels are made in large variety to cut, grind and polish many materials. Some carvers and turners use finer grades of these wheels after grinding to make their bevels mirror-smooth. If you use them, the wheel must turn away from the edge and the point of contact should be well back on the bevel to avoid dubbing the edge.
- Glass is the most common binder for grinding wheels. The strength of this vitreous bond can be controlled so the particles break out before they are completely dull. This has two main benefits. The wheel stays sharp as new particles are exposed, and the hottest particles leave, keeping the wheel cooler. Such wheels are said to be 'soft'.
- The gray Carborundum wheels that come with most grinders are for rough, forceful use. Their binder does not release the grains under easy use, so the particles get dull. The wheel is said to be glazed. It must be reconditioned by cutting off the dulled particles with -- you guessed it -- a harder abrasive, often diamond.
- Sandpaper is used to smooth wood. If the backing block is hard, it will keep the surface flat. However, if it is soft, it will abrade the soft summer growth quicker than the harder winter wood. If you *really* like the grain to stand out, you might try wire brushes that have a burnishing effect as well. Hand or power, the length, gauge, and material of the wires can be varied to get the desired effect. Don't push so hard that you bend the bristles; get a tougher brush.
- Holes are cut in the hardest, most refractory materials using diamond core bits. Brass is used as a matrix to hold the diamonds in place. The bits are water-cooled to keep the diamonds from melting out of the brass.
- Metal parts are often tumbled in barrels. The variables to be controlled are the angle of the axis of rotation (horizontal to vertical), the speed of rotation, the shape of the barrel interior (hex, octagon, round, fins, etc.), wet or dry, presence of abrasive particles; their size and shape. With this process you can remove the burr from a stamping, modify the surface finish, or even radius all the corners. The abrasive can be grains of any grit size (to grind, hone, or polish) but they are often small stones, called *media*, whose shape, size, and abrasive qualities are selected for particular results.
- A similar technique substitutes a vibrating bowl for the tumbling barrel. This is called vibratory finishing.
- Water-washed pebbles are not rounded by the water flow. The came all the way down from the hills being tumbled against each other until all the corners were worn off.
- For my last example I will give the largest, slowest abrasive I know. When a glacier comes down a valley that is V-shaped it drags a lot of stones along. Think of the ice as the matrix holding the abrasive stones against the bedrock. In a few thousand years the valley is scooped out to a flat bottom, like Yosemite, much lower than the original valley, and the side streams are now 'hanging valleys' high up the cliff face with waterfalls to the flat floor. The original valley has spread the rocks and gravel out onto the plain below or sent them down the river as soil.

Shaping a tool

Grinding an appropriate bevel on a tool requires removal of a lot of metal. Heat build-up is a problem, since the metallurgy of steels changes when the annealing temperature is reached. For older lathe tools (carbon steel) this occurs about the time the tool turns blue. All the blued material should be ground away without overheating to expose harder material. This nicety is not important for wood turning since even softened steel can cut wood. The effect is: the tool will get dull much sooner. After a few regrinds the tool will be back to normal life between sharpenings.

High-speed steel is a big improvement for three reasons. The metal is harder so the tool does not get dull as fast, it is tougher so a narrower cutting angle, 25°, is possible without the edge crumbling or bending, and the annealing point is much higher so a blued tool is still hard.

The usual figure for the improvement over carbon steel is eight times. This doesn't quite work out in practice, because the turner doesn't mind touching up the tool occasionally. However the improvement is so great and the cost so reasonable that no one should buy carbon steel tools. If you *find* one, O.K. but don't *buy* one.

How do you sharpen without overheating?

- Go slowly. Very light force against the wheel, slow surface speed.
- Cool the tool in a water pot frequently. Run your hand down the tool's shank toward the edge (but not far enough to get burned) to judge the temperature.
- For Carborundum (gray) wheels dress the wheel when it gets shiny.
- Don't use Carborundum wheels. White or pink aluminum oxide wheels grind cooler for the same metal removal rate.
- Use a water-cooled slow-speed wheel. Caution. Some of these machines (depending on RPM) must be emptied between sessions. One side of the wheel is soaking in water while the other side dries and is therefore lighter, causing a severe imbalance.
- Lift the tool off the surface of the wheel but keep it in the 'breeze' that the rotating wheel creates.
- Sharpen a few tools at once, laying each one aside to cool while you grind the next for a while.
- Do not let the grindstone accelerate to full speed. Shut the motor off and use the wheel while it is coasting. This is a poor technique, but may get you through some delicate job.

Bevel shape

Three styles are possible; hollow-ground, flat, and convex. Although all are used, hollow-ground is by far the favorite of knowledgeable turners. While flat bevels may seem better in theory, since the bevel must rub the work, in actuality only the heel of hollow-ground tools rubs work whose diameter is larger than your grinding wheel and that seems to be satisfactory. I understand carvers use convex bevels for better control, prying the edge upward while moving forward to generate a curved surface.

Although grinding jigs make a perfect shape, it might be better to learn to do it freehand. Perfection of shape is not required since the tool is hand-guided in use. You can then sharpen anywhere, on anyone's grinder. It gives a craftsmanlike feeling, taking you back to olden times.

There are two ways to hand grind the fingernail shape. The best way is to swing the handle from side to side as the tool is twisted. Once roughly shaped, try to make one smooth pass to the left and one to the right, keeping the area being ground at right angles to the wheel's motion.

The other way is to keep the tool pointed in the same direction (no swing) but raise it higher on the wheel as you twist around to the sides. I find it harder to get consistent results and the striations are not perpendicular to the edge.

Why hollow-ground?

After gouges are ground, the bevels are striated (grooved) but the flutes are polished (that is, the striations are much finer). There is a burr thrown into the flute by the grinding action. If the grinding has been delicate, the burr can be removed by stabbing it into end grain. A slipstone can also be used to remove the burr, holding it flat and moving it toward the edge onto the tool. The burr will often come off in one piece, and is therefore called a 'wire edge'. If the next use is a rough cut, there is no need to remove the burr. The ground tool, complete with burr, is put to use and the flying chip carries the burr away. The edge, though, has "teeth" whose size corresponds to the abrasive's grain size.

If a finer edge is desired, a finer abrasive, called a hone, is used on the bevel. It is used across the hollow- ground bevel, bridging from heel to edge. The heel must be kept against the hone to keep the angle at the edge. Only a few strokes are required even though the abrasive is fine since you are only cutting down the points of the striations at the very edge (and at the heel). The resultant flat areas can be seen and perhaps a smaller burr is raised in the flute. This can be felt (easier than it can be seen) by moving your finger off the tool across the edge. It can most likely be ignored, or a single sweep of the same slipstone can be used, keeping it down against the metal of the flute, of course.

A roughing gouge is ground 'straight across', giving a long curved edge that is everywhere the same angle to the handle. It is used in one spot until it dulls and does not cut as well. Then the tool is rolled slightly and the next bit of sharp edge is used until it also is dull. This continues until the whole edge is used up.

This gives a functional meaning to the word ‘dull’: It does not cut as well. Under a microscope the edge can be seen to have a radius instead of a sharp angle. This makes it require more force to sever the wood since the force is spread across a larger area. It also means that the angle where the tool hits the wood at the edge while the bevel is rubbing is much larger.

It is also possible to see the dulled edge. Hold the tool toward a light source so the light glances off the tool toward your eye. You cannot see a sharp edge, but the dull areas look bright.

The tool should be sharpened. However, it is not necessary to regrind it. It can be honed to a new edge. This time, however, you are not just removing the scratches from the grinder. You have to hone away the complete radius. A coarser hone may minimize honing time. How can you tell when you’ve gotten it all? While the radius is still there, no burr is raised. When the edge becomes thin enough, the abrasive particles coming toward the edge bend it back, forming a burr. Stop honing when you feel a slight burr along the whole edge. Then one or two strokes of the slipstone removes it.

Honing can be repeated a number of times. Each time the flats are larger in area and honing takes longer. When you find it taking too long, regrind, but not all the way to the edge. Just clear away the metal to narrow the flats at heel and edge to make honing easier. In this way the edge is always sharpened with the finer abrasive and you get maximum use of the metal.

Honing can also be motorized. Commercial machines are available, but a hone can be made on your lathe to fit a grinder. Use an anisotropic material like particle board. Make it larger than your grindstone. Then load it with an aggressive compound. In use it turns away from the edge and the hand-held tool is placed with the bevel flat, then raise the handle or draw back slightly to hone to the edge.

Diamond-impregnated hones are most satisfactory because their surfaces remain flat. With other hones or bench stones you must sharpen tools all over the abrasive surface to keep it flat or else grind the surface flat periodically, which wastes the material.

A slipstone can be much finer abrasive than the hone since it only removes a small area of metal, the burr. When used, it also polishes the flute.

Those striations

Even the hone or the slip leaves striations, although they are smaller. If the hone is used parallel to the edge, that last groove next to the edge is going to weaken the metal and it may break off in use. Also, the chip is going to grate across those grooves. It is better to have the groves at right angles to the edge, which may look like a microscopic sawtooth, but the chips will be sliding along the grooves on the surface and the metal of the edge will be well supported.

Moving the hone at right angles to the edge is easy with a straight-edged tool or a roughing gouge, but a fingernail gouge requires a curving, tilting sweep.

One difference between a chisel and a gouge is the absence of a polished flute where the chip slides. This doesn’t seem to matter to me since I sand my work, but if you are making a lot of spindles you can cut down the amount of sanding required by polishing your skew’s bevels.

Loading

Sometimes the chips cut by the abrasive particles adhere to the wheel and interfere with the cutting action. This is a second reason to dress the wheel.

This is generally true of abrasive processes. The chips and spent abrasive particles are called swarf.

- Sandpaper must be clapped occasionally to clear away the sawdust.
- Orbital sanders are provided with holes through which the sawdust is drawn.
- If sandpaper loads when sanding an oiled finish it can be cleaned with a wire brush.
- Oil or water is used on bench stones to permit the swarf to be picked up by a rag or paper towel.
- The rag must be rinsed occasionally when you compound a car.
- Japanese water stones use an abrasive that breaks down in use. These finer particles load the stone, keeping the coarser particles below from cutting, and polishing the bevel without a second operation.
- The water used to cool diamond core bits also carries the ‘chips’, in actuality dust, away.

Some other points

When sandpaper is manufactured static electricity is used to align the particles and stand them on end in the glue matrix. This means the longest, sharpest points are facing out. As the sandpaper is used these scratchy points are dulled or broken out and the sandpaper cuts like a finer grit. Us frugal people keep using it, but others discard it and take a fresh piece.

One problem with abrasives is mixing a grain (or more) of a coarser abrasive with a batch of uniform size. This is common with sandpaper and causes a new scratch instead of removing the previous scratch pattern. There is no way to fix it but starting over with a grit coarse enough to rapidly remove the scratch and then repeat the finer grades. This can be minimized by keeping fine sandpaper on top in your drawer or cabinet and shaking or brushing each piece before use.

When sanding near a corner do not apply force. The high pressure caused by the smaller area causes the corner to round very quickly. Of course, if you want to round the corner....

Very thin abrasive wheels are used to slit or cut off. They must be carefully chosen for the machine and the material to be cut. Wheels with a resinous bond are only slightly flexible. Others are so flexible they can be used in a hand-held saw without danger. Some are used with coolants or lubricants.

An edge dulls in three ways. If the metal is too soft the edge is pounded down, plastic deformation. If too hard it may be brittle and fracture. If just right, the metal wears away, abrasive wear.

During grinding the metal is removed as tiny curl chips, not as powder. A magnet can separate them from the spent abrasive.

Natural and man-made materials are used as abrasives. It is only necessary that the material break to form sharp edges. The solid material is milled to break it into small particles. It is possible to do this by hand using a mortar and pestle or a metal rolling pin on a flat plate, but nowadays heavy machinery is used. The harder the machine's elements the better; but the mill doesn't have to be harder than the material. Hammer mills, ball mills, rolling mills, etc. all apply crosswise force to the pieces, exceeding the strength of the material and fracturing it along crystal planes. The basic process is crushing, but naturally there is also abrasion. The mills wear out.

The final product from the mill has a large range of particle sizes. It is classified by screening it through finer and finer sieves, giving the grit (screen size) numbers. When this cannot be continued the remaining particles are put into water jars and shaken. They are allowed to settle for a while. Then the liquid is carefully poured off, leaving the larger particles on the bottom of the jar. This settling is done repeatedly, making finer and finer polishes. In the old days these were called by the settling time, i.e. "30 minute polish", etc.

Our ancestors developed these techniques about one hundred thousand years ago, as shown by their polished stone tools. The New Stone Age is defined by the technique of abrading. Before that they could only pressure-flake their stone tools to get edges sharp enough to cut wood. Technology marches on, but the older techniques are always available to us. It is still possible to use a broken piece of window glass as a cabinet scraper.

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