taking control of your own metallurgy

Woodturning Chisels You Can Make

by Jon Siegel

Figure 3 – Grinding a Flute. The round nose grinding wheel is used to grind the flute into the steel rod. Grind to a depth that is just a little more than half way.

Anyone can make woodturning chisels by following these instructions. In doing so, you are not trying to approximate a standard factory-made chisel. Instead you are creating a "hard tip" tool. In many ways, this is better than a factory chisel. The cutting edge is extremely hard and durable, while the shank is tough and strong. A gouge made with a short flute is much more rigid than one with the flute running the whole length – Figure 1.

There are many approaches to making chisels in your own shop. You can use pre-hardened high speed steel (tool bit stock). This was covered in an excellent article by Bob Rosand in *American Woodturner*, Summer 2001. I do not use this type of material because it is available only in a limited number of sizes and it is expensive. Or you could use files, springs, saw blades, etc., and this is covered by John Lucas in *American Woodturner*, Spring 2001.

But in this article, I will explain how to make chisels out of high carbon tool steel, such as drill rod, which you can buy from any machine shop supplier. I prefer this type of steel, because it is consistent, easy to harden, and very low cost.

Heat Treatment

Much mystery has been attached to heat treatment because it has a long and somewhat clouded history. The discovery of how to convert iron into steel and its heat treatment (Anatolia, 1200 BC) is what made iron superior to bronze and ushered in the Iron Age. The result of this is that today 95% of all metal products are made from iron.

Centuries ago, those early smiths did not have the advantage of micro photographs, testing apparatus, or formulas which are available to the modern metallurgist. Instead they were guided only by trial and error. Yet they were able to make astonishing tools, swords, armor, and cutlery of every description. This is because heat treatment is essentially a simple process which requires only two things…

- Control the amount of carbon in the iron thus making "steel".
- Apply heat and cold to manipulate the crystals in the iron.

Fortunately, the first part is taken care of for us. Tool steel (which is a blended mixture of iron and carbon, plus a few other additives) is made in many varieties by steel manufacturers, and can be ordered from any machine shop or industrial supply company. "Carbon tool steel" is the direct descendant of those earliest types of steel discovered thousands of years ago.

Figure 1 – A collection of carving and turning chisels made by the author.

Heat Treatment Made Easy

When the steel is heated to the red-hot temperature of 1450 degrees F, the crystal structure changes. If then allowed to cool slowly, it goes back to its original form. But if it is cooled quickly (hundreds of degrees per second), that is, quenched in liquid, it will become set into a new crystalline form and thus become hard. This process is called *hardening* and it works best if the steel has around 0.9% carbon.

After the hardening, the piece may be too hard and brittle to be safely used. It is possible to take away some (controlled) amount of the hardness in the second part of the heat treatment process called *tempering*, which is *softening*.

Some authors refer to the whole heat treating process as tempering, and this is confusing. Hardening and tempering are separate processes within the heat treatment.

Before hardening, the steel can be easily cut with a hack saw or machined, but after applying the heat treatment described here, carbon tool steel can attain great hardness, which, if you want to get technical, is in the 60s on the Rockwell C scale. In other words, in the fully hardened state (called Martensite) it cannot be filed, sawn, or scratched by any steel tool. It is not machinable, and can only be worked with abrasives.

One of the most amazing things about this hardening process is that it is reversible. By simply heating the steel as before (to 1450 F), but cooling it slowly, the steel is made soft again. That is the opposite of hardening, and is called *annealing*. Fast cooling makes it hard, and slow cooling makes it soft. This process can be reversed a number of times if necessary until eventually the carbon evaporates from the surface.

Using Known Tool Steel vs Unknown Scrap Steel

At one time, I thought it was clever to beat the system and make tools out of free pieces of high-carbon steel – springs, axles, etc. I had been influenced by Alexander Weygers, a wood sculptor who took up blacksmithing in order to make better chisels. He wrote two excellent books with lots of good information on hardening and tempering with simple equipment. They are *The Making of Tools* (ISBN 0-442-29360-7) and *The Modern Blacksmith* (ISBN 0-442-29363-1). Although woodturning chisels are different from sculpting chisels, these books are a great starting point.

However, now I purchase new tool steel to make my chisels. It didn't take long before I realized that I had invested too much labor in the forging and grinding of the tools, only to have them fail later because of imperfections (cracks), or in the heat treatment process. I realized that compared to this labor, the cost of new tool steel is minimal.

Which Steel to Buy

Steel that is near one percent carbon and is specially formulated to be hardened is called "tool steel".

Basic carbon tool steel comes to two varieties – a type to be quenched in water W-1, and a type to be quenched in oil O-1. The latter type O-1 is somewhat more expensive, but is less likely to crack in the quenching process. Also O-1 comes in rectangular shapes as well as round, while W-1 usually comes only in rounds (referred to as "drill rod"). W-1 is still my favorite for making turning chisels, because I make both skews and gouges from round stock, which is very inexpensive. For example, one piece of ⅜″ drill rod (36 inches long) cost $3.15, and is long enough to make four chisels. That's $0.79 per chisel!

Sources for Tool Steel

MSC Industrial Supply Co.
800-645-7270 *www.mscdirect.com*
ENCO
800-873-3626 *www.use-enco.com*

When you receive your tool steel, you may want to take a small piece through the hardening process just for practice and then test it to see if the hardening transformation has taken place as planned.

How can you test the hardness without a $5,000 testing machine? The most common method used by general mechanics is the file test. Simply use an ordinary file on the workpiece. If the file "bites" and scratches the steel and there are some shiny filings produced (no matter how small), then the steel is not hardened. If on the other hand, the file slides over the workpiece as if the file had no teeth, then the steel is hardened. Note that this action will ruin the file. It is best to keep a few throwaway files on hand for this test.

Shaping the Chisels

Grinding the bevel on some chisels, such as skews and scrapers is a simple operation. The only additional thing you will need to make your own chisels is a VERY COURSE GRINDING WHEEL. You should not attempt to use the same grinding wheel for shaping the steel as you use for routine sharpening. These are distinctly different processes, and require different tools. For shaping steel, I recommend a 24 to 40 grit wheel. This will allow you to shape the point of a rough blank in a few minutes with a minimum of heat build up.

Making Gouges

Grinding the flute into a gouge is more complicated than making skews or scrapers. It requires the use of a grinding wheel with a convex radius which matches the shape of the flute.

Figure 2 – Dressing the Wheel. The diamond dressing tool is used to form the grinding wheel to a round nose.

It is easy to round the edge of a grinding wheel to any radius desired with a diamond dressing tool. Many woodworkers do not own diamond dressers because they incorrectly think they are expensive. In fact, small diamond dressing tools (¼ carat) cost only about $6. If you own a grinding wheel, then you should own a diamond dressing tool. The tool consists of a round steel rod (about 6″ long) with a diamond attached to one end.

Source for Diamond Dressers

ENCO
800-873-3626 *www.use-enco.com*

To use the diamond dressing tool, place it on the tool rest of your grinder and work it slowly the same way you would use a small scraper to turn wood – Figure 2.

Always use a dust mask or a collector because there will be a lot of abrasive dust produced. Be careful that only the diamond touches the grinding wheel and do not to let the wheel touch any part of the metal rod or you may grind away the metal which is holding the diamond in place – the diamond will fall off.

Wheels for Grinding Flutes

In recent years, woodworkers have discovered that white and pink aluminum oxide grinding wheels are better than the old fashioned gray wheels. They are softer, and as the surface breaks away, they continuously expose sharp grains of abrasive. Therefore they grind with less heat build up, and since they are "friable," they are easy to shape with a dresser. I have found that the least expensive are 7″ diameter wheels designed for surface grinding machines. They are available in ¼″ and ½″ thickness for under $10. The only catch is that they have a hole size of 1¼″. This means that you will have to make a bushing to reduce the hole size to fit your grinder. Of course it is best to go into the machine shop and make one out of metal, but *perfectly good reducers can be made out of maple.*

What You Need for Making Chisels

1. Tool steel – either round rods or rectangular flat stock
2. Hack saw
3. A very coarse grinding wheel for "roughing" the shapes
4. Several thin grinding wheels
5. A diamond tool for dressing grinding wheels into round profile shape for grinding flutes
6. Propane Torch (or two) – MAPP is better
7. Magnet
8. Water
9. Motor oil
10. Chisel handle – turn your own

Procedure

1. Cut the steel to length. Use a hack saw. Allow for one or two inches to go into the handle. Lightly chamfer the cut edge on a grinder or belt.

2. Drive the steel into the handle. Nothing could be easier than fitting a round rod into a handle. If your chisel is made from flat stock however (for example a ¼″ x ¾″ skew chisel), you will have to make a TANG on the end which fits into the handle. If you have a way to hot forge, this is the best. Another way is with a metal cutting band saw, but if you don't have one, just grind the material away with a very coarse wheel.

3. Rough grind the point. Skews, flat chisels, parting chisels, beading tools, etc. are easy to grind. Grinding the flute in a gouge however, takes some time – Figure 3. When rough grinding the chisel at this stage, you do not have to worry about overheating because the heat treatment comes later. **Follow all safety procedures for grinding wheels and always use a guard even if one is not shown in the photos.**

4. Heat the steel to 1450 degrees F. You can tell when you have reached this temperature because a magnet will no longer stick to the steel. While heating the steel, touch the magnet in quick jabs. Do not let the magnet get hot or it will be ruined.

   As you heat the steel, the first thing you notice is oxidizing of the surface and several colors are seen. These are the tempering colors, and are not important for now, as we pass through this temperature range (about 500 degrees F) on the way up to 1450 degrees F.

Figure 4 –Heating to the Hardening Temperature (1450 degrees F). Notice that the magnet and the quenching liquid are within inches of the torch.

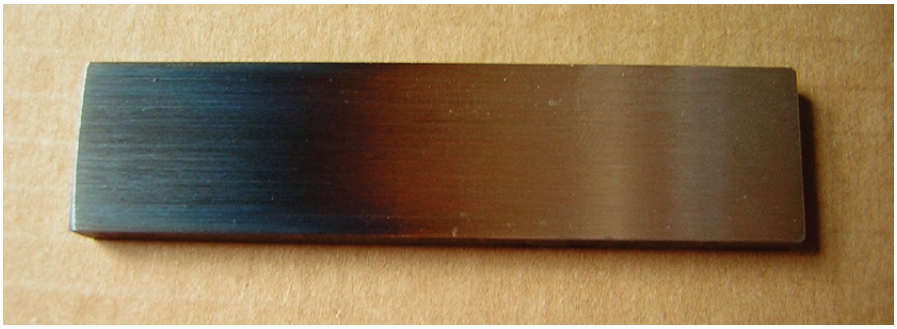

Figure 5 – Tempering Colors. The first tempering color to be seen is light straw, and this is sufficient for woodturning chisels.

At some point, you will see the metal start to glow. The temperature of the first noticeable glow (blood red) will vary depending on how bright it is where you are working. In a darkened room, it will be about 1000 degrees F, but in bright light, it could be 1200 or 1300 F. You should start checking with a magnet at this point. Do not let the temperature drop as you do the magnet test. Keep the temperature rising. The color gradually changes from dark red to cherry red – Figure 4. When the first inch or so of the chisel is glowing evenly and the magnet does not stick at all, you are ready to quench the steel.

Steel above ⅜″ diameter may be difficult to reach temperature with an ordinary single propane torch – MAPP is better. Two torches working together will handle up to ½″ thick steel. Oxyacetylene, however, is ideal for larger sizes.

5 Quench in water or oil. As you take the chisel from the flame to the quench, do it instantly so there is no time for it to cool off en route. Have the quench liquid within inches of the location where you are heating. As the chisel enters the liquid, SWISH IT VIGOROUSLY IN A CIRCLE. Continue the motion until the cooling is complete – about 5 seconds. Use either water or oil according to the type of steel.

6 Draw the temper. Tempering is the reheating of the chisel this time to a much lower temperature (300° to 600° F) to remove some of the hardness and brittleness. Not all chisels need to be tempered. You will lose some hardness in the tempering. But chisels with very acute edges need to be tempered to prevent the edges from chipping. The right temperature is judged by comparing the color of the oxide coating – Figure 5.

To see the oxide coating, you must, before tempering, remove the black scale which formed in the hardening stage. Use an oilstone or some fine sandpaper until the surface is bright at least on one side.

You should stop at the FIRST tempering color which is YELLOW (440 degrees F). Subsequent colors correspond to these temperatures – straw = 480, brown = 510, purple = 540, blue = 580. These represent greater degrees of softening. Tempering beyond yellow or straw will reduce the edge holding properties of the chisel, but might be necessary for some chisels such as those for mortising deep holes.

7 Finish grind. As with all carbon steel tools, do not let the steel get above the tempering color (yellow) during finish grinding or the hardness will be lost. If you let the steel get to the purple or blue color, even for an instant, it is ruined, and will have to be rehardened. Therefore when you grind the tool, keep the point of the chisel cool by using light pressure, and cooling in water if necessary. If the chisel sizzles when it hits the water, it's too hot!

I hope this article has helped to "demystify" heat treating and tool making for you. I have found there is nothing more satisfying than turning wood with chisels I made myself. ■

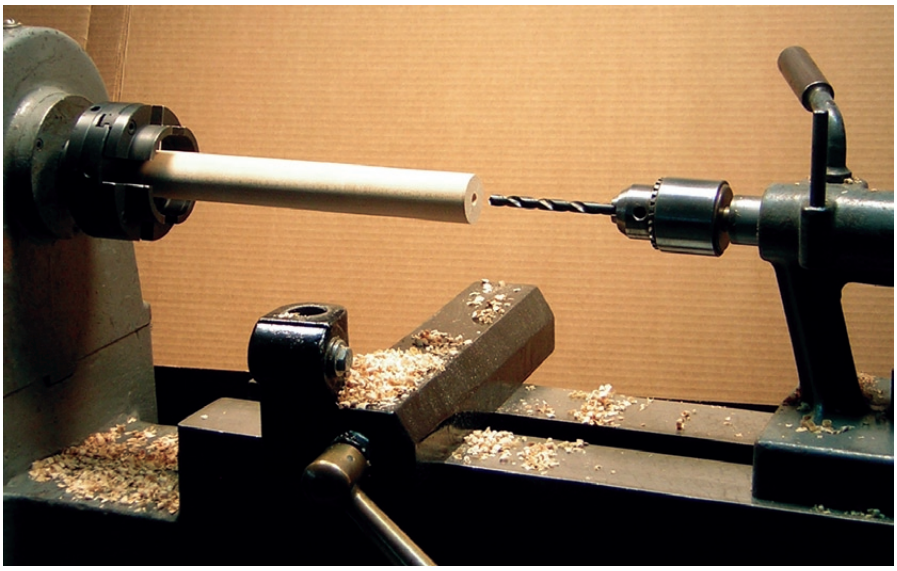

Figure 6 – Drilling the Handle. After the drilling, the work is placed between centers, and the tailstock center fits the drilled hole.