

Steps in making turning tools using high carbon steel

One of the nice things about using high carbon steel for turning tools is:

1. It is cheap and readily available.
2. It is easy to work in the home workshop using normal tools.
3. It is easy to draw the temper of a tool providing a hard enough steel to hold an edge yet flexible enough to resist breaking.
4. It allows for the fabrication of special tools to do a specific job quickly and cheaply.

But, high carbon steel has its drawbacks as well:

1. It doesn't stand up well to heavy cutting on the lathe. The cutting edges are dulled quicker than high speed steel tools.
2. Heavy cutting at high turning speeds can heat the tool up and draw the temper from the steel.
3. One must be more careful when sharpening on the grinder as this can also overheat the steel and draw its temper.

It is important to introduce the term temperability of steel at this point. When high carbon steel is tempered it is heated to a specific critical temperature and quickly cooled in oil, brine or water. This produces steel at its maximum hardness or temper. You can then heat gently and draw the temper to make the steel softer and less likely to break under mechanical stress yet retain sufficient hardness to hold a cutting edge.

If you purchase your steel commercially, specify O-1 steel. This is steel that must be quenched in oil when tempering. Water quenches steel very quickly and it may develop internal stresses that may result in the metal cracking spontaneously. If you choose to use free steel (junk pile), you need to make sure that the steel is capable of being tempered. One of the best ways to test an unknown piece of steel for temperability is to heat it to a cherry red color (about 1400 degrees F). At this critical point, the hot metal loses its magnetic properties (a magnet will not attract it). If the hot steel is cooled (quenched) by immersing in a volume of room temperature boiled linseed oil or olive oil (a much safer quench all around), the metal surface should have a pearl grey color. Run a file across the pearl grey area and if the steel is temperable, the file will skip across the metal surface like a needle over glass. This state of the metal is called "dead hard" and is extremely hard and very brittle. Conversely, if you take steel and heat it to the critical temperature (where it loses its magnetic properties) and cool it slowly by thrusting it into a can filled with dry sand and allowing the metal to cool to the touch, it will lose all temper and become very soft and malleable. This is called annealing the steel.

The best steel to use is drill rod that can be purchased in some tool stores and machine shop supply stores. Used steel such as car springs, solid valve stems and even old bed rails are good sources of temperable steel. Old files are excellent carbon steel but

extremely hard and brittle and can break along the grooves of the file if used without removing them . The files must first be heated and slowly cooled to remove the temper of the metal (annealed) and all of the grooves ground off. The file can then be shaped by grinding and hand filing and then reheated and quenched to dead hardness.

Drawing the temper of steel

As a steel heats, its shiny surface changes color caused by the oxidation of the metal and each temperature produces a distinct color. Each color corresponds to a specific hardness of the metal. This gradation of color is known as the oxidation color spectrum. The chart below illustrates how color equates to hardness relative to its use as a tool.

Light Blue	640 deg F	No temper remaining-maximum softness to the steel	
Full Blue	590 deg F	Temper mostly gone	
Purple	550 deg F	Too soft for tool use	
Peacock	540 deg F	For thin delicate tools-hand pushed	
Bronze	520 deg F	For heavy gauge wood carving gouges-hammer struck or lathe tools	
Deep Straw	475 deg F	For center punches, small cold chisels, etc.	
Straw	440 deg F	For large cold chisels, star drills, etc	
Light Straw	400 deg F	Probably too brittle for most tool use.	

Making your first tool.

Equipment you will need to make a tool of high carbon steel.

1. Temperable steel or drill rod. This is locally available at most jobber's tool stores (not Lowe's!) and machine shops. It comes in 3/16" to 1" diameters and 3 ft long. About \$3-\$6 depending on the diameter. This steel is already soft (annealed) and requires no heating and slow cooling to remove the temper.
2. Grinding wheel
3. 4-1/2" hand held grinder
4. Hack saw
5. MAPPS gas and MAPPS torch head.
6. Standard propane gas and propane torch head.
7. 220 and 320 grit abrasive roll
8. Magnet
9. Vise, pliers, mill file
10. Boiled linseed oil or olive oil.

Step 1:

Cut a piece of drill rod 8-9" long. Shape the tool cutting edge profile with a grinding wheel. Don't worry if the steel gets hot and turns blue...you will re-temper it later on.

Step 2:

Using a MAPPS torch, heat the 1st two inches or so of the cutting tool end. Bring the color of the metal to a bright cherry red or until it loses its magnetic properties. Then quench the steel into a container of linseed oil or olive oil. When cool test for dead hardness with a file.

Step 3:

Polish the grey oxidation with fine abrasive cloth. The shinier the better because it will be easier to see the oxidation colors when you draw the temper in the next step.

Step 4:

Use the standard propane torch as a heat source for this step. Heat from propane is not as intense as MAPPS and is easier to control the drawing process.

Have a can of water close at hand. Gently heat the first 3-4" of the tool for about 30 seconds by moving the steel through the flame. Start the annealing or drawing-the-temper process by focusing the flame about 3" from the tip of the tool turning it slowly in the flame. Watch closely and the metal will start to go through the oxidation spectrum. The first color to appear is faint straw. This may be difficult for the beginner to spot but the next color (straw) is easier to see. The successive colors of the oxidation spectrum (see chart above) form as the steel get hotter at the heating point. The spectrum moves away from the heating point in both directions. Once the blue/peacock color forms you will want to pull the steel away from the flame a bit to reduce the speed at which the color spectrum moves toward the tool point. Watch carefully and when the bronze color covers the 1st inch or so of the tool point rapidly cool the steel in the water bath. If you miss the quench point and the color of the 1st inch of the tool is blue, simply reheat and quench the tool to dead harness, polish and repeat the annealing process.

If you have a small deep fat electrical fryer, ie. *Fry Baby* and it will heat oil to at least 450 degrees Fahrenheit, you can anneal the dead hard tool by immersing it for an hour or so.

Sources:

1. MAPPS and propane gas and torches can be found at home improvement and hardware stores such as Lowe's, Home Depot, etc.
2. Drill rod is available at most jobbers tool stores such as Fastenal in Temple and I believe in Waco as well. You can order O-1 steel from Enco Supply (use-enco.com) or MSC (mscdirect.com)

Web links:

1. alanlacer.com. Alan describes the making of the basic hook tool.
2. aroundthewoods.com. This is Darrell Feltmate's web site that describes the making of all sorts of tools. Highly recommended.
3. laymar-crafts.co.uk. Excellent source for tool-making ideas.
4. woodturningonline.com. Another great source for tool-making ideas.