OFFICIAL JOURNAL OF THE BRITISH HOROLOGICAL INSTITUTE

The Horological Journal

DECEMBER 2022
www.bhi.co.uk

Constructing a Wedge-Style Hand Vice

Part 1/2 – First Steps in Design and Making

Clickspring

The need to hold small work pieces securely has led to the invention of many different types of hand vice. The popular wedge-style vice is one such device that is perfect for holding thin rods as well as many other small shapes, **Figure 1**. The design for the version I will discuss in the first of this two-part article performs well for many common workshop requirements, and I have given it a mildly horological styling, with cheese head screws for the pivot/fasteners, and a pleasing contoured profile.

Figure 1. The popular wedge-style vice.

Of course, this sort of tool could be easily bought from a commercial tool supplier. However, there is much valuable workshop experience to be gained from making this sort of tool from scratch. The parts list is quite variable in terms of the operations required, and it presents an excellent opportunity to build experience on both the lathe and mill, as well as several hand-finishing processes commonly required in the horological field, **Figure 2**.

Figure 2. The parts list presents an opportunity to build experience with several hand-finishing processes.

For materials, I used O1 tool steel in the form of a drill rod and ground flat stock for most of the main structure of the tool, free machining brass for the jaw ends, and EN8 medium carbon steel for the fasteners. Commercial wooden handles are readily available, but a turned handle could, of course, also form part of the project if desired*.

The Threaded Cone

The project commences with what I have called the threaded cone. I made this from a length of 1in diameter drill rod, with a view to heat-treating it. The steel is probably hard enough as provided in its annealed state to resist significant marring from the jaws as the tool is operated, however heat-treating the part after the features have been produced will remove any doubt and ensure a longer tool life.

As a preference, I do almost all of my turning (regardless of the material) with tools made from high-speed steel cutters: I like the flexibility of being able to grind any shape I need for the job and I find it gives an excellent surface finish.

It's rarely practicable to grind in a chip breaker, and usually this doesn't present a problem. However, O1 steel often tends to produce long stringy chips. They're super sharp, with nasty serrated edges just looking for a finger to cut. So, in this situation, I will generally make life a little more pleasant, and switch to carbide inserts for the bulk stock removal, see **Figure 3**.

In my limited experience of using this sort of turning insert, I've noticed that they seem to generate the most manageable chips when loaded up with a decent depth of cut (DOC), in this case 1.2 mm. However, experimenting with the depth of cut will show what works best for your given combination of lathe and cutter. For the final pass, I generally return to HSS to leave a suitable surface for the next operation.

The taper for the threaded cone is produced using the lathe top slide, suitably set up for an included angle of 30 degrees,

* 'Drill rod' is the American term for what we traditionally call 'silver steel'; this is normally supplied as centreless-ground bar. Similarly, 'gauge plate' is the usual term for 'ground flat stock'. – *Tech Ed.*

Figure 3. Switching to carbide inserts for the bulk stock removal.

Figure 4. Set up for an included angle of 30 degrees.

Figure 5. Note the undercut at the start of the thread.

Figure 6. Wire and powdered boric acid paste is applied.

Figure 7. Polishing permits observation of the tempering colours.

Figure 8. Running the oxide colours up from the shank section.

Figure 9. The part is tapped home into a suitable handle.

Figure 4, and the centre hole is drilled and tapped according to the accompanying drawings. One point worth noting is the undercut at the start of the thread, **Figure 5**. This is intended to permit the threaded insert to pass cleanly into the opening when the tool is fully closed.

Next up is the heat treatment, and care should be taken to protect the internal threads from oxidation during this process. Powdered boric acid mixed into a stiff paste with methylated spirits is an effective protective measure, and in this case it should be generously packed into the internal thread as well as around the exterior of the part. The common 'wire-basket' is an acceptable method to keep the paste proximate to the part exterior during the heating process, again with a generous application of both wire and paste, **Figure 6**.

Once heated and quenched, an old file (dedicated to this role) serves as a convenient and reliable test of the effectiveness of the hardening process. If it should skate over the surface, then all is well. Should the file bite, even just a little, then something has gone awry with the heating and quenching process, and it must be repeated.

Assuming all is well, the part is returned to the lathe for polishing to permit clear observation of the tempering colours, **Figure 7**. A gentle heat from a propane torch on low is sufficient to temper the cone section to a medium straw, most conveniently by running the oxide colours up from the shank section, **Figure 8**. Another polish of the main tapered surfaces on the lathe will enhance the final surface of the tapered area, and the part can then be tapped home into a suitable handle to complete this part of the tool, **Figure 9**.

The Threaded Insert and the Centre Pivot Block

Next is the central body of the tool, which accepts the jaws, pivot screws and the return springs. It would be quite reasonable to fashion this component from a single length of round stock. However, to keep things a little more straightforward, I've specified construction as two separate components, to be assembled with a press-fit upon completion.

One part is the threaded cylinder that feeds into the tapped cone, and the other is the pivot block that holds the jaws. Even with this simplification, there are some interesting features to be formed for the pivot block which require a bit of forward planning to ensure a good result. The central hole needs to be sized for the aforementioned press-fit, and the other features must be well centred on the axis of the part for the tool to work correctly. The order of operations is illustrated in **Figures 10 to 15**, which brings the component to the point when it is ready to be pressed on to the threaded insert, **Figure 16**.

Next is the threaded insert, starting with the thread itself. I have to admit I'll take just about any measure to avoid having to use the change wheels on my lathe; they really are just so

Figure 10.

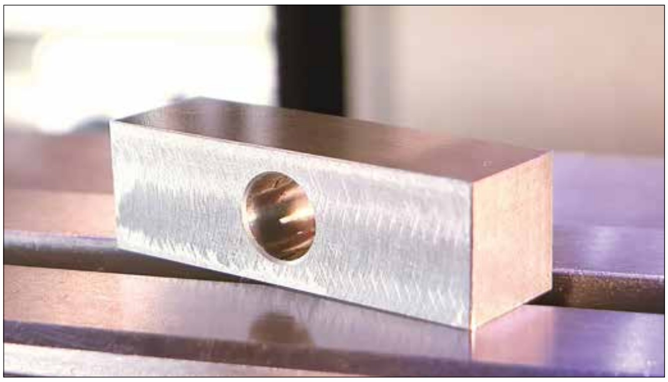

Figure 11.

Figure 12.

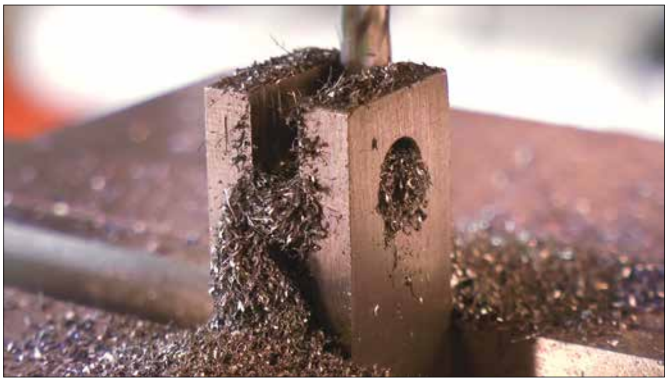

Figure 13.

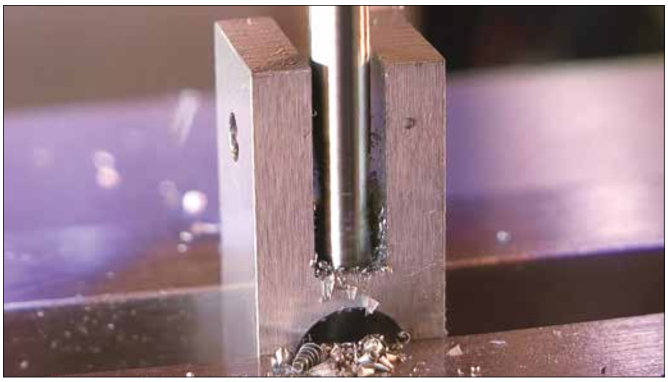

Figure 14.

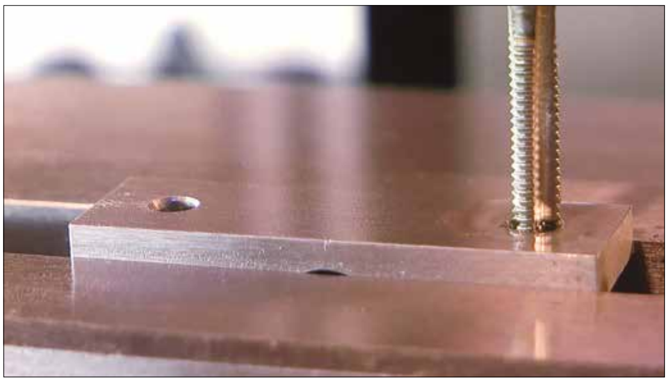

Figure 15.

inconvenient. Generally, my preference is to use a die to cut threads up to about 8 mm. If you have a lathe with a screw-cutting gearbox, this becomes much easier. Beyond 8mm it gets a bit hard to muscle a die around the work, and the surface finish can also suffer from tearing, perhaps even more so in the case of tool steel. So, in this case, I elected to cut the thread in the lathe.

As is usual for 'single point threading', some preparation is required. First is the cutting tool, which can be hand ground to a satisfactory standard with a 60 degree included angle, as well as the appropriate relief clearances and tip width. More detail on this can be found in the *Machinery's Handbook*[1] under the categories 'Threading, Relief Angles for Single-Point Thread Cutting Tools' and 'Metric Screw Threads', **Figures 17 to 19**.

The tool needs to be adjusted to be at the centre-height of the lathe, and the top-slide (assuming a 60 degree thread) set to 29.5 degrees, to ensure chip formation only on the leading edge of the cutting tool, as seen in **Figure 20**.

Should the graduated angle-setting scale on the lathe top-slide be deemed unreliable for this purpose, the angle may be set with precision using a dial indicator, using the side of the installed chuck as a reference surface. Considerable side force will be placed upon the workpiece during cutting, and given that it will be extended quite some distance from the chuck, tailstock support is essential. Most importantly, the threading tool must be set normal (square) to the work, prior to commencing cutting. This is a lot of set-up work only to discover later that the thread was cut slightly off-axis!

I won't labour the details of the threading process here: readers will find several videos on YouTube that cover the process well. However, it is worth mentioning that it is a somewhat complex sequence of steps, unforgiving of error. In fact, I don't mind admitting that it takes all of my concentration to stay focused on not losing track whilst single-point threading. However, like all demanding procedural tasks, a careful 'rehearsal' of the process in one's mind for a few minutes before engaging the power generally helps to secure a good outcome.

The components have been sized for a locational interference fit, as per *Machinery's Handbook's* data[1], and a light chamfer on the mating parts will assist when it comes to the press fit. Alignment of the components can be achieved using a simple drilling vice for uprighting the centre pivot block, and the threaded insert can be manually held with the flat end against the arbor press column with sufficient control to achieve satisfactory initial alignment.

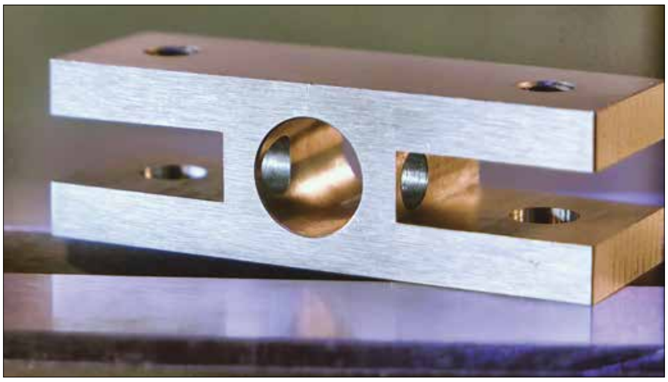

Figure 16. Ready to be pressed onto the threaded insert.

Figure 17.

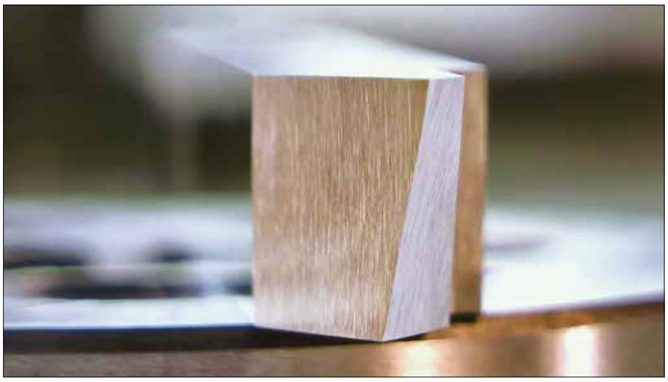

Figure 18.

Figure 19.

Figure 20. The top-slide (assuming a 60 degree thread) is set to 29.5 degrees.

The parts are first lightly located, with only that amount of insertion that will *just* hold the parts together, **Figure 21**. This permits a thorough alignment check from several angles before committing to the final press. Once all is confirmed by inspection to be as it should, the insert is pressed home with a firm, deliberate action of the arbor press arm.

The design calls for the outer ends of the centre pivot block body to have gentle arcs centred around the pivots. This feature can be formed using a rotary table, belt sander, or files as appropriate. A little time on some abrasive paper is sufficient to apply a workshop standard grained finish on the flat surfaces, and an Arkansas stone is effective for lightly breaking the corners of the part. I find this abrasive stone approach to be less aggressive than using a fine file, and for a workshop tool like this, can give quite a consistent, professional appearance with little effort.

This brings us to a good place to pause for this Part 1 of the project. In Part 2, the tool will be completed by building the jaws, making some fastener pivots and winding two small return springs.

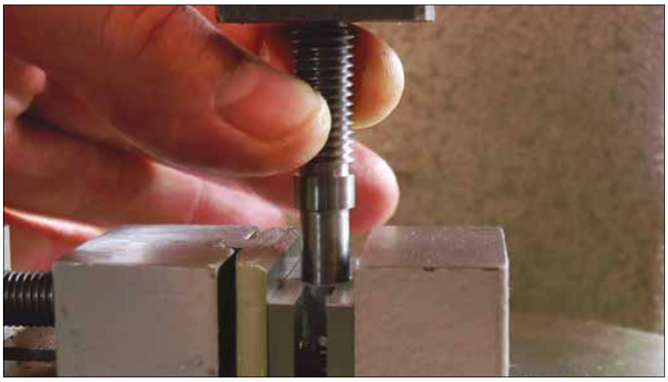

Figure 21. The parts are lightly located, with a gentle force that will just hold the parts together.

REFERENCE

1. Erik Oberg, Franklin D. Jones, Holbrook L. Horton, and Henry H. Ryffel, *Machinery's Handbook: A reference book for the mechanical engineer, designer, manufacturing engineer, draftsman, toolmaker, and machinist* (New York, Industrial Press, 2020).

Note

During the peer review it was questioned whether the author had not intended to say ‘borax’ rather than ‘boric acid’. He explained that whilst they are essentially different formulations of the same compound, boric acid is the better performer for scale minimisation. In his experience it tends to be more viscous at red heat (better adhesion), leaves a brighter surface to the workpiece than borax, and almost entirely shatters off the part on quench, thus minimising any hot water soak/cleanup. In his words: ‘Whenever anyone asks which is better to use for scale minimisation I always recommend boric acid in preference to borax.’