PART HOLDING:
Vacuums and Bridges

by Pete Sorenson

Photos and drawings by Author

Holding material to be machined can be the most difficult part of a project. In need of some "zero clearance" throat plates for my 14" wood cutting band saw, I combined the features of tabs, or bridges, and vacuum tooling when cutting the parts on the mill. While I have included some drawings of the parts, my goal is more a demonstration of work holding techniques and machining strategies.

The Pump

The holding force of a vacuum fixture is a function of the surface area of the part and the inches of mercury your pump can create. My pump will create 23 in/Hg^2 if the fixture has a good seal (***Photo 1***).

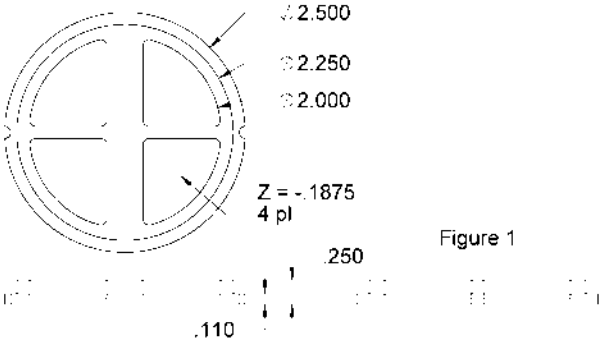
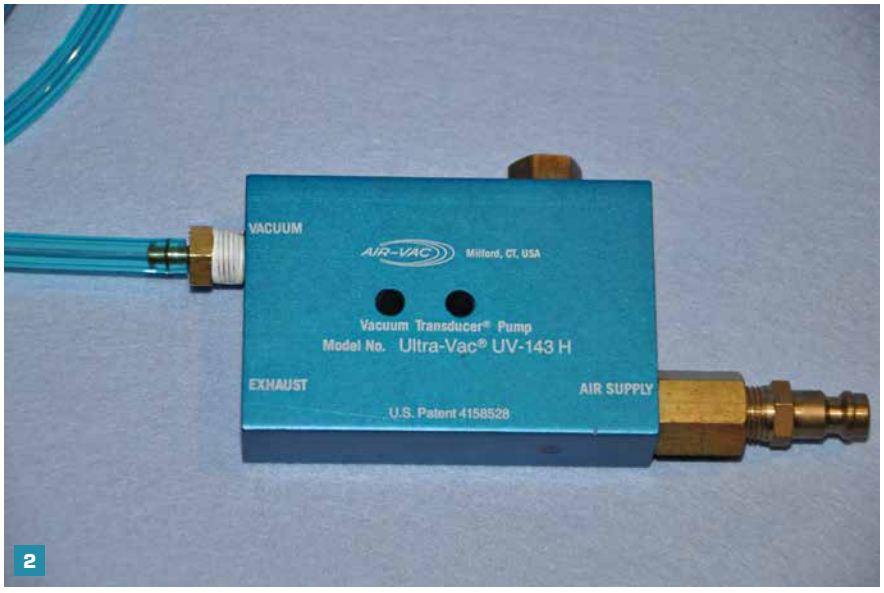


Figure 1

Another choice would be an air-operated vacuum generator, a device that uses compressed air to create a vacuum. The generator shown in ***Photo 2*** will create up to 29 in/Hg^2 and is less expensive than a pump. For the small parts my machine is capable of, a standard shop vacuum would not create enough force to hold the part. The shop vacuums I tested, both new in the store and used in my shop, produced only 4 to 5 in/Hg^2.

The Drawing

A CAD drawing is used to create the tool path to machine the fixture, as well as creating the tool paths needed to build the part. After measuring the saw to determine the size and shape of the opening in the table, a 3D model of the throat plate was created using Rhinoceros®. Because the machining was going to be a series of 2D tool paths, the 3D model was converted to a 2D drawing (***Figure 1***). With a part as simple



as this one, it requires only a top view to create both the part and the fixture. The side and front views are needed for the Z values when setting the machining parameters. A more complicated part with 3D surfaces might require all three orthographic views as well as the surfaces.

The Fixture

The fixture has two tasks: first, to locate the part and, second, to provide a seal for the vacuum. The locating features also serve to help hold the part in the X and Y directions.

A friend of mine, who is a luthier, introduced me to the 1/8″ diameter EPDM sponge rubber cord he uses for sealing fixtures on his CNC router. A simple groove in the fixture for the rubber cord works well to hold the ends of the cord in place and also aids in sealing when the rubber is compressed (***Figure 2***). Machining with a 1/8″ ball end mill results in a half round groove that holds the cord in place securely and enlarges the sealing area beyond what you get with a straight-walled groove.

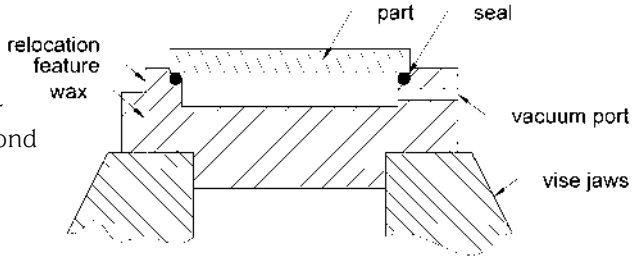
I used the parts drawing and the CAM software to create the tool path for cutting the fixture. At this time you need to determine how you will hold the fixture on the milling machine when it is ready to use. This leaves you with decisions to make regarding material and cutter profiles.

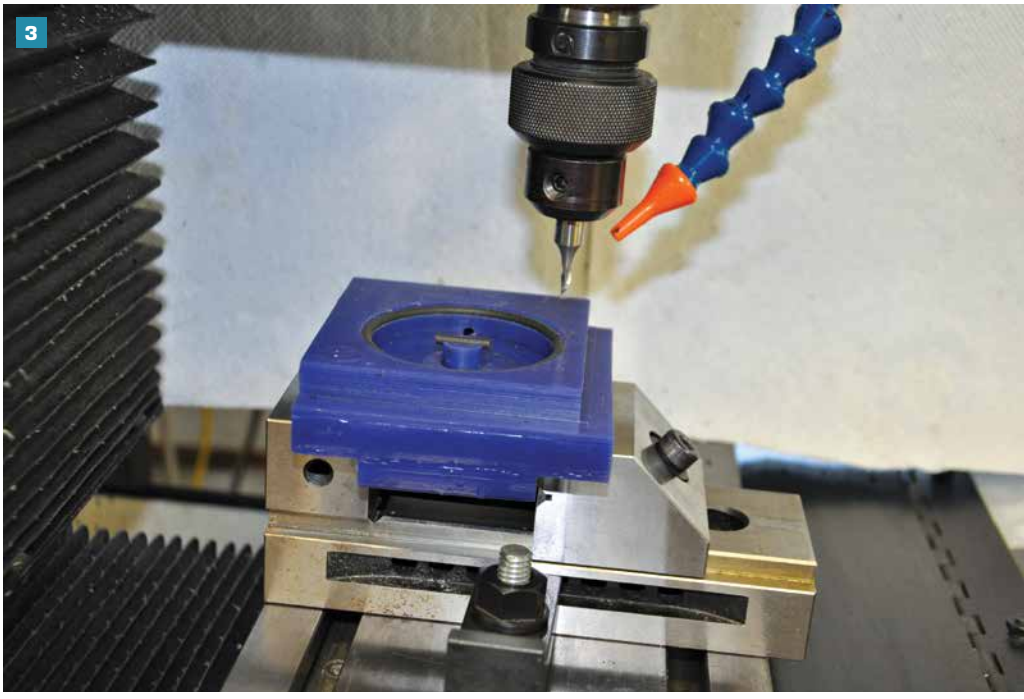
For this project I chose to make the fixture out of machineable wax, for several reasons: the first being the speed of machining achievable and the second was the ability to melt and reuse the wax. More on the wax block in a bit…

When deciding how to cut the fixture, you will want to create some relocation features in the fixture that you can use when returning it to the milling machine, should you want to reuse it. This fixture block is intended to be held in the machine vise and the parallel shoulders ensure the block will sit the same way in the vise for each use.

After placing the block in the vise, I plane the top surface of the wax and then determine where the X and Y zero will be located. A feature with a known X and Y value is machined so it can be used to relocate the tooling in the vise. ***Photo 3*** shows the fixture in the vise with the rubber cord in place.

Figure 2





Making the Part Blank

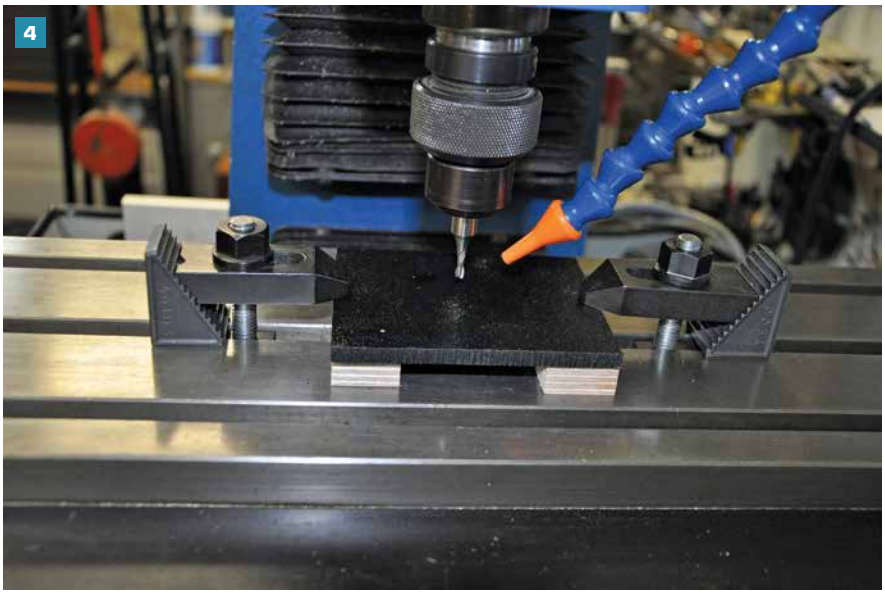
In this case, the first step was to machine a part blank with the outside diameter matching the finished size of the part and the matching recess in the wax fixture. Using the Rhinoceros drawing and RhinoCam®, I did a profile cut on the outside of the 2-1/2″ diameter circle. In RhinoCam, as well as some other programs, one can choose to create tabs or bridges. In this fixture there were four bridges, each measuring 1/4″ long by .031″ tall, created to hold the part while the rest of the material was cut entirely through. Note the sacrificial Baltic birch blocks used to elevate the material above the machine table (***Photo 4***).

Because this part is plastic, the bridges were able to be removed with an X-acto knife. For metal parts a jeweler's saw can be used to remove the bridges. In ***Photo 5*** you can see both the front and back of a part with the bridges intact.

The Wax Block

The block was machined in wax because it is fast, both the part and the chips are reusable, and I do not have to store a fixture that I might or might not use again someday. The wax is not cheap, but with a crock pot and some molds one can use it over and over. If it turns out to be a fixture that is used often, the wax works well for the proof of concept stage and can then be replaced with a metal fixture.

When designing the fixture for use with a vacuum, keep in mind that it is the surface area of the pocket, not the volume, that determines holding force on the part. You will notice a tower in the center of the pocket on my fixture; this is necessary for both large parts and parts with a relatively thin wall. With a larger surface area of the part, a stronger vacuum source, or both, there is a greater need for a tower, or even multiple towers, to prevent the vacuum from bowing the part.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Materials

The materials for the fixture need to be non-permeable, as well as rigid. The other deciding factors are cost, the capabilities of your machine, intended usage, and what is in the scrap bin. I have used aluminum, machineable wax, ABS, and HDPE – all with success. You could use MDF or plywood too, if you wish to go to all the work of sealing the surfaces.

Advantages and Disadvantages

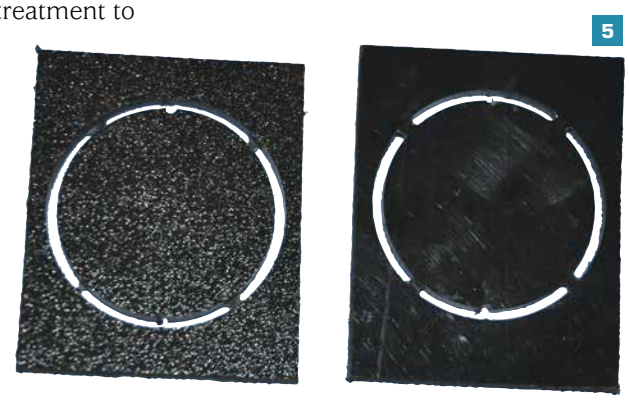
The bridges allow one to machine completely through the material with a simple setup. The downside of bridges is they have to be removed without damaging the part and will need surface treatment to blend with the rest of the part. For the throat plate, there was not a blending issue because the remnants of the bridges were machined off when machining the blank in the vacuum fixture.

The vacuum fixture allows the machining of all the exposed surfaces of the part. Additionally, the fixture is quick to load and unload, a plus when doing multiple parts. On the downside is the time needed to build the fixture and the added expense of the vacuum source. Also, one has to design the fixture with sealing surfaces to compensate for any through holes in the part.

Bridges and vacuum fixtures may not be the answer for every situation, but they are pretty handy options to have.

Resources

Rubber cord and wax; *www.MSC.com*
Rhinoceros; *www.Rhino3d.com*
RhinoCam2014; *www.Mecsoft.com*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