Recently I joined a do-it-yourself organization called TechShop. They have facilities around this area and a few scattered across the country. They have almost every tool known to man, including a few that I plan to make good use of. The first is a Tormach PCNC 1100 CNC milling machine.

Figure 1- Tormach CNC Mill

Here's what they look like new. The one I have access to is in use from 9:00 AM until midnight, seven days a week, and it's not quite as pretty as this one, but it works great and that's all that matters.

Even though I have a manual milling machine, there are things that I just can't do with it, like cut arcs, circles, or any other irregular shapes. At the moment I'm confining myself to 2D and 2.5D parts. Those are parts that do not need to be rotated during machining. My first project was a vertical compass bracket that will mount on the top of the instrument pod to one side. My second project is an improved fuel probe mounting plate. I'll show you how I did that one here…

My idea was based on trouble that I had on my first Helicycle trying to mount the fuel probe in the tank. There is a nut plate that goes inside the tank, then the mounting plate, with an O-ring on each side, and finally the fuel probe. It all has to be sandwiched together and held in position with five screws. The trick it to keep the two O-rings from falling out of their grooves, and hold the nut plate piece inside the tank with a finger or two and then get it all secured into position without damaging the very thin and fragile O-ring or dropping the nut plate into the tank.

The plates that come with the kit have the O-ring grooves, but they are not drilled for the five screws and the center is not cut out – both are a chore to do manually. I decided to start from scratch. My plan is to add a second set of socket head cap screws (SHCS) that will be recessed into counterbored holes. That set of screws will attach the mounting plate to the tank and secure it with the nut plate inside the tank. So there are only three items to worry about – the nut plate, the mounting plate, and the lower O-ring.

Once those pieces are secured into place, the second O-ring can be placed in its groove on the top of the mounting plate, and the fuel probe can be easily secured with the second set of special sealing screws which have O-rings in their heads. This will make life a lot easier during installation and is a good project to work on while I get up to speed on the Tormach and the software tools I need to master.

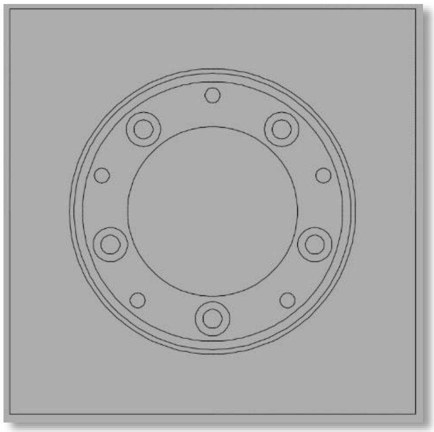

Figure 2- AutoCAD 1:1 Drawing of Plate (Top View)

The first step is to draw up the top view scaled 1:1. The five small holes will be 8-32 threaded and mount the fuel probe. I'll use screw-locking Helicoils on these. The remaining five holes are counterbored for 8-32 SHCS and configured so the screw heads will be slightly below the face of the plate. Those five screws will secure the plate to the tank with the internal nut plate.

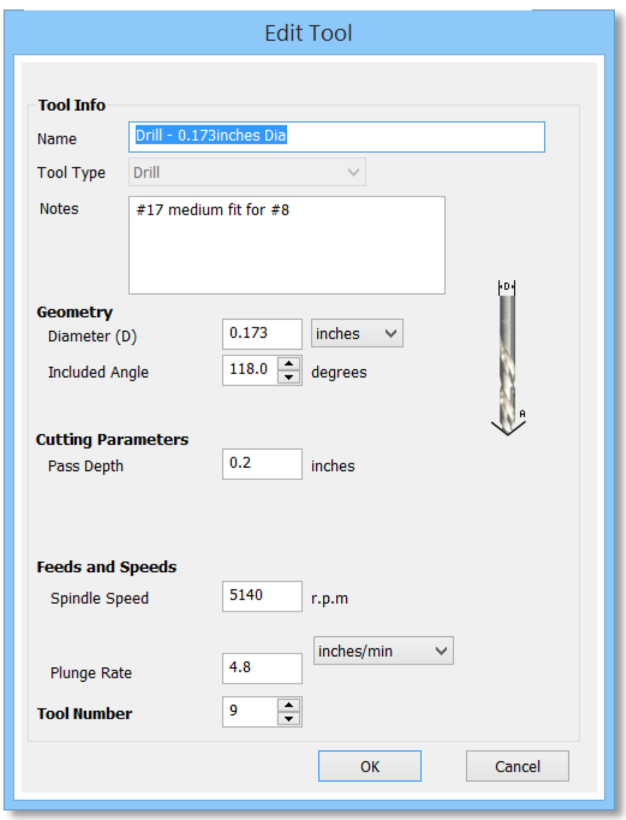

Figure 3 - Tool Setup for a Drill

I'm using a program called VCarve to take the CAD drawing and generate the tool paths. After importing the AutoCAD drawing into VCarve you set up your material size, thickness, and the location of the zero points for the X and Y axis. Then for every tool you will be using, you need to determine the spindle speed, the feed rate, the plunge rate and pass depth (Figure 3.) This little project will use one drill and two end mills. I save their characteristics in a tool database for easy retrieval.

I've tried to optimize each tool that I will use for the Tormach. I'm more interested in the quality of the cut and less interested in the speed of the operation, unless it gets to be very slow.

Since the Tormach uses flood cooling the tools can run very fast as they are literally flooded with coolant. Most of the operations I'm running on this part use a spindle speed of 5140 RPM (Figure 3.)

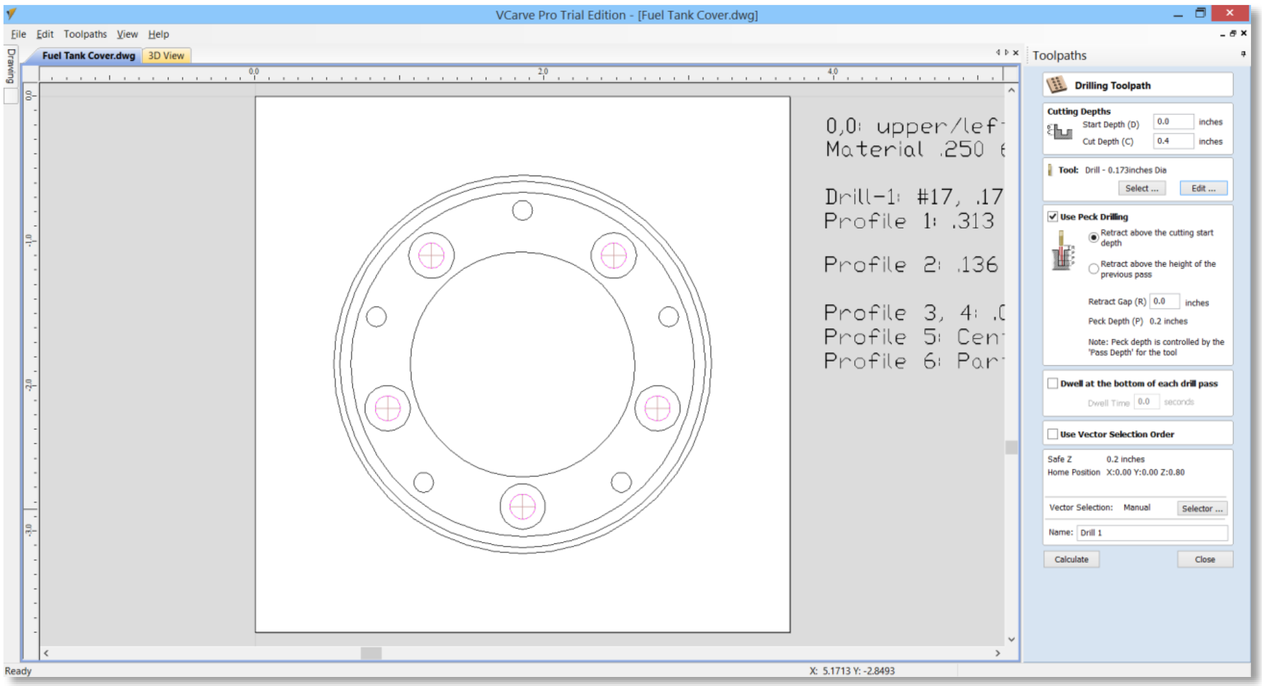

Figure 4 - VCarve Screen Showing Toolpath for a Drill (Holes are Highlighted in Red.)

In the first operation I'm going to drill the five 8-32 SHCS holes that I have selected (highlighted in red.) On the right side of the screen I've set the start and stop depth of the cuts and selected peck drilling which will pull the bit out of the hole periodically to clear out the chips. The next step is to calculate the tool path by clicking the box at the bottom of the drilling toolpath box. I did the same steps for the SHCS counterbore holes and the Helicoil holes to be tapped using a drill and a ¼-inch end mill.

Once all the holes were drilled I used two toolpaths to cut the O-ring groove using a 0.075-inch end mill. I used a 1-inch ramp to ease the mill down into the material. All these variables are set in this program. Once the O-ring groove was cut and all the holes drilled, the work was flipped over and the O-ring groove was cut in the back side. The last two operations were to cut out the center hole and then partially free the part from the work. I used three small tabs to keep the part attached to the material so it wouldn't get flung across the room as it came loose at the end of the machining operations.

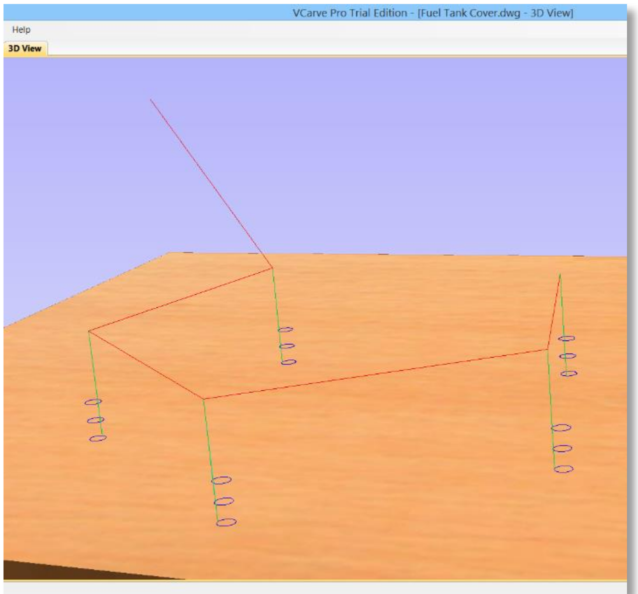

Figure 5- Spiral Toolpath of End Mill

Here's the toolpath for the .250 end mill (Figure 5) that will be cutting the counterbore for the SHCS heads. You can see that the mill will be spiraling as it penetrates into the material to create a 0.313 diameter hole. The red line shows the toolpath starting at the 0,0,0 position .8-inches above the upper left corner and then taking the shortest path to each of the five holes. The green lines show the movement in the Z axis.

I'm using a 0.075 end mill to cut the O-ring grooves. That's a very small tool, and the spindle motor is rated at 1.5 horsepower. Any mistakes with your programming and you can kiss the tool goodbye.

Figure 6 - Completed Fuel Probe Mounting Plate

Here's the finished mounting plate fabricated from .250" 6061-T6. You can see the five 8-32 screw-locking Helicoils that will secure the probe to the plate (red colored.)

The O-ring fits perfectly into its groove!

You can also see one of the sealing screws that I'll be using to seal up the assembly. The O-rings will seal against the top of the fuel probe.

Figure 7- Sanding Disc

The O-ring needs a good flat surface to mate to and the texture of the tank outer surface is rough. I made this sanding disc out of two circular pieces I machined on the Tormach. I made two versions of the smaller piece that is used to center the disc by riding inside the access hole – one slightly smaller than the other. The larger disc is just a tad bigger than the fuel probes and the interfacing plates. I picked up an assortment of adhesive-backed sand paper at Sears and stuck a sheet on both sides of the big piece and then screwed it together with an AN-4 bolt that had the head cut off. When the paper on one side wore out I could flip it over, and when both sides were used they could be peeled off and replaced easily. I started with a course grit and moved to a fine grit to finish up.

Figure 8- Prepared Fuel Probe Mounting Hole

Here's a prepared mounting hole ready to go. Judging from experience, this should be smooth enough to allow a good seal. I'll have to wait for a leak test sometime in the future to confirm that…

Figure 9 – Here's the plate mounted on my top tank. It was a very simple process to install the bottom O-ring on the mounting plate and then hold the nut plate inside the tank with one finger while lining up the mounting plate and getting one screw to engage. Once one screw is installed the others are installed as you see. The socket head cap screw heads are all recessed below the surface.

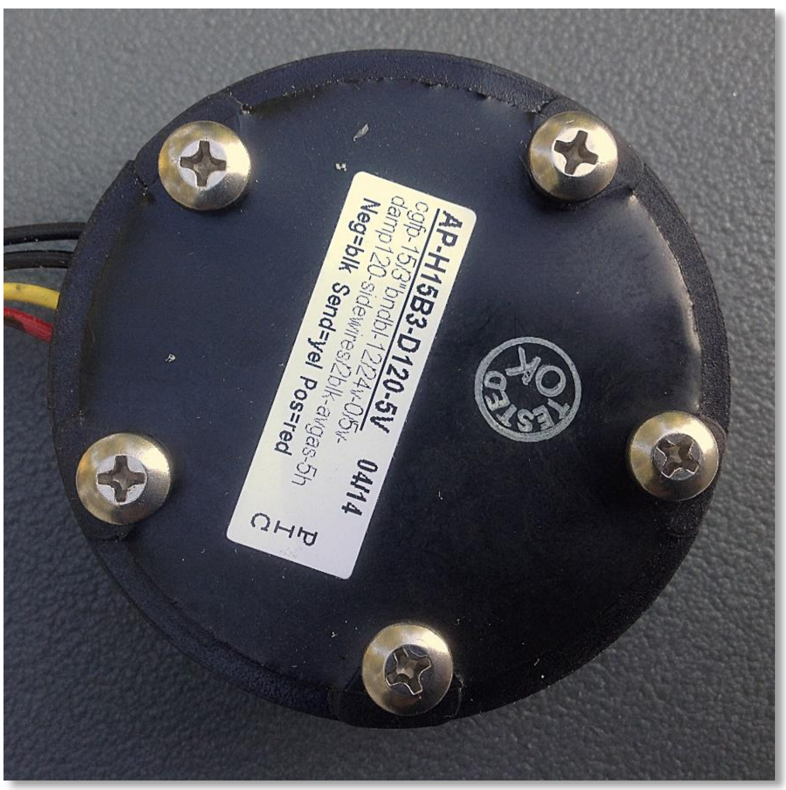

Figure 10 – The next step, which is even easier, is to install the top O-ring and then the fuel probe with the O-ring sealing screws.

This project is an example of a project that I simply could not complete without a CNC mill. Also, unlike a manual operation, now that I have the code dialed in I can make more of these and they will all be identical.