Turning a Precision Washer

By R. G. Sparber

Turning a thin disk such that its two faces are parallel can be deceptively difficult. I will show you one way to do it. Hopefully, others will respond to this article with their favorite method so more options will be offered when version 2 comes out.

Let's think about this washer for a moment. Beyond having its faces parallel, I might want the hole in the middle centered. I might also want the outside diameter true. The thinner the washer, the less metal is available for holding it which makes machining more of a challenge. The key thing to remember is that one face of the washer will be a reference surface along with the hole in the middle. All other surfaces will be cut with respect to them.

I started by chucking up a piece of 12L14 leaded steel in my lathe. I faced the end to define my first reference surface.

I then use a spotting drill to cut a cone shaped hole.

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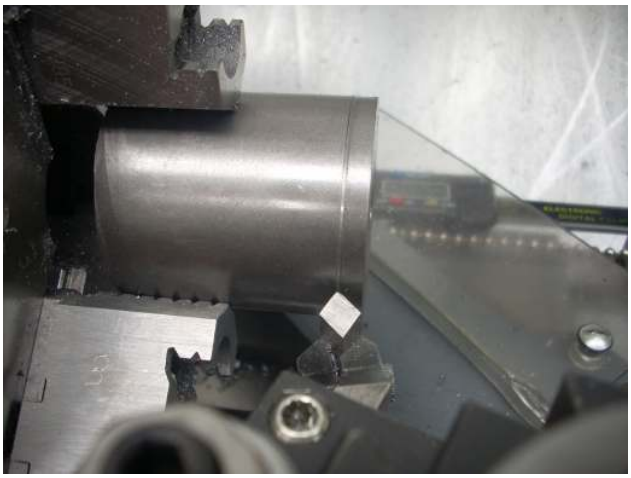
I used a 1/4", 3/8", and 31/64" drill to a depth of about 1/2" for a 0.2" thick washer. I want to be sure that the cone in the bottom of the hole is not within the washer blank being made.

I next ran a 1/2" reamer through the hole. The washer might not need this precise a hole but my fixture will.



I then cut a groove about 0.05" beyond the finished thickness of the washer. It will help me to set my band saw blade in the right location.

I touched a file to the outer edge to remove the burr.

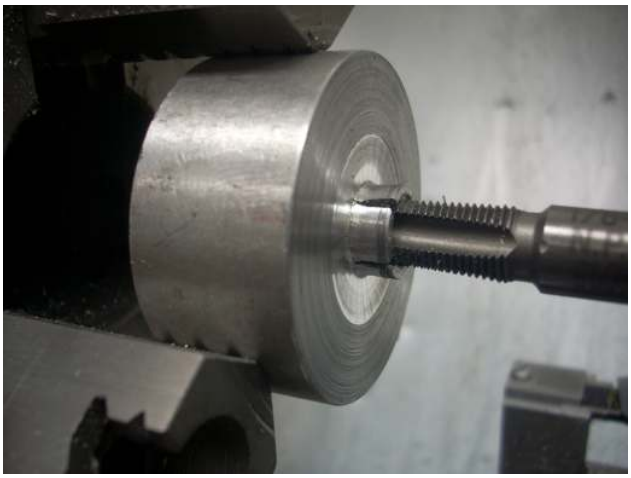
I could have used a parting tool here but prefer to saw it off. Ideally, the parting tool cuts true and I would be left with my washer. However, it is slow going and wastes a lot of material.

I removed the bar from the chuck and clamped it into my band saw. The roughed out washer is sliced off. I then used a deburring tool to clean up the 1/2" hole.

If I wanted more washers, I would return the bar to the lathe, face the end, drill and ream my 1/2" hole, and cut my groove. Then it is back to the saw to cut off the slice.

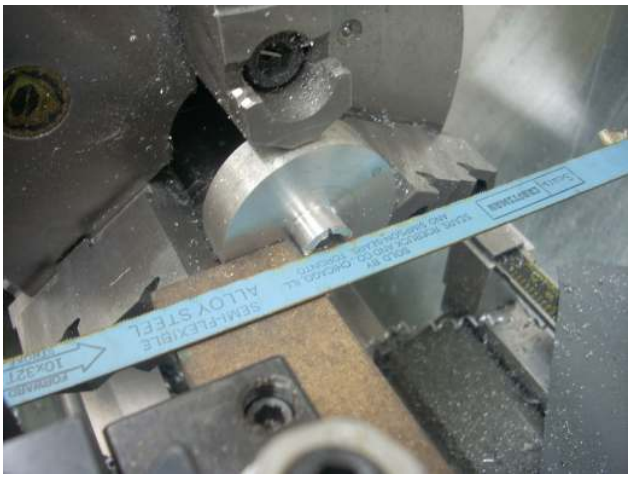
All of the needed washer must be ready for this next step because my lathe set up cannot be disturbed until the job is done. Time to make the machined in place mandrel.

I'm back on the lathe now. A piece of aluminum round stock slightly smaller in diameter than the washer blank has been chucked up. I turned down a length about 0.1" longer than the rough thickness of the washer to a diameter of 0.500 + 0, - 0.004". I also cut a recess around this smaller diameter so the washer will not come into contact with the small radius at the bottom. The rest of the face has been lightly cut so it is true. This picture shows some saw cuts but I'm getting ahead of myself there.



I next drill a 21/64" pilot hole for a 1/8 -27 N.T.P. pipe tap. The tap is tapered which means that when I screw in this stud, the diameter of the turned 1/2" part will expand. This expansion will lock the washer in place.

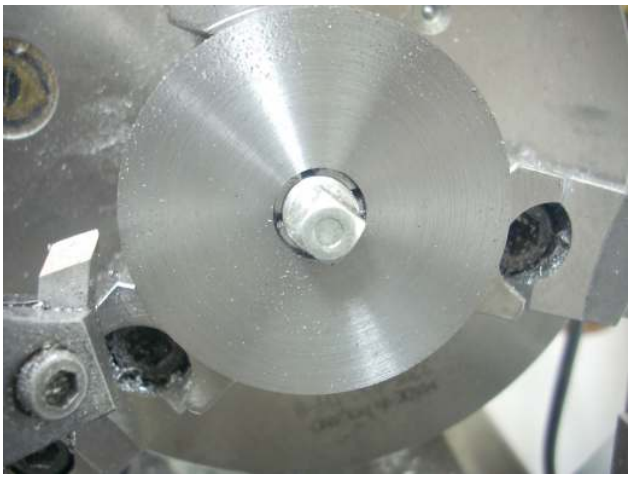
Well, at least that was the theory. It took me a while to realize that having this part of the mandrel straight sided doesn't work. The expansion force tended to lift the washer blank off of the mandrel's reference surface. I solved this problem by re-cutting the 1/2" diameter part to have a 10° taper with the wide end facing out. Then, as the mandrel expands, it both centers the washer blank and pulls it into the reference surface.



After tapping the hole, I can finally show you how I cut the slots. I clamped a piece of scrap MDF into a spare Quick Change Tool Post tool holder. The height was set such that when I put a hacksaw blade on the MDF, it was on the centerline. It was then a simple matter to saw down to my reference surface. The part was turned about 90° and a second cut made.

Here is the finished mandrel with plug installed. Its accuracy is only present until it is removed from the chuck. If you do remove the mandrel, you will have to reface it and possibly re-cut the 1/2" part. Worst case, you will have to make a new one.

Time to install my first washer blank. It is essential that there are no burrs on the mandrel or the washer blank. All mating surfaces must also be absolutely clean.



My washer blank reference surface is in contact with the reference surface of the mandrel. With the plug screwed part way in, the expanding part evenly clamps the reamed hole while forcing the washer blank down on the reference surface of the mandrel.

It is hard to see, but the 1/2" expanding section does extend beyond the face of the washer. As I face the surface of the washer blank, I will cut slightly into the mandrel to insure that no ridge is left near the center hole. This is where the expanding mandrel really shines. If I had used a bolt, some of the washer's face would be covered. Here I get full access. I also have access to the perimeter so will cut it to be concentric with the reamed hole.

I have shown you pretty much smooth sailing but the problem with the straight sided expanding mandrel had me going for a few days. I was seeing errors of up to 0.005" and that far from what this set up can do. This next section of the article shows you some of the "detective work" I did to track down the problem.

I used two instruments in order to see what was going on. The first was a Dial Test Indictor (DTI) that could sense variations in the outside face of the washer. The second was my micrometer.

I started by verifying that the reference face of my mandrel was true. As I slowly turned the chuck, I saw that the DTI's needle moved less than 0.0001". This says my lathe was not the problem.

I then took my first washer that had been machined all over. I put a black tick mark on one face and used it as a position reference for measuring its thickness. I zeroed my mic at 12:00, and then measured the variation at 9:00, 6:00, and 3:00 near the perimeter. I then went back to 12:00 to verify that I again got zero.

Next, I mounted the washer on my mandrel. This time I used my DTI to measure these same locations. If the washer was properly bedded on the mandrel, then the DTI should give me about the same values as my mic. It didn't so I knew the washer was not laying solidly on my mandrel's reference surface.

It didn't take long for the light bulb to come on. Once I realized that the washer was not contacting the mandrel, I realized that my expanding part was the problem. Adding that 10° of taper came next. Then it was back to mounting the washer and taking a new set of readings. This time my DTI was within a few tenths of what the mic told me.

I faced the washer and deburred it. Then I carefully inspected for burrs and cleaned the face. With this face now against the mandrel's reference surface, I cut my second face. After deburring, I used my mic to inspect the part. This time I saw a variation of thickness of +/- 0.0002". Now, that is more like it!

Ah, 'tis a thing of beauty! And I learned an important lesson in designing my next mandrel.

I welcome your comments and questions. All of us are smarter than any one of us.

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