Warped Aztec / Mayan Calendar

The Calendar has become a staple project of CNC routers. In addition to testing how well the machines work with fine cuts and precise positioning, it gives lots of opportunities for different finishes. Plus, it just looks cool. You can find lots of information on the real thing on Wikipedia :

http://en.wikipedia.org/wiki/Aztec_calendar_stone

My machine can cut these about 20" in diameter; generally they look better when large and with deeper cuts (i.e., smaller inside angles on the bits). Searching on CNCZone and the Vectric forums will turn up many very nice examples of the Calendar, as well as DXF and CRV files to do this yourself.

I did a warped version of the Calendar that was 18.8" across, using a V60 bit from Lee Valley Tools for the artwork. My target was a domed shape that was 0.5" high and 0.25" thick at the rim, cut from standard 0.75" thick Home Depot MDF. Here are the steps.

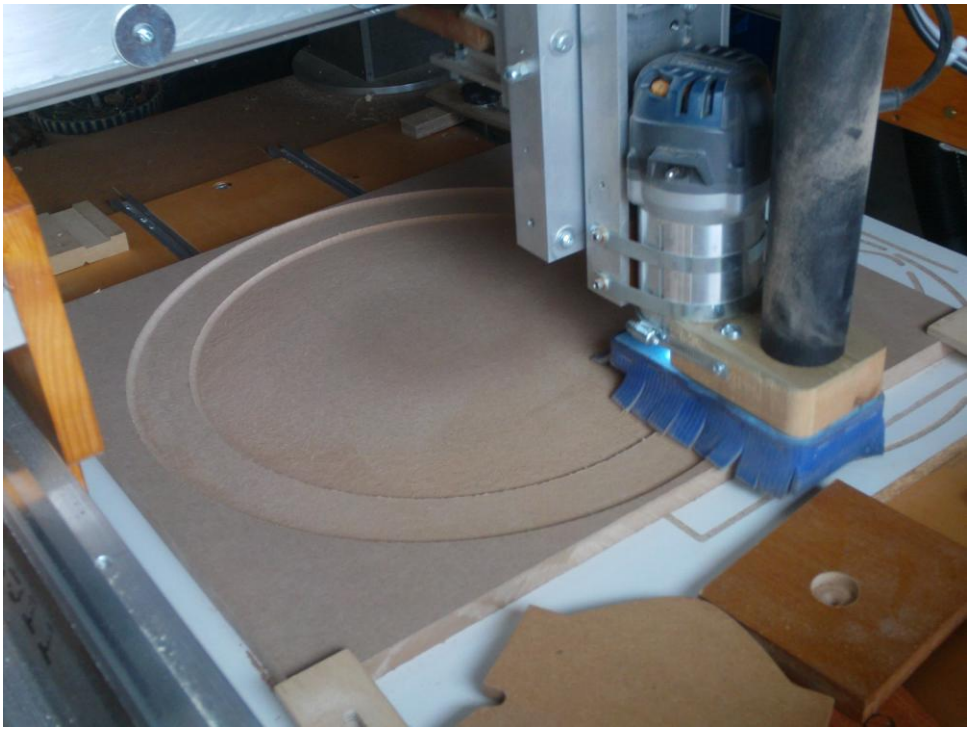
1) Prepare the standard toolpath for the V-bit of your choice, and save the g-code to a file. To make sure that my bit did not cut through the MDF (remember it is thinner at the rim!) I limited the depth to about 0.3". I did not use a separate tool for the flat areas.
2) Prepare a zero-depth pocket using the end-mill or ball-nose cutter of your choice. It should have a small-ish step-over. I used a 0.25" diameter end mill, with a 0.040" stepover, arranged in the Offset Pocket mode of VCP that started in the centre and worked its way out. The diameter of this zero-depth pocket should exceed the cutting size; I used a 20" diameter circular vector to define the pocket. Save this g-code to a file.
3) Prepare a cutout profile cut with the tool of your choice. I used a 0.25" endmill, with tabs to secure the middle region. Save the g-code to yet another file.
4) Run WarpDriver, and wait until the nagscreen has disappeared. Click on the 'Elliptical Dome' model, then the profile graph near the middle-bottom of the window. It should show a convex shape.
5) Adjust the parameters for the dome. Because the end-mill has a flat bottom, I used X radius and Y radius that were LARGER than the desired size by ½ of the EM diameter. This made the end of the curved area match the desired dome diameter exactly. If you wanted to cut an Elliptical Dish (i.e. a Dome with negative height) then you would make these radii smaller than the final dimensions that you want.
   Xcentre = 0.0, Ycentre=0.0, Xradius=9.4+0.125, Yradius=9.4+0.125", Height=0.500", N=1.00.
6) I used N=1.0 because I wanted the dome to slope smoothly out to the edge. If N<1.0 it makes a pill-box shaped dome with steeper edges, and N>1 makes it more pointed with a steeper centre.

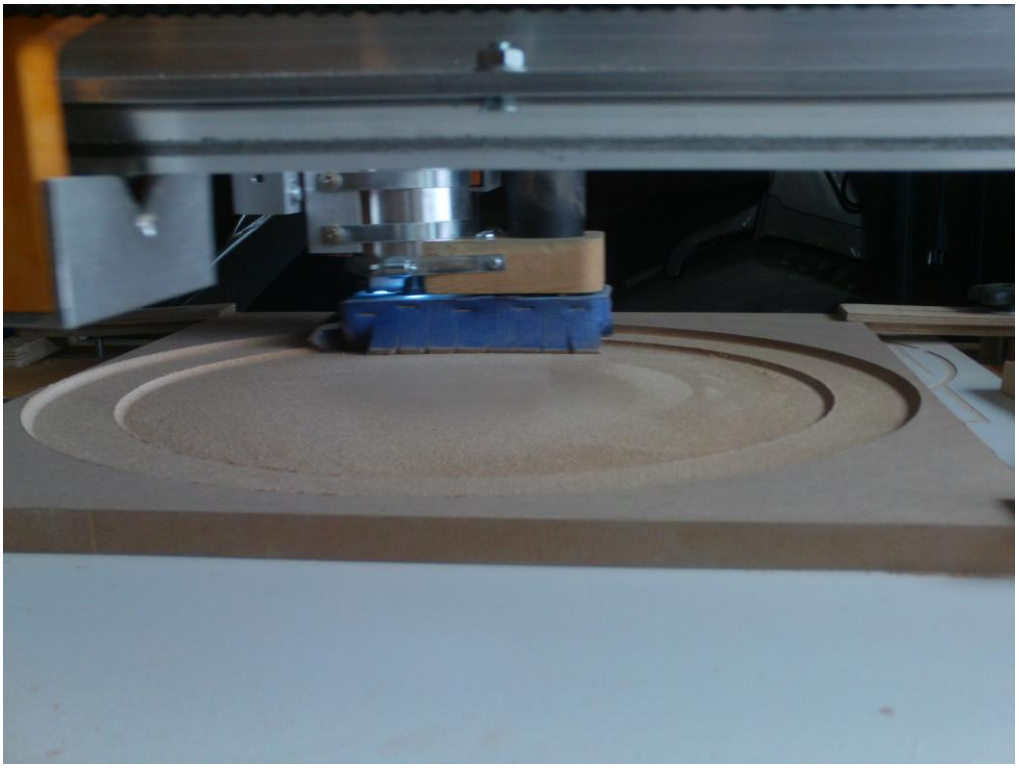
7) Load the G-code for the zero-depth pocket that you made at step (2) above. It will show up in the left-hand editor on the front panel of WarpDriver. The title bar of the window will show the source filename, as well as the default save filename (which is just the loaded file with a W in front). Press 'Select All' to warp the entire file; this is OK because the zero-depth pocket is the only toolpath in the file.
8) On the right side, set Passes=2.0, which will generate code for 2 equal roughing passes. The first will start at Z=0.00" at the centre of the disk and go to Z=-0.25" at the rim, while the second pass will start at Z=0.0" at the centre and go to the full Z=-0.50" at the rim.
9) Generate the warped roughing pass g-code, and save it to the name of your choice. Preview the g-code to make sure it is what you expect. Verify that the minimum Z is -0.500".
10) Now load the artwork g-code created at step (1) above. Modify the warping parameters to have X radius=9.40", Yradius=9.40" which will be the correct size of the actual dome that you have cut from the warped g-code in step (9). Press 'Select All'.
11) Change Passes to 1.0. There is no reason to make roughing passes on the V-carve toolpath because it is relatively shallow and VCP will have already taken into account the depth of cut defined for the bit.
12) Generate the warped artwork toolpath, and save it to the filename of your choice. Preview it to make sure it is as expected. Verify that the minimum depth does not exceed 0.75" below the Z=0.00" surface of the material.
13) There is no need to warp the cutout profile from step (3).
14) Time to make MDF dust. Lots and Lots of MDF dust. Make sure your dust shoe and collector system are working.
15) Secure the MDF to the table, and set Z=0.00" to the top of the material, ideally near the middle of the piece.
16) Load and run the warped zero-depth pocket toolpath that you created at step (9). It will be a big file, and may take some time to load and process. You may want to get some coffee at this point, because even at 200 ipm, the fine step-overs make this a long procedure.
17) When that is done, change the bit to the V-bit defined for your pattern in VCP, and rezero Z=0.00" at the centre of the pattern. In this case the centre of the disk is relatively flat, so this is not too tough. Other patterns may be more difficult.
18) Load the warped artwork toolpath generated at step (12), and run it as you would any other file. This too will take quite a while.
19) Finally, load the cutout profile toolpath generated at step (3) and run it with the end mill that has been properly set to Z=0.000" at the centre of the calendar. If properly configured it should cut out the calendar, except for a few tabs.
20) Manually cut the tabs, and check your work! You will probably have to do some light sanding on the edges and on the exposed surfaces of the model.

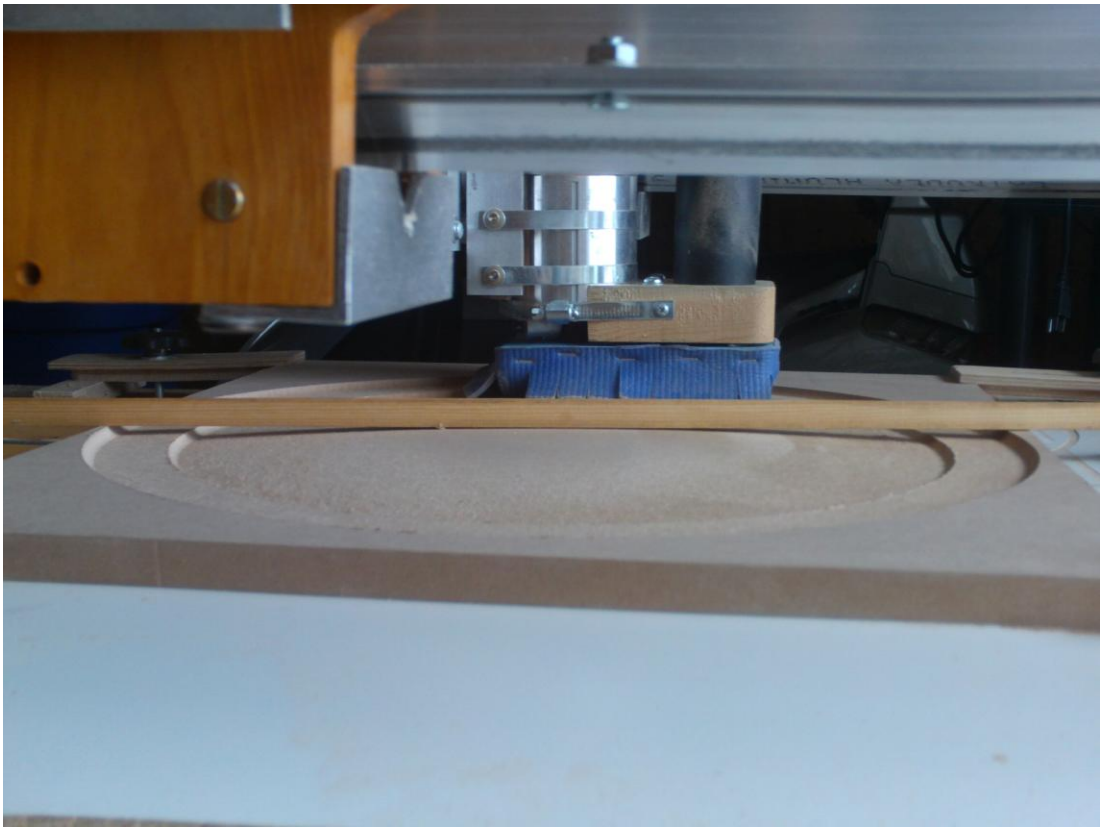
I like the look of this calendar better than the standard flat version, with one caveat. MDF has a surface skin that is stiffer and holds detail better than the inside material. As a result, the centre face and surrounding squares of the calendar will be sharper than the

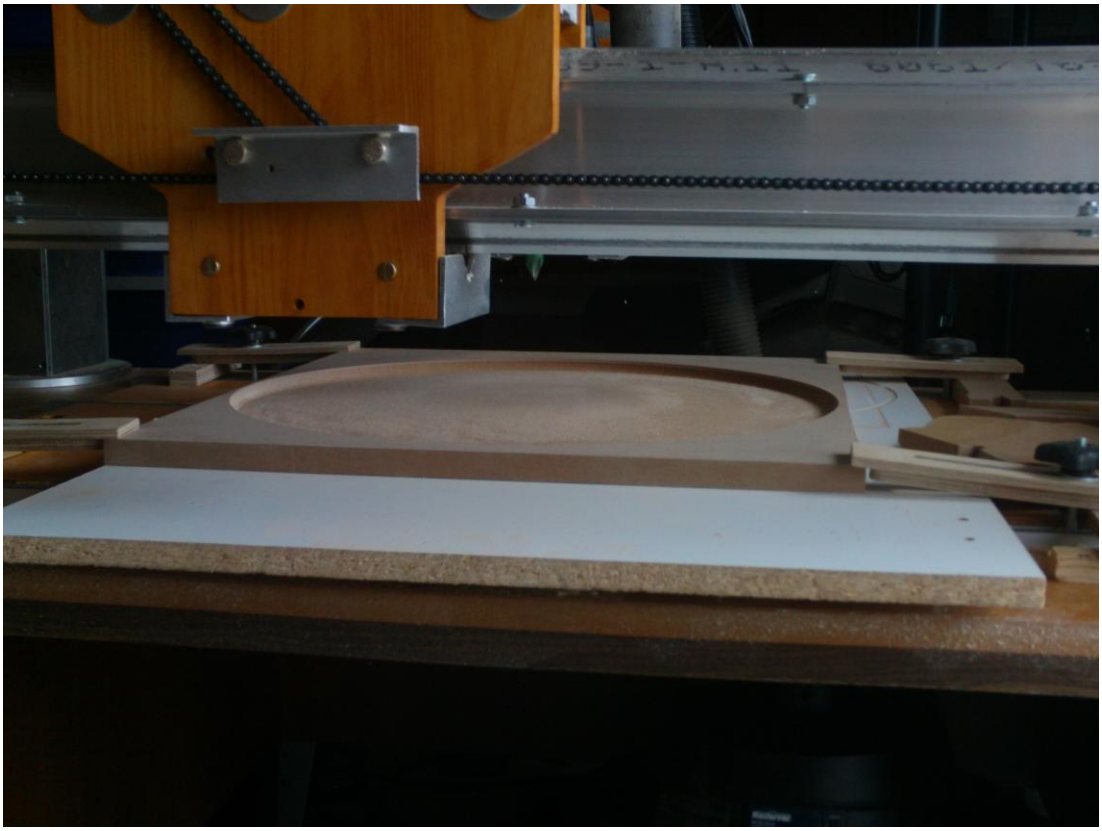
cuts near the rim regions. In my case, the ring of squares near the rim that have the flowers show a loss of detail : most of the chevron stripes have torn out of my warped calendar (see last 2 photos). This would probably not be true if you use wood instead of MDF.

Here are some photos taken during the cutting and finishing of this calendar.









The finishing was

1) 2 brushed on coats of MinWax Polycrylic (Clear Satin) sealer, lightly sanded between coats. Make sure you don't miss anywhere or the Hammered Copper will turn out silvery. Give the back a coat or two for good measure.
2) 2 coats of Rustoleum 'Hammered Copper' spray paint. Go heavy on this for best effect.
3) Brushed on Winton oil colour irregularly and with inconsistent strokes and concern for coverage to simulate centuries of being buried (various mixes of Paynes Gray + Burnt Sienna + Raw Umber deep into the recesses, wiped off the accessible surfaces and let dry, followed by Burnt Sienna with wiping to contrast and tint the top parts of the calendar).

4) 

The new Calendar in the background is compared to the standard flat calendar made with the same files (although the bit was 90 degrees in the flat calendar). The domed calendar is less than ½ the weight, and reflects light in a more interesting way (IMHO).

Cheers!

p.r.