How to make a turner's tetrahedron out of acrylic using a 3 axis CNC mill

by Steve Kranz

WORK IN PROGRESS

Sections

The story

This section will tell the story behind the turner's cube and will define a turner's tetrahedron.

The math

This section will explain how to calculate the geometry necessary to machine the tetrahedron

The work

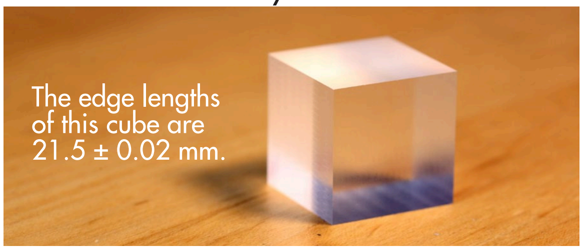
This section details the fabrication of the turner's tetrahedron using a 3 axis CNC mill.

The goods

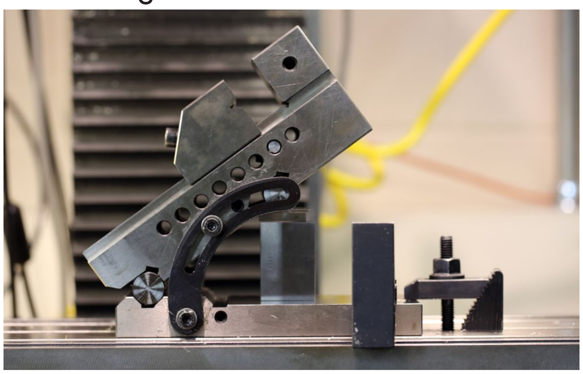
This section will be composed of flattering photographs of the turner's tetrahedron.

The work

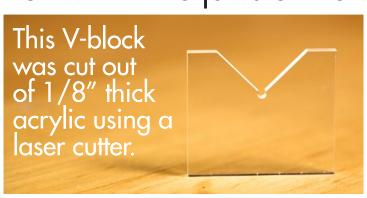
1. Start with a cast acrylic cube.

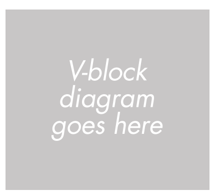


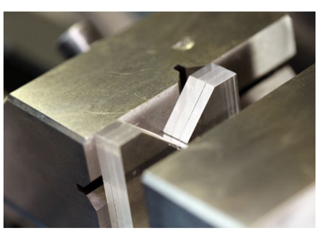
2. Clamp a sine vise onto the table of a mill. Set the angle of the sine vise to 35.26°.

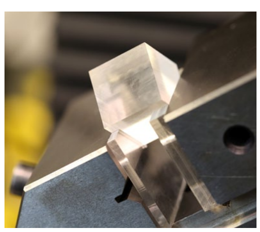


3. Use V-blocks to angle the cube 45° within the jaws of the vise.

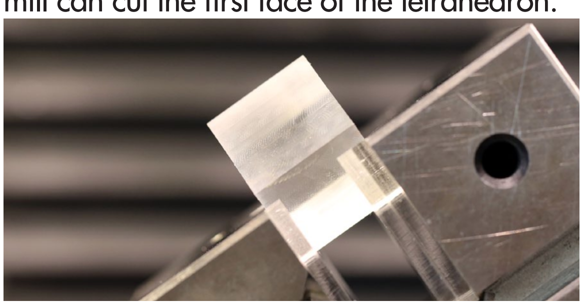




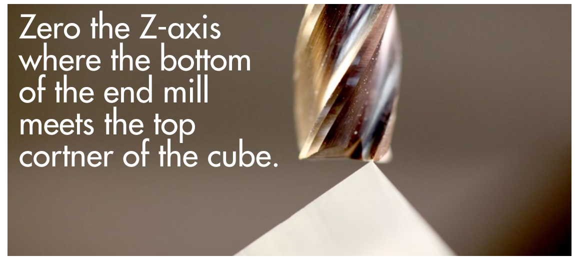




4. The cube is oriented so the bottom of the end mill can cut the first face of the tetrahedron.

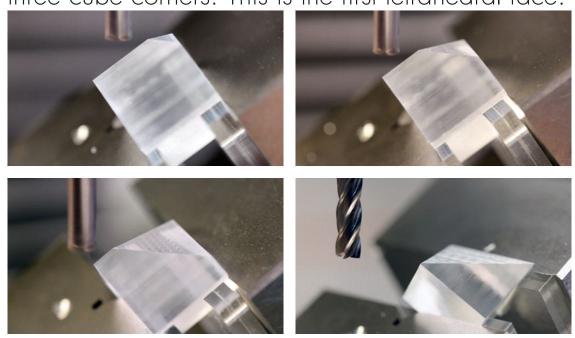


5.

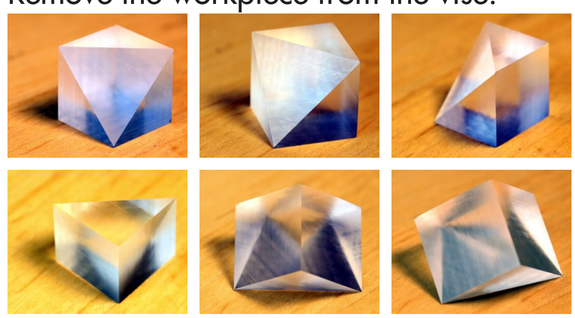


6. Face mill the corner of the cube until the tetrahedron face is formed.

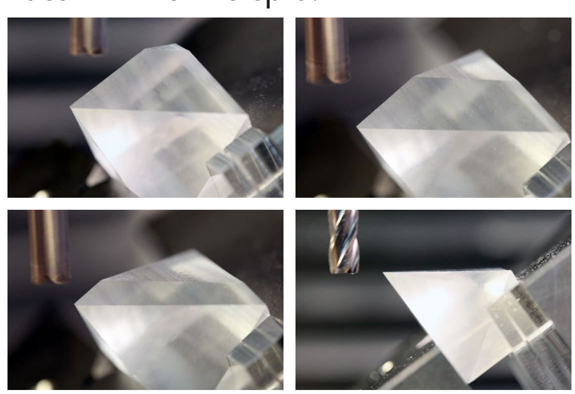
Here, the four rough cuts are 4 mm deep. A finishing cut 0.4 mm deep forms a face that intersects three cube corners. This is the first tetrahedral face.



7. Remove the workpiece from the vise.

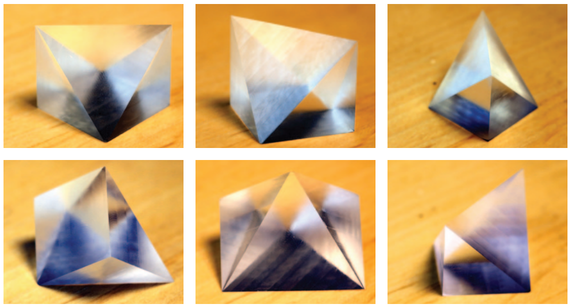


8. Replace the workpiece in the vise. This time, orient a different corner upwards. Face mill like in Step 6.

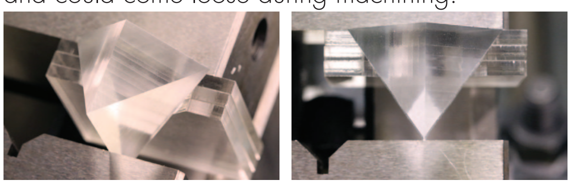


The work

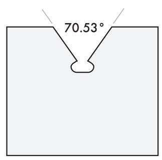
9. Two of the tetrahedron faces are visible.

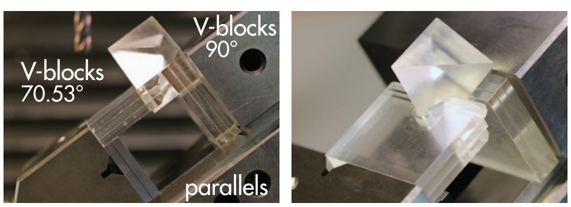


10. There's a problem! If the workpiece is put back in the vise for the third cut, a sharp edge is up against the jaws of the vice.
If the vise is tightened, if could damage the tetrahedral edge. Worse, the workpiece is not very stable and could come loose during machining.

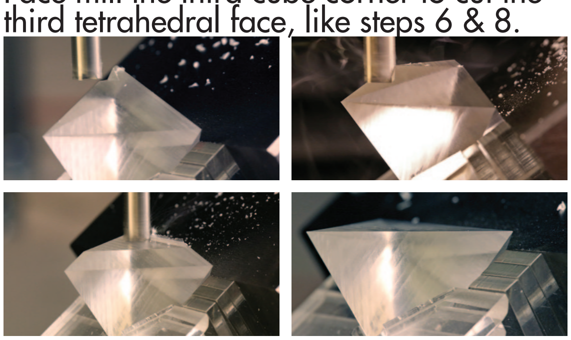


11. Use a second set of V-blocks to stabilize the workpiece. They have a 70.53° angle V to match the edge-to-edge angle of the tetrahedron.

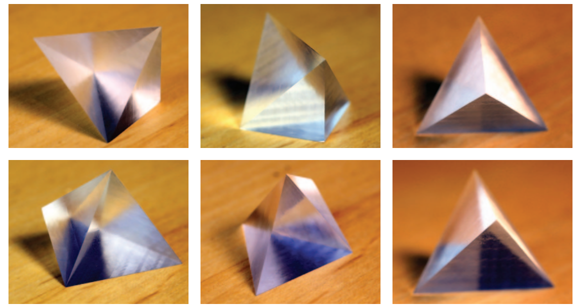




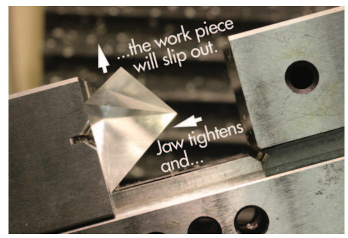
12. Face mill the third cube corner to cut the third tetrahedral face, like steps 6 & 8.



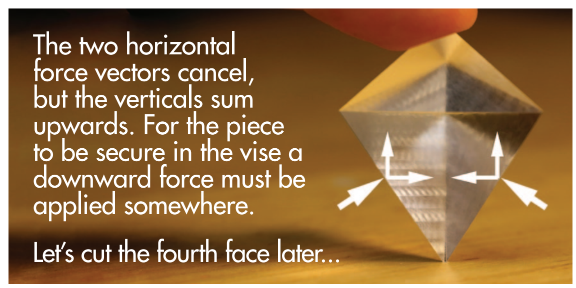
13. Three of the tetrahedron faces are cut.



14. Another problem! How do we cut the fourth face of the tetrahedron?

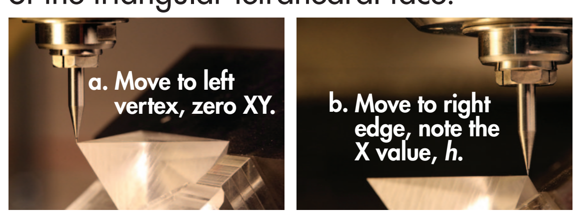


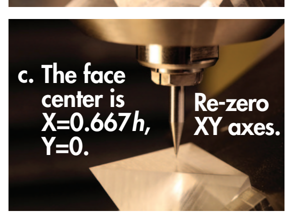
When it is oriented to machine the fourth face, the workpiece can't be secured in place. The tightened jaws will push it up and out of the vise.

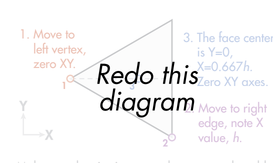


15. Place the workpiece back in the vise and insert a pointed tool into the spindle.
Orient the workpiece in the vise such that one of the three tetrahedral faces is parallel to the XY axis of the mill, like it is at the end of step 12.

16. Use the pointed tool to locate the center of the triangular tetrahedral face.

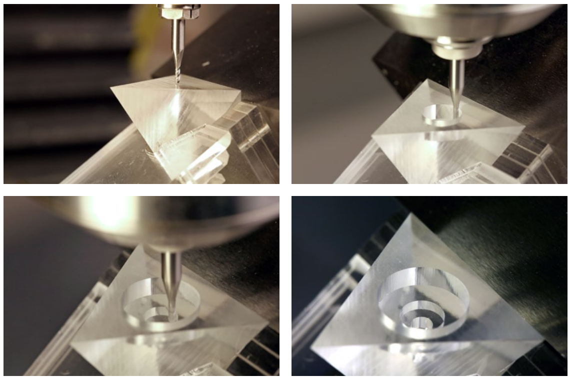




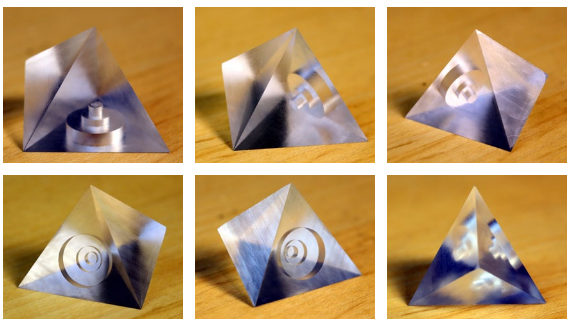


The work

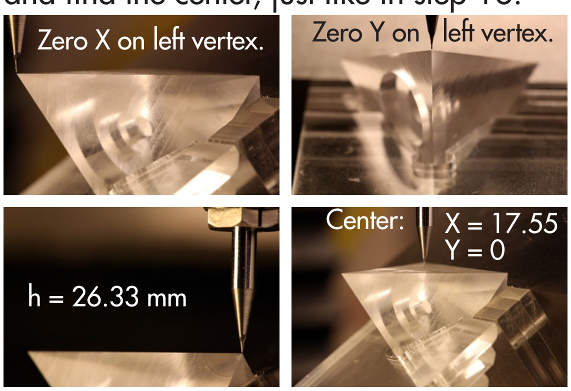
17. Cut the first set of circular pockets.
1.19 mm, 4 flute end mill. 500 mm/min, 25k RPM. 0.15 mm stepover, ~2.5 mm depth of cut.



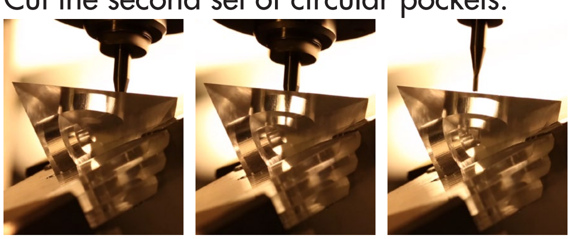
18. Take it out of the vise and have a look.



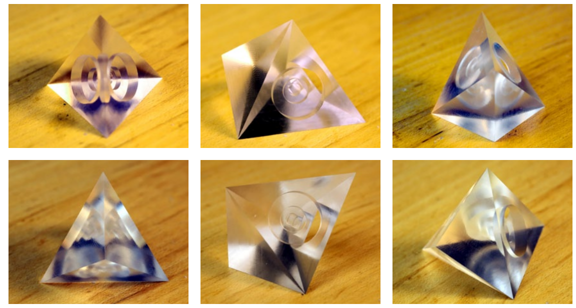
19. Orient the piece to cut another set of pockets. Switch back to the sharp tool and find the center, just like in step 16.



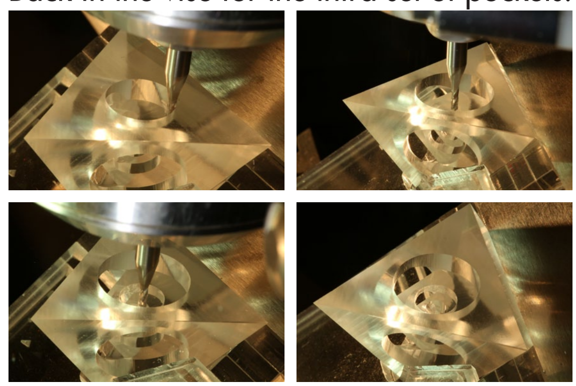
20. Cut the second set of circular pockets.



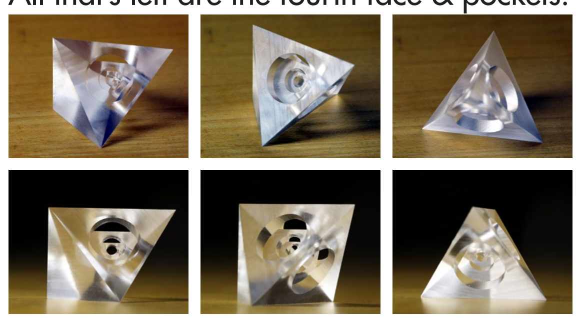
21. You can start to see the inner tetrahedra.



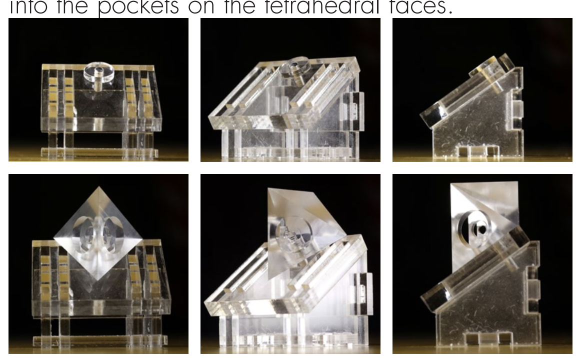
22. Back in the vise for the third set of pockets.



23. All that's left are the fourth face & pockets.

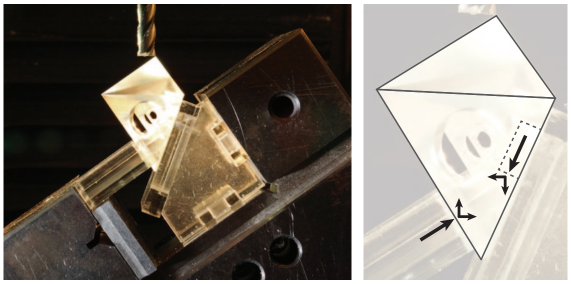


24. Use an angled "table" to orient the workpiece in the vise to machine the final face.
It is angled at 54.736° and has a plug that fits into the pockets on the tetrahedral faces.



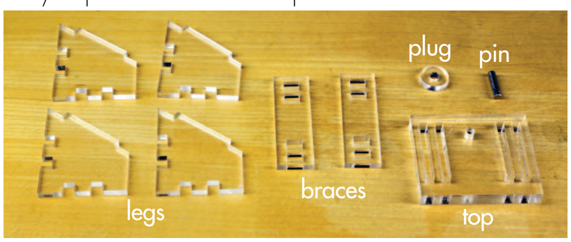
The work

25. The plug applies a downward force which prevents the piece from slipping upward.

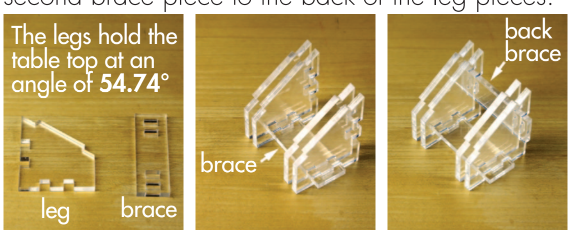


26. Here's how to construct the table.

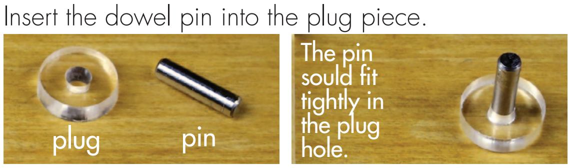
This table is made using several laser-cut pieces of acrylic plus a steel dowel pin.



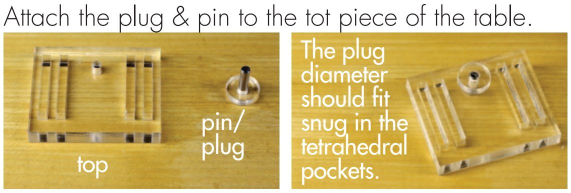
Insert the each of the four leg pieces into the four holes in a brace piece. For extra stability, attach a second brace piece to the back of the leg pieces.



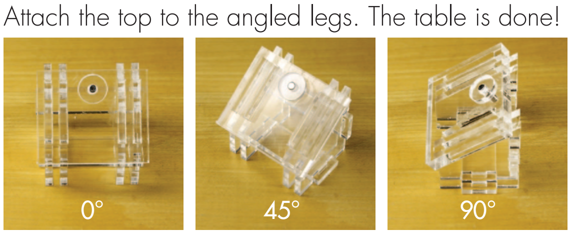
Insert the dowel pin into the plug piece.



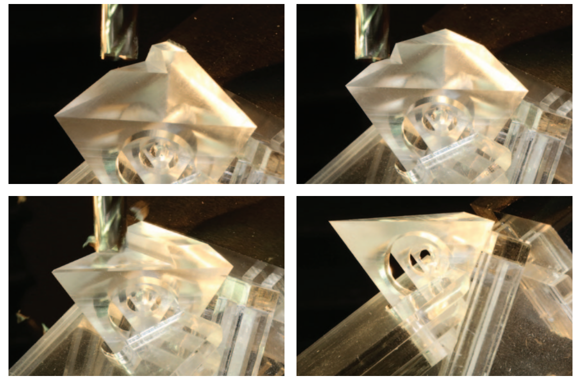
Attach the plug & pin to the tot piece of the table.



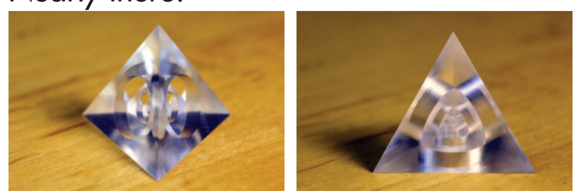
Attach the top to the angled legs. The table is done!



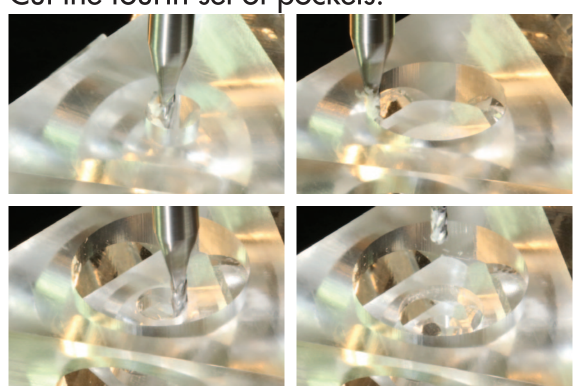
27. The angle of the table aligns the fourth tetrahedral face parallel to the XY axes.



28. Nearly there!



29. Cut the fourth set of pockets.



30. The turner's tetrahedron is complete!