ENGR 1330
Tesla Turbine Operation Sheets

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Overall Procedure

1. Cut stock for all parts
2. Make Pulley (Lathe) and Inlet Block (Mill)
3. Make Clamp Plate and Housing Cover (CNC Mill)
    1. Prep both pieces for mounting in fixture
    2. Once both pieces are ready: secure fixture in vise, zero on center of fixture, finish both parts without having to re-setup the machining fixture
4. Make Bearing Housing (Lathe and CNC Mill)
5. Make Rotor Shaft (Lathe and CNC Mill)
6. Make Turbine Housing (CNC Mill)
7. Finish Rotor Disks and Spacers

Stock Materials and Sizes

- Pulley and Bearing Housing: 3”(min) x 2” dia. 6061 Al rod (Make pulley first, use remaining for bearing housing.)
- Inlet Block: 1.5” (min) x 1” x 1” Al bar
- Clamp Plate: 1.5” x 1.5” Al plate, min .150” thick
- Cover: 5” x 5” x 3/8”-thick clear polycarbonate
- Rotor Shaft: 3.6” x 1 3/8” dia. 416 ½-hard stainless steel rod
- Turbine Housing: 5” x 5.125” x 1.75”-thick 6061 Al bar

Plate, Clamp – 2 Axis CNC Mill

Operation 1

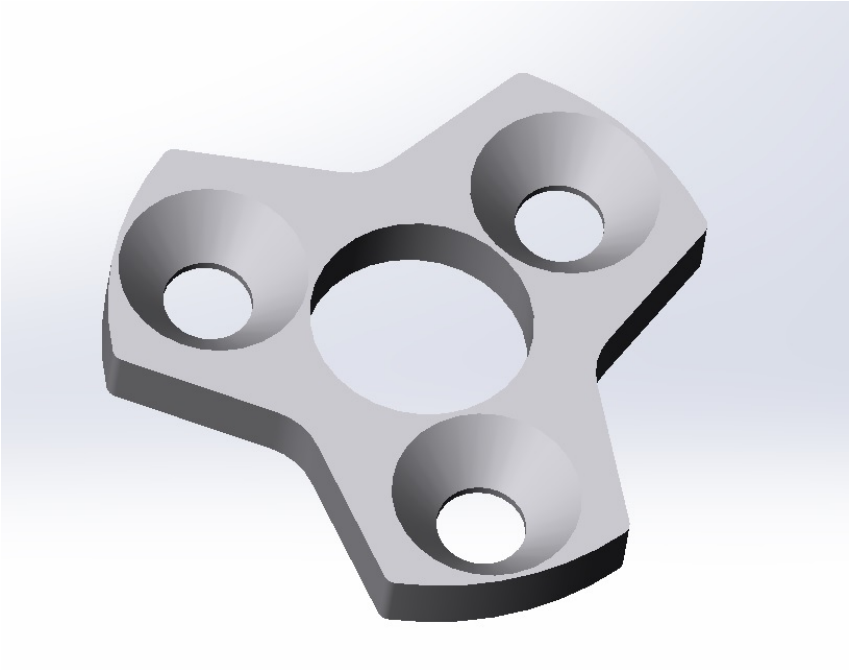
1. Cut a piece of 1.5” x 1.5” stock from min .150” thick aluminum plate (can be from scrap)
2. Do not bother squaring the edges.
3. Set up in mill and set zero to center of stock.
4. Face part to bring it to final thickness
5. Program outer hole pattern, drill, and countersink outer 3 holes
6. Drill[1] and ream[2] center hole

[1] Be sure to step up drill sizes and leave roughly 5% of the final hole size to remove with the reamer

[2] Ream at about ½ the speed that you would drill at

Operation 2

1. Mount machining fixture in mill and set zero to center of the fixture
2. Bolt your part to the fixture using the 3 countersunk holes
3. Use existing program to machine outer profile of part



Cover, Housing – 2 axis CNC Mill

Operation 1 – 5 min

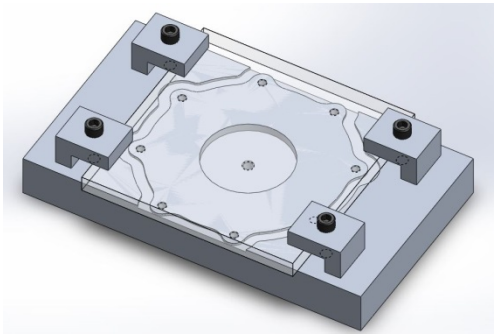
1. Cut a piece of 5x5 stock from 3/8 thick polycarbonate.
2. Do not bother squaring the edges.
3. Set fixture up in mill. Make sure the “UL” mark is in the upper left corner of the vice. Set your zero using the circle pocket in the center of the fixture.

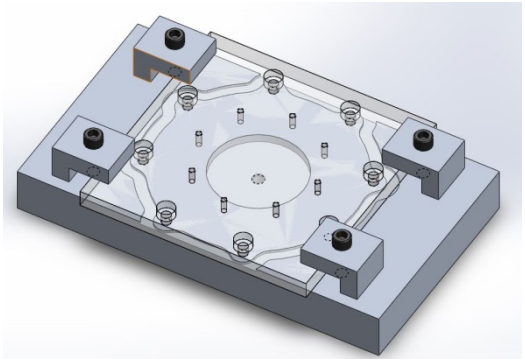
Operation 2 - 45min

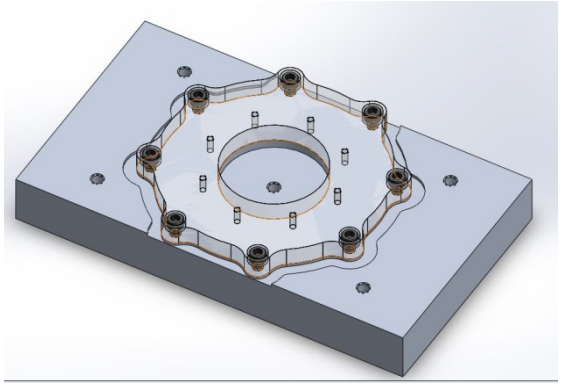
1. Mount polycarbonate square in machining fixture. Clamp as shown in top picture.
2. Use existing CNC program to drill and counter bore the 8 outer holes. **Be sure to check that your drill bits won’t run into the finger clamps while rapid moving!**
3. Drill and tap the 8 smaller holes. Be careful to not go all of the way through the plastic!

Operation 3 – 20 min

1. Clamp the part down using the counter bored holes and supplied fasteners.
2. Remove the 4 finger clamps.
3. Machine center circle and outer profile using CNC program.







Shaft, Rotor – Lathe + CNC Mill

Operation 1 - 40 min

1. Cut stock 3.6” long from 416 ½ hard SS
2. Hold in 3-jaw chuck
3. Rough red area . RPM=470, F=.005, DOC=.050
4. Finish red area. RPM=860, F=.005, DOC=.015

Operation 2 – 50 min

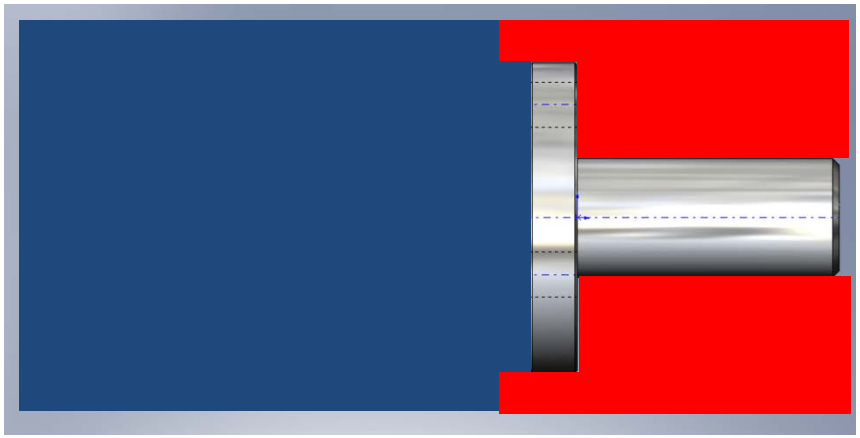
1. Hold in collet.
2. Rough red area(use same settings as rough above).
3. Finish red area (use same settings as rough above).
4. Thread end using die and die holder.

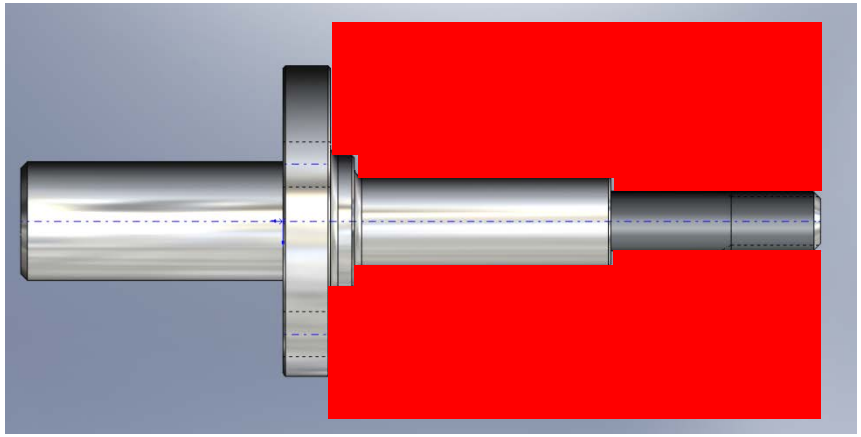
Operation 3 – 30 min

1. Use collet block to fix part in vise on mill
2. Create a CNC program for the bolt circle
3. Drill and tap the 3 bolt holes

Hints:

- **DO NOT USE CUTTING FLUID**
- Only use the **TiN-coated carbide inserts!**
- **Minimum DOC should never be less than .010”** when cutting SS. Trying to remove smaller amounts of material when getting close to the final diameter will cause taper in your part and poor finish.
- Cut down the outer diameter in small steps along the length of your part to minimize deflection
- Let part cool to room temperature before measuring or making final cut!





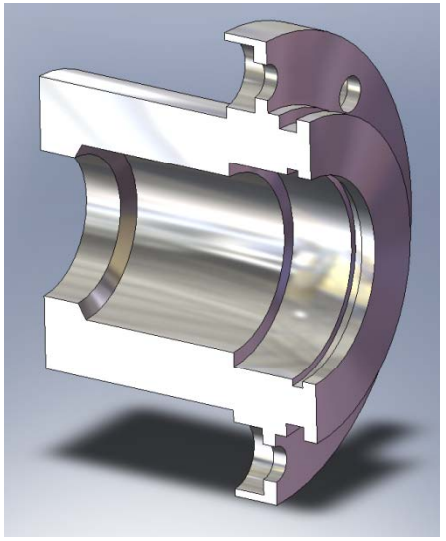
Bearing Housing-2 axis CNC mill

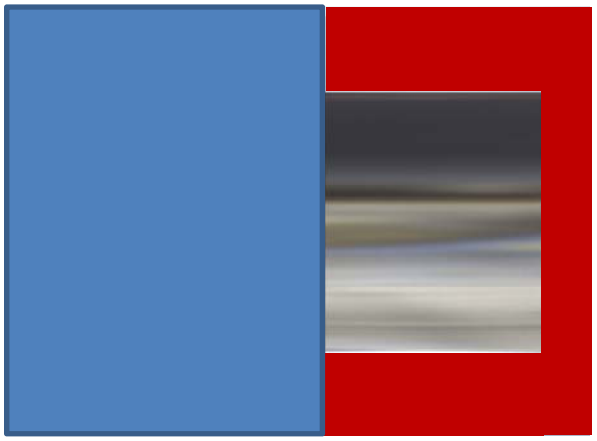
Operation 1 - 30min

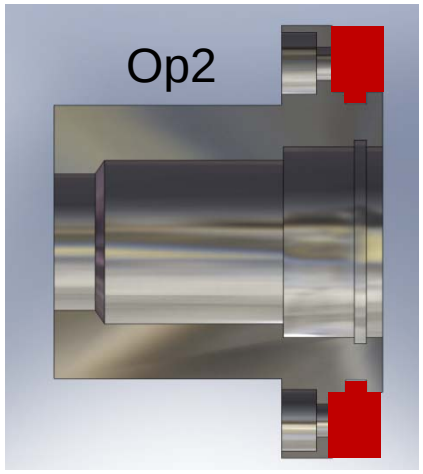
1. Cut stock 2.0” long from 2” dia 6061
2. Hold in 3-jaw chuck
3. Rough red area . RPM=860, F=.010, DOC=.100
4. Finish red area. RPM=860, F=.005, DOC=.005

Operation 2 – 50 min

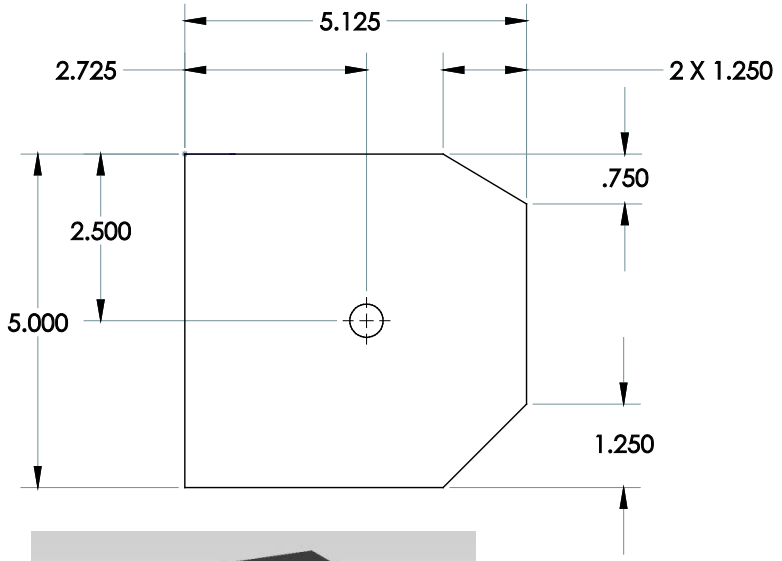
1. Hold in 3 jaw chuck
2. Face end to bring part to proper length
3. Drill .75 dia hole to depth shown.
4. Bore large diameter (.8745) first!
    1. Hint: always machine for MMC (maximum material condition = smallest hole or largest diameter).
    2. Hint: Make sure you can accurately bore a smaller dia hole in the part before trying to hit the close tol diameters. For example, try boring a hole .8500-8505 before boring the .8745 hole. If you can make this hole, then you can make the other 2 with confidence.
5. Bore the small diameter hole.
6. Machine the red area.
7. Machine the internal groove
8. Setup on mill and drill and c’bore the fastener holes.







Turbine Housing



Operations

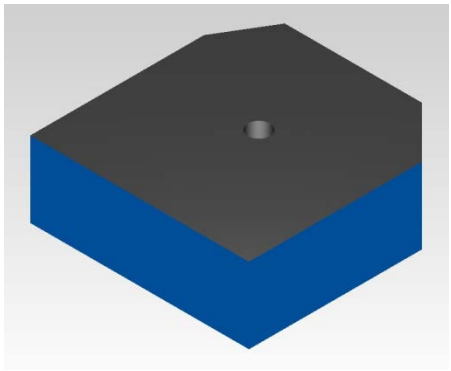
1. Cut stock to 5.125” x 5” and remove corners as shown at right,
   Set up on mill and face top surface—DOC .020”,
   Set 0 at 2.725”, 2.5” and drill 0.5” hole through all.

CNC pedestal milling:

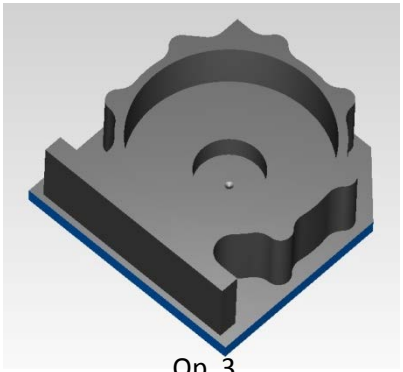
2. Rough outside profile, large circular pocket, and center 1.375” hole
   BE SURE TO FLOOD WITH COOLANT
   3 flute ¾” HSS roughing end mill, F=10 ipm, DOC=.300, S = 2400 rpm
   Leave .020” for finish pass on bottom of large circular pocket
3. Finish outside profile, large circular pocket, and center hole
   3 flute ¾” HSS end mill, F=10 ipm, DOC=full height, S = 2400 rpm
4. Spot drill perimeter holes with mill drill
5. Chamfer outer profile with mill drill
6. Chamfer inner edge of large pocket—be sure to leave enough material for the wall of the o-ring groove!
7. Chamfer inner edge of center 1.375” hole
8. Drill and rollform tap perimeter holes

BE SURE TO USE RIGHT DRILL SIZE FOR **ROLLFORM TAPPING**!

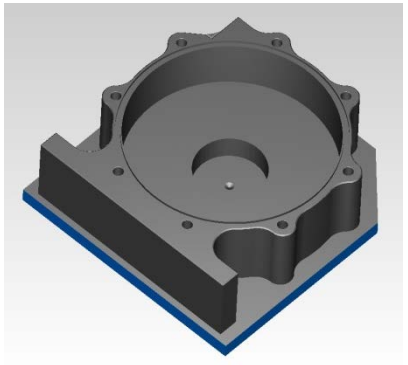
2. Mill O-ring groove
   2 flute 3/32” carbide end mill, F=5 ipm, DOC=full, S=2500 rpm



Op. 1



Op. 3



Op. 9

Turbine Housing, Part 2

Flip part over and mill back features:

1. Machine off pedestal using ¾” 2-flute end mill
2. Make finish pass on back side using face mill
3. CNC mill backside pockets (4 passes)
    1. ¼” 2-flute end mill, DOC .120
    2. Same tool, DOC .240
    3. Same tool, DOC .250
    4. ¼” ball end mill, DOC .250
4. Chamfer outer profile with mill drill
5. Chamfer center hole with mill drill
6. Spot drill drill, and rollform tap hole circle

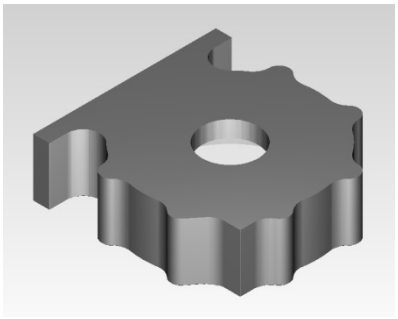
(Be sure to use the right size drill for **rollform tapping!**)

Set up in vise with base facing up:

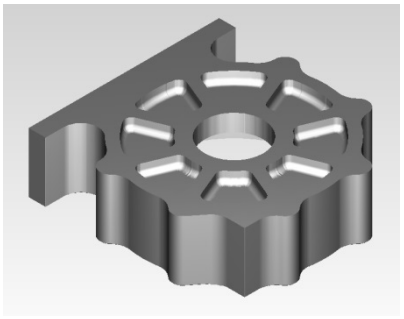
7. Mill mounting slots

Set part up on side; finish inlet face:

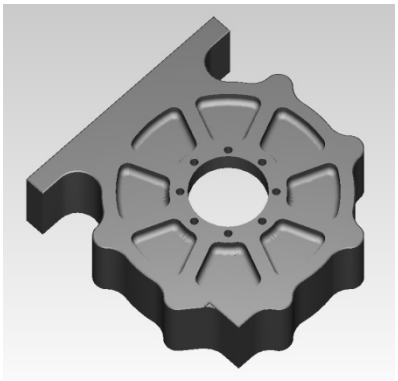
8. Finish inlet face
9. Mill inlet pocket
10. Drill inlet holes
11. Drill and tap inlet block mounting holes



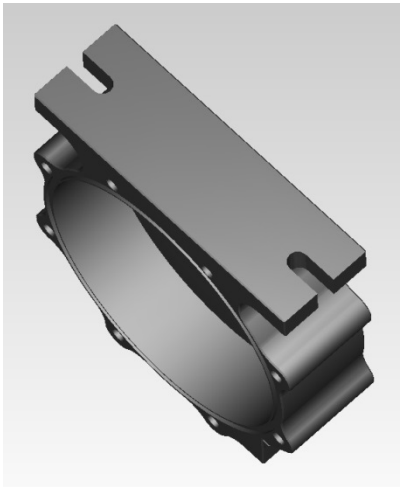
Op. 1 + 2



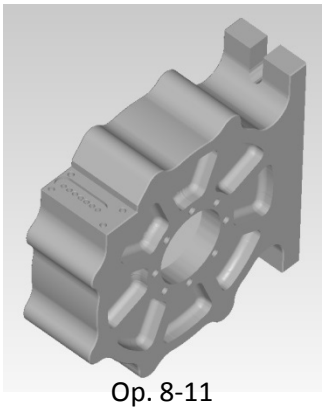
Op. 3



Op. 4 - 6



Op. 7



Op. 8-11

Turbine Disks and Disk Spacers

- Deburr all edges and holes on spacers and discs
- Ream and deburr center holes on spacers and disks
- Mount disks on rotor shaft using the two large clamp plates (see picture)
- Turn outer diameter of discs down to size
- Deburr outer edges of discs