Making Simple "Fixed Jet" Injector Plates for Patrick Carroll's AeroTech RMS 54/1280 Hybrid Revival Project V.1

Leland R. Dexter – nmrockets@yahoo.com

This is a set of procedures using a conventional "hand dialed" lathe, drill press and optional "hand dialed" milling machine to make simple "fixed-jet" injector plates for use with Patrick Carroll's revival of the *AeroTech* RMS 54/1280 Hybrid rocket motor. For more information see **https://pcarroll2525.com/high-power-rocketry/**

The original injector plate supplied with the *AeroTech* 54/1280 RMS Hybrid motor is a bit complicated. Arranged symmetrically around the base of the central depressor pin (used to open the pin valve of the flight tank) are 8 holes. Half of the holes are drilled through (the actual 1/16" orifice size) and also partially drilled and tapped 3-48 for set screws. Every other hole is blind-drilled and also tapped for 3-48 set screws. The idea is that set-screws can be used to block off unwanted injector jets and the blind holes can be used to store extra set-screws (as shown in the photos below).

This makes a nice CNC project as demonstrated by Jordan Slavish's work and as seen on Patrick's web site! However, my approach is much simpler and involves only basic lathe and drill press work to make serviceable injector plates. Optionally, a milling machine with a rotary table attachment will do a beautiful job of precisely locating and drilling the orifice jet holes. A minor inconvenience of this approach is that the plate must be switched out to change jet configurations.

Objectives:

Five main operations need to be performed to make simple fixed-jet injectors. First, using the lathe, turn down a piece of aluminum (or stainless steel) round bar to form the general OD of the part. Second, further turn down the forward section of rod to form the depressor pin. Third, cut off the part to rough length and reverse it in the chuck. Fourth, face off to finished length and turn the O-ring recess. Finally, use a drill press to carefully drill the desired number of injector ports. Optionally, a milling machine with a rotary table can be used to do a nicer job on locating and drilling the injector holes.

Step-by-step Directions:

Lathe procedures:

- Turn down the major OD of the injector body.
    a. Cut a length of 3/4" round bar stock.
        i. The *AeroTech* original is 303 stainless steel.
        ii. I used 6061 T6 aluminum.
    b. Chuck with a protective collet if possible (see my pin valve paper for details of these collets).
    c. Face off the end.
    d. Turn to 0.680" diameter x about 0.4" long (0.070" total off the diameter or 0.035 on a side (OAS) (this equals 1x20, 1x10 and 1x3 cuts then measure the cut required to finish).
- Turn down the pin valve depressor pin.
    a. Turn the forward portion of the injector body down further to 0.100" diameter x 0.164" long stock dimension or 0.234" long for use with the modified *Interstate Pneumatics* brand pin valve modification discussed in my pin valve modification document (an additional 0.580" off the diameter or 0.290" OAS = 14 x 20 cuts + 1 x 3 cut then measure the cut required to finish).
    b. Set the compound rest to 15^{o}, pick up the pin tip and cut in .010" to .020" on the cross slide but using the compound rest dial to do the actual cut along the angle. This should produce an angled tip extending about half the length of the pin.

c. OPTIONAL METHOD: do not use 0.164” or 0.234” turned aluminum depressor pin but rather drill 0.1” diameter x 0.125” deep hole and insert a 0.101” x 0.289” long drill rod pin press fit into the hole. Use whatever works for you.

- Cut off the injector body to rough length.
    a. Use a small parting tool (0.054” tip width or so).
    b. Step in at least 0.233” plus your parting tool tip width from main face of part.
    c. Plunge in and cut-off the plate.
    d. Measure the resulting thickness (should be in excess of the required 0.223”).
- Face off the rear of the injector body and turn the O-ring recess.
    a. Chuck the part in reversed with 0.100” tip or full diameter using a protective collet if possible.
    b. Face to the final 0.223” plate thickness.
    c. Cut a step to 0.375” OD (0.153 OAS) x 0.068” deep (this is 7x20 and 1x10 cuts, then measure the remainder and cut on in to finish).
    d. For my setup only, I center drill & drill 0.128” by about 3/32” deep to locate the rotary table pin.
    e. The injector plate blank is now complete.

Drill Press procedures (option #1):

- Lay out your desired hole pattern.
    a. Apply machinists blue dye to the top face of the part.
    b. Scribe the geometric layout to locate the hole locations around the central depressor pin or simply “eyeball” your desired hole locations.

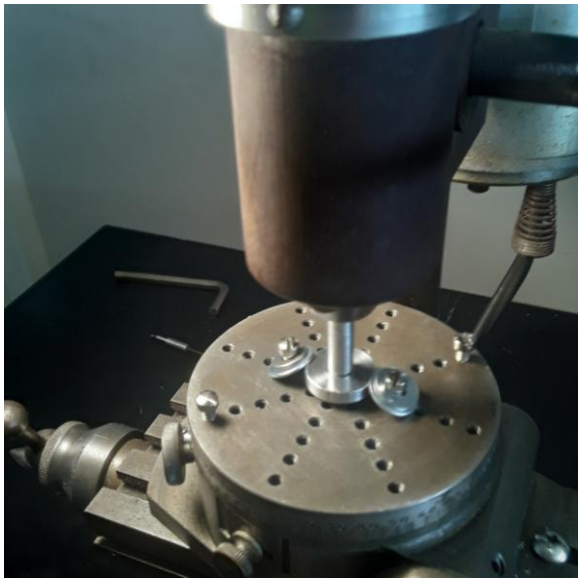
- Carefully drill the holes as close to the depressor pin as is possible
    a. Use a 1/16” drill bit.
    b. Using the depressor pin as a reference, crank the drill down to the part and make sure the drill will not contact the pin.
    c. Drill the hole through the part and repeat as needed.
    d. Check the bottom of the injector after each drilling. As long as the hole remains inside the raised section in the center of the O-ring groove you should be fine.
- You are finished with your injector plate.

Mill and Rotary table Procedures (option #2):

- Attach and center the rotary table to the mill.
    a. Follow the directions for your particular mill and rotary table combination. A few of these steps are tuned for my specific machine. My rotary table uses a small central pin as a reference (photo below)

and I turned a special cylindrical fitting from 3/16” diameter aluminum to locate the injector part under the spindle by centering it on the depressor pin (photo below).

    b. Lightly clamp rotary table to mill table so it can still slide.
    c. Clamp the injector plate loosely to the center rotary table.
    d. Work the feeds on the mill table until the rotary table is centered under the spindle of the mill.
    e. Drop the spindle to hold the part to the table with the centering arbor for the final clamping (see photo below).

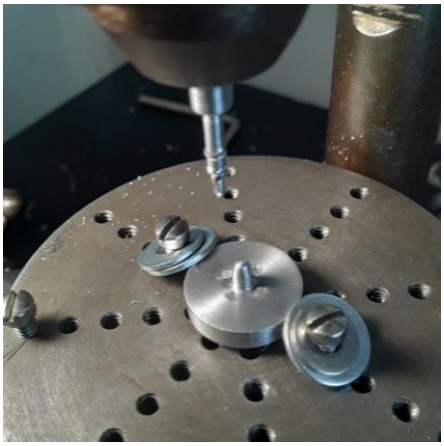


f. Tighten down the rotary table securing screws then finish clamping the part securely to the table.
g. Freeze the Y-axis feed and be careful not to bump or accidentally turn.
h. Lift the spindle and remove the centering arbor.

- Set up the drill in the spindle and locate the first hole.
  a. Step off 0.125” on X-axis .
  b. Insert the 1/16” drill bit into the mill collet. For me, this is a custom made tool where a standard 1/16” drill is epoxied inside a 3/16” diameter aluminum sleeve with a reduced section to clear the depressor pin while limiting the depth of the hole thus avoiding drilling into the rotary table.

c. Finish off by drilling the blind holes through on a drill press.

- For the two jet injector:
  a. Drill with the custom 1/16” drill.
  b. Turn the rotary table 2 x 90^{o} and drill with the 1/16” drill again.
  c. This completes the 2 jet injector.
  d. Remove the part and replace with new blank.
- For the three jet injector:
  a. Drill with the custom 1/16” drill.
  b. Turn the rotary table 120^{o} and drill with the 1/16” drill again.
  c. Turn the rotary table 120^{o} and drill with the 1/16” drill again.
  d. This completes the 3 jet injector.
  e. Remove the part and replace with new blank.
- For the four jet injector:
  a. Drill with the custom 1/16” drill.
  b. Turn the rotary table 90^{o} and drill with the 1/16” drill again.
  c. Turn the rotary table 90^{o} and drill with the 1/16” drill again.
  d. Turn the rotary table 90^{o} and drill with the 1/16” drill again.
  e. This completes the 4 jet injector (photo below):



f. Remove the part and replace with new blank.

- For the five jet injector:
  a. Drill with the custom 1/16” drill.
  b. Turn the rotary table 72^{o} and drill with the 1/16” drill again.
  c. Turn the rotary table 72^{o} and drill with the 1/16” drill again.
  d. Turn the rotary table 72^{o} and drill with the 1/16” drill again.
  e. Turn the rotary table 72^{o} and drill with the 1/16” drill again.
  f. This completes the 5 jet injector.
- Clean up the holes.
  a. Finish drilling through all blind holes with a 1/16” drill on the drill press.