Re-building and Re-furbishing AeroTech Phenolic/glass Nozzles for use with Patrick Carroll's AeroTech RMS 54/1280 Hybrid Revival Project V.4

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This is a two-part set of procedures using a conventional "hand dialed" lathe to re-build used *AeroTech*[tm] phenolic/glass nozzles with graphite throat inserts and then re-furbish them for repeated use. These nozzles are intended for use with Patrick Carroll's revival project of the AeroTech 54/1280 RMS Hybrid rocket motor.

https://pcarroll2525.com/high-power-rocketry/

Part 1 shows the procedures for re-building the nozzle after the first burn in native AeroTech configuration. Part 2 shows the procedures for all subsequent re-furbishings.

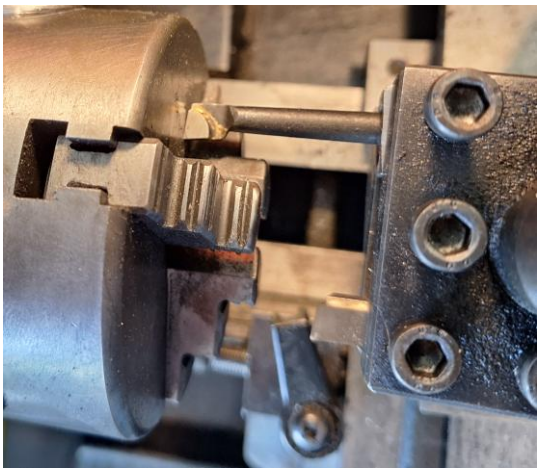
Objectives for Part 1:

1. Bore the burned out throat to form a partially floored cavity
2. Cut and cement in a cylindrical graphite slug
3. Drill a new throat through the graphite plug
4. Re-shape the convergent and divergent cones
5. This will produce a nozzle that can be reused several times

Lathe procedures:

Bore the throat cavity and install the graphite plug:

- Cut a slug of ¾" graphite rod ½ to $^{5}/_{8}$" long
- Clamp an appropriate boring bar (with a small enough tip to clear the desired throat diameter and about 1 ½" to 1 ¾" reach) into the lathe tool holder
- Index the boring bar tip against the chuck face
    a. Begin by setting the measurement collar on the compound rest to 0.0 in about the middle of its range of travel
    b. Crank the carriage in toward the chuck until the tool tip lightly contacts the face of the chuck itself
    c. Lock the bed stop against the carriage



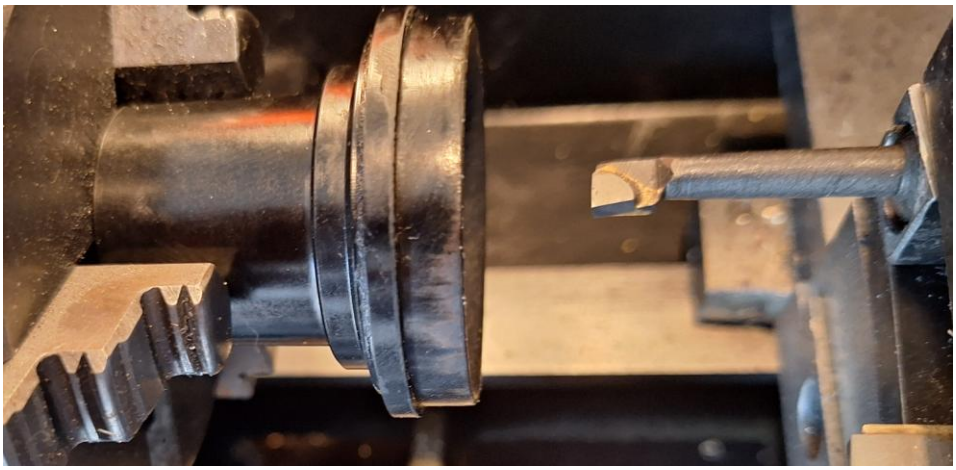
d. Back the compound rest dial counter-clockwise (outward) by 0.700”
e. This will set up the depth of the bore

- Index the cross-slide to set the tool tip at the centerline of the nozzle
    a. Begin by turning the cross-slide dial clockwise (inward) so that the cutting end of the boring bar will be well on the back side of the work
    b. Chuck in a short length of ¼” drill rod extending about 1” out of the chuck
    c. Turn the cross slide dial counter-clockwise (outward) so the boring bar tip touches the drill rod

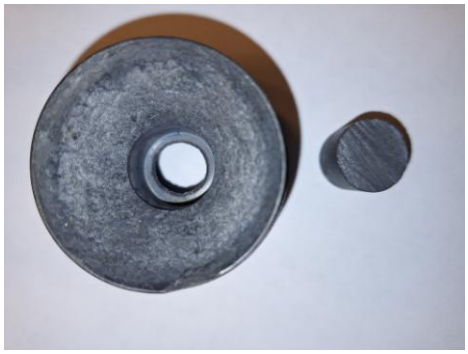
    d. Set the cross-slide measurement collar to 0.025 while keeping light pressure against the rod
    e. Remove the drill rod from the chuck

f. Continue turning the cross slide dial counter-clockwise (outward) by an additional two and one half turns (0.025” + 0.050”+ 0.050 for a total of 0.125”). The cross-slide measurement collar should now read 0.0 and the boring bar tip will be located at the centerline of the nozzle

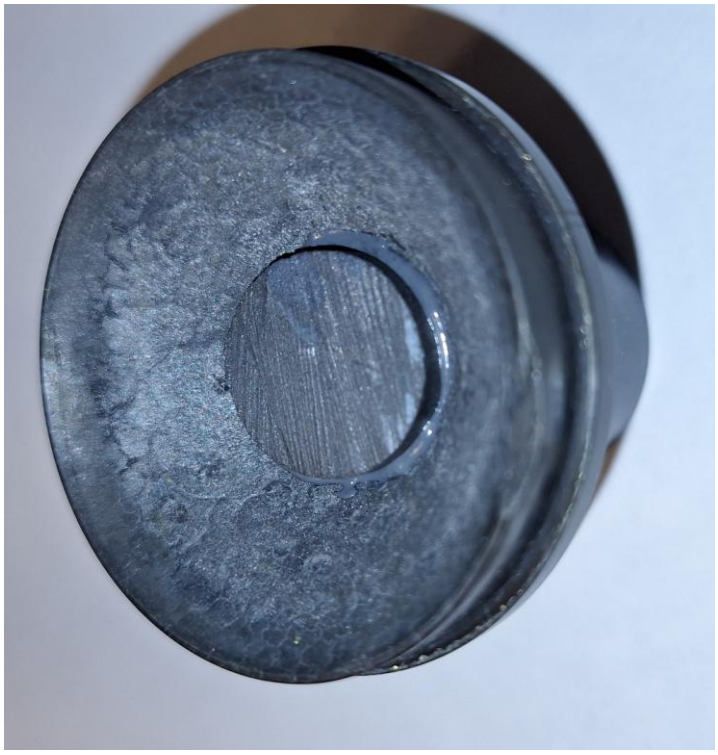
- Back the carriage out of the way
- Chuck the nozzle with the end of its exit cone flush against the chuck face or even with it for larger chucks



- Bore the throat cavity to 0.750” diameter by about 0.50” deep
    a. Make the cuts by simply cranking the carriage back-and-forth to the bed stop as you dial the cross slide counter-clockwise (outward) for each cut
    b. Count the cuts. This will total 18.7 cuts of 0.020” each. The first ten to twelve cuts are “air cuts” as the tool will simply pass through the eroded throat space. Once you are actually cutting phenolic, do the remainder of the 18 full cuts, then make additional smaller cuts to allow a press fit of the slug
- Clean the chips and dust from the nozzle



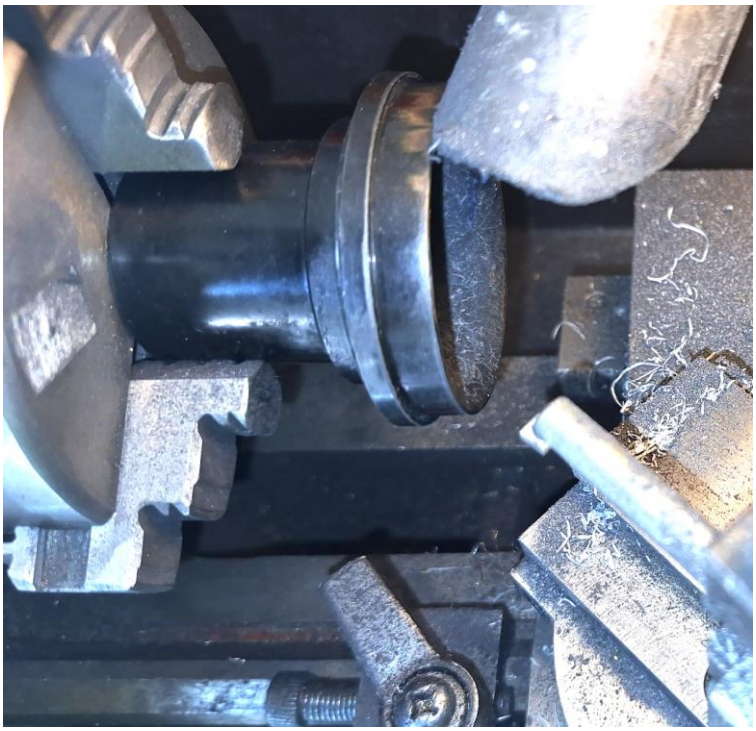
- The shelf at the bottom of the cavity should be at least 0.125” wide. If it is less than this, do not re-use the nozzle
- Using *JB Weld*[tm], epoxy the graphite slug into the cavity firmly seated against the shelf and let cure



<u>Drill the throat and re-shape the entrance and exit cones:</u>

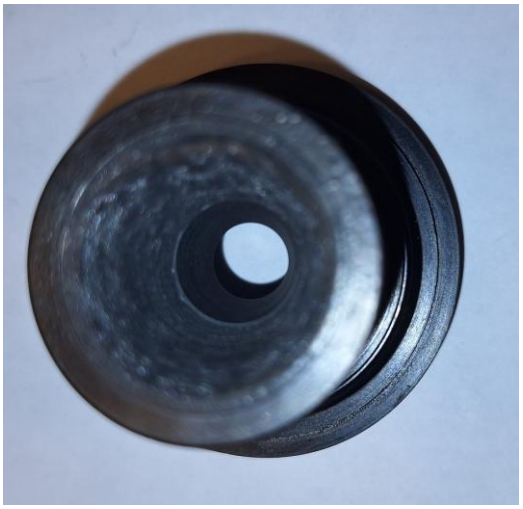
- Chuck nozzle by its exit cone,
- Center drill and drill 0.313” (5/16”) for the stock AeroTech nozzle or drill any other throat diameter you desire (see end notes)

- Insert the boring bar into the tool holder
- Set the compound rest to the converging angle of 45^{o}

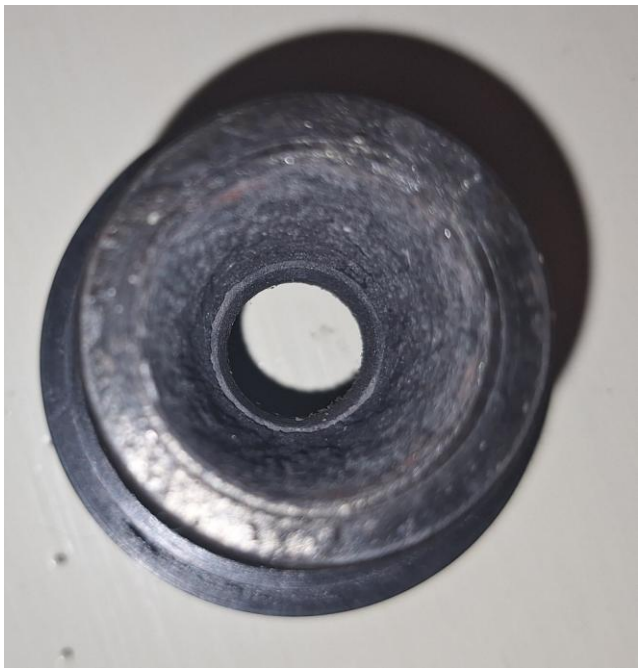


- In small steps:
    a. Cut away the graphite plug until the cone surfaces are nearly flush

    b. Dial the compound rest as far back (counter-clockwise) as is reasonable and set the measurement collar to 0.0
    c. Pick up the convergent cone 45° angle surface and skim-cut in at least 1.06” from the outer lip of the cone to smooth the entire surface
- Re-chuck the nozzle by its converging end
- Set the compound rest to the diverging angle of 15°
- In small steps:
    a. Cut away the graphite until the cone surfaces are nearly flush
    b. Set the compound rest to 0.0 and dialed as far back as is reasonable
    c. Pick up the cone 15° angle surface at the edge of the exit cone
    d. Skim-cut in at least 0.964” to smooth the entire surface
- Finish any irregularities as needed
    a. Turn more off the diameters
    b. Use sandpaper
    c. Finish with steel wool



- Important notes
    a. Wear a particulate mask/respirator and use a vacuum system to help control phenolic/glass and graphite dust
    b. The graphite throat will not ablate appreciably so account for that when choosing the new throat diameter
    c. The interior surfaces of the nozzle body will still ablate to some degree so the number of re-uses will be limited by the amount of that erosion (photo below shows a divergent cone after one burn)



<u>Objectives for Part 2:</u>

1. Fill the burn pits and crevices with epoxy
2. Sand all burned surfaces to a reasonable degree of smoothness

Procedures:

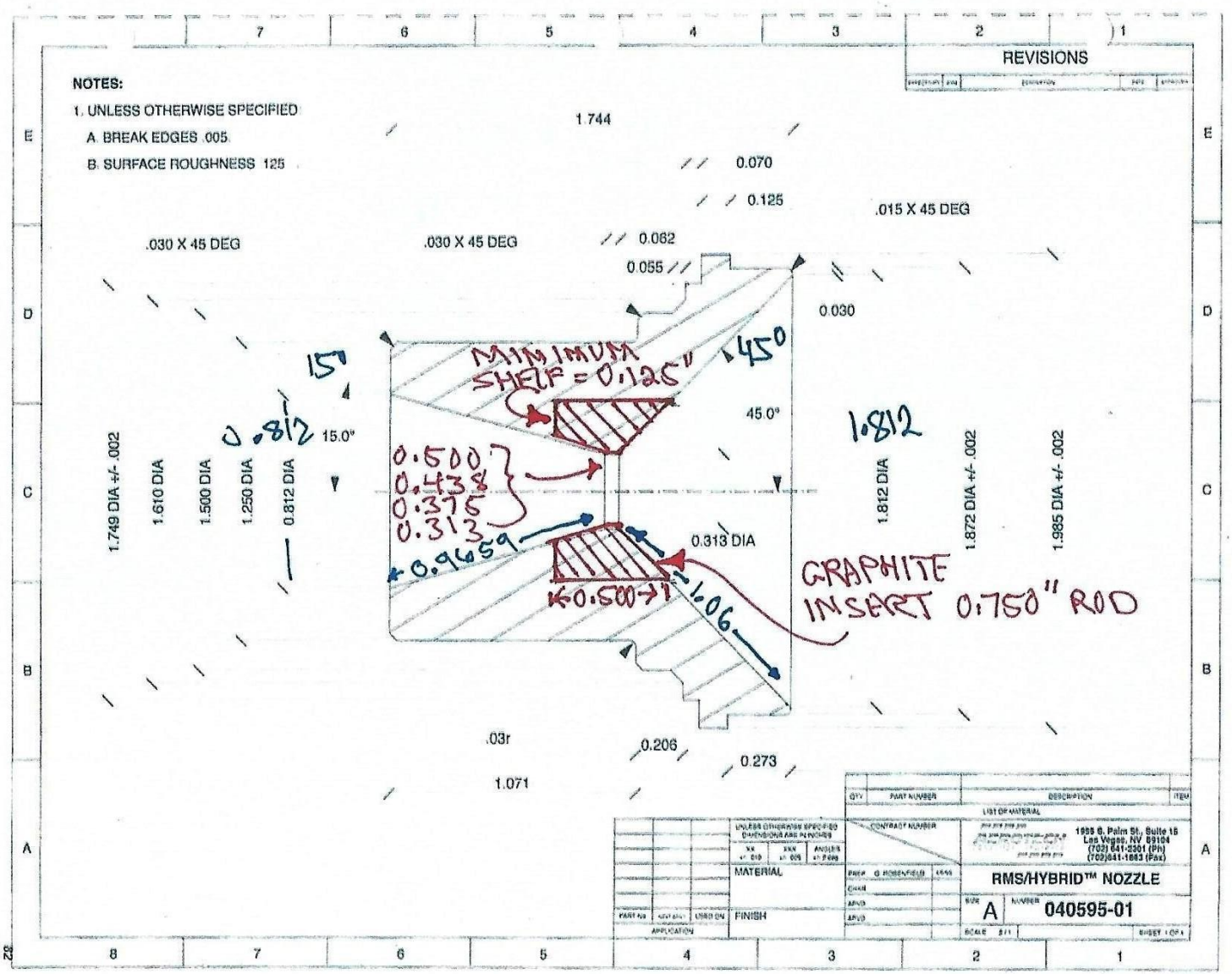
- The re-built nozzle will incur additional ablation of the phenolic/glass portion of the nozzle with repeated use

- My approach is to refill the major grooves, pits and crevices with JB Weld^{tm} epoxy

- Once cured, chuck the nozzle back into the lathe then sand and steel wool the excess epoxy and major burn pits in the phenolic/ glass surfaces down to a reasonable level. This won't be perfect but is certainly useable

- Once the surfaces are smoothed to your satisfaction, re-measure the new throat diameter or re-drill to new specifications. Minimally, this typically amounts to about 1/64" erosional increase of the throat diameter per firing

- The epoxy will ablate out along with more of the phenolic/glass surfaces. So you will need to keep refurbishing with these procedures until the nozzle is no longer useable. You should be able to get several firings from a stock original AeroTech nozzle. This will keep one of the major costs of firing these hybrids down to just a few dollars per burn


REVISIONS
NOTES:
1. UNLESS OTHERWISE SPECIFIED
A. BREAK EDGES .005
B. SURFACE ROUGHNESS 125
1.744
0.070
0.125
.015 X 45 DEG
.030 X 45 DEG
.030 X 45 DEG
0.062
0.055
0.030
MINIMUM SHELF = 0.126"
15°
45°
45.0°
15.0°
0.812
1.812
0.500
0.438
0.375
0.313
0.9659
0.313 DIA
0.500
1.06
GRAPHITE INSERT 0.750" ROD
1.749 DIA +/- .002
1.610 DIA
1.500 DIA
1.250 DIA
0.812 DIA
1.812 DIA
1.872 DIA +/- .002
1.985 DIA +/- .002
.03r
0.206
0.273
1.071
QTY
PART NUMBER
DESCRIPTION
ITEM
LIST OF MATERIAL
CONTRACT NUMBER
1955 S. Palm St., Suite 15
Las Vegas, NV 89104
(702) 641-3301 (Ph)
(702)641-1883 (Fax)
MATERIAL
FINISH
RMS/HYBRID™ NOZZLE
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