# CCBCMD CAMM112 Air Motor Project
## March 1, 2015
## PES

1. **Base**
   a) Cut 1/2" x 3" aluminum 6061 stock to 6.25"
   b) Square edges to size and finish using side cutting end mill.
   c) Clamp in vise with parallels to expose 0.31" of edges
   d) Using 1/2" ball mill, machine contours on edges.
   e) Locate holes using prick punch, center punch, and spot drill.
   f) Drill through holes 9/32" and deburr
   g) Using flycutter, finish top surface, removing no more than 0.002".
   h) Flip over and finish bottom surface.
   i) Countersink holes
   j) Remove from machine and hand file all sharp edges smooth.

2. **Manifold**
   a) Cut 1" x 1" steel 1018 stock to 4.5"
   b) Mill both ends square and length to 4.255" (0.005" oversize)
   c) Lightly mill stock surfaces square to greater than 0.997" (0.002" oversize)
   d) Layout, locate, drill, and tap two holes in end to match base
   e) Layout and locate one hole on surface "A" and four holes on surface "B"
   f) Drill 3/8" pilot hole in surface "A"
   g) Using 7/16" end mill, make flat bottomed hole 0.50" deep
   h) Tap for 1/4-18 NPT
   i) Countersink to 0.530" D
   j) Drill one hole 0.201" D (#7) 0.62" deep
   k) Tap 1/4-20
   l) Countersink to 0.25" D
   m) Drill two holes 0.156" D, one thru, other 0.5" deep into NPT hole
   n) Drill 0.359" (23/64) thru hole
   o) Ream to 0.375" RC5 fit on 3/8" dowel (-0, +0.0009) for dowel 0.001 to 0.0016 undersize
   p) Countersink to 0.015" over (0.390" D) ?
   q) Chamfer 5 corners 1/16" x 45 degrees (hand file?)
   r) Surface grind all surfaces flat and perpendicular to 63 micro-inch finish.

3. **Crankshaft**
   a) Cut 0.25" piece of 1.25" diameter round aluminum 6061 stock
   b) Using soft jaws on lathe, face one end flat
   c) Reverse, and face to 0.214" thick
   d) Drill center and follow with 0.359" (23/64) drill
   e) Ream to 0.375" FN2 fit for 3/8" dowel (+0, -0.0006) for dowel 0.001 to 0.0014 oversize
   f) Press dowel into hole
   g) Insert dowel into collet and fasten to rotary table on mill with 1/4" sacrificial spacer

h) Center mill on dowel and zero DRO or hand dials
i) Align rotary table to 0 degrees
j) Move table to 0.050" and drill 0.172" (11/64) hole through piece and into spacer
k) Ream to 0.1875 FN2 fit for 3/16" dowel (-0, +0.0005) for dowel 0.0007 to 0.001 oversize
l) Clamp part over hole
m) Install 1/4" end mill and turn table 180 degrees. Set milling table to 1.125"
n) Mill down through part into washer
o) Turn table 90-35 degrees (55 degrees for one section of arc).
p) Using mill table, mill straight section on one side.
q) Return to previous position, and turn rotary table 55 degrees in other direction.
r) Use mill table to complete other side
s) Use hand file to break sharp edges
t) Press 3/16" dowel into hole

4. **Cylinder**
   a) Cut 2.50" piece of 1" x 1" aluminum 6061 square stock.
   b) Lightly mill all surfaces flat and square
   c) Locate center of one end with cross lines using 45 degree or center head on square
   d) Mark location with prick punch and center punch
   e) Secure piece in 4-jaw chuck in lathe, using tailstock center on hole location
   f) Drill a center, followed by a 3/8" diameter drill, to depth of 1.375"
   g) Using a boring bar in the toolholder, adjust carriage stop for depth of 1.350"
   h) Bore hole to 0.625" diameter (use telescoping gauge to check)
   i) Make sure bottom of hole is flat; increase depth and bore deeper if needed
   j) Measure actual depth of hole, and face end until actual depth is 1.344"
   k) Use flycutter to machine surface "A" to 63 micro-inches.
   l) Mark surface "A" with layout dye, and locate positions of two holes 1.250" and 1.750"
   m) Drill one hole 0.156" (5/32) into bore
   n) Drill one hole 0.297" (19/64) thru
   o) Ream 5/16" for shoulder bolt
   p) Use 5/16" locating pin in center of rotary table, and a sacrificial 1/8" to 1/4" spacer
   q) Clamp down to table using 0.625" rod in bore
   r) Use 1/2" radius corner rounding end mill to produce profile per drawing
   s) Spotface 5/16" hole to 0.375" D
   t) Break all sharp edges 0.015 max with hand file

5. **Piston**
   a) Cut 0.625" steel 1018 round stock to 2.0" long
   b) Face one end
   c) Drill small center hole (optional)
   d) Extend piece so 1.50" extends from chuck
   e) Use small live center to support end in tailstock (optional)
   f) Turn connecting rod to 0.375" diameter 1.25" to square shoulder
   g) Face inside edge of shoulder square.

h) Reverse piece and hold in chuck using 0.375" connecting rod (maybe use a collet)
i) Face end of piston to 0.531" long
j) Mark 1.750" on end of connecting rod
k) Hold piston in chuck and face end of connecting rod to 1.750"
l) Mark 0.188" from end of connecting rod
m) Use file to chamfer edges 0.005-0.010"
n) Support connecting rod on parallels in milling vise
o) Locate center of shaft and end of shaft with edge finder, and set DRO or dials
p) Use spotting drill or center drill to locate hole
q) Drill 0.172" (11/64) diameter hole
r) Ream to RC7 fit for 3/16" dowel (0.1875 to 0.1887 for 0.1856 to 0.1863 dowel)

6. **Flywheel**
   a) Cut 2.00" diameter aluminum 6061 rod to 1.25" long
   b) Face both ends square
   c) Drill center and support with live center in tailstock
   d) Turn to shoulder 0.875" diameter 0.380 to 0.390" long
   e) Face shoulder smooth and square
   f) Remove live center and replace with drill chuck.
   g) Drill 0.359" (23/64) hole through flywheel
   h) Bore 3/8" for RC6 fit on dowel (0.375"-0.3765" for 0.3731" to 0.374" shaft)
   i) Face shaft connector to 0.375" long
   j) Reverse part in chuck and face outside end to 1.125" total length
   k) Chamfer all edges with file, and polish surfaces with abrasive cloth
   l) Support flywheel in milling vise using V-block
   m) Locate center and edge using edge finder, and set DRO or dials
   n) Locate 0.188" from end and use spotting drill or center drill to start hole
   o) Drill 0.201" (#7) into bore
   p) Tap hole to 1/4-20
   q) Countersink to 1/4" diameter