V2.03 Part manufacturing sequence

Wednesday, November 2, 2016 12:55 PM

To manufacture the parts, follow the steps in the following sections:

Current estimated machine time: 249m/2 = 124.5m per part :(

Version this run:

And this was supposed to be a simple rework! LOL.

Precautions

IMPORTANT: **Do NOT over-torque the vise handle** by pushing it beyond the clear "firm" location. If you've f*cked it up, you'll feel the following in sequence, as you go through the tightening motion: first it's the loose backlash slop, followed by engagement, light tightening, resistance, (!) followed by a plateauing of the total torque force, followed by smooth rotation of the vise handle through whatever range is pressed. If you don't stop when you feel that initial resistance, you will have moved the vise. It's not a question of whether, it's a question of how much you screwed it up. The transition from stiction to moving friction is marked by that transition from a clamping to a sliding condition. Once you're in that plateauing of force phase, the vise's rear jaw has already started actively moving, and the alignment is, at that very moment, f*cked. Don't tighten it too much!

Machine Preparation & Checkout

Perform or check the following before starting a run of the 2016-010 parts

Op #	When to Verify	Tool, workstop changes, work
☐ 1	Every time	Ensure sufficient stock of U:0.1875 RAD EM 2FL 0.5LOC 0.020R (3 min including in-use), W: 0.250D RAD EM 2FL 0.375LOC 0.030R (2 min), V-Bit 60 deg 0.125 inches (3 min) bits. Larger-lot Minimums: 1 set: 2 bits; 2-5 sets: 4 bits; 5+ sets: estimated 2 + (1 bit / 3 sets).
☐ 2	Every time	Ensure bed has only aluminum chips on it, to avoid contamination of recycling
☐ 3	Every time	Ensure vacuum has uncontaminated aluminum chips in it, and the filter is the one marked as being for aluminum.
☐ 4	Every time	Ensure air and misting nozzles are pointed correctly for the bit, material and processing.
☐ 5	Every time	Ensure compressor is on and at working pressure (120+ PSI, switch and power on)
☐ 6	Every time	Ensure there is Kool-Mist fluid and the lines are charged
☐ 7	Each shift	Replace blue-tape shielding with new
☐ 8	Each shift	Ensure starting coolant temp is < -10C
☐ 9	Each shift	Swing indicator down and tram rear vise jaw with fixture and spacers in place, vise, tightened nominally to ensure it's ready for the shift.
☐ 10	Work Halt!	Ensure no machine crashes have occurred (X0Y0Z0 must all be re-established if it has). Single-axis crashes require full re-capture nonetheless
☐ 11	Work Halt!	Ensure no machine crashes into the stationary-jaw vise. If any contact occurs, vise must be re-trammed
☐ 12		Other, observed needs

Material Prep

Cut and prep material steps:

Op #	Est/Real time	Tool, workstop changes
☐ 0	0m	Bring transport washtub and sufficient red wrapping cloths up to garage
☐ 1	5m	Setup horizontal bandsaw for **9.25", +0.015,-0.00"**
☐ 2	20m/cut?	Cut lengths of 4x3x3/8 (or 4x4x3/8) 6061 extruded aluminum angle, Two lengths per set. Before cutting, make sure material is of sufficiently high surface quality that it will meet final visual inspection!
☐ 3	10s	Wipe off oil and cut material

☐	**4**	5m	Coarse wire-brush for deburring and to give the pieces a consistent finish. More finishing will have to be done after machining, but this will set a base level of finish and to verify the stock is usable without significant defects.
☐	**5**	30s	Wipe to remove any clearly-visible oil or debris from the piece Wrap piece in red shop cloth to protect it from injury Place wrapped part in carrier to go downstairs
☐	**6**	2m	When all pieces have been cut, bring downstairs for processing

Initial Registration

To setup the workstops, and gather the machine X0Y0Z0 datum, follow these steps. This typically only needs to be done at the start of a shift, or when the machine's been turned on/off, or somehow lost its registration accuracy.

	Op #	Est/Real time	Position	Tool, workstop changes	Cutting Paths / Comments
☐	**1**			**Load real stock part**, aligning approximately aligned with the vise jaw left edge, and tighten vise.	The exact alignment is not critical, align by finger-feel is adequate. Part marking for position memory is not necessary.
☐	**2**			**Set workstop snugly**, but lightly, in the body of the angle, below the upper arm's bulk.	Use 0.85" or so down from the top, or a 2" setup block and one of the trimmed angle workstops. This location point must be at least 0.3750" down from the 1.50" top of the short leg surface, otherwise the workstop will hit inside the curvature of the radiused corner when in position 3.
☐	**3**			**Loosen vise**, slide stock to right then lightly back to the workstop, then re-tighten vise.	Align the piece not as "the part the workstop was pushed up against", but as "the part that was pushed lightly up against the not-under-stress-displacement workstop". The second is definitely better, since it allows the workstop to start the alignment from an unstressed position, which by definition is slightly different from when the workstop was pushed up against, and then the clamp-bolt tightened. There is always either slight residual stress (and thus displacement), or it's not really contacting the part. Either way, re-locating the part is the way to go.
☐	**4**			**Insert Electronic edge-finder** (no collet insert needed) Plug in red shorting plug. Turn on coolant (charge, then slow to trickle) **Set spindle ON and 0.9k RPM**	
☐	**5**			**Capture X0 (set to -0.100) and Y0 (set to +0.100) from the part**	Take this measurement approximately 0.1" from, the rear-left corner. Manually feel for high spots, just in case.
☐	**6**			**Turn OFF spindle.** Jog spindle to ~X2.25 for future mid-point touchoffs, Jog as needed and remove electronic edge finder and red shorting plug. Return edge finder and shorting plug to their case. Jog spindle to rear parking area.	

Primary Machining

- In the below, PAUSE indicates custom code to move the head to a place where a tool-change can be accomplished, and with sufficient room to change material positioning in the vise to position 2.
- Start coolant and pre-heat spindle for a few minutes before cutting
- Only remove the bit (B: 1875D SQ EM...) when you're ready to move to the engraving. Otherwise, avoid moving that bit at all, to help prevent positioning errors.
- Chip evacuation air flow descriptor: specifies the relative open settings of three valves. Each valve has 90-degree angle the actuator moves through. Fully open, set as 1.0 (100%) is when the turning handle is inline with the inlet and outlet ports. Fully closed, set as 0.0 (0%) is when the turning handle is perpendicular with the inlet and outlet ports. Values are shown in decimal fraction with one digit significance. Proportionality of flow rate versus angle is not linear, so just use the angle and don't worry about the flow rate. The valve on the primary inlet tube, labeled "A", determines the overall level of flow to the nozzles. The "B" valve, located on the right-hand (Y-positive) side of the z-axis carriage, adjusts the air flow to the bottom of the bit. The "P" valve, located on the left-hand (Y-negative) side of the z-axis carriage, adjusts the airflow the form a horizontal air curtain, keeping most of the chips down on the bed surface.
- Spritzer timer settings (remember that the compressor has to be on!) are given as two time values. The first is the off time (T), and the second is the on time, or pulse width. Both are in decimal seconds to two decimal places maximum, and are limited by the allowed timer settings. An example of the lines below is: Spritz: T4.5s, W0.29s

	Op #	Est/Real time	Position	Tool, workstop changes	Cutting Paths / Comments
☐	**1**			**Load tool: U:0.1875 RAD EM 2FL 0.5LOC 0.020R and 3/16" collet insert**	

				Capture Z0 from approximate middle of X-length, and Y-0.7500" from the angle apex, using the 0.020" touch-plate, pressed carefully to the top of the material. Jog Z to 0.500"; if this is not possible, this will be a problem!	
☐	**2**			**Load fixture, 1 spacer (position 2) and 1 pc Material (position 1)** and register the fixture and workpiece against workstops Tighten vise to "standard" torque and lever position If using stock type B (3x4x3/8x90 6061 aluminum angle, versus type A, which is 4x4...angle), use a 1.0" spacer in this operation (Op1) to raise the material sufficiently.	**Repeats start HERE**
☐	**3**			**Adjust air and spritzer nozzles** to the length of bit and cuts about to be made. Jog spindle/gantry to parked location with X still at ~2.25 Add velcro-attached chip guard	
☐	**4**	**47m Predicted 51 m Predicted by controller**	**Op1**	**Cut holes and profile for long leg** **Combi--Op1--2016-010-021 v2.03.005.XXX.tap** **Spindle: 21.5K RPM** (22000 recommended) **Run file, Ok, Continue**	**S01--jA: Pckt-LongLegHoles (18m)** Air:1.0 (100%), B(it): 1.0 (100%), P(lane): 0.6 (60%) Spritz: OFF **S02--jA: Pckt-LongLegPerimeter (41m)** Air:0.8, B:0.6, P: 0.8 Spritz: Off Time (T): 4.5s, Pulse Width (W): 0.29s (can turn off mister here, ~48m) **S03--jA: PrFin-LongLegPerimeter-Pass1** **S04--jA: PrFin-LongLegPerimeter-Pass2** Air:0.8, B:0.6, P: 0.8 Spritz: OFF
☐	**5**			**Turn spindle speed knob to zero** and wait for it to stop. **Loosen vise and remove part**	
☐	**6**		**Op2**	**Remove any significant burrs** from the "outside" perimeter chain. Rotate the piece of stock, then re-insert the part into the next position. Note that this means flipping the part end-for-end in the vise. Be careful to avoid damaging the parts, moving the workstop, or over-torqueing the vise handle. **Tighten vise**	The outside perimeter chain is for the top, as opposed to the "inside" perimeter chain for the underside. Deburr the outside loop so the burrs can't affect part placement/registration against the workstop or against the vise jaw. Burrs on the inside chain are fine, will deform the fixture, and will be removed in secondary processing. The workstop will be against a smooth, machined face in this step. Ensure lightly-moderate force against the work-stop, but do not displace or move it.
				NOTE: Should we be re-capturing Y0 here? There's a note we should, but seems undesirable due to the multiple tool changes.	
☐	**7**			**Capture Z0 from approximate middle of X-length, with Y-0.7500" from the angle apex, using the 0.020" touch-plate** **Jog back to the park** location.	For now, let's do this for all parts.
☐	**8**	**1h2m Predicted** **1h14m est by Ctrlr**		**Cut slots and short-leg profile** If using 4x3x3/8 angle, add weight so the tail falls correctly, using large binder clips. Be careful to avoid interference with bit. Verify: • Spindle speed is correct (21.5K) • Bit is still sharp (check with spindle stopped!) • Spritzer timer is still running (should not be spritzing), • There's still sufficient cool-mist in the container • Coolant is keeping spindle case <70F, freezer coolant temp is <+ 10C • If needed, stop spindle and ensure bit is not damaged **Combi--Op2--2016-010-021 v2.03.005.XXX.tap** **Spindle: 21.5K RPM** **Run file, Ok, Continue**	**S01--jB: Pckt-ShortLegSlots** Air:1.0, B:1.0, P:0.6 Spritz: T4.5s, W0.29s **S03--jB: Pckt-ShortLegPerimeter** Air:0.8, B:0.6, P: 0.8 Spritz: T4.5s, W0.29s **S02--jB: PrFin-ShortLegSlots-Pass1** Air: 0.8, B:0.6, P:0.8 Spritz: OFF
☐	**9**			Loosen vise, remove parts and fixture, carefully wrap and place in part holding area/bin. Clean area in general and top of fixture with brushing and vacuuming to clean chips out of area.	
☐	**10**			**For processing more using the same 3/16" bit, loop to step 1.**	

☐	11			**Check for and remove any chips** that have entered the work area. Replace fixture and install part into the positon 3 location.	Note that this means swapping the (now 2) pieces in the vise, back to the positons they started at in step 5. Be careful to avoid damaging the parts!
☐	12			**Insert pieces of thin paper** and the part in Position 3 and a dummy part in the right-hand side, and clamped into place. Push down at the angle apes, so it's flat against the back jaw. This is THE critical alignment here. If it's not seated fully **down** then it won't be properly aligned. If it can be moved up in the vise jaws, loosen, re-align and retighten so it does not move. **Align one (1) stock part in position 1, and a second more than 0.250" separated**, but able to take the vise clamping load. with 3x card slices under the toe, apply light pressure to the left-hand part and fixture against the work stops, and tighten vise.	Make sure short leg face is seated flat against vise jaw face. You might need to place a shim at the toe of the right-hand (dummy) part for the vise to correctly seat.
☐	13			**Insert red finder shorting plug** Load electronic edge finder (no collet insert) **Capture Y0** from top inside edge of the short arm, at approximately X2.25".	
☐	14			**Remove electronic edge finder** Remove red finder shorting plug	
☐	15			**Load W: 0.250 RAD EM 2FL 0.375LOC 0.030R 1.5LBS with 1/4" collet insert**	
☐	16			**Capture Z0** from the middle of the bottom part, at approximately Y-0.510" (relative to the just-captured Y0). The material radius is supposedly gone by 0.375, and the bit is 0.125R, so use 0.51". Rotate the flutes so they are parallel to the x-axis.	Remember that this location is very likely at the THINNEST part of the arm! Because of the local curvature, make sure to CAREFULLY press the touch plate into the stock.
☐	17			**Move spindle/gantry to park** location with X slightly positive.	
☐	18	**30m Estimated 20m est by ctrlr**		**Cut slots and perimeter of short leg** **Combi--Op3--2016-010-021 v2.03.005.XXX** **Spindle: 15.6k RPM** Air: M0.9B1.0P0.6 Mist: 2.5sT, 028sP	**S01--jC: PrRgh-DamperSlotNear** **S02--jC: PrRgh-DamperSlotFar** Air:1.0, B:1.0, P:0.6 Spritz: T4.5s, W0.29s These next steps do not need mist or air, for that matter. If you're going to monitor the passes while present, the air can be turned off for operator hearing comfort. If no one is present, the air is best left on. **[Blower not needed]** **S03--jC: PrRgh-AngleInsideFacePrepPass1 (shim)** **S04--jC: PrRgh-AngleInsideFacePrepPass2 (shim)** **[Blower needed from now]** **S05--jC: PrRgh-AngleInsideFacePrepPass3 (shim)** **S06--jC: AdvR-AngleCleanout-Pos1 (shim)** **[Blower can be stopped]** Air:1.0, B:1.0, P:0.6 Spritz: OFF **Shim = Y-0.020 Z+0.015** **s03..s05** might eventually be deleted if we have no contact in those paths. If the bottom is safe, that's awesome! Mist is only needed (or useful) during the slot-cutting part. After that, it will be fine without it; very light cuts are used for the angle-cleanout.
☐	19			**Brush / blow chips** off part to minimize chips on them **Loosen vise**, remove part and fixture Re-wrap part in red shop-cloths Set parts into carrier for transport upstairs Clean area with to clean chips out of area.	Important: Keep track of which piece was in which position, and do not switch registered ends (that is, which end is against X0).
☐	20			**Resume CNC work with step 1 (for Op1 - Op3 repeats), or with step 11 (for Op3 repeats).**	
☐	21			Remove bit and collet insert and store	
☐	22			**Perform Secondary processing** (see section below)	This includes tapping the holes, relieving any material deformation from that, wire-brushing on the machined areas, degreasing, washing and drying. Parts must be clean for engraving.
☐	23			Check the parts per the Quality Control section below	Engraving quality, obviously, cannot be verified yet
☐	24			**Perform steps in the Engraving section below**	

☐	**25**			Once cleaned and wrapped, machining steps are complete	

Revised Angle Cleanout process:

1) X0 stays the same
2) Y0 becomes the inside top edge of the short leg, taken from the approximate middle
3) Z0 becomes the inside face of the long leg, taken just outside the inner radius, on the flat. However, this should be approached and considered carefully, given the slightly (~0.010") bowed top surface.
4) Run the angle cleanout program
5) You can run the same registration settings if the second piece is from the same stock piece. Otherwise, the Y0 and Z0 need to be retaken. Yikes. Do they really?

Secondary Machining and Cleaning

	Op #	Est/Real time	Position	Tool, workstop changes	Cutting Path / Comments
☐	**1**			Transport machined parts upstairs in washtub with red cloths covering, put slight relief into top for 6 holes before tapping	
☐	**2**	**5m predicted**	**Op1**	Tap 1/4-20 holes in all parts (6 holes per bracket) Fix deformation of material out of the tapped holes Blow/wipe and remove any tapping oils or debris	We had originally expected tapping to be from "inside", but I can see how from the top would be a lot easier with the vise, tapmatic, etc.
☐	**3**		**Handheld**	File/grind remains as needed Prime machined surfaces with the coarse wire-brush to blend in machined areas, and cover deepest file marks. Normalize strokes across the surface, but don't take too much time; the glass beading will help tremendously.	
☐	**3**	**2m predicted**		Wash in simple Green and dry using cloths that will not be used for touching "clean" parts. These cloths will be usable, but will be essentially contaminated with the Simple Green. Rinse in very hot water to remove remaining oils. During the bead-blasting process, the parts must be dry and completely oil-free. Pat dry with clean cloth/towel and allow to air-dry (Use hot air fan or blow-dryer if desired)	
☐	**4**	**5m predicted**		Glass-bead the surface to even out all areas on the parts, in strokes across the surface. This is putting the final finish on the part, and so must be handled to avoid marring this delicate surface.	
☐	**5**	**2m predicted**		Brush off residual blast media, then wash in dawn dishwashing liquid and very hot water (again). Pat dry with clean cloth/towel and allow to air-dry. Use a warm oven (200F or so) to dry the parts faster, to avoid water-spots forming. Place on clean painting rack, transport to paint area.	**NOTE: AVOID TOUCHING PARTS WITH HANDS AFTER WASHING**

Quality Control

Check for the following when doing final inspection. Defects may be fixed or the article rejected at "management" discretion.

- ☐ Parts have consistent finish of fine luster
- ☐ Parts are clean with no residue, especially in tapped holes
- ☐ Fasteners thread cleanly without cross-threading, and are normal to the surface
- ☐ Angle clean-out is done well: blended, fully into the corner, good surface quality, no weird high-spots
- ☐ Engraving is high quality, legible and adds beauty (only possible after Op4)
- ☐ Blending of curves into stock edges is even and smooth
- ☐ There are no obvious machining gouges or terrible surfaces
- ☐ There are no rough edges or any significant chance of cutting anyone bare feet when properly installed
- ☐ Stack the set of four on end, nested, and see that they are all the same height
- ☐ Verify each hardware bag is properly labelled and contains correct hardware items
- ☐

Engraving

- The following steps are only for engraving the company information into it. This is optional for the first couple sets, but will eventually become required.
- Run these steps in bulk after a production run of several units, because this step requires a change to the bit, and thus Z0, so avoid those if possible.
- This is a good case for obtaining a smaller engraving-only machine, since the parts are small enough for one that size.
- These steps MUST be run AFTER all the wire-brushing, so that the engraving isn't wiped away by that brushing. It's not so much that it "won't", but more that "the amount of obscuration will vary across the part based on local variation in wire-brushing force".

- **Based on analysis of the Vectric Vcarve toolpath generated, we might want to start with Z0 moved up approximately 0.010".** At least on a test. Currently, the toolpaths coming out of Vcarve show a bottom 10 mils down, even though it's only supposed to be a 5 mil etch line. By working it down into the material, hopefully we'll find a final place that's effective and non-destructive.
- After measuring the first-set stock, it appears the 9.0" dimension that will be there at engraving time will actually be closer to 8.95.

IMPORTANT: This process is still in need of refinement, including S&F, machine/part datum, as well as the strange settings needed for the spring-loaded engraving bit.

Op #	Est/Real time	Position	Tool, workstop changes	Cutting Paths / Comments
☐ 1			Loosen vise Clean (brush, blow, wipe) any aluminum chips or other waste that could affect part placement. Load stock part in Op4 Position, short leg horizontal at top, registered to the workstop. With two business cards between bracket and rear vise jaw. Load reference part in Op4 Position, short leg horizontal at top, approx. 0.25" separated from stock part. As with the stock part, place two business cards between the reference part and the rear vise jaw.	You'll want to register the part against the workstop. It's less critical than in other cuts, but accuracy is still a good thing.
			WARNING: BEWARE OF INSULATED PARTS WHEN USING EDGE AND HEIGHT SENSORS THAT REQUIRE CONDUCTIVITY! ENSURE THERE IS PROPER PATH.	
☐ 2			Load electronic edge finder and red plug **Spindle: 1.0k RPM** **Capture Y0 from part middle** (X~2.25) at the back edge of first stock part. Turn spindle OFF Remove electronic edge finder and red plug, return to storage case.	
☐ 3			Load tool: spring-loaded engraver with V-Bit 30 degree (total included angle) 0.125 inches and 1/4" collet insert	
☐ 4			**Capture Z0 from part middle, at ~Y-0.500** Jog Z to 0.500"; if this is not possible, this will be a problem!	**IMPORTANT: you MUST recapture this Z0 for each part**
☐ 5			Move gantry and head away from vise area	
☐ 6			Wipe off any built-up edge aluminum from bit using gray abrasive pad	
☐ 7	39m Predicted 20m Est by ctrlr	Op4	Engrave logo and other information **For a FRONT bracket:** **Combi--Op4--2016-010-021 v2.03.005.104** **Spindle: 24.0k RPM** Air: M0.6B0.8P0.0 Mist: none **Combi--Op4--2016-010-021 v2.03.005.104** **Spindle: 24.0k RPM** Air: M0.6B0.8P0.0 Mist: none **For a REAR bracket:** **Combi--Op6--2016-010-021 v2.03.005.XXX** **Spindle: 24.0k RPM** Air: M0.6B0.8P0.0 Mist: none **Combi--Op7--2016-010-021 v2.03.005.XXX** **Spindle: 24.0k RPM** Air: M0.6B0.8P0.0 Mist: none **Run file, Ok, Continue**	**S01--jD: Vcrv-4UpPos1Engraving (shim)** **S01--jD: Vcrv-4UpPos1Engraving (shim)** **Shim = Z+0.010, Y-0.030**
☐ 8			Brush / blow chips out of working area Loosen Vise and remove parts Re-wrap part in red shop-cloths Set part into carrier for shipping activities Resume Engraving work with step 4, recapturing Z0 for every part.	

If it becomes necessary to re-cut any of the engravings, below are the toolpaths and what they cut

Step	What gets cut…
S01--jD	All Lines
S02--jD	All Fills (no ThomR.com logo)

S03--jD	Part number and style
S04--jD	Made in and USA
S05--jD	Lines of the 4ceLnk logo
S06--jD	Filled regions of the 4ceLnk logo
S07--jD	ThomR.com logo
S08--jD	Two TM symbols

Machine Configuration Decommissioning

Do the following when it comes time to move to another project. Note that these steps do not include restoring the stationary vise position to some default place. Each job has to specify its own setup.

Op #	Est/Real time	Position	Tool, workstop changes	Cutting Path / Comments
☐ 1			Remove and store the fixture	
☐ 2			Trowel / Vacuum out aluminum chips, transfer to recycling bag	
☐ 3			Remove work-stops	
☐ 4			Sweep floor of chips as needed	
☐ 5			Turn off compressor and drain tank	Should happen at least every two days, and preferably before any downtime > 1/2d.

Pause GCode

UPDATE: 18 Nov 2016: This code Has / Has NOT been approved for use yet. The coordinates appear correct and attainable at all machine origin settings and park locations, but the start/stop of the blower motor, etc., has not been verified.

This section contains the raw GCode that will be used for the pause command between CNC Positions 1 and 2

Now that we have X0Y0, and that we're only using the one bit (B: 0.1875 SQ EM 2FL 0.31LOC 1.50LBS), and we know there's no worry about height issues and bit-length or carriage clearance, we can just use the coordinates:

X20.00 Y0.00 Z0.50

In addition, that turning on and off the spindle actually turns on and off the chip blower and the spritzer. Which means that you should definitely turn it off during the pause, but there's no need to do any dwell after restart. The spindle will already be at speed.

```
( ---- START PAUSE CODE ----- )
M05
G01 Z0.5000
G04 P0.2500
G00 X20.0000 Y0.0000
G04 P0.2500
M06 T01
M03
G00 X0.0000 Y0.0000
( ---- END PAUSE CODE ----- )
```