Ring Design Notes

Thursday, January 29, 2015 7:40 PM

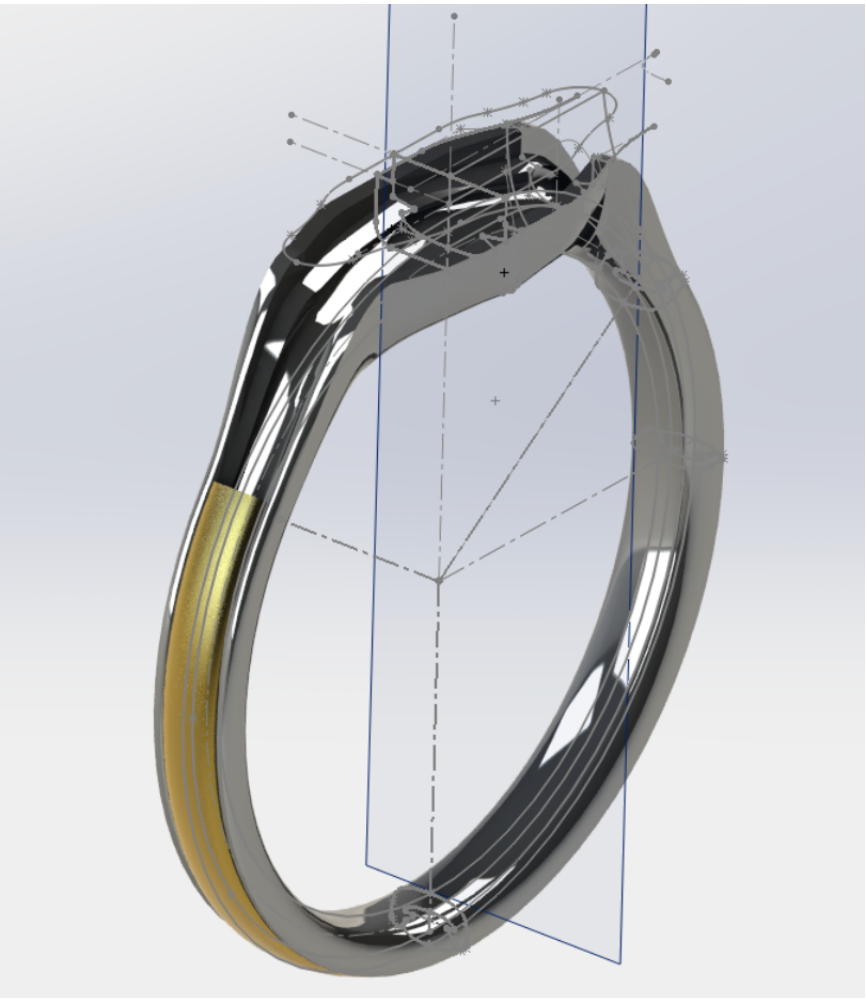
Technical notes:

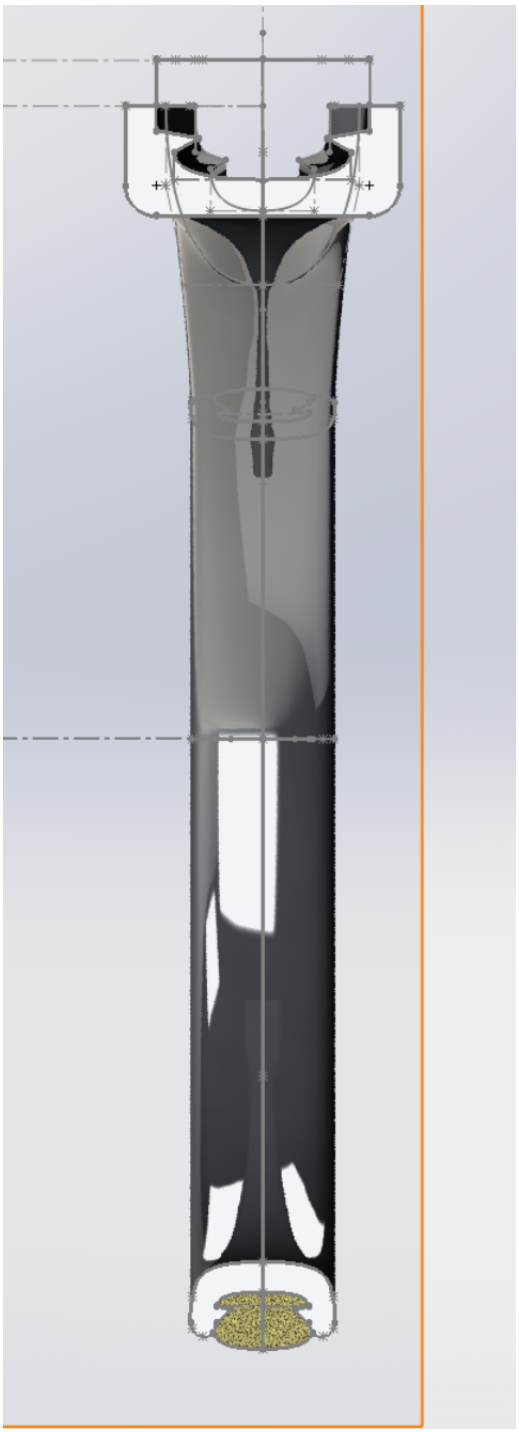
- Bi-metal casting: http://www.ganoksin.com/borisat/nenam/casting-gold-to-platinum.htm
- Instructables casting rings: http://www.instructables.com/id/Casting-Rings-From-Startup-to-Finish/?ALLSTEPS
- Bi-metal basics: http://technical-articles.hooverandstrong.com/wordpress/bi-metal-basics/
- Question about bimetal casting from instructables: http://www.instructables.com/answers/Jewellery-made-from-both-silver-and-gold/
  - Precious metal clay may be an option for the second casting?
- Setting stones in wax: http://ganoksin.com/blog/gerrylewy/2012/11/01/setting_stones_in_wax/
- Casting with gemstones: http://technical-articles.hooverandstrong.com/wordpress/casting-with-gemstones/
  - Appears that reduced temperatures are required for casting gemstones in-place, even with diamonds (seen everywhere from 1000 F down to 800 F recommended.
- Flush-setting stones: http://www.instructables.com/id/How-to-flush-set-stones/?ALLSTEPS
  - Also known as burnish setting, shot setting or gypsy setting
- Another neat option - electroforming: http://www.instructables.com/id/Unique-Geode-Pendant-using-Electroforming/?ALLSTEPS
  - Also electroplating. What is difference?
    - Appears that electroforming is just heavy-wall electroplating. We could do electroplating instead if needed.

Material Temperatures:

- Clays
  - PMC III: Minimum 1110F for 30 min; recommended 1650 for 2 hrs
    - Melting point is 1762 F
  - PMC Gold: 1290F for 90 mins; no max recommended time
    - MP is 1832 F.
- Casting Grains
  - 18kt Yellow Gold: Liquidus = 1650F. Cast = 1800F
  - 22kt Yellow Gold: Liquidus = 1832F. Cast = 1965F
  - 24kt Yellow Gold: Liquidus = 1945F. Cast = 2100+F
  - Platinum: Solidus temp = 3,235F. But platinum is also really hard to cast.
- More melting temps: http://www.jewelryartistsnetwork.com/index/metals-melting-temperatures/
- **Looks like best bet may be gold base, silver stone-setting.**

Solidworks Work:





Material Pricing:

- Volume is currently 179.36 cu mm (min thk) to 307.21 cu mm (max thk). Assuming pure gold, weighs 2.43 g (min thk) to 5.84 g (max thk).
    - This is .179 cc to .307 cc
- `1.555 g per dw, 31.10 g per TO

Name	Price	Wax Factor	Liquidus	Notes
14 Kt Palladium White Casting Grain (white gold with no nickel):	$49.82/dw	14	1880F	Probably will be insufficiently white
22 Kt Yellow Casting Grain	$70.52/dw	21	1850F	
10 Kt Extra White				Contains nickel.
Fine Silver	$25.97/troy oz.	11	1761 F	Probably too soft.

10kt X1 Grain	$34.71/dwt		1755-1850F	Need to call & find out about wax factor.
14kt X1 Grain	$46.24/dwt		1682-1730F	Probably melts too low.
PMC III Silver	$18.08/6.3 = $2.87/g, (18.08 for 6.3g packet)			
PMC Gold	$190.62/pkt (190.62/3 = $63.54/g			

Total Cost Estimate

Ring ideas - Spreadsheet

Name	*Units*	*Value*	*Notes*		*Conversions*			Options:						
Model Mass	g				dwt/g	1.55517		Inner	Outer	**TOTAL**				
Model volume	cc	0.65			dwt/TO	20		203	190.62	393.62	10kt X1 + PMC Gold			
Button pctge	%	10						661.46	18	679.46	22kt Yellow + PMC Silver			
Total volume require	cc	0.715												
Material used		10KT X1												
Density		10.49	10kt X1: 11.17. 22kt: 17.86. Fine Silver: 10.49											
Amt req'd	g	7.50035												
	dwt	11.66432												
Price/dwt	$/dwt	1.304												
Cost	$	15.21027												

More notes:

- Discouraging piece on challenges of firing moissanite into PMC: http://www.ganoksin.com/borisat/nenam/firing-stones.htm
- List of safe/unsafe stones for PMC firing: https://www.riogrande.com/Content/Stone-Firing-Guide-CG-html
- Very cool technique for forming-in plugs that are later replaced with heat-sensitive stones: https://www.riogrande.com/Content/Forming-Onto-Plugs-HT-psd

Final design:

- 642.25 cu mm - call it 650 cu mm, or 0.65 cc.

Rings

- Smaller: Bigger than 0.5 kt - 0.5 to 0.75 kt
  - 0,5 was $2200.
- GIA Certificate - don't buy without

Notes on casting process

- David Adamson reports good burnout with 6-stage sequence, even when using regular satin cast.
  - His burnout cycle: Fast climb to 290 - hold 2 hrs -700 1 hr - 1350 1 hr - down to casting temp
  - Elsewhere, recommends initial burn of 290 for 4 hours.
  - Apparently very important to start below 300 to avoid resin expansion
- Quick explanation of what each phase of burnout does: http://forum.formlabs.com/t/castable-resin-burnout-schedule/3453/2
  - Mentions wet flask burnout…
- Another post mentioning 8 hr burnout : http://forum.formlabs.com/t/heating-investment-mold-for-better-results/8274/2
  - Rule of thumb - mold at 1/2 melt temp, lower for thicker objects.
- Plasticast TDS recommends 8 hr burnout - exactly what David Adamson does

Investment notes:

- Furnace temps:
  - 5 seems to get us to ~ 260 F
  - Drew lines at region that gets us to ~290 F
- Sprue Weights:
  - A: 0.8 g
    - Good quality
    - Volume: pi*2.75*(1.85/2)^2 = 7.392069339126358 cu in
      - Powder: 21*7.39 = 155.19 g
      - Water: 8*7.39 = 59.12 g
  - B: 1.0 g
    - Better quality
    - Volume = 7.39 cu in
  - C: 1.1 g
    - Better quality
    - Extra wax at sprue/ring interface to improve flow
    - Volume = 7.39 cu in
  - D: 0.6 g

        - Best quality
        - Matt's flask
        - Volume : pi*2.5*(2.36/2)^2 = 10.93588402714607 cu in
            - Powder: 21 * 10.93 = 229.53 g
            - Water: 8*10.93 = 87.44 g
    - E: 1.9 g
        - Terrible quality
        - 2 rings on same sprue
        - Volume: pi*3*(2.37/2)^2 = 13.23450883196138 cu in
            - Powder: 21*13.23 = 277.83 g
            - Water: 8*13.23 = 105.84 g

- Total powder and water
    - Powder: (3*155.19) + 229.53 + 277.83 = 972.93 g
    - Water: (3*59.12) + 87.44 + 105.84 = 370.64 g

- Oven timing
    - 700 - 1350: Turned to ~ 15, I think this is where the right temperature will be hit.
        - 5 min: 950 F(may have missed a little)
        - 10 min: 1100 F
        - 15 min: 1225 F
        - 20 min: 1325 F (I think I've turned it up too high!)
        - 25 min: 1410 F
        - Turned down to 14 at this point. Correct setting is marked
        - **Slope: 22.9 deg/min**

- Plan for Wednesday:
    - Arrive @ 7 AM
    - Start oven preheat to 290 (should be fast - ~30 mins)
    - Submerge flasks in water for 1 min (check for other recs for overnight leaving)
    - Load flasks - hold ~~2 hrs (9:30)~~ 2.5 hrs (10 AM)
        - START: 6:45
        - At 7:07 checked with external thermocouple - oven wasn't as hot as dial said (only ~134 F). Cranking up temperature with thermometer in.
        - Got to ~correct temperature around 7:41
        - END: 9:45
    - Ramp to 700 - hold 1 hr (11:30 for 1 hr ramp)
        - START: 9:45
        - END RAMP: 10:45
            - For ramp, assuming 22.9 deg/min:
                - (700-290)/22.9 = 17.9039 min for direct heating
                - If we want it to take 1 hr: 17.9/60 = 0.2983
                - Roughly, breaking the heat cycle up into 4 parts should work
            - Ramp Notes
                - Started at 306 F
                - 15 mins: 367 (should be 404)
                - 30 mins: 445 (should be 502)
                - 45 mins: 530 (should be 600)
                - 60 mins: 645(should be 700)
                - Boosting output slightly to get to 700.
                - Wound up overshooting a little - hit 750. For 1350 bake, going to specified temperature and holding there.
        - END BAKE: 11:45
    - Ramp to 1350 - hold 2 hrs (3:00 for 1.5 hr ramp)
        - START: 11:45
        - END RAMP: 12:45
            - For ramp (assuming 22.9 deg/min)
                - (1350-750) = 600
                - 600/22.9 = 26.2009 min for direct heating.
                - Thus, to heat over 1 hour, break cycle into 3 parts. This time, start with larger increases and only slightly bump up to hit 1350.
            - Ramp Notes:
                - Started at 752
                - 20 mins (950 des): 975
                - 40 mins (1150 des): 1142
                - 60 mins (1350 des, okay to overshoot): 1291 at 12:45
                - Cranked dial higher to try to reach ~1400
        - END BAKE: 4:15 (reduced time slightly to compensate for missed temp at startup
    - Cool to ambient.
    - Take to Matt's
        - Cast bronze first (E, then A)
            - Get parameters from Matt
        - Cast silver second (start with D, remelt and retry as needed)
            - Recommended covering flame over sprue gate to reduce oxygen
            - Also can add charcoal to melt to absorb excess oxygen
            - Flask temperature:1150 to 1300 deg F.
            - Casting range: 1922 to 1940 deg F
            - Quenching: Air cool to black heat and then quench in water.

Tests for PMC

- Test Round 1:
  - Rough Fine Silver Ring: PMC Silver, test with plug and slight opening. This test should most closely resemble final product
  - Bronze Ring: PMC Silver, test with plug and smaller opening.
  - Sterling ring: No PMC silver - just heat test to make sure it doesn't melt.
  - Melting points:
    - Pure Silver: 1762 F
      - Solidus: 1761 F
    - Sterling Silver: 1640 F
    - Bronze: 1562-1832
      - Solidus: 1715F
  - Kiln Temps:
    - Preheat to 1000 - let part heat up at that temp
    - Then ramp to desired temp - 1500

- Tools to get together
  - DI water
  - Toaster oven
  - Sintering oven
  - Blocks for supporting ring stand
  - Teflon or glass flat sheet
  - Glass or plastic roller (clear acrylic rod?)

- Super valuable resource: http://www.metalclayacademy.com/pdfs/

- Questions for first bake
  - Does PMC ring hold together, or does it snap?
  - How much shrinkage?
    - Should I build thick (bronze ring) or thin (silver ring)?
  - Stone setting
    - Does stone fit?
    - Do I need a bezel?

- Notes from first bake:
  - Small crack across entire bronze ring. Tried to fix with slip - will see how it goes.
  - Placed rings in at ~975F for 1 hr
  - Then, turned up to 1500F for 1 hr
    - Checked at 20 mins:
      - 1430 F
      - Cracked ring broken through as expected.
      - Sterling ring sagging but not damaged.
  - Outcome
    - Bronze ring
      - Cracked badly - broke in another place as well. Eventually, all silver came off. Bond between silver and bronze is not great!
      - Clearly some sort of carbonization happening with bronze - turned black all over. Probably not appropriate for this process regardless.
      - Ring could be re-used for further testing if needed
      - Metal is too high above ring on band, just right on top.
      - Setting too large.
    - Sterling ring
      - Seems to be fine. No obvious damage to material. **I still think we should go with pure silver ring, though - sterling may also offgas strangely like bronze did. Definitely some tarnish on ring.**
    - Silver ring
      - Metal nicely inset in band, maybe (?) too low on top? But very clearly defined.
      - Gaps in metal are very obvious. Need to be careful to go back in after first drying and re-fill.
      - Band cracked around stone setting - too little material
      - Stone setting too large
      - Mechanical bond is strong. I can pull material out of channel - no actual fusing - but it's in there pretty good

- Plan for next attempt
  - Use PMC silver plus **sterling** ring
  - Clean inside of ring depression with acetone before starting
  - Make mutiple thin wires of material, wrap **completely** around outside, making sure to press into corners and bond to each other with water
  - Build up top with thin ropes of material - fuse to each other with water/slip.
  - Make band slightly (0.5 mm) above flush to ring band
  - Make top 0.75 mm above flush to ring band
  - Make smaller stone setting - use stone to create hole, and then drop smaller plug into place
  - Make bezel around stone
  - Allow to air-dry to leather-hard. Then finish to final shape, making sure to smooth with water. Fill any voids with slip (this seems to work well)

- Notes from meeting with Tara Fadenrecht (2017-02-21)
  - General procedure
    - Cast
    - Cut gold fill-in

        - Hammer into place
        - Solder
            - Alternative - hammer/solder in sections
            - Join at thinnest part of ring
        - Set stone
            - Bezel setting - maybe do this - start at noon/six, 3/9, etc.

    - Other notes
        - Annealing - generally a good idea
        - US clean after polishing
        - Optionally, pickle before doing PMC - gives it an acid finish
        - Re-melting --> cast to ingot --> rolling mill & anneal: can try this
            - Ingot mold - can make myself out of steel, just need to oxidize surface so that it doesn't bond to the surface
            - Alternatively, investment cast, but make neck between sprue and ingot thn
        - Extra studs inside of band - good call.

JL & AD's wedding rings
- Sizes
    - AD: 5.25 loose to 5.5 tight. Probably design for 5.25
    - JL: 8

Casting weights spring 2017
- ADSK pendant: .646 oz, no button
- AD ring: .429 oz, no button
- JL ring: .483 oz, no button

Casting sprues:
A. AD ring, lateral sprue
B. JL ring, lateral sprue, higher quality
C. JL ring, lateral sprue, broken
D. ADSK Pendant (now has E body)
E. JL ring, vertical sprue (now has D body)

Burnout Plan
- Preheat to 300
- Load investments, hold for 2 hrs
    - START: 9:45 AM
        - Started at 350 F - a little over. LOW (0) setting seems to match this
        - Actually, LOW setting slowly crept down towards 300. Pushing back towards 0.5
        - Kept creeping to ~400F at 11:37
    - END: 11:45 AM
- Ramp to 700 for 1 hr (#1.6), hold for 1 hr
    - START: 11:45 AM
    - END RAMP: 12:45 PM
        - Only at 600 at end of ramp - continuing to ramp, will see how long it takes us to get to 700.
        - 650 at 12:21
        - 700 at 12:30
        - Crept to 850 by 1 PM
    - END BAKE: 1:45 PM
        - Finished at around 950. Whoops :-/
- Ramp to 1350 for 1 hr (#3.1), hold for 2 hrs
    - START: 1:45 PM
        - Cranking up to 2 initially. I don't think we're going to need to go to 3 to get to 1350.
    - END RAMP: 2: 45 PM
        - Ended ramp at 1300 F. Monitoring closely to make sure we don't exceed by too much.
    - END BAKE: 4:45 PM
- Ramp to 900 for 1 hr (#2), hold for 1 hr
    - START: 4:45 PM
    - END RAMP:5:45 PM
    - END BAKE: 6:45 PM

- Burnout other notes:
    - Assuming linear response in holding temperature as function of dial position, we should have ~300 F per notch on dial
    - After initial testing, it looks like 1 is closer to 350. This makes sense if low is 0 - this gives us the response we expected. However, that doesn't make sense if low is > 0. We should probably underestimate
    - Temperature has kept creeping. Using mapRange --> 430/div. This roughly corresponds to what we've been seeing. Numbers above now reflect this

- Casting silver
    - Flask temperature:1150 to 1300 deg F.
    - Casting range: 1922 to 1940 deg F
    - Quenching: Air cool to black heat and then quench in water.