

## 2.008 Yoyo Project Deliverables 4

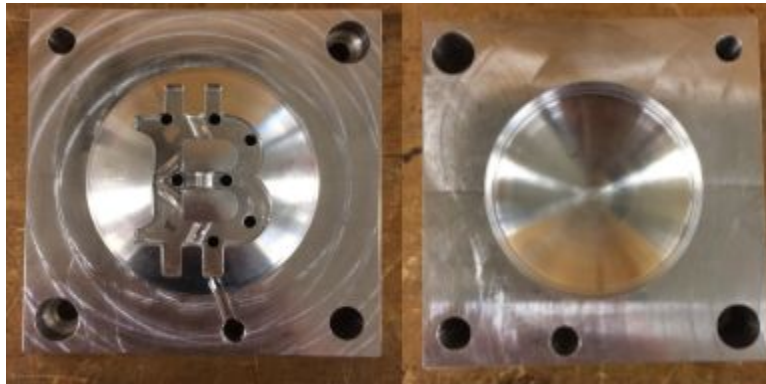
Team Tropical Escape (Lab: W AM)

Anna Yoon, Susan Yoon, Jeremy Noel, Ethan Perrin, Mitchel Guillaume, Nina S. Fraticelli

### 1. Parts

#### 1.1. The "B"

##### a. Tooling:



Core

Cavity

##### Representative Part:



##### b. Process Parameters

Parameters	Values	Reasoning
Shot size (in)	0.60 in	We began with a shot size of 1.20 and gradually decreased the value since flashing was occurring at the top left edge of our part. We experimented with decreasing the shot size to 0.55 but that caused a short shot. Thus, we moved up to 0.60 and avoided the short shot and the flash.
Pack time (s)	6 s	We began with a time of 2.5s but gradually increased it to 6s to improve the sinking/dishing at the surface. This number might be changed in the following weeks' iterations.
Cool time (s)	20 s	The cooling time began was first placed as

		an estimate but has been found to be a good amount of time to avoid any significant shrinkage.
Temperature Profile (°F)	[351, 390, 385, 300] °F	Default settings in Engel machine
Pressure Profile (psi)	[325, 325, 325, 325, 325, 325, 325, 325] psi	The piece is relatively small, so these arbitrary values were chosen. We might tinker with these parameters in order to fix some of our remaining issues.

c. Key Dimensions

Location	Dimensions	Expectations
Height of B	2.078in	2.07in
Depth of B	0.121in	0.12in

From the design review, the main dimension we changed was the extrusion depth of the B. Originally, it was planned to be 0.45in, but was changed to 0.12in because that amount of extrusion would make it difficult for us to snap-on the part to the dome, as was the original plan. After deciding to overmold, we wanted to ensure even thickness in the part so that when it cooled, it didn't deform. We also wanted the B to be the same thickness as the surrounding yo-yo body.

d. Defects and Imperfections

- Shrinkage: Overall, the B fabrication did not suffer a significant amount of shrinkage, as we did account for it when creating our molds.
- Flashing: Originally, this was occurring on the top left part of the B tabs. To eliminate this, we played with the shot size and have now been able to eliminate the flashing.
- Welding line at top left of the B: This is the are where the plastic flowing from two distincts directions meet and is showing a welding line. The root of this problem could be that the plastic is cooling too rapidly. To fix this, we plan on maintaining the plastic hotter for a longer period of time by increasing the injection pressure and maybe increasing the shot size a bit more. Furthermore, we noticed the line is more visible when using gold colored beads versus a non-metallic color like red. So, another possibility would be to change the color with which we plan to make the final yo-yo.

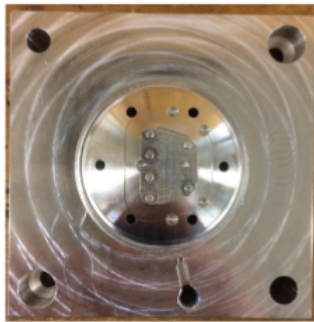
- Sinking/Dishing: The surface of the B demonstrates some sinking occurring. Thus, not enough plastic was injected to fully fill the entire shape. Just as for the welding line problem, increasing shot size, along with injection pressure could solve this problem. Furthermore, increasing the cooling time could also help avoid some shrinkage that might be happening.

e. Notable variation

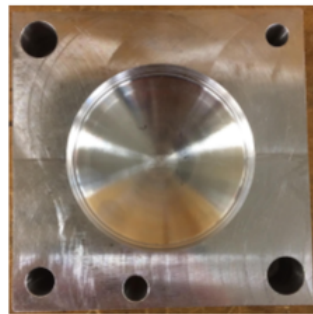
When looking at our expected dimensions and actual dimensions for the height and depth of the Bs fabricated, our sigma values for both dimensions are relatively small (0.0047 and 0.00690, respectively). So, no significance variation is present.

1.2. "B" Overmold

a. Tooling:



Core



Cavity

Representative Part:



b. Process Parameters

Parameters	Values	Reasoning
Shot size (in)	3 in	We can fill the cavity with as little as 2", but a bigger shot size helps pack the mold and reduce dishing/sinking.
Pack time (s)	25 seconds	We have a longer pack time to

		try to counter dishing/sinking.
Cool time (s)	25 seconds	We have a moderately long cooling time because this is one of our largest and most complex parts, and we want to reduce deformation as much as possible.
Temperature Profile (°F)	[351, 390, 385, 300] °F	Default settings in Engel machine
Pressure Profile (psi)	Initially: [700, 700, 700, 650, 650, 600, 550, 500, 450, 400] Now: [1200, 1200, 1200, 1200, 1200, 1200, 1200, 1200]	Over our test run we've been steadily increasing the injection pressure in hopes to reduce sinking in the overmolded part.

c. Key Dimensions

Location	Dimensions	Expectations
Snap Fit Diameter	2.256"	2.25"
Outer Diameter	2.483"	2.5"

d. Defects and Imperfections

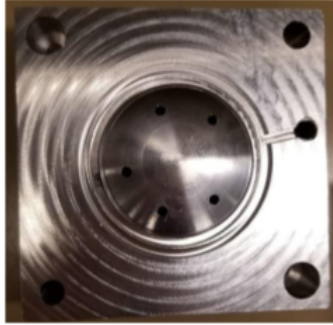
There are essentially two defects. The first is dishing/sinking near the B, particularly for the plastic that has flowed into the center of the B. We were able to improve this, but not yet completely resolve, by increasing injection pressure and hold time. The second defect is that as the overmolded plastic cools, it contracts, leaving a ridge at the B / overmolded transition (the B is slightly taller than the cooled plastic surrounding it).

e. Notable variation

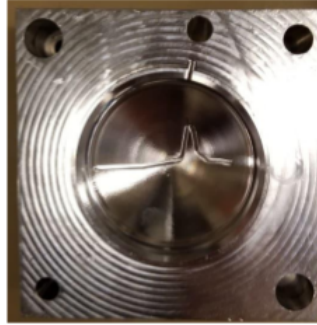
The only notable variation is that on earlier parts (with lower pressure and hold time) the diameter of the snap fit varies by about .005" around the yoyo. The smallest measurement is along the vertical axis of the B, and the largest measurement is along the horizontal axis. This variability seems to be mostly resolved with the latest test parts.

1.3. Stockline

a. Tooling:

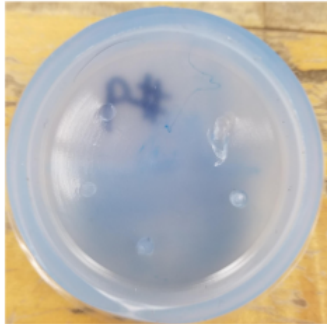


Core



Cavity

Representative Part:



Inside



Outside

b. Process Parameters

Parameters	Values	Reasoning
Shot size (in)	2.25 in	By testing out range between 2-2.5 in, this shot size was adequate preventing short shot.
Pack time (s)	8 s	This was a good enough time to pack the mold after the cavity is filled while minimizing flash.
Cool time (s)	50 s	Since this part is thicker than other parts, this was just enough time for the piece to cool off and be ejected while maintaining the shape.
Injection speed (in/s)	4 in/s	We decreased the injection speed to reduce flash.
Temperature Profile (°F)	[351, 390, 385, 300] °F	Default settings in Engel machine

Pressure Profile (psi)	[1201 1201 1201 1201 1201 1201 1201 1201 1201 1201] psi	It was already set up this way and seemed fine for our part, but we will tinker with it to eliminate remaining flash.
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c. Key Dimensions

Location	Dimensions	Expectations	Difference
Stockline Width	0.074"	0.060"	+0.014"
Outer Diameter	2.270"	2.250"	+0.020"
Inner Diameter	1.981"	2.000"	-.019"

d. Defects and Imperfections

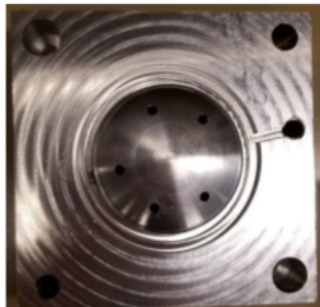
Short shot was fixed by increasing the shot size.

Flash will be eliminated by lowering the injection pressure.

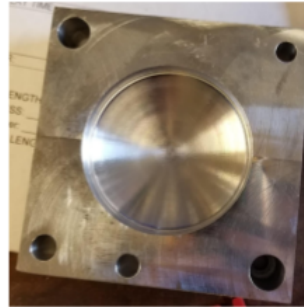
e. No notable variations on this series of injection molded part.

1.4. Stockline Overmold

a. Tooling:



Core



Cavity

Representative Part:



Inside



Outside

b. Process Parameters

Parameters	Values	Reasoning
Shot size (in)	2"	By testing out range between 2-2.5 in, this shot size was adequate preventing short shot.
Pack time (s)	5 s	This was a good enough time to pack the mold after the cavity is filled while minimizing flash.
Cool time (s)	50 s	Since this part is thicker than other parts, this was just enough time for the piece to cool off and be ejected while maintaining the shape.
Temperature Profile (F)	[351, 390, 385, 300] °F	Default settings in Engel machine
Pressure Profile (psi)	[801 801 801 801 801 801 700 700 700 600] psi	It was already set up this way and seemed fine for our part.

c. Key Dimensions

Location	Dimensions	Expectations
Height of the dome	.8835"	0.8"
Outer diameter of the body	2.523	2.5"

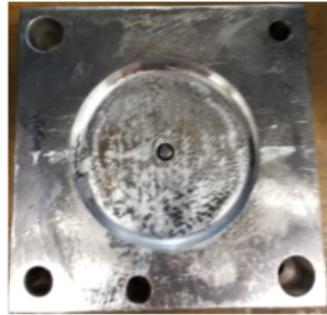
d. Defects and Imperfections

No defect. The black mark in the front side is from sharpie. The black part on the back is burn from the previous under-molded part.

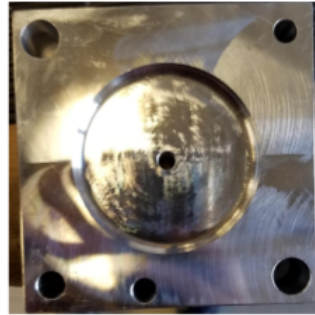
e. No notable variation on this series of injection molded part.

1.5. Snap Fit

a. Tooling:



Core



Cavity



Shaft for hexnut

Representative Part:



Inside



Outside

b. Process Parameters

Parameters	Values	Reasoning
Shot size (in)	2.25 in	To prevent overflow or short shot while accounting for material plasticity and heat expansion.
Pack time (s)	8.0 s	To accommodate shrinkage, sink marks, and other defects.
Cool time (s)	25.0 s	Optimal amount of time for the plastic to cool off and solidify.
Temperature Profile (°F)	[351, 390, 385, 300] °F	Default settings in Engel machine. To prevent wasting the material, dimensional issues, warpage, burning, black specks, and etc.
Pressure Profile (psi)	[1201 1201 1201 1201 1201 1201 1201 1201] psi	Default settings in Engel for a large piece.

c. Key Dimensions



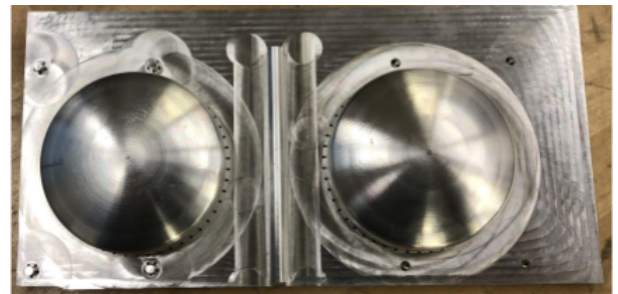
Location	Dimensions	Expectations
Outer Diameter	2.504"	2.500"
Inner Diameter	2.224"	2.230"
Interference	0.011"	0.010"
Thickness	0.129"	0.100"

d. No defects or imperfections.

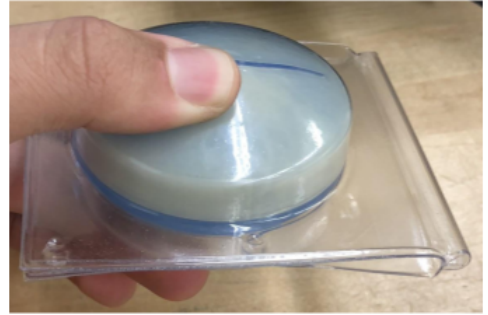
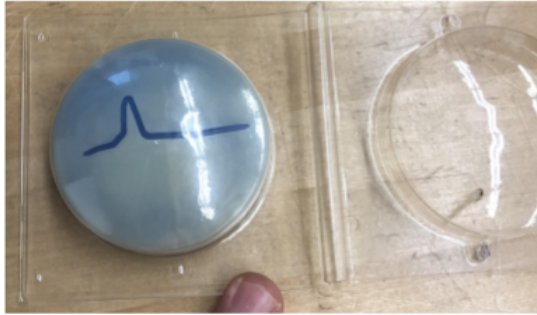
e. No notable variations on this series of injection molded part.

1.6. Thermoform Packaging

a. Tooling:



Representative Part:



b. Process Parameters (how/why chosen)

Parameters	Values	Reasoning
Heat time	35 seconds	Enough time for the plastic to melt.
Vacuum time	10 seconds	Fully fills the cavities
Cooling time	40 seconds	Enough time for the mold to not invert

c. Key Dimensions

Location	Dimensions	Expectations
OD of yoyo	2.505	2.505
Rest of the case	non-critical	non-critical

d. The plastic is not filling in the indents as expected probably due to the pull distance being too far. There will be two steps to alleviate this. First, the holes will be larger this will give more area for the vacuum to pull on. Second, the temperature of the plastic will be elevated. Another option which is more time intensive would require enlarging the vacuum holes in these locations.

e. No notable variation on this series of injection molded part.

2. Assembled YoYo and Process Optimization



The assembled stock line yoyo half fits together with the snap ring, pending a few optimizations. It currently requires a significant amount of force to be fitted together. The overmold process worked quite well with regards to the external appearance, but appears to have a small amount of flash that forms around the lip where the snap ring must take place, requiring removal by hand before the parts will snap together. There is also about a 0.010" gap between the overmold core groove and the ID of the stock line part (pre-overmold) that causes some movement and imprecise alignment. This can be resolved by doing a production run of 80-100 of the pre-overmold part, then adapting the overmold core to fit the dimensions of the molded parts much more precisely. Updating the lengths of the ejector pins on the first mold to protrude from the curved surface will also prevent bosses forming that prevent the part from seating on the overmold core, which would use recessed pins.

In addition, there is a dimensional discrepancy between the depth of the snap ring features that has caused a gap to form when the parts are fully assembled. This will require updating of one of the parts to close the gap.

### 3. Table of Critical Dimensions

Parts	Mean Value	3 $\sigma$ Tolerance	Changes in Dimensions
Outer Diameter of Body	2.504"	$\pm 0.019$ "	No changes in dimensions
Height of the Dome	0.8835	$\pm 0.0233$ "	No changes in dimensions
Height of the B	0.121"	$\pm 0.021$ "	Changed from 0.45" to 0.12" because deep extrusion would make it difficult for us to snap-on the part to the dome, as was the original plan. Then, we decided to

			overmold, so we wanted to ensure even thickness in the part to prevent deformation when it cooled. We also wanted the B to be the same thickness as the surrounding yo-yo body.
Width of the B	2.078"	±0.013"	No changes in dimensions
Width of Stockline	0.074"	±0.003"	Changed it from the original 0.63" because we decided that it would be easier to IM and overmold the part if it was thinner.
Thickness of IM Parts	0.129"	±0.005"	Our YoYo design and the balancing for weights made the thickness dimension larger than the original 0.08±0.01".

**Critical Dimensions from Design Review:**

[https://docs.google.com/presentation/d/1wLqDERGpKbCKSLjp1sJ9ukYPTXH9-bIVYUctNbF5Cf0/edit#slide=id.g43eeb4d62f\\_0\\_40](https://docs.google.com/presentation/d/1wLqDERGpKbCKSLjp1sJ9ukYPTXH9-bIVYUctNbF5Cf0/edit#slide=id.g43eeb4d62f_0_40) (Slide 11)

**Blog post:**

<https://wikis.mit.edu/confluence/display/2008Yoyo/2018/11/14/First+Injection+Molding+of+all+parts>