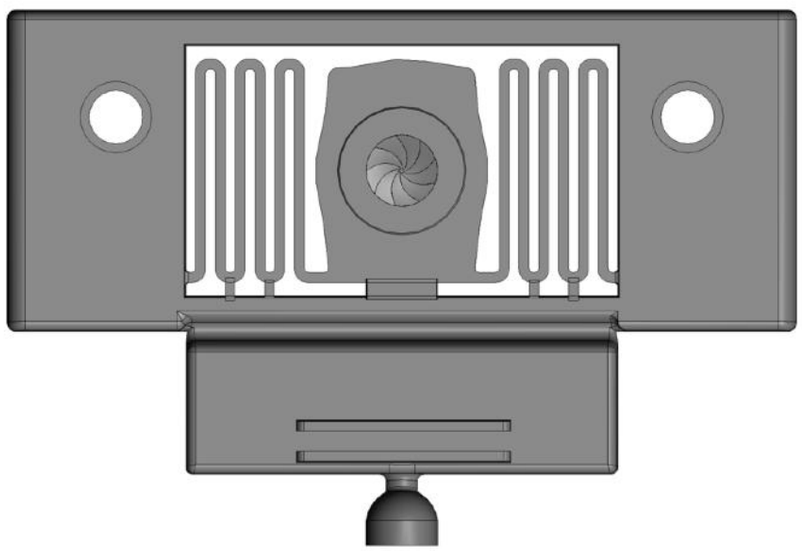
Injection Molding Kodak Brownie

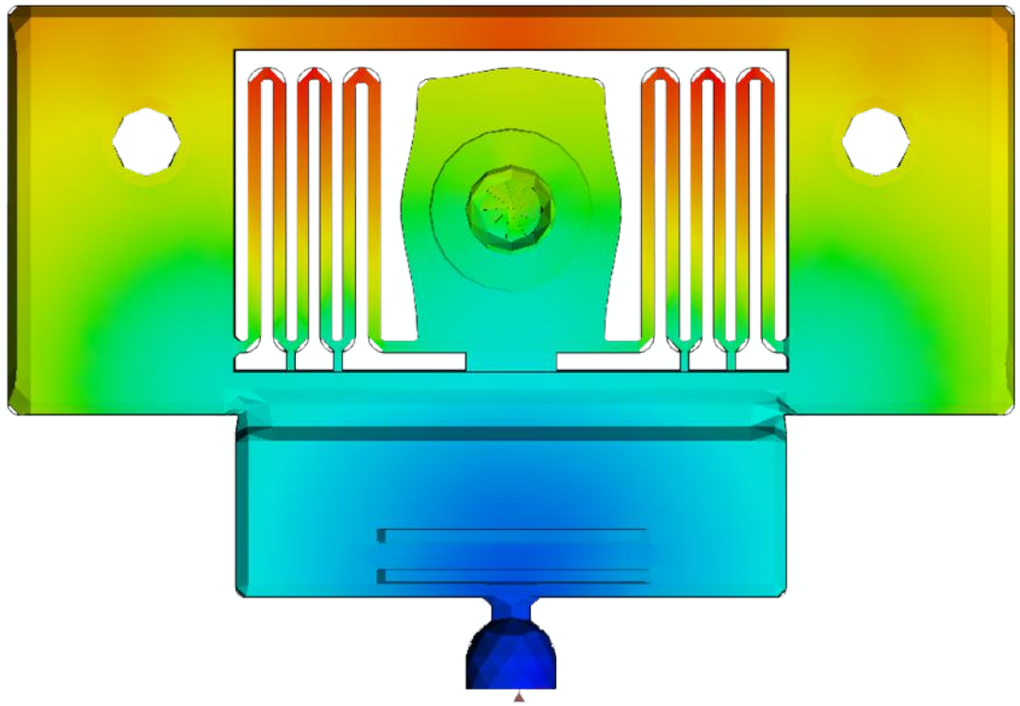
Design

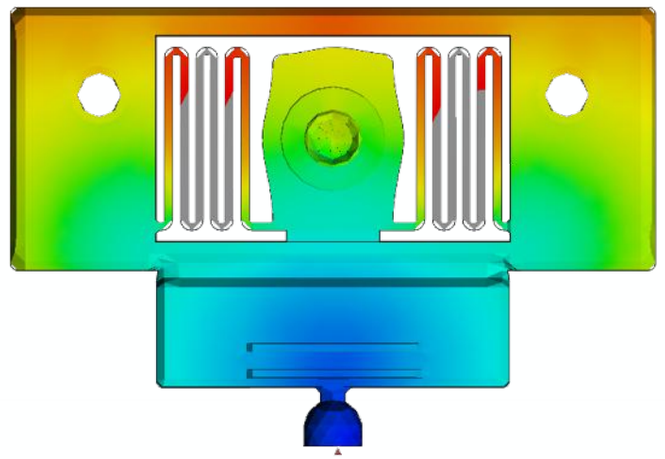
As a collector of antique cameras and avid photographer, I was inspired to make this rendition of a Kodak No. 3A Folding Brownie Camera. A design constraint for this project I sought to capitalize on were the holes left behind from the ejector pin bosses - these become strap holes. A living hinge was used for the main door on the front of the camera that the lens mounts into and the lens is attached to the body through an abstract bellow design.

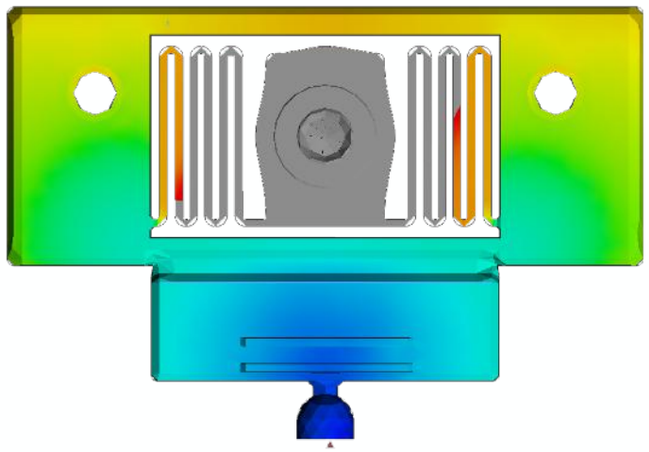


Flow Simulation

A major challenge in the design was getting the HDPE to mold through multiple flow restriction points. In the first simulation (bottom) the bellows barley began to fill because the plastic would cool in the narrow 1/32” trace. When a film gate was added at the base of the lens (middle), the bellows began to fill from both sides however the middle sections regardless of how big the traces were 1/32”-1/16” would not fill. Small additional gates had to be added to the mold. The gates are . 020” deep.

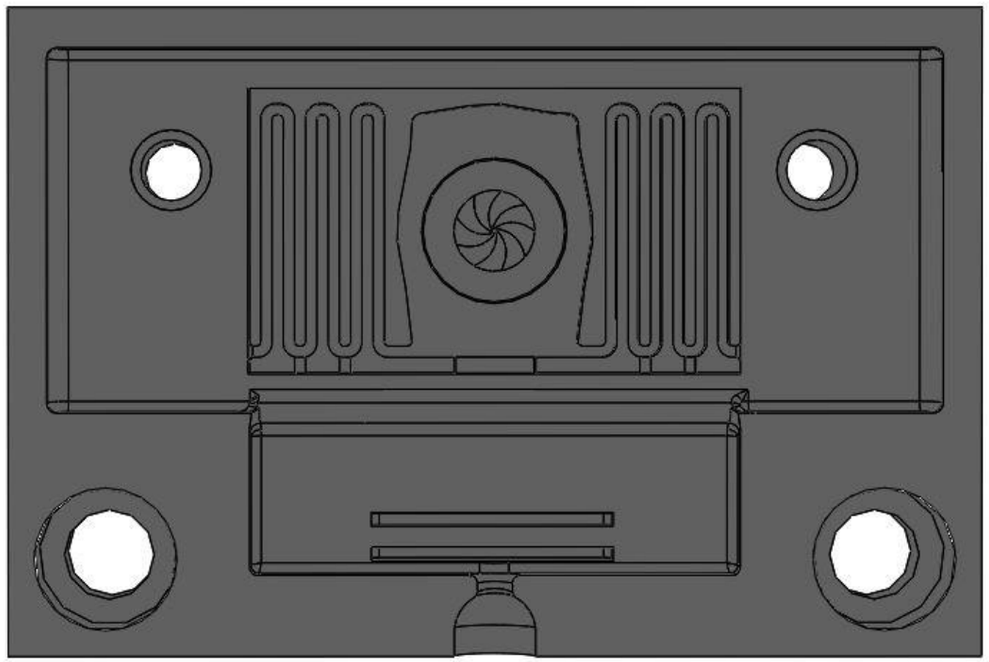


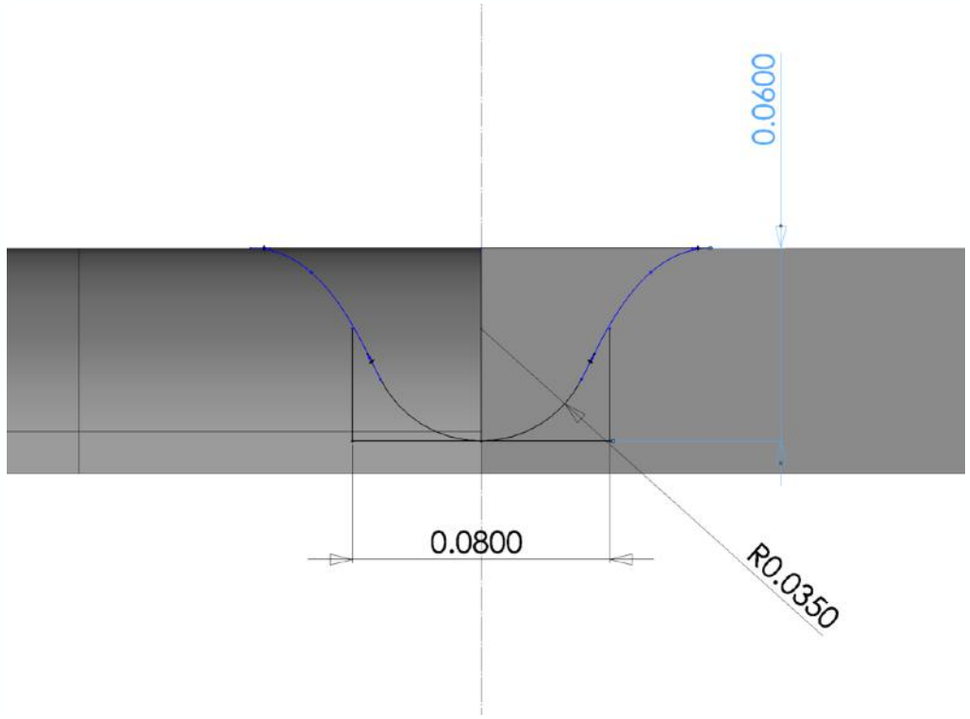




Living Hinge

The nature of the living hinge for the camera is a bit unorthodox as it is intended to remain bent. Limited by only being able to machine one side of the mold, it was essential to reduce as much material as possible in this area. Rather than 0.012” the hinge was made to be .010”. Furthermore the hinge is wider to accommodate the 90 degree flexure required of the design.

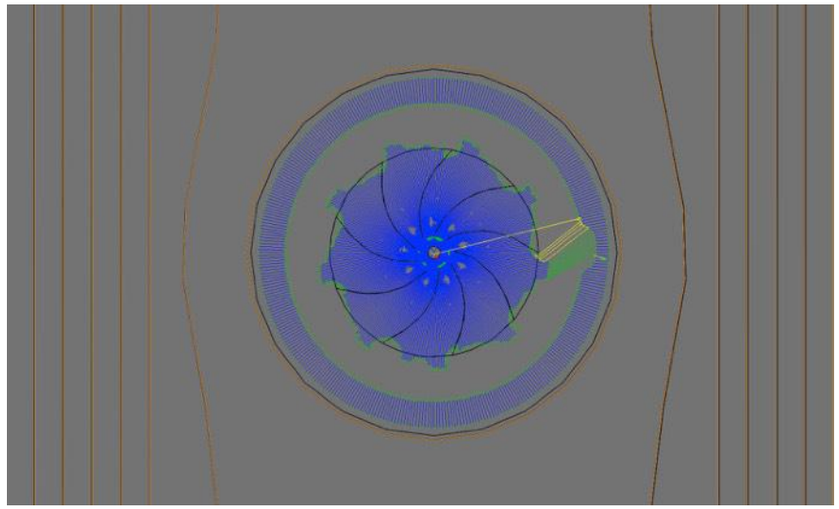


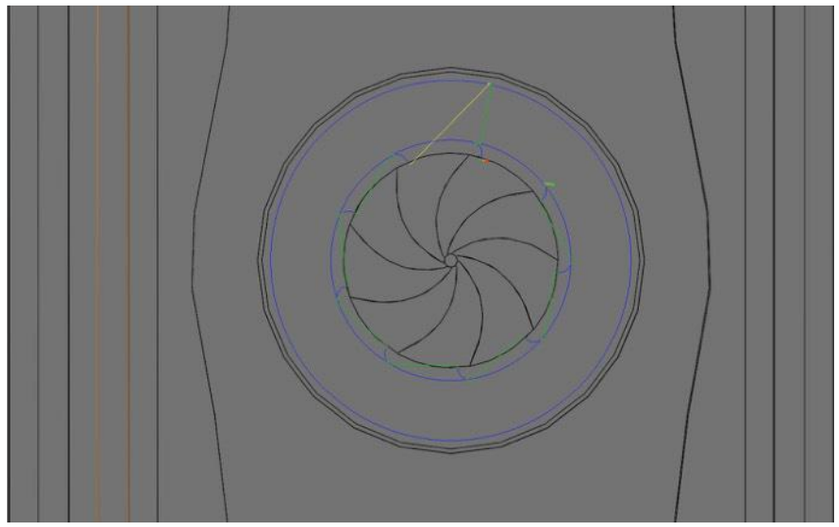


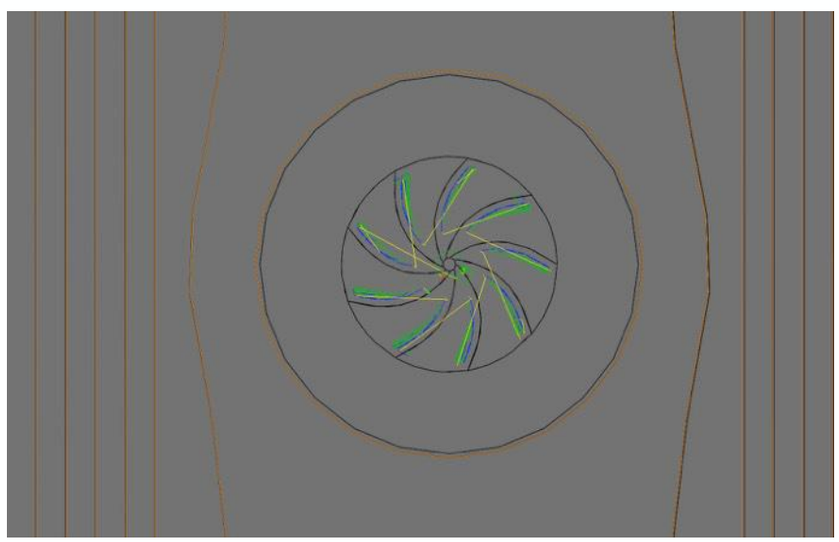
CAM

For the gate and runner, I had difficulty in CAM modeling the runner. I began by roughing, followed by a pencil operation. However, this still left a step pattern due to poor alignment during remounting the mold. When re-machining I opted for a trace operation. Runner 1/4” half round. Gate 1/8” half round, 1/16” depth.

The iris in the center of the part proved troublesome and slow to CNC. As a 3D surface with less than .010” difference in height between the center and edge of the design a 1/32” and 1/64” end mill was required. The 1/32” ball end mill created the contours radially while the 1/64” (ignoring cusps less that . 00025”) sharpened the corners. First a radial pass was performed, followed by a pencil, and finished with a pocket operation.

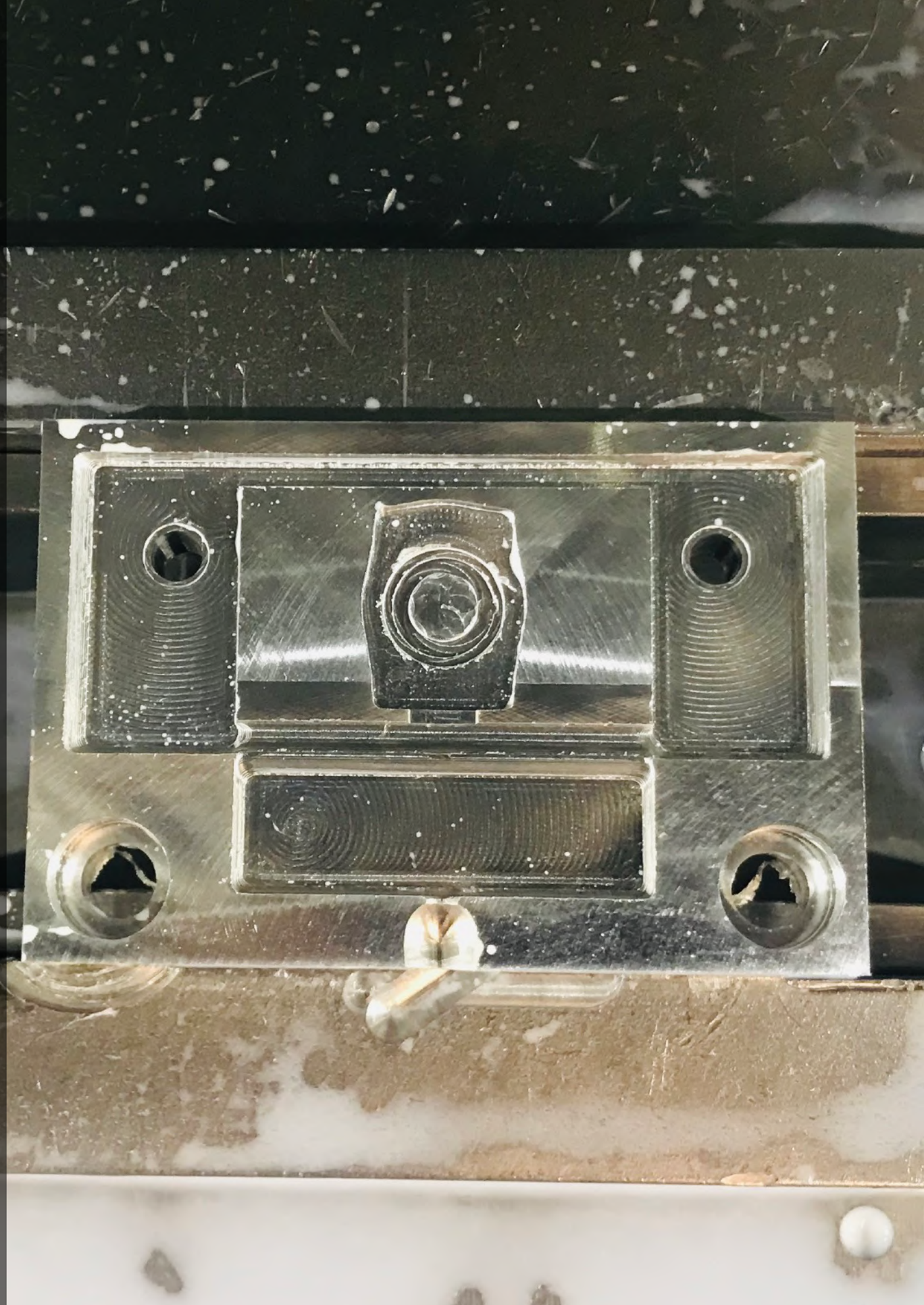






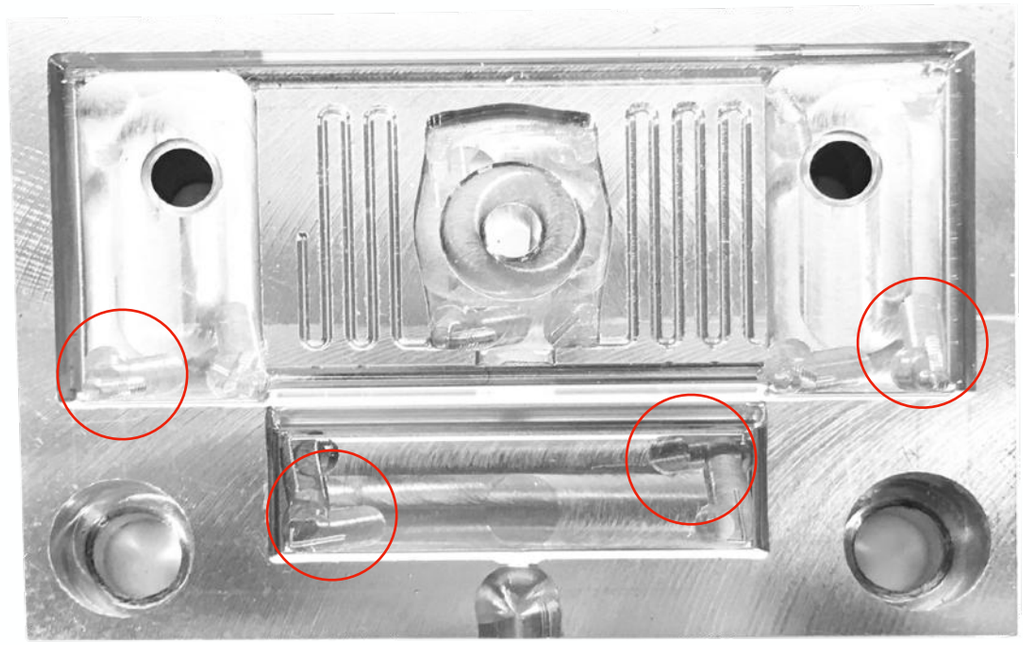
3D CNC Milling

Shell mill 3” 6 flute
Drill .1719”
Drill .281”
Center Drill #1
Reamer 3/16”
Flat end mill .25” 4 flute
Ball end mill .25” 4 flute
Flat end mill .125” 3 flute
Ball end mill .125” 3 flute
Flat end mill .0625” 3 flute
Ball end mill .0625” 3 flute
Flat end mill .03125” 2 flute
Ball end mill .03125” 2 flute
Flat end mill .01563” 4 flute

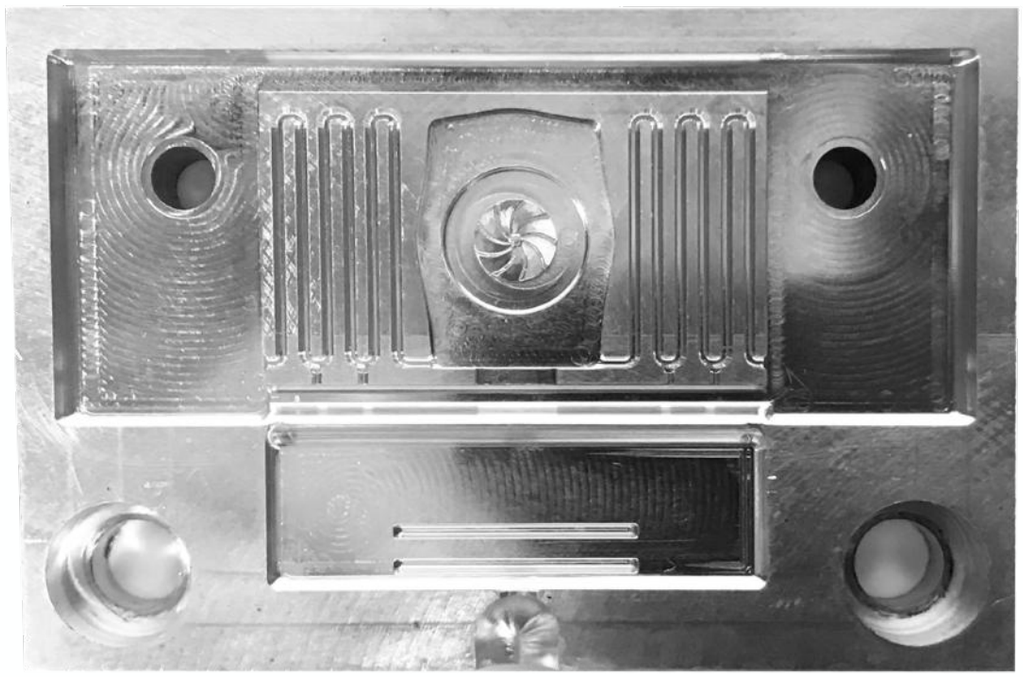


3D CNC Milling

During the first time machining, most of the CAM operations used pocket rather than adaptive; this inconsistent cutter engagement resulted in two 1/32” end mills breaking. Additionally, remounting the mold in the CNC (due to a long cut time) caused a ~.003” difference in Z offset which is visible in the final molded part.



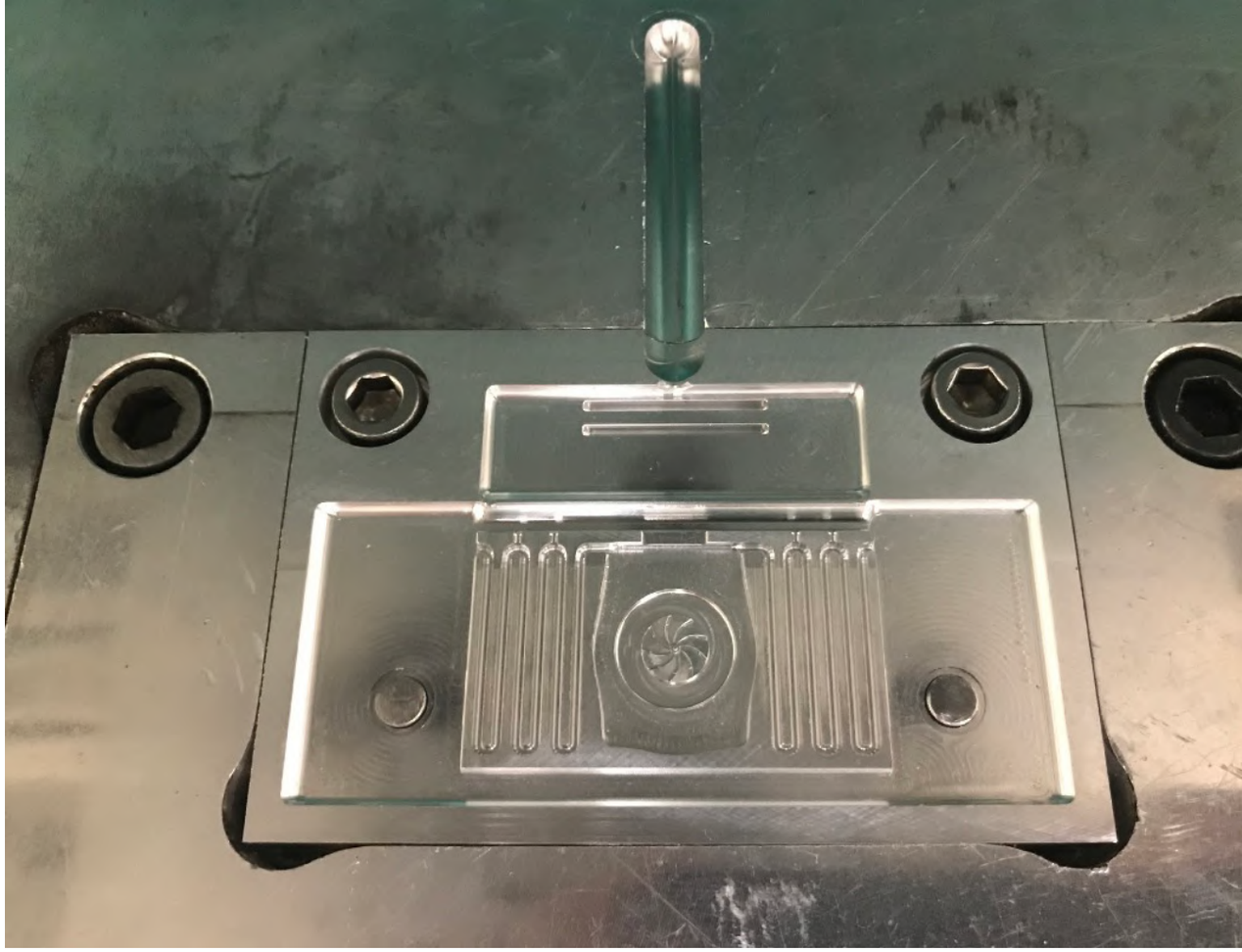
A new mold was created paying careful attention to when it was mounted and unmounted. After finishing all the roughing operations I removed the stock and upon remounting I ran the last 1/16” roughing pass for a second time shaving off the few thousands difference that may have occurred during mounting.



Molding

Mold: 2x3
Clamping force: 10.0 t
Dosage volume: 0.6800 in3
Injection rate: 1.50 in3/s
Injection pressure: 14000 psi
Holding pressure: 8000 | 8000 psi
Holding time: 0.10 | 0.50 s

Molding



Shrink

Once the molding sequence was dialed in so it filled completely, I removed with an x-acto the gates and runners between the body and the bellows/lens. Having designed a snug fit between the lens (.070”) and the folded component (.071”) I did not expect a loose, slip fit. Upon measuring with calipers the lens area shrunk in thickness from .070” to .0625”. Re-machining the mold, I removed an additional .007” from the width on the folded component and increased hight of the grove from .050” to .075” (the maximum depth of the 1/32” ball end mill).

Flow

During molding additional defects included small eddys that formed as the plastic flowed over the living hinge and into the main cavity. An increase in injection pressure and spraying mold release minimized this defect.