3D Modeling

The first task in this report was to use SolidWorks to design a 3D model of the P1 (#98461) part according to a provided blueprint. A few key features of the design included creating three different sketches for the outside circles, inside circle, and outside contour. In Fig. 1, each feature is designated with red, green, and blue colors, respectively. The extrude, shell, and fillet features were used to create the 3D body.

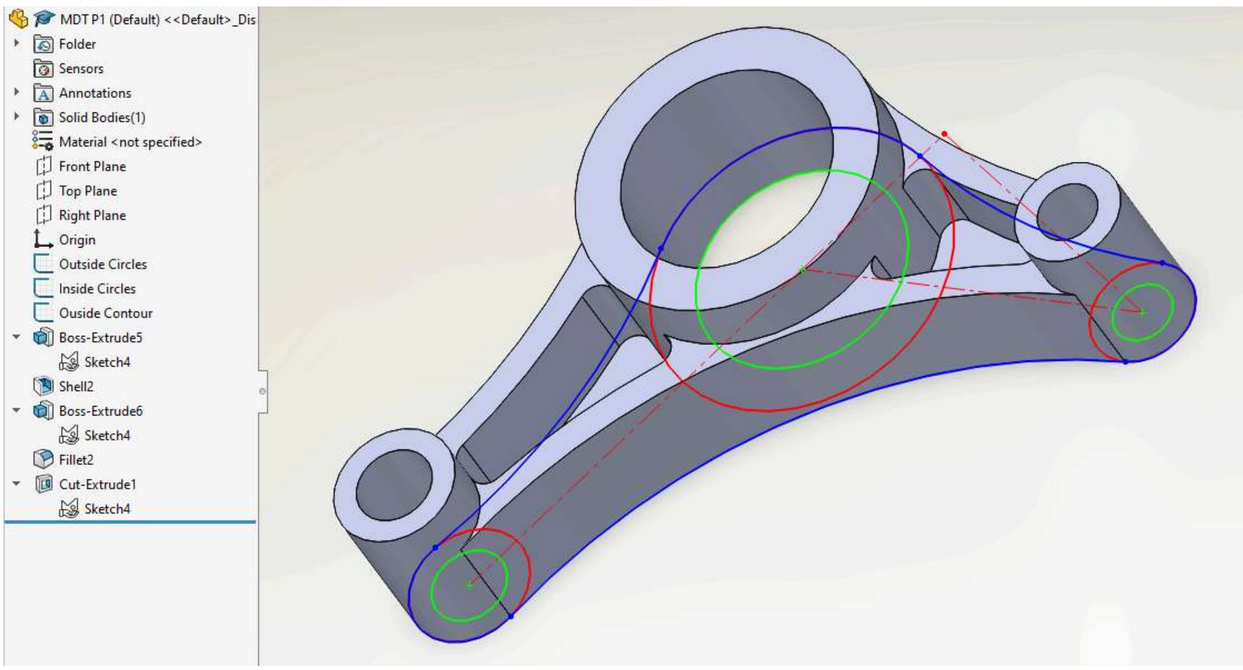

Fig. 1: 3D SolidWorks Model of P1 (#98461)

Similarly, a model was created for P2 (#98462). The primary difference between the two models was that the base of P1 was shifted to the center of the part to create P2. This can be visualized by the location shift of the red, green, and blue colors between Fig. 1 and Fig. 2.

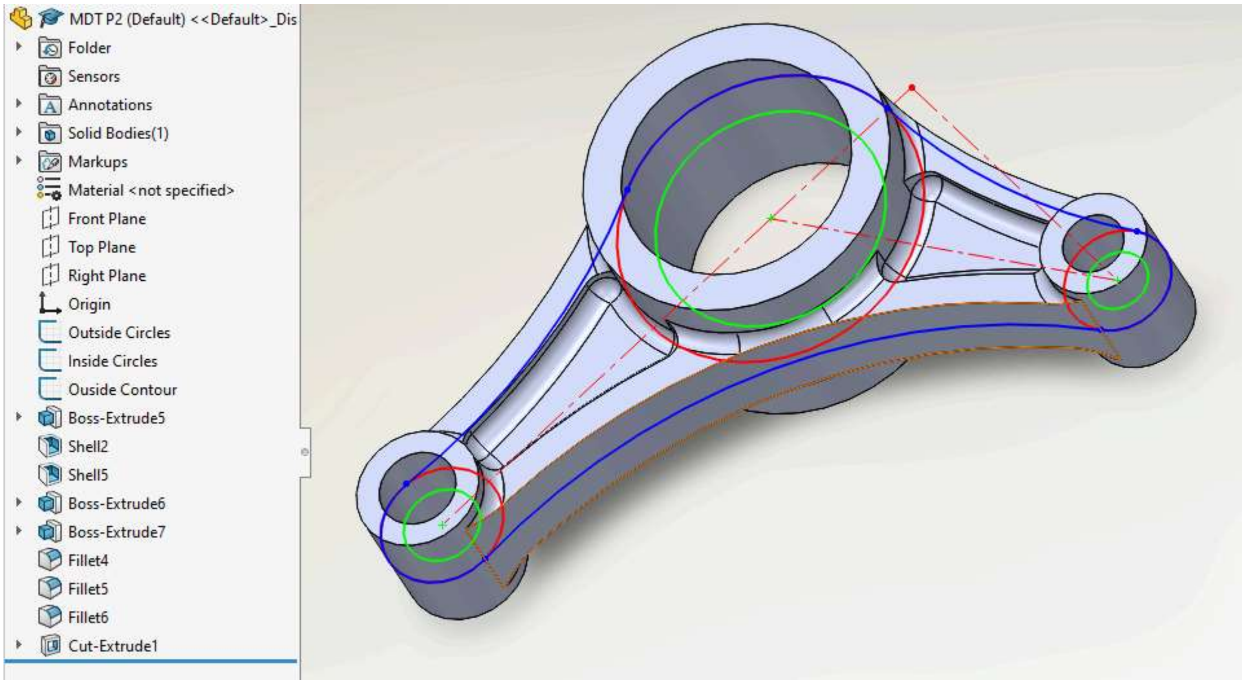

Fig. 2: 3D SolidWorks Model of P2 (#98462)

FEA Studies

A static study finite element analysis was performed in SolidWorks for each part. Materials for each part were Aluminum 6061-T6. Each part was fixed at the largest (middle of Fig. 3 & 4) and smallest (right side of Fig. 3 & 4) holes, and a force of 500 lbs was applied to the third hole (left side of Fig. 3 & 4).

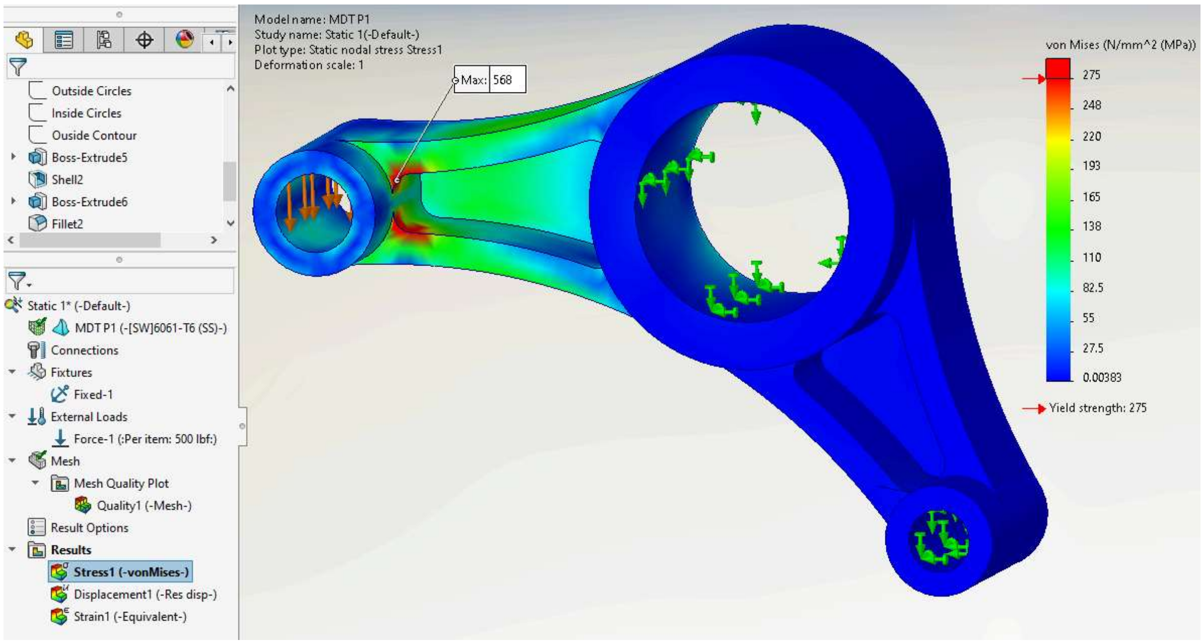

Fig. 3: Static Finite Element Analysis Study of P1

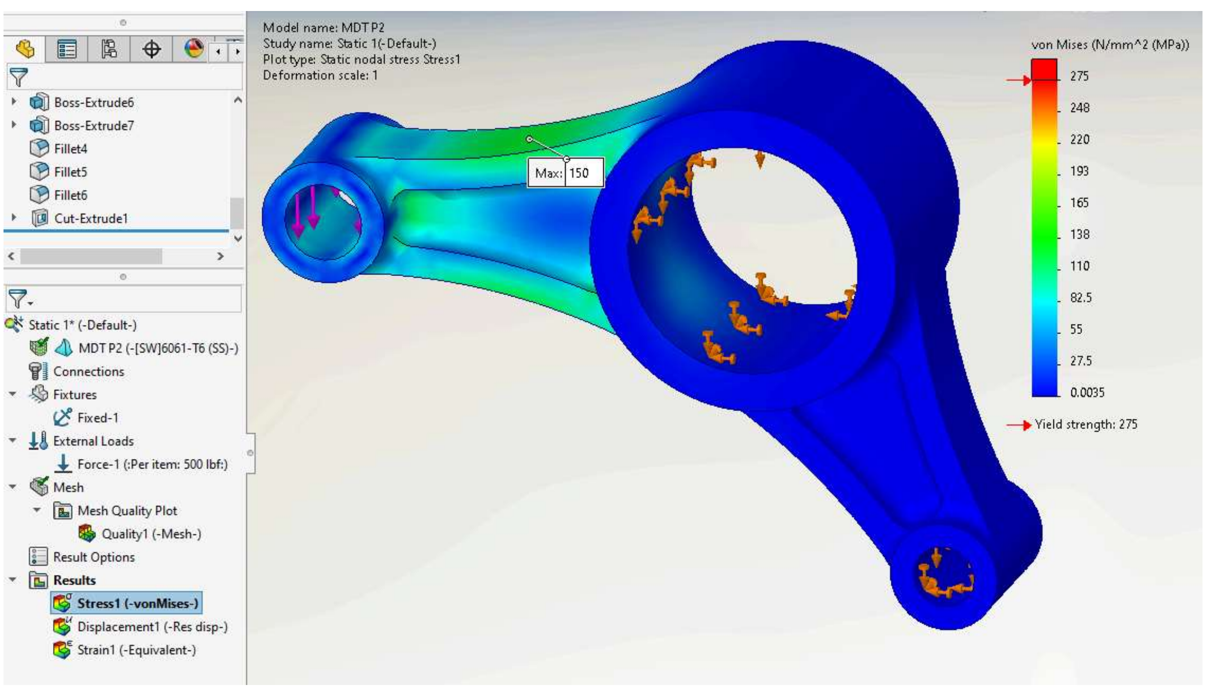

Fig. 4: Static Finite Element Analysis Study of P2

Factor of Safety (FOS) reports were also provided for each part. Blue regions indicate higher safety factors, thus indicating a lower chance of failure according to the Von Mises FOS evaluation used in Fig. 5 & 6. Table 1 summarizes the results from the FEA studies conducted on P1 and P2.

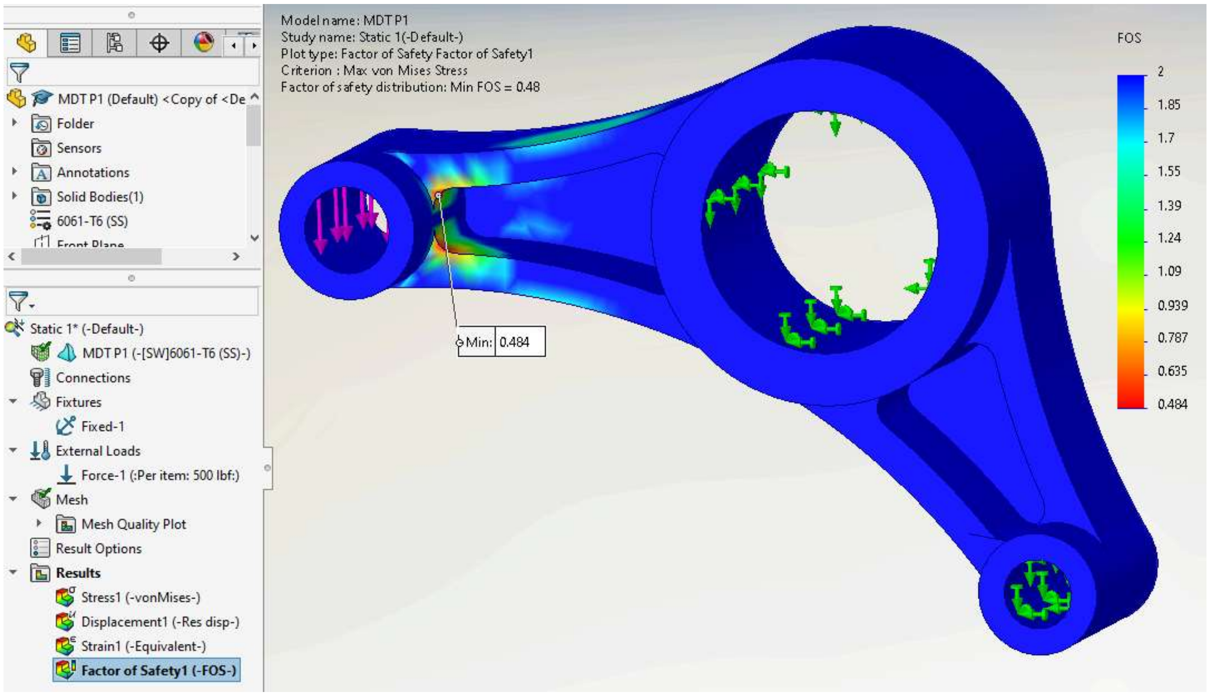

Fig. 5: Factor of Safety Report for P1

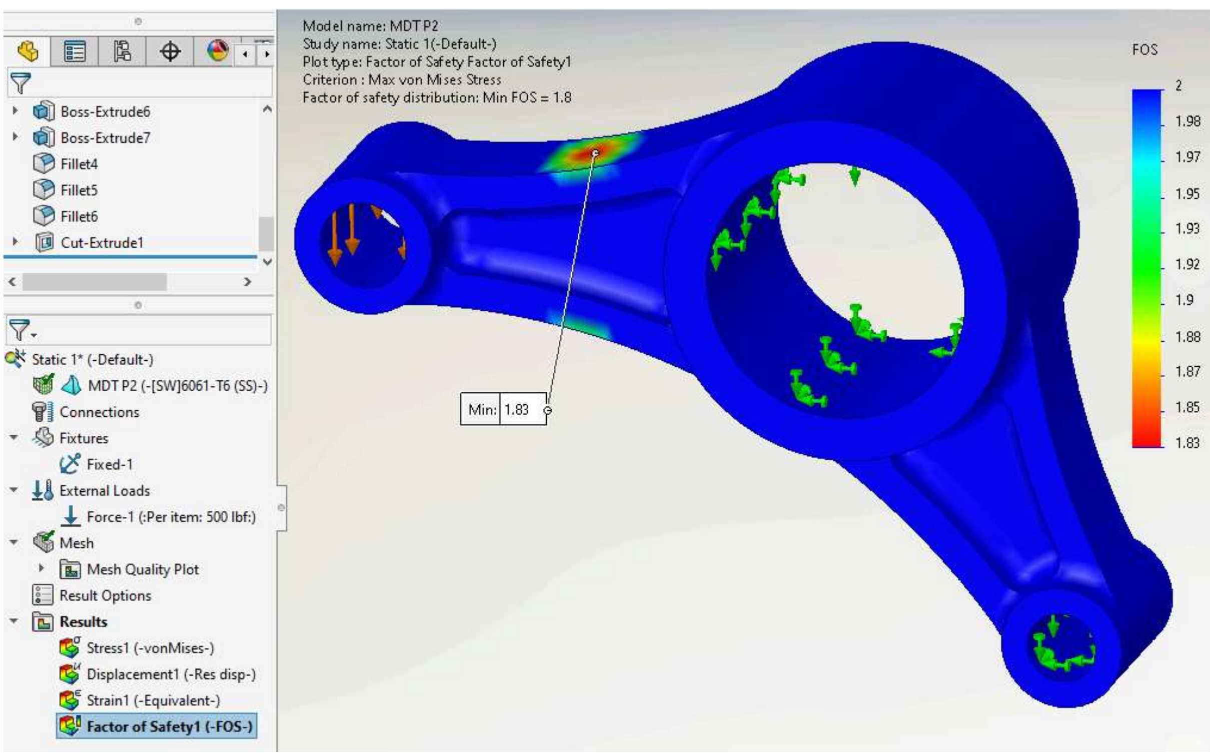

Fig. 6: Factor of Safety Report for P2

	P1	P2
Maximum Stress Under 500 lb. Load	568 MPa	150 MPa
Minimum Factor of Safety	0.484	1.83

Table 1: Maximum Stress and Minimum FOS for P1 and P2

The results from this table indicate that P2 is a better design for this loading scenario. P2's maximum Von Mises stress is significantly lower than the 275 MPa yield stress of Aluminum 6061-T6. Further, FOS values lower than 1 indicate that the part is no longer under elastic deformation. The FOS comparison shows that P2 is sufficiently lower than the yield stress point by a factor of 1.83, outperforming P1 with an FOS of only 0.484.

Ultimately, two primary design decisions improved the part's performance under load from P1 to P2. One change was the location of the main contour from the far edge of the holes to the center of the holes as discussed in Fig. 1 & 2. The other useful design improvement was the incorporation of fillets along the main contour. These fillets addressed unnecessary stress concentrations and effectively strengthened the part for this loading scenario. One other notable design change that increased the strength of the part was the thickening of the center wall.

2D Drawings*

Next, drawings were created for both P1 and P2. Each drawing includes an orthographic projection (top view in this case) on the top left, a section view in the bottom left, a detail view in the top right, and an isometric view in the bottom right. Different views are used to better visualize the dimensions and characteristics of every feature of each part. GD&T symbols, including Profile of a Line, Perpendicularity, Position, and Symmetry, are used to convey tolerancing requirements of various features. These symbols differ from the title block tolerancing convention to ensure that the corresponding features physically fit their purposes throughout the manufacturing process or in practical post-manufacture use. These drawings can be seen in Fig. 7 & 8 below.

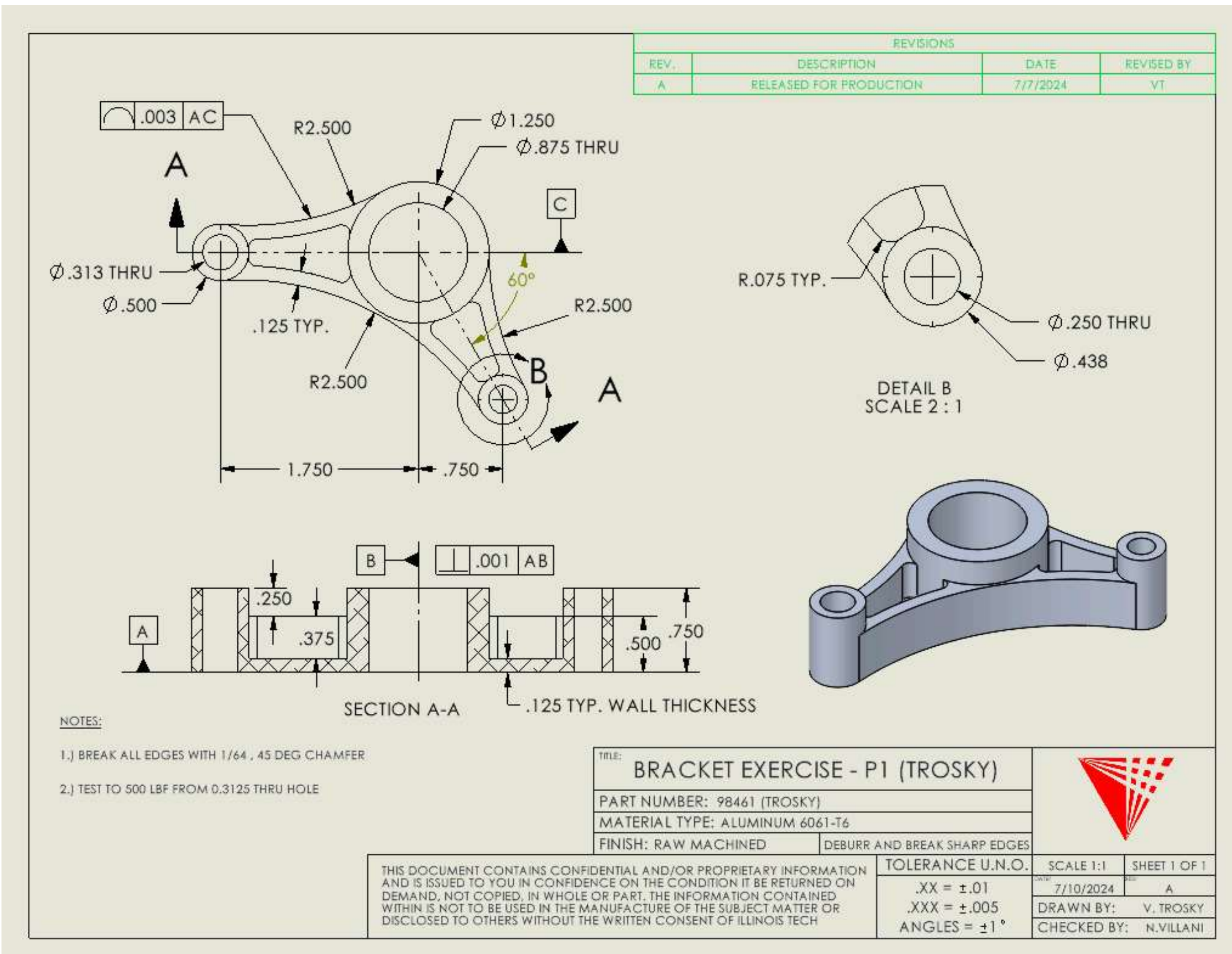

Fig. 7: SolidWorks Engineering Drawing of P1

*A third drawing was created, but was included instead in the 3D Assemblies section for better readability.

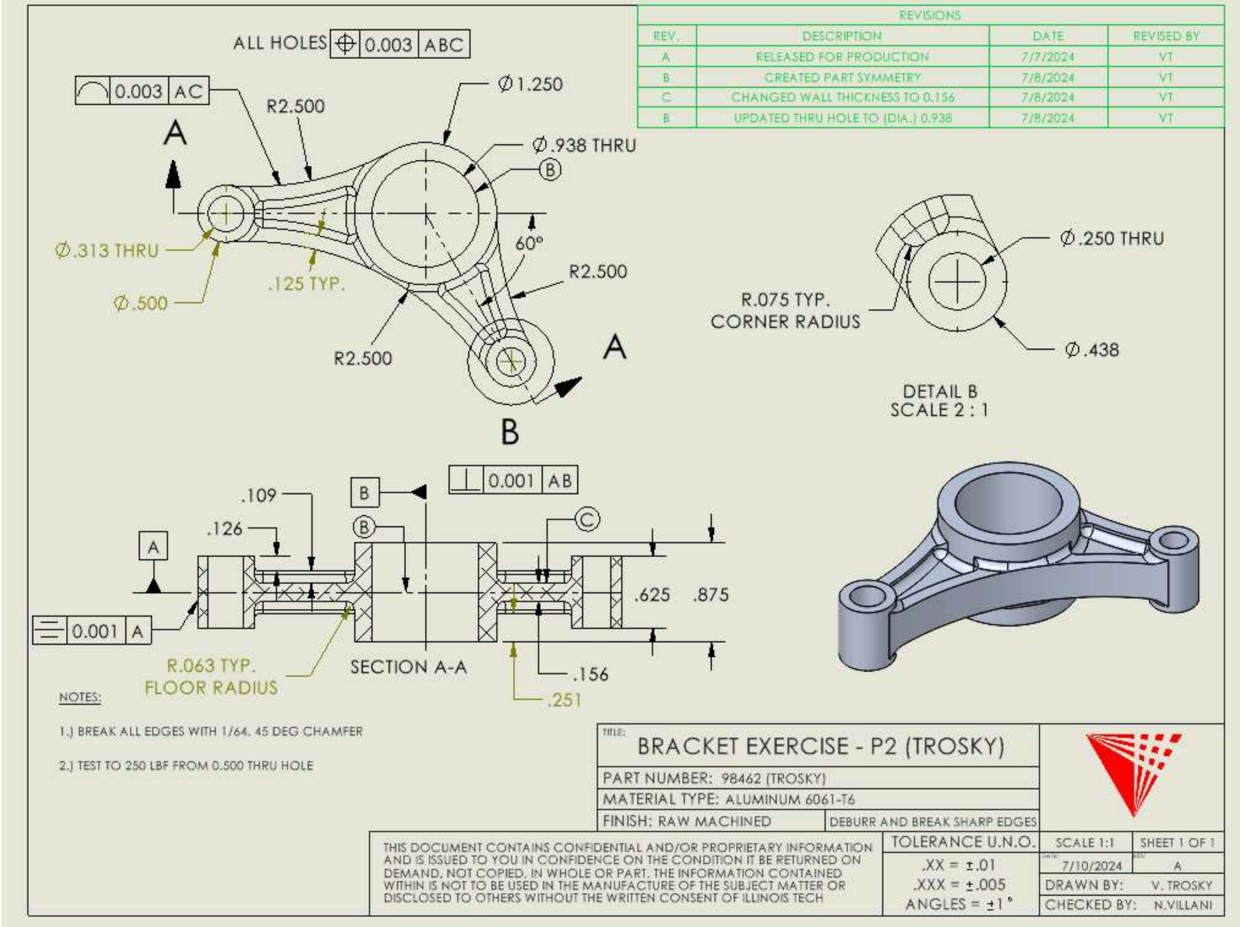

Fig. 8: SolidWorks Engineering Drawing of P2

3D Assemblies

After the drawings of each individual part were created, a 3D assembly was created with P1 and a 5-axis vice and riser with soft jaw blanks. In the assembly, the soft jaws were set to a fixed distance of 0.0625 in. Then, the outer contour of P1 was projected onto the soft jaw blanks and extruded according to the dimensions seen in Fig. 9 below.

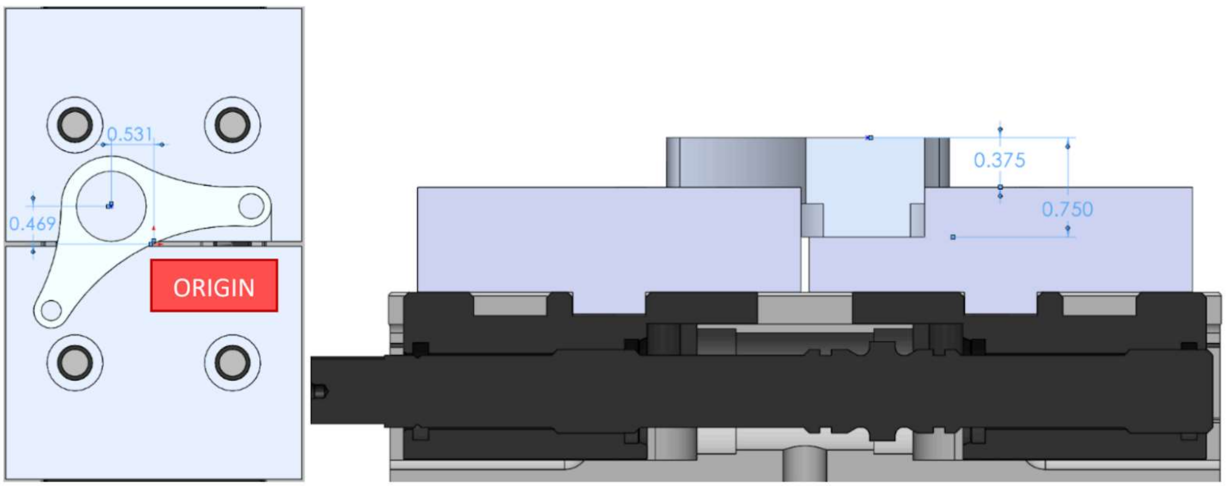

Fig. 9: Configuration of Vice and Riser with P1 Mounted into Soft Jaws

The result can be seen in Fig. 10 below.

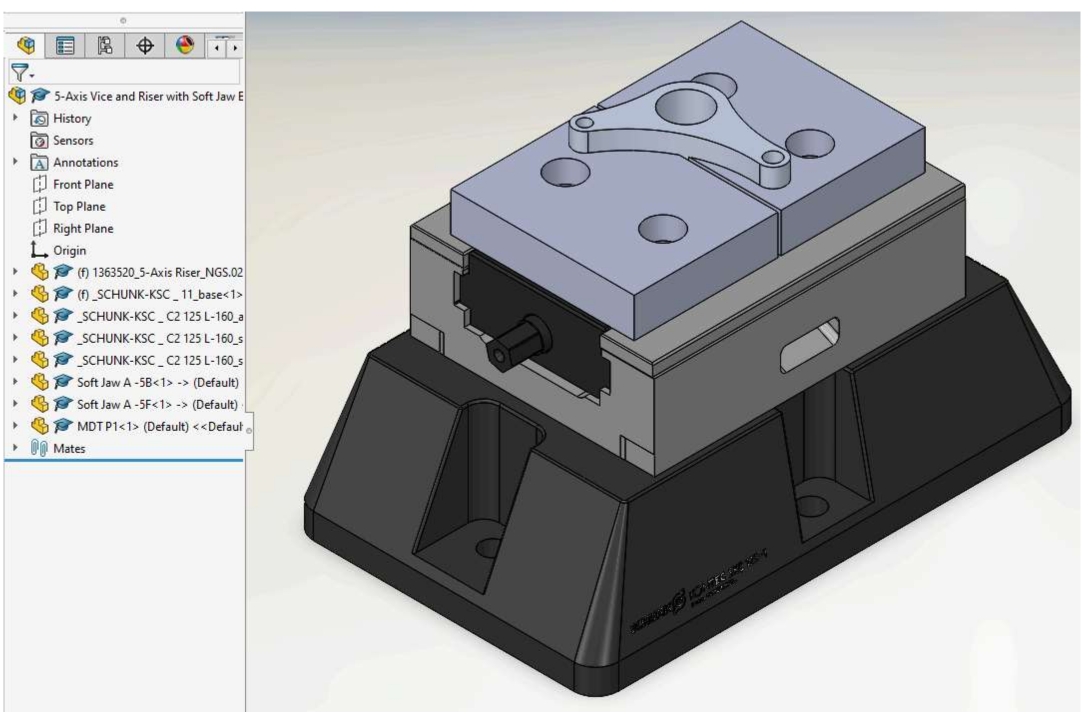

Fig. 10: SolidWorks Assembly of Vice and Riser with P1 Mounted into Soft Jaws

Next, an exploded view configuration was created to better visualize each part in the assembly. A drawing of the exploded view was also created, incorporating a BOM and numbered bubble callouts. The results can be seen in Fig. 11 & 12 below.

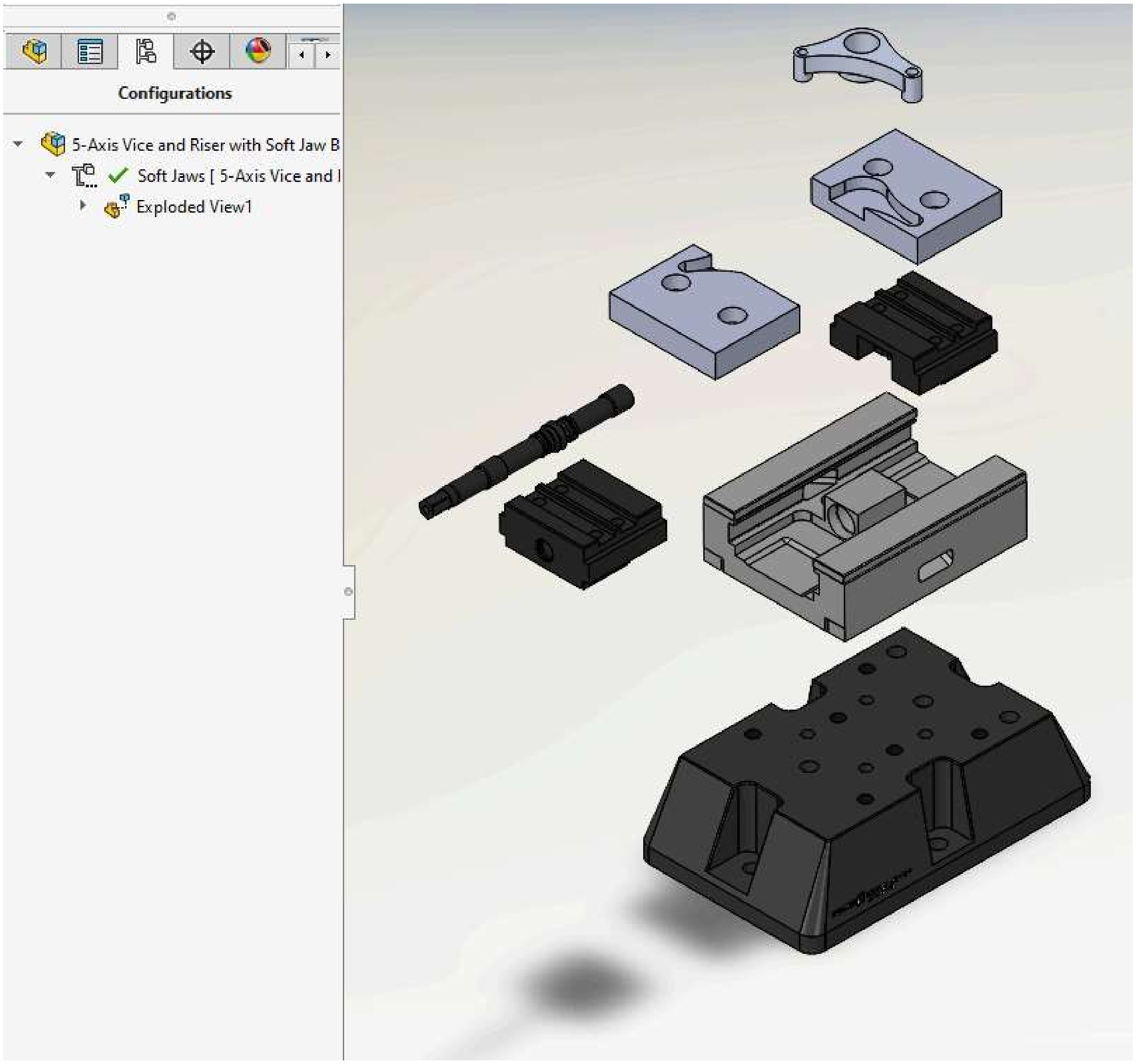

Fig. 11: Exploded View Configuration of Vice and Riser with P1 Mounted into Soft Jaws

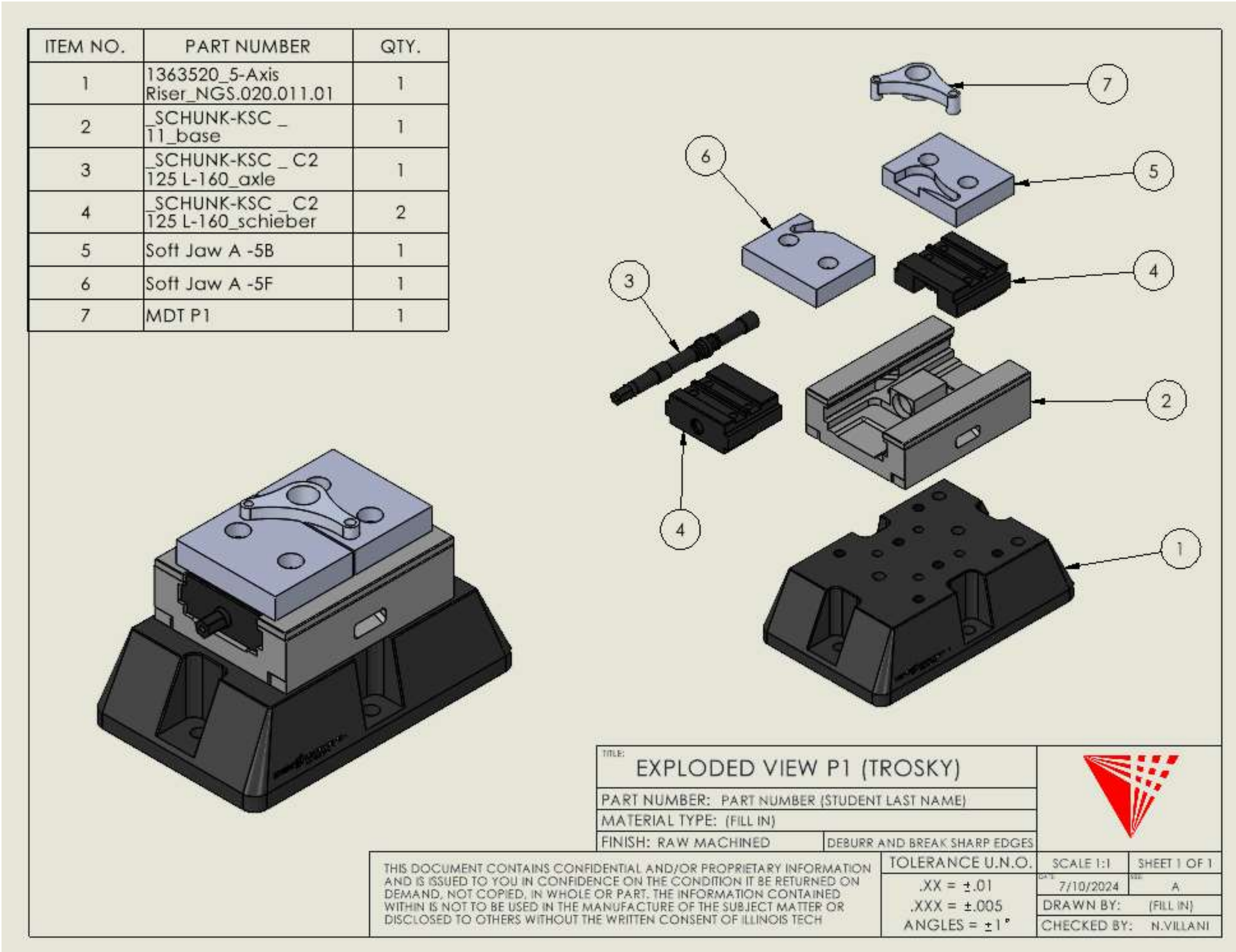

Fig. 12: Exploded View of P1 Vice and Riser Assembly

One important aspect of SolidWorks assemblies is the parent-child relationship organization structure. Assemblies are made up of multiple child files, as seen by the eight parts listed in the left column of Fig. 10. These child files can be moved around and edited within the assembly. However, these edits are not made to the original file, or the parent file. As seen in Fig. 11, the two soft jaw blanks were edited as children to fit the P1 bracket. These edits are not reflected onto the soft jaw blank parent file. Edits made to any parent file will be reflected throughout all of its child files. This hierarchy is crucial for effectively designing and managing parts and assemblies in SolidWorks.

Programming

Finally, both P1 and P2 were imported into MasterCAM to program the G-Code necessary for machining this part on a DMG Mori DMU-50. Two operations were performed on 3.75 x 3.00 x 1.00 in. (XYZ) stock material for both P1 and P2. Each operation was isolated to its own plane. The result of the first operation of P1 can be seen in Fig. 13 below, where leftover stock material can be seen surrounding the part in blue and purple.

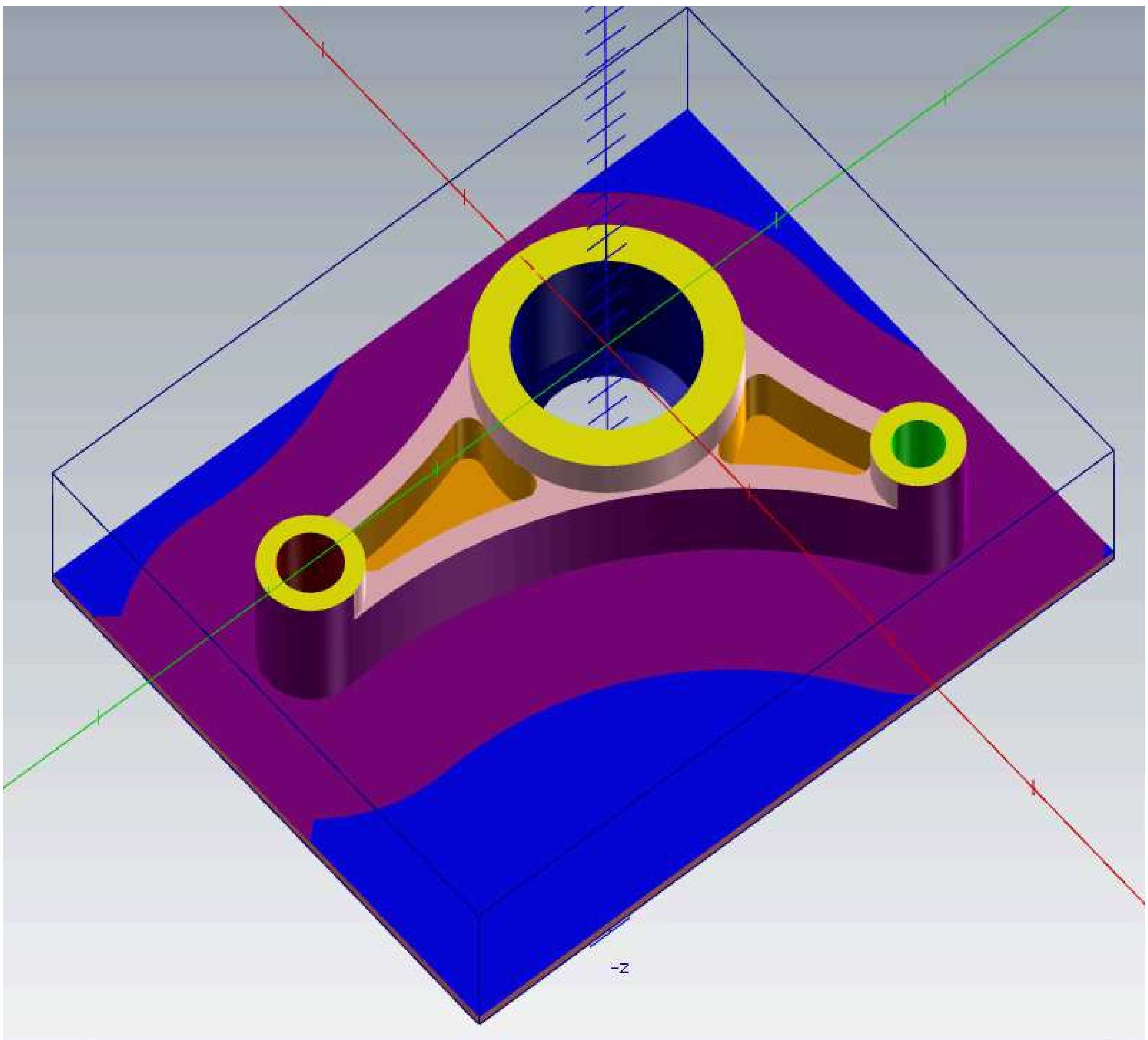

Fig. 13: First Operation of P1

The second operation on P1 required the top side of P1 to be placed into the soft jaw fixture, and use a face mill to remove the remaining stock on the bottom side. The part and working coordinate system (WCS) were flipped into the correct configuration, and the result can be seen in Fig. 14 below.

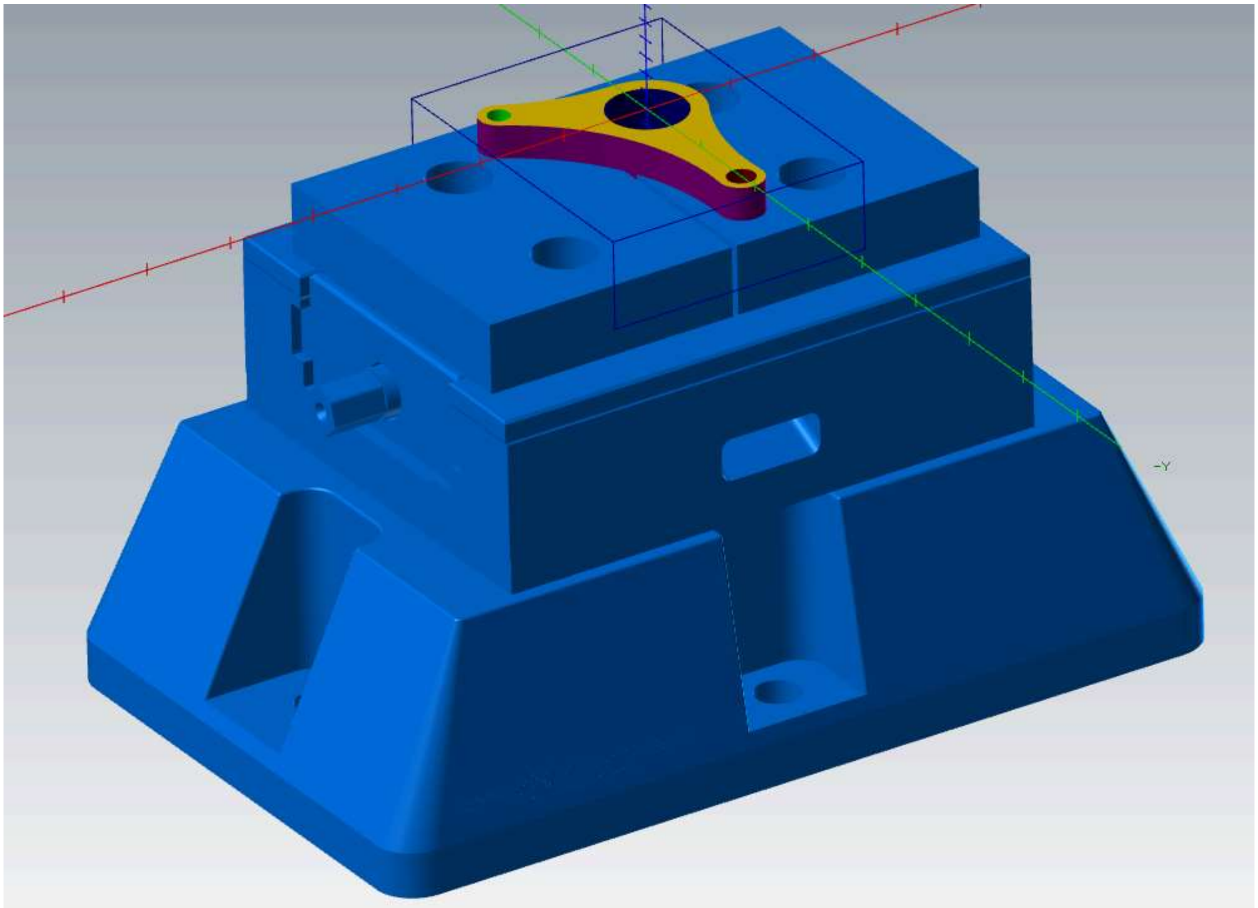

Fig. 14: Second Operation of P1

A few revisions were made between the first operations of P1 and P2, most notably for the pockets. Machining the floor and walls of the pocket proved to be more difficult on P2 because the radii of the corners were 0.075in and the walls were 0.0625in. This revision was made because cutting with a 0.125in diameter ball mill in a corner 0.0625in radius engages too much of the tool at once, stressing the tool and resulting in a poor finish. One cutting feature that was incorporated into the P2 first operation was a surface finish flowline. While the finish was poor, it was a neat alternative to milling the pocket entirely with a bull nose endmill. The bull nose in my case was not working, but I realized that I mistakenly made all of the pocket radii 0.075in, so I did not go back and change it. If I did, I would have machined the entire pocket with bull nose and ball nose endmill. This unique but incorrect approach to the first operation of P2 can be seen below in Fig. 15.

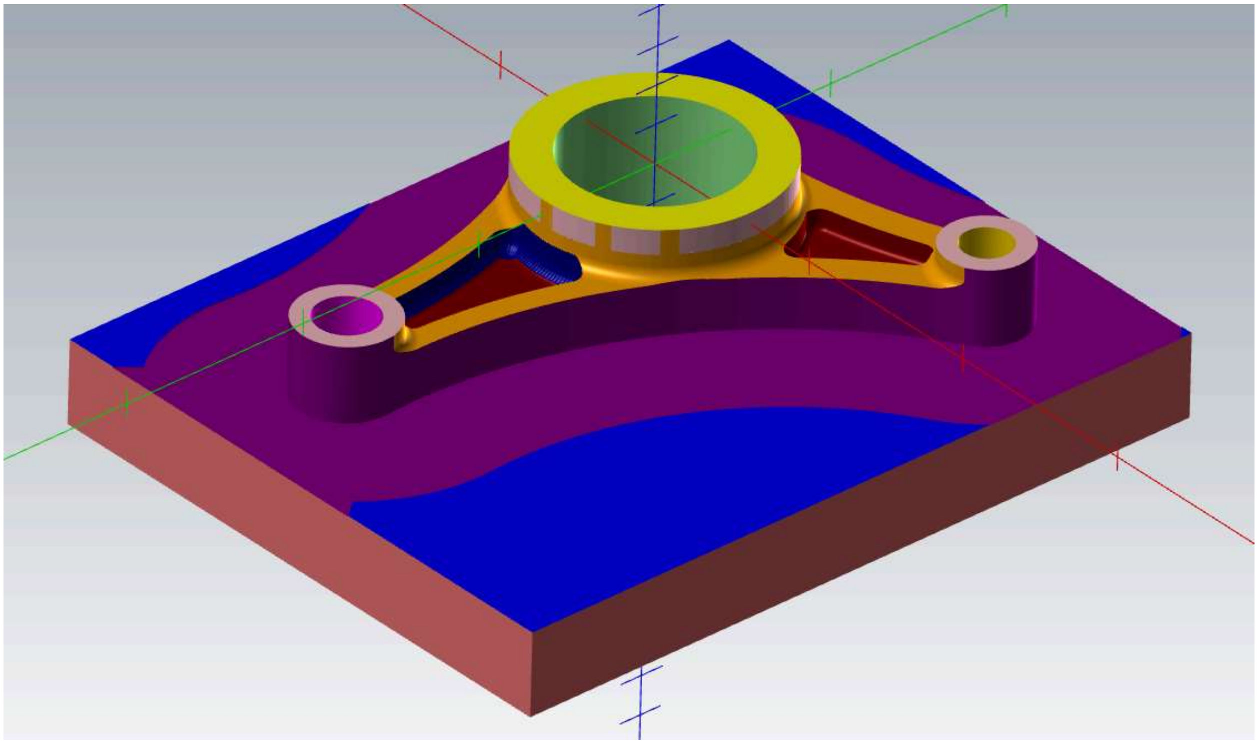

Fig. 15: First Operation of P2

The underside of the part was cut similarly to P1, where the first operation side was placed into the soft jaws. However, a near replica of the first operation was copied onto the second operation to finish P2. The result can be seen in Fig. 16 below.

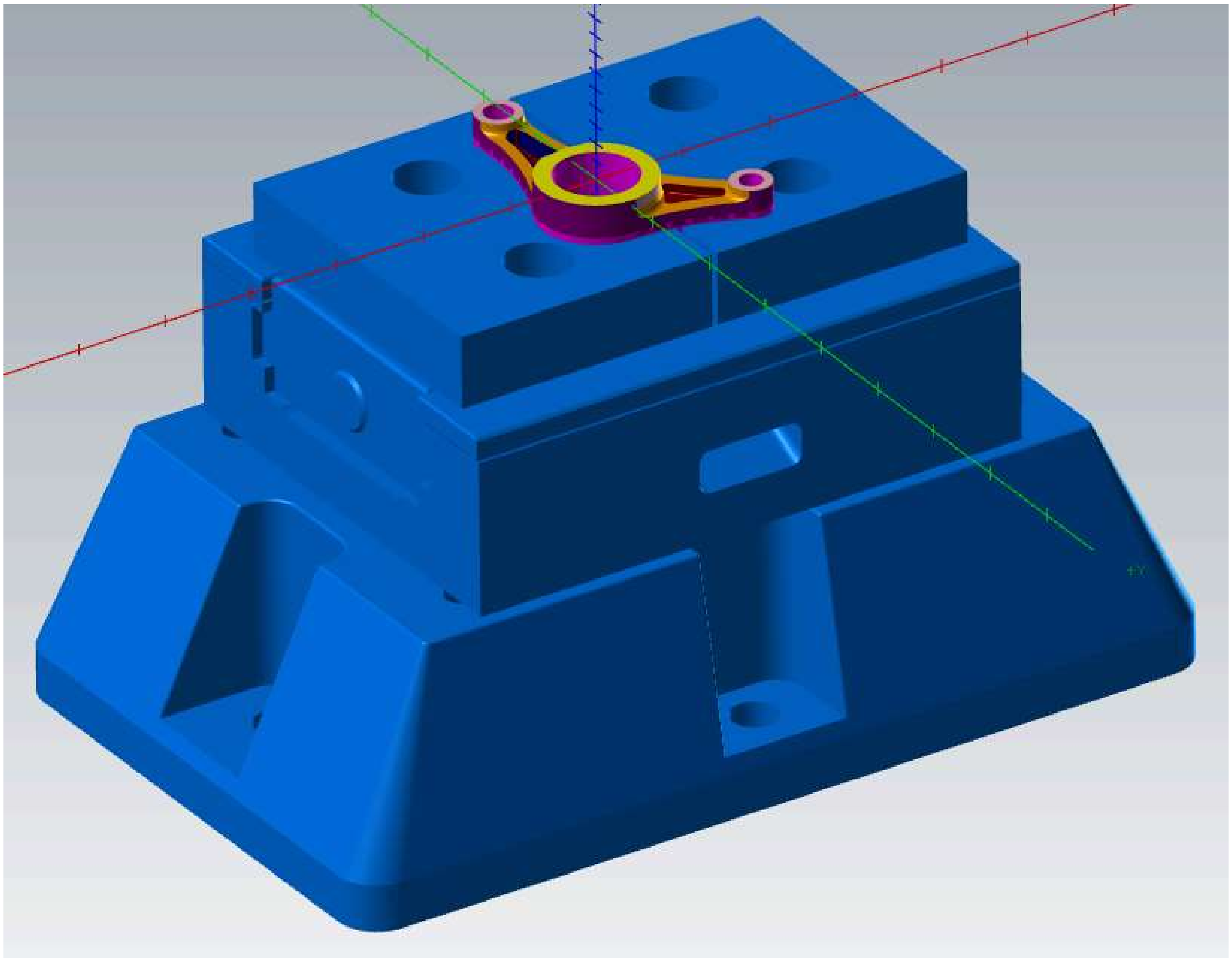

Fig. 16: Second Operation of P2