Project 1: Design of a Machined Part

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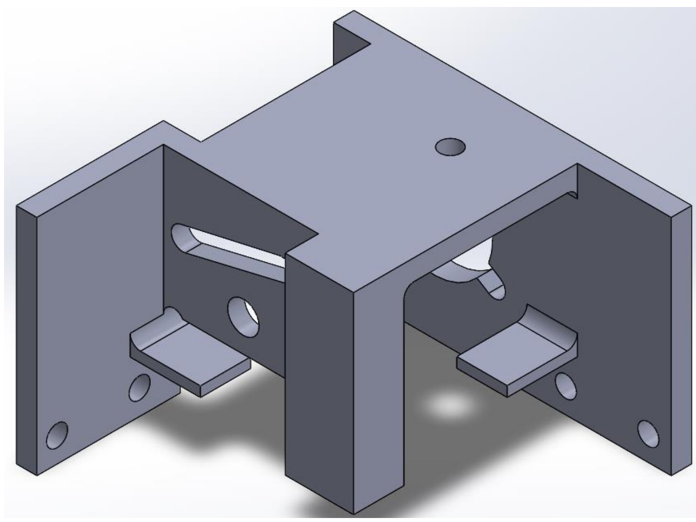

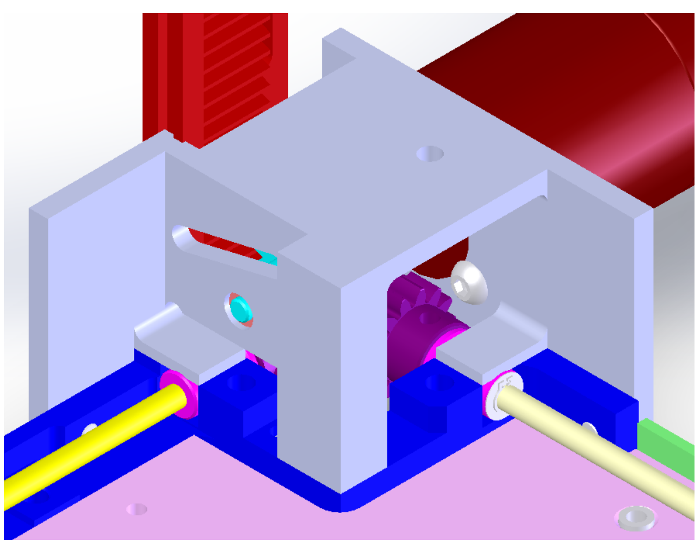

Introduction

The purpose of this machined part was for a motor mount for an archive data storage system. The system includes a gear rack, three gears, a motor, and three bearings; the machined part must accommodate all these parts. The machined part would mount to the blue shaft alignment part. The design began with a 63.5 x 63.5 x 63.5 mm cube of aluminum 6061, which can be found on McMaster (the equivalent of 2.5 x 2.5 x 2.5 in). After the formation of the initial cube, material was cut to accommodate for the requirements. The part is positioned inconsistently with the rest of the assembly, where the right plane and front plane are opposite. To assemble into the system, coincident mates must be made between both sides of the blue shaft alignment part and the inside faces of the machined part, and a third coincident mate must be made with the bottom of the machined part and the bottom of the blue shaft alignment part. The motor is attached to the part using three holes, excluding the hole on the bottom left because it is inaccessible with the design.

Design Decisions

All design alternatives were a decision. This section will detail each decision and why it was chosen.

The holes are toleranced at .127 mm, which is equivalent to .005 inches, a standard tolerance. Moreover, the sizes of the holes that attach to the blue shaft alignment part and the hole on the top are 3.175 mm (+ .127 mm), a standard size equivalent to 1/8 inch, and can be seen in figure 1. The hole on the top allows for access to the purple set screw. The size of the hole that secures the flange bearing for the shaft is 4.7625 mm (+ .127 mm), a standard size equivalent to 3/16 inch, which fits the size of the bearing rigidly and can be seen in figure 2. The tight fit ensures security to limit flexure of the motor shaft, which would cause a misalignment between the gears, and subsequently accelerate gear tooth wear. The slotted hole above this bearing, also seen in figure 2, is the same size as the holes for the top screws connecting the machined part to the motor. This allows the installer to connect and disconnect the screws that attach the motor with the machined part. Further, there is room above the diving board that is extruded along the front plane, and this empty space allows for attaching the third, bottom right screw using a short arm hex key, as seen in figure 3. This empty space also allows access to the purple and light blue set screws. This hole was created as a slotted hole for ease of manual connecting the motor with the part. Extra room to fidget provides ease for the installer.

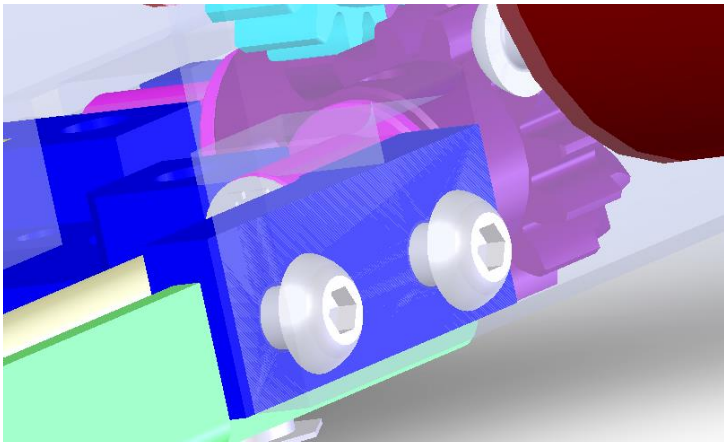

Figure 1: First alignment between the machined part and assembly, using screws.

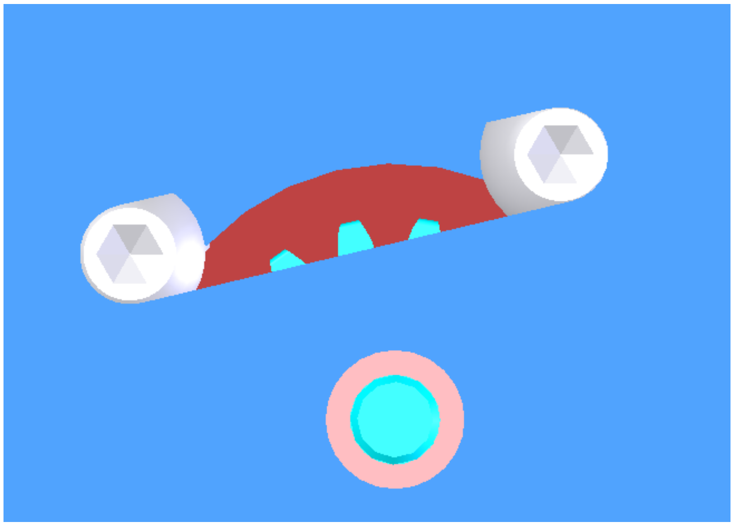

Figure 2: Slotted hole and hole for flange bearing of the shaft.

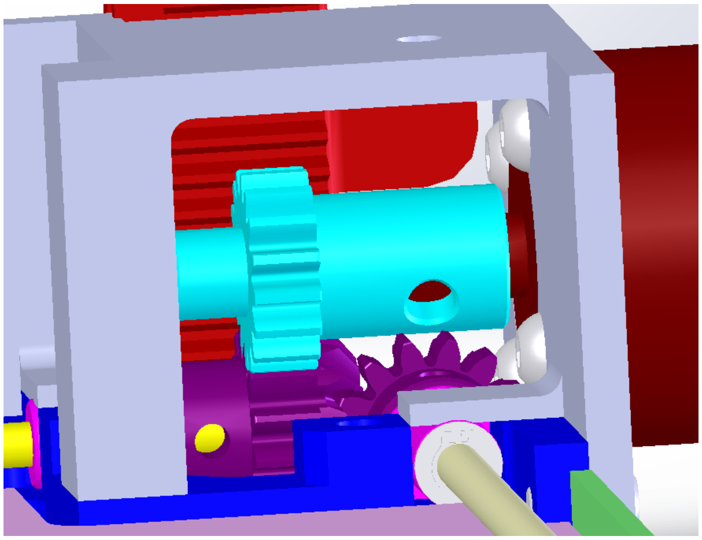

Figure 3: Front face of the machined part containing empty space for access to the bottom right screw.

To ensure strength, every thickness is at least 3.175 mm, equivalent to 1/8 inch, aside from the diving boards. The diving boards are thinner than the rest of the material to allow for flexure, and those calculations can be seen in the section titled *Calculations*. Further, the machined part is aligned to the assembly at three parts: with screws on both inside faces to the sides of the blue shaft alignment part, as seen in figure 1, and with a pin at the rectangular block between the diving boards, as seen in figure 4. The three separate alignments ensure security of the connection between the machined part and the rest of the archive data storage system.

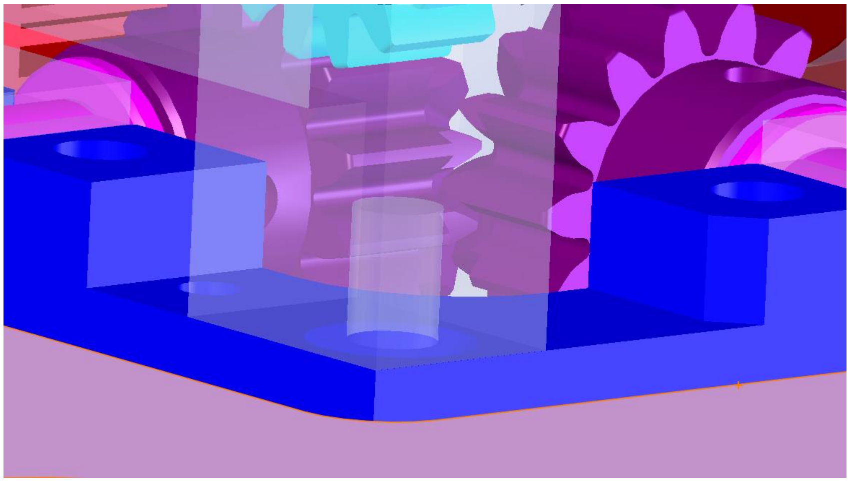

Figure 4: Third alignment between the machined part and assembly, using a pin.

The diving boards, as seen in figures 5 and 6, have identical geometries to accommodate for ease of machining and design. The diving board that extrudes along the right plane contains a circular cut above it. This cut is necessary to machine the diving board with a sufficiently sized fillet.

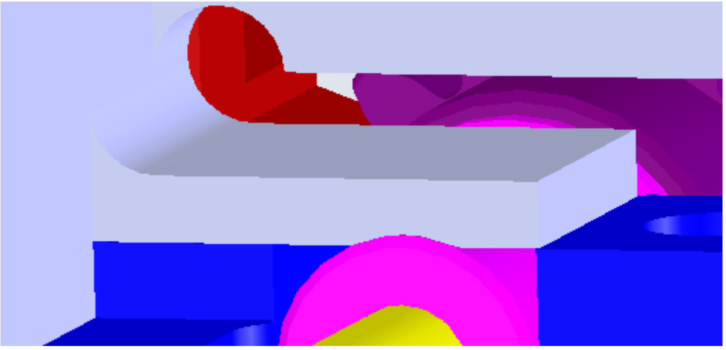

Figure 5: Diving board 1, extruded along the right plane.

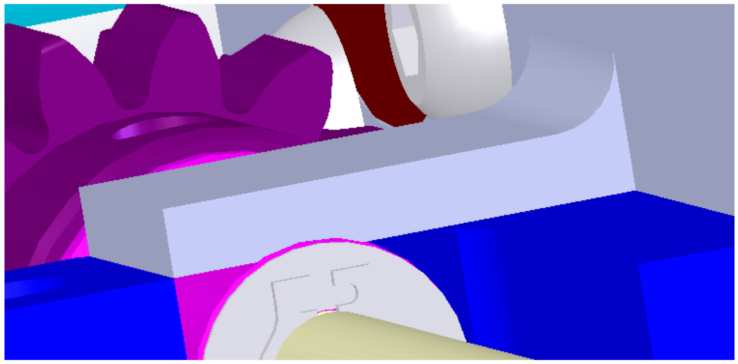

Figure 6: Diving board 2, extruded along the front plane.

Machining

The machining process includes 5 set ups and will necessitate a CNC mill. The goal was three set ups, but because of the complexity of the diving boards, 5 is necessary. The only face that is not needed to set up for machining is the ZX, which is the downward facing top plane. The order of machined planes is outlined below.

1. The ZY Plane (figure 7), excluding the holes. Use a 1/8th inch mill.

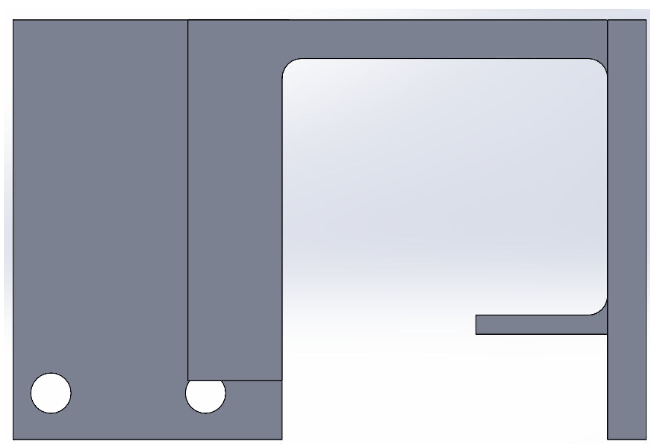

Figure 7: The ZY plane.

2. The YZ Plane (figure 8). Use a 1/8th inch mill.

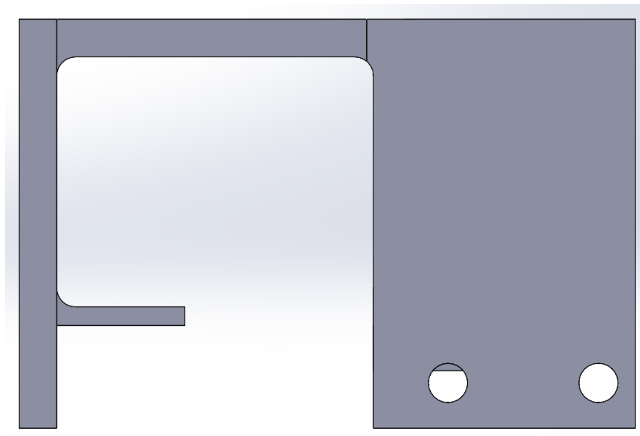

Figure 8: The YZ plane.

3. The YX Plane (figure 9). This is necessary for the holes and cannot be completed concurrently with the XY plane because the slotted holes do not fit properly over the holes that attach to the motor. Use a 1/16th inch mill. This is the smallest mill that needs to be used and the only face that it needs to be used for because it is necessary for cutting the material directly above the diving board.

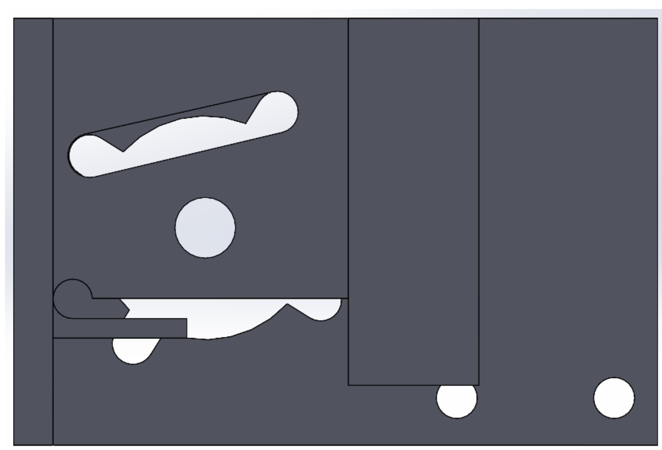

Figure 9: The YX plane.

4. The XY Plane (figure 10). Use a 1/8th inch mill.

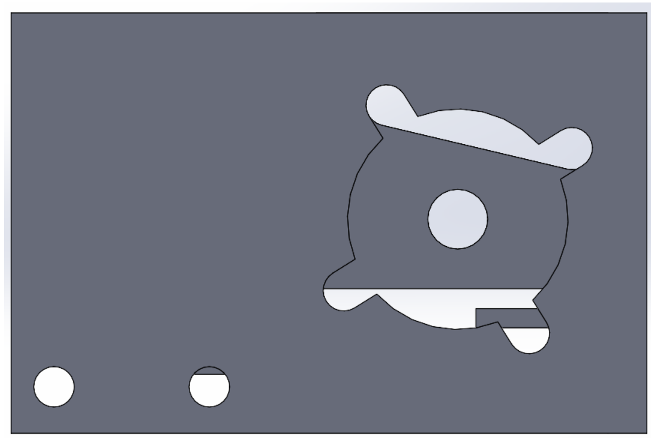

Figure 10: The XY plane.

5. The XZ Plane (figure 11). Use a 1/8th inch mill.

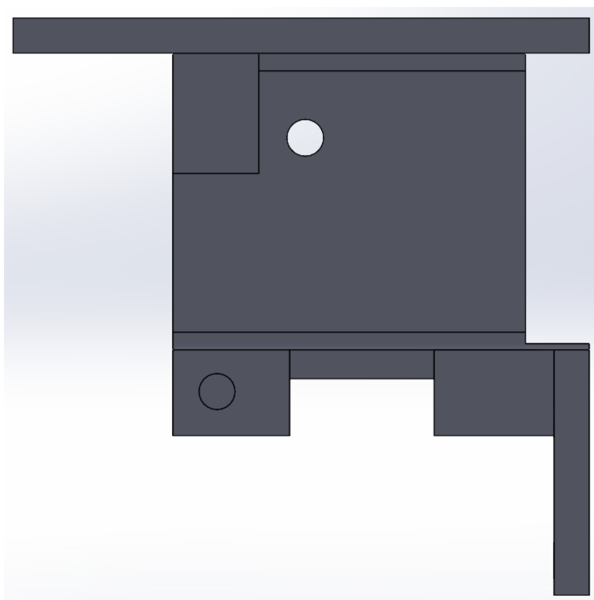

Figure 11: The XZ plane.

By machining from these five faces, the part will function, including the necessary fillets. There are no fillets on the bottom of faces because the final machining set up will cut these without needing a fillet. A 1/8th inch mill is used for nearly the entire design to keep consistency for the machinist and most fillets and holes require a 1/8th inch mill.

Calculations

The deflection of the diving boards to accommodate for the pink flange bearings and reduce and compression, seen in figures 5 and 6, was calculated using the cantilever beam deflection formula of a point force on a beam:

$$\delta_{max} = \frac{P*a^2*(3*L-a)}{6*E*I} \quad (1)$$

Where δ_{max} is the maximum deflection, P is the force, a is the length from the front of the beam to the force, L is the total length of the beam, E is the elasticity constant, and I is the moment of inertia. For 6061 aluminum, the elasticity constant is 68900 MPa. The moment of inertia was calculated using the equation for moment of inertia of a rectangular cross-section:

$$I = \frac{b*h^3}{12} \quad (2)$$

Where b is the length of the base and h is the height of the cross section of the diving board. The diving boards had identical sizes and properties for ease of manufacturing, design, and calculations. Table 1 shows the variables and their corresponding values, with units. The maximum deflection for a 15-pound point force was .0936 mm, and for a 35-pound force it was .2185 mm. The deflection goal was .08 mm, and both maximum deflections marginally exceed that goal, so they will deflect enough without breaking when the bearing puts upward force on them.

Table I: The variables and corresponding values used to calculate the deflection of the diving boards.

Variable	**Value**
Base (mm)	7.75
Height (mm)	1.57
Length to Force (mm)	7.645
Total Length (mm)	10.82
Elasticity Constant (MPa)	68900