Project 2: Design of a Sheet Metal Part

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MECH 518: Design for Manufacturing

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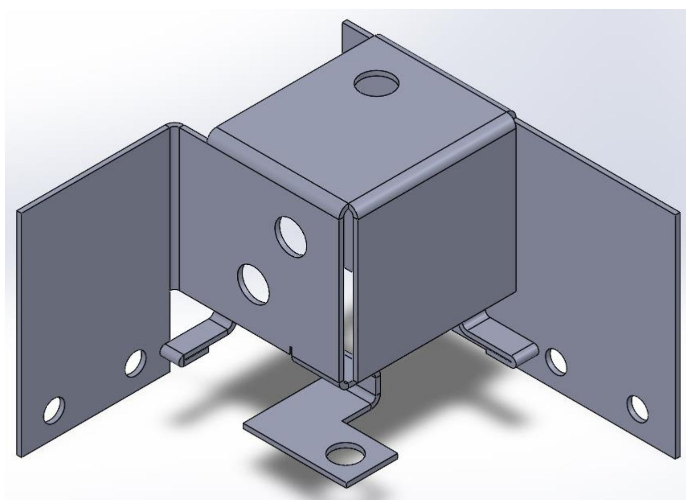

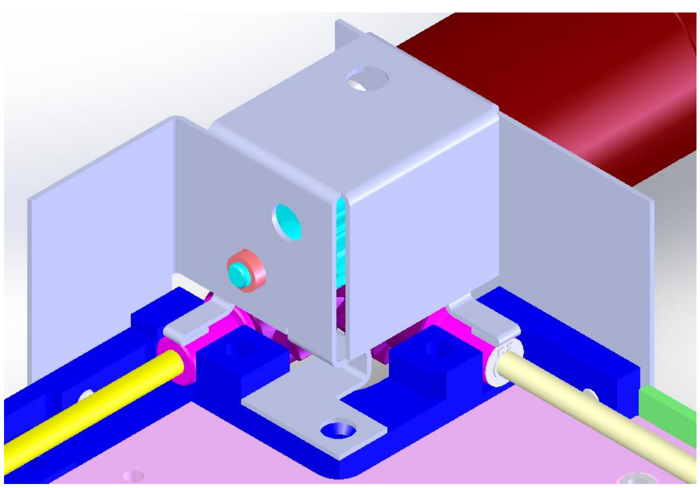

Introduction

The purpose of this sheet metal 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 sheet metal part must accommodate all these parts. The sheet metal part would mount to the blue shaft alignment part. The design began with a base flange rectangle of 34.42 mm height, 52 mm width, and .7366 mm thickness, which fit the parameters, has sufficient strength, and was the default on SolidWorks. Every bend radius was .7366 mm, matching the thickness, and all bends were at a 90-degree angle, for ease of bending. The material used was low carbon steel, which is common for sheet metal using laser cutting. The entire part was designed for laser cutting because it is a low volume part, and laser cutting is cheap and has high precision. After the formation of the initial rectangle, material was added using bends to accommodate for the requirements, then holes were placed. 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 right because it is inaccessible with the design. All design alternatives were a decision. This section will detail each decision and why it was chosen. The flat pattern of the part can be seen in Figure 1, and the unflattened part both by itself and in the assembly can be seen on the title page.

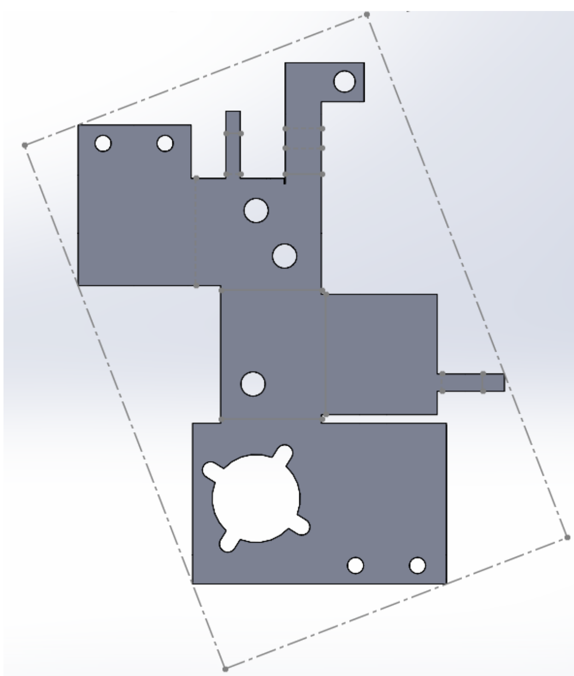

Figure 1: Flattened sheet metal part.

Design Decisions

All design decisions strictly followed the parameters necessary for structurally sound laser cuts, bends, blanking, and piercing. Despite the sheet metal part being machined with laser cutting and bending, parameters for blanking and piercing were also followed for transferability between sheet metal processes and ensuring strength. The specific parameters that were referenced are as follows:

- Slots or tabs widths (W) > 1.5 * Thickness
- Slot or tab length (L) <= 5 * Width
- Minimum hole diameter (D) >= 1.2 * Thickness
- Web (distance from hole to edge or hole to hole) >= 2 * Thickness
- Hole to bend distance >= 2.5 * Thickness + bend radius
- Minimum flange width >= 4T + R
- In reference to blanking parameters, not all corners used fillets or radii to avoid sharpness because that was unachievable given the design.

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, which can be seen in figure 2. The size of the hole that secures the flange bearing for the shaft, as seen in Figure 3, is 4.7625 mm (+ .127 mm), a standard size equivalent to 3/16 inch, which fits the size of the bearing rigidly. 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 hole above this bearing, also seen in figure 3, and on the top of the sheet metal part, seen in figure 4, are the same size, for consistency. These two holes are larger than necessary, but do not significantly diminish the strength of the part, ensuring ease of manufacturing and accessibility. The hole on the top allows for access to the light blue set screw. Both purple set screws can be accessed from the bottom, as seen in figure 5. The hole above this bearing allows the installer to connect and disconnect the top right screw that attaches the motor with the machined part. The top and bottom left screws can be accessed through the side with the gear rack.

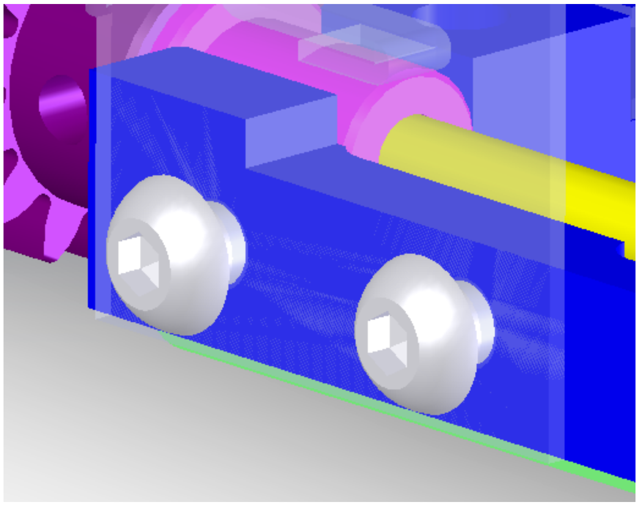

Figure 2: First alignment between the machined part and assembly, using screws.

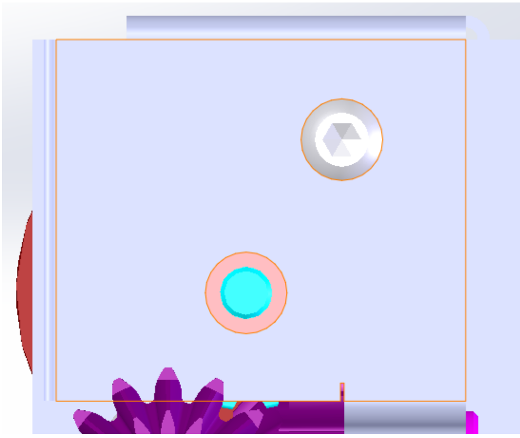

Figure 3: Holes for flange bearing of the shaft and assembly of top right screw.

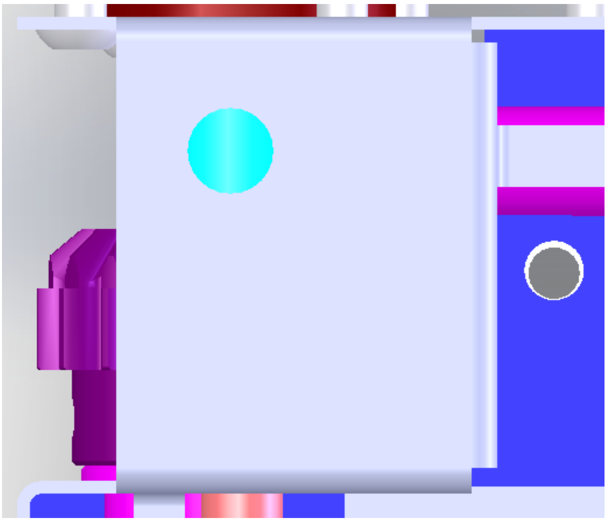

Figure 4: Top view of hole that provides access to the light blue set screw.

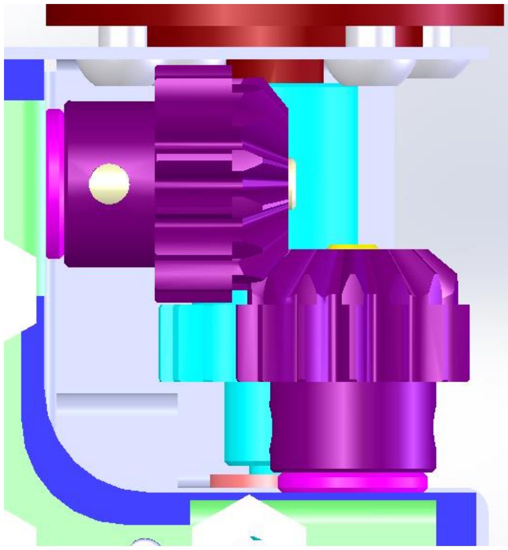

Figure 5: Bottom view showing open access to purple set screws.

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 2, and with a screw at the hole between the diving boards, as seen in figure 6. This hole is 4.2 mm in diameter, coinciding with the tap drill size. Tolerancing was not used for this hole because the hole is already sufficient to fit the screw that goes into the grey base. Further, the hole size was not consistent with the 4.97 mm of the three other holes on the part because that size was too big. Following piercing specifications, holes must be greater than two times the thickness of the material from the side. Moreover, a unique shape was used to allow this hole to fit into the correct spot. This shape included three bends, which ensured that the hole piercing would occur far enough from the bend to not cause a failure. The three separate alignments ensure security of the connection between the machined part and the rest of the archive data storage system.

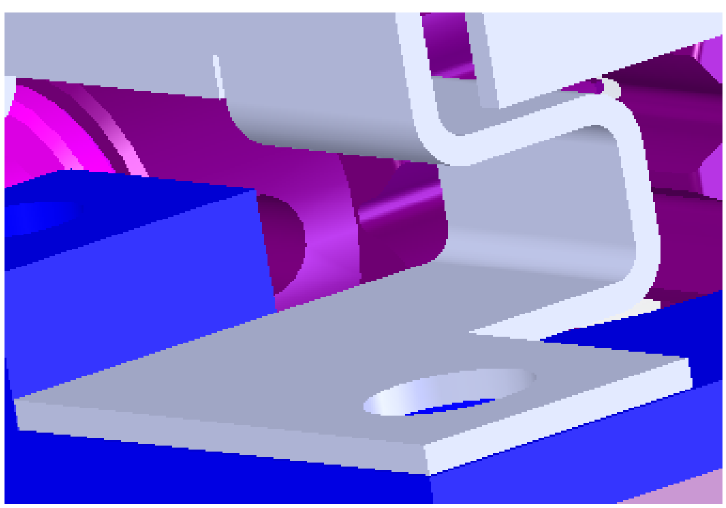

Figure 6: Third alignment between the sheet metal part and assembly, using a screw.

The diving boards, as seen in figures 7 and 8, have identical geometries to accommodate for ease of manufacturing. They both use the hem feature, which allows the diving board to rest parallel to the bearing, as opposed to perpendicular to it. Further, the full length of the bend is less than five times the width to accommodate for bending parameters. The base is as thin as possible to accommodate laser cutting parameters. The sizes are precise to accommodate for deflection, and the deflections calculations can be seen in the *Calculations* section.

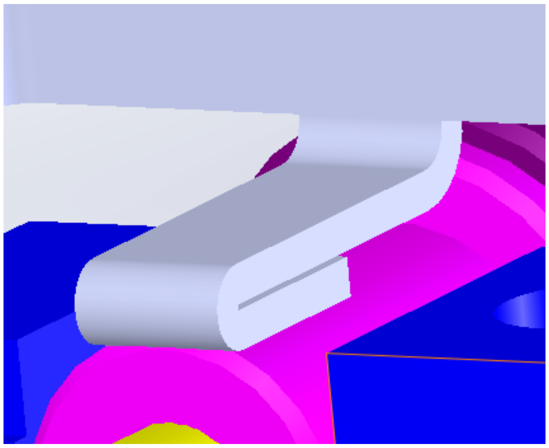

Figure 7: Diving board 1.

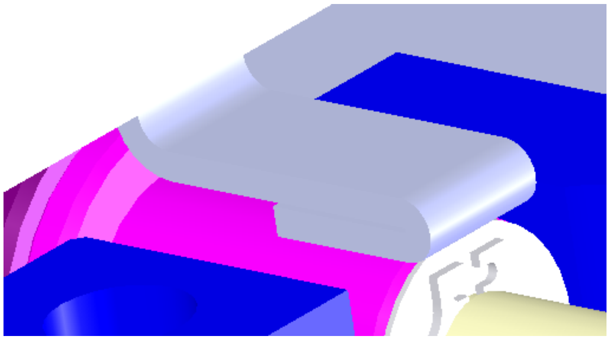

Figure 8: Diving board 2.

Manufacturing

The machining process can best be understood with Figure 1. It starts with a rectangle of .7366 mm thickness carbon steel with dimensions 114.83 mm by 75.06 mm. From there, the schematic is etched using a laser cutter, including all the holes. The bending process is ordered in Figure 9, with each numbered line corresponding to when it will be bent. The parameters for hole sizing, lengths between cuts, and other necessary components are explained previously in the sections titled *Introduction* and *Design Decisions*.

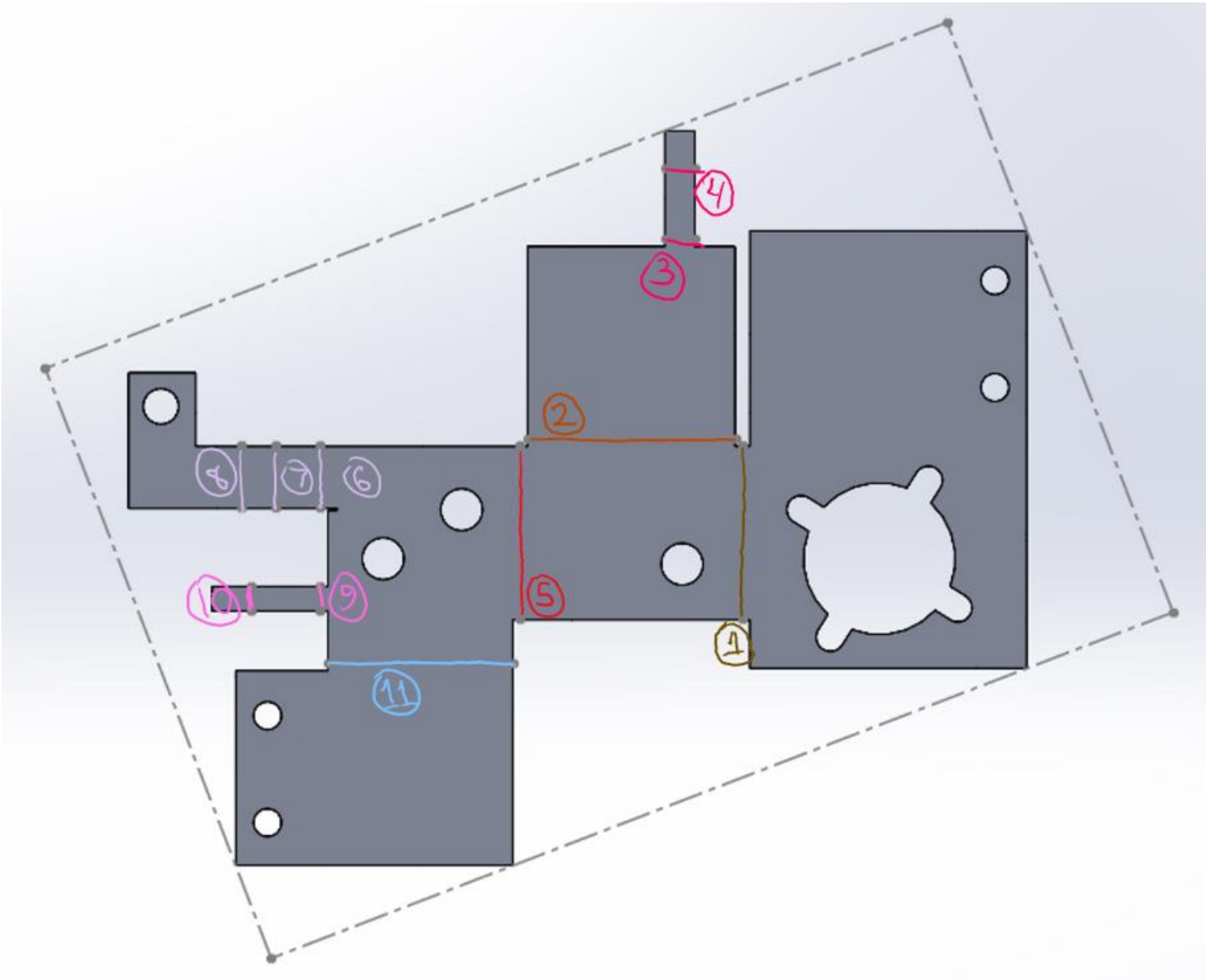

Figure 9: Order of bending.

Calculations

The deflection of the diving boards to accommodate for the pink flange bearings and reduce compression, seen in figures 7 and 8, 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 low carbon steel, the elasticity constant is 200000 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. Due to the unique shape of the hem, the deflection was considered a point force, where the force is exerted in the center of plane that is touching the pink bearing. This assumes that the force is evenly distributed along the face of the board that touches the pink bearing. 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 .032 mm, and for a 35-pound force it was .076 mm. The deflection goal was .03 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)	2.954
Height (mm)	1.57
Length to Force (mm)	5.72
Total Length (mm)	7.57
Elasticity Constant (MPa)	200000