A.C. Moyer Eye-Cap Manufacturing
Final Design Review
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Abstract

This report serves as the final design review for the eye-cap manufacturing project for A.C. Moyer company. Concept development and design selection are discussed. Justification for chosen design direction as well as results and details of the actualized design. Also included in this document is information on background and project management to provide context for the project.
Statement of Disclaimer

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1.0 Introduction

A.C. Moyer company has been making eye caps as a family business since 1947. Eye caps are a product used during the embalming process. Currently the machines being used to produce the eye caps are outdated and unsafe. We are a team of 5 mechanical engineering students tasked with either designing new machines or updating the existing machines to make the manufacturing process more efficient, automated, and safer. This document describes the design process, provides background, relevant research, establishes project objectives, and defines plans for project implementation.

2.0 Background

Before beginning the design project, we spent time doing research and collecting background information. This was done to provide context to the project and to ensure that alternative, obvious, or ubiquitous solutions were not overlooked.

2.1 Customer Need

We visited our sponsor, A.C. Moyer Co, to gain insight into how the current manufacturing process works and identify the problems associated with it. The current manufacturing process is both slow and unsafe. Primarily, A.C. Moyer is concerned with the amount of operator interaction needed to produce the product, especially when this interaction is both dangerous and repetitive. We have been tasked with updating the manufacturing process to provide increased capacity, safety, and automation, while adding the potential to manufacture oval eye caps.
2.2.1 Related Product Research

Table 1. Related Products Summary

<table>
<thead>
<tr>
<th>Product</th>
<th>Product Description</th>
<th>Relevance to Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTQD-50 Pneumatic Punch Press</td>
<td>Utilizes compressed air as power source; high efficiency and easy operation; can reduce labor; can be applied to manual operation integration; automated assembly line.</td>
<td>High</td>
</tr>
<tr>
<td>Cleveland Steel Tool Porta-Punch 35-Ton</td>
<td>35-Ton portable hydraulic punching unit; weighs just 31 pounds; easy to use and punches in seconds.</td>
<td>Medium – Not automated</td>
</tr>
<tr>
<td>Bench-Mount Air-Powered Presses</td>
<td>For punching, pressing, and swaging operations, these presses provide consistent pressure and faster operation than manual presses. The air power controls the pressing and return of the ram. The two-handed safety controls meet OSHA regulations. These presses can be used with die sets.</td>
<td>Medium – Not automated</td>
</tr>
</tbody>
</table>

2.3 Patent Table

Table 2. Relevant Patents and Key Characteristics

<table>
<thead>
<tr>
<th>Patent Name</th>
<th>Patent No.</th>
<th>Key Characteristics</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermoform dish</td>
<td>USD382974</td>
<td>A container used for storing food, which is thermoformed and cut in a way similar to that of the current eye cap manufacturing process.</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Patent Number</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Microperforator</td>
<td>US4667552</td>
<td>A sheet film perforation utilizes a series of heated pins to perforate film being drawn across a rotating cylinder. Perforation dimensions can be controlled by micro-adjusting hot pin penetration into the film.</td>
<td></td>
</tr>
<tr>
<td>Vacuum Forming Machine</td>
<td>US3751208A</td>
<td>A machine that forms plastic sheets via a perforated mold above a vacuum reservoir. A heating device heats the plastic from above, the plastic sheet is clamped to the mold platform and sealed to the mold.</td>
<td></td>
</tr>
<tr>
<td>High Speed Perforation Machine for Perforating Predetermined Repetitive Patterns</td>
<td>US5083487A</td>
<td>Machine uses a high-pressure water jet to perforate plastic sheets.</td>
<td></td>
</tr>
<tr>
<td>Method for Die Cutting Plastic Foam</td>
<td>US4856393A</td>
<td>The die cutter has a rule die blade, which defines the shape of the product. This is held by a die holder, which has an opening corresponding to the die blade, so that the cut can pass through the die holder.</td>
<td></td>
</tr>
</tbody>
</table>
2.4 Technical Research

The topics we wanted to research before analyzing various manufacturing processes was material properties of plastic, thermoforming, and die cutting.

The article “Everything You Need to Know about PVC Plastic”, published by Creative Mechanisms Staff (a prototyping and product design firm), allowed us to have a better knowledge of the plastic material that is being used to manufacture these eye caps, including its key characteristics and applications. With regards to thermoforming, we delved into “Vacuum Forming Guide for the Classroom”, a guide published by Formech, a design and manufacturing company of thermoform machinery. This guide outlined the vacuum forming process, mold materials, mold design, and various plastics with their corresponding characteristics and heating times. Note that thermoforming is the process of heating a plastic sheet, and dropping the sheet onto a mold, forming the plastic to the shape of the mold once cooled. A similar publication, Handbook of Plastic Processes, includes a thermoforming chapter that explains the processes, equipment, and tools used in the processes, as well as tradeoffs for the selection of materials that can be used in thermoforming. Furthermore, a book published by the Society of Manufacturing Engineers, Thermoforming: Improving Process Performance, describes the thermoforming process for plastics and how to improve the process to achieve the highest quality product. It also covers trimming, punching, and die cutting manufacturing processes, as well as a brief description of various plastic properties. In addition, the article “Taming Plastics” discusses various methods for die cutting, perforating plastics, and how to achieve the highest quality cuts through the design of cutting rules or pins.

2.4.1 Safety Standards

Although there are few industry standards regarding eye cap manufacturing, there are many regulations that highlight the safety of die cutting machines. The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) provides a publication, “Safeguarding Equipment and Protecting Workers from Amputations: Small Business Safety and Health Management Series” to help identify any hazards associated with operating and using stationary equipment. The publication delves into the two basic safeguarding methods, guards and devices, and outlines the various types of machine guards and safeguarding devices with their respective advantages and limitations. Furthermore, Part 1910 of Title 29 of the Code of Federal Regulations (CFR) establishes industry standards for occupational safety and health that should be implemented into our machinery design. (Administration, 2001)
Reciprocating action hazards are created by machinery that can strike or trap a worker between a moving part and fixed object. The current machinery used in the production process of eye caps has large hazards of this type. One mitigation method recommended by OSHA is the addition of guards, or physical barriers, between the user and any hazard zones.

Other hazardous situations can occur even while the machine is stationary, including clearing jams, adjusting machine elements, cleaning, and regular maintenance. If proper safety methods and controls are not implemented it is possible for dangerous situations to arise. OSHA recommends the addition of devices that interrupt or impede the operation in some way when an operator is in a hazardous position.

Regardless of the safety measures implemented, it is important that they do not interfere with the operation of the machine, are not easily tampered with, and are durable enough to last the life of the machine. Another point of importance is allowing for safe lubrication, maintenance, and die changing of the machine.

3.0 Objectives

3.1 Problem Statement

A.C. Moyer Company, a family-run eye cap manufacturing company, needs a way to improve the quality, repeatability, efficiency, and safety of their manufacturing process by integrating automation in an ergo-friendly process.

3.2 Boundary Diagram

![Boundary Diagram of Current Manufacturing Process](image)

This represents the current manufacturing process. The main opportunities for increased production reside in the perforation and punch stage, which currently only produces one eye cap per punch.
3.3 Summary of Customer Need

The customer, A.C. Moyer, has specified the following wants and needs:

- Safe and automated operation
- Low noise level
- Minimal punch force to floor
- Oval Die (Small, Medium, Large)
- Simultaneous system operation
- Easy die change and cleanability
- Increased production yield and speed
- Increased moldability success
- Fits within current operation environment

3.4 QFD Process Overview

Several engineering requirements were created to account for the wants and needs of A.C. Moyer, with each requirement related back to the need(s) it will assist in satisfying to understand what requirements catered to the most needs. While developing the Quality Function Deployment (refer to Appendix A), we noted that the only customer would be A.C. Moyer, and any potential benchmarks were unattainable due to the lack of information on current processes utilized by the competition. A majority of our evaluation tactics will be qualitative, with the main exceptions including size, punch production time, thermoforming temperature accuracy, and die disassembly time.
3.5 Engineering Specifications and Measurement

3.5.1 Specifications Table

<table>
<thead>
<tr>
<th>Spec #</th>
<th>Description</th>
<th>Target Requirement</th>
<th>Tolerance</th>
<th>Risk</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shock Absorption</td>
<td>&lt;140 dB</td>
<td>MAX</td>
<td>M</td>
<td>Test</td>
</tr>
<tr>
<td>2</td>
<td>Pneumatic Power</td>
<td>Present</td>
<td>MIN</td>
<td>M</td>
<td>Inspection</td>
</tr>
<tr>
<td>3</td>
<td>Electric Power</td>
<td>Present</td>
<td>MIN</td>
<td>H</td>
<td>Inspection</td>
</tr>
<tr>
<td>4</td>
<td>Additional Die-Cut Shapes</td>
<td>6 Dies (3 Oval, 3 Circular)</td>
<td>MIN</td>
<td>H</td>
<td>Inspection</td>
</tr>
<tr>
<td>5</td>
<td>Cut Multiple Caps Simultaneously</td>
<td>&gt; 2 Caps/Punch</td>
<td>MIN</td>
<td>H</td>
<td>Inspection, Test</td>
</tr>
<tr>
<td>6</td>
<td>Vacuum Former Case</td>
<td>Present</td>
<td>MIN</td>
<td>L</td>
<td>Inspection</td>
</tr>
<tr>
<td>7</td>
<td>Self-Locating</td>
<td>Consistent Origin Placement</td>
<td>± 1 cm</td>
<td>M</td>
<td>Test</td>
</tr>
<tr>
<td>8</td>
<td>Collar Release</td>
<td>Accessible – Customer Rated</td>
<td>MIN</td>
<td>L</td>
<td>Test</td>
</tr>
<tr>
<td>9</td>
<td>Pin Release</td>
<td>Accessible – Customer Rated</td>
<td>MIN</td>
<td>L</td>
<td>Test</td>
</tr>
<tr>
<td>10</td>
<td>Quick Disassembly</td>
<td>60 Seconds</td>
<td>± 60 Seconds</td>
<td>M</td>
<td>Test</td>
</tr>
<tr>
<td>11</td>
<td>Thermoformer Temperature Evaluation</td>
<td>5 % Error off Plastic Temperature Profile</td>
<td>± 5%</td>
<td>L</td>
<td>Analysis, Test</td>
</tr>
<tr>
<td>12</td>
<td>Vacuum Seal Improvement</td>
<td>Reduce Leakage by 5%</td>
<td>MIN</td>
<td>M</td>
<td>Test</td>
</tr>
<tr>
<td>13</td>
<td>Size</td>
<td>&lt;200 sq ft.</td>
<td>MAX</td>
<td>L</td>
<td>Analysis, Inspection</td>
</tr>
</tbody>
</table>

The current measurement techniques proposed for each specification are as follows:

- **Shock Absorption** - Utilize a decibel reader to understand the typical range of dB generated by the punching process.
• **Pneumatic Power** - The presence of pneumatic power will satisfy this requirement.
• **Electric Power** - The presence of pneumatic power will satisfy this requirement.
• **Additional Die-Cut Shapes** – Adjusting the current die shapes to fit the new manufacturing process and adding three oval die sizes will satisfy this requirement.
• **Cut Multiple Caps Simultaneously** – Producing more than 2 eye caps per iteration of the second stage of manufacturing.
• **Vacuum-Former Case** – The presence of a case surrounding the vacuum former to isolate fumes and increase temperature control.
• **Self-Locating** – To create an automated punching process, the plastic sheets must be located. The addition of a locating process will satisfy this requirement.
• **Collar Release** – Ability to release the collar quickly, safely, and ergonomically. To be evaluated by the customer.
• **Pin Release** – Ability to release the pins quickly, safely, and ergonomically. To be evaluated by the customer.
• **Quick Disassembly** – Total disassembly of die system to be achieved in under 60 seconds.
• **Thermoformer Temperature Evaluation** – Use specific plastic temperature profiles to compare to the currently achieved temperature profile. The maximum and minimum temperature obtained should be within 5% of identified ideal values.
• **Vacuum Seal Improvement** – Difficult to measure. Identify current leakage points and reduce by 5%.
• **Size** – Entire setup fits within the allocated space, the garage of the customer.

The high-risk specifications identified include providing electric power, adding additional die shapes, and cutting multiple caps simultaneously. We expect that the power restrictions of the current garage setup along with integration of electricity with the manufacturing process will require heavy analysis. Die shapes pose another challenge, with the manufacturing of oval dies themselves requiring high level machining to achieve the low tolerance shapes. The cutting of multiple caps simultaneously requires in-depth analysis of several different possibly manufacturing processes, including roll die cutting, the introduction of automation, etc.

### 4.0 Concept Design

#### 4.1 Ideation

In the first phase of ideation, we focused on the thermoforming process and how we could develop a simple yet effective solution for the quality issues presented. We quickly arrived at the solution of designing a box, shown in Figure 1 of Appendix B, that would enclose the thermoforming machine and provide better insulation, as this is a crucial aspect of properly molding plastic. However, we wanted to ensure that there was some way for the fumes from the thermoforming machine to leave the area, since this was a safety hazard that we were concerned about. Other features that we wanted to include were a lower mounting area for the plastic roll (to minimize the physical strain for the user), an area attached to the box to cut the eye cap sheets after they were formed, and the addition of a temperature sensor, such as a thermocouple, for the user to better understand the operating conditions of the thermoforming machine. These features are summarized in Figure 2 of Appendix B.
Once we were able to narrow down our ideas for the thermoforming machine, we then shifted focus to the die cutting machine. In order to develop our concepts, we brainstormed ideas for each function that was crucial to the final design. We first looked at concepts that would fulfill the overall goal of creating an automated machine that has increased production yield. One idea that was chosen early on as a part of our final design is to have the same concept as the current cutting machine of attaching the dies to a plate that would move vertically along guide rails. We then delved deeper into how many dies we wanted to integrate into the plate—this was ultimately decided by finding a balance between the overall cost to produce dies, increasing the production yield, and the ability for the pneumatic actuator to provide enough force to punch through the sheet. Our ideal design would be one that allows for a single cut to punch out all of the eyecaps on the entire sheet; however, the cost of dies and the amount of force required for this motion eliminated this idea. We eventually narrowed down the amount of dies integrated into the machine to three dies and three perforation pin sets. Various die layout sketches are provided in Figure 3 of Appendix B.

Furthermore, we brainstormed several ideas to answer the question of how the bottom half of the machine (where the sheet will be mounted) should interact with the top half (the plate with the dies). We wanted to limit the directions of motion that each component of the machine would allow for, as this would increase the complexity of the design and risk of the component not performing each step of the process at the correct time. Originally, we investigated a design where either the sheet plate or the die plate would move in two dimensions. The machine would run through twenty rows of eyecaps, with three eyecaps being cut at each step. The die location on the plate or the bottom plate where the sheet is would then shift over by three eyecaps, and the process would be repeated until the entire sheet was cut. However, as mentioned before, having either component move in more than one direction increases complexity and risk of the machine not properly cutting at the right time. Consequently, we decided on a design where the user would cut the 15 x 20 sheet into strips of 3 x 20; this strip would then be fed into the machine, where three caps would be cut at each step.

The final function we investigated is how to feed the strip of eyecaps through the machine. A key part of choosing a design for this function is ensuring that the mechanism can lift the sheet so that each eyecap can be properly removed from the die cut hole without catching on the female part of the die. The first design idea was to integrate a cam on a shaft; the protruding part on one side of the cam would push the sheet up and move it linearly over by one row with one rotation on the shaft. As the sheet moves up, a roller towards the back of the sheet would limit the movement of the entire sheet. This idea is shown in Figure 4 of Appendix B. An additional idea that could be implemented into this design is to have a cutting mechanism at the end of the machine, as shown in Figure 5 of Appendix B, to decrease the size of the scrap material produced after this process, which could potentially help with the recycling or removal of the material. With this cam design, however, there is no way for the sheet to be moved through once the machine has cut through most of the rows as the cam would not be in contact with the sheet at this point. This issue generated another idea, where the empty areas of the die layout on the plate would contain pins that would move vertically after each cut (see Figure 6 of Appendix B). Once the sheet is lifted, there is a continuously spinning roller that would then move the sheet over one row. The difficulty of timing the horizontal movement from the roller with the vertical movement of the pins, however, caused us to move away from this design. The final design we developed is a gear integrated in a roller chain, wrapped by a belt on which the sheet sits. As the gear rotates to move the sheet horizontally, the gear also moves vertically on a linear rail to allow the sheet to be lifted in and out of the female die. Figure 7 in Appendix B outlines this design idea.
4.2 Pugh Matrices

One of the methods used to make design decisions for various functions within the thermoforming and die cutting machines was the creation of a Pugh matrix. We created three matrices that each covered a crucial function of the project: insulating the thermoforming machine, the layout of the dies on the plate for the die cutting machine, and the method by which the automated cutting machine would move the formed sheet through. Refer to Appendix B for the corresponding Pugh Matrices.

4.3 Selected Concept Design

In addition to creating Pugh matrices to determine which design ideas best correspond to the desired function of the machine, we developed a weighted decision matrix, attached in Appendix B, to decide which design options best satisfy the required customer needs. As shown in the matrix, the final design includes three key features: a box surrounding the thermoform machine for better insulation, a staggered layout on the die cutting machine of three dies and three perforation pin sets, and a rotational gear with a linear vertical rail to allow for sheet movement through the machine.*

*Indicates a part of the design that has been modified or is no longer within the project scope.
The first section of the selected concept design focuses on the thermoformer insulation box. The front access panel is hinged on the left side, allowing the user to open the panel to access the inside of the box, and adjust the plastic sheet into the frame prior to running the thermoformer. The right access panel allows the user to cut and remove the thermoformed plastic sheet. The box is designed around the dimensions of the thermoformer, with cut-outs for the control panel, plastic loading slit, and plastic roll truss. The top panel has three cut-outs, two for the cooling fans to pull air through, and one for the exhaust fumes created during the thermoforming process. The box will be constructed out of clear acrylic, with an initial prototype constructed out of plywood. Each separate panel will be cut by on-campus technicians and built by our team at the site of A.C. Moyer. The exact thickness of the acrylic will be determined after further thermal analysis, but the anticipated thickness is currently 0.25 inches. To assist with the insulation of the box, we will install rubber around the access panels. The hinges on the access panels will be selected after material thickness has been finalized, to account for the weight loads caused by the access panels.

![Image](image.png)

Figure 4. Isometric view of concept die layout and linear sheet movement.

The remainder of the concept design pertains to the eye cap puncturing and die cutting process. The two main goals for this portion of the design are to improve production rates and provide a safe production process that does not pose hazards for operators. To improve the production rates, we plan on using multiple dies in parallel to process more eye caps for each punching operation. This will greatly improve the production rates, possibly even removing the die cutting process as the bottleneck for production. Some analysis and testing is still needed to determine the number of dies that can be used in parallel. To accomplish the safety goals of this design we intend to make the sheet automatically feed into the die cutter to remove fingers from dangerous areas of operation. Additional safety guards that will prevent access to the punching process, but still allow for visibility will also be added.

4.4 Preliminary Analysis

Thus far, no preliminary analysis has been performed. There are not enough knowns to provide stress analysis on the die cutting portion, and the thermal analysis for the thermoformer will require outside help for 3D finite analysis.
4.5 Current Risks
There are a variety of safety hazards associated with the process outlined. Refer to Appendix B5.5 for an outline and description of risks. Potential unknowns in the design is how insulation of the thermoformer will potentially affect individual thermoformer components. Additionally, the manufacturing of the oval dies within the die cutting portion of the design is unknown, as the process may be extremely expensive and difficult to actually meet the tolerance of.

In terms of determining the system’s necessary performance values (such as die cutting force), we are expecting to iterate through multiple sets of eye caps with varying pressures on the current die setup to determine the minimum pressure necessary for a clean cut. There is a risk that this experiment may not provide accurate ranges with comparison to our final die cutting portion.

5.0 Final Design

5.1.0 Die Cutting Machine
The overall design of the die cutting machine is similar to that outlined above, with three sets of dies and pins to increase production rates of the eyecaps. To allow for the eyecap sheets to move through the machine with no human interaction, a conveyor belt mechanism was designed. A design selection was also made for the air cylinder attachments.

A cost breakdown of each assembly within the die cutting machine is shown below.

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyor Belt</td>
<td>$251.82</td>
</tr>
<tr>
<td>Die Cutting Machine</td>
<td>$6161.73</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>$936.99</td>
</tr>
<tr>
<td>Control</td>
<td>$55.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$7405.54</strong></td>
</tr>
</tbody>
</table>

5.1.1 U-Shape Cylinder Attachment and Pneumatic Assembly*
With increased size of the die cutting machine, we wanted to use two rods to move the top plate up and down for the cutting mechanism, rather than the one rod used on the current design. Therefore, we developed a U-shape attachment for the cylinder, as shown below.

*Indicates part of the design that has been modified or is no longer within the project scope
After calculating the required punch force to cut three eyecaps at a time, we determined that the purchase of a new cylinder is required. A similar mechanism for attaching the cylinder to the work table will be used; however, as we haven’t been able to review the mounting mechanism and record any relevant dimensions, we have yet to create a design for these mounts. The air cylinder is attached to a coupling nut that is attached to a threaded rod (to extend the overall cylinder rod length to prevent any collisions with other parts). This rod is then fastened to an aluminum bar, with two threaded rods on either end that are then attached to the top plate.

In order to determine if this attachment can withstand the force required to punch eyecaps, finite element analysis was performed for the assembly. Simplifications for the study include removing threads from threaded components and bonding components together and anchoring the assembly by fixing the bottom face of the cylinder rod. The maximum possible force provided from the compressor was used (1413 lbf total). Note, however, that the calculated punch force required to cut the eyecaps is 64 lbf. As shown below, the minimum factor of safety for these conditions is 4.5.
The thermoformed plastic eye cap sheets fed into the machine will be cut to 3 x 20 in size. In order to both locate each eye cap shape and index the sheet forward, a conveyor belt assembly with a negative three-dimensional print mounted on the belt will be assembled at the feed entrance of the die-cutting machine. The conveyor belt will be driven by a position-control motor, which will be programmed in coordination with the die-punching actuator in order to index the plastic sheet forward one eye-cap-row length forward, following each punch. After one full eye-cap sheet has been punched, the conveyor belt will retract back to its original position, another sheet will be manually loaded onto the belt, and the process will repeat. An isometric view of the assembly modeled in SolidWorks can be seen in Figure 5.1.3.

*Indicates part of the design that has been modified or is no longer within the project scope
The conveyor belt assembly will consist of two rollers, attached to four ball bearings, one of which will contain an extruded shaft connected to the driving motor. The front conveyor roller and two ball bearings, closest to the die-cutter machine input, are attached to a sub-assembly, allowing the adjustment of the linear distance between the two rollers. This will allow the conveyor belt to be properly tensioned both when assemble and when a belt replacement is required in the future. The sub-assembly is comprised of 8020 aluminum parts, which allow the position of the attached ball bearings to be easily adjusted without the necessity of disassembling entire 8020 sub-assembly. A schematic of the sub-assembly is shown in Figure 5.1.4.

Figure 8. 8020 Aluminum Parts Sub-Assembly 3D Isometric View

An additional mechanism at the exiting end of the die-cutter is required in order to grab the sheet and assist its forward motion for the last few eye-cap rows of the sheet, when the input conveyor belt is no longer in contact with the plastic sheet. This will consist of two rollers, attached to four ball bearings and a wooden block, which will be mounted to the worktable using eight corner brackets. One or both motors will be attached to the roller axles to drive the rollers and index the sheet forward in synchrony with the conveyor belt driving motor. The plastic sheet will be fed into the small gap between the two rollers, in which frictional forces will feed the sheet forward. In order to account for the difference in heights of the punched-out eye-cap sheets, which will differ depending on what sized eye cap is being punched, an elastic rubber material, with rubber finger-like extrusions will be wrapped around each roller. This material coating will also increase the friction factor between the rollers and the plastic sheet to ensure that there will be no slippage. The exiting roller configuration is shown in Figure 5.1.5. (rubber roller coating not shown).

Figure 9. Exiting Dual Rollers Assembly 3D Isometric View
The exiting roller assembly also serves another function as to apply one of two downward forces on the plastic sheet in order to remove the sheet from the male-side of the dies after each punch. The other of the two downward force will be applied on the other side of the die-cutting machine, on the conveyor belt. An additional roller will be built into the conveyor belt assembly in which it will sit on top on the plastic sheet, which will not inhibit the forward, linear motion, but will restrict up-and-down motion, thus applying the second required downward force upon the plastic sheet. This additional roller is not shown in Figure 5.1.3, but will be modeled in the final assembly.

Future analyses to be performed are the driving forces of each motor to determine if our selected motors will be able to provide the torque needed for their respective applications and the upward forces applied on the rollers when the male dies retract upwards after each punch.

5.2.0 Thermoformer Cabinet*

The thermoformer cabinet will contain five major subsystems: beam support, panel enclosure, front door, side door, and ventilation assemblies. This cabinet serves one main function: to prevent heat and plastic fumes from escaping into the surrounding workspace. The beam supports (sourced from 8020) are designed to hold the wooden panels cut to the geometry of the actual thermoformer, ensuring an enclosure with minimized leakage. An acrylic front door seals the thermoformer just over the control panel, allowing the user to load and interact with the thermoformer in the same fashion as previously. The side sliding door functions as a removal access point, allowing the user to slice and remove the plastic after the molding process. A circular cutout on the top of the thermoformer enclosure will connect to a ventilation assembly, which will utilize an exhaust in-line duct fan to remove plastic fumes immediately after the forming stage. Note the duct fan was sourced to specifically handle higher temperature gases, as many duct fans typically advise lower than 120 F gases.

*Indicates part of the design that has been modified or is no longer within the project scope

Figure 10. Thermoformer Cabinet CAD
Originally, the beam support structure was to be manufactured out of wood. Due to the advice given by our advisor, the beam support structure will now be manufactured from 8020 materials. This will assist in part maintenance, as a majority of the beam structure and hinge components are readily available from 8020, and easy for our sponsor to access. Additionally, it will reduce the risk of tolerance failure and/or leakage due to inconsistency in wooden materials.

Our greatest concern with the thermoformer is it will contain too much heat, and warp or damage either the thermoformer or thermoformer cabinet materials. We hope to perform some heat transfer analysis as part of our next steps in design verification.

5.3.0 Design Changes following CDR
Due to recent time and accessibility constraints, the automation aspect of the die-cutting machine has been completely eliminated from the design and overall scope of the project. As a result of this decision, the plastic
sheet indexing assembly and the exiting roller assembly will not be built. Instead the focus of the design will be on increasing the safety of the die-cutting process. This will be achieved through the design and construction of an acrylic box which will be secured around the die-cutting machine in order to prevent operator injury.

The cabinet design for the thermoformer enclosure has been reduced to the installation of insulation panels surrounding the upper-exposed portion of the thermoforming machine. This design change significantly reduces the cost and manufacturing time of the project while still achieving initial goals for heat loss reduction and increased thermoformer module yield.

Additionally, a few other minor design changes have been finalized. The U-Shape assembly (Figure 12) will feature a clevis attachment between the horizontal bar and the cylinder rod in order to relieve stress on the assembly. Linear bearings will be incorporated in the plate assembly at the hole locations for the guide rails and the two rods from the U-shape assembly.

![Figure 12. Updated U-Shape Air Cylinder Attachment Design](image)

The female dies and perforators (Figure 13) will rest on top of the plate, while the male dies and perforator pins will be inserted into the top plate with both being secured in place with snap rings around the shaft at the location of a machined groove. Collection tubes attached to the end of the female dies underneath the bottom plate will remove and organize the punched eye caps. The oval dies and perforator pins will feature press-fit dowel pins, which will slide into a corresponding notch on the top and bottom plates in order to properly align the male and female parts and restrict their rotational movement.
Note the wooden panel in the final die cutting assembly CAD (Figure 14). This serves as the interface between the old system and new system. The wooden plate will bolt into the spring system that already exists on the old system, and the new system will connect with two running rails that interface between the wooden panel and bottom plate.

Refer to Appendix D for updated drawings that reflect the changes made after the CDR. These drawings are the final iteration sent to the machinist.

6.0 Manufacturing Plan

6.1.0 Thermoformer Insulation Manufacturing Plan

**Step 1 – Preparation of Back-Top-Front Panel Insulation**
Prepare the thermoformer insulation roll for cutting. Using an exacto-knife, cut 125” off of the roll to create the base layer of the back-top-front insulation panel. 35” from the bottom of the cut panel, cut two 9x10”
squares for the top fans. Recommended to use a sharpie to outline the cut with respect to the thermoformer fan system. Once the fan cuts have been made, fit the panel on top of the fans, and let it fall naturally elsewhere as seen in the figure below:

![Figure 15. Back-Top-Front Insulation Panel](image)

Secure the panel to the back and top using the ventilation tape. Above the thermoformer control panel, attach the stick-on Velcro strip horizontally across the front length for the connection of the front panel door. On the thermoformer insulation, attach the partner Velcro strip and secure the panel to above the control panel.

**Step 2 – Preparation of Wooden Vertical Supports**
Prepare two wooden blocks of 2”x3”x16”. These will support the thermoformer insulation to equalize the height on the top plane. Tape the wooden blocks at the top of the thermoformer rails, aligning the front plane of the wooden block with the front plane of the thermoformer.

**Step 3– Attachment of Right-Side Panel**
Cut a 35”x25” insulation panel. Using the ventilation tape, attach to the fan support bar. On the base of the thermoformer attach stick-on Velcro and connect the partner Velcro to the right-side panel. Add additional insulation to the right of this panel to cover any additional holes.
Step 4 – Attachment of Left-Side Flap
To account for the vertical movement of the plastic roll during the thermoforming process, only a flap will be added to the left-side. Cut a 25”x15” insulation panel and use the ventilation tape to secure it to the top insulation panel.
6.2.0 Die Cutting Machine Manufacturing Plan

**Step 1 – Installing new air hoses**

0.75” Air hose at 2 feet long from compressor hard line to regulator. Clamp air hoses with hose clamp, regulator has a quick disconnect connection.

0.75” air hose at 3 feet long from regulator to solenoid, from the regulator QD to another hose clamp before the solenoid.

Install solenoid directly to the rod end of the air cylinder using a 0.75” NPT fitting.

**NOTE:** Install another line with a T fitting off of the Regulator to Cylinder line to connect to another solenoid on the cap end of the cylinder.

**Step 2 – Manufacturing and Assembly of U-Shape Attachment for Cylinder**

Machine 0.75” thick x 2” wide x 7” long 2024 aluminum bar.

Drill two ½-13 UNC through holes through the aluminum bar spaced 5” apart (distance of 1” from each end of the aluminum bar) and two ¼-20 UNC through holes spaced 2.25” apart with respect to the center point.

Insert 12” long threaded 6061 aluminum rods (threaded on ends) into holes and secure with a 0.5” nut and washer on both sides of plate.

Machine 0.625” thick stock into 3.5” by 2” plate. Drill 0.625” hole through center of plate and two ¼-20 UNC 1” deep holes spaced 2.25” apart on the top surface of the plate with respect to the center point.

Assemble the bar and plate together with the appropriate fasteners.

Attach clevis to cylinder, then attach the clevis/cylinder assembly to the clevis attachment plate with the provided pin.

Machine 1.25” thick aluminum stock into bracket shape, as shown by the drawing specification for the top cylinder mounting block. On the top surface of each prong, machine a 1” deep 3/8 -16 hole located at the center point of the area. On the top surface of the T-area, machine a ½ inch thru clearance hole.

For the cylinder mounting block, machine a 0.75” thick aluminum stock to be 3.13” by 2.44”. Drill a ½ inch thru clearance hole and two 5/16 inch thru clearance holes in areas indicated.

Attach the cylinder mounting block to the cylinder with four 5/16-24 screws. Attach the top cylinder mounting block to the bottom cylinder mounting block with a ½ inch bolt and nut.

**Step 3 – Manufacturing the Bottom Platform of Die Cutting Machine**

Machine 6.5” by 6” stock aluminum plate for overall dimensions of 1” thick x 6” wide x 6.5” long aluminum extrusion on a mill.

Drill 4-.749” diameter holes on the edges of the part through for the guide rails to be press fit in place.

Drill 2-.547” diameter holes through the part along the edges for the air cylinder rods.

Drill 3-.753” diameter holes through the part in the middle for the perforating pins.

Drill 3-.113” diameter holes through the part in the specified locations for the dies.

Tap & Thread 4-3/8”-16 threaded holes on each lateral side of the part for the running rails to attach to.

Extrude Cut 6-.065”x.124” notches on the edge of each hole for the dowel pin to nest in.

Press fit 4-.75” diameter aluminum bars in the 4.75” diameter .75” depth holes to act as guide rails.

**Step 4 – Manufacturing Top Platform of Die Cutting Machine**

Machine 6” by 6” stock aluminum bar for overall dimensions of 1” thick x 6” wide x 6” long aluminum extrusion on a mill.

Drill 4-.75” diameter holes on the edges of the part through with linear bushings added for guide rails.
Drill 2-.547” diameter holes through the part along the edges for the air cylinder rods.
Drill 3-.753” diameter holes through the part in the middle for the perforating pins.
Drill 3-1.113” diameter holes through the part in the specified locations for the dies.
Extrude Cut 6-.065”x.124” notches on the edge of each hole for the dowel pin to nest in.

Step 5 – Manufacturing Cylinder Mounts, Assembly of Cylinder Mounts to Table
Machine aluminum billet on mill according to technical drawing for both the top and bottom cylinder mounting blocks. Bolt bottom cylinder mounting block to top block; bolt bottom cylinder mounting block to the mounting holes at the top of the cylinder.

Step 6 – Assembly of Die Cutting Machine
Cut two blocks of 1.5” thick wood, join them with two steel bars and two wood screws on each side section of the wooden panel. Ensure the steel to wood mounting does not interfere with the vertical connections between the running rail and wooden panel. The gap between the two panels is outlined in the drawing. Once assembled, drill four 7/16” holes to bolt the wooden panels into the spring system already on the old system. Machine the running rails from aluminum stock according to the drawing specification. Drill the required holes according to the drawing specification. Attach the running rails to the bottom plate with the appropriate fasteners.
Mark the areas in the wooden spring plate that will be drilled in order to attach the running rail/bottom plate assembly, then drill the appropriate-sized holes.
Attach the running rails to the spring plate with the appropriate fasteners.
Press fit guide rails (pre-purchased) into Bottom.
Slide U-attachment rods through holes of bottom from underneath. Attach the mounting block/cylinder assembly to the bottom plate with the appropriate fasteners. Put nut and washer on at lower end of the top threaded portion of the U-attachment rods. Slide top plate on. Place nut and washer above plate on top side of the U-attachment.

Step 8 – Manufacturing of Dies/Pins
Machine steel bar stock to specified dimensions on technical drawing.

Step 9 – Assembly of Pins and Dies
Top plate: slide dies in and secure with pin. Slide pins in and bolt pins down.
Bottom plate: Slide dies in. Slide securing plates in and bolt down. Slide pins in and bolt down.

6.3.0 Plastic Sheet Feeder Manufacturing Plan*

Step 1 – Manufacturing Eye Cap Negatives and Indexing Wall
3-D print 20 three-rowed eye caps negatives and one indexing wall.

Step 2 – Assemble Belt
Cut rubber conveyor belt piece to length and attach ends using elastomer adhesive. Attach and align eye cap negatives and indexing wall to rubber conveyor belt with elastomer adhesive.

*Indicates part of the design that has been modified or is no longer within the project scope
Step 3 – Manufacturing 8020 T-Slots
Drill two Ø¼” thru holes in each of the two 6” long 8020 t-slot pieces as specified on drawing sheet. Drill two Ø½” countersunk holes concentric to the Ø¼” thru holes.

Step 4 – Assemble Rollers and Ball Bearings
Insert three conveyor roller axles into ball bearings. On the fourth axle, connect 3” - Ø¼” shaft with a set-screw shaft coupler. Insert shaft extension through the fourth ball bearing. Couple the 3” shaft extension and the motor shaft with a ¼” set-screw shaft coupler. Slide conveyor belt over the two rollers and adjust placement to the center of the two rollers.

Step 5 – Mount Motor, 8020 T-Slots, and Ball Bearings
Mount driving motor to table with two routing clamps and 4-40 screws. Drill 4 4-40 holes in conveyor table. Mount 8020 t-slots to table and screw in 1-1/2” 4-40 screws to secure. Mount two rear ball bearings to conveyor table with ¼” 4-40 bolts.

Step 6 – 8020 Sub-Assembly
Slide t-nuts through t-slots, place 8020 external connection plates directly over the t-nuts and secure with 8020 screws. Place ball bearings on the opposite end of the 8020 external connection plates and insert 1” 4-40 bolts through ball bearings and external connection plates. Place size 8 washers through the bolts on the underside of the external connection plates, then secure with 4-40 nuts.

Step 7 – Final Assembly
Bolt down two rear ball bearings. Adjust the locations of the front two ball bearings using the adjustable 8020 sub-assembly to properly tension the conveyor belt. Wire and program the driving motor.

7.0 Design Verification
*For the thermoformer cabinet assembly, the main specifications to be tested are security of fasteners, ability to trap and evacuate the heat/fumes generated during the heating process, and easy accessibility for the user. To do so, we are planning on ordering a small batch of components to build small sections of the frame. Specifically, we are to verify that the t-nut fasteners can be secured vertically without any additional drilling through the vertical beam supports. With the presence of COVID, we are unable to run actual heat transfer experiments, but we are planning on running a simplified heat transfer model to identify worst case scenario issues with our cabinet. To investigate accessibility, we are hoping to build the sliding door portion of the thermoformer cabinet, allowing us to hands-on experiment with the friction and usability of the design. This will require us to purchase some McMaster hinge and bracket components along with our wooden panel.

Further testing is to be performed on the frictional forces of the male die on the plastic sheet. Our design calls for two rollers on either side of the die-cutting machine, surrounding the inlet and outlet, which will hold down the plastic sheet to disconnect it from the male die after each punch. We plan to do a load analysis on the two rollers. Since it is not possible to do this analysis in-person, the analysis will be done using FEA software within SolidWorks. However, for the first few and last few rows of the eye cap sheet, the sheet will only be in contact with one of the two rollers. We are unsure whether this will be enough to remove the eye
cap sheet from the male dies and are planning to perform tests with A.C. Moyer’s current die-cutting set-up, with various forces applied on one side of the eye-cap sheet at various punching forces.*

7.1 Punch Force Functionality Test

Test Assignee – Team Respect Women
Location – AC Moyer Workspace
Equipment – Die Cutting Setup, Plastic Mold Strips, Camera, Ruler
PPE – Safety Glasses, Gloves
Safety Procedures – No loose jewelry/clothing/hair

Set Up
1. Set up camera. Should be mounted securely, facing the side view of the die cutting machinery.
2. Gather plastic mold strips.
3. Mount ruler vertically.

Procedure
1. Turn on compressor. Adjust regulator to 120 psi.
2. Turn on camera. Record and hold notecard up with current pressure.
3. Insert plastic eye cap sheet.
5. Repeat 5x per pressure.
6. Turn off video.
7. Repeat by reducing pressure by 5 psi until 100 psi.
8. Turn off compressor and remove ruler.
9. Study each sample and record findings.

Planned Analysis
1. Investigate minimum pressure to cut through eye cap sheet.
2. Investigate quality of cut as a function of pressure (refer to Qualification Table)

Table 5. Punch Force Qualification Table

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not fully punched through. Stuck on die.</td>
</tr>
<tr>
<td>2</td>
<td>Burred edges, obvious shape deformation.</td>
</tr>
<tr>
<td>3</td>
<td>Minimal deformation. Clean edges.</td>
</tr>
</tbody>
</table>

*Indicates part of the design that has been modified or is no longer within the project scope
7.2 Fit Check Test

Test Assignee – Team Respect Women
Location – AC Moyer Workspace
Equipment – Manufactured die sets: 9 circular dies and 3 oval dies
PPE – Safety Glasses, Gloves
Safety Procedures – No loose jewelry/clothing/hair

Set Up
1. Prepare the dies and plates for assembly.

Procedure
1. Perform male and female die check prior to assembly.
   a. Insert each male die size into each potential female.
2. Assemble and check that the air cylinder to mounting block connection is secure.
3. Assemble and check the hexagonal fit between dies and bottom plate.
4. Rods on U-Shape assembly correctly align into holes of bottom plate.
5. Assemble and check the hexagonal fit between dies and top plate.
6. Rods correctly align and fit with top plate.
7. Manually lower top plate to check die alignment between top and bottom plates.
8. Actuate system with foot pedal for final fit check.
9. Document total findings and assess design functionality.

Planned Analysis
1. Tolerance stack prior to fit check to identify expected alignment and position scenarios.
2. Investigate the overall system alignment.

8.0 Project Management

8.1 Planned purchases
Please refer to the indented bill of materials attached for specific cost breakdown of each part of the project. Several purchases will be made throughout the duration of this project in order to reach the goals set for improving the eye cap manufacturing processes. First, a 3-way toggle switch will be installed in the garage to allow all of the power supply to be fed to either the thermoforming machine or the die cut machine to maximize the amount of power used in either process.
*With regards to the thermoforming box, a variety of 8020 products, wooden planks, and ventilation products must be purchased. These materials will be put together with a hand drill. Prior to buying all of the necessary components, we are aiming on buying a portion of 8020 products to ensure the products will behave as we have imagined for our design. Furthermore, we plan on manufacturing additional dies (both oval and circular) and perforation pin sets in order to allow for the three-die setup on the die cut machine.
For the die cutting machine, we will need to purchase raw material for prototypes, which will be made of PLA if we 3D print the parts or sheet metal, and for the final product, where metal stock will be used. Additional components for the die cutting assembly include rods, nuts, and washers. Purchases will also be made for the actuation components of the die cut machine; we are using a new air cylinder, solenoids, and diverting valve. In addition, various components will need to be purchased for the sheet movement mechanism, such as a belt drive system (including a motor).

8.2 Construction and Testing Plans
Due to the current situation regarding COVID-19, we anticipate delays in the manufacturing process. We plan to begin construction at the beginning of fall quarter, with the goal of having all parts machined by November. Additional parts will be sourced and ordered in waves, with the primary sources being McMaster and Home Depot. Note that any of these plans are subject to change, depending on how the situation develops over time.

8.3 Deliverables & Project Timeline

Table 6. Deliverables of Project Dates

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Date</th>
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<tr>
<td>Scope of Work</td>
<td>2/3/20</td>
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<tr>
<td>Preliminary Design Review (PDR)</td>
<td>3/2/20</td>
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<tr>
<td>Interim Design Review</td>
<td>4/9/20</td>
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<tr>
<td>Critical Design Review (CDR)</td>
<td>5/19/20</td>
</tr>
<tr>
<td>Manufacturing Test &amp; Review</td>
<td>6/4/20</td>
</tr>
<tr>
<td>Confirmation Prototype Review</td>
<td>10/20/20</td>
</tr>
<tr>
<td>Final Design Review (FDR)</td>
<td>11/26/20</td>
</tr>
<tr>
<td>Senior Project Exposition</td>
<td>11/27/20</td>
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9.0 Conclusion

This final design review documents our design process, decisions made towards completing the project, and the final design manufacture, assembly, and functionality. The first part of the report reviews the project background and objectives; an additional section was added to review design concepts. After obtaining sponsor agreement, we determined the critical functions of each manufacturing process that we wanted to focus on in our designs. We then utilized various methods throughout the brainstorming process, including a Pugh matrix and weighted decision matrix, to analyze each of the ideas we conceptualized for each function. The final designs are then outlined with details of the various components of each design. Additionally, we have outlined the manufacturing and assembly processes undergone as well as the functionality test procedures and their corresponding results. Engineering analyses for each manufacturing process and engineering drawings are provided as well.
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### Appendix A: Quality Function Deployment, House of Quality

**Customer Requirements (Whats):**

<table>
<thead>
<tr>
<th>Customer Requirements</th>
<th>Engineering Requirements (HOWS)</th>
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<td>Minimal punch force to floor</td>
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<td>Automated</td>
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<td>Low Noise Level</td>
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<td>Oval Die (S.M.L.)</td>
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</table>
Appendix B: Initial Ideation

B.1 Summary of Brainstormed Ideas

Figure 1. Initial thermoform box sketch.

Figure 2. Thermoform box with mounted roller, ducts for fumes, and cutting station.

Figure 3. Various die layout concepts.

Figure 4. Sheet movement - rotational cam idea.
Figure 5. Cutting mechanism for die cutting machine to reduce scrap volume.

Figure 6. Sheet movement - Vertical pins with roller idea.

Figure 7. Sheet movement – gear on roller chain and linear railing idea.
### B.2 Pugh Matrices

**Sheet Movement**

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<th></th>
<th>1</th>
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<tbody>
<tr>
<td><strong>Adjustable movement distance</strong></td>
<td>D</td>
<td>S</td>
<td>+</td>
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<tr>
<td><strong>Movable from both sides</strong></td>
<td>A</td>
<td>S</td>
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<tr>
<td><strong>Automated</strong></td>
<td>T</td>
<td>S</td>
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<td>S</td>
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<tr>
<td><strong>Vertical movement</strong></td>
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<td>S</td>
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<td><strong>Sum (+)</strong></td>
<td>M</td>
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<td><strong>Sum (-)</strong></td>
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<td><strong>Sum (S)</strong></td>
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</table>

**Concept**

1: Cam rotation with roller

2: Cam rotation with stop wall cut

3: Rising pin system with roller
4: Rotational gear, linear vertical rail

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<tr>
<td>Multiple punches at once</td>
<td>D</td>
<td>+</td>
<td>S</td>
<td>+</td>
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<tr>
<td>Low cost (more dies = mo’ money)</td>
<td>A</td>
<td>-</td>
<td>S</td>
<td>-</td>
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<tr>
<td>Accommodates for sizes of dies</td>
<td>T</td>
<td>S</td>
<td>S</td>
<td>-</td>
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<tr>
<td>Limits horizontal motion (along x-axis)</td>
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<td>-</td>
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<td>S</td>
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<tr>
<td>SUM (+)</td>
<td>M</td>
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<td>SUM (-)</td>
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<td>SUM (S)</td>
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</tbody>
</table>

Concept

1: Staggered dies

2: Die placed at every other eyecap location (7-8 dies total)

3: Die placed at every six eyecap locations

Concept Drawing

- Staggered: Plate to hold dies (forward view)
  - Dies
  - Plate top view
  - Eyecap location

Drawing

- Every other plate top view
  - Eyecap location
  - Plate location
  - Die locations
4: Die placed at every eyecap location

**Thermoformer Box**

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<td>Vents Air</td>
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<td>Sum (S)</td>
<td>1</td>
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<td></td>
</tr>
</tbody>
</table>

**Concept**

1. Acrylic/Sheet metal box with access front and right side, vents for heating and cooling

2. Wooden box with hinged access
3. No Box
### B.3 Weighted Decision Matrix

**Morphological Matrix**

<table>
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<tr>
<th>Function</th>
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<td><strong>Sheet Movement</strong></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
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<tr>
<td>(S)</td>
<td>Cam rotation with roller for sheet movement. Staggered die placement. Fitted thermoformer box.</td>
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<tr>
<td><strong>Die Layout</strong></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
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<tr>
<td>(D)</td>
<td>Rotational gear with linear vertical rail for sheet movement. Staggered die placement. Fitted thermoformer box.</td>
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<tr>
<td><strong>Thermoformer Box</strong></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>(T)</td>
<td>Cam rotation with roller for sheet movement. Die placed at every other eyecap location (7-8 dies total). No thermoformer box.</td>
<td></td>
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</tr>
</tbody>
</table>

**Option 1: S1+D1+T1**
Cam rotation with roller for sheet movement. Staggered die placement. Fitted thermoformer box.

**Option 2: S3+D1+T1**
Rotational gear with linear vertical rail for sheet movement. Staggered die placement. Fitted thermoformer box.

**Option 3: S1+D2+T3**
Cam rotation with roller for sheet movement. Die placed at every other eyecap location (7-8 dies total). No thermoformer box.

**Option 4: S2+D2+T2**
Rising pin system with roller for sheet movement. Die placed at every other eyecap location (7-8 dies total). Completely enclosed thermoformer box.

**Option 5: S3+D3+T3**
Rotational gear with linear vertical rail for sheet movement. Die placed at every six eyecap locations. No thermoformer box.
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<th>Option 2</th>
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<th>Option 4</th>
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<td>Increased moldability success</td>
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<td>1.</td>
<td>Yes</td>
<td>Will any part of the design create hazardous revolving, reciprocating, running, shearing, punching, pressing, squeezing, drawing, cutting, rolling, mixing or similar action, including pinch points and sheer points?</td>
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<td>Yes</td>
<td>Can any part of the design undergo high accelerations/decelerations?</td>
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<td>3.</td>
<td>Yes</td>
<td>Will the system have any large moving masses or large forces?</td>
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<td>4.</td>
<td>Yes</td>
<td>Will the system produce a projectile?</td>
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<td>5.</td>
<td>Yes</td>
<td>Would it be possible for the system to fall under gravity creating injury?</td>
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<td>6.</td>
<td>Yes</td>
<td>Will a user be exposed to overhanging weights as part of the design?</td>
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<td>7.</td>
<td>Yes</td>
<td>Will the system have any sharp edges?</td>
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<td>8.</td>
<td>Yes</td>
<td>Will any part of the electrical systems not be grounded?</td>
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<td>9.</td>
<td>Yes</td>
<td>Will there be any large batteries or electrical voltage in the system above 40 V?</td>
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<td>10.</td>
<td>Yes</td>
<td>Will there be any stored energy in the system such as batteries, flywheels, hanging weights or pressurized fluids?</td>
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<td>11.</td>
<td>Yes</td>
<td>Will there be any explosive or flammable liquids, gases, or dust fuel as part of the system?</td>
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<td>12. Will the user of the design be required to exert any abnormal effort or physical posture during the use of the design?</td>
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<td>13. Will there be any materials known to be hazardous to humans involved in either the design or the manufacturing of the design?</td>
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<td>14. Can the system generate high levels of noise?</td>
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<td>15. Will the device/system be exposed to extreme environmental conditions such as fog, humidity, cold, high temperatures, etc?</td>
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<td>16. Is it possible for the system to be used in an unsafe manner?</td>
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<td></td>
<td>17. Will there be any other potential hazards not listed above? If yes, please explain on reverse.</td>
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</tbody>
</table>

For any “Y” responses, on the reverse side add:
(1) a complete description of the hazard,
(2) the corrective action(s) you plan to take to protect the user, and
(3) a date by which the planned actions will be completed.
<table>
<thead>
<tr>
<th>Description of Hazard</th>
<th>Planned Corrective Action</th>
<th>Planned Date</th>
<th>Actual Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>The die-cut machine will include punching, perforating, and most likely rolling actions.</td>
<td>The machine will be automated so that there is minimal operator interaction with these hazardous parts/functions. Additional guards will be put in place to prevent accidental injury.</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
</tr>
<tr>
<td>The automated plastic sheet movement can undergo high accelerations/decelerations for quick movement between each cut.</td>
<td>Since the sheet movement is less than 2 inches, the safety hazard is negligible.</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
</tr>
<tr>
<td>The die-cutters and the attached block will create a large force coming down to cut and perforate the eye caps.</td>
<td>Automation will prevent the operator from having to be near the cutter when this action is being performed. Additional guards will be put around this portion of the machine to prevent injury.</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
</tr>
<tr>
<td>There will be sharp edges on the die-cutters.</td>
<td>The sharp edges are necessary for the part; however, the guards and automation of the system will prevent operator interaction with these parts while the machine is running. When die changing/maintenance is necessary, the operator should wear gloves to prevent injury.</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
</tr>
<tr>
<td>Equipment</td>
<td>Hazard Prevention Measures</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>The die-cutter will be powered pneumatically, which could cause hazard because of the pressurized air.</td>
<td>Test to ensure that there are no air leaks.</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
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<td>The pneumatic punch will generate high noise levels.</td>
<td>The operators will use hearing protection, while the machine is in use.</td>
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<td>TBD</td>
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<td>The thermoformer is subjected to high temperatures.</td>
<td>A box around the thermoformer will prevent persons from accidental contact with the hot surfaces.</td>
<td>End of Spring Quarter</td>
<td>TBD</td>
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<tr>
<td>It is possible for the system to be used in an unsafe matter if the operators interfere with the punching action while the machine is running.</td>
<td>The added guards will prevent the operator from interacting with the machine in this way.</td>
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<td>TBD</td>
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Total Parts: 88
Total Cost: $8,351.18
Appendix D: Drawing Packages

D.1 Conveyor Belt Drawing Package

- View: Scale 1:12, Exploded View, Part No.
- Material: Aluminum
- Break Shrap
- Inside Tool: 0.010
- Tolerances: 0.010

Notes:
- Unless otherwise specified, all dimensions in inches unless otherwise indicated.
4. Break sharp edges .01 MAX
3. Inside tool radius .02 MAX
2. Tolerances
1. All dimensions in inches

NOTES:
5. 8020 Aluminum Part No. 1050
4. Break Sharp Edges 0.1 Max
3. Inside Tool Radius 0.2 Max
2. TOLERANCES
1. All Dimensions in Inches

NOTES:

UNLESS OTHERWISE SPECIFIED:

2X Ø 1.25

2X 0.50

1.00

0.77

6.00

4X R 1.25
5. 8020 ALUMINUM PART NO. 4107
4. BREAK SHARP EDGES 0.1 MAX
3. INSIDE TOOL RADIUS 0.02 MAX
   X.XXX = ±0.05
   X.XX = ±0.1
2. TOLERANCES
1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED.
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<td>3. INSIDE TOOL RADIUS 0.2 MAX</td>
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<tr>
<td>X.XXX = ±0.005</td>
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<td>X.XX = ±0.01</td>
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**NOTES:**
5. 8020 ALUMINUM

4. BREAK SHARP EDGES .01 MAX

3. INSIDE TOOL RADIUS .02 MAX

X X X = ± .005

X X X = ± .01

2. TOLERANCES

1. ALL DIMENSIONS IN INCHES

UNLESS OTHERWISE SPECIFIED

NOTES:

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

DATE: 05-15-2020

SCALE: 2:1

DRAWN BY: HANA WELSH

CHECK BY: ME STAFF

DRAWN BY: HANA WELSH

SCALE: 2:1

DATE: 05-15-2020

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400

NOTE: 8020-1-NUT

ASSIGNMENT: 0

Job Section: 0

ng 0:19400
Washer number 94051A206

Washer may vary from 0.03" to 0.045" in thickness.

Screw size for #4
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NOTES:
1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED.
2. TOLERANCES
3. INSIDE TOOL RADUIS 0.2 MAX
4. BREAK SHAPE EDGES 0.1 MAX

DRAWN BY: HANNA WEISH
DATE: 05-15-2020
SCALE: 1:4
EDD: 019000
DATE: 09-20
PACKAGE DRAWING

D.2 Roller Assembly Drawing Package

CINDY M. WEAVER

ME 429 - SPRING 2020
CED Poly Mechanical Engineering

D.2 Roller Assembly
1. ALL DIMENSIONS IN INCHES
   UNLESS OTHERWISE SPECIFIED.

2. TOLERANCES

3. INSIDE TOOL RADIUS .02 MAX
   X.XXX=+.005
   X.XXX=-.010

4. BREAK SHARP EDGES .01 MAX

NOTES:
## Pneumatic Assembly Drawing Package

### NOTES:

**UNLESS OTHERWISE SPECIFIED:**

1. **DIMENSIONS IN INCHES**
2. **TOLERANCES**
   - \( X.XX = \pm 0.005 \)
   - \( X.X = \pm 0.01 \)
3. **ANGLES:**
   - \( 90 \pm 1 \)°
4. **TOOLING:**
   - **INSIDE TOOL RADUS:** 0.2 MAX
   - **INSIDE TOOL RADUS:** 0.1 MAX
5. **POSITIONAL TOLERANCES APPLY:**

### UNLESS OTHERWISE SPECIFIED:

- **ITEM NO.**
- **PART NO.**

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<td>AIR CYLINDER</td>
<td></td>
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<tr>
<td>1</td>
<td>CLEVIS PIN</td>
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<td>038360</td>
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<tr>
<td>1</td>
<td>CLEVIS ATTACHMENT PLATE</td>
<td>038362</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>U-SHAPE ASSEMBLY BAR</td>
<td>038370</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>U-SHAPE ATTACHMENT RODS</td>
<td>038310</td>
<td></td>
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**Cal Poly Mechanical Engineering**

**ME 430 - FALL 2020**

**Dwg. No.:**

**Title:** U-SHAPE ASSEMBLY

**Scale:** ME 430 - FALL 2020

**Cal Poly Mechanical Engineering**
<table>
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<tr>
<th>ITEM NO.</th>
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<th>DESCRIPTION</th>
<th>QTY.</th>
</tr>
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<tr>
<td>1</td>
<td>028380</td>
<td>ALUMINUM BAR</td>
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<tr>
<td>2</td>
<td>028310</td>
<td>U-SHAPE ATTACHMENT RODS</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.5 IN WASHER</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>028330</td>
<td>0.3 IN HEX NUT</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTES:
1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED.
2. TOLERANCES X +.01 X -.005.
3. INSIDE TOOL RADIUS .02 MAX.
4. BREAK SHARP EDGES .01 MAX.

CDR Design
Information in this drawing is provided for reference only.

http://www.mcmaster.com

Thread Length:
- 1 1/4"
- 1 1/4"
- 1 3/8"
- 1 3/8"
- 1 1/16"
- 5/8"

Part Dimensions:
- 1
- 1 1/2"
- 2 3/4"
- 3/4"-10 Thread
- 13/16" 11/16" 3/4"
- 4"
- 1 1/4"
- 11/16"
- 5/8" 1 1/4"

Thread:
- 3/4"-10 Thread

Material:
- Steel

Part Number:
- 6071K34
Information in this drawing is provided for reference only.
http://www.mcmaster.com
3/4" 7/16"
1/2"-13 Thread
98797A523
Hex Nut
© 2015 McMaster-Carr Supply Company
Thread length may vary from 1.34" to 2.14" in length.
Socket Head Cap Screw
Zinc-Plated Alloy Steel

PART NUMBER 90128A753

MCMILLAN-CARR

© 2014 McMaster-Carr Supply Company

http://www.mcmaster.com

Thread

5/16"-24 Thread

0.3125"

1 1/4"

5/16" Hex

1 3/32"

1 1/4" Hex

1 3/32"
Alloy Steel Socket Head Cap Screw

Ultra Corrosion-Resistant Coated

PART NUMBER 91274A316

© 2014 McMaster-Carr Supply Company

http://www.mcmaster.com

0.375
1/2
3/8

3/8-16 Thread

Hex 5/16
9/16
1. All dimensions in inches unless otherwise specified.

Notes:

4. Break sharp edges 0.1 max

3. Inside tool radius 0.2 max

2. Tolerances

X XXX= 0.005
X XX = 0.1
X X = 0.15
X = 0.1

1.18

33.50

88.0

2.76

2.00

3.3

4X Ø 3.1
1. TOLERANCES
   2. ALL DIMENSIONS IN INCHES
   3. INSIDE TOOL RADIUS: 0.02 MAX
   4. BREAK SHARP EDGES: 0.01 MAX

NOTES:
ITEM NO. | PART NUMBER | DESCRIPTION
--- | --- | ---
4 | 111400-5 | SCREWS CORNER
2 | 111400 | CORNER
1 | 111300 | BEAM TOP HORIZ
2 | 111100 | BEAMS 60" VERT

NOTES:
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES
ANGLES = ±1°
X.XXX = ±.005
X.XX = ±.01

UNLESS OTHERWISE SPECIFIED

15°
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
<th>NOTE</th>
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<tr>
<td>1</td>
<td>Acrylic Panel</td>
<td>113100</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Vertical Frame</td>
<td>111100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hinge</td>
<td>113200</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Screw</td>
<td>111320</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Nut</td>
<td>113290</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. All dimensions in inches.

2. Tolerances:

   - X.XXX = ±0.05
   - X.XXX = ±0.1

3. Angles = ±1°
4. Break sharp edges 0.1 MAX
3. Inside Tool Radius 0.02 MAX

ANGLES = ±1°
X*XXX = ±0.005
X*XX = ±0.01

1. All dimensions in inches
Unless otherwise specified:

NOTES:
4. BREAK SHARP EDGES, .01 MAX.
3. INSIDE TOOL RADIUS, .02 MAX.
 ANGLES = ±.01
X.XXX = ±.005
X.XX = ±.01
X.X = ±.01
2. TOLERANCES
1. ALL DIMENSIONS IN INCHES
UNLESS OTHERWISE SPECIFIED.
NOTES:
1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

NOTES:

2. TOLERANCES
3. INSIDE TOOL RADIUS 0.2 MAX
4. BREAK SHARP EDGES 0.1 MAX

ANCHRS 1.0
X.XX = 0.05
X.XX = 0.1

SOLIDWORKS Educational Product For Instructional Use Only
NOTES:

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS IN INCHES.

2. TOLERANCES:

   1. ANGLES = ± 1°

   2. X.XXX = ± .005

   3. X.XX = ± .01

   4. X.X = ± .05

   5. X.X = ± .1

   6. X.X = ± .2

   7. X.X = ± .5

   8. X.X = ± 1

   9. X.X = ± 2

   10. X.X = ± 5

   11. X.X = ± 10

   12. X.X = ± 20

   13. X.X = ± 100

   14. X.X = ± 1000

   15. X.X = ± 10000

   16. X.X = ± 100000

   17. X.X = ± 1000000

   18. X.X = ± 10000000

   19. X.X = ± 100000000

   20. X.X = ± 1000000000

   21. X.X = ± 10000000000

   22. X.X = ± 100000000000

   23. X.X = ± 1000000000000

   24. X.X = ± 10000000000000

   25. X.X = ± 100000000000000

   26. X.X = ± 1000000000000000

   27. X.X = ± 10000000000000000

   28. X.X = ± 100000000000000000

   29. X.X = ± 1000000000000000000

   30. X.X = ± 10000000000000000000

   31. X.X = ± 100000000000000000000

   32. X.X = ± 1000000000000000000000

   33. X.X = ± 10000000000000000000000

   34. X.X = ± 100000000000000000000000

   35. X.X = ± 1000000000000000000000000

   36. X.X = ± 10000000000000000000000000

   37. X.X = ± 100000000000000000000000000

   38. X.X = ± 1000000000000000000000000000

   39. X.X = ± 10000000000000000000000000000

   40. X.X = ± 100000000000000000000000000000

   41. X.X = ± 1000000000000000000000000000000

   42. X.X = ± 10000000000000000000000000000000

   43. X.X = ± 100000000000000000000000000000000

   44. X.X = ± 1000000000000000000000000000000000

   45. X.X = ± 10000000000000000000000000000000000

   46. X.X = ± 100000000000000000000000000000000000

   47. X.X = ± 1000000000000000000000000000000000000

   48. X.X = ± 10000000000000000000000000000000000000

   49. X.X = ± 100000000000000000000000000000000000000

   50. X.X = ± 1000000000000000000000000000000000000000

   51. X.X = ± 10000000000000000000000000000000000000000

   52. X.X = ± 100000000000000000000000000000000000000000

   53. X.X = ± 1000000000000000000000000000000000000000000

   54. X.X = ± 10000000000000000000000000000000000000000000

   55. X.X = ± 100000000000000000000000000000000000000000000

   56. X.X = ± 1000000000000000000000000000000000000000000000

   57. X.X = ± 10000000000000000000000000000000000000000000000

   58. X.X = ± 100000000000000000000000000000000000000000000000
<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>FRONT PANEL</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>TOP PANEL</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>BACK PANEL</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>RIGHT SIDE PANEL</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>LEFT SIDE PANEL</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>CAL POLY Mechanical Engineering</td>
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</tr>
</tbody>
</table>

**Part Numbers**

- FRONT PANEL: 113100
- TOP PANEL: 112100
- BACK PANEL: 112200
- RIGHT SIDE PANEL: 112300
- LEFT SIDE PANEL: 112220
- TOP PANEL: 112100

**Notes**

- SOLIDWORKS Educational Product. For Instructional Use Only.
5/16-18 Tall Self-Aligning Roll-in T-Nut with Spring Leaf

A  1.500"
B  .365"
C  .770"
D  45°
E  .265"
F  .195"
G  .700"
H  .600"
J  .300"
15 Series Standard Sliding Door Glide Profile

A  1.500"
B  .365"
C  .770"
D  45°
E  .265"
F  .195"
G  .700"
H  .600"
J  .300"

© 80/20 Inc., All Rights Reserved
1.50" X .75" Lite T-Slotted Profile - Single Open TSlot

© 80/20 Inc., All Rights Reserved
Hidden Corner Connector: Inside-Inside

A  .827"
B  .750"
C  .236"
D  .307"
E  .621"
F  .323"
G  .228"
H  .638"
J  1.181"
K  5°
L  .228"
M  .313"
N  M6 X 12
5/16-18 Slide-in Economy T-Nut - Offset Thread

A  .984"
B  .281"
C  .638"
D (Thread)  5/16-18
E  .080"
F  .222"

© 80/20 Inc., All Rights Reserved
5/16-18 x .500" Flanged Button Head Socket Cap Screw

A .660"
B 3/16
C .166"
D (Length) .500"
E .060"
F (Thread) 5/16-18

© 80/20 Inc., All Rights Reserved
15 Series & Ready Tube 4 Hole - Aluminum Hinge

- A: 3.000"
- B: .686"
- C: .750"
- D: 3.000"
- E: .328"
- F: 1.500"
- G: 1.500"
- H: .328"
- J: .686"
- K: .250"
- L: .250"
- M: .125"
5/16-18 Hex Nut

A
(16-18)

B 12.50mm

C 6.70mm
D.5 Die Cutter Assembly
1. BREAK SHARP EDGES 0.1 MAX
3. INSIDE TOOL RADIUS 0.2 MAX

ANGLES = 1
X.XXX = 0.05
X.XX = 0.1

2. TOLERANCES
1. ALL DIMENSIONS IN INCHES
UNLESS OTHERWISE SPECIFIED.
NOTES:
NOTES:

1. All dimensions in inches.
2. Tolerances.
3. Inside tool radius 0.02 max.
4. Break sharp edges 0.01 max.
5. Unless specified the following applies:
   A. Angles = ±0.05
   B. ±0.01
   C. ±0.003
   D. ±0.531
   E. ±0.266
   F. ±0.75

UNLESS OTHERWISE SPECIFIED:

Positional Tolerance Applies:

Dwg. #: T.BERTOLUS
Title: U SHAPE ASSY BAR
Scale: ME 430 - Fall 2020
Cal Poly Mechanical Engineering
ADJUST KEY LOCK INSERTS HERE

NOTES:
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES
3. INSIDE TOOL RADIUS 0.02 MAX
4. BREAK SHARP EDGES 0.01 MAX
5. UNLESS SPECIFIED, THE FOLLOWING APPLIES:
   A. ANGLES = 1.0
   B. XXX = 0.05
   C. XXX = 0.1
   D. UNLESS OTHERWISE SPECIFIED:

Title: Clevis Attachment Plate
Scale: ME 430 - Fall 2020
Cal Poly Mechanical Engineering

By: T. BERTOLUS
Dwg. #: 1/4-20 x 1.00
1. All dimensions in inches.
2. Tolerances unless otherwise specified.
3. Inside tool radius 0.02 max. 
   Angle = 45° ± 0.05
   XXXX = 10°
4. Break sharp edges 0.1 max.
5. Unless specified the following positional tolerance applies.
1. ALL DIMENSIONS IN INCHES
UNLESS OTHERWISE SPECIFIED:

2. TOLERANCES

3. INSIDE TOOL RADIUS 0.02 MAX
XX=0.005
XX=0.015

4. BREAK SHARP EDGES 0.1 MAX
ANGLE=15

5. UNLESS SPECIFIED THE FOLLOWING:
POSITIONAL TOLERANCES APPLY:

A,B: HANA WELSH

1.250 0.002
.5 0.004
.056 0.004
.087 0.002
.175 0.010
1.000 0.010
1.100 0.002
1.110 0.002
NOTES:
1. All dimensions in inches, unless otherwise specified.
2. Tolerances
   2.1. All dimensions in inches, unless otherwise specified.
3. Inside tool radius 0.2 max.
   X X X = ± 0.05
   X X X = ± 0.1
4. Break sharp edges 0.01 max.
   ANGLES = ± 1
5. Unless specified, the following positional tolerances applies:
   ±0.01
4. BREAK SHARP EDGES: 0.1 MAX
3. INSIDE TOOL RADIUS: 0.2 MAX
2. TOLERANCES
1. ALL DIMENSIONS IN INCHES
UNLESS OTHERWISE SPECIFIED.

NOTES:

SECTION A-A
Appendix F: Operation Manual

A.C. Moyer Company

Written and developed by Senior Project Team 42 – Respect Women
Eyecap Manufacturing Process

Step 1: Mount the plastic roll on the thermoformer.
Step 2: Load a sheet of plastic into the thermoformer frame.

Step 3: Run the heating cycle program on the thermoformer.
Step 4: Remove and cut off newly thermoformed eyecap sheet (15x20 eyecaps).
Step 5: Slice the eyecap sheets into rows of 3.
Step 6: Insert an eyecap sheet into the die cutter.
Step 7: Feed the sheet from right to left, using the foot pedal to trigger the air cylinder motion to cut the eyecaps out of the sheet.

Figure 18. Thermoformer Machine Setup
Die-Changing Process

Step 1: Use snap ring pliers to remove the snap rings from the currently mounted dies (both male and female sides) on the die-cutting machine.
Step 2: Remove the top and bottom dies.
Step 3: Place the desired dies into the top and bottom plates by sliding the hexagonal portion in to align the die orientation.
Step 4: Using snap ring pliers, fix snap rings back into place onto the grooves onto the die, closest to the plate.

Figure 19. Top of die-cutting machine.