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Summary

The goal of this project was to design a motorized peeler from scratch, with both the rotary motion of the object and translational motion of the cutter being motorized by a single motor. The project was broken up into 4 different milestones so that the process can be split into significant stages. First the product design specifications were listed out as well as a concept design to build from. Then a more detailed design was formed incorporating DFM for thermoplastics. From the results of the DFM, the design was reassessed using DFA and redesigned for the final time. Special software was utilized to assess design for manufacturing as well as assembly, along with the use of CAD software. The results and any findings of each milestone was utilized to come up with the most optimal design that benefits in costs, manufacturing and assembly of the product.

Introduction

Designing for manufacturing is an iterative process that involves many stages and redesigns to create the most efficient, cost effective and optimal design. This project incorporates concepts from designing for manufacturing and designing for assembly. Firstly, the goals of the design must be clearly defined so that the scope of the project can be reflected in the initial design. Some of these goals include the functional and performance characteristics the product should achieve, quality and reliability, manufacturing and materials. Before designing it is important to get a reference design which must be improved upon in all ways mentioned for the goals.

The first iteration of the design is to create a conceptual sketch to create a general design of the product and assess the pros and cons of each design depending on how well each concept fulfills the goals. The next stage in the design process is to create a more detailed design and incorporate design for manufacturing for injection molding. When designing the product, the material and manufacturing process of each part needs to be determined. In this project, the plastic parts will be done through plastic injection molding. Other parts such as the blade will need to be created from metal which can be done through CNC machining. Additionally, external parts need to be specified such as gearboxes, fasteners and battery. When using DFMA, it is important to consider the type of manufacturing process in which plastic injection molding is being used. For the plastic injection molding there will be a core and cavity where the heated plastic gets injected under pressure and then cooled. This process is important to DFMA because in injection molding there needs to be design considerations when creating the parts such as avoiding sharp edges, rounded corners, uniform thickness, draft angles, parting line etc. These considerations will allow for a higher quality design and reduce manufacturing failures.

When using DFM and DFA there are many design considerations that need to be addressed which will allow for an optimal design. In DFM, it is focused on the manufacturing process, in this case plastic injection molding. In this process, the first step is to select the manufacturing process using the current knowledge about the process and cost. The next step is to improve the design for better manufacturability. This analysis is done by examining various design features and ensuring that the rules of design are followed. Lastly, the cost must be analyzed through DFMA software to determine if the product can be finalized. In this project some of the design rules for manufacturing include having uniform thickness, draft angles, fillets, ribs, bosses, gussets, ejector pin bosses, venting, holes and shutoffs, snap connection. These considerations allow for a better manufacturing process such as no warping, not enough material flowing to all parts, difficult removal, direction of solidification etc. Another importance of the DFM analysis is also to address the economic concerns. These considerations can optimize the design as well as make a cost efficient design by not wasting material but achieving all design goals. When assessing the cost of the design some important considerations are the process costs, cost per piece, set up cost, material cost and tooling costs.

When using DFA specifically, there are numerous considerations that need to be taken into account for primarily cost reasons. Firstly, the design must have an initial estimate in cost for each part and overall cost. Next, there needs to be an analysis to reduce the cost of each component, reducing the cost of the assembly and the costs of the supporting productions. Furthermore, the DFM consideration needs to be applied here in an iterative process to determine where design improvements can be made. Some design for assembly considerations include reducing the number of parts, the handling of parts (such as the orientation, weight, size and reach distance), the part insertion and direction of fixture and methods of fastening (using fasteners, snap fit etc). After these design considerations are exhaustively considered and implemented, a cost analysis must be carried out to determine the amount of reduction resulting from the DFMA changes.

In the next iterative process of the design, there needs to be additional redesigns which need to address the issue of cost. Using DFA analysis, the minimum number of theoretical parts can be calculated to find essential and non essential parts. The next step is to make DFMA change the non essential parts and use the DFMA - Boothroyd Dewhurst tool to find the overall cost of the new and previous designs. When creating the final design, Solidworks was used to model the components and imported to DMFA software to determine the cost per part.

Some key objectives of this project are to redesign the peeler using an iterative process for DFM and DFA, using software and other tools along the way for assistance. This can be done by focusing on design considerations to optimize the design to meet functional, manufacturing and economical requirements.

Mechanical Design

Product Design Specifications

There were multiple product design specifications that were important for designing the motorized peeler, however 2 of them were the main focus of this project. Manufacturing and material selection was crucial in the design process, as the goal was to create a motorized peeler with DFMA applied to it, as well as material selection impacting the design choices.

In order to achieve manufacturing goals such as large scale manufacturing, the product itself would need to be designed in a way that would be able to support this. Manufacturing of this product can be broken down into several categories, such as component parts production, components costs, assembly time and operations needed. Optimizing these categories can make a substantial difference in overall manufacturing cost and time.

Additionally, material selection was also an important process in the mechanical design stage. The parts will be made through plastic injection molding, which impacts part designs and features since plastic injection molding has its limitations and key guidelines to optimize parts. Material selection is further expanded on in the discussion section.

Concept Iterations

There were multiple iterations that were made before coming up with the final design of the motorized peeler. The first two concepts (as seen in appendix 1) were against the project requirements and were immediately corrected to bring the third and final design. In concept 1, the design was similar to the existing design of the fruit peeler, however the peeler arm was manually operated to peel the fruit instead of automated. Since this was not allowed, the manual peeler arm was replaced with a motorized peeler arm, which generated the second concept.

Concept 2 generated the overall framework for what would become the final design concept, with only minor internal changes occurring from this concept to the final one. In the project requirements, both the rotary and linear peeler motion must be motorized with only a single motor. Concept 2 utilized individual motors for each motion, so the final design concept addressed this by using a singular motor and gearbox to generate the 2 motions.

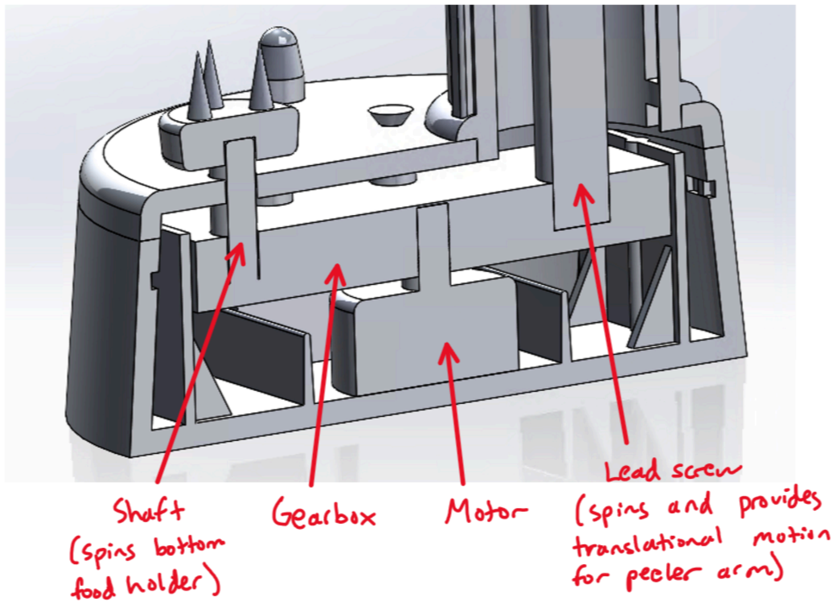


Figure 1. Section View of Motorized Peeler Showing the Internal Components

As seen in the figure above, the singular motor is responsible for spinning the gears inside the gearbox, which in turn spin both the shaft and lead screw at the end to provide rotational motion for the bottom food holder, as well as translational motion from the peeler arm.

Since this project focused heavily on the design for manufacturing and assembly process, functional and outsourced parts were not heavily considered during the CAD process and placeholder parts were created to show how the parts are incorporated into the design. Because of this, in figure 1 the gearbox has no internal gears inside, and the lead screw and other phillips screw is not threaded. Instead, the general outline of the part is used as a placeholder during assembly.

For the first CAD model of the product, the following parts listed in table 1 were utilized to complete the assembly:

Table 1. List of Parts

Part Type	**Part Name**	**Total**
Custom Parts	Base, base lid, power button, bottom food holder, shaft, peeler arm holder, peeler arm, blade holder clip, blade holder arm, blade holder, upper food holder, cap	12
Outscored (Placeholder Parts)	Motor, gearbox, lead screw, philips 10-24 ¾ inch screw, battery,	5

When it came time to create each custom part, milestone 2 focused on designing for manufacturing. This meant proper DFM guidelines must be incorporated for plastic injection molding and thermoplastics. Multiple design decisions were made for each part to make it manufacturing friendly, which will be briefly expanded on below in table 1. Further details can be found in milestone 2.

Table 2. Design Details Used for Custom Parts

Design Detail	**Part(s) Affected**	**Reasoning**
Uniform Thickness	All	● Nominal walls were made to not vary by more than ±10% in order to reduce the change to warpage, sink marks, cracks, and premature manufacturing defects
Draft Angle	Base, base lid, bottom food holder, power button	● Adding draft angles helps with part removal when dealing with large parts ● Recommended having 1 degree of draft for every 1 inch of cavity depth, but the greatest possible draft angle was used when possible
Fillets	All	● Rounding corners is crucial for reducing the overall stress ● Largest possible fillet was applied to each applicable part
Ribs	Base	● Increases rigidity throughout large hollow structures ● Used in the base to provide strength due

		to the large hollow spaces
Bosses	Base, base lid, shaft, upper food holder,	● Extruded bosses made around holes for fasteners offers reinforcement and greater strength
Gussets	Base, base lid, shaft, upper food holder,	● Further reinforces bossed holes and large walls by distributing load over a larger area
Ejector Pin Bosses	Base	● When wall heights are 3 times the thickness of parts, providing an ejection surface helps maintain part integrity ● Due to the complex geometry inside the base, ejector pin bosses were provided to main integrity during mold ejection
Venting	Base	● Venting allows freestanding projections to be connected to the main part to allow for a better flow ● Prevents air from being trapped in the mold during the injection process
Holes and Shutoffs	Blade holder arm, power button	● Through holes were used throughout the design when possible ● Side holes were avoided due to the need for a side action process, greatly increasing the mold cost ● Shutoffs were used instead of side holes to eliminate the need for a side action
Snap Connections	Peeler arm, blade holder clip, blade holder arm, blade holder	● Eliminates the need for dedicated fasteners by utilizing the flexibility and low stiffness of plastic for snap connections

In the next milestone, the mechanical design of the motorized peeler was further optimized by implementing design for assembly. In this stage, parts were modified to reduce assembly time and costs. A major conflict in this stage was the interference between DFA and the previous DFM guidelines. By introducing DFA elements to reduce the assembly time, this impacted certain parts by creating more complex parts and even increasing the assembly cost. In this stage, the key element was finding the right balance between the two and creating a fully optimized design.

By using the Boothroyd-Dewhurst DFMA software, DFA analysis could be achieved in the current design. In this stage the following problems were identified with the existing library of parts, as listed in the table below:

Table 3. DFA Considerations for Current Design

Category	**Part**	**Reasoning**
Category 1	Cap	• Could be combined or incorporated into other parts and features, reducing the number of parts
Category 2	Philips 10-24 ¾ Screw	• Fasteners and Connectors can be incorporated into functional parts through other securing methods
	Blade Holder Clip	
Category 3	Base Lid	• Difficulties associated with the following parts include handling, insertion and alignment • Since it is not always possible to make changes in this category, it is the lowest priority for improving DFA
	Bottom Food Holder	
	Power Button	
	Peeler Arm	
	Blade Holder Arm	
	Blade Holder	
	Upper Food Holder	

The DFA analysis showcased potential areas where parts could be redesigned to reduce both overall cost and assembly time. Taking this into consideration, the following parts were either modified or removed, listed in the table below:

Table 4. Summary of Changes Made to Current Design

Parts to be Redesigned	**Redesigned/ Total Quantity**	**Reasoning**
Base	1/1	● Redesign to allow for snap fit connection with the base lid ● Added slots throughout the walls to serve as connection points between the base lid
Base Lid	1/1	● Added cantilever snap joints around the underside perimeter to snap fit onto the base
Shaft	1/1	● Redesign to allow for interference/force fit between the shaft and base lid
Peeler Arm	1/1	● Incorporate blade holder connection point into the peeler arm, allowing for the blade holder clip to be removed
Parts to be Removed	**Removed/ Total Quantity**	**Reasoning**
Philips 10-24 Screw	6/10	● Can be replaced with integral fastening elements that are already incorporated into parts where possible
Blade Holder Clip	1/1	● Possible to be combined with the peeler arm to eliminate the need for an additional connection part between the peeler arm and blade holder arm

** Not all design considerations were able to be incorporated which is further expanded on in the discussion section.*

From the table above, parts were redesigned and removed which substantially helped lower overall cost and production time. Going back to the product design specifications, this helps with the manufacturing criteria by supporting the possibility to manufacture this product at a large scale. Further iterations of this DFA process could help further optimize the process, however with each iteration the overall time reduced wouldn't make as great of a difference as the first iteration performed. Because of this and time restraints, the DFA iterative process was stopped here and further DFM was not applied to parts. If this process were to keep going though, DFM could be applied to parts to assist with category 3 suggestions, by reducing the handling, insertion and alignment time to further reduce assembly time. However, as stated before changes in this category would not make substantial assembly time changes, and there is a possibility that the additional DFM increases the overall cost of the assembly which would not make the redesign viable.

The finalized design of the motorized peeler was completed at the end of milestone 3. All part drawings and DFMA analysis information can be found in appendices 2-4. Further discussion of the production and manufacturing process, as well as design process will continue in the upcoming section.

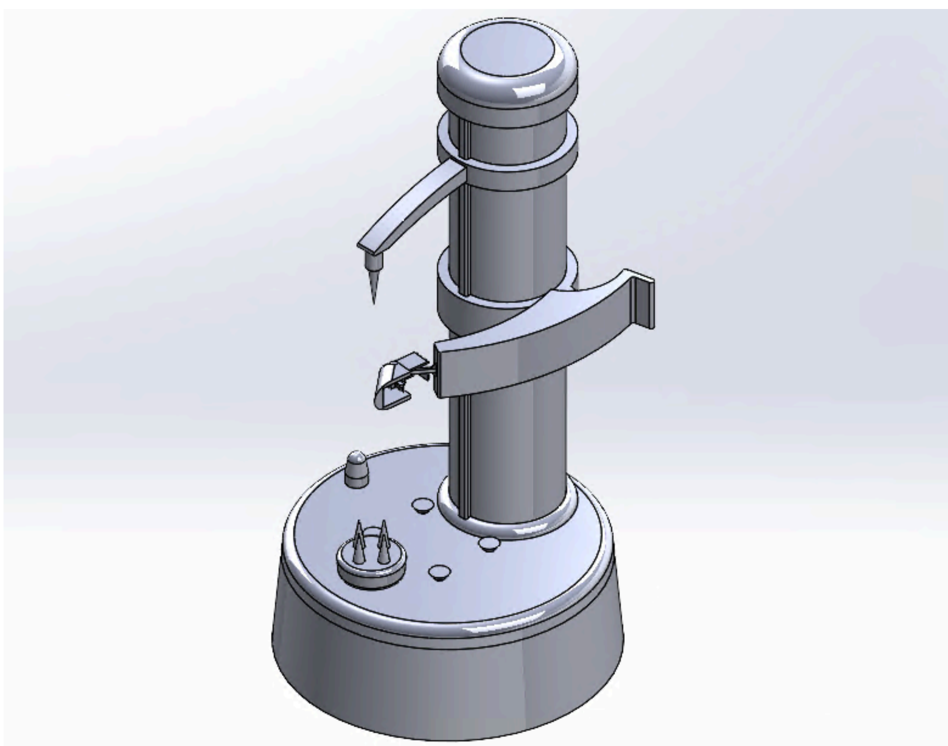
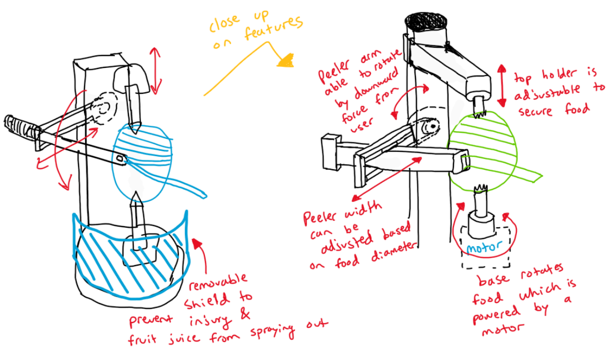


Figure 2 Final Design of Motorized Peeler Design

Discussion

With the product design specifications in place, a concept design was created which will further be expanded out in the next part of the project. These specifications targeted were Functionally and Performance, Safety, Quality and Reliability, Manufacturing, Aesthetic, Ergonomic, Timing, Life Cycle, and the usage of concept sketches. Two possible concept sketches were determined for further detailed design processing. These initial concept sketches are shown below.



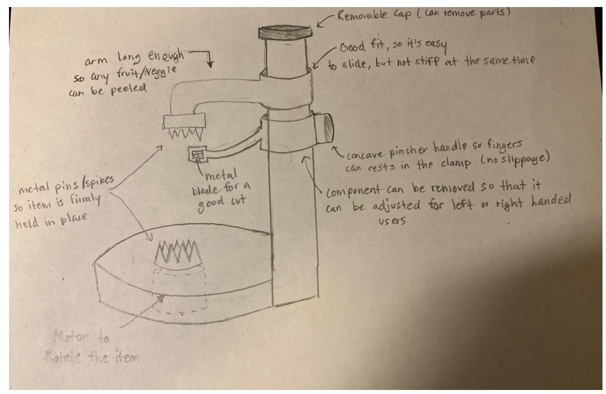


Figure 3: Concept Sketch 1

Figure 4: Concept Sketch 2

Using gathered information and specifications, a detailed design will take place while incorporating design for manufacturing for thermoplastics throughout the system. Manufacturing processes for all custom parts, as well as design details for specific manufacturing processes will be documented, along with a cost estimate before and after applying DFM.

Milestone 2

All custom parts in the product were made using plastic injection molding. Plastic injection molding contributes to nearly 80% of everyday durable plastic items [5]. The mold of a specific part is required and consists of a core and cavity portion. This is then placed into an injection machine and the plastic is then heated until it turns into molten [5]. The molten is put into the empty cavity of the mold under very high pressure and then cooled to later be ejected from the mold for manufacturing readiness [5]. The advantage for choosing this manufacturing process is that the parts could be made quickly and good surface finishing will be achievable at low costs [5]. Production efficiency will increase as a result and more products can be produced at manufacturing company standards in a time efficient manner. Profit will increase as a result of this. The kitchen peeler is a domestic home product and has a wide range of users and audience that could benefit from buying a kitchen peeler for their kitchen. Thus, the overall price including manufacturing costs should be kept low too so more customers are inclined to buy this product.

When performing injection molding, sharp edges will be avoided to promote uniform thickness and help eliminate inconsistencies during the cooling process that could result in possible sink marks. Draft angles should be considered when de-moulding. The type of plastic was selected through means of promoting an environmentally safe type of plastic since food such as fruits and vegetables will be in contact with the peeler. This product falls under cooking and consumption and therefore it is important to create a product that is safe for individuals to use. For appropriate plastic types to look out for that contain specific chemicals that are harmful for food usage. PVC (polyvinyl chloride), which contains additives such as phthalates that continue to release hazardous chemicals as time goes on [6]. BPA is another hazardous chemical in plastics to look out for, which is bisphenol-A [6]. This is a specific type of polycarbonate and can be hazardous overtime as well [6]. Another important chemical to watch out for is polystyrene. Polystyrene releases amounts of styrene, neurotoxins, and carcinogens [6]. These plastic parts for this kitchen peeler will be PVC, BPA, and polystyrene free respectively. The final decision was to use high density polyethylene for the main material of the device.

There was only one part in the product that was chosen to be manufactured as a metal. This was the actual blade for cutting the food and this was made using CNC manufacturing. The specific type of metal material that will be used is stainless steel, to ensure no corrosion or rust is built over time. In stainless steel there are different types of stainless steel used for industries. However, there are three main food grade types of stainless steel metals that can be used for the kitchen peeler [7]. They are food grade stainless steel 304, food grade stainless steel 316, and food grade stainless steel 340 [7]. Food grade stainless steel 304 is the most common stainless steel alloy compound that is used in various industries [7]. It is corrosion resistant when in contact with various chemicals during activities such as kitchen cleaning products or soap.

However, an excessive amount of salt or some chemicals can still damage the 304 SS (Stainless Steel). 316 SS consists of a stainless steel alloy with a proportion of chromium and nickel in high amounts added. It is suitable for high temperature exposures, ranging from above $800^{\circ}C$ or $1472^{\circ}F$ [7]. It is highly resistant to acids, alkalis, and chloride salts unlike 304 SS, which can be damaged from salts contained in food products [7]. This food grade is exceptional for food containers in the industry [7]. The last grade is 430 SS, which is similar to 316 SS since it has the same amount of chromium in the compound [7]. However, it only boasts a smaller amount of nickel in the compound [7]. It is very resistant to stress erosion cracking, which are cracks formed during contact of corrosive materials [7]. It is also very resistant to acids that are organic and nitric, which come in various foods, fruits, and vegetables [7]. A consistent exposure to mild acidity is a concern due to extensive damage but 430 SS is used to resist the constant exposure [7]. It is also resistant to sulfur and oxidation, making it strong to a variety of corrosive and acidic materials [7]. For this kitchen peeler, the food grade stainless steel 430 was found to be the most appropriate to be used for this kitchen peeler. This is because it prevents damage from constant exposure of organic and nitric acids, which are commonly found in many fruits and vegetables. This is useful since the metal blade used to cut and hold the fruit/vegetables will be in constant contact. Also sulfuric and oxidation that can take place from leftover residue from fruits/ vegetables will not be able to damage the stainless steel [7]. Cleaning chemicals and soap used on the product will not damage the metal parts due to corrosion resistance [7].

Looking more into CNC machining, this manufacturing process will be used strictly for the metal blade. This process turns metal into the desired manufacturing shape in a machining centre [8]. A cutting tool will be used to rotate and cut the desired material and remove any excess material [8]. The workpiece is held in place with a clamping device and the cutting tool axes are moved into the workpiece, which creates the desired shape and the complex geometries needed for the part [8].

All external parts require purchase for mass production and full assembly incorporation. These parts were not acquired to be made in a factory setting and include the lead screw, motor, gearbox, screws, and battery power. The screw being used is the Paulin 10-24 x ¾ inch 18.8

Stainless Steel Flat Head Phillips Machine Screw [1]. For bulk pricing, 1000 pieces are sold at $59.19, which could be used to situate costs in the future [2]. The power system (battery) is four AA batteries attached to each unit for simple functioning power. The gearbox and motor will be purchased separately and included during the assembly. This will be incorporated once completion occurs of the remaining manufacturing processes for the plastic and metal parts are completed. The gearbox and motor will be purchased with reference to 6 Volts. The motor used is the Nichibo Taiwan RF-500TB-1256-R. Motor with 2100 RPM and 6 V (DC) [3]. The gearbox is the Augiimor 6 V DC 1000 RPM Gearbox [4].

When it comes to functionality, one motor is used to control both motions. This works by the motor spinning the drive gear, which then in turn drives a gear positioned on both sides of the drive gear. One of the two driven gears will have a spindle connected to the top which will then be used to turn the bottom food holder. The second driven gear will have a lead screw connected to the top and it will spin this lead screw to aid the conversion of rotational motion to translational motion. The peeler arm holder will either move up or down depending on the lead screw movement and position. For the CAD assembly, there are five placeholder parts that outline the actual parts. These parts include the lead screw placeholder, motor placeholder, gearbox placeholder, screw and battery placeholder. These parts are considered placeholders due to the fact that they are not custom made parts through manufacturing processes and are instead obtained from external sources and purchased.

Looking into the design details, there are some factors to be considered. The nominal walls should not vary more than $\pm$ 10%. This falls under uniform thickness and setting these guidelines reduced chances of possible warpage, sink marks, cracks, and premature manufacturing defects. Since the largest part in our overall design system is the base, uniform wall thickness of 0.5cm was kept throughout the whole base part. This guideline was also incorporated in the other parts when necessary to keep an achievable uniform thickness. However, complex geometry of some parts made a 0.5 cm wall of uniform thickness unattainable. Parts such as the peeler arm and blade holder clip had to have their wall thickness reduced to 0.2 cm and 0.15 cm. Therefore, $\pm$ 10% was not always applied for these parts. In cases where this was not possible, further design considerations for manufacturing were discussed to combat problems such as sink marks, warpage, and stresses.

A draft angle was considered to be added with requirements to allow easier removal from the mold when plastic injection molding. In every 1 inch of cavity depth it was recommended to have a 1 degree of draft [11]. Although it was not possible for every part to have a draft angle due to size and geometry, it was incorporated when possible. The base, base lid, bottom food holder and power button all required a draft angle. The minimum draft angle used for the 5 cm (1.97 inches base) was 2 degrees but the team used a 5 degree draft angle to make removal easier for the hollow base. This was also included for the base lid and bottom food holder. The power button was a simple shape so a 10 degree draft angle was used.

For plastic injection molding the main weakness was identified to be stress. To solve this problem, edges were considered to be smoothed out to avoid high stress at these points and avoid any failures such as warpage and sink marks. The larger the fillet, the lower the stress in that specific area. The largest fillet was applied to each part. An example of this was the base lid having a 0.50 cm radius fillet and the cap was discussed to have a fillet size of 1 cm. Adding ribs was another method useful to increase strength of the parts in hollow parts while keeping weight and cost at minimum values [10]. When reinforcing the rib the thickness of the rib must be less than the thickness of the wall. Ribs were used for the hollow parts to introduce more strength. The thickness of the rib was decided to be half of the thickness of the wall.

Holes were added to prevent breakage in plastic. An extruded boss was made around holes and fasteners with ribs or gussets being added to bosses for additional reinforcement. The bosses were included in the base, base lid, and outer shaft area near fastener holes to provide additional strength. Gussets were used to spread load over area more evenly, thus creating more surface area strength. This eliminates the need to add more material that increases weight and cost. The use of gussets were used in the base and shaft to reinforce the bossed holes. They were also used inside the base along the ribbed walls to reinforce the surface. The requirements of the gusset were that it should have a length of at least two times the thickness and height of 50% of the boss height. The width should also be half part thickness. The base had a thickness of 0.5 cm and boss height of 4 cm. The dimensions were 1cm x 0.25cm x 2cm. The shaft had a connecting rib attached and a thickness of 0.5 cm and width of 0.25 cm was incorporated.

To maintain the part integrity, ejection surface was crucial to add since height of a wall is three times the overall thickness of the part. This was added to the base and knockouts were added through the ribbed sections to counteract ejection. Metal inserts, pillars and ribs are common surfaces to eject from to prevent breakage and ejector pin mark defect [10]. Snap connections are great to use for plastics because there is good flexibility of plastic [11]. This was used in the blade and peeler arm. The team used a cantilever snap fit to join the parts together. The blade holder clip fits into the peeler arm through friction fitting by pinching the ends of the clip and sliding it through the peeler arm.

In the design, both blind cores and cores were used throughout the design. The requirements for blind cores were to have a height of maximum three times the diameter. This can be seen in the power button, where the diameter of the hole was made to 1 cm and the height to 2 cm. Shutoffs are a method used to create side holes without having a side action. This saves money when creating a side hole which is done by extending the hold to the surface parallel to the mold direction. Our design implemented shutoffs in the blade holder arm where the top hole was extended to the sides to prevent the need for side action.

Free standing projections should be avoided when possible, but in this design it was needed since a battery housing was to be added to the base. To combat this, venting was used to allow for a safer injection process. By adding a rib connecting it to the outer wall, it prevents trapped air during the molding process. When molten plastic is poured into a mold, air inside the mold is constantly pushed away from the flowing plastic. When there is a freestanding projection, air can become trapped which can affect the final finish of the part. Venting allows freestanding projections to be made possible by connecting the projection to the main part through gussets and ribs.

Milestone 3

A DFA analysis was done on both the current and redesigned motorized peeler. One of the main stages was finding ideal candidates for elimination, and this was based on 4 requirements and criteria. These factors included the parts moving relative to other assembled parts, the part must be a different material, the part must be isolated from the other assembled parts, and the part needs to be separate for maintenance and assembly to occur. If the parts did not meet the requirements they were deemed unessential. After this breakdown, two out of 13 parts were determined unessential. There were 22 total parts due to duplicates but the amount of unique total parts were taken down to 11 parts. Both the current and new and improved design were analyzed with respect to design for manufacturing and assembly to see if the changes made optimized the design.

After the redesign, DFA cost analysis showed the new cost value was $9.73, which was down from $11.18. This decrease can be due to the reduction in the number of parts because of the new design changes. Some of the design changes were using more snap fit and less screws which would lead to a cheaper cost and less parts needed in the assembly. Additionally, our team adjusted the design of the peeler to use 1 less part which would result in less material being used and not needing additional parts of connections. Another factor to this new cost value was the tooling cost. This is important because there were less parts therefore less tooling costs and the design was more optimized, therefore tooling costs were reduced from $8.18 to $6.80.

The significance of the new design allowed for manufacturing tooling investment and part processing costs to decrease because there were less individual parts required in the assembly. Furthermore the new DFA shows that the labour time was reduced from 195 seconds to 143 seconds. The duration of manufacturing work has decreased and therefore more products can be produced and sold. By eliminating parts and redesigning other parts, this allowed for a more efficient assembly time. Furthermore, reducing fasteners, connectors and part handling also contributed to a shorter assembly time.

The new DFA analysis helped reduce costs and increase efficiency. The total number of part entries were shortened to 25, with 11 parts meeting minimum part criteria, four parts that were candidates for elimination, two subassemblies, and eight entries for separate assembly operations. The total number was cut down from the original number of entries, which were 34 entries at first. Assembly labour time was also improved with 66.01 seconds for parts that met minimum criteria, 30.28 seconds for elimination facing parts, 7.84 seconds for subassemblies, and 38.10 seconds for separate assembly operations. This is an improvement from the timeline of the previous assembly duration of 195 seconds to 142 seconds in total time. The DFA index for efficiency was 27.98, compared to 20.46. This shows that the new improved design has a greater value for overall efficiency by 7.52%. The assembly process only yielded 1.86% rather than the original percentage cost of 2.55%, assembly tools took up 0% of the total cost, manufacturing tool cost percentage decreased to 29.37% from its original percentage of 30.06% , and manufacturing piece part was improved to 4.94% from 5.63%. The lower cost percentage shows that more money has been saved overall for the production.

In this stage of the design process, optimization was key and finding the right balance between DFM and DFA was crucial to lowering both costs and assembly time. After the DFA analysis, certain redesigned parts had more material and increased costing and processing time, however these changes helped vastly reduce and even eliminate other parts and processes, which is why the net value resulted in a positive change.

Conclusions

From the first milestone it was evident there was much detail lacking such as how each mechanism functions for the peeler, as well as needing separate sketches for each part of the peeler for planning. There were also many justifications lacking for the choices being made during the process of forming a concept design. This feedback was utilized for milestones 2 and 3 in which CAD models for every part were provided as well as redesigning the peeler by designing for manufacturing and assembly. Both softwares for DFM and DFA proved to be easy to use due to their simple UI and simplicity. These softwares helped to redesign and lower the overall cost which was discussed thoroughly.

Overall the project was deemed a success as a final design was reached after working on different sections across 3 milestones. The main initial product design specifications were met which is what mattered in this project. A functional and well performing peeler was designed with simple/easy to assemble parts. The mechanism met the requirement of only using one motor to rotate both the bottom food holder and peeler arm. After designing for both manufacturing and assembly, the initial cost of $11.18 was brought down to $9.73. The price was decreased due to the fewer number of parts required as well as parts being formed together making an overall simpler design. This allows for the design to be easily produced at higher quantities due to the ease for manufacturers as well as assembly of the peeler. This in turn creates larger profits and a better product for market value.

The value of DFMA was taught through this project, as the initial product our team designed was further improved when implementing both manufacturing and assembly guidelines for plastic injection molding. If this project was to be further expanded on, more DFMA iterations would be performed to find the most optimized state of the product. Each additional iteration would slightly reduce both cost and assembly time, and with enough iterations the most optimal version of the product can be achieved which is the goal when designing a new product.

References

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Appendix 1: Milestone 1

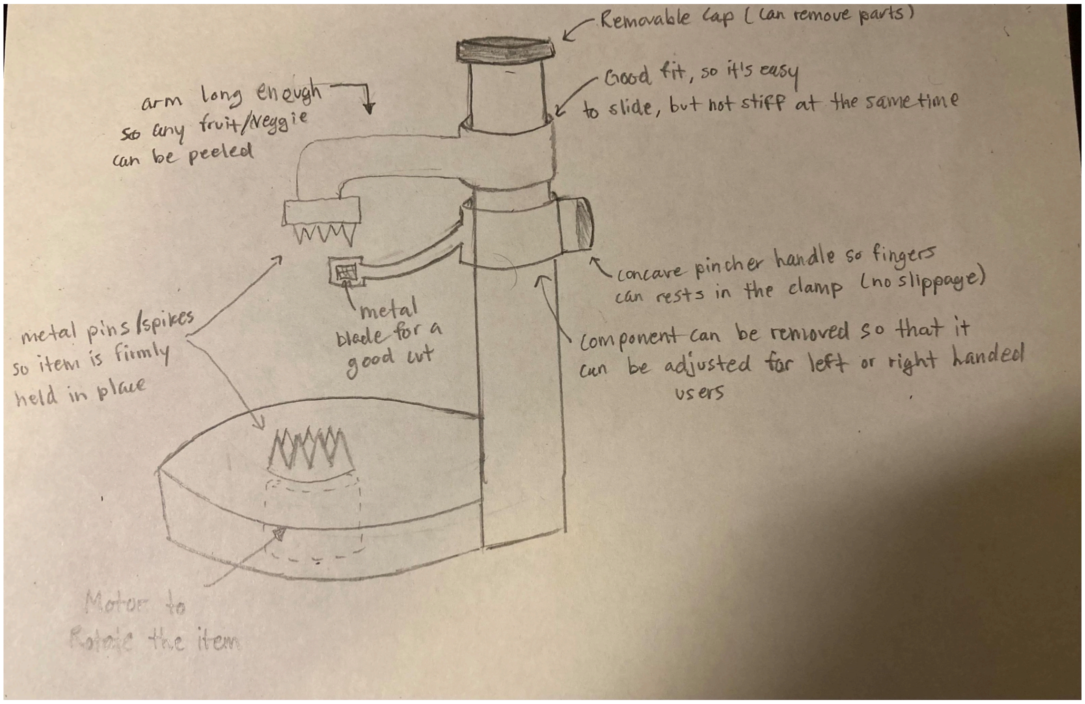


Figure 5: Sketch of Concept 1

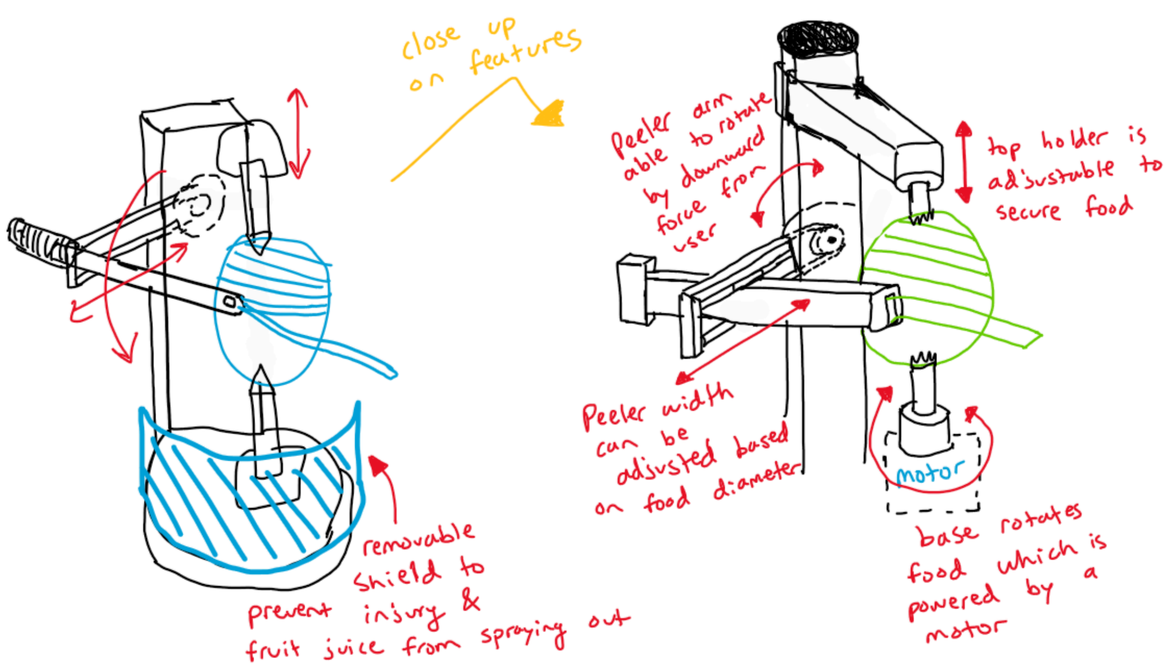


Figure 6: Sketch of Concept 2

Appendix 2: Milestone 2 DFM

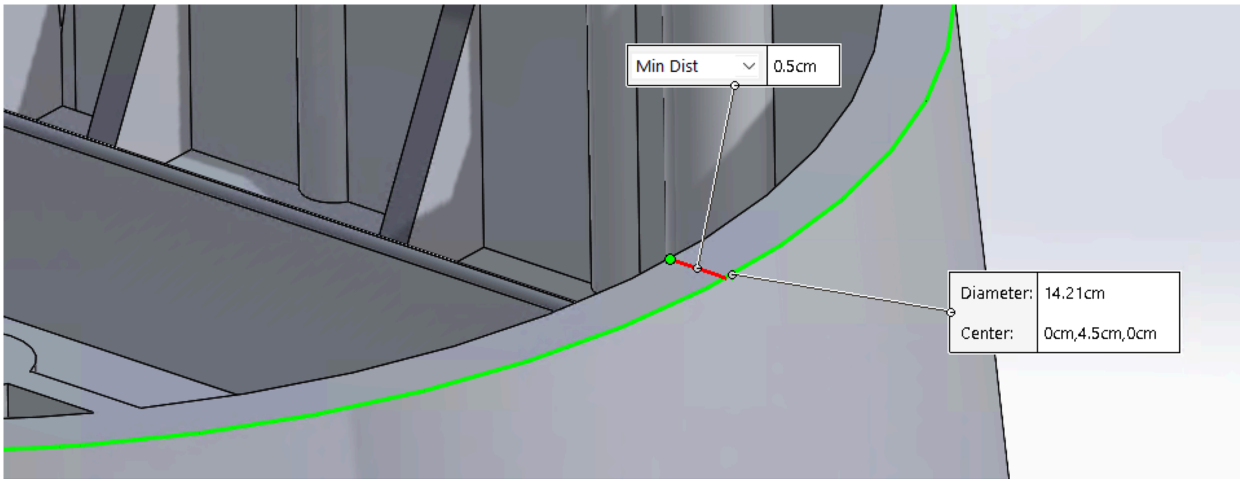


Figure 7: Uniform Wall Thickness Throughout the Base

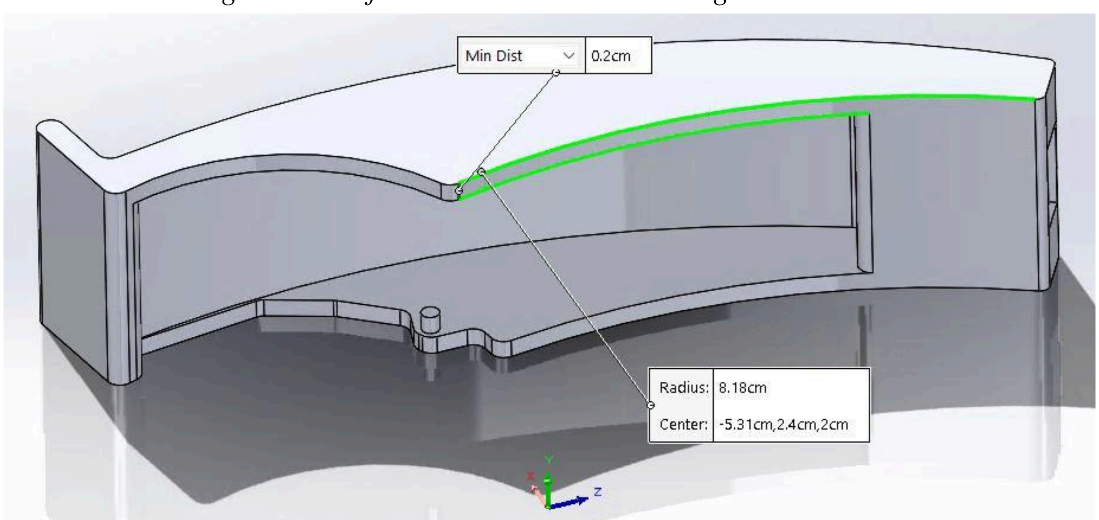


Figure 8: Uniform Wall Thickness Throughout the Peeler Arm

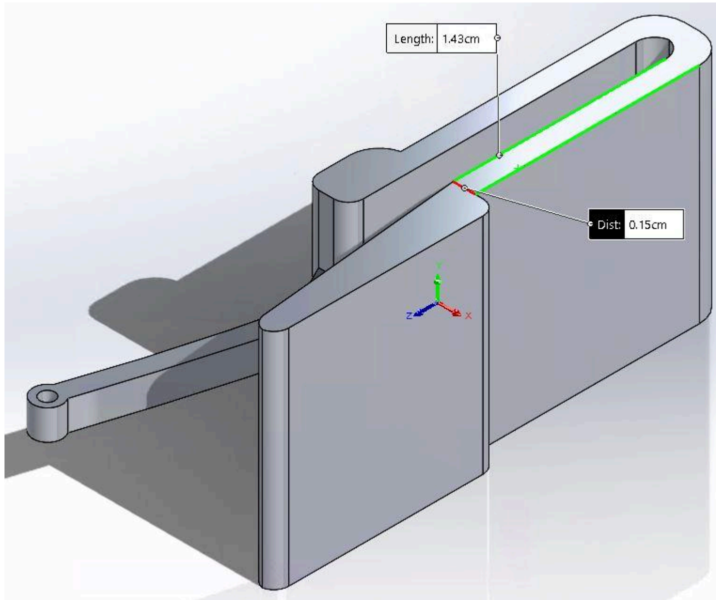


Figure 9: Uniform Wall Thickness Throughout the Blade Holder Clip

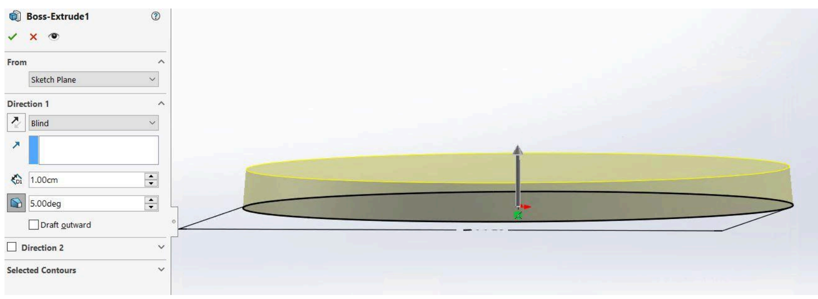


Figure 10: Draft Angle in the Base Lid

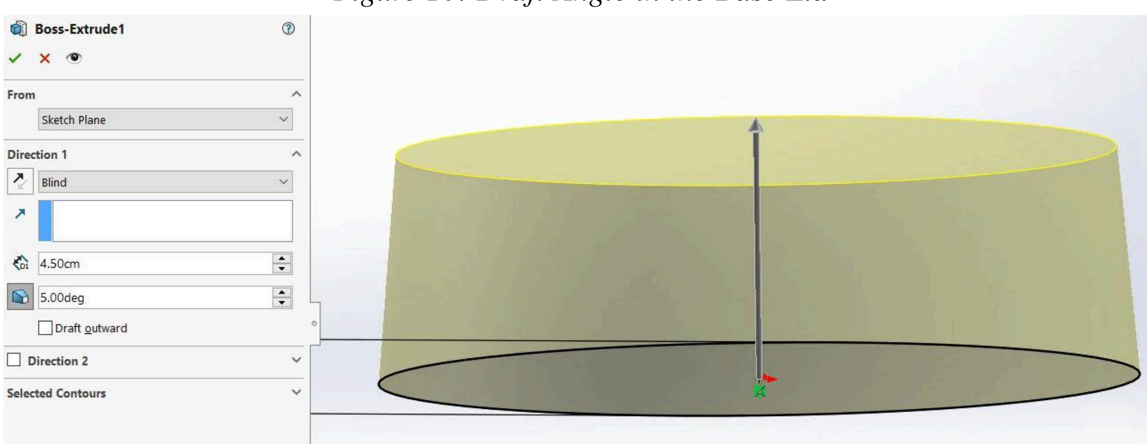


Figure 11: Draft Angle in the Base

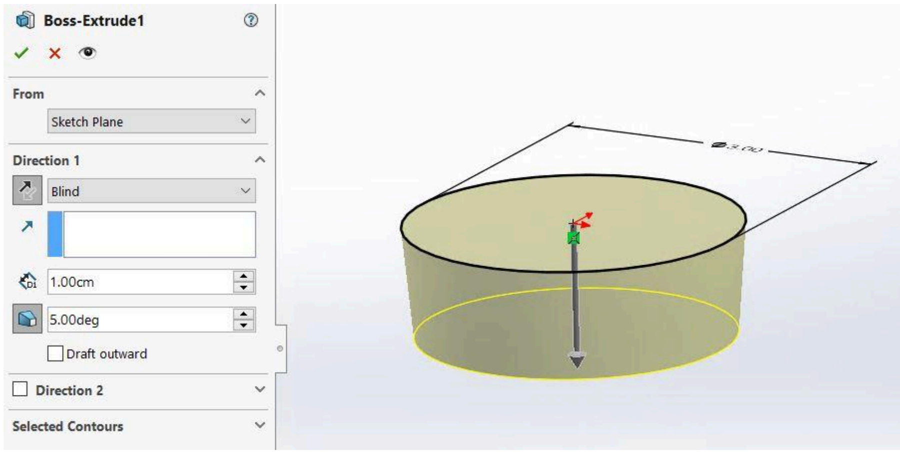


Figure 12: Draft Angle in the Bottom Food Holder

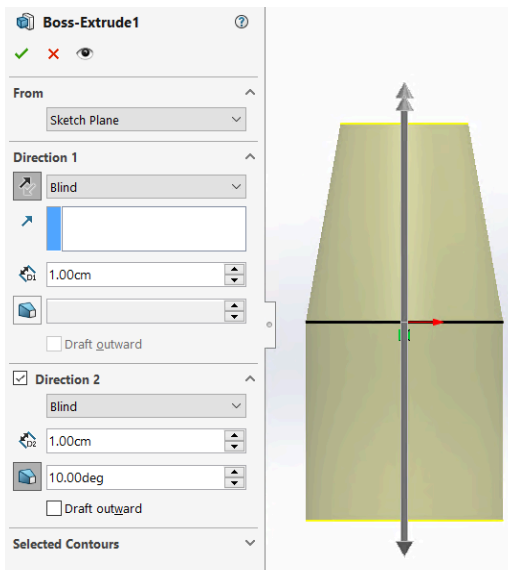


Figure 13: Draft Angle in the Power Button

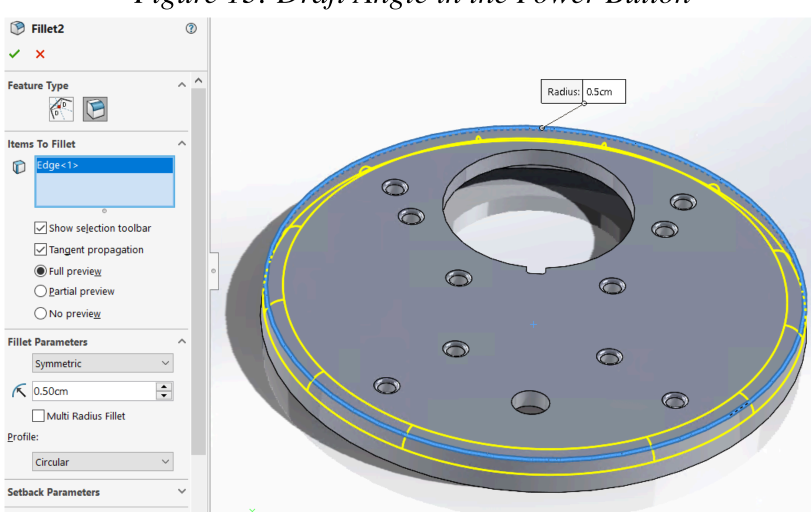


Figure 14: Fillets Used in the Base Lid

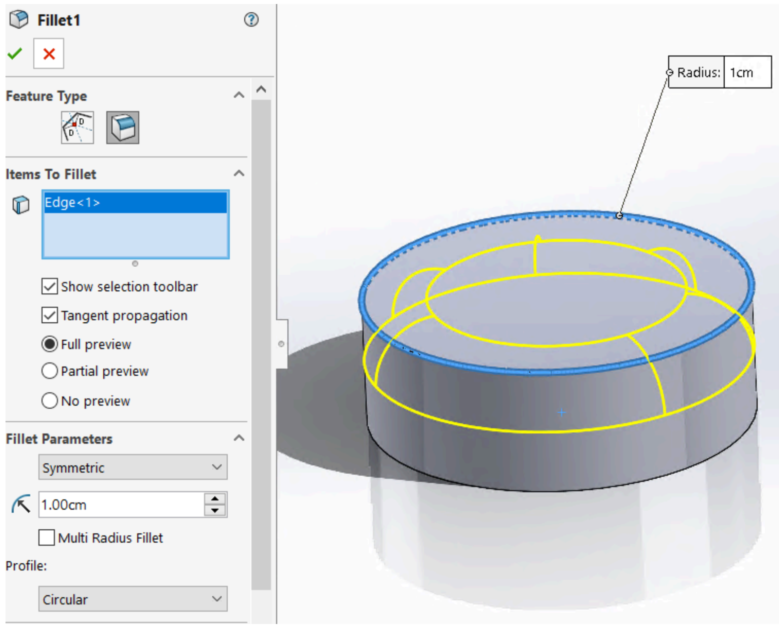


Figure 15: Fillets Used in the Cap

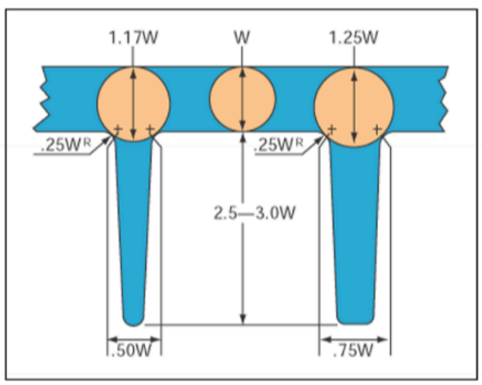


Figure 16: Common Relations Between Ribs and Joint Walls

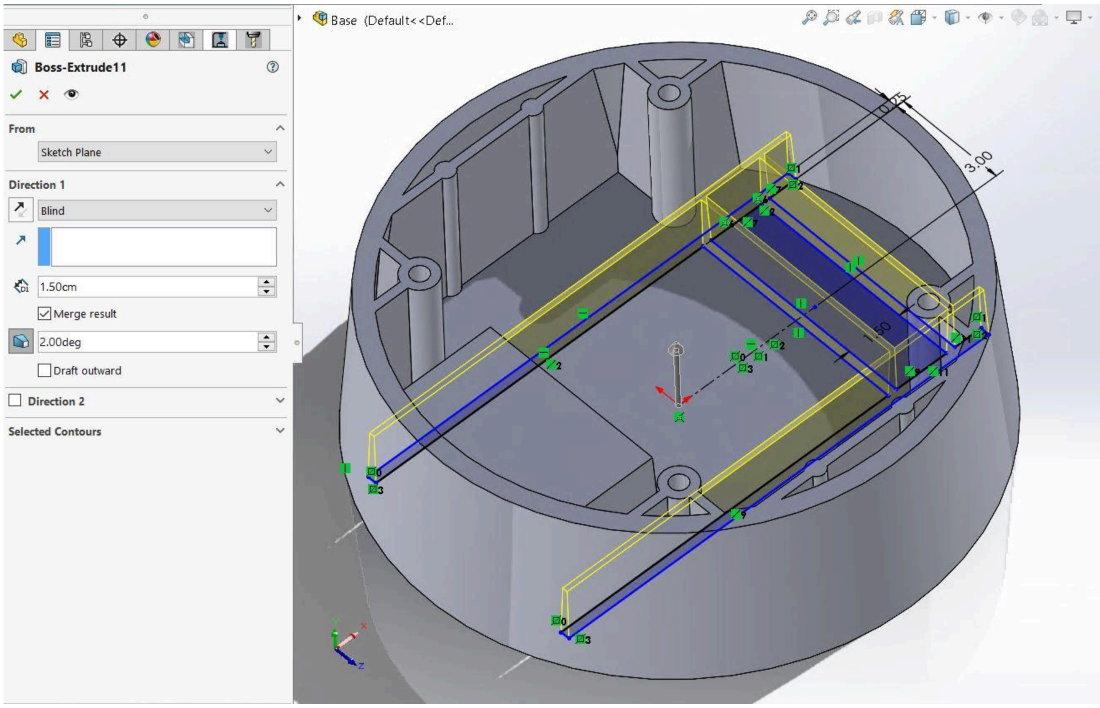


Figure 17: Ribbed Wall Inside Base

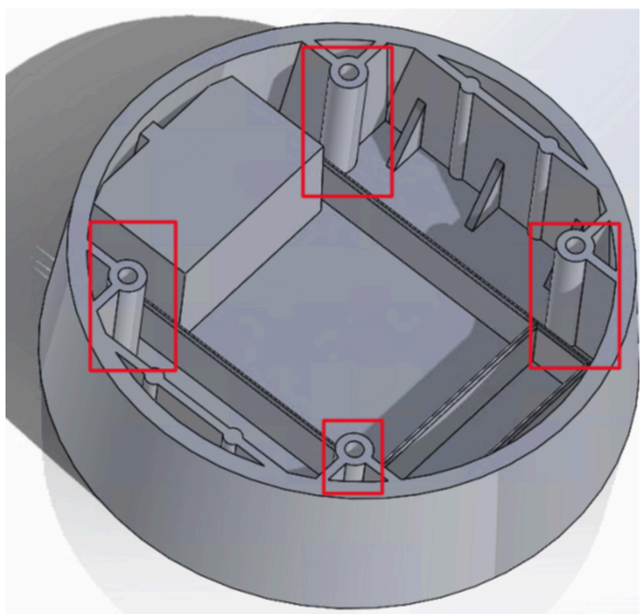


Figure 18: Bossed Holes in the Base

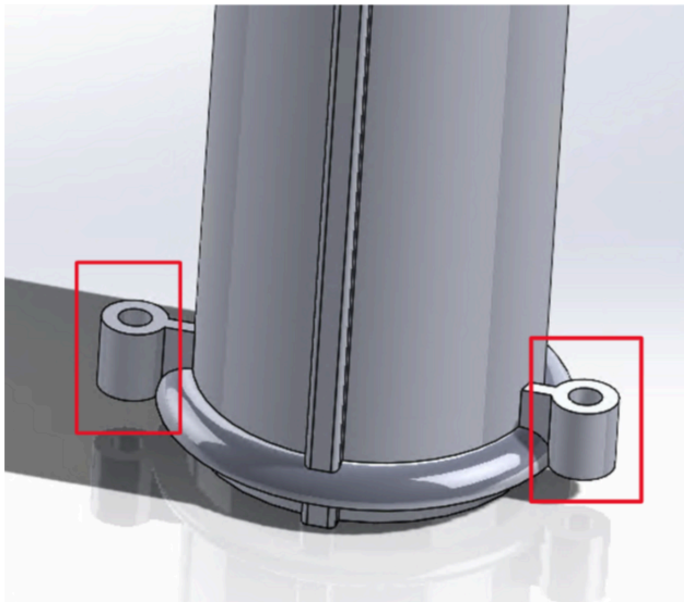


Figure 19: Bossed Holes Outside the Shaft

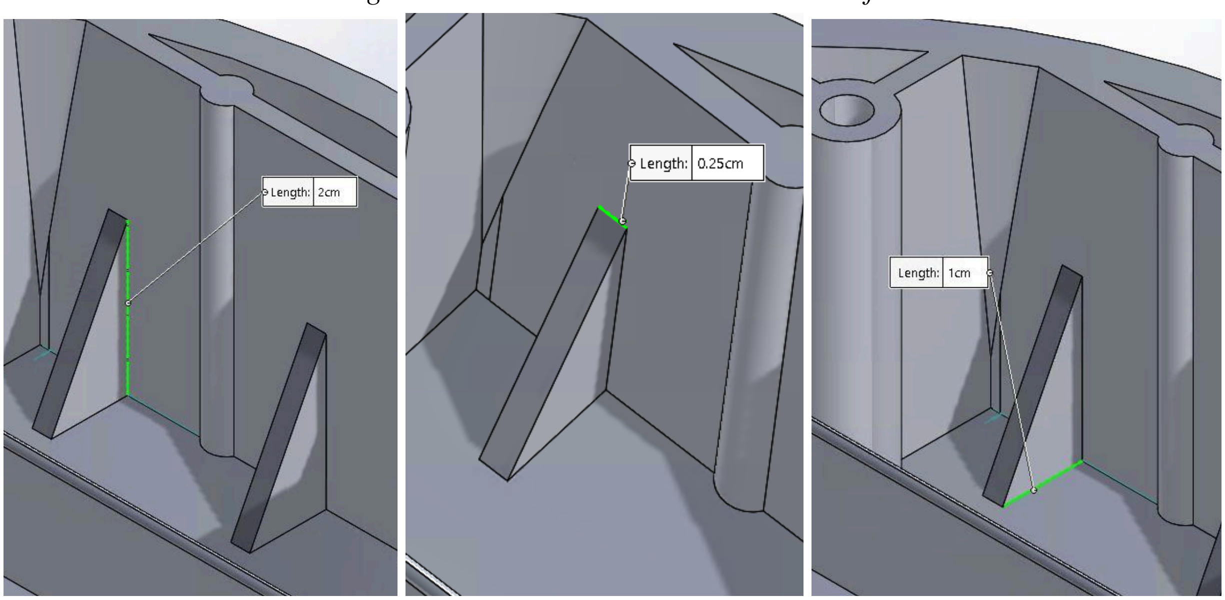


Figure 20: Gussets Used Inside the Base

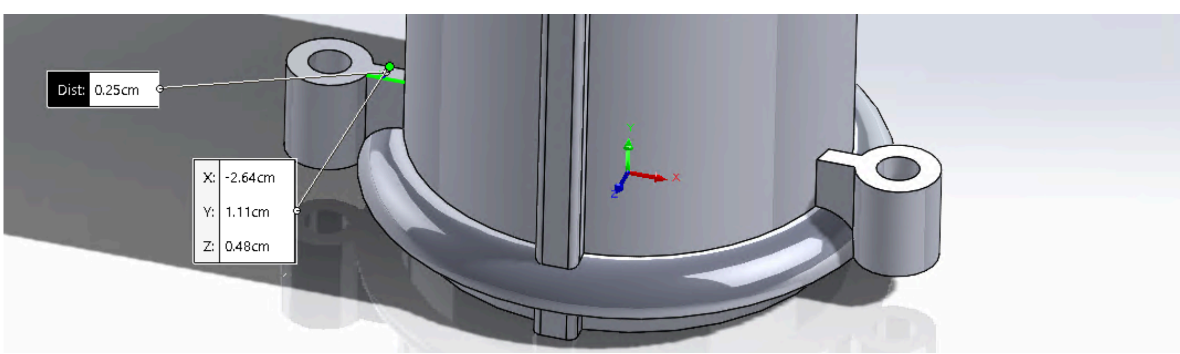


Figure 21: Gussets Used Outside the Shaft

Projections:ejection

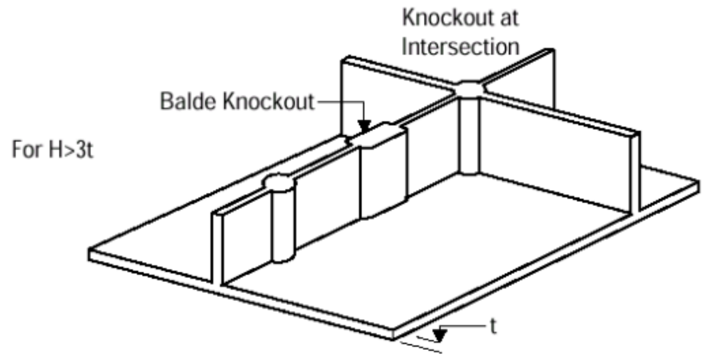


Figure 22: Ejector Projection Diagram

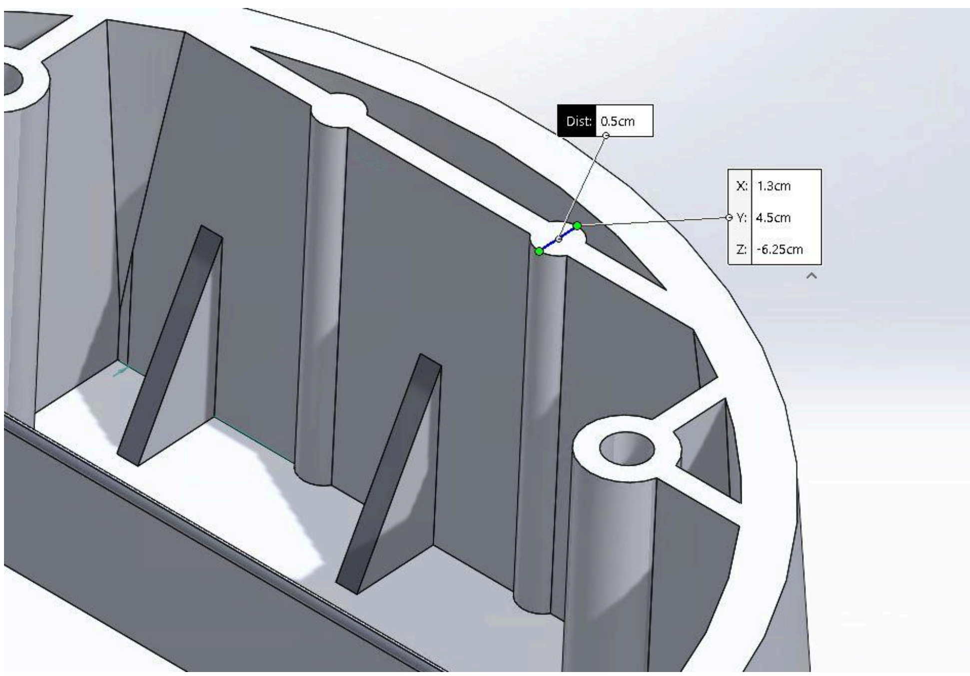


Figure 23: Ejector Pin Knockouts Inside Base

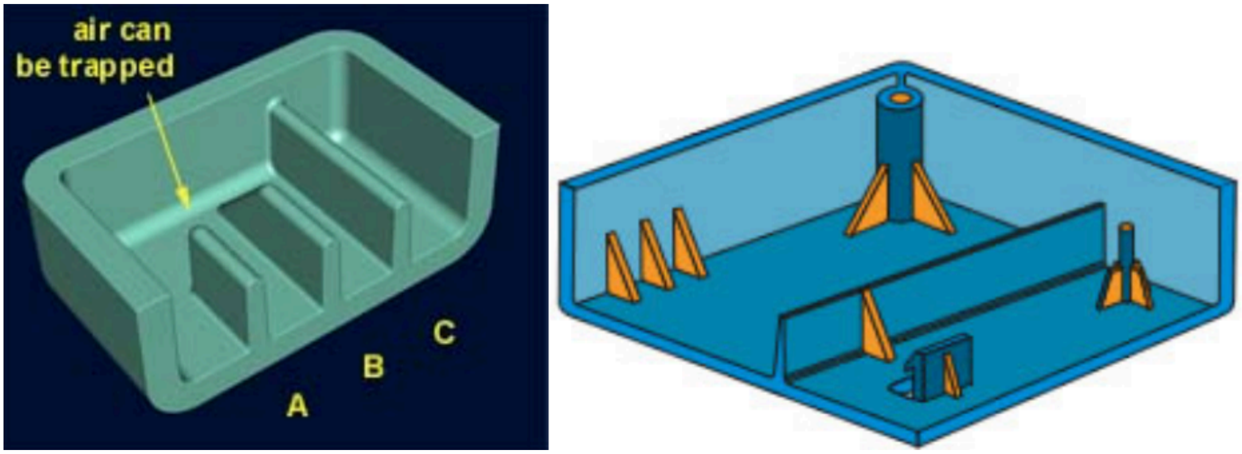


Figure 24: Examples of Venting in a Part

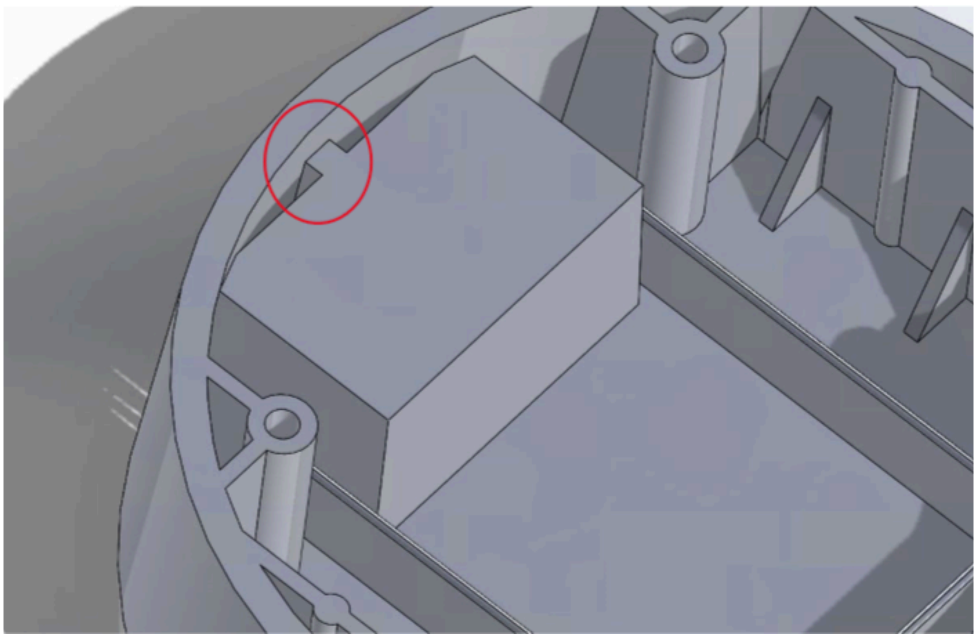
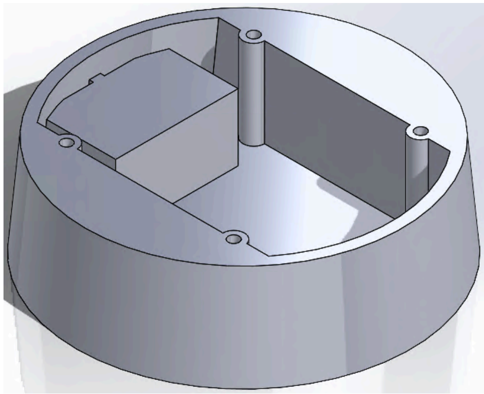
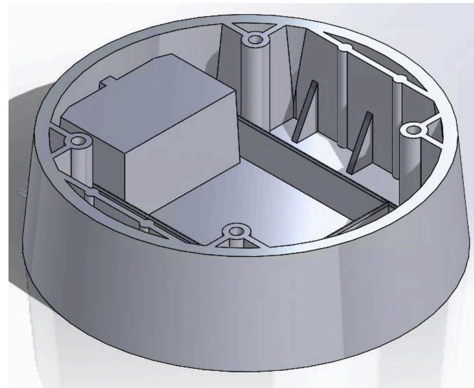
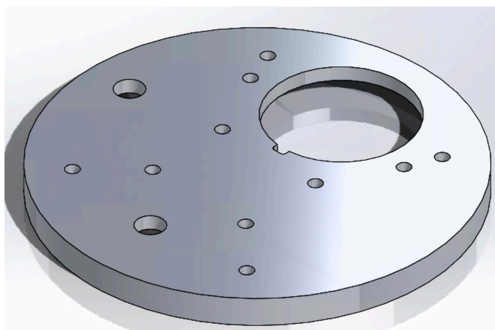
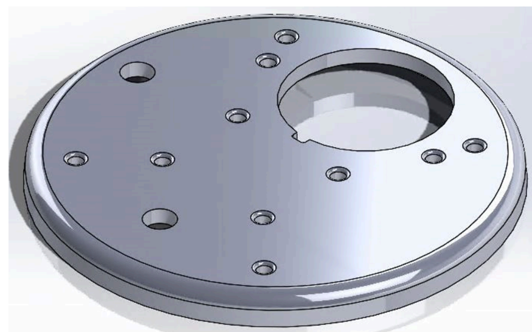
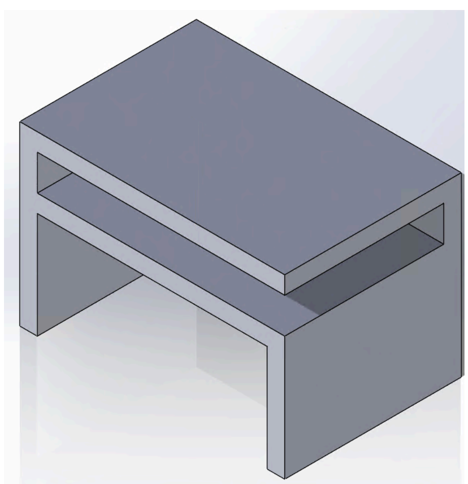
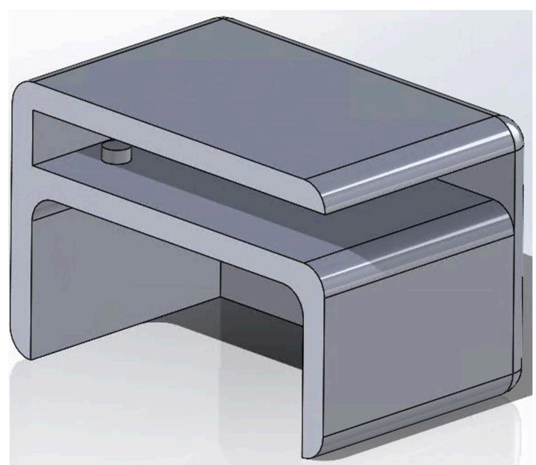
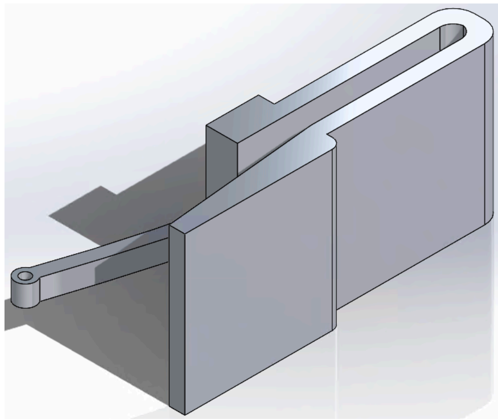
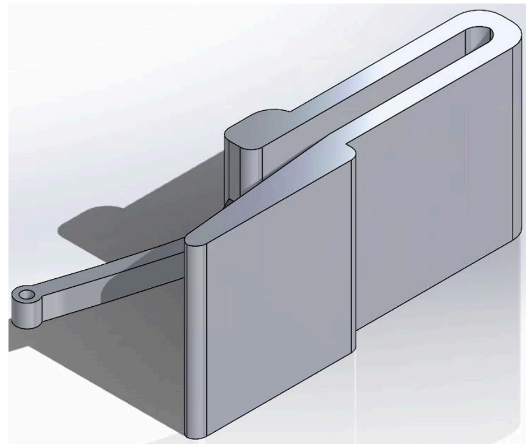
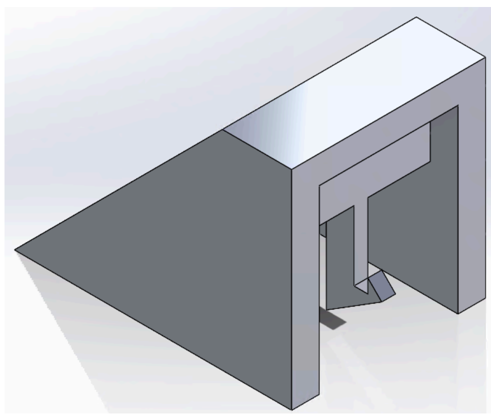
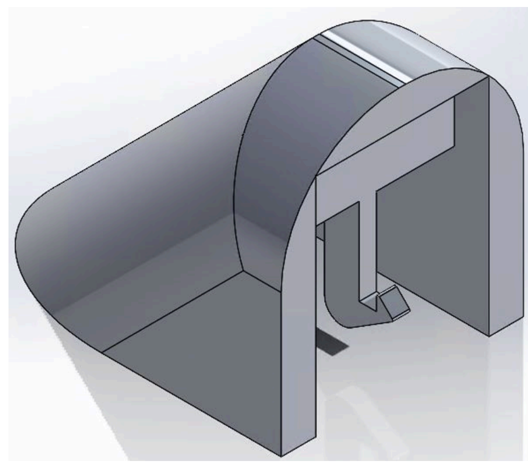
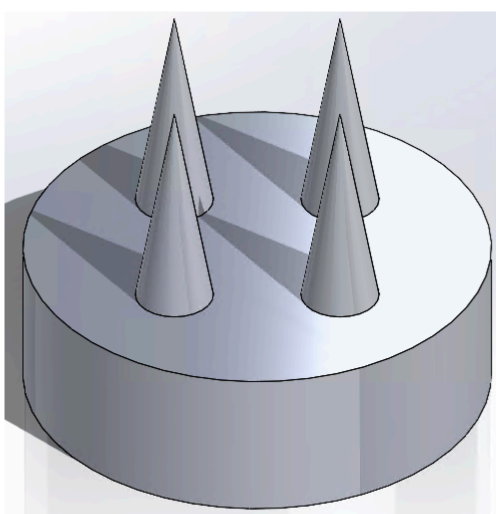
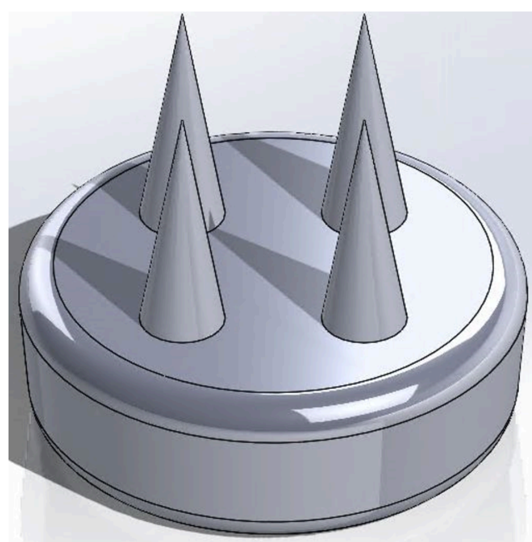
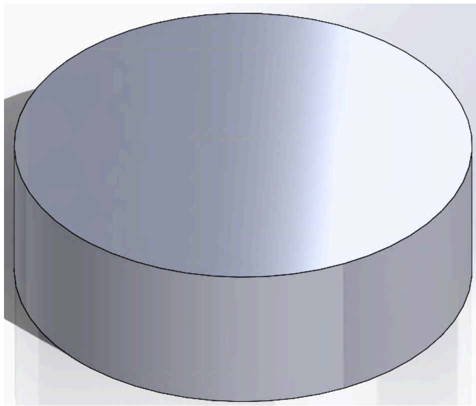
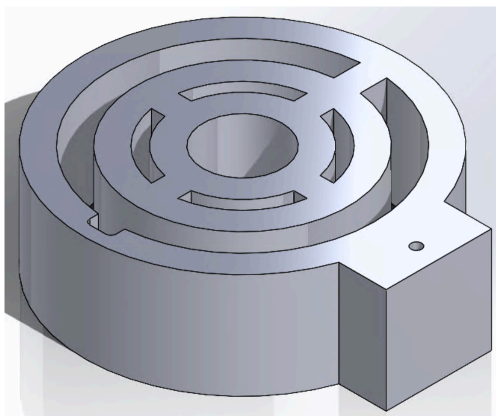
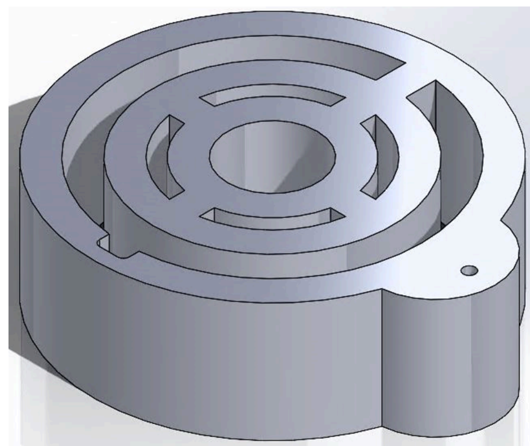
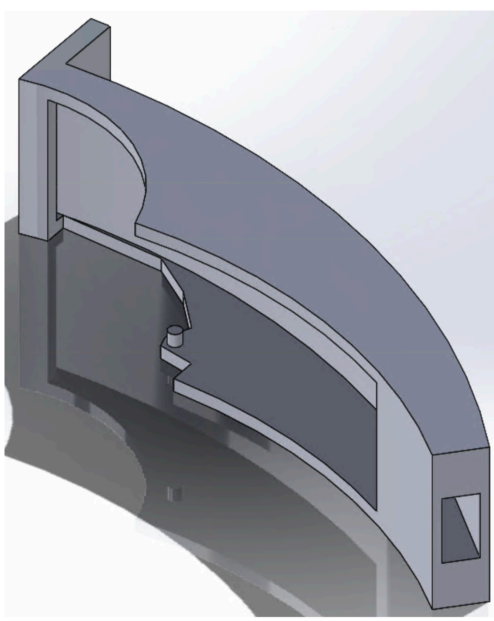
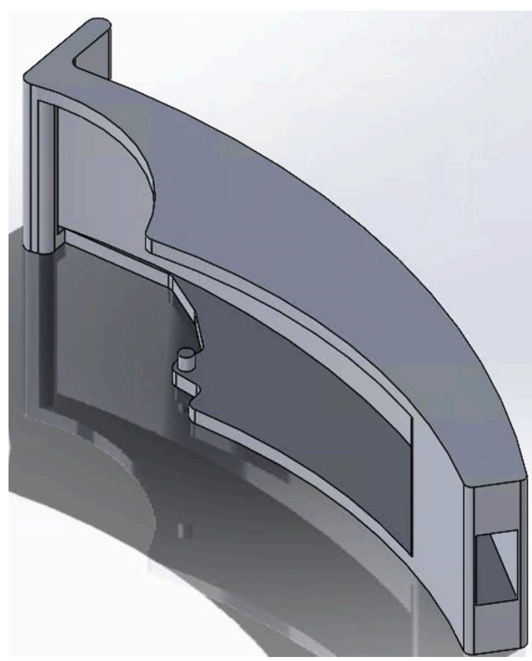


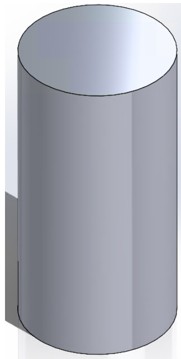
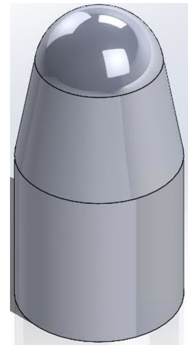
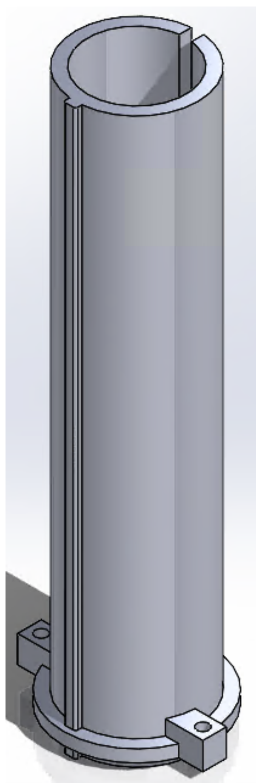
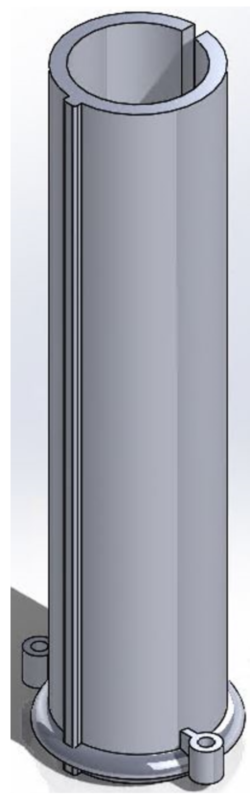
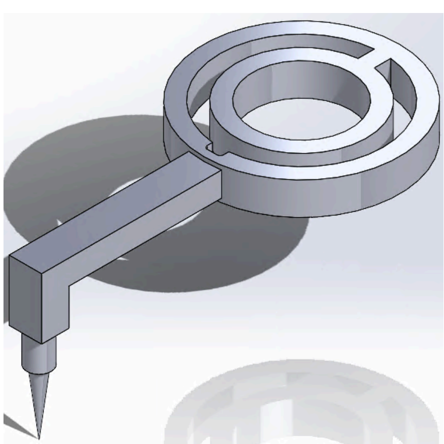
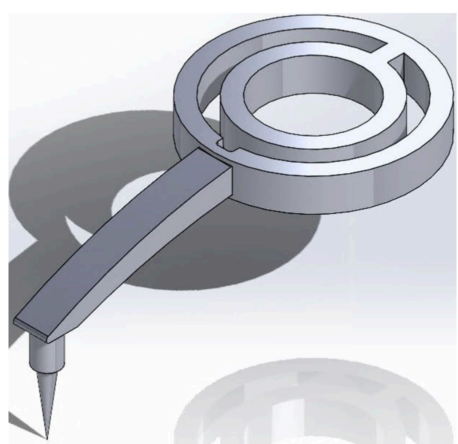
Figure 25: Venting Used Inside the Base

Table 5: Before and After DFM is Implemented

Part Name	Before DFM	After DFM
Base		
Base Lid		
Blade Holder Arm		

Blade Holder Clip		
Blade Holder		
Bottom Food Holder		

Cap		
Peeler Arm Holder		
Peeler Arm		

Power Button		
Shaft		
Upper Food Holder		

Before DFM:

Analysis Name	no-dfm-Base-Lid
Part name	no-dfm-Base-Lid
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0645
Setup	0.0054
Process	0.3475
Rejects	0.0017
Piece part	0.4192
Tooling	0.2260
Total	0.6452
Initial tooling investment	22603.5570

Life volume	100,000
Batch size	12,500
Part weight	0.165

Figure 26: Cost Estimate for Base Lid

Analysis Name: no-dfm-Base-Lid
Part name: no-dfm-Base-Lid
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.6452
Piece part cost, $	0.4192
Initial tooling investment, $	22,604

The chart shows a breakdown of cost per part, $

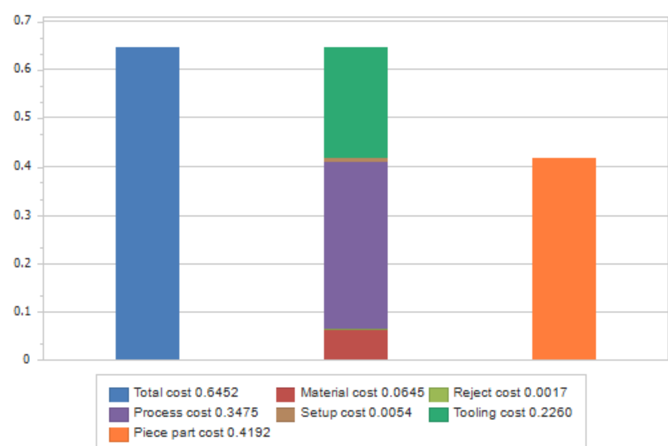


Figure 27: Executive Summary for Base Lid

Analysis Name	no-dfm-Base
Part name	no-dfm-Base
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.2787
Setup	0.0136
Process	1.3144
Rejects	0.0066
Piece part	1.6134
Tooling	1.4403
Total	3.0536
Initial tooling investment	144027.0767

Life volume	100,000
Batch size	12,500
Part weight	0.715

Figure 28: Cost Estimate for Base

Analysis Name: no-dfm-Base
Part name: no-dfm-Base
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	3.0536
Piece part cost, $	1.6134
Initial tooling investment, $	144,027

The chart shows a breakdown of cost per part, $

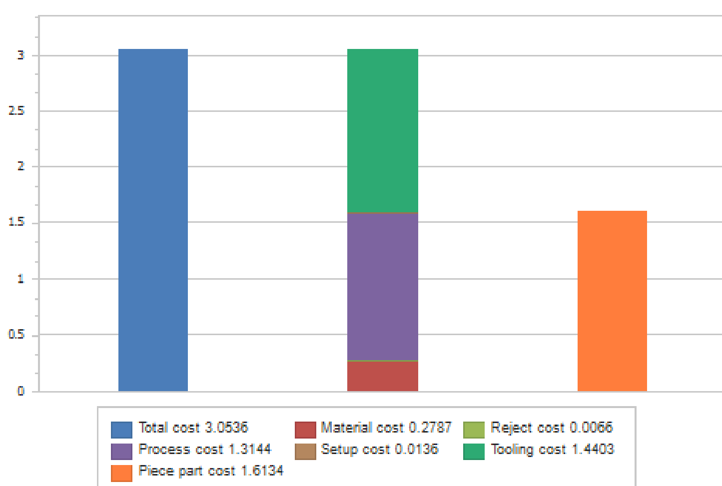


Figure 29: Executive Summary for Base

Analysis Name	no-dfm-blade-holder-arm
Part name	no-dfm-blade-holder-arm
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0010
Setup	0.0048
Process	0.0562
Rejects	0.0003
Piece part	0.0624
Tooling	0.0867
Total	0.1491
Initial tooling investment	8669.4765

Life volume	100,000
Batch size	12,500
Part weight	0.001

Figure 30: Cost Estimate for Blade-Holder-Arm

Analysis Name: no-dfm-blade-holder-arm
Part name: no-dfm-blade-holder-arm
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.1491
Piece part cost, $	0.0624
Initial tooling investment, $	8,669

The chart shows a breakdown of cost per part, $

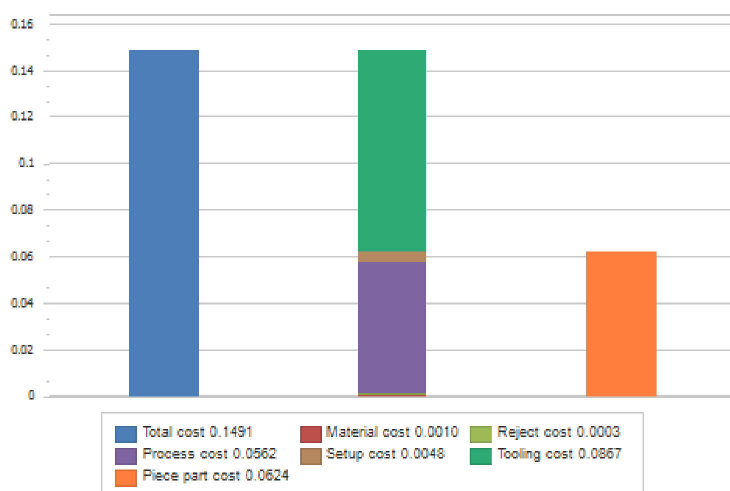


Figure 31: Executive Summary for Blade-Holder-Arm

Analysis Name	**no-dfm-blade-holder-clip**
Part name	no-dfm-blade-holder-clip
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0022
Setup	0.0048
Process	0.0818
Rejects	0.0004
Piece part	0.0892
Tooling	0.0791
Total	0.1683
Initial tooling investment	7907.0941

Life volume	100,000
Batch size	12,500
Part weight	0.003

Figure 32: Cost Estimate for Blade-Holder-Clip

Analysis Name: no-dfm-blade-holder-clip
Part name: no-dfm-blade-holder-clip
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.1683
Piece part cost, $	0.0892
Initial tooling investment, $	7,907

The chart shows a breakdown of cost per part, $

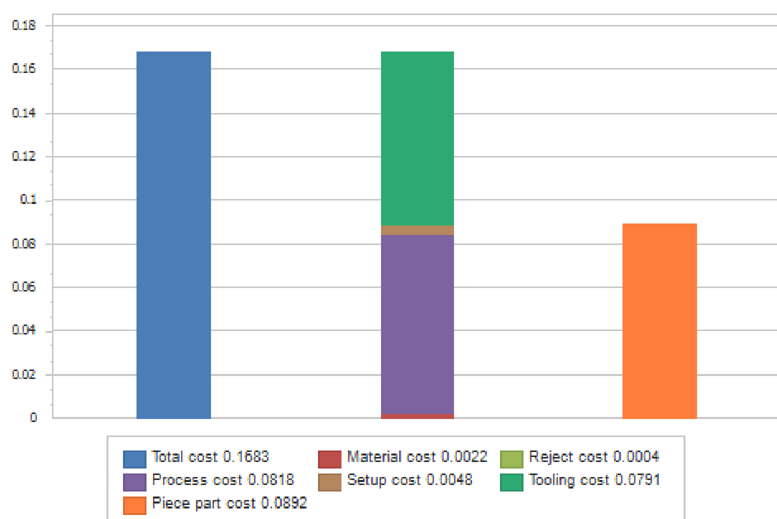


Figure 33: Executive Summary for Blade-Holder-Clip

Analysis Name	no-dfm-blade-holder
Part name	no-dfm-blade-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0020
Setup	0.0048
Process	0.0789
Rejects	0.0004
Piece part	0.0861
Tooling	0.1116
Total	0.1977
Initial tooling investment	11162.4304

Life volume	100,000
Batch size	12,500
Part weight	0.003

Figure 34: Cost Estimate for Blade-Holder

Analysis Name: no-dfm-blade-holder
Part name: no-dfm-blade-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.1977
Piece part cost, $	0.0861
Initial tooling investment, $	11,162

The chart shows a breakdown of cost per part, $

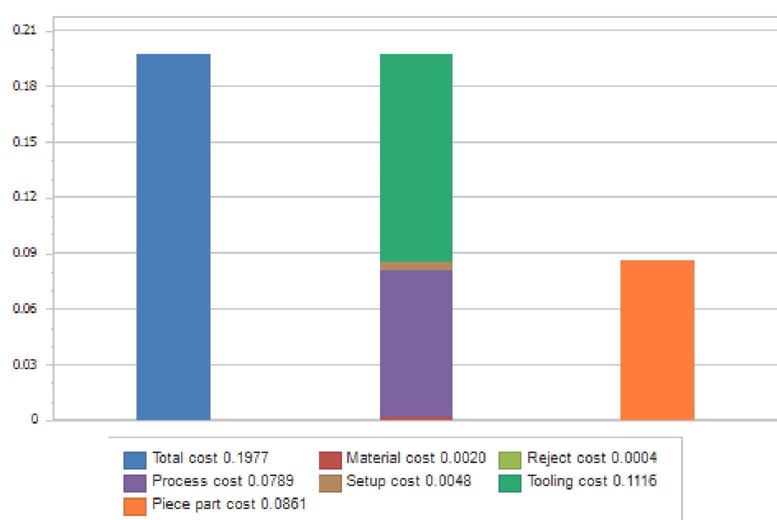


Figure 35: Executive Summary for Blade-Holder

Analysis Name	no-dfm-bottomfood-holder
Part name	no-dfm-bottomfood-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0069
Setup	0.0052
Process	0.2209
Rejects	0.0011
Piece part	0.2341
Tooling	0.1948
Total	0.4289
Initial tooling investment	19477.8076

Life volume	100,000
Batch size	12,500
Part weight	0.015

Figure 36: Cost Estimate for Bottom-Food-Holder

Analysis Name: no-dfm-bottomfood-holder
Part name: no-dfm-bottomfood-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.4289
Piece part cost, $	0.2341
Initial tooling investment, $	19,478

The chart shows a breakdown of cost per part, $

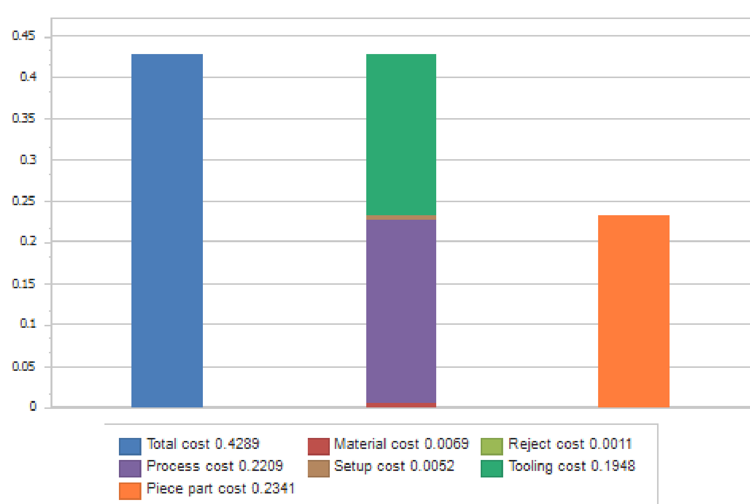


Figure 37: Executive Summary for Bottom-Food-Holder

Analysis Name	no-dfm-cap
Part name	no-dfm-cap
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0345
Setup	0.0060
Process	0.5837
Rejects	0.0029
Piece part	0.6272
Tooling	0.4023
Total	1.0294
Initial tooling investment	40225.0097

Life volume	100,000
Batch size	12,500
Part weight	0.088

Figure 38: Cost Estimate for Cap

Analysis Name: no-dfm-cap
Part name: no-dfm-cap
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	1.0294
Piece part cost, $	0.6272
Initial tooling investment, $	40,225

The chart shows a breakdown of cost per part, $

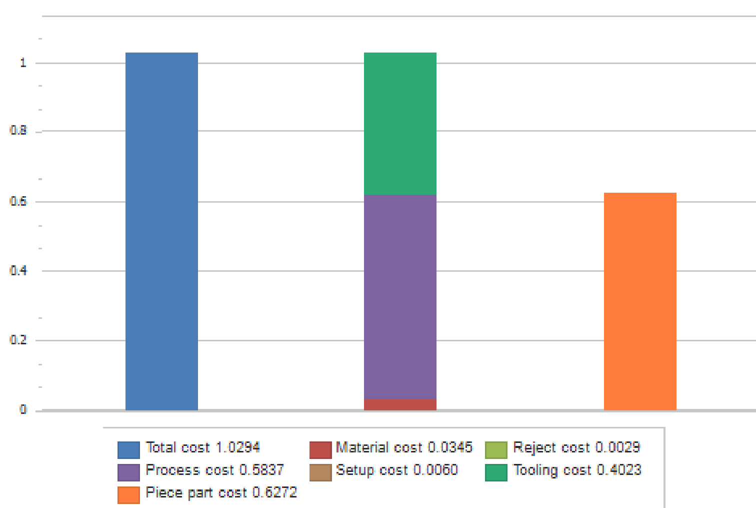


Figure 39: Executive Summary for Cap

Analysis Name	no-dfm-peeler-arm-holder
Part name	no-dfm-peeler-arm-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0315
Setup	0.0060
Process	0.3986
Rejects	0.0020
Piece part	0.4380
Tooling	0.3896
Total	0.8276
Initial tooling investment	38960.6929

Life volume	100,000
Batch size	12,500
Part weight	0.081

Figure 40: Cost Estimate for Peeler-Arm-Holder

Analysis Name: no-dfm-peeler-arm-holder
Part name: no-dfm-peeler-arm-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.8276
Piece part cost, $	0.4380
Initial tooling investment, $	38,961

The chart shows a breakdown of cost per part, $

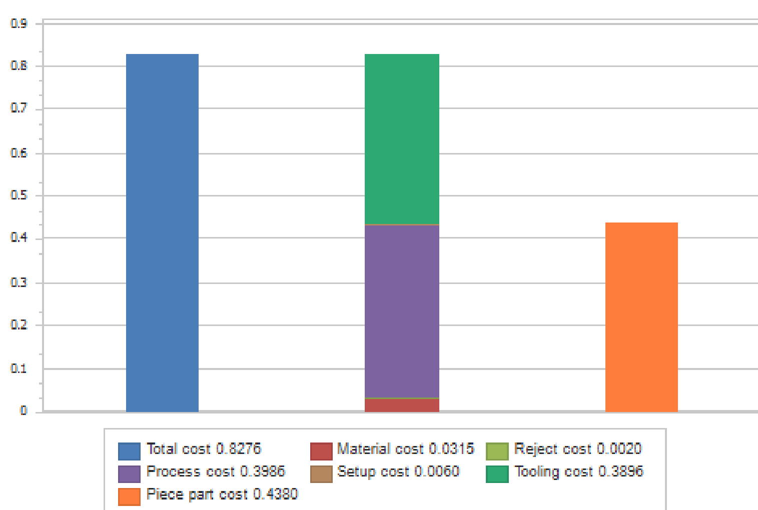


Figure 41: Executive Summary for Peeler-Arm-Holder

Analysis Name	no-dfm-peeler-arm SLDPRT
Part name	no-dfm-peeler-armSLDPRT
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0106
Setup	0.0052
Process	0.1091
Rejects	0.0006
Piece part	0.1255
Tooling	0.1590
Total	0.2846
Initial tooling investment	15904.5348

Life volume	100,000
Batch size	12,500
Part weight	0.025

Figure 42: Cost Estimate for Peeler-Arm

Analysis Name: no-dfm-peeler-armSLDPRT
Part name: no-dfm-peeler-armSLDPRT
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.2846
Piece part cost, $	0.1255
Initial tooling investment, $	15,905

The chart shows a breakdown of cost per part, $

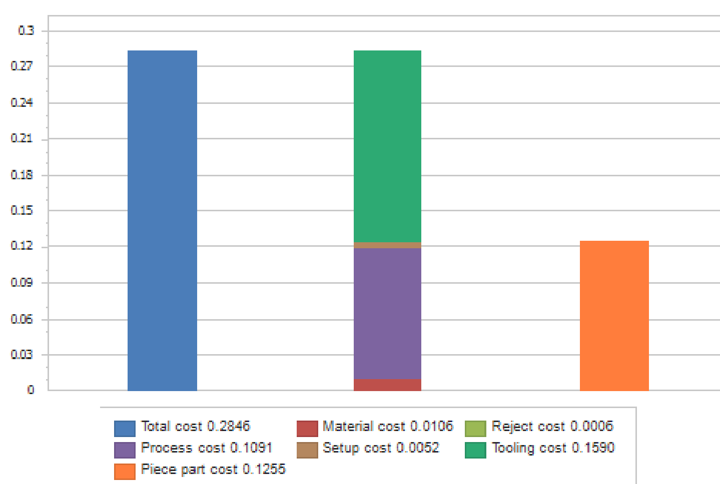


Figure 43: Executive Summary for Peeler-Arm

Analysis Name	no-dfm-power-button
Part name	no-dfm-power-button
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0018
Setup	0.0048
Process	0.0864
Rejects	0.0004
Piece part	0.0934
Tooling	0.1373
Total	0.2307
Initial tooling investment	13725.2680

Life volume	100,000
Batch size	12,500
Part weight	0.003

Figure 44: Cost Estimate for Power Button

Analysis Name: no-dfm-power-button
Part name: no-dfm-power-button
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.2307
Piece part cost, $	0.0934
Initial tooling investment, $	13,725

The chart shows a breakdown of cost per part, $

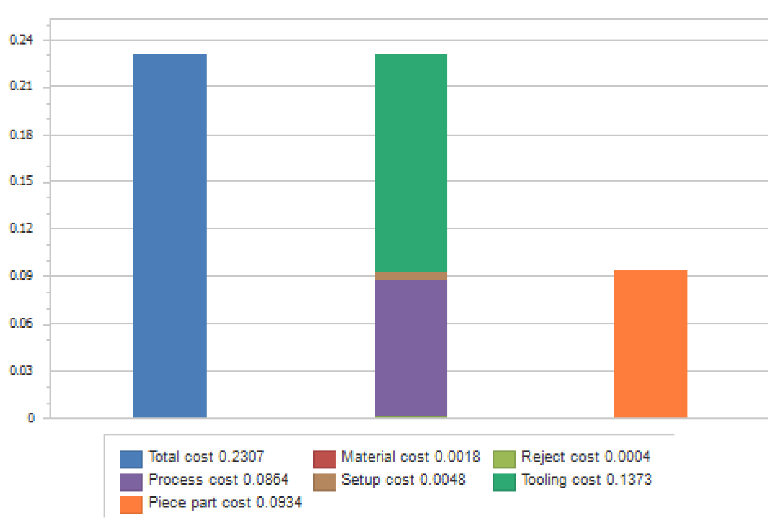


Figure 45: Executive Summary for Power Button

Analysis Name	no-dfm-shaft
Part name	no-dfm-shaft
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.1344
Setup	0.0072
Process	1.0082
Rejects	0.0051
Piece part	1.1549
Tooling	0.5255
Total	1.6804
Initial tooling investment	52551.6174

Life volume	100,000
Batch size	12,500
Part weight	0.345

Figure 46: Cost Estimate for Shaft

Analysis Name: no-dfm-shaft
Part name: no-dfm-shaft
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	1.6804
Piece part cost, $	1.1549
Initial tooling investment, $	52,552

The chart shows a breakdown of cost per part, $

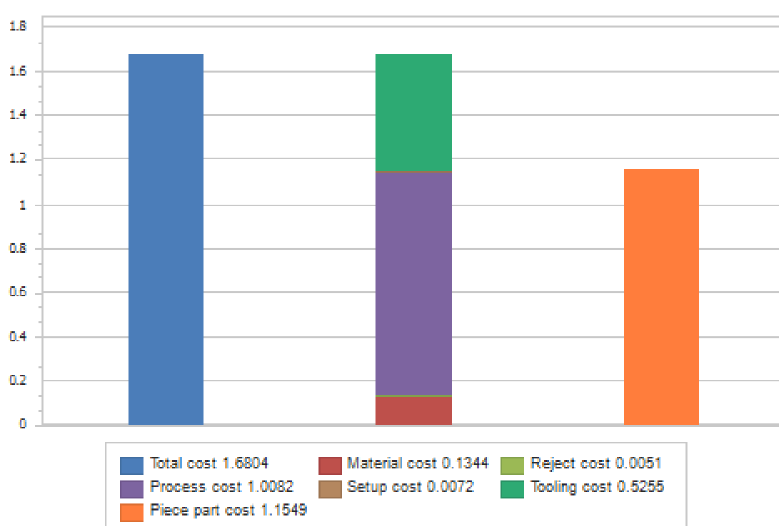


Figure 47: Executive Summary for Shaft

Analysis Name	**no-dfm-upper-food-holder**
Part name	no-dfm-upper-food-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0166
Setup	0.0052
Process	0.1090
Rejects	0.0006
Piece part	0.1314
Tooling	0.2030
Total	0.3344
Initial tooling investment	20300.1808

Life volume	100,000
Batch size	12,500
Part weight	0.041

Figure 48: Cost Estimate for Upper-Food-Holder

Analysis Name: no-dfm-upper-food-holder
Part name: no-dfm-upper-food-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.3344
Piece part cost, $	0.1314
Initial tooling investment, $	20,300

The chart shows a breakdown of cost per part, $

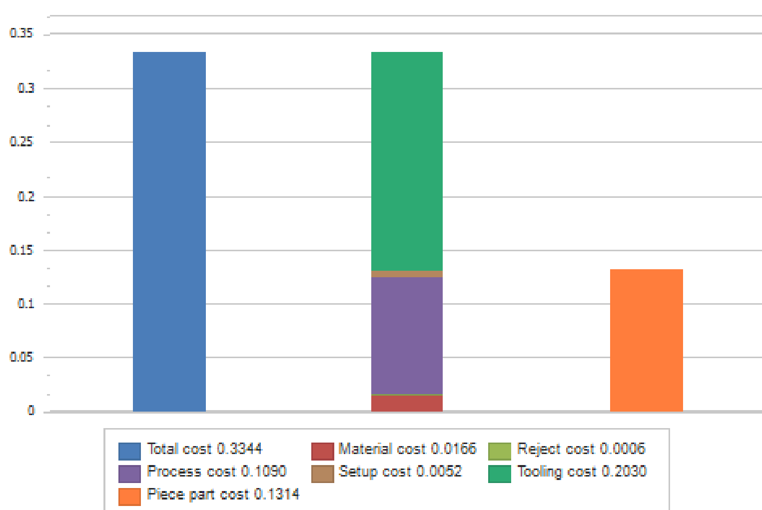


Figure 49: Executive Summary for Upper-Food-Holder

After DFM:

Analysis Name	Base
Part name	Base
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.1872
Setup	0.0072
Process	1.1901
Rejects	0.0060
Piece part	1.3904
Tooling	0.5697
Total	1.9601
Initial tooling investment	56972.7835

Life volume	100,000
Batch size	12,500
Part weight	0.480

Figure 50: Cost Estimate for Base

Analysis Name: Base
Part name: Base
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	1.9601
Piece part cost, $	1.3904
Initial tooling investment, $	56,973

The chart shows a breakdown of cost per part, $

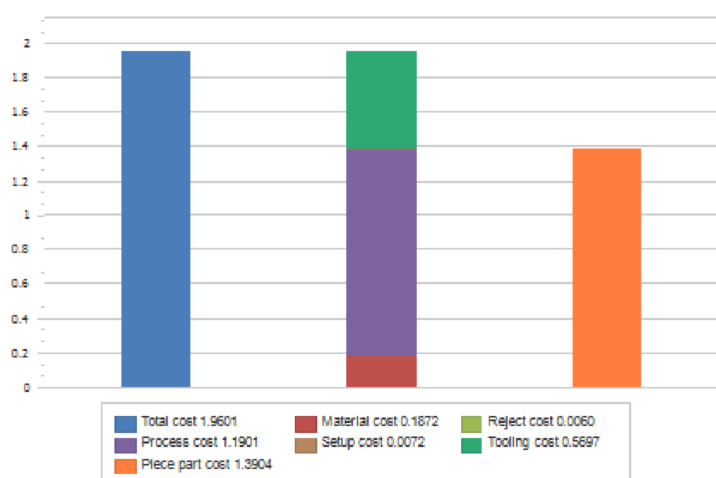


Figure 51: Executive Summary for Base

Analysis Name	Base-Lid
Part name	Base-Lid
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0618
Setup	0.0054
Process	0.3277
Rejects	0.0016
Piece part	0.3965
Tooling	0.2220
Total	0.6185
Initial tooling investment	22197.5701

Life volume	100,000
Batch size	12,500
Part weight	0.158

Figure 52: Cost Estimate for Base Lid

Analysis Name: Base-Lid
Part name: Base-Lid
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.6185
Piece part cost, $	0.3965
Initial tooling investment, $	22,198

The chart shows a breakdown of cost per part, $

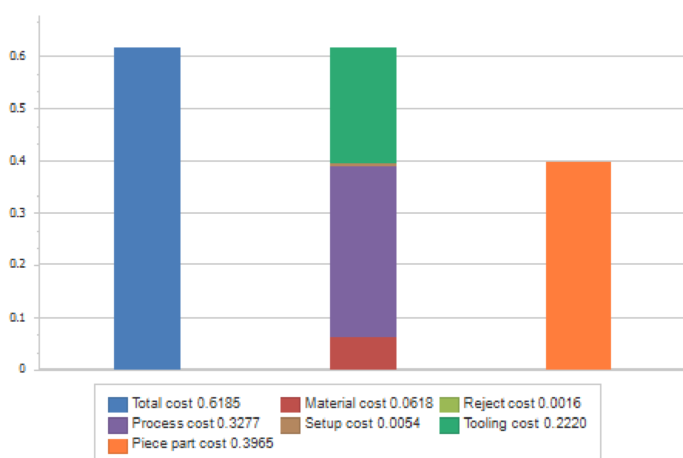


Figure 53: Executive Summary for Base Lid

Analysis Name	blade-holder-arm
Part name	blade-holder-arm
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0010
Setup	0.0048
Process	0.0538
Rejects	0.0003
Piece part	0.0599
Tooling	0.0867
Total	0.1466
Initial tooling investment	8669.4765

Life volume	100,000
Batch size	12,500
Part weight	0.001

Figure 54: Cost Estimate for Blade Holder Arm

Analysis Name: blade-holder-arm
Part name: blade-holder-arm
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.1466
Piece part cost, $	0.0599
Initial tooling investment, $	8,669

The chart shows a breakdown of cost per part, $

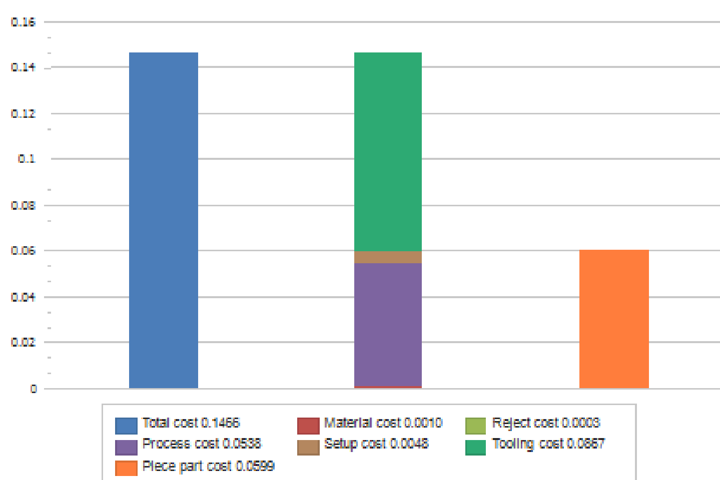


Figure 55: Executive Summary for Blade Holder Arm

Analysis Name	cap
Part name	cap
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0315
Setup	0.0060
Process	0.4909
Rejects	0.0025
Piece part	0.5308
Tooling	0.3887
Total	0.9195
Initial tooling investment	38866.1184

Life volume	100,000
Batch size	12,500
Part weight	0.081

Figure 56: Cost Estimate for Cap

Analysis Name: cap
Part name: cap
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.9195
Piece part cost, $	0.5308
Initial tooling investment, $	38,866

The chart shows a breakdown of cost per part, $

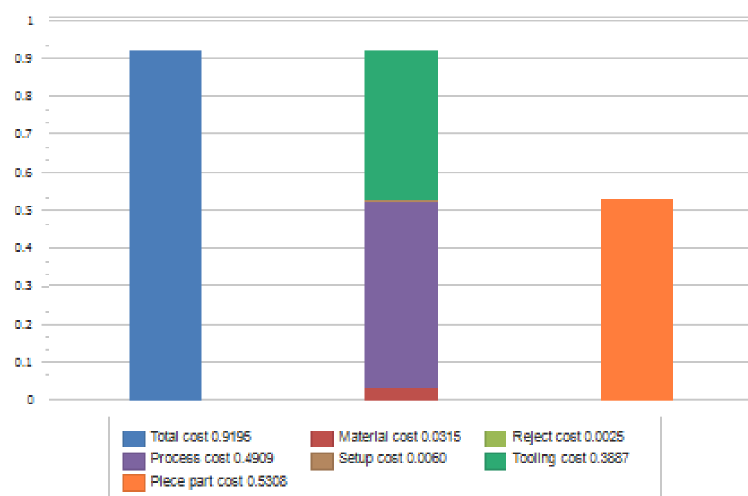


Figure 57: Executive Summary for Cap

Analysis Name	blade-holder-clip
Part name	blade-holder-clip
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0021
Setup	0.0048
Process	0.0805
Rejects	0.0004
Piece part	0.0879
Tooling	0.0791
Total	0.1670
Initial tooling investment	7907.0941

Life volume	100,000
Batch size	12,500
Part weight	0.003

Figure 58: Cost Estimate for Blade Holder Clip

Analysis Name: blade-holder-clip
Part name: blade-holder-clip
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.1670
Piece part cost, $	0.0879
Initial tooling investment, $	7,907

The chart shows a breakdown of cost per part, $

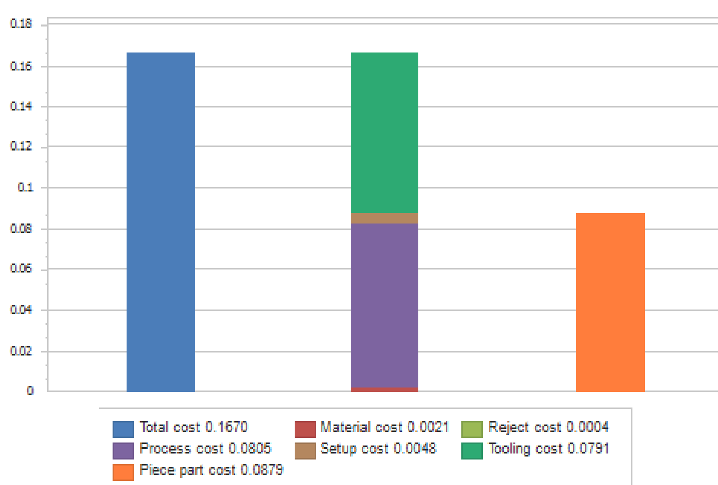


Figure 59: Executive Summary for Blade Holder Clip

Analysis Name	peeler-arm-holder
Part name	peeler-arm-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0308
Setup	0.0060
Process	0.3826
Rejects	0.0019
Piece part	0.4213
Tooling	0.3877
Total	0.8090
Initial tooling investment	38766.9996

Life volume	100,000
Batch size	12,500
Part weight	0.079

Figure 60: Cost Estimate for Peeler Arm Holder

Analysis Name: peeler-arm-holder
Part name: peeler-arm-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.8090
Piece part cost, $	0.4213
Initial tooling investment, $	38,767

The chart shows a breakdown of cost per part, $

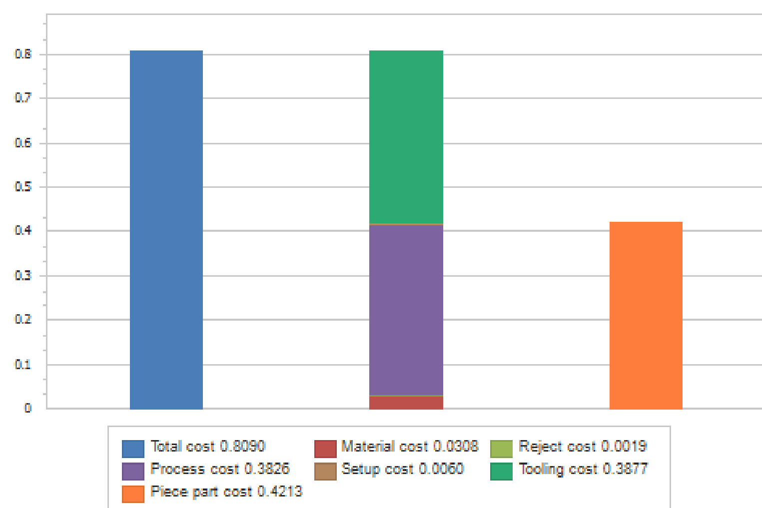


Figure 61: Executive Summary for Peeler Arm Holder

Analysis Name	peeler-arm SLDPRT
Part name	peeler-armSLDPRT
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0106
Setup	0.0052
Process	0.1113
Rejects	0.0006
Piece part	0.1277
Tooling	0.1589
Total	0.2866
Initial tooling investment	15889.3760

Life volume	100,000
Batch size	12,500
Part weight	0.024

Figure 62: Cost Estimate for Peeler Arm

Analysis Name: peeler-armSLDPRT
Part name: peeler-armSLDPRT
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.2866
Piece part cost, $	0.1277
Initial tooling investment, $	15,889

The chart shows a breakdown of cost per part, $

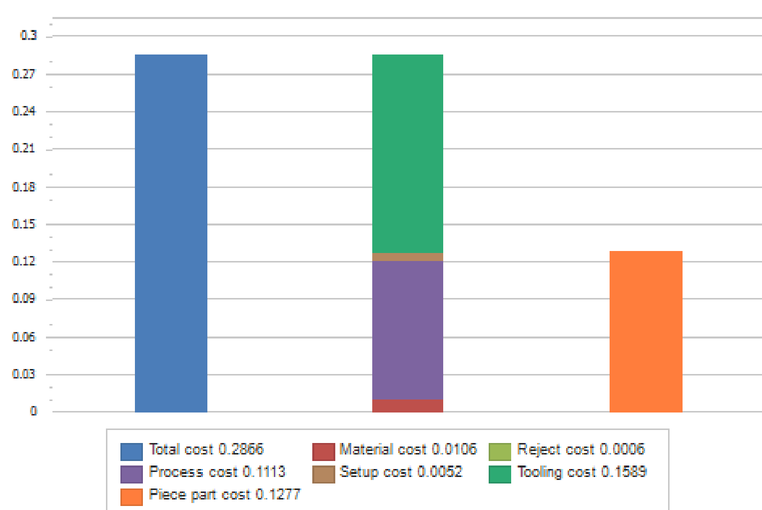


Figure 63: Executive Summary for Peeler Arm

Analysis Name	**shaft**
Part name	shaft
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.1330
Setup	0.0072
Process	0.9891
Rejects	0.0050
Piece part	1.1343
Tooling	0.5227
Total	1.6570
Initial tooling investment	52269.0625

Life volume	100,000
Batch size	12,500
Part weight	0.341

Figure 64: Cost Estimate for Shaft

Analysis Name: shaft
Part name: shaft
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	1.6570
Piece part cost, $	1.1343
Initial tooling investment, $	52,269

The chart shows a breakdown of cost per part, $

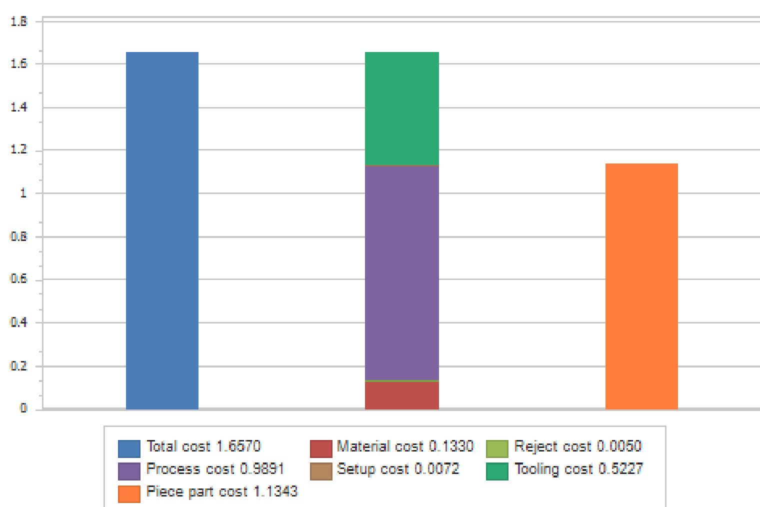


Figure 65: Executive Summary for Shaft

Analysis Name	blade-holder
Part name	blade-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0015
Setup	0.0048
Process	0.0437
Rejects	0.0002
Piece part	0.0502
Tooling	0.1010
Total	0.1512
Initial tooling investment	10102.8362

Life volume	100,000
Batch size	12,500
Part weight	0.002

Figure 66: Cost Estimate for Blade Holder

Analysis Name: blade-holder
Part name: blade-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.1512
Piece part cost, $	0.0502
Initial tooling investment, $	10,103

The chart shows a breakdown of cost per part, $

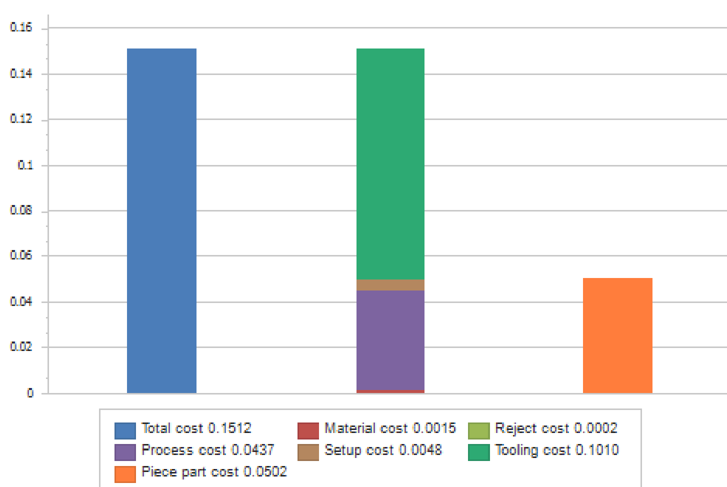


Figure 67: Executive Summary for Blade Holder

Analysis Name	bottomfood-holder
Part name	bottomfood-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0065
Setup	0.0052
Process	0.1990
Rejects	0.0010
Piece part	0.2117
Tooling	0.1898
Total	0.4015
Initial tooling investment	18984.9483

Life volume	100,000
Batch size	12,500
Part weight	0.013

Figure 68: Executive Summary for Bottom-Food Holder

Analysis Name: bottomfood-holder
Part name: bottomfood-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.4015
Piece part cost, $	0.2117
Initial tooling investment, $	18,985

The chart shows a breakdown of cost per part, $

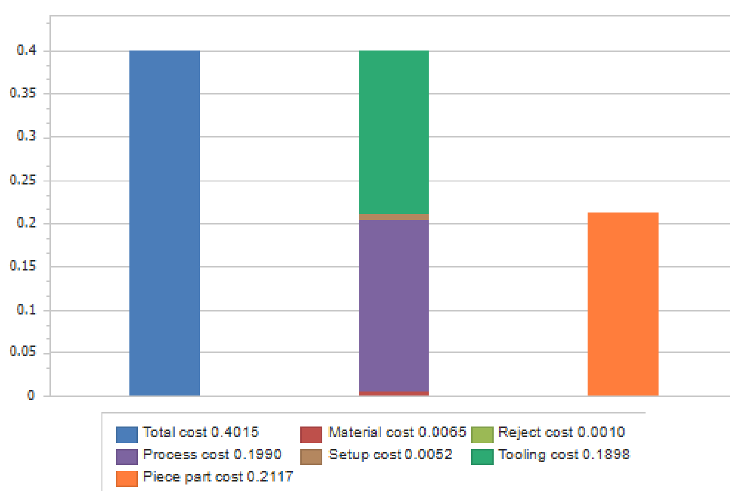


Figure 69: Executive Summary for Bottom-Food Holder

Analysis Name	power-button
Part name	power-button
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0016
Setup	0.0048
Process	0.0935
Rejects	0.0005
Piece part	0.1004
Tooling	0.1021
Total	0.2025
Initial tooling investment	10206.3420

Life volume	100,000
Batch size	12,500
Part weight	0.002

Figure 70: Executive Summary for Power Button

Analysis Name: power-button
Part name: power-button
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.2025
Piece part cost, $	0.1004
Initial tooling investment, $	10,206

The chart shows a breakdown of cost per part, $

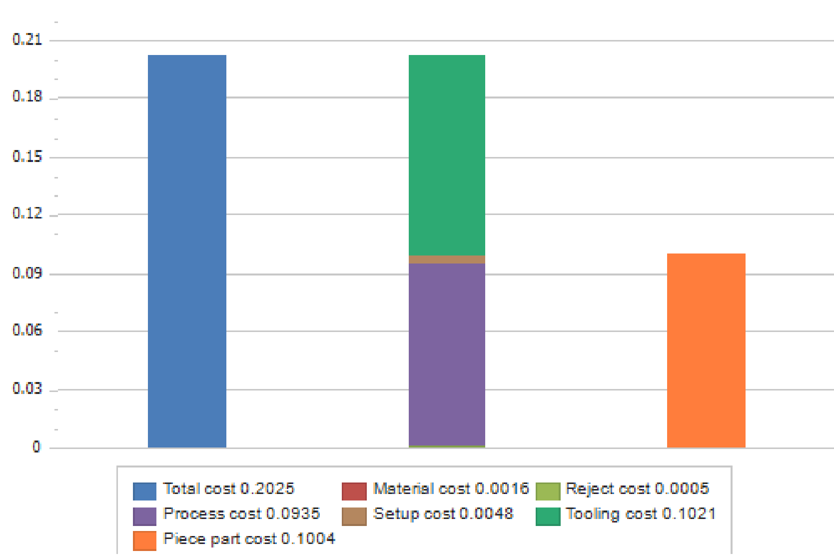


Figure 71: Executive Summary for Power Button

Analysis Name	upper-food-holder
Part name	upper-food-holder
Part number	
Material	High density polyethylene
Manufacturing process	Injection molding
Manufacturing profile	20A BDI North America

Cost per part, $	Value
Material	0.0155
Setup	0.0052
Process	0.0995
Rejects	0.0006
Piece part	0.1207
Tooling	0.1975
Total	0.3182
Initial tooling investment	19747.1744

Life volume	100,000
Batch size	12,500
Part weight	0.038

Figure 72: Executive Summary for Upper-Food-Holder

Analysis Name: upper-food-holder
Part name: upper-food-holder
Part number:

Material name: High density polyethylene
Manufacturing process: Injection molding
Manufacturing profile: 20A BDI North America

Product life volume	100,000
Batch size	12,500
Total cost, $	0.3182
Piece part cost, $	0.1207
Initial tooling investment, $	19,747

The chart shows a breakdown of cost per part, $

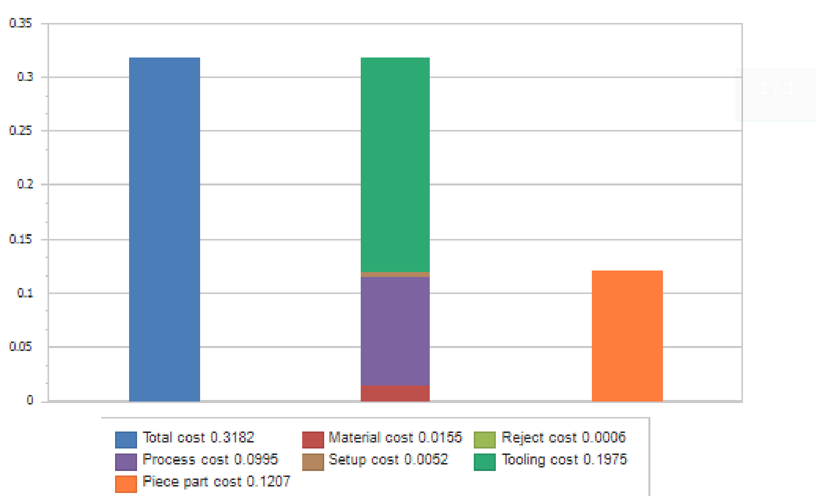


Figure 73: Executive Summary for Upper-Food-Holder

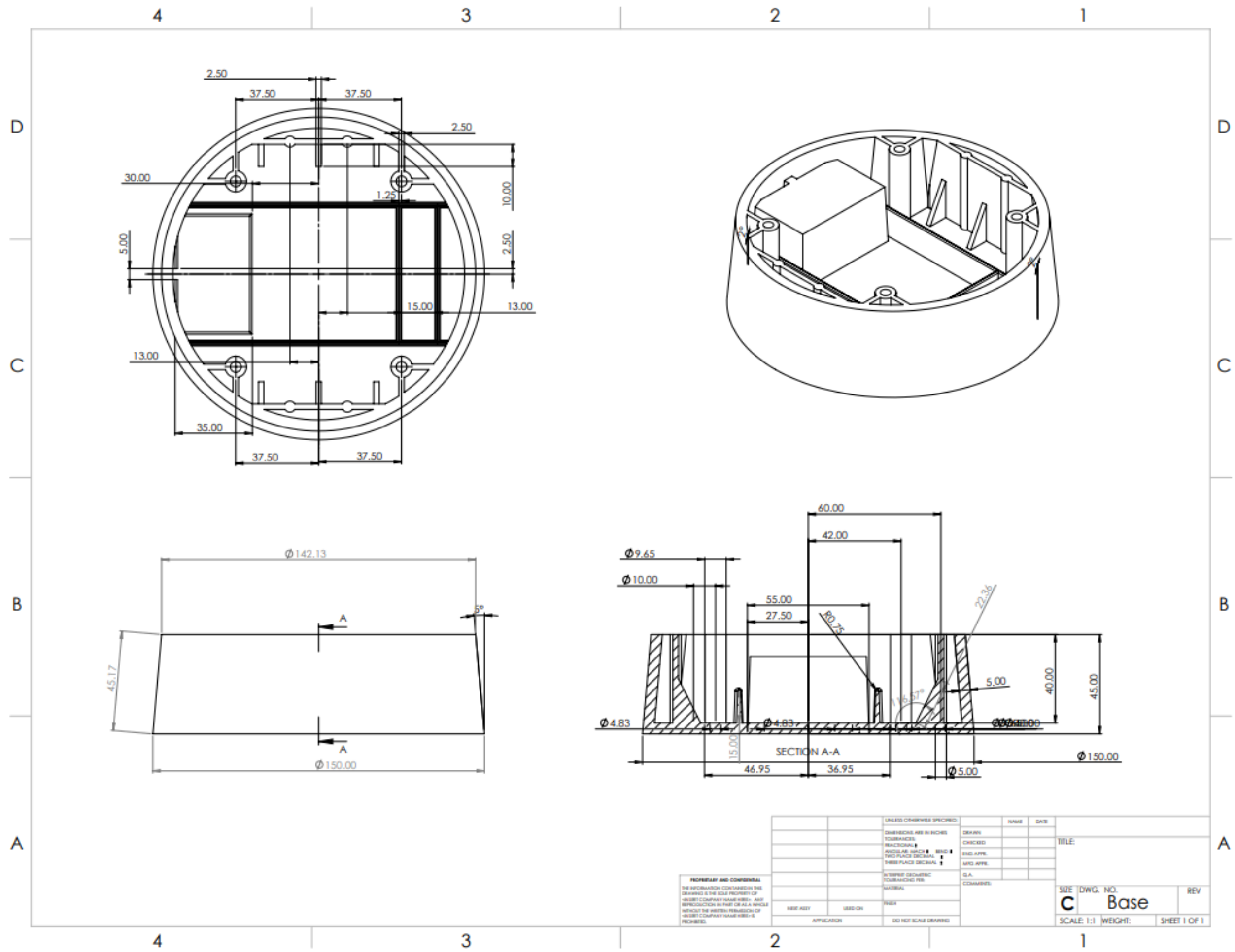


Figure 74: Drawing of Base

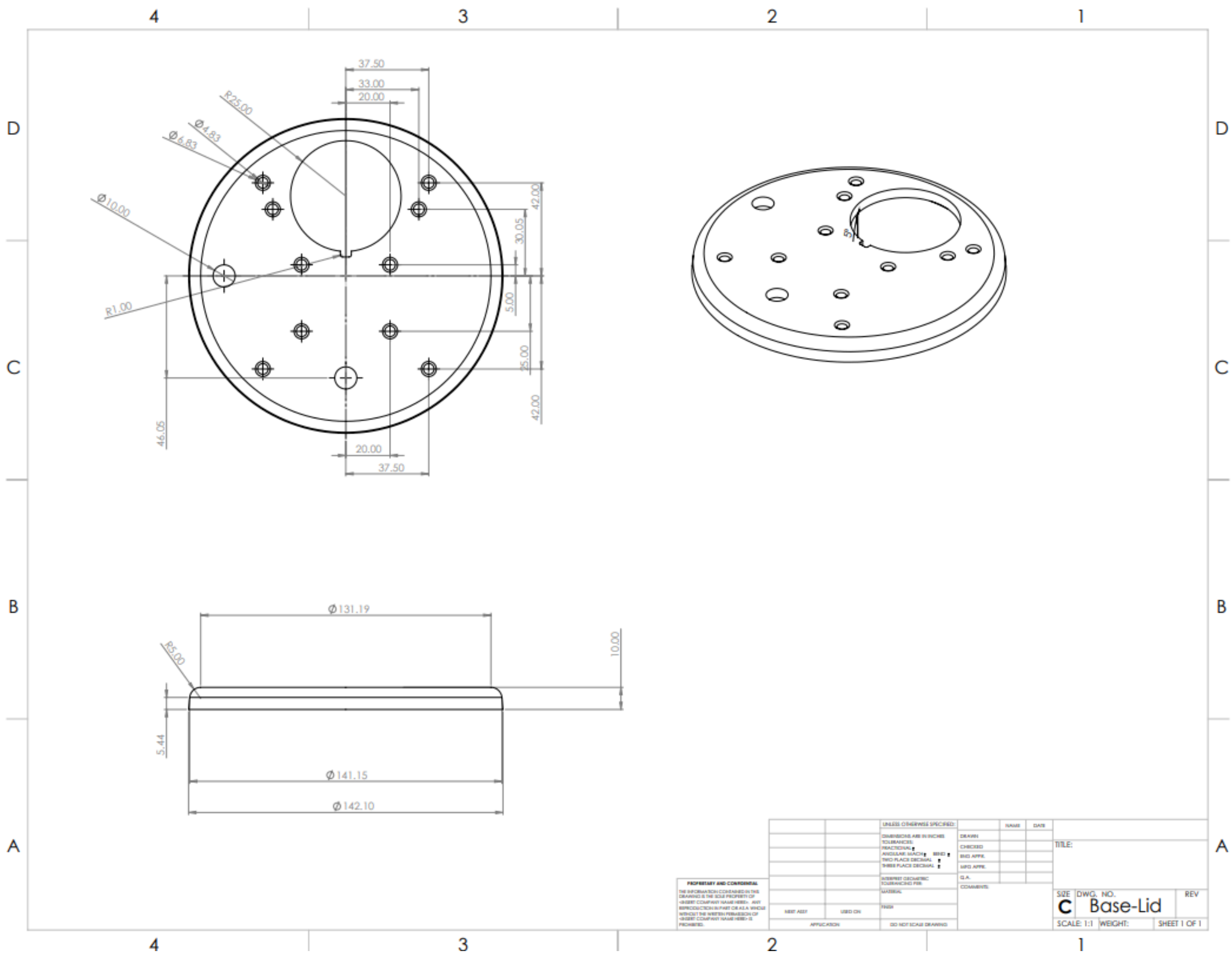


Figure 75: Drawing of Base Lid

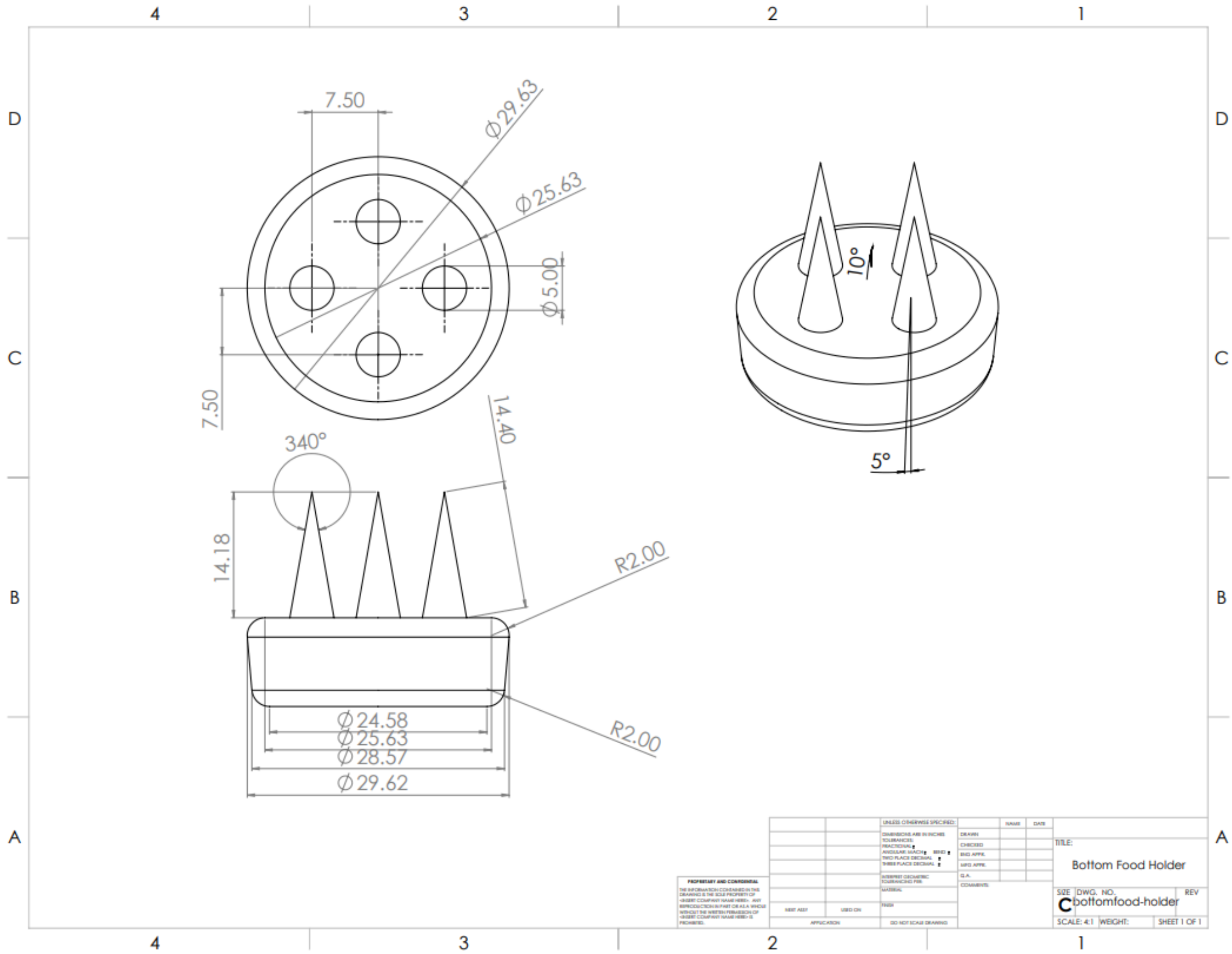


Figure 76: Drawing of Bottom Food Holder

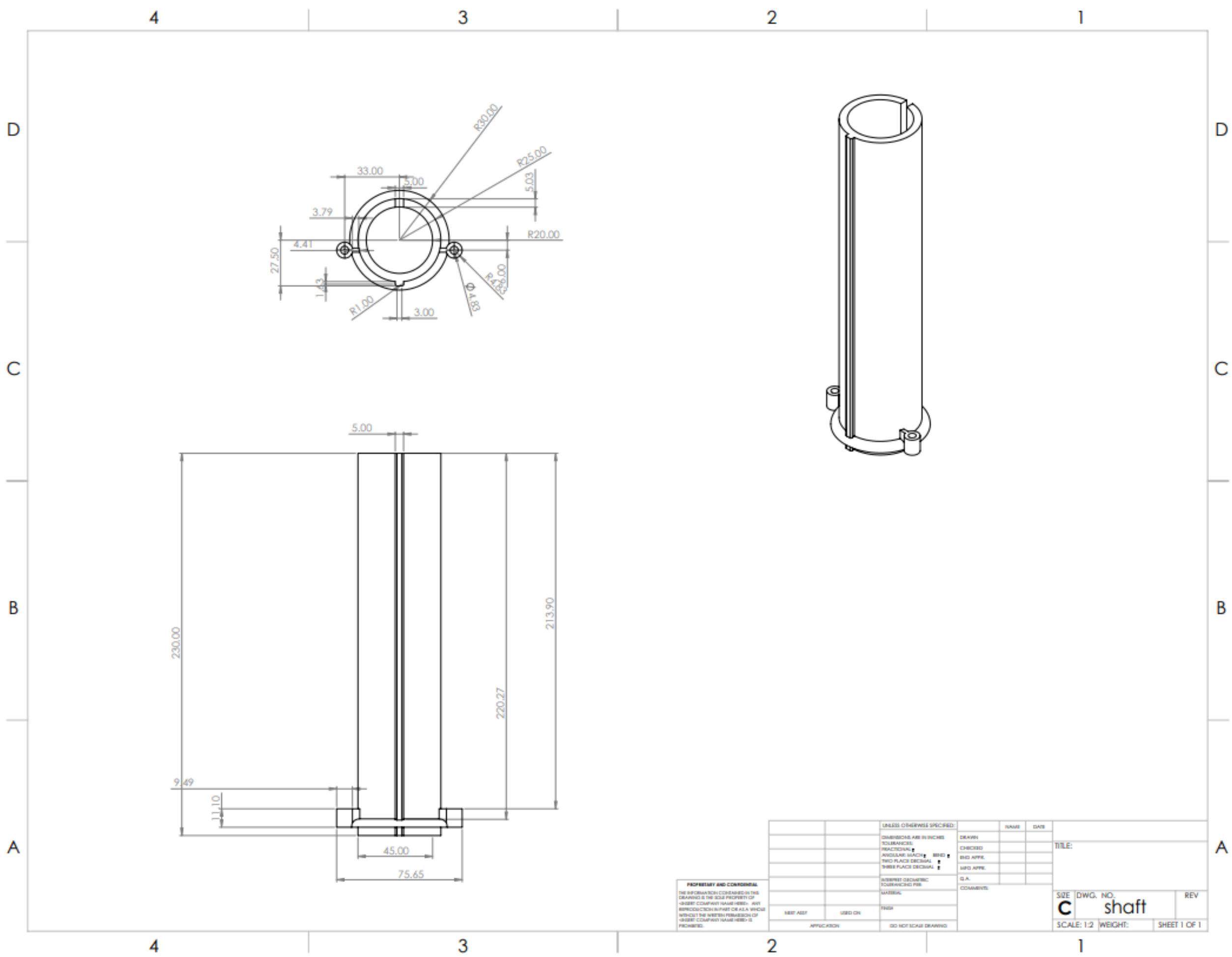


Figure 77: Drawing of Shaft

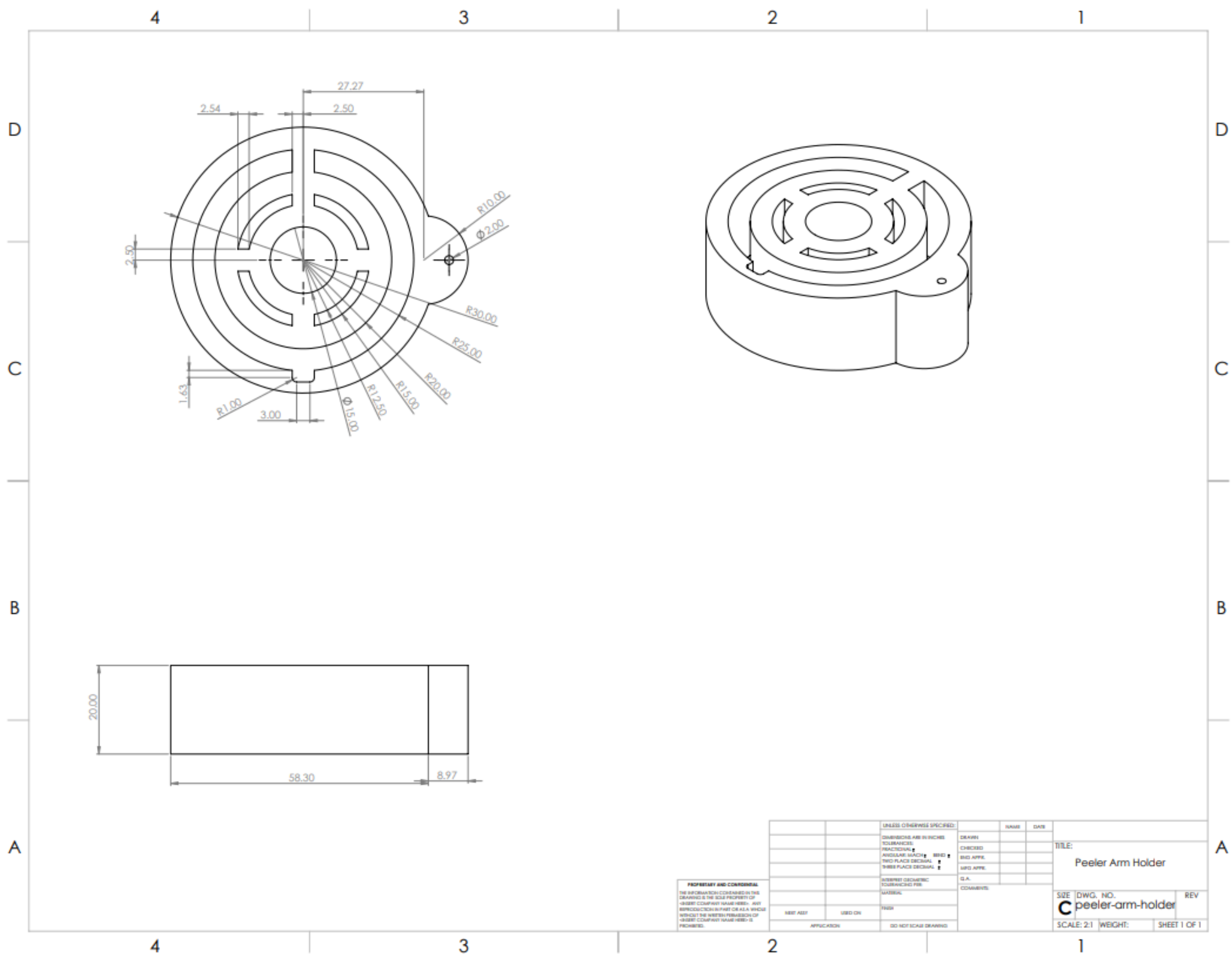


Figure78: Drawing of Peeler Arm Holder

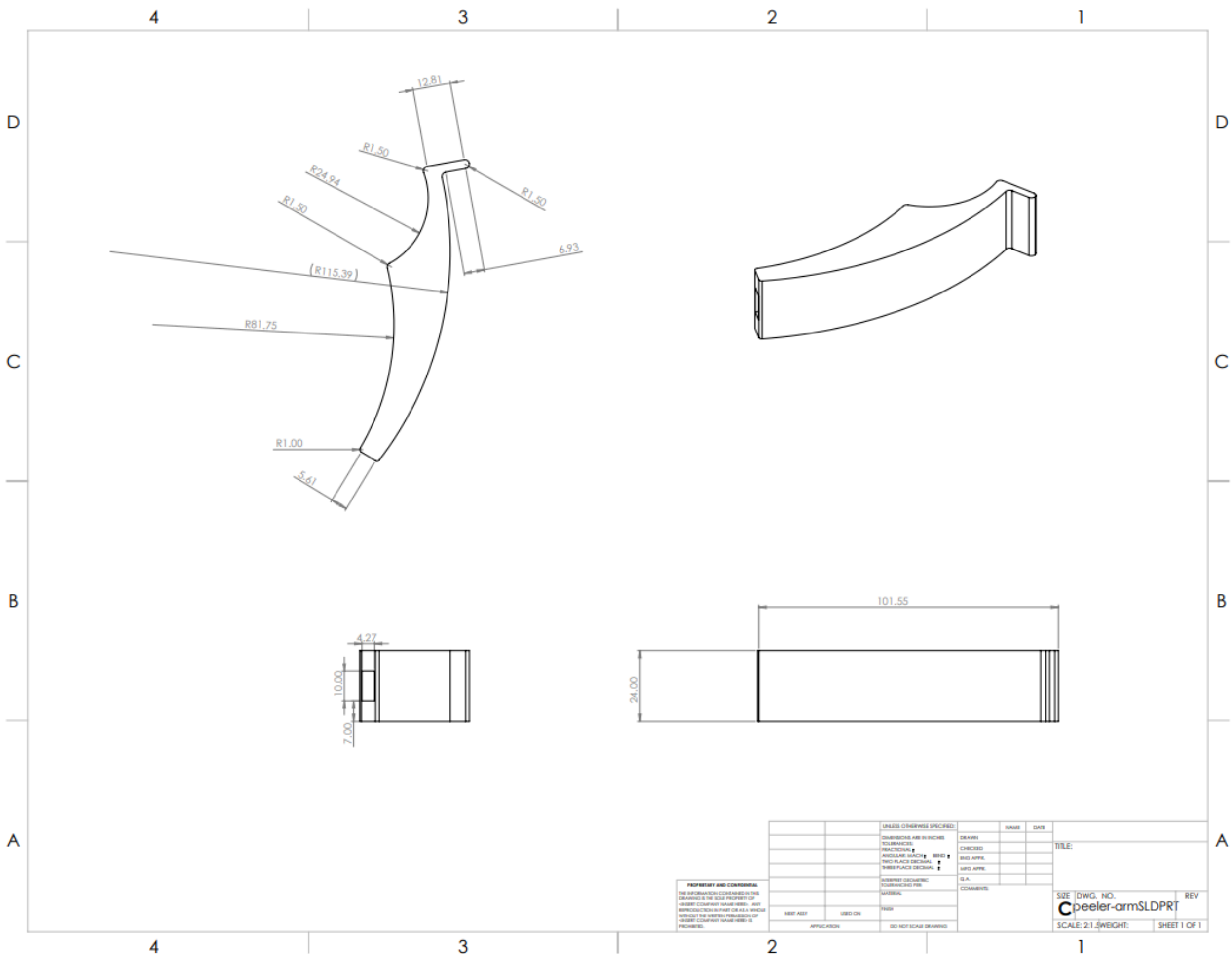


Figure 79: Drawing of Peeler Arm

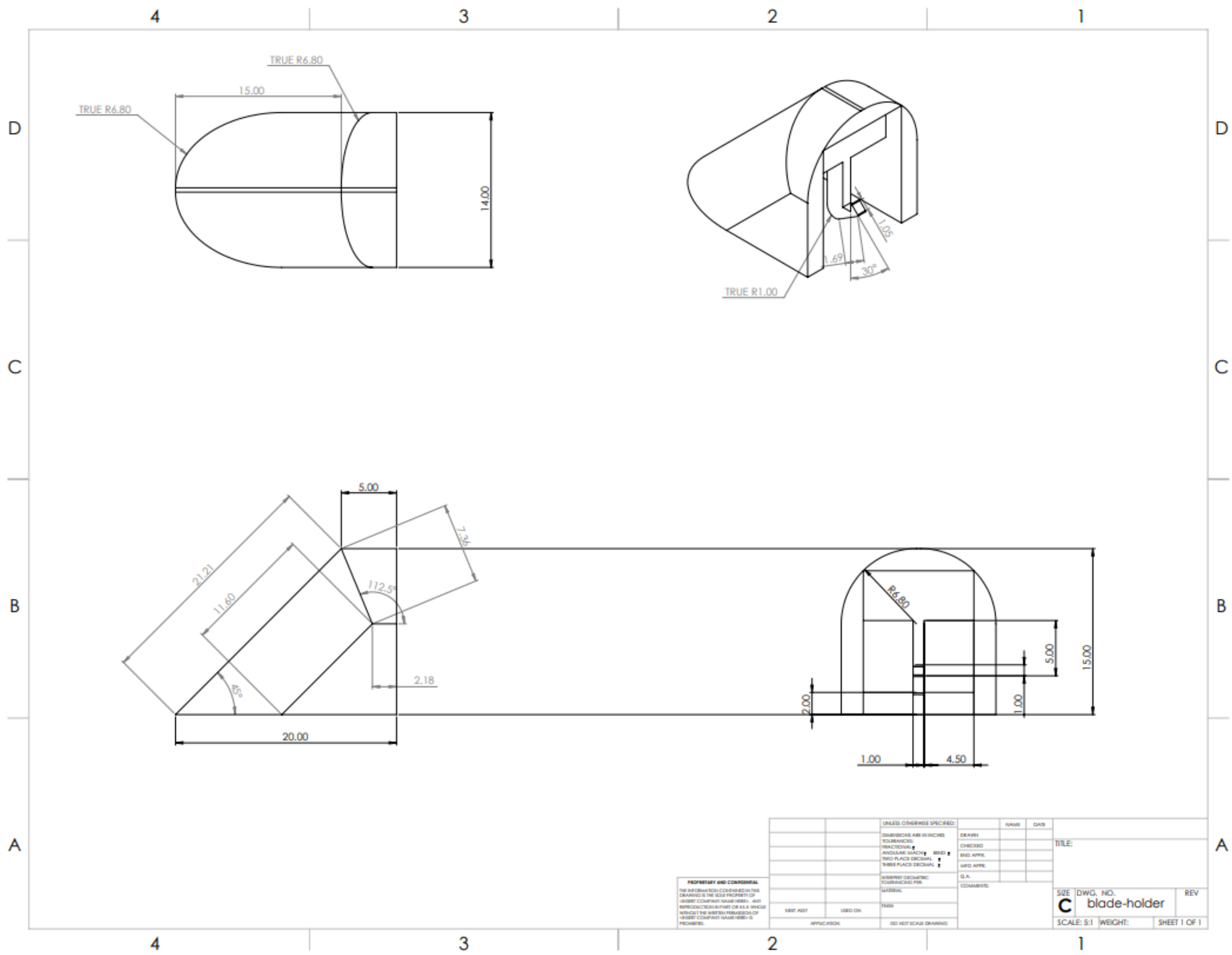


Figure 80: Drawing of Blade

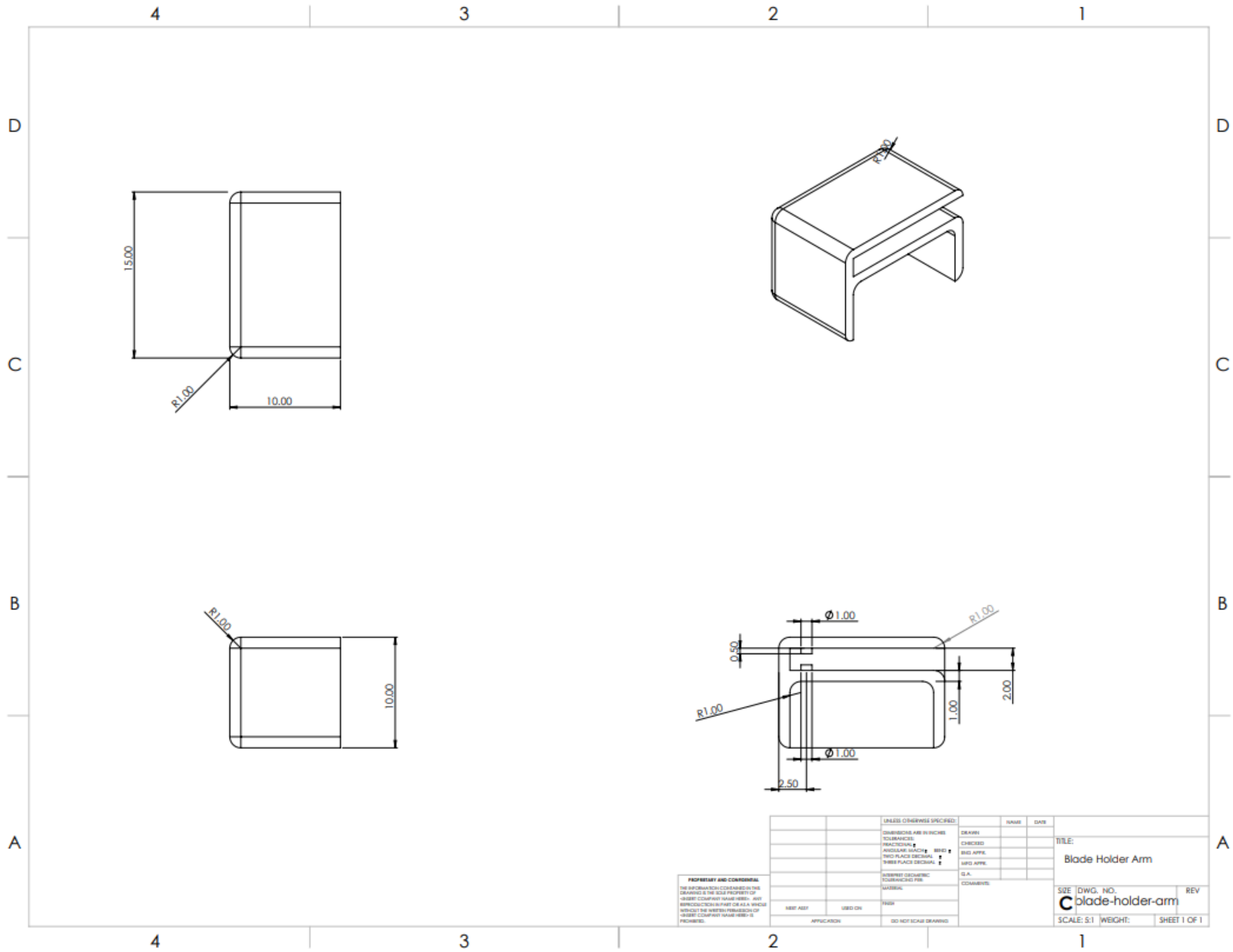


Figure 81: Drawing of Blade Holder Arm

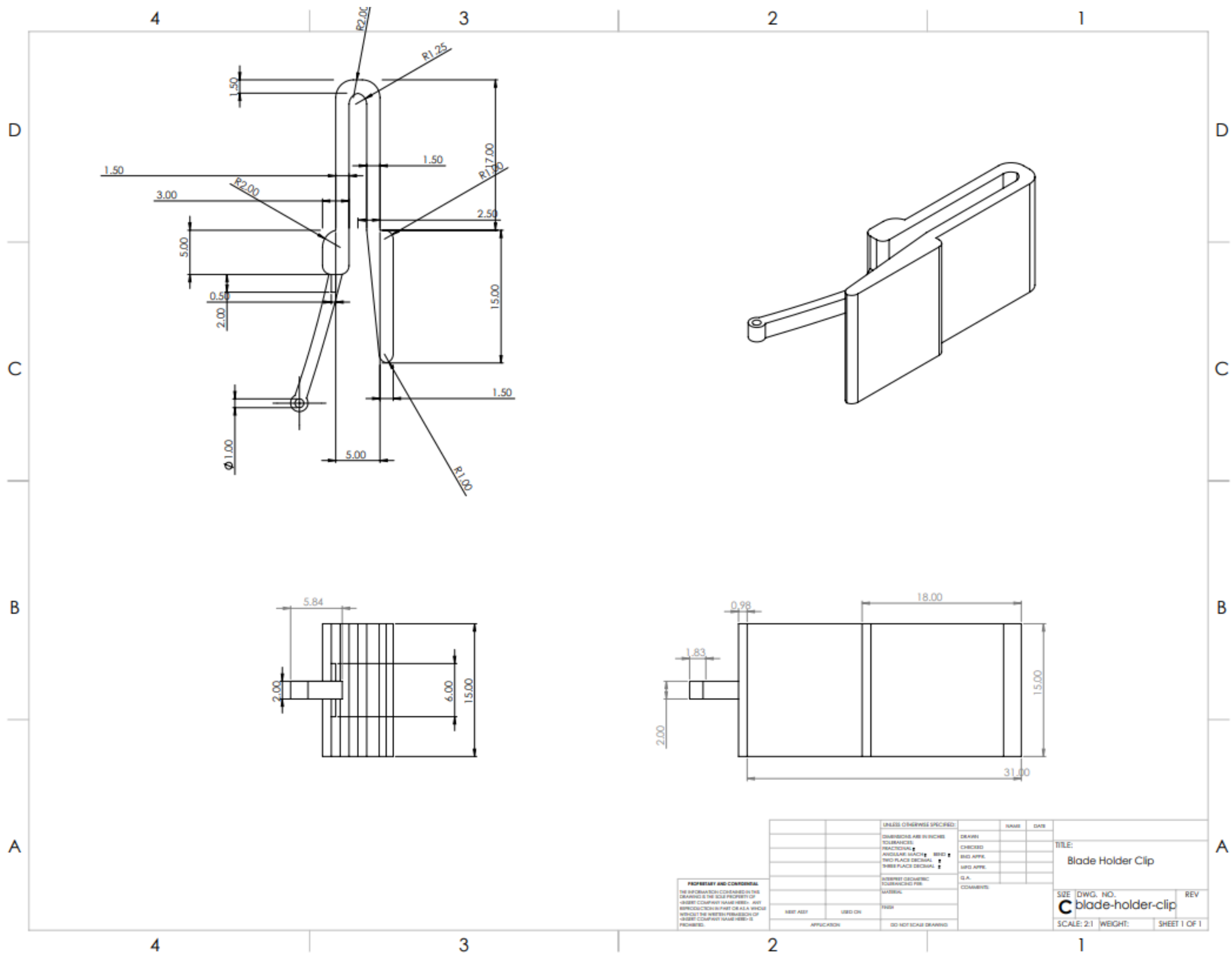


Figure 82: Drawing of Blade Holder Clip

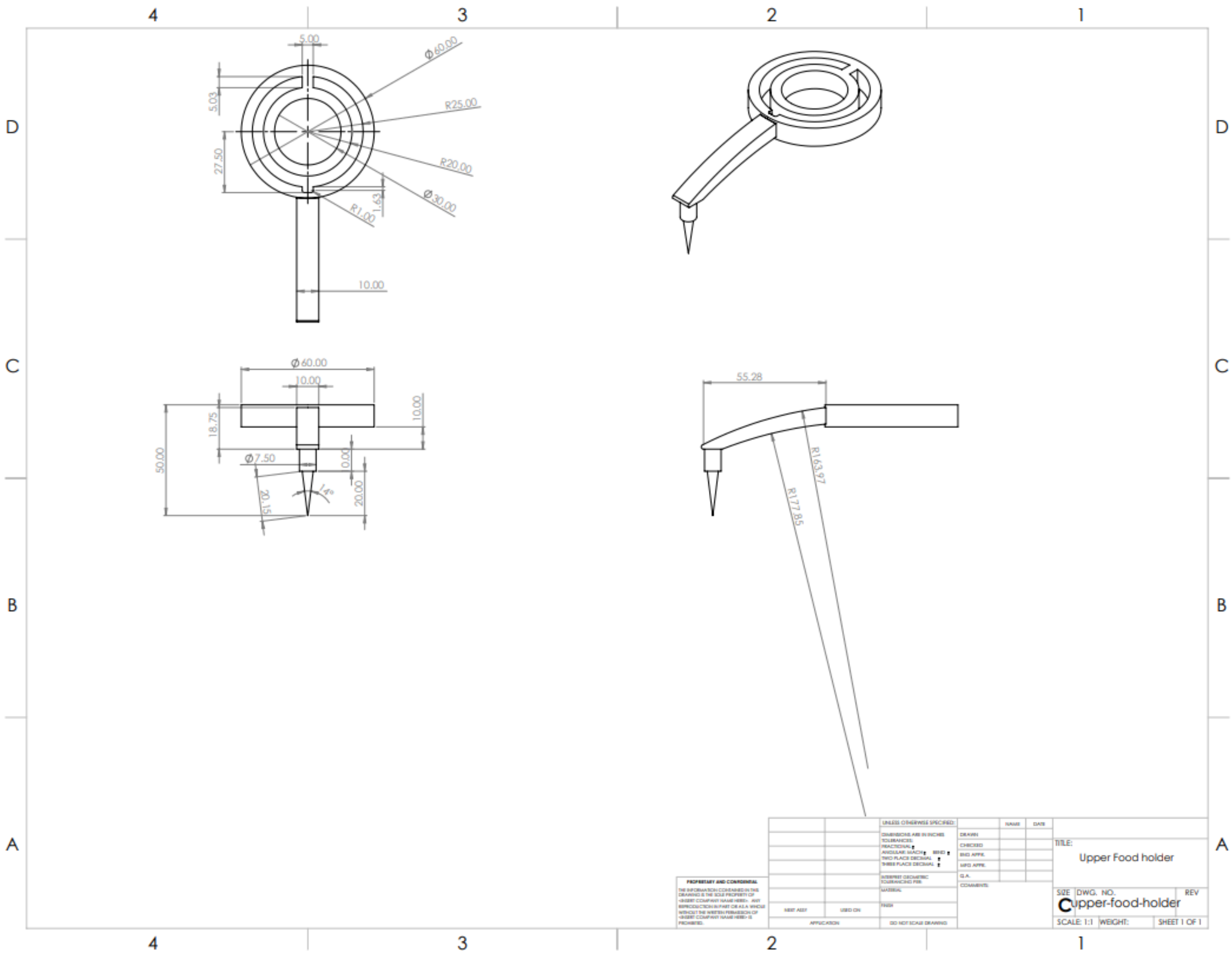


Figure 83: Drawing of Upper Food Holder

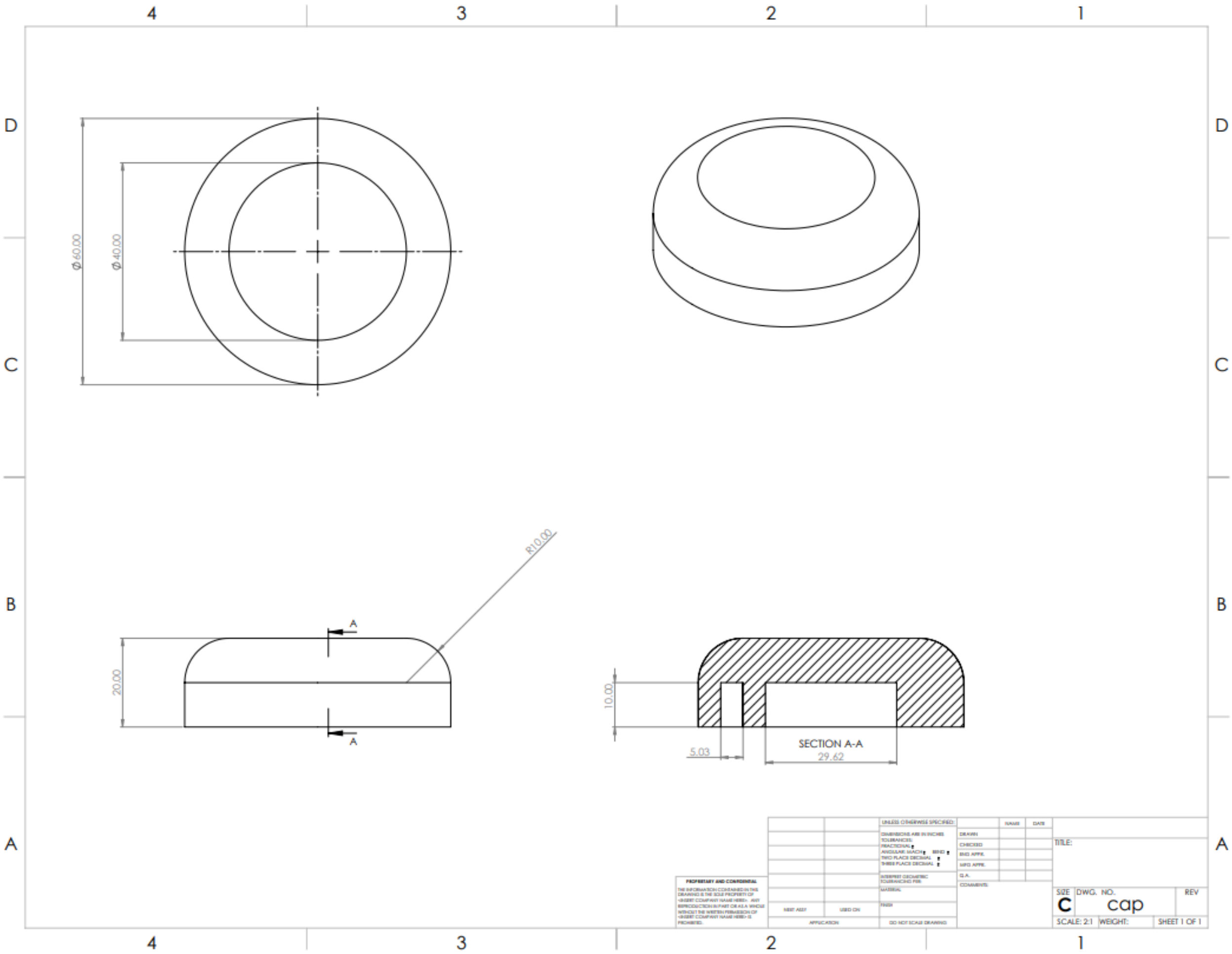


Figure 84: Drawing of Cap

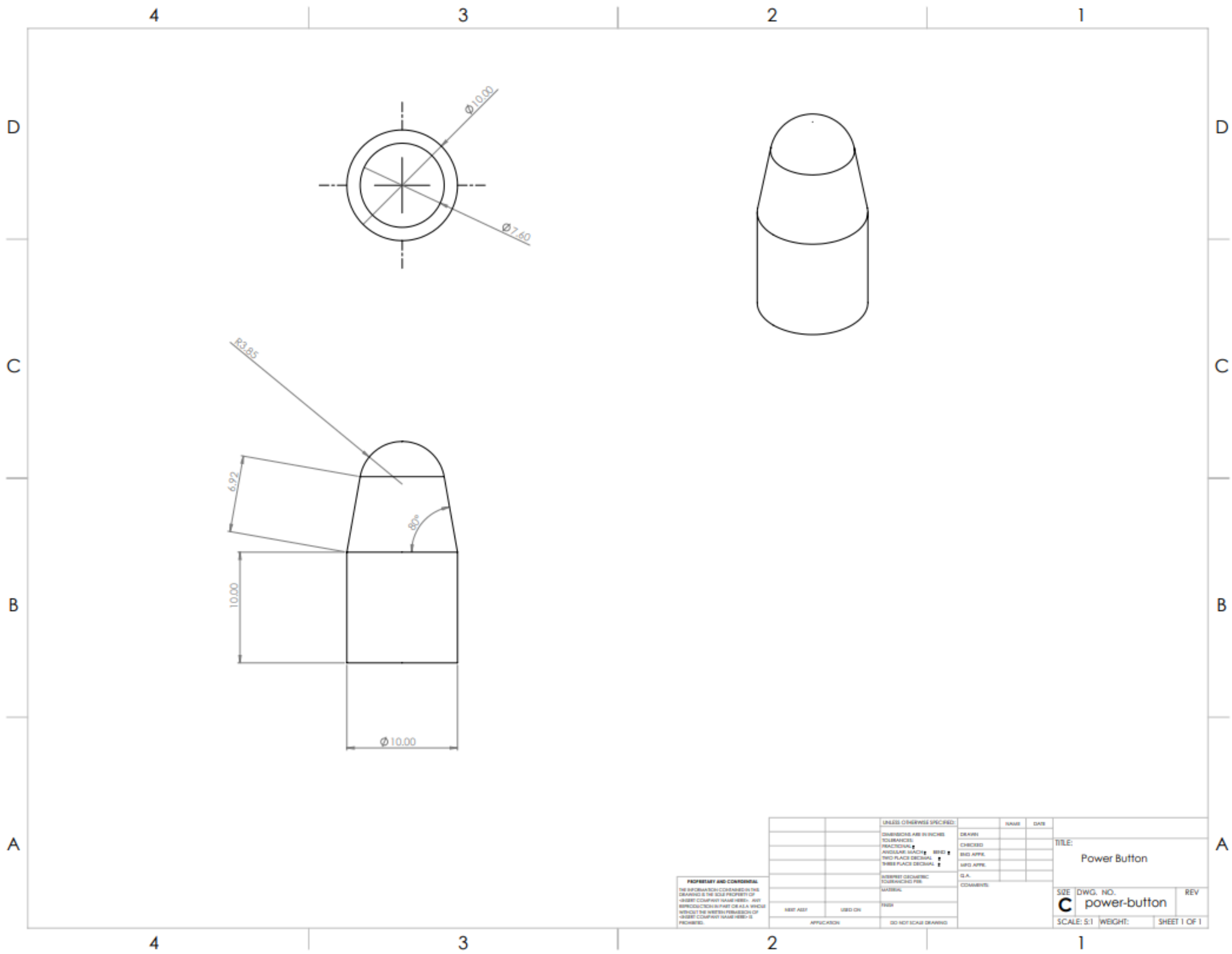


Figure 85: Drawing of Power Button

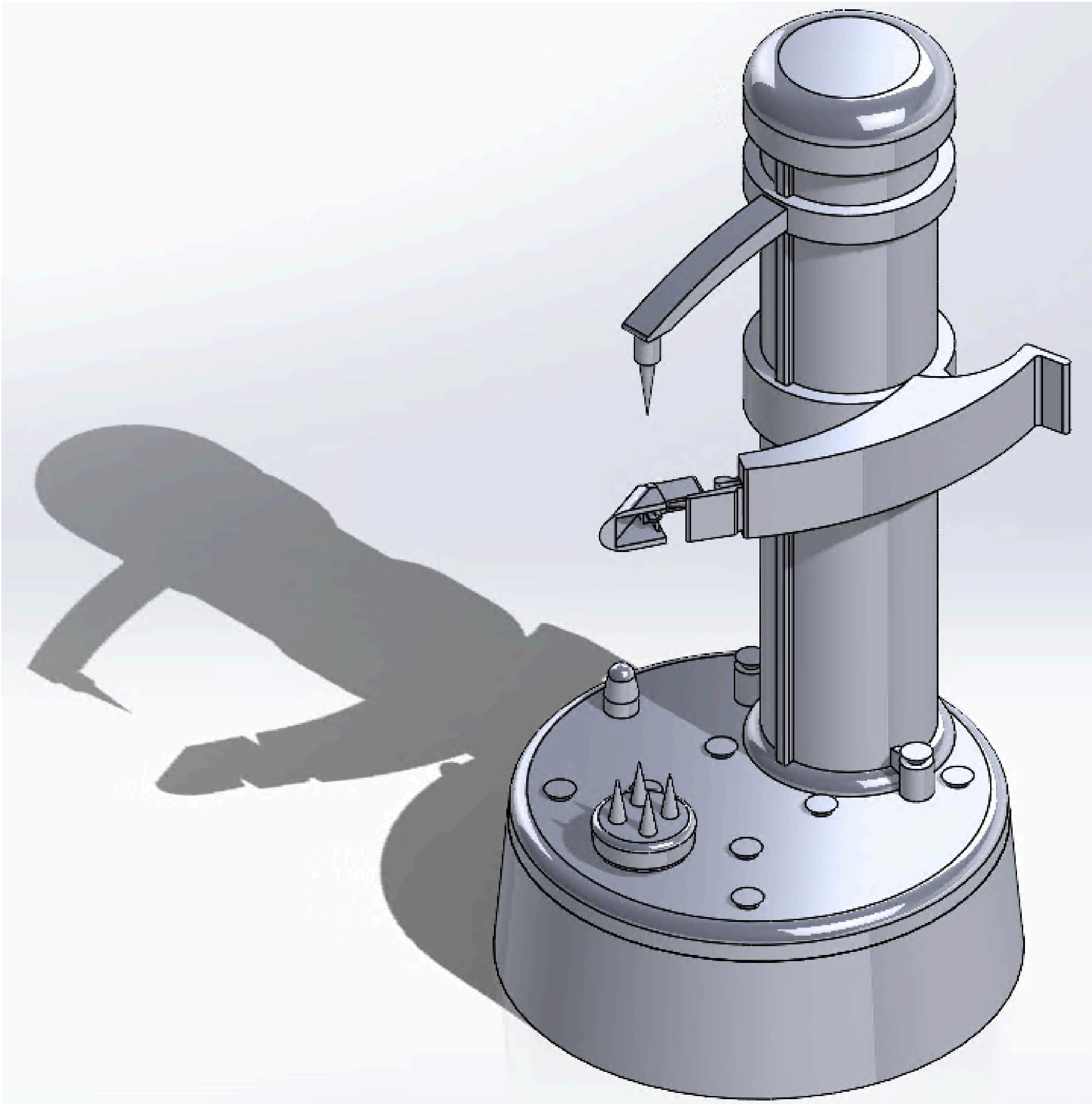


Figure 86: Final Assembly of Kitchen Peeler (Before DFA)

Item No.	Part	Qty.
1	Base	1
2	Base Lid	1
3	Motor	1
4	Gearbox	1
5	Lead Screw Shaft	1
6	Shaft	1
7	Philips 10-24-0.75	10
8	Bottom Holder	1
9	Battery	1
10	Power Button	1
11	Blade Holder Arm	1
12	Blade Holder Clip	1
13	Cap	1
14	Blader Holder	1
15	Peeler Arm	1
16	Upper Holder	1
17	Peeler Arm Holder	1

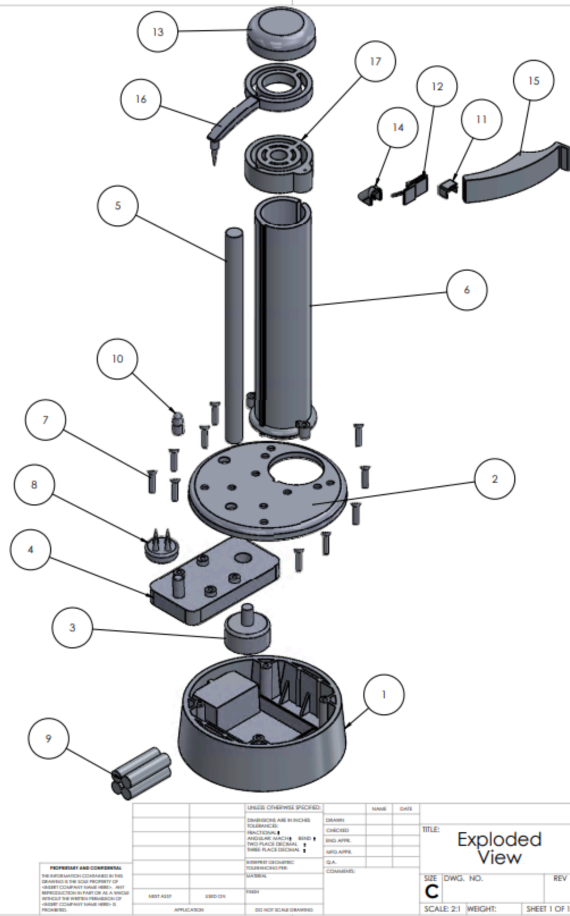


Figure 87: Exploded Assembly View of Kitchen Peeler

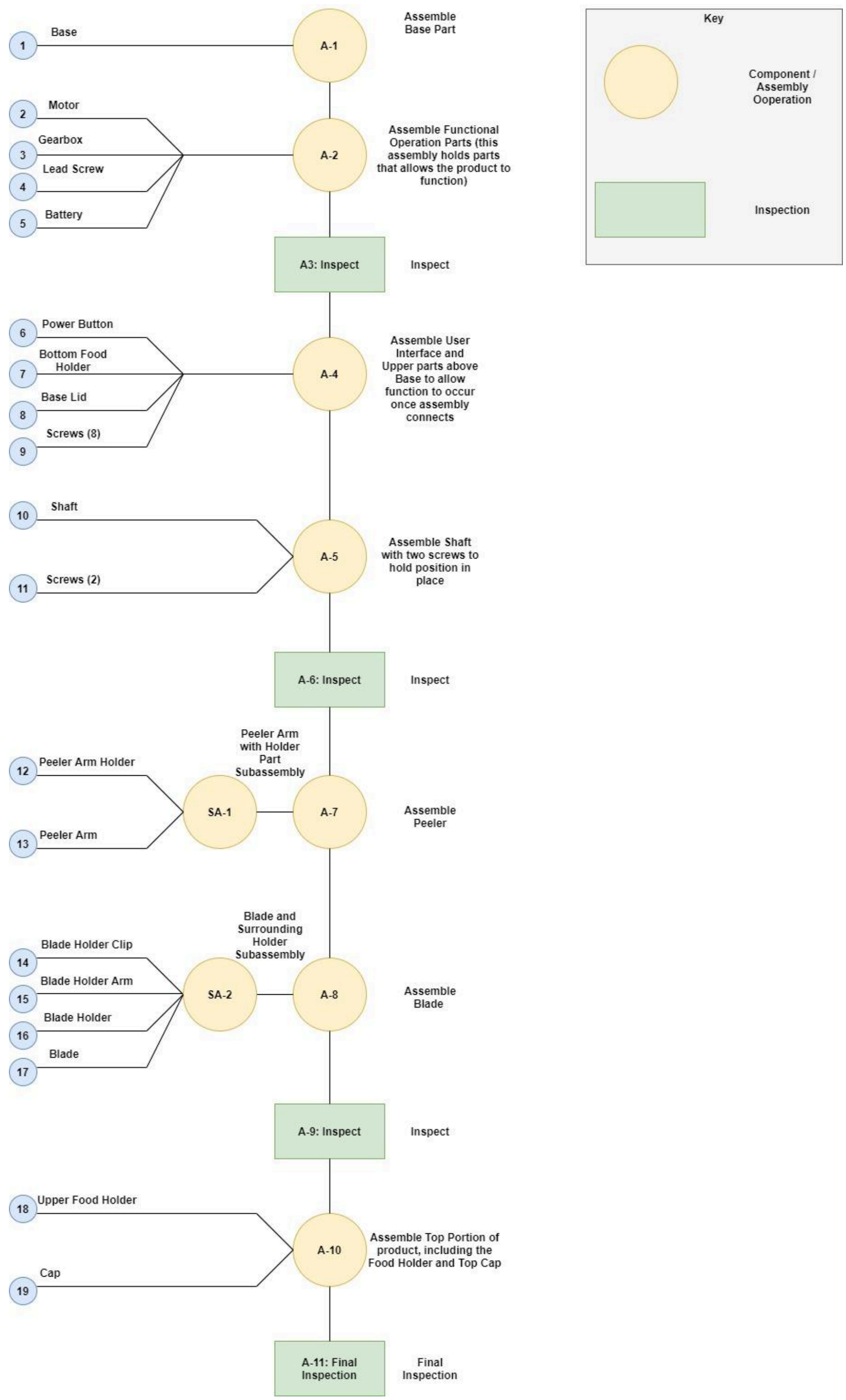
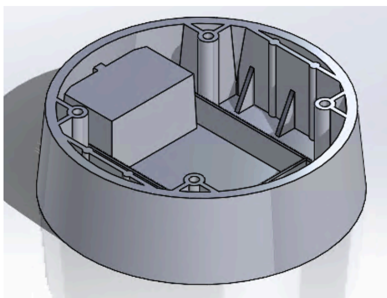
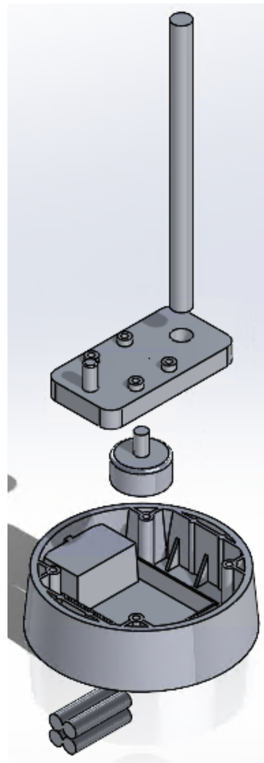
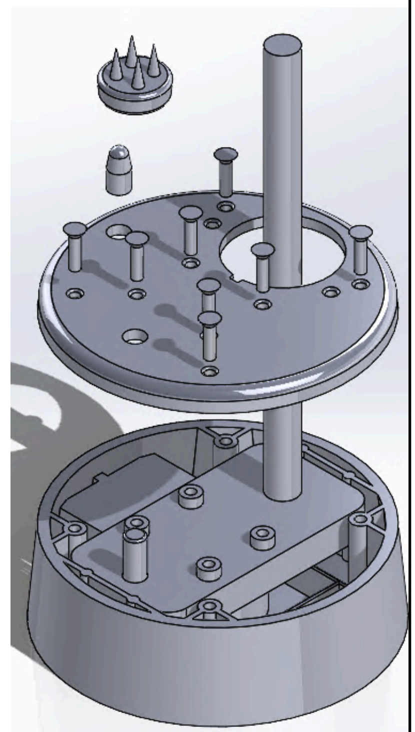
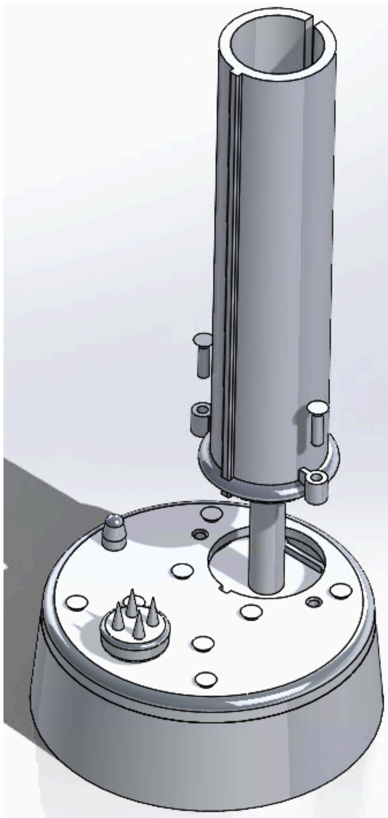
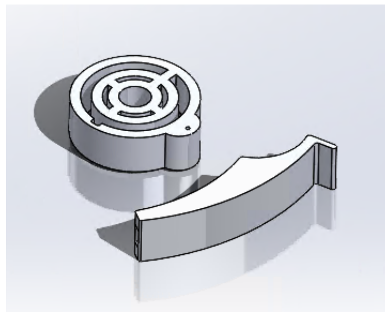
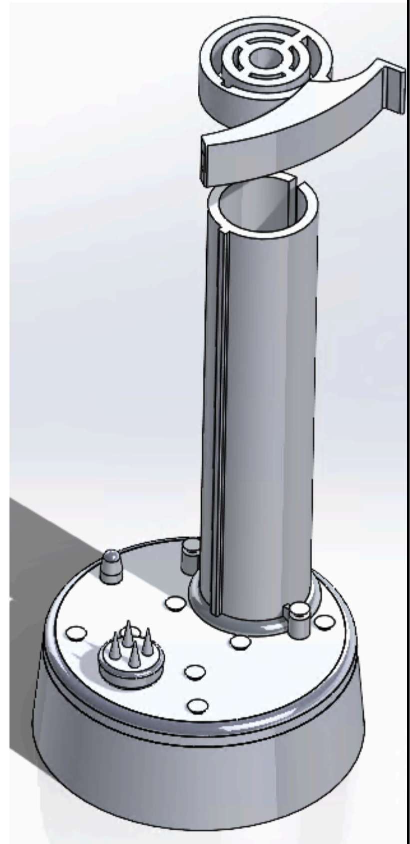
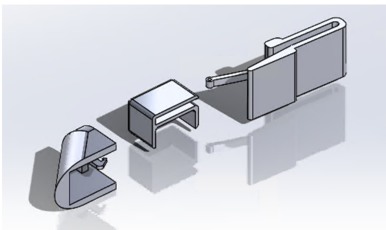
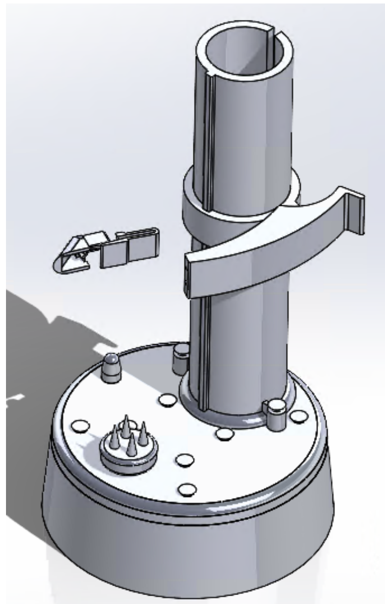
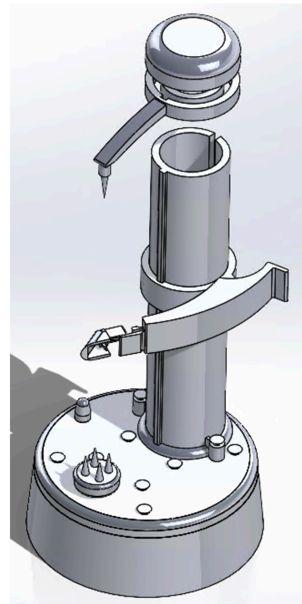


Figure 88: Assembly Chart

A1	A2	A4
		

A5	SA1	A7
		

SA2	A8	A10
		

Final Assembly

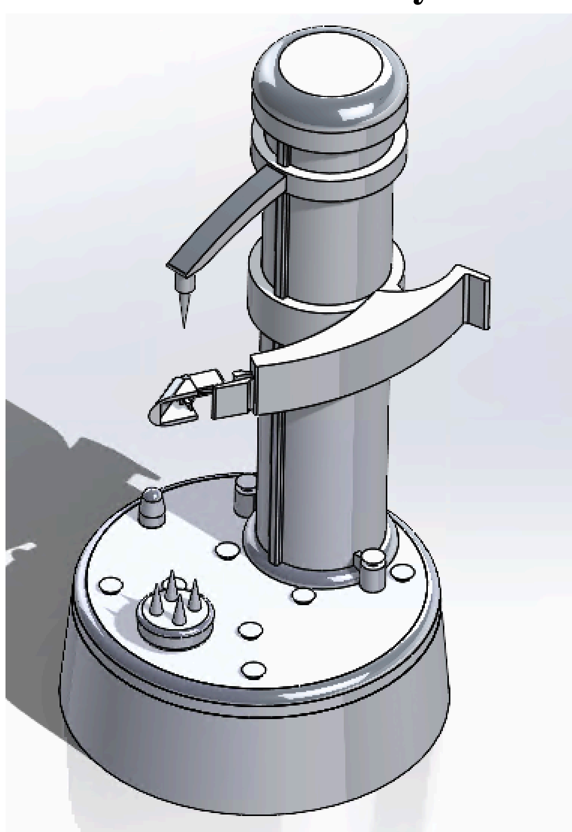


Figure 89: Exploded View Assembly Chart

Appendix 3: Milestone 3 DFA

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Assembly Totals for Design for Assembly (DFA)
November 26, 2021

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DFA-Current-Peeler.dfax

Entries including repeats	Original
Parts meet minimum part criteria	11
Parts are candidates for elimination	11
Analyzed subassemblies	2
Separate assembly operations	10
Total entries	34

Assembly labor time, s	
Parts meet minimum part criteria	58.27
Parts are candidates for elimination	78.79
Insertion of analyzed subassemblies	7.84
Separate assembly operations	49.80
Total assembly labor time	195

Design efficiency	
DFA Index	20.46

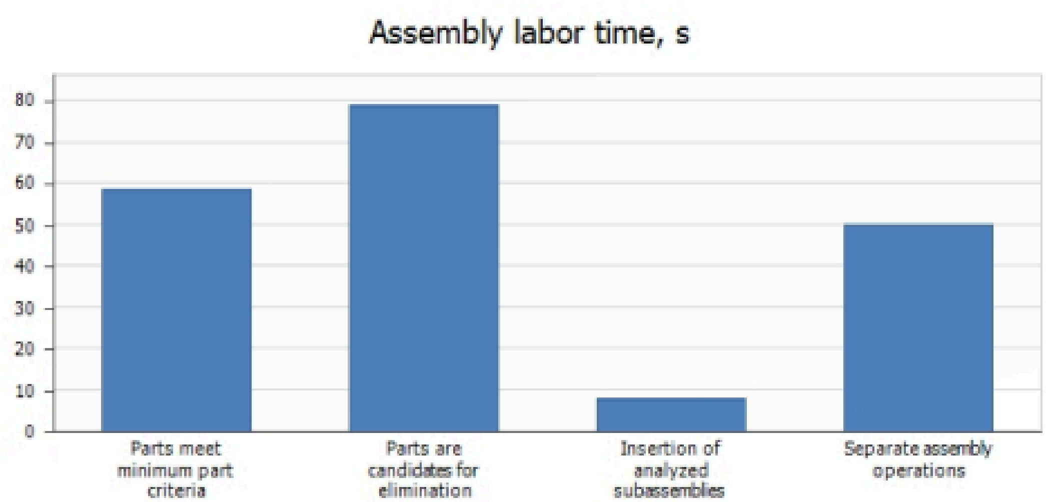

Figure 90: DFA Current Design

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Product Worksheet

DFMA
BOOTHROYD DEWHURST

Original

November 26, 2021 DFA-Current-Peeler.dfax

Name	Part number	Repeat count	Total count	Minimum items	Minimum part criteria	Process time per entry, s	Process time per product, s
Motorized Peeler			34	11			194.70
Base		1	1	1	Base part	3.54	3.54
Base-Lid		1	1	1	Assembly	4.54	4.54
power-button		1	1	1	Movement	4.73	4.73
bottomfood-holder		1	1	1	Movement	4.73	4.73
philips-10-24-0.75-placeholder-packandgo		8	8	0	Fastener	57.86	57.86
Threaded fastening		8	8			38.10	38.10
shaft		1	1	1	Assembly	3.22	3.22
philips-10-24-0.75-placeholder-packandgo		2	2	0	Fastener	16.64	16.64
Threaded fastening		2	2			11.70	11.70
Peeler Arm Subassembly		1	1			4.30	4.30
peeler-arm-holder		1	1	1	Movement	3.54	3.54
peeler-armSLDPRT		1	1	1	Movement	9.29	9.29
Blade Holder Subassembly		1	1			3.54	3.54
blade-holder-clip		1	1	0	Connector	4.29	4.29
blade-holder-arm		1	1	1	Movement	10.59	10.59
blade-holder		1	1	1	Movement	5.38	5.38
upper-food-holder		1	1	1	Movement	4.73	4.73
cap		1	1	1	Assembly	3.98	3.98

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Figure 91: DFA Product Worksheet - Current Design

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Product Worksheet

DFMA® BOOTHROYD DEWHURST

Original
DFA-Current-Peeler.dfax

November 26, 2021

Name	Process cost per product, $	Piece part cost per item, $	Piece part cost per product	Total cost per product without tooling, $	Assembly tool or fixture cost, $	Manufacturing tooling investment, $	Manufacturing tooling cost per item, $
Motorized Peeler	2.55		5.63	8.18	0.00	300579.00	
Base	0.05	1.39	1.39	1.44	0.00	56973.00	5.70
Base-Lid	0.06	0.40	0.40	0.46	0.00	22198.00	2.22
power-button	0.06	0.10	0.10	0.16	0.00	10206.00	1.02
bottomfood-holder	0.06	0.21	0.21	0.27	0.00	18985.00	1.90
philips-10-24-0.75-placeholder-packandgo	0.76	0.10	0.80	1.56	0.00	0.00	0.00
Threaded fastening	0.50			0.50	0.00		
shaft	0.04	1.13	1.13	1.18	0.00	52269.00	5.23
philips-10-24-0.75-placeholder-packandgo	0.22	0.10	0.20	0.42	0.00	0.00	0.00
Threaded fastening	0.15			0.15	0.00		
Peeler Arm Subassembly	0.06	0.00	0.00	0.06	0.00	0.00	0.00
peeler-arm-holder	0.05	0.42	0.42	0.47	0.00	38767.00	3.88
peeler-armSLDPRT	0.12	0.13	0.13	0.25	0.00	15889.00	1.59
Blade Holder Subassembly	0.05	0.00	0.00	0.05	0.00	0.00	0.00
blade-holder-clip	0.06	0.09	0.09	0.14	0.00	7907.00	0.79
blade-holder-arm	0.14	0.06	0.06	0.20	0.00	8669.00	0.87
blade-holder	0.07	0.05	0.05	0.12	0.00	10103.00	1.01
upper-food-holder	0.06	0.12	0.12	0.18	0.00	19747.00	1.97
cap	0.05	0.53	0.53	0.58	0.00	38866.00	3.89

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Figure 92: DFA Product Worksheet - Current Design

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Product Worksheet

November 26, 2021

DFMA BOOTHROYD DEWHURST

Original
DFA-Current-Peeler.dfax

Name	Item cost per item, $	Item cost per product, $	Total cost, $	Notes
Motorized Peeler		8.64	11.18	
Base	1.96	1.96	2.01	
Base-Lid	0.62	0.62	0.68	
power-button	0.20	0.20	0.26	
bottomfood-holder	0.40	0.40	0.46	
philips-10-24-0.75-placeholder-packandgo	0.10	0.80	1.56	
Threaded fastening			0.50	
shaft	1.66	1.66	1.70	
philips-10-24-0.75-placeholder-packandgo	0.10	0.20	0.42	
Threaded fastening			0.15	
Peeler Arm Subassembly	0.00	0.00	0.06	
peeler-arm-holder	0.81	0.81	0.86	
peeler-armSLDPRT	0.29	0.29	0.41	
Blade Holder Subassembly	0.00	0.00	0.05	
blade-holder-clip	0.17	0.17	0.22	
blade-holder-arm	0.15	0.15	0.29	
blade-holder	0.15	0.15	0.22	
upper-food-holder	0.32	0.32	0.38	
cap	0.92	0.92	0.97	

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Figure 93: DFA Product Worksheet - Current Design

DFMA® - Boothroyd Dewhurst, Inc.

Design for Assembly
Suggestions for Redesign

Original

November 26, 2021

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Category 2: Fasteners, Connectors, Separate Operations

Incorporate integral fastening elements into functional parts, or change securing methods, to eliminate as many as possible of the listed separate fasteners. The design improvements which are realized by following Category 2 suggestions are somewhat smaller than those realized from the Category 1 suggestions. For that reason, these suggestions should only be considered after all practical Category 1 suggestions have been exhausted.

Name	Notes	Part number	Total quantity	Process time per product, s	Parent assembly
philips-10-24-0.75-placeholder-packandgo			8	57.86	Motorized Peeler
philips-10-24-0.75-placeholder-packandgo			2	16.64	Motorized Peeler

Combine connected items or attempt to rearrange the structure of the product to eliminate the listed items whose function is solely to make connections. The design improvements which are realized by following Category 2 suggestions are somewhat smaller than those realized from the Category 1 suggestions. For that reason, these suggestions should only be considered after all practical Category 1 suggestions have been exhausted.

Name	Notes	Part number	Total quantity	Process time per product, s	Parent assembly
blade-holder-clip			1	4.29	Blade Holder Subassembly

Eliminate or reduce the time for the listed separate operations which may add no value to the product and may contribute significantly to the overall assembly time. The design improvements which are realized by following Category 2 suggestions are somewhat smaller than those realized from the Category 1 suggestions. For that reason, these suggestions should only be considered after all practical Category 1 suggestions have been exhausted.

Name	Notes	Total quantity	Process time per product, s	Parent assembly
Threaded fastening		8	38.10	Motorized Peeler
Threaded fastening		2	11.70	Motorized Peeler

Category 3: Handling or Insertion Difficulties

Reduce difficulties associated with handling and inserting the listed items. The design improvements realized by following a Category 3 suggestion are typically the smallest. No parts or separate operations are eliminated and the product structure is not simplified. Only existing parts are made easier to assemble. For this reason, Category 3 suggestions should be the lowest priority of all redesign suggestions.

Name	Notes	Part number	Total quantity	Handling or insertion difficulties	Process time savings, s	Parent assembly
philips-10-24-0.75-placeholder-packandgo			8	Slippery	6.00	Motorized Peeler

DFMA® - Boothroyd Dewhurst, Inc.

Design for Assembly
Suggestions for Redesign

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blade-holder-arm			1	Nest or tangle, Slippery, Careful handling, Restricted vision, Obstructed access	5.08	Blade Holder Subassembly
peeler-armSLDPRT			1	Restricted vision, Obstructed access	4.00	Peeler Arm Subassembly
philips-10-24-0.75-placeholder-packandgo		2		Slippery	1.50	Motorized Peeler
blade-holder			1	Nest or tangle, Slippery, Careful handling	1.08	Blade Holder Subassembly
Base-Lid			1	Alignment	1.00	Motorized Peeler
power-button			1	Slippery	0.75	Motorized Peeler
bottomfood-holder			1	Slippery, Careful handling	0.75	Motorized Peeler
blade-holder-clip			1	Careful handling	0.75	Blade Holder Subassembly
upper-food-holder			1	Careful handling	0.75	Motorized Peeler

Figure 94: Suggestion for Redesign

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Cost Breakdown
November 26, 2021

DFA-Current-Peeler.dfax

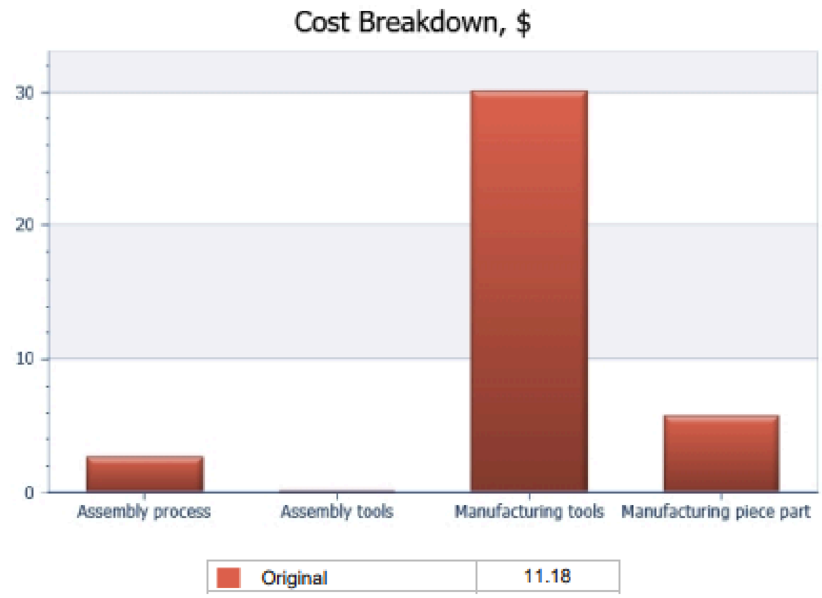

Figure 95: DFA - Cost Breakdown - Bar Graph

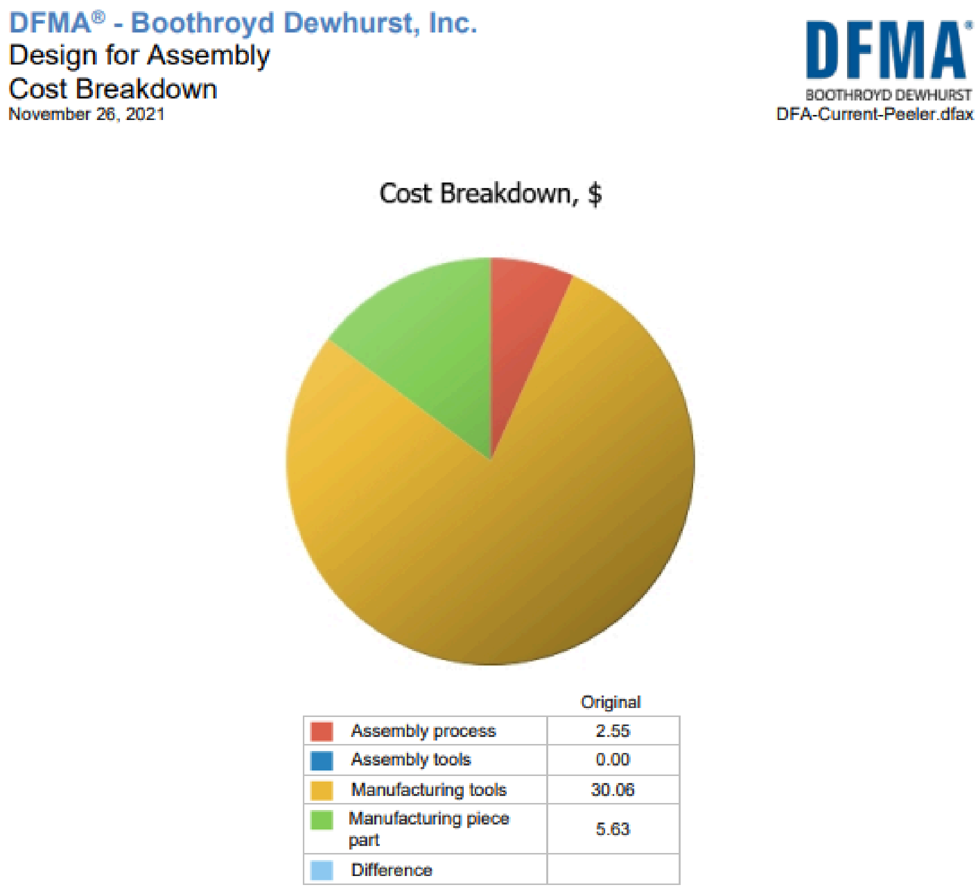

Figure 95: DFA - Cost Breakdown - Pie Chart

Table 6: Functional Analysis of Parts

<u>**Part #**</u>	<u>**Part Name**</u>	<u>**QTY**</u>	<u>**Functional Analysis**</u>	<u>**Reason**</u>
1	Base	1	Critical	• Needs to be separate to make assembly possible
2	Base Lid	1	Critical	• Needs to be separate to make assembly and maintenance possible
3	Power Button	1	Critical	• Part moves relative to other assembled parts
4	Bottom Food Holder	1	Critical	• Part moves relative to other assembled parts
5	Philips 10-24 0.75in Screw	10	Not Critical	• Doesn’t meet any of the 4 criteria • Can be replaced with snapfits

6	Shaft	1	Critical	• Needs to be separate to make assembly possible
7	Peeler Arm Holder	1	Critical	• Part moves relative to other assembled parts
8	Peeler Arm	1	Critical	• Part moves relative to other assembled parts
9	Blade Holder Clip	1	Not Critical	• Doesn't meet any of the 4 criteria • Can be combined with the peeler arm
10	Blade Holder Arm	1	Critical	• Part moves relative to other assembled parts
11	Blade Holder	1	Critical	• Part moves relative to other assembled parts
12	Upper Food Holder	1	Critical	• Part moves relative to other assembled parts
13	Cap	1	Critical	• Needs to be separate to make assembly and maintenance possible

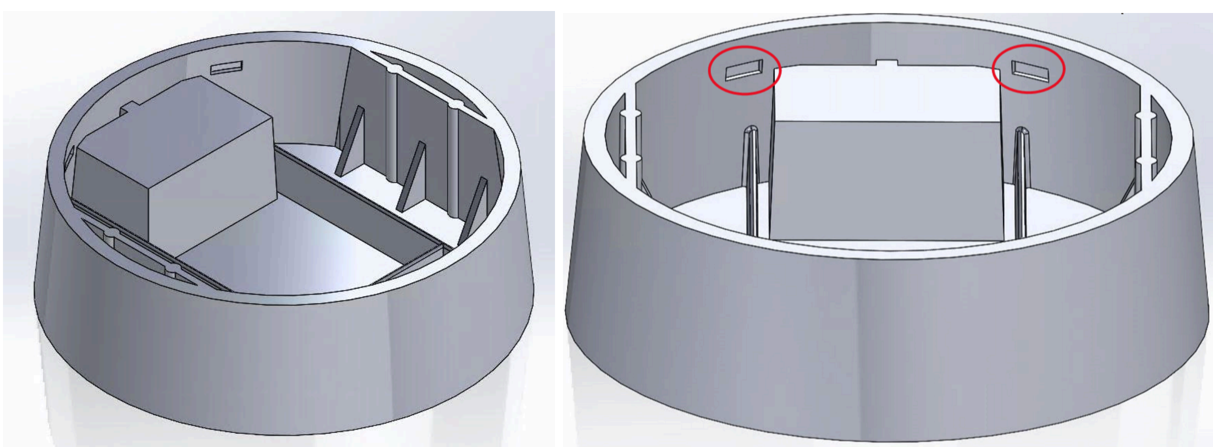

Figure 96: Redesigned Base

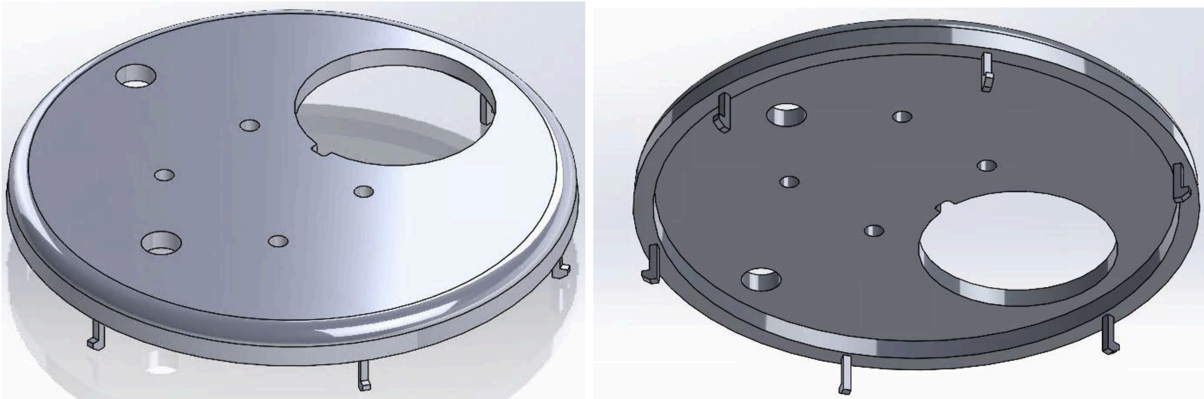

Figure 97: Redesigned Base Lid Part

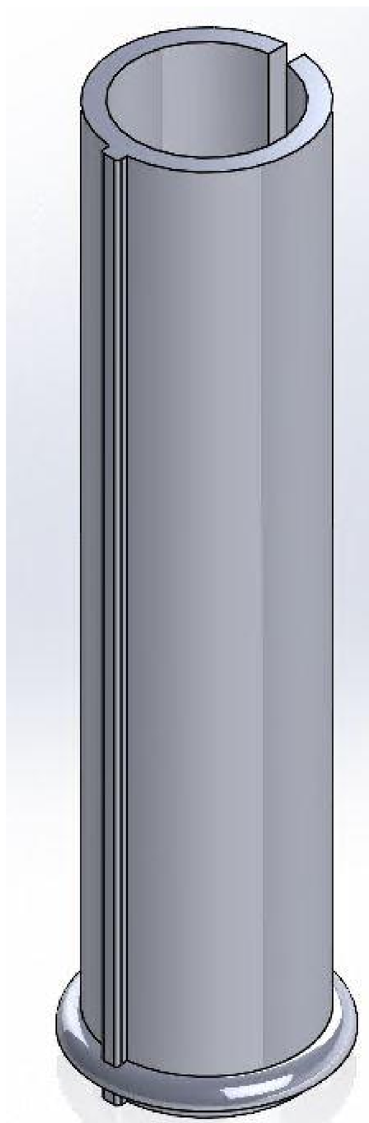

Figure 98: Redesigned Shaft

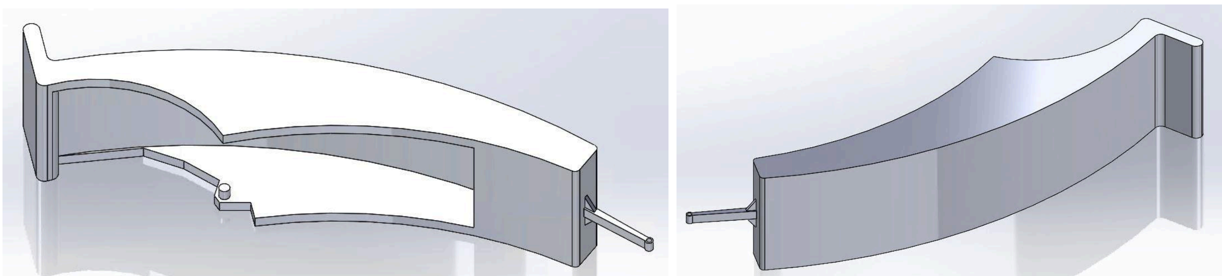

Figure 99: Redesigned Peeler Arm

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Assembly Totals for Design for Assembly (DFA)
November 26, 2021

DFA-Redesign-Peeler.dfax

Entries including repeats	Original
Parts meet minimum part criteria	11
Parts are candidates for elimination	4
Analyzed subassemblies	2
Separate assembly operations	8
Total entries	25

Assembly labor time, s	
Parts meet minimum part criteria	66.01
Parts are candidates for elimination	30.38
Insertion of analyzed subassemblies	7.84
Separate assembly operations	38.10
Total assembly labor time	142

Design efficiency	
DFA Index	27.98

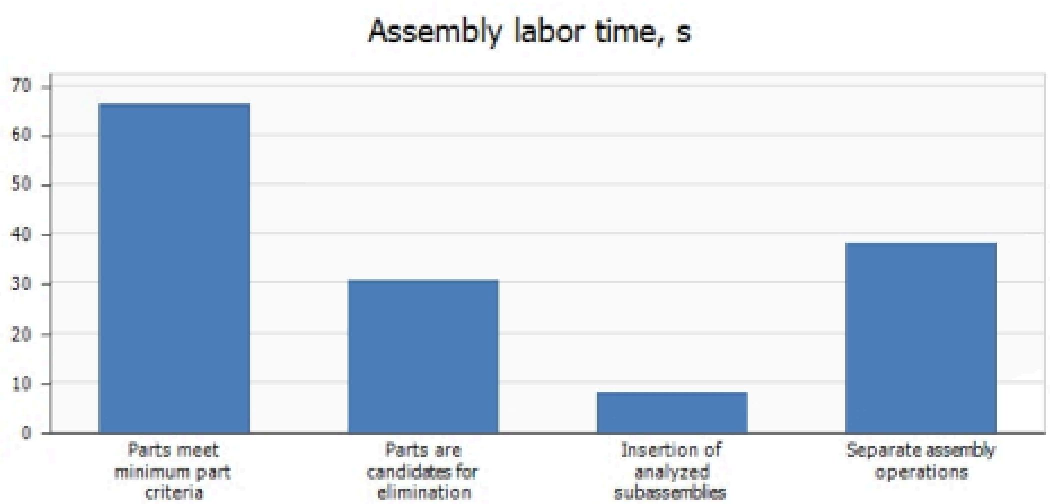

Figure 100: DFA - Redesign

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Product Worksheet

Original
November 26, 2021 DFA-Redesign-Peeler.dfax

Name	Part number	Repeat count	Total count	Minimum items	Minimum part criteria	Process time per entry, s	Process time per product, s
Motorized Peeler			25	11			142.33
Base		1	1	1	Base part	3.54	3.54
Base-Lid		1	1	1	Assembly	10.76	10.76
power-button		1	1	1	Movement	4.73	4.73
bottomfood-holder		1	1	1	Movement	4.73	4.73
philips-10-24-0.75-placeholder-packandgo		4	4	0	Fastener	30.38	30.38
Threaded fastening		8	8			38.10	38.10
shaft		1	1	1	Assembly	3.98	3.98
Peeler Arm Subassembly		1	1			4.30	4.30
peeler-arm-holder		1	1	1	Movement	3.54	3.54
peeler-armSLDPRT		1	1	1	Movement	10.05	10.05
Blade Holder Subassembly		1	1			3.54	3.54
blade-holder-arm		1	1	1	Movement	10.59	10.59
blade-holder		1	1	1	Movement	5.38	5.38
upper-food-holder		1	1	1	Movement	4.73	4.73
cap		1	1	1	Assembly	3.98	3.98

Figure 101: DFA Product Worksheet

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Product Worksheet

Original
November 26, 2021 DFA-Redesign-Peeler.dfax

Name	Process cost per product, $	Piece part cost per item, $	Piece part cost per product	Total cost per product without tooling, $	Assembly tool or fixture cost, $	Manufacturing tooling investment, $	Manufacturing tooling cost per item, $
Motorized Peeler	1.86		4.94	6.80	0.00	292672.00	
Base	0.05	1.39	1.39	1.44	0.00	56973.00	5.70
Base-Lid	0.14	0.40	0.40	0.54	0.00	22198.00	2.22
power-button	0.06	0.10	0.10	0.16	0.00	10206.00	1.02
bottomfood-holder	0.06	0.21	0.21	0.27	0.00	18985.00	1.90
philips-10-24-0.75-placeholder-packandgo	0.40	0.10	0.40	0.80	0.00	0.00	0.00
Threaded fastening	0.50			0.50	0.00		
shaft	0.05	1.13	1.13	1.19	0.00	52269.00	5.23
Peeler Arm Subassembly	0.06	0.00	0.00	0.06	0.00	0.00	0.00
peeler-arm-holder	0.05	0.42	0.42	0.47	0.00	38767.00	3.88
peeler-armSLDPRT	0.13	0.13	0.13	0.26	0.00	15889.00	1.59
Blade Holder Subassembly	0.05	0.00	0.00	0.05	0.00	0.00	0.00
blade-holder-arm	0.14	0.06	0.06	0.20	0.00	8669.00	0.87
blade-holder	0.07	0.05	0.05	0.12	0.00	10103.00	1.01
upper-food-holder	0.06	0.12	0.12	0.18	0.00	19747.00	1.97
cap	0.05	0.53	0.53	0.58	0.00	38866.00	3.89

Figure 102: DFA Product Worksheet

DFMA® - Boothroyd Dewhurst, Inc.
Design for Assembly
Product Worksheet

November 26, 2021

Original
DFA-Redesign-Peeler.dfax

Name	Item cost per item, $	Item cost per product, $	Total cost, $	Notes
Motorized Peeler		7.87	9.73	
Base	1.96	1.96	2.01	
Base-Lid	0.62	0.62	0.76	
power-button	0.20	0.20	0.26	
bottomfood-holder	0.40	0.40	0.46	
philips-10-24-0.75-placeholder-packandgo	0.10	0.40	0.80	
Threaded fastening			0.50	
shaft	1.66	1.66	1.71	
Peeler Arm Subassembly	0.00	0.00	0.06	
peeler-arm-holder	0.81	0.81	0.86	
peeler-armSLDPRT	0.29	0.29	0.42	
Blade Holder Subassembly	0.00	0.00	0.05	
blade-holder-arm	0.15	0.15	0.29	
blade-holder	0.15	0.15	0.22	
upper-food-holder	0.32	0.32	0.38	
cap	0.92	0.92	0.97	

Figure 103: DFA Product Worksheet

DFMA® - Boothroyd Dewhurst, Inc.

Design for Assembly Suggestions for Redesign

DFMA BOOTHROYD DEWHURST

Original

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Category 2: Fasteners, Connectors, Separate Operations

Incorporate integral fastening elements into functional parts, or change securing methods, to eliminate as many as possible of the listed separate fasteners. The design improvements which are realized by following Category 2 suggestions are somewhat smaller than those realized from the Category 1 suggestions. For that reason, these suggestions should only be considered after all practical Category 1 suggestions have been exhausted.

Name	Notes	Part number	Total quantity	Process time per product, s	Parent assembly
philips-10-24-0.75-placeholder-packandgo			4	30.38	Motorized Peeler

Eliminate or reduce the time for the listed separate operations which may add no value to the product and may contribute significantly to the overall assembly time. The design improvements which are realized by following Category 2 suggestions are somewhat smaller than those realized from the Category 1 suggestions. For that reason, these suggestions should only be considered after all practical Category 1 suggestions have been exhausted.

Name	Notes	Total quantity	Process time per product, s	Parent assembly
Threaded fastening		8	38.10	Motorized Peeler

Category 3: Handling or Insertion Difficulties

Reduce difficulties associated with handling and inserting the listed items. The design improvements realized by following a Category 3 suggestion are typically the smallest. No parts or separate operations are eliminated and the product structure is not simplified. Only existing parts are made easier to assemble. For this reason, Category 3 suggestions should be the lowest priority of all redesign suggestions.

Name	Notes	Part number	Total quantity	Handling or insertion difficulties	Process time savings, s	Parent assembly
blade-holder-arm			1	Nest or tangle, Slippery, Careful handling, Restricted vision, Obstructed access	5.08	Blade Holder Subassembly
peeler-armSLDPRT			1	Careful handling, Restricted vision, Obstructed access	4.75	Peeler Arm Subassembly
philips-10-24-0.75-placeholder-packandgo			4	Slippery	3.00	Motorized Peeler
Base-Lid			1	Careful handling, Alignment	1.75	Motorized Peeler
blade-holder			1	Nest or tangle, Slippery, Careful handling	1.08	Blade Holder Subassembly
power-button			1	Slippery	0.75	Motorized Peeler
bottomfood-holder			1	Slippery, Careful handling	0.75	Motorized Peeler
upper-food-holder			1	Careful handling	0.75	Motorized Peeler

Figure 104: DFA Redesign Suggestion - Redesign

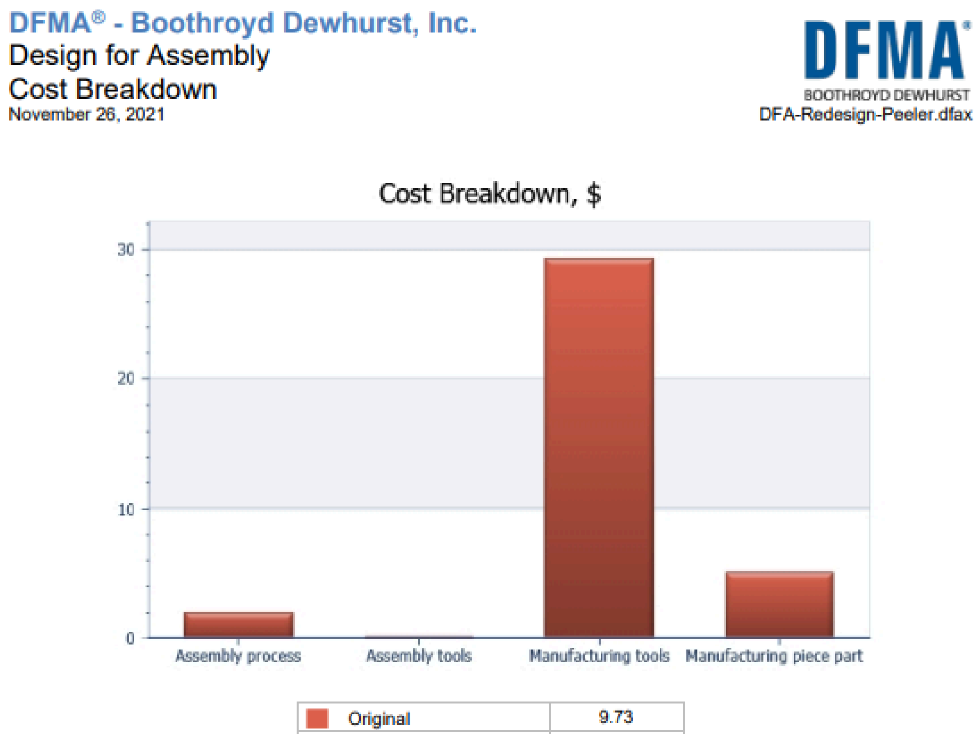


Figure 105: Redesign Cost Breakdown - Bar Graph

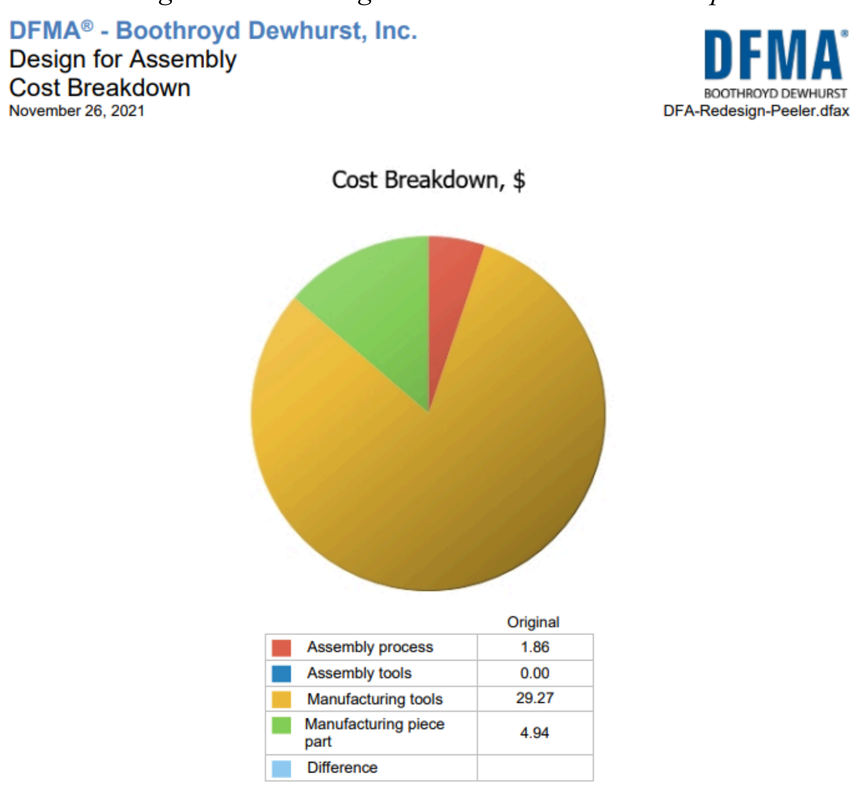
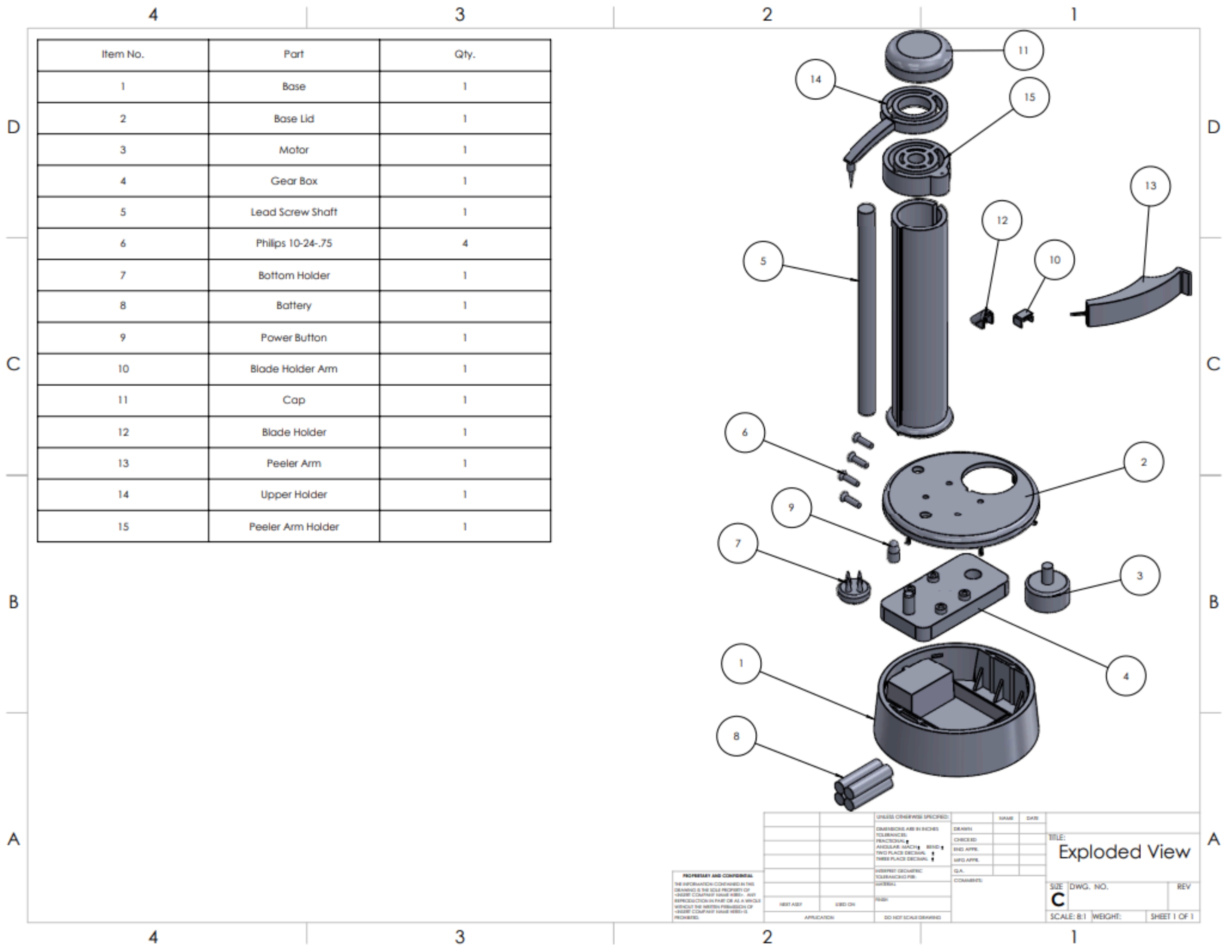


Figure 106: Redesign Cost Breakdown - Pie Chart

Appendix 4: CAD Drawings



Item No.	Part	Qty.
1	Base	1
2	Base Lid	1
3	Motor	1
4	Gear Box	1
5	Lead Screw Shaft	1
6	Philips 10-24-.75	4
7	Bottom Holder	1
8	Battery	1
9	Power Button	1
10	Blade Holder Arm	1
11	Cap	1
12	Blade Holder	1
13	Peeler Arm	1
14	Upper Holder	1
15	Peeler Arm Holder	1

Figure 107: Exploded View Drawing of the Redesigned Motorized Peeler

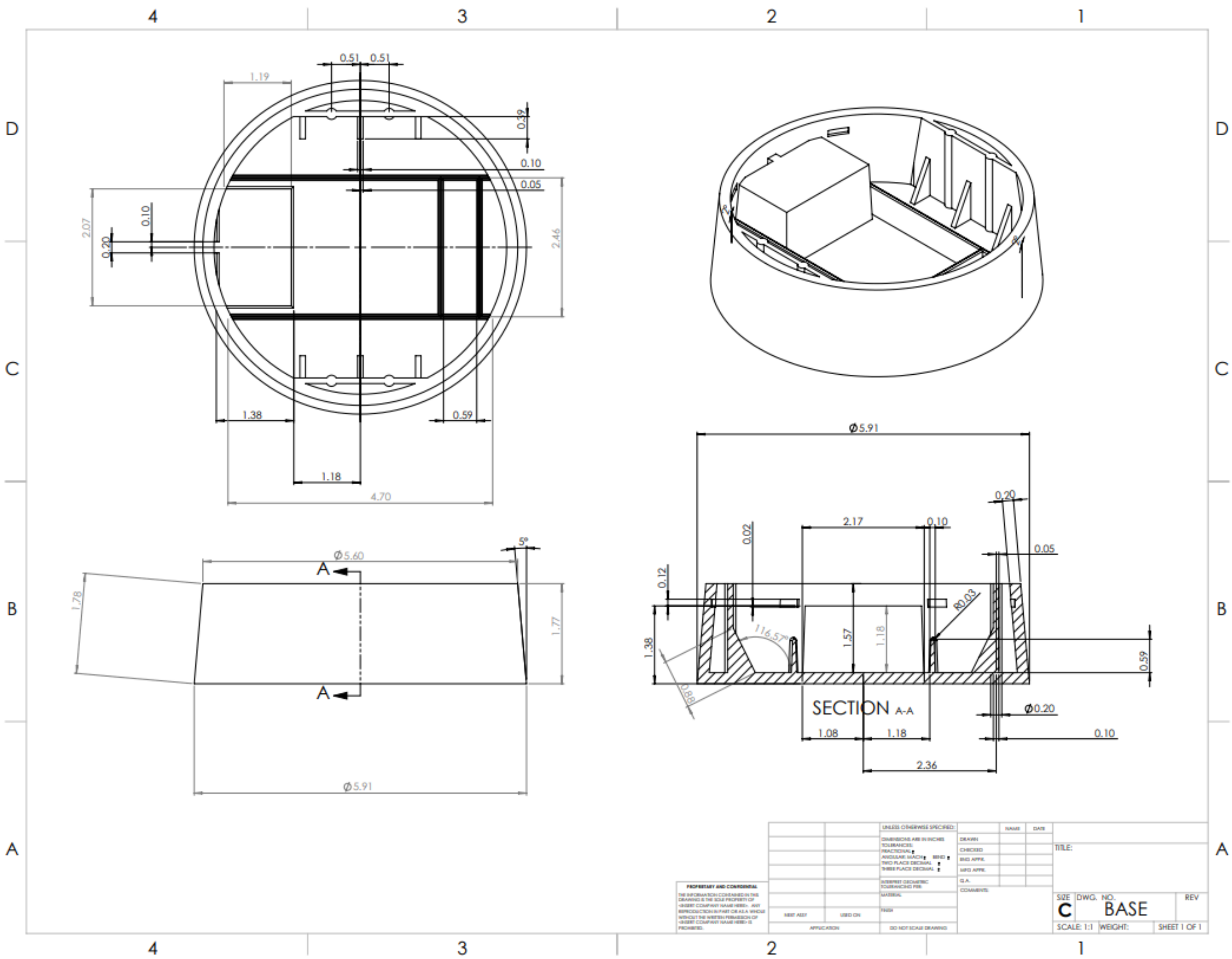


Figure 108: Redesign Drawing of Base

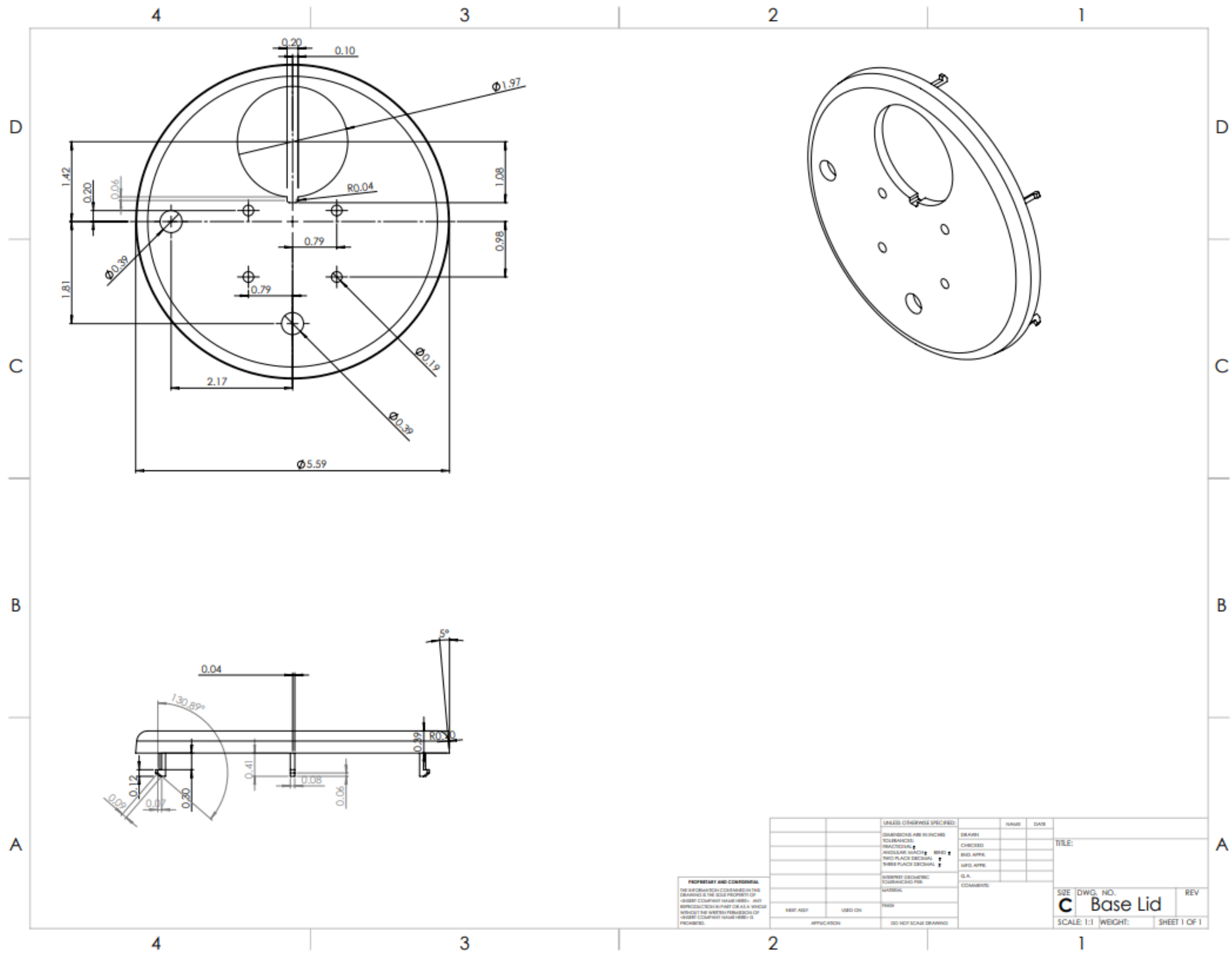


Figure 109: Redesign Drawing of Base Lid

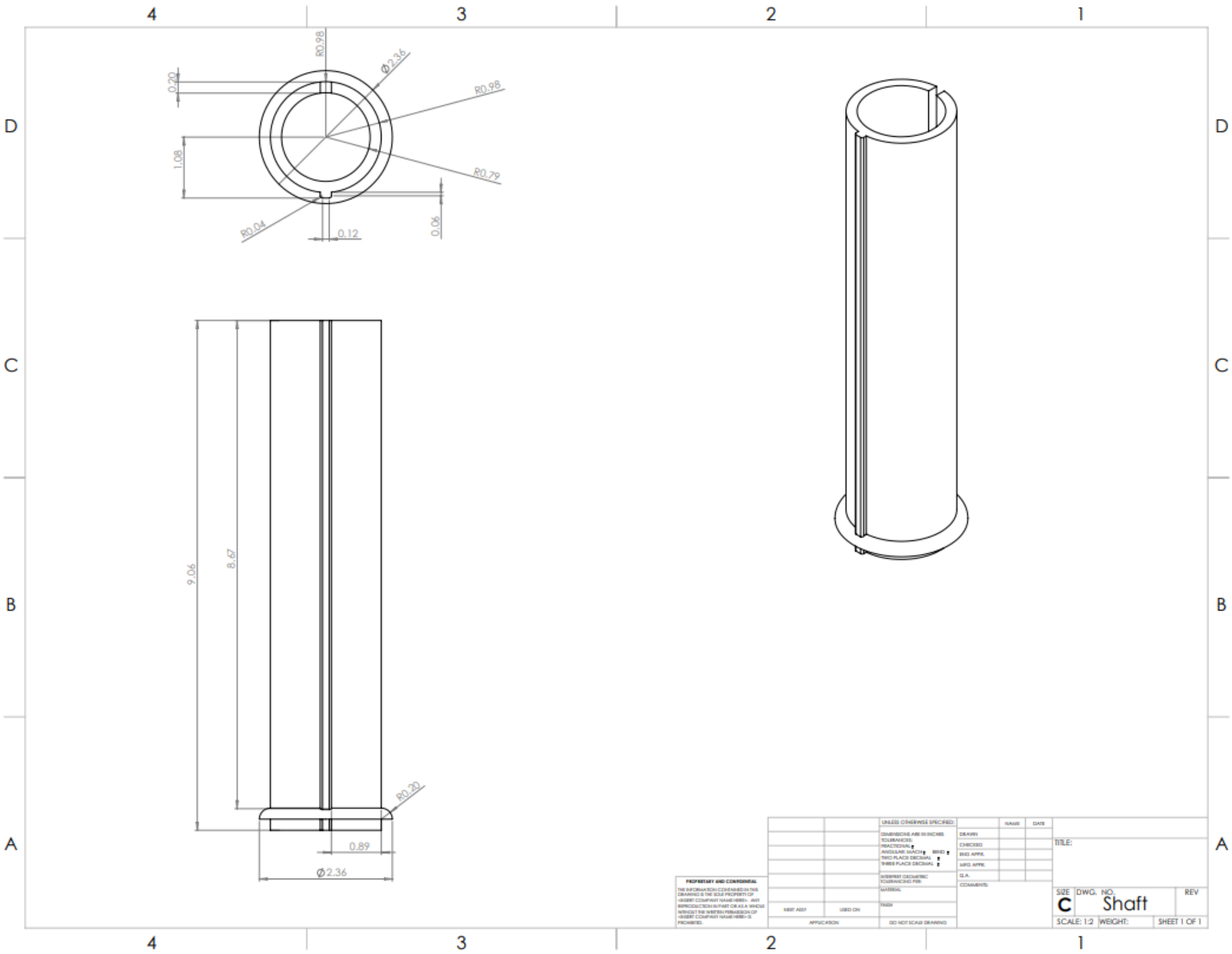


Figure 110: Redesign Drawing of Shaft

<u>Peeler Arm Redesign</u>

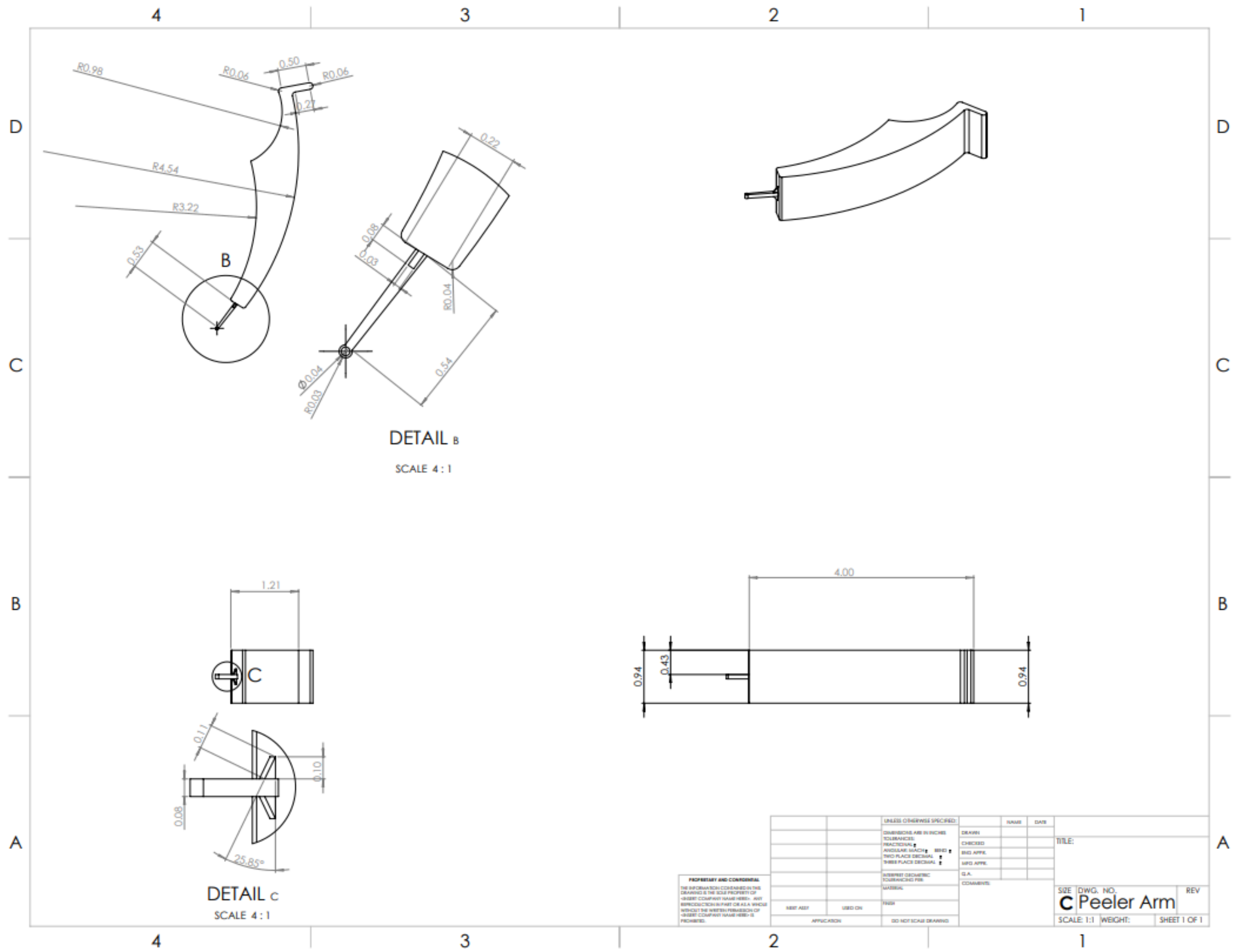


Figure 111: Redesign Drawing of Peeler Arm

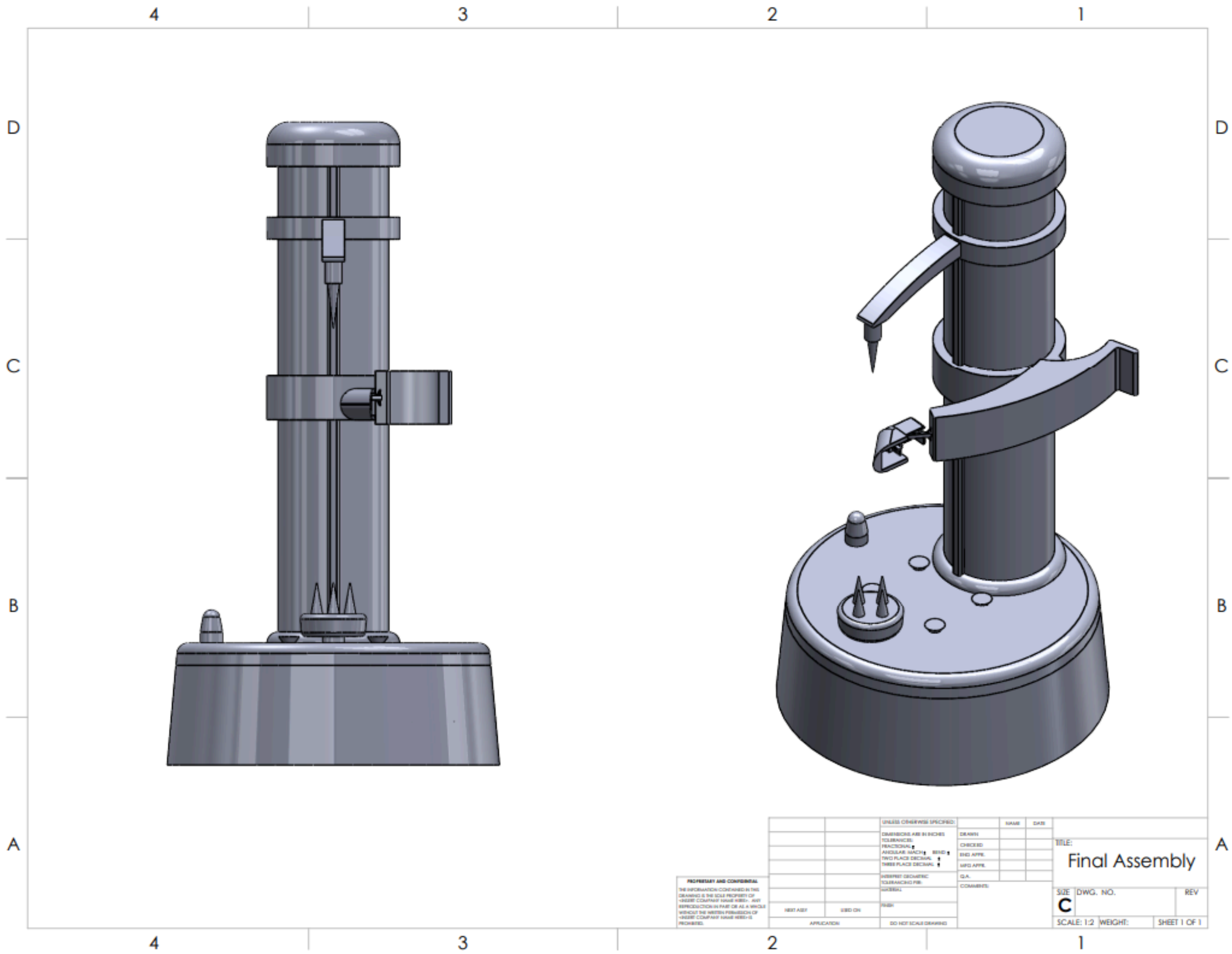


Figure 112: Redesign Assembly View Drawing