Corn Shucker Conceptual Design Report

Introduction:

The following report outlines potential designs for a product that will effectively and efficiently shuck and clean corn on the cob. The issues involved with shucking corn were initially presented in a design brief that had objectives, constraints and corresponding metrics, and criteria listed and justified with references. This design brief has undergone minor reframing and refining in order to ensure that all of the original objectives are fully taken into consideration. Our design process, the ideation tools utilized, and the four resulting conceptual designs are presented and justified in the body of this report. In addition, out of the four conceptual designs, the one chosen for further analysis and development will be justified as to why it is the best choice. Finally, further objectives for detailed analysis of the chosen conceptual design by other members of the engineering firm will be stated.

Reframing/Refining of the Corn Shucking Design Brief:

The design brief required little reframing and refining due to it effectively stating the problem and outlining three suitable primary objectives. These objectives both consider the necessary and effective removal of husks and silk hairs on the corn in addition to the messiness of removal. Constraints and their corresponding metrics, along with the criteria, have been carefully outlined, considered, and justified through valid supporting evidence.

Despite the design brief being well-organized and easy to use, there has been one major reframing and two small changes made to the **Constraints and Corresponding Metrics** section of the report. Concerning the framing, the primary concern has been with the Dfx's that have been prioritized. Though "design for usability" and "design for affordability" are essential in this conceptual design, it is believed that "design for safety", "design for efficiency", and "design for effectiveness" must also be incorporated. The original two Dfx's do not fully take into account the primary concern of the design brief, which is the time associated with shucking the corn. In addition, the "design for safety" Dfx must be incorporated due to the four conceptual designs involving the use of sharp metal blades (for the purpose of removing the husks). It should be noted that these Dfxs are very general and apply to almost all products. In order to ensure that the conceptual designs are effective, more specific Dfxs have been applied to the issue of shucking corn. One of these Dfxs is "Design for Ergonomics according to the shape of the human hand", while another is "Design for Ease of removing corn husks". These non-general Dfxs have been incorporated into the conceptual designs. The first minor refinement relates to the first item in the **Constraints and Corresponding Metrics** section, which states that the product designed must require less than 6 mechanical operations. Mechanical operations has been changed to human operations, due to the effort associated with shucking corn primarily being human effort [1]. This is also due to the idea that a machine/product can still be just as effective even though it requires more than 6 mechanical operations (such as having 10 smaller and faster operations instead of 5 that are less efficient). The second change relates to the constraint that states the product must fit into one hand. This has been altered to two human hands in order to allow more freedom for the product. The maximum diameter of a cylinder that fits into a human hand is 59 mm. This is much too small a diameter for an apparatus responsible for housing corn as well [2]. A summary of the refinements is on the next page.

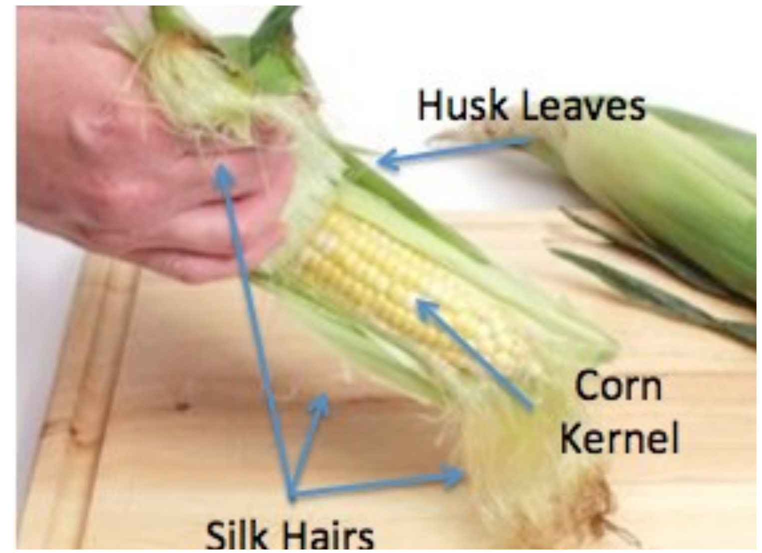


Figure 1: The current process involved in shucking corn[12].

Reframing:

- The DfXs of "Safety", "Effeciency" and "Effectiveness" have been incorporated.
- Non-general Dfxs: "Design for Ergonomics according to the shape of the human hand" and "Design for Ease of removing corn husks".

Refined Constraints:

- Must require less than 6 human operations
- Must fit within the shape of two human hands

Review of Key Stakeholders:

As outlined in the design brief, the following stakeholders have been taken into consideration when proposing four conceptual designs:

1. Consumers
2. Corn Vendors and Producers

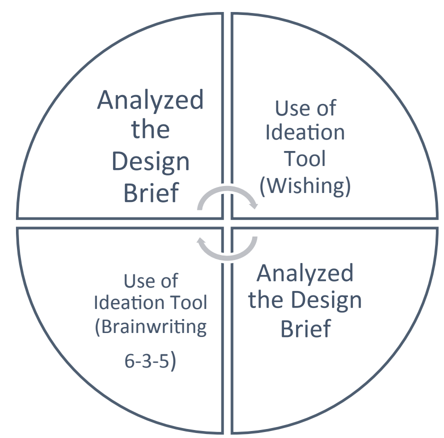
Engineering Design Process:

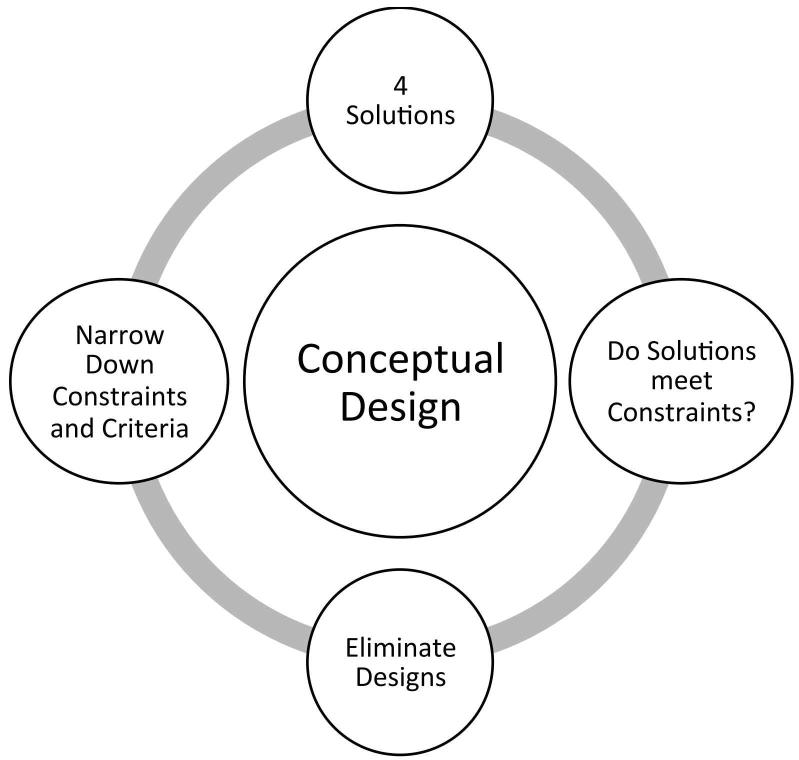
This section has been included for the reader for the purpose of outlining the design decisions made in the creation of the four conceptual designs. It is hoped that this will aid the reader in understanding how the issue presented was analyzed and what key design decisions were made in the creation of the four conceptual designs. Flow charts have been included as visuals below along with additional explanatory text. This specific design process can essentially be described as two cycles (not simultaneous).

The first cycle is the preliminary stage of the conceptual design. The design brief was analyzed in conjunction with the ideation tools "Wishing" and "Brainwriting 6-3-5". "Wishing" was initially chosen due to the belief that it is effective in determining the desires of the designer. Its allowance of creative development aids the designer in finding all potential solutions and then narrowing them down into feasible designs. A variety of ideas were developed through utilizing this ideation tool. Some examples are as follows:

- I wish corn could shuck itself
- I wish there could be a machine that would immediately shuck corn with no user input required
- Wouldn't it be nice if there was an animal that was trained to shuck corn?

After "Wishing" was used as the individual ideation tool, the brief was once again analyzed in order to ensure that any new ideas would take into account the objectives and constraints. "Brainwriting 6-3-5" was the next ideation tool used, primarily due to the team element associated with it. Ideas and preliminary designs developed during the "Wishing" process were presented and improved upon. New designs were not developed during this team process, as the primary focus was on improving the individual ideas. This cycle culminated in a final analysis of the design brief, with the cycle restarting in the case of the designs not fully abiding by the constraints.





Once four solutions were developed, they were analyzed according to the constraints. Any solutions that did not fully abide by these restrictions were eliminated, in addition to the narrowing down of any constraints and criteria that were considered less important (though all have still been kept and considered). Once solutions were eliminated, others were developed in order to ensure that there were four at all times. The cycle continued until the final four solutions (the ones presented in the report) were determined.

There were many ideas that were developed during the conceptual design process, but many were discarded due to their impracticality or inability to effectively and efficiently shuck corn on the cob. Two of these designs are briefly described on this page.

Discarded Design #1:

This design's main feature was a rotating blade that was attached to two cables placed on wheels. The rotating blade contained an opening in the middle that would fit a cob of corn and would initially be placed at the top of the cob. To begin the process, the user would gradually move the wheels attached to the cables further and further apart. This would cause the rotating blade to move down the cob and (hopefully) cut off the husks. However, this was deemed unsuitable for a number of reasons. Firstly, there was no safety mechanism designed to ensure that the user was protected during the cutting process. Secondly, the rotating blade could have easily ripped off the corn kernels in addition to the husks. Finally, to successfully design a rotating blade that would sufficiently complete the shucking and cleaning process was deemed as improbable for first year engineering students.

Discarded Design #2:

This design also incorporated rotating blades in the shucking process. Two blades would be attached to the sides of a rectangular apparatus on wheels. The cob of corn to be shucked would be supported horizontally (which was not yet determined at the time). The apparatus would be located at one end of the cob at the beginning of the shucking process and move through translational motion along the cob. Meanwhile, the two blades would begin rotating and remove the corn husks. This design, in a similar fashion to the first discarded design, was eliminated due to safety reasons. No safety mechanism was developed to protect the user from the rotating blades. In addition, it was highly improbable that first year engineering students could design a machine that could move in translational motion by itself with rotating blades.

Contribution to Conceptual Designs:

These discarded designs suggested the necessity of closed system devices that would protect users from harm. In addition, it illustrated that some user input would still be required (with the objective that it still be minimized as much as possible).

Conceptual Design #1:

The sketch (Figure 2) represents the first conceptual design. Its features are described within and below the sketch. The procedure required to operate it is also explained.

Procedure of Operation:

1. Open the top like a hatch and insert the corn, with its base at the top.

2. Close the hatch and grasp the handle connected to the claw inside.

3. Grip the handle until the claw firmly grasps the corn.

4. Begin moving the handle and claw up and down in a linear motion until the blades and bristles completely shuck the corn.

5. Open the bottom to remove the corn and the leftover husks and silk hairs.

Key Design Features:

Overall Design (Blades and Bristles):

The primary system is enclosed by a rectangular apparatus (similar to a tall box). The system consists of small blades along the sides that are responsible for the cutting of the husks. The sides of the blades cannot exceed the thickness of the corn husk, which is approximately 2 mm (an estimated value by the design team due to the actual value not being found), in order to ensure that the corn is not affected. The blades should be made of a strong and durable metal that will not be affected by water in a dishwasher (in order to ensure that the device is easily cleaned). Aligned between the blades are thin bristles (similar to the Lehman solution)[3] that must be longer than 2 mm in order for them to reach the silk hairs that line the corn. The bristles will be most effective if they are, firstly, durable (are not affected by a dishwasher) and flexible. The overall material must be see-through so that the user can view the

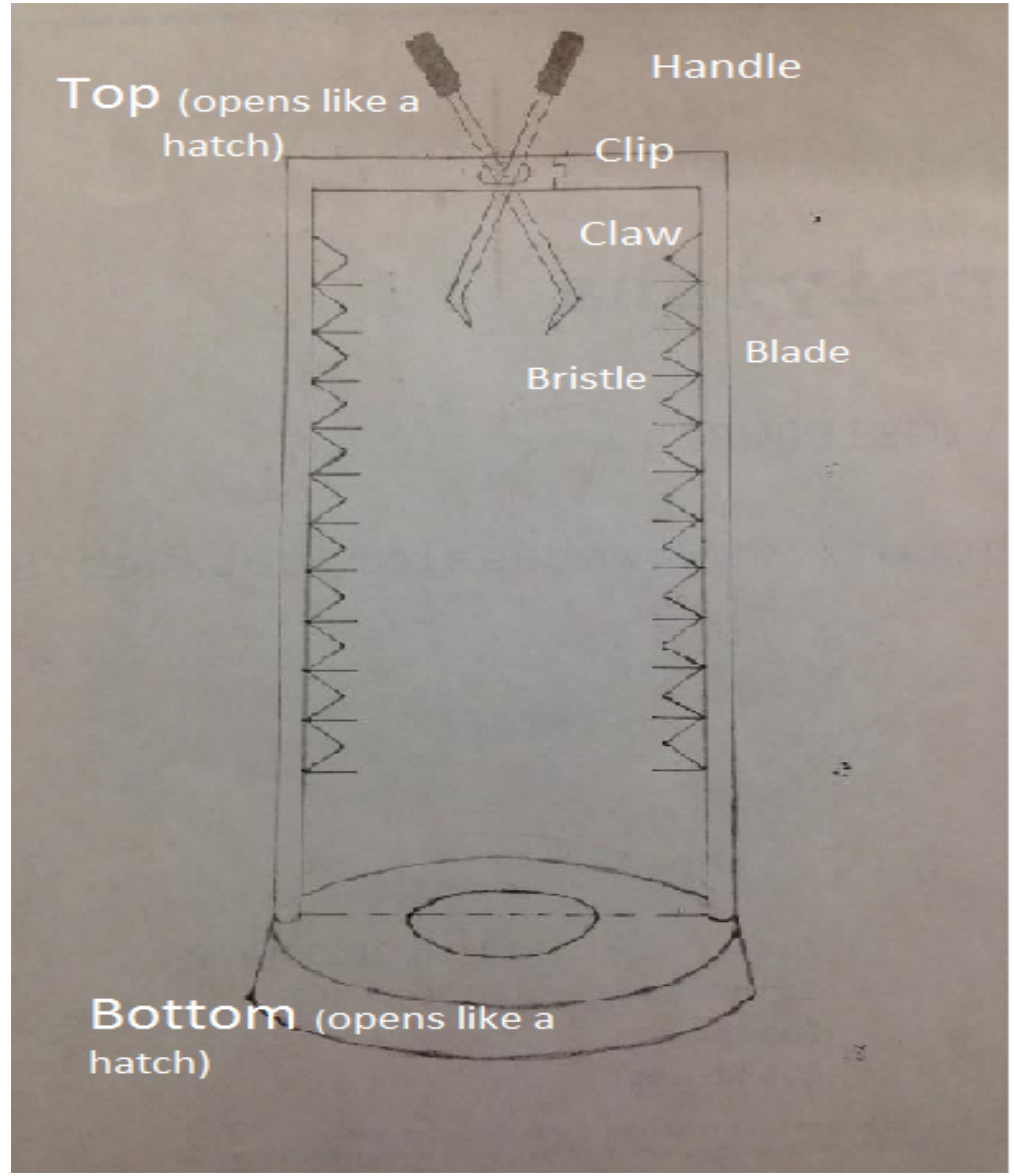


Figure 2: Conceptual Design #1

shucking process as it is occurring. This material must also be durable so that the product lasts for a long period of time and is not affected by a dishwasher. The apparatus must be taller by at least several centimeters (approximately 6-7) than the average length of an ear of corn (approximately 17.8 cm) so that the corn can fit vertically inside.

Claw and Clamp:

The claw contained at the top of the inside of the apparatus will be responsible for gripping onto the corn and must be strong enough to lift approximately 320 g of corn (the average size of an ear of corn)[4]. Connected to the claw through a small opening at the top of the apparatus is a handle that, when gripped, clamps the claw on to the corn. The user then moves the claw up and down until the corn is fully shucked and cleaned by the blades on the side. The claw itself must not be heavy to minimize effort by the user and should also be made of a material that is durable.

Clip:

A unique design feature is the placement of a clip at the top of the apparatus.
This allows the user to easily split the apparatus in half so that two smaller pieces can fit inside a dishwasher instead of one larger piece.

Top and Bottom Hatches:

Finally, the top and bottom of the corn shucker will act like hatches. The top will be able to be opened (along with handle and the claw) in order to allow the corn to be placed inside and be taken out. The bottom will be accessible for the purpose of removing the husks and silk hairs after the shucking is complete. For the bottom to be opened over a waste basket easily, the corn shucker must be portable and fulfill the refined constraint of easily fitting into two hands.

Benefits:

The primary benefit of this solution is that it meets the three primary objectives contained within the design brief. The blades and bristles are responsible for removing the husks and corn hairs (the first two objectives). In addition, the enclosed system and the bottom hatch reduce the mess produced with the current corn shucking process. This applies to the key stakeholders outlined above, as the product can be easily used and cleaned by both vendors/producers and consumers.

This corn shucker also easily meets the Dfxs outlined above. It is easily usable, as it is a perfect fit for the human hand ("Design for Ergonomics according to the human hand") and safely removes the corn husks ("Design for Ease of removal of corn husks"). The general Dfxs of safety and durability are also considered, with safety being met by the fact that it is an enclosed system. Durability will also be met if the right materials are chosen (if the detailed design process of this product occurs). Finally, the shucking process can be controlled by the user and does not require any complex mechanical operations. The user can choose to end and restart the shucking process at any time (general Dfx known as "Design for Usability").

Conceptual Design #2:

Procedure of Operation

1. While inserting the corn in the apparatus, the eight needle blades will cut the cornhusk vertically. The user will then rotate the apparatus manually with the help of the wheels to cut the cornhusk circumferentially.

2. The needles will be pulled out of the corn container, but remain within the apparatus, so that they will not harm the user. The corn will also be taken out to separate the cut husks from the corn.

3. The corn without the husk will be put back in the apparatus to clean the corn of all the silk hairs with the lining of the corn container by rotating the apparatus.

Key Design Features

Corn Container Lining:

The lining will be responsible for removing the silks similar to how the Lehman Corn Silk Remover [3] brushes the hairs off the corn. It should be made of a flexible, rugged material. This will allow for the container to be somewhat deformable to account for the varying sizes of corn. It must be rough enough to remove the silk hairs like the brush bristles of the reference design, but soft enough to not harm the edible parts of the corn.

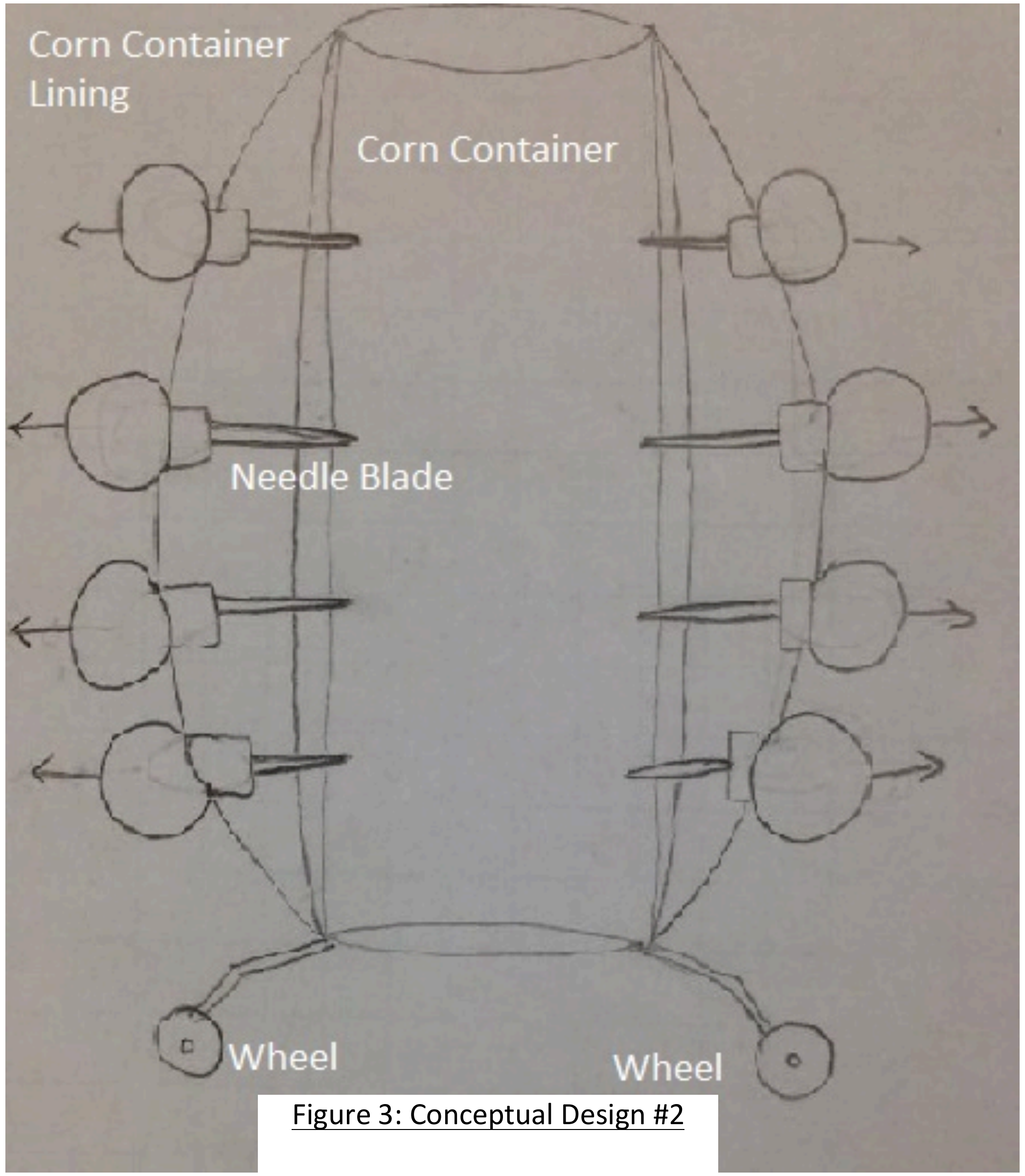


Figure 3: Conceptual Design #2

Wheels:

The wheels will be responsible for the rotational motion of the apparatus. They will help in the cutting of the husks by allowing the blades to cut the husk circumferentially. This will make it easier to remove the husks before the silk removal process. The wheels also make it easier for human operation. Instead of the user struggling to cut the husks by hand, which is how shucking is generally done, the wheels allow for a smoother and more effective cut. This meets the main objective of reducing human effort.

Corn Container:

The container will be 20.0 cm in height because the average corn length is between 6 inches and 9 inches [5], and it will encase the corn during the cutting of the husk and the removal of the silk stages. This is to address the issue of safety, so the user won't cut themselves with the blades. It must be made of a light material to meet the given constraint in the design brief that the apparatus must weigh less than 1 kg. The apparatus must fit within the average human hand according to the given constraints and the criteria of an ergonomic design. The maximum grip diameter (determined by the diameter of the cylinder a human can wrap their hand around between the middle finger and thumb) of the human hand is 59.0 mm [2], so the apparatus will have an outer diameter no bigger than twice this diameter, still allowing for a human to hold it with two hands instead of one. The corn container will also house the flexible, rugged material that will be responsible for removing the silk hairs. This material must be rough enough to remove the silk hairs, but soft enough to not damage the corn. The enclosed container will also be responsible for keeping the messiness of the removal of the silk hairs under control.

Needle Blade:

The needle blades are to be inserted into the corn container to cut the husk of the corn vertically when the corn is first inserted and circumferentially when the apparatus is rotated with the help of the wheels. The blades must not penetrate more than 2.0 mm into the corn because that is the estimated thickness of the cornhusk (see note). The blades are able to come out of the corn container so that they do not damage the edible parts of the corn once the husk is removed. Needle blades were chosen because they are able to exert the concentrated applied force onto a very small area, penetrating the surface easily. Vegetables have a low elastic modulus, so the sharpness of the blade is more important than the angle that the blade is applied at. Thus needle shaped blades are the optimal type of blade for this conceptual design.

Blade Guarders:

The blade guarders are used to cover the blades when pulling them out of the corn container but are attached to the overall apparatus, so that they don't come out and hurt the user. This is to meet the constraint of safety posed by the initial design brief.

Benefits:

The number of human operations required is less than six, which also meets a given constraint. The apparatus materials will be chosen based on the constraint that the overall cost must be less than $21.00. Less expensive materials, such as rubber, cloth, or nylon will be used for the lining. The outer container must be made of a light, inexpensive material (i.e. plastic). The apparatus will be hand washable to maintain sterilization for long-term usability.

This conceptual design meets most of the constraints and criteria proposed in the design brief. It was chosen based on its ability to incorporate the main objectives presented in the brief, such as reducing the amount of effort and time required to shuck the corn. It was designed for domestic purposes and affordability because the key stakeholders are household users. At the same time, it has applications on the producer level as well.

Thus by meeting the constraints and addressing the main objectives of the design brief, which were usability, ergonomics, ease of removal of corn husks, and affordability, this conceptual design is within the scope of the design brief.

Conceptual Design #3:

This design primarily focuses on control of the corn shucking process by the user. It consists of two gloves, with one enabling the user to remove the husks and the other enabling the user to remove the silk hairs.

Procedure of Operation**:**

1. Put on the gloves and hold the corn with the Silk Hair Removal glove.

2. Use the hooks on the Husk Removal glove to cut the husks of the corn.

3. Remove the husks by using two hands to drag the husks along the cutting lines.

4. Put the corn under running water and use the hand with the Husk Removal glove to hold the end of the corn. Use the Silk Hair Removal glove to scrub it.

Key Design Features:

Husk Removal Glove**:**

The glove should be made of soft and elastic materials, with the ring being made of a harder material (the ring has a width of approximately 2-3 cm). The diameter of the ring is about 2-2.5 cm [7]. There is a hook located on the end of the ring that has the primary function of cutting the husks. When the user wears the glove, the hook should be in front of the thumb. A second hook is located on the end of the index figure, with the diameter of this ring being approximately 1.8cm (due to the index finger being less thick than the thumb) [7]. Both hooks are to be made of a hard material. The hooks are thin but not very sharp in order to effectively cut the husks and prevent the user from being harmed.

Silk Hair Removal Glove**:**

This glove is made of the same materials as the first one, but there are many small bristles on the in-hand side of the glove. The material of the bristles should be elastic and flexible in order to effectively remove the silk hairs.

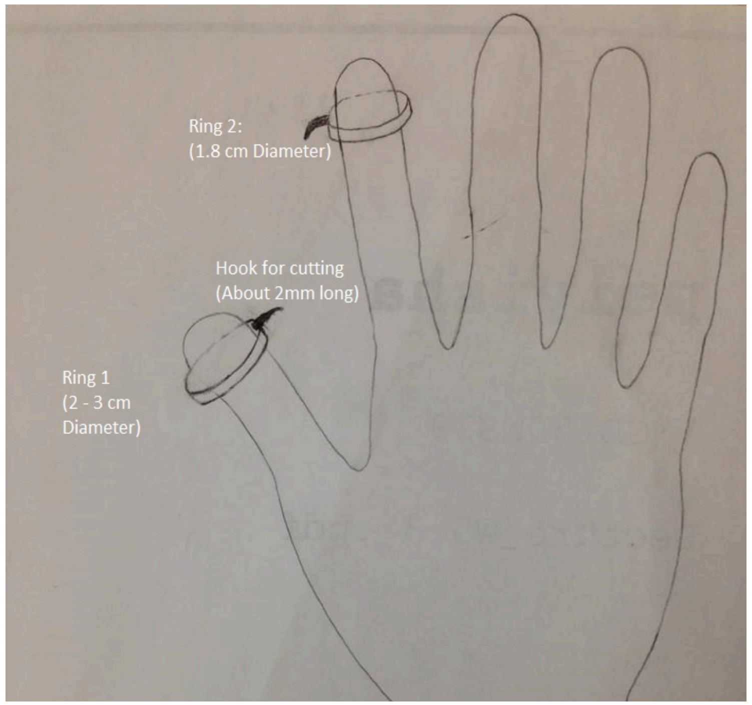


Figure 4: Conceptual Design #3 Part 1

Benefits:

This design is based on regular working gloves used in daily life, but has been altered to match the specific Dfxs outlined in the refinements section of the report. The hook-ring combination on one glove and the multitude of bristles on the other corresponds to the design for ergonomics. The materials to make the hook and ring are not very sharp, which correspond to the added design for safety Dfx. The additions to everyday working gloves are minimal, which correspond to the Dfx of affordability (as specified by the metric less than $21 in the report) [8]. In addition, this design corresponds to the metrics outlined by the design brief. The process requires less than 6 human operations and the design can easily be fitted to a 172 mm hand. In addition, it can be made to have a mass of 100-200 g [9]. Finally, it has no electrical components that may harm the user it will not chemically alter the corn.

When analyzing the association with the key stakeholders, this product is both suitable for use in the home and for corn vendors and producers. Its application to both industrial and consumer needs and processes enable it to fit the requirements outlined by the original design brief.

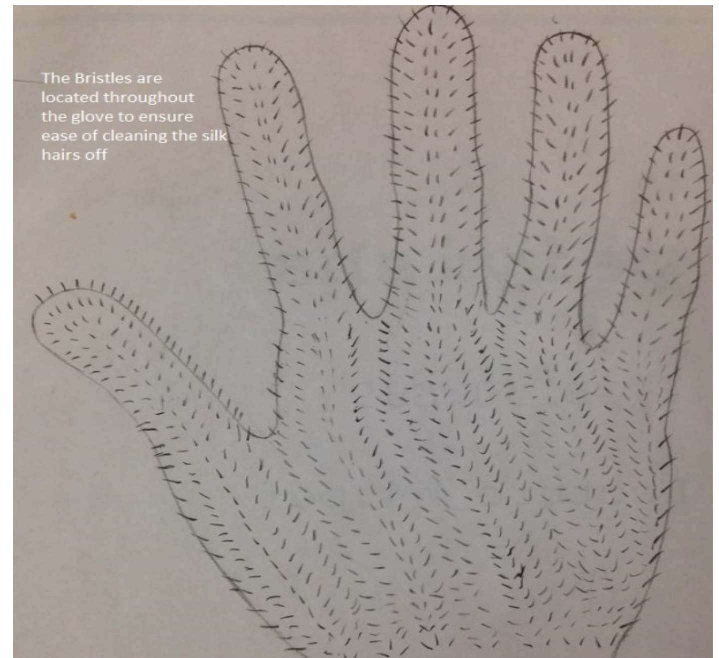


Figure 5: Conceptual Design #3 Part 2

Conceptual Design #4:

Procedure of Operation:

Step 1: Put the corn into the corn husker (through the side with the sharp hooks).

Step 2: The corn husker will adjust to the relative size of the corn as it is pushed through the bottom and top halves of the cylinder. The bottom ring lined with the hooks will cut the husks first.

Step 3: The staggered stoppers in the middle ring will push down the leaves to reveal the edible part of the corn.

Step 4: As the corn is pushed into the top half of the cylinder, the top ring will remove the silk hairs on the corn with the stiff bristles. When the corn is removed from the apparatus, it will have been thoroughly shucked.

This corn shucker was designed with safety, usability, and effectiveness in mind. As such, all design decisions reflect these values and meet the constraints set out by the refined design brief. The corn shucker is a hollow cylinder consisting of three rings. The size of the corn husker was designed with the dimensions of the refined design brief in mind.

Key Design Features:

Top, Bottom, and Middle Rings:

Key features of the corn shucker include the design of the top ring, bottom ring, and middle ring. The bottom ring consists of sharp hooks that will be responsible for removing the corn husks once it is placed in the apparatus. The top ring has bristles that will perform the function of removing the silk hairs after the husks are removed.

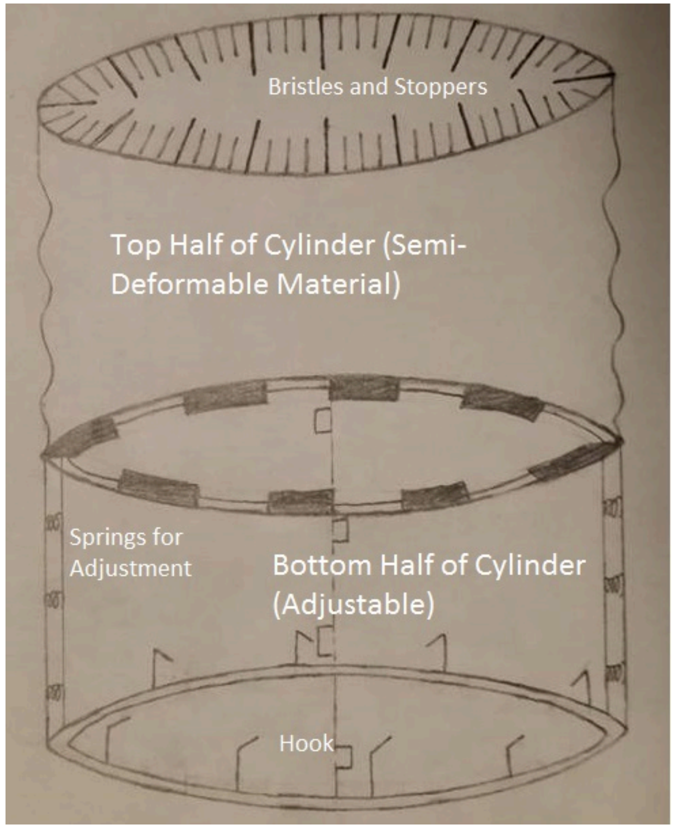


Figure 6: Conceptual Design #4

The top and bottom rings of the hollow cylinder will be separated by a staggered set of stoppers in the middle ring. The staggered stoppers will prevent the husks from entering the section of the cylinder that will be responsible for removing the silk hairs. The bottom half of the cylinder will have an outer wall and an inner wall made of a light, but stiff, material. The inner and outer walls will be separated by a lining of small springs so that the bottom section may maintain its stiff frame but adjust to the varying size of the corn.

The top ring of the hollow cylinder will be responsible for removing the silk hairs. The top half of the cylinder must be made of a semi-deformable material in order to adjust to the dimensions of the corn. This will allow the brushes to clean the corn thoroughly. As a result, it improves the effectiveness of removing the silk hairs and remaining leaves. This material must be flexible enough to clean the corn without harming the kernels. The brushes differ in size, with sixteen slightly longer bristles separated by the same distance along the circumference to account for the average row distance of corn.

Focusing on the Materials of the Design:

With respect to the choice of materials for cutting and removing the husks, the materials of the hook blades and stoppers should be chosen to maintain the functionality of the corn husker for a long period of time. The length of both the blades and the stoppers should be restricted within one to two millimeters (the thickness of the corn husk) as to not harm the corn kernels throughout the procedure. The brushes that will be responsible for the removal of the silks in the top ring of the hollow cylinder must be made of a material similar to most vegetable and fruit brushes. [10]

Design for the Human Hands:

The hollow cylinder should be ergonomically designed to fit into a pair of human hands comfortably and equipped with a deformable material for the lining. This will make it adjustable for different sized ears of corn. In addition, the middle cross-section was designed similar to a mosaic, which allows the hollow cylinder to be divided into two parts. This part of the design makes the cleaning of the corn easier and faster because then the user does not have to remove the husks manually after they have been cut. The top and bottom sections are also separable to ease the cleaning process performed by the user.

Benefits:

The benefits of this corn husker stem from the design decisions. The corn husker's design takes into consideration the usability, accessibility and affordability of home consumers and other common requirements (including safeness and ergonomics). The hollow cylinder should be designed to fit into a pair of human hands. According to the reference 'Hand Tool Ergonomics'[11], the diameter of a cylinder that fits into one human hand is 60 mm. Seeing as this product will use two hands, the diameter should not exceed twice this distance. Furthermore, consumers can be comfortable to wash the tool after disassembling those three sections. The types of materials must be chosen so that they will not alter the nature of the corn. Last but not least, the price of the corn husker must be less than $21.

Chosen Conceptual Design:

This section of the report provides justification for which design is considered the best and should be brought to the detailed design team. This design is **Conceptual Design #4.** We have decided upon this using what is known as the Cardinal method, which outlines the key aspects of each design and assigns them numerical values according to their effectiveness in these areas. The figure illustrates the chart that was created through the implementation of this method.

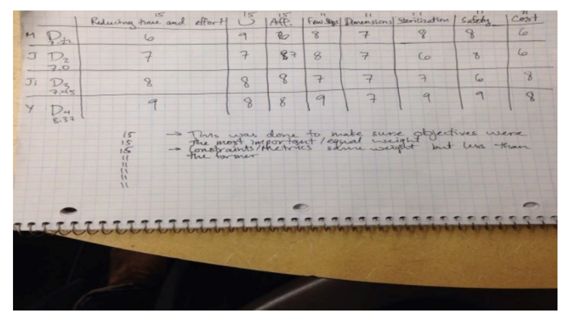


Figure 7: The Cardinal Method. This was used in determining the best conceptual design.

The key aspects analyzed through this chart are as follows:

1. Reducing time and effort
2. Usability
3. Affordability
4. The amount of steps required
5. Dimensions (general overview not specific)
6. Sterilization
7. Safety
8. Cost

The first three items on this list primarily relate to the overall issue with the current corn shucking process and the objectives of the design brief. As a result, they are weighed equally (15% each) and also more heavily (only slightly) than the other items (which are 11% each). The other items relate to the constraints which, though they are essential in the design of the product, do not represent the overall goals of the brief and this Conceptual Design Report. The values of 15% and 11% were simply utilized in order to obtain a total weight of 100%.

Each conceptual design was assigned a numerical value out of 9, with the greater coverage of each aspect resulting in higher numerical values. These values were simply determined through the key design features and how they abided by the constraints and fulfilled the objectives. Once all of the numerical values were assigned, they were totaled with the weights taken into consideration. The overall score was out of ten. As a result of this method, **Conceptual Design #4** received a score of 8.37 (while the other received scores in the 7-8 range). 8.37 is very respectable due to the tradeoffs that are always associated with the engineering design and the fact that a design can never be perfect. **Conceptual Design #4** is the best representation of an overall holistic and analytic solution to the issue of the inefficient corn shucking process outlined in the original design brief. It should be noted that the Cardinal Method was simply used to help organize the positive and negative traits of each design. It was not solely responsible for choosing the conceptual design that will be further developed.

Key Design Decisions;

Thus after careful selection of the best concept through several iterations of the design process, the conceptual design team has chosen these four design decisions to be further looked into by the detailed design team.

1. The Materials:
   - Must adhere to the constraint set by the design brief of cost efficiency (i.e. the cost of the product must not exceed $21).
   - Must be chosen based on the requirements of the material set by the selected conceptual design.
2. The Dimensions:
   - Must adhere to all constraints set by the refined design brief and constraints set by the conceptual design.
   - Must be chosen based on cost efficiency and to optimize effectiveness of the product.
3. The Aesthetics of the Design:
   - Must not reduce overall effectiveness of the product.
   - Must not change key operations within the conceptual design.
4. The Refinement of the Design:
   - Must adhere to the objectives and constraints set by the refined design brief.
   - Must not reduce the effectiveness of the product to act as a solution to the original problem.

Upon the selection of these critical aspects, the design process may then continue with initial production of the corn shucker that will resolve the issue outlined in the original design brief.

References

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[12]Figure 1 was obtained from the original design brief.

Overall your report presented some good designs to the corn shucking problem that appeared to be developed through a clear process.

You present a logical reframing of the brief, however given the organization of the first page it is really difficult to parse out what changes you have actually made. A list of changes or list of final constraints/criteria would have greatly enhanced the readability of this section.

You presented a clear process, and your flowcharts really helped me in understanding what you were doing. Listing some of the ideas that you came up with in Wishing or brainwriting would have greatly strengthened the quality of your report. Additionally providing some information as to which designs were and were not excluded as you moved through your second process would have been beneficial to understanding how you arrived at your four candidate designs.

Your descriptions of your designs and the figures presented were really helpful in understanding your candidate solutions. In particular, your Procedure of Operation greatly assisted me in understanding what your designs were and how they worked. However, each design appeared to be presented in a slightly different format - be careful to make sure this doesn't happen in the future and that the format of your documents are unified.

Your process of selecting your preferred design was not clear as you did not exercise any engineering judgment in making the decision. You cannot delegate ownership of the decision to an MCDM/A tool, and declare one the winner simply because it has the highest score. MCDM/A tools are meant to assist you in understanding the relative performance of the designs, and to help inform you as to how you would want to make a decision. But, they do not make decisions.

Process of deciding last one unclear - cannot delegate ownership of decision

Two more deliverables remain in the Conceptual Design. Based on the first deliverable, your grade so far is B-.