Cal Poly Caramel

Counter Top Candy Wrapping Machine

Final Design Report

By:

Alexander Miller

Trevor Steele

Roman Stambaugh

Sponsor: Erin James

Senior Project Advisor: Lee McFarland

Contact Information:

amiller137@icloud.com

trev3.18ak@gmail.com

rstambaugh01@gmail.com

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Introduction

Erin James, a caramel candy proprietor and sponsor of this project has requested the design and build of a machine that will allow her to reduce the amount of time spent cutting and wrapping homemade caramels as this process currently takes too long to be commercially competitive. As a small batch confectioner who uses her home kitchen, Erin requires a machine that is low cost, compact enough to store and operate in her house, and capable of wrapping one batch, or 144 caramels, in approximately 10 minutes. This would reduce the amount of time it takes to complete this process by 35 minutes from the current time of 45 minutes that it takes her to cut and wrap the caramel by hand. While there are already a variety of machines from industry that perform this process, they are too large and/or expensive for the required small scale use for this project.

The purpose of this project is to prototype a caramel wrapping machine that fits easily in her home kitchen storage space, costs equal to or less than $2000, and reduces the overall time and effort spent wrapping a batch of caramel candies from 45 minutes by hand to approximately 10 minutes. Per the sponsor's request, the caramels will be wrapped in wax or parchment paper with a double end twist and conform to FDA requirements for food safe handling.

Background Products

Background research on existing similar products was performed in order to gain perspective on how to successfully design the automated candy wrapping machine that is desired. The research proved to be helpful as many different yet similar designs were found that helped the team come to a better understanding of how industry is capable of achieving the candy wrapping process. Although a machine that fulfills the project requirements does not exist, there are many machines that perform similar functions that have proven to be very enlightening. The designs that proved most beneficial to the research shown below includes the Bees Brothers Homemade Double Twist Candy Wrapper, Bafu DWM550 Double Twist Packing Machine, Bafu DWC 300 Double Twist Chocolate Packing Machine, and finally the Savage Bros Company Carousel Cream Center Extruder & Cutter.

The most similar design that was found throughout the research process was the "Homemade Double Twist Candy Wrapper" design by the honey caramel business, Bees Brothers [1]. This design, shown in Figure 1, follows a similar process of double twist wrapping a small piece of candy using identical rotating claws located on the opposite sides of the candy. This homemade candy wrapper also shares a similar size to what is required of the final design of this senior project. However, the design is slow, lacking the desired quantity of candy wrapped over time, and fails to incorporate cutting the candy or wrapping paper from its initial size. Another large concern is that this design would not meet FDA standards based off the observed materials utilized to build this product as well as the lack of a surrounding structure.

Figure 1. Bees Brothers Homemade Double Twist Candy Wrapper.

The product research then shifted to the larger, more expensive machines used in industry to achieve a fully automated candy wrapping process. It was quickly observed that the Taizhou Bafu Machinery Corporation provided the best opportunity to gain valuable insight on existing machine designs that fulfilled the various candy wrapping requirements. The Bafu webpage publicizes that their company has "offered extensive and innovative solutions in packaging equipment and systems for more than 20 years" while specializing in "horizontal flow wrappers,

candy packaging machines, chocolate packaging machines, double twist packing machines & automatic packaging lines" [2].

The first Bafu design explored was the Bafu DWM550 Double Twist Packing Machine found in Figure 2. This machine performs the candy wrapping process at a rate of 550 pieces per minute. This candy wrapping rate immensely exceeds the scope of this project, which is reflected in the proportionally increased price of the machine of approximately $10,000. Although the Bafu DWM550 performs the necessary function of double wrapping the candies, it was designed to function with the far less complicated hard candy product. These hard candies do not have the challenges associated with caramel such as stickiness and size deformations associated with external forces and temperature variations. However, observing the machine while functioning provided noteworthy insights into possible conceptualization techniques to incorporate into the final design. These techniques include the machine's ability to place the candy in a place where the machine can grab each candy and wrap it with a relatively low error rate of less than 1%. However, the problems associated with high cost, power consumption, and large size results in the DWM550 machine being ill-suited for the sponsor's requirements.

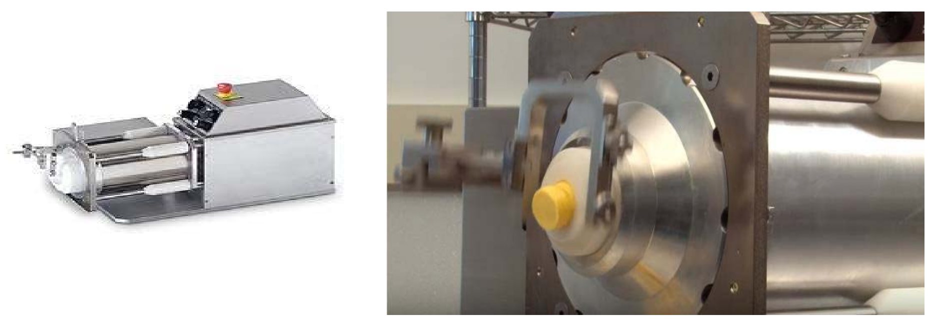
Figure 2. Bafu DWM550 Double Twist Packing Machine.

The second Bafu design that was investigated is listed as the DWC300 Chocolate Wrapping Machine from Figure 3 [2]. Although similar to the overall function of the DWM550, the DWC300 provides the operator with an alternative candy locating style. Instead of allowing the candy to be grabbed off of a conveyor belt, the candy is automatically pushed into a small cranny on a rotating feeding plate. The candy is then pushed up into a separate rotating arm that grips the candy and places it with the small piece of wrapping paper that will eventually be double wrapped to encase the candy in the final stage of the process. For this reason, DWC300 is considered to be the superior design in terms of creating an attainable solution for the problem arising from what happens to the candy after it is cut into its final shape. This design helped further conceptualization of how to create a successful machine, but the same factors of cost,

size, and power consumption render both Bafu models unrealistic for the design required for this project's specific needs.

Figure 3. Bafu DWC300 Chocolate Wrapping Machine.

The last design that was explored to help better understand industrial machines and further the focus on brainstorming was the Savage Bros Company Carousel Cream Center Extruder & Cutter [3]. This machine, shown in Figure 4a, does not follow the same candy wrapping process as the previously mentioned designs. However, this machine provided insight on how to incorporate the initial cutting of the caramel. With a similar shape and consistency as the material shown in Figure 4b, the same function as shown in the device can be utilized to ensure that the final design can successfully cut the caramel into the necessary shape and size as requested by the sponsor. The Savage Bros product may not be much help for the entire process, but it provided valuable insight to further conceptualization of an important component of cutting the material in the process.



(a) (b)

Figure 4. (a) Savage Bros Company Carousel Cream Center Extruder & Cutter including (b) the machine while operating.

Technical Research

A large desire for this design is the wrapping paper. The ideal wrapping paper material has been specified to be parchment paper due to its homemade feel. The problem that arises with parchment paper is that the rolls the sponsor buys from a wholesale store are 15” [4]. These rolls are not suitable for the final wrapping of the candy as the required size for the final stage is approximately 3”x4”. The 15” roll needs to be cut along two sides in order to get the square shape required to wrap the candy. Ideally, the machine would make a single cut along one side to create a 3”x4” piece of paper. It is possible to make two cuts on the 15” roll but this would not be ideal. An idea that was formulated was to have a separate function or machine which could cut the 15” roll into five 3” rolls. From here the 3” roll could be fed into the wrapping machine and single cuts could be made easily. After looking at many parchment paper manufacturing companies, it became obvious that small 3” or 4” rolls are not readily available. The closest thing found was a roll of parchment paper 4” wide and 13 feet long [5]. The problem is each square would come out to $0.11 per square when the current cost of a 15” roll comes out to only ⅓ of one cent per square. The problem remains that two cuts need to be made on the 15” roll in order to get the required square size. After exploring the internet for parchment paper distributors, a company based in Wisconsin was found that produces all kinds of paper rolls, specifically food quality paper [6]. The company, BPM Inc., did not have much information about size and pricing on the website, so they were contacted in an attempt to gain more information. It is unclear at this point if they sell parchment paper or just other kinds of wax wrapping paper. It was noted that the company sells food safe paper rolls in multiple colors, which the sponsor mentioned as a future desire to index her candies for distribution.

A large portion of the research that was performed was related to existing FDA regulations that must be met in order for the sponsor to utilize the resulting candy wrapping product to perform its task and sell her candies. After discussing the topic of FDA regulations on the Cal Poly campus with an expert on the topic, Dr. Kathuria, the conclusion was made that the design must follow the guidelines laid out in the U.S. Public Health Service Food Code and the Code of Federal Regulations Title 21.

Another important aspect to this project is the usability and ergonomics of the device. While specifics cannot be identified at this stage, the need for a user friendly device is evident. It has been noted that the machine needs to be able to be operated and moved between the operational and storage spaces by one person, which limits the size and weight of the final product. It will be taken into consideration that the operator will be standing during this process and would like to be comfortable as they operate the machine.

Objectives and Scope

The requirement for this project is to reduce the labor and time involved in the wrapping process. The final working prototype should be able to perform the following functions:

- Cut parchment paper to size
- Cut caramel into a specific predetermined size
- Fold and double-twist wrap the caramels within the newly cut parchment paper
- Wrap approximately 12 caramels per minute, or one batch of 144 candies in 12 minutes
- Perform these functions within a semi-automated process

Cutting parchment paper to size:

Cutting the parchment paper is one of the most valuable operations needed from the candy wrapping machine. Other than hand wrapping, this task is the most labor intensive and needs to be automated in order to reduce labor and time.

Cut caramel into pieces:

Whether the machine is fed a tray of caramel or a strip of caramel, the machine design will have the function of creating bite sized pieces of candy to be wrapped. It has not been determined if the machine could be fed an entire tray which would be most ideal. However due to time constraints and storage size constraints, it seems more likely than not that the machine will be fed strips of caramel. Another idea was the machine could be fed a blob of caramel. However, this seems well out of the project's scope as the machine would have to salt and cool the caramel as well because part of what makes the sponsor's caramel unique is the way she salts the caramel, and the machine would need to replicate this. Another idea is that the machine would perform a cubing function separate from the automation. After being cut to size, the user could then place the cubed candies into the machine. This idea is not ideal because it leans more heavily on being semi-automated, but it is not being ruled out.

Double-twist wrap:

This function is the sponsor's desired wrapping style of the caramel candy. All the functions of the machine will set up the candy and paper for double twist wrapping. The main challenge present in this function is the synchronization of the caramel and paper to set up for the twisting.

Wrapping speed:

The output goal of the machine is to wrap 12 caramels per minute. This number was decided based upon the created Quality Function Design (QFD) located in Appendix C. Knowing that a strip of the sponsor's caramel produces 12 candies, it was decided to aim for one strip of 12 candies per minute. While competing machines like the Bafu DWM550 wrap 500 pieces of candy per minute, the small scale needs of this project do not require that high of a wrapping rate.

Semi-automated:
From the QFD in Appendix C, having one user was determined to be of the utmost importance. Therefore, it is desired that the user will only need to perform minimal functionality duties. The user feeding in caramel or placing the pieces in the machine hopes be the most interacting the user will need to perform. From that point on the machine will be completely automated. The goal of this machine is to reduce labor for the user, so the least amount of user responsibility along this candy wrapping process is the goal of the final design.

After analyzing the wants and needs of the sponsor along with what was determined as obtainable goals, other necessities were determined for this machine. All these valuable necessities, and how they were determined are outlined below and in the QFD in Appendix C.

Cost - The budget to create a prototype of this machine has been set by the sponsor to be $2000. Cost estimations, money spent and remaining budget will be kept track of by the treasurer and saved in a spreadsheet.

FDA - A significant requirement of the design and materials to be used to build the machine is that they must be food safe and FDA approved. The U.S. Public Health Service Food Code and the Code of Federal Regulations Title 21 will act as guidelines to ensure the final product is safe and approved.

Machine life - 3000 hours. A machine designed to this specification would last about 18,000 batches of caramel.

Speed - Currently it takes about 45 minutes to an hour to wrap a batch by hand. This project is aimed at cutting that time down. An output of 12 pieces per minute has been set as the goal and seems obtainable within the project's constraints. This machine would wrap a batch of 144 candies in 12 minutes, which significantly reduces the current time. To achieve this rate, the throughput rate of the machine will be calculated during the design stages and the machine will be tested over multiple batches during the testing stage.

Size - This machine must be storable in the sponsor's closet space. To fit in the closet, the machine can be no larger than 2' x 3.5' x 5'. However, the machine can be designed in sections, which are storable but can expand to a larger size when in use. When designing the machine, all functions will be constrained as necessary.

Setup and cleanup
In order to speed up the process the setup and cleanup must be worthwhile. It seems reasonable that it would take 10 minutes or less to set up and 10 minutes to clean and put away. When designing the machine this will be taken into consideration.

Safety

Due to the fact that this machine will be used in a home where small children are present, safety for the operator and anybody near the machine while in operation is important. The goal is to design a machine which is user friendly and very safe. For this reason, blade guards and shielding will be implemented where necessary.

Design Development

The first step in the design of the machine was to define every function the machine must perform. The following nine functions were determined to be essential to the candy wrapping process:

Feeding the caramel - The way the caramel is placed into the machine
Moving the caramel - The caramel must be moved throughout the machine
Cutting the caramel - The caramel strips or tray must be cut into cubes
Feeding the paper - The paper roll must be fed in a way which places it with the caramel
Moving the paper - Once fed, the paper must be moved throughout the machine
Cutting the paper - The paper must be cut to size for folding, about 3x4 inches
Locating the caramel and paper - The two items, candy and paper, must be located together
Folding the paper - The paper must be folded all the way around the caramel
Double twisting - The machine must double twist the candy and paper

The next step toward developing ideas for a complete layout was to brainstorm as many ideas as possible. During this time no ideas were rejected. This allowed for many ideas to be formed. Each group member felt comfortable voicing any possibilities for each function that he could imagine. This method resulted in multiple ideas for each function as every voiced idea was written down during the brainstorming session, which can be observed in Figure 5.

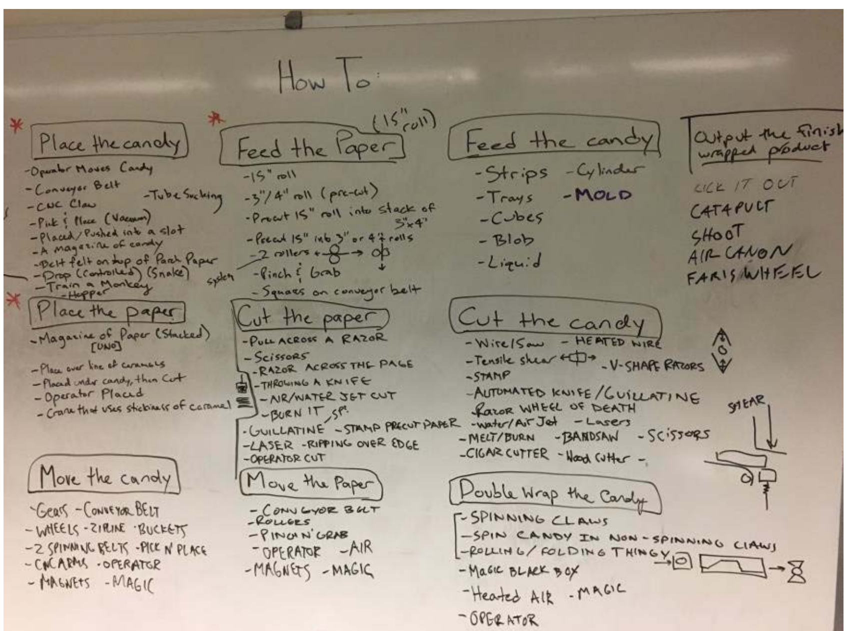
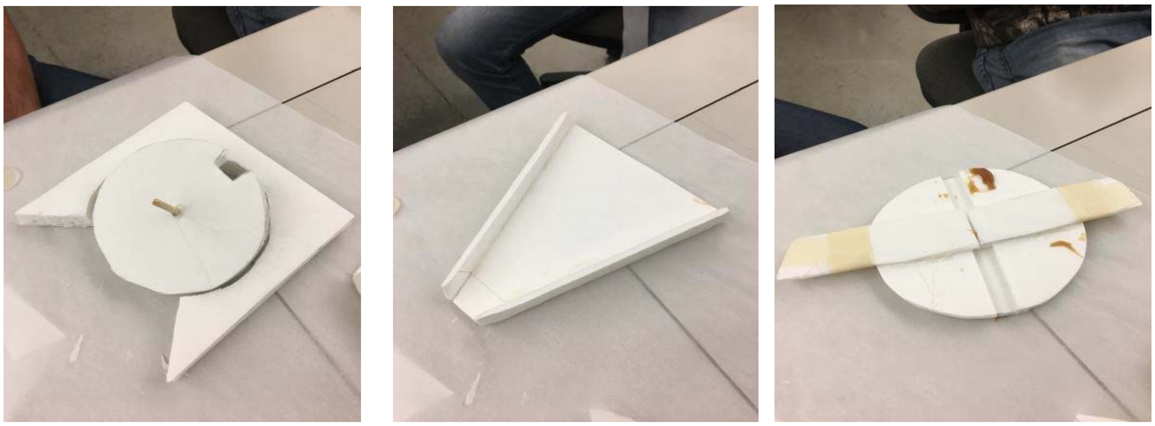


Figure 5. List of concepts resulting from the brainstorming session.

Once a list of ideas was formed from brainstorming, the next step was to analyze each idea and cut down the list to a few top concepts for each function. Each idea was tested by making simplistic foam board models to observe simple functions of each idea. This step allowed for discarding unrealistic and impractical concepts to allow for a list of remaining sensible concepts

that could be incorporated into the final product to allow for the machine to accomplish its task. Functions such as cutting the caramel, moving the caramel, cutting the paper, and placing the caramel in a slotted wheel and folding the paper as the wheel rotates around a wall were included in the functions that were tested through foam models.



(a) (b) (c)

Figure 6. Basic material concept testing of (a) slotted wheel (b) extruding and moving the caramel (c) cutting the caramel with a wire.

Pugh matrices were utilized to rate the practicality of each concept and rank them against one another to find the best solutions. An example of one of these Pugh matrices can be observed in Table 1 while the rest can be found in Appendix E.

Table 1. A Pugh matrix utilized to find the top concepts for how to move the paper.

Criteria	Cost	Meets FDA Specs	Part Life	Size	Error Rate	Added Weight	Blade Life	Safety	Maintenance Cost	Power consumption	Realistic
Options											
Conveyor Belt	+		-	-	+	-		+			
Rollers	D		A		T			U			M
Pinch and Grab	+		-	-	-	-	-		-	-	-
Air	-	-	-		-	-	-	-	-	-	-
Magnets		-		-	-	-		+	-	-	-

The results of the pugh matrices provided us with key top concepts for each function for the candy wrapping design. These top concepts include:

Feeding the Caramel
- Pushing wheel
- Conveyor belt

Moving the Caramel
- Conveyor belt
- Compartment wheel
- Actuator pusher arm

Cutting the Caramel
- Wire
- High Speed Blade

Locating the Caramel and Paper
- Mechanical Puncher
- Conveyor belt to conveyor belt
- Pick and place

Double Twisting
- Mechanical Claws
- Small motor-powered claws

Feeding the Paper
- Rollers

Moving the Paper
- Rollers
- Conveyor belt

Cutting the Paper
- Guillotine
- Pull across a razor
- Roll across a razor wheel

Folding the Paper
- Slotted wheel and wall
- Mechanical folding arms

Preliminary Testing

Once the top concepts were decided upon, the next step was to physically test the concepts with miniature models to gain a better understanding on how each concept performed. Methods that were tested included cutting the caramel, cutting the paper, and folding the paper. Figures 7-11 show the prototypes that were tested. Building and testing these functions allowed for a better understanding of what will work and what won't.

Figure 7. Slotted walls to hold paper as caramel spins to twist ends.

Figure 8. Slotted wheel to fold paper around candy and hold candy in place during paper twisting.

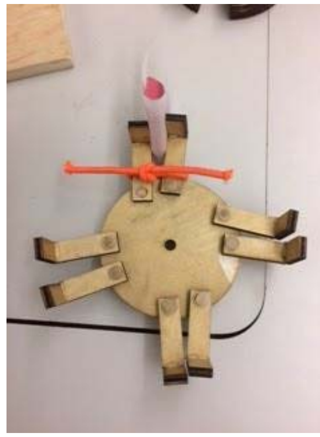


Figure 9. Claw wheel to fold paper around candy and hold candy in place during paper twisting.

Figure 10. Wire cutter to cut caramel strips.

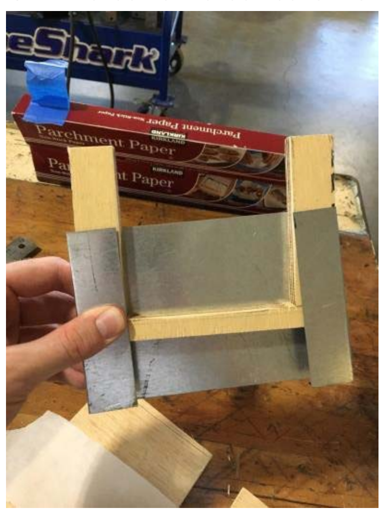


Figure 11. Guillotine type cutter to cut caramel and/or paper.

Experimenting with the models resulted in incorporating the following details into the final design:

- Strips of caramel will be fed into the machine
- A 3 inch roll of paper will be fed into the machine
- The caramel will be cut with a wire or a spinning blade
- The paper and candy will be folded against a wall as it rotates in a clamp
- The paper will be twisted by claws which clamp and twist

It is desired to feed 3 inch rolls of paper into the system to simplify the machine but there have been difficulties finding rolls of this size. After contacting companies to see if they would be capable of providing 3 inch rolls of parchment paper failed, a process of experimenting with other methods of producing properly sized rolls began. The easiest option that had positive results was running the roll through a vertical band saw. Figure 12 shows the roll after being cut with this process. This would allow for a standard 15 inch roll to be bought from the supermarket and modified to fit the size needs of the candy. If a future version is necessary to adjust to different sized candies, this process could still be used to modify existing rolls of parchment paper to the proper size.

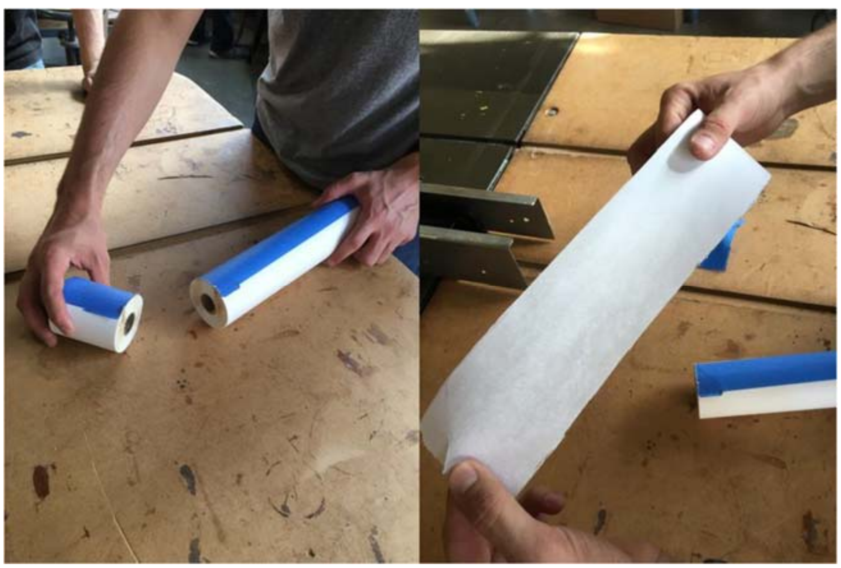


Figure 12. Roll of parchment paper cut with a vertical band saw.

Using the results of the pugh matrices and testing, plausible system layouts were created. The best ideas from each function were combined in a way which seem to flow best. Two full system designs were developed based off these layouts, which are shown in Figures 13 and 14. Below are the two system layouts which implement these design aspects as well as other intermediary steps. The second layout, or system B, acts as the current favorite as it is believed to be the most practical and will best meet the specifications defined earlier. However, these layouts are still preliminary and subject to change as the way the caramel is fed and cut may still be updated upon further testing.

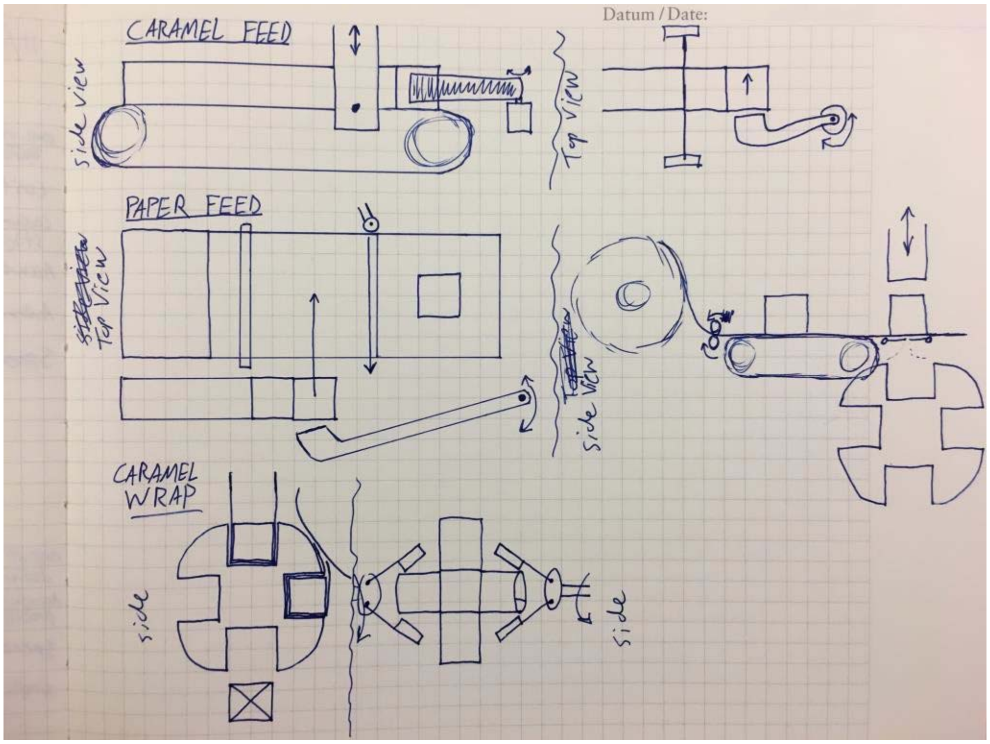


Figure 13. Full system layout A.

System A. This system runs two parallel conveyors side by side. One moves the caramel and the other moves the paper. As the caramel moves down the conveyor it is cut by wire and then punched off onto the other conveyor belt with paper. The paper and caramel then move together until they reach a spring loaded door. The paper is then cut by a rolling razor wheel and the paper and caramel are punched through the door and into a slotted wheel. As the caramel and paper are pushed into the slot, the paper is forced to fold around three sides of the caramel. Then the caramel and paper are rotated around and against a wall which folds the final side of the candy. After all folds have been made the claws clamp on both open ends of the paper and rotate to give the paper its twist.

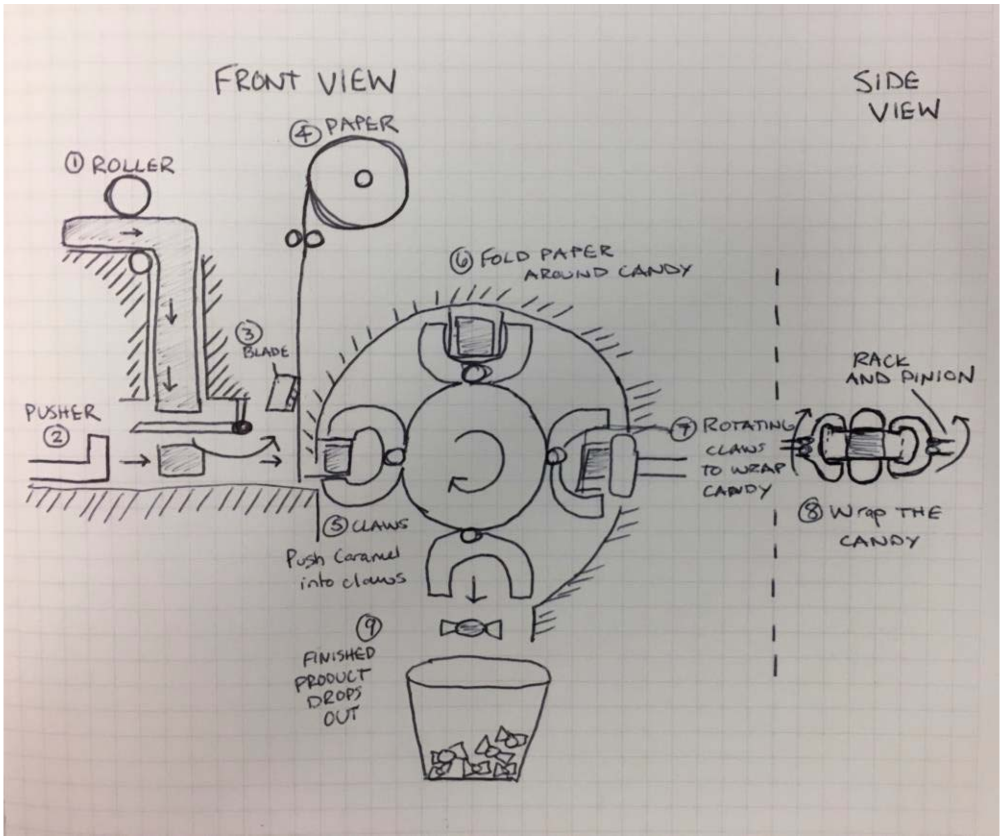


Figure 14. Full system layout B.

System B. In this system the machine takes a strip of caramel and pushes it downwards. The downward force is created by a roller wheel with little teeth that grab the candy and push it forward. A spinning blade swings around and around and cuts the caramel as it is pushed down. The caramel cube is then pushed into a square of paper and then into a clamping slot. The paper is fed down by rollers and then cut to square by a guillotine blade. Once the caramel and paper is clamped it is revolved along a wall which gives it the final fold. The paper is then twisted by two claws that grab and twist.

Method of Approach

To create a viable, well designed system, the following stages will be followed over the next 30 weeks: problem definition, conceptual solutions, analyze concepts, evaluate concepts, detailed design, manufacturing, validation, and final reporting. Table 2 outlines the major dates and deliverables over the next year. A detailed Gantt chart is shown in Appendix F.

Table 2. Senior Project Timeline.

Problem Definition	October 25, 2016
Project Proposal	October 25, 2016
Conceptual Solutions	November 1, 2016
Analyze Concepts	November 10, 2016
Preliminary Design Review	November 15, 2016
Evaluate Concepts	November 22, 2016
Critical Design Review	February 7, 2017
Detailed Design	February 14, 2017
Manufacturing	March 16,2017
Safety Inspection	March 16,2017
Senior Project Expo	June 2, 2017

In the problem definition stage, the problem as well as the purpose of the solution was identified. This process was completed by meeting with the sponsor, which allowed for a clear understanding of what she needed and how she wanted this machine to perform, while also interviewing individuals with knowledge of the food packaging industry and researching existing solutions. This stage was completed on October 25, 2016 and outlined in the project proposal.

In the solution conceptualization stage, research was conducted on current products and interviews with potential users were utilized to generate as many solutions as possible. Methods such as brainstorming and writing were also used to aid in the ideation process. This stage was completed on November 1, 2016.

In the concept analysis' stage, small scale and proof of concept testing was performed to validate the conceptual solutions and completed on November 10, 2016.

In the concept evaluation stage, the results of the testing done in 'Analyze Concepts' was used to determine which solutions were practical and met requirements. During this stage, a preliminary design review (PDR) was held to pitch the best ideas to the sponsor and the senior project advisor, Professor Lee McFarland. The PDR took place on November 15, 2016 and was utilized to gain feedback from the sponsor and advisor on which design was most feasible and fit her needs and desires. After the PDR, feedback was received on each design to put together a single design, layout C, on November 22, 2016. This design can be observed in Figure 15.

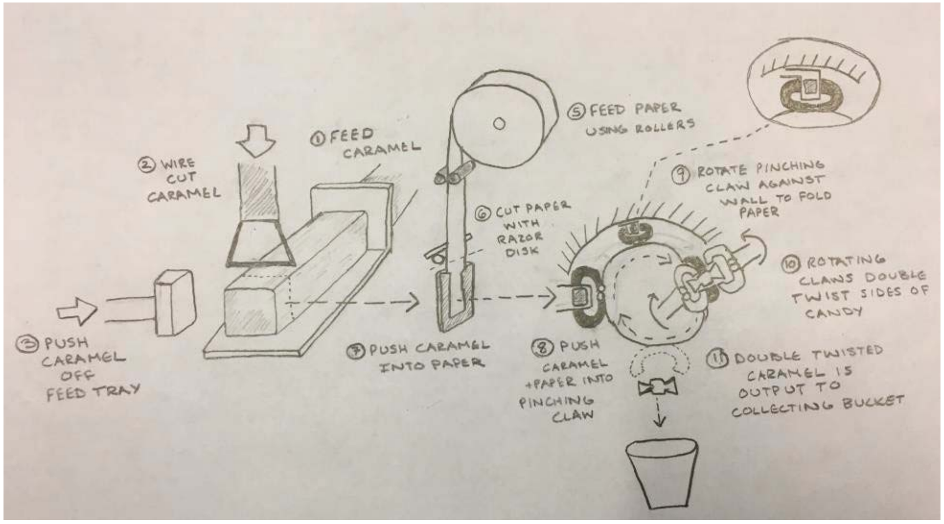


Figure 15. Full system layout C. The caramel is fed on a tray and cut by a wire cutter before being pushed into roller fed paper that is cut by a horizontal disc cutter. The caramel is placed into the paper and pushed into a pinching arm on a rotating disk that is rotated 180 degrees, which folds the paper around the caramel, and eventually wrapped by two rotating claws before exiting using gravity as the pinching arms open.

In the detailed design stage, each component of the machine was fully designed for strength and geometry. On February 7, 2017 a critical design review (CDR) was held in front of the sponsor, senior project advisor, and fellow peers to review and address all details of the design. After the CDR, the feedback was used to correct any shortcomings of the design and a complete final design will be finished by February 10, 2017, or 4 days earlier than the initial date estimate of February 14th, 2017.

In the manufacturing stage, detailed drawings were created for each component. Most of the commercially available parts and war materials will be ordered and finally the machine will be assembled after the parts are manufactured. Items with long lead times will need to be ordered before this time to allow for prompt assembly and testing of the machine, as such those items will be selected as early as possible and may need to be ordered before the CDR. A fully assembled prototype will be completed by March 16, 2017.

In the validation stage the machine will be tested to ensure it meets the specifications defined in this proposal and rework areas that fail to meet specifications. On March 16, 2017 the senior project advisor and any necessary specialists will inspect the machine for safety considerations. After passing the safety inspection, the testing stage can commence.

In the final reporting stage, the results of the final design and testing will be summarized in a report and demonstrate the use of the machine at the senior project expo on June 2, 2017.

Design Description
After further refining the PDR design, Solidworks was used to illustrate a full design layout implementing the functions shown in system C from figure 15. The overall design will be powered by an operator driven hand crank that will drive a chained system of gears to rotate the shafts at designated rotational speeds. Descriptions and illustrations are highlighted for each function below.

Feeding the caramel - The way the caramel is placed into the machine
The caramel will be fed into the machine on a specially designed tray, shown in Figure 16, that will be able to hold a strip of caramel candy. The tray portion that will be in contact with the caramel has been designed to be 12.08 inches in length and 0.75 inches wide and will be made out of sheet metal with a 0.048-inch thickness. The back wall of the tray will also be 1.2 inches tall to keep the caramel in place as the tray experiences an acceleration.

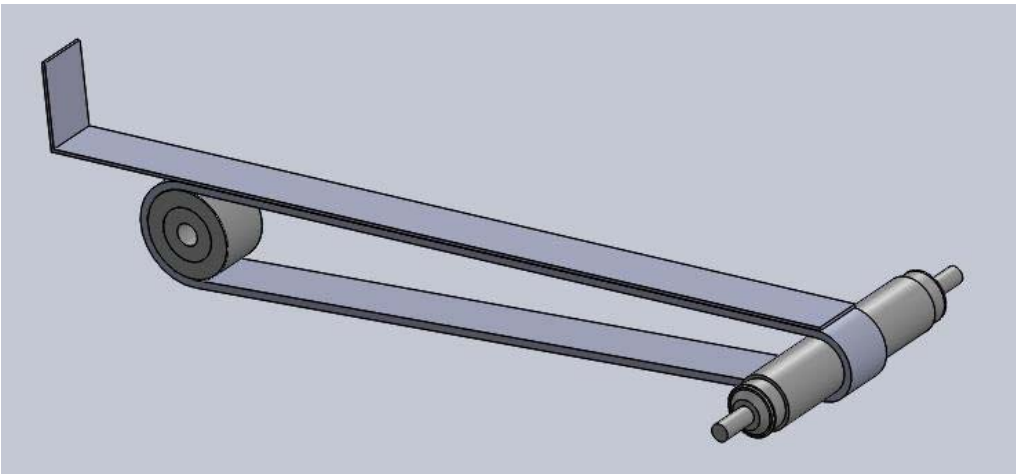


Figure 16. Feeding tray used to feed the initial strip of caramel.

Moving the caramel - The caramel must be moved throughout the machine
The tray that the caramel will be loaded onto will be carried by a conveyor belt, which is driven by a Geneva mechanism that is designed to drive the belt that will push the tray in one inch linear increments towards the wire cutter. The Geneva mechanism was designed using triangular geometry shown in Figure 24.

Cutting the caramel - The caramel strips or tray must be cut into cubes
As the caramel is moved in one inch increments on the tray, a wire cutter, shown in Figure 17, connected to a 2 bar linkage system will be mechanically synchronized to slice through the caramel strip as the caramel lays stationary as a result of the Geneva mechanism. The wire cutter is designed to separate the caramel by slicing the strip of candy every inch.

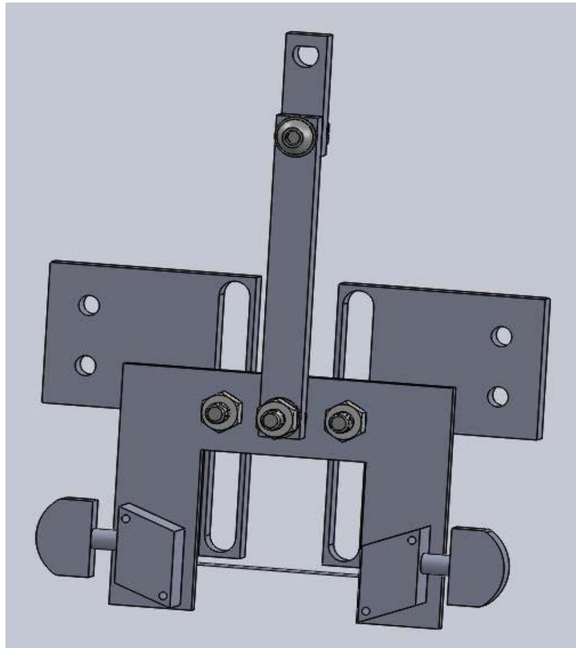


Figure 17. Wire cutter utilized to cut the caramel.

Feeding the paper - The paper roll must be fed in a way which places it with the caramel
A 4” long roll of parchment paper will be placed on a rotating shaft above the pusher mechanism in a position where the paper will feed into rollers that are responsible for moving the paper into the proper positioning. The diameter of the rollers in contact with the paper located on the driven Geneva shaft are subject to change as more length per revolution will be required to ensure a paper output of 3 inches before it is cut.

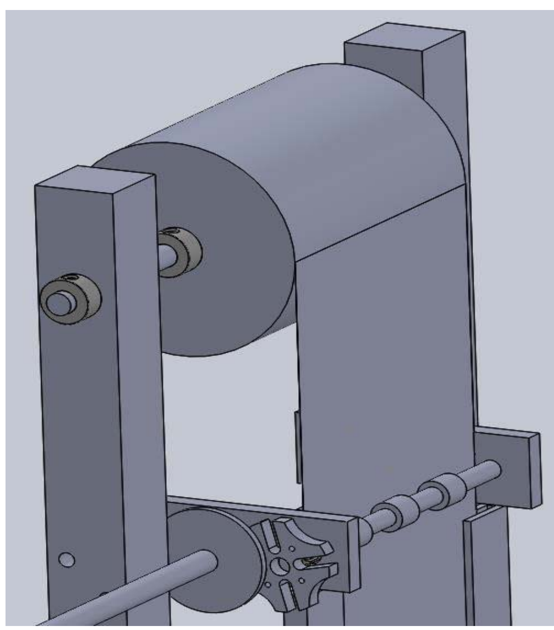


Figure 18. Paper feeding system to input parchment paper.

Cutting the paper - The paper must be cut to size for folding, about 3x4 inches
A shaft will drive a 2 bar linkage system, shown in Figure 19, that is connected to a disk blade. This blade will cut the parchment paper horizontally into individual 3 x 4” pieces.

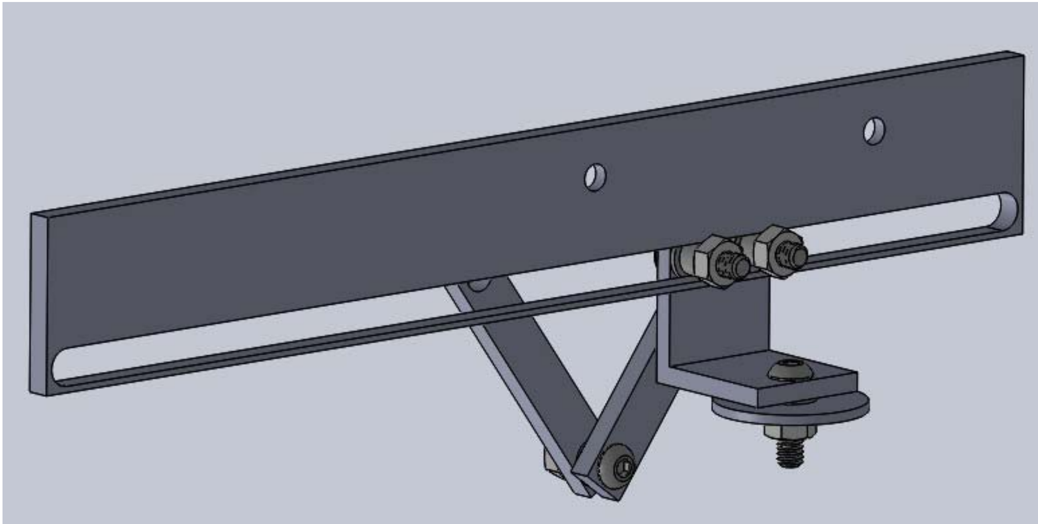


Figure 19. Disc cutter connected to 2 bar linkage used to cut the parchment paper.

Moving the paper - Once fed, the paper must be moved throughout the machine
The paper will be fed into rollers connected to a Geneva mechanism that is designed to move the paper in 3 inch increments into a paper support structure that will hold the paper as it awaits placement of the caramel from the pusher arm.

Locating the caramel and paper - The two items, candy and paper, must be located together
After the strip of caramel is cut into inch long increments by the wire cutter, the pusher arm from Figure 20 that is attached to a 2 bar linkage system will push the freshly cut caramel piece into the middle of the 3x4” piece of parchment paper. The caramel and paper is then pushed into the slotted disk pincher system that is spring loaded to catch the candy once it is pushed into the slot.

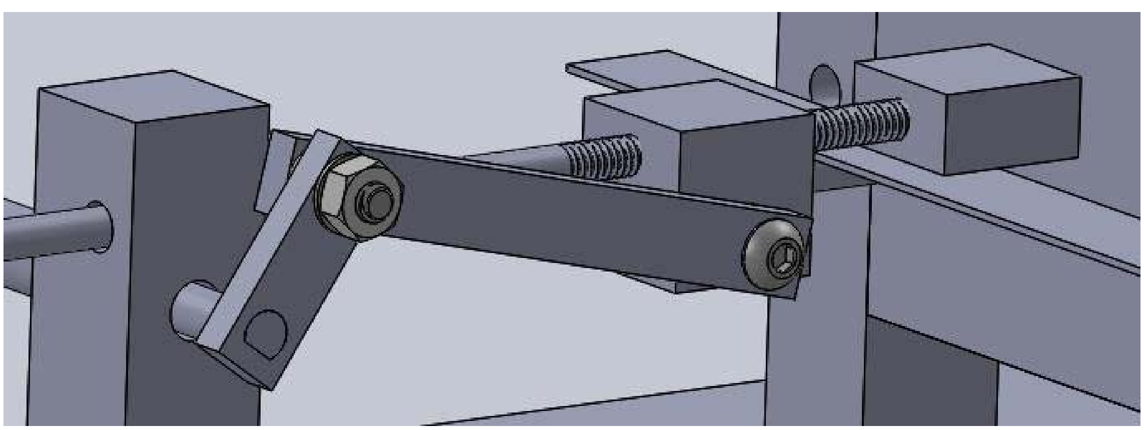


Figure 20. Pusher arm used to push the previously cut caramel into the parchment paper.

Folding the paper - The paper must be folded all the way around the caramel
A wall, shown in Figure 21, will surround the top 140 degrees of the slotted disk and will fold the extruding parchment paper as a Geneva mechanism drives the disk 180 degrees counterclockwise to place the now folded candy piece in position for the double twisting to occur.

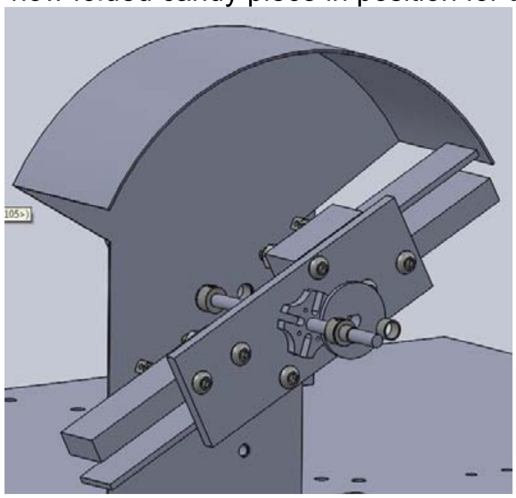


Figure 21. Surrounding wall utilized to aid with folding of parchment paper.

Double twisting - The machine must double twist the candy and paper
Once the candy has completed the half rotation of the slotted disk, two rack and pinion driven claws, which can be observed in Figure 22, will clamp onto the sides of the parchment paper as a result of cam followers forcing the rack driven gears to close. Mechanically tuned gears will then drive the claws to rotate a full 360 degrees to ensure one full double twist of the candy before the cam followers force the claws to open back up as each rack is driven back into its initial location. A device will need to be implemented into the system shown in Figure 22 that will allow the claws to remain in the same location without moving linearly with the rack.

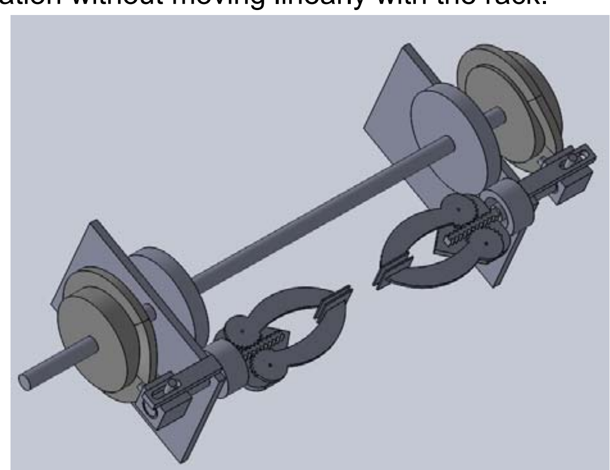


Figure 22. Claw subassembly of rack and pinion driven claws used to double wrap the candy.

Output - Outputting the caramel after it has been successfully double wrapped in parchment paper

The slotted plate, shown in Figure 23, will then rotate 90 degrees counterclockwise where a pin will force the spring loaded slot to reopen and drop the now double wrapped caramel through a rectangular opening of the base and into a basket; thus, completing the candy wrapping process.

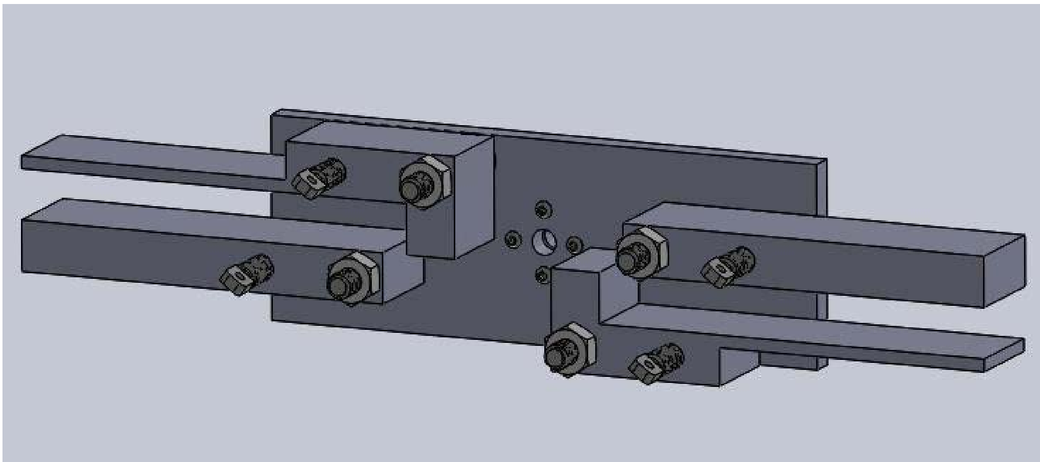


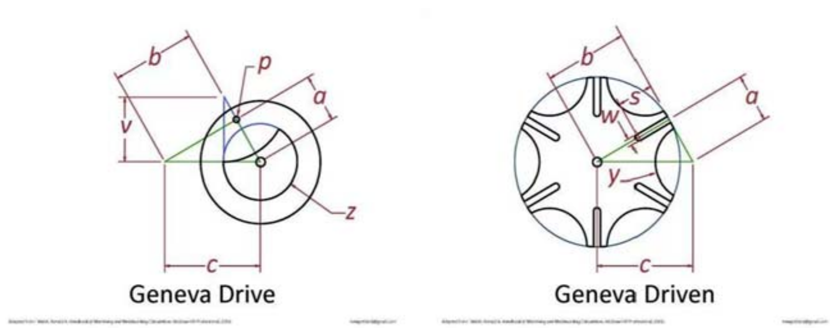
Figure 23. Subassembly or spring loaded slots that will open to input and output the caramel.

The final product will be designed to operate with a series of chain powered gears to transfer power throughout the system. To ensure the system is mechanically synchronized and timed correctly to allow the differing functions to operate in unity the rotating shaft speeds were calculated. The rotational speed of each shaft can be observed in Table 3.

Table 3. Rotational speeds of individual shafts. [* denotes a rotational speed subject to change]

Shaft Location	ω [rpm]
Feed Tray Geneva	12
Paper Feed Geneva	36*
Caramel Cutter	12
Paper Cutter	12
Caramel Pusher	12
Pincher Wheel Geneva	24
Cam Shaft	12
Twisting Claws	60

A Geneva mechanism is utilized to drive differing parts of the machine in one inch increments. In order to ensure that a 90-degree rotation of the Geneva gear would linearly move each part one inch, calculations were carried out, which determined that the radius of the Geneva mechanism to be approximately 0.64 inches. An analysis and design of the gear using this value and following the geometry displayed in Figure 16 through the New Gottland website was then created [7]. The Geneva mechanism can be observed through drawings 02-001 and 02- 002 located in Appendix H.



Determine drive crank radius a

b = Geneva wheel radius
n = driven slot quantity
p = drive pin diameter
t = allowed clearance

c = center distance = $b / \cos(180 / n)$
a = drive crank radius = $\sqrt{c^2 - b^2}$
s = slot center length = $(a + b) - c$
w = slot width = $p + t$
y = stop arc radius = $a - (p\ 1.5)$
z = stop disc radius = $y - t$
v = clearance arc = bz / a

newgottland.com

Figure 24. Geneva mechanism geometries utilized to design the Geneva gears in the final design.

Solidworks was utilized to perform the weight analysis shown in Figure 25 once every part material was specified. The calculated value came out to 105.6 pounds, which means that a cart will be necessary to move the machine around by one operator as 50 pounds was specified as the max weight for one operator to move.

Mass properties of FinalAssem_2_4
Configuration: Default
Coordinate system: -- default --

Mass = 105.60 pounds

Volume = 903.48 cubic inches

Surface area = 5177.85 square inches

Center of mass: (inches)
X = 0.79
Y = -3.86
Z = -3.82

Figure 25. Property analysis from Solidworks

Cost Analysis

A cost analysis was performed by summing the total cost from ordering raw materials and parts, estimated manufacturing costs, shipping costs and a contingency fund to incorporate unanticipated error. An order sheet can be found in Appendix G containing the following items;

- Assembly
- Vendor
- Item number
- Quantity needed
- Quantity receiving
- Description
- Individual price
- Total price
- Order date
- Received date

The total price after adding an estimated shipping and manufacturing cost of $300.00 and $200.00, respectively, and a 20% contingency factor came to $1590.88. Adding this to the already existing expense sheet for miscellaneous items from Appendix D produces a total of $1624.62, which shows that the project is still $375.38 under the $2000 budget at this point.

Potential Issues

There are many concerns that are present as the building and testing phases approach.

The biggest concern for the upcoming testing phase is the potentially disastrous factors that exist such as friction, wear and fatigue throughout the gearing system. The timing of the functions will all be connected through a chain system that powers each shaft at a designated rotational speed. Even the slightest disruptions to the processes could be detrimental to the functionality of the whole machine.

Another potential issue is the unpredictability of the caramel as it is characteristically sticky. The stickiness of the caramel could result in jamming and not allowing the processes to function properly if the caramel gets stuck or warped.

Parchment paper placement is another looming concern as the paper is unpredictable with how it will react to the disk cutting and roll feeders. A slight increase or decrease in the expected paper driving distance would warp the paper and may result in misalignment and eventual system jamming.

Manufacturing Plan

The material specifications for each full assembly were decided upon during the design phase of the project. FDA approved materials are required to ensure that the final design meets FDA standards. Research on plausible materials dictated that the materials chosen for the majority of the machine's parts will consist of 6061 Aluminum, acrylic, delryn, and multipurpose 304/304L stainless steel. Detailed descriptions of the materials chosen for each part can be found in Appendix G with the order sheet. This order sheet outlines the assembly part, item number, company, quantities needed and received, description, price, total cost, and ordered/received dates. This order sheet will help aid with organization and total cost of the materials ordered from online websites.

Once the materials are obtained, the next step is to manufacture the parts to the specifications outlined in the drawings from Appendix H. These parts will be manufactured in the campus shops with the aid of shop technicians as many manufacturing practices will be necessary to create the individual parts needed to assemble the final product. Once the parts have been created and closely inspected by each member of the team as well as shop technicians, a full assembly build will commence to put the machine together to conduct testing upon.

The Gantt chart located in Appendix F illustrates the expected timeline for the ordering of the materials along with completing the manufacturing portion of the project. Materials are expected to be ordered by Monday February 13th. A duration of 27 days from Monday, February 13th to Wednesday, March 15th has been designated as the manufacturing timeline before a safety inspection of each individual part will take place. In the event that additional manufacturing time is necessary, the additional time will be secured from the testing portion timeline as extra days were given to this portion to provide a security buffer. The full assembly will be put together by Wednesday, March 15th.

Design Verification Plan

Once the final product has been assembled, testing will need to take place to ensure that the machine can perform safely and correctly. Each function will be individually tested first to check for inconsistencies and possible malfunctions that would stop the design from carrying out the candy wrapping process. The first tests will be conducted at slower operating speeds so the processes can be observed for possible problems. Once each function has been tested and the overall safety of each function design has been confirmed, a full system test with each function connected to one another will take place again with a very slow power input for observational purposes. Full speed testing will also take place once the slower operating speed testing has finished. A time duration of 57 days from Thursday, March 16th to Thursday, May, 11th has been set aside for testing. This allows for 5 days to be set aside for testing and tuning of each individual function before taking the final two days of the testing duration to test the whole machine together.

The plan for testing will follow the acronym SMARTER, which is defined as ensuring that goals will be specific, measurable, achievable, relevant, time bound, evaluated, and reviewed. The goals and testing plans are outlined in Table 4.

Table 4. Testing plan and goals for each individual function.

Function	Testing Plan	Testing Goals
Feeding the caramel	● Observe caramel reaction to being placed on the tray of a designated material ● Drive the tray to the ending point	● Confirm caramel stickiness will not interfere with feeding process ● Confirm tray will stay in horizontal orientation throughout the feeding process
Moving the caramel	● Measure the linear distance traveled for each Geneva mechanism step	● Ensure that the tray travels 1" for each Geneva step
Cutting the caramel	● Run wire cutter through multiple full strips of caramel ● Closely observe the cutting process for multiple strips of caramel	● Measure each length of caramel to confirm they are correct size ● Confirm wire will not stick to caramel and that there is a clean cut and separation of each caramel piece
Feeding the paper	● Run paper feed for full roll of parchment paper and when parchment roll is nearly empty	● Find any places that might obstruct paper from feeding

Feeding the paper	● Run the feeding mechanism through a full roll of parchment paper	● Observe characteristics of paper under differing conditions such as introducing outside elements liquids, wind, and other possible environmental effects
Cutting the paper	● Run the paper cutting disk against the parchment paper for multiple repetitions ● Measure the length and width of a cut piece of parchment paper	● Ensure that the cutting process is completed with no concerns of failure ● Ensure that the finished cut out product is 3 x 4”
Moving the paper	● Measure the linear distance traveled for each Geneva mechanism step	● Ensure that the paper travels 3” for each series of Geneva steps before the paper is cut
Folding the paper	● Run the rotating disk with caramel and paper in place in the pinching arms	● Ensure the spacing distance is correct and that the parchment paper gets properly folded before the claw positioning takes place
Double Twisting	● Run the rack and pinion/cam follower mechanism by hand ● Wrap multiple pieces of caramel repetitively	● Ensure rack and pinion/cam follower mechanism perform as expected by hand ● Ensure that the caramel is properly wrapped 1 revolution in the correct orientation
Outputting the wrapped caramel	● Allow rotating pinching arm disk to complete multiple full rotations	● Ensure the pin causes the pinching arms to open enough to output and drop the wrapped candy out the bottom base wall of the machine

Manufacturing and Testing

Manufacturing

The final design required many hours of manufacturing in the shops due to the unique quality of the parts that make up the machine. The raw food grade materials were ordered online before machining them to the required specifications. The following processes were utilized to create the individual parts for the final product;

- o *Mill and Lathe*
- o *Drill Press*

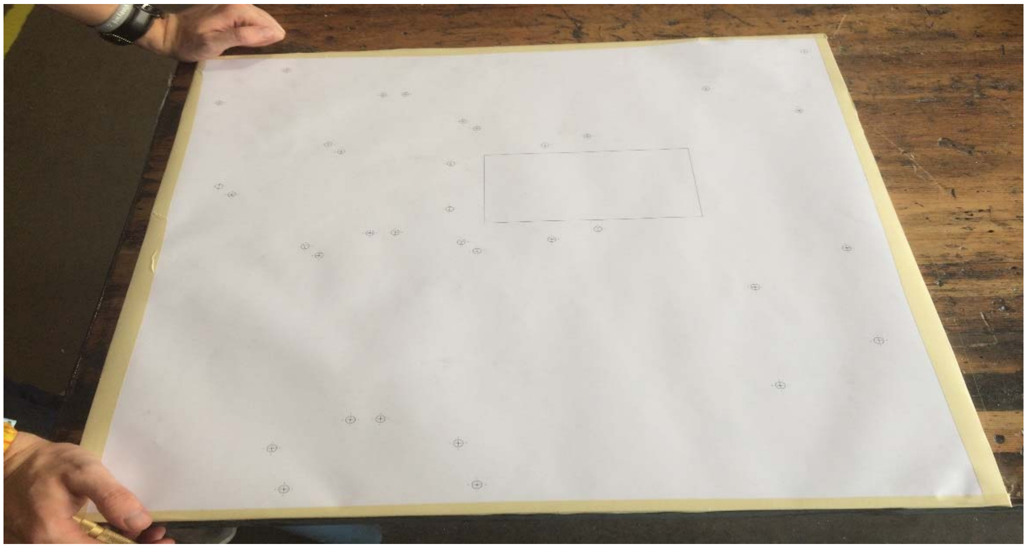


Figure 26. The base plate set up before using a drill press to drill and chamfer the specified holes.

- o *Waterjet Cutting*

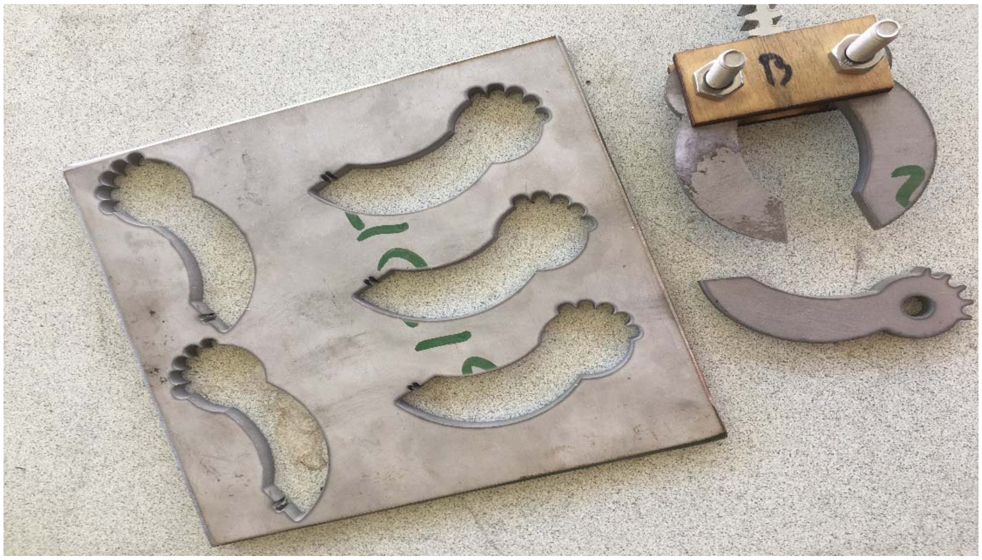


Figure 27. The claw arms were made using waterjet cutting to ensure a precise and quick process.

o *Plasma Cutting*

Figure 28. A plasma torch was used to cut out the exit section of the base plate.

o *CNC, or computer numerical control, Machining*

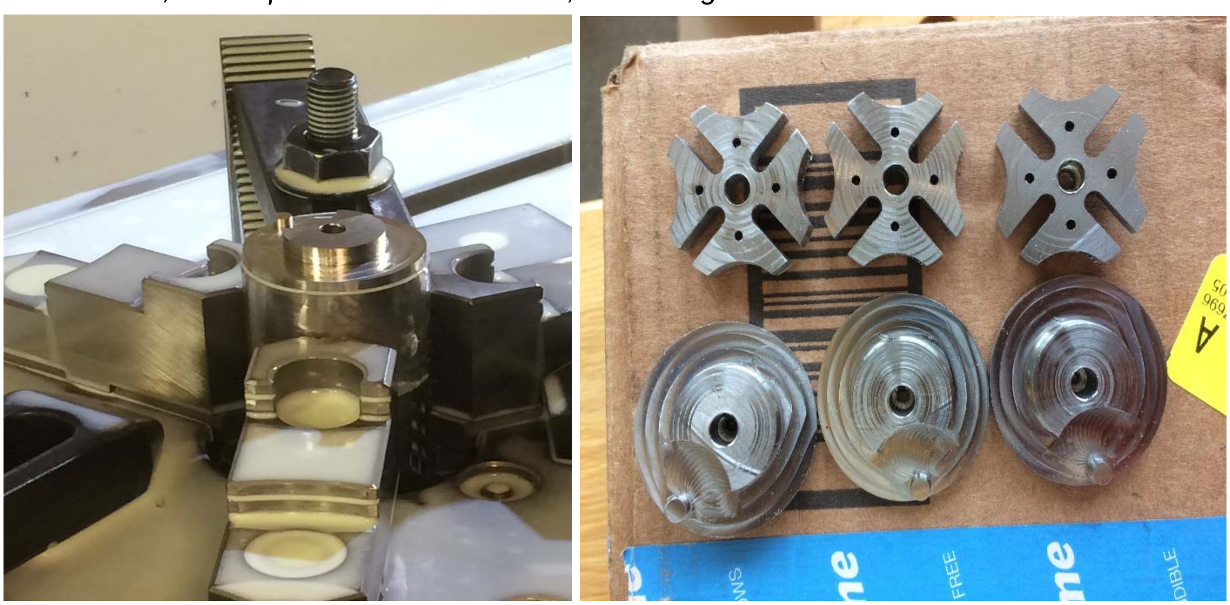


Figure 29. The intricate Geneva mechanisms and cam follower parts were created from the CNC machining process.

Just as expected, the manufacturing phase was the most time consuming portion of the project. Many challenges were faced throughout the time spent in the shops including excess time spent learning how to use the equipment and measurement errors that required more materials to be ordered. In order to improve the design in the future, changes could be made to design the parts to reduce manufacturing time by modeling them closer to existing parts that can be purchased.

Testing

Due to the manufacturing phase taking more time than we had initially planned for, testing of the various functions was postponed until a later date. However, testing of the various prototypes was completed to validate the designs of the parts. Although they were made from different materials such as plastic and wood, these can be considered valid tests since they were the correct size and proved the correct functionality of each of the mechanisms. The testing of these various prototypes allowed improvements and the ability to move on to the manufacturing of the parts from their actual material. An example of the tested prototypes can be found in Figure 30.

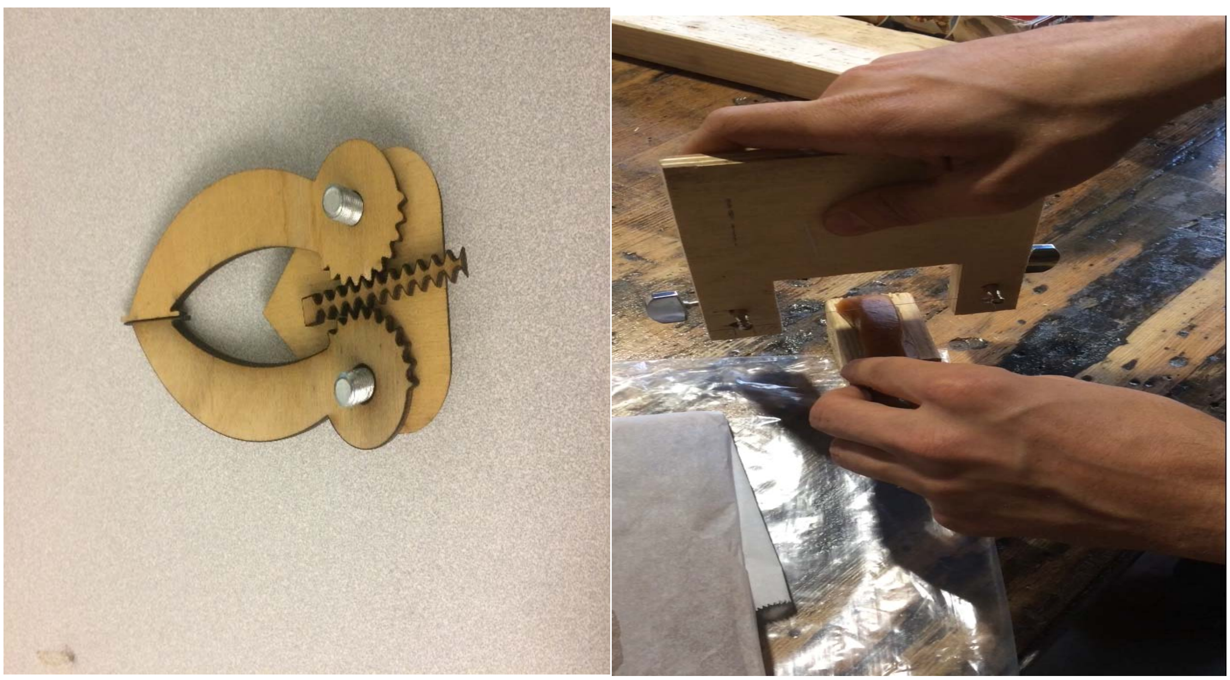


Figure 30. (Left) Claw mechanism testing prototype made from a laser cutter and (Right) wire cutting prototype to test cutting of the caramel.

The Final Design

After nine months of researching, designing, testing, manufacturing and assembling, the final product was completed to the best of our abilities under the time constraint that we faced. Further manufacturing and testing will need to be completed before the machine can be completely assembled. Although the final product is still under development, the final CAD rendered version of the machine can be observed below in Figure 31.

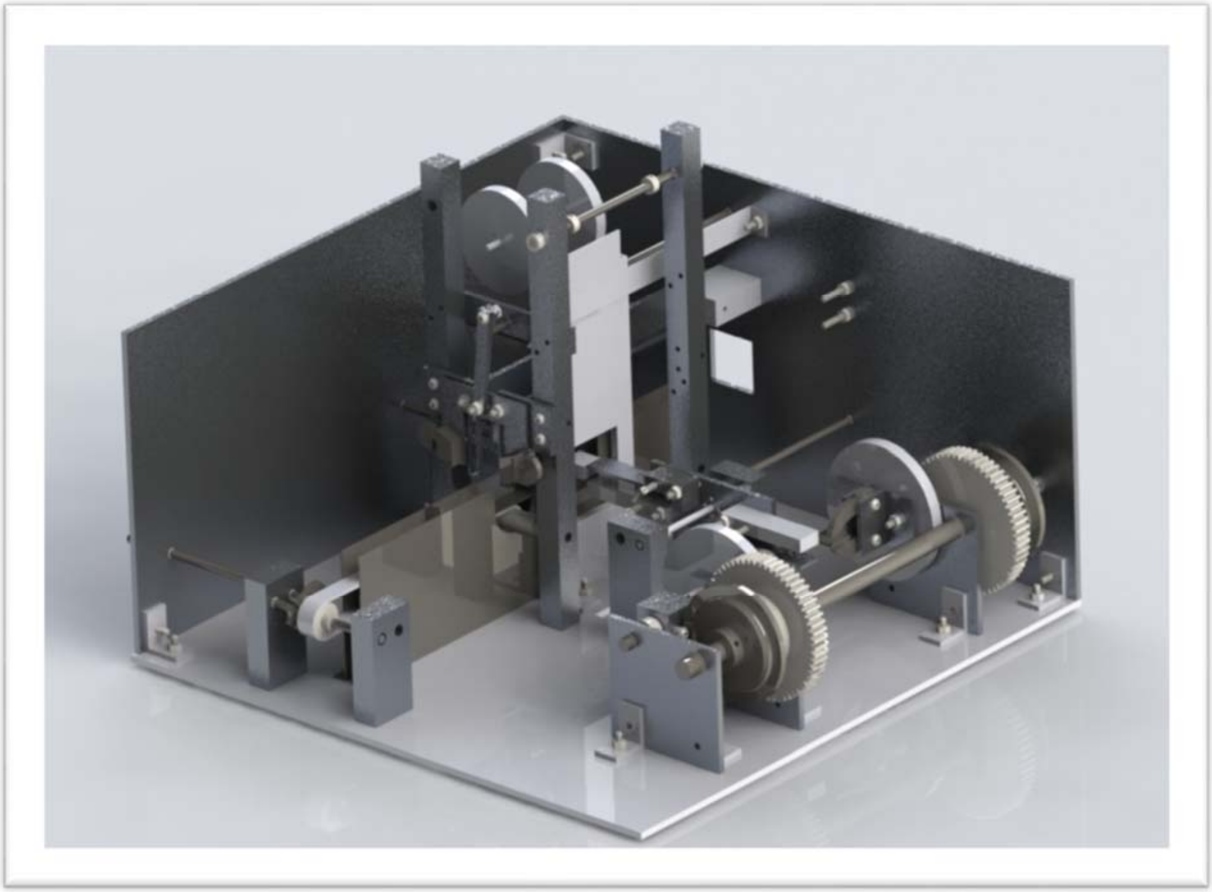


Figure 31. The final automated candy caramel wrapping design.

The final design is an assembly of the nine functions;

- Feeding the caramel
- Moving the caramel
- Cutting the caramel
- Feeding the paper
- Moving the paper
- Cutting the paper
- Locating the caramel and paper
- Folding the paper
- Double twisting

Support structures were inserted to bear the load from the weight of the materials as well as aid with the assembly placement. The support structures were drilled and threaded to allow for attachment from button head screws connected to the base and side plates. Brackets were also utilized to attach all of the walls together and connect the support structures for the gear assembly shafts. The hand crank transfers power to the machine's shafts through a gearing network. This power, along with the proper gearing ratios, allow the shafts to rotate at their required speeds to ensure all of the moving parts stay in sync.

The final product cost $1,825.52 and weighed a total of 120.6 lbs. The progress that had been made on the machine was showcased by the team in Figure 32 at the Cal Poly Mechanical Engineering Senior Project expo on June 2nd, 2017.

Figure 32. The Cal Poly Caramel Team at the Senior Project expo on June 2, 2017.

Safety and Maintenance

Safety

The most important aspect to keep in mind during the design process for a machine such as this one is safety. Safety consideration allowed for the inspection of the machine to locate the most threatening operation hazards, which consists of pinching points, sharp objects, and moving parts capable of crushing body parts if the operator is not careful. The warning labels from Figure 33 will be placed on the machine in order for those present when the machine is in use to be aware of the possible dangers.

Figure 33. Warning labels associated with the possible safety hazards of the machine [8].

In order to protect the operator and anybody else present while the machine is running, we designed an acrylic housing to completely cover the machine. This housing, shown in Figure 34, will protect against pinch points, moving parts, the wire cutter, the sharp razor that cuts the parchment paper and possible caramel projectiles. The casing is designed to completely cover the machine and renders the hand crank useless if the casing is not in place during the machine's operation. This allows for the increased safety benefit for when cleaning and maintenance are required.

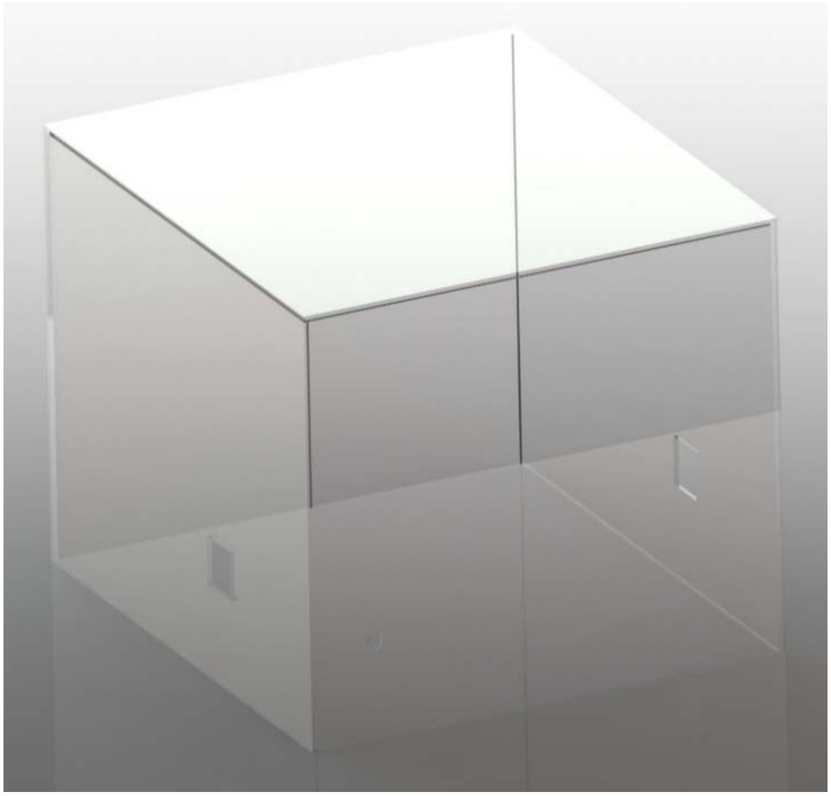


Figure 34. Acrylic housing designed to ensure safety.

The final machine has been estimated to weigh 120.6 lbs when the assembly portion is completed. For this reason, there is also the safety consideration associated with the potential risks of injuries while moving the machine as well as it tipping and falling. To combat this safety hazard, a cart with wheels will be designed once the final product is complete to allow for ease of moving and ensuring the machine is properly secured.

Maintenance

The materials chosen to build the machine and the low rotational speeds of the shafts allow for an incredibly long life expectancy. Therefore, the design is not expected to face any major endurance issues, which was a necessity from the complicated and unique design of the machine's parts.

Regular maintenance will include cleaning the parts that contact food once the safety housing is removed and replacing the roll of parchment paper. Due to the characteristics of caramel, the cleaning of the wire, tray and pusher will need to be completed after each batch of caramel has been wrapped. Failure to routinely clean of the parts that will contact the candy will result in an increased risk of error that will impede the ability of the machine to wrap the caramel.

Closing Remarks

Overall, the process for designing an automated caramel candy wrapping machine proved to be both challenging and rewarding for every member of the group. Each one of us was pushed to grow as students and engineers in aspects such as critical thinking, creativity, project management, communication, design considerations and manufacturing practices. Countless hours were spent in the labs and shops feverishly working to meet our goals and conquer the challenges that seemed to constantly show up.

Although the project has not been completely finished, the progress that was made over the last nine months is evident from the advancements that have been made from a simple problem statement. The months of brainstorming, planning, testing, drawing, building and learning have all accumulated into the design that we have today that eliminates the need to wrap candy by hand.

In hindsight, there are a few changes that could have been made to allow for a simplified and less challenging experience. First off, designing and building a prototype out of plastic and allowing the designs to be given to a professional machine shop would have been beneficial. Second, understanding FDA guidelines better allowed us to realize that most of the metallic parts could have been made with plastics, which would have significantly decreased manufacturing time and costs. Lastly, designing parts that could be ordered instead of made from raw materials would have also assisted with the difficulty of the project.

We would like to extend a thank you our incredible advisor, Professor Lee McFarland, as well as our talented candy creating sponsor, Erin James. We could not have made the progress we did without the help and support that we received along the way from shop technicians and our fellow engineering students and campus staff.

Sincerely,

CAL POLY TEAM CARAMEL

Alexander Miller - Roman Stambaugh - Trevor Steele

Appendices

A. Sources

B. Management Plan

- Team contract

C. QFD

D. Expense Sheet

E. Pugh Matrices

F. Gantt Chart

G. Order Sheet

H. CAD and Detailed Drawings (See attached CD)

I. Bill of Materials

J. Operations Manual

Appendix A

[1] "Homemade Double Twist Candy Wrapper." *YouTube*. YouTube, 26 May 2015. Web. 18 Oct. 2016. <https://www.youtube.com/watch?v=M2WgUsxColM>

[2] Bafu, n.d. Web. 18 Oct. 2016. <http://www.bafupackaging.com/proshow.aspx?id=6>

[3] "Carousel Cream Center Extruder & Cutter." - *Savage Bros.*N.p., n.d. Web. 18 Oct. 2016. <http://www.savagebros.com/p.24/carousel-cream-center-extruder-cutter.aspx>

[4] "Daily Chef Non-Stick Parchment Paper - 205 Sq. Ft. - Walmart.com."*Walmart.com*. N.p., n.d. Web. 23 Oct. 2016. <https://www.walmart.com/ip/109207037>

[5] "Parchment Paper." *Rawthentic*. N.p., n.d. Web. 23 Oct. 2016. <http://rawthentic.com/parchment-paper/?age-verified=3dfc7b764c>

[6] BPM Inc. A Specialty Paper Mill. "BPM Inc. A Specialty Paper Mill." *BPM Inc. A Specialty Paper Mill*. N.p., n.d. Web. 23 Oct. 2016. http://www.bpmpaper.com/

[7] "Make Geneva Wheels of Any Size." *New Gottland*. N.p., 01 Dec. 2015. Web. 22 Jan. 2017. https://newgottland.com/2012/01/08/make-geneva-wheels-of-any-size/

[8] "Pinch Point Labels I Nip & Pinch Point Safety Labels." *MySafetylabels.com.* N.p., n.d., Web. 25 May 2017.

Management Plan

The responsibility breakdown will be as follows:

1. Alexander Miller
    a. Communications Officer
        i. See section 2-part D of the Team Contract Appendix B
    b. CAD and Drawings
        i. Must be accurate
        ii. Must have proper dimensions and tolerances
        iii. Must be done with proper techniques (no workarounds)
    c. Manufacturing
        i. Designs must be able to be manufactured (no square corners, etc.,)
        ii. Create process sheets for parts
2. Trevor Steele
    a. Treasurer
        i. See section 2-part D of the Team Contract Appendix B
    b. Analysis
        i. Document all analysis performed
        ii. Must use valid models to represent the system
        iii. Must use proper techniques and validation for FEA
3. Roman Stambaugh
    a. Recorder
        i. See section 2-part D of the Team Contract Appendix B
    b. Editor
        i. Proof all reports for correctness, grammar, and coherence
        ii. Proof all presentations for completeness and slide order
    c. Testing
        i. Test plans
            1. Must document test plans prior to any testing
            2. Must document results after testing
            3. Design test fixtures and techniques
        ii. Safety
            1. Must document potential safety hazards and counteractions prior to events
            2. Implement necessary safety measures in the event of an emergency

All decisions and conflicts will be handled per the Team Contract in Appendix B.

The financial side of the project will be tracked with the expense sheet shown in Appendix D. This expense sheet was designed to track detailed information on the date, description, who spent it, estimated cost, actual cost, notes, remaining budget, and amount spent.

Team Contract

Mission:

The mission of the Cal Poly Caramel is to design and prototype a machine that reduces the time it takes a person to cut and wrap caramel candies and can be used and stored in a home sized kitchen.

Section 1—Name

A. This organization shall be known as Cal Poly Caramel.

Section 2—Membership

A. Members of the team include: Alexander Miller, Trevor Steele, and Roman Stambaugh.
B. No member shall purport to represent the team unless so authorized by the team.
C. Each member shall be provided a copy of the team contract.
D. Officers of the team shall include those listed below with their designated responsibilities. (spell out specific responsibilities of each officer position, some suggestions below).

1. Communications Officer
    a. Be main point of communication with sponsor
    b. Facilitate meetings with sponsor
    c. Write agendas for meetings with sponsor and faculty advisor
    d. Send a weekly update to the sponsor
2. Team Treasurer
    a. Maintain team's travel budget
    b. Maintain team's materials budget
    c. Purchase components and materials
    d. Keep track of components and assemblies
3. Recorder
    a. Maintain information repository for team (e.g. team binder, google docs site, etc..)
    b. Create gantt charts and keep the team on schedule
    c. Write and keep meeting minutes

Section 3—Decision Making

A. Decisions shall be decided by consensus
B. When many options are available and no consensus can be reached the multi-voting method will be used to reduce the number of options until a consensus can be reached

1. Multi-voting shall proceed as follows:
    a. Each member gets votes equal to the number of available choices divided by three.
    b. Each member may use as many or as few of their votes for each option.
    c. After voting, the options with the most votes are then discussed to try and reach a consensus.

C. In the case where no consensus is reached after multi-voting the decision will be made by ⅔ majority.

Section 4—Team Interactions

A. All affairs of the team shall be governed by Robert's Rules of Order, unless otherwise specified.
B. Meetings shall be held each Thursday at 11:45.
C. Unless otherwise noticed, all meetings will be held on campus in room 192-131.
D. Special meetings of the team may be called by proposal during the regular team meeting.

E. Attendance is mandatory unless prior notice and permission of absence is given 24 hours in advance except in cases of emergencies.
F. Meeting discussions will be conducted in a conversational format with special regard for a dialogue that is respectful and considerate of all members in attendance.
G. A meeting agenda, distributed 1 day in advance, will guide meeting topics and timing.
H. The length of meetings shall be stated in advance.
I. All team members are expected to be punctual.
J. Violation of team meetings will be publicized to members using: phone calls, e-mail, and texting.
K. Violation of team rules will result in buying a round of drinks for the other members.

Section 5—Conflict Resolution

A. The team decides when it is necessary to form a special work group.
B. Work groups shall report to the team and these reports shall be entered into the minutes.
C. Committees can be standing or ad-hoc in nature.
D. If the conflict exists between 2 members, the third member shall act as a moderator.
E. If no member is impartial in the conflict a third party shall be brought in to moderate the resolution of the conflict.

Section 6—Amendments

A. Amendments may be added to the end of this contract.
B. Amendments shall be proposed during a team meeting.
C. Voting on amendments shall take place at least 48 hours after the amendment's proposal.
D. All members must vote in favor of the amendment for it to be added to this contract.

Section 7—Effective Date

A. This contract of the Cal Poly Caramel team shall become effective on October 11th, 2016 at 3:00 PM.
B. Dates of amendment must be recorded in minutes of meetings at which amendments were approved, together with a revised set of bylaws.

Section 8—Intellectual Property Agreement

A. The Parties hereby agree that all rights and title to Intellectual Property, whether patentable or copyrightable or not, resulting from any project conducted under this agreement and made jointly by the parties shall belong jointly to the parties. The parties will negotiate in good faith an equitable sharing of such Intellectual Property. All rights and title to Intellectual Property whether patentable or copyrightable or not, resulting from any project conducted under this agreement and made solely by Student or Advisor of Cal Poly shall belong to Cal Poly. All rights and title to Intellectual Property, whether patentable or copyrightable or not, resulting from any project conducted under this agreement and made solely by Sponsor or employees of Sponsor shall belong to Sponsor. Any existing Intellectual Property owned by Cal Poly prior to the effective date of any collaboration shall remain the sole property of Cal Poly and not subject to the terms of this agreement. Any existing Intellectual Property owned by Sponsor prior to the effective date of any collaboration shall remain the sole property of Sponsor and not subject to the terms of this agreement. Accordingly, this agreement does not grant any license of the Sponsor's Intellectual Property to the University, Advisor, or Student nor does it grant any license of University, Advisor, or Student intellectual property to the Sponsor.

Section --Signatures

Alexander Miller

x ____________________ Date: 10/11/2016

Trevor Steele

x ____________________ Date: *10/11/2016*

Roman Stambaugh

x ____________________ Date:

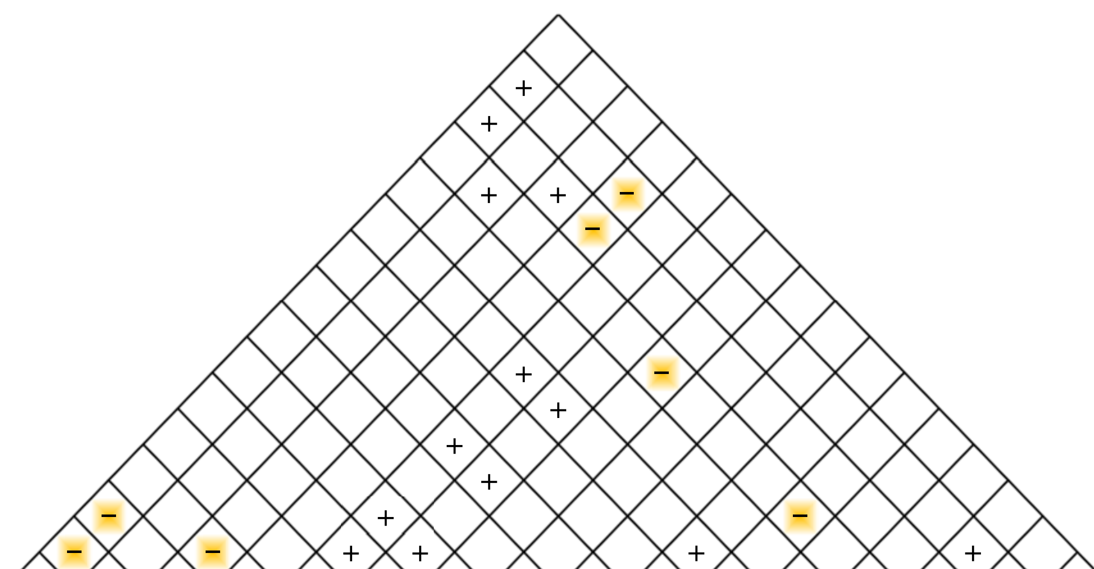
Appendix C

QFD: House of Quality
Project:
Revision:
Date:

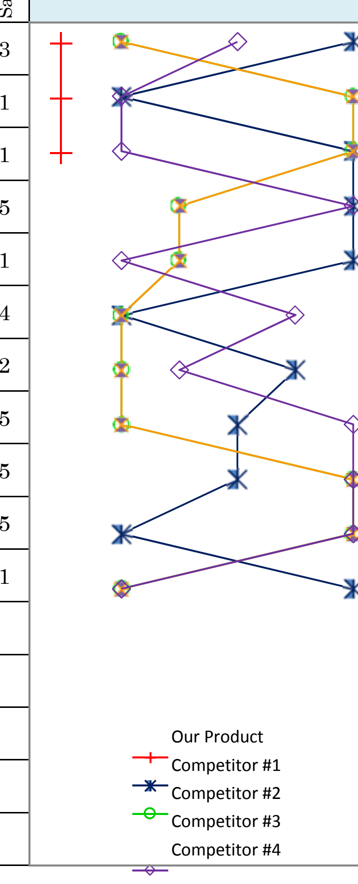
Correlations	
Positive	+
Negative	−
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

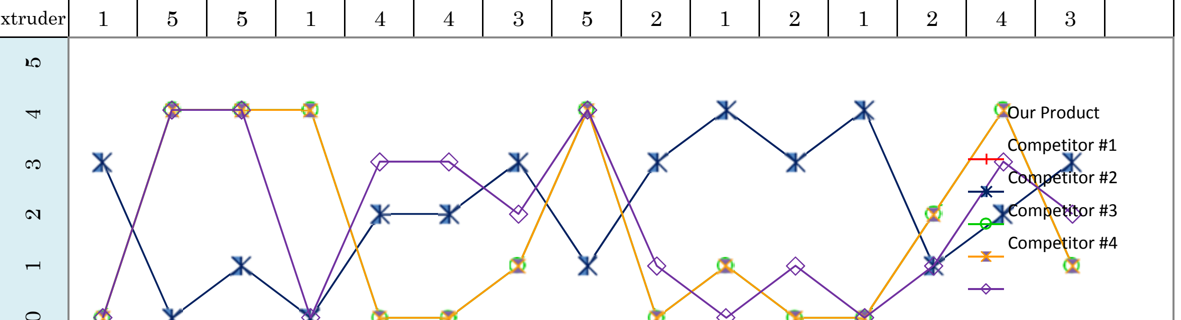


				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	NOW: Current Product Assesment - Customer Requirements					
	WHO: Customers			Direction of Improvement	▼	◇	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	◇	▲	▼							
Row #	Relative Weight	Erin	Maximum Relationship	WHAT: Customer Requirements (explicit & implicit) / HOW: Engineering Specifications	prototyping cost	meets fda specs	machine life	pecies per minute	size when in use	size during storage	set up time	error rate	machine weight	clean up time	take down time	power consumption	safety	blade life	maintenance cost		Our Current Product - None	Bees Brothers - Homemade Machine	Bafu -DWM550 Packing Machine	Bafu - DWC300 Chocolate Wrapper	Savage Bros Co. - Carousel Extruder	Row #
1	9%	4	9	cheap	●														●		0	5	1	1	3	1
2	11%	5	9	wrap faster than by hand				●			▽				▽						0	1	5	5	1	2
3	9%	4		douple twist wrap																	0	5	5	5	1	3
4	11%	5	9	useable by 1 person					●	●	▽				▽		○					5	2	2	5	4
5	5%	2	9	easy to clean		○								●								5	2	2	1	5
6	9%	4	9	cuts the caramel		●		▽				○		●			●	●	○			1	1	1	4	6
7	7%	3	9	movable by 1 person					●	●	▽		○		▽							4	1	1	2	7
8	11%	5	9	storable in hall closet						●												3	1	1	5	8
9	7%	3	9	repeatability			▽	○				●										3	5	5	5	9
10	11%	5	9	FDA compliant	○	●											○					1	5	5	5	10
11	9%	4	1	house wall outlet for power												▽						5	1	1	1	11
12	0%																									12
13	0%																									13
14	0%																									14
15	0%																									15
16	0%																									16



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HOW MUCH: Target	<$2000	Meet All FDA Regulations	3000hr	12 ppm		2'x3.5'x5'	10 min	<1%					All moving components			
Max Relationship	9	9	1	9	9	9	1	9	3	9	1	1	9	9	9	
Technical Importance Rating	3	5	1	4	3	4	2	4	2	2	2	5	5	1	2	
Relative Weight	7%	11%	2%	9%	7%	9%	4%	9%	4%	4%	4%	11%	11%	2%	4%	0%
Weight Chart																
Our Product	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Bees Brothers - *Homemade Machine*	4	1	2	1	3	3	4	2	4	5	4	5	2	3	4	
Bafu - DWM550 Packing Machine	1	5	5	5	1	1	2	5	1	2	1	1	3	5	2	
Bafu - DWC300 chocolate Wrapper	1	5	5	5	1	1	2	5	1	2	1	1	3	5	2	
Savage Brothers - Carousel Extruder	1	5	5	1	4	4	3	5	2	1	2	1	2	4	3	

Current Product Assesment - ...neering Specifications



Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Template Revision: 0.9 Date: 4/23/2010
Christopher Battles

Appendix D

Team Candy Expense Sheet				Project Beginning Budget		2000.00	
Date	Description	Who Spent it	Estimated Cost	Actual Cost	Notes	Remaining Budget	Amount Spent
11/8/2016	ruber pad	Roman	8.66	12.16	4"x4" samples 1/16,1/8,1/4 thickness	1987.84	12.16
11/8/2016	guitar wire	Roman	4.29	8.04	12 x .01" guitar wires	1979.80	20.2
11/8/2016	wire tensioners	Roman	6.54	6.54	6 wire tensioners	1973.26	26.74
02/07/2017	3D printed prototypes	Alex	7	7	Cam follower, claw wheel, 2 path circle, contact pin	1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
				0		1966.26	33.74
Sum				33.74		1966.26	67.48

Appendix E

Criteria	Ease of Design	Cost	Caramel Stick	Accuracy	Automation	Speed
Concept						
Non-Stick Conveyor	Datum					
Chain Conveyor	s	-	-	s	s	s
Placement Wheel	-	s	-	+	-	s
Pick and Place	-	-	s	+	+	-

Figure 1. Pugh matrix for moving the caramel.

Criteria	Ease of Design	Accuracy and precision	Speed	Simplicity
Concept				
Conveyor to conveyor	Datum			
Pick and Place	-	+	-	-
Caramel pushed into paper	s	+	s	s
Paper placed on caramel	-	s	+	-

Figure 2. Pugh matrix for locating the caramel with the paper.

Criteria	Accuracy	Ease of design	Complexity	Clean fold	Speed
Concept					
Folded against wall	Datum				
Soup folder	s	-	-	s	-
Two conveyor paper roll	-	s	+	-	+

Figure 3. Pugh matrix for folding the paper around the candy.

Criteria	Cost	Meets FDA Specs	Part Life	Size	Error Rate	Added Weight	Blade Life	Safety	Maintenance Cost	Power consumption	Realistic
Options											
Pull Across Razor					-	+		+			
Scissors			D	A		T		U	M		
Razor Across Page					-	+					
Air/Water Jet Cut	-	-	-	-	+	-	+	+	-	-	-
Guillotine				-	+			+	-	-	-
Laser	-	-	-	-					-	-	-
Stamp/Precut Paper					-	+	+	+			

Figure 4. Pugh matrix for cutting the paper.

Criteria	Cost	Meets FDA Specs	Part Life	Size	Error Rate	Added Weight	Blade Life	Safety	Maintenance Cost	Power consumption	Realistic
Options											
Rotating Wheel	-	-	-	-	-	-	-	-	-	-	-
Tensile Sheer	-	-	-	-	-	-			-	-	-
Automated Knife	-	-	-	-		-		-	-	-	-
Guillotine	-	-	-	-		-		-	-	-	-
V-Shape Razor	-	-	-	-		-		-	-	-	-
Water/Air Jet	-	-	-	-	+	-	-	-	-	-	-
Heated Wire			-		-				-	-	-
Wire/Saw				D	A	T	U	M			
Punch Down	-	-	-	-		-	-		-	-	-

Figure 5. Pugh matrix for moving the paper.

Criteria	Cost	Meets FDA Specs	Part Life	Size	Error Rate	Added Weight	Blade Life	Safety	Maintenance Cost	Power consumption	Realistic
Options											
Conveyor Belt	+		-	-	+	-		+			
Rollers	D		A		T			U			M
Pinch and Grab	+		-	-	-	-	-		-	-	-
Air	-	-	-		-	-	-	-	-	-	-
Magnets		-		-	-	-		+	-	-	-

Figure 6. Pugh matrix for cutting the caramel.

Criteria	Cost	FDA	Life	Speed	Set up time	Storage size	Error rate	Manuverability
Concept								
Geared Claws	Datum							
Electronic Claws	+	+	s	s	s	s	-	s
Tension wire Claws	+	+	-	s	s	s	-	s
Folding Block	+	+	+	-	s	s	-	s

Figure 7. Pugh matrix for twisting the paper closed.

Criteria	Cost	FDA	Life	Speed	Set up time	Storage size	Error rate	Manuverability
Concept								
Toroidal Rollers	Datum							
Spring Pusher	+	s	s	-	-	+	-	+
Ramp	+	s	s	s	s	+	-	+
Conveyor Belt	+	-	-	+	s	+	s	+
Pocketed Wheel	-	s	s	-	-	s	-	s
Mold	-	s	s	-	-	+	-	+
Extruder	-	s	-	-	-	s	-	s
Roller Wheel	+	s	s	+	s	+	+	+

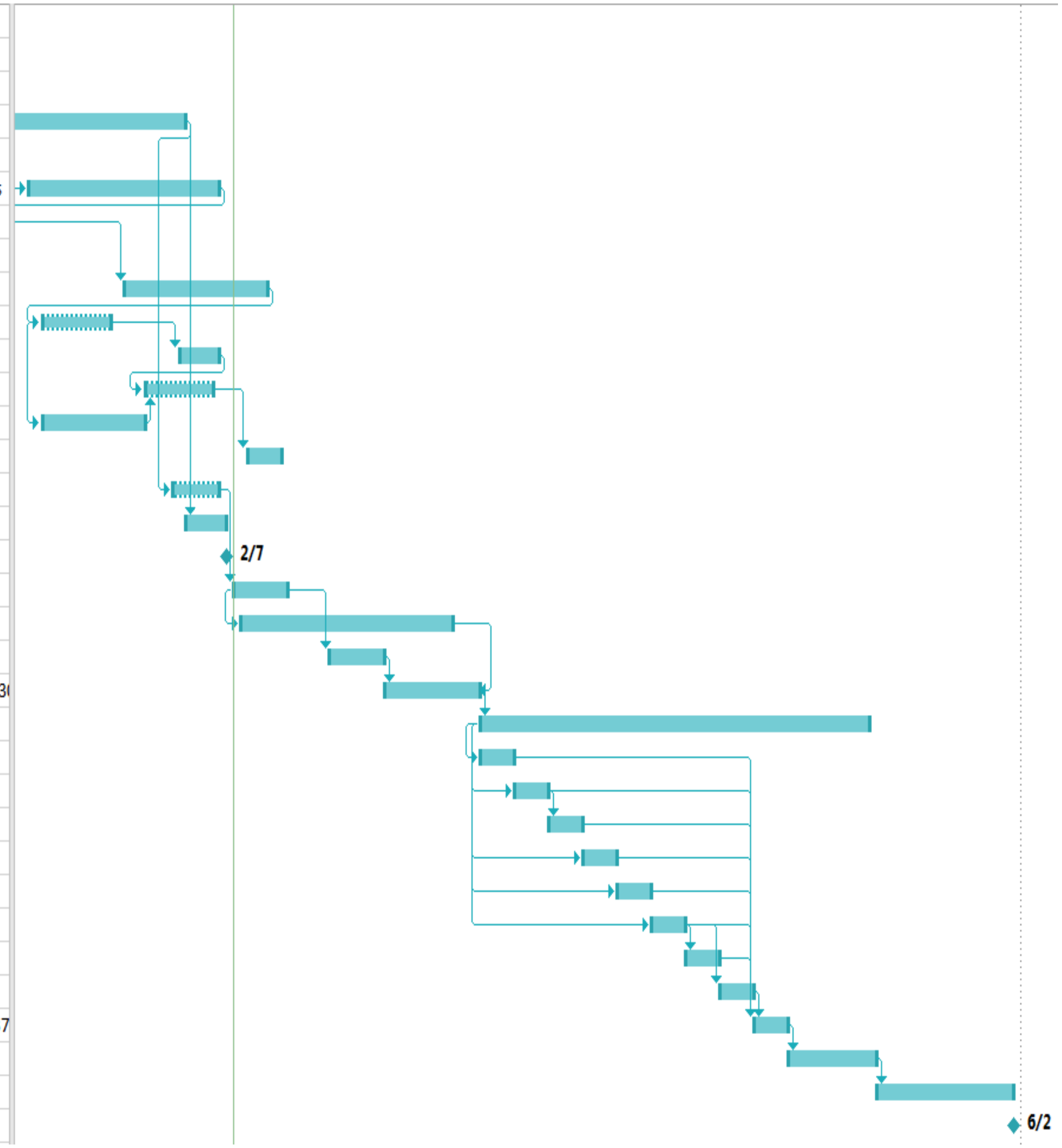
Figure 8. Pugh matrix for feeding the caramel.

Criteria	Cost	FDA	Life	Speed	Set up time	Storage size	Error rate	Manuverability
Concept								
Rollers	Datum							
Conveyor Belt	-	-	-	s	s	-	s	-
Pinch and Pull	-	-	-	-	s	-	s	-
Card Dealer	+	+	+	-	-	-	-	s

Figure 9. Pugh matrix for feeding the paper.

Appendix F

	Task Name	Duration	Start	Finish	Predecessors
	Preliminary CAD	2 days	Thu 11/10/1(	Fri 11/11/16	10
	PDR Report	5 days	Thu 11/10/1(	Mon 11/14/1	10
	PDR Presentation	0 days	Tue 11/15/1(	Tue 11/15/1(	
	Detail Design	78 days	Tue 11/15/1(	Tue 1/31/17	12
	General Geometry ar	26 days	Tue 11/15/1(	Sat 12/10/16	14SS
	Solidworks Parts	28 days	Mon 1/9/17	Sun 2/5/17	15SS+14 days
	Functional CAD Suba	5 days	Tue 12/20/1(	Sat 12/24/16	16
	Gear Ratios	7 days	Sun 12/11/1(	Sat 12/17/16	15
	Structural Analysis	21 days	Mon 1/23/17	Sun 2/12/17	17
	Final Geometry and I	10 days	Wed 1/11/17	Fri 1/20/17	19
	Functional Full CAD /	6 days	Tue 1/31/17	Sun 2/5/17	20
	BOM	10 days	Thu 1/26/17	Sat 2/4/17	21,23
	Part Costing	15 days	Wed 1/11/17	Wed 1/25/17	20SS
	Order Materials	5 days	Fri 2/10/17	Tue 2/14/17	22
	CDR Report	7 days	Mon 1/30/17	Sun 2/5/17	14
	CDR Presentation	6 days	Wed 2/1/17	Mon 2/6/17	14
	CDR	0 days	Tue 2/7/17	Tue 2/7/17	
	Manufacturing Drawi	8 days	Wed 2/8/17	Wed 2/15/17	25
	Manufacturing	31 days	Thu 2/9/17	Sat 3/11/17	28SS+1 day
	Assembly Drawings	8 days	Wed 2/22/17	Wed 3/1/17	28
	Assembly	14 days	Thu 3/2/17	Wed 3/15/17	29FF+3 days,3(
	Testing	57 days	Thu 3/16/17	Thu 5/11/17	31
	Caramel Feed Testin	5 days	Thu 3/16/17	Mon 3/20/17	32SS
	Paper Feed Testing	5 days	Tue 3/21/17	Sat 3/25/17	32SS
	Paper Holder Testing	5 days	Sun 3/26/17	Thu 3/30/17	34
	Caramel Cutter Testi	5 days	Fri 3/31/17	Tue 4/4/17	32SS
	Paper Cutter Testing	5 days	Wed 4/5/17	Sun 4/9/17	32SS
	Claw Wheel Testing	5 days	Mon 4/10/17	Fri 4/14/17	32SS
	Claw Pusher Testing	5 days	Sat 4/15/17	Wed 4/19/17	38
	Paper Twist Testing	5 days	Thu 4/20/17	Mon 4/24/17	38
	Fixing Systems	5 days	Tue 4/25/17	Sat 4/29/17	33,34,35,36,37
	Full Process Testing	13 days	Sun 4/30/17	Fri 5/12/17	41
	Tuning	20 days	Sat 5/13/17	Thu 6/1/17	42
	Senior Project Expo	0 days	Fri 6/2/17	Fri 6/2/17	



Appendix G

Assembly	Company	Item Number	Quantity Needed	Quantity Receiving	Description	Price	Quantity	Total	Order Date	Recieved Date
Casing	professionalplastics.com	SACR.125CCP	2	2	FDA approved acrylic sheet (28 x 13")	20.00	2	40.00		
Casing	professionalplastics.com	SACR.125CCP	1	1	FDA approved acrylic sheet (28 x 28")	20.00	1	20.00		
Caramel Cutter/Paper Cutter/Pushing Arm	Mcmaster.com	95649A232	13	50	Pack of 50 1/4" UHMW plastic washer	14.90	1	14.90		
Caramel Cutter/Paper Cutter/Pushing Arm	Mcmaster.com	92949A541	4	50	Pack of 50 18-8SS 1/4-20, 7/8" SCREW	6.94	1	6.94		
Caramel Cutter/Pushing Arm	Mcmaster.com	92949A548	4	25	Pack of 25 18-8SS 1/4-20, 1 3/4" SCREW	6.32	1	6.32		
Caramel Cutter/Paper Cutter/Pushing Arm	Mcmaster.com	91845A029	10	100	Pack of 100 18-8SS 1/4-20 NUT	3.85	1	3.85		
Caramel Cutter/Paper Cutter	Mcmaster.com	2706T13	4	4	PTFE 3/8" FLANGED BUSHING	4.17	4	16.68		
Paper Cutter	Mcmaster.com	92210A542	1	50	Pack of 50 18-8SS 1/4-20, 1" COUNTERSUNK SCREW	8.84	1	8.84		
Paper Cutter	Mcmaster.com	92210A544	1	25	Pack of 25 18-8SS 1/4-20, 1 1/4" COUNTERSUNK SCREW	5.47	1	5.47		
Claw Wheel	Mcmaster.com	92320A283	4	4	Stainless Steel Spacer 1/8" OD, 1/16"Length (Price goes to 0.87 each whenordering 10+)	1.07	4	4.28		
Claw Wheel	Mcmaster.com	92949A320	4	100	Pack of 100 18-8SS Hex Drive Rounded Screw Head	6.54	1	6.54		
Bushing/Bearing	Mcmaster.com	6952K62	10	10	1/4" Bushing	0.53	10	5.30		
Bushing/Bearing	Mcmaster.com	6952K65	10	10	1/2" Bushing	0.68	10	6.80		
Bushing/Bearing	Mcmaster.com	2639T22	?	?	1/2" Dry Sleeve Bearing	4.52		0.00		
Geneva Mechanism	Mcmaster.com	89535K55	1.8 inches	6 in	Multipurpose 304/304L Stainless Steel Rod (24.52/6")	24.52	1	24.52		
Cam	Mcmaster.com	89535K83	8 inches	1 ft	4" diameter 304/304L stainless steel rod	191.94	1	191.94		
Paper Holder etc.	Mcmaster.com	8983K154	2	12" x 18"	304 Stainless Steel Sheet 12 x 18" 0.48" thick	19.12	2	38.24		
Casing - Wall	Mcmaster.com	8975K142		12" x 24"	6061 Aluminum .25" thick 12" width	45.56	1	45.56		
Casing - Wall	Mcmaster.com	8975K143		12" x 36"	6061 Aluminum .25" thick 12" width	63.34	1	63.34		
Casing - Base	onlinemetals.com	- -	0.25" x 24" X 24"	0.25" x 24" X 24"	0.25" Aluminum Plate 6061-T651	91.30	1	91.30		
Support Structure	Mcmaster.com	9008K14	1" x 1" x 60.5" (3 x 16", 1 x 7.5", 1 x 5")	1" x 1" x 96"	6061 Aluminum 1 x 1" 6 ft long	28.81	1	28.81		
Support Structure	Mcmaster.com	8975K237	1" x 2" x 17.5" (2 x 4", 2 x 4.5")	1" x 2" x 24"	6061 Aluminum 1 x 2 x 24"	32.03	1	32.03		
Sprocket	Mcmaster.com	2737T11	6	6	ANSI Roller Chain 1/4" pitch, 18 teeth	11.04	6	66.24		
Sprocket	Mcmaster.com	2737T11	1	1	ANSI Roller Chain 1/2" pitch, 18 teeth	11.04	1	11.04		
Sprocket	Mcmaster.com	2737T1	2	2	ANSI Roller Chain 1/4" pitch, 9 teeth 1/4" bore	8.68	2	17.36		
Bevel Gear	Mcmaster.com	6529K16	2	2	Metal Miter Gear - 20 degree pressure angle	28.66	2	57.32		
2 bar linkage	Mcmaster.com	8975K577	15"	24"	6061 Aluminum 1/8" x 1/2"	1.84	1	1.84		
Rotating Claw "Disk"	Mcmaster.com	8975K432	0.25" x 2" x 6"	0.25" x 5" x 6"	6061 Aluminum .25" thick 5 x 6"	6.11	1	6.11		
Shaft Collar	Mcmaster.com	6432K12	2	2	Set Screw Shaft Collar	0.94	2	1.88		
Pusher	Mcmaster.com	89415K33	3"	6"	1"x1"x6" 304ss stock	14.38	1	14.38		
shipping						300.00	1	300.00		
manufacturing						200	1	200.00		

Total Cost	1337.83
20% fudge factor	1605.396

Appendix I

Assembly	Part	Assembly #	P/N	Qty	Drawing Number	Drwn By	Part Cost	
Wrapping Machine		00	00 - 000	1	00 - 000			
Structure		01	01 - 000	1	01 - 000			
	Bushing	11C	11C -			STOCK		
	Paper Cutter Support	01	01 - 002	1	01 - 002	TS		
	Tall One Inch Support	01	01 003	3	01 - 003	TS		
	Pusher Support	01	01 004	1	01 - 004	TS		
	Tray Two Inch Support	01	01 005	2	01 - 005	TS		
	Disk Two Inch Support	01	01 006	2	01 - 006	TS		
	Wire Cutter Support	01	01 007	1	01 - 007	STS		
	Folding Wall	01	01 008	1	01 - 008	RS		
Casing		01A	01A - 000	1	01A - 000			
	Front Wall	01A	01A - 001	1	01A - 001			
	Rear Wall	01A	01A - 002	1	01A - 002			
	Left Wall	01A	01A - 003	1	01A - 003	RS		
	Right Wall	01A	01A - 004	1	01A - 004	RS		
	Base Plate	01A	01A - 005	1	01A - 005	RS		
	Top Plate	01A	01A - 006	1	01A - 006			
Drivetrain		02	02 - 000	1	02 - 000			
	Geneva Driver	02	02 - 001	3	02 - 001	AM		
	Geneva Receiver	02	02 - 002	3	02 - 002	AM		
	Drive Shaft	02	02 - 003A-003G	1 ea.	02 - 003			
	add bearings					STOCK		
	18t #25 Sprocket	02	02 - 2737T11			STOCK		
	9t #25 Sprocket	02	02 - 2737T1					
Caramel Feed		03	03 - 000	1	03 - 000	AM		
	Belt	03	03 - 001	1	03 - 001	STOCK		5999k5
	Drive Roller	03	03 - 60885K17	1		MCMASTER		
	Tray	03	03 - 002	1	03 - 002	AM		8983K154 ONE SHEET FOR ALL
	Conveyor Roller	03	03 - 2297T11	1		MCMASTER		
	#8-32, 1/8 18-8 set screw	11A	11A - 92311A188	2		STOCK		
Caramel Cutter		04	04 - 000	1	04 - 000	AM		
	Wire Bracket	04	04 - 001	1	04 - 001	AM		
	Wire Tensioner, Left	04	04 - 002A	1		STOCK		
	Wire Tensioner, Right	04	04 - 002B	1		STOCK		
	Wire	04	04 - 003	1		STOCK		
	GUIDE RAIL, Caramel Cutter	04	04 - 004	2	04 - 004	AM		
	1.5" DRIVEN	10	10 - 001A	1	10 - 001	AM		
	4" Link	10	10 - 002C	1	10 - 002	AM		
	UHMW Washer 1/4"	11C	11C - 95649A23	4		MCMASTER		
	18-8SS 1/4-20, 7/8" SCREW	11A	11A - 92949A54	1		MCMASTER		
	18-8SS 1/4-20 NUT	11A	11A - 91845A02	4		MCMASTER		
	PTFE 3/8" FLANGED BUSHING	11B	11B - 2706T13	2		MCMASTER		
Paper Feed		05	05 - 000		05 - 000	AM		
	Feed Roller 1	05	05 - 001	1		STOCK		
	Feed Roller 2	05	05 - 002	1		STOCK		
	ROLLER BRACE	05	05 - 003	2	05 - 003	AM		
	Geneva Receiver	02	02 - 002	1	02 - 002	AM		
Paper Cutter		06	06 - 000	1	06 - 000	AM		
	Disk Blade	06	06 - 001	1	06 - 001	STOCK		
	L-Bracket	06	06 - 002	1	06 - 002	AM		
	Guide Rail, Paper Cutter	06	06 - 003	1	06 - 003	AM		
	3" Driven	10	10 - 001B	1	10 - 001	AM		
	3" Link	10	10 - 002B	1	10 - 002	AM		
	PTFE 3/8" FLANGED BUSHING	11B	11B - 2706T13	2		MCMASTER	$4.17	
	UHMW Washer 1/4"	11C	11C - 95649A23	5		MCMASTER		
	18-8SS 1/4-20 NUT	11A	11A - 91845A02	4		MCMASTER		
	18-8SS 1/4-20, 1" COUNTERSUNK SCREW	11A	11A - 92210A54	1		MCMASTER		
	18-8SS 1/4-20, 1 1/4" COUNTERSUNK SCR	11A	11A - 92210A54	1		MCMASTER		
	18-8SS 1/4-20, 7/8" SCREW	11A	11A - 92949A54	2		MCMASTER	0.1388	
Pushing Arm		07	07 - 000	1	07 - 000	AM		
	Contact Head	07	07 - 001	1	07 - 001	AM		
	Threaded Rod	07	07 - 002	1	07 - 002	AM		
	Clevis	07	07 - 003	1	07 - 003	AM		
	1.5" Driven	10	10 - 001A	1	10 - 001	AM		
	4" Link	10	10 - 002C	1	10 - 002	AM		
	UHMW Whasher 1/4"	11C	11C - 95649A23	4		MCMASTER		
	18-8SS 1/4-20, 7/8" SCREW	11A	11A - 92949A54	1		MCMASTER		
	18-8SS 1/4-20, 1 3/4" SCREW	11A	11A - 92949A54	1		MCMASTER		
	18-8SS 1/4-20 NUT	11A	11A - 91845A02	2		MCMASTER		
Claw Wheel		08	08 - 000	1	08 - 000	AM		
	Mounting Disk	08	08 - 001	1	08 - 001	AM		
	Fixed Arm	08	08 - 002	2	08 - 002	AM		

	Rocker Arm	08	08 - 003	2	08 - 003	AM	
	MOUNTING SHAFT	08	08 - 004	1	08 - 004	AM	
	Spring	08	08 - 9654K963	2	08 - 9654K963	STOCK	
	Geneva Reciver	02	02 - 002	1	02 - 002	AM	
	Stainless Steel Spacer 1/8" OD, 1/16" Len	11C	11C - 92320A28	4		MCMASTER	1.07
	18-8SS 2-56, 7/8" Screw	11A	11A - 92949A32	4		MCMASTER	6.54
	UHMW Whasher 1/4"	11C	11C - 95649A23	2		MCMASTER	
	18-8SS 1/4-20, 1 3/4" SCREW	11A	11A - 92949A54	4		MCMASTER	0.2528
	18-8SS 1/4-20, 3/8" SCREW	11A	11A - 92949A53	2		MCMASTER	
	18-8SS 1/4-20 NUT	11A	11A - 91845A02	4		MCMASTER	
	1/4-20 spring anchor stud	11A	11A - 95907A48	4		MCMASTER	
Twisting Mech.		09	09 - 000	1	09 - 000		
	Cam	09	09 - 001	2	09 - 001	AM	
	Cam Shaft	09	09 - 002	1	09 - 002		
	Guide Rail, Twising Mech.	09	09 - 003	2	09 - 003	AM	
	Cam Follower	09	09 - 004	2	09 - 004	AM	
	Claw Arm	09	09 - 005	2	09 - 005	AM	
	Rack	09	09 - 006	1	09 - 006	AM	
	COVER Plate	09	09 - 007	2	09 - 007		
	Hollow Shaft	09	09 - 008	1	09 - 008		
2 Bar Linkage		10					
	1.5" Driven	10	10 - 001A		10 - 001	AM	
	3" Driven	10	10 - 001B		10 - 001	AM	
	4" Driven	10	10 - 001C		10 - 001	AM	
	1.5" Link	10	10 - 002A		10 - 002	AM	
	3" Link	10	10 - 002B		10 - 002	AM	
	4" Link	10	10 - 002C		10 - 002	AM	
Hardware		11				STOCK	
Fasteners		11A				STOCK	
	18-8SS 1/4-20, 7/8" SCREW	11A	11A - 92949A541			MCMASTER	0.1388
	18-8SS 1/4-20, 1 3/4" SCREW	11A	11A - 92949A548			MCMASTER	0.2528
	18-8SS 1/4-20 NUT	11A	11A - 91845A029			MCMASTER	
	18-8SS 1/4-20, 1" Screw	11A	11A - 92210A542			MCMASTER	0.1768
	18-8SS 1/4-20, 1" COUNTERSUNK SCREW	11A	11A - 92210A542			MCMASTER	
	18-8SS 1/4-20, 1 1/4" COUNTERSUNK SCR	11A	11A - 92210A544			MCMASTER	
	18-8 SS Hex Drive Rounded Screw Head	11A	11A - 92949A320			MCMASTER	6.54
Bushings/Bearings		11B				STOCK	
	1/4" Bushing	11B	11B - 6952K62			MCMASTER	
	1/2" Bushing	11B	11B - 6952K65			MCMASTER	
	1/2" Dry Sleeve Bearing	11B	11B - 2639T22			MCMASTER	
	PTFE 3/8" FLANGED BUSHING	11B	11B - 2706T13			MCMASTER	$4.17
Spacers/Rollers		11C				STOCK	
	UHMW Washer 1/4"	11C	11C - 95649A232			MCMASTER	
	Stainless Steel Spacer	11C	11C - 92320A283			MCMASTER	1.07
	Shaft Collar 1/4	11C	11C - 6432K12	2		MCMASTER	
	Shaft Collar 5/16	11C	11C - 6432K13	4		MCMASTER	
	Shaft Collar 1/2	11C	11C - 9946K15	2		MCMASTER	

OPERATIONS MANUAL

Automated Table-Top Candy Wrapping Machine

California Polytechnic State University
Senior Project

June, 2017

Alexander Miller

Roman Stambaugh

Trevor Steele

Revision Sheet

Release No.	Date	Revision Description

OPERATIONS MANUAL

TABLE OF CONTENTS

1.0 GENERAL INFORMATION

1.1 System Overview

The purpose of this machine is to cut and wrap caramel candy. It was not designed for any other type of candy or food, and use of these items will result in the machine failing. The machine functions by cubing caramel strips and cutting paper squares. The two items are then merged together before the paper is finally wrapped and twisted around the caramel.

This machine is hand powered by one hand crank located on the outside of the machine. This crank turns all the parts in unison to provide fluid continuous operation.

The machine is mounted to a rolling cart for easy movement and storage. The machine is too heavy for one person to lift alone and therefore the cart is the only sufficient means of transportation.

The Automated Table-Top Candy Wrapping Machine is still currently in development.

1.2 Authorized Use Permission

This machine is not intended to be used by children. There are many moving parts and pinch points even with the protective casing. It is strongly advised that anyone wishing to operate this machine has thoroughly read the operating instructions.

1.3 Part Inventory

For a full list of parts see bill of materials.

2.0 OPERATING HAZARDS AND SAFETY

2.1 Sharp Edges and Pinch Points

The Automated Table-Top Candy Wrapping Machine has a few sharp moving pieces which the user should be aware of. Firstly, as the caramel moves from becoming a strip to cubes it passes under a thin cutting wire. This wire should be avoided by fingers and hands as it could cause serious cutting damage when moving. The paper is also cut by a very sharp razor wheel which moves back and forth quickly across the paper. When cleaning or replacing this wheel, caution should be taken. As well, this wheel should be avoided when the machine is in operation.

Due to the highly-mechanized aspect of this machine, many pinch points are created. Hands and other body parts must stay outside the protective casing during operation. Most notably is the chain system which could cause serious damage to fingers or hair if caught in the sprockets/chain. There are also large heavy gears located near the twisting mechanism that should be avoided when the machine is in operation. Large heavy gears tend to crush or pinch easily.

2.2 Safety Guards

The Automated Table-Top Candy Wrapping Machine has a protective plastic housing which encases the entire machine. This housing is meant to keep hands and fingers away from all moving parts. When the housing is removed the hand crank cannot be turned. Any attempt to force the crank will break the machine. DO NOT ATTEMPT TO OPERATE THE MACHINE WITH PLASTIC CASING REMOVED.

2.3 Transportation

The Automated Table-Top Candy Wrapping Machine is approximately the size of two microwave ovens. It also weighs over 120 pounds. Due its size and weight the Automated Table-Top Candy Wrapping Machine cannot be carried safely by one person. When moving it around a kitchen the machine should be rolled by the provided cart. This cart is meant to help with transportation as well as a stationary counter when the machine is in use. THIS MACHINE SHOULD NEVER BE CARRIED BY ONE PERSON.

3.0 OPERATING INSTRUCTIONS

3.1 Hand Crank

The hand crank is the one of the few inputs into this machine. It is the sole operating mechanism to cause the machine to run. The user should rotate the crank at about 12 revolutions per minute to ensure about 144 caramels are wrapped in 12 minutes. The crank can be turned slower or faster but this will affect production rate. 12 revolutions per minute is recommended.

3.2 Loading Paper

The Automated Table-Top Candy Wrapping Machine was designed for 4-inch-wide rolls of parchment paper. A roll is to be loaded into the machine at the top and fed down through the sheet metal guide. The rolls can be loaded and unloaded by removing the paper roller. Shaft collars are removed with a small hex wrench and a new roll can be loaded.

3.3 Loading Caramel

The caramel is meant to be fed to the machine in strips via a tray. This tray is fed in on one side and comes out the other. The tray is the transportation mechanism for which the caramel moves through the machine before being wrapped. The tray is the only other input to the machine than the hand crank.

4.0 MAINTENENCE

4.1 Cleaning

All parts are made of aluminum, stainless steel, delrin, or acrylic. These parts are food grade and can be washed by hand. Parts should be washed with warm water and dish soap. The caramel tray should be washed regularly as well as the caramel pusher and the wire caramel cutter.

4.2 Troubleshooting

If candies begin to not be cut cleanly, the stainless steel wire can be replaced. Unwind the wire from the guitar tuners and rewire. The razor wheel for cutting paper can also replaced with a new razor when dull. If the hand crank becomes hard to turn than the STOP TURNING IMMEDIATELY. Check the machine for caramel lodged in the machine. Places where caramel could potentially get stuck are the wire cutter, the pusher and the caramel pusher. Clean if necessary. Check that the paper is properly aligned and that the tray is not stuck.