BOX IT UNLIMITED

Fall Report 2012

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1. Project Overview

1.1. Mission Statement

Box It Unlimited is a company devoted to find solutions to processing problems.

1.2. Problem Statement

Our objective is to automate the uncuffing process in the Bama Companies, Inc., handheld pie production line. By developing a machine that's automate the process it will save the company money.

1.3. Background

Bama Companies, Inc. is a provider of baked items to some of the largest restaurants in the world. One of the items they specialize in are handheld pies and the North Tulsa facility a main producer of those pies.

Bama Companies, Inc. wishes to enhance the efficiency of the facility from an engineering stand point as well as from a financially. They currently have a manual process of uncuffing the plastic bag liner that protects the pies within the cardboard boxes, but would like to automate this process.

The purpose for the facility to cuff the plastic bag over the boxes is due to another automated process currently used by the company. They currently have an automated process to pick up the pies and place them in the boxes. This process uses multiple arms that randomly place the pies in different boxes. In order for the arms to efficiently place the pies in the boxes and not encounter an obstacle form the bag itself, the bag needs to be securely fixed around the flaps of the box.

2. Statement of Work

2.1. Scope of Work

Bama Companies in Tulsa, OK has requested that Box It Unlimited design a machine that will automatically uncuff the plastic bag that is placed inside boxes filled with small frozen pies.

Box It Unlimited will submit a design proposal report in December of 2012 for the customer to review. This report will include:

- A project overview with a mission statement, problem statement, and background on the project

- A statement of work with a delivery schedule, location of work, period of performance, and any special delivery requirements
- A work breakdown structure
- Customer design requirements
- All design research
- An overview of all designs
- Market research and budget proposal
- A Gantt chart with project task list and scheduled dates

By the end of April 2013, Box It Unlimited will present a fully working prototype and final design report to Bama Companies as well as a panel of OSU professors. The final report will include:

- Technical specifications
- Test Analysis Completed
- Overall budget
- Market and economic analysis

2.2. Location of Work

Box It Unlimited will perform all prototype building, research, test, and other analysis on the Oklahoma State University Campus. Research and design will be performed in the Biosystems and Agriculture Engineering (BAE) computer labs. Actual construction of the prototype will be done in the BAE Design Lab. Other material testing will performed in the Civil Engineering materials laboratory. The final prototype will be delivery to Bama Companies in Tulsa, OK, if requested.

2.3. Period of Performance

- Project start date: Sept. 9th, 2012
- Project end date: April 26th, 2012

2.4. Deliverables Schedule

Due Date	Task
Oct. 29th, 2012	Statement of Work
Nov. 2nd, 2012	Work Breakdown Structure
Nov. 5th, 2012	Task List
Nov. 9th, 2012	Design Sketches Finalized

Nov. 19th, 2012	1st Draft of Design Report Completed
Dec. 7th, 2012	Design Review and Presentation
Dec. 7th, 2012	Fall Design Report
Dec. 10th, 2012	Company Website
Mar. 4th, 2013	Prototype Construction Completed
Mar. 30th, 2013	Prototype Testing Completed
April 19th, 2013	Final Presentation
April 19th, 2013	Final Design Report

2.5. Delivery Requirements

CAD software needed to design the parts and other aspects of the machine will be SolidWorks, ProEngineer, or AutoCAD. There will also need be knowledge of PLC operation deceives to control the machine. The machine will be designed with Allen Bradley system of standards and NEMA 4X enclosure of the electrical system.

Box It Unlimited will need cooperation from the BAE lab to manufacture the parts needed to build and prototype the machine.

The machine itself will need to be compliant with the voltage and the maximum pneumatic pressure that if offered at the facility. It will also need to be no larger than 6 feet (length) x 10 feet (height) x 4 feet (width).

3. Work Breakdown Structure

3.1. Design Initialization

3.1.1 Project Overview – **Oct. 15th, 2012**

3.1.2 Brainstorming Ideas - **Oct. 29th, 2012**

3.1.3 Customer Requirements - **Oct. 15th, 2012**

3.2. Background Research

3.2.1 Patent Research - **Oct. 15th, 2012**

3.2.2 Relevant Parts - **Nov. 12th, 2012**

3.2.3 Possible Materials – **Nov. 12th, 2012**

3.3. Economic and Cost Analysis

3.3.1. Cost Breakdown – **Nov. 19th, 2012**

3.3.2. Cost Analysis - **Nov. 19th, 2012**

3.3.1 Supplies Cost - **Nov. 19th, 2012**

3.3.3. Maintenance - **Nov. 19th, 2012**

3.3.4. Cleaning Cost - **Nov. 19th, 2012**

3.3.5. Overall Benefit - **Nov. 19th, 2012**

3.4. Communications

3.4.1. Customer Communications **– April, 2013**

3.4.2. First Draft of Website **– Nov. 26th, 2012**

3.4.2.1. Team Picture **– Nov. 16th, 2012**

3.4.3. Final Website **– Dec. 10th, 2012**

3.4.4. Design Review, Approval, Peer and Class Evaluation **– Dec. 14th, 2012**

3.5. Documentation

3.5.1. Hand-drawn Sketches – **Nov. 12th, 2012**

3.5.2. Preliminary Solid Works, AutoCAD, and Pro-Engineer Designs - **Nov. 12th, 2012**

3.5.3. Finalized Solid Works, AutoCAD, and Pro-Engineer Designs - **Dec. 2012**

3.5.4. First Draft Fall Report – **Nov. 19th, 2012**

3.5.5. Finalized Fall Report – **Dec. 7th, 2012**

3.5.6. Fall PowerPoint Presentation - **Dec. 7th, 2012**

3.5.7. First Draft Spring Report – **April, 2013**

3.5.8. Finalized Spring Report – **April, 2013**

3.6. Construction and Evaluation

3.6.1. Construction of prototype – **March 15th, 2013**

3.6.1.1. Concept and Design – **March 4th, 2013**

3.6.1.2. Electrical - **March 4th, 2013**

3.6.1.3. Pneumatic - **March 4th, 2013**

3.6.1.4. Mechanical - **March 4th, 2013**

3.6.1.5. Programmable Logic Control – **March 15th, 2013**

3.6.1.6. Safety - **March 4th, 2013**

3.6.2. Completed Testing Prototype – **Mar. 30th, 2013**

3.6.3. Customer Approved Testing – **April, 2013**

3.7. Final Customer Approval

3.7.1. Final Spring Presentation – **April, 2013**

3.7.2. Final Spring Prototype Demonstration - **April, 2013**

4. Customer Design Requirements

The machine itself needs to operate on a PLC, 480 volts, 24 volt control, 60 hertz, and a 3-phase power supply. It also needs to run off of a maximum of 110 PSI pneumatic line. There is the need for a mushroomed shaped Emergency Stop button, for safety purposes. The reliability of the machine itself needs to be 98% or higher, as the maintenance department is prompt to fix any problems.

The customer requests that the machine be able to uncuffed the boxes at a maximum rate of 20 per minute, with an average rate of 15 boxes per minute. The recommendation was to use two uncuffing machines to process the boxes at a reasonable speed. It is also necessary that the final product be made out of stainless steel and easy to wash down a maximum of once every two weeks.

5. Design Research

5.1. Standards

The standards that the facility is subject to bases on FDA codes or food processing plants must be followed. The main standard that the machine will be subject to is making sure that of making sure that no substance contaminates the box.

5.2. Competitors Analysis

5.2.1. There are many different models of bag inserters and bag uncuffers made by various companies. However, there are currently no models that will uncuff that bag that is around the flaps while the flaps are still positioned in the down position. Below are the companies and models that are relevant to our project and are similar. The images for the models can be found in Appendix D.

<u>Pearson Bag Inserter and Uncuffer - Model UC15:</u>

- Pneumatic forks to lift the bag on each corner
- Small metal plates that pull the flaps from the bag and
- Rods that fold the flap away from the box

<u>K&R Equipment, Inc. - PBD-FC™ Polybag In-Box Decuffer Folder Closer</u>

- Pneumatic forks to lift the bag
- Suction cups to pull the flaps down, then push the bag inside the box using and shooting out steel bar/plate
- Rolls and pushes the flaps over to close the box
- Tapes it shut

<u>OK International Group - Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer</u>

- Pneumatic forks on a sliding bar to lift the bag over the flaps
- Plastic disk that push the bag slightly in and pull the flaps out
- Metal plate that flattens the bag in the box

<u>Pattyn - DS-11 Bag decuffer sealer</u>

- Pneumatic forks to lift the bag on each of the 4 corners
- Rollers that drop straight down and close the bag inside the box
- A hook mechanism that pushes the back flap into the box to close it
- A slant to push the front flap into the box
- Side slant bars that close the side flaps into the box

Wayne Automated Corp - Random Bag Uncuffer / Case Sealer:

- Uses a vacuum of four suction tubes to suck in the bag and lift it over the flaps then puts the bag inside the flaps.

5.3. Patent Search

The following patents are relevant to our design. There were no patents that currently uncuff a plastic bag with the flaps located in the down position. However, there are patents that pertain to other devices and mechanisms used in the design and are therefore relevant. Entirety of patents can be found in Appendix A.

Patent 1: Apparatus for closing bags

Patent Number: 5,279,094

Assignee: Bemis Company, Inc.

This patent is a design that is made to uncuff the bag when the flaps of the box are located in the up position and the bag is light draped over them. After the machine uncuffs the bag it then closes the bag inside the box. The corner placed devices that lift the bag are the relevant part to our design, but not a part chosen to use. The claims in this design pertain to the uncuffing of the bag and pulling all sides of the bag inward to close this bag. It also has a claim on the way the conveyor brings the box to the machine. But this patent has expired so there will be no infringement on this design.

Patent 2: Continuous bag closing apparatus and method

Patent Number: 6,920,740 B2

Assignee: AMCOL International Corporation

This patent is a design that pertains to our design the most. Like the other design the flaps start in the up position, with the bag draped around them. To uncuff the bag from the flap there are two fluid jets positioned on two side of the box on the machine. The fluid pushes the bag up so it is no longer over the flaps. After which, the machine closes the bag. Because this design is similar to a part of our design we will note it to make sure no copyright infringement occurs.

The claims in this design include a variety of fluid jet placements with respect to the box size and placement on the conveyor. In this patent, any type of fluid jet dispensing between the values of 70 and 75 PSI is accounted for when it placed in the position that it will blow the bag in an upward direction. In this design the fluid jets are used to blow the bag completely off the cuffs of the box. We will have to keep this in mind when developing our design.

6. Design Overview

6.1. Design Proposal

Our design options include two different types of bases and three different types of bag lifting mechanisms. Each of the bag lift options can be place on either of the two bases. Each of the assemblies is designed using a design factor of 1.25, a number of safety aspects, and electronic devices that will be standard for each of the designs discussed. These devices will be:

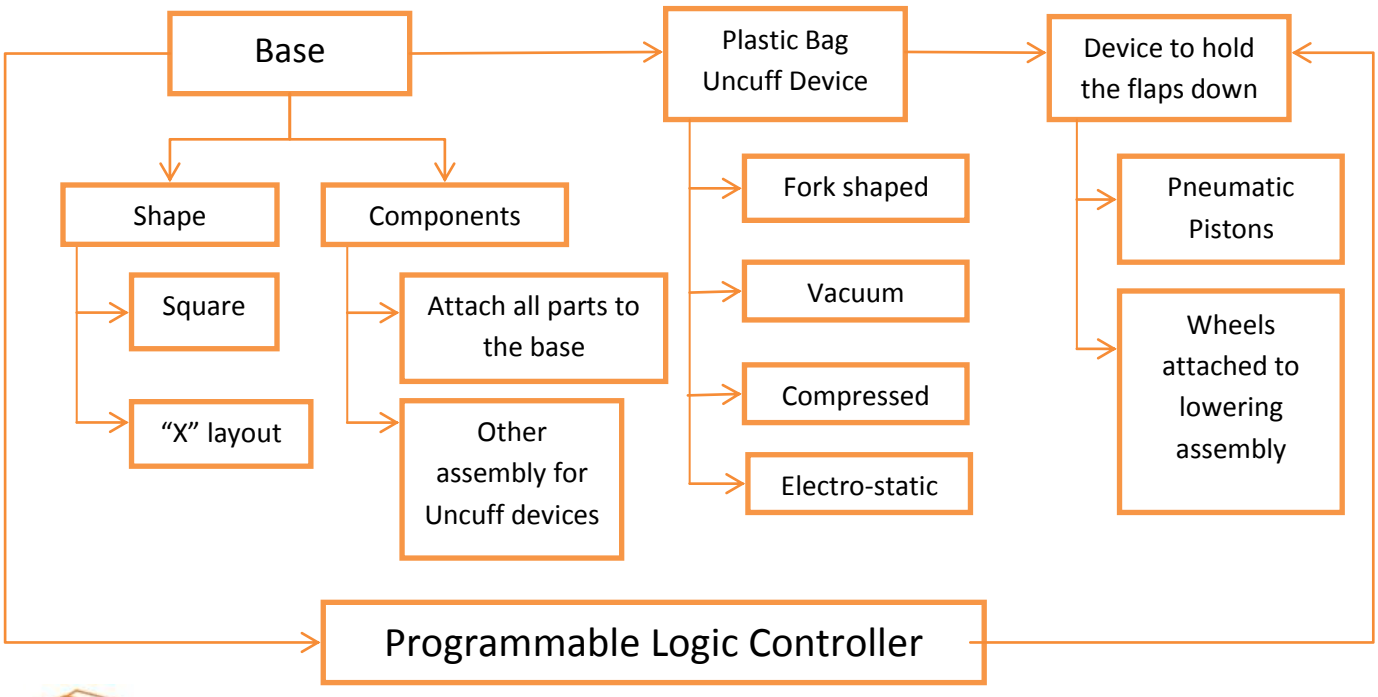
A PLC to operate all electronic deceives

Rounded edges

No pinch points

A mushroom shaped emergency stop button

6.2. Design Process Flow Chart



6.3. Designs

6.3.1.1. Base Design 1

Base design 1, as seen in figure 1 and 2, includes four flap compressing pinchers that come from the base of the machine to compress the flaps of the box, so they are flat against the box. The box will enter the system using powered conveyor rollers, where sensors will be placed to line the box. Once the box is in place the pinchers will move the spring up and compress the flaps. The lift mechanism, which is positioned in all four corners, will release. Then the assembly will lift up pulling the bag with it and over the flaps of the box.

The pinchers will be powered by a servo motor. The servo motor requires 440 oz-in of torque, to compress the flaps flat against box. To find this we used the equation:

$$T = 5.5\ in * 5lb * 16\ oz/lb$$

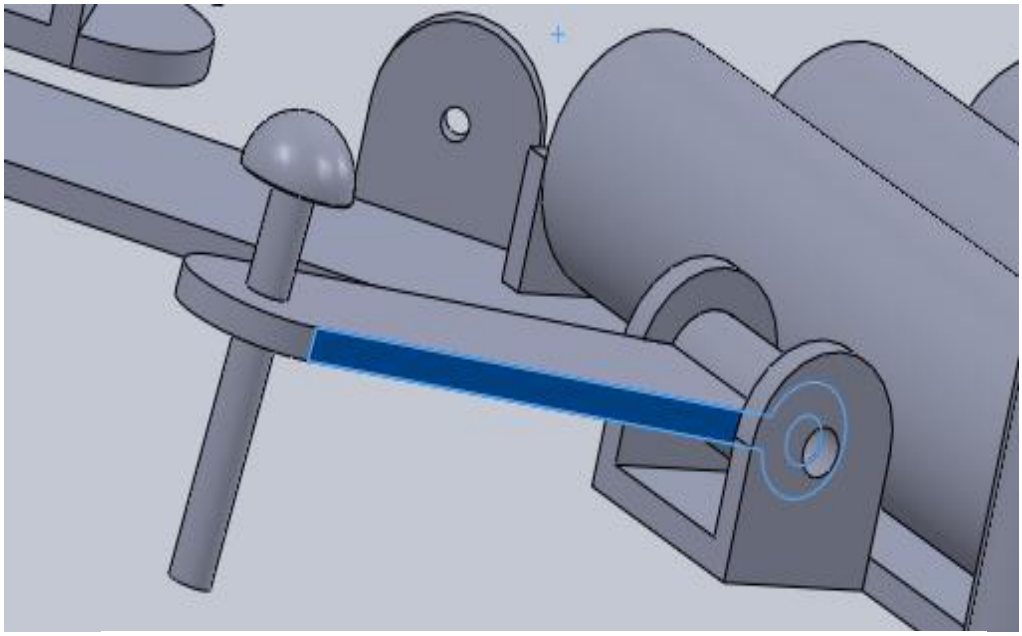


Figure 1: Close up of flap compressors (pinchers)

Figure 2: Base Design 1

6.3.1.2. Base Design 2

Base design 2, as seen in figures 3 and 4, includes a lowering assembly with rollers attached to the four sides of the square vertical adjusting mechanism. The box will enter the system using powered conveyor rollers, where sensors will be placed to line the box. Once in the correct position the assembly will lower onto the box, using the rollers to push the flaps inward. After which, the lift mechanism will release horizontally, then the assembly will move up to its original position, lifting the bag over the flaps of the box.

The wheel mount has a spring attached to it to allow for adjustment of the wheel.

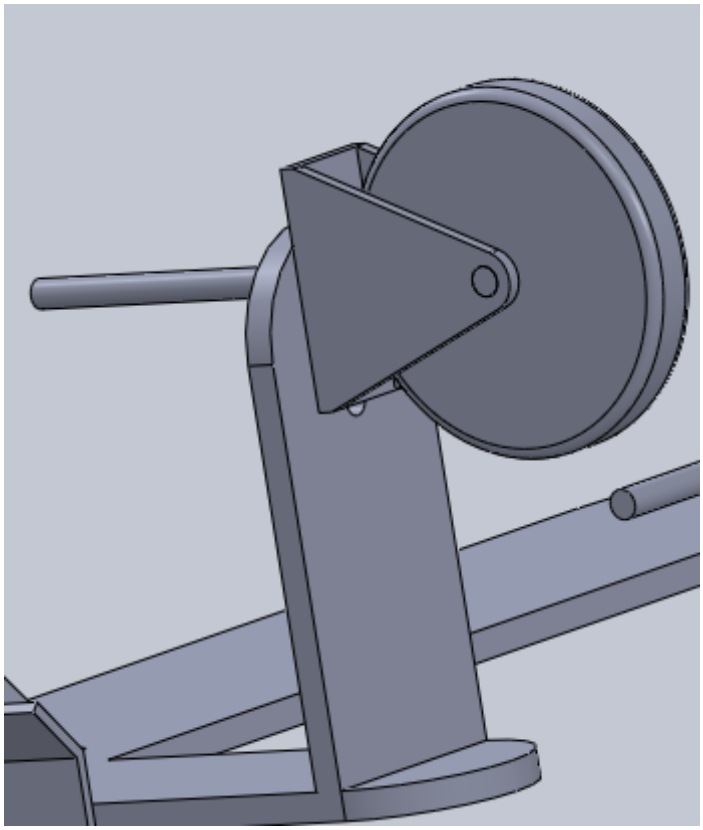


Figure 3: Close up of flap compressors (rollers)

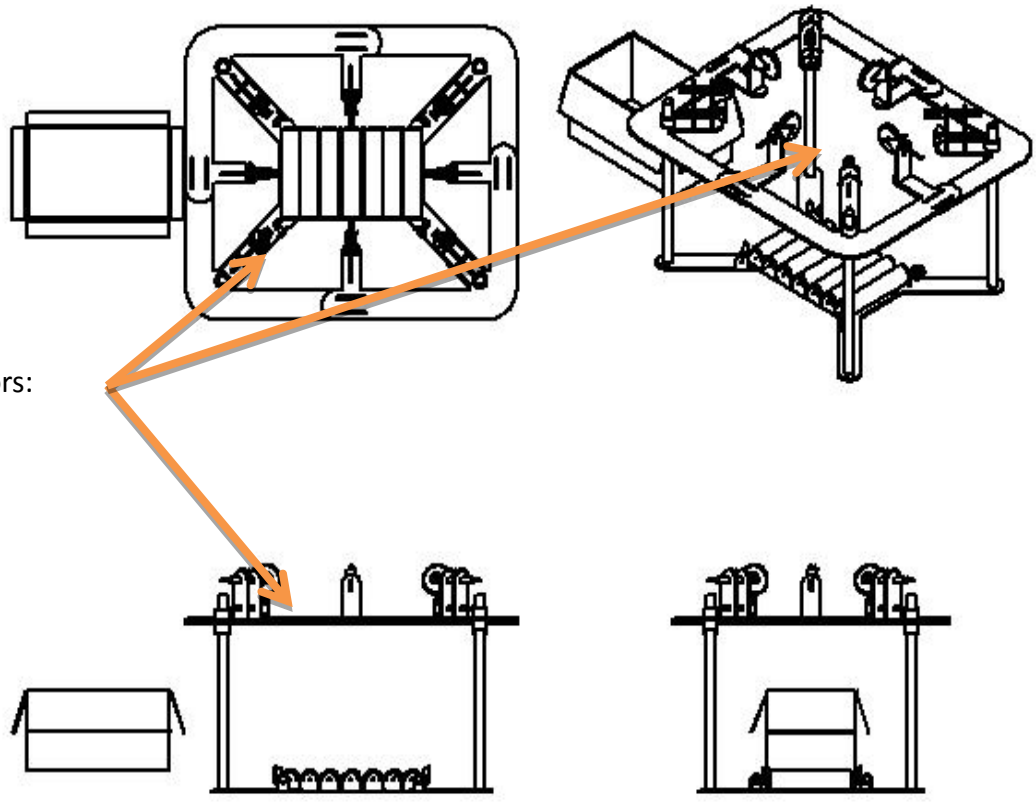


Figure 4: Base Design 2

6.3.1.3. Vertical Adjusting Assembly

The vertical adjusting assembly, as seen in figure 5, is attached to the part of the machine that raises and lowers to lift the bag over the cuffs of the box. The assembly will be mounted to the under part of the base. It uses a bar system that is connected to a pneumatic piston that will have bore size of 2 ½ inches with a stroke length of 4 inches. As the piston releases it causes the assembly to lift up. With vertical adjusting assembly can be attached to either base. Calculations for piston size can be found in Appendix C.

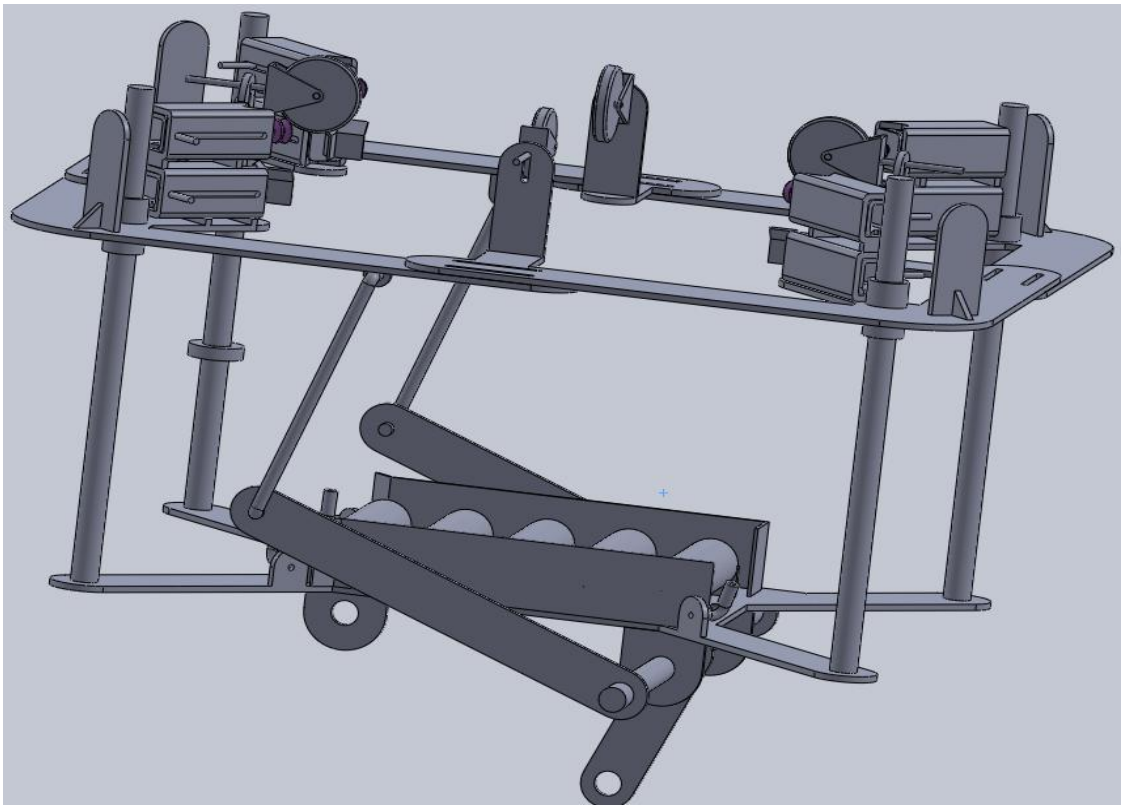


Figure 5: Vertical Adjusting Assembly

6.3.1.4. Lift Mechanism Design 1: Suction Cups

Lift mechanism design 1, as seen in figure 6, includes four corner positioned fork objects, as well as four corner positioned suction cups. The suction cups are made so that they will cling to the plastic of the bag

after being applied. These two mechanisms will release horizontally when the box is positioned correctly. The suction cup will move backward slightly, pulling the bag away from the corners of the box. After which the assembly will lift up and pull the bag over the flaps.

The eight lift mechanisms are attached to a small pneumatic cylinder, with stroke length of 3 inches, which is attached to the base of the machine.

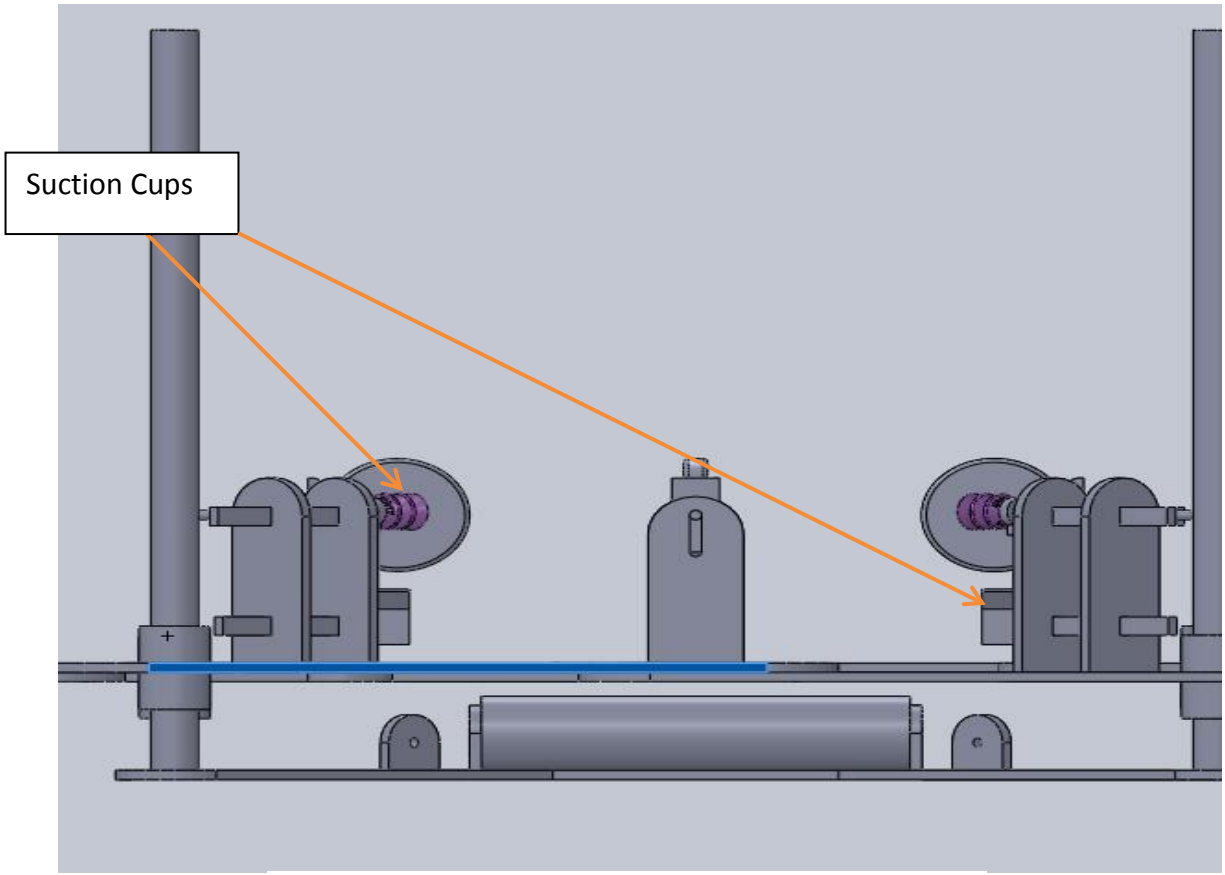


Figure 6: Lift Mechanism 1 – Suctions Cups

6.3.1.5. Lift Mechanism Design 2: Air Jets

Lift mechanism design 2, as seen in figure 7, includes four corner positioned fork mechanisms, as well as four corner positioned air jets. The air jets will blow the bag up slightly, then the forks will release horizontally when the box is positioned correctly. After which the assembly will lift up and pull the bag over the flaps.

The air jets are made using modular adjustable hosing.

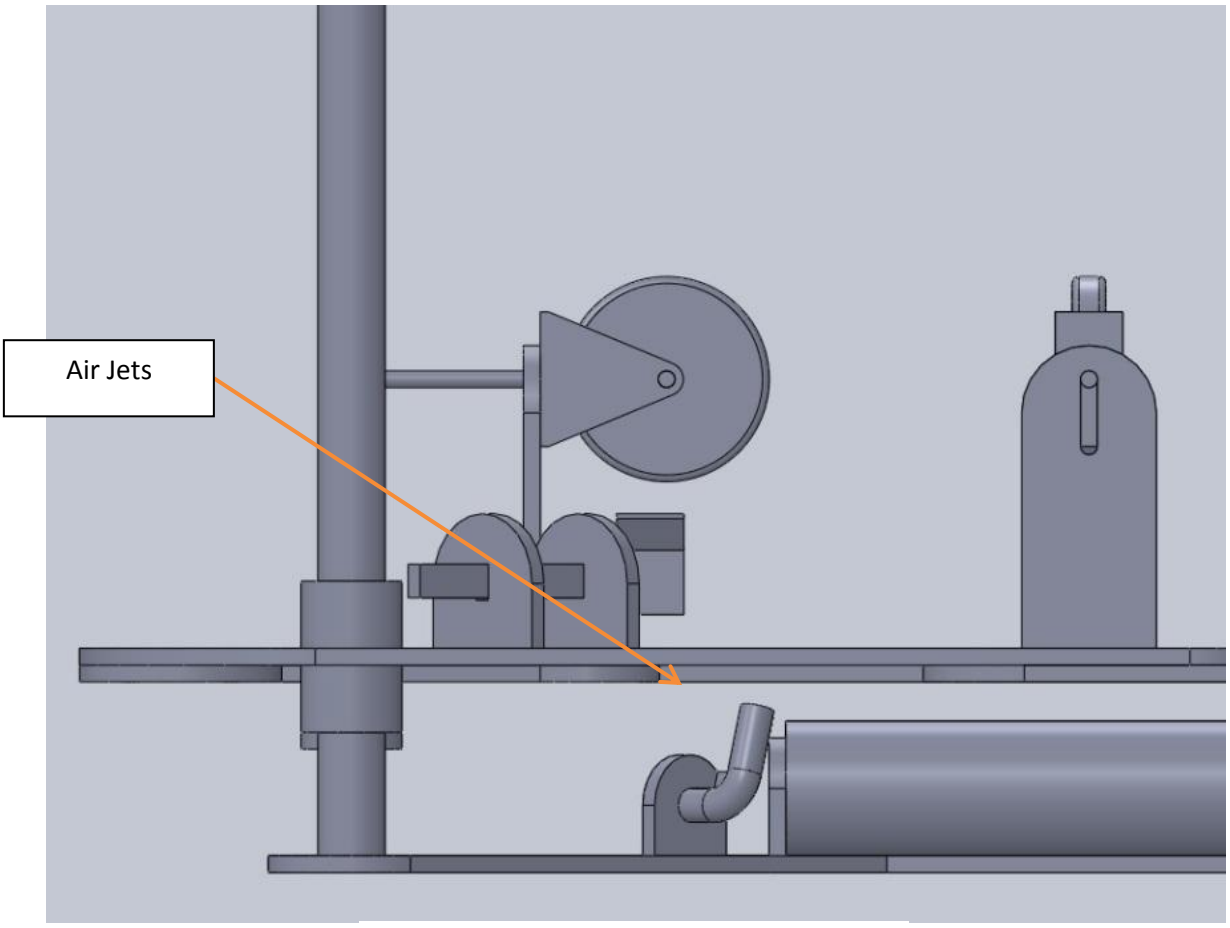


Figure 7: Lift Mechanism 2 – Air Jets

6.3.1.6. Lift Mechanism Design 3

Lift mechanism design 3, as seen in figure 8, is a combination of lift designs 1 and 2. It includes both the previously discussed suction cups and air jet mechanisms. In this design the air jets will blow the bag away from the corners, the suction cup will release and slightly pull the bag back and away from the corners of the flaps. After which, the forks will release under the bag and as the assembly moves up the bag will be pulled over the flaps.

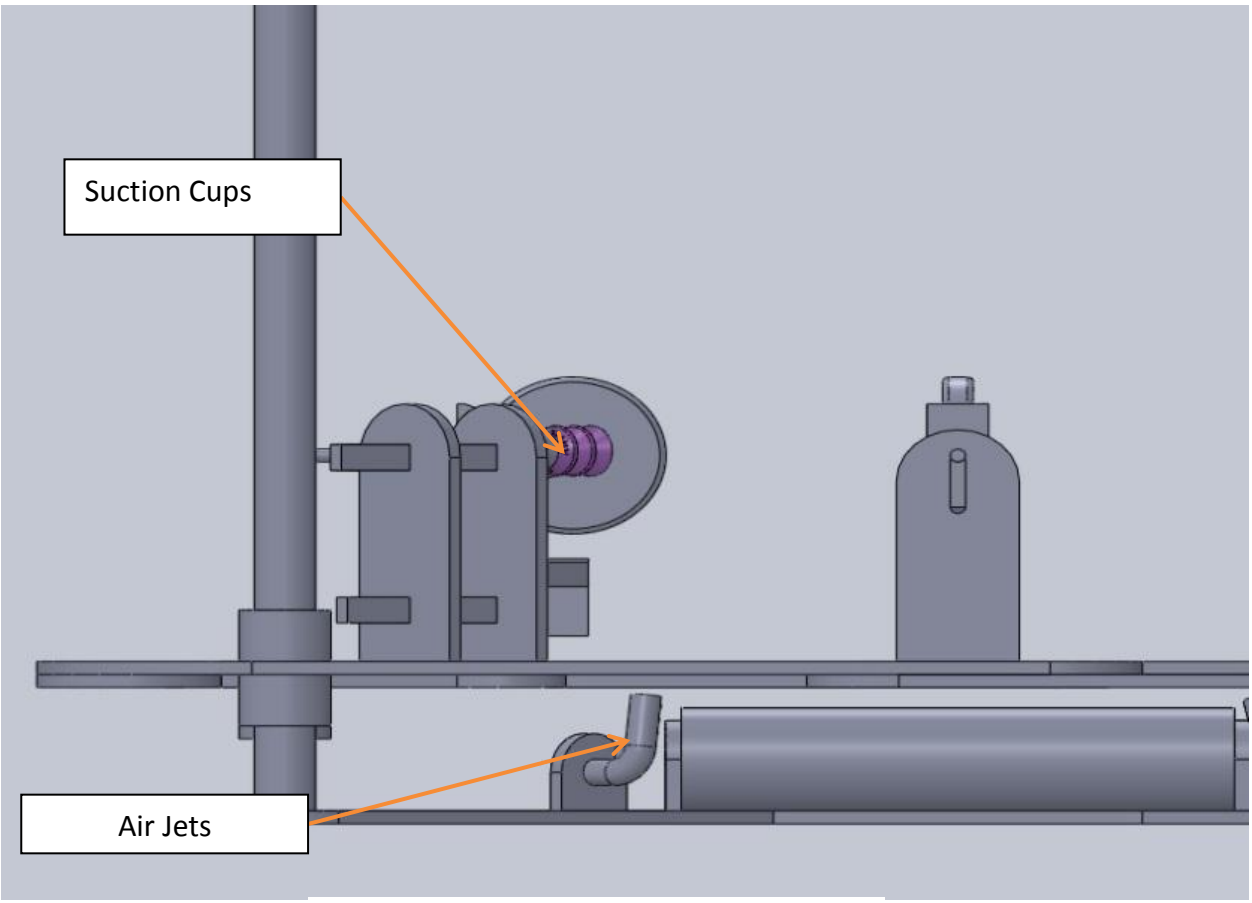


Figure 8: Lift Mechanism 2 – Air Jets

6.3.2. Jammed and/or improperly uncuffed boxes

In the case that the something in the system of the machine does properly do its job, an alarm will sound letting the monitor of that part of the line know that it needs to be checked. If the emergency stop button is pressed, the box will be release to a side conveyor to be checked and not back up the line.

6.3.3. Programming

For the programming of the machine we have created a logic flow chart. A more detailed version of the flow chart, including an IF-THEN statement will be developed later in the prototyping stage.

See Appendix D for logic flow chart

6.4. Design Analysis/Recommendation

This section includes the details of the analysis we performed on the designs.

6.4.1. Design Calculations

6.4.1.1. Weld Analysis: After performing a weld analysis on the lift assembly arm we found that the weld would be more than enough to support the base. The safety factor on the design was equal to 8. The engineering calculations are found in Appendix C.

6.4.1.2. Operational Speeds

20 boxes/min = 1 box/6 secs

To stay in the maximum time allowed by the customer, the machine needs to process one box every 6 seconds. Using competitor's videos and the bag inserter used by the customer, we estimated the time it would take for each design to go through the uncuffing process. We had a scope of how long different mechanical processes occur. Using this scope we calculated the different times needed to complete each design. We estimated that without any assist we could complete each task in 4.75 sec and with assist the vacuum added 0.75 of second to the process and air would add 0.5 seconds to the process. See Appendix C for the break down calculation of each design.

6.4.2. Design Recommendation

Our recommendation is that the prototype be developed using a base design 2. The downward compression of the flaps secures them more than the pinchers used in the base design 1. We also recommend testing all 3 of the bag lifting mechanisms. This will allow us to successfully conclude which mechanism is best and will not add to the cost.

7. Project Management

7.1. Budget

As discussed with Bama Companies, Box It Unlimited has a maximum budget of $10,000 for the construction of the prototype and all parts needed. The exact estimate for the prototype will vary depending upon the type of base and lift mechanism that is used. Refer to Appendix C for parts list and pricing.

7.2. Estimated Prototype Budget

The estimated budgets for our prototype are broken down into six different combinations for the design. Those breakdowns can be seen in Appendix C.

7.3. Cost/Benefit Analysis

The cost to be analyzed in this project is automation versus manual labor. Currently the customer uses two individuals at the uncuffing station on the production line for each shift.

There are 4 shifts that take place in the facility, which means a total of 8 workers. Each worker gets an estimate of $12.00 per hour, which means a total of $25,000 per year per employee. After factoring the benefits (40% of the yearly salary) each employee cost the customer $35,000 per year, with a total of $280,000 per year for all employees to work on that line.

We predict that the machine as a final product when implemented in the facility will cost the customer $100,000 dollars to buy out right. This price is based on the prices of our competitors who make similar machines for uncuffing boxes. We will further research final product pricing estimates in the Spring Semester after prototyping the machine.

7.4. Market Research

As previously discussed, there is currently no machine on the market that uncuffs the bags with the flaps in the down position. Most companies do not seem interested in designing a machine that uses this method as they do not get many requests for it.

8. Project Schedule

8.1. Our Schedule for the fall semester (listed above in section 2.5) is covers the design process, prototype design, market research, and financial analysis. The schedule for the spring semester is included in the in Appendix B and covers the prototype construction as well as implementation analysis.

8.1.1. Gantt chart

See Appendix B

9. References

Pearsons Packaging Systems. Digital image. Model UC15.Web. Nov.16 2012. <http://www.pearsonpkg.com/products/showCategory/Bag-Inserters-Uncuffers>.

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Pattyn Packing Lines. Digital image. DS-11 Bag decuffer sealer. Web. Nov.16 2012.<http://www.pattyn.com/en/62/packaging_machines/4/bag_closer/12/ds_11>.

Wayne Automation Corp. Digital image. Random Bag Uncuffer/Case Sealer. Web. Nov.16 2012.<http://www.wayneautomation.com/bag_uncuffer.html>.

Pricing quotes from Bama Companies, Inc.