BOX IT UNLIMITED

Spring Report 2013

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Appendices

1. **Project Overview**

1.1. Mission Statement

Box It Unlimited is a company devoted to finding 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 automated 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 is 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 financial stand point. 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 25th, 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. 11th, 2013	First Draft Spring Report Due
Mar. 30th, 2013	Prototype Testing Completed
April 1st, 2013	Second Draft Spring Due
April 22th, 2013	Final Design Report
April 26th, 2013	Final Presentation

Table 1: Deliverables Schedule

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 26th , 2013**

3.7. Final Customer Approval

3.7.1. Final Spring Presentation – **April 26th, 2013**

3.7.2. Final Spring Prototype Demonstration – **April 26th, 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 uncuff 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 and to have all moving parts fully enclosed for safety reasons.

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

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 F.

<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

OK International Group - Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer

- 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

Pattyn - DS-11 Bag Decuffer Sealer

- 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 and Analysis

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. Fall Semester 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

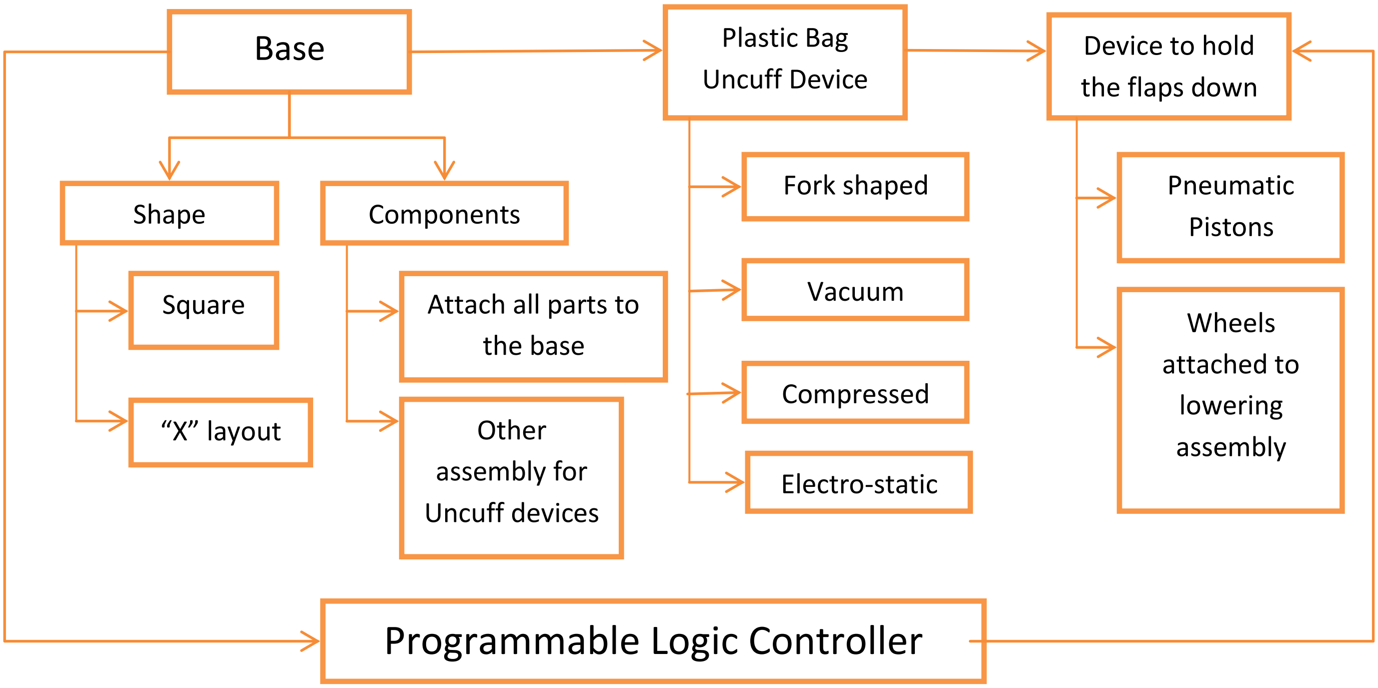


Figure 1: Design Process Flow Chart

6.3. Fall Designs and CAD drawings

See Appendix D

6.3.1. 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.

6.3.2. 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 F 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

We decided to locate the weld that would have the largest force applied to it. The weld we decide to check was the weld located on the L arm of the Bag lifter assembly that connects directly to the pneumatic cylinder. 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

Our objective given by our customer is 20 boxes every minute = 1 box every 6 seconds.

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 E 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.

After talking to our customer they have agreed to our recommendation. They would however like us to complete a proof of concept of the bag lifter assembly first before moving on to a full prototype. We plan to do this by first building the lifter assembly and get that operating to 98% efficiency before continuing the prototyping process.

7. Spring Design Overview

After careful discussion and time analysis with our customer during the fall semester, we have decided to build and test our prototype based on the design concept itself. We will be testing the prototype for the effectiveness of the design and the individual mechanisms.

7.1. Prototype Description

The design prototype includes all of the previous design options that were proposed in the fall 2012 report. The prototype itself can be seen in the pictures below.

7.1.1. Pneumatics, Valves, and regulators

For our pneumatic cylinders we used 1.062" X 3" bore cylinders, this gave us the amount of space we needed to reach the bag with enough force. We used ¼" quick connects for all pneumatic connections and ¼" hosing for the tubing. There were also various tee and elbow connections for the pneumatic line. We used Festo solenoid valves to control the direction of the pneumatics and regulators placed on different parts of the line to control the amount of pressure needed for each mechanism.

7.1.2. Framing

All of the framing used in our design was made of steel of various dimensions. There are two sizes of square tubing in that attaches to the pneumatic cylinders. These are different sizes, due to the fact that one fits inside of the other. These square tubing have slots cut inside of them, to make it easier to move the pneumatic cylinder. There are various sizes of L-brackets that attach to the pneumatic cylinders. These are welded, than bolted into the frame of the prototype. The flap compressors are large 3" diameter caster wheels that are also bolted to the frame of the prototype.

7.1.3. Suction/Vacuum

The vacuum is powered by a venturi tube, where air is forced into the assembly creating suction. This suction is then distributed to the suction cups via pneumatic line.

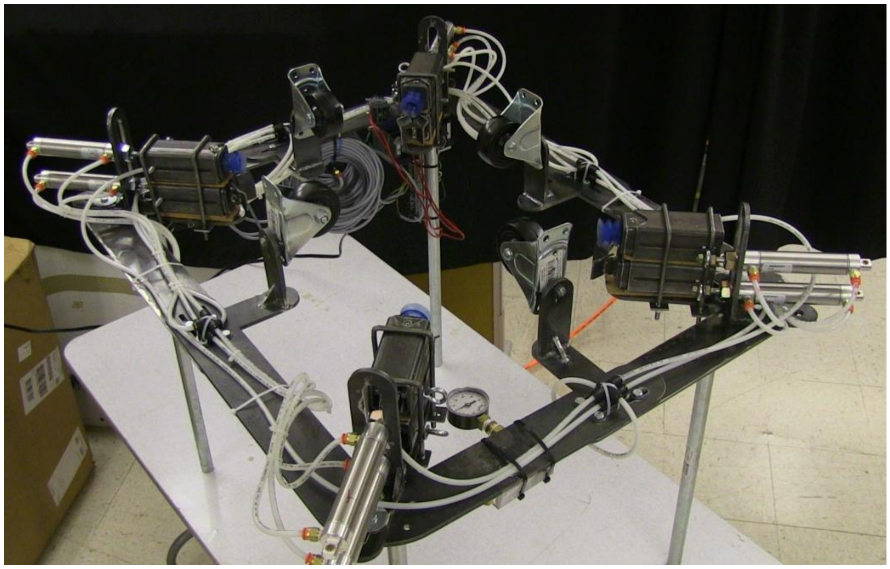


Figure 2: Top view of final prototype

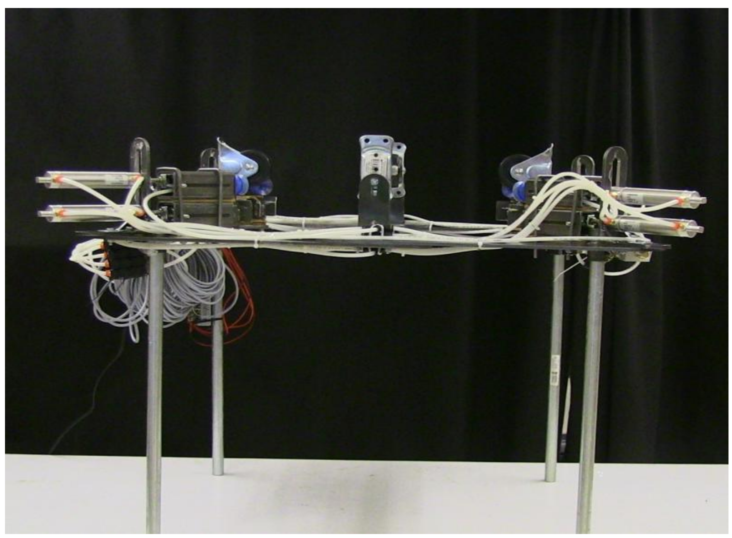


Figure 3: Front view of final prototype

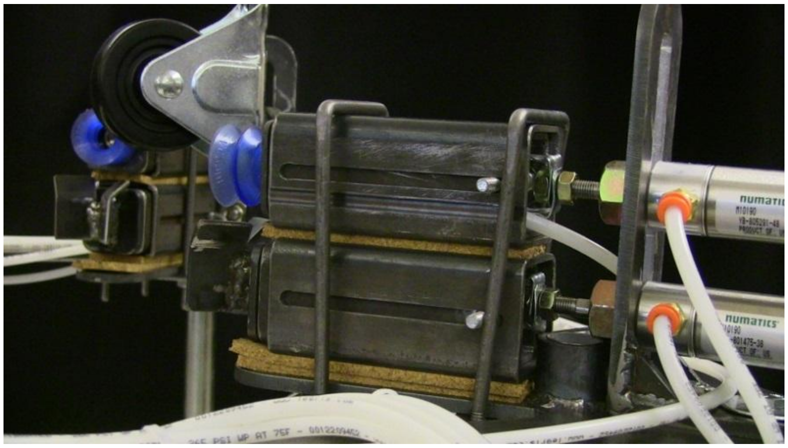


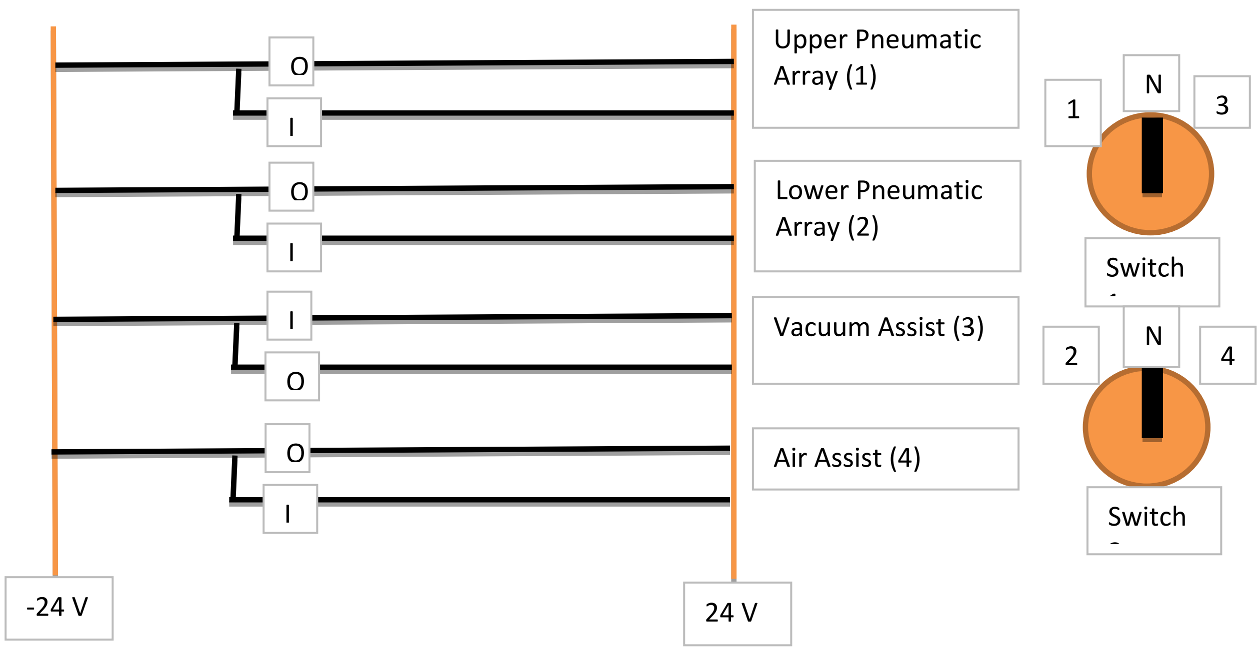
Figure 4: Close up view of suction and fork mechanism

Figure 5: Modular hosing layout

Figure 6: Flap compressors

7.1.4. Electronics and Wiring Description

We wired all of our pneumatic cylinders and valves to a 24V power supply. After which we connected the valves to 2 separate 3-position switches. One switch controls the upper pneumatic cylinder, or the suction mechanism, and the vacuum. The other switch controls the lower pneumatic cylinder, or the fork mechanism, and the air jet mechanism.



7.2. Testing Results

We tested our design to determine the reliability of the concept, the results of those test are as follows.

7.2.1. Test 1: Pneumatic placement test

7.2.1.1. Overview of Test

For our first test pneumatic cylinder test we placed the cylinders on the outside of the lift mechanism, as seen below. After this test we then tested the effectiveness of the pneumatic cylinders placed inside of the square steel tubing, also seen below.

Figure 7: Center positioned pneumatic cylinders

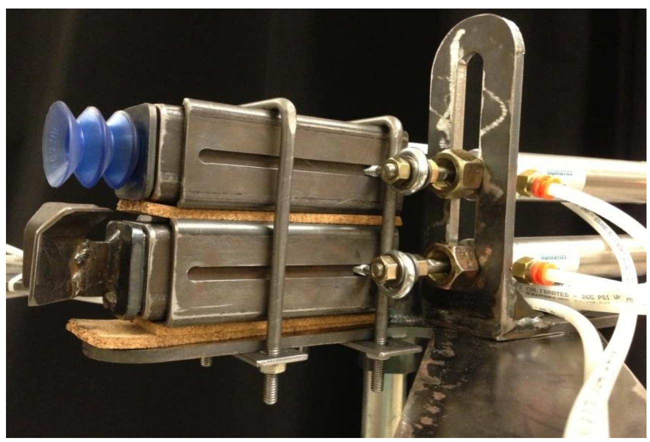


Figure 8: Side positioned pneumatic cylinders

7.2.1.2. Results of Test

The testing of continuous back and forth movement of the square tubing, we noticed that at some points the tubing would get jammed and not retract fully in some places. We tried to adjust this by placing a spring on the on the tubing to help it retract. This would work most of the time, but it was not reliable enough to conclude that it was the best method.

After realizing this method was not best, we then proceed to place the cylinders inside of the square tubing. This method was successful 100% of the time. There was never a jam in the tubing.

7.2.2. Test 2: Air Jet (Modular Hosing) Test

7.2.2.1. Overview of Test

We tested the air jets to see its effectiveness in lifting the bag away from the flaps of the box. We attached multiple nozzles to the end of the modular hosing to determine which one is would blow the bag the best

7.2.2.2. Results of the Test

The different nozzles of the modular hosing had very little effect of the distance of the bag away from flaps of the box. After multiple operations it was clear that the air jets in no way helpful in the uncuffing process.

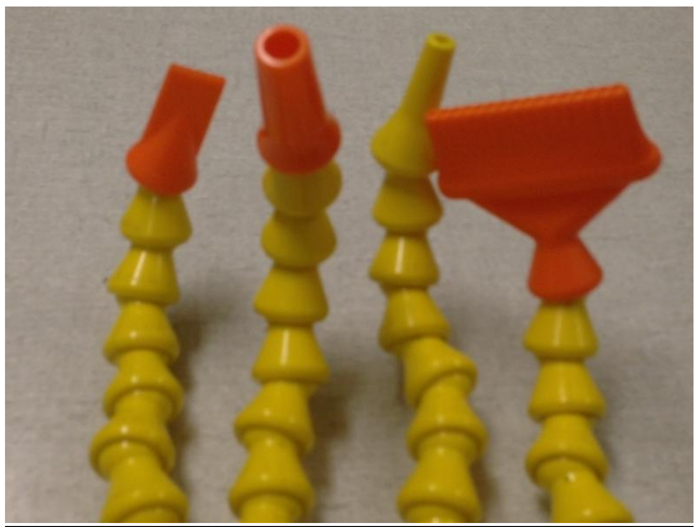


Figure 9: Modular hosing and variety of nozzles

7.2.3. Test 3: Suction Mechanism

7.2.3.1. Overview of the Test

We concluded that we suction was effective to uncuff the bag. We tested two aspects of the suction mechanism: (1) whether the suction would pull the bag away from the box flaps, as well as (2) whether the suction would uncuff the bag as the only mechanism that would be operated.

7.2.3.2. Results of the Test

The results of the suction mechanism test showed that out of the 50 times it was test 94% of the time the bag cleared the flaps completely. While our test also concluded that the vacuum suction was not powerful enough to pull the bag away from the flaps of the box, as it was only successful 2% of the time out of our 50 test.

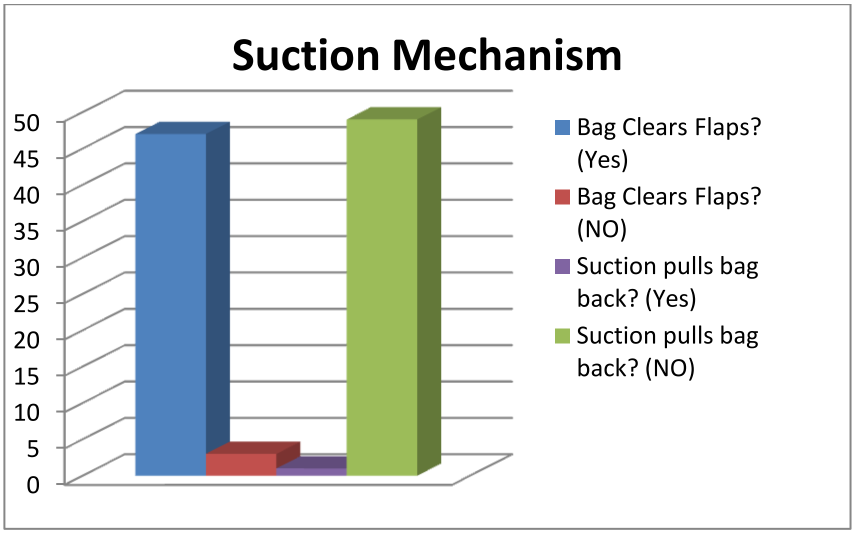


Figure 10: Graph of suction mechanism of test result

7.2.4. Test 4: Fork Mechanism

7.2.4.1. Overview of the Test

In this test we tested the effectiveness of the forks to lift the bag over the flaps of the box without tearing the bag.

7.2.4.2. Results of the Test

For our accuracy test we determined that amount of time our lifting mechanism were successful. We performed the lifting test 10 times. And 5 of the 10 times it was successful. This gave us a 50% accuracy percentage. We then concluded this test after the 10 trials due to its failure rate early on in the process.

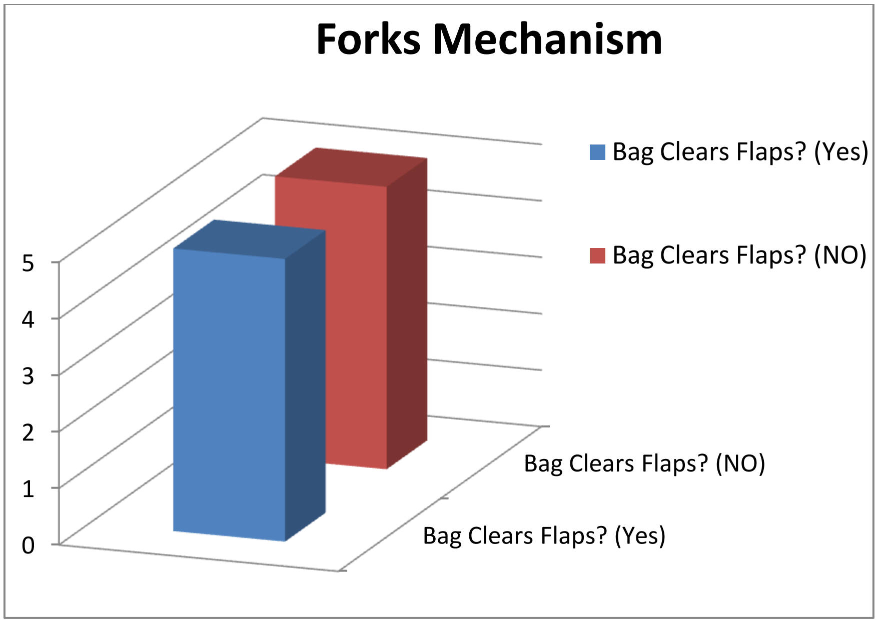


Figure 11: Graph of fork mechanism test results

7.3. Design Conclusion and Discussion

7.3.1. Air Jets Mechanism

The air jets were not effective. The amount of distance that the bag was blown away from the corner of the box was not enough to make a difference on picking the bag up.

7.3.2. Suction Mechanism

The suction method was the most effective, as seen in the results above. It was successful 47 out of 50 times and had 94% reliability. While it did not pull the bag away from the box, it did uncuff the box, which was our objective.

7.3.3. Fork Mechanism

The fork mechanism was not as effective as the suction mechanism, but was more effective than the air jet mechanism. The results of our testing show that the fork mechanism failed to properly uncuff the bag because of the material and shape used in its design. Therefore we believe that if the design material is changed to something lighter and more flexible it will be successful in the bag uncuffing process and not tear the bag.

7.4. Design Recommendation

After testing and determining that our design concept works, we believe that our customer should refine and perfected the prototype, as our prototype is simply a rough design. It is not up to the food industry standards that were discussed earlier in the report.

We also recommend that the customer patent this design as there is nothing similar to it currently on the market. We believe that once other processing companies become aware of this design they will also use it, as having the flaps of the box in a downward position is a very effective method of packing.

Lastly we recommend the implementation of a side conveyor belt and vertical lift assembly as discussed in the fall semester design section of the report.

8. Project Management

8.1. 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.

8.2. 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 H.

8.3. Actual Prototype Budget

The cost break-down of our prototype can be seen in Appendix G. Below is the final prototype cost of this semester not including labor.

Description	Total + Shipping, tax, and labor
Electrical: Switches, Power supply, wiring, and terminals	$136.24
Modular Hosing and suction cups	$113.75
Framing	$349.68
Pneumatic Quick Connectors, pneumatic tubing, fittings, and plugs	$373.86
Pneumatic cylinders	$466.40
Valves and cables	$746.10
Vacuum pump, regulators, and gauges	$463.29
Miscellaneous	$75.00
Total	$3031.97

Table 2: Actual prototype budget

9. Financial Analysis

9.1. 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. But this price will be and is multiplied by two because there will be two machines which makes it $200,000. 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.

9.2. 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. But we believe that when other companies see its success they will start to use this method of having the flaps in the downward position.

10. Project Schedule

10.1. Overview of Schedule

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.

10.1.1. Fall semester Gantt chart

During the fall semester our time was spent on designing a mechanism and modeling it in SolidWorks to present to our customer, the breakdown of this time can be seen in Appendix B.

10.1.2. Spring semester Gantt chart

Our plans for the spring semester were to spend most of our time on construction and testing of our prototype. We also built in other days for updating our customer and other Biosystems engineering faculty. This can be seen in Appendix B.

11. References

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

K&R Equipment, Inc. Digital image. PBD-FC™ Polybag In-Box Decuffer Folder Closer. Web. Nov.16 2012.< http://www.kandrequip.com/products_pbd.html>.

OK International Group. Digital image. Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer.Web. Nov.16 2012. < http://www.okcorp.com/products_decuffer_sc500.html>.

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>.

J.K. Evicks Pricing from Bama Companies, Inc.

Appendix

A. Patents
   Patent 1: Apparatus for closing bags

<u>Overview:</u>

Current U.S. Classification: 53/139.1; 53/170; 53/370.6; 53/583
International Classification: B65B 5106

Inventors: **Odom; Robert E.** (Blaine, MN)**, Field; Roger A.** (Andover, MN)
Assignee: **Bemis Company, Inc.** (Minneapolis, MN)
Appl. No.: **07/909,968**

Filed: **July 7, 1992**

Issued: January 18, 1994

<u>Abstract:</u>

A method of and apparatus for uncuffing a bag in a case, forming the top of the bag into a neck, and taping the neck, operable on non-square rectangular cases as well as square cases of different sizes.

<u>Drawings:</u>

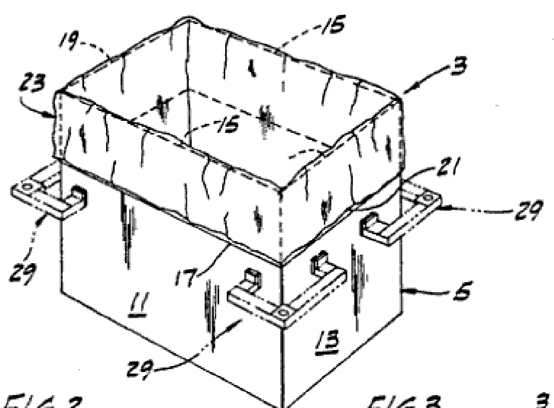


FIG.2

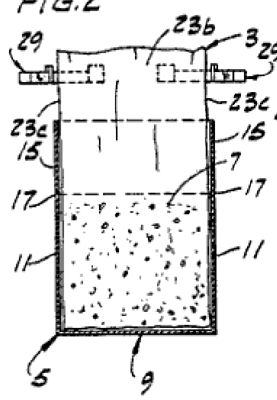
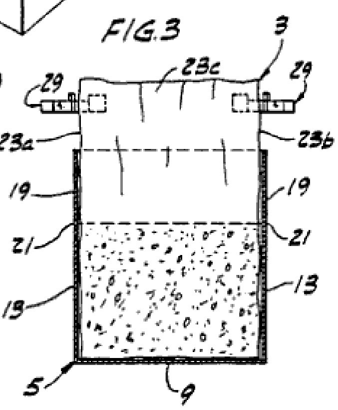


FIG.3



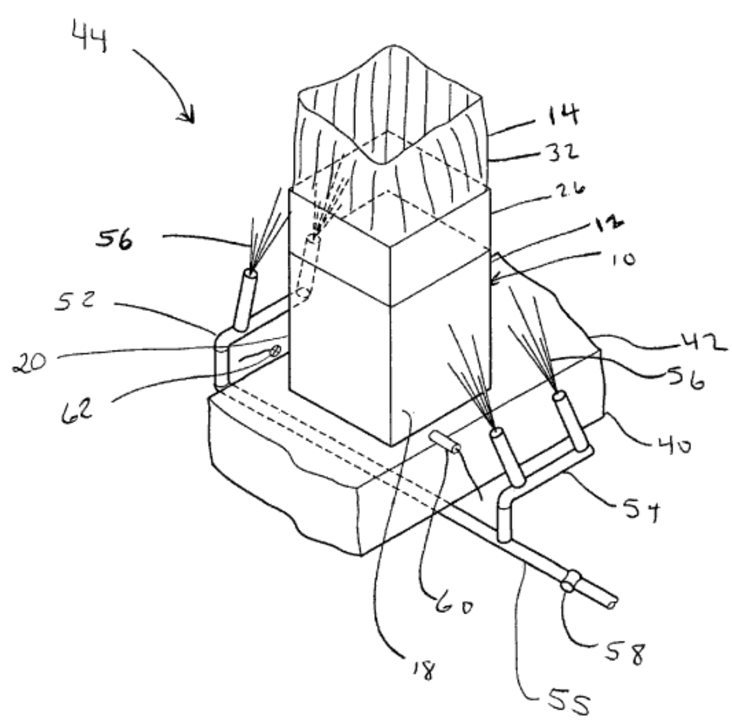
Patent 2: Continuous bag closing apparatus and method

Overview:

Inventors: **Blake; David J.** (Belle Fourche, SD)**, Muhm; Cory** (Belle Fourche, SD)
Assignee: **AMCOL International Corporation** (Arlington Heights)
Appl. No.: **10/701,903**
Filed: **November 5, 2003**
Issued: **July 26, 2005**

Abstract: A packaging apparatus and method to uncuff a package assembly is disclosed. The package assembly includes a container with at least one upstanding sidewall defining an open top. A bag is disposed within the container and a top portion of the bag is folded over the at least one sidewall at the open top to define a cuff. The packaging apparatus includes a first fluid jet directed substantially upward that is configured to uncuff the top portion of the bag from the container. An automatic bag closer gathers the top portion of the bag and applies a clip to close the bag. A second fluid jet is directed substantially downward and is configured to push the top portion of the bag substantially within the container.

Drawings:



B. Gantt Chart

i. Spring 2013 – Task layout

	Indicators	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**Box Uncuffing Machine**	**79 days**	**Mon 1/7/13**	**Thu 4/25/13**	
2			**Construction**	**51 days**	**Mon 1/14/13**	**Mon 3/25/13**	
3			CAD drawing review	6 days	Mon 1/7/13	Sun 1/13/13	
4			Send parts list to customer	0 days	Mon 1/14/13	Mon 1/14/13	
5			Send CAD drawings to the machine shop	0 days	Fri 1/18/13	Fri 1/18/13	
6			First Prototype Assembly	12 days	Fri 1/18/13	Sun 2/3/13	
7			**Testing**	**30.5 days**	**Mon 2/4/13**	**Fri 3/15/13**	
8			Placement of the box in the machine	14 days	Tue 2/5/13	Fri 2/22/13	
9			Vacuum suction	7 days	Mon 2/25/13	Tue 3/5/13	8
10			Air jets	8.5 days	Wed 3/6/13	Fri 3/15/13	9
11			**Documentation**	**76 days**	**Mon 1/7/13**	**Mon 4/22/13**	
12			Record design adjustments	61 days	Mon 1/14/13	Mon 4/8/13	
13			First Draft Report	31 days	Mon 1/28/13	Sun 3/10/13	
14			Record testing data	30.5 days	Mon 2/4/13	Fri 3/15/13	
15			First Draft Report Due	0 days	Mon 3/11/13	Mon 3/11/13	
16			Second Draft Report Due	0 days	Mon 4/1/13	Mon 4/1/13	
17			Final Report	1 day	Mon 4/22/13	Mon 4/22/13	
18			**Presenting**	**8 days**	**Mon 4/15/13**	**Thu 4/25/13**	
19			Preliminary presentations	7.5 days	Mon 4/15/13	Tue 4/23/13	
20			Final Presentation	0 days	Thu 4/25/13	Thu 4/25/13	

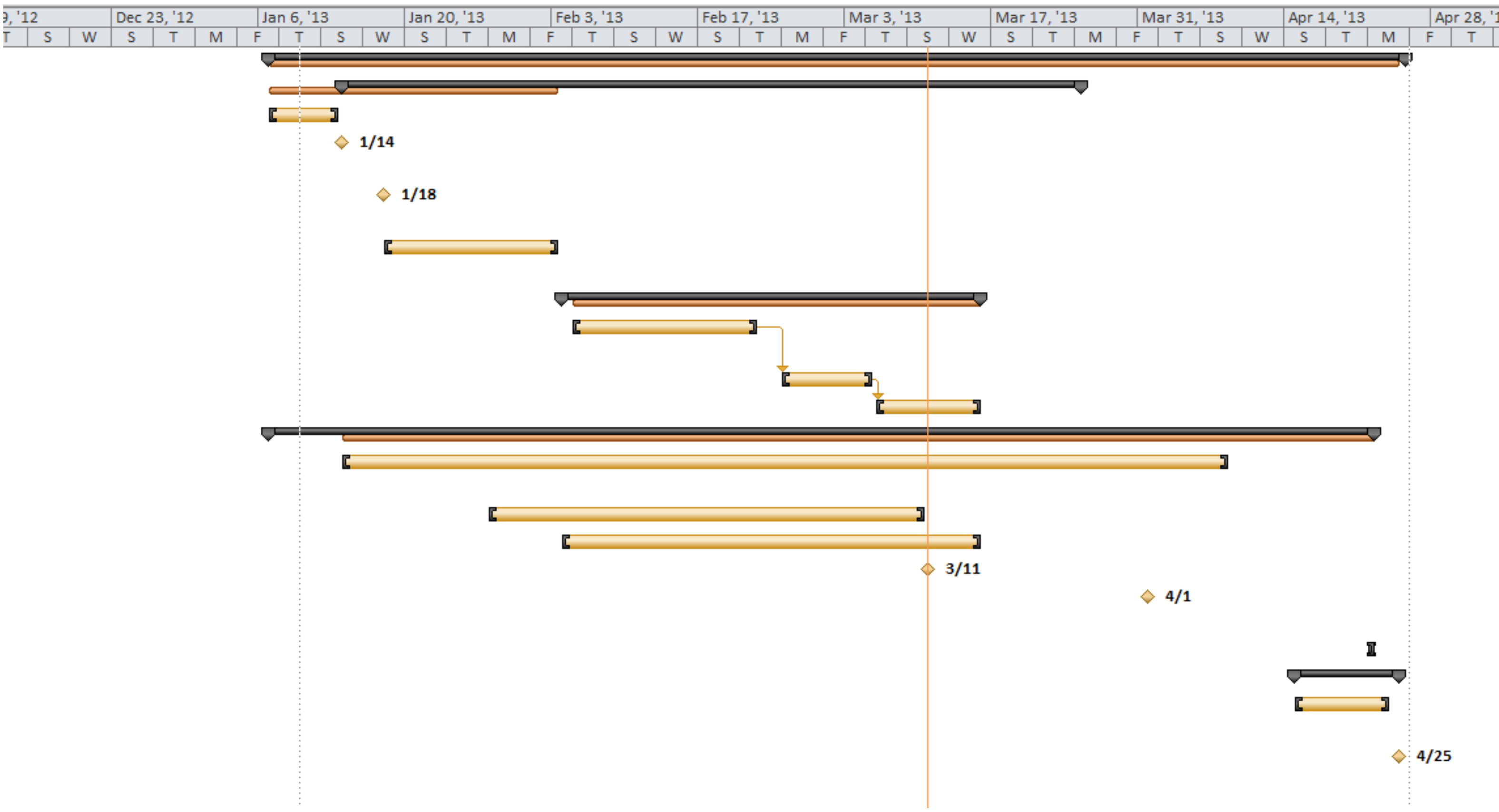
ii. Fall 2012 - Task layout 1

		Task Name	Duration	Start	Finish	Predecessors
1		**Box Uncuffing machine**	**706.13 days**	**Mon 9/3/12**	**Fri 4/26/13**	
2		**Design Initialization**	**169.13 days**	**Mon 9/3/12**	**Mon 10/29/12**	
3		Project Overview	127.13 days	Mon 9/3/12	Mon 10/15/12	
4		Customer Requirements	127.13 days?	Mon 10/15/12	Tue 11/27/12	3
5		Brainstorm Ideas	169.13 days?	Tue 11/27/12	Tue 1/22/13	4
6		**Background Research**	**211.13 days**	**Mon 9/3/12**	**Mon 11/12/12**	
7		Patent Research	127.13 days	Mon 9/3/12	Mon 10/15/12	
8		Relevent Parts	82.13 days	Tue 10/16/12	Mon 11/12/12	7
9		Possible Materials	82.13 days	Mon 11/12/12	Mon 12/10/12	8
10		**Economic and Cost Analysis**	**22 days**	**Mon 11/12/12**	**Mon 11/19/12**	**9**
11		Cost Breakdown	22 days	Mon 11/12/12	Mon 11/19/12	
12		Cost Analysis	22 days	Mon 11/12/12	Mon 11/19/12	
13		Supplies List Cost	22 days	Mon 11/12/12	Mon 11/19/12	
14		Maintenance	22 days	Mon 11/12/12	Mon 11/19/12	
15		Cleaning Cost	22 days	Mon 11/12/12	Mon 11/19/12	
16		Overall Benefit Cost	22 days	Mon 11/12/12	Mon 11/19/12	
17		**Communications**	**682.13 days**	**Tue 9/11/12**	**Fri 4/26/13**	
18		Customer Relations and Emails	682.13 days	Tue 9/11/12	Fri 4/26/13	
19		**First Draft of Website**	**43.13 days**	**Mon 11/12/12**	**Mon 11/26/12**	
20		Group Picture	1 day	Mon 11/12/12	Mon 11/12/12	
21		Finalized Website	40.13 days	Tue 11/27/12	Mon 12/10/12	
22		Design Review, Approval, Peer and Class Evaluation	1 day	Fri 12/14/12	Fri 12/14/12	
23		**Documentation**	**706.13 days**	**Mon 9/3/12**	**Fri 4/26/13**	
24		Hand-drawn Sketches	3 days	Mon 9/3/12	Tue 9/4/12	
25		Preliminary Solid Works, AutoCAD, and Pro-Engineer Designs	3 days	Tue 9/4/12	Wed 9/5/12	24
26		Finalized Solid Works, AutoCAD, and Pro-Engineer Designs	3 days	Wed 9/5/12	Thu 9/6/12	25

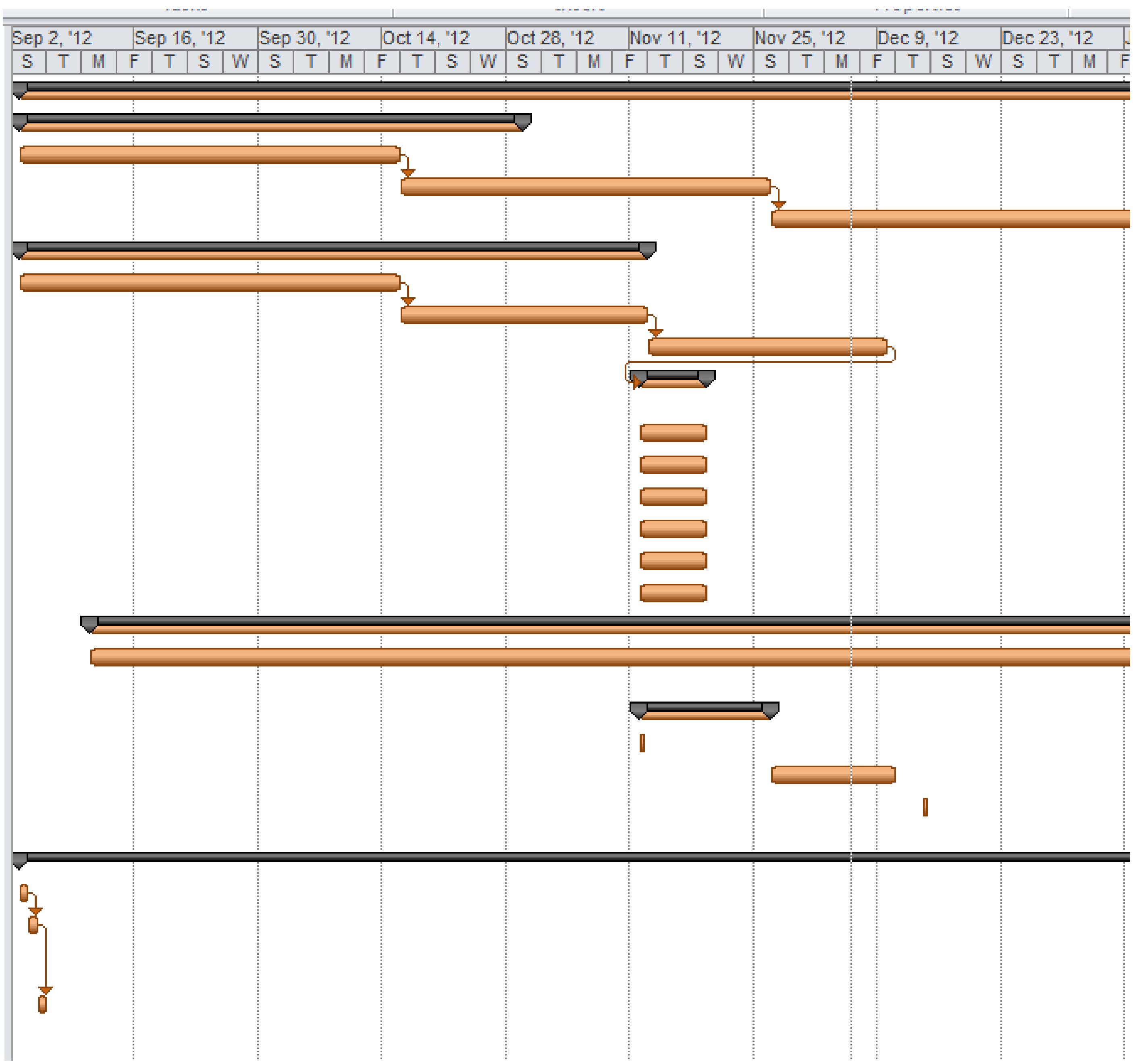
iii. Fall 2012 - Task layout 2

		Task Name	Duration	Start	Finish	Predecessors
27		**Reports**	**706.13 days**	**Mon 9/3/12**	**Fri 4/26/13**	
28		First Draft Fall Report	64.13 days?	Mon 10/29/12	Mon 11/19/12	
29		Finalized Fall Report	34.13 days	Mon 11/26/12	Fri 12/7/12	28
30		Fall PowerPoint Presentation	34.13 days?	Fri 12/7/12	Wed 12/19/12	29
31		First Draft Spring Report	43.13 days?	Mon 3/25/13	Mon 4/8/13	29
32		Finalized Spring Report	52.13 days?	Tue 4/9/13	Fri 4/26/13	31
33		**Construction and Evaluation**	**286.13 days**	**Mon 1/14/13**	**Fri 4/19/13**	
34		**Construction of Prototype**	**280.13 days**	**Mon 1/14/13**	**Wed 4/17/13**	
35		Concept and Design	43.13 days?	Mon 1/7/13	Mon 1/21/13	
36		Electrical	187.13 days?	Tue 1/22/13	Mon 3/25/13	35
37		Pneumatic	187.13 days?	Tue 1/22/13	Mon 3/25/13	35
38		Mechanical	103.13 days?	Tue 1/22/13	Mon 2/25/13	35
39		Programmable Logic Control	187.13 days?	Tue 1/22/13	Mon 3/25/13	35
40		Safety	103.13 days?	Tue 1/22/13	Mon 2/25/13	35
41		Complete Prototype Testing	0 days	Mon 4/1/13	Mon 4/1/13	
42		Customer Approval of Prototype	0 days	Mon 4/8/13	Mon 4/8/13	
43		**Final Customer Approval**	**22.13 days**	**Fri 4/19/13**	**Fri 4/26/13**	
44		Final Spring Presentation	1 day	Mon 4/22/13	Mon 4/22/13	
45		Final Spring Prototype Demonstration	1 day	Tue 4/23/13	Tue 4/23/13	

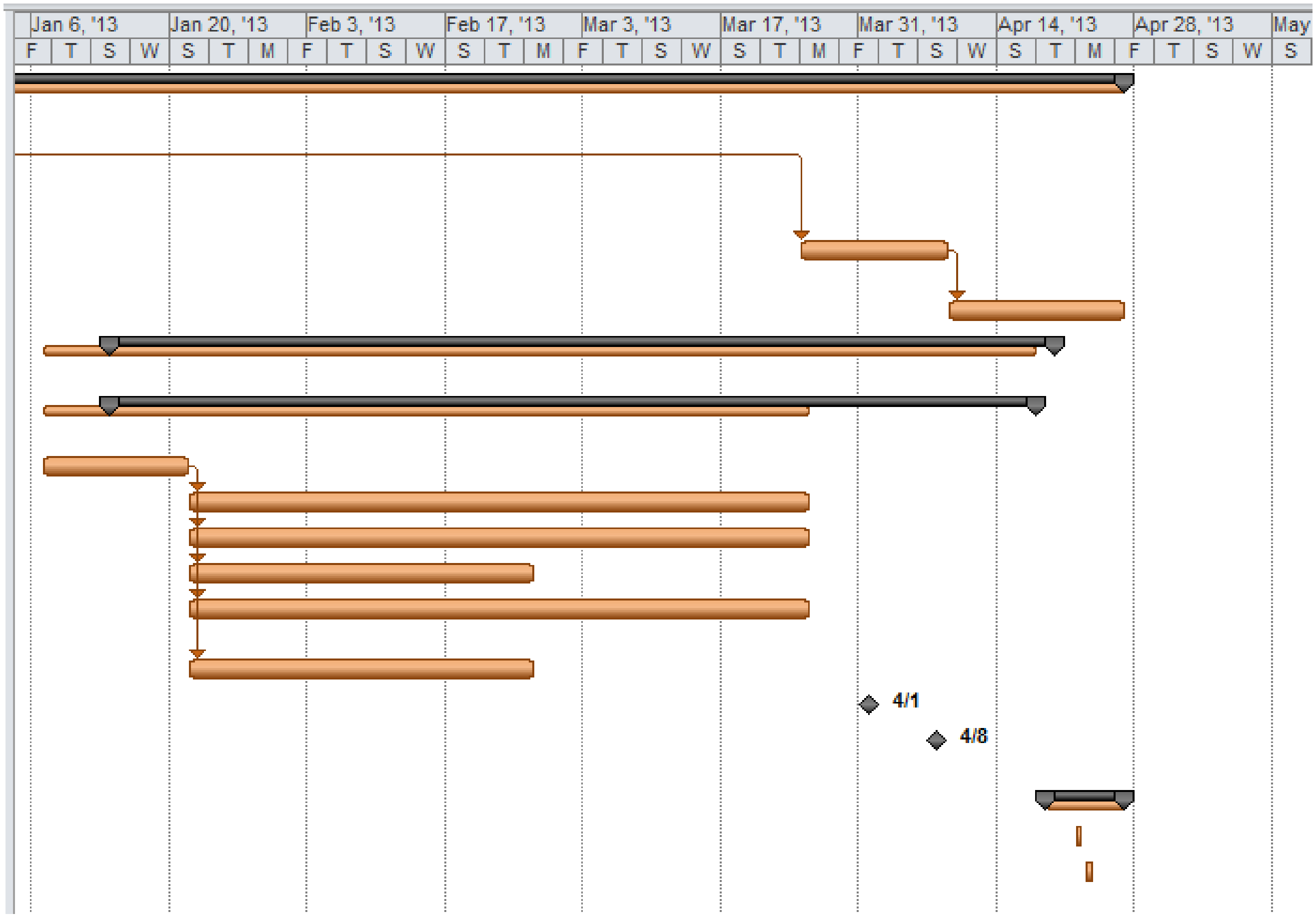
iv. Spring 2013 Grantt Chart



v. Fall 2012 - Gantt Chart 1

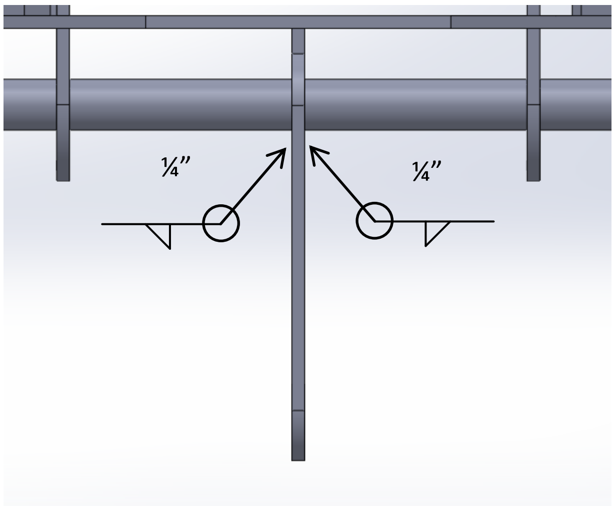


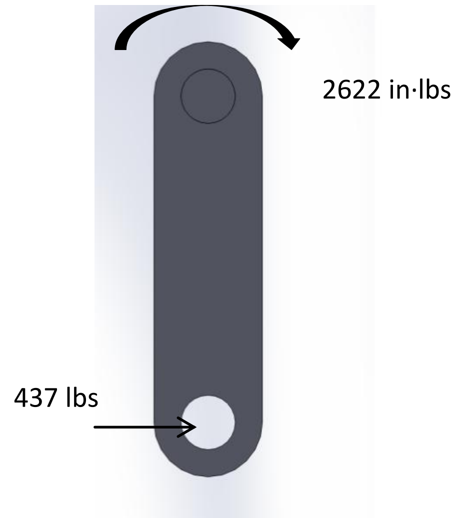
vi. Fall 2012 - Gantt Chart 2



C. Engineering Calculations

i. Weld Analysis





(Jamming Situation)

E60xx

$h = Weld\ throat\ (in)$

$r = radius\ of\ bar = .5\ in$

$J = .707hJ_u$

$J_u = 2\pi r^3$

$A = 1.414\pi hr$

$M_{Bmax} = 437\ lbs * 6" = 2622\ in \cdot lbs$

$V_{max} = 437\ lbs$

$$\tau' = \frac{V}{A} = \frac{437lbs*0.5}{1.414*\pi*\frac{1}{4}in*0.5in} = 393psi$$

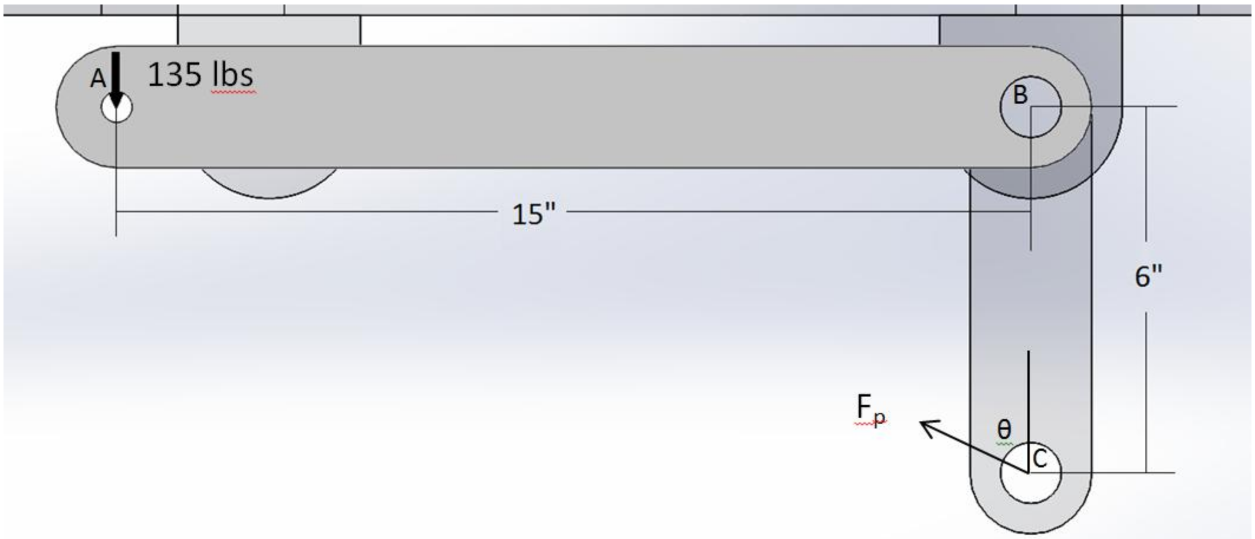
$$\tau" = Mr/J = \frac{2622in \cdot lbs * 0.5in * 0.5}{0.707 * \frac{1}{4}in * 2 * \pi * (0.5in)^3} = 4722psi$$

$$\tau = \sqrt{\tau'^2 + \tau"^2} = \sqrt{393^2 + 4722^2} = 4738psi$$

$$\tau_{permisible} = 0.4 * 30kpsi = 12\ kpsi$$

$$n_s = \frac{\tau}{\tau_{permisible}} = 2.53$$

ii. Force Analysis



$M_B = 135\ lbs * 15" = 2025\ in \cdot lbs$

$\theta = 64°$

$F_{Pmin} = \frac{M_B}{\sin\theta * 6"} = 375\ lbs$

Piston Size Analysis:

$P_{max} = 110\ psi$

$F_{Pmin} = \frac{P_{max}}{A} = 375\ lbs$

$A = \frac{\pi(D-d)^2}{4}$

$D = 3"$

$d = .75"$

$F_{Pmax} = 437\ lbs$

D. Fall Design Description and CAD drawings

1. Base Design 1

Base design 1, as seen in figure 3, 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:

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

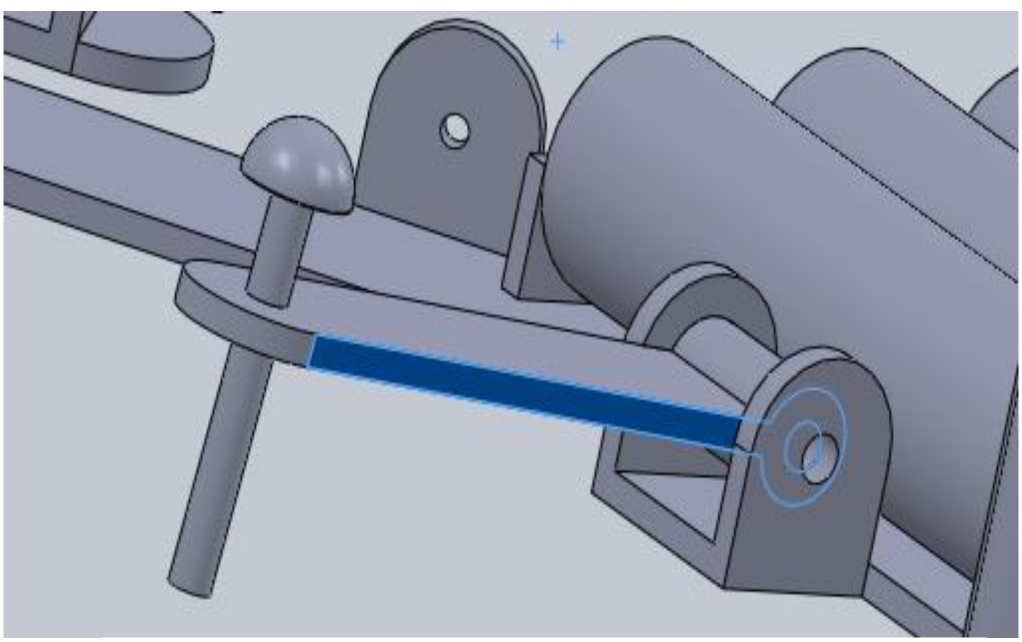


Figure 2: Close up of flap compressors (pinchers)

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: Base Design 1**

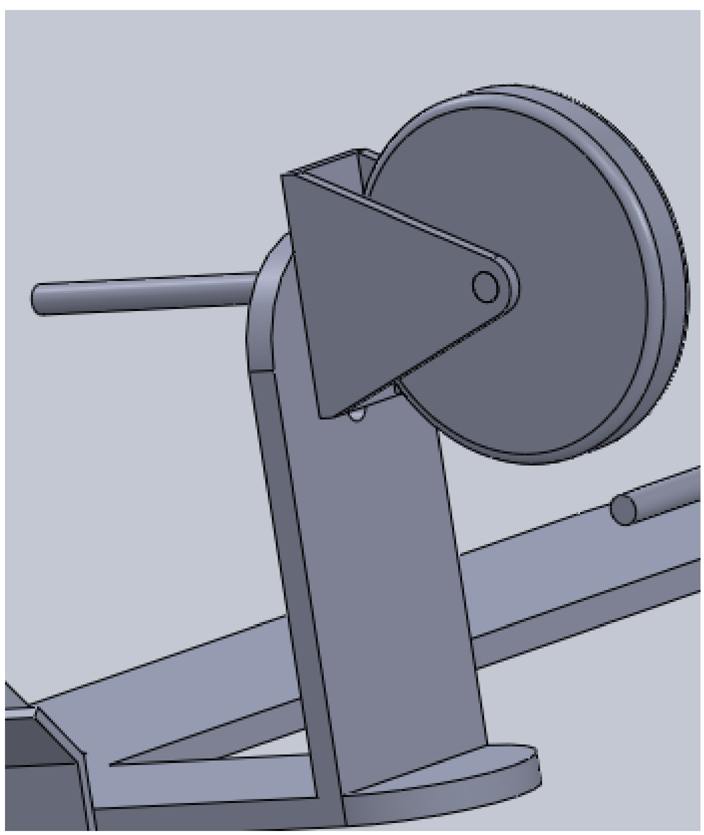


Figure 4: Close up of flap compressors (rollers)

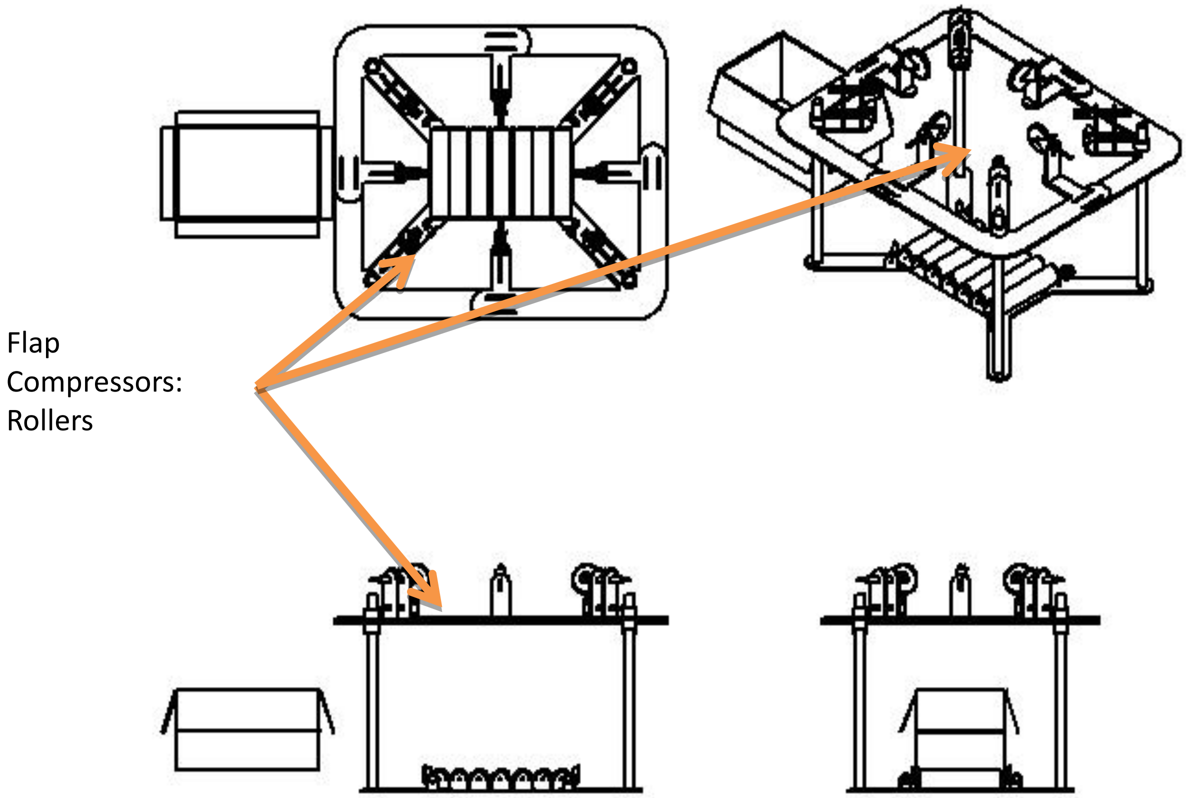


Figure 5: Base Design 2

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.

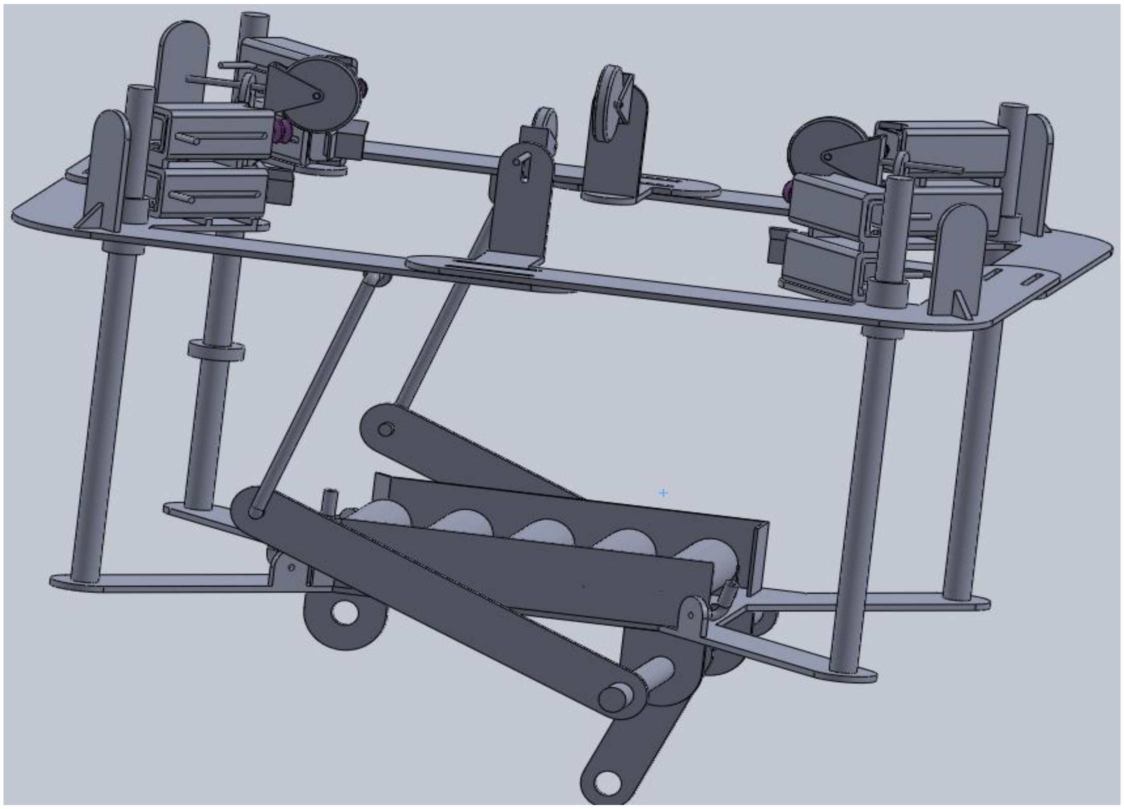


Figure 6: Vertical Adjusting Assembly

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.

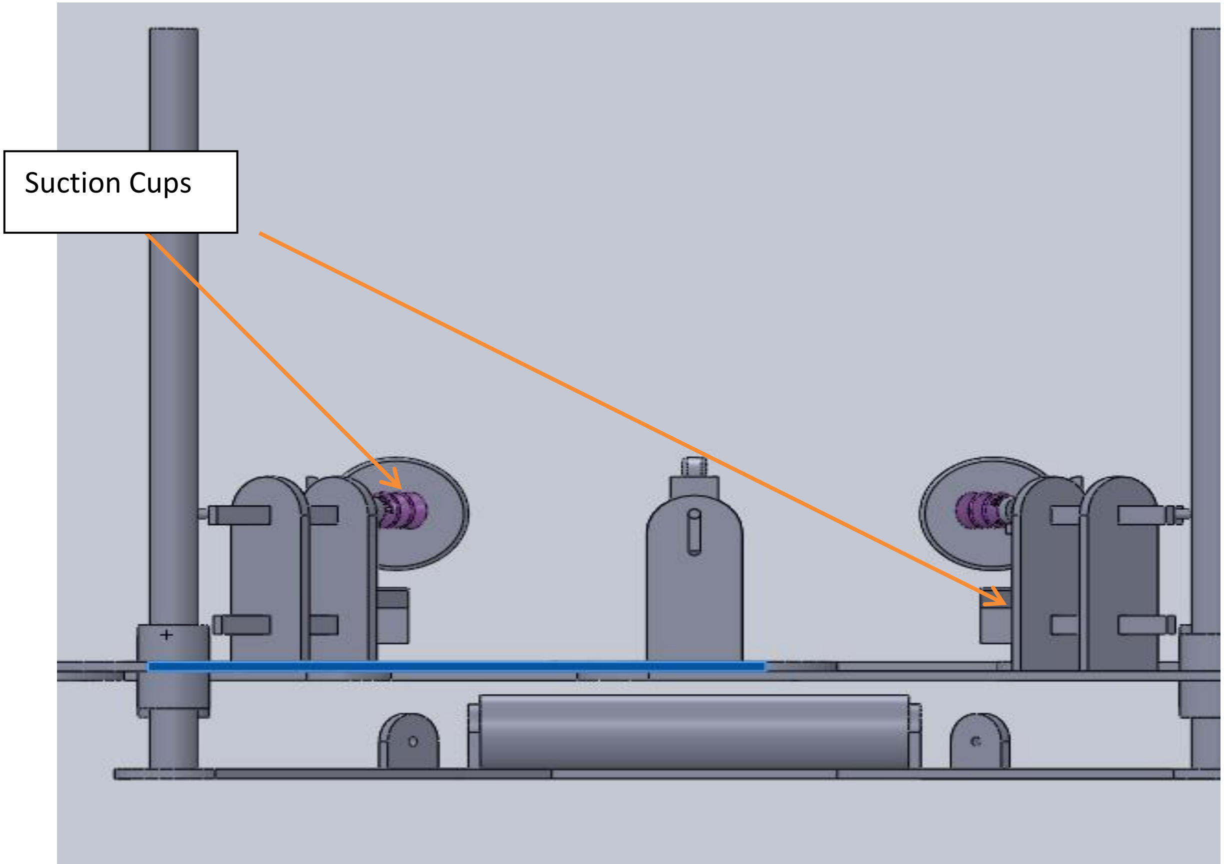


Figure 7: Lift Mechanism 1 – Suctions Cups

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. These air jets will be made using modular adjustable hosing to allow use to find the optimum location for the jet of air.

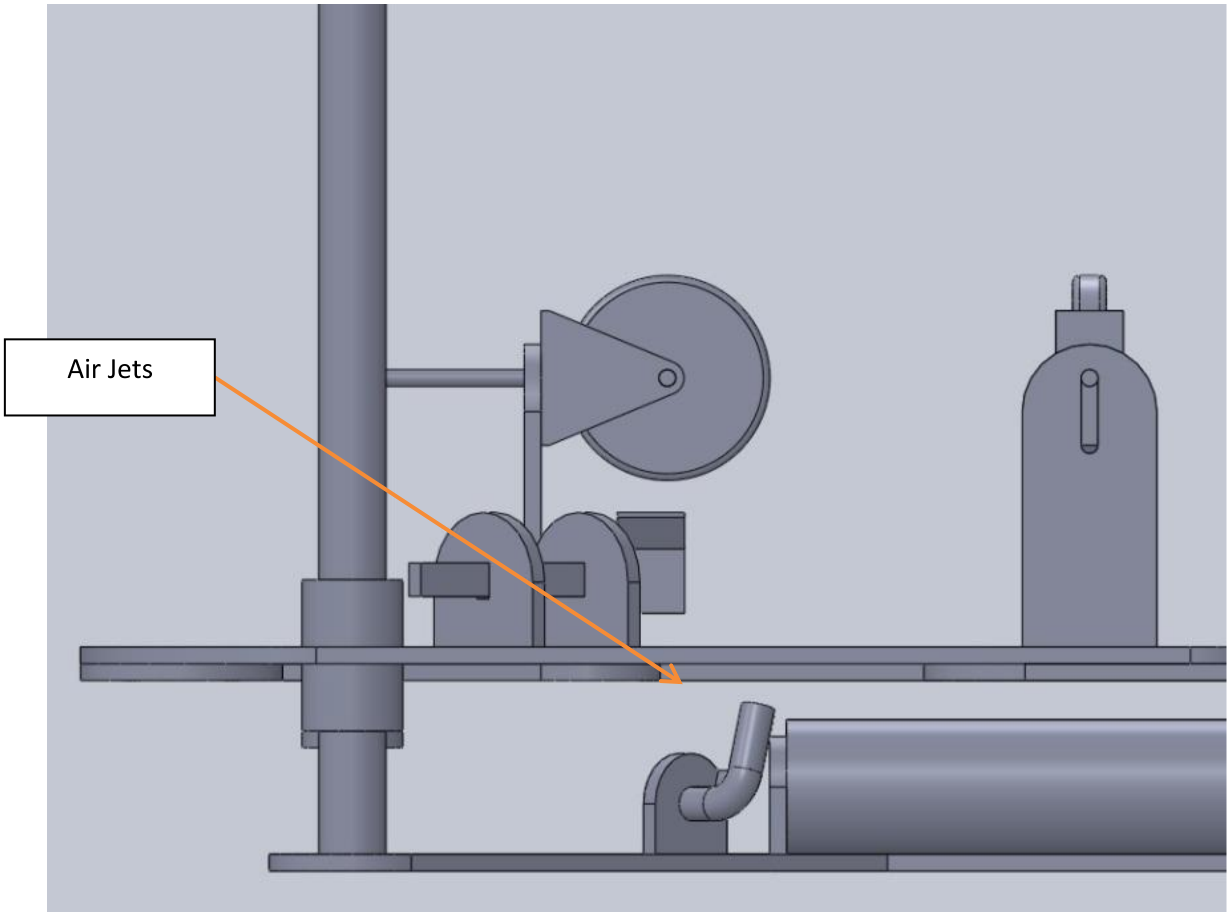


Figure 8: Lift Mechanism 2 – Air Jets

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.

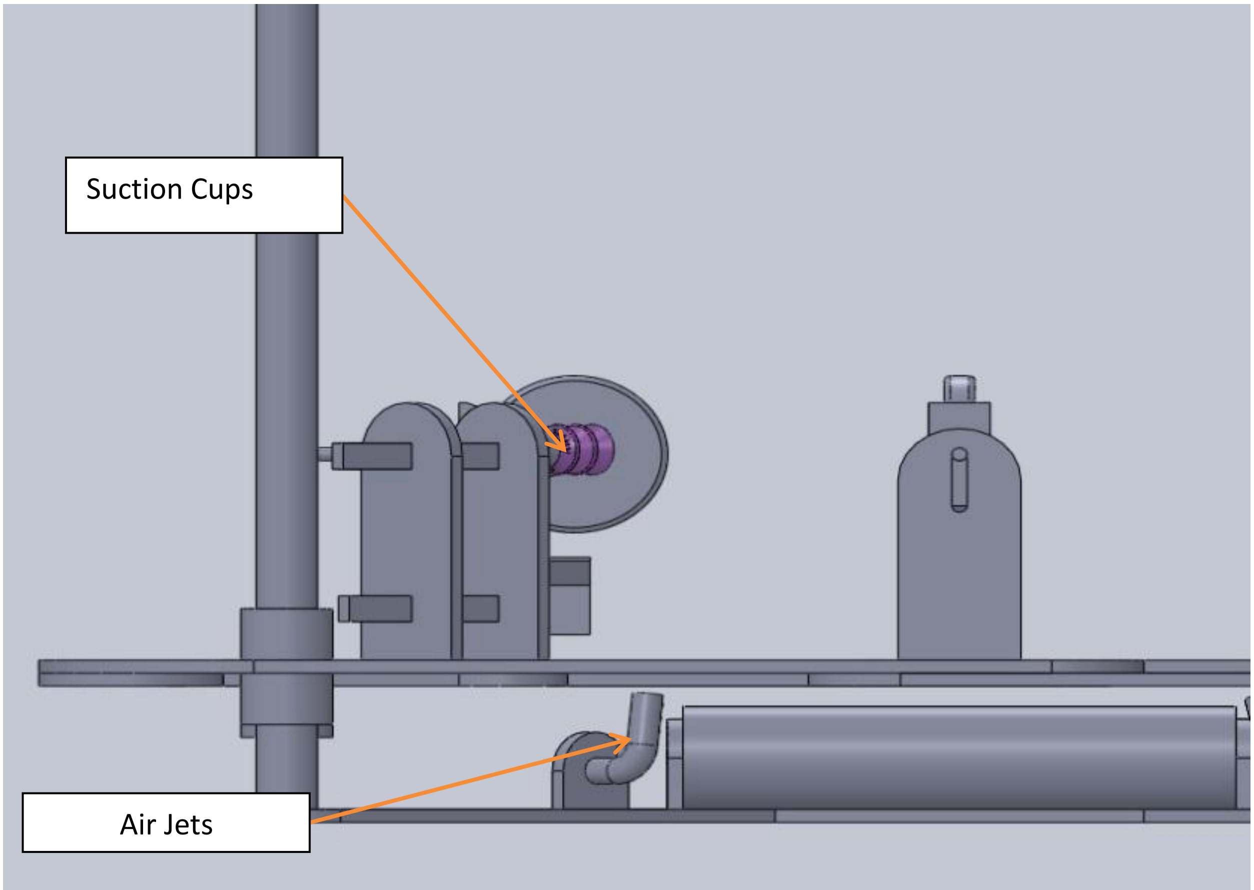


Figure 9: Lift Mechanism 2 – Air Jets

E. Fall Estimated Operational Speeds

Base Design 1 (with vacuum suction)	
Part	**Movement Time (seconds)**
Line the box in the machine	1.5
Pinchers	1
Vacuum	0.5
Vacuum pulls back	.5
Forks (horizontal)	0.25
Forks (vertical)	1
Push the box out	1
TOTAL	5.75

Base Design 1 (with air jets)	
Part	**Movement Time (seconds)**
Line the box in the machine	1.5
Pinchers	1
Forks (horizontal)	0.25
Forks (vertical)	1
Air jets	.5
Push the box out	1
TOTAL	5.25

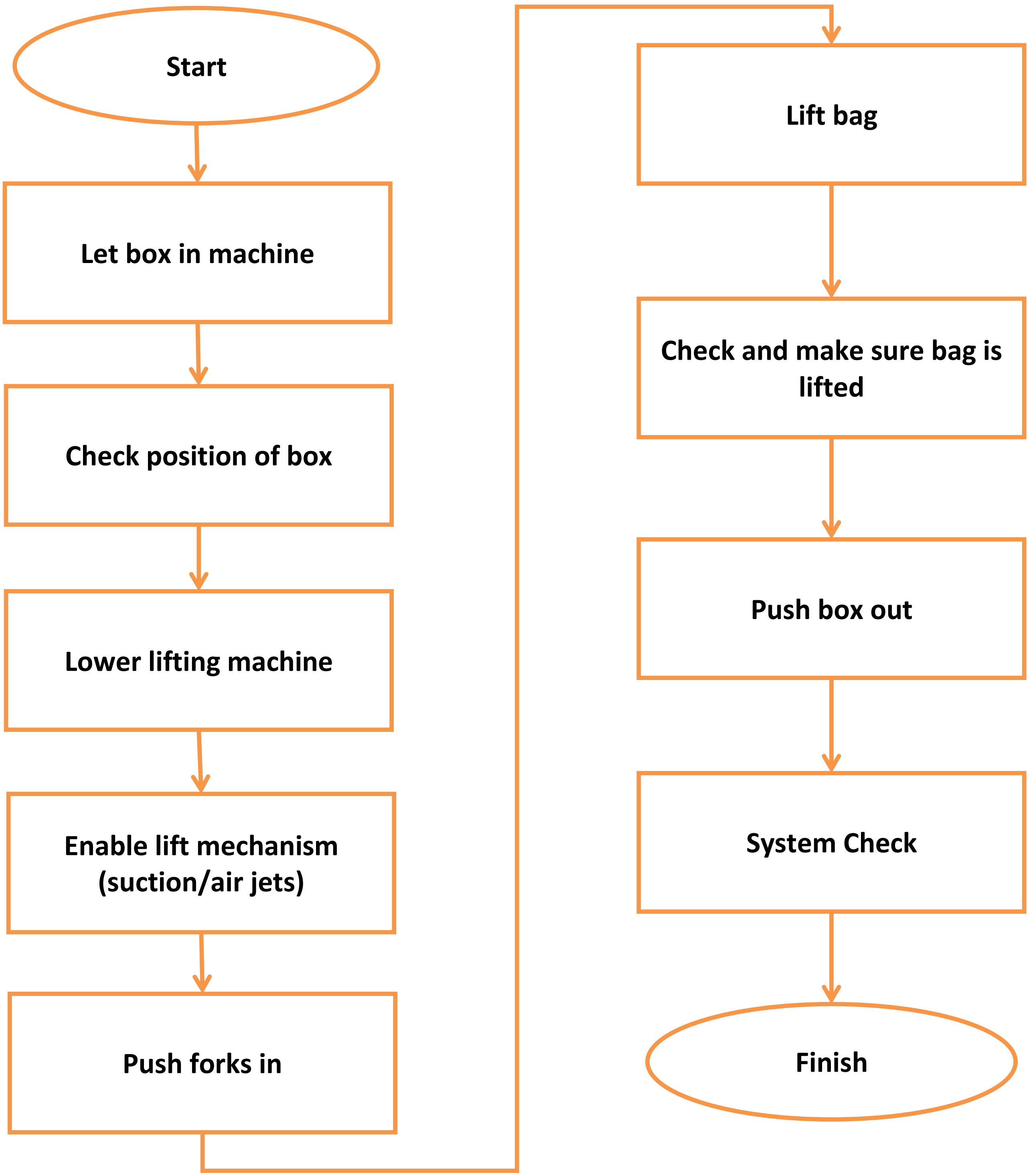
Base Design 1 (with both suction and air jets)	
Part	**Movement Time (seconds)**
Line the box in the machine	1.5
Pinchers	1
Vacuum	0.5
Vacuum pulls back and air jets	.75
Forks (horizontal)	0.25
Forks (vertical)	1
Push the box out	1
TOTAL	6

Base Design 2 (w/ suction)	
Part	**Movement Time (seconds)**
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Vacuum	0.75
Forks (vertical)	1
Push the box out	1
TOTAL	5.5

Base Design 2 (w/ air jets)	
Part	**Movement Time (seconds)**
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Air jets	0.5
Forks (vertical)	1
Push the box out	1
TOTAL	5.25

Base Design 2 (w/ suction and air blown)	
Part	**Movement Time (seconds)**
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Vacuum	.5
Vacuum pulls back and air jets	0.75
Forks (vertical)	1
Push the box out	1
total	5.5

F. Logic Flow Chart



G. Spring 2013 Budget

i. Steel and Framing

Quantity	Description	Unit Price	Total Price
1	Steel for framing: 1/4 x 4 x 8	$165.75	$165.75
24	Steel Square Tubing: 2"	$2.15	$51.60
N/A	Miscellaneous steel parts	$17.69	$17.69
4	Caster Wheels	$6.44	$25.76
N/A	Nuts and Bolts		$88.88
1	Conduit (9ft)	$7.89	$7.89
	Total		$357.57

ii. Mechanisms

Quantity	Description	Unit Price	Total Price
2	3 – Position Switch	$68.12	$136.24
1	Power Supply : 120 VAC – 24VDC 10AMP	$234.65	$234.65
24	Terminal Blocks	$1.47	$35.30
6	Terminal End Blocks	$0.66	$3.98
1	Wiring	$11.15	$11.15
1	Modular Flex Hose: Spare pack	$33.38	$33.38
1	Modular Flex Hose Replacement Kit	$47.25	$47.25
8	Suction Cups	$4.14	$33.12
	Total		$535.07

iii. Pneumatics

Quantity	Description	Unit Price	Total Price
16	Quick Male Connector 1/8 x 1/4	$2.91	$46.56
34	Quick Male Connector 1/4 x 1/8	$2.21	$75.14
26	Quick Male Connector 1/4 x 1/4	$2.21	$57.46
1	Quick Elbow connector 1/4 (16)	$49.35	$49.35
10	Pneumatic Plugs: 1/8"	$1.72	$17.20
30	Pneumatic Plugs: 1/4"	$1.61	$48.30
N/A	Fittings: Couplers and Bushings	N/A	$59.70
1	Pneumatic Tubing (roll)	$20.15	$20.15
6	Festo Pneumatic Plugs and Cables	$31.23	$187.38
2	Quick Connect Tees	$44.84	$89.68
6	Festo Valves (DC)	$93.12	$558.72
2	Quick Connect Tees (20)	$44.84	$89.68
8	Numatics - Pneumatic Cylinders	$58.30	$466.40
3	Regulators	$21.16	$63.48
1	Vacuum Pump	$362.63	$362.63
1	Vacuum Pressure Gauge	$7.24	$7.24
3	Pressure Gauge	$9.98	$29.94
	Total		**$2,139.33**

iv. Simplified Budget

Description	Total Price
Electrical: Switches, Power supply, wiring, and terminals	$421.32
Modular Hosing and suction cups	$113.75
Framing	$357.57
Pneumatic Quick Connectors, pneumatic tubing, fittings, and plugs	$463.54
Pneumatic cylinders	$466.40
Valves and cables	$746.10
Vacuum pump, regulators, and gauges	$463.29
Miscellaneous: Tools need, air filter, etc.	
Total	$3106.97

H. Fall 2012 Budget Options

i. Base Design 1 (with ONLY suction)

Quantity	**Description**	**Unit Price**	**Total + Shipping and tax**
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
8	Suction Cups	$5.75	$46.00
4	Pololu Servo motors (583 oz-in)	$59.95	$239.80
1	Speedaire Air cylinder (3in bore, 6in stroke)	$156.24	$156.24
8	Bimba Cylinders (1/2in bore, 3in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$250.00
10	Control Valve	$125.00	$1,250.00
1	Igus Chain	$50	$50

	Misc.		$500
		TOTAL:	**$6,680.38**

ii. Base Design 1 (with ONLY air jets)

Quantity	**Description**	**Unit Price**	**Total + Shipping and tax**
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
4	**Pololu Servo motors (583 oz-in)**	**$59.95**	**$239.80**
8	Steel Conveyor Rollers	$22.03	$220.30
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
4	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
4	**Modular Air hose system (packs of 10)**	**$10**	**$40.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6786.94**

iii. Base Design 1 (with both)

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
4	**Pololu Servo motors (583 oz-in)**	**$59.95**	**$239.80**
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
1	Speedaire Aitr cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Pneumatic Cylinders (small cylinders)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$250.00
10	Control Valve	$125.00	$1,250.00
4	**Modular Air hose system (packs of 10)**	**$10**	**$30.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6832.94**

iv. Base Design 2 (with ONLY suction)

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
3	**Wheels (pairs)**	**$9.25**	**$27.75**
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6590.89**

v. Base Design 2 (with air jets)

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
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1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
3	**Wheels (pairs)**	**$9.25**	**$27.75**
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
4	**Modular Air hose system (packs of 10)**	**$10**	**$40.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6574.89**

vi. Base Design 2 (with both)

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square metal tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
3	**Wheels (pairs)**	**$9.25**	**$27.75**
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
4	**Modular Air hose system (packs of 10)**	**$10**	**$40.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6620.89**

I. Competitor Designs

Pearson Bag Uncuffer – Model UC15:

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

OK International Group - Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer

Pattyn - DS-11 Bag decuffer sealer

Wayne Automated Corp - Random Bag Uncuffer / Case Sealer:

Box It Unlimited

Box It Unlimited is a company devoted to finding solutions to processing problems

Spring 2013

Andrew McMahan
Justin Frazier
Denise Young

Problem Statement

- Our objective is to automate the uncuffing process in the Bama Companies, Inc., handheld pie production line.

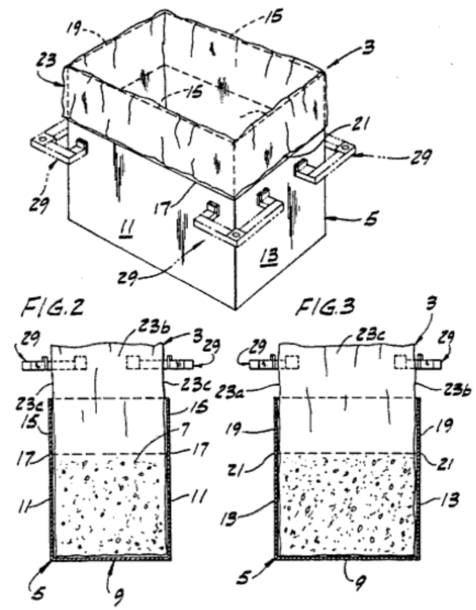
- By developing a machine that's automated the process, it will save the customer money.

BACKGROUND

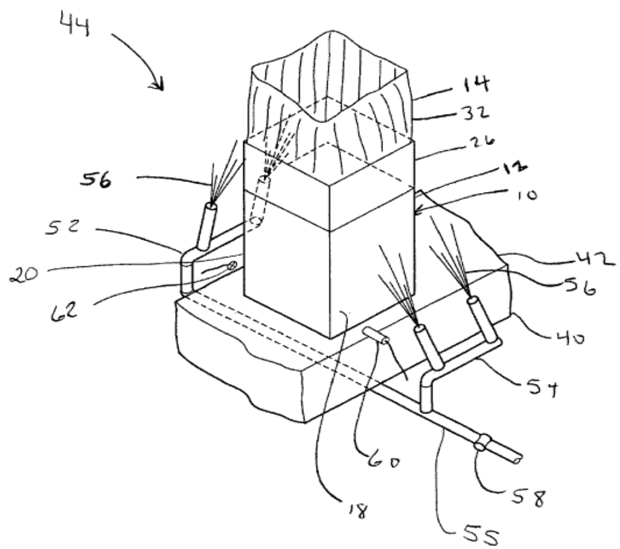
- Flaps are currently positioned down
  - This is for another automated process on the line
- The bag covers the flaps
- The level of the cuff of the bag varies
  - The top of the cuff varies from 1 in to 3 in
  - The bottom of the cuff has standard height

Patent Research

- This patent covers the use of a corner positioned lift mechanism and a method of closing the bag after uncuffing it



- This patent covers the use of air jets to dispense fluid to push the bags over the flaps
  - Blowing the bag completely off the upward directed flaps



Competitor Analysis

- Many companies make a version that uncuffs with the flaps up and closes the bag after the uncuffing process
  - Various methods of uncuffing:
    - Suction cups
    - Various corner positioned lifts
- The companies and machines that related most to our prototype were:
  - Pearson Bag Inserter and Uncuffer
  - K&R Equipment, Inc.
  - OK International Group Folder Closer
  - Pattyn
  - Wayne Automated Corp

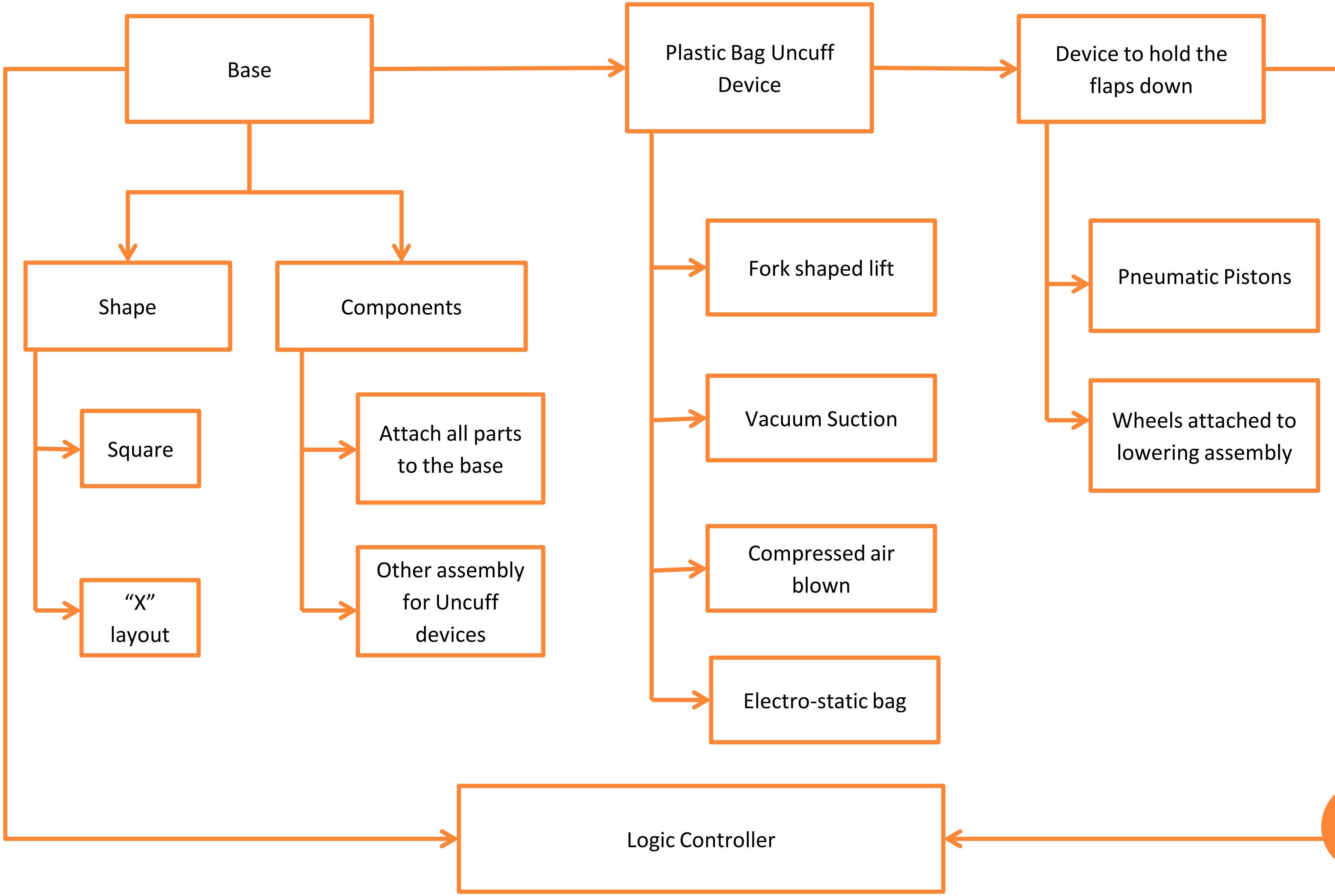
Spring Semester Plans

		Task Name	Duration	Start	Finish	Predecessors
27		**Reports**	**706.13 days**	**Mon 9/3/12**	**Fri 4/26/13**	
28		First Draft Fall Report	64.13 days?	Mon 10/29/12	Mon 11/19/12	
29		Finalized Fall Report	34.13 days	Mon 11/26/12	Fri 12/7/12	28
30		Fall PowerPoint Presentation	34.13 days?	Fri 12/7/12	Wed 12/19/12	29
31		First Draft Spring Report	43.13 days?	Mon 3/25/13	Mon 4/8/13	29
32		Finalized Spring Report	52.13 days?	Tue 4/9/13	Fri 4/26/13	31
33		**Construction and Evaluation**	**286.13 days**	**Mon 1/14/13**	**Fri 4/19/13**	
34		**Construction of Prototype**	**280.13 days**	**Mon 1/14/13**	**Wed 4/17/13**	
35		Concept and Design	43.13 days?	Mon 1/7/13	Mon 1/21/13	
36		Electrical	187.13 days?	Tue 1/22/13	Mon 3/25/13	35
37		Pneumatic	187.13 days?	Tue 1/22/13	Mon 3/25/13	35
38		Mechanical	103.13 days?	Tue 1/22/13	Mon 2/25/13	35
39		Programmable Logic Control	187.13 days?	Tue 1/22/13	Mon 3/25/13	35
40		Safety	103.13 days?	Tue 1/22/13	Mon 2/25/13	35
41		Complete Prototype Testing	0 days	Mon 4/1/13	Mon 4/1/13	
42		Customer Approval of Prototype	0 days	Mon 4/8/13	Mon 4/8/13	
43		**Final Customer Approval**	**22.13 days**	**Fri 4/19/13**	**Fri 4/26/13**	
44		Final Spring Presentation	1 day	Mon 4/22/13	Mon 4/22/13	
45		Final Spring Prototype Demonstration	1 day	Tue 4/23/13	Tue 4/23/13	

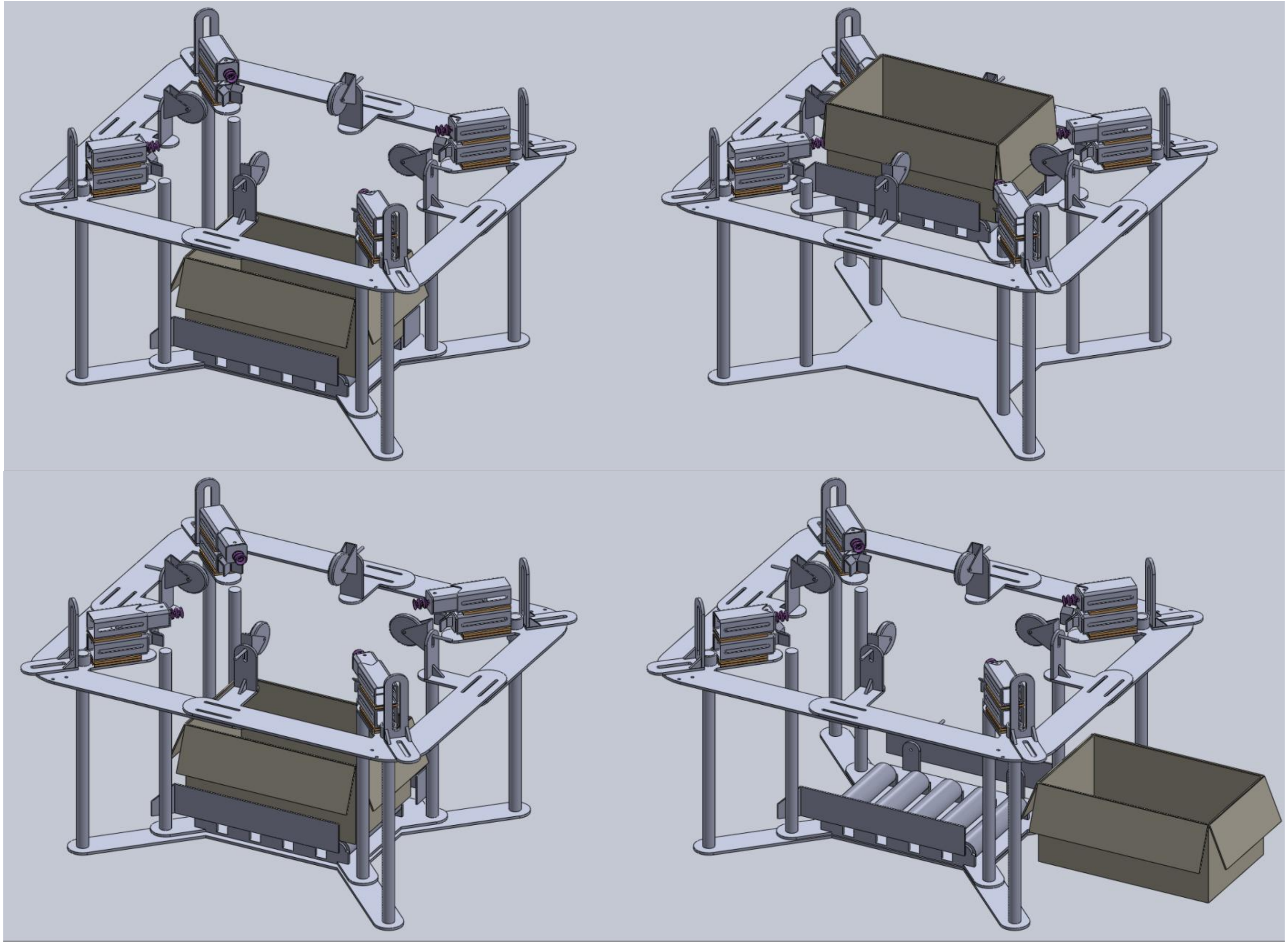
FALL SEMESTER DESIGN

Design process and processing timing

Design Process



Prototype Design



Fall Semester Projected Processing Time

Compressed Roller, Forks, Suction	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Vacuum	0.75
Forks (vertical)	1
Push the box out	1
TOTAL	5.5

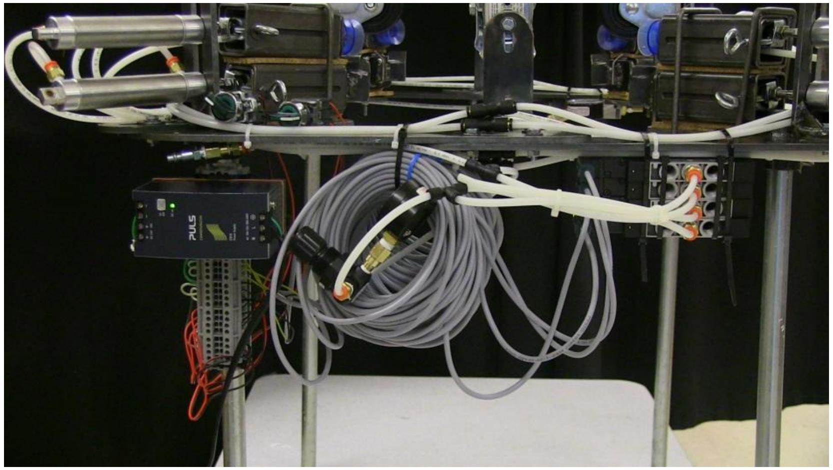
Compressed Roller, Forks, Air Jets)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Air jets	0.5
Forks (vertical)	1
Push the box out	1
TOTAL	5.25

Compressed Roller, Forks, Suction and Air Blown	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Vacuum pulls back and air jets	0.75
Forks (vertical)	1
Push the box out	1
TOTAL	5.5

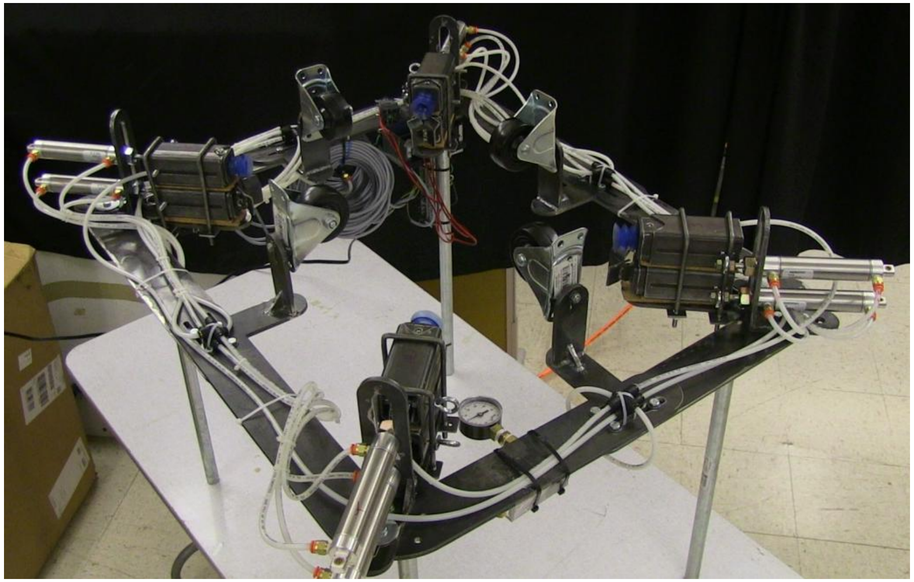
SPRING SEMESTER PROTOTYPING

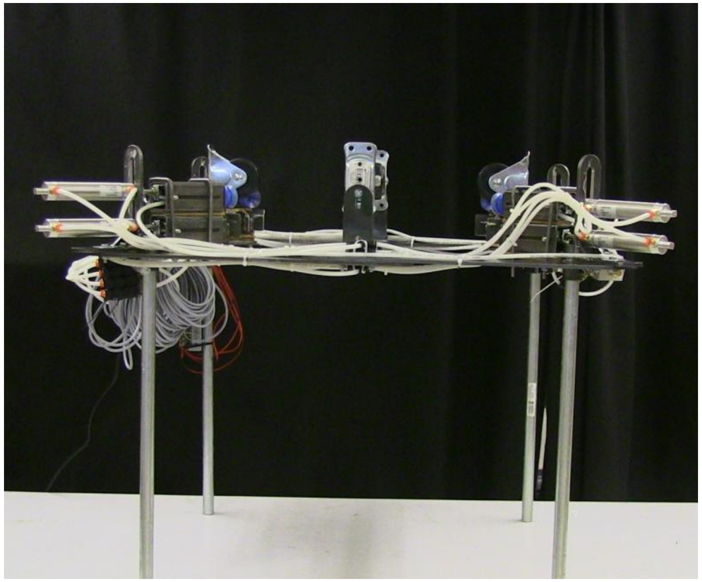
Prototype Build

- Controls
  - 24 V power supply
- Pneumatics
  - Pneumatic cylinder
  - Solenoid powered valves
- Vacuum
  - Venturi system
  - Suction cups
- Air Jets
  - Modular hosing



Prototype design



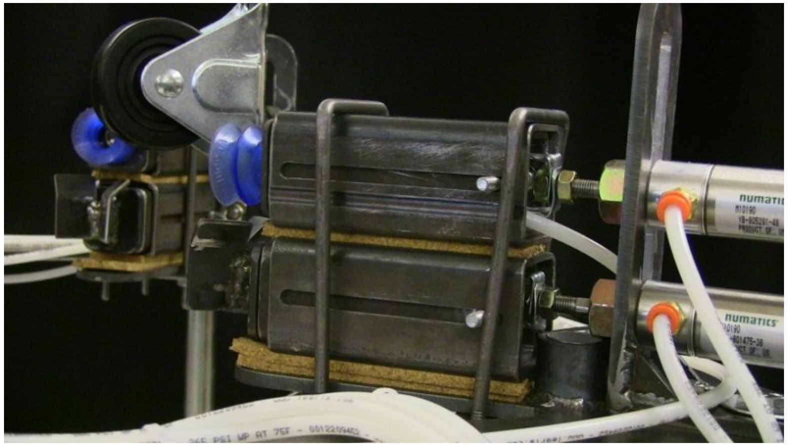


Prototype Design

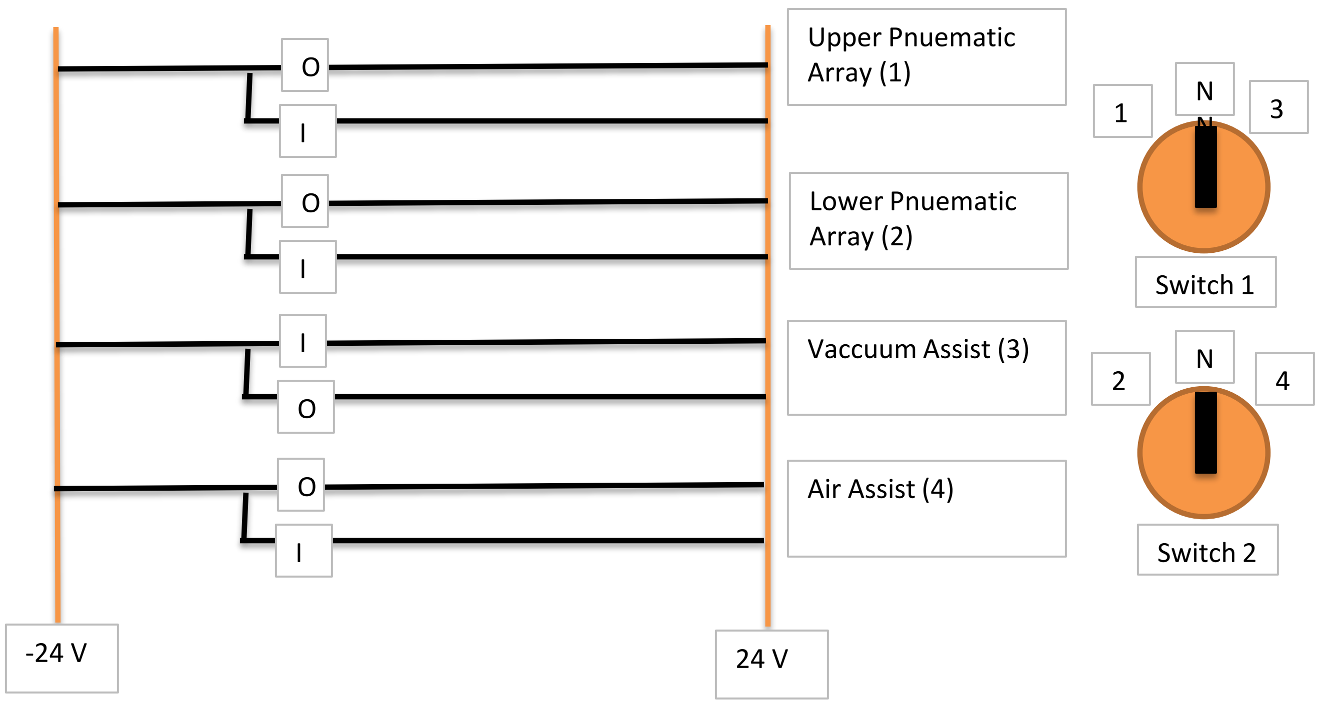
- Base Design
  - Design 1: Flap compressors

Prototype Design

- Bag Lift Design
  - Suction cups
  - Air jets
  - Forks



ELECTRONICS DIAGRAM

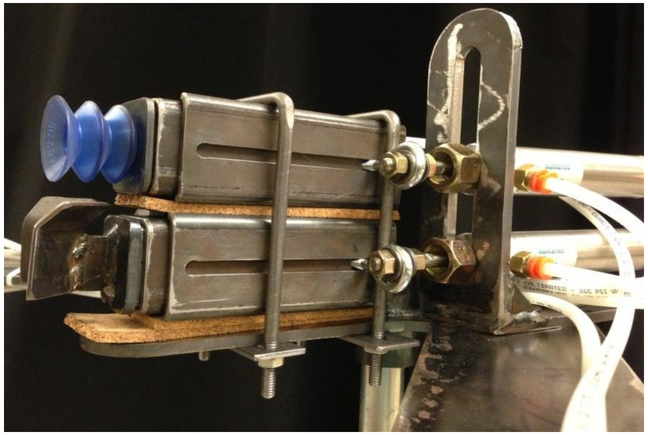


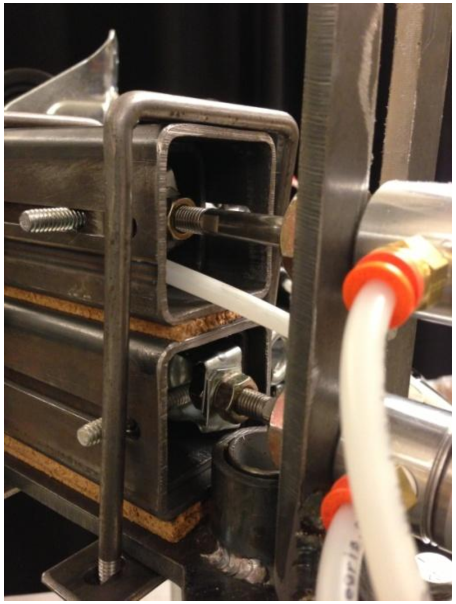
TESTING DATA AND RESULTS

Objective of our tests were to lift the bag over the flaps enough to close the flaps of the box

Pneumatic Placement test

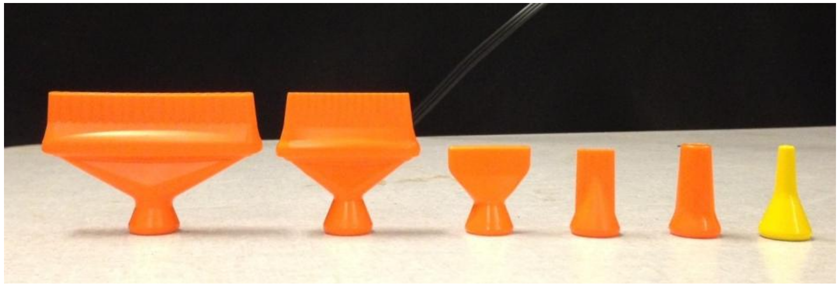
- Placement of the pneumatic cylinders test
  - Placed the cylinders on the outside of our square tubing
    - Due to the angular forces and the placement of the eye bolts in this was NOT the most effective placement
  - Placed the rods of the pneumatic cylinder inside of the square tubing
    - This was a better position for the corner cylinders

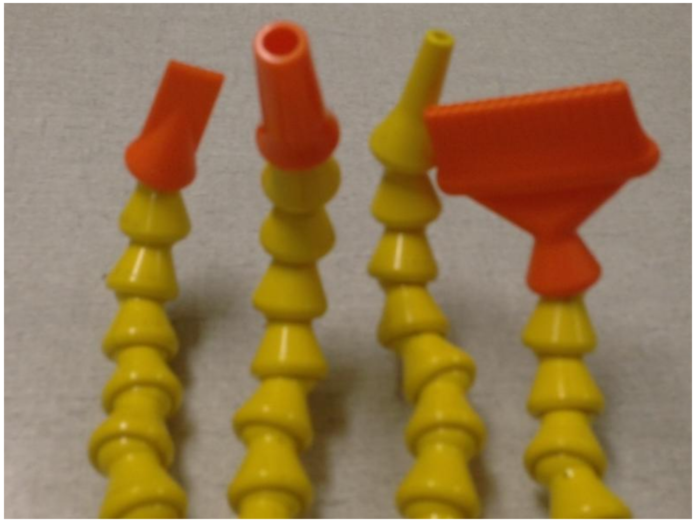




Air Jet Test

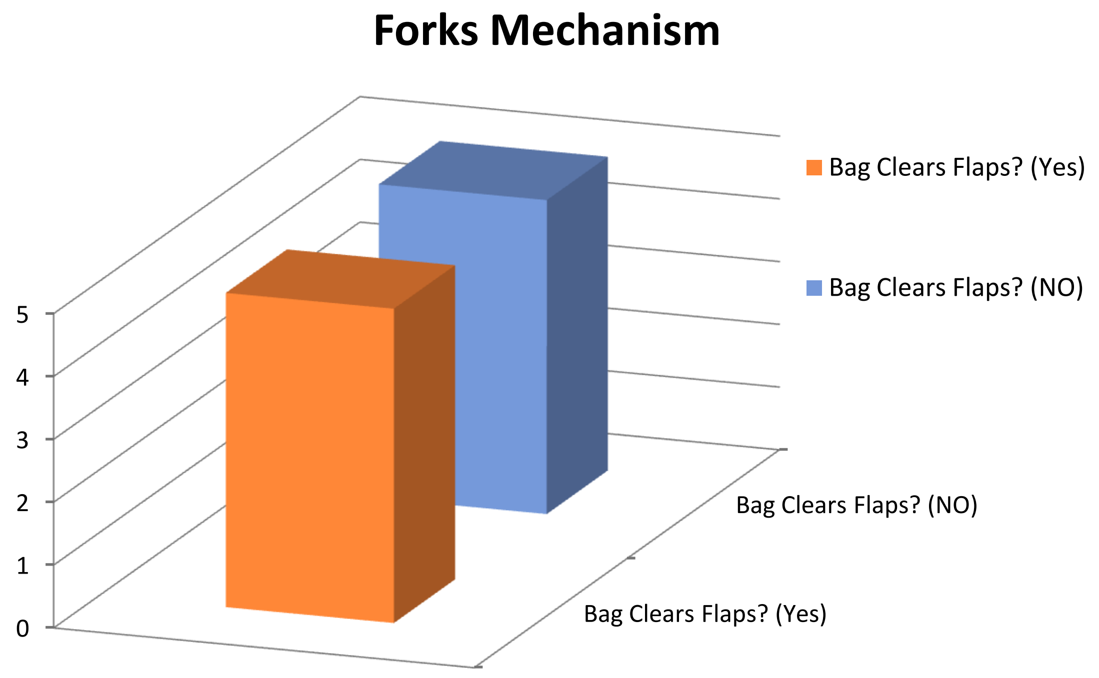
- Test for the bag distance away from the box corner
  - Different nozzles to test most effective
  - Used a variety of pressures
    - 25 to 60 PSI
- Concluded that none were effective enough to blow the bag away from the boxes





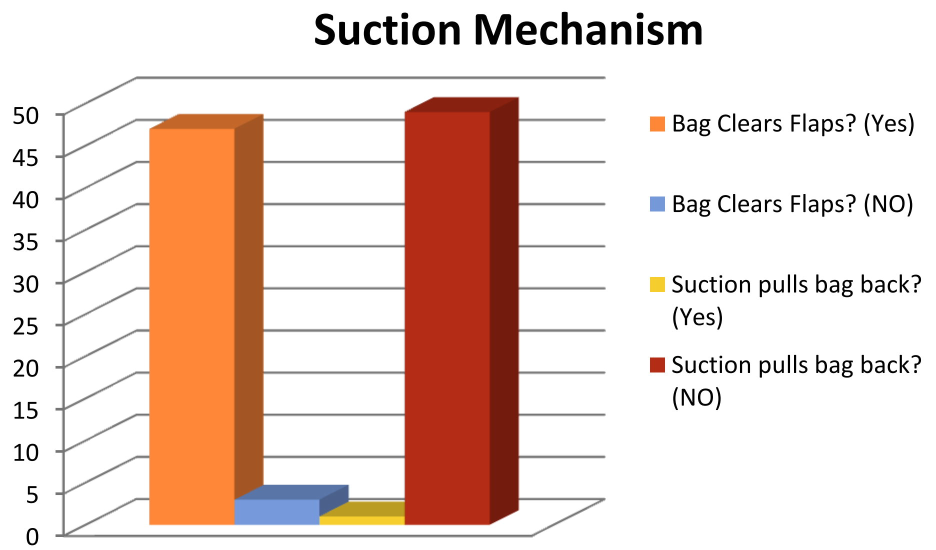
Fork Mechanism

- Tested for effectiveness of pulling the bag over box
  - Tested for rips and tears in the bag and scratches on box
  - 10 Trials
    - 4 Bag rips

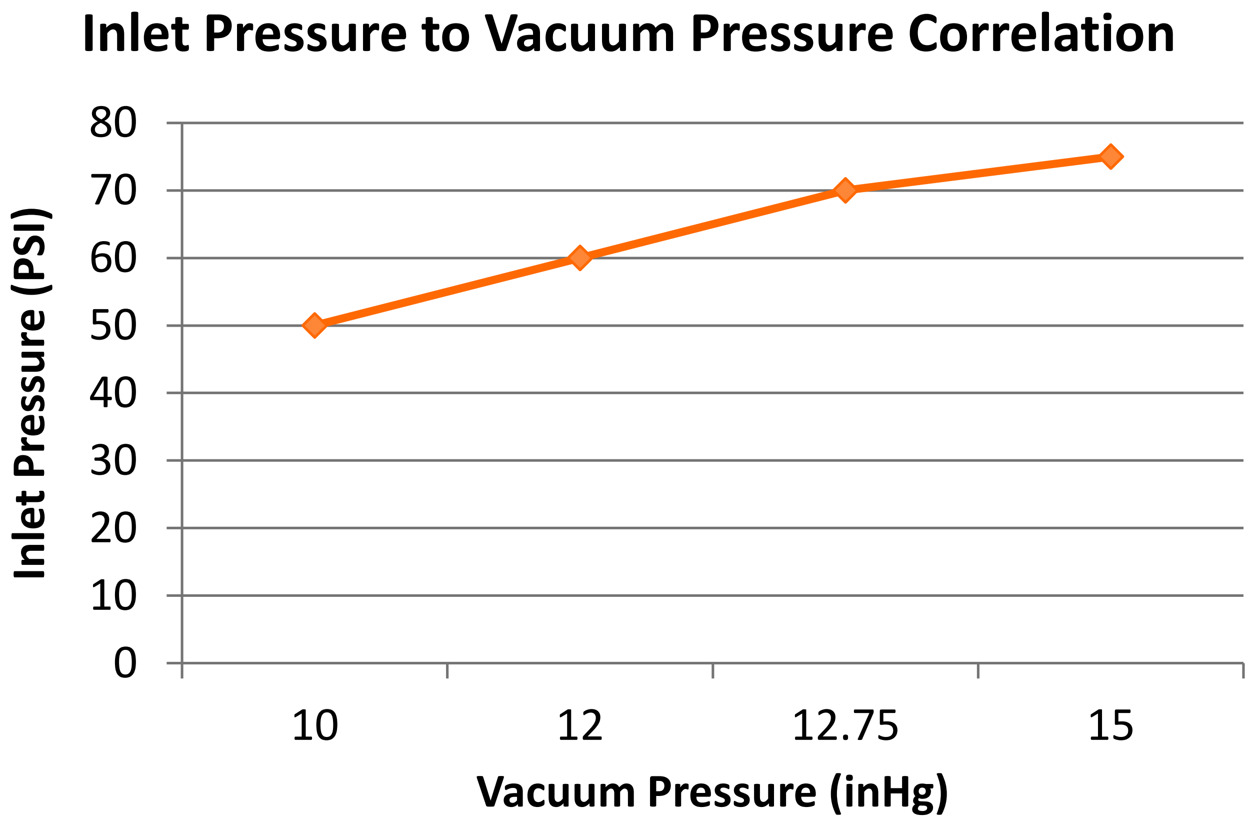


Suction Mechanism

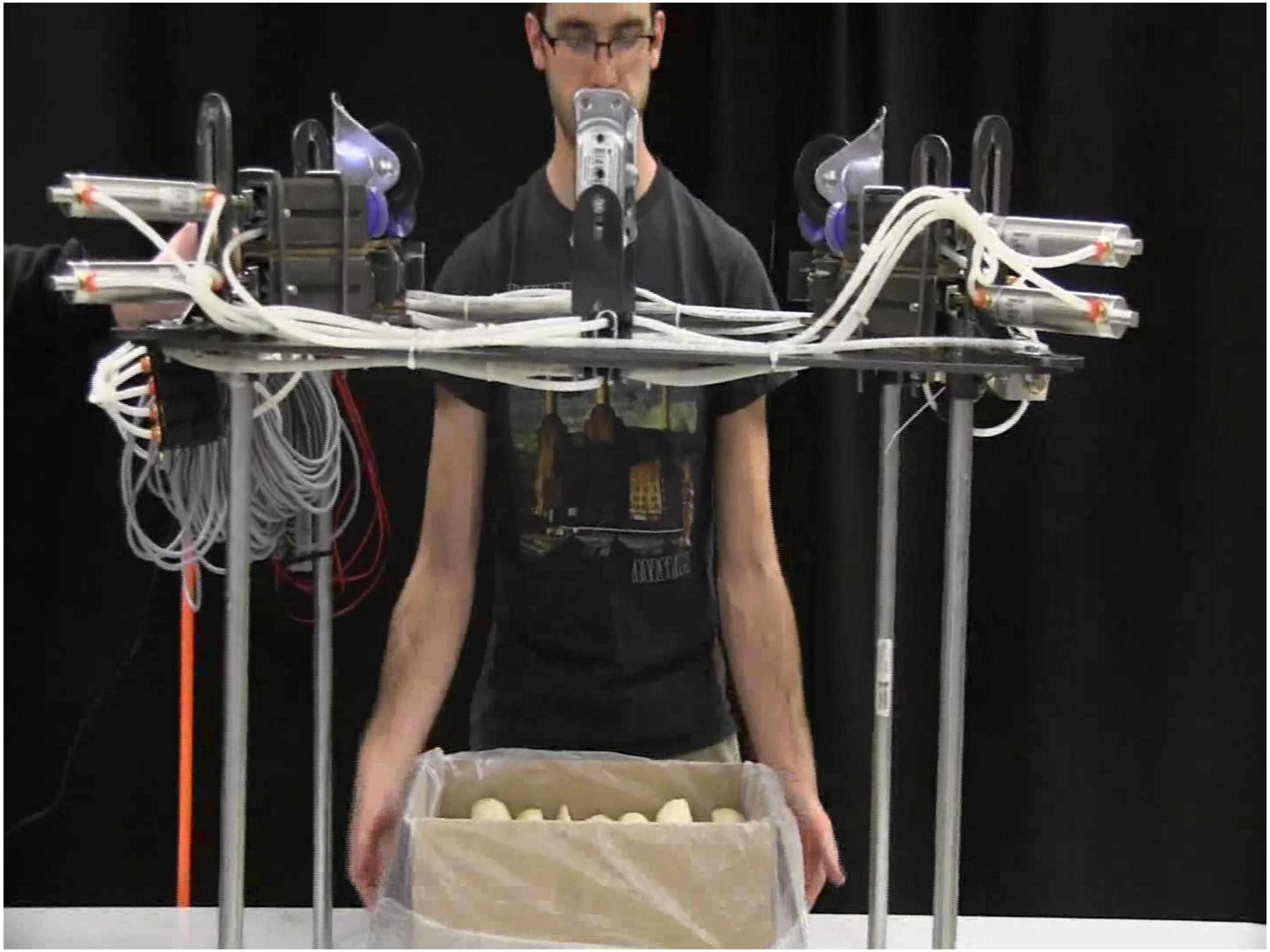
- Tested this mechanism for 2 constraints
  - Will the suction mechanism pull the bag away from the flaps?
  - Will the suction mechanism uncuff the bag?



Suction Pressure Rating



Final Testing Video



Testing Conclusion

- Air Jets
  - Not effective
- Fork Mechanism
  - Not effective
  - If modified, the design of the fork mechanism could become more effective
- Suction Mechanism
  - Most Effective

Design Recommendations

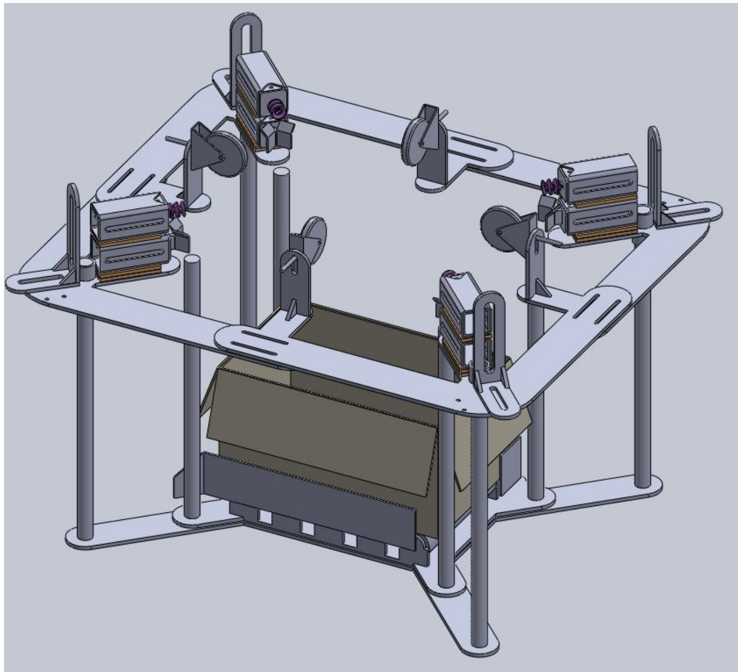
- Send the prototype to be perfected
  - Stainless steel
  - Sensors and controls
    - PLC
    - Placement
  - Fork redesign
    - Teflon
    - Rounded design
  - Look at powered rollers
- Patent the design
  - Currently nothing like it
- Jammed boxes
  - Conveyor Roller
- Vertical movement

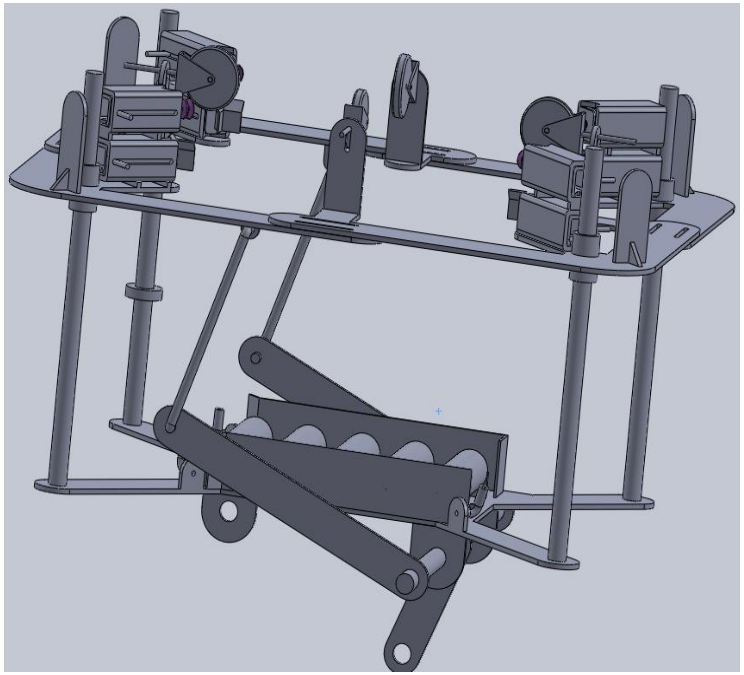
Further Design Recommendations: What to do if boxes jam?

- In the case that something in the system of the machine does not properly do its job, an alarm will sound letting the monitor of that part of the line know that it needs to be checked.

Design Recommendations:
Vertical Adjusting Assembly

- Pneumatic cylinder power leg lift system
- Attaches to base





Proposed Prototype Budget

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square metal tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
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1	Programmable Logic Controller	$2,000	$2,000.00
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2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
4	Modular Air hose system (packs of 10)	$10	$40.00
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6620.89**

Actual Prototype Budget

Description	Total + Shipping and tax
Electrical: Switches, Power supply, wiring, and terminals	$136.24
Modular Hosing and suction cups	$113.75
Framing	$349.68
Pneumatic Quick Connectors, pneumatic tubing, fittings, and plugs	$373.86
Pneumatic cylinders	$466.40
Valves and cables	$746.10
Vacuum pump, regulators, and gauges	$463.29
Miscellaneous	$75.00
Total	$3031.97

Cost/Benefit Analysis

- Current facility cost:
  - Four shifts with 2 people/shift = 8 workers on the line
  - Estimated $12/hr = $25,000 per year for each employee
  - Account for benefits at 40% of the annual salary
  - Costing the facility $280,000 per year for that line
- Estimated price of finished product will cost:
  - $200,000 – One time cost for both machines

Loan Payoff

Loan Pay Off	Year 1	Year 2	Year 3	Year 4	Year 5
Beginning Balance	$200,000	$165,909	$129,090	$89,326	$46,381
Interest Rate	8.00%	8.00%	8.00%	8.00%	8.00%
Interest	$16,000	$13,273	$10,327	$7,146	$3,710
Annual Payment	$50,091	$50,091	$50,091	$50,091	$50,091
Principal	$34,091	$36,819	$39,764	$42,945	$46,381
Ending Balance	$165,909	$129,090	$89,326	$46,381	$0

References

- Pearsons Packaging Systems. Digital image. Model UC15.Web. Nov.16 2012. <http://www.pearsonpkg.com/products/showCategory/Bag-Inserters-Uncuffers>.
- K&R Equipment, Inc. Digital image. PBD-FC™ Polybag In-Box Decuffer Folder Closer. Web. Nov.16 2012.< http://www.kandrequip.com/products_pbd.html>.
- OK International Group. Digital image. Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer.Web. Nov.16 2012. < http://www.okcorp.com/products_decuffer_sc500.html>.
- 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>.
- Matrix Material Handling, Inc. Digital image. Belt Driven Roller Conveyor. Web. Dec. 1 2012. <http://www.wayneautomation.com/bag_uncuffer.html>.

References

- Budynas & Nisbett Shigley's Mechanical Engineering Design 9th

Acknowledgements

- J.K. Evicks & representatives of Bama Companies, Inc.
- Bama Companies, Inc.
- Dr. Weckler
- Dr. Bowser
- Wayne Kiner and BAE Shop
- Aaron Franzen
- AG Econ. Students
  - Tera Schnbal
  - Meghan Emerson

Thank you for your time!

QUESTIONS???

Fall Report 2012

Andrew McMahan
Justin Frazier
Denise Young

Table of Contents

Appendices

Appendix A: Patents

Appendix B: Gantt Chart

Appendix C: Engineering Calculations

Appendix D: Logic Flow Chart

Appendix E: Parts List

Appendix F: Images

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. 9^{th}, 2012
- Project end date: April 26^{th}, 2012

2.4. Deliverables Schedule

Due Date	Task
Oct. 29^{th}, 2012	Statement of Work
Nov. 2^{nd}, 2012	Work Breakdown Structure
Nov. 5^{th}, 2012	Task List
Nov. 9^{th}, 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.

Pearson Bag Inserter and Uncuffer - Model UC15:

- 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

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

- 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

OK International Group - Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer

- 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

Pattyn - DS-11 Bag decuffer sealer

- 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:

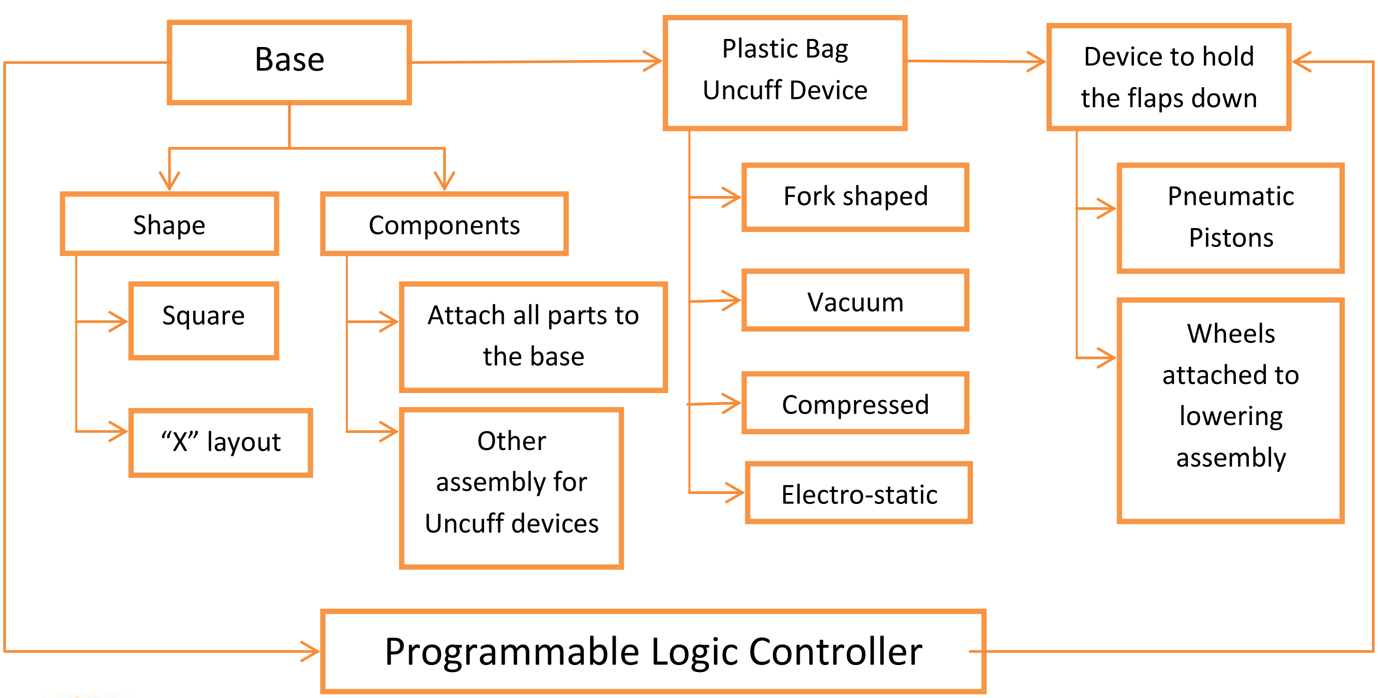
A PLC to operate all electronic deceives

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:

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

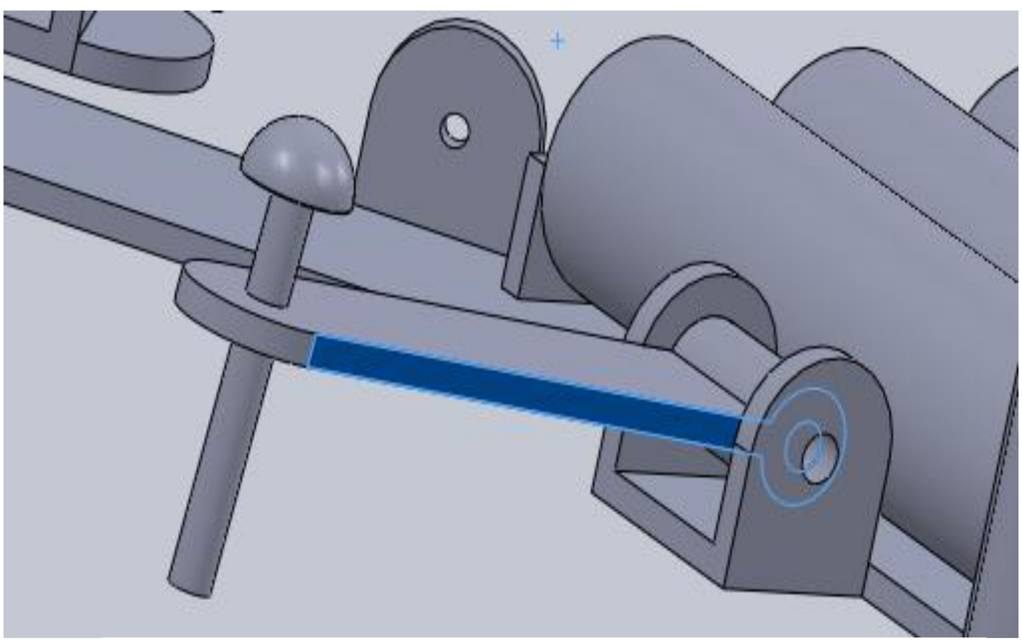


Figure 1: Close up of flap compressors (pinchers)

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.

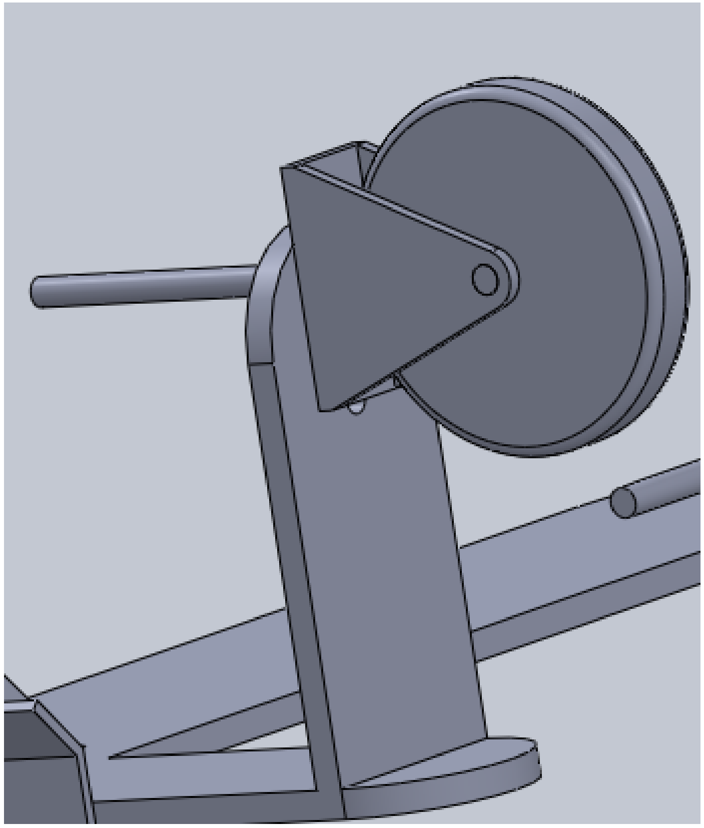


Figure 3: Close up of flap compressors (rollers)

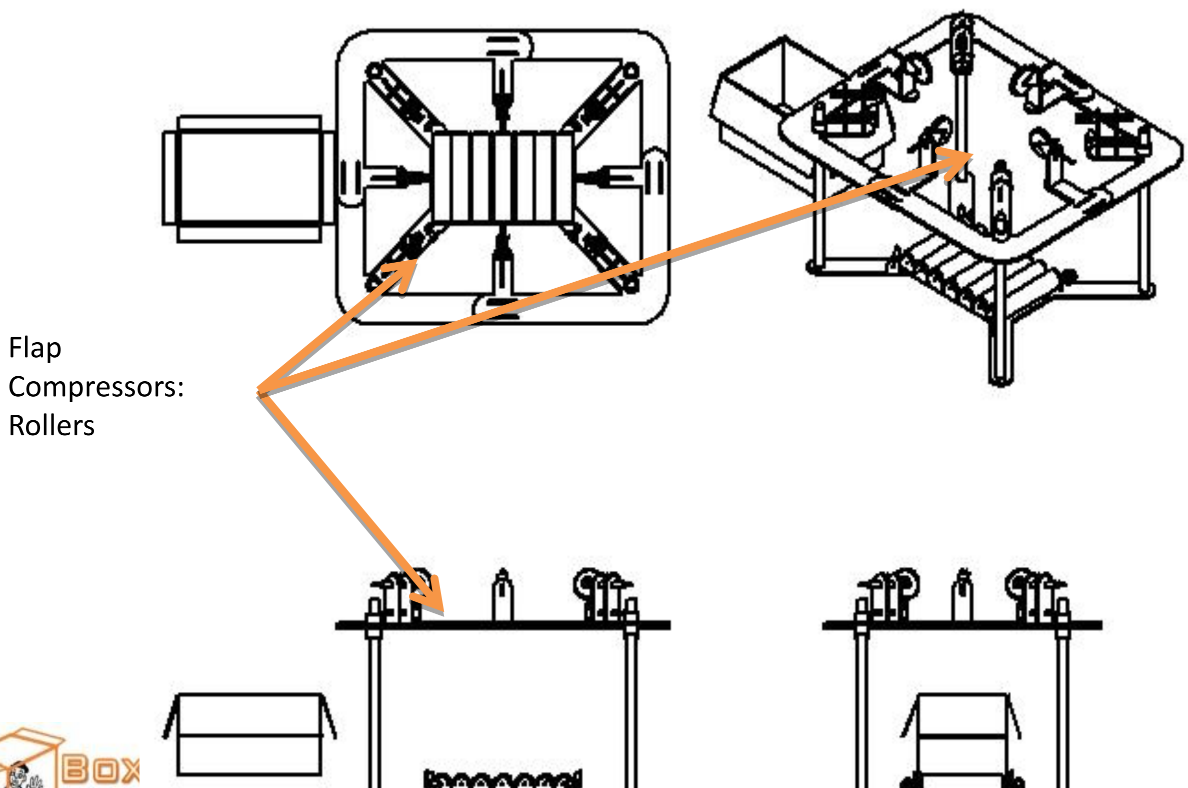


Figure 4: Base Design 2

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.

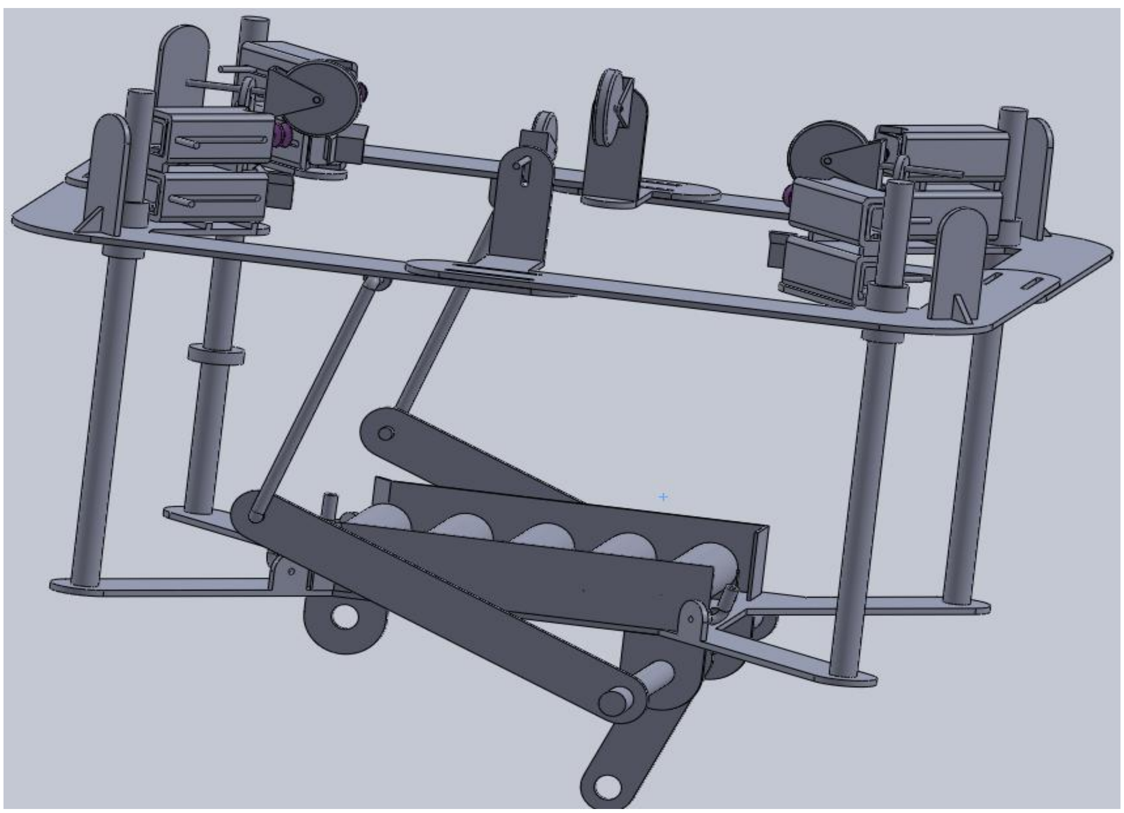


Figure 5: Vertical Adjusting Assembly

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.

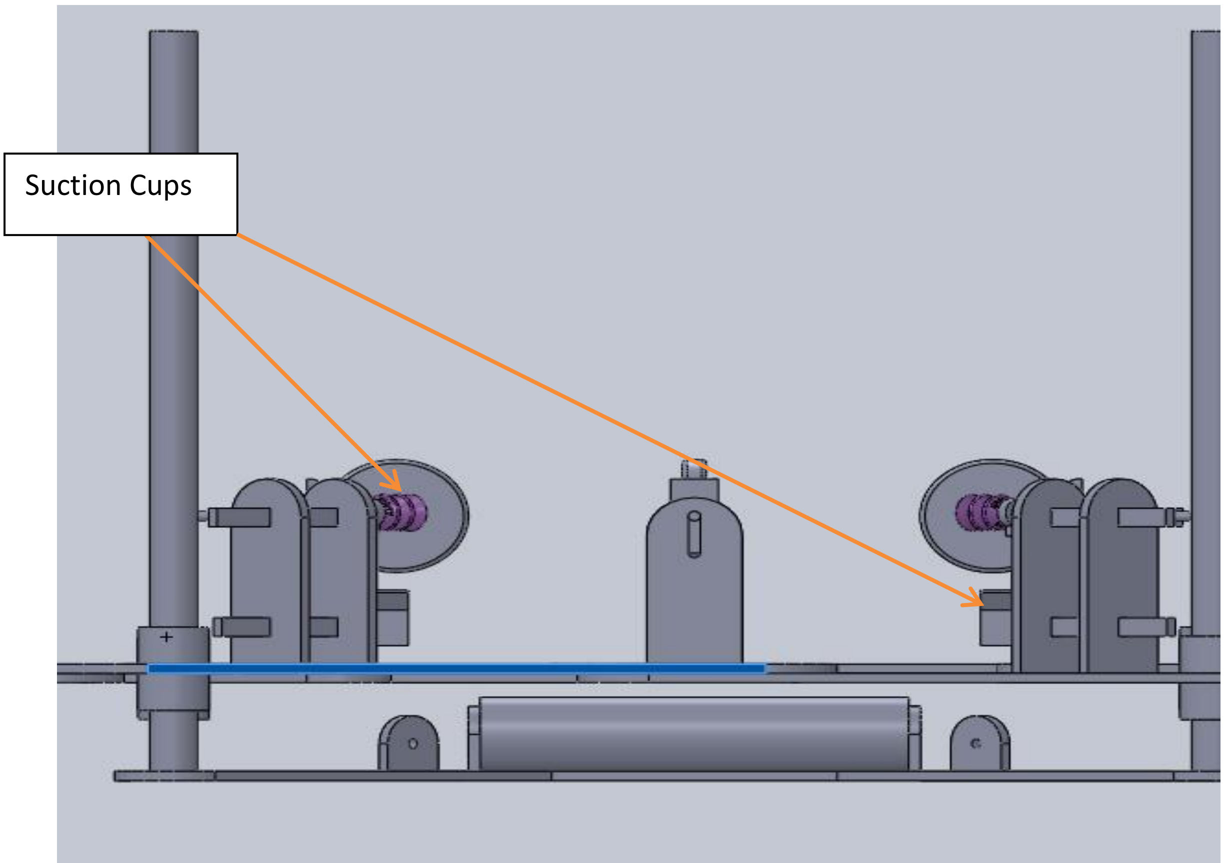


Figure 6: Lift Mechanism 1 – Suctions Cups

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.

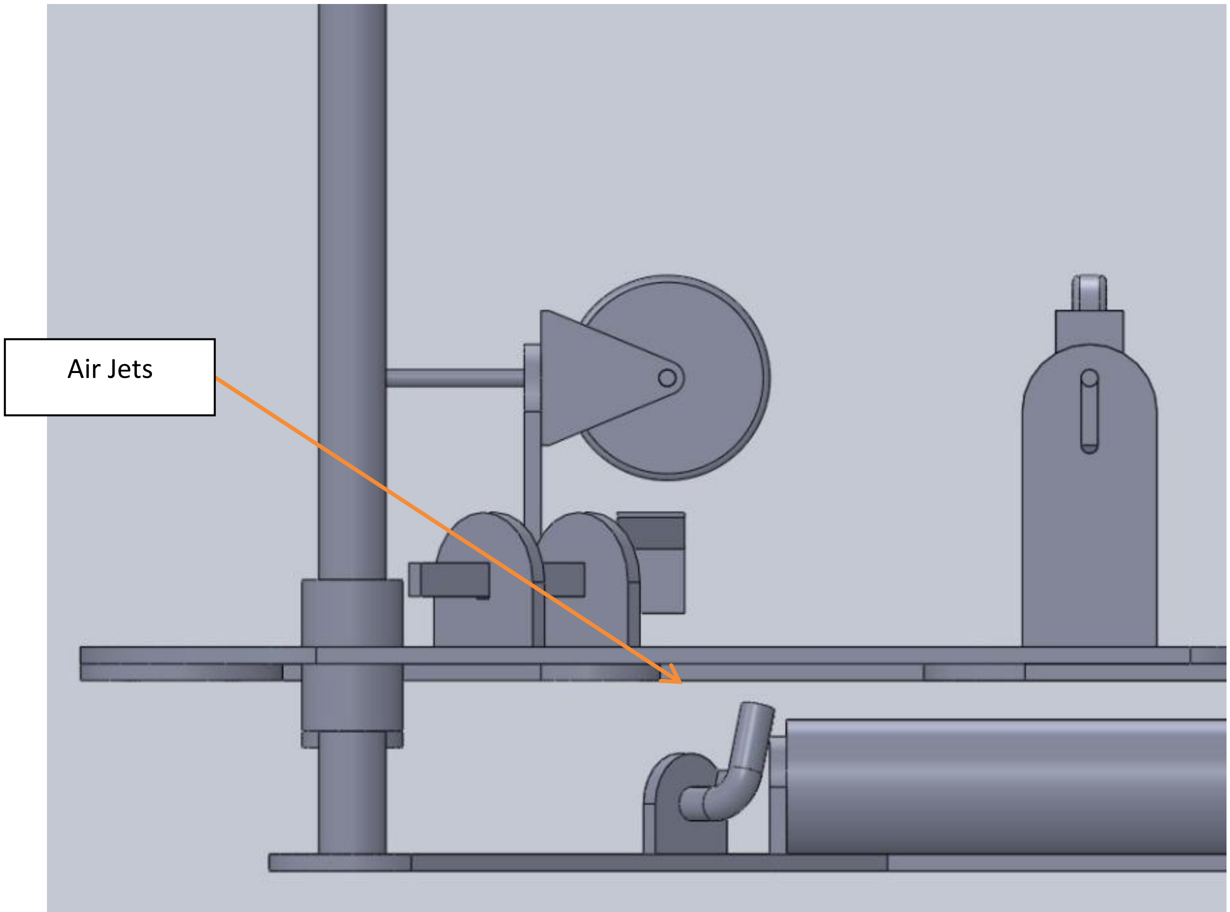


Figure 7: Lift Mechanism 2 – Air Jets

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.

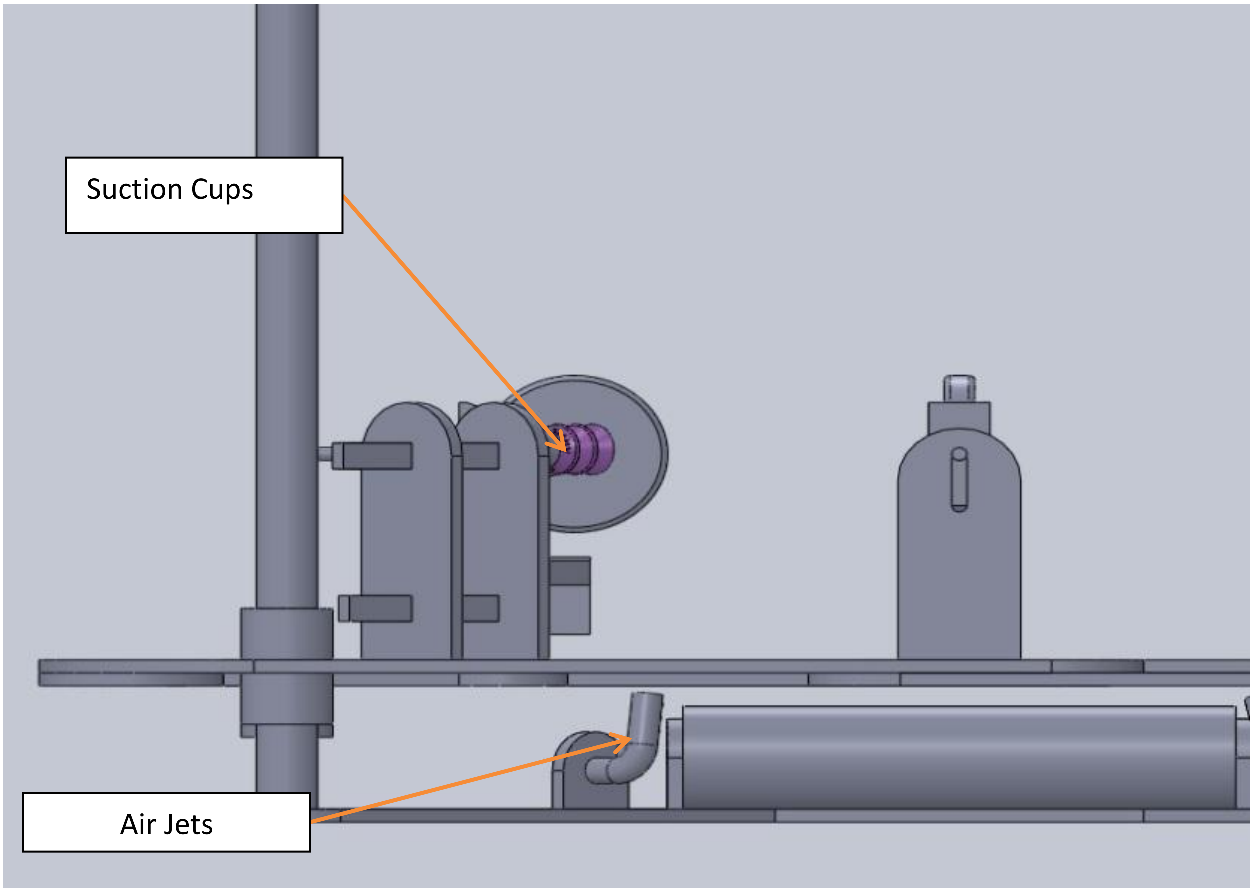


Figure 8: Lift Mechanism 2 – Air Jets

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>.

K&R Equipment, Inc. Digital image. PBD-FC™ Polybag In-Box Decuffer Folder Closer. Web. Nov.16 2012.< http://www.kandrequip.com/products_pbd.html>.

OK International Group. Digital image. Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer.Web. Nov.16 2012. < http://www.okcorp.com/products_decuffer_sc500.html>.

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.

Box It Unlimited

Andrew McMahan
Justin Frazier
Denise Young

Mission Statement

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

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.

BACKGROUND

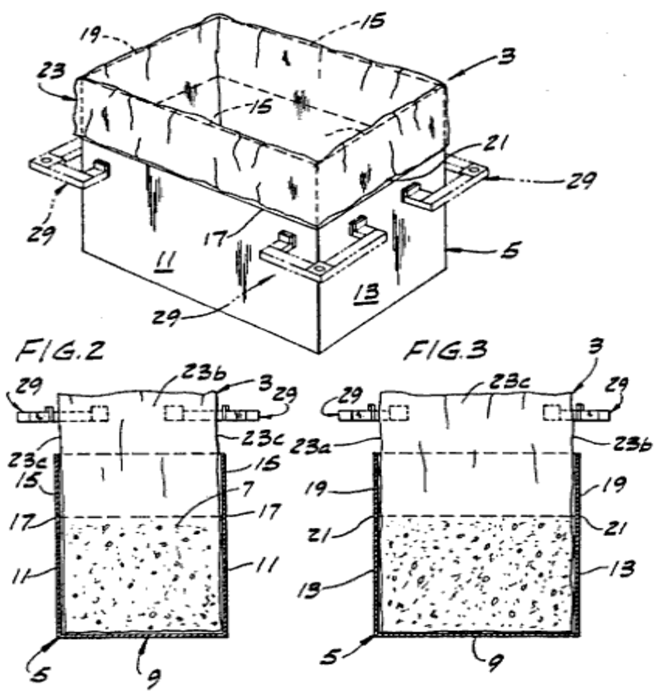
- Flaps are currently positioned down
- Position like this because of another automated process on the line
- The bag covers the flaps
- The level of the cuff of the bag varies
  - The top of the cuff varies from 1 in to 3 in
  - The bottom is pretty standard

Customer Requirements

- Facility runs off a maximum of 480 Volts
- Operate on a PLC
  - 24 Volt control
  - 60 hertz
  - 3 phase power supply
- NEMA 4X enclosure
- Maximum pneumatic line of 110 PSI
- Mushroomed shaped emergency stop button
- Reliability of 98% or greater
- Process a maximum of 20 boxes/minute
  - Split into 2 lines
  - 1 box every 6 seconds

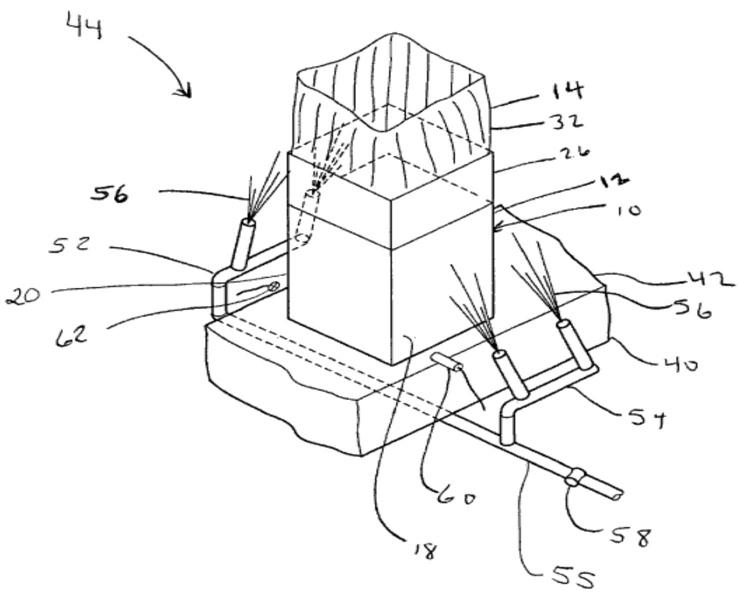
Patent Research

- This patent covers the use of a corner positioned lift mechanism and a method of bag closing the bag after uncuffing it



Patent Research

- This patent covers the use of jet to dispense fluid to push the bags over the flaps
  - Claims: discusses fluid dispensing jets
    - Blowing the bag completely off the upward directed flaps



Competitor Analysis

- No company currently makes an cuffing machine with the flaps positioned down and the bag covering them

- Many companies make a version that uncuffs with the flaps up and closes the bag after the uncuffing process
  - Various methods of uncuffing:
    - Suction cups
    - Various corner positioned lifts

Competitor Analysis (continued)

- Pearson Bag Inserter and Uncuffer - Model UC15:

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

Competitor Analysis (continued)

- OK International Group - Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer

- **Pattyn - DS-11 Bag decuffer sealer**

Competitor Analysis (continued)

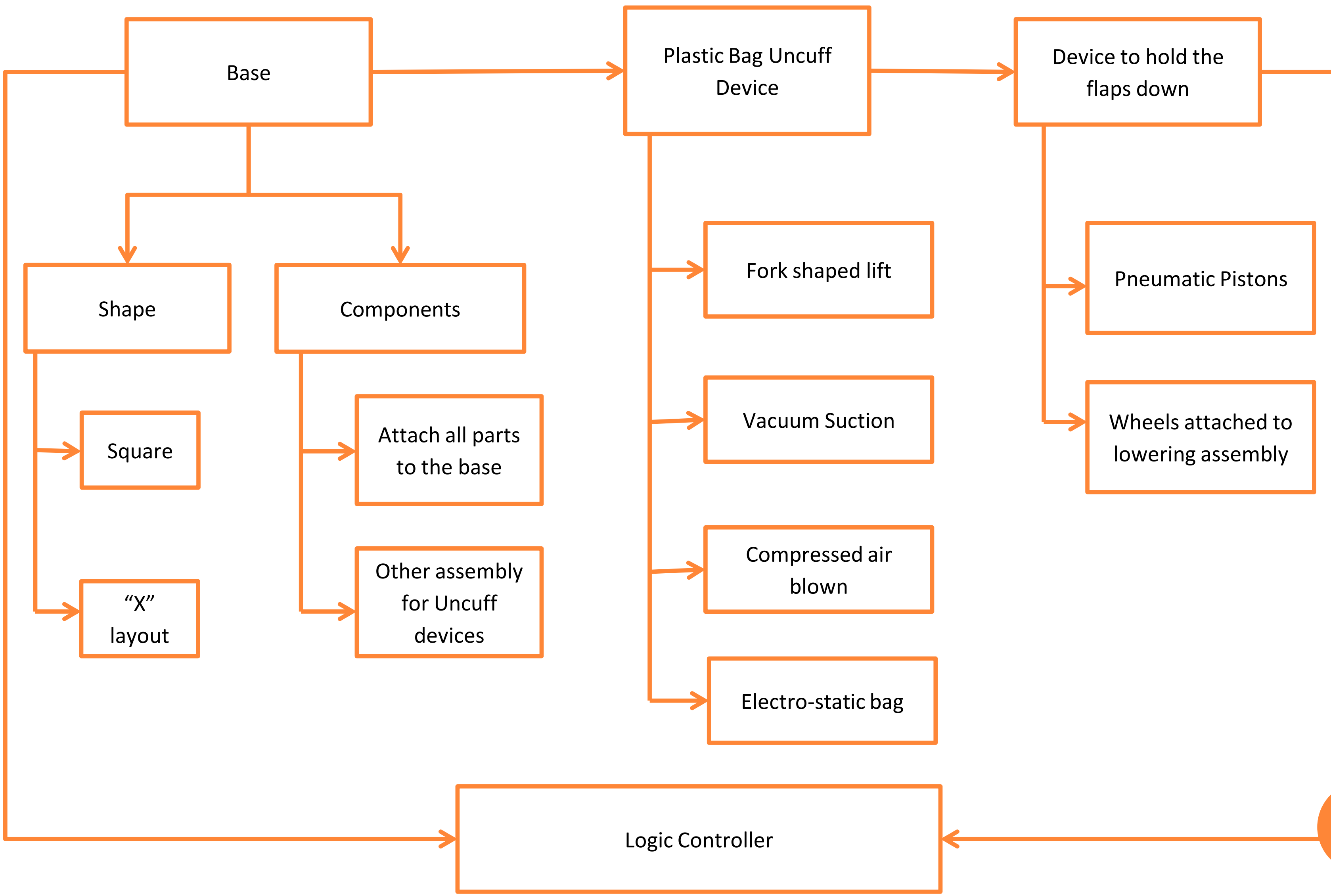
- Wayne Automated Corp - Random Bag Uncuffer / Case Sealer:

Design Options Overview

- Base Design
  - Design 1: Bottom placed flap compressors
  - Design 2: Adjusting assembly

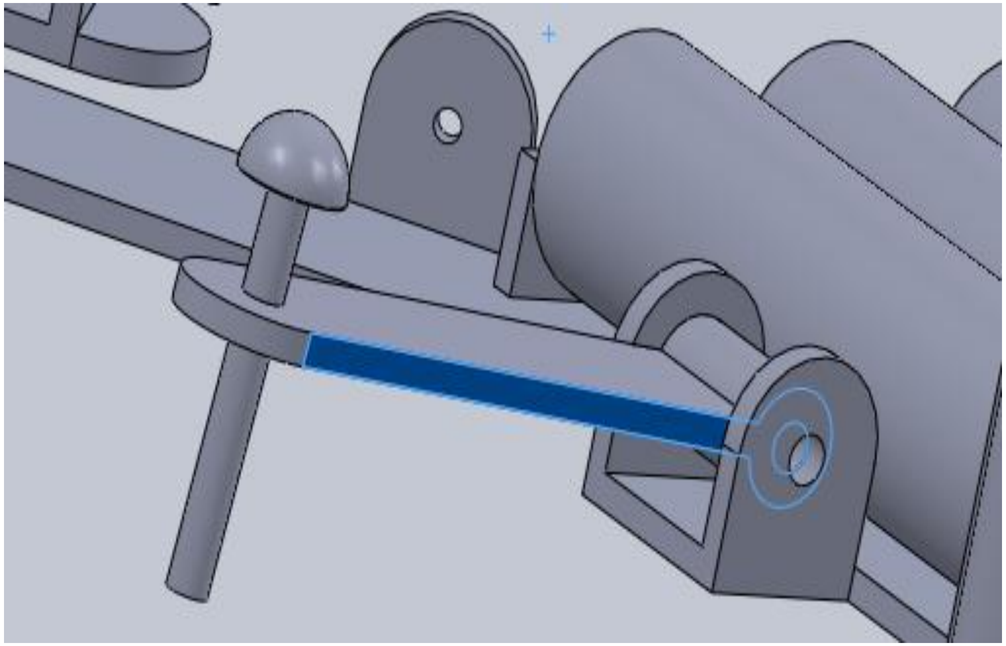
- Bag Lift Design
  - Design 1: Suction Cups and Forks
  - Design 2: Air blown and Forks
  - Design 3: Suction cups, air blown, and forks

Design Process

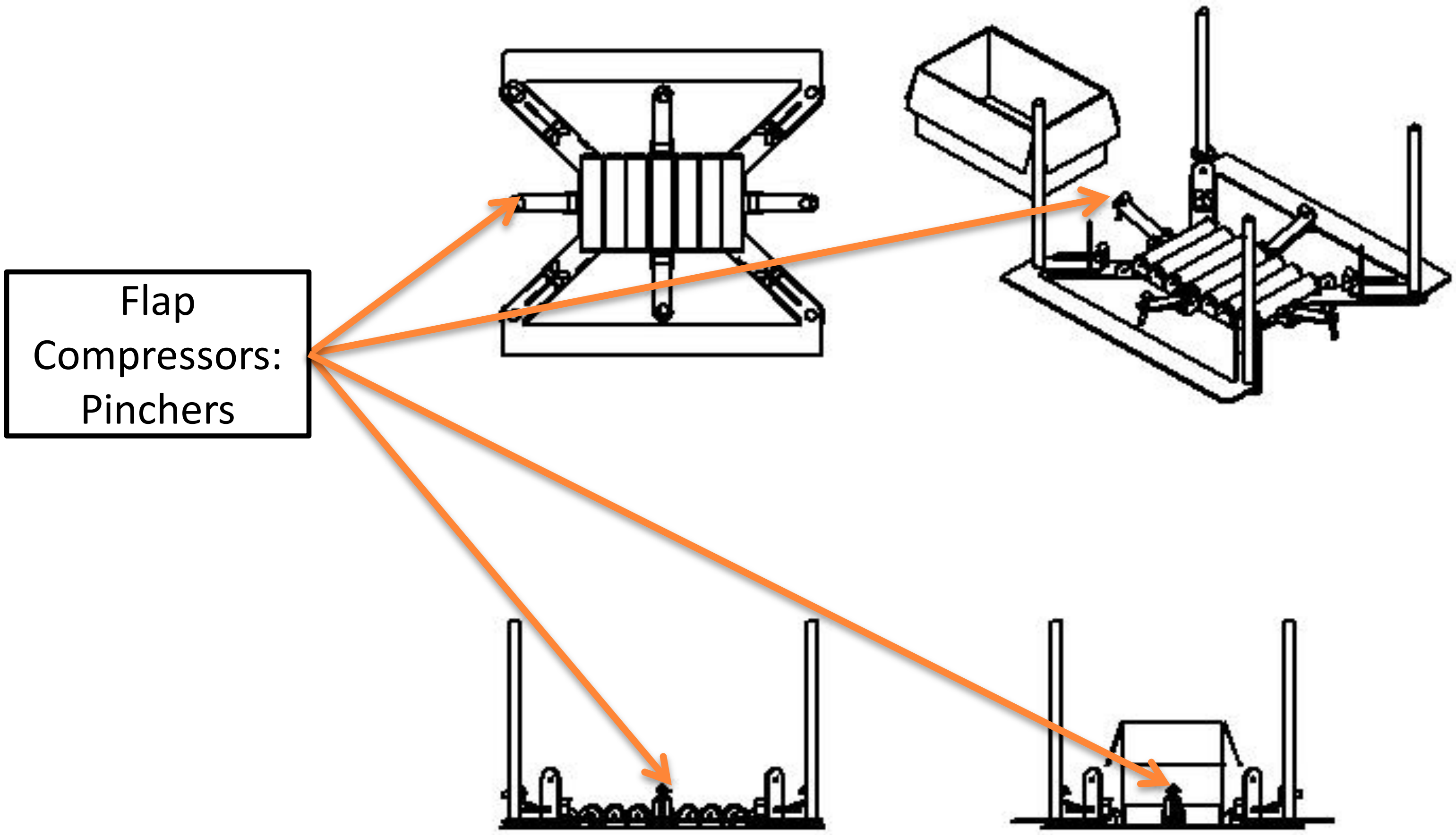


Base Design 1

- Four Flap Compressing Pincher
- Powered by four independent servo motors
  - 440 oz in of torque (T= 5.5 in * 5lb*16 oz/lb)

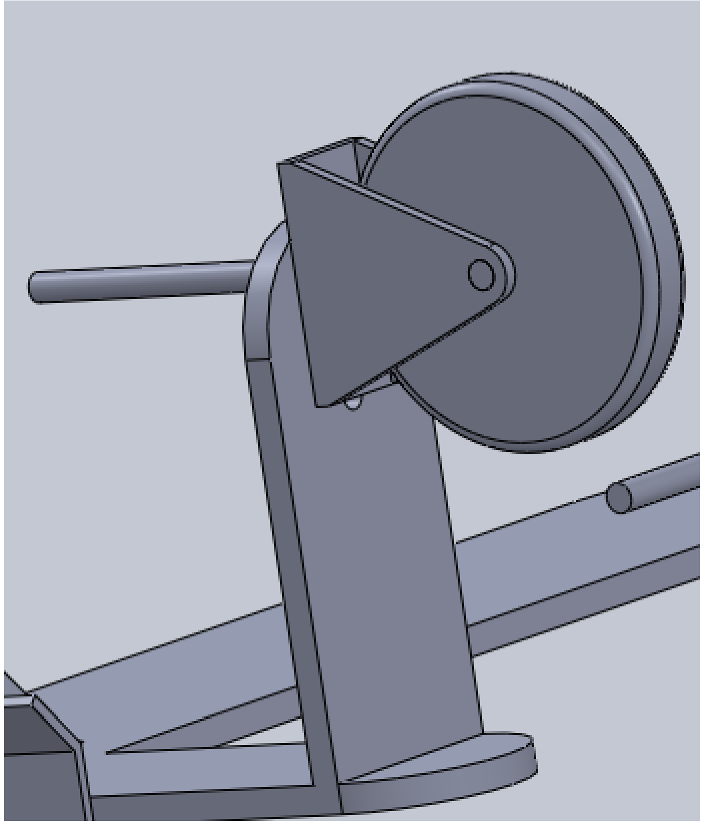


Base Design 1

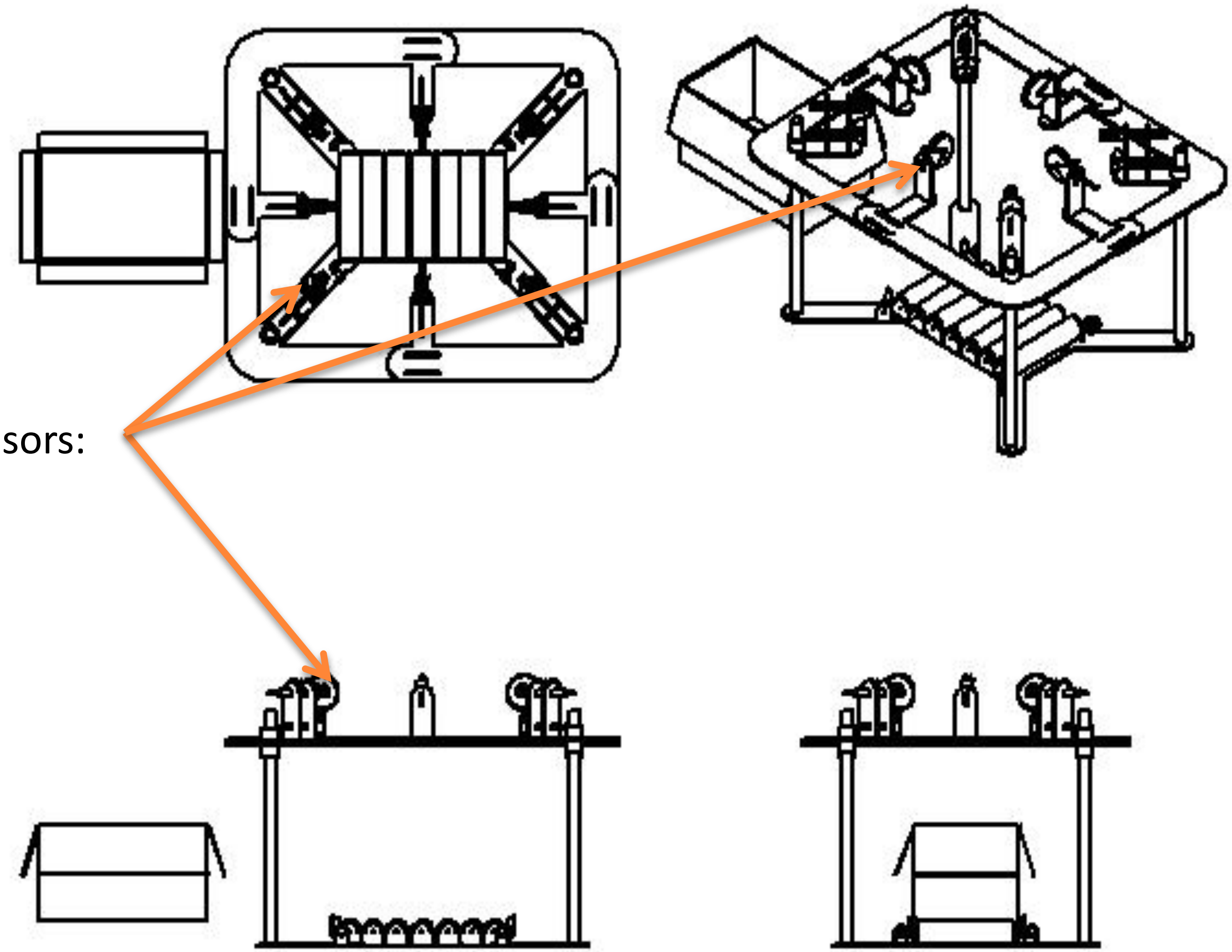


Base 2 Design Overview

- Lowering assembly
- Four side positioned rollers to compress the flaps



Base Design 2



Flap
Compressors:
Rollers

Contrast Base 1 & Base 2

Base Design 1

- Advantages
  - Less movement required
  - Less weight on the lifting mechanism
- Disadvantages
  - More complex base
  - Costs more

Base Design 2

- Advantages
  - Cost less
  - Easier to clean
  - Less maintenance
- Disadvantages
  - Has to be more centrally located
  - Higher chance of deforming the box

Contrast base design 1 & base design 2

- The main differences between base design 1 and base design 2 are:
  - Flap Compressors: Pinchers
  - Flap Compressors: Rollers
- Operating speed is a key factor in our choosing a design

Base 1: Operation Speed

- With all Lift Mechanisms

Base Design 1 (with vacuum suction)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Pinchers	1
Vacuum	0.75
Vacuum pulls back	.5
Forks (horizontal)	0.25
Forks (vertical)	1
Push the box out	1
TOTAL	6

Base Design 1 (with air jets)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Pinchers	1
Forks (horizontal)	0.25
Forks (vertical)	1
Air jets	.5
Push the box out	1
TOTAL	5.25

Base Design 1 (with both suction and air jets)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Pinchers	1
Vacuum	0.75
Vacuum pulls back and air jets	.5
Forks (horizontal)	0.25
Forks (vertical)	1
Push the box out	1
TOTAL	6

Base 2: Operation Speed

- With all Lift Mechanisms

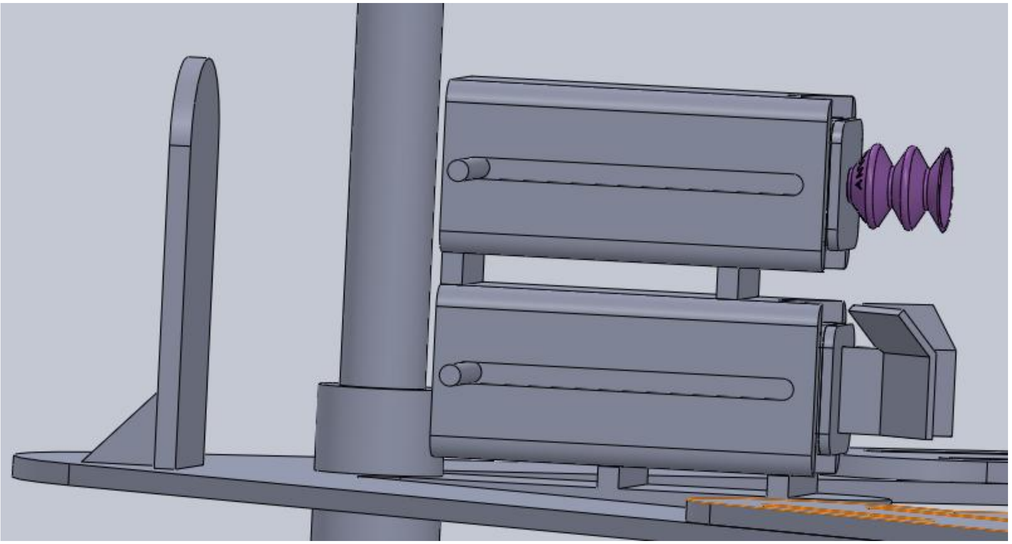
Base Design 2 (w/ suction)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Vacuum	0.75
Forks (vertical)	1
Push the box out	1
TOTAL	5.5

Base Design 2 (w/ air jets)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Air jets	0.5
Forks (vertical)	1
Push the box out	1
TOTAL	5.25

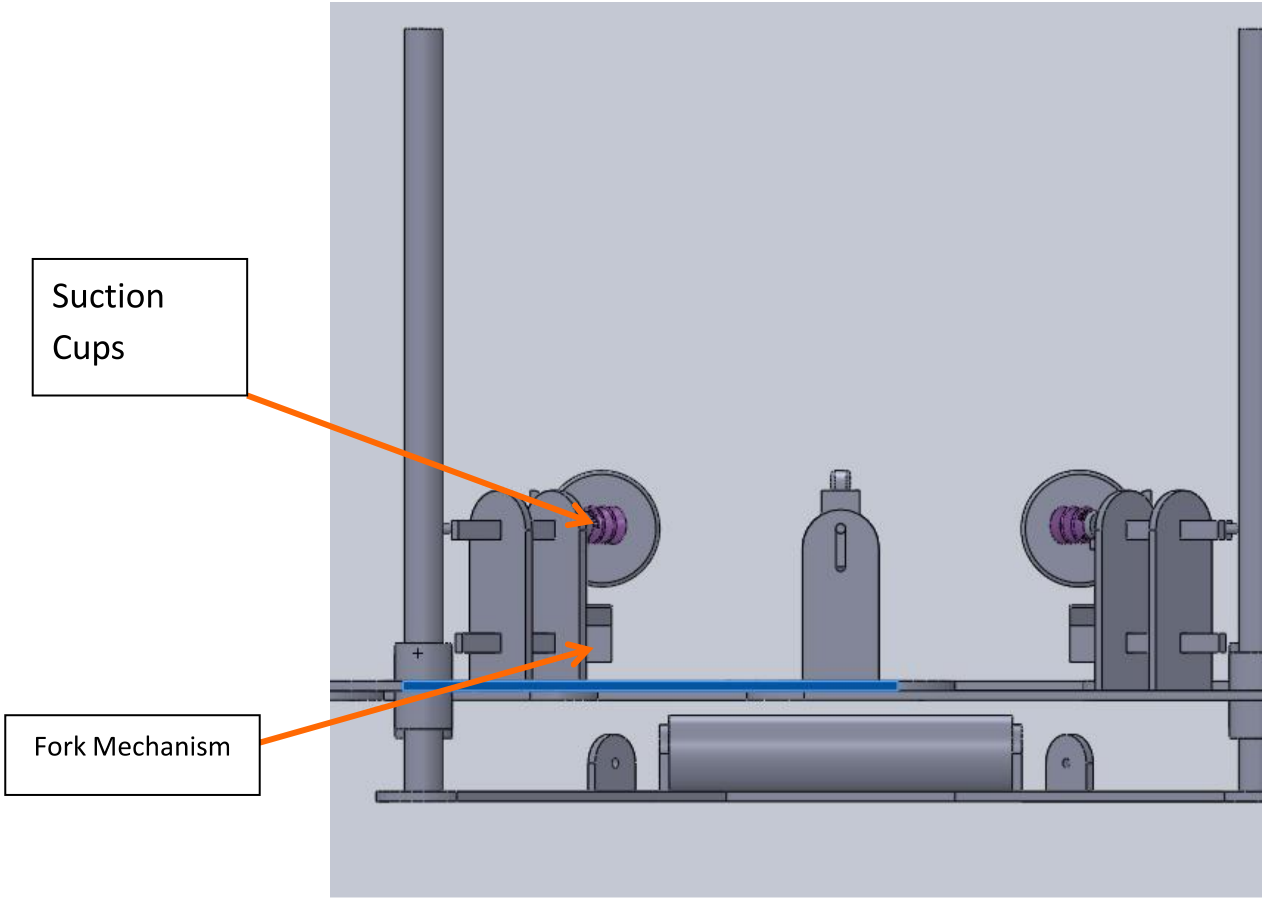
Base Design 2 (w/ suction and air blown)	
Part	Movement Time (seconds)
Line the box in the machine	1.5
Lower system	1
Forks (horizontal)	0.25
Vacuum pulls back and air jets	0.75
Forks (vertical)	1
Push the box out	1
total	5.5

Suction & Fork Mechanism

- Placed on the 4 corners of the machine
- Horizontally extends a maximum of 3 inches
- Will retract slight pulling the bag away from the box
- Operated using a pneumatic piston:
    - 1/2 in bore, 3 in stroke

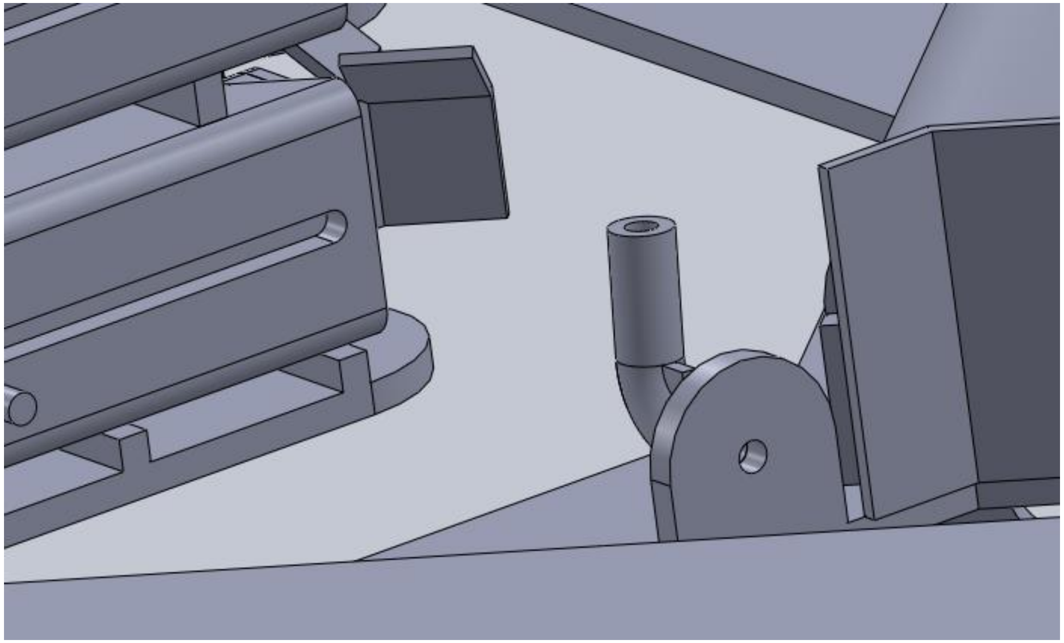


LIFT MECHANISM DESIGN 1:

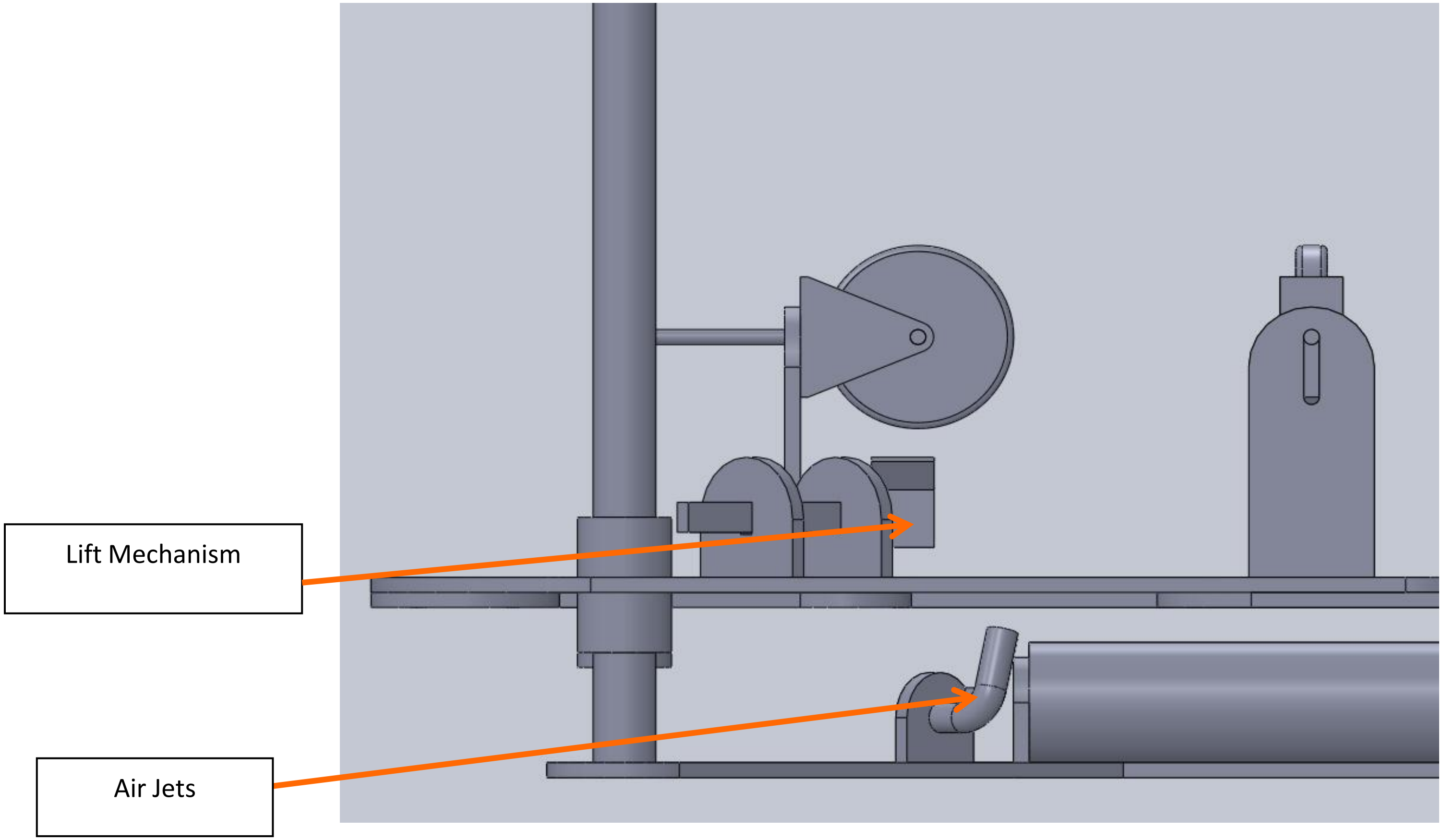


Air jets & Fork Mechanism

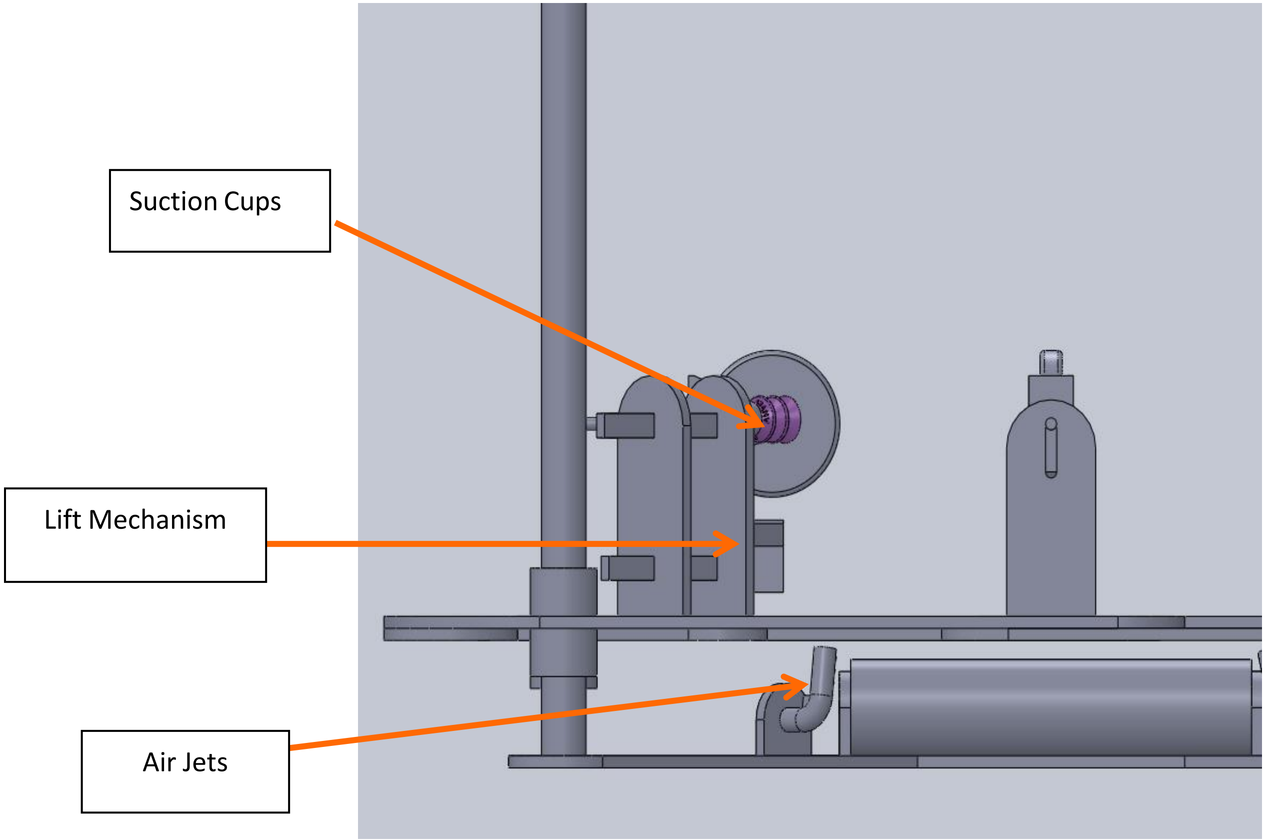
- Attached to the base system
- Place under the four corner of the of the box
- Modular hosing connected to a pneumatic line
  - Pressure of 50 PSI



Lift Mechanism Design 2:

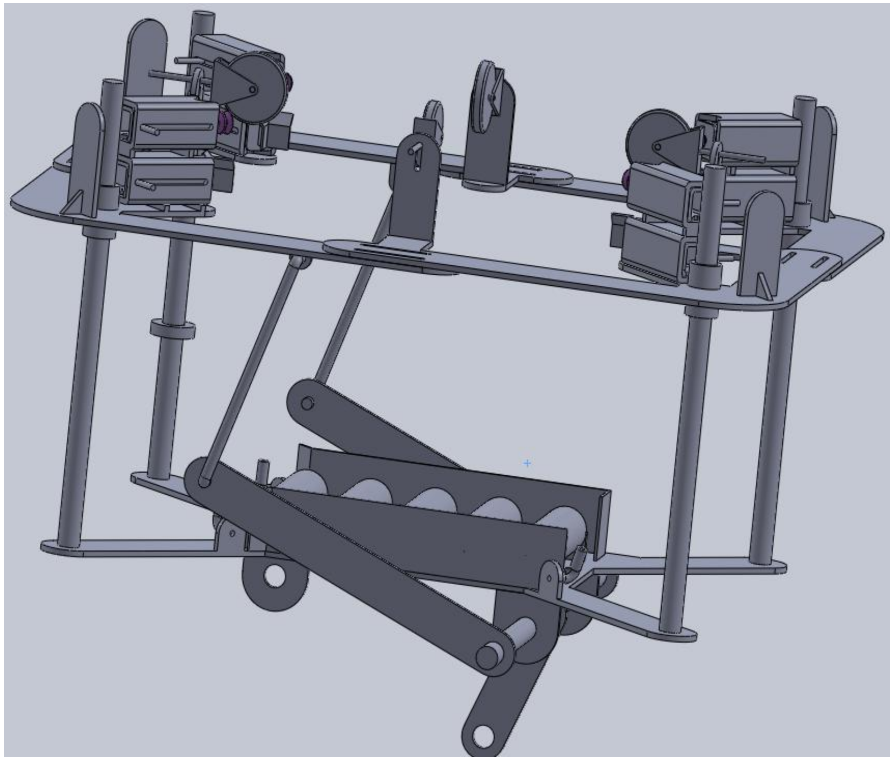


Lift Mechanism Design 3 :



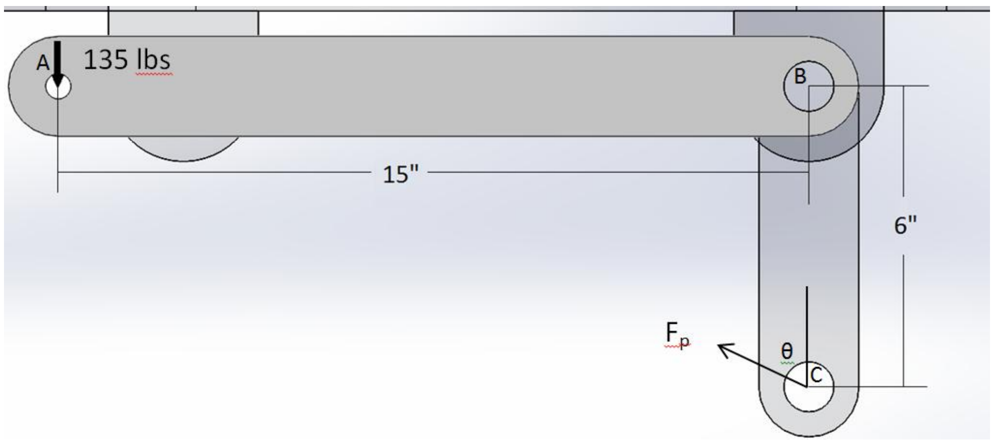
Vertical Adjusting Assembly

- Pneumatic cylinder power leg lift system
- Attach to either base versions



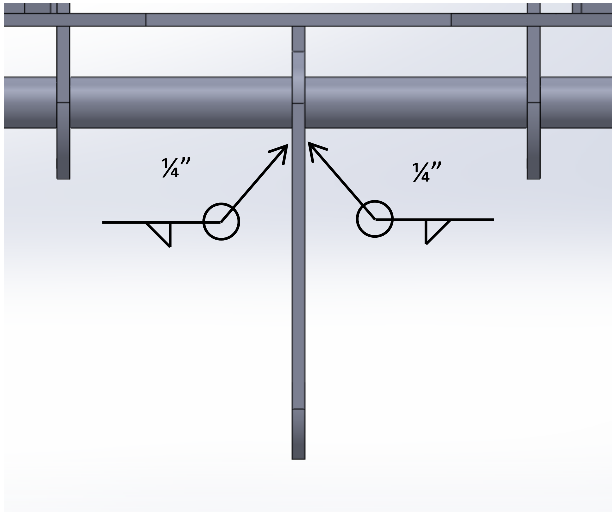
Vertical Adjusting Assembly Calculations

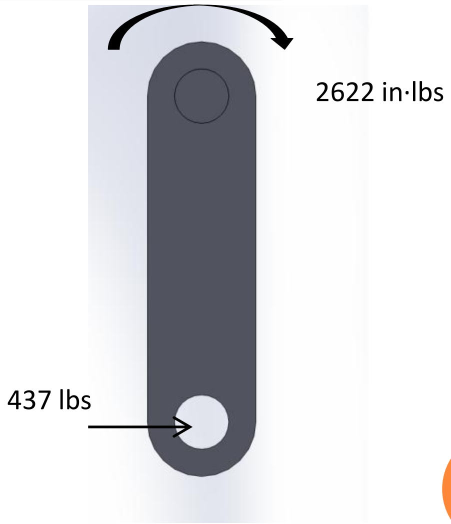
- $M_B = 135\ lbs * 15" = 2025\ in \cdot lbs$
- $\theta = 64°$
- $F_{Pmin} = \frac{M_B}{\sin\theta * 6"} = 375\ lbs$
- **Piston Size Analysis:**
- $P_{max} = 110\ psi$
- $F_{Pmin} = \frac{P_{max}}{A} = 375\ lbs$
- $A = \frac{\pi(D-d)^2}{4}$
- $D = 3"$
- $d = .75"$
- $F_{Pmax} = 437\ lbs$



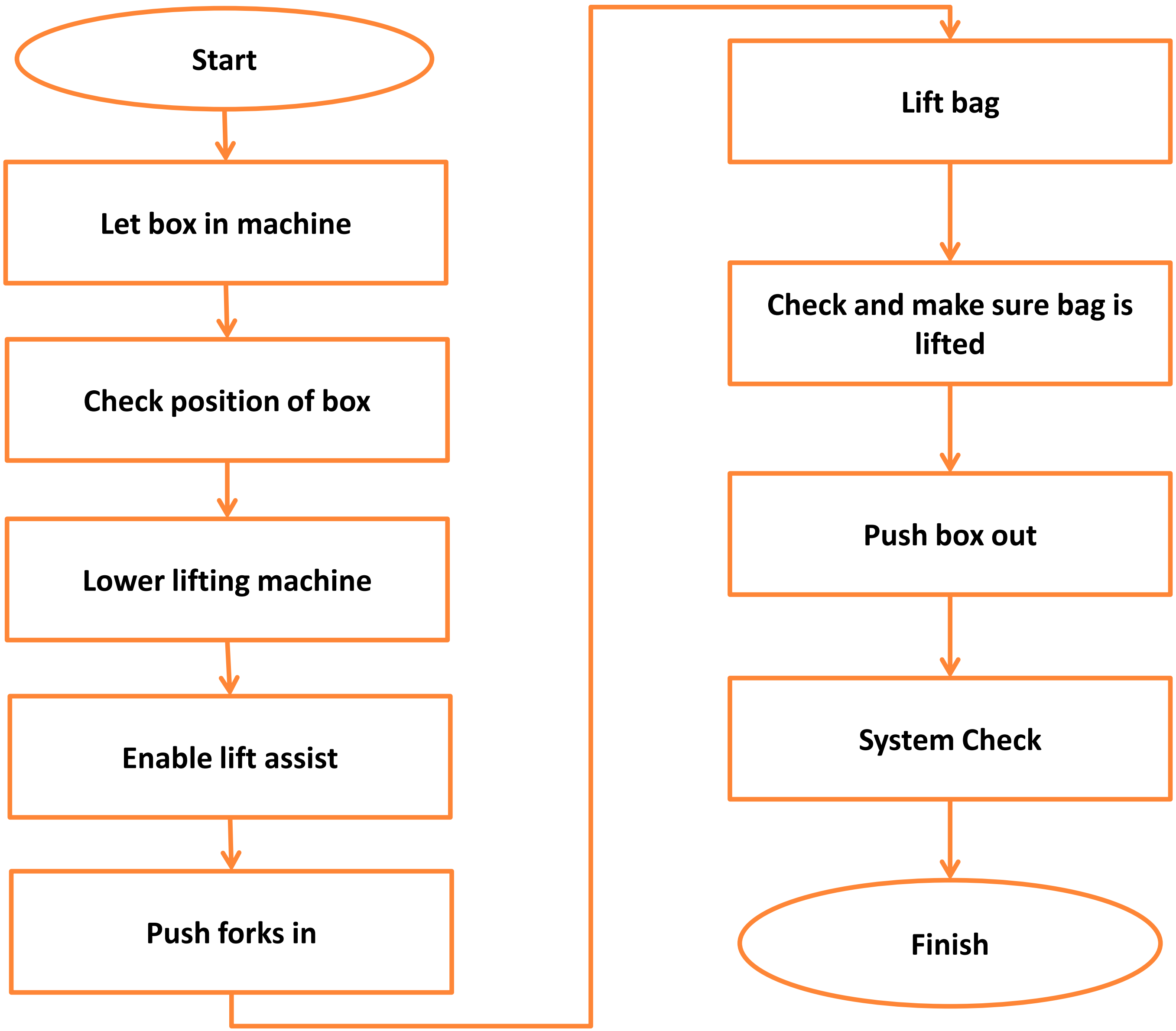
Weld Analysis

- Jamming Situation
  - Where: E60xx
- $h = Weld\ throat\ (in)$
- $r = radius\ of\ bar = \ .5\ in$
- $J = .707hJ_u$
- $J_u = 2\pi r^3$
- $A = 1.414\pi hr$
- $M_{Bmax} = 437\ lbs * 6" \ = \ 2622\ in \cdot lbs$
- $V_{max} = 437\ lbs$
- $\tau' = \frac{V}{A} = \frac{437lbs*0.5}{1.414*\pi*\frac{1}{4}in*0.5in} = 393psi$
- $\tau" \ = \ Mr/J \ = \frac{2622in\cdot lbs*0.5in*0.5}{0.707*\frac{1}{4}in*2*\pi*(0.5in)^3} =$ $4722psi$
- $\tau = \sqrt{\tau'^2 + \tau"^2} = \sqrt{393^2 + 4722^2} =$ $4738psi$
- $\tau_{permisible} = 0.4 * 30kpsi = 12\ kpsi$
- $n_s = \frac{\tau}{\tau_{permisible}} = 2.53$





Programming



WHAT TO DO IF JAMMED 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.

Recommended Design

- 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.

DESIGN BUDGET COMPARISONS

- Prototype Base 1 Design Budget
  -
- Prototype Base 2 Design Budget

Estimated Prototype Budget

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
4	**Pololu Servo motors (583 oz-in)**	**$59.95**	**$239.80**
1	Speedaire Pneumatic piston (3in bore, 6in stroke)	$ 268.80	$268.80
8	Bimba Pneumatic piston (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6,680.38**

Base Design 1 (with ONLY suction)

Estimated Prototype Budget

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
4	**Pololu Servo motors (583 oz-in)**	**$59.95**	**$239.80**
8	Steel Conveyor Rollers	$22.03	$220.30
1	Speedaire Air cylinder(3in bore, 6in stroke)	$ 268.80	$268.80
4	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
3	**Modular Air hose system (packs of 10)**	**$10**	**$30.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6776.94**

Base Design 1 (with ONLY air jets)

ESTIMATED PROTOTYPE BUDGET

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
4	**Pololu Servo motors (583 oz-in)**	**$59.95**	**$239.80**
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Pneumatic Cylinders (small cylinders)	$28.71	$229.68
8	Steel rod		
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
3	**Modular Air hose system (packs of 10)**	**$10**	**$30.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6822.94**

Base Design 1 (with both)

Estimated Prototype Budget

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
3	**Wheels (pairs)**	**$9.25**	**$27.75**
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6580.89**

Base Design 2 (with ONLY suction)

ESTIMATED PROTOTYPE BUDGET

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square tubing (1.5”x1.5”x4’) 11 gauge	$17.52	$17.52
1	Square tubing (2”x2”x4’) 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
3	**Wheels (pairs)**	**$9.25**	**$27.75**
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
3	**Modular Air hose system (packs of 10)**	**$10**	**$30.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6564.89**

Base Design 2 (with ONLY Air Jets)

Estimated Prototype Budget

Quantity	Description	Unit Price	Total + Shipping and tax
1	Steel plate (4 ft X 4 ft X ¼ in, A 36)	$ 137.12	$137.12
1	Steel Shaft (8ft length & 2in diameter)	$86.48	$86.48
1	Square metal tubing (1.5"x1.5"x4') 11 gauge	$17.52	$17.52
1	Square tubing (2"x2"x4') 0.25 wall	$34.24	$34.24
8	Steel Conveyor Rollers	$22.03	$220.30
8	**Suction Cups**	**$ 5.75**	**$46.00**
1	Speedaire Air cylinder (3in bore, 6in stroke)	$ 268.80	$268.80
8	Bimba Cylinders (1/2 in bore, 3 in stroke)	$28.71	$229.68
1	Pneumatic tubing (50ft rolls)	$13.00	$13.00
3	**Wheels (pairs)**	**$9.25**	**$27.75**
1	Programmable Logic Controller	$2,000	$2,000.00
1	Power Supply	$800.00	$800.00
3	Pressure Sensor	$130.00	$390.00
4	Wire	$15.00	$60.00
2	Photo Sensors	$100.00	$200.00
10	Flow rate control valves	$25.00	$ 250.00
10	Control Valve	$125.00	$1,250.00
3	**Modular Air hose system (packs of 10)**	**$10**	**$30.00**
1	Igus Chain	$50	$50
	Misc.		$500
		TOTAL:	**$6510.89**

Base Design 2 (with both)

COST/BENEFIT ANALYSIS

- Current facility cost:
  - Four shift at 2 people/shift = 8 workers on the line
  - Estimated $12/hr = 25,000 per year for each employee
  - Account for benefits at 40% of the annual salary

    = $35,000 total year, per employee
  - Costing the facility of $280,000 per year for that line

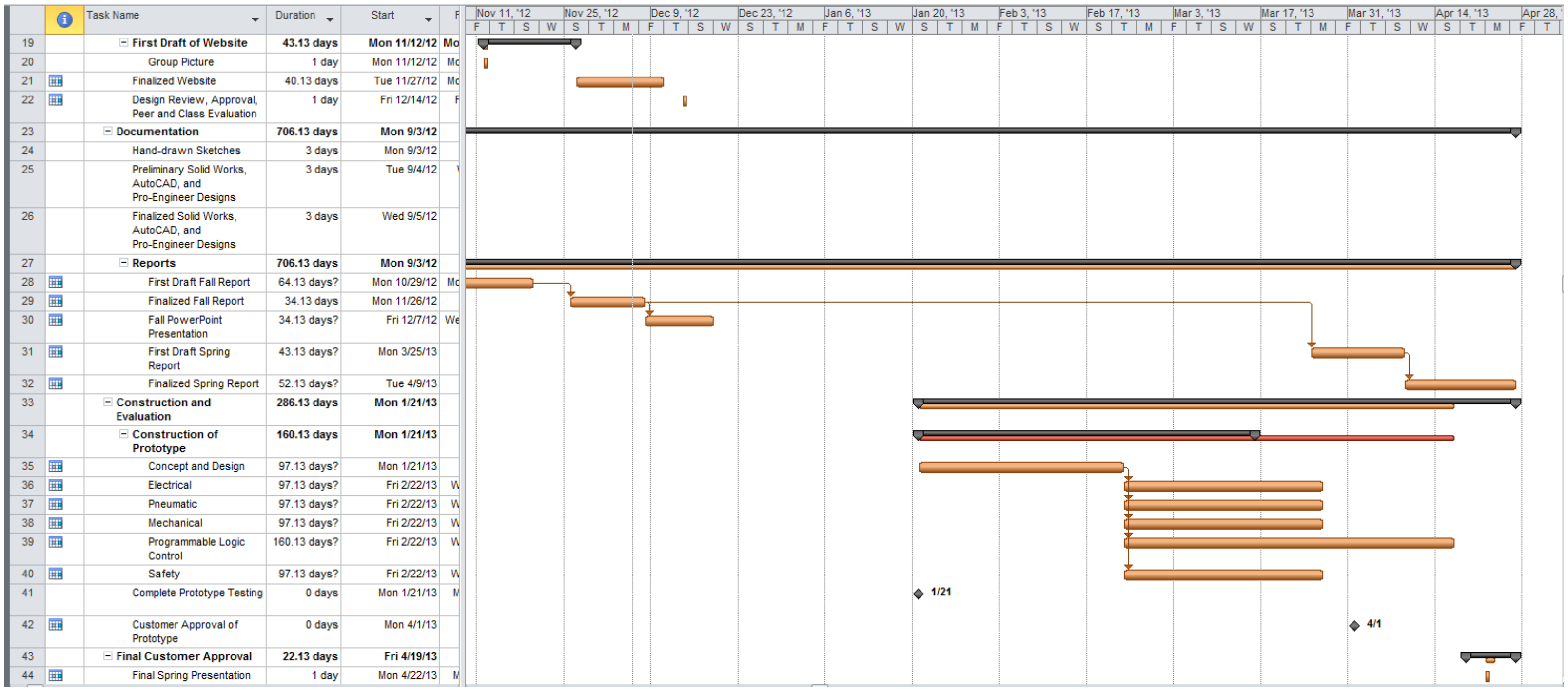
- Estimated price of finished product will cost:
  - $100,000 – One time cost

LOAN PAYOFF

Loan Pay Off	Year 1	Year 2	Year 3	Year 4	Year 5
Beginning Balance	$100,000	$82,954	$64,545	$44,663	$23,190
Interest Rate	8.00%	8.00%	8.00%	8.00%	8.00%
Interest	$8,000	$6,636	$5,164	$3,573	$1,855
Annual Payment	$25,046	$25,046	$25,046	$25,046	$25,046
Principal	$17,046	$18,409	$19,882	$21,473	$23,190
Ending Balance	$82,954	$64,545	$44,663	$23,190	$0

Spring Semester Plans

- Gantt Chart



ID	Task Name	Duration	Start	F
19	First Draft of Website	43.13 days	Mon 11/12/12	Mo
20	Group Picture	1 day	Mon 11/12/12	Mc
21	Finalized Website	40.13 days	Tue 11/27/12	Mc
22	Design Review, Approval, Peer and Class Evaluation	1 day	Fri 12/14/12	F
23	Documentation	706.13 days	Mon 9/3/12	
24	Hand-drawn Sketches	3 days	Mon 9/3/12	
25	Preliminary Solid Works, AutoCAD, and Pro-Engineer Designs	3 days	Tue 9/4/12	\
26	Finalized Solid Works, AutoCAD, and Pro-Engineer Designs	3 days	Wed 9/5/12	
27	Reports	706.13 days	Mon 9/3/12	
28	First Draft Fall Report	64.13 days?	Mon 10/29/12	Mc
29	Finalized Fall Report	34.13 days?	Mon 11/26/12	
30	Fall PowerPoint Presentation	34.13 days?	Fri 12/7/12	We
31	First Draft Spring Report	43.13 days?	Mon 3/25/13	
32	Finalized Spring Report	52.13 days?	Tue 4/9/13	
33	Construction and Evaluation	286.13 days	Mon 1/21/13	
34	Construction of Prototype	160.13 days	Mon 1/21/13	
35	Concept and Design	97.13 days?	Mon 1/21/13	
36	Electrical	97.13 days?	Fri 2/22/13	W
37	Pneumatic	97.13 days?	Fri 2/22/13	W
38	Mechanical	97.13 days?	Fri 2/22/13	W
39	Programmable Logic Control	160.13 days?	Fri 2/22/13	W
40	Safety	97.13 days?	Fri 2/22/13	W
41	Complete Prototype Testing	0 days	Mon 1/21/13	M
42	Customer Approval of Prototype	0 days	Mon 4/1/13	
43	Final Customer Approval	22.13 days	Fri 4/19/13	
44	Final Spring Presentation	1 day	Mon 4/22/13	M

References

- Pearsons Packaging Systems. Digital image. Model UC15.Web. Nov.16 2012. <http://www.pearsonpkg.com/products/showCategory/Bag-Inserters-Uncuffers>.
- K&R Equipment, Inc. Digital image. PBD-FC™ Polybag In-Box Decuffer Folder Closer. Web. Nov.16 2012.< http://www.kandrequip.com/products_pbd.html>.
- OK International Group. Digital image. Supercloser SC400™ Polybag-in-Box Decuffer Folder Closer.Web. Nov.16 2012. < http://www.okcorp.com/products_decuffer_sc500.html>.
- 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>.
- Matrix Material Handling, Inc. Digital image. Belt Driven Roller Conveyor. Web. Dec. 1 2012. <http://www.wayneautomation.com/bag_uncuffer.html>.

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Thank you for your time!

QUESTIONS???