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INSCO Group Seal Stamping Process Design

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INSCO Group Capstone Project
Team 7
The Seal Stampers

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Abstract

It is not unusual for a company to miss out on potential profits simply because they cannot produce a desired quantity with the equipment they own. In some instances, a manufacturers process is streamlined to the point where overproduction becomes a possibility. Efficient companies have the luxury of being able to meet demand quotas, stockpile product for future orders, and spend time on research and development projects. How well a system is designed can either lift a company to monopolistic power or quickly send it into bankruptcy. Businesses that rely on manufacturing products as means of revenue must stick to a very precise set of specifications as a model but be able to flex to a changing market or any problems that may arise.

The project in question focuses on the Insco Niantic Group in Lincoln, Rhode Island. The company produces a variety of mechanical seal components such as o-rings, gaskets, and other miscellaneous products. Insco does not produce considerably large batches of a single type of seal because their customer base only requests small batches of custom made seals. This prevents the company from being able to stockpile product for later dates because it is impossible to anticipate demand of such a volatile commodity. Instead of designing a system to pump out large quantities of seals, it would be a better idea to design a system that can quickly change what product is being produced. The most time consuming portion of a batch of any size is the preparation period. During prep time, the seal presses must be loaded with the appropriate die punch, controlling program, and calibrated to prevent failure. Raw material must also be sized down to a width that the seal press is capable of handling. In short the goal of this project is not to increase production speed but rather upgrade the rate at which different products can be produced.

Contents

List of Acronyms

CAD	Computer Aided Design
OSHA	Occupational Safety & Health Administration
QFD	Quality Function Deployment
URI	University of Rhode Island

Nomenclature

W	Width of slit material
n_L	number of parts (Length)
T	tolerance between parts
n_W	number of parts (Width)
t	total stamping time
n_{Total}	number of parts (Order Total)
D	Diameter of part
L_{Total}	Total Length of Material required for Order
R	Strokes per Minute

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1 Introduction

The task given from Insco was a complete redesign of one of their seal stamping operations. This operation started with the preparation of the raw material for manufacturing. The raw material is ordered in fifty foot lengths and varied in width from thirty-six to forty-eight inch widths. The current process involves breaking the material down to a desired three inch width roll. This first process of preparation involves an electric slitting machine. The raw material is fed through the machine which has cutting wheels which slice the material to the desired width. As the material is cut it is collected on the ground, once the entire roll of material is processed through the slitting machine it moves to the next step of rolling the material.

The rolling process starts with attaching one of the ends of the cut material to the motorized rolling mechanism. Once the first section of material is attached the motor responsible for turning the shaft is operated through a foot pedal that the user can regulate the rolling speed. As the user is controlling the rolling speed, he/she also manually guides the material while it is being rolled. Once the end of the section is reached the user stops the motor. Next the user fixes another section of prepared material to end of the previously rolled section. This process is called Splicing , it starts with trimming the ends square that will be mated together. After the ends are trimmed they are cleaned with water and then dried, next the glue is applied to both ends and pressed together. After the glue has been given sufficient time to dry, masking tape is applied to ensure the ends stay bonded together. Then the user moves back into position for the rolling process, and rolls the newly spliced section onto the mechanism. The splicing and rolling process continues until five sections of prepared material and properly spliced and rolled. Next the pre-rolled material is moved onto a feeding mechanism, and the end is started into the preco stamping machine. Next the user selects the specific program through the interface on the preco, then the user examines the process until the desired number of parts manufactured is reached.

The goal of the project was to analyze the entire process and re-evaluate how it could be done differently to optimize the output while keeping high precision in mind. This optimization would decrease operating costs such that the company could take on new clients with the ability to offer competitive pricing despite the initial set-up cost. The first step of analyzing is recording each step of the process such that the individual estimated time can be calculated. Once these time studies have been properly parameterized, then a model can be made to accurately approximate the time required for manufacturing a given number of parts. Now each step can be reviewed and the optimization can begin. The optimization process is extremely complex and requires knowledge of each step such that improvements in certain steps do not complicate other areas. Once these optimizations have been theorized, they must be conceptualized and tested. This is where the initial designs will be revised until the desired outcome is reached.

2 Project Planning

For this project, the plan was essential to success. Due to the nature of senior year and the number of projects and assignments for all of the classes the plan must utilize and optimize the amount of time spent that is necessary. The schedule for this group was therefore very periodic in nature because those were the best and longest times we could meet. The schedule can be divided into a number of sections where the purpose and length of the meeting will vary, and these sections are as follows: group meetings; personal meetings; exterior meetings, and assignments.

The teamwork during this project is necessary to complete all the work on time and well, and because of this, the group meetings were where a large portion of the work was completed. Even though all the group members were present for most of the meeting, that does not mean they were all working on the same project but they were working in unison. Many portions of this project were divided based on the qualifications of this project. Each of the members had their respective fields but was not limited to assisting in that section alone. Much of the work done was cross referencing another member's work, and because of this, the group meetings were the most efficient work environments. As mentioned previously, the meetings were periodic because of the hectic schedules. To get the entire group together it was much rarer to find a time for everyone to meet but realizing this was the most efficient use of time, the possible meeting times were taken advantage of. In the Gantt chart pictured in figure 20 it is shown the times possible for group meetings were mostly Thursday mornings for a few hours but as the schedule goes on the meetings become longer and incorporate Tuesday mornings more frequently. In the first semester it was Tuesday and Thursday but in the new semester it was Wednesdays and Fridays and the meetings continued as frequently as the first semester.

The personal meetings were divided by the person at the meeting and what was being worked on. Austin took a managerial role to designate the sections and also work on studies to improve the layout and process that was being asked to improve. Nick worked on the time studies and the proof that we were improving the process. Connor worked on machine selection, improving the layout, and designing and constructing a new pneumatic punch out station. Lincoln mostly worked on the CAD design of the Spooling cart and splicing station. Most of the personal meetings were done after or before a group meeting was taking place. Some of the personal meetings were with another member if necessary for both members to work on the project together. As the dates go on the meeting again become more frequent and longer as shown below. In the next semester Austin mostly worked on the brochure and poster and Connor worked on the building of the punch-out frame and Lincoln worked on the building of the spooling cart. This is shown in figure 21 in the appendix.

The exterior meetings include meetings with the company itself and meetings with Professor Nassersharif. There have been three meetings with Insco and also the presentation they gave initially for the problem on September 22nd, which was to decrease the minimum number of parts per job to increase the number of possible customers. There was one meeting with Rob to discuss the project goals and possible ideas. After the project had begun the CEO, Rob, who gave the problem initially, left the company with no warning to us or Professor Nassersharif. This raised the question of whether or not the project will still be in effect and if so then what will this new CEO want differently than Rob. The second meeting with Insco was with the new CEO, Dave, on the 18th of October. The group had to convince Dave to continue the project and understand what he wanted. After the meeting Dave decided to continue the project and also to broaden it to just improve the process wherever possible. This was good news and led the group to then take measurements of the floor plan currently being used. The third and final meeting was not with Dave but with Jeff, the head floor technician, to discuss floor plans and ideas he has had to improve the process. The fourth meeting was focused on finalizing the dimensions, such that construction could take place of the spooling cart, and the revised pneumatic punch out frame. The fifth and final meeting with INSCO was to install the finalized pneumatic punch out station, and then rigorous testing took place. In the Fall semester there were two meetings with Professor Nassersharif to discuss the concepts being generated by the group and the design review a month later. The concept meeting was to encompass the project details and possible areas of improvement that should be focused on. During this meeting the design notebooks were checked and graded as well as the ideas of the group and work achieved. During the second meeting the design would be reviewed and evaluated so the proof of concept and prototyping was not a waste of time. In the Spring semester we had an initial meeting with Professor Nassersharif to update what the status of the project was, and what the initial plan for the semester was. Throughout the semester a few more casual meetings with the professor took place such that our progress could be noted, and so the professor could provide his input while reviewing our designs, and future plans. This is shown in figure 22 in the appendix

The final section of the plan was the assignments to be given and completed throughout the semester, and this includes the individual assignments, progress reports, quizzes, lectures and presentations. The individual assignments included a patent search on the project and which ways we could use them to improve the designs. There was a QFD assignment to prioritize the aspects considered when designing the project. Another assignment was the concept generation where each member must have 30 designs to improve the process and discuss amongst themselves which is the best. There was a design specifications assignment where the aspects of the assignment were listed and discussed as opposed to the QFD where it is visualized. There were two quizzes on reading assignments throughout the semester. The progress reports had to be submitted every Monday before 5 pm and had to include project plan updates and tasks completed. There were two presentations in the Fall semester that had to be completed and they were on the critical design review and the proof of concept. The first presentation was supposed to include the top ideas being considered for implementation and the second presentation was on which idea was chosen and how the group created this idea and justifies it. In the spring semester we had one last presentation and it was on the Building and Testing. This presentations purpose was to update the progress made from the initial conceptualization to the physical building of our designs, and what test procedures were taken to find any additional revisions would need to be made. The final meeting with the professor was to discuss our redesigns and improvements that would be implemented for our final design. The final event that took place in the Spring semester was the design showcase. This showcase was where we presented our final constructed designs for URI Faculty, friends, family, and Sponsors. This is all shown in figure 23.

3 Financial Analysis

Since Insco is still in a recovery period from being run by the bank, it is imperative to keep the costs as low as possible on this project. Thankfully, some of the solutions that had been proposed have little to no cost, or can be fabricated in house at a fraction of the cost of retail machinery. Improvements such as the layout and the machinery capacity can be changed with just the cost of labor. Other ideas included expensive machinery and would not be recommended to management to purchase unless they feel it is necessary to make the initial investment. For example, the slitting machine that was researched and quoted seemed like a very useful machine with many other applicable functions, but with a price tag of $12,500, it would not be wise to go through with it. Instead, it would be more intelligent to focus on machinery that does not cost as much as a family sedan. The carts that hold and transport the reels of raw material is where we looked to invest funds because they are inexpensive to improve and would profoundly improve the process. When the rubber is not on the shelf, being slit, or being stamped, it is stored on the rolling carts. Financing carts that are specially designed for the current situation would vastly improve transport times and ergonomics and would cost less than a grand for a set of spooling and collection carts.

We proposed to build out new motorized spooling cart and the improved knockout frame system to accompany it. We looked to make the cart design at around $500 without a motor and no other investments. This initial thought was the bare outline of our project for it only included a frame, wheels, bar, and bearings. With the design looking to increase the length and also the width of the material being fed there are other side investments that were looked to be added such as a motor and the knock out system. The motor made the length of the rolls easier to work with and the knockout system allowed the width of the part to increase. From these two big side improvements the motor added about another $700 projected expense increase. The knockout system had many small parts to it and was projected to increase the expenses by another $387 as shown in figure 25 appendix B. Totaling the costs of what was spent on the knockout system the team finished it with only spending $88.49 as seen in figure 26 appendix B. The only cost that was not included in that analysis was the work expense which we projected to be about right with our initial analysis of 15 hours. This expenses was $0 because we werent paid to fabricate it and didnt take up any employee time.

When comparing our spooling cart expenses, we projected a cost of $290.71. Without the motor, the expenses that were actually made were only $390.65. This was still under the budget that we initially proposed because our design changed to cut the collection cart section that would have added $570.58 to the project. We put in about 25 hours of fabricating work on the cart itself but again the hourly pay was not added because we were not getting paid for the work.

One section of our initial financial analysis that we researched for the company was the new die fabrication which is more for the future plans of the project. With information being taken from the floor engineers and employees we projected an $85 expense per die. It was later brought to our attention that a new die was made during the time that we were working on the project and the cost was about $235 for a new die. This may skew the final financial results for the future but because we made a new system that can handle longer and wider die arrangements we still recommend that the company carries out the needed die redesigns. At this new price, the optimized dies will bring a fast return of investment.

We studied one part the gets run at 2.5 inches that would be optimized at 5 inches wide we could see returns in the near future. Upon the motor expense and installation as well as a new die at this optimal width we could expect a final expense at about $1464.14. With the time savings study that our team performed where we project a saving of 27.38 minutes every job, it would take about 53 job orders to see a full return on the investment as shown in Figure 25 appendix B. With our tracking of jobs, that would translate to about 2 months time to overcome that investment.

4 Patent Searches

Even with a small budget, it was decided that a crucial component to the upgraded seal stamping system was a new cart to carry the reels of rubber around the factory floor. Currently, the operators have been splicing the strips of rubber into combined rolls to keep the machinery running without having to shut down. The problem is that only so many three inch wide strips can be merged before the reels become too heavy to handle. After about nine or ten strips, the roll weighs about 45 pounds, which is about the maximum that OSHA allows to be lifted by hand. In order to increase batch size, it is required to create a way to lift more burdensome rolls without causing harm to the staff.

To boost machinery capacity, the reels must become wider and have a greater diameter. To achieve target goals, the reels will weigh in the ballpark of 200-300 pounds; much heavier than legally allowed to lift without the help of machinery. To rectify this quandary, a cart that can hoist the rolls and ferry them across the factory floor would help tremendously. The company already has a machine used to roll the strips of rubber into a roll very quickly via a motor driven shaft, but this apparatus is stationary and must be unloaded by hand [**?**]. Given that the budget for this project is considerable small, professional grade machinery cannot be purchased and a reel cart must be designed and fabricated in house.

To gain ideas for the reel cart while making sure that no designs were stolen, four patents were located that are similar to the situation at hand. The first is the Patent 4,746,078 Reel Lifting & Support Device shown in figure 28 appendix C. This Device is relevant because has the ability to lift very large reels without minimal effort and does not require expensive motors or parts. It is simply a fulcrum placed on wheels and is a very nice example of what is needed for the project.

Next is Patent 4,447,012 Portable Reel Jack Stand shown in figure 29 appendix C. This machine would be awkward to use in this situation because the reel must already be placed on the ground or a secondary machine would be required to lift the reel onto it. However, it is a good example of how to raise a reel off a surface and move it around through the use of simple hydraulics. This type of machine would be more expensive than the Lifting & Support Device, but it would be more user friendly.

Third is Patent 4,762,291 Self Loading Reel Trailer shown in figure 30 appendix C. This device is very large, requires a truck to move, and is simply unnecessary to these circumstances. That is not to say that the designs of mechanical components on it are not absolutely genius. The trailers arms reach out behind itself to pick up a reel of enormous size and roll it onto its bed. To scale it down to a size more suitable, it would still take up a decent piece of real estate within the plant and probably take more time to design and build than what is acceptable, but that does not mean this is a bad patent to reference.

Finally, Patent 6,086,311 Handtruck With Deflectable Mandrel was studied shown in figure 31 appendix C. This design is quite similar to the Lifting & Support Device proving that simplicity is king when design machinery. This cart also includes a fulcrum on wheels to be operated by hand with a slight variation to the contact point for holding the reel. The mandrel that lifts the reels includes a joint so that it can get under the reel to be inserted and then locks into place as it picks up the roll. It is quite thin and can only lift rolls designed for it otherwise it may topple over and cause an accident.

The designs of these patents show that there are many different ways to accomplish the same task and that expensive machinery is not required to complete easy tasks. Even Einstein stated that Everything should be made as simple as possible, but no simpler. A cart to lift incredibly reels can easily be achieved with the correct shape and would not require motors or any costly parts. It is recommended that a cart with a hydraulic system is used because it can be built with minor costs, is easy to maintain, and would be the easiest for factory workers to use.

5 Evaluation of the Competition

In their most basic form, the products that are being produced at Insco are free of any patent restrictions. Aside from seals and o-rings made with newly developed materials, techniques, and technology, they are not controlled by federal law. This can be both an advantage and a disadvantage. On the plus side, Insco can produce any item that is ordered by a customer in the field, but the problem is, so can anybody else. Much like the steel industry, anyone who makes the initial investment and purchases the machinery necessary to make production happen can become a player in the business. The seal industry is no different and Insco has a countless number of competitors across the country. While each company may specialize in certain types of seals and try to avoid stepping on the feet of other companies, that does not mean competition is not present. Because so many mechanical components require fresh seals, companies must rely on sheer quantity of production to remain competitive. Factories that can manufacture more product with less waste of time and materials will obviously be able to profit more than a company that does not optimize their production lines.

The quality of the seals also crucial to the competitive stance of a seal manufacturing company. Since seals are used in so many mechanical components, it should be expected that every seal is no less than perfect. This is not always the case however, to remain competitive in the quantity aspect, some companies cut costs and limit quality control in order to meet orders. This can generate an imperfect fit of a seal and could result in machinery failure, which may mean lawsuits for the company. As production quantity increases, it becomes harder and harder to perform quality control. One operator cannot be expected to check every seal if continuous production is achieved. Simply checking the time is enough for a bad seal to make its way into the final batch. An autonomous system would have to be create if quantity becomes too large.

Because seals are mostly the same product despite what company produces them, and because quantity and quality go hand in hand, it should be expected of seal manufacturers to simply make the best product they can in the numbers they can achieve. For safety reasons, quality should never dip below the minimum required for a product. After quality is determined, then a company can work to produce as much of it as possible. When a steady form of profit is being produced, then the company can invest time and money in developing new products to be sold in the market. In order to truly remain competitive, the company must always be producing, improving, and changing.

6 Specifications Definition

The specifications of the design came from multiple sources and changed several times as well. The areas that added to the specifications came from the multiple CEOs, VPs, and sponsorship representatives that cycled through during the year. In the end we picked up many specifications that resulted in one big and vague outline for what we were going to accomplish. The leading specification was to increase the efficiency of the seal stamping process. This includes following OSHA safety requirements that would protect the workers on the floor. I our initial brain storm of ways we looked to define our project we wanted to optimize the stamping process and reduce the time that it would take for the material to complete a job to be prepared. Through this we compiled a list of company and design team specifications as seen in Table 1.

Requirement	Engineering Specification
Knockout Specifications	
Wider Material Strips	Optimize die arrangement- 2.5 in to 5 in
Consistent Knockout System	8 in parallel piston guides
Versatile Knockout System	14 in wide adjustable and rearrange able tips
Spooling Cart Specifications	
Cost Conscious	2 year ROI Max
Portable system	Rolling Spooling cart
Transportation Safety	2 Locking casters min
Manageable weights	Cart Weight ~ 22 lb
Increase Spool Length	300 ft
No Material Warping	Material in straight rolls
Safety Factor	SF 4 min
No Material Contamination	Keep rolls off the floor
	No grease bushings

Table 1: Specifications of Design

Following each requirement was difficult to come to a final solution for our project but we found that each was very important to satisfy the company and create quick overall system change. For the new knockout design, we created several solutions that allowed the user to adjust the configuration for the outer diameter and inner diameter pattern. Every product and die being run is different and require their own set of needs. To solve all of the knockout needs in one design we made is still run with their single piston arrangement but looked to have it push a changing number of pins through the cut material. The amount of stamped parts also changed for each so we looked to have t able to punch out up to 5 pieces in one stroke. The design also needed to punch out the outer diameter on the next stroke so the design was simply fabricated twice to accommodate.

When looking at what we wanted from a front end spooling cart there were many different options that did about the same thing. We wanted it to be compact and movable to a rolling cart that had that ability to move larger weights was a top contender in our designs and redesigns. Justify a cost for this was a nice requirement because it pushed the team to be creative and not feel bogged down by price as long as we could show that the investment was worth it. The basic structure was changed a couple times but we always looked to make sure the safety factor requirements were being met as well. We had many design options that included bushings and rolling on the floor or bunching up material but we found the material consistency is what was one of our highest priorities when manipulating and processing the product through manufacturing. Cutting out grease fil bushings and lifting the material off the ground and out of the buckets used prior was a must. Designs were expanded upon and rethought as we ran into complications so returning to our design specifications was very important.

7 Conceptual Design

As the progression of the seal stamping improvement project progressed so did the range and depth of the teams design concepts. After consulting with INSCO Group representatives and uncovering the system in more depth the capstone team found that the system could be vastly improved. The system had many flaws in the large array of subsections. Each member generated many designs to solve parts of the system with a total of one hundred and thirteen solutions. Not all ideas could be used but many were very similar and aided in creating a hybrid solution. The proposed solution took small parts from many of these ideas so the group could create an optimal system. The concepts that were used came from a few main ideas which included stamping die redesigns, slitter and splicing, waste knockout, and floor layout.

The final areas of the project had a large range of designs but by breaking each design down the four core areas of improvement led the group to our most successful idea. When the system is broken down there is a lot of waste when it comes to material preparation time and material, stamping rates and output, and operator utilization. Shown in the vast amount of designs there are plenty of material preparation carts, floor redesigns, and die redesigns which also calls for a more adverse knockout system. From the four main areas of improvement our team focused on refining each part and how to make the systems flow together.

7.1 Die Redesign

When discussing the die redesign patterns there was a consensus that it was resulting in one of the largest system set-backs. The current designs vary but generally are linearly oriented and ranging from about 2.5-inches wide to 5-inches wide. When inspecting the machine stamping face dimensions the team quickly learned that the machine could stamp up to 19-inches wide. Being an older tool it was deemed that creating accurate parts and not over stressing a more delicate tool that a 12-inch width would be more appropriate. From this discovery, there were several main talking points which included increased width of die and material strips being fed, increase in depth of the die arrangement, and positioning of part layout.

After reviewing the designs the width of the dies was found to be a realistic and good improvement with very little fall backs. The typical 3-inch strips could be quadrupled with a simple new and larger die. The output of parts every minute shows so much potential an improvement with little direct down side cost or time increases.

The idea of making the die size have more depth to them was heavily reviewed as a potential option as well. This configuration is shown in figure 1 The team studied the increased output and time for the machines to be reprogrammed in order for the waste to me taken out properly as well as the feed rate and progression that it would not create enough efficiency. The team looked at ideas to have a larger depth and found that setup times increased far too much and that the knockout system could not get accurate enough with time and resources available.

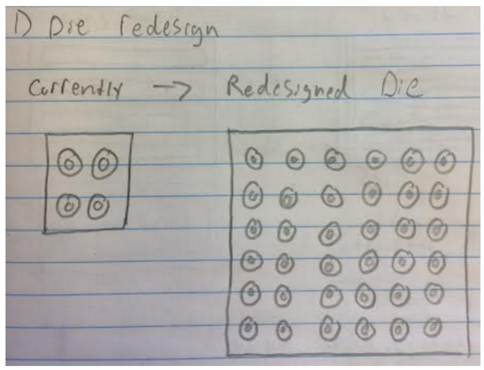

Figure 1: Die Depth and Width Increase

When the group considered the part layout of the die there were many possibilities and looked to implement the idea. The design as shown in figure 2 depicts how a linear layout could be offset so that the parts are stamped out in a reduced area. The advantages of this concept include a reduction in waste material and more room for extra parts to be stamped. While this seems to be common sense the offset pattern is more part specific. This small improvement is a great idea for the future of the company to take on but with the project outline ending with-in a year there were some flaws to trying to apply this. All the dies would need to be studied individually and improved which is an extremely time consuming task and more of a long-term goal. To optimize a few test parts was found to be the more appropriate task as we progressed with the entire project and this idea in general.

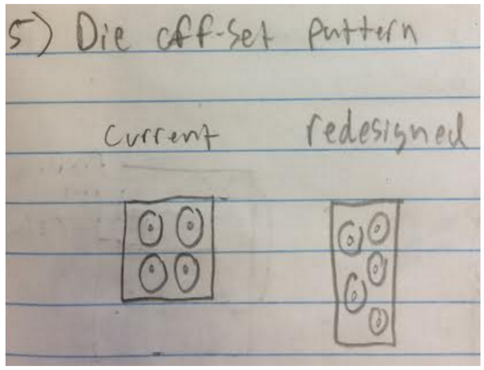

Figure 2: Offset Die Design

7.2 Slitting and Splicing

The concept generation from all the members showed a strong focus on the material preparation area. This includes the raw material at the slitter machine and to the splicing station until a roll of material is ready to be fed into the stamping process. With a high importance of staging more material more quickly the team moved to find possible solutions. With the concepts and further research the team looked more directly at creating a larger or longer roll and ease of splicing material ends together.

Many ideas came up to create a more continues system so the machine had less down time. Original concepts of a material accumulator were brought up. As shown in figure 3 the material would be run through a series of rollers and tensions so that one end was not dependent on the other for a period. The stamper could progress the material while there was an excess of material to be taken up. During this break the operator would be given time to work on splicing the other end of the material to newly added strips. This continuous flow of material would only have to end when the job was complete which satisfied our initial thought of stream lining the system more but has complications. After more research was preformed there was a large amount of concern as to the worker being over loaded. With little time to check on the controls, parts, and knockout area the team deemed it far more unsafe. This design also complicated the teams desire to make the process a dual stamping machine system.

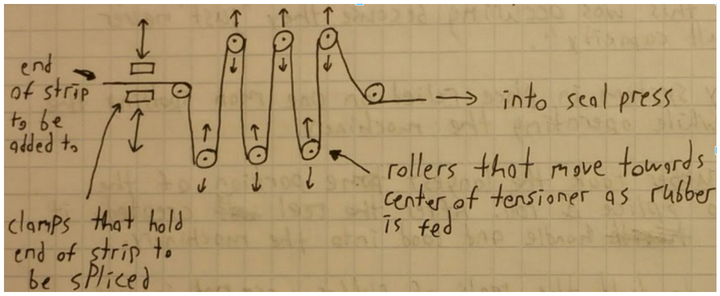

Figure 3: Material Accumulator

The teams concepts also focused on improved ways to bound the ends of the materials so splicing material was less time consuming. We created concepts to dove tail the ends together but it proved to only be more time consuming and a larger waste of material. Ideas were drawn up to make simple connectors that held the ends together (shown in figure 4). This idea interfered with the safety of the machines as well as increase costs and dimension tolerances. With very little improvements seen from a vast amount of research the group reconsidered the concept previously used but integrate it in the slitting area. With this new concept the worker would cut down on travel time and all operators would already have the appropriate training to splice material together.

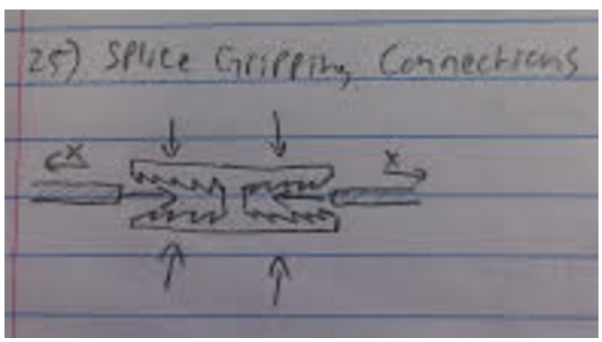

Figure 4: Splice Connector

In order to work multiple ideas into on process we wanted to optimize the width of the material which created an area of the project that forces the fixtures to work on material ranging from 2.5-inches to 12-inches. We looked for a solution that could accommodate to this design specification. This cut some of our ideas out but made characteristics like rolls and carts more attractive. Concepts we created that used plywood walls to organize the material (seen in figure 5) showed to not be accurate enough or efficient enough to accumulate late amount of prepared material in a short amount of time like a roll of material could do.

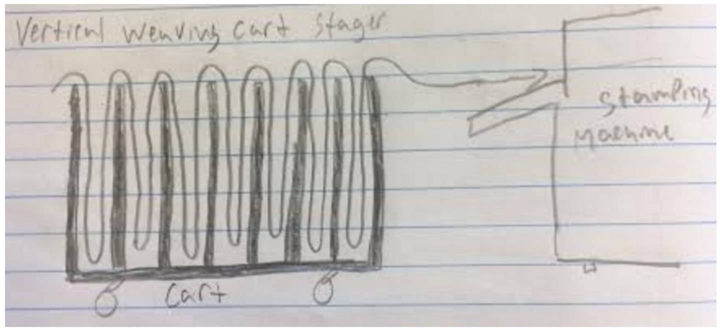

Figure 5: Weaving Material Cart

7.2.1 Slitting Machine

Insco Niantic Seal Company currently owns two seal press machines functioning under one operator. Large rolls of rubber, plastic, and other raw materials are shipped to the factory and are stored on shelves until they are needed. When an order comes in, the raw material is selected and sent through a slitting machine to be prepped for the seal presses. The presses can only intake strips of material that are a maximum of twelve inches wide. After the strips are cut from the large rolls, the operator glues the butts of the strips together to minimize having to reset the presses to work on a new strip. The presses take in the strips, punch out the seals, and move them onto the punching table. Pneumatic pistons punch the seals and the excess into appropriate bins where they are inspected and readied for the customer.

When a good chef wants to prepare a meal, they first consult the recipe they are attempting to create and they might head to the market to pick up any ingredients that they do not have stocked up. Then they lay out all the components so they are within arms reach when it is necessary to use them and preheat any cooking surfaces. Once everything is prepped, the chef can begin cooking and all the steps are executed quickly and correctly. A bad chef will not take any time to prepare what they are making, maybe even forget ingredients that were crucial to the dish, and then probably burn it in the time they were looking for necessary items. The point is, the chef that set up their work station before attempting anything had a much easier time creating the product and did not end up burning the house to the ground. The same can be applied to this process, meaning the more that can be prepped before running the system, then seals could be created much quicker and the easier it will be for the operator.

Before raw material can be fed into the Preco machine, it must be sized down into strips that the press can handle. As common sense may dictate, if the Preco machine can handle a twelve inch wide strip, then that width should be used to maximize output. This is not the case in the current setup. The factory is using strips of three inch wide material to be fed into the Preco. Reasons for this occurrence are vaguely explained but it is assumed that the operator just feels more comfortable with a lower output as increasing output increases the workload. To help escalate batch yield and sooth worker's anxieties, it is recommended to expand the strip width to at least ten inches wide and if the operator feels capable, maximum capacity can be attempted. The only problem with increasing the strip size is the slitting machine that creates them.

Insco owns a Campbell-Randall leather strip cutting machine with a cutting surface of 1 9. This machine can easily handle cutting strips of ten or twelve inches wide, but when a fifty foot long, forty-eight inch wide roll of raw material needs to be processed, the job can become slightly awkward. The rolls must be fed through multiple times and with only one operator, the task can become quite tedious. One roll at forty-eight inches wide being cut into 10.5 inch strips must be fed through two times to obtain four strips and six inches of excess is created. This can become quite a lot to ask of a worker who is constantly on their feet moving materials around all day. The strips that come out of the slitter are dumped into a large drum and can become tangled and knotted, not to mention quite heavy. If a slitting machine with a cutting bed wide enough to cut a large roll of raw material all at once was purchased, slits could be produced instantly, stored on individual reels, and readied to be adhered. This not only saves time in the prepping process, but also minimizes waste and improves ergonomics.

If strips were cut at maximum width all during one pass through the slitting machine, then it would be very easy to roll them onto one reel cart with four or five rolls stationed right next to each other. From there, one roll at a time could be transferred onto a secondary reel cart. When one roll is completely transferred, the next roll could easily be spliced onto the previous one. All of the rolls could be created via the slitting machine and combined into one super roll in half the time that it takes currently. According to time studies, it currently takes 29 minutes to take one roll of raw material, cut it into the three inch wide strips and splice them into one roll to fed into the machine. This super roll is about 800 feet long and would take the Preco about 35 minutes to process into seals. If a new slitting machine was purchased and cut the slits into 11.8 inch wide strips, it would take about 10 minutes to create the strips and combine them into the super roll. Because this roll is wider, the roll would only be 200 feet long and the Preco could process it in 10 minutes. With the new machine the time to would be reduced from over an hour to about 20 minutes, or a 30% increase in production speed.

The downside of suggesting to purchase a new slitting machine is that while it may have a significant increase in production, it is not a budget piece of equipment. Insco recommending contacting one of their vendors that they have used in the past and he recommended a top of the line slitting machine used in high scale production. His machine was quoted for for between \$20,000 to \$25,000. Upon further research, the company that produced their current slitting machine, Campbell-Randall, also produces a leather strip cutting machine with an appropriate cutting bed and was quoted at \$12,500. This is considerably less than the previous quote, but it is still quite a large sum of money for Insco to spend on this type of instrument. Refer to Table 2 for the list of researched slitting machines. This type of machine, however, has such a large spectrum of tasks that it can accomplish, it will be up to the management of Insco to decide if they would like to invest in this component.

Slitter Machines								
Manufacturer	Model	Slitter Width	Arbor	Weight	Price (estimate)	Description	Available Accessories	Shipping Location
Van Mark	Trim-A-Slitter S36C	36"	2"	103 Lbs	$1,735.00	Hand Crank slitter, standard table top slitter 36"	Motor Drive, Ribformer, Perforator, Worktable	Michigan
Van Mark	Trim-A-Slitter S48CB	48"	2"	131 Lbs	$2,542.32	Hand Crank slitter, standard table top slitter 48"	Motor Drive, Ribformer, Perforator, Worktable	Michigan
Van Mark	Industrial Slitter Combo SCI48	48"	2"	265 Lbs	$4,220.41	Industrial slitter with motor drive standard. Installed on roller table.	Ribformer, Perforator	Michigan
Smart Slitters	Genesis G836	36"	8"	310Lbs	Quote Required	Max roll OD: 8", 0.75 HP Motor standard, Single cutter, can only cut one slit at a ime bu can be programmed to cut in succesion		China
Smart Slitters	Genesis G862	62"	8"	345Lbs	$5,676.00	Max roll OD: 8", 1 HP Motor standard, Single cutter, can only cut one slit at a time but can be used to make cuts in succesion		China
Tin Knocker	1624 Slitter	24.25"		550 Lbs	$2,795	0.75 HP motor standard		Ontario
Parkinson Technology	Model 861	80"	2"		Quote Required	Full width slitter multiknife, hand adjustable shaft height		China
Shear Cutters								
Manufacturer	Model	Shear Width	Mechanism	Weight	Price (estimate)	Description	Available Accessories	Shipping Location
Grizzly	G5772	52"	Foot Press	1150 Lbs	$1,400	Basic sheet metal shear cutter, operated by foot lever.	Grease proof floor mat, sliding compound	Missouri
Grizzly	G0629	52"	Hand Lever	791 Lbs	$1,404	3 in 1 sheet metal former. Able to shear, bend, and roll sheets up to 20 gauge steel. Can be used to trim rubber strips and can be repurposed for future projects		Missouri
Bulman	A694-48	48"	Rotary Shear	<100Lbs	$346.99	Rotary Shear cutter, can cut sheets of plasctic up to 7/8"		Michigan
Dehnco	APN-5064	50"	Rotary Shear	<100Lbs	$848.00	Compression style rotary shear cutter, can cut Plastic, Foam, Fiberglass, Vinyl ,Rubber, Fabric, etc.		Illinois

Table 2: Slitter Machine Comparison

7.3 Waste Knockout

In the process of creating plausible concepts the waste knockout section was a byproduct of the effects the system would see. With a possibility of making different dies and material sizes the knock out area would need to accommodate. In order to have the system run more uniformly the knock outs would need a new design. A couple designs considered this initially and were further expanded on. A concept that gained heavy consideration was the knockout wheel as seen in figure 6. A wheel would be set just above the output table and roll along the flat surface. When a specific part gets produced the technician would find its parts specific wheel cover. This rubber cover would be molded so the waste section of the part gets discarded below, leaving the part intact. A second roller, if needed, would follow to punch out the final part into a separate collection bin below. For this no power or pneumatics would be required unlike the current set up which is another appealing aspect. A down fall of this concept is that the entire line of products would need a custom wheel cover causing a huge investment in material and design work to create the covers.

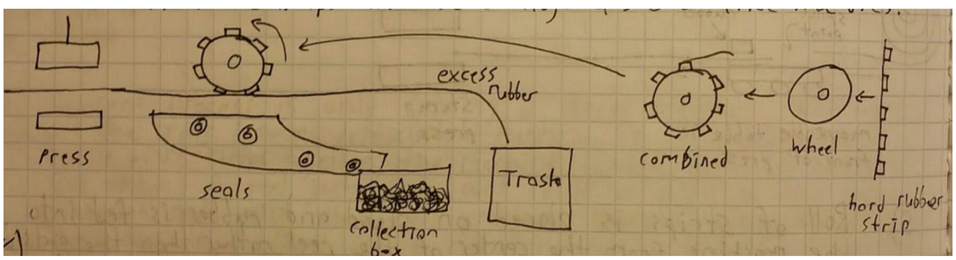

Figure 6: Rubber Wheel Knockout System

A second concept was brought up later to simply increase the current knockout layout which is far more uniform. This is set up by the technician every time as it is currently done. With a larger area to knock out the smallest amount of error from the knockout surface the part would be missed and possibly backed up or stuck as observed in the groups visits to the company. To avoid this inaccuracy the thought of adding guide rods for the plate to follow was implemented. This short fix improves the current design and can accommodate to the new proposed concept.

7.4 Floor Layout

To create a more systematic work flow that makes the most out of the area that was provided the team made a conscious effort to create several floor layouts. After reviewing the current layout shown in figure 32 appendix D, the team felt that the amount of wasted time and production could be fixed with a new floor plan. Being able to have the worker cut down the amount of travel time required was a focus point for a new design. Other considerations included the ability for one operator to be stationed at one location but work both stamping machines and the locations of power sources or fixed elements were heavily considered.

A big concept that was brought up several times was the center station layout as seen in figure 7 appendix D. This design makes a standing area for the operator to work all components that are needed to run the system. With work flow of material coming from the material rack the product is sent through its processes and up to where it gets sent to packaging. The travel is reduced greatly but could cause limitations on room to work on small unexpected tasks.

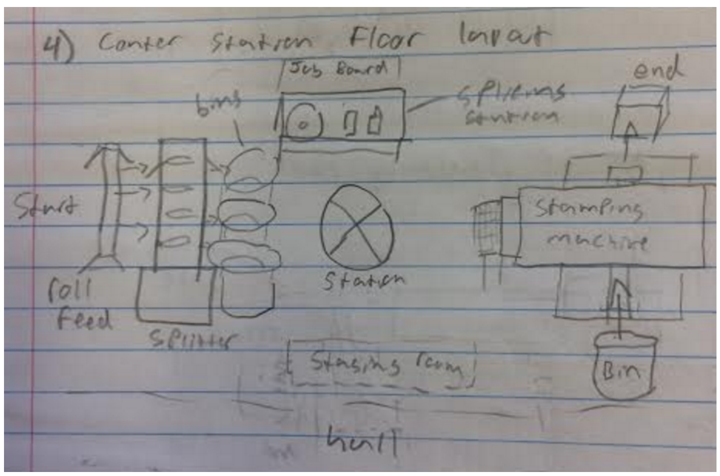

Figure 7: Center Work Station Layout

Most of the concepts generated had the work flow in one direction coming from the slitter then going into the stamping area. To move an entire floor layout the team didnt want to restrict the potential of what the company could see in the future when staffing sees a possible increase. Concepts were also made so that the work flow of prepared material could split off into both stamping machines. With the controls on the same side, the operator has the potential to work two machines at the same time. This increase in work demand isnt necessary unless the product orders or company finds that the two stamping stations should run simultaneously. This ability to double the output of completed job is a benefit if the managerial staff seems fit at the time and doesnt restrict the company of what they could do for production from the two machines.

8 QFD

This project is different than most in that it covers many small problems rather than one large one. To make the machinery perform at top efficiency, minor tweaks and changes to be applied throughout the entire system. Since the project contains so many different variables, the QFD was loaded with small goals that should be achieved by the end of the Spring semester. These goals include, decreasing the minimum batch size, decreasing the die change time, improving splicing, upgrading ergonomics, enhance quality control, and reduce the overall waste produced. Supplementing all these areas even just a small amount, collectively means a large boost in production rates in the future. A depiction of the teams QFD chart can be seen in figures 35 and 36 appendix E.

Because Insco was operated by a holding firm just looking to cut costs until they found an appropriate buyer to sell to, the systems were being run in less than favorable conditions. This gives an opportunity to wipe the entire process clean and start from the beginning. As mentioned previously in this project, the strips being fed into the machine were nowhere near what the machine is capable of. Simply doubling the width of the strip means doubling the output while the machine is running. Of course this does not enhance die changing and machinery priming time. However, small adjustments can be applied to those areas for improvement as well, such as designing a standardized die model to be followed when constructing new dies.

The goals created that are believed to have the largest impact on output are: running at full capacity, splicing without having to shut down, improved layout, use of mobile reel carts, and standardized dies. Obviously the easiest design changes should be incorporated first such as the layout and the reel carts. The layout will make it easier for the one operator to use both Preco machines at the same time without becoming overwhelmed and the reel carts with help with ergonomics and usability. The carts will be designed to compliment the new layout and make it easier to transport and store reels of material. The carts serve a second purpose and will contain a splicing table where splices can be executed without having to run to the toolbox for necessary equipment. When done correctly, the splices should be able to be finished without have to stop the seal press. Once the easy design changes are made, then the more advanced ones can start to be implemented. New dies will take much more than a year to create to replace the old one and can be quite expensive. It will be up to Insco to decide which dies need updating and how much money they would like invested in the process.

Finally, the waste that is produced while making seals needs a better destination than the trash bin. Insco produces a large amount of seals over the course of the year which means it throws out tons of material that could be reused. Not many of the materials that are used can truly be recycled but that does not mean the material cannot be repurposed. As long as the material remains sorted by type, it could be shredded and sold to companies that have the resources to process that material. It could be used as filler in plastic and rubber household products to reduce the use of raw material.

9 Design For X

When creating a design, whether it be personal, or industrial, there must be specific design factors that mold the design but not all of these design factors will be quantitative and will be discussed in a more general sense. The design factors will vary based on the application of the design but the main topics of design factors will stay generally the same. The design factors being considered during this project will be safety, cost, manufacturability, and time efficiency.

9.1 Safety

The safety factor being considered is part ergonomics and also equipment. The ergonomics being considered for this project is mainly the weight of the rolls being reeled and the transportation of those rolls. The current rolls weigh approximately fifty pounds so to use the new implemented width it would also increase the weight by a factor of potentially three or four. This would make the weight much higher than the OSHA sanctioned fifty pounds. To relieve the workers of this problem the design has been made to include the same dimension for the radius of beam and height to the center of the beam making the transfer process much less stressful. There is also a method they have used in the past of spooling the strips on cardboard rings slightly larger than the beam itself making the transition process easier.

The equipment aspect of the safety design factor is because of the need for cutting the strips even before the splicing process can begin. The current method is to use a paper cutter on a rolling cart. This raises the possibility of injury from the open blade. A simulation of this being implemented into our design is pictured below in figure 8 and pictured in figure 37 appendix F. The new possibility to have a blade incorporated into the table would remove most of the concern for injury from the pre-splicing preparation and that design is pictured below in the open position in figure 9 and closed in figure 10. These preliminary designs for the table were realized to be difficult to incorporate in the existing table because of the height limitations of the spooling beam. This led to us to redesign the frame to one that no longer had the accommodations for the table.

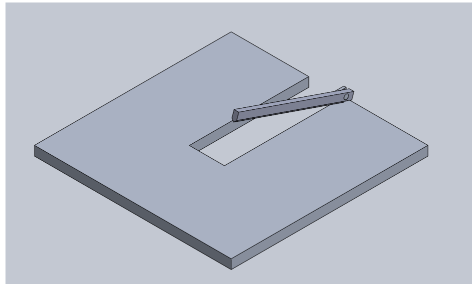

Figure 8: Splicing Blade with Open Cutting Edge

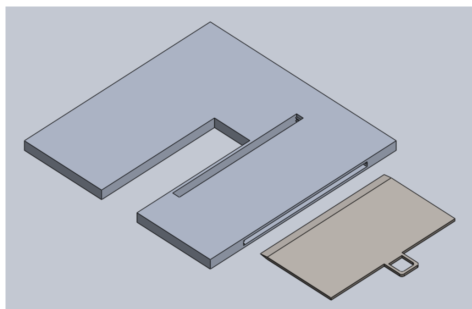

Figure 9: Safe Cutting Edge: Open

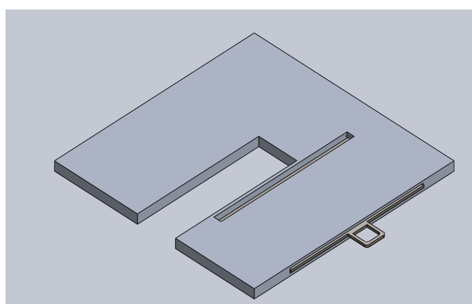

Figure 10: Safe Cutting Edge: Closed

9.2 Cost

The second factor to be considered when creating the design is the cost[5]. This is a very important factor to all companies and will be considered with any design. The main detail about this design contributing to the cost is going to be the material used for the frame. A depiction of the original frame is pictured below in figure 11 to show the amount of material that was being used. In table 3 there is a description of the material properties that were being considered. The final decision for A36 steel was made because all the extra strength from the 1018 alloy would be unnecessary because the design with A36 steel has a safety factor of almost 6 with a force of a thousand pounds. A picture of that study is below in figure 12. The A36 steel will be more than strong enough and is less expensive than the 1018 alloy. Another factor for cost was the wheel type, when considering this we decided we needed a wheel that could withstand up to 400 pounds and be able to pivot radially. The wheel was chosen for its strength and maneuverability and is pictured in figure 38 appendix F. After the wheel was chosen the next step was to find a motor to spin the bar and reel the roll. The motors pictured in figure 39 appendix F were found on amazon and have the strength to roll up the reel.

As anyone who has been in the industry knows, not everything designed and considered will actually be the plan executed and our interaction with this came after we finally got the designs approved from a financial specialist at INSCO. We had met with them on Wednesday and ordered the parts on Thursday but we discovered over the weekend that we could not use the websites we had originally planned because this website did not have part numbers, there was just a link, and this made it impossible to fill out the correct forms to order them with the school. Because of this we had to order all of the parts from McMaster Carr which changed our options. This error led to the beam being smaller in radius and the material of it being changed to 4130 alloy steel and the square tube to be low carbon steel. The strength of these materials being similar to the original material picked told us there would not be a huge difference in the safety factor. This also led to us receiving smaller wheels than we had ordered but still with a locking mechanism and swivel ability and also not knowing what motor we should order also in part to our contact Jeff telling us they could potentially supply us with a motor in house. This ordering issue was hurried because of the bureaucracy it took to have a design approved and time was running short so when we lost even those 4 days from Thursday to Monday could have made the difference between having nothing and having a mostly finished product. Subsequently we did run tests on the new system with its new materials and it did pass the simulated tests before the actual practical tests and this is shown in figure 13.

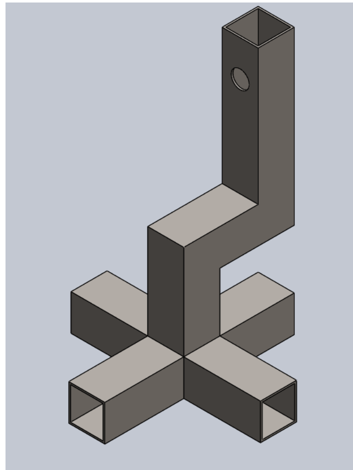

Figure 11: Spooler Frame

	A36	1018
Tensile Strength	58,000 psi	63,000 psi
Yield Strength	36,300 psi	53,700 psi
Elongation (50 mm)	20%	15%

Table 3: Spooler Frame Material Comparison

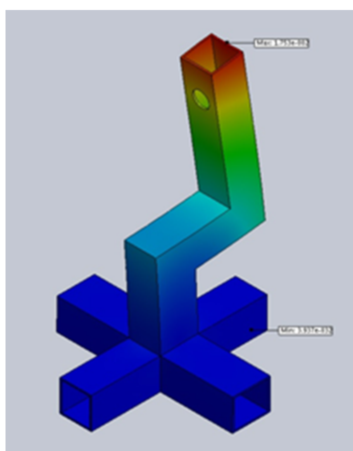

Figure 12: Spooler Frame Force Study

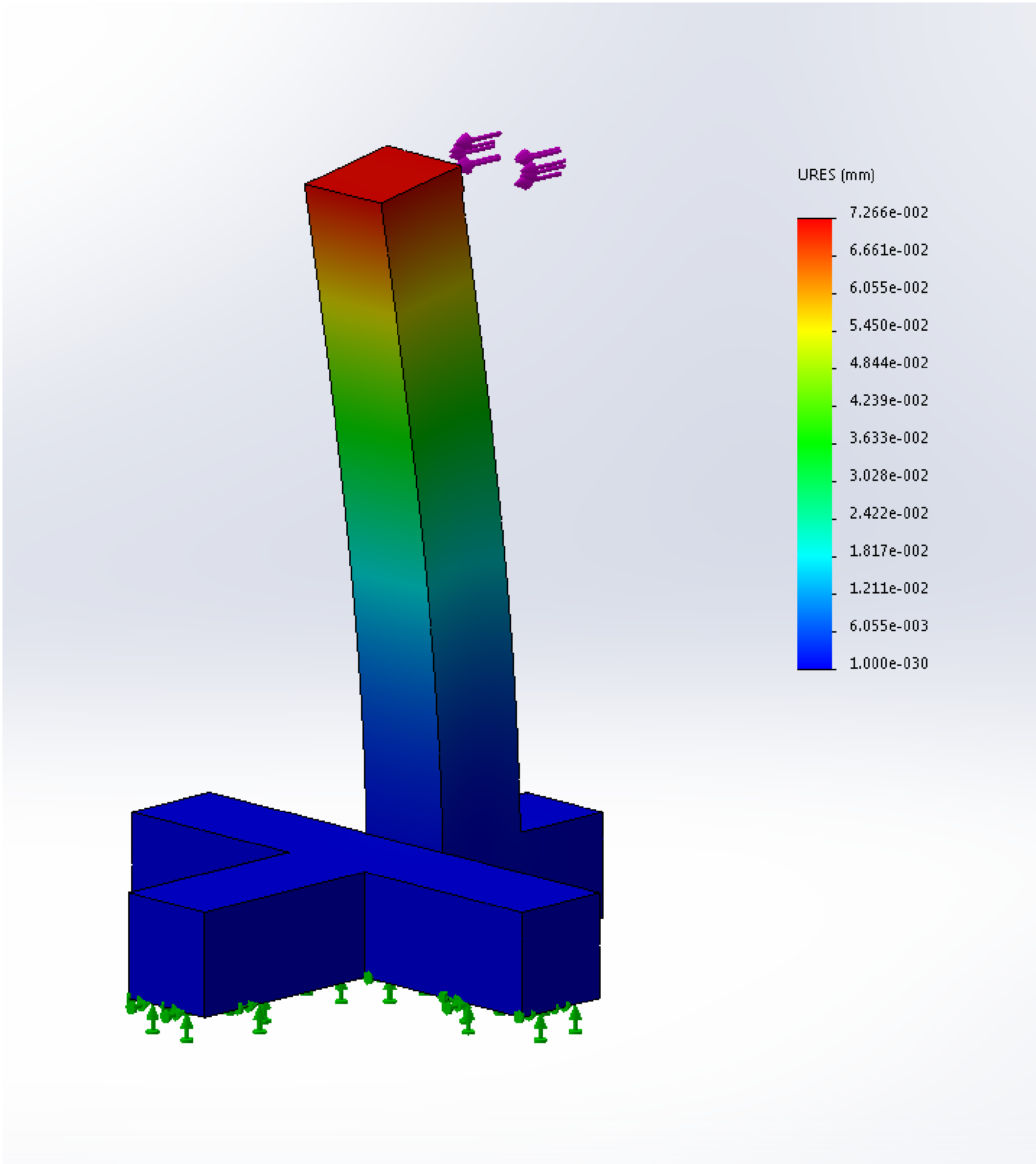

Figure 13: New Frame Being Tested

9.3 Manufacturability

The manufacturability aspect of this design came when creating the frame. There were three basic designs for the frame when proceeding through the design process. One was the initial design which was quickly eliminated but it is shown in figure 40 appendix F. The other two designs were close because the first was designed for the least material and ergonomics while the other was for strength and manufacturability. The ergonomic design is shown in figure

41 appendix F. The manufacturability was the largest difference and would end up costing more than the difference in material so the mid-semester final design selection was the frame for strength and manufacturability which is shown as a full assembly in figure 42 appendix F. This was changed when the table was taken out of the design because we could then remove an extra 4 of steel from the design and also realign the center of balance for the frame. This frame was entirely constructed with approximately six hours in the machine shop in total. It took an hour to slice the square tube and round beam and about three hours to weld and grind the pieces together. Next was the drilling in the square tube for the bearings and beam which only took an hour or two and then after realizing the tolerance of the beam has put it over the max of 2 to fit inside the bearings so it had to be turned down about a sixteenth of an inch in radius for nine inches from the end.

9.4 Time Efficiency

The time efficiency aspect of this design has many parts because of the nature of the process. It involves a series of steps to complete the process so the efficiency will be distributed into sections. The time efficiency increase from the spooling cart would be due to the wheels and nature of the cart. This cart was made to ease the process of spooling and remove step such as having to transport the rolls with pure human strength.

The largest reduction time within the process will be achieved by the layout of the machine shop floor. To have a shop running well there must be a certain flow of the material. As it passes through each area it is manipulated and sent to its respective station and eventually is sent out. In the current layout the flow is time consuming from traveling from the slitting machine to the splicing cart and from the staging area to the feeding machine. This then makes job times longer. The current floor layout is a less organized as shown in figure 32 appendix D. A poor floor layout is shown here because the path is unnecessary. The path could be much shorter and more efficient if the company would employ our new floor layout plan which is shown in figure 34 appendix D. This new layout uses much less space and is organized in a way where both Preco punch machines could be operated simultaneously by the same operator. This design also has the material moving in one direction. It may have to be divided up between the machines but the product is always moving from the left to the right and never backwards.

10 Project Specific Details and Analysis

While the project was being analyzed there are a few specific details which must be included and acknowledged. The first is the available layout dimension which was measured to be twenty-six feet by sixteen feet and six inches. This must be taken into account as any redesign in layout must lie in these dimensions. Next are the dimensions of the machinery and die-storage area. The dimensions of the machinery are as follows: PRECO(1) five feet and two inches by five feet and eight inches, PRECO(2) four feet and nine inches by two feet and eleven inches, CAMPBELL RANDALL R-47 SLITTER five feet and seven inches by four feet, STATIONARY REEL two feet and three inches by three feet and nine inches. The average feed rate for the slitter was calculated to be an approximate twenty-three feet per minute.

10.1 Product Design Teams

The polymer seal gasket market is extremely large totaling to an estimated seventy-five to eighty billion dollars[4]. Insco Group's contribution to the market is extremely small which makes it an excellent candidate to grow. As seen in the gross revenue of the entire market, the demand for polymer seals is exceptionally large. These seals are used in countless different applications. INSCO Groups Seal stamping department serves Aerospace and Aircraft, Industrial, Defense and Homeland Security, Electronics, Filtration, Medical and Pharmaceutical, Semiconductor, and Telecommunications[6]. The market for Polymer Seals Gaskets is going to continue to grow as more customized solutions with more demanding environments are required from each of the related markets.

The cost associated with manufacturing includes many different parts. The direct cost, which first involves the startup cost associated with producing a new line of products. This would involve, the price of the die, the time for the engineers to calculate the specific width required for manufacturing along with the stroke length, stamping rate, and feed rate. The direct cost also includes the wage of the user, the cost for the raw material (thirty-nine dollars per square yard), and any distribution cost associated with producing the product. Next we have the indirect cost, this is any expense unrelated to production and is difficult to track, for instance die replacement, and electricity specifically required for manufacturing. The variable cost in analyzed next and it includes anything that fluctuates as the level of output in production changes. This would include packaging costs, and waste disposal costs. Finally we have operating costs, this is the day-to-day expenses associated with manufacturing. This would include but is not limited to maintenance costs for the machinery, and storage costs.

10.2 Process Design Teams

To lower costs as much as possible and improve output, both Preco machines must be able to be operated by one worker. Rearranging the placement of all the machinery in the area should improve the problems being worked on in this project. This will prevents having to hire a second worker to run the system and makes the job much more user-friendly for the one employee already working it. To start, the region should be free of any unnecessary obstructions that will limit the operators mobility. For example, both Preco machines are separated by a large work station that prevents the worker from running between machines which means only one machine can be run at one time. The workbench is very useful and will be kept within the perimeter, but just by moving it to the side and moving the seal presses closer together will improve the ergonomics tremendously.

10.2.1 Single Direction Process

The seal stamping process has a set of easy steps that must be followed in order to create the gaskets. Raw material must be taken off the shelf, cut into strips, spliced together into rolls, fed into the Preco presses, and sorted for shipment. Obviously, much like traveling, the shortest way to complete these steps is in a straight line as shown in figure 34 appendix D. Though space is limited and some turns will have to be set up within the layout, the idea remains. Aligning all the steps from beginning to end will make it easier for everybody operating it. Because there are two preco machines, they can be set up in parallel and share paths where similar actions are executed. For example, both machines take the same raw material, so it would be unwise to create two storage racks rather than one big one. When the actions differ, such as the split to each press, appropriate actions will take place.

There are a few options that will improve the layout. The simplest one as stated above is the straight line concept. The best part of this solution is it allows the worker to walk up and down both production lines and reach every component without having to travel too far. Both controllers will be right next to each other, the operator simply needs to turn around from one controller and they are already at the next. They will no longer have to run around long barriers to access controls or quality control stations. At the end of the process, the seals can be loaded onto the conveyor belts that the factory already owns and sent down to storage.

10.2.2 Dual Direction Process

The other option would be to have both production lines run the perimeter of the set area in opposite directions. Again, both controllers will be right next to each other so it is easy to run both machines simultaneously and both machines will take supplies from a communal storage area. The only difference really is that the lines run away from each other, take two turns, and come back to a shared collection area. This design leaves a large area in the center of the area so movement is never limited.

11 Detailed Product Design

The problem given to this group was to improve the process of creating seals. This process covered many aspects and therefore the solution must cover all of the aspects contained in the process. The steps in the process are the material slicing, reeling, splicing, feeding, punching, and collection. Not all of these aspects will have new machines or designs to improve them. Many processes are being improved by rearrangement or something that does not involve new machines for improvement. The designs made by this group were focused on improving specific steps greatly and ease the stress of other steps. The final design is a cart with a reeling device. Because the machine shop already had a stationary feeding device it was decided to use the resources already given to better improve the process. Some of the dimensions from the feeder shown in figure 14, will be used for the design of the reeler.

11.1 Spooling Fixture

The design process began when the group had decided a new transportation method was necessary to improve the process. During the first visit to the floor the CEO at the time, Rob, had mentioned increasing the width of the strips from 3 to a possible 12. This would potentially quadruple the rate of production but also have a proportional effect on the weight of the roll which was already around 50 pounds. To implement this idea, a new form of transportation of the rolls would be necessary, and thus the cart became an idea. Another important aspect of the carts initial design was that the strips of material were initially being kept in barrels and not being put onto the feeder because there was no specific machine to help spool them except the stationary feeder so the strips were put into barrels, spooled on the feeder, where they would be spliced about five times, and put off to the side to then be later put on the feeder again and pressed. This process seemed inefficient to us so we decided if there was a way the cart could spool the strips itself and also make the transportation easier it would meet several of our design spec goals. In the first design, pictured in figure 43 appendix H, there was a double sided support for the beam to go in. The dimensions used for this frame were of the diameter of the beam on the feeder, which was 2, and the height from the center of the beam to the floor, which was 32. The design was constructed of 4 x 4 hallowed steel bars. This design offered a 21 x 21 square table for the splicing to be done. This design was very heavy because of the material being used so the second design, shown in figure 44 appendix H, was an alteration of the first design except it used less material. The second design also had a larger table extended about 13 and the legs were more spread out. The design of the leg system was actually based on the design of an office chair because it would offer similar structural stiffness but use less material. Note that this design also had a double sided support for the beam. This is the last design that implemented it.

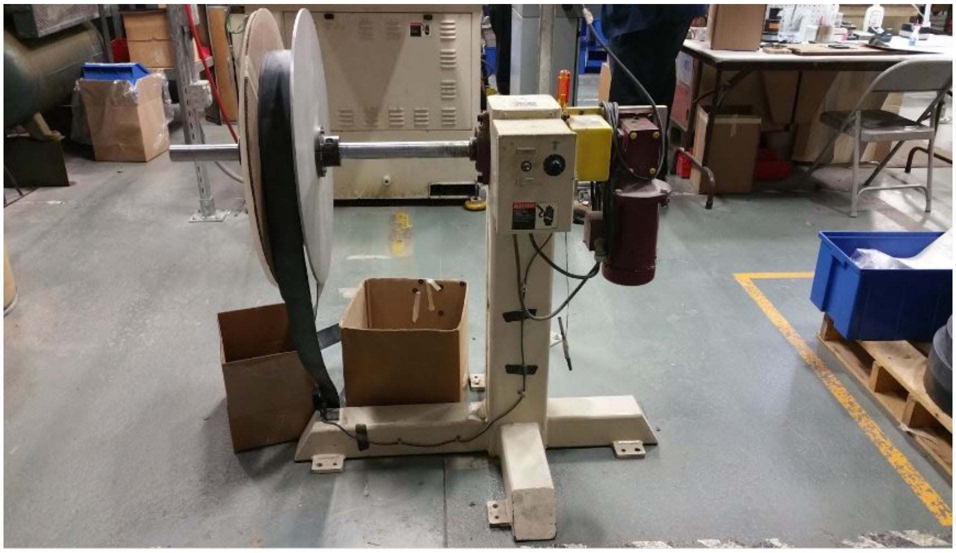

Figure 14: Material Strip Feeder

The third design, shown in figure 45 appendix H, of the cart kept the design of the leg system except this is the first design to use a single support for the beam. This key element of the design made the ease of transporting the material much greater. Because this design included only one support it was initially created without the table being a part of the part so it could be individually tested. Pictures of this testing is shown in the design for X section of this report. The table was later incorporated into the design as an assembly. This frame is still being designed of the same material but now uses significantly less of it. This design and the fourth design, shown in figure 41 appendix F, were the final designs considered for the project. The fourth design was made with more of an ergonomic shape for the handler and the least amount of material. Both frames were designed to have a table fitted to them after the construction process. The main deciding factor for the final design of the spooler was the manufacturability. Both of the designs would have worked very well but the fourth design would have been too difficult to manufacture and the tolerances would probably not have been met. Both designs had relatively the same safety factor associated with the potential weight that it would be introduced to so that was not a large factor in decision making. The fourth design was much more aesthetically pleasing and used less material but the cost would have been greater from the difficulty and time it would take to have the prototype created.

After the fourth frame had been chosen there were a number of decisions that still had to be made. The table had to be designed and would actually be more complex than initially foreseen. After the simple table had been designed and put into place, one of the group members, Nick, had mentioned that they were using a paper cutter to prep the material for splicing and asked if it could fit on the table being designed for the mobile station. It could but using a paper cutter for this plastic seemed very archaic and dangerous. Because of this, it was decided to put an option forward for the company to create a table with a blade inside it to not only make it easier and more accurate but also much safer than having an open blade being wheeled around. This design is shown in figure 46 appendix H. If the company decides that the design is not economically viable or necessary, there is another table designed without the blade and even a mock design of a table with a paper cutter. Another small detail added to the table was because they use glue and small tools to splice the material and instead of having those tools laid about the table a small cup was created just to hold those tools in place and is made of standard PVC but could be any material. The complete design of the frame with the bladed table and tool cup is shown in figure 47 appendix H. After the table had been designed, there had to be a choice made for wheels. The wheels were not extremely influential to the design, the only stipulating factor would be the weight limit. We decided to go with the wheels, pictured in figure 48 appendix H, because they had a weight limit of 800 pounds and they were not too expensive. Another part of the selection was the swivel aspect of the wheel. It is important to have wheels that can swivel because in a machine shop environment there are going to be a lot of hazards and tight pathways where it is absolutely essential to have the maneuverability to be able to work around these obstacles and also be able to protect the material from being damaged. Because the measurement from the original spooler was from the center of the beam to the floor, after the wheels had been chosen the height of the frame must be altered so that the dimension of beam to floor would stay consistent and this is why the first two designs have a clean 32 from center to floor and the newer, more refined designs have an altered height to account for this. After the designs had been repeatedly sent to INSCO it had been decided that the splicing station being designed as a part of the spooling station would not work. Because of this

The idea behind this cart was variability. These seals come in so many sizes and thicknesses there isnt going to be an optimize length for all the seals it is something that will have to be done individually for each style seal. This is why we made the beam have a clearance of 14 so that if 12 is the optimized width then it can be achieved but is not necessary to use for this cart. If the strips are going to be 12 wide, then the cart can only spool one strip at a time and the typical rolls come in strips of 48 so there are then three strips that would have to be put into drums and eventually spliced onto the roll. To avoid this the team has designed a rolling cart with three more sections used for spooling. This design is shown if figure 49 appendix H. The design for this cart had to be more structural because it would be holding much more weight. As shown it has a beam of 61 so that one solid beam could be divided into the three sections, go through all structural elements and still extend out of the side of the cart. The reason it extends outside the main portion of the cart is so that it can be linked with the spooling cart. This carts design did not implement a motor because if it can connect to the other spooler it does not need one, which will save on the budget. There is a small hole in the beam towards the end where a pin can be placed between this beam and the beam of the spooler to have the beams essentially connected. The linked design with the spooler and cart combined is shown in figure 50 appendix H. The important part of this design is that as soon as the first roll is spooled it can be separated and moved throughout the other channels of spooling and the material can be spliced right there at the station with the splicing table on the original spooling cart. If the company decides to keep the width of the strips the same as they are now, the cart can be redesigned to better incorporate that. Currently on the feeder unit they already have, there are separating disks that will keep the strips in their respective areas and prevent spooling at an angle, which will be considered as a solution to this problem. This additional cart was designed for future implementation. A cart of this size would have taken triple the time to get approved and built so we decided to give them the option of this additional cart if they wanted to increase their production even more.

11.2 Knockout Design

The punch out area of the seal press can be upgraded at minimal costs to Insco. Presently, they are using a pneumatic piston with a round tapper mounted on the end, shown in figure 15. As the seals pass under the piston, the rod shoots out and the tapper removes the inside round of raw material where it is sent to the trash bin. As the seal moves on, it passes under another piston where a tapper that is slightly larger in diameter pushes out the seal and sends it to collections. This is a very good technique to remove the waste and separate the final product and will not change drastically during this project. The problem surfaces when the output rate of the seal press is increased. As it resides now, the piston only removes seals from narrow strips of raw material. That means only one or two seals or created at a time and it is easy for the piston to strike these small targets. If the strips being fed into the seal press are widened to the maximum capacity, then the punch out area will need to be modified to ensure accuracy is preserved.

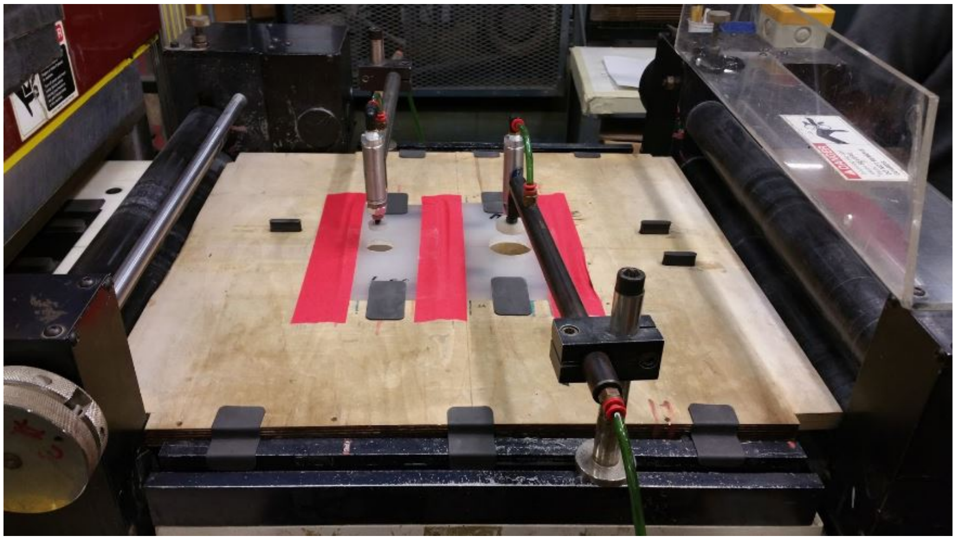

Figure 15: Current Piston Knockout System

Punching out more seals in a single stroke means that the piston will need to perform more work at a given moment. The pneumatic pump provides enough power to force the piston through raw material and will have no problem pushing out perforated seals from the rubber or plastic. However, the amount of power that the piston generates is a double edged sword. As it may slide through the rubber like a hot knife through butter, it can create quite a bit of stress on the piston itself. As the process is repeated again and again, it was discovered that the piston rotates inside of the case it is manufactured in. Insco pointed out that they purchase rotation proof pistons, but it still seems to happen in this instance. If the machine is only punching out one seal at a time as it is now, then the problem disappears, but it is magnified as more seals are punch out at a given moment. If the press was processing a strip ten inches wide, a rotation of 20 degrees would mean the punch would completely miss the seal it was aiming for.

To mend this predicament, a rail guide has been designed for the piston, shown in figure 16. Instead of the round tapper that is currently being used, a long board with protruding teeth would be fitted so that every seal can be hit. The teeth would be able to slide along the board to fit the order requirements and can even be removed. To prevent the long board from rotating, guides will jut up from the base of the press through the board. This will allow the board to move up and down punching out the seals, but stave off any rotation that might occur. This new design will save on prep time because the punch will not need a new tapper for each job, only the board that guides the seals into the collections will need to be modified.

To keep costs low on the build of the knock out system, the model was redesigned using mainly quarter inch steel rod and one eight inch steel bars. These materials have been shown to remain rigid and in place even in the event of most workplace incidents. Unfortunately the steel is also considerably brittle and can crack if bend to extremes. To protect against excessive bending, the new design encompassed an A-frame build that also prevented machine shake and twisting. The members in the frame were laid out to push and pull on each other creating an equilibrium. They also created a support for the long beams that were disposed to brittle fracturing. Now a generously sized object could be dropped directly on top of the frame with little to no consequences. The energy imparted by the fall is redirected to mounts of the frame at the rail of the PRECO press. Not only does using steel beams and bars make the frame durable, it also makes it economically attractive. Cold rolled steel is one of the most affordable materials to use in engineering processes. And because the system incorporates the existing pneumatic punches, it proves that a company does need to spend a fortune to acquire new machinery. The frame was budgeted for one hundred US dollars for materials including the steel rods, bars, and some other various parts to make it complete. Because the fabrication of the frame did not have to budget for labor time, the build stayed well within the desired cost. The build time took a total of 6 hours of work and could have easily been completed in a single day if one aspired to.

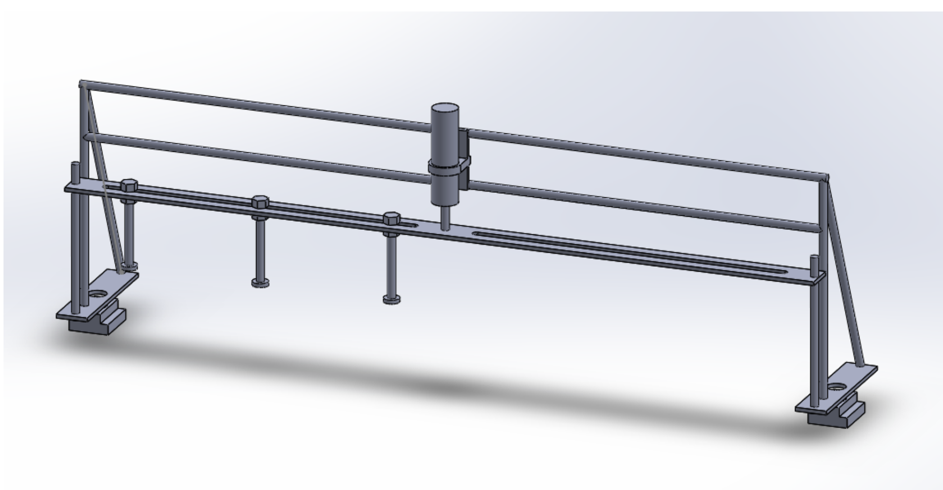

Figure 16: Current Piston Knockout System

12 Engineering Analysis

The analysis of the frame was something that was done in a very general sense. The frame is subjected to minor loads on an elongated beam extruded from the top of the frame. The weight of the beam was measured at around 80 pounds and would have a roll or a series of rolls that could accumulate up to 150 pounds in addition to that. Because the weight could be distributed in various ways and because the force could be acting in various ways the tests were done at a much higher weight. A force of 800 pound feet was used so the variations could be taken into effect. This force was applied in multiple ways including on the perimeter of the slot for the beam and on the face around the beam slot. After this analysis was done it was discovered that there was a safety factor of around 6 so that would account for the failure load and the repetitive fatigue of the frame. The analysis of this frame is depicted in figure 12 Because this was done in a general way the specific numbers for deformation and stress are not completely applicable but the factor of safety being this high for an additive load should account for all possibility of failure.

$$n_w = (W\text{-}T)/(D+T)$$

$$n_L = (L_{Total}\text{-}T)/(D+T)$$

$$n_{Total} = [(W\text{-}T)/(D+T)][(L_{Total}\text{-}T)/(D+T)]$$

$$L_{Total} = [((n_{Total}(D+T))/n_W)+T]$$

$$t = n_{Total}/(R*n_W)$$

These were the derived equations used for calculating the change in total length of slit material, and total time needed for stamping based on the slit material width. Although this would effect the total time needed to manufacture a given number of parts. The additional material waste and die redesign cost could not justify the proposed change.

13 Proof of Concept

In this section of the project a full explanation of how the final concept was proved to be the best option. The design and thought process gets broken down into parts that justify why certain options were taken rather then others and how these parts effect the system. The team also helps justify why having changes are worth being made as the work progresses in coming time. The proof of concept is broken down into a floor layout map, die redesign, production rate, fixture design. The process of design in nature is very periodic in the sense of new ideas or problems arising and the process to solve them eventually comes to possible solutions and those solutions are weighed to find the best and most reliable design. This process was repeated throughout all of the steps of the design.

13.1 Floor Layout

To prove that the new layout had substantial improvements behind it a time study was conducted. The team analyzed videos of the setup of the material preparation and production of the seals. We collected the times for slitting and splicing the material, travel time between areas, and production rates. A ProModel simulation was then created for this layout as shown in figure 51 appendix I. It was discovered that there is a total of about 28 minutes spent on just moving from one spot to the next. When the team redesigned the floor layout a similar ProModel simulation was created as shown in figure 52 appendix I. In this layout, the process is made more stream line so that the worker doesn't need to back track in the work flow. The newly proposed solution is designed so that the two stamping machines are side by side with control centers next to each other. This was done so that the worker can prepare all the material needed then continue to the next area. The first machine can be set up and then set to run as normal. Rather than walking back to prepare material and try to work at a further distance the second machine has all its resources in the immediate area. This reduced the travel times projected after doing the actual walking study and adding that into the simulation. After reviewing the results of the new layout simulation, the travel time was cut down to 17 minutes. This saved a total of 11 minutes per job as shown in figure 24 appendix B. The new layout is proven to show improvements in the reduction of the travel time by these means.

The layout also allows the production of these two areas to have machines running simultaneously. From a new system that utilizes the resources available the amount of down time for each machine decreases dramatically. From the simulation, it showed that the current layout using one stamping machine took 225 minutes to set up and run a job. With this new layout that offers more possibilities the two machines could run together preforming two jobs and completing them both after 247 minutes. This amounts to doing the same job but nearly doubling the production output by a factor of 2. There are clearly drastic improvements with the new layout when considering a simultaneous production system.

13.2 Die Redesign

In order to justify our concept of redesign the die layouts there were several studies to back it up. Insco runs a large variety of of parts through the preco stamping machines. Because every part is different in some way we tried to justify at least one part which was part 45-3001 FA103. This part was selected to be studied because we found that it was the highest running part in the job tracker [1] we were provided. The study required the width of the strip efficiently run on currently, width of the material roll that gets brought in, and material costs.

For part 45-3001FA103 we found all of its characteristics. The width is 2.5 inches wide, roll width of 36 inches wide, and a material cost of $39 per square yard. This part currently has minimum waste when run at 2.5 inches wide considering the 36 inch roll. The most optimal width to run the part strip would be at 5 inches wide as shown in figure 17. This part still only losses 1 inch due to waste and trimming the unfinished edges but allows the part to be run with double the amount of output. This simple analysis of the material being used in production proves that the die would est be run at a width of 5 inches rather then 2.5 inches.

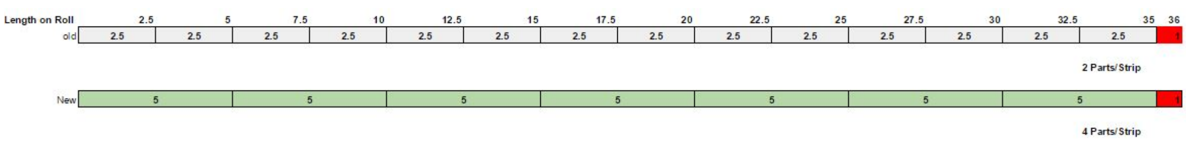

Figure 17: Material Strip Showing Width Optimization

13.3 Production Rate

The Production Rate is dependent on a few different variables. The first variable that affects production rate is the raw material break down rate. Before the stamping process can take place the raw material must be cut to the correct width, rolled, and spliced. The larger the total number of parts needed to be manufactured the more raw material will be needed for the parts order. The next variable which affects the production is the feed rate for stamping. This is amount of distance which is pulled through the stamping machine per unit time. This variable is dependent on the stamping rate, material used, and part outermost dimension. Our concept generation strictly affected the raw material breakdown part of the total production rate. As any modification in material width would require a much higher investment cost (revised die design, stamping feed rate, and possible increased waste of raw material).

13.4 Fixture Design

In the early stages of this design, it was not completely decided what the cart would look like or even the full extent of it. The first trip to the machine floor it was apparent that the current method for transportation of the material was not efficient or effective and it had to be redesigned. The first few designs had bars that would spool the material as opposed to the original method of putting them into drums and the potentially spooling them after. There were occasional designs with multiple bars that would tense the material but it was discovered that the act of tensing it was not necessary and not economically viable so a single beam design was mainly continued after the beginning stages. Another design consideration that was made during the end of the of the beginning of the process was the double-sided restraint of the beam. It was originally considered to have more structural support because of the weight of the rolls. After analysis, had been done on the beam and the frame itself, it was discovered that a single support system would be able to take the weight of the bean and current strip size and the potential quadrupled size for the rolls. This single support system had not only again decreased the material being used but also made the transfer of the material from the mobile cart to the feeding spooler much easier because they no longer needed to disconnect the beam from one of the supports. The aesthetics of the cart was considered slightly but was not a very influential part of the design process. The aesthetics of the cart did contribute to many cart designs but because of the nature of the aesthetics it took a lesser role in the design than the cost of effectiveness of the design and therefore was not something that won out over many other potential design aspects.

The table that was added to the cart was considered from the beginning but not truly finished until towards the end of the process. A station for the splicing was one of the main ideas behind the cart originally so it was always a part of the design but it was not truly completed until all the parts of the table were considered. The original design for the table was very bulky and a waste of material. The team had not decided on the material for the table until the later designs, debating between plastic and wood, so in the beginning the table was depicted as the same material as the frame but it was always known it would be a weaker less resilient material. After the table, had been trimmed down it was mentioned that the strips sometimes had to be cut after the slicing step because they had to be completely flat to get a true splice that would work with this machine. The current process involved a large paper cutter on a mobile plastic cart that was normally stationed near the slicing machine. This method seemed out-of-date with some of the team members and it was decided to give the option of putting a blade on the table so that there were not too many rolling carts being implemented at one time. The nature of this blade was still up for debate because some of the members thought it would be better to keep the old set-up because we already had the materials, which was the cutter currently being instituted, and it would be the easiest option. The other side thought it would be safer and more efficient to put a blade inside the table to remove the possibility of injury by enclosing the blade and giving a larger working area on the table. Because the team does not have the final say as to what is financially viable, it was decided to make two drafts of the table and give two proposals to the Insco company so that they could make the decision of which table to go with.

The wheels were an aspect of the design that was much less time consuming. There were not very many design constrictions for the wheels so it was not difficult to find wheels that could match those constraints. The restrictions that the wheels would be under are the weight limit and the necessity for mobility. The weight restriction could vary so it makes the most sense to consider the highest weight limit which would be the 12" strips and the beam. This would be roughly 400 pounds so the wheels would ideally have at least an 800-pound weight restriction to give a safety factor of two. The other design restriction comes from the nature of a machine shop. Machine shops are very dangerous and usually clustered. This machine shop in specific was very loud and poorly set up so it had narrow walkways and poor movement space. Because of those reasons the wheels had to be connected in a way that would give them the maximized mobility, in other words the wheels had to be swivel wheels. With these two restrictions, the only thing left to be considered would be the price and after scouring many wheel possibilities, the current wheels were found with a weight restriction of eight hundred pounds and they were swivel wheels for only 22 dollars so it was the optimal wheel for this project.

14 Build and Manufacture

The ultimate goal during the construction process was to cut down on costs as much as possible. With the budgets set in place for materials, it is key to design the machinery in a way that will minimize labor expenses. For example, requiring a new process to be attempted in the product, the builder might have to invest in new machinery. But if the designer takes note of the tools that the builder has already acquired, then they can design accordingly. Luckily in the case of this project, the University of Rhode Island graciously allowed access to their entire machine shop filled with tools. The shop contained basic hand tools, a welding unit, and some nice lathes and drills. David Ferreira also offered any help that was required with every project which was greatly appreciated.

Construction of the pneumatic punch press was simple because in contained simple parts. The frame was decided to be made entirely out of steel so it could be welded together. It was also possible that the frame could have been made out a tube and couple system, but the steel rods cut down on costs significantly. Far before any welding was attempted, the length of each piece was calculated out on a draft. Then each piece of the rods could be systematically cut to length on the large band saw. The stabilizing plates of the frame were cut to length and had a large hole drilled down the center where the bolt would be fit through. after all the components were cut and prepped, they were ready to be welded. Because the rods were relatively thin, it was a possible that the welder might warp the metal. To prevent against this, a wooden block was drill into a jig to hold and the parts together perfectly straight. A spot weld is all it took to bind each part in place,reinforcing welds were placed where needed. The jig also made it possible to make identical parts that fit together like a puzzle which aided in build time. when the frame was completed, it was just a task of bolting all the remaining components onto it, making a complete system. During installation at Insco, it was noticed that the piston created so much force, the frame experienced some vibrating. This problem was easily solved by having an in-house welder tack on a plate runner the width of the frame. The frame no longer vibrates and can work continuously.

The rolling material cart was designed much the same way as the frame in order to reduce costs and ease in construction. The cart was also make of steel so that the welder could be utilized. Much like the frame, the individual peices were carefully planned out on paper before making any cuts or welds. Measure twice cut once goes a long way in projects of any type. The thick square steel tubes were cut to length using the band saw. The cart did not require a jig to ensure straight welds because the cart simple needed to sit flat on the floor. With all the parts laid out on the ground a spot weld could be applied before setting anything in with a line weld. The mast that would hold the rod out was cut and had six holes drilled towards the top. One for the rod to fit through and four for the bearings to be bolted to. The mast could simply be placed on top and spotted in with the welder since the band saw makes nice, straight cuts. After the frame of the cart was all welded together it was again a case of bolting the remaining parts onto it. The bearings bolted onto the sides and the rod was inserted down the center. Worm screws inside the bearings were tightened to secure the rod in place. On the bottom of the frame, pilot holes were drilled to the casters to be mounted. It was decided that the use of self tapping screws were reduce costs. A hand held drill had more than enough power to drive the screws into the pilot holes.

15 Testing

In the testing phase of this project we looked to challenge our design to see that it was holding true to our assigned design specifications and analyze production floor situations. In our tests we looked to challenge the structural integrity of the spooling cart and the accuracy and reliability of the knockout system.

15.1 Cart Testing

Our team first looked to test that the spooling cart could handle large loads of pressure which would come from the increased roll sizes. The cart frame was designed to withstand a 1000 lb load coming down on the shaft. The specifications of the wheel that we installed was the limiting factor at an 800 lb load approval. Looking to not test the cart until failure we applied a constant 200 lb force to the shaft. There was zero deflection upon the results of this test. The procedure of this test was done by creating a large roll of material on a stock cardboard sleeve and then have it sit on the beam for an extended period of time as shown in Figure 18. We had the weight on the beam for almost all of our tests which showed that for 3 hours it could handle the load. Knowing that the designed new spools could get up to almost 150 lb we looked to test just above this limit.

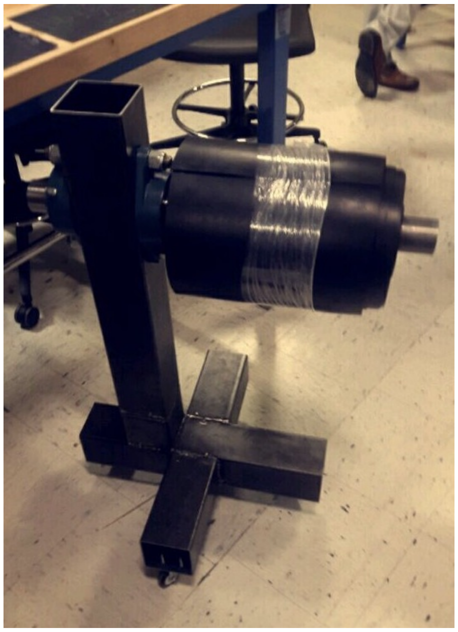

Figure 18: Spooling Cart with material role applied

The next step in this test was to see if the shaft would rotate at different weights applied to it. Without the motor installed just yet we did a preliminary test that was hand powered for general results. The beam was applied with 50, 100, and 200 lb loads with different size. The team then spun it at all load amounts and the results were pleasing. The shaft rotated fairly easily even at the highest load where we could expect a full spool. Taking into consideration that the recommended speed controlled motor has plenty of force behind it, the rotational load test passed.

The cart was also tested for ease of transportation in several aspects. The first test asked the question, can the cart easily move around on a shop floor with a full load applied? The second question being, can the cart be easily transported to and from separate locations in the event that it would be brought to the capstone presentations? When diving into tests of shop floor movement we had the full over-sized spool on the shaft because in most transportation it would be with full sized spools. We pushed the material around the floor to see how fast the loaded cart could move and if there were any complications. We found that a cleared floor was easy to move on and the locks on the casters were successful in securing the cart when at the unloading stage. The cart however did see some floor cracks and debris which held it up from smoothly rolling. Our cart was originally designed to have larger wheels but the project was forced to replace the wheels with smaller 2 inch casters. This failure was one that was discovered late in the fabricating process as well. The team concluded that it was a minor failure but under proper conditions is was successful.

The cart was also challenged in being able to transport easily from place to place. With and over all weight of about 22 lb it was easily manageable to carry into a small car or lift up stairs. The test was used on a small compact car when looking to see if we could drive the fixture from the company and to the machine shop. Being a compact design also helped us stay within the design specifications determined at the beginning of our project.

15.2 Knockout System Testing

The next area to be tested was the knockout system design which had several areas to be tested as well. In our testing phase we looked to test accuracy, consistency, and versatility. First we built the frames with small welds and outfitted them with the guide rails for the piston to be secured to. After fabrication we installed the frames to the back end of the Preco seal stamping machines as shown in Figure 19. To test the accuracy, we laid down a board to be tapped by the protruding knockout pins. We ran the machine for 20 minutes at a time and then inspected the punched area. The marks were all in a diameter of 1.5 cm for each pin which is a very accurate region. The team set an initial goal to have it hit within a max region for every hit of 2.75 cm with 90% of the hits to be within 2 cm and we achieved our goal. This test also showed no soft markings which tells us that all the hits were with good force at each position on both frames. After running a small test section that had 3 cavities we found that there was enough pressure supplied by the pneumatic piston to hit all the parts out each time. This section of the test was a complete success.

Figure 19: Installed knockout frame being tested.

To test the versatility aspect of the system was one of the most challenging parts when designing the frame in the beginning. To test this, we ran another part that would have a different arrangement for the cavities being pressed. We timed the alteration process for moving the setup from one position to the next and it only took 2 minutes and 39 second to fully switch the setup. We can all that a success because it opens up a great amount of potential for the process while only taking an additional 42 seconds. We are projecting a 20% decrease in knockout setup time when the operator gains familiarity and experience with the fixture. In the end our team would call all of the knockout system tests a complete success.

16 Redesign

In the redesign process it is important to look at the successes and failures of the testing stage. Some of the redesign has already been theorized in the imaginary aspect that has been worked on all year because we knew that this process could be improved in so many ways and also knew that spreading ourselves too thin could result in many unfinished products. This is why we had some of our ideas remain in a theoretic place so we could focus on creating the products that can work together and best improve the system in the amount of time given. Because of these reasons, we have a plan for this system that would involve improving the lesser result to some of the unsuccessful tests and expand on our ideas in any future works.

One possible improvement would involve the wheels. As it has been mentioned before the wheel that are on the frame are smaller than the wheels originally imagined. This was either because they had accidentally packaged the wrong wheels or on our end with the order form but either way these wheels do still have the swivel aspect and the locking mechanism so they still meet our design needs. The only issue that occurred from this was not in the testing phase but actually in the transporting of the cart from the machine shop on campus to Schneider Electric. There was a crack in the pavement filled with sand and it had gotten slightly stuck. This did not damage the cart but was certainly an inconvenience for us. In the future it could be considered to put larger wheels on the frame if they wanted to transport it on rougher terrains than a machine shop floor but if it is to stay in the shop then these wheels should suffice well.

Another future possibility was actually thought of at the mid point this year where there would be a collection cart similar to the spooler except this cart will be able to collect the full width of the spool. A depiction of this cart is in figure 49 in the appendix. Allow me to explain, the raw material that is used in the stamping process comes in rolls of a width of 48" so with only the ability to spool up to 12" strips there is still 36" left that would still have to go into the drums to be spliced later on. This would be missed time, from the effort of having to align a strip with that width, that could be recovered if there was a method of getting the strips held still for the easy application of the tape and glue. There was a plan to have small holes drilled into the side of the beams and a pin will be placed between them so that the larger axle will not need a motor assuming the one placed on the single spooler is strong enough to move it.

The last section of the future improvements for the project involve the variable sized strips. The design of the single spooler was one that would allow for variable width strips.

This is because there are so many different sizes for the seals so there will be no optimized width for all of the seals because the waste and max amount of dies so it will be individual for each one. The die process is a very expensive one so it is assumed that as the system we designed shows improvement the company will optimize each seal individually, starting with the most produced part. This process is one that will take time but as they are optimized the dies can be recreated and the amount of parts being created will potentially quadruple while also decreasing the waste in the process. If it is discovered that some parts are best at the 3” strips this system can also handle four of those strips with the cardboard dividers.

17 Operation

For actual use of the products that we have built and implemented there are some very important operations to follow. For the spooling cart there is still future work to be done on the cart. The installation of the motor to drive the shaft will be a main factor playing in this. To use it properly the operator will first take the empty cart and roll it on the back end of the slitting machine. Slide a cardboard sleeve on the shaft and prepare the buckets next to the end of the cart to catch the extra strips. Feed a few feet of material out and stop the slitting process. Secure the first strip to the cardboard sleeve and lead the other strips into separate buckets. In the case that the speed control motor gets installed set it to the pace that allows it to spool up while the material is being cut. Splice the ends of the material together and accumulate a full role. Unlock the casters and roll the cart to the feeding machine. Secure the cart again and slide the role off the cart shaft and over onto the feeding shaft. Remove the cart and set the stamping press up as normal. Feed a test material through to be ready for the knock out system. With a new knockout system design the operation has changed some but the concept has remained the same.

For the new knockout system that can run independently from the spooling cart, there are several new adjustments to be made. First take notice to the number of cavities that are being pressed out from the die. Have material stamped and under both knockout frames for the ID and OD stages. The pins that come down are adjustable in length and in cross section position. Twist the wing nut and hex nut to let the pins slide into the correct position where the inner diameter gets pushed out first and the second stage hits the outer diameter. When the pins are secured for the right height and position turn the air on the will power the pneumatic piston. Run the machine to confirm that the parts are being hit through as intended. This adjust ability will need to be checked and adjusted for each part but adds a much larger amount for part production rates.

18 Maintenance

Like any machine, special cares must be taken to ensure longevity and smooth operation. If signs of required maintenance are ignored, then the machinery can become damaged or experience failure. Signs to repair machinery include, but are not limited to, loud grinds and bangs, shaking or vibrating, smoking, and the launching of projectiles. Malfunctions are costly and can pose a danger to nearby personnel. Having been said, long term damage can be prolonged indefinitely in proportion to timely maintenance. Most machines are quite simple with one or two moving parts that can be ignored for the majority of the year. It is highly recommended to go over machinery at least once a year whether or not it requires it, even if it just needs a dusting. Other simple quick fixes are oiling and greasing joints, checking for rust or other impurities, and tightening any nut or bolt that might come loose.

Luckily, the machinery created in this project are relatively simple when it comes to maintenance. The cart only has one moving part, the spinning axle that holds the material, accompanied with an electric motor. There are also four casters along the bottom of the cart. All of these parts are fitted with points for a grease gun to attach to and pump in lube. Every month or so, the bearings should be lubricated with fresh grease. This keeps the moving parts gliding smoothly and it can push out some dirt particles that have gotten trapped. In longer terms, it may want to be considered to have the cart painted. This will deter rust from forming on the machine. If the machine has already been painted, it sit for a while before having to be repainted. About a decade is a reasonable lifespan for a respectable paint job on a piece of working equipment. As stated before, it is wise to keep the machine in a clean state when possible. The motor is the main component to keep clean since dirt can get inside and cause harm to it. The motor has a separate set of instructions and requirements, reading the manual before operation is recommended.

The pneumatic punch press has many of the same maintenance needs as the cart. The posts that guide the part up and down should be greased at least monthly. A low viscosity lubricant seems to work best with this machine. The piston can also be lubricated if it is jamming or overheating, though it should not need to be. The driving pneumatic compressor should be cleaned and oil constantly just like the motor to prevent any malfunction. The frame can be painted periodically to discourage rust from forming on the steel. Nuts holding the tappets along the rail should be tightened enough to keep from sliding out of position. With a little common sense and some foresight, these machines can be maintained for as long as the company wishes to possess them.

19 Additional Consideration

While the improvements made in this project may not be Earth shattering in any form of the definition, a great deal can be learned from it. Upon arrival to the factory it was apparent that the company was in a state of reorganization. Chair positions in the company change quite a bit over the course of the past year and the project was initiated by an individual who did not stick around to see it to completion. To assume that the replacing CEO had the same vision as the prior is madness. That being said, this project definitely surfaced some good lessons that the company could follow for future improvements. Fundamentally, a company that relies on sheer quantity to make profits, such as a gasket and o-ring manufacturing facility, will want to maximize those numbers for the greatest outcome. If demand outweighs supply then the supplier should find a way to increase their inventory. There is also never a cap on production output, only a cap on the funds used to buy more machinery. Furthermore, existing machinery can typically be modified to create more products. Whether it be in the form of simply speeding up the machine or increasing the input, a trick can usually be uncovered.

A similar method to increasing output is decreasing waste. Waste is, in literal terms, careless misuse of an investment. Granted, some waste will always be created during a mechanical process and it is almost impossible to eradicate, but that does not mean one should not try. Engineers who achieve this improbable goal become the subjects of literature and other forms of media. Not only is waste the root to financial headaches, it can cause a burden on the planet as well. Non-recyclable materials are often thrown in the trash without second thought, but that does not mean the material has been taken care of. Especially when dealing with nuclear materials, companies should take extra precautions when dealing with waste output. Fortunately for Insco, they do not handle radioactive material which makes life a little easier. The disposal of rubber and plastic products should not cause mutation in freshwater organisms. But those same fish could potentially become tangled up in the plastic, either suffocating or starving to death, so the waste can still be a danger to the environment.

Before any of the previously mentioned tips should be heeded, a company should always make sure that their product is of the highest quality possible. Nobody would like to purchase that is either malfunctioning or broken and could potentially harm them. In the case of Insco, failure of a single gasket used on an aircraft could result in catastrophe and ultimately death. The company would have to undergo drawn out legal proceedings and probably a hefty fine. It is cheaper in the long run to simply make quality products that work the way they are intended to. Samsung lost a large customer base when a particular model of their phones were prone to spontaneous combustion. It became a felony worldwide to bring the handset into an airport or other high security areas. It is clearly easier to do it right the first time.

The aforementioned guidelines all push and pull at each other, it is the job of the company to create a balance between the three. Output, waste, and quality all need to be considered in depth before any actions are taken and any money is spent. The government can also play a big part in how products are produced. Often times, regulations are in place to ensure that high quality is achieved and waste is minimized before quantity is contemplated. Consequently, a good manufacturer should intend to make a great deal of money, it should strive to make an impressive product, and the money will be sure to follow.

20 Conclusions

The initial customer requirement was improving one of their seal stamping processes. This involved reviewing the entire process and deciding which areas affected the processes efficiency the most. The next step was to assess the problem areas of the manufacturing process. The concept generation took place which involved every team member. Then the initial concept generation from each member was reviewed and theoretical effect on the process was then calculated. This process was repeated until the best solutions were found. Now that the best solutions have been found, the conceptualization process could take the next step. This next step is completing more specific information for each of the solutions (while acknowledging dimension, and cost constraints). After this step we finalized our concept generation and produce more precise theoretical calculations for improvement can be generated. This finalized improvement can be seen in Appendix B: Financial Analysis. This improvement can be seen as an approximate twenty percent decrease in raw material processing time. Although this did not reach our target goal of thirty percent, given the limited time for assessing the task, and low initial investment to improve the process, our complete design improvement can be viewed as a success.

Now that the theoretically finalized concepts have been generated, construction took place. During the construction process revisions to the designs were made. After the basic construction was revised and completed, the physical testing took place. For the Spooling cart a range of weights were loaded onto the structure and it's reactions were recorded. This reinforced our theoretical calculations, and proved that the design would function in it's final location at INSCO. The testing procedure for the revised punch out station required the installation of the station at the INSCO location with the pneumatic cylinder attached and then a range of sample parts were run on the PRECO stamping machine and the punch out station's performance was observed and recorded. After the tests were concluded the designs were proven to function with an exceptional level of performance. The tests success reinforces our improvement implementations and finalizes the CAPSTONE project.

21 Further Work

The future of this project is dictated mainly by the prototype. The prototype of our design will be the main goal of the Spring semester and the group will hopefully start on the prototype shortly after the semester begins. The only problem with the prototype is the current design. We are glad with the way it has come out but it can always be better. If we decide to make a prototype too early it could result in us wasting time and resources, of which, we have little. The finalizing process of the design will be a long one that will take all of the design specifications and factors into effect. The production of a prototype before the design has been finalized would be a blatant waste of materials. Our plan for the upcoming semester will begin with the design refining and then the actual construction of the prototype. The manufacturing of this prototype will definitely be the lengthiest part of the plan and will encompass a couple of months ideally but with the possibility of having to start from scratch it could be close to the time constraint which is why we do not want to spare any ideas that could improve the design before the prototyping has begun. Another part of the improvement of this process involves the layout which will hopefully be implemented soon. If they do decide to go with our designs for the new floor plan then part of our schedule will go to visiting the company floor and assisting with the new setup. The final outcome is to leave this company with a better process than they had before, where they can produce more seals faster, while using less waste and space.

22 References

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23 Appendices

23.1 Appendix A: Project Plan

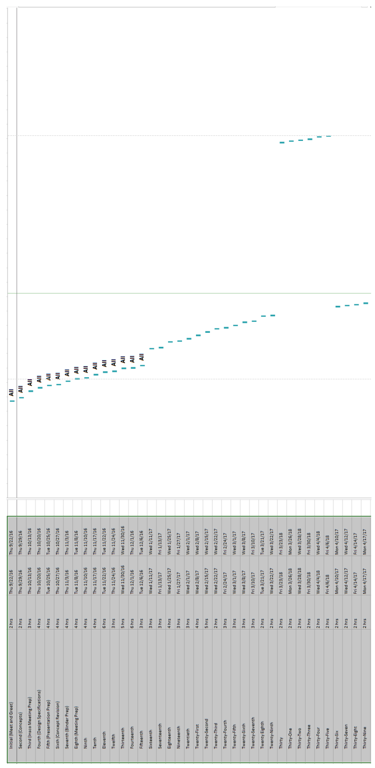
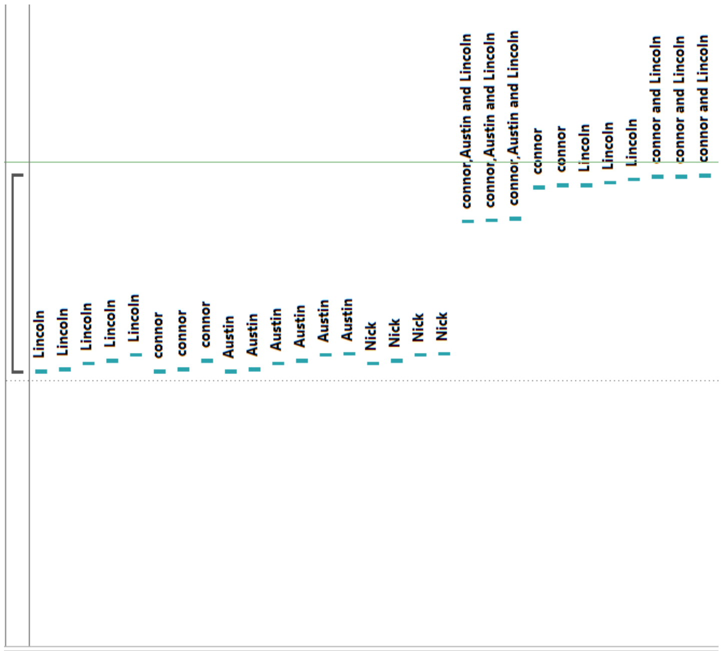
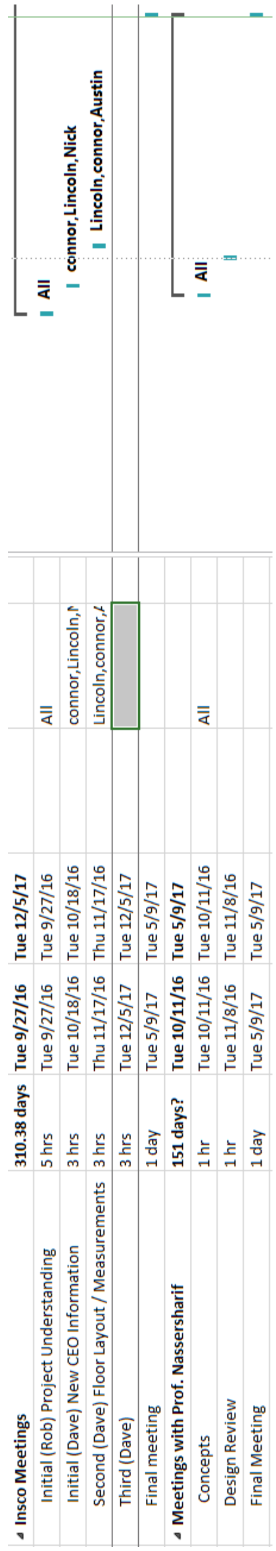


Figure 20: Gantt Chart of Group Meetings



Solo Meetings	**117.38 days**	**Tue 11/15/16**	**Thu 4/27/17**	
Designs	3 hrs	Tue 11/15/16	Tue 11/15/16	Lincoln
Designs	3 hrs	Thu 11/17/16	Thu 11/17/16	Lincoln
Designs	3 hrs	Tue 11/22/16	Tue 11/22/16	Lincoln
Designs	3 hrs	Thu 11/24/16	Thu 11/24/16	Lincoln
Designs	3 hrs	Tue 11/29/16	Tue 11/29/16	Lincoln
Slicer Research	3 hrs	Tue 11/15/16	Tue 11/15/16	connor
Slicer Research	3 hrs	Thu 11/17/16	Thu 11/17/16	connor
Slicer Research	3 hrs	Thu 11/24/16	Thu 11/24/16	connor
ProModel	3 hrs	Tue 11/15/16	Tue 11/15/16	Austin
ProModel	3 hrs	Thu 11/17/16	Thu 11/17/16	Austin
ProModel	3 hrs	Tue 11/22/16	Tue 11/22/16	Austin
ProModel	3 hrs	Thu 11/24/16	Thu 11/24/16	Austin
ProModel	3 hrs	Tue 11/29/16	Tue 11/29/16	Austin
ProModel	3 hrs	Wed 11/30/16	Wed 11/30/16	Austin
Time Studies	3 hrs	Tue 11/22/16	Tue 11/22/16	Nick
Time Studies	3 hrs	Thu 11/24/16	Thu 11/24/16	Nick
Time Studies	3 hrs	Tue 11/29/16	Tue 11/29/16	Nick
Time Studies	3 hrs	Wed 11/30/16	Wed 11/30/16	Nick
Poster/Presentation	3 hrs	Mon 3/20/17	Mon 3/20/17	connor,Austin ar
Poster/Presentation	3 hrs	Tue 3/21/17	Tue 3/21/17	connor,Austin ar
Poster/Presentation	3 hrs	Wed 3/22/17	Wed 3/22/17	connor,Austin ar
Build	4 hrs	Mon 4/17/17	Mon 4/17/17	connor
Build	4 hrs	Wed 4/19/17	Wed 4/19/17	connor
Build	2 hrs	Wed 4/19/17	Wed 4/19/17	Lincoln
Build	2 hrs	Fri 4/21/17	Fri 4/21/17	Lincoln
Build	2 hrs	Mon 4/24/17	Mon 4/24/17	Lincoln
Build	6 hrs	Wed 4/26/17	Wed 4/26/17	connor and Linco
Test	3 hrs	Wed 4/26/17	Wed 4/26/17	connor and Linco
Test	3 hrs	Thu 4/27/17	Thu 4/27/17	connor and Linco

Figure 21: Gantt Chart of Personal meetings



Insco Meetings	310.38 days	Tue 9/27/16	Tue 12/5/17		
Initial (Rob) Project Understanding	5 hrs	Tue 9/27/16	Tue 9/27/16		All
Initial (Dave) New CEO Information	3 hrs	Tue 10/18/16	Tue 10/18/16		connor,Lincoln,N
Second (Dave) Floor Layout / Measurements	3 hrs	Thu 11/17/16	Thu 11/17/16		Lincoln,connor,A
Third (Dave)	3 hrs	Tue 12/5/17	Tue 12/5/17		
Final meeting	1 day	Tue 5/9/17	Tue 5/9/17		
Meetings with Prof. Nassersharif	151 days?	Tue 10/11/16	Tue 5/9/17		
Concepts	1 hr	Tue 10/11/16	Tue 10/11/16		All
Design Review	1 hr	Tue 11/8/16	Tue 11/8/16		
Final Meeting	1 day	Tue 5/9/17	Tue 5/9/17		

Figure 22: Gantt Chart of Exterior meetings

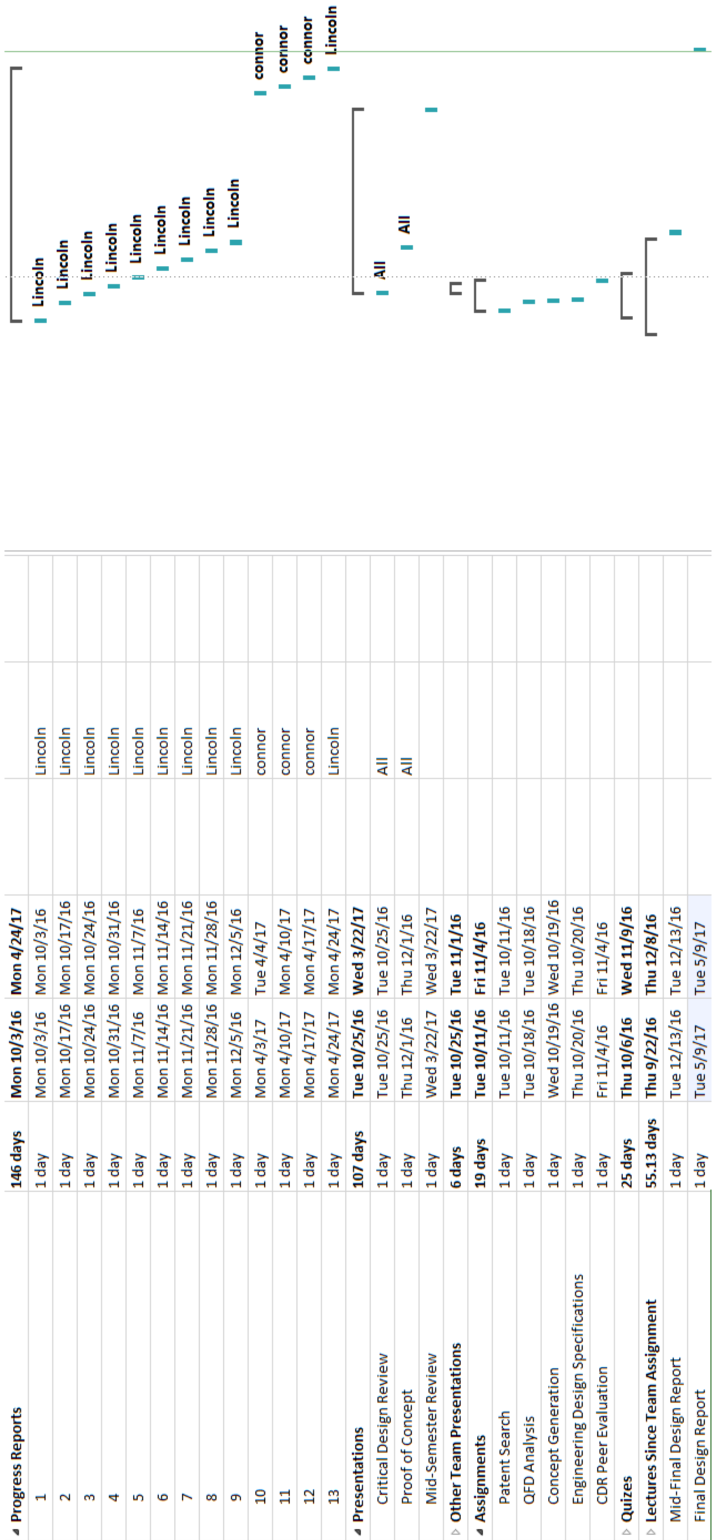


Figure 23: Gantt Chart of Assignments

23.2 Appendix B: Financial Analysis

Savings				
Location	Current Time (min)	Proposed Time (min)	Time Saved	
Slitting/ Splicing	70	42	28	
Preco 1	127	94	33	
Preco 2	127	93	34	
Travel Time	28	17	11	
		Total	106	
		Cost Saved (Wages)	27.38	Per Job
		Jobs Until Profit	**56**	
		about 4 months		

Figure 24: Time Reduction Spread Sheet

29-Nov	Cost Analysis	
Main Spooler		
Item	**Amount**	**Cost**
A36 4" OD Square tube .12 Thickness	71.75" ~ 6'	$66.21
A36 2" D Hot Rolled Mild Steel	22" ~ 2'	$43.30
Mauler Caster 4.5 x 4" Phenolic Wheel	4	$106.20
Motor off Amazon	1	$75
	Total:	$290.71
Collection Cart	**Amount**	**Cost**
A36 4" OD Square tube .12 Thickness	206" ~ 208"	$272.48
A36 2" D Hot Rolled Mild Steel	59.75" ~ 60"	$85.70
Mauler Caster 4.5 x 4" Phenolic Wheel	8	$212.40
	Total:	$570.58
New Die Fabrication	**Amount**	**Cost**
Wood 3/4"	1 (10"*8")	$6
Steel edging	4	$47
Work	2hr	$32
	Total:	$85
Knock Out Redesign	**Amount**	**Cost**
Piston	Supplied	$0
PLywood	4 Sheets	$50
Metal guides	$4	$112
Work	15	$225
	Total	$387
	Total: Costs	**$1,539.00**

Figure 25: Initial Investment Costs

Quantity	Part Number	Description	Unit $	Subtotal
4	22955T41	MAULER CASTER 4-1/2" x 4" PLATE	$26.55	$106.20
1	6527k444	LOW CARBON STEEL SQUARE TUBE	$74.34	$74.34
2	5968K83	TWO BOLT FLANGE MOUNT BALL BEARING	$96.23	$192.46
4	90002A135	HIGH STRENGTH STEEL HEX SCREW 3/4"-10	$2.65	$10.60
1	95615A270	PACK STEEL NYLON LOCK NUT 3/4"-10	$6.96	$6.96
1	92620A656	PACKAGE OF 25 3/8"-24 BOLTS	$9.09	$9.09
1	89955K601	4130 ALLOY STEEL ROUND	$72.73	$72.73
1	90499A815	PACKAGE 100 3/8"-24 HEX NUTS	$6.76	$6.76
				$0.00
				$0.00
		No Tax -- URI is Tax Exempt -- RI Tax Exempt 189		$0.00
		Shipping Cost		$0.00
			Total	$479.14

Figure 26: Total Expense Sheet

expense current	$479.14	
die cost	$235.00	
motor costs	$750.00	
	$1,464.14	Total cost
	53	Jobs until profit

Figure 27: Jobs Return On Investment

23.3 Appendix C: Patent Search

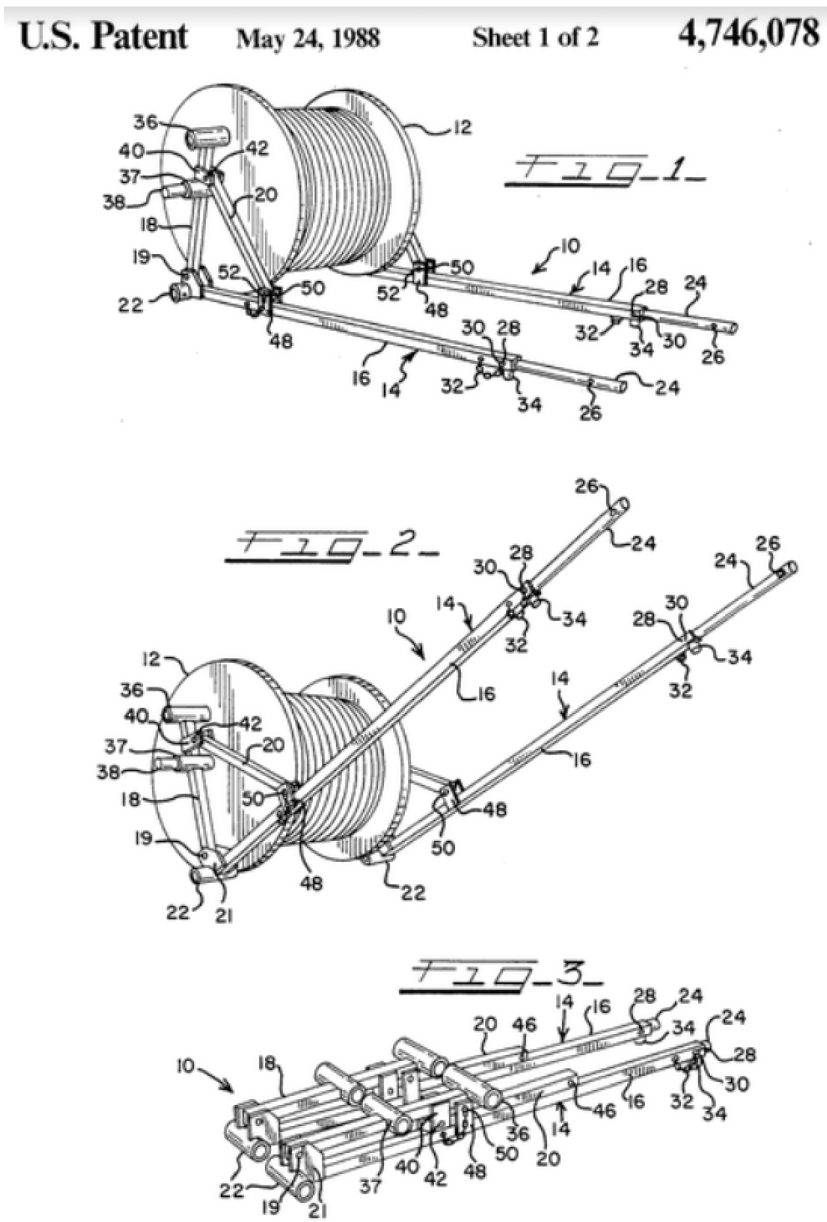


Figure 28: Patent Search Wheel Trailer

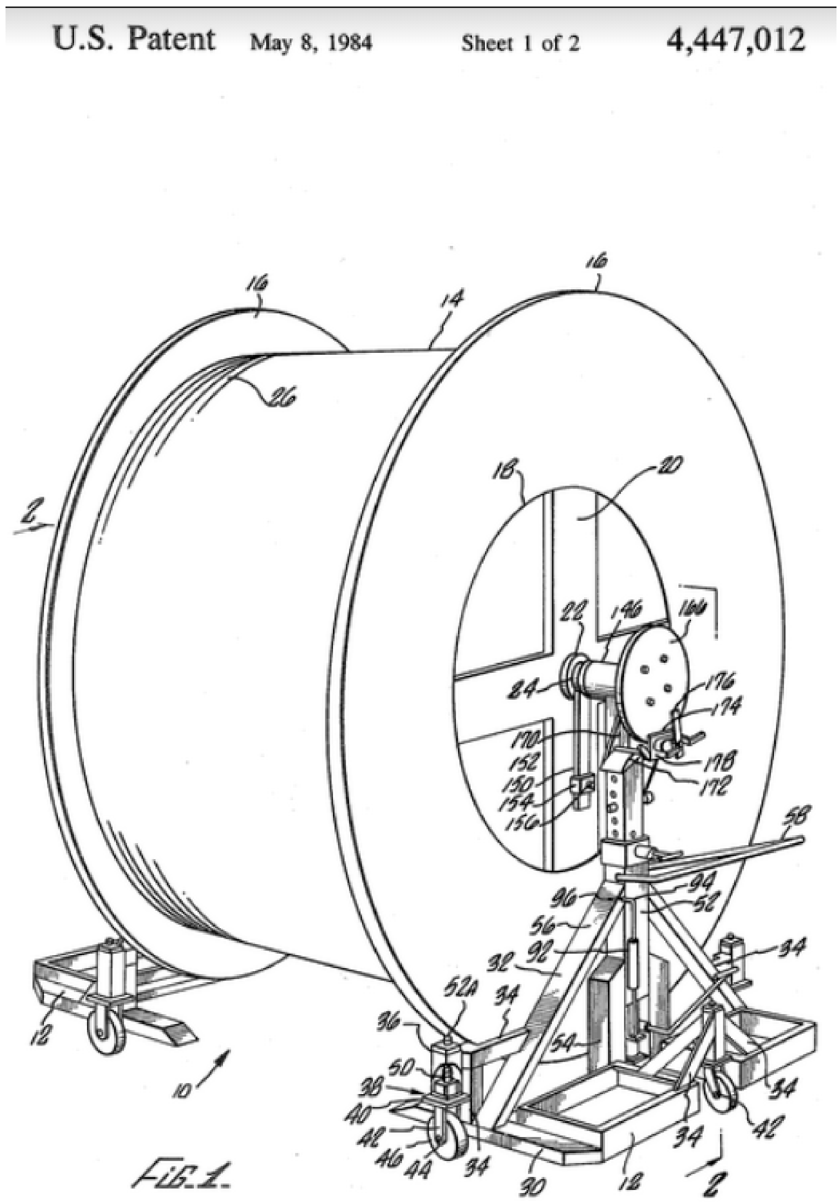


Figure 29: Patent Search Wheel Rack

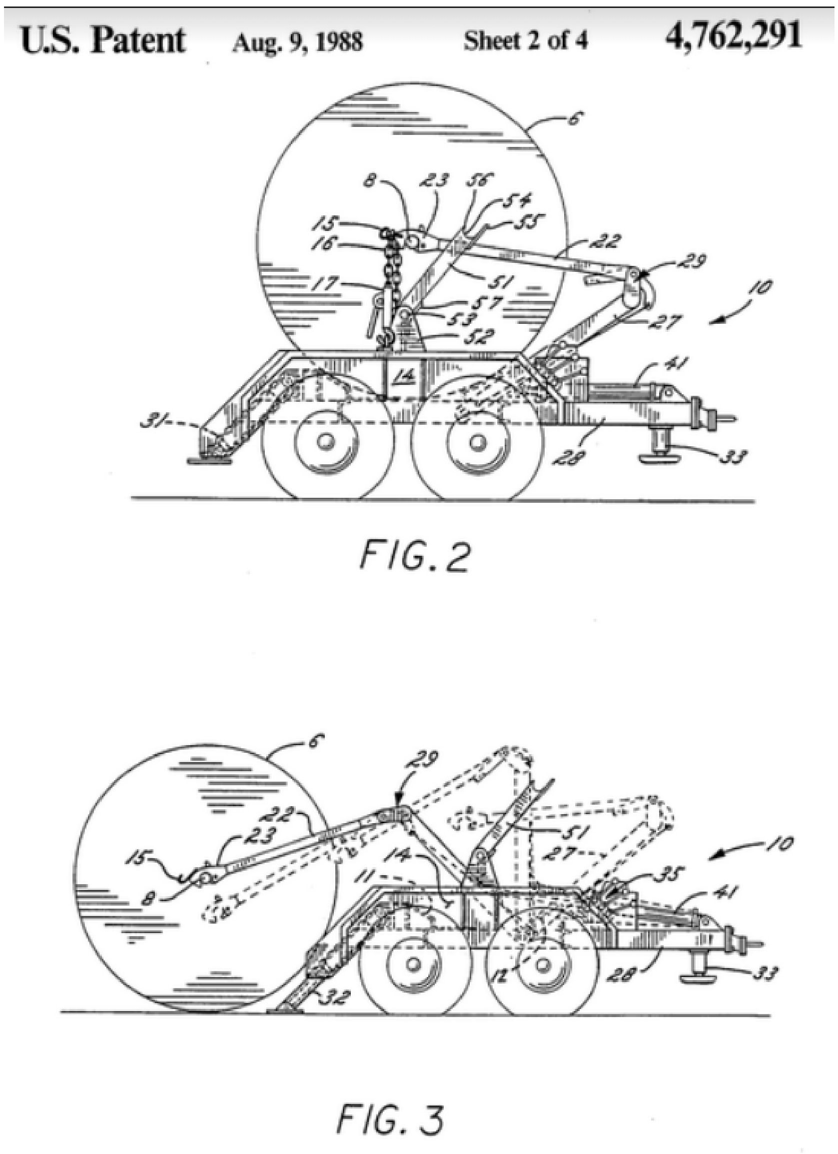


Figure 30: Patent Search Wheel Mechanics

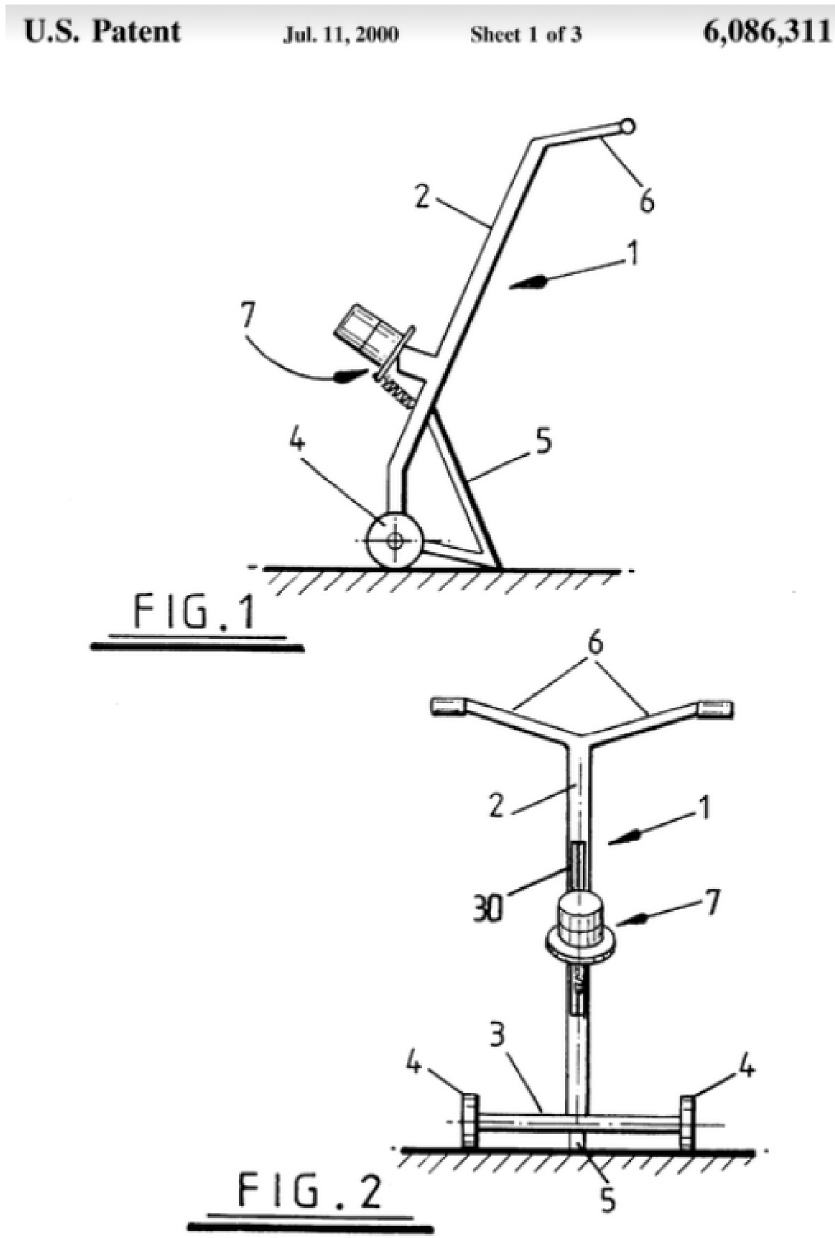


Figure 31: Patent Search Wheel Truck

23.4 Appendix D: Layout

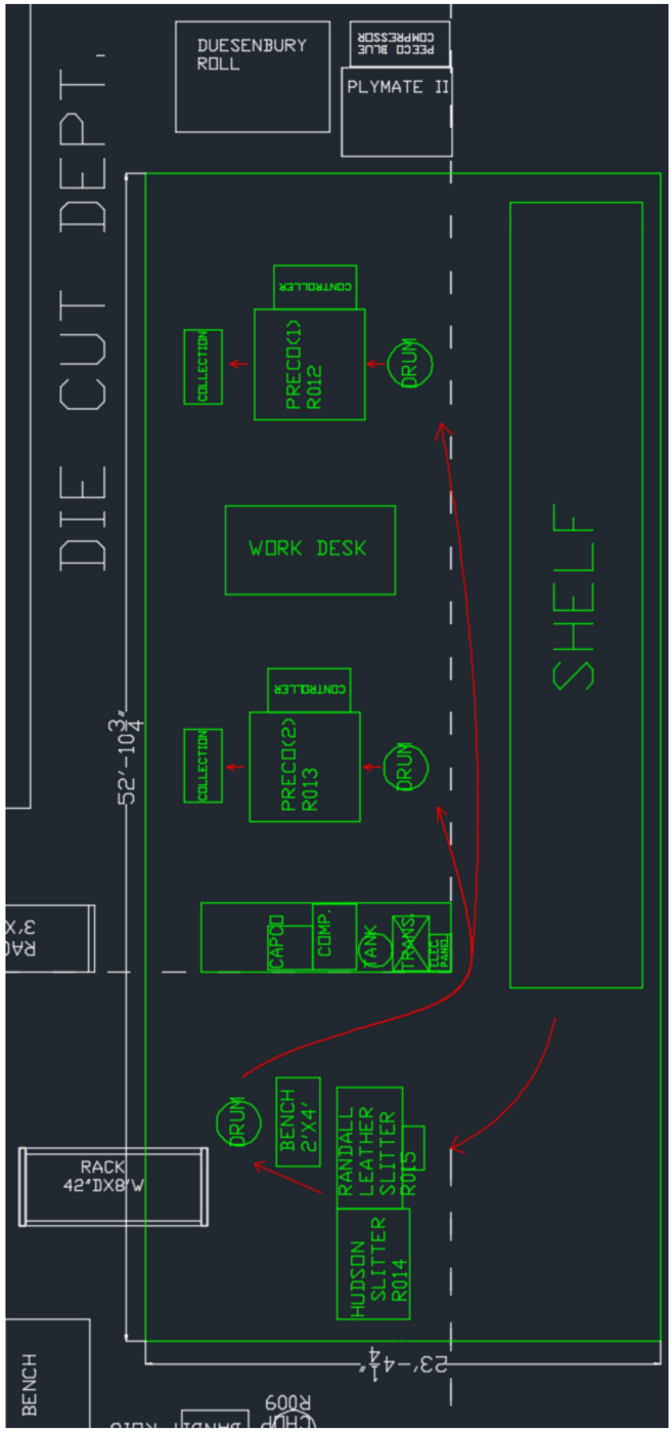


Figure 32: Current Floor Layout

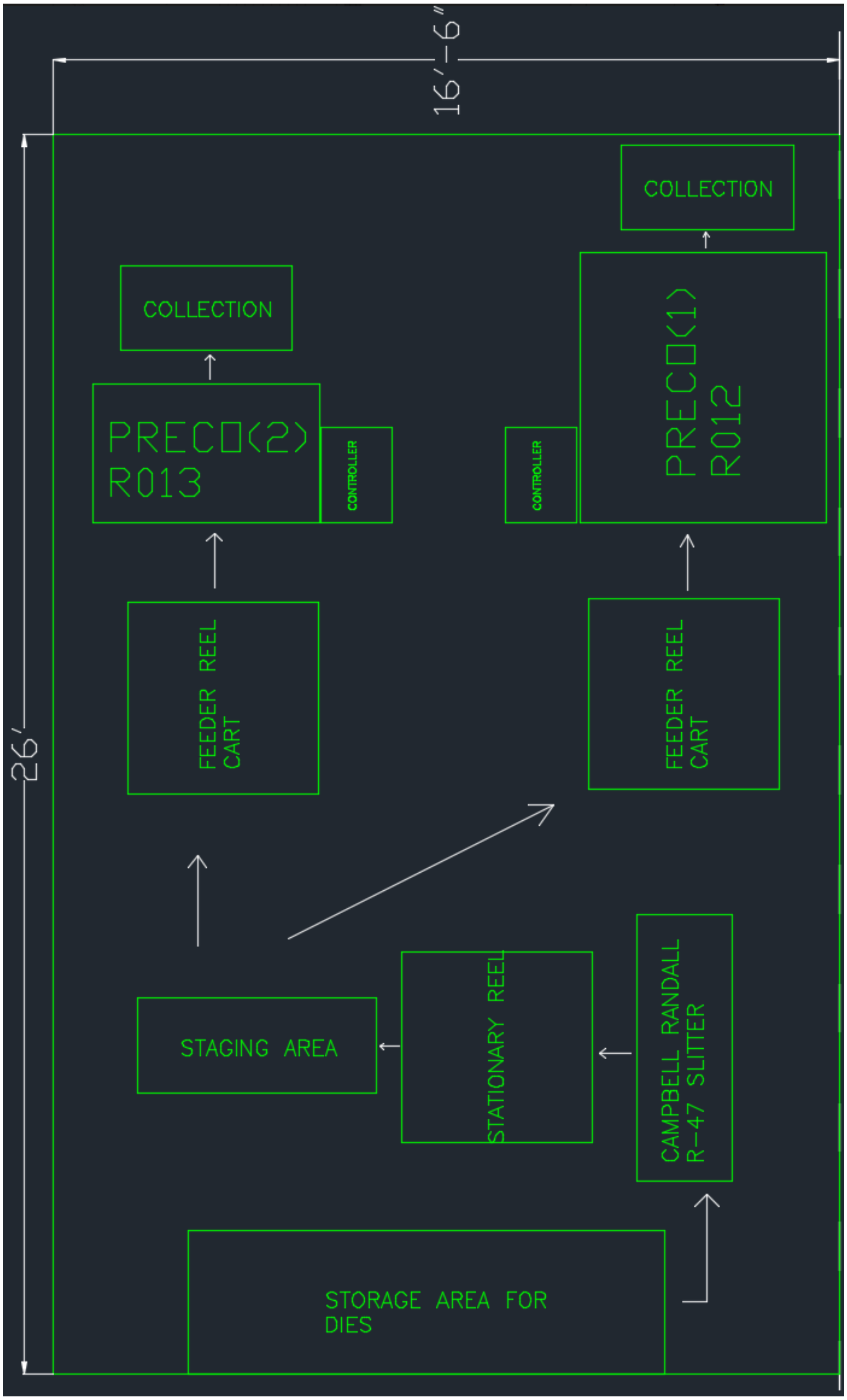


Figure 33: Straight Floor Layout

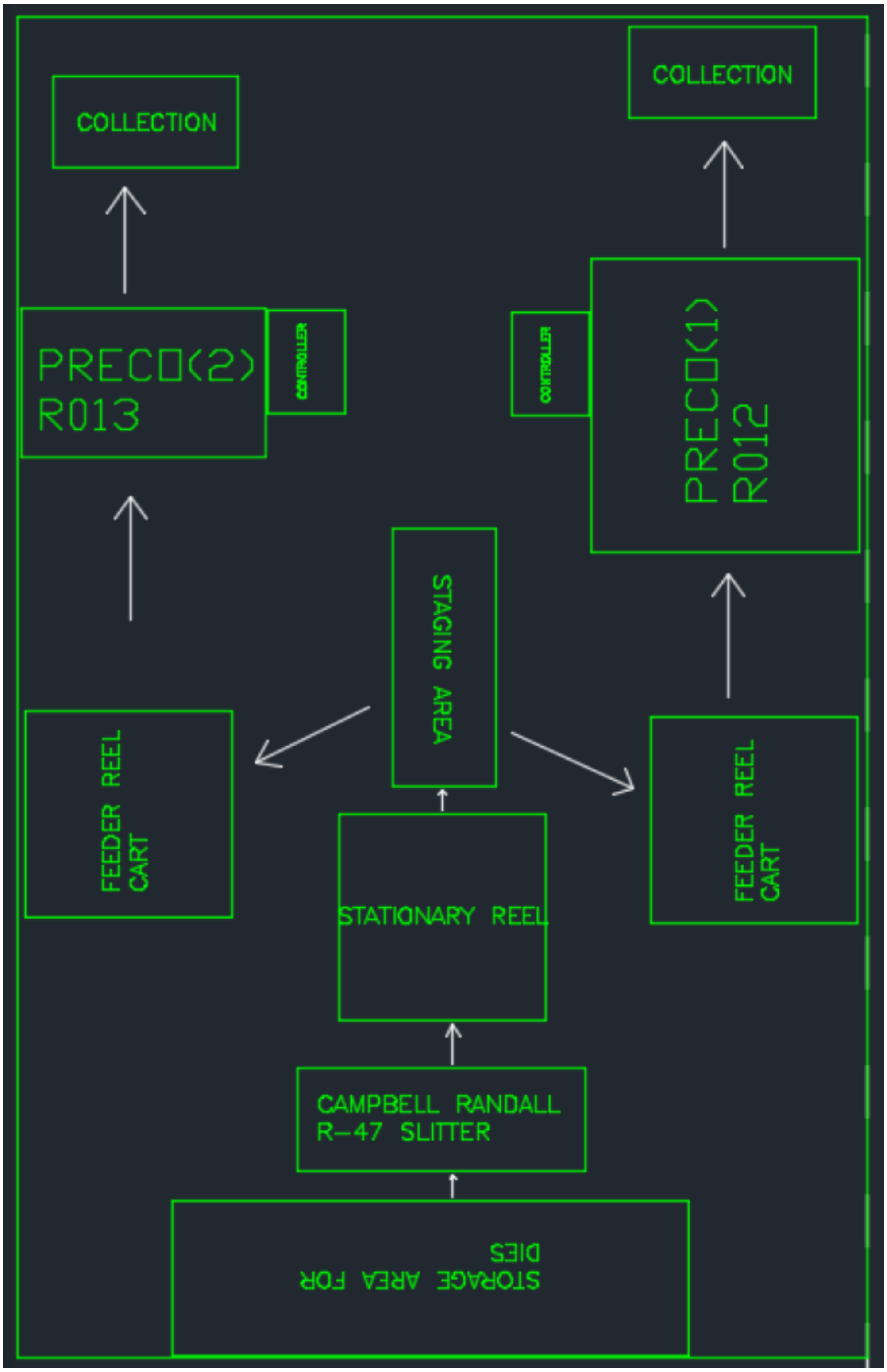


Figure 34: New Floor Layout

23.5 Appendix E: QFD

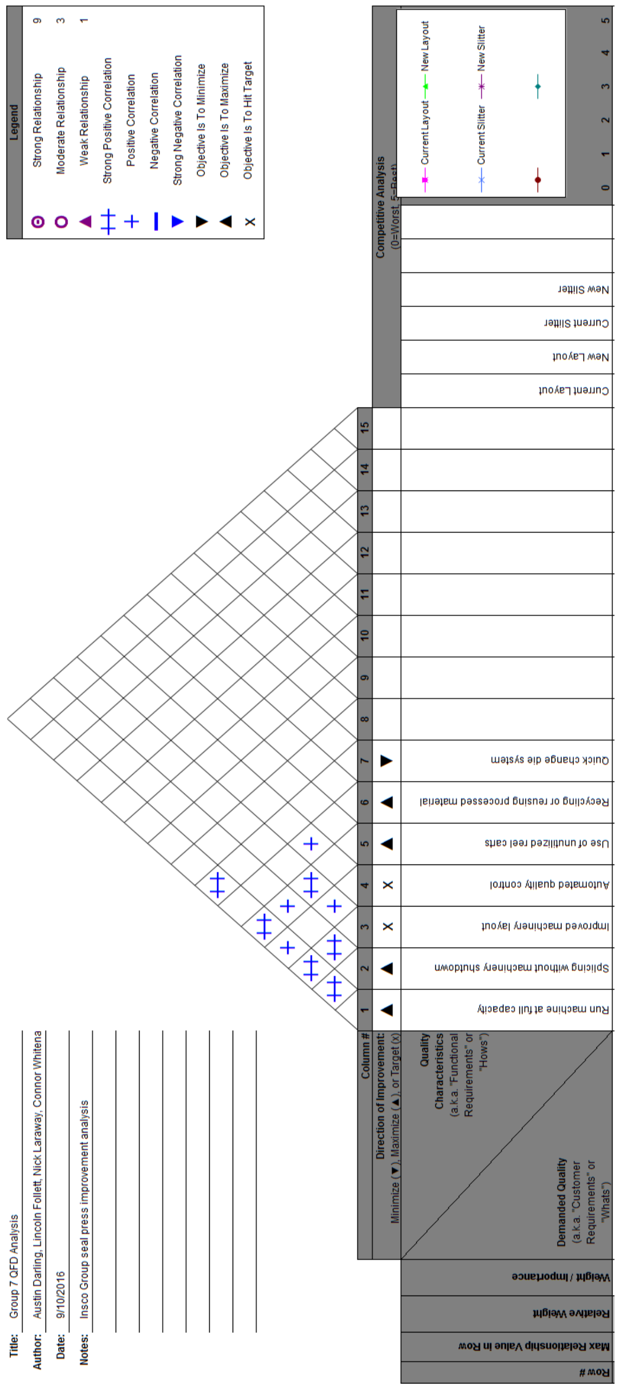
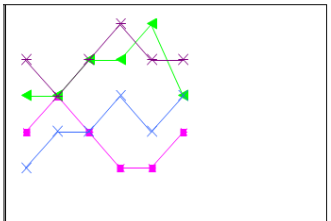


Figure 35: QFD Top

#	Max Rel.	Rel. Weight	Weight	Customer Requirement	<500 per batch for minimum	Continuous splicing	ergonomic for one operator		use of current cart + 1 improved cart	Find way to recycle or sell material	<10 minutes				
1	9	28.6	6.0	Decrease in minimum batch size	⊙	⊙		○	○		⊙	2	3	1	4
2	9	23.8	5.0	Faster die change times			▲				⊙	3	3	2	3
3	9	9.5	2.0	Increase in quality control				⊙				2	4	2	4
4	9	19.0	4.0	Faster splicing method		⊙	○		○			1	4	3	5
5	9	14.3	3.0	Improved ergonomics			⊙		⊙		⊙	1	5	2	4
6	9	4.8	1.0	Less waste of materials	○					⊙		2	3	3	4
7															
8															
9															
10															
				Target or Limit Value	<500 per batch for minimum	Continuous splicing	ergonomic for one operator		use of current cart + 1 improved cart	Find way to recycle or sell material	<10 minutes				
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	6	6	5	9	4	7	8				
				Max Relationship Value in Column	9	9	9	9	9	9	9				
				Weight / Importance	271.4	428.6	209.5	171.4	271.4	42.9	600.0				
				Relative Weight	13.6	21.5	10.5	8.6	13.6	2.1	30.1				



Powered by QFD Online (http://www.QFDOnline.com)

Figure 36: QFD Bottom

23.6 Appendix F: Design For X

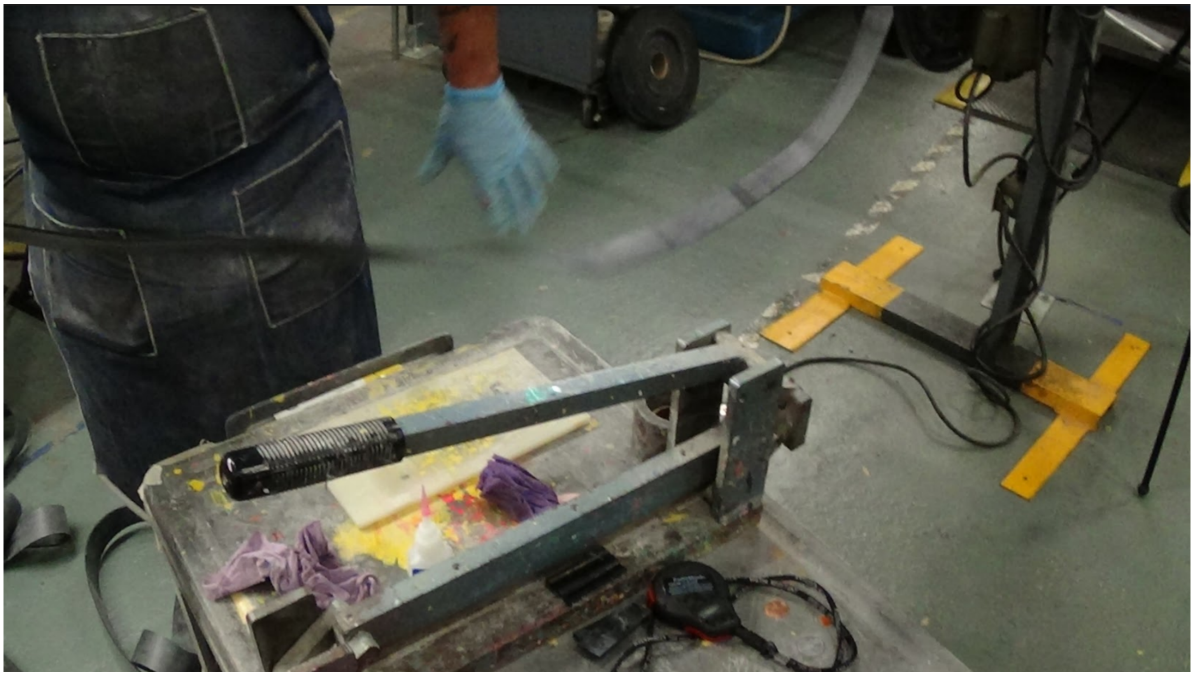


Figure 37: Production Floor Splicing Blade

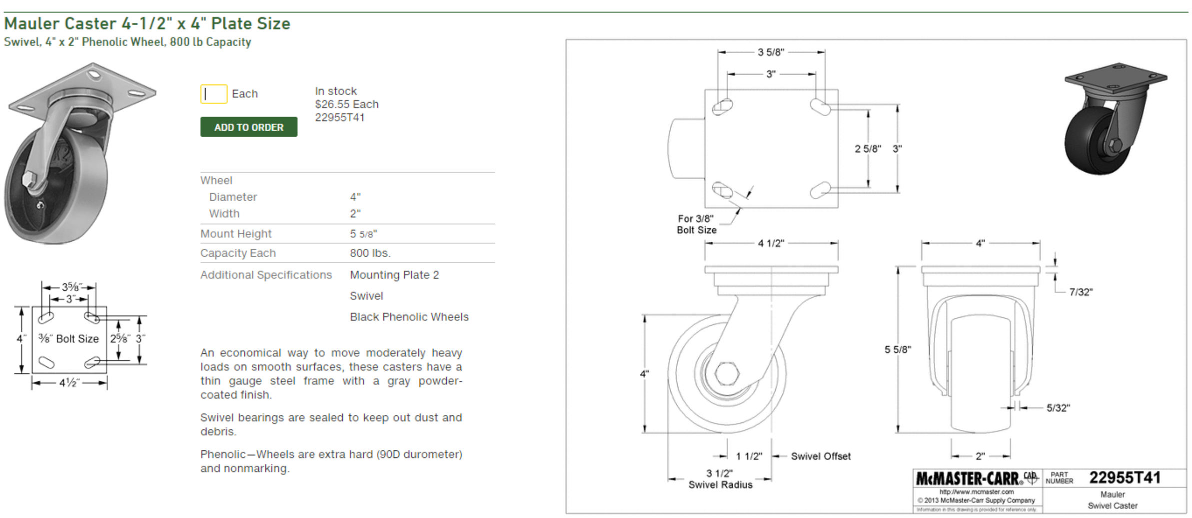


Figure 38: Spooling Cart Casters

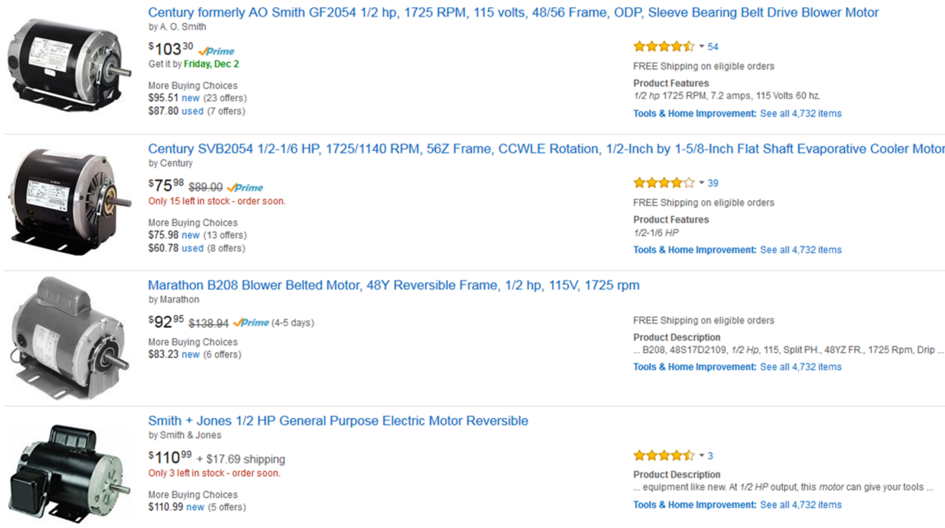


Figure 39: Spooling Cart Motors

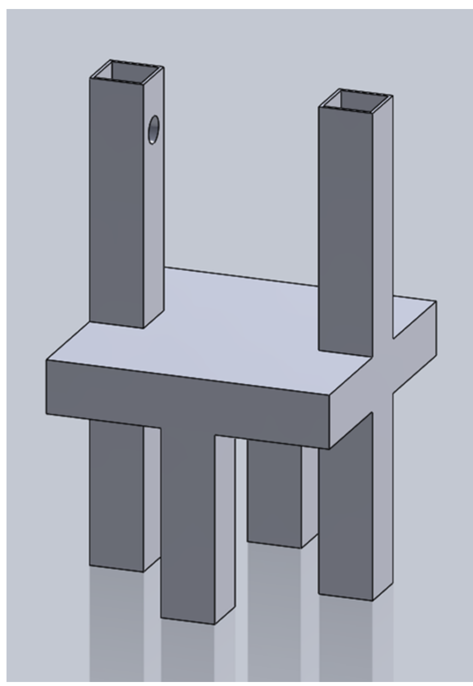


Figure 40: Spooling Cart Initial Design Draft

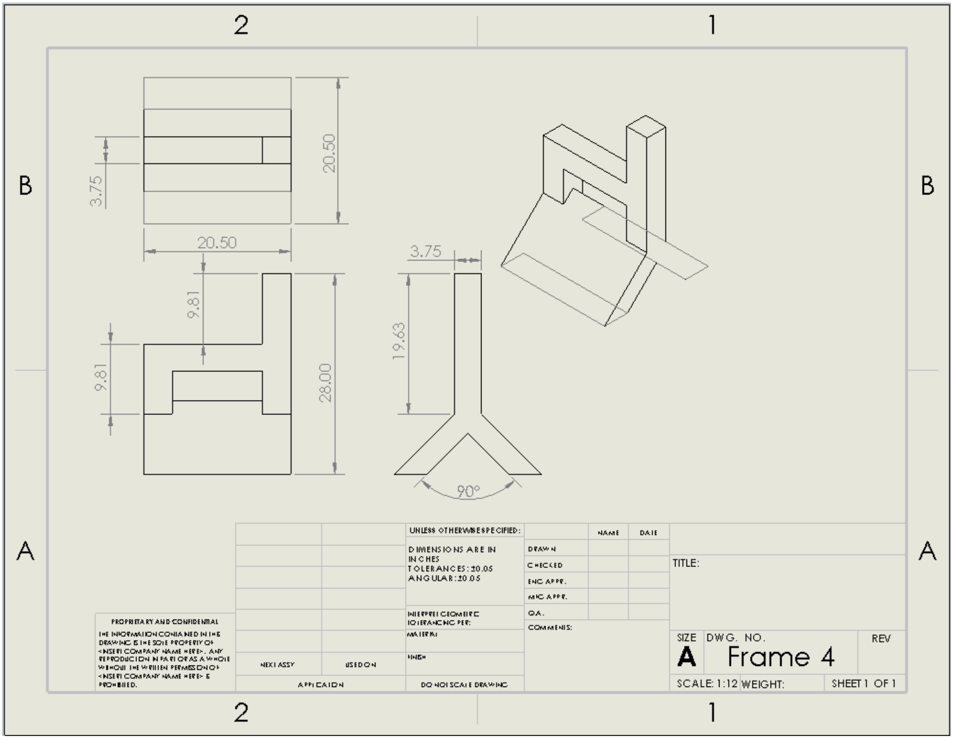


Figure 41: Spooling Cart Ergonomic Draft

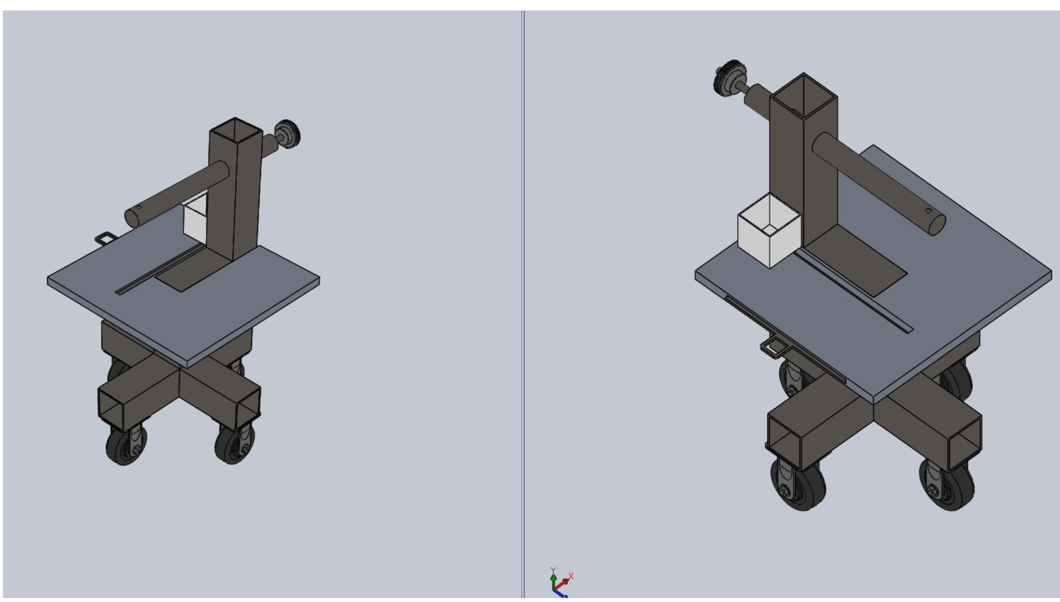


Figure 42: Spooling Cart Full Assembly

23.7 Appendix H: Detailed Product Design

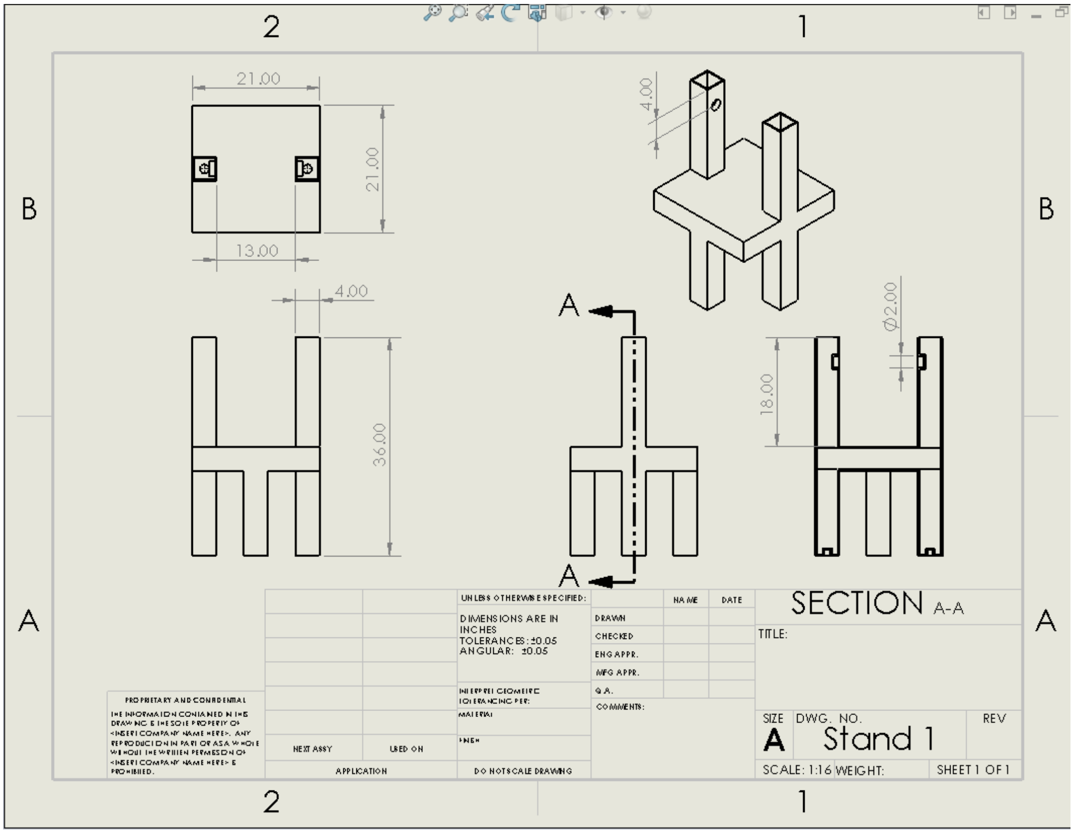


Figure 43: Initial Spooling Cart Full Assembly

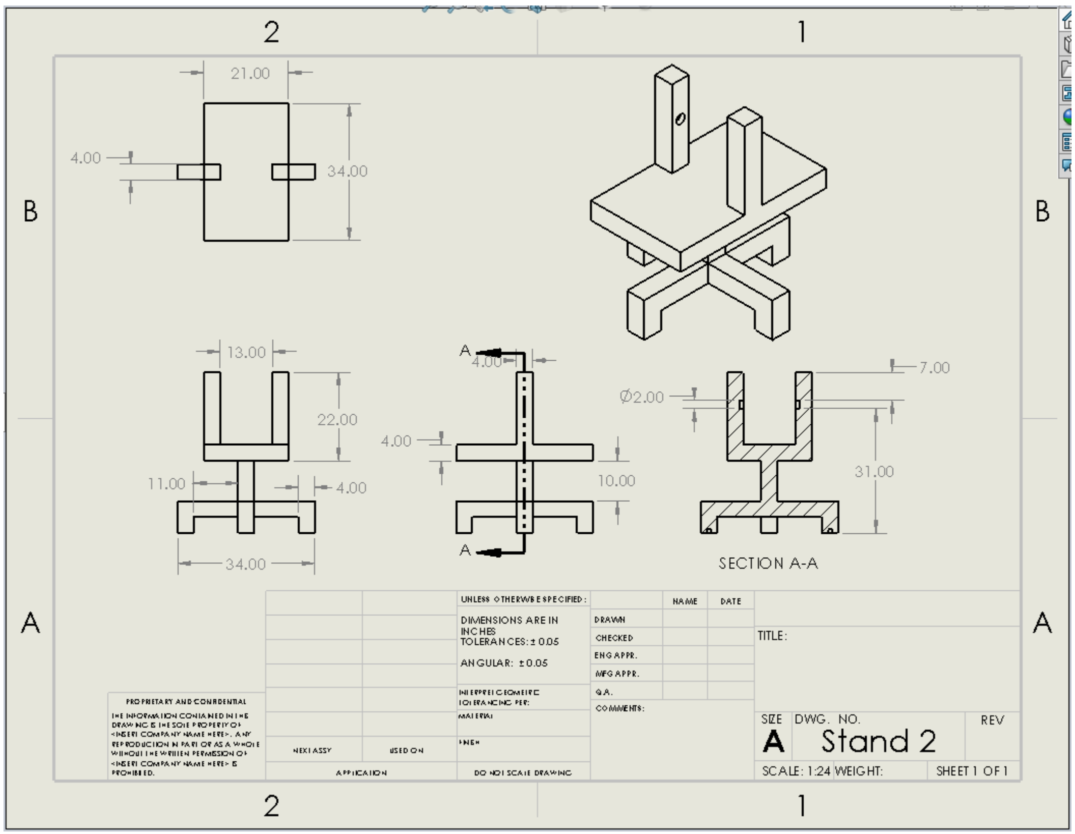


Figure 44: Initial Spooling Cart Full Assembly With Table

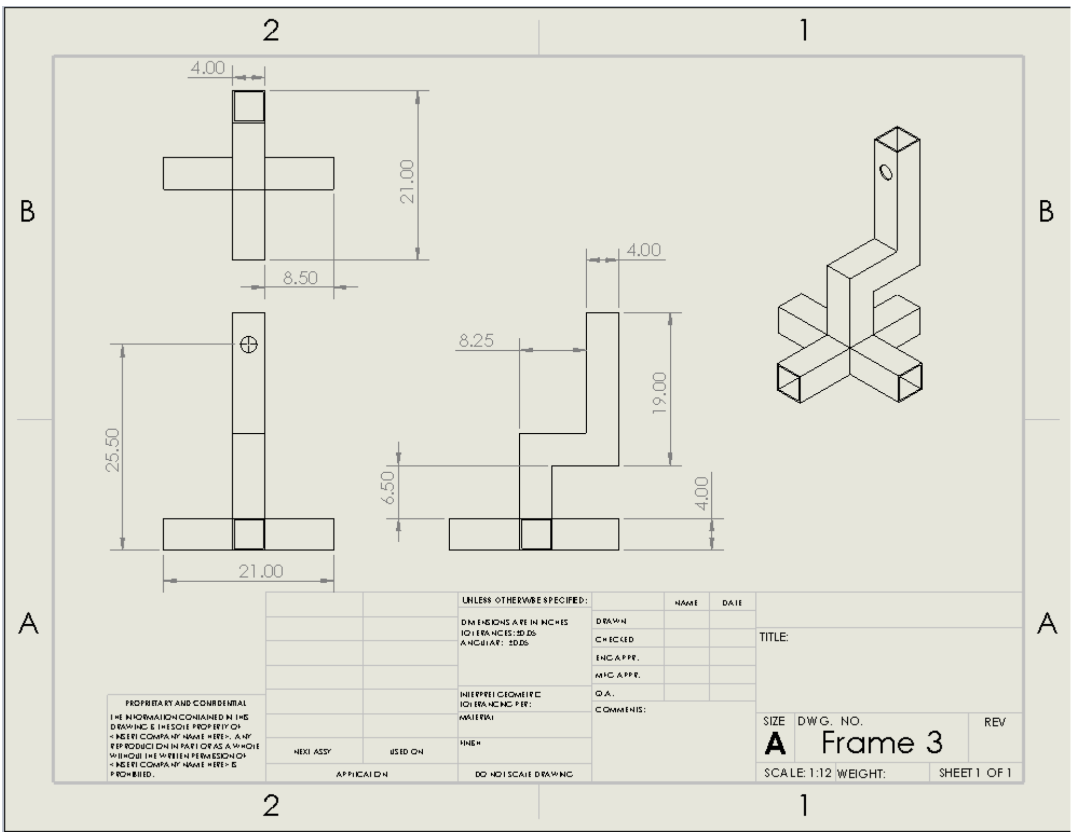


Figure 45: Spooling Cart Frame Dimension

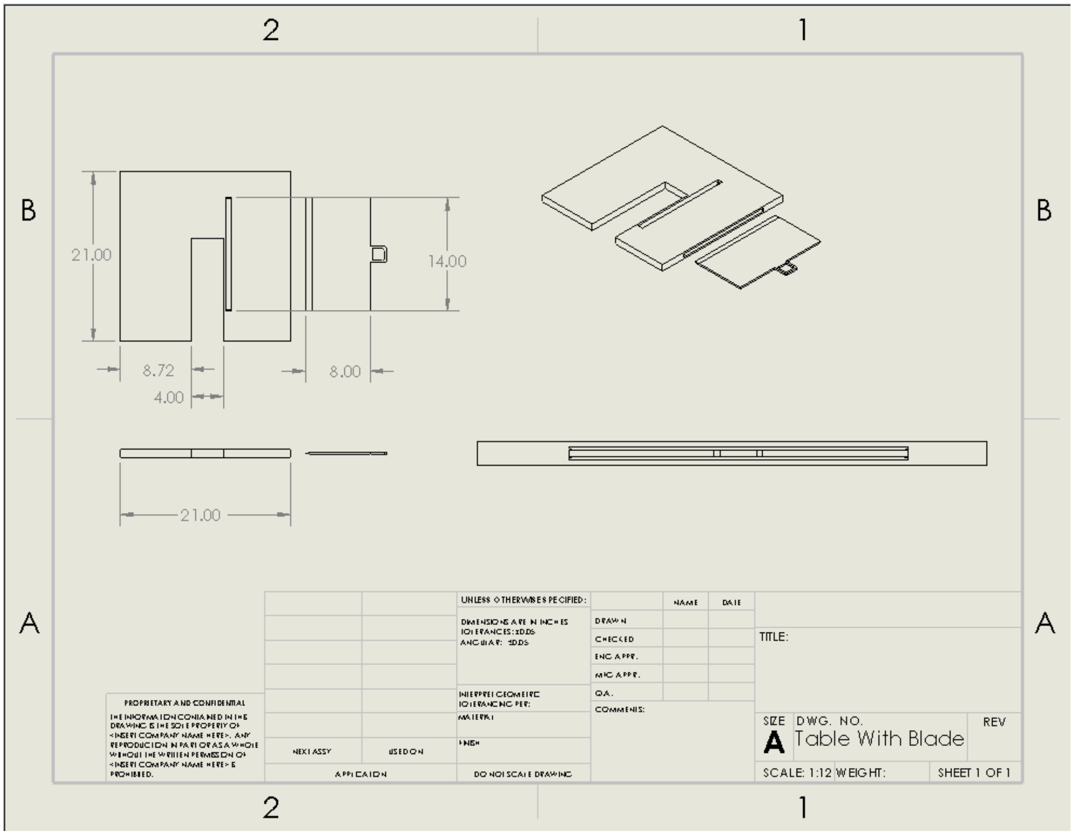


Figure 46: Safe Splice Cutting Dimension

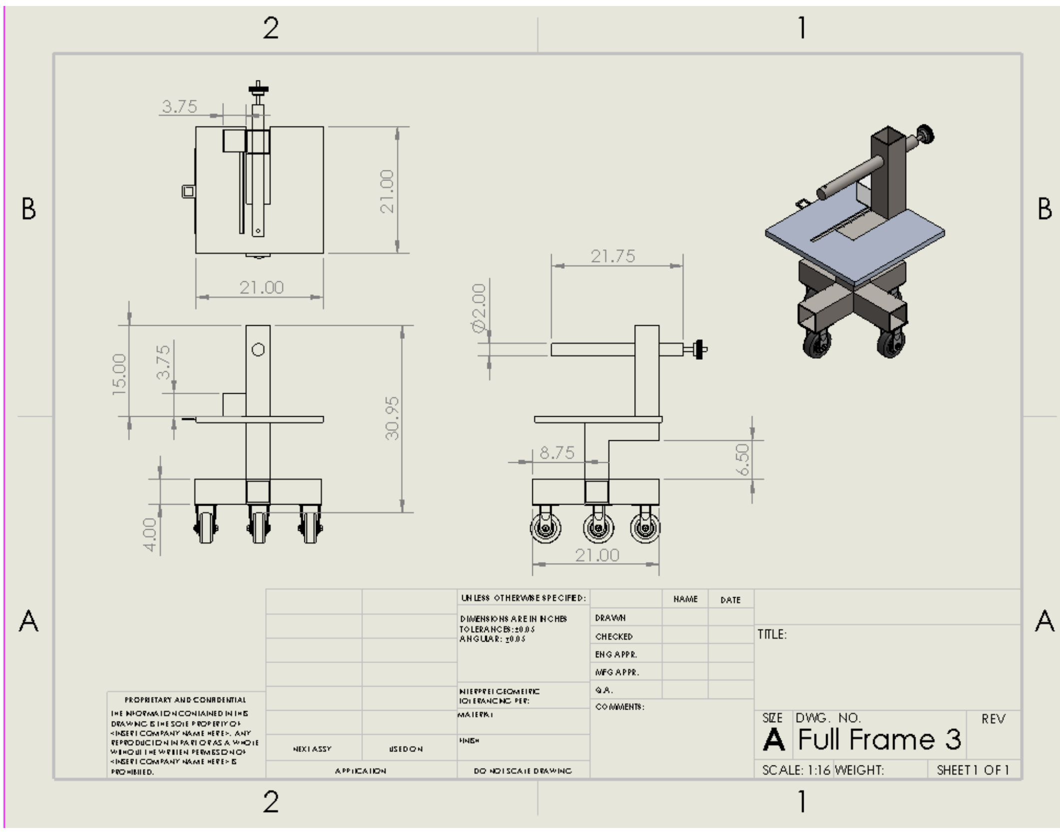


Figure 47: Spooling Cart Full Assembly

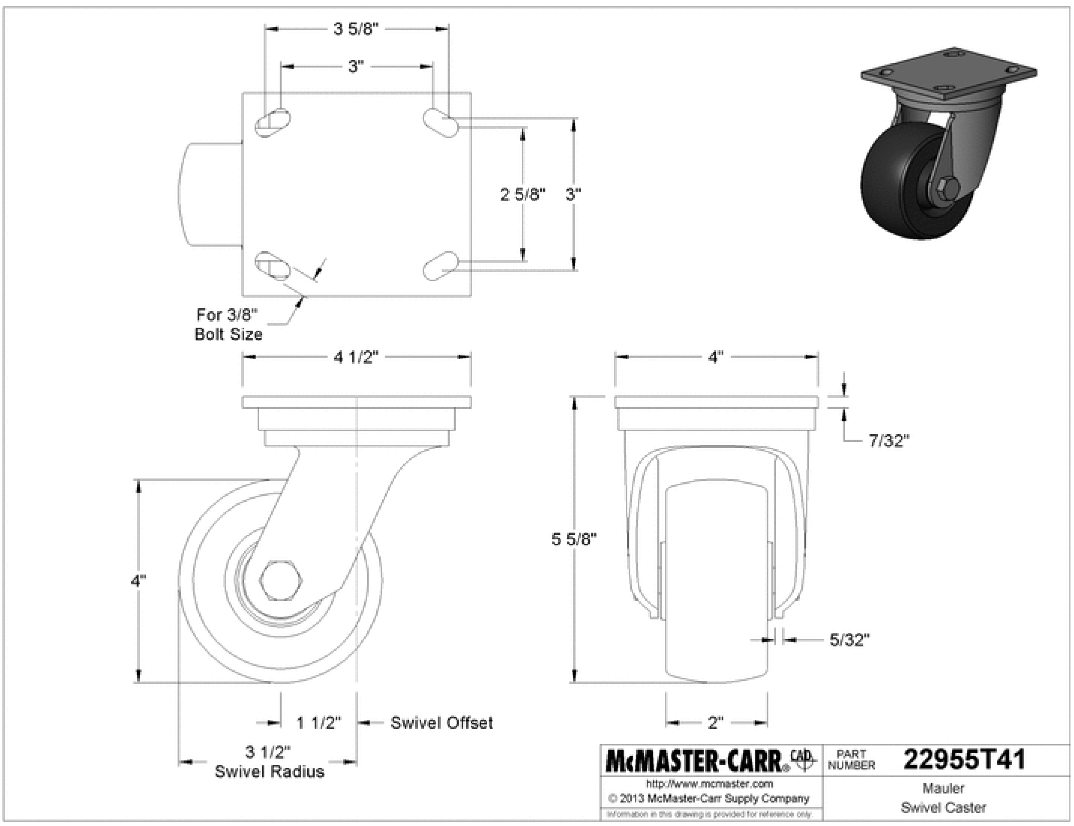


Figure 48: Caster Dimension

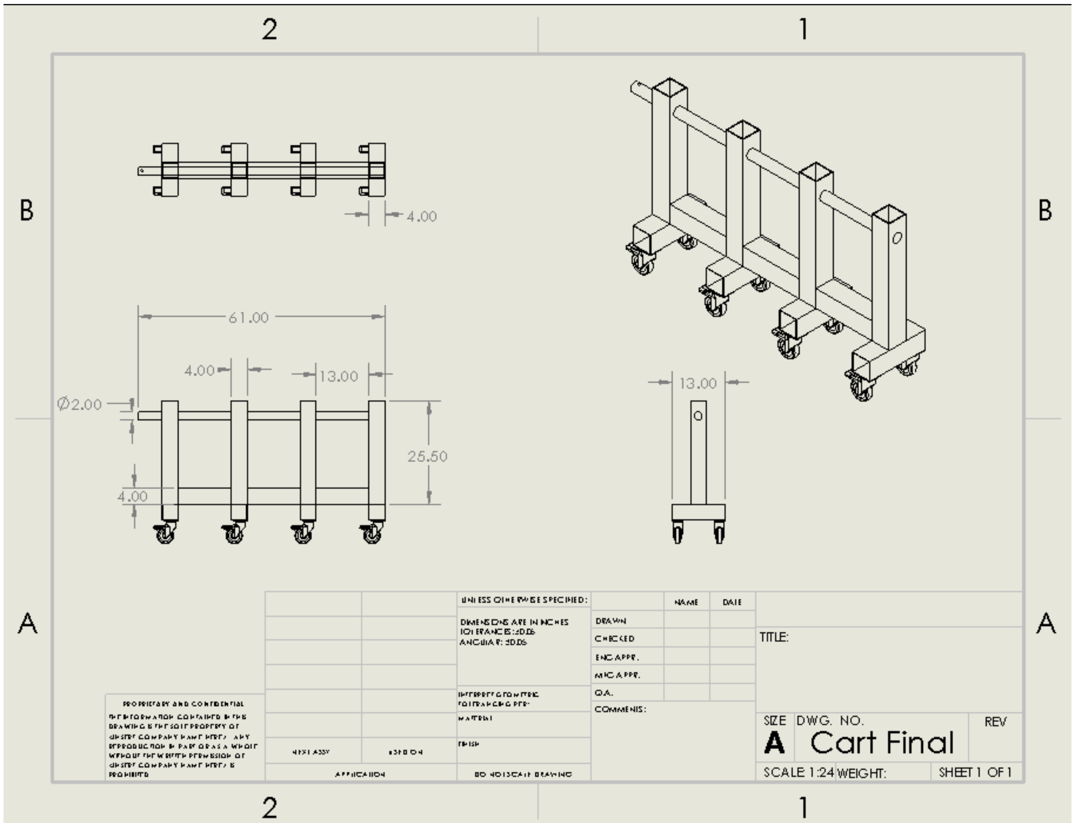


Figure 49: Material Accumulating Fixture

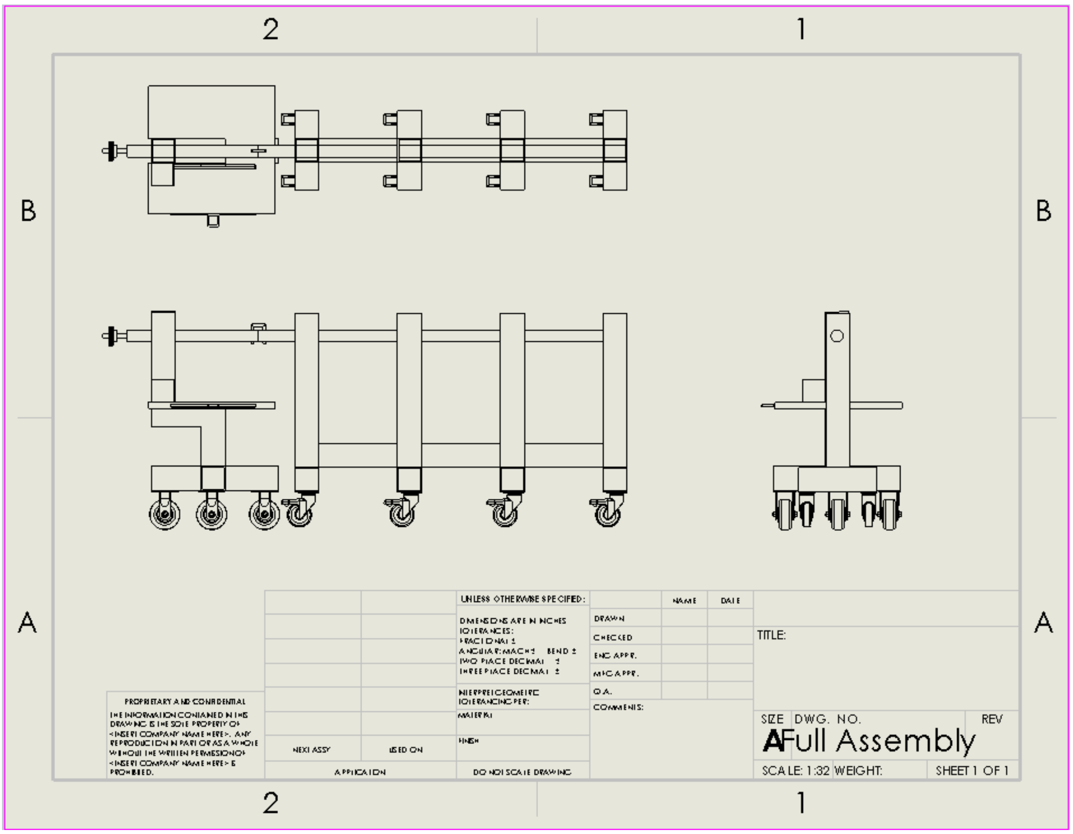


Figure 50: Spooling System Full Assembly

23.8 Appendix I: Proof of Concept

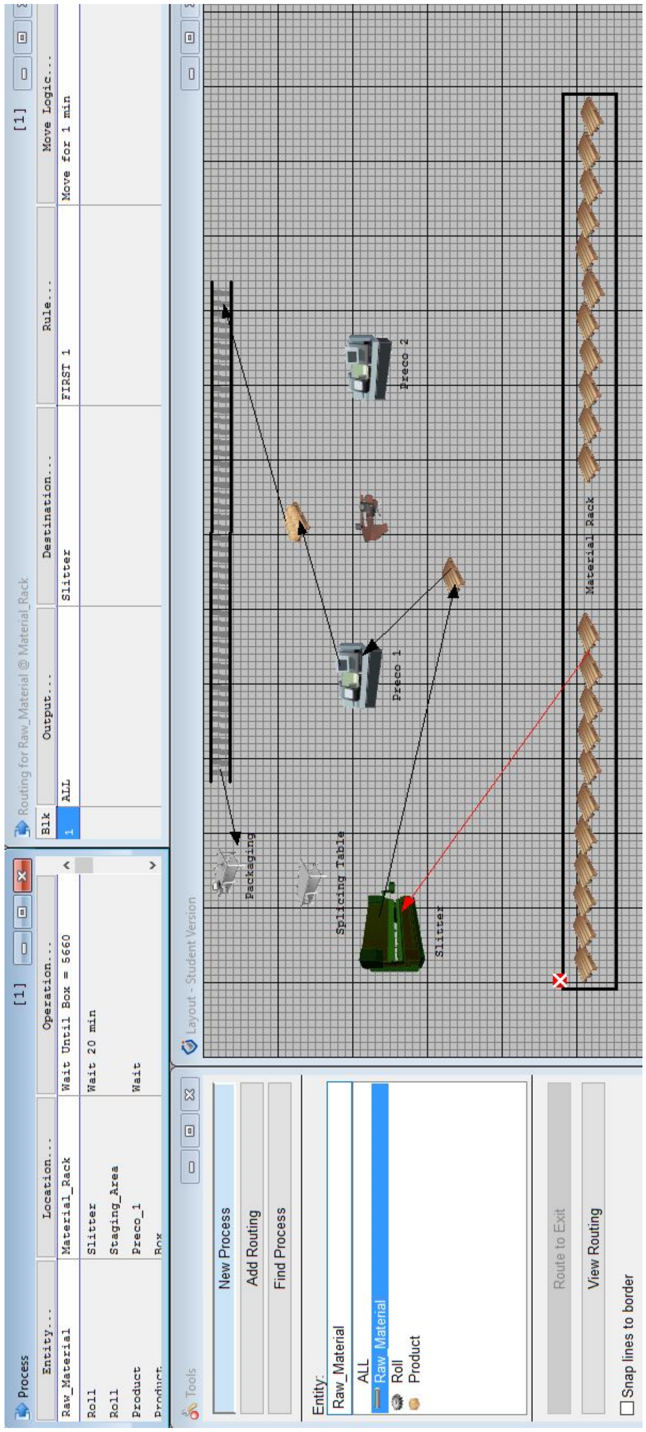


Figure 51: Current System Simulation in Pro Model

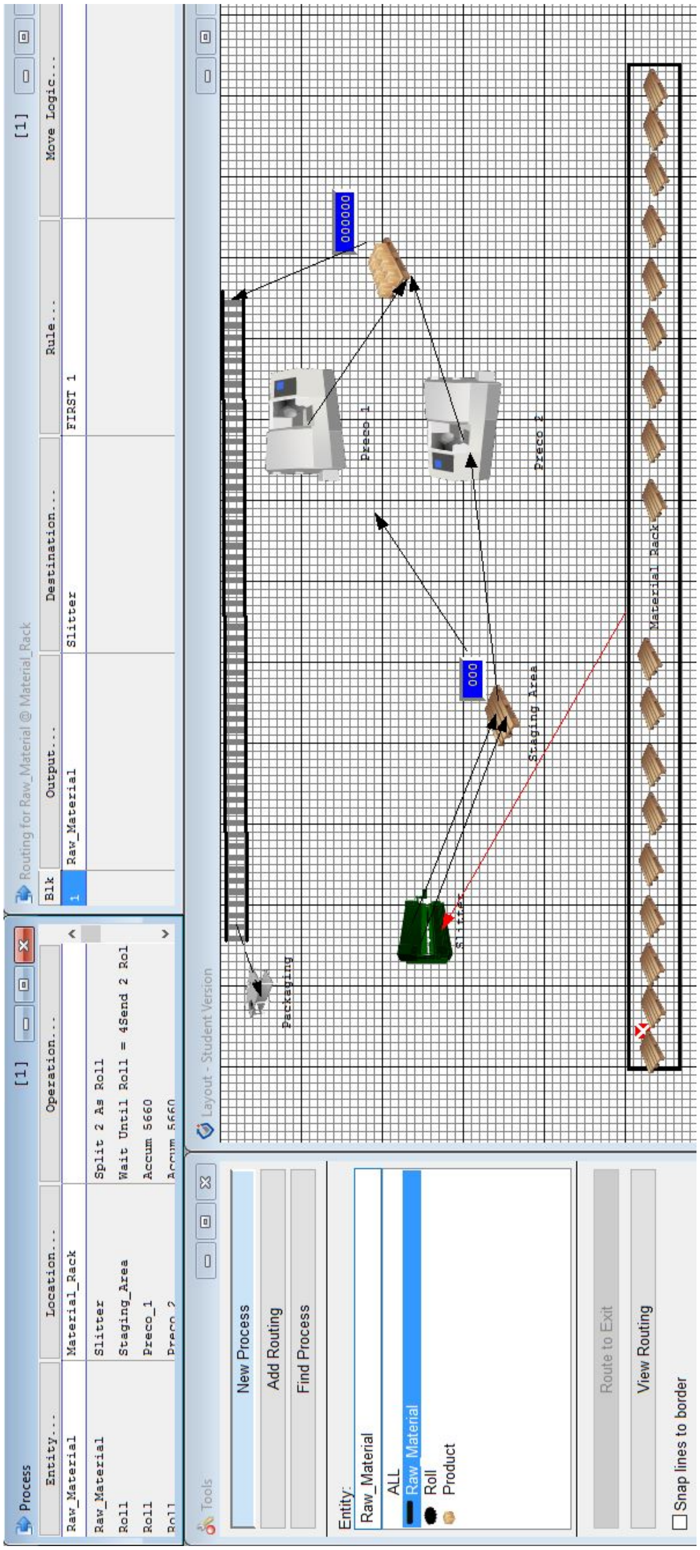


Figure 52: Proposed System Simulation in Pro Model