Engineering Management
Field Project

Determining the Location of Packaging Operations at Company X

By

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Executive Summary

As a leader in electronic devices, Company X works diligently to design and manufacture products that enrich their customers' lives. To provide innovative yet affordable products, Company X continually searches for methods to improve upon its processes and eliminate waste. In adherence to this mentality, this project analyzes a method to reduce Company X's costs as it relates to its supply chain and packaging practices.

Many large retailers in the electronics industry require products to be sold in clamshell packaging due to its anti-theft properties. This clamshell adds additional material and transportation cost to Company X products. To reduce this cost, the same product can be sold without the clamshell for other customers. If retailers request more clamshelled product than what is available, non-clamshelled product can be converted to the clamshelled version. This project develops an analysis and implementation plan to organize consistent and reliable information for the supply chain team to make quick and accurate decisions as to the economical location of clamshell packaging rework. Additional research is performed to determine if a leaner process may result by moving the clamshell packaging process to be completed just-in-time for the customer who requests it.

Chapter 1—Introduction

Company X, a company that designs, manufactures, markets, and distributes electronic devices, prides itself in its vertical integration philosophy. The company has experienced substantial growth in the past several years, requiring each division of the company to grow in proportion to its increasing sales. To illustrate the magnitude of growth, the company's second quarter sales in the year 2000 were 321,000 units versus 3.7 million units in the second quarter of 2009. Not only has the company doubled in growth for many years, but it has now sold eleven times over its volume in 2000. To accommodate such rapid growth, vertical integration has been a key component of the company's success. By performing nearly all business aspects in-house, the company can react quicker to changes throughout its business functions.

Competition is fierce in any electronics industry. As product popularity increases, technologies age, and once cutting-edge products become a commodity, prices are driven down by competition. Shrinking profit margins have given Company X extra motivation to evaluate systems within its Operations division to reduce waste and eliminate non-value added processes. Due to the considerable volume of product that Company X now distributes, small changes in its Operations can result in significant savings for the company and customer. Reductions in process cycle times assist in surpassing the competition in the speed of the product to market.

The supply chain team within Operations has shown an interest in understanding rework costs and where rework functions should be performed. As it applies to Company

X, rework is defined as any effort required to re-package, re-program, or modify a product before selling it to a customer. Company X has multiple facilities, but manufacturing and rework operations are typically performed in the Midwest region of the United States, Taiwan, and United Kingdom locations. It can be difficult for the supply chain team to know where it is most economical to perform rework functions due to numerous factors such as transportation, labor costs, available resources and existing location capacity.

A common rework function performed is that of repackaging a product to be placed in a plastic clamshell. Clamshells are often requested by large retailers to better display the product in stores and as anti-theft measures to reduce shrinkage (an example of a clamshelled product can be found in Figure 1). Shrinkage is a term used by the retail industry for unaccounted inventory that is lost due to theft. If not enough clamshelled product was forecasted and the supply chain is running low, the same product sold in a cardboard gift box (Figure 2) can be converted to the part number or UPC requested by the retailer by adding the plastic clamshell. A UPC, or Universal Product Code, is a unique number to identify the product world-wide by all retailers. This process of packaging conversions is considered rework which can be very time-consuming and costly for the company.

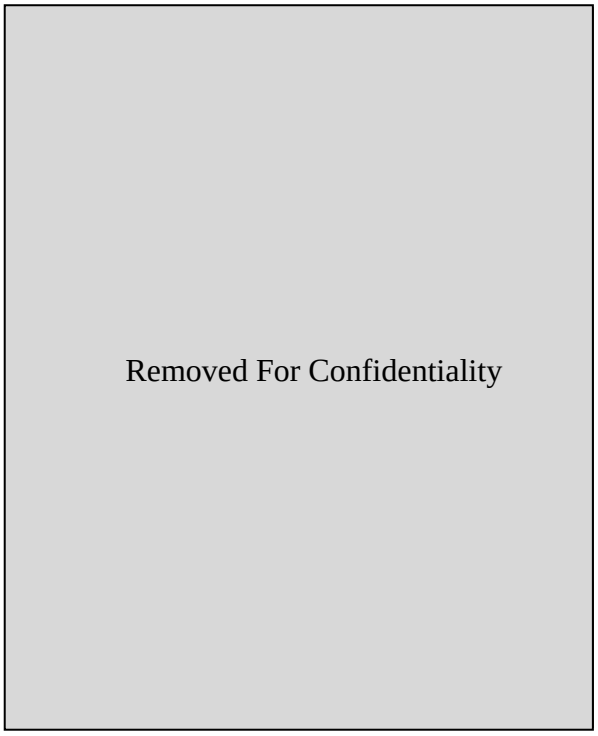

Figure 1: Clamshelled Product

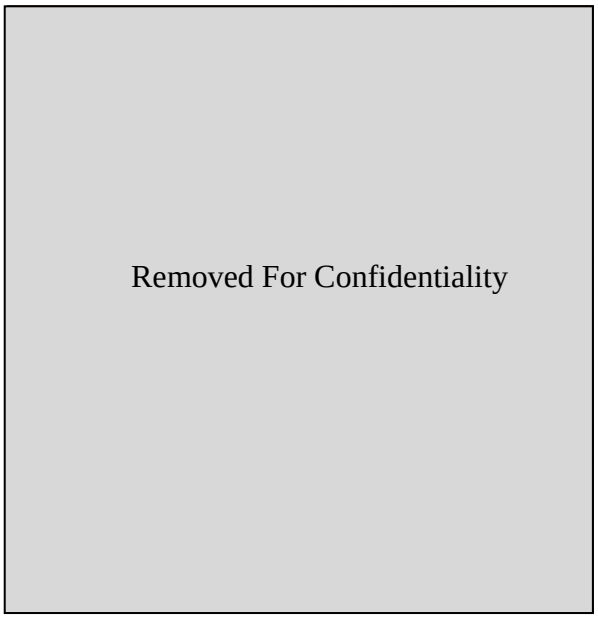

Figure 2: Product Packaged in a Gift Box

Rework Decisions Today

The supply chain team currently monitors on-hand inventory and works with each Company X location to determine where inventory should be sent. When the situation arises to convert a part number, inventory planners work with each Company X location to determine if the product should be reworked on-site or sent to another location within the company to complete the task. The planner will evaluate the quantity of product to be reworked and what resources (people and equipment) are available for the work. Largely, costs of shipping the product to another location and the costs of other locations' labor are not well known and not factored into the decision. This decision making process with little available information is a remnant of having to react quickly to previous years' growth in volume. Time was not always available to capture the costs of the rework, but it was needed in order to sell the product to a larger retailer. Healthier profit margins left room for error.

If the planner wanted to research costs further, they called engineering support teams to better understand the process costs among other factors. Industrial Engineers would often make a one-time analysis specific to the rework at hand to assist the planner in making their decision of where the rework would be performed.

Problems with the Current Process

One of the first questions that is often asked is why does the company have rework at all? The supply chain group monitors their accuracy in supplying product to the right location at the right time to improve upon their forecasting accuracy. However when extrinsic market factors change rapidly, it becomes more important for the supply

chain to be able to react quickly to demand—necessitating the need for rework. The process of continually interacting with other Company X locations and calling upon engineers for a situational review, further delays the teams' speed of response.

The one-time analyses of a specific rework request provided by the industrial engineering team can vary by individual. Although the same data inputs are used, a consistent format has not been developed—causing the planner to take extra time to understand the assessment and extra time for the industrial engineer to create it. Planners who receive an assessment from the engineering staff (usually via email) hold on to them and apply the data to future rework scenarios. The process of making decisions off of old assessments and data can be dangerous, as it can lead supply chain planners to make poor decisions based on out of date information. Assessments can be forwarded to other teams or management, which could also cause the engineering team to appear as providing faulty data if the assessment is not used for its original purpose. All of the above scenarios are prone to miss-communication.

Project Objectives

The intention of this project is to develop a consistent tool to guide the supply chain team in making quick and accurate decisions on where to perform clamshell packaging rework. A review of the longevity of clamshell packaging in the retail industry will be performed to determine the lifespan of the tool. While researching the above, there may be additional benefits in evaluating all clamshell packaging (not just rework) to determine if final clamshell packaging should occur further downstream in the supply chain.

Project Benefits

One of the first anticipated benefits of the project is consistency in the decision process for clamshell packaging rework. It will save the industrial engineering team time in performing one-time analyses for supply chain planners and lessen the time it takes for planners to review each individual assessment. Data can be stored in one central location and updated periodically to avoid numerous emails and miscommunication. One controlled location for such data can provide a better sense of trust that the data is accurate and maintained.

The potential move of the final clamshell packaging process to a later point in the supply chain may result in savings in transportation, labor, and material. The "just-in-time" concept of clamshell packaging may reduce the number of products that would be clamshelled for no reason as the large retailers did not purchase them in the volumes anticipated. The average cycle time of product from the point of manufacturing to the end customer may shorten, as only the value added work requested by the customer (or in other words, the extra clamshell packaging) would be added for the exact number needed by that customer.

In addition to all of the above, a tool developed to convey rework information can also be used to calculate rework costs. It is important for the entire company to understand how decisions impact other departments within the company. Should a design engineer or marketing team member make a small change to the packaging that requires rework of inventory on-hand, a tool to convey the costs of such a decision may help create a more cost-conscious culture and give the engineer or marketer information to make a fact-based decision.

Project Goal

It is expected that the project will develop and organize consistent and reliable information for the supply chain team to make quick and accurate decisions as to the economical location of clamshell packaging rework. It is anticipated that after review of such information, a lean process may result by moving the clamshell packaging process to be completed just-in-time for the customer who requests it.

Chapter 2—Literature Review

Since plastic clamshell packaging is the source of the rework discussed throughout the project, research was conducted to determine if plastic clamshells have a positive and lasting future in the packaging industry. Such information would determine the longevity of the project as it relates to clamshell rework and determine if there is a more efficient packaging practice to be considered.

In this research, numerous articles were discovered about consumer "wrap rage," a term used to describe the frustration and anger some consumers encounter while trying to open packaging from their latest purchase. There is a market of products solely supporting wrap rage to make opening plastic clamshells easier for the consumer. Tools such as the Package Shark or Plastic Surgeon designed to help open clamshells (Brad and Matt 2008) are not only making a profit on consumer wrap rage, but looking to reduce the large number of injuries encountered every year. The New York Times cites the Consumer Product Safety Commission that about 6,000 Americans go to the emergency room each year due to injuries from trying to open their purchases (Brad and Matt 2008). Consumer Reports has gone to the extent of creating an award for the most difficult and frustrating package to open each year titled The Oyster Awards (Anonymous 2007; Brad and Matt 2008).

Due to this large backlash consumers have against clamshell packaging, Amazon (a large on-line retailer) has started a campaign to provide "frustration-free packaging" for its customers. Although such an initiative is easier for Amazon than most retailers in that it is does not have to worry about the physical appearance of a product to convince their customer to buy it; even traditional retailers such as Best Buy and Wal-Mart are

looking for new packaging options. Sony is researching packaging with adhesives that make a loud Velcro®-like noise when opened to deter theft, but make the product easier to open (Brad and Matt 2008). Sam's Club, a warehouse retailer, utilizes a cardboard display in which you can take a cardboard voucher that displays the product to an electronics counter to receive your product after purchase.

Even though there is a movement to help ease the wrap rage experienced by some consumers, other research indicates plastic clamshells may linger in industry for a while longer. Plastic clamshells still effectively meet the demands of retailers and manufacturers alike to help deter theft, help market the product and clearly convey features, allow the consumers to interact with the product, and allow the package to remain environmentally friendly. Per Consumer Reports, "The National Association for Shoplifting Prevention estimates losses from pilferage at more than $25 million per day." (Anonymous 2007)

Additional research indicates that the plastic clamshell industry is still strong. Packaging Digest reviewed a different sealing method for clamshells than the typical ultra-sonic or RF welding techniques that currently create such a solid bond between clamshell plastic. Partner Pak Inc., has developed a liquid plastic that solidifies when exposed to UV light, sealing two clamshells together. GameStop has implemented the technology for their refurbishment operation, reducing the amount of labor required to package their product than previous methods (Mans 2008).

Volo®, a cable manufacturer for TVs, gaming systems, and other electronic equipment, has begun using a new packaging product called Natralock®. Natralock® is a packaging that claims to be eco-friendly and utilizes 50 to 60 percent less plastic on

average than traditional clamshell packaging. Although very similar to plastic clamshells (and even has plastic blisters—the bubble cavity that holds product), it also employs the use of paperboard (Laposky 2009).

While numerous versions of the same plastic clamshell are introduced to improve upon its original design to make it safer to open—yet shoplifter-proof, other companies are sticking to the traditional clamshell for now. TracFone® Wireless is one such company who has sent box cutters with its clamshelled product to retailers such as Radio Shack. The company's intentions are that the retailer will open the product for the consumer (Brad and Matt 2008).

Green Packaging and the Supply Chain

Sustainability has been a significant driver in changing packaging design. As ecological concerns and regulations increase, consumers are demanding more environmentally responsible choices from manufacturers. Packaging is one aspect of products that are relatively easy for the manufacturer to change to claim its efforts towards being a green company. Wal-Mart has helped jumpstart the sustainable packaging trend since it set goals to cut waste generation to zero by 2025 (Forcinio 2008).

Forcinio cites the Sustainable Packaging Coalition in that sustainable packaging includes attributes such as safety and health for communities throughout the product lifecycle, consumes renewable or recycled source materials, utilizes clean manufacturing techniques, and optimizes materials and energy. The Coalition also recommends that the

product is “sourced, manufactured, transported and recycled using renewable energy.” (Forcinio 2008)

Clamshell packaging falls into the sustainable realm in that it can be recycled depending on the plastic it is manufactured from. PVC (or polyvinyl chloride) is a commonly used resin in clamshell packaging that has been banned by many retailers and deemed unfriendly to the environment as it is believed to emit a toxic chemical, dioxin. However it is produced from salt and natural gas—not oil like other resins. “A life cycle study by Plastics Europe shows that PVC clamshells consume less energy and generate less greenhouse gas than clamshells made of other polymers.” (Forcinio 2008) Nevertheless, retailers have approved other plastic clamshell materials such as PETG (Polyethylene Terephthalate Glycol) to be used in products they procure to avoid the stigma of PVC, but retain the robust anti-theft packaging qualities.

Although clamshells are recyclable, it is important to note that it still may not be the best for the environment compared to other materials. Active recycling programs must exist to salvage used packaging. Manufacturers must view used packaging as a source for raw material. The United States does not have as high of recycling rates for packaging as other countries. Acknowledging the above observations, it may be better for a company to use a material that may expend more raw material and consume more energy to produce, but may be recycled at a higher rate than a more “green” material (Forcinio 2008).

Packaging can have a huge impact on a company’s supply chain. Although it is an environmental aspect, packaging is also a marketing function and can facilitate a better logistics flow. It can have a large impact on customer satisfaction as the packaging can

affect the price of the product not only due to material costs, but also due to transportation and handling. These cost reductions are where companies can gain a sizeable competitive advantage by reducing supply chain costs (Jesús and José Carlos Prado 2008). Typically, companies are becoming more "green" due to the supply chain benefits and efficiencies they reap—while being able to tout their environmental prowess (Miller 2008).

Packaging reduction is an additional approach for companies to make their organization more efficient. It can significantly reduce operational costs in that there are fewer raw materials to purchase. Products can be shipped in less space, reducing transportation costs throughout the supply chain. Less storage space is required, potentially reducing warehousing costs. Andrew Miller stresses the concept of removing non-value added activities and of operations to improve the company's bottom line (Miller 2008). This is a concept that has been around for many decades and is a key component of Lean Manufacturing.

Location

Because this project also analyzes the location of where packaging processes should be performed within Company X, articles discussing Taiwan's labor versus the United States were reviewed. Taiwan was found to produce the majority of all electronics world-wide—for example, 82% of notebook computers (Russell 2006). It was interesting to note that most research reviewing Taiwan labor referred to China, where more Manufacturing is taking place than Taiwan. China has even become the world's third largest packaging country (Anonymous 2007).

Although other locations could be considered for packaging in addition to existing Company X affiliates, many articles noted that consolidation is an important part of streamlining processes. Andrew Miller notes that consolidation of offices and distribution centers can help reduce electricity, infrastructure costs, transportation, and inventory carrying costs (Miller 2008). In their review of their new packaging, Volo® has declared that the majority of their products ship as raw materials to their fulfillment centers. It decreases their transportation—therefore reducing emissions, and keeps jobs within the United States (Laposky 2009). Consolidation and outsourcing can both be debated, and there is usually a break-even point to both scenarios. Due to Company X's strong culture of vertical integration, existing affiliates will be considered for the purposes of this project.

Literature Review Summary

Plastic clamshell packaging can cause much grief for the end consumer, but through the above research, appears that it is here to stay. The traditional clamshell continues to be improved upon, but with many of the same physical attributes as the original designs. It has proven to be recyclable, meeting retailers' requests for green packaging while maintaining theft deterrent qualities. Packaging reduction may help reduce supply chain costs, indicating there may be an opportunity to recoup Company X's rework costs by packaging clamshelled product in the Midwest. As Kay Cooksey, a professor at Clemson University's Department of Packaging Science, notes "…packaging is perceived by industry as a necessary evil…" (Anonymous 2007). If Company X can

convert that necessary evil into a value-added process, it may soar ahead of the competition.

Chapter 3—Requirements

In order to capture and organize information, to improve communication between departments, and facilitate quick and accurate decisions about rework—it was imperative to discuss the project with all parties involved. The marketing, supply chain, planning, information technology (IT) and industrial engineering teams all play an important role in the success of the project. By reviewing the project with these teams early in the development stages, it helped spark interest in the project as well as meet each individual teams' needs.

Marketing designs and generates prototypes for the gift box packaging that will be used on all consumer products. Gift boxes are the direct packaging that houses the product to be purchased. This packaging is an integral part of the marketing scheme to catch the consumer's eye and convey the many features of the product. The gift boxes are then placed into a master carton (or shipping carton). Marketing associates in the Midwest collaborate with packaging engineers in Taiwan to determine how the product will fit into its master carton as well as determine the quantity per case. In discussions with the Marketing team, their information indicates that clamshells will be used as packaging at Company X for at least two more years. Several large retailers are requesting that the product they purchase must be placed in a clamshell to deter theft and allow the product to be displayed on peg boards in their stores. Since marketing also generates the BOM (Bill of Materials) for packaging, they acknowledged that there are very few differences between clamshelled and non-clamshelled product. As noted in Figure 1 and 2 above, the two products have the same gift box. The primary difference is that the clamshelled product gains a new part number label and the plastic clamshell to

convert the base product to meet retailer requests. Although not all products are as easy to convert to retailer part numbers, marketing felt that the BOMs on all new products could be structured to make it as easy as the above description from here forward. By doing so, this will make the conversion of product to clamshelled part numbers much easier to perform at the Midwestern facility. Marketing expressed some interest in the results of the project in that they have been working diligently to reduce the size of packaging on products. It is helpful for the Marketing group to understand how the changes they make in the packaging BOM and size of the package impacts other departments and the overall cost of the product.

The supply chain teams and inventory planners monitor inventory at all Company X facilities. If they detect that not enough clamshelled product is on hand to meet retailer demand, they generate orders for more clamshelled product through Company X Taiwan, generate a request to convert current on-hand inventory to the clamshelled part number on-site, or send the current product back to Taiwan for it to be clamshelled. One of the later two scenarios may be chosen to keep inventory relatively low throughout the supply chain. This group would like reliable information readily available to help make the decision of where product should be re-clamshelled in a timely manner.

The industrial engineering team assists the supply chain and inventory planners to determine the best location for the clamshelling rework to be performed. As noted previously, different engineers create different styles of analyses. There is not a standard format, and not one consistent location for all previous rework studies to be kept. The data used in the analyses such as labor costs and transportation costs change periodically. Accounting and transportation departments are consulted to update relevant data. By

developing one format for rework analyses and clearly outlining the dates at which input data must be updated, it will reduce non-value added time spent by the industrial engineering, accounting, and transportation teams.

After examining previous rework analyses and condensing each department's requests above, it has been surmised that in order to determine where the economical location for clamshell rework is to be performed, the following information must be captured:

1. Process steps and time to clamshell product
2. Labor costs in Taiwan and the Midwest
3. Transportation costs
4. Cycle time
5. Speed of product to the customer

To determine if all clamshell packaging should be performed in the Midwest instead of Taiwan, historical and forecast information should be reviewed to evaluate the volume anticipated in conjunction with the above. Several questions arise based on the volume sent through the Midwest facility such as accessible capacity, available resources, and speed of response.

Finally, IT will be a resource to help determine a location to consolidate all information as well as automating processes where possible. By involving them early in the project, the team may be able to gain insight into available features as well as limitations in our IT systems.

Chapter 4—Methodology and Implementation

To undertake a project with such a wide-range of variables and collaboration between teams, the below steps have served as a guideline to prepare for implementation.

Steps

Step 1: Gather requirements from all involved parties

As noted in Chapter 3, the marketing, supply chain, inventory planning and industrial engineering teams have a list of desired information and features that they would like to see consolidated into a single location.

It is the goal of the project to develop and organize consistent and reliable information for the supply chain team to make quick and accurate decisions as to the economical location of clamshell packaging rework. After gathering the above information, it can also be used to determine if all clamshell packaging should be completed just-in-time at the Midwest facility for the customer who requests it. The IT department will be valuable to include in the beginning of this process to determine any potential system constraints.

Step 2: Capture information

Numerous Company X departments have to be consulted to provide accurate data for this project. To help facilitate consistent information, all data will be broken down to display cost in USD (United States Dollars) per unit. To begin, transportation costs are a large portion of the data review. The following scenarios were discussed with the transportation team to capture accurate product costs. All scenarios include transportation to and from the Midwest and Taiwan:

1. Cost of air shipments
2. Cost of sea shipments
3. Cost of LTL (Less than Truck Load) shipments
4. Cost of FTL (Full Truck Load) shipments
5. Other transportation fees, taxes, or duties
6. Time for transport

Midwest labor costs are compared against Taiwan labor. Again USD was chosen as the unit of measure for a fair comparison. Benefits and administration costs are also included.

The process to clamshell existing product at the Midwest facility versus Taiwan's re-clamshelling process will be mapped out to determine similarities and extra non-value added steps. The initial, high-level Midwest process map can be found in Appendix A. Times will be associated with each process to determine if one facility is able to process the rework faster than the other. The time of each scenario with the transportation time above will be combined to determine process cycle time.

Calculations to determine the volume (both dimensionally and quantitatively) will be needed in order to estimate transportation costs. Company X keeps a master list of all items available to produce that includes the unit's gift box dimensions and weight. It also links the gift box to its master carton which includes quantity of gift boxes per carton, master carton weight, and master carton dimensions. The list further explodes down to the detail of the pallet weight, quantity of master cartons per pallet, and dimensions. Item information can be exported out of Company X's ERP (Enterprise Resource Planning) software, Oracle.

The Midwest facility has one clamshelling machine that is not used every day with plenty of extra capacity. The volume of an occasional rework job would be able to be handled with the single machine. If clamshelling all products in the Midwest versus Taiwan is considered as a viable implementation, a machine capacity plan will need to be developed to determine if there is a need for additional equipment. Initial time studies of the Midwest clamshelling process indicate that the equipment used by one operator can yield 1,080 units processed per shift.

Step 3: Organize available information

In order to develop a consistent and reusable format to display the available data, a list of each rework step will be developed to evaluate all possible rework variables. The list will then be organized to determine which pieces of data would be consistent in each rework scenario versus those that would not. This process helps to determine the inputs into a tool to calculate the break-even point to perform clamshell rework in the Midwest versus Taiwan.

Step 4: Determine process to maintain information

Variables that regularly change will be highlighted on the list of inputs to the analysis tool. These pieces of information will need a consistent course of action to update the information on a timely basis. In discussions with the key players that would utilize the data, quarterly updates to the information would suffice for their purposes. Therefore a trigger to update the information in the data set is required. Several processes could handle this—a calendar reminder could be created that would automatically email the appropriate teams (transportation, industrial engineering, and accounting) to update the data that they owned. An individual from each team will be

chosen to monitor the data and serve as a point of contact listed on the website should there be any questions with that piece of data. In the data summary, a calculation can be added to warn the user if the data was older than the agreed upon three months. Ideally, a more automated system would be preferred and further options will be discussed with IT.

Step 5: Establish location for the information to reside

Company X's IT department has recently developed a Microsoft Office SharePoint Website for Company X teams to share and expand a knowledge base. Although the tool is relatively new to most departments, it is the sole internal website that is consistently used among the majority of Company X associates. SharePoint will be a tool that is readily accessible by all Company X associates and has features to email users as the site changes. For the purposes of this project, SharePoint will be utilized for a period of time to determine the amount of use the tool will see.

Step 6: Develop Trial

A trial version of the rework packaging tool will be placed on SharePoint for a smaller group of users to test the program. Users will be encouraged to break the tool and provide feedback in regards to its value. A section on the SharePoint site will be dedicated for feedback and a link to a survey will be included. The tool will be revised based upon the information received.

Step 7: Go-Live

Once the tool has gone through its experimental phase and has been revised, it will be opened up to all users. An email publicizing the tool and its location on SharePoint will be sent out to the marketing, supply chain, inventory planning, and industrial engineering teams. The value of the tool will be stressed along with potential

uses to encourage users to go to the site. So that each department is fully aware of all the tool's features, a short demonstration and question/answer session will be set up so that the potential users will have an opportunity to familiarize themselves with the tool. As with any project, it is important to monitor and measure performance after a go-live of a project. A feedback section will remain on the website to encourage users for recommendations for improvements or additions to the site. IT will plan to capture the number of users on the site per day in order to measure if there is steady or increased use of the tool. While the new information available is still fresh in the users' minds, a follow-up email will be sent for feedback and an additional, voluntary question and answer session will be setup to address and resolve any lingering questions or issues.

Implementation Plan

The implementation plan for the above steps has been outlined in Microsoft Project. A snapshot of the timeline to implementation can be seen in the Appendix B.

Risks

There are several risks with developing a tool to capture so many variables in an analysis. Each variable must be updated in a timely manner (such as the agreed upon quarterly review). Each department that will update data that expires will be responsible to manually go to the tool and update their information. There may be times that a department could forget to do so or their electronic reminders may fail to work. The end user will at least be warned that the data may be out-of-date; however it still may be utilized to make rework decisions.

Old habits are hard to break and it may be difficult to get each department to consistently rely upon and utilize the tool instead of reverting back to email and phone call requests to the industrial engineering team. The engineering group will need to refer others to the tool to remind them of its value. Although users may revert back to their old ways, it is not as likely if the tool is publicized properly. Additionally, it will be critical that the tool is easy to use and is accessible for all users. People will not use a tool if it is difficult to find and is cumbersome to work with. Most teams at Company X are very anxious to obtain data for review—but just need a means to acquire it.

As a final risk, customer requirements will likely change in the future. It is unknown how long this tool will be useful for the Company X departments outlined, however it is the intentions of this project that the tool will be useful for at least two years. Inevitably, new customer requirements will arrive and the tool may need to be modified at that time to accommodate a new packaging process.

Chapter 5—Summary of Project to Date

Adhering to the comprehensive implementation plan, the project is on schedule and is in the completion stages of step two and beginning step three (capturing information and organizing it for use). As noted in the project plan, a significant amount of time has been allocated for capturing and organizing information as well as the trial period in order to fully test all potential uses for the system. Other seasonal factors were included in the extended time range in anticipation of potential and likely delays. First, because numerous departments are involved, their schedules were taken into consideration. Company X sees an increase in sales during the fall and winter seasons, which is accompanied by extra work and planning for many of the departments involved in the project. Additionally, time is reserved for associates, managers, and supervisors in October and early November for the yearly performance evaluation process. Each year there is a noticeably quieter week with fewer meetings while associates and managers prepare for the evaluation process. Finally, there is a language barrier, location barrier, and significant time difference between the Taiwan and Midwest facilities. Taiwan has many associates who speak English well. However as with any second language, it can be difficult at times to communicate requirements for project work that are not a part of normal daily requests. Pictures have literally proven to be worth a thousand words between the two facilities. Such communication and notation of the different clamshelling equipment between facilities can be found in Appendix C and D. It was predicted in the beginning of the project that additional time would be needed due to the above barriers as well as the time difference delay. The two facilities work on nearly completely opposite schedules, usually causing at least a day delay in communication.

In the beginning stages of the project, it became clear that improved communication between many of the departments involved with this project is needed. Requests for information originally arose from upper management in the supply chain team. It was later found through the data capture step in this project that much of the data that the supply chain was searching for was already available through the transportation team and it had been developed with members of the supply chain team. This provides another argument to locate operational data in one location for all departments to use. A central location of this data will reduce duplicated efforts and allow all associates to become more knowledgeable about Company X's costs.

Interestingly, during the data capture step of the project, old analyses in regards to warehouse cycle time provided by the industrial engineering department in years past had been forwarded as helpful information to include in the packaging tool. Unfortunately the data that surfaced was a situational based study and was out of date, therefore not something that should be included. Since it was noted that the data would be helpful to some of the teams if accurate, the industrial engineering team is considering revising the information and providing it on the SharePoint site.

While reviewing former cost analyses, other helpful information was uncovered that could be considered as relevant information to share between departments. To ensure all departments are kept informed of the project and all expectations are met, a representative from each department will re-group to confirm direction of the project and which information may be the most desirable to start the SharePoint site. The outlined implementation steps and project plan will still be met, but some content of the tool and website may change.

Through the data captured thus far, a preliminary study could be performed on whether or not all units should be clamshelled at the Midwest facility instead of Taiwan. This review did not include many additional costs in the process such as planning, transactions, BOM configuration changes and additional equipment required which would increase the cost of clamshelling in the Midwest and far exceed the cost to package in Taiwan. Transportation costs did not prove to be substantial enough to justify the move of the clamshell process for all products to the Midwest. Although this scenario may not fit a traditional lean model of producing and providing the product only when needed, it still proves to be advantageous for the company at this time.

A second scenario will be reviewed with more detailed information to determine if the clamshell packaging process should be performed in the Midwest when the unit is shipped from Taiwan via air transportation only. If the unit is being shipped by air transportation, it is an item that must be available quickly to the customer. The analysis will review if the cycle time to clamshell in the Midwest will be short enough for the customer and cost advantageous for the company. Labor costs are less in Taiwan and the clamshell process cycle time is quicker than in the Midwest—which are two factors that will impact the study. The process of clamshelling the unit in the Midwest would have to cost less than $0.53 for the project to be considered.

Last, high-level transportation data suggests that all clamshell rework that needs to be performed for the Midwest facility should occur there if clamshell tooling is available. Transportation costs to ship rework product two ways—from the Midwest to Taiwan and back—are more expensive than performing the rework in-house. For those units where tooling to fit the clamshell is not available in the Midwest, they can be sent to

Taiwan or additional units can be procured from the Taiwan facility in the configuration needed. Additional data, such as the risk of excess inventory, is being captured for the last two scenarios to establish a financial break-even point.

Preliminary data also indicates that Taiwan may be faster at packaging than the Midwest facility—indicating that the cycle time of the process and speed of product to the customer is currently shorter when packaging in Taiwan. Although out of scope for this project at this time, it is recommended to benchmark with Taiwan to determine what factors cause Taiwan to be faster in their process and if the Midwest facility can be improved.

Chapter 6—Conclusion

As the project has progressed, it is expected that the goal of developing and organizing consistent and reliable information for the supply chain team to make quick and accurate decisions in regards to rework will be met. Over the course of the project, it has been confirmed that rework and cost information will benefit several other departments as well. Most of the desired information on rework costs has been compiled in individual departments, but are not consistent, shared, nor reside in one location.

Research has indicated that clamshell packaging causes a great deal of frustration for the end customer, but it is still favored by many retailers for its theft prevention properties. Most clamshells are recyclable, adding to its desirable packaging qualities. New types of packaging materials are being developed that may soon replace clamshell packaging, however investigation has suggested clamshells will endure in the packaging world for at least a couple more years. With this information, it is estimated that the data compiled in regards to rework packaging for the supply chain team will be valid for at least two more years.

The exercise of capturing rework information for publication has uncovered communication gaps between operational departments. Adding information to a consolidated location accessible to all operations associates may increase awareness of costs and could eventually be shared with other departments to enable fact based decisions on costs for the betterment of Company X. Furthermore, information located in one location may reduce redundant activities to capture the same information across multiple departments.

The process of clamshelling units to convert or rework a unit has proven to be cost effective in the Midwest if the tooling is available. However the process of packaging units into clamshells has not proven to be cost effective to perform in the Midwest facility for all units. Further research may denote a break-even point where the clamshell packaging process may be cost advantageous in the Midwest when the base units are shipped from the Taiwan facility via air transportation. Although shipping clamshelled units via ocean transportation is cost effective for the company, it does not completely fit the model of "just-in-time" of providing only what the customer wants, when they want it. As Company X improves processes and eliminates non-value added work content, the current paradigm may shift to a leaner process.

Chapter 7—Suggestions for Additional Work

This project has revealed other opportunities for Company X to improve upon its processes. The following topics may prove to be worth evaluating in further detail.

1. Affiliate Processes: Company X has grown considerably in the past few years with numerous acquisitions. This has caused different Company X facilities to perform the same process differently. Company X may benefit from benchmarking between its own facilities to determine best practices, provide knowledge sharing, and implement consistent practices across the company.
2. Outsourcing: Although Company X has developed a strong philosophy of vertical integration it may be advisable to research the outsourcing of small processes that are not a part of Company X's core competencies. In the case of packaging rework, it may be cheaper and quicker to perform this function with an outside supplier.
3. Packaging Materials: Additional research could be completed to provide a recommendation for a packaging change for Company X units. Customers are now looking for green products much more than in the past. Research indicates this trend will only continue. It may be wise for the company to lead the industry in green initiatives. Green practices are often times a cost savings for the company, but can also provide a new marketing feature.
4. Oracle Tools: The project worked to capture data in systems outside of the company's ERP system, Oracle, as there was not a known way to integrate this information into the system in a quick manner. Further research and potential

upgrades to the ERP system may expose a better process to capture and maintain information within Oracle.

5. Knowledge Sharing: The company has grown so rapidly that a great deal of information captured over the recent years has not been stored or shared in a manner that can be utilized by people outside a given department. Additional research on the topic of knowledge management company-wide may prove to be beneficial for Company X.
6. Facilities: Finally, research could be performed in determining the break-even point of procuring or renting an additional Company X facility near transportation ports and hubs to reduce transportation costs. These facilities may be ones that only store product or convert base units into clamshelled versions for cheaper transportation from Taiwan, but yet quick to distribute.

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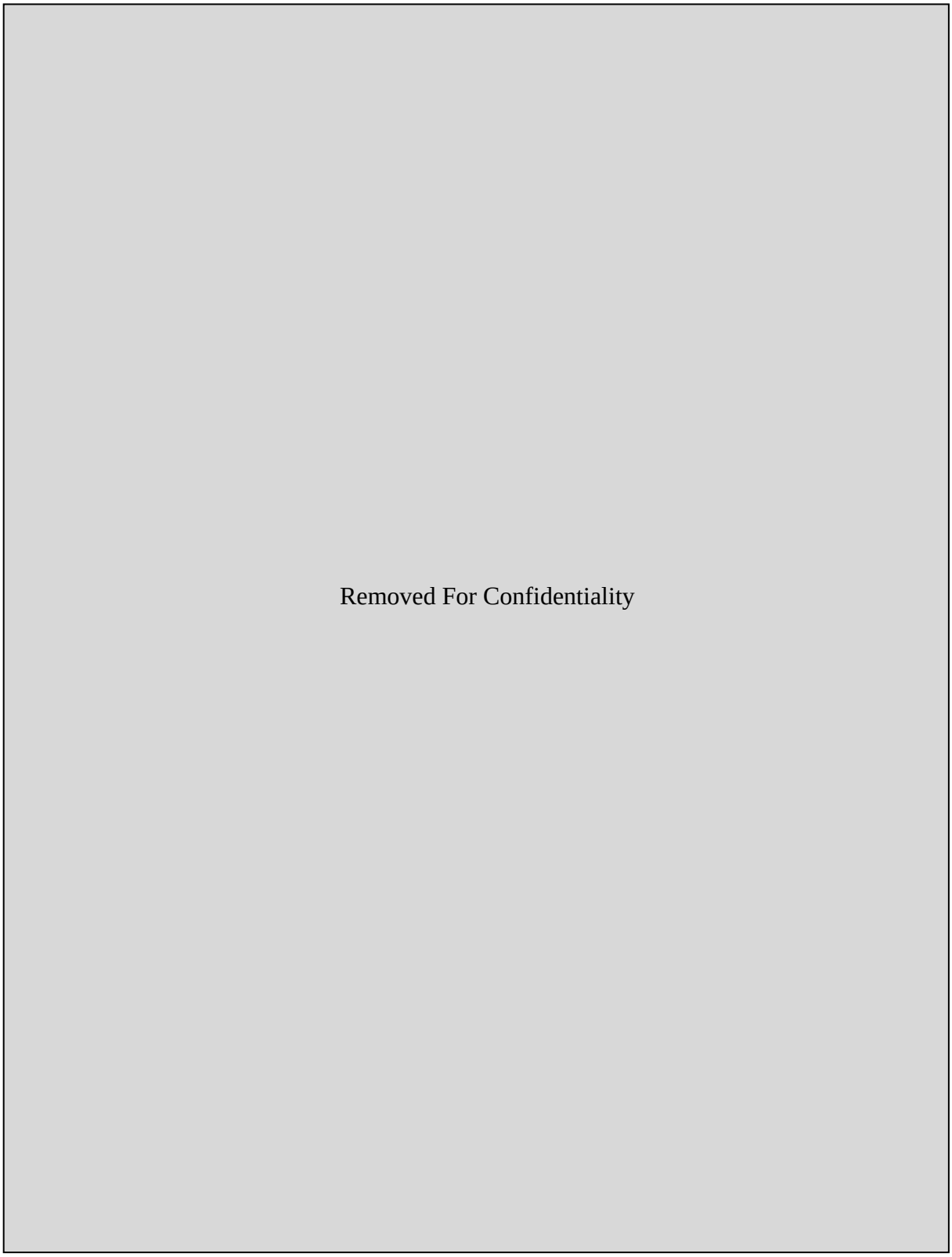
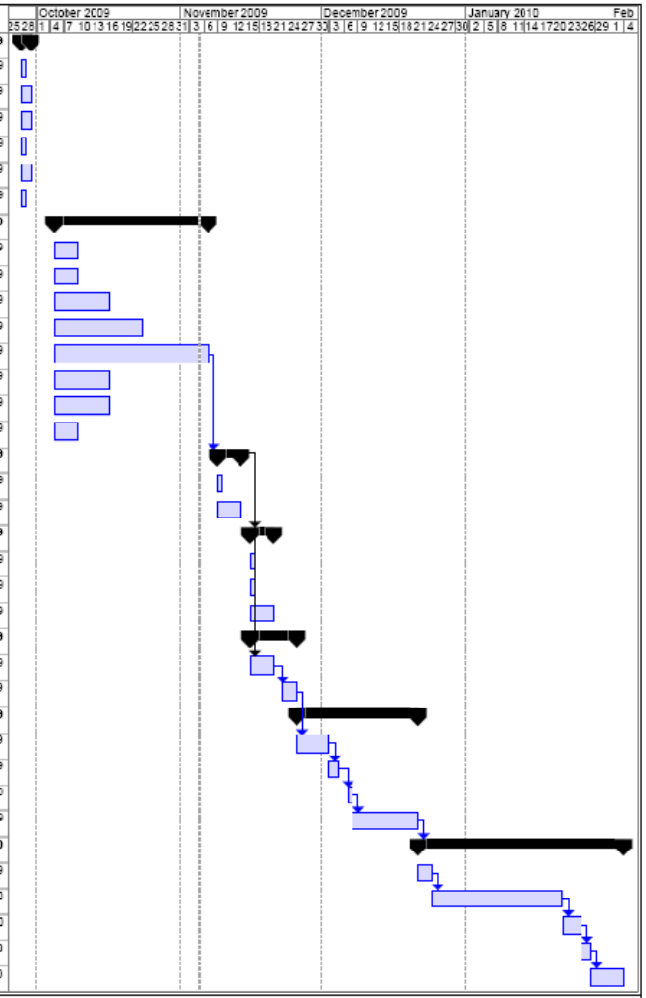
Appendix A: Clamshell Process Flow Chart



Appendix B: Project Implementation Schedule

ID	Task Name	Duration	Start	Finish
1	**Gather Requirements/Define Scope**	**2 days**	**Mon 9/28/09**	**Tue 9/29/09**
2	Marketing	1 day	Mon 9/28/09	Mon 9/28/09
3	Industrial Engineering	2 days	Mon 9/28/09	Tue 9/29/09
4	Supply Chain	2 days	Mon 9/28/09	Tue 9/29/09
5	IT	1 day	Mon 9/28/09	Mon 9/28/09
6	Transportation	2 days	Mon 9/28/09	Tue 9/29/09
7	Inventory Planning	1 day	Mon 9/28/09	Mon 9/28/09
8	**Information Capture**	**25 days**	**Mon 10/5/09**	**Fri 11/6/09**
9	Transportation Costs	5 days	Mon 10/5/09	Fri 10/9/09
10	Transportation Time	5 days	Mon 10/5/09	Fri 10/9/09
11	Duties and Taxes	10 days	Mon 10/5/09	Fri 10/16/09
12	Labor, Admin and Benefit Costs	15 days	Mon 10/5/09	Fri 10/23/09
13	Detailed Process Map of Current Clamshell Processes	25 days	Mon 10/5/09	Fri 11/6/09
14	Item Master Detail	10 days	Mon 10/5/09	Fri 10/16/09
15	Process Cycle Time	10 days	Mon 10/5/09	Fri 10/16/09
16	Equipment Costs	5 days	Mon 10/5/09	Fri 10/9/09
17	**Organize Information**	**5 days**	**Mon 11/9/09**	**Fr 11/13/09**
18	List Steps of Rework	1 day	Mon 11/9/09	Mon 11/9/09
19	Determine and Capture Additional Data Needed	5 days	Mon 11/9/09	Fr 11/13/09
20	**Develop Process to Maintain Tool**	**5 days**	**Mon 11/16/09**	**Fr 11/20/09**
21	Resolve Who Owns Data	1 day	Mon 11/16/09	Mon 11/16/09
22	Develop Data Revison Schedule	1 day	Mon 11/16/09	Mon 11/16/09
23	Develop Prevention Process (exclude bad data from being used)	5 days	Mon 11/16/09	Fr 11/20/09
24	**Establish Location for Tool to Reside**	**8 days**	**Mon 11/16/09**	**Wed 11/25/09**
25	Develop SharePoint site	5 days	Mon 11/16/09	Fr 11/20/09
26	Test Program	3 days	Mon 11/23/09	Wed 11/25/09
27	**Trial**	**18 days**	**Thu 11/26/09**	**Mon 12/21/09**
28	Complete Prototype	5 days	Thu 11/26/09	Wed 12/2/09
29	Set up Trial and Feedback System	2 days	Thu 12/3/09	Fri 12/4/09
30	Notify Test User Group	1 day	Mon 12/7/09	Mon 12/7/09
31	Revise Trial System Against Feedback	10 days	Tue 12/8/09	Mon 12/21/09
32	**Go-Live**	**32 days**	**Tue 12/22/09**	**Wed 2/3/10**
33	Publicize	3 days	Tue 12/22/09	Thu 12/24/09
34	Monitor	20 days	Fri 12/25/09	Thu 1/21/10
35	Maintenance Schedule	2 days	Fri 1/22/10	Mon 1/25/10
36	Measure Performance	2 days	Tue 1/26/10	Wed 1/27/10
37	Revise System as Needed/Close Project	5 days	Thu 1/28/10	Wed 2/3/10



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Appendix C: Pictures of Taiwan Clamshell Equipment

Figure 3: Side View; Taiwan Clamshell Machine

Figure 4: Front View, Taiwan Clamshell Machine

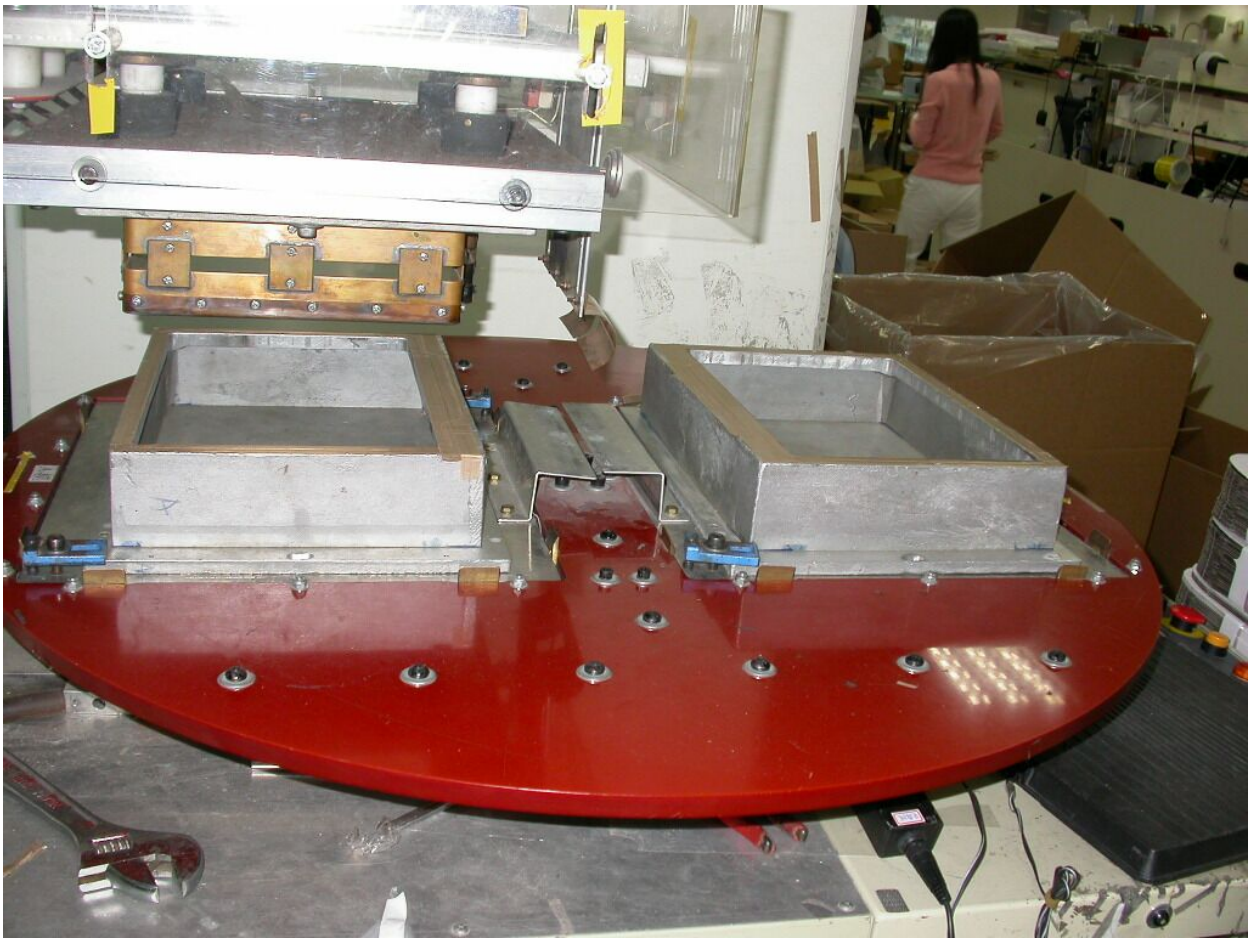

Figure 5: Taiwan Rotary Clamshell Machine

Appendix D: Pictures of the Midwestern Clamshell Equipment

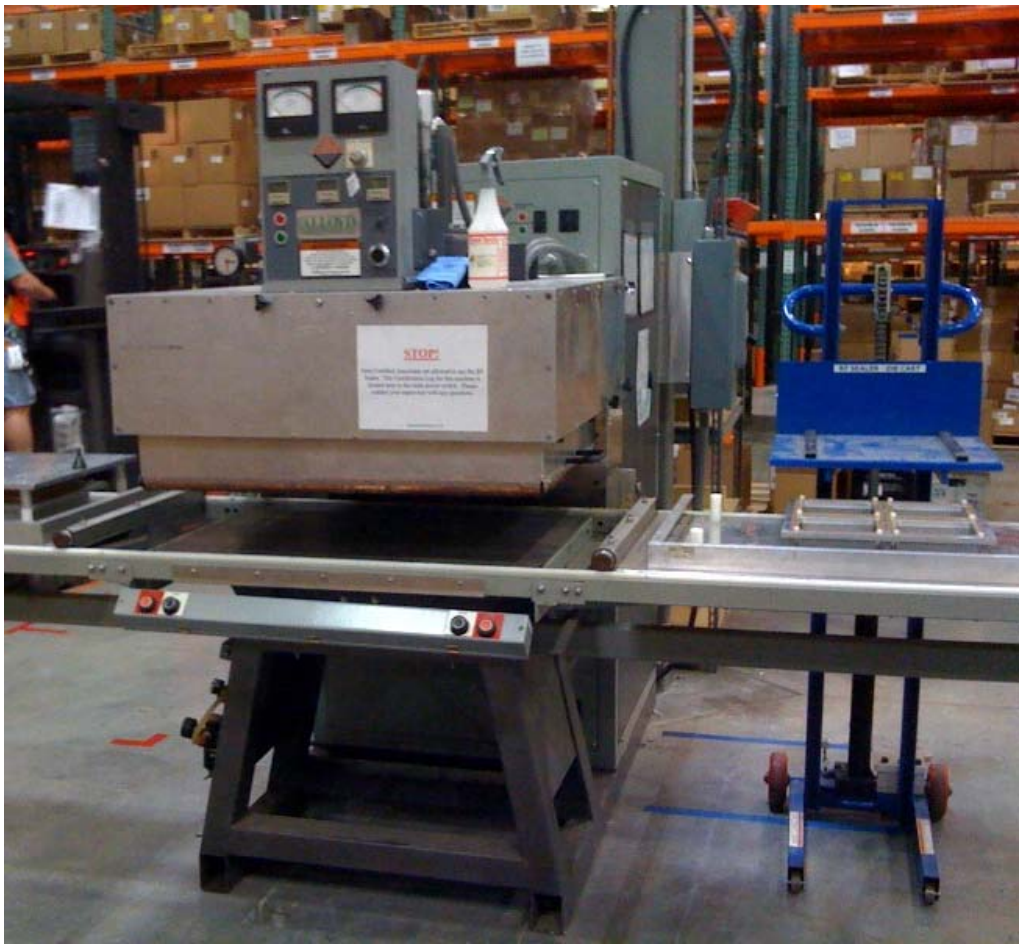

Figure 6: The Midwestern Dual-Sided Clamshell Machine

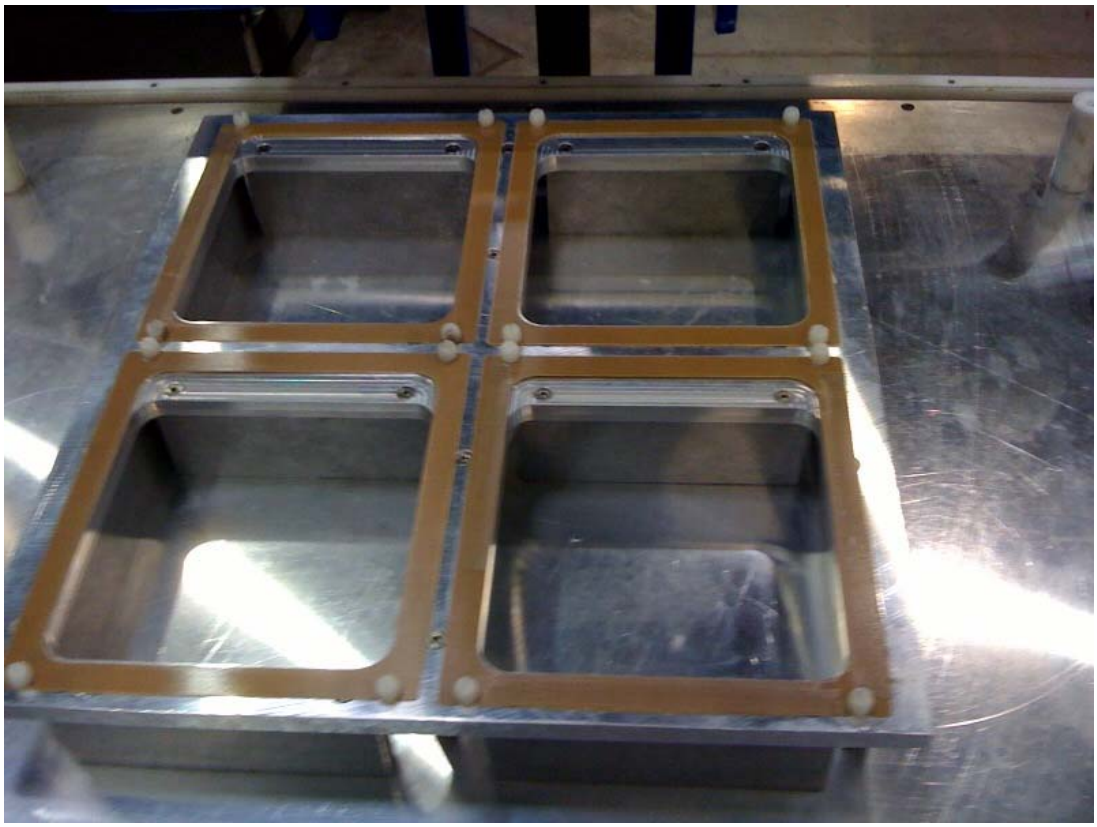

Figure 7: Tooling for the Midwestern Clamshell Machine

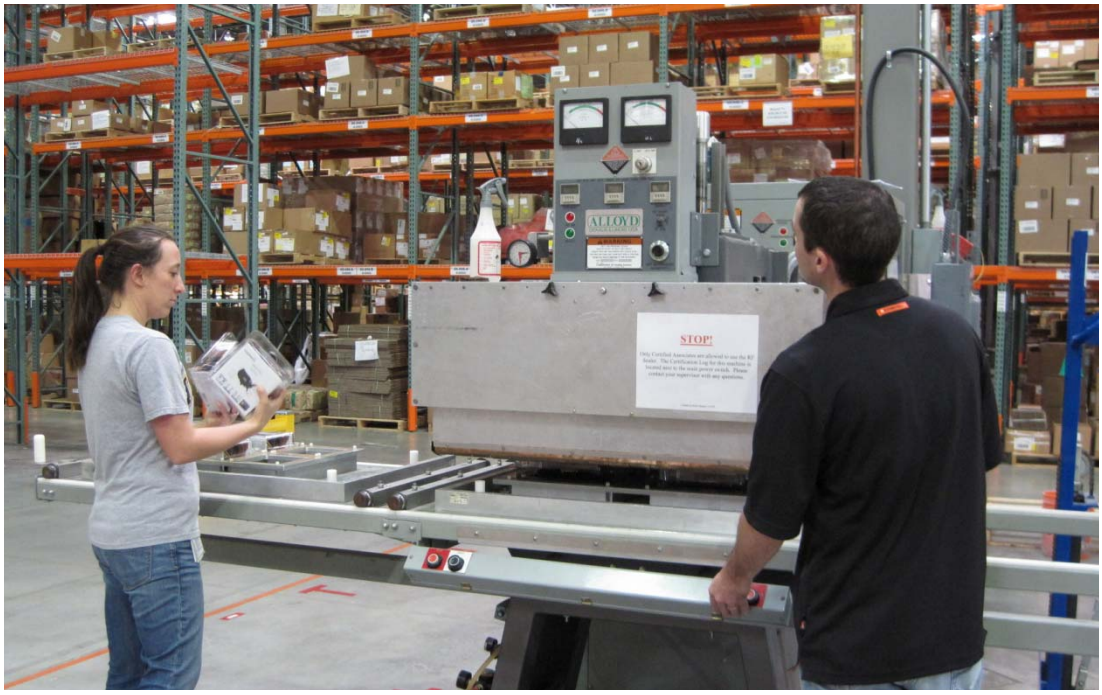

Figure 8: Associates using the Midwestern Clamshell Machine