Project Number: ZAZ-M101

Warehouse Redesign for Bay State Milling Corp.

A Major Qualifying Project Report
Submitted to the Faculty
of the
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
in Management Engineering
by:

Benjamin Goldberg

John Gikas

Nicholas Vaughn

Date: 1/12/2011

Approved:
Prof. Amy Zeng, Major Advisor

Contents

List of Tables

List of Figures

Acknowledgments

We would like to thank both Worcester Polytechnic Institute and Bay State Milling Corporation for making this project possible. We would like to personally thank Amy Zeng, Mike Walsh, Dennis King, and Tom Nellis for providing answers to all of our questions as well as guiding this project all the way through to its end.

Abstract

The goal of the project was to increase the efficiency of BSMs inventory management system at their Clifton Facility. The team evaluated the procedures, diagnosed the problems, and built recommendations to address their problems. Through the provided data and observation, we discovered their current inventory layout inefficient for their inventory flow system, that the current policy regarding customer practices was too lenient, and that BSM does not collect metrics regarding inventory movement. We then developed short term, intermediate and, long term recommendations to combat the problems we identified.

Authorship

The project team was comprised of three members, John Gikas, Ben Goldberg, and Nicholas Vaughn.

John Gikas

John presented a deeper knowledge of the technical analysis side of the project, and was thus responsible for the analyses regarding the inventory in all its aspects. He wrote portions of chapters 3, 4, and 5 specifically regarding the analyses and their results in those chapters. He also had a design portion of the project which was comprised of the actual redesign of the warehouse. John built models in CAD software and helped decide on the final configurations.

Benjamin Goldberg

Ben Goldberg presented more advanced writing skills than the other members and therefore wrote a large portion of the report and was also responsible for the final edits. Furthermore, he helped with the analysis of johns parts and advises during the final design discussions for the configurations. The specific methods used, problems derived, and research regarding the recommendations can be attributed to him. Chapters 1, 2, 3, 4, 5, and 6, along with the two appendices were in part or full, written by Ben Goldberg.

Nicholas Vaughn

Nicholas Vaughn joined the team after the project had begun; however, he became a valuable member to the team. He presented the team with a balancing mind and valuable editing abilities. He wrote portions of chapters 3 and 4 as well as a majority of chapter 5. He also helped significantly with the research and development period of our project, and also acted as equal partners with Ben Goldberg when contacting companies for information regarding the recommendations.

Executive Summary

Bay State Milling Company, the fourth largest producer of flour in the United States, has been experiencing efficiency problems at their milling facility in Clifton, New Jersey. This problem was exacerbated when BSM decided to upgrade their packing machines. This would create an even larger flow of product into their limited inventory space located in their warehouse at plant. BSM realized this impending issue and hired a WPI MQP team to come up with a more efficient warehouse design which could handle the new production level and streamline their warehouse. To assess this problem, the team was given production data, allowed observation of the facility, and conversed with the staff of the Clifton Facility. The results of these methods of analysis was to provide BSM with a new warehouse design which would increase the overall efficiency of the entire facility, move BSM out of the rear warehouse which is a costly building for BSM to occupy, and also develop a solution to the current issue regarding customers who pick up their orders late.

To achieve the goals of the project, the team developed methods through which we could collect and analyze data. Data collection coupled with the observation of the facility and conversation with the staff, gained the team valuable insight through which our results, conclusions and recommendations were derived from. The first of these methods was an analysis of the data given by BSM. The team did a number of analyses including ABC and EOQ. The next step was to observe the facility and converse with its staff to uncover other issues. With the data collected and other information gathered by the observation and conversions, the team had developed a full picture of exactly where inefficiencies were in the warehouse and where they were generated within the company.

With the problems and the inefficiencies targeted, the team then moved to tackle each problem by developing a tailored solution. First, the inventory management flow system needed to be addressed for two reasons, one the new machine would be pushing out more product more quickly, and two the current system was found to be generally inefficient. To combat the inefficiency and space for production, the team recommended installing gravity/inertia power flow racking systems. Second, the current customer practices were

costing BSM money because of their late pickups. The sensitive relationship BSM has with their customers is a facet of the industry; however, it is the customers that decided on the pickup dates of their orders. Thus, to deal directly with this problem, the team decided that building more stringent contracts that layout exactly what the repercussions are for late pickups. Third, the lack of metrics to track where costs were being developed was also an issue to be addressed. This problem stood as a very large issue because BSM did not know exactly where the extra costs of the product were generates from, thus, the team developed a few metrics which should help them track down and neutralize the problems. However, to fully understand what costs are being generated and where they are coming from, it is imperative that BSM continue to develop metrics to help them track practices that may be generating extra costs.

All in all, BSM is a company poised to move into the top tier of the flour industry. To do this, BSM will have to improve its efficiency at all of its facilities and change certain practices which generate non-value adding costs to their product diminishing their profit margin. The efficiency can be improved by implementing the new pallet flow racking system will also help organize their warehouse. By changing their current policy with customers, BSM will no longer be held responsible and suffer the consequences produced by the late pickups. Finally, if BSM were to start collecting data on metrics and developing further metrics; they would have a better understanding of what contributes to the costs of production and movement of their product. With all of these recommendations, the team feels that BSM could greatly increase the efficiency of their Clifton, New Jersey facility.

1. Introduction

Factories, mills, and any sort of facility that produces a product, struggle with efficiency, the organization of inventory, and management systems for their inventory. Some companies like Toyota and GE have pioneered different ideas and theories which help build an efficient factory and remove wasteful practices through methods derived from Six Sigma. However, those companies such as GE and Toyota who have pioneered ideas such as Six Sigma have millions of dollars to spend across multiple factories which all see the benefit over time making the return on investment worthwhile. Companies on a smaller scale are faced with a myriad of constraints which make investing in such ventures difficult. They have much tighter budgets; the staff may not be trained to observe the factory floor from the necessary point of view, and the company's facilities might not be able to shut down or have enough space to handle a full redesign. However, that is not the only way to increase efficiency, remove wasteful practices, and manage inventory better. An analysis of the scheduling of orders for production, the order of processes, and the position of machines on the floor are all things that are free in a monetary sense and can highlight areas in need of attention. Areas of attention include bottlenecks and poorly organized or managed systems and processes. Fixing these areas will result in a more efficient process, inventory management system, and an overall more efficient facility. All in all, a factory is part of a business which has the overall goal of making money by producing and selling a quality product. Applying the ideals of Six Sigma and other lean principles to production are two practices which companies should adopt as it will positively impact their bottom line.

Factories, mills and facilities that have an efficient process of production have an instant strategic advantage over their competition whose production is not as efficient. These companies hold an obvious advantage in their market because they can create a product for a lower cost, in a shorter time and, more efficiently than their competitors. This means they can charge the same or even lower prices than their competitors and still have the same or even greater profit margin while still having the capacity to cater to more customers with their expanded production capabilities.

Another improvement companies have taken advantage of is having an efficient means of managing their inventory. If a company can place the inventory in an easy to access and easy to manage environment with the correct inventory flow system, the company will be able to organize and ship orders more efficiently. This efficiency translates into inventory that is on the floor for shorter periods of time, workers spend less time managing and organizing the inventory, and more inventory can be held at one time with a decreased holding cost. These contribute directly to competitive advantages over industry competitors who do not have as efficient inventory management systems.

Finally, companies have a cost of doing business associated beyond the labor and materials cost of producing a product. These are indirect costs that must be minimized as they add little to no value as seen by the customer. Companies must build efficient facilities that have designs which promote an inventory flow system in place while being void of wasteful practices. This is paramount for companies in small margins industries if they desire to stay competitive.

1.1 Problem Statement

As the cost of doing business goes up, companies are looking for ways to reduce them. The cost of doing business can go up because of internal or external forces, some which can be managed and others which cannot. These expenses range from increased raw material costs, something a company must deal with because it is out of their control, to a lack of efficiency on the warehouse floor which is within their realm of control and can be addressed. Companies try many different methods and strategies to lower costs and increase their efficiency by removing non-value adding processes. Bay State Milling Company, a national producer of flour has been looking for ways to increase its efficiency and remove non-value adding process in its warehouse inventory management system and organization system.

Bay State Milling produces flour, a product which travels through many linear processes before it can be packaged and shipped to its customers. The waste these processes produce have been minimized as technology has increased over time. The industry, including BSMC, has moved towards fully automated systems which have removed the human component almost entirely from the production process. While the production may be at its current technological efficiency limit, the other procedures, post product production, still have areas where improvements can be made.

As technology has pushed the industry towards a fully automated production system, the only processes still controlled manually are the packaging and shipping processes. These remain as the only two areas at Bay State Milling Corp. which still see direct human interaction which control the speed of production. Because of the manual interaction, there is a greater chance for wasteful practices and management systems to not be run at their peak capacities. Currently, these processes force the facility to run between 40% and 60% depending on the order schedule and inventory management efficiency.

To find the opportunities to remove these wasteful non-value adding practices, research must be done to see where improvements can be made. Looking at their current warehouse design, personnel practices, inventory management and organization, order scheduling, and their shipping techniques, we found practices which can be removed, realigned, or modified to create a more streamlined packing and shipping process for BSM.

1.2 Goals and Objectives

The Objective of our project is to propose an optimal warehouse layout and operating plan for the packing and shipping department for BSM's Clifton Facility. Through the analysis of the current inventory management and organizational practices, we evaluated areas for improvement and set goals.

Minimize inventory and Maximize inventory flow:

The amount of inventory being held was more than necessary; we wanted to reduce the number of pallets being stored on the inventory floor at any given time. Furthermore, the layout of the inventory storage area was not conducive to the desired inventory flow methodology implemented by BSM.

Reduce Costs and Improve Customer Relations:

The ultimate goal of our project was to provide suggestions and recommendations that would save BSMC money. We also wanted to address the ongoing late pickup problem plaguing their warehouse and reducing their efficiency.

Create enough space to move bags and spare parts out of back building:

The building that BSMC was using to store bags and spare parts was extremely expensive to rent. By minimizing inventory we hoped to create enough space to move the contents of the back building into the warehouse to save BSMC money as they would not have to renew their lease on the property. (lease expires in 2012)

This was done through an analysis of the mix of flour products, the production schedule, the inventory management system, and the inventory organization system. Through the proposal of new inventory flow machinery, management systems, removal wasteful practices, and a reorganization of the current inefficient usage of space, we planned to phase out the existing usage of an attached rented warehouse and increase their overall inventory management efficiency.

1.3 Expected Results

The team expected results to be derived from multiple avenues of analysis. The team expected results from the analysis of the data given by BSM, our teams models built from observation of BSMs current practices, and through the development of metrics for BSM.

The results were derived from multiple methods. First the team ran an analysis of the data given to us by BSM and built current state models of their inventory management system and flow. First the model of the current setup was created and ran. The analyzed data gave the team the results which the alterations and improvements were derived from for the inventory management system and flow. They came in the form of reducing the number of touches each pallet receives while it is moving through inventory to shipping. Second, the data regarding the production rates, demand, and orders were further analyzed. With this data we developed trends which the team saw in the production of different brands of flour. After determining which flour types had the largest production percentages, the results pointed to adding hardware to handle these flour types specifically. The added hardware would couple the above reduction in touches and help organize the floor. With these results the team expected to develop a return on investment timeline for BSM.

Other results were expected to come from the observation of practices at BSM. The observations resulted in recommendations built to better handle to their current issues with customers regarding agreements for the pickup dates of their orders. The team expected that if our suggestions were followed that the problems from late pickups that Bay State Milling Corp. had been experiencing with their inventory will be substantially diminished or removed completely.

All in all, the results show that through a warehouse redesign, a reduction in the number of touches to each pallet, and through more stringent contractual agreements with customers; the inventory floor will be better organized, the amount of moving each individual pallet experiences will be reduced, company will save time and money, and the efficiency lost from late pickups will be diminished or removed all together.

1.4 Company Profile

The Bay State Milling Corp. (BSMC) is a flour milling company with many locations across the continental United States, such as the mill located in Clifton, New Jersey. They are in the middle of redesigning the packing and shipping sections of their Clifton warehouse. Currently their production is at about 40-60% of capacity based on which machine is running. The lack of efficiency within the company is having a negative effect on the company's ability to compete because they are losing almost an entire shift or eight hours of work across and entire work week. This lost production time turns into lost profit, wasted product, and an overall waste of time which can be directly traced to the company's financial statements. To overcome this issue and raise their efficiency, the BSMC has brought in a three man team from Worcester Polytechnic Institute to look at their product facility, specifically, their packing and shipping warehouse. The team will use data collected through multiple visits to their facility as well as company's provided records and data which will be analyzed to locate and remove wasteful practices while streamlining their process.

Leaning out their current production facility of the BSMC will have a dramatic effect on all facets of their company. It will position BSMC more competitively in their market, and they will also be able to absorb more orders which will increase their profits and market share. To do this, we will apply lean principles which were pioneered by companies such as GE and Toyota, for example GE developed Six Sigma and Toyota TPS or Total Production System, both are new developments from the 1990s. Lean manufacturing was developed to increase the value to the customer by decreasing the costs to the producer through the removal of all wasteful practices or processes that do not add value to the product.

The BSMC would like to apply these lean practices to its facilities in the hope to increase its efficiency from its current average of about 50% to somewhere in the 70% range. To do this the team will have to analyze data collected from the packing and shipping sections of the warehouse to identify and remove any non-value adding processes. We are only collecting data from those two sections for two reasons. One, they are the only two sections of the warehouse that can be impacted because the actual milling process is completely automated, and secondly, this is where they have found the greatest loss in efficiency within their production line. Furthermore, these two areas are the only areas where humans are in direct contact with the process and dictate its speed. Thus, we are trying to streamline these two sections of their production facility.

BSMC is relying on us to help increase the efficiency of their facility in Clifton, New Jersey. They have given us a goal of achieving 70% efficiency across their production floor. We are going to do this through applying lean principles and ideas from Six Sigma to their packing and shipping processes. This will include analyzing the order schedule, the lead times of orders, the warehouse design, and finally the production rates including switchover times. Through the removal of all non-essential non-value adding practices we hope to fully streamline their production to the efficiency levels they desire. Once we have completed this study we will provide suggestions and recommendations to achieve this goal which will be presented to the Bay State Milling Company.

2. Company Profile

2.1 Company History

In 1899, five gentlemen, Bernard J. Rothwell, H.B. Goodwin, Charles H. Adams, Leroy Brown, and Herbet C. Gavin bought the idle L.Cl. Porter Mill, a spring wheat mill on the lower levee of the Mississippi river in Winona, Mississippi. This was the beginning of the Bay State Milling Corperation.

The buy in Winona would eventually become and stay the flagship mill for BSMC as it expanded. It remained a base of operations until 1967 when they were consolidated to Boston. BSMC and its owner Bernard J. Rothwell, was founded on a dedication to produce and provided not only a top notch product, but also top notch service to its clients.

In March the doors to the mill at Winona opened and production began. The mill was very centrally located in a great market. There was a ready source of labor nearby, the raw materials and fuel were close, the rail service went right to the mill, and the price was right. To make sure that Rothwell's new venture would match up to what he had hoped to stand by, quality in their product and service, within the first week a barrel of their product was sent to A.W. Howard in Minneapolis. A.W. Howard was regarded as an expert on flour at the time. He would rate the quality and then report back. Rothwell's flour was given the best rating out of the 24 samples that Howard saw.

(Continued in Appendix A)

BSM Timeline

Table 1

1869	**1995**
Bernard J. Rothwell emigrates from Dublin, Ireland to Boston Massachusetts.	Indiantown, FL mill is doubled in size to support new growth.
1899	**1997**
The Porter Mill at Winona, MN is purchased and renamed Bay State Milling Company.	Winona, MN mill undergoes a major modernization and is expanded by 25%.
1940	**1998**
Bernard J. Rothwell is named the Chairman and Paul T. Rothwell the first President of Bay State Milling.	Milling capacity is doubled at Moorseville, NC and Tolleson, AZ.
1959	**1999**

Paul Rothwell is named Chairman and CEO and Bernard J. Rothwell II is named President.	Bay State Milling Company celebrates its 100th anniversary. Bay State Milling creates a joint venture: Rocky Mountain Milling in Platteville, CO.
1963	**2000**
Bay State Milling purchases the New Jersey Flour Mills, located in Clifton, NJ.	Bay State enters the dry blending business and secures its first major mix customer.
1973	**2006**
Bay State Milling acquires the Mooresville Flour Mills in Mooresville, NC.	Bay State Milling develops Grain Essentials™ White Whole Wheat Extra Fine flour.
1977	Bay State extends its blending capabilities to the East Coast.
New company logo designed and introduced.	**2007**
1981	Bay State Milling acquires additional interest in Rocky Mountain Milling, LLC, resulting in a majority ownership of the Platteville,CO facility.
Bay State Milling acquires the Hayden Flour Mills in Tempe, AZ.	Bay State Milling Company expands its dry blending capabilities by acquiring Premier Blending in Wichita, KS.
1985	**2008**
Bay State Milling opens the country's newest flour milling facility in Indiantown, FL.	Organic flour milling capabilities and organic certification extended to Winona, MN and Mooresville, NC.
1987	Bay State Milling Company enters the gluten-free marketplace with a dedicated production area in Wichita, KS.
Bernard J. Rothwell III named Chairman; Brian G. Rothwell named President.	**2009**
Bay State Milling acquires the ConAgra flour milling facility in Tolleson, AZ.	Brian G. Rothwell named Chief Executive Officer; Pete F. Levangie named President and Chief Operating Officer.
1989	**2010**
Bay State Milling reopens a 12,000-cwt modern milling facility in Clifton, NJ.	Bay State Milling completes purchase of Rocky Mountain Milling, LLC, becoming largest miller of organic flour in U.S.

2.2 The 1st Visit to Bay State Milling's Clifton Mill

After a complete tour of the Bay State Milling Company - Clifton, New Jersey location, it was evident where improvement could be made. The facility was divided into three separate areas of operation. The areas included storage, which is handles the reception of raw materials and storage in 3 Silos. The second area, milling, is a set process for removing the flour product from the wheat. The milling process is the largest area of the milling plant. The process ends in the packing and shipping bay. This area takes the final product, packs it, stores it in inventory until it is ready to be shipped, and then is sent out.

Storage

BSM receives all its wheat by train, which come in on a need based rate. The wheat goes through multiple sets of elevators which in turn gets the wheat to the storage silos. Despite the fact that this plant is one of the top flour producers on the east coast, the amount of storage space they have is far below par, 250,000 bushels compared to many other mills of similar production capacity which have an average storage capacity of 500,000 or more bushels.[1] There are two new silos, these silos are the only silos that wheat can be directly taken out to be milled. The other silos feed into the two new silos and then from the new silos, the raw wheat material is brought into the mill. Since that is the case, the three older silos are used to store over stock and back up supply. The older silos hold far less wheat then the two new silos.

Figure 1 – Left

Silos filled with the raw material the flour is made from.

Figure 2 – Right

This is the train track station right outside the facility where the raw material comes in and is moved from the cars to the silos of the mill for storage.

In the near future BSM hopes to increase the usable storage space. To do so it was hoped that the older silos could be knocked down to make room for more silos to be built. The older silos were constructed from very thick concrete. The amount of time, storage space, and cost that would be wasted by the demolition of these silos makes this an impossible scenario. A new scenario that is currently being looked into would be to build smaller silos atop the older

[1] Personal Correspondence, Mike Walsh, Bay State Milling Company

silos for extra space. Though this would store less wheat than the new silos, it seems to be the best scenario.

Milling

Once the wheat leaves the Silo it then enters the milling area. Again an elevator system is used to bring the wheat to the top floor of the building, where the first step of the process begins. The milling area is comprised of 6 stories of the factory. Each level has a different step of the process; the first at the top going down until the last at the bottom. The system is set up in this way in order to use gravity to their advantage. The wheat/flour runs down pipes in essential free fall through the different steps of the process. This process is repeated 4 times to ensure the pure flour product is rendered at the end. Again an elevator system was implemented to bring the flour up to the top story where the process gets repeated. Throughout the process the flour is segregated into multiple stages and types. The most basic separation is into two categories, which sit on opposite sides of the building. These categories are White Flour and Wheat Flour. After that the flour is separated into which run through the floor it is on: first, second, third, or fourth.

Figure 3

After the flour is made pure and completely milled, it must be met to spec. depending on the company and type. In this process the flour must first be divided based on the amount the order is for. Once the allotted amount of flour is separated it must be mixed with other ingredients. The flour that is bagged is not pure flour it is mixed with an exact amount of other ingredients such as yeast.

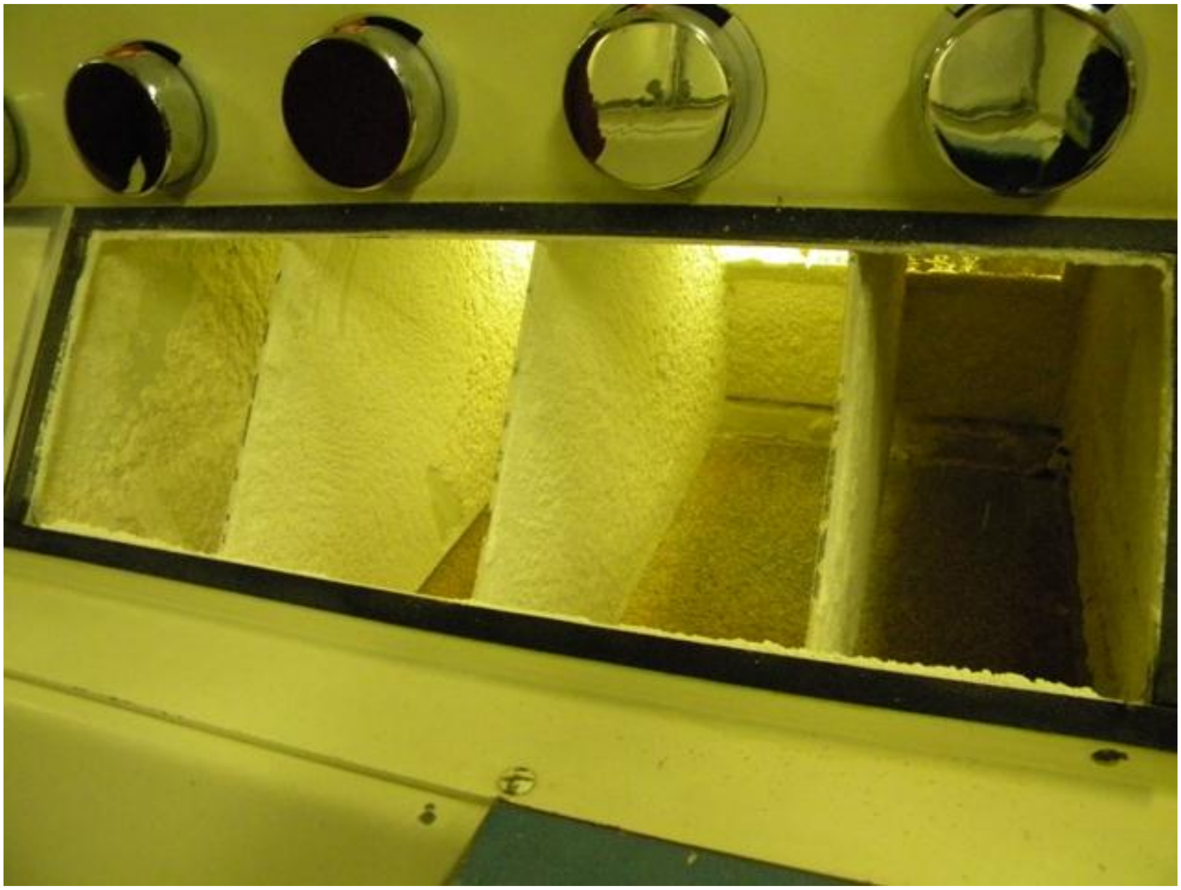


Figure 4
This is a flour sifting machine.

This system is a series of pipes and machines which are built into the building. This means that there is no possible way to rearrange the layout for increased effectiveness. There is little human interaction and the process is already as lean and streamlined as possible. Thus, the efficiency is at its peak and there is nothing that can be redesigned in our timeframe. BSM is not worried about this area of the process. The only foreseen improvement going forward would be a restructured attendant schedule and a decrease in down time.

Figure 5

This is 2nd to last floor where the flour is in its final production stages, just before it is fed into the packers.

Packing & Shipping

Below the milling area is where the flour is packed and stored. Once the flour passes through the milling process it is ready to be packaged. BSM currently operates three packing machines; two machines pack fifty and twenty five pound bags while the third machine packs hundred pound bags. The milled flour is fed into the appropriate machine where it is packaged into the appropriate bag. Once it is in the bags, the bags are loaded into a palletizer. The palletizer flattens the bags as much as possible and then organizes them on the pallets. Once a pallet is completed, it is brought to the final machine which wraps the loaded pallet with plastic wrap for protection from moisture and the elements. These are the first areas where humans come in contact with the flour, and their interactions are crucial.

The packing machine employs one or two employees. A worker loads one bag into the machine. The machine then fills the bag to the set weight. While this is happening, a worker is replacing another bag to be filled. After one order of wheat is done and a switch to a new mix is necessary, they start right in on a new type of flour. This creates an issue occasionally because the milling processes often leaves a residual mix from the previous mix in the machinery. Thus, the first ten bags automatically go to feed in. On the tenth bag of the new mix, the flour is sampled and tested. If it is mixed properly, they start into the order. If it is not at the proper mixture, the packing machine operators run another ten bags, and then test the final bag.

After an order is filled it is palletized and put into inventory where it waits to be shipped. The inventory system is set up in lines coming out from the wall in which each brand of flour is separated. The oldest flour is to be placed in the front so it can be shipped out. The average shelf life of flour is 90 days. The area in which the flour is stored is positioned right next to the packing machines and is in a very easily accessible area to be retrieved to be shipped

Figure 6

A view of the inventory channels.

BSM has two separate methods of shipping out the final product. One method is bulk loading customer's trucks and the other is for pallet orders. There are the two bulk shipment bays in the plant and then the rows of palletized packaged flour in the warehouse. Each of the bulk load bays are located in a garage on the back side of the mill. The flour is taken directly from the mill and dropped into trucks from overhead loaders. This manner of shipment is more cost efficient as a result of eliminating the packaging costs and entire inventory process. The warehouse shipping involves a much more labor intensive process. Once the pallet is wrapped it is picked up by a forklift. The forklift then brings it to its indicated storage row. However, because they have a first in first out setup, the entire row of currently stored pallets must be moved out of the way before the newly palletized flour can be put in place. So the forklift moves all the currently stored flour out of the way. Once the stored flour is out of the way, the new flour is put all the way at the end of the row and the already stored, now displaced flour is put back in its row. Once an order comes through, the forklift then goes to the proper row and collects the brand of flour specified in the order and brings it to the shipping area. The shipping area also has rows similar to the warehouse layout. Each order is designated one row for that order. The forklift then drops the pallets of flour in the designated row in shipping. Once the customer comes to collect its order, the forklifts then take the order from its row in the shipping area and move it onto the customer's vehicle. This then completes the order.

This is the area in which BSM hopes to implement more efficient methods. The first area to look at is the packing machines. These machines are currently monitored by a manual system using paper records in which they can determine the down time of the machines and the efficiency of orders. For these machines 100% efficiency is never met; on average the packing process attains approximately 50-60% efficiency; they want a minimum of 70% efficiency going forward. Bay State Milling's records show that on average they lose about two shifts a week in down time. This is a result of multiple factors; said factors include workers running the machine too slowly, having an out of spec mix of flour, and the switching time for the bags between flour types. By December 2010 BSM will be replacing the fifty and hundred pound packing machines with one machine which can pack both fifty and hundred pound bags. This machine will not only reduce space but has a faster packing rate than the two current machines combined.

The inventory flow philosophy BSMC utilizes is FIFO or First in First out. This means that the first products into the inventory pool are the first ones shipped to customers. This is because of the products short shelf life. FIFO inventory systems work cyclically where the inventory is loaded on one side and pulled from another. The inventory system at BSMC does not follow this pattern however. The pallets of flour are lined up in channels against the back wall of the warehouse across from the packing machines. This means that to complete the cycle, all the pallets must be moved out, the new pallets moved to the rear of the channel against the wall, and the older pallet placed back into the channel. The channels are kept based on types of flour. Multiple forklifts manage this organization and movement of the inventory in inventory area and to the shipping queue.

2.3 The 2nd Visit to Bay State Milling's Clifton Mill

The second trip to Bay State Milling Company's Mill in New Jersey served as a second opportunity to observe the functions of the warehouse as well as take measurements. The trip started with a meeting with Tom Nelis who inquired to our groups needs and the timeframe in which they could be met. Our goal of the second trip was to not only become more familiar with the Mill and the practices of the company, but to take the necessary measurements to digitally recreate the factory floor. After our meeting with Tom, our group spent time shadowing Denis King, the factory floor manager. We came to understand the role that Denis has in the company and the problems he faces with the inventory practices of the company, we also were taught how the Mill and specifically Denis measure the efficiency of machines. The next meeting was with Robert Krautheim, who holds the position of Lab Tech Quality Assurance, the second day. Robert is in charge of scheduling. We watched how Robert uses the company's program to predict and order the milling of different types of flour. The meeting with Robert was very informative and gave our group great understanding of how the orders are put through. We also became familiar with the scheduling of bulk orders which greatly effects how much, and when flour is produced. The next step was to take measurements. We took notes, pictures, and measured distances of the different aspects of the factory floor. Counting and watching the pallets of inventory through their journey through the factory and into shipping gave us greater insight into the overall inventory practices of the mill. Our goal was to record enough information to recreate the factory floor and the processes that happen on it. After taking the measurements and watching the processes that were happening in the factory, we brainstormed about how our group could resolve some of the issues that were causing problems in the factory.

The most apparent problem that we decided to discuss was the system BSM implemented for inventory storage. The process they used was, and is very time consuming. Pallets are stacked in columns that stretch from the back wall towards the packers. This becomes a problem when the company needs to get to the back pallets and must move up to 29 pallets that are in the way. Our group discussed implementing an automated system, as well as a simple rearrangement of their inventory, at much length. The next topic we discussed was the problems that the company has had we late pick-ups. We discussed options the company could take to help remedy the problems as well as the implications they could have. Lastly we discussed the use of a back building which served little purposed and was very expensive. We decided that by reducing the size and increasing the efficiency of BSM's inventory storage process, we could get BSM out of the building, allowing the company some leverage when they renegotiate their lease on the property in 2012.

Finally we had a joint meeting to present our ideas and to ask questions with Mike Walsh, Mike, and Denis. We discussed our ideas for rearranging the factory floor and possibly moving to an automated system, as well as their problems with late pickups, and the fact that they pay too much for a building that serves no purpose. We told them that we understood the sensitivity of the dealing with customers who are late to pick up, but that the actions of their customers were unfair to the company and there should be contracts that allow for repercussions if customers do not keep their end of the bargain. We told them that we hoped that our suggestions if implemented correctly, would allow them to move all processes that occur in the back building to become obsolete so that, come 2012 when they renegotiate, they can truly say that the building serves no purpose and that BSM either wants to buy it or wants no part in renting it. Mike, Mike, and Denis all liked our ideas and are looking forward to seeing our models.

3. Literature Review

3.1 History

The advent of farming and agriculture changed the face of humanity forever. When the first humans started to settle and build villages and move away from the nomadic lifestyle, a food source to sustain their permanent residence was needed. With this need, grain was discovered to be a food source. The first grain was ground by hand between two rocks. These two rocks later evolved into what is now known as a mortar and pestle. Different forms of the mortar and pestle evolved until the millstone was developed. This new technology was basically an oversized mortar and pastel. The Millstone technology utilized two large stones spinning against each other which were moved via a power source. The millstones worked by placing one vertical wheel spinning against another horizontal wheel with the grain being ground between the two wheels. Originally, these wheels were powered from either human labor or animal labor. However, around 25 BC an architect and engineer named Vitruvius from the Roman Empire combined the waterwheel and the millstone into a milling machine that utilized one horizontal milling wheel and another vertical wheel both powered by water. This was the first technological advancement in milling technology until the middle ages when the windmill reached the European continent from the Far East through the crusaders who brought the technology home with them from the Arabian world.

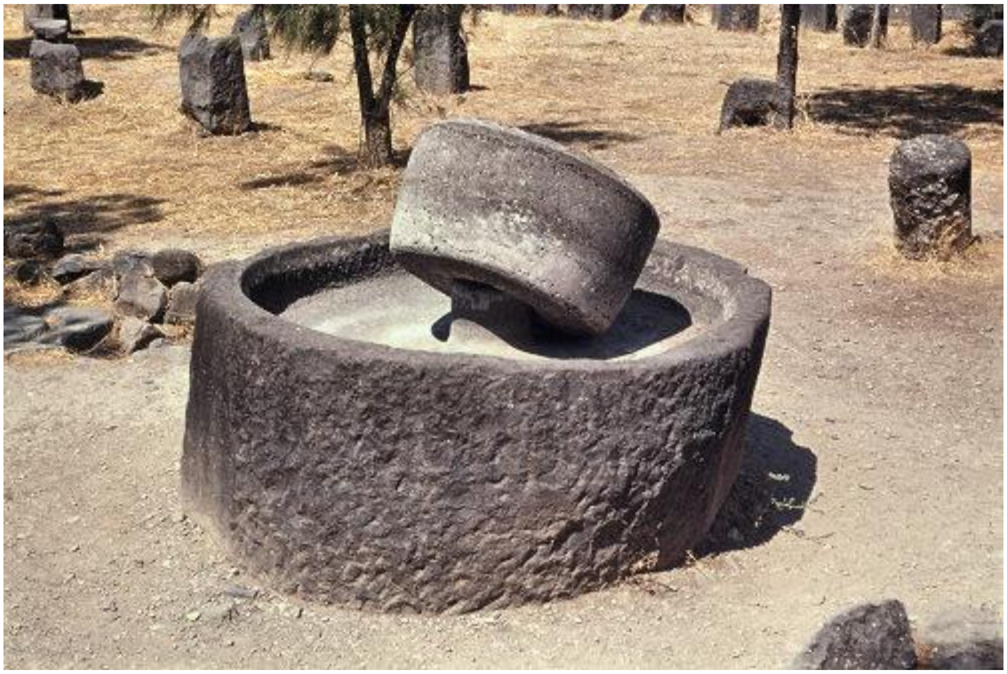


Figure 7

This is an Ancient mill stone. The smaller top stone spun around in the cavity of the other larger stone grinding the wheat into flour.

The next technological advancements sprang up in Europe from the 1800s onward. Steam power entered the industry in the second half of the 1800s with the industrial revolution and the Albion Mill in London which was the first mill documented to use steam power. In Germany at the end of 1837, the first steam roller mills began popping up across the landscape. This system used rollers made of hard metals instead of stone to grind down and pulverize the raw grain. It was more effective, the yield was more uniform, and it also produced higher quality flour in greater amounts than the stone mills could.

The first mill in North America appeared in Boston in 1632 and was powered by wind. Wind power became obsolete and was replaced by water. There was an abundance of flowing rivers in the colonies which allowed the mills to spread across the countryside with the venturing colonists. Water allowed plants to be running constantly rather the relying on the wind or manual labor to power them. Also, the water ways allowed for easier and quicker shipping of product because it could be loaded right from the mill to a ship.

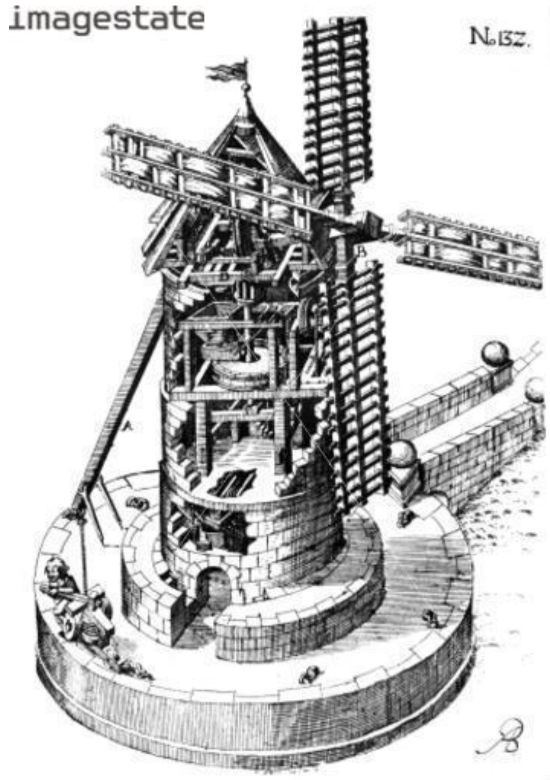


Figure 8

Old Windmill from Europe.

The next evolution of the American mill came in 1784 from Oliver Evans of Philadelphia. He designed and built a fully automated mill. Over the next few years the infrastructure of the America grew and expanded westward with the population. The west held vast plots of land to utilize meaning more grain to harvest. With this, and the expanding railroad network, the capital for milling changed, moving from the east in Pennsylvania to the middle of the country in Minneapolis, Minnesota.

Over the next century, incremental improvements were made in the mill but no substantial changes to the landscape happened until 1865 when Edmund La Croix introduced the first middling's purifier in Hastings, Minnesota. This screening device consisted of a set of vibrating screens where each level of screens had different size holes. The grain was passed through the screens and thus sorted. It also used air to remove any unwanted particles in the raw material. This allowed for a high quality of flour to be produced because all of the impurities were removed before the grain was ground.

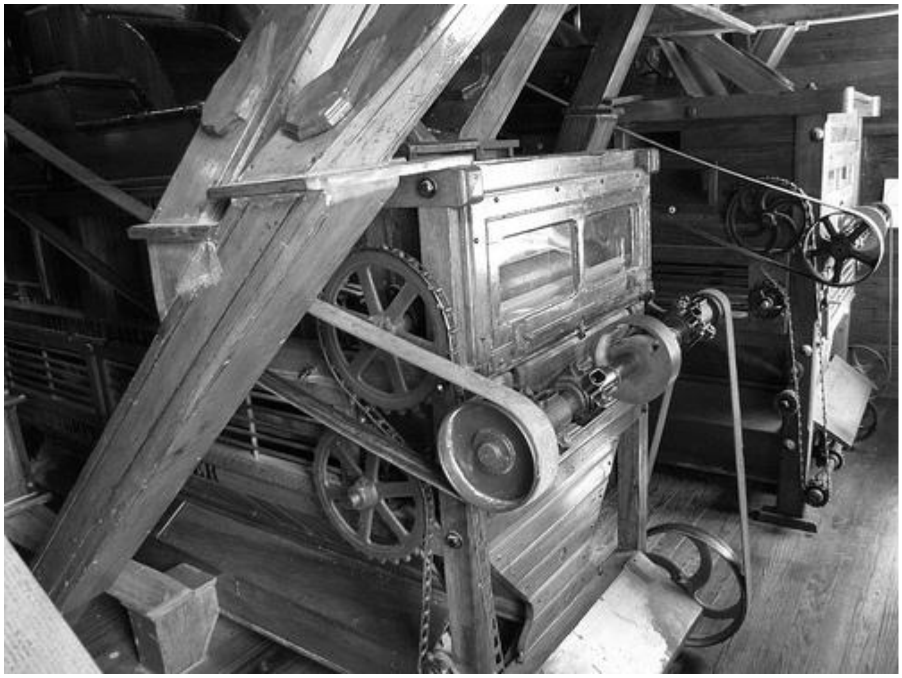


Figure 9

One of the first Midding's purifier machines used to further improve the quality of the flour produced.

By the late 1870s the first roller mill designs were popping up, coming over from Europe. This new type of mill, coupled with the Middling's purifier revolutionized the business. The rollers were more efficient than the millstones currently being used, they were less expensive to maintain, the product was ground more accurately and evenly, and they were cleaner than the millstones which would give off dust and eventually start breaking themselves down into the grain. This design was so efficient that it is still being used today, with major modification and the inclusion of new technology, however, the basic design remains with the middling's purifier and the roller systems being used to sort and then mill the grain.

Figure 10

There are some of Bay State Milling's metal rollers outside of their machines. These ones were ready to replace the warn rollers currently in the machines.

3.2 Environment

The food goods industry and specifically the perishable goods and dated products see challenges that most industries with non-perishable goods do not. For example, after a certain date, their product is deemed unfit for sale and must be destroyed. Sometimes that period is only a few weeks from the end of production to expected consumption. Beyond that challenge, the sheer number of products and competitors means that the industry as a whole has extremely thin margins. Furthermore, government, industry regulations, and connected industries constantly change forcing the industry to adapt. With all of these challenges facing companies in the perishable goods industries, finding any competitive advantage over others can mean the difference between becoming a successful company or going bankrupt.

There are many different avenues to take when looking for a competitive advantage. Economies of scale allow larger companies to remove competition because of the volume they produce allows them to charge less per item because the cost of production is spread across a larger amount of product, thus reducing the cost. This forces the competition to drop prices as well to stay competitive and most the time, unless they can produce on a similar scale, forces them out of business because they cannot survive on the smaller margins. Other companies look to find the cheapest raw materials to lower the overall cost of the product at the bottom line. This allows them to also charge lower prices and purchase more raw materials, but they tend to create a lesser quality product. Finally, the most effective means comes from making the entire process of production as efficient as possible. This means removing any and all non-essential non value adding processes. The result is enhanced efficiency, reduced inventory levels, decreased logistics costs, and an overall improvement in company performance. Applying lean principles to a company as a whole can save large amounts of money and really make a non-competitive company competitive.

Some companies focus on different areas to optimize their company. Often, what gets optimized is based off what the company can afford to optimize in a certain time period, and also which will yield the largest savings. Usually it is either the facility equipment or labor processes which are optimized. This is done through analyzing the different processes to remove wasteful practices, maximizing the utilization of space, analyzing worker utilization, optimizing the scheduling of the product production to reduce switchover costs, and workload planning to balance the capabilities and increase overall productivity.

Government regulations can have a dramatic impact on an industry much like the "Federal Agricultural Improvement and Reform Act of 1996" or the "Freedom to Farm" Act of 1996 as it was called by the industry. The bill effectively eliminated the safety net, or minimum price, for grain supported by the government. It also allowed the farmers to plant any crops they chose rather than the crops the American government approved of. The act lowered government subsidizes and was supposed to move the agriculture industry from a government subsidized venture to a free market venture.

Another industry change sprang out of the change from the railroad industry. Originally, the shipping was setup and seen as one trip from the raw materials being picked up, to delivery as a finished product to customers. The milling process and stop was seen as an "interim" stop and no costs were incurred or charged to the mills. However, this all changed when in the

1960s. The railroads began to charge different rates for raw and finished materials and broke up the shipping costs. The cost for shipping finished product was now more expensive than shipping raw materials. This brought upon a milling industry shift. Originally, all the milling companies had their mills close to the raw materials because it was hard to ship large amount of grain large distances, and adding costs because of distance was not optimal. With the change in the railroad industry, the new mills were being built in close proximity to their customers to reduce the finish product shipping costs since those were higher than the raw material shipping costs. This was called Destination milling and its idea was founded by Bernard Rothwell the 2nd.

All in all, companies need to assess what their competencies are and then make the proper investment to optimize their competency through investment in all or one of these lean principles mentioned above. These companies need to be adaptable to changing environments in the industry and regulations set by governing bodies. By doing this, they can maintain their competencies, focus on their strategic advantage and increase their margins by reducing their costs, increasing their overall production, and increase their total capacity.

3.3 Seed Breakdown

The basic grain kernel or seed is made up of three main parts. There is the outer shell which is called the bran. This is a covering to protect the internals of the seed. The next part of the seed is the endosperm. This is where our flour comes from. The last part is the germ. The germ is the embryo of the seed. Each one of these parts is used in different products which a flour mill produces. Nearly all of the seed, its endosperm, germ, and bran are all transformed into a product to be sold.

The endosperm is the life source of the seed. It provides the nutrition to the seed's germ in the form of starch. It makes up the largest percentage of the seed at about 83% of the seeds weight. Aside from the nutrition for the seed, this protein rich starch is where flour comes from. The endosperm itself contains a number of valuable nutrients. It holds protein, fiber, b-vitamins, carbohydrates and, iron. Thus, the goal of a flour mill is to remove as much of the endosperm from the bran in each seed as possible. (In whole wheat grain, all of the seed is ground up and used in the flour, not just the endosperm.) This is where the milling process comes in. Over the history of the human race, the increased demand for flour has always pushed the milling technology forward. This demand has refined the milling process over hundreds of years to optimize the harvested material output in amount and quality.

The germ part of the seed is actually the smallest part of the seed; however, it is the most nutritional. At only about 2.5% of the seeds mass, it still contains the most nutrients. The name Germ comes from the word germinate. As it is the reproductive material of the seed, the germ is what is fertilized and what would eventually grow into the wheat grass we see at a farm. In a milling process, the germ is separated from the bran and the endosperm. This is because of its perishable oil content which would severely reduce the shelf life of flour if it was included. This oil is sometimes harvested from the germ for is strong nutty flavors and its expensive market price as an extract. [2]

The bran is the outer shell of the seed. It is roughly 14% of the seeds mass and protects the seed from the exterior world while the germ is fertilized and begins to grow. The bran is a hard protective layer made up of aleurone protein and a pericarp tissue. These two combine to make the hard exterior of the seed. Bran is part which from which the endosperm is removed through the milling process, but it is not waste. The bran is used for many different products such as feed for livestock and in breakfast cereals because of its high levels of dietary fiber and essential fatty acids. It also contains a host of other vitamins, proteins, and minerals in smaller amounts.[3]

2 http://www.food.com/library/wheat-germ-633
3 http://en.wikipedia.org/wiki/Bran

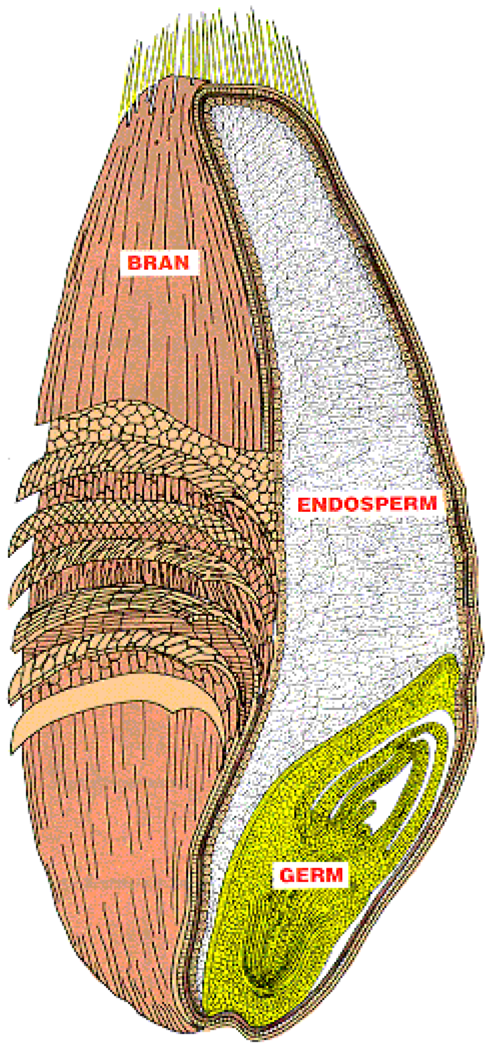


Figure 11

A Cutaway of a wheat kernel, the three sections are labeled.

3.4 Warehouse Organization

A company has to create or offer something for their customers to purchase. With this creation or service offering, a company uses raw materials or supplies which take up space at the company's location. Companies must manage these materials efficiently or chaos would ensue. This is because employees would be looking for materials without knowing where they are, the company would never know when they are running out of materials, and the company would run extremely inefficiently. To handle these issues a number of organizational practices have been invented for managing materials and inventories.

There are a number of different systems which companies can implement from simple racking systems and warehouse layouts to complicated scanning barcodes and RFID tags. All of these organizational and management systems produce information and organization which the company can use to manage its materials and inventories.

The first of these management methods is the general reorganization of a company's materials and warehouse. It is necessary for a company to understand the flow of materials or product on their own grounds. This is because without this understanding, money, time and, workers are being wasted because there is no streamlined organization to where things are placed or why they are where they are. Thus, an observation of the movement of materials or inventory at a company's warehouse is beneficial and can greatly improve the efficiency of the warehouse once the data is analyzed. Time can be saved because materials are placed closer to the machines or stations which use them. Money can be saved because of the reduced time spent locating and moving the materials. The number of workers can be reduced because the materials require less management.

The second type of the material management methods is a technology known as racking systems. These systems are metal or wooden structures which are used to organize the materials, supplies, or inventories of a company to make them more accessible and organized. These systems can be static, gravity powered, or a use form of power to move the materials as needed. Bay State Milling uses pallets to hold their product in their warehouse. Pallet racking systems come in many different forms. Some are static systems which require human labor to move the pallets. Some use gravity and a slope which allow the pallets to roll forward on small wheels down and track. Others use a conveyor belts, or even more complicated elevators systems to move pallets through the racking systems. The automation of these systems can help companies more efficiently stack and manage their inventories. They can cut down on the labor intensive movement of materials or inventory because the systems do it for them. They can also hold more because the systems are compact and do not require as much labor to get the materials or inventory to the desired section. An example of this would be the gravity operated pallet racking systems. For First In First Out inventory systems.

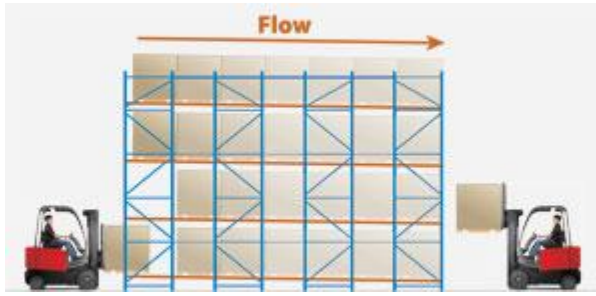


Figure 12

This is an example of a FIFO Pallet Flow Racking System. The Forklifts load on one side and are removed from the other.

These systems are built of racks and rollers on an incline plane. The pallet is loaded at one end which it is considered "First In" to the holding system. Then it rolls to the end which is considered the "First Out" side where the pallet is picked up and put in its specific customer order when the order is being filled. The pallet is first into the inventory management system and first out when it is called up to fill the customer's order.

The third type of inventory and supply management comes in the form of scanning barcodes and RFID chips. These barcodes or RFID chips are on or inside a sticker which can be applied to the packaging of inventory and materials. Once the materials are collected to be used, the barcode or RFID chip is scanned and the item is marked in a software package that it has been consumed or it is being used to fill the order of a customer. This technology offers a twofold benefit to companies who implement it. The first benefit is a tangible inventory management system combined with software which can be programmed to send alerts when materials or supplies are low. The second benefit is that all inventory or supplies can be tracked and usage can be obtained from the software. This is great for managers and companies who are looking to become more efficient because they can track almost everything about the inventory of materials being used at the company.

All in all, these methods of inventory and supply management provide numerous benefits to a company who has to manage supplies or inventory. They save the company money and also can provide useful data and other metrics which the company can analyze to further enhance the efficiency of its operations.

3.4.1 Inventory Methods

Inventory methods have a large portion of how a company is run. Without a tailored and effective system a company can waste material, time, and space. Having the proper amount of inventory is important because extra inventory is product not sold and having to little inventory is revenue not made. This is where inventory management comes in. A company must optimize all aspects of their inventory system as to maximize profit and minimize waste. First in first out is the solution that BSM has implemented to help manage their inventory and reduce their costs.

3.4.2 Types of Inventory

Inventory management can be split up into three areas: raw materials, processed goods, and finished goods[1]. The management of raw materials and when they are ordered is arguably the most crucial area of inventory. This area controls the materials needed to produce a profitable product. If there are not proper materials for production then the line comes to a halt. Keeping one line at a halt could affect the scheduling for other product lines, resulting in a vast amount of waste. In contrast, there is some risk involved with overstocked material. If an excess of raw materials is ordered it could result in unused material which costs money. If this happens with multiple materials in multiple product lines that profit margin for a company and profit per unit will decrease.

In-process inventory deals with the partially finished product. The amount of area needed for this aspect depends on how much product will be processed at any given time. Though it does not seem so, while a product is be processed it is inventory. When material is between processes, it still counts as inventory. In the case that a machine is down or a pipe is clogged then the product must be stored somewhere until it can be used again. A company must make sure that there will be room for all aspects of this type of inventory. Transportation from one process to the next will count as inventory as well, but this type cannot be clogged or used for a long period of time or it will limit the transportation methods.

Another crucial area that must be managed optimally is inventory of the finished product. The company must make sure there is finished product present to be shipped to the customer. The area designated for inventory must be well organized so that when new finished products come in, there is a place to store them. Some companies work off of a just in time system. The product is finished right in time to be sent to the customer. Some companies create finished goods consistently with no regards to how the product us being ordered.

3.4.3 Purchasing Plan

Many companies use a tool referred to as a purchasing plan. This helps a company create a repeatable standard to use to plan ahead and guarantee the required elements are in place. A purchasing plan is the backbone of the whole process. It takes time to prepare materials for production. A company must first find the material needed. This takes time to get quotes and determine the supplier with optimal quality and cost for that particular job; companies typically have multiple suppliers. After, the order must be processed by the supplier and shipped to the company. For many companies such as food production, the material cannot go straight from the means of shipping straight too production it must be stored first. More time is added in dealing with products which need multiple materials from multiple vendors.

Another aspect of a purchasing plan is determining the depletion and depreciation of the inventory. Some companies buy stock in bulk to save money. A company can determine when more material must be ordered by predicting and planning future orders by the customers. Though some companies, such as specialty machine shops, cannot do this, companies such as flour mills can. Wheat has a shelf life which must be calculated in order to calculate how much material in buy. A company must know that they cannot buy material if it cannot be used by its shelf life, otherwise it was just money lost.

3.4.4 Push – Pull Systems

There are two basic ideals adopted by most companies when dealing with inventory: quality based and scheduling. Both ideals are very much opposing ideals and it depends on the company's needs to determine which to use. Some companies develop a system in which these two ideals work hand in hand. This helps a company combine the strengths of both systems without the weaknesses; strengths and weaknesses differ depending on the company.

Item	Quantity Approach (Pull)	Scheduling (Push)
Characteristics	1. Reactive or pull method	1. Schedule used to determine requirements
	2. Inventory is used as a buffer against uncertainty	2. Materials may arrive JIT or from inventories
	3. Priority is to maximize output	3. Priority is to coordinate flow of materials
	4. Demand may be lumpy or irregular	4. Demand is reasonably known
Usage	1. Usually used for relatively low value items	1. Usually used for high value, custom made items
	2. Can be used with minimal information	2. Requires some information processing
Weaknesses	1. Requires higher levels of inventory than scheduling methods	1. Not as simple to implement and operate as quantity methods
	2. There is little coordination among business functions	2. Requires more precise management control

Table 2

Pull System

Quality based inventory also referred to as a pull system. This type of systems functions as the inventory gets pulled through the system. Once the material reaches a certain point more is ordered. A company knows based on past management at which point the material needs to be reordered. Primarily used as a way to maximize output, it is generally used on low value material. This is because of the risk as stated in prior sections. If the material is high value and it gets wasted the company stands to lose much more. One of the strengths of this system is it requires minimal information to run efficiently. Although this system is best for low value inventory, it requires very high amounts of inventory. This system is best used without a just in time system.

Push Systems

In a scheduling based system inventory is “pushed” through the system. This type of system requires a vast amount of information about how the company operates. Instead of ordering material when inventory is low, it is based off a set schedule created by the information given. Some of the strengths of this system are that it is used for custom, small orders. Ultimately a push system wants to eliminate inventory as much as it can. Generally one wants high valued material for this system; thus, it makes sense to minimize held material because it carries a lot of value. The weakness of this system is that it is very hard to implement into a company and if there is high variability among orders or lead time it can be highly inefficient.

Combination System

Rarely does anyone combine these two systems to create a hybrid system implementing both ideals. Sometimes however when a JIT system is implemented, one particular system does not quite fit the mold. Professors from Cornell and Auburn created a method which will minimize the expenses of inventory while making sure the product is at a proper quality and is delivered on time. Essentially they use a push system for the expensive products with unpredictable demand and make the parts as they are ordered; they then keep inventory for the more general parts that they know will have a consistent demand. It works for many companies that make a product but puts out different grades of that product.

3.5 Plant layout Design

The design of a factory's layout is centered on optimizing utilization and efficiency in a given area. When properly executed the lead time of a product line can be minimized. Some vital factors must be collected before this process can start; the number of machines, size of the facility, and the order of stations for each product line. The ultimate goal is to minimize the total travel time of all the products over the whole process. Different layouts can also affect the type of inventory needed for each company. This procedure is more of an artistic method driven by observational and mathematically developed data.

Before designing the layout for a food production plant there are specific constraints that must be recognized that other plants may not have. It is important to design the most optimal layout possible, but certain guidelines for food sanitation must be followed. An example of this is machine maintenance; during maintenance no open containers of food can be present. This would result in three machines not being used because one machine needs repairs. This is referred to as Sanitary Design. It is required by the FDA and the USDA and food production plants follow the defined code.

4. Methodology

The project was built around four methods for determining our solution to the inventory management problem Bay State Milling Co. was facing. The first method used was an assessment of their current systems which was done it two parts. First, the group was given a tour of their entire facility, and then the collected data to be analyzed so we could identify the systems which could be modified for the most benefit. The systems assessed included their production method and the production schedule, their packing practices and procedures, their inventory management and holding practices, and finally their shipping methods. The second method the team used was a period of research and development. This period gave us insight into the industry's methods and technologies currently implemented to solve similar problems to Bay State's. Out of these research sessions, a multitude of designs which were modeled in warehouse design software and suggestions were derived. The third method used was the application of the restraints the team was given by the company to our designs. These included a set budget amount, spatial constraints, and time restrictions. These constraints were applied to our hypothetical design solutions. Finally, all these assessments, designs, and constraints were all brought together, analyzed, and assessed to construct two final possible solutions for their inventory management system and a multitude of other suggestions and recommendations for the improvement of their operations.

4.1 Project Plan

The project had a direct plan which kept the team on track and aligned with its desired ending result, being a new warehouse design to help with the management of the Bay State Milling Co.'s inventory. This project plan spanned fourteen weeks which culminated in a final presentation of our results to the company and a write up explaining everything we did to reach them.

All fourteen weeks were split up into different steps and methods of advancing our project. The first step was to familiarize ourselves with the company, its facility, its employees, and orient ourselves with its practices. This resulted in a number of visits, each with a different goal to the mill in Clifton, NJ. The first visit included making connections with the employees of

Bay State Milling that were needed in order work with to understand the processes of the company. Observing their packing and shipping behaviors, especially in regards to their inventory management process and, measuring the space we were constrained to, was also a goal of the visit. The second step was to conduct extensive research. The team researched for three weeks, developing a full understanding of the flour production process, milling history in general, and about Bay State Milling Company's process specifically. Then our group researched inventory management, organization methods, and systems. Once we had done the research, the team reflected on the current state to assess where changes could be made to improve their process. This included building a current state model of the company's inventory warehouse area in SolidWorks and then manipulating it to see how different changes would affect the process.

The second seven week period opened with a second visit which included finalizing the dimensions of the area we were constrained to and assessing some preliminary ideas with the upper management of the company. With the model complete, a second analysis and development period began with the results focusing on building different inventory designs which were then simulated and analyzed. With the new models tested, we then developed our results and conclusions which were put into the write up which covered everything in our project. The write up was then finished; the final presentation was constructed, practiced, and presented to the company and its upper management in their office in Quincy Massachusetts.

- Week 1
  - Visit the company facility in Clifton, New Jersey
  - Develop understanding of current state of company procedures
  - Write first chapter of report
- Week 2
  - Research history of flour development
  - Research history of Bay State Milling Company
  - Write second chapter
- Week 3
  - Research Inventory Management Methods
  - Research Inventory Management Technolgoies
- Week4
  - 2nd Visit for dimensions and analysis
- Week 5
  - Build current state model
- Week 6
  - Start writing chapters three and four
- Week 7
  - Finish chapters three and four
- Week 8
  - Research new design
- Week 9
  - Develope new design
- Week 10
  - Test and analze new designs
- Week 11
  - Finalize designs
- Week 12
  - Start writing chapters five snd six
- Week 13
  - Finish fifth and sixth chapters and finish report
- Weel 14
  - Final Write-up
  - Presentation

Figure 13

This is a chart that displays the weekly breakdown of our project.

4.2 Assessment and Data Collection

The first method was as assessment of all current systems and the methods used to manage these systems at Bay State. This assessment was derived from two actions. The first action in the assessment was a tour of the entire facility that covered every facet of flour production, packaging, inventory management, shipping, order scheduling, sales, and the upper management staff. The second action in this assessment was an analysis of the provided data. Bay State provided us with a year's records of sales and production figures. Machine production rates, packing rates, and order schedules. This data was coupled with the team's measurement and analysis of blue prints of the warehouse floor to gather dimensional constraints for the space we would be working with.

4.2.1 Tours

The first action in the assessment was taking a tour of their facilities and analyzing all of the company's different facets and workings. The tour started with an introduction to the mill's upper management team. This was followed by a tour of the main plant and mill facilities. These included a tour of the production systems which were responsible for the production of the flour, the packing machinery which bags and palletizes the product into shippable quantities, and an introduction to the inventory and warehouse area including a review of the inventory flow system responsible for the movement of inventory. Finally, the shipping area was toured and its operation was explained to the team. The last introductions were to the sales staff who explained the procedures they follow. The second tour included an introduction and explanation of the order scheduling and the staff in charge of what took place. Also, we took further measurements of the area the team was tasked with redesigning, and did more analysis and got further clarification of their operations. This gave us an idea of exactly what the team should focus on to make the largest impact. We identified a number of different components and bottlenecks of their system which could be altered to dramatically increase and streamline the plant's operations.

4.2.2 Data and Analysis

The second action in the assessment was an analysis of the data the company provided. Bay State Milling provided us with a data extending the past 12 months. The data included their production schedule, the number of products the produce for customers they have, and process data which included: lead times, down times, overall efficiency of each process, and total production data. Through the use of Microsoft Excel, the data was taken and converted into usual and relevant information. Such Information included: an EOQ analysis, Kanban System, ABC analysis, etc. Other data the team collected came from a dimensional analysis of the specific areas we would be working with. We measured the inventory area, the actual size of an individual unit (a pallet in this case), and got the dimensions for the shipping area as well. Other dimensions collected included travel lanes and distances from one area to another. A blueprint was provided which helped us collect and accurately determine these numbers. With the data and dimensions, we were prepared to research and develop our own inventory management systems and produce other recommendations to streamline and lean their inventory methods.

4.3 Research and Development Period

This period was used to gather data and do research on the available methods and technologies in the industry to solve the problems Bay State Milling Corp. was experiencing with their inventory systems and then design some hypothetical solutions in modeling software.

4.3.1 Research

The research done spanned the entire food production industry initially but was then focused to specific areas of interest. These specific areas of interest were the inventory management methods, analysis, and technologies available to the industry. We focused on the inventory management methods and the technology to promote the flow designs, first in first out, just in time, and push-pull systems. The analysis included calculations for a Kanban system and EOQ. The next area of research focused on the technologies currently being used in the industry. These included racking systems, automated, inertia/gravity, static systems, rollers, and general inventory layouts and warehouse designs.

4.3.2 Design Development

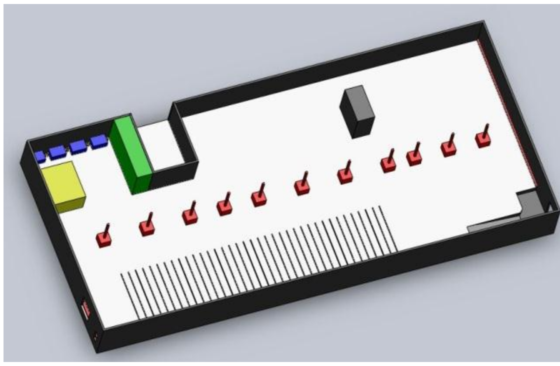
After the research was completed and decisions had been made on which of the technologies and methods best suited the company's current state, a number of different designs were developed and modeled. We decided upon inertia/gravity powered racking systems which would utilize a First in First out inventory method. This was chosen because of their current model which also followed First in First out, but lacked the racking systems. Due to the lifespan of flour, it is imperative to have a First in First out inventory system in place.

The designs consisted of a number of different configurations of racking systems and specific orientations. The designs were modeled in Solid Works CAD software. The configurations fell into two categories, hybrid systems which consisted of static free standing pallets, not in a racking system, as well as racking elements which would hold and manage other pallets. The other type was a purely racking system design. The purely racking system designs had all the pallets in racking systems, with no pallets in a static free standing zone, however, were very expensive. Both configurations types had two to three designs which were all analyzed once the constraints were applied to them.

4.4 Warehouse Modeling

The modeling software was used to help with the spatial awareness needed to develop the redesign of the warehouse. The software used to gain the spatial awareness was Solidworks. The first model was the entire warehouse from the blue prints BSM supplied, then models containing different warehouse layouts were developed, and finally, the final two designs.

The group first modeled the current state of the warehouse floor. This involved building the warehouse floor in the software and laying out the different structures in the model with direct spatial awareness and constraints. Once the floor of the warehouse and its columns were modeled, the offices and other structures were placed. Finally, the measured inventory area was highlighted and the channels the inventory sat in were modeled.



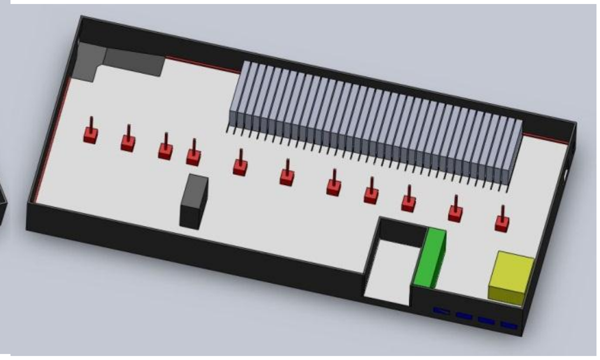


Figure 14

Figure 14 is a current state without the current pallet layout. This was known as the shell model.

Figure 15

Figure 15 is the current state shell with the inventory layout modeled.

Once the current state warehouse floor was modeled, the next step was to model the configurations the team developed. This involved taking the current state model and modifying it. In most cases only the inventory area was changed. The changes involved building structures on the floor which represented the pallet flow racking systems. The team developed four different configurations in total and then narrowed it down to just two for the final recommendations.

All in all, the models allowed us to develop our configurations and observe exactly how they would impact the warehouse. Without the models, the team would have never been able to develop such an accurate spatial awareness.

4.5 Constraints

The designs derived from the research then had the constraints the company specified applied to them. The constraints included a budget limit, space limit, and a time limit. With these constraints we were able to identify what designs were plausible and qualified for further development and analysis.

4.5.1 Budget Constraint

The company gave the team a set budget amount from which we could work with. The budget for this project was set at roughly 250,000 dollars.[4] With the budget set and the data we received from the racking system companies regarding the pricing of the racking systems we had chosen, we were able to further refine the designs and optimize them.

[4] Personal Correspondence, Dennis King, Bay state Milling

4.5.2 Space Constraints

The company's warehouse has set space limits and the inventory only is allowed to take up a specific amount of that space. The space constraints gave us the limitations for the racking systems length and height and the overall space it could occupy. We also derived from the dimensions recorded the current and projected total pallet amount the area would be able to hold.

4.5.3 Time Constraint

Bay State Milling had already ordered a new packing machine at the start of our project. This machine was to be delivered on 12/13/2010. This new machine will quickly outpace the two old machines it is replacing and is thus the reason for a new inventory management system. This constraint helped us decide on which inventory method and technology to implement. We took into account the installation time, which is about a month, the training associated with new equipment, the training associated with a new inventory management method if one were to be implemented, as well as the new spatial constraints.

4.6 Final Designs and Return on Investments:

A return on investment analysis was run for the two final designs the team decided upon. The two designs met all the constraints including budget, spatial, and the time constraints set by the company for the project. Giving the BSM a return on investment analysis will help them decide which design to implement and give them an idea for which how long it will take for the company to recoup its investment.

5. Results and Analysis

Through the analysis of the data given by BSM, the conversations we shared with the staff of the Clifton facility, and the observations the team has done, we have identified three areas where BSM could greatly improve their efficiency by changing some of their practices and implementing new technology. The current state of the inventory and warehouse area is not optimized and does not promote the inventory flow method they are currently utilizing. Another area we analyzed was the customer relations regarding the handling of late pickups. The current protocol for handling this situation is hurting the efficiency of the facility. Also, the facility does not have any sort of metrics and no technology for collecting them. After identifying these problems, the team began analyzing each one and the results are as follows.

5.1 Inventory Management

Inventory management is very important in manufacturing. Through our analysis, the team has discovered that the current state of the warehouse, regarding the layout of the pallets for storage before shipment, is not optimized for their inventory flow system they use. BSM uses a First In First Out inventory flow system. This means the first product into inventory is the first to be pulled out and shipped. It creates a cycle which directly fits with BSMs product because of its limited shelf life. This method minimizes what BSM calls "Feed In" or product which has sat past its allowed shelf life and has spoiled. (Feed In is also comprised of the product that has not met the standards of quality set forth by BSM and is therefore put into Feed-In to be remanufactured.)

The team identified that the current state is not optimized for the First in First out (FIFO) inventory flow that BSM currently implements. After a research period and an analysis of the data the team collected, the resulting solution is the recommendation of implementing of a new inventory layout. With the constraints the team had to work within, a full redesign using new hardware was not feasible; however, the team developed multiple layouts which are a hybrid of the current static standing pallet layout and new hardware. The new layouts all maximize the ease of movement in a FIFO flow by targeting the most produced products and having them on flow through the hardware because they are the products which are moving regularly. The other less produced products will remain in a smaller section set up in a similar fashion to the current system.

The layout designed maximizes the ease of movement of the most moved products by minimizing the number of touches by a forklift they receive while moving through the inventory warehouse floor. Through an observation and study of the current layout, it was discovered that all of the products are touched (moved) a significant number of times as a direct result of the current layout. By altering this layout with new hardware to minimize touches of the most moved products, BSM will realize savings in the form of time and money not spent moving the product around the warehouse floor. Furthermore, because of the reduced number of touches the new hardware will grant BSM, BSM's warehouse will also become more efficient.

5.2 Customer Policy

BSM currently services 174 different customers through its Clifton Mill. The team spoke with upper management and analyzed the relations with the customers and discovered an issue which has negative effects on the efficiency of the facility that BSM has only recently begun to realize. This problem is the effect from customers not picking their orders up on time. The result is inventory which BSM has not been paid for yet, sitting on their warehouse floor in inventory or shipping taking up space that could be used for more current orders. This stems from the customers not having to sign any sort of contract or be held accountable for their product up until they come to BSM's facility to get it. Furthermore, BSM's practice of not invoicing the product until the customer comes to pick the order up exacerbates this issue because the customers are not forced to pay until they actually come to get the order.

An analysis of this problem resulted in the discovery of the overall efficiency of the warehouse being diminished. We found that because of the limited warehouse space at the Clifton facility, product taking up space that is past due has a greater impact compared to the other inventory which is still within its designated time window. BSM produces its orders within a specific window to maximized manufacturing efficiency and minimize warehouse sitting time. When this window is violated because of a late pickup, that space is not open for newer orders which now have no place on the inventory floor. This ripples back through the manufacturing and thus decreases the facilities efficiency. This also costs BSM money. "We are effectively storing the product for our customers"[5] To combat this issue the team has developed recommendations that directly address the time payment issue and the late pick up issue.

5.3 Metrics and Information Technology

"To achieve maximum efficiencies and financial results in turbulent business and financial markets, executives and senior managers must revisit their business models to make certain measurements lead to the right behaviors."[6] BSM is inefficient at measuring the day to day operations of its warehouse floor. This is done through developing metrics, or the measurements that can be taken from a procedure which describe the different facets of that specific procedure. For example, the time it takes for the procedure to be completed, the cost associated with that time, and the effect it has when that procedure is altered because of another directly associated procedure being affected. Once the data has been collected, it can be analyzed and then the procedure, movement or, action can be altered to streamline that process. The metrics BSM collects data on are currently limited and to further optimize the efficiency of their facility, BSM must develop new and enhance their current metrics which help them identify wasteful and mal practices. The team has developed a few metrics for BSM which will help them initiate their metric data collection.

5.4 Other Results

5.4.1 Data in Excel

A detailed excel file was provided by BSM containing a forecasted shipment plan. CWTs and profit margin were the two data types extracted from this database. The CWTs were converted into pallets with the knowledge that one pallet holds 2500 LB. This ultimately allowed the number of pallets produced daily, weekly or monthly to be identified. The profit margin was already provided so no conversion was needed for this data. Ultimately this data

[5] Personal Correspondence, Mike Walsh, Bay State Milling
[6] http://asq.org/qualityprogress/topics/index.html?topic=26&mode=nav&lst=more&parentTopic=QP3

was separated into multiple tables. Such tables held data on pallets of all brands, bag sizes, (25, 50, 100 lb) and percentage on annual profit margin by flour type.

5.4.2 ABC analysis

After deciphering the data from the spreadsheet supplied by BSM, it was determined that an ABC analysis could be created. The goal of this analysis is to stratify the flour by production rate, demand and, profit. The results of this analysis help determine which types of flour are produced consistently and inconsistently. Due to the design and constraints of the new pallet flow racking systems, the inventory space in the racks will be limited. Thus, knowing which products are produced consistently will help with determining which products should be placed in the racks.

Recently, another philosophy that utilizes ABC has been pioneered by Cornell Professors Joseph Thomas and John McClain, and Auburn University Assistant Professor Charles Sox. "Stock your high-demand products, but give them low production priority. Do not stock products for which demand is unpredictable, but give these non-stock items high production priority"[7] The philosophy has been implemented successfully by a number of other companies in varied industries such as cosmetics, and electronics. The benefits are numerous. For example, the philosophy reduces the stresses on customer services caused by a JIT production philosophy because it maintains an adequate inventory for the high demand products while still giving a "High Priority" label to the low production products. It also minimizes inventory by stocking the products with predictable demand. Lastly, for facilities near capacity, the prioritization allows for a more efficient and flexible facility without extensive equipment upgrades.

Two more ABC analyses were done to further stratify the flour. The first ABC analysis determined the profit margins for each brand of flour and then split the flour into three groups. The steps to do this were to develop a profit margin spread sheet which displayed all the flour brands and their profit margins. The next step was to stratify the total list into sections. This was done by taking the flour brands and their profit margins and breaking them into groups

[7] http://www.mountain-plains.org/pubs/pdf/MPC96-62A.pdf

based on their percentage contributions to the overall profit margin. Thus, the following was developed. Group A, the top produces flour brands, consisted of 12 brands, which accounted for 56% of the annual profit margin, Group B the next tier of flour brands consisted of 19 brands and accounted for 28.5% of the annual profit margin. The last section, Group C accounted for the rest of the brands and the remainder of BSM's profit margin.

The second ABC analysis was defined by the units of each brand that were shipped annually. The same steps can be used to in this analysis as was used it the above analysis. First the flour was ordered in terms of how many pallets are shipped annually. Group A contained the brands that shipped the highest percentage of the total units shipped annually. Group B contained the next highest percentage and Group C contained the lowest percentages. The proper division line between Groups A and B was determined to be 2.50%. This left Group A containing 13 different brands of flour that ship approximately 58% of BSM's total annual units; Group B contained 15 brands and accounted for about 25%.

Group A				Group B			
Flour Brand	Bag Size	Annual Profit	Percentage of Annual Profit	Flour Brand	Bag Size	Annual Profit	Percentage of Annual Profit
H & R ENR (BALES)	2/25	$271,458.90	9.01%	LIL CAESARS RND ENR W/WWG	2/27	$78,568.40	2.61%
ROYAL SPECIAL	100#	$264,372.23	8.77%	LITTLE CZR HI GL ENR UNBR	2/27	$76,068.58	2.52%
PURE WHITE RYE	50LB	$159,331.60	5.29%	ROYAL H&R ENR BL BRO-BALE	2/25	$68,691.21	2.28%
FOUR STAR ENR	100#	$150,423.83	4.99%	BOUNCER ENR	100#	$61,339.80	2.04%
WINONA ENR UNBL UNBRO	50LB	$142,994.96	4.74%	FOUR STAR ENR	50LB	$60,562.62	2.01%
BOUNCER ENR UNBL UNBRO	100#	$127,069.41	4.22%	YOSHON BOUNCER ENR BL BR	50LB	$48,452.55	1.61%
LIL CAESARS RND ENR W/WWG	2/27	$122,188.18	4.05%	BIG YIELD BL BR ENR	100#	$48,447.11	1.61%
WHOLE WHEAT FINE	50LB	$110,508.67	3.67%	PERFECT DIAMOND ENR	100#	$47,332.78	1.57%
YOSHON BOUNCER ENR BL BR	100#	$85,024.55	2.82%	PERFECT DIAMOND ENR	50LB	$47,178.77	1.57%
DIAMOND BRAND H&R (BALE)	2/25	$84,767.50	2.81%	ROYAL FOUR STAR ENR SP BL	100#	$40,988.49	1.36%
KING HACKO ENR	100#	$84,309.45	2.80%	WINONA ENR	50LB	$40,160.38	1.33%
BOUNCER ENR	50LB	$79,441.84	2.64%	WINONA ENR UNBL UNBRO	100#	$33,772.70	1.12%
Total Percentage		55.80%		WHOLE WHEAT FINE	50LB	$33,289.23	1.10%
				THOROBREAD PATENT	50LB	$31,886.98	1.06%
				DUNKIN DONUTS DUSTING FLR	50LB	$30,140.16	1.00%
				STAR WHITE SP BL ONLY	100#	$29,787.99	0.99%
				ROYAL 888	100#	$28,909.28	0.96%
				ANA CAPRI-GREEN ENR	50LB	$28,232.55	0.94%
				WINONA ENR	100#	$27,239.52	0.90%
				Total Percentage		28.57%	

Figure 16
This figure illustrates that of the 95 different brands of flour produced annually, 29 of those brands account for over 75% of BSM's profits margin, and 12 brands of flour account for over 50%.

Group A				Group B			
Flour Brand	Bag Size	Annual Profit	Percentage of Annual Shipped Product	Flour Brand	Bag Size	Annual Profit	Percentage of Annual Shipped
ROYAL SPECIAL	100#	12212900	10.33%	DIAMOND BRAND H&R (BALE)	2/25	2828000	2.39%
FOUR STAR ENR	100#	7975300	6.74%	LITTLE CZR HI GL ENR UNBR	2/27	2764854	2.34%
H & R ENR (BALES)	2/25	7821950	6.61%	WHOLE WHEAT FINE	50LB	2572050	2.17%
WINONA ENR UNBL UNBRO	50LB	6324100	5.35%	PERFECT DIAMOND ENR	100#	2468400	2.09%
KING HACKO ENR	100#	5124000	4.33%	PERFECT DIAMOND ENR	50LB	2419450	2.05%
PURE WHITE RYE	50LB	4913550	4.15%	ROYAL FOUR STAR ENR SP BL	100#	2088900	1.77%
BOUNCER ENR	50LB	4153150	3.51%	YOSHON BOUNCER ENR BL BR	100#	2017100	1.71%
BOUNCER ENR UNBL UNBRO	100#	4045600	3.42%	STAR WHITE SP BL ONLY	100#	1726700	1.46%
LIL CAESARS RND ENR W/WG	2/27	3567888	3.02%	WINONA ENR	50LB	1707700	1.44%
LIL CAESARS RND ENR W/WG	2/27	3305934	2.80%	BIG YIELD BL BR ENR	100#	1706400	1.44%
BOUNCER ENR	100#	3065900	2.59%	WINONA ENR UNBL UNBRO	100#	1654000	1.40%
FOUR STAR ENR	50LB	3033350	2.56%	ANA CAPRI-GREEN ENR	50LB	1386550	1.17%
ROYAL H&R ENR BL BRO-BALE	2/25	3006750	2.54%	ROYAL 888	100#	1361200	1.15%
Total Percentage		57.96%		DUNKIN DONUTS DUSTING FLR	50LB	1252000	1.06%
				WINGOLD SPEC-ENR UNBL UNB	50LB	1165000	0.99%
				Total Percentage		24.62%	

Figure 17

This figure illustrates that of the 95 different brands of flour produced annually, 28 of those brands account for over 80% of the total units shipped annually, and 13 brands account for just short of 60%.

This analysis does not take into account certain details. For instance, though H&R ENR accounts for the highest percent of annual profit, there could be weeks in which there is no demand. A template was created in excel that data can be added to weekly, monthly or seasonally. This will allow the ABC analysis to be performed when the need arises and help determine rack optimization.

Each analysis has specialized strengths and weaknesses. The first analysis will help to maximize revenue. This occurs as a result of the brands being held primarily on their percentage of annual profit margin. This, however; will sacrifice flow through the factory. Even though each group accounts for a high percentage of revenue, they are not the brands that are the most consistently produced. Inversely the second analysis depends directly on brands that are produced and shipped consistently at a high rate. Using this analysis will maximize the flow of flour through the factory, but with the possibility of a drop in revenue. Neither analysis alone is enough. They both have the capability of increasing profit and efficiency. Thus, BSM must do both analyses for each of the groups A and B every time they want to update their inventory organization. This will help them determine which will garner the most benefit for that coming period of time. Group C is too stratified and variable in its production and number of brands for either analysis to truly benefit the company.

All in all, the decision between which ABC analyses depends on which aspect of the contributing factor to their profit margin they are trying to optimize. It depends on the ratio of profit earned by maximizing revenue vs. costs reduced by optimizing factory flow. The ABC analysis based on profit margin should be more heavily weighted if the company's profit will be maximized by maximizing revenue as opposed to reducing production cost. Inversely, the second analysis is more beneficial to the company if the maximal profit is a result of minimized production cost instead of just maximizing the revenue.

5.4.3 Kanban Analysis

Companies as large as BSM sometimes encounter problems keeping up with their inventory demands. Companies sometimes focus purely on production, but forget to assess the stock levels across all of their product lines. A Kanban system can only be applied to products which are constantly being produced and stocked in inventory. Companies with sporadic or irregular production schedules would have a problem implemented a Kanban system. A Kanban system would only be effect with groups A & B of BSMs products because together they account for more than 75% of the demand and are produced on a regular basis with a predicable demand schedule. It is assumed that as a result these groups would hold 75% of the inventory floor and are thus being consistently produced. A Kanban system could not be applied to BSM's Group C products because of the significant variety of brands which are sporadically ordered and produced. Thus, the current inventory system of static free standing pallet stacks works perfectly for Group C with the Just in Time (JIT) system currently implemented.

The Kanban equation took into account, the demand rate, lead time, maximum replenishment rate, and capacity of one pallet. One pallet can hold 2500 lb of flour thus, that was determined to be the Kanban bin because it is consistent for each bag size. Multiple equations exist to determine the appropriate Kanban system. The following is the equation used to determine the Kanban system for BSM:

Kanban = ((AD * RT) + (SF * SD))/SCQ

- AD = average period demand
- RT = replenishment time (in the same time bucket as AD)
- SF = the Z factor, typically 1.645 for 95%
- SD = demand standard deviation
- SCQ = the standard container quantity

This equation was first broken down to determine each individual variable. The average demand (AD) was found from the data supplied by BSM. The AD for BSM is in units of demand per bag; this corresponded with the standard container quantity (SCQ) with was determined to be one pallet. (Pallet contains 25 CWTs). Again the replenishment time (RT) was derived from the information provided. In order find RT the following factors were taken into account: the supplied lead time per bag, the average nonproductive time as a result of bag change, the average number of bag changes a week, and transportation time per pallet. The demand standard deviation (SD) was found in a spread sheet. For SD, the sum amount of demand was found per week, and the standard deviation was calculated from that information

Kanban Cards Required By Bag Size					
25 Lb Bags		50 Lb Bags		100 Lb Bag3	
AD	1180.993	AD	1461.076	AD	1868.067
RT	0.000174	RT	0.000208	RT	0.00026
SF	1.645	SF	1.645	SF	1.645
SD	551.3933	SD	557.7319	SD	625.9989
SCQ	100	SCQ	50	SCQ	25
Kanban	5.532433	Kanban	11.19363	Kanban	25.12521

Figure 18
This is a chart showing the different bins for the Kanban analysis based of the different bag weights.

5.5 Description of Warehouse Design Alternatives

5.5.1 Assumptions

Design Assumptions:

When the team began to design the racking systems and contact companies which would supply them to BSM, the team discovered that we had to make certain assumptions. The assumptions are as follows:

- Each Pallet Position Costs: ~$400[8]
- Pallet Dimensions: 46" Wide, 48" Tall, and 42" Deep
- Added Racking Frame Dimensions: 4" Each Side, 4" Top and Bottom
- When the team refers to the dimensions of the racking system, we are speaking in terms of pallet positions, which coordinate to exact measurements that can be derived from the above dimensions.

Return on Investment Assumptions:

When calculating the return on investment, a few assumptions were made and are as follows:

- The profit margin per sack is 2.73% on average and therefore, the profit margin on an entire pallet is also roughly 2.73%.
- Every time a pallet is moved roughly 2% of the price of that pallet is added
- In the current state a pallet receives 5 touches before it arrives in shipping
- In the two proposed configurations a pallet is only touched 3 times
- Each touch currently costs BSM about 90 cents
- BSM moves 47300 pallets a year

5.5.2 Design A and ROI

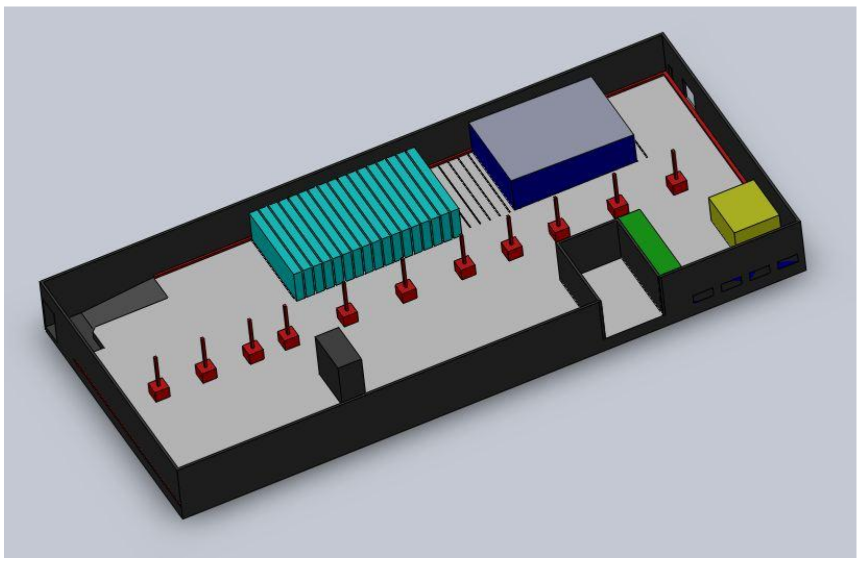
Design A is a hybrid system with two individual areas. Area one is setup and utilizes their current method of inventory organization and management, static free standing pallet stacks. This will take up approximately 50% of the area the team was to redesign. The other half is to be occupied by a racking system with the dimensions 9 rows of 12 pallet positions deep and 3 pallet positions high. This design holds 324 individual pallets and has 27 pellet channels. Between the static standing pallets (the old inventory organization and management method) will be a 12 foot channel for the forklifts to maneuver in and load the pallets into the flow racking systems. The flow of the racking systems will flow towards the shipping, loaded from the middle channel and taken out on the back side closest to shipping to minimize the distance traveled to shipping for each pallet.

[8] Personal Correspondence, Racking Companies

Advantage: The advantage to this setup is that there are 27 channels which mean the top 27 brands of flour that can be loaded and savings realized on each pallet of each brand loaded into the flow racking systems. It also provides 21 channels 9 pallet positions deep and 3 pallets high in static standing inventory. Thus, there are 324 pallet positions in the racking system and 567 pallet positions in the static standing inventory system. This system has a total of 891 pallet positions. This design maximizes the number of pallets in the racks and number of brands which BSM can realize the savings from.

Disadvantage: Design A loses 8% of the storage space compared to both Design B and their current setup. The design losses come from the channel for the movement of the forklifts.

Layout Picture: Design A



Cost: $129600

ROI Equation:

$$\frac{Cost\ of\ New\ Racking\ System}{Pallets\ Shipped\ per\ Year * Cost\ per\ Touch * \%\ of\ Pallets\ in\ Racks * \#\ Reduced\ Touches} = ROI$$

ROI Analysis: 4.22 Years

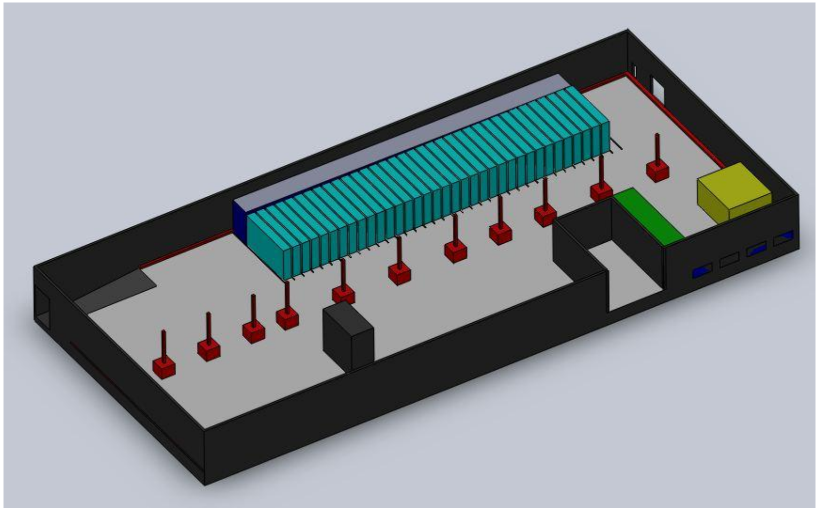
5.5.3 Design B and ROI

Design B is also comprised of two areas, a static standing pallet section in a similar fashion to BSM's current layout and a pallet flow racking system. The pallet flow racking system of Design B is 2 rows, 36 pallets positions deep and, 3 pallet positions high. This gives a total of 6 different brand channels and 216 individual pallet positions. This setup puts the racking system along the entire rear of the inventory area stretching the entire back wall. The flow of the pallet flow racking system is set towards shipping like Design A. Thus, the pallets are loaded on the far side furthest from the shipping area and the pallets are pulled from the shipping side to minimize the distance. The current state static standing pallet system is to be setup in front of the hardware taking up the remained of the available inventory space. This leaves another 36 channels, 7 pallet positions deep and three high for the static standing system.

Advantage: This allows for the six top produced flours to be put in the pallet flow racking system in 216 individual pallet positions. This minimizes the touches that the six most produced flours receive, saving money on the most produced products and increasing the profit margin on each pallet of those six brands. Furthermore, this setup has more static standing space than Design A and it is similar in design to the current setup implemented at BSM's warehouse. Overall this setup has 756 static standing pallet positions and 216 pallet positions in the flow racking system for a total of 972 which is exactly their current maximum number of pallet positions. This means there is less reorganization, less training, and less of a learning curve for the workers.

Disadvantage: The disadvantage of this setup is that it is limited to only six brands of flour being put into racks and therefore, fewer saving across the board of flour brands. Secondly, there are still free standing static pallet channels which still operate in the inefficient manner as before.

Layout Picture: Design B



Cost: $86400

ROI Equation:

$$\frac{Cost\ of\ New\ Racking\ System}{Pallets\ Shipped\ per\ Year * Cost\ per\ Touch * \%\ of\ Pallets\ in\ Racks * \#\ Reduced\ Touches} = ROI$$

ROI Analysis: 4.6 Years

5.6 Racking System Philosophies

The way BSM uses the pallet flow racking system will dictate the benefit they receive from them and the savings they will realize. The benefit of the racking system is the fact that it will greatly reduce the number of touches each pallet receives while moving through inventory to shipping. This is because the flow system will alleviate the need for forklifts to move the pallets each time they need to be moved forward in the inventory layout. Minimizing the number of touches will not alone cause BSM to realize savings. This is because the proper products must be placed in the racking systems. Because of this, our group has determined a few different ways the racking systems can be used to generate the most savings and shorten their return on investment. First off, the ROI on Design A is longer than Design B, purely because Design A has more pallet positions and therefore, costs more. However, Design A also provides savings for 27 brand of flour verse on 6 brands in Design B. Thus, the ROIs will have a similar timeline.

The way to optimize the utilization of these racks comes from the top produced products being put into the racks. For design A there is room for up to 27 different brands to be stored, but in smaller quantities than Design B. In Design B, there are only 6 channels or 6 available slots for the different products, however, the volume of product capable of being stored is three times of any of those stored in Design A. Thus, it is up to the company to determine whether or not there are 6 products of great volume, or 27 products of lesser volume that are the most produced.

Through our analysis, we have discovered that there are two groups of products which make up over 75% of their inventory at any given time. Group A is made up of 12 products and 56% of their total production. Group B is made up of another 19 products which make up the 29% of total production. The remainder is made up of over 95 other types of flour. Our team has determined that utilizing the racks to hold group A and group B in design A will benefit the company if they choose Design A. If BSM chooses Design B, only 6 products, or the top products of Group A should be loaded usually.

However, the production of most of these brands varies significantly on a regular basis across the year; thus, it is hard to say that strictly certain brands should be loaded into the racking systems across the entire year because there could be stints where there that product is not produced at all. Due to this variation in production, it will be up to BSM to determine every week or month, which brands of flour, would generate the most savings by being loaded into the racks. Thus, it is hard for the team to specifically target individual brands. That being said, the two groups of product mentioned above, A and B, are good candidates. Finally, if BSM chooses to only follow the production of a certain number of brands, the team urges them to follow the brands that fall into group A and B.

6. Conclusions, Discussions, and Recommendations

6.1 Conclusions

Through the analysis of the data given to us by BSM and the observation done on the trips to the facility, we have concluded that BSM is plagued with four main problems. First off BSM is holding more inventory on their warehouse floor than needed and their current inventory management design is not optimized for their inventory flow method. Because of this, moving the inventory is an inefficient and laborious process costing BSM money and time. Secondly, BSM needs to reduce their costs. The team found a number of different items that increased cost at BSM but the main problem comes from their current policy regarding late pickings by their customers. This is a huge cost generator because of its impact on the efficiency of the entire manufacturing process. Third, the lack of inventory tracking leads to many issues including lost time trying to identify product and lack of knowledge regarding how much and each product is on the inventory floor. Finally, the last issue is their current occupation of the back warehouse. This is a costly occupancy and BSM asked us to find a way to alleviate their need to be there.

First off, the current system is not designed for a first in first out inventory flow system. Because of the setup, the inventory channels must be completely emptied only after the channel is completely emptied can the latest product be placed into the inventory channel. Then the previously removed inventory must then be replaced back into the inventory channel. The process is inefficient because of the current inventory setup. This setup results in a large number of touches which equate into time and money. Leaning out the movement process of inventory and reorganizing the inventory flow will reduce the number of touches leading to savings in time and money as well as a move efficient warehouse floor.

The second issue facing BSM is the current policy for handling the late pickups. Currently, some customers utilize BSM's warehouse as their own inventory storage area. This creates a space issue. BSM produces its orders in a time window that maximizes the production efficiency and minimized the products time on the inventory floor. In this time window, the efficiency of BSM is maintained; however, late pickups diminish that efficiency and incur costs to BSM which are never recovered.

The third issue is the lack of information regarding what is on the inventory floor and how costs are generated from it being there. Currently to check the amounts on the floor, one must check the production logs and then match that with the channels each pallet of product is placed in. This is a timely and inefficient measure of current inventory.

The final issue is BSM current occupation of the back warehouse. They have been working to move out of the back warehouse, however, they still occupy it with a few loose ends which they have not found space for.

All in all, these three problems cost BSM money every day. Removing these issues will create an even greater positive cash flow and a more efficient warehouse. Through the reduction in touches to each pallet, BSM will save money and streamline their inventory movement. With new policies regarding late pickups, BSM will be able to maintain its warehouse efficiency and reduce costs. The development of metrics and tracking technology will keep BSM more informed about what is on their inventory floor and help them target cost generating practices and naturalize them. And finally, the minimized inventory and reduction in late pickups will free enough space for BSM to finally move out of the back warehouse.

6.2 Recommendations

In an effort to help BSM streamline its warehouse in Clifton New Jersey, our team has developed recommendations and solution that directly target the mal practices and weakness in the current layout. We have developed short term, intermediate and long term goals for BSM which if applied to the Clifton Facility, will greatly improve all facets of its operation. The short term goal is for BSM to install an inertia/gravity power racking system in their warehouse. The intermediate goal we have developed targets the mal practices of their customers who consistently pickup their orders late and thus reduce the efficiency and increase costs of BSM's warehouse. Finally, the long term goal for BSM is to develop metrics which will track where extra costs are being generated due to inefficient practices and also develop and implement a bar code scanning system to help maintain and inform workers exactly where and what is on the inventory floor at any given time.

First off, the short term goal for BSM is to install one of the two configurations of inertia/gravity power racking systems we have designed for their warehouse. By installing these systems, the movement of pallets in time and the number of touches by personnel on the warehouse floor will be reduced. This results in saved time and money and also greatly increases the efficiency of inventory movement on the warehouse floor.

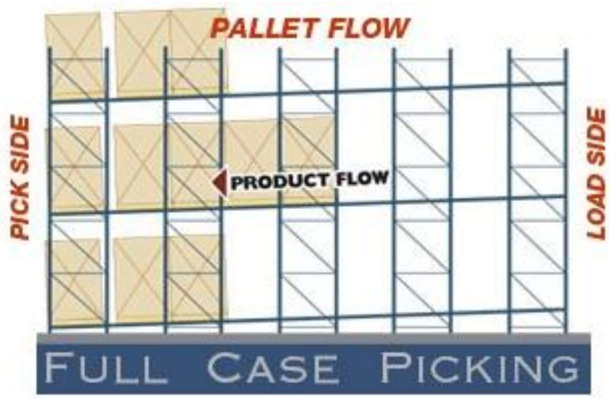


Figure 19
This is a diagram of how a Pallet Flow Racking system works. One side is a load side where the product is placed into the inventory system. The other side is where the inventory units are removed and brought to the shipping queue.

Secondly, BSM has had issues with mal practices of some of their customers. These customers have consistently picked up their orders late. BSM produces its product in a certain time window that maximizes production efficiency and minimizes inventory sitting time. A late pickup means that an order is violating that time window's boundaries which results in a serious deterioration of efficiency in the warehouse. It also means that the cost of that product is increasing with every day extra it spends in inventory. To combat this issue, our team recommends that BSM build more stringent contracts with their customers that clearly state the pickup date, their policies regarding late pickup and the ramifications in the form of monetary compensation for a late pickup.

The third and final recommendation for BSM is broken down into two long term goals. First BSM should invest in bar code scanning equipment and second, to take advantage of that equipment, develop metrics which can be tracked via the scanning of the bar codes to be placed on each pallet. Through doing this, BSM will have a greater understanding of what is on the inventory floor at any given point in time. Also, because each time the pallet is touched, it will be scanned and its movement will be tracked, BSM can then identify poor and wasteful practices, target and analyze them, and remove them. Furthermore, the more metrics that are being tracked, logged, and analyzed the greater amount of data BSM can use to further streamline is warehouse. The metrics we suggest BSM starts tracking are the number of touches each pallet receives, the time it takes to move a pallet, forklift utilization, worker utilization, and extra time inventory spends on the warehouse floor.

Finally, these recommendations will only benefit BSM if the company, as a whole, is willing to commit to them fully. Through a full commitment the recommendations full potential can be realized. BSM will have to install a configuration of the racking system and use them properly, they will have to renegotiate and develop more stringent contracts with their customers and hold them to the decided terms, and finally, they will have to develop metrics that use the bar code scanning technology to garner the full benefits of these recommendations. The team feels that through these recommendations, the optimization and efficiency of the Clifton facility can be greatly increased.

7. Bibliography

Hedrick, Floyd D. "Inventory Management." *U.S. Small Business Administration*. N.p., n.d. Web. 12 Dec 2010. <http://www.sba.gov/idc/groups/public/documents/sba_homepage/pub_mp22.pdf>.

Barber, Jason T. "INVENTORY PRACTICES OF FLOUR MILLING FIRMS." *Mountain Plains Consortium*. N.p., Jun 1996. Web. 12 Dec 2010. <http://www.mountain-plains.org/pubs/pdf/MPC96-62A.pdf>.

Nenes, George, Sofia Panagiotidou, and George Tagaras. "Inventory management of multiple items with irregular demand: A case study." *European Journal of Operational Research* 205.2 (2010): 313-324. Web. 12 Dec 2010.

Bowman, D. Jerry. *"If You Don't Understand JIT How Can You Implement It?"* Industrial Engineering. February 1991, 38-39.

Alfaro, Jose A., and Luis A. Rabade. "Traceability as a strategic tool to improve inventory management: A case study in the food industry." *International Journal of Production Economics* 118.1 (2009): 104-110. Web. 12 Dec 2010.

Rkoc, Murat, Eleftherios T. Iakovou, and Andre E. Spaulding. "Multi-stage onboard inventory management policies for food and beverage items in cruise liner operations ." *Journal of Food Engineering* 70.3 (2005): 269-279. Web. 12 Dec 2010.

Fellows, Peter, and Barrie Axtell. *Appropriate Food Packaging*. Amsterdam, nl: Tools Publication, 1993. Print. N. HUMA, S.U. REHMAN, J.A. AWAN, M.A. MURTAZA, M.U. ARSHAD, . "Effect of PAckaging Materials on the Quality of Iron-Fortified Wholemeal Flour During Storage." *Journal of Food Processing and Preservation*31.6 (2007): 659-670. Web. 12 Dec 2010.

Robertson, Gordon L. *Food Packaging Principles and Practice*. 2. Boca Raton, FL: CRC Press, 2006. Print. Maroulis, Zacharias B., and George D. Saravacos. *Food Process Design*. New York, NY: Marcel Dekker, Inc., 2003. Print.

Cramer, Michael M. *Food Plant*. Design, Maintenance, and Good Manufacturing Practices. Boca Raton, FL: CRC Press, 2006. Print.

Hazen, Theodore R. "The History of Flour Milling In Early America." *Mill Restoration*. N.p., 1999. Web. 12 Dec 2010<http://www.angelfire.com/journal/millrestoration/history.html>.

"The History of Flour." *World Food History*. N.p., 21 Jan 2007. Web. 12 Dec 2010. <http://www.world-foodhistory.com/2007/01/history-of-flour.html>.

"The History of Flour: from the Mortar to the Industrial Mill." *Art and Flour*. N.p., n.d. Web. 12 Dec 2010. <http://www.art-and-flour.de/english/history.html>.

McGowan, Kathryn. "A Brief History of Flour." *Blog.com*. 12 Dec 2009. Web. 12 Dec 2010. <http://blog.kathrynmcgowan.com/2009/12/14/a-brief-history-of-flour/>.

Hazen, Theodore R. "The Automation of Flour Milling in America."*Mill Restoration*. angelfire.com, 1996. Web. 12 Dec 2010. <http://www.angelfire.com/journal/millrestoration/more.html>.

Kozmin, Peter A. "Flour Milling: A THEORETICAL AND PRACTICAL HANDBOOK OF FLOUR MANUFACTURE FOR MILLERS, MILLWRIGHTS, FLOUR MILLING ENGINEERS, AND OTHER ENGAGED IN THE FLOUR MILLING TRADE." *Pond*

Lily Mill Restorations. N.p., n.d. Web. 12 Dec 2010. <http://www.angelfire.com/journal/pondlilymill/kozmin.html#anchor394332>.

"Flour." *How Products are Made* 3. (2006): n. pag. Web. 13 Dec 2010. <http://www.madehow.com/Volume-3/Flour.html>.

"Capernaum, Ancient Millstone." *Living Travel - Middle East 1965*. Web. 13 Dec 2010.

"Tower mill, 1620." *Heritage Images*. Web. 13 Dec 2010.

"Mill Wheat Purifiers" *Flickr.com.* Web. 13 Dec 2010.

"A Kernel of Wheat." *A Brief History of Flour*. Web. 13 Dec 2010.

"Pallet Flow Rack." *How to Build a Warehouse*. Web. 13 Dec 2010. <http://www.konstant.com/How-to-build-a-warehouse.asp>.

"Comparison of Quantity Based and Scheduling Inventory Management Methods.." *Inventory Practices of Flour Milling Firms*. Web. 13 Dec 2010.

Appendix A: Bay State History

In 1899, five gentlemen, Bernard J. Rothwell, H.B. Goodwin, Charles H. Adams, Leroy Brown, and Herbet C. Gavin bought the idle L.Cl. Porter Mill, a spring wheat mill on the lower levee of the Mississippi river in Winona, Mississippi. This was the beginning of the Bay State Milling Company.

The buy in Winona would eventually become and stay the flagship mill for BSMC as it expanded. It remained a base of operations until 1967 when they were consolidated to Boston. BSMC and its owner Bernard J. Rothwell, was founded on a dedication to produce and provided not only a top notch product, but also top notch service to its clients.

In March the doors to the mill at Winona opened and production began. The mill was very centrally located in a great market. There was a ready source of labor nearby, the raw materials and fuel were close, the rail service went right to the mill, and the price was right. To make sure that Rothwell's new venture would match up to what he had hoped to stand by, quality in product and service, within the first week a barrel of their product was sent to A.W. Howard in Minneapolis. A.W. Howard was regarded as an expert on flour at the time. He would rate the quality and then report back. Rothwell's flour was given the best rating out of the 24 samples that Howard saw.

Aside from having some of the best flour around, two other events lent to the success of the Winona mill. The first was the 1900 state Grocers Convention held in Winona which helped Rothwell reach a wider market and the heavy rains which destroyed key local dams which disrupted the production of the water powered mills nearby by. The competition's production capacity was effectively destroyed leaving Rothwell's mill the only one producing in the area.

By 1911, Rothwell's mill and their product "Wingold" were synonymous with superior quality. He was catering to the entire eastern seaboard of the United States and European markets. The mill was producing up to 3500 barrels of flour daily. However, on July 28th, a fire ripped through most of the Winona mill causing over 600,000 in damages. The mill warehouse, elevator and 12 rail cars were all engulfed and destroyed. To cope with the destruction and keep production running, Rothwell leased another local mill while the new mill, on the sight of the old, was built. The foundation was poured only four weeks after the fire. Seven months later on March 4, 1912, the new mill, capable of delivering 4000 barrels of wheat flour and 500 barrels of rye flour was completed. It was the biggest and most advanced mill of the time.

Throughout World War I and the great depression, the mill survived. It produced flour for the allies in WWI and survived the depression because of its business practices and dedication to its employees. In 1921, H.C. Garvin stepped down from general manager. His position was taken by Frank Allen, an office boy at the opening of the company in 1899 who had risen through the ranks of the company. Garvin stayed on as vice president.

In 1913, Paul Rothwell, the son of Bernard Rothwell joined the company and would work many different jobs across the company until he was named president in 1940. Paul Rothwell had an intimate idea of what was going on around the company as he had worked in the mill as a child, then moved to the Boston offices to be a sales assistant in 1919. In 1920 he was promoted to the assistant to the eastern sales manager and in 1925, he became the eastern sales manager.

The years leading up to WWII were very difficult. The mill was only running part time because demand was so low. However, once the war started, the mill was back to full production. In 1944, the one millionth bag of flour produced by the company was filled and by 1947, 7.5 million dollars in government contracts had been completed.

Tragedy struck in the second half of 1948 when the last of the founders passed away which was followed by stiff competition and price wars in the 1950s. In 1951 Frank Allen retired from vice president and general manager. M.A. Laberee was named Vice President and George Kelley became the General Manager. By 1953 the price wars were a serious issue for the company and Paul Miner was promoted to sales manager to help strengthen the company's sales efforts.

In 1954 the J.C. Lysen Mill in Leavenworth, Kansas was acquired. It was the 2nd mill for the bay state milling company. The mill was updated when it was purchased. The upgrades were overseen by the vice president at the time, R.R. Brotherton. When the modern equipment was installed, the mill was capable of 7300 hundred weights a day and could store up to 750,000 bushels of wheat.

From 1959 through the 1960s many changes to the industry and bay state occurred. The entire idea of where to produce the product changed dramatically because of new railroad fees. Thus, companies began to put their mills near their customers because it became cheaper to ship in raw material and more expensive to ship out finished goods. Originally it was the same fixed price and the stop at the mill to convert raw material to finished flour was considered an interim stop. Thus, being close to raw materials was no longer as important as being close to the customers. The idea of "destination mill" was born from this changed. During this time, Bay State was in a period of expansion and change. Bernard Rothwell the 2nd was named president in 1959. In 1960 George Kelley retired from his position as general manager and Paul Miner took over. In 1961 the La Grange Mill in Red Wing, Minnesota was acquired. Bay State was expanding into spring wheat production and needed a mill specialized for it. La Grange did just that. It was supposed to be a short term investment because Winona was operating over its capacity. The mill at Red Wing was capable of 3200 hundred weights.

In 1963 the Clifton, New Jersey site was acquired. This was the first mill under the destination milling theory for Bay State. It also expanded Bay States market because the mill at Clifton was half soft wheat. Again in 1964, Camp Hill, Pennsylvania was acquired. This mill brought Bay States total milling capacity up to about 30,000 hundred weights a day. Later on it took over all of the soft wheat production and the Clifton Mill was upgraded to produce 5000 hundred weights a day. However, during this time of expansion, the United States was seeing a decline in flour consumption per capita. In 1965, the average American was only consuming 116 pounds of flour a year compared to the 137 in 1947. Furthermore, the overall market was shrinking. In 1947 there were 412 mills in the country. In 1965 that number had fallen to only 224 mills. Also, the overall output had fallen from 112 million pounds in 1947 to just 95 million pounds in 1965. Beyond the troubles associated with the declining market, demand, and overall decline of the industry, the CEOs of the six largest milling companies were indicted on fixing the prices of flour. Bay state was one of the companies fined. The spell of bad luck did not stop there. A flood shut down the Winona Mill on the Mississippi for three weeks in April, 1964 and there was a twelve week strike at Winona, Leavenworth, and Camp Hill because of a Union request for a master contract governing the conditions at the three mills that Bay State would not agree to.

In 1967 Bay State consolidated its office operations in an office located in Boston. Originally, all the office responsibilities were split among multiple offices across the country. New York was the location for the sales staff, the Executive offices were in Boston and, the general offices were in Winona. Also, Bay State diversified its portfolio through the acquisition of Viva Macaroni. It gave Bay State the avenue into the consumer market it was looking for. However, the company divested from the venture in 1972 due to poor performing equipment which needed to be replaced and the decline of the flour market because of the massive worldwide drought in 1972. At the time, the United States had built up a considerable surplus of grain through the grain exchange. The United States began selling its surplus to countries in need, mostly Russia and its annexed countries it had promised to support. Russia began purchasing in such amounts that the surplus was soon a deficit and the prices for grain began to skyrocket.

In 1973, another venture for Bay state outside of the milling business manifested itself in the Sports Information Center in Boston which kept the statistics for the MLB. It stayed in business and kept recording statistics until 1986 when the MLB switched to IBM. 1973 also held another tragedy for BSMC. The Red Wing mill burnt down; however it was quickly replaced by another destination mill in Mooresville, North Carolina. The Mooresville Flour Mill was Bay State's gate to entering the southeastern markets of the United States. Upon its acquisition, the mill could only produce 2200 hundred weights. Bay state continued to update the Mooresville facility until it could produce 10,000 hundred weights by 1998.

In 1974, Bernard Rothwell the 2nd stepped down from President and took his seat as chairman of the board. Norm Kautz took over the presidency and became the first president of Bay State not a family member. In 1976, Paul T. Rothwell died which prompted Bernard Rothwell the 2nd to buy the remaining 31% of the common stock which was held by his now deceased father. To help with his purchase, Bernard Rothwell the 2nd founded a holdings company, Trinitas, to hold the debt he built up with the purchase of the stock. He now owned the entire company, and the debt to go with it.

Between 1979 and 1982, the presidency again was changed when Norm Kautz stepped down and Allen Surplus replaced him. The Bay State Milling Company acquired the only flour mill in Arizona, the Tempe Mill. And, the Leavenworth mill was closed because the railroad access to the mill was removed due to railroad regulation changes. Beyond the loss of the rail access, the competition in Kansas proved to be a serious issue for the Leavenworth Mill which helped with the decision to close it down.

1983 held more expansion but also more financial problems for Bay State. The company was looking to further expand south into Florida's flour market and found a perfect location at Indiantown Florida; however, money became an issue. Bay State did locate funding for th4e purchase and renovation from Florida's largest bank after they have exhausted all their other resources. The construction of the Indiantown Mill became in the summer of 1983. This was the first mill built from the ground up by Bay State. It would be capable of 5000 hundred weights at its completion and hold 250,000 bushels of grain in storage. Indiantown came online in November of 1985. Other changes in 1983 included another switching of the guard. Allen Surplus retired and Murray Swindell took over. Swindell brought with him some serious changes in the finical sector of the company starting with his changed direction for the insurance policies from the company.

Troubles for Bay State continued into 1984 with the destruction of the Clifton Mill in New Jersey due to fire. This was one of Bay states most profitable plants and its loss had a huge toll on the company. The current projects and poor performing mills pushed Bay state even further into the red. Bell Sheskey took over as president to turn things around and things started to look up in 1986 when all of the debts held by the Trinitas Company of Bernard Rothwell the 2nd had been settled. With the new equity in the company, Bernard Rothwell the 2nd bought a parcel of land in Quincy, Massachusetts. It would be the sight of a new office building for Bay State.

In 1987 Bernard "Buck" Rothwell the 3rd took his seat as chairman of the board, Brian Rothwell was named president and the family was now back in control of the company. However, the industry was being rocked by serious changes. The industry giants, International Multifoods, Peavey, Dixie-Portland and, Pillsbury were all sold. To stay competitive Bay State moved even further into its quality niche. It became the quality oriented industrial sack and specialty supplier with an emphasis on service. With this new more focused direction, another plant, Tolleson Mill in Arizona was acquired from ConAgra. The mill was capable of 8500 hundred weights and this purchase of this mill eliminated the competition from ConAgra. Together with the other mill in Arizona, profits skyrocketed as competition was no existent for Bay State in that region.

Finally in 1989, after extreme difficulty with the reconstruction of the Clifton Mill, it came back online, completely computerized and automated. It was now capable of 12,000 hundred weights a day. The 1990s contained optimization for Bay State. They wanted to remain competitive with the top three millers in the country and to do this they spent a lot of resources optimizing all of their processes. They also started a program to bring the Winona Mill up to spec and have it reclaim its position as the flagship mill of Bay State. With the new focus and optimization, Bay State sold off its only soft wheat mill, the Camp Hill Mill, to Archer Dennis Midland (ADM) in 1991. In 1993 the updates to Tolleson were completed. It was now completely computerized and automated like Clifton.

In 1996 the updates spread to Indiantown. It was now capable of 9500 hundred weights and had a holding capacity of 500,000 bushels. However, the Freedom to Farm act of 1996 had a serious impact on the business. With the passing of the Freedom to Farm Act, the bottom-line price was no longer regulated by the government effectively removing the milling business's safety net. Furthermore, it removed the incentives given by the American government to the millers for producing American favored crops over the European or worldwide favored crops.

In 1997 further optimizations continued to the Tempe and Tolleson Mills. Tempe and Tolleson split their duties. Tolleson became the bulk milling mill and Tempe took over as a Durum mill. Originally both mills were doing a combination of both bulk and durum manufacturing.

In 1997 the market was recovering. Flour consumption had reached a new high of 150 pounds per capita and the population of the country had increased by 31%. However Bay State was still not in the top three for suppliers of flour. They sat in the fourth position behind ConAgra, ADM, and Cargill who together held more than 50% of the countries flour output.

In 1998 the offices at Quincy opened and the Texas market was entered via a Co-Op with two other companies who pooled their resources to build and operate a mill.

Today Bay State Milling Company has 6 flour mills and 1 blending mill with 58,555 hundredweight capacity across the country. They serve 954 customers and make 922 products.[9]

[9] Personal Correspondence

Appendix B: Bay State Facts

Mills in the company: **6 Flour Mills/1 Blending Plant**

Products Produced by Mill:

Flour	
Clifton, NJ	143
Indiantown, FL	161
Mooresville, NC	75
Platteville, CO	50
Tolleson, AZ	127
Winona, MN	211
Total Flour	767

Blend	
Wichita, KS	129
Winona, MN	26
Total Blend	155

Hundredweights per day by Mill:

Sum of Daily CWTs	Column Labels						
Row Labels	**A MILL**	**B MILL**	**DURUM MILL**	**RYE**	**Pastry Flour**	**WW MILL**	**Grand Total**
CLIFTON	4,555	4,693				1,483	10,731
INDIANTOWN	4,114	5,082					9,196
MOORESVILLE	2,892	1,794			1,375		6,061
PLATTEVILLE	516	2,063					2,579
TOLLESON	4,558	4,309	3,520				12,387
WINONA	15,018			1,362		1,220	17,600
Grand Total	**31,652**	**17,943**	**3,520**	**1,362**	**1,375**	**2,703**	**58,555**

****A Mill/B Mill regular flours with varying proteins (to protein free or gluten free) and type of Wheat (Spring/Winter crops, hard/soft wheat, and red/white wheat). The product matrix comes from the combination of those characteristics.**

Customers by Mill:

Flour	
Clifton, NJ	174
Indiantown, FL	117
Mooresville, NC	80
Platteville, CO	39
Tolleson, AZ	123

Winona, MN	330
Total Flour	863

Blend	
Wichita, KS	90
Winona, MN	1
Total Blend	91

Delivery Date of new packer: **12/13/2010**
Installation date of new packer: **12/13/2010 to 1/15/2011**
First operation of new packer date: **1/15/2011**