Enhancement of a Distribution Center Process using Lean Six Sigma

Christian Laboy Aponte
Master in Manufacturing Competitiveness
Carlos González, Ph.D.
Industrial Engineering Department
Polytechnic University of Puerto Rico

Abstract *— The competition between manufacturing & distribution companies increases every day, in the present world of competitive business, cost minimization and efficient management of manufacturing unit is not an easy task. For many years, many companies have debated about the best way to boost profits and being more efficient. This has been a debated topic because the industries have different methods to do so. This attitude of always looking to improve is important and even more when the market is volatile and unpredictable. Some of them prefer to focus in process, quality or production in order to improve production and revenues. To be competitive, the industry is seeking for tools to be used in order to reduce cost and improve manufacturing capacity without compromising the quality of the products. One methodology used to reduce manufacturing cost and increase process capacity is Lean Manufacturing. This methodology is used to reduce sources of muda or in other words, waste. Muda can be associated to downtime, waiting time, unnecessary movements among others things that do not create value to the customer. This article discusses the improvement of the efficiency of the process in a Warehouse Company. The methodology selected for the implementation of the possible improvement was Lean Manufacturing using the DMAIC tool as a systematic approach.*

Key Terms *— Capacity, DMAIC, Lean Manufacturing, Process Flow.*

INTRODUCTION

In todays' highly competitive market, there is an intense drive to ensure that organizations operations are as productive as possible. This is possible by implementing the "lean methodology" in the corporation process's .The benefit that results from becoming a "Lean Company" include the freeing up of capital, the reduction of inventory exposure during periods of slowdown, and the ability to qualify as a preferred supplier as Juran, Joseph explain in his book "Lean Techniques: Improving Process Efficiency" and Womack James "*Lean Thinking: Banish Waste and Create Wealth in your Corporation*". This approach will help the company in the marketing area due to the benefits that offers. Companies around the world are competing against each other in order to obtain long-term contracts with the clients that consume their products and expand their offers to the market. To be competitive and obtain their contracts, these companies are recurring to methods to reduce cost but at the same time, improve their capabilities of the process and its efficiency in order to comply with the increased demand. Therefore, many companies are recurring to Lean Methodology and Six Sigma Tools in order to achieve the desirable results.

Research Description

A Warehouse company is confronting a large amount of waste and is struggling with the efficiency in their process. To the company is extremely important to attack the problem that is resulting a waste that is estimated to be $12,500 per month. These losses represent 12% of the total losses of the company. The annual amount is $150,000. The main cause of waste is the merchandize broken in the warehouse or "MRA". This research is focused in finding a way to reduce this type of waste. This research will try to demonstrate if it is possible to reduce the waste and improve the material handling with out having to add the quantity of employer that the company currently have assigned to the warehouse department that currently is 131 in the two (2) shifts.

Research Objectives

This research is designed to analyze the current manufacturing process in order to identify opportunities to improve the material handling in order to reduce waste. The objective is to design and implement a strategy to reduce product waste and eliminate the bottleneck in order to boost the product efficiency of the company process without affecting the quality of the product.

Research Contributions

The research discussed in this article will contribute to the warehouse and distribution center company to increase its efficiency. In addition, the research contributes in reducing costs associated to the bottleneck and "MRA" without compromising the quality of the product. The goal of the research is to provide processes that deliver the goods without waste. From the client perspective, the client will receive a product with high quality and will not have to wait more than it settle in the contract to. The company will increase its capacity to meet the customer demand for the goods.

LITERATURE REVIEW

Warehousing companies are facing an aggressively competitive environment in order to attract new customers but at the same time, to retain the existing customers. In order to be more competitive, the warehouse companies are recurring to the Lean Manufacturing methodology as a technique to improve manufacturing costs by eliminating the process muda. Muda is a Japanese word that means waste.

Jamie Flinchbaugh and Andy Carlino define the term "lean" in the book "*The Hitchhiker's Guide to Lean*" as a systemic method used for the elimination of waste (muda) in the manufacturing process. This principle is derived from the Japanese manufacturing industry. John Krafcik first introduced this concept in the 1988 in the article "*Triumph of the Lean Production System*". Toyota promote a different approach to the lean manufacturing called "*The Toyota Way*" in which the focus is upon improving the "flow" or smoothness of work, thereby steadily eliminating muda. This philosophy has two major pillars concepts witch are: just in time or flow and automation. The difference between these two approaches is not the goal itself, but rather the approach to achieving it. The implementation of smooth flow exposes quality problems that already existed, and thus waste reduction naturally happens as a consequence.

Many companies utilize Lean Manufacturing methodology as a systematic approach to eliminate process muda with the objective of reducing manufacturing cost, processing time and excess of inventory. In the Lean Manufacturing technique, muda refers to activities that are performed to a process that does not add value to the customers. Taiichi Ohno (1912-1990), the Toyota executive who was the most ferocious foe of waste human history has produced, identified the first seven types of muda [1]. The types of muda on a manufacturing process are:

- Defects - defective products and rework to fulfill customer needs.
- Overproduction – produce more than or sooner than it is required by internal or external customers
- Waiting – any delay between activities; idle time due to operator, machine or material
- Transportation – transport or double handling of materials or products
- Inventory – excess supply of raw material, sub-assemblies, work in progress (WIP) or finished good at any point in time
- Motion - physical motion of people or machinery that do not add value (searching, walking, stretching, bending, etc.)
- Excessive Processing – to do more than the customer requires, activities that are transparent to the customer.

Companies to increase their production capacity can use the Lean Manufacturing technique as a systematic approach. Richard L. Maclnnes describe the lean system or methodology as a tool that emphasizes in the prevention of waste: any extra time, labor or material spent producing a product or

service that does not add value to it. A lean system's unique tools, techniques, and methods can help the organization to reduce cost, achieve just-in- time delivery, and shorten lead time. The initiative of "lean" is divided in four main goals [2]:

- Improve quality – quality is the ability of the products or services to conform to your customers, wants and needs (expectations and requirements).
- Eliminate waste – Waste is considered any activity that takes up time, resources, or space but does not add value to a product or service.
- Reduce lead-time – Lead-time is the total time it takes to complete a series of tasks within a process.
- Reduce the total cost - Total costs are direct and in-direct cost associated with the production of a product or service.

A lean system allows productions of a wide variety of products or services, efficient and rapid changeover among them as needed, efficient response to fluctuating demand, and increased quality. This strategy can be achieved by identifying the associated processes that perform poorly or need performance improvement. In this case is a bottleneck.

The process will consist in understanding the causes of a bottleneck. A bottleneck in a manufacturing process is when a machine or equipment or stage has high processing time compared to others equipment on the same manufacturing line and the product accumulate in the slower station waiting to be processed. A bottleneck limits the capacity of the process and affects the output of products per hour that a manufacturing line can produce. Bottlenecks affect the continuous flow of the manufacturing process. In the article "REMOVING BOTTLENECK FROM A MUNUFACTURING UNIT: a case studies to BET-KER", Binod Timilsina described the bottlenecks characteristics that can be presented in the process.

The author establishes that some bottleneck can be associated to the capacity and performance and may not be easily identified. Also, a bottleneck can be caused by mechanical problems, problems with equipment yield and changeovers.

Lean Manufacturing

The Lean Manufacturing methodology has the objective of eliminating and/or reducing muda (waste) to a process to reduce costs and improve efficiency. Muda can be classified as Muda Type One or Muda Type Two. Muda Type One is the waste that does not add value to the customer but cannot be eliminated because it is necessary to the process and current technology cannot be used to eliminate it. On the other hand, Muda Type Two is the activities that do not ads value to the customer and can be eliminated immediately. Figure 1 shows the five (5) principles of the Lean Manufacturing methodology [3], there are:

1. Value – the customer can only define Value of a process. Companies need to improve the process considering the Voice of Customer (VOC). In this principle, the company needs to understand the customers and their requirements. In others word, the companies need to understand what the customer wants for a specific product.

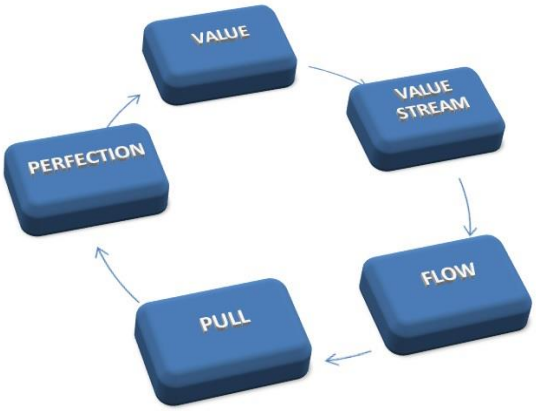

Figure 1
Lean Principles

2. Value Stream – The value stream is the activities required to produce a product or service required by the customers. This principle has the objective to create a process map (Value Stream Mapping) of the activities required to produce a product or service in order

to determine which activities creates value or not creates value from the customer perspective.

3. Flow – This principle is used to eliminate waiting times or obstacles that do not allow the process to be performed without interruptions or continuous flow.
4. Pull – This principle allows the customer to pull the product from the manufacturing facilities as needed instead of pushing the product to the customer. In other words, manufacturing facilities will produce their products only if the customers require it.
5. Perfection – The perfection principle is not the end of the process. On the other hand, perfection refers to repeating the Lean cycle to continue with the improvement process to offer the product that the customer wants.

METHODOLOGY

A systematic approach needs to be used as a methodology to achieve the goals of the project. Since the purpose of the project is to improve the process efficiency on a Warehouse company, the Lean Manufacturing methodology was selected. The Lean Manufacturing methodology is used to eliminate the muda (waste) and non-value activities of any process. The project will be divided into five phases (Figure 2) following the DMAIC tool (Define, Measure, Analyze, Improve and Control). Each phase will be reviewed before continuing to the next phase. The tools to develop the DMAIC were selected from George, Michael, L "*The Lean Six Sigma Pocket Toolbox"* [2].

Figure 2
DMAIC Process Steps

Define Phase

The define phase is utilized to determine the direction of the project and serve as a commitment of the team members that will be working on the project. The objective of this phase is to reach a balance between the multiple processes that happen simultaneously, the team members and the champion of the project. The agreement includes the problem statement, project goal, team members, business impact and project start and end date. As part of this phase, the deliverables include a Project Charter and a SIPOC diagram.

- **Project Charter** – Defines the scope, objective and overall approach of the project to be completed. The project charter is a critical element for initiating, planning and executing the project. The document defines the project goals, objectives and team members. Also the document is a commitment between the project team and project sponsor.
- **SIPOC Diagram** – The SIPOC diagram is utilized as a high level view of the process. The SIPOC diagram helps to understand which are the suppliers and customers of the process, the input and output variables of the process, and finally the process steps.

Measure Phase

The measure phase is used as a data gathering of the actual process to understand its current state and the metric that will be cash. This phase provides a clear focus on the improvement effort by collecting information and relevant data on the current situation in the manufacturing process. One goal of the measure phase is to establish a baseline of the current process using the data gathered in order to identify the problem. The deliverables of the measure phase includes a Process Map and metrics related to the objective and goal of the project.

Analyze Phase

The analyze phase is used to identified the causes that affect the current process by using the data gathered during the measure phase. During this phase, the team will document potential causes of the

problem that are impacting the process. In addition, the team will identify causes that are creating muda on the process that are affecting the manufacturing line capacity in order to increase the quantity of product that can be produced.

Improve Phase

The improve phase has the objective of performing changes to the process in order to eliminate the root causes of the problem identified during the analyze phase. During the improve phase, the potential solutions are documented and prioritized.

Control Phase

The control phase has the objective to standardize processes that help prevent the problem recurrence and sustain the gains. During this phase, new and/or updates documents are added to procedures that are in place. Operators are trained on the procedures and metrics established to monitor the process.

RESULTS AND DISCUSSION

The results obtained during the project execution are discussed in this section following the systematic approach of DMAIC.

Define Phase

A project charter was developed on the define phase with the purpose of defining the project scope and objective. The project charter defines the problem statement, goals, business impact and the team members of the project. Figure 3 presents the project charter that was developed. In addition to the project charter, a SIPOC diagram was developed in order to define the suppliers, input, output and customers of the manufacturing process related to the project. The SIPOC diagram of actual process is defined in Figure 4.

Measure Phase

This phase will determine the base line and target of the process, defines the input/output and will validate the measurement system. The current manufacturing process flow is defined during the measure phase to understand the current manufacturing process.

Project Tittle	***Enhancement of distribution center processes using Lean Six Sigma***		
Project Leader	Christian Laboy Aponte	**Sponsor/ Champion**	Manager of Engineering Department
Start day		Target Close Date	
Problem	The company is having a large amount of waste in the process of the warehouse due to the main focus is production over the quality and the consequences of this are reflected in a monthly waste of $12,500. This company is located in Puerto Rico and is dedicated to manufacturing and distribution companies in the area of consumer-packaged goods, Hotel properties a real estate venture. The main area of waste is the warehouse in which is located the biggest economic loss ascending to $150,000 annually which represents the 12% of the total losses of the company.		
Project Goal	• Decrees the waste of the company in the warehouse department • Reduce the lead-time of the goods delivery		
Team members	Christian Laboy- Project leader Manufacturing Department Employees of the warehouse		
Business impact short term	• Increase the actual process efficiently • Boost in profits		
Business Impact long term	• Increase the capacity of distribution due to a more efficient process with the same personal • Reduce cost of labor		

Figure 3

Project Charter

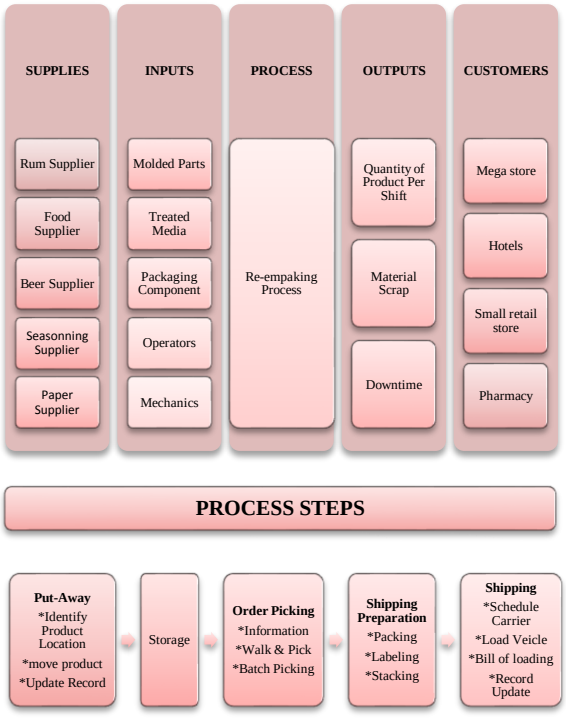

Figure 4
Process SIPOC

Since the scope of the project is to increase the process capacity and efficiency process, by reducing the waste produced by each station and by

implementing the proper backup to each workstation. The data collected during the period of 4 weeks shows that the majority of the orders are placed on Monday, and the preparation of those order's are ready the next day.

Analyze Phase

By collecting information during four (4) weeks a descriptive statistic was created (Figure 5) and it demonstrate the Mean, SE Mean, ST Dev. and Median. The orders that are placed are processed the next day. By analyzing the table created it shows that the days that have more orders placed are Monday and Thursday.

Table 5
Descriptive Statistics

Variable	Mean	SE Mean	St.Dev	Median
Monday	9.250	0.750	1.500	10.000
Tuesday	9.250	0.479	0.957	9.500
Wednesday	8.000	0.408	0.816	8.000
Thursday	6.000	0.913	1.826	6.000
Friday	6.750	0.479	0.957	6.500

With the descriptive analysis of the orders that the company receive during the period of four (4) figure five (5) to nine (9) were was developed. The Standard Deviation witch is the average distance each data point is from the average of the entire data will be utilize as a flexible parameter due to it "free" nature to implement the new SOP. By analyzing the work demand during the week is possible to find the best day to implement improvements.

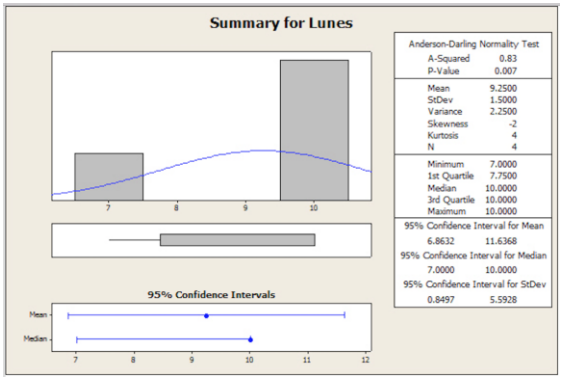

Figure 5
Descriptive Statistic - Monday

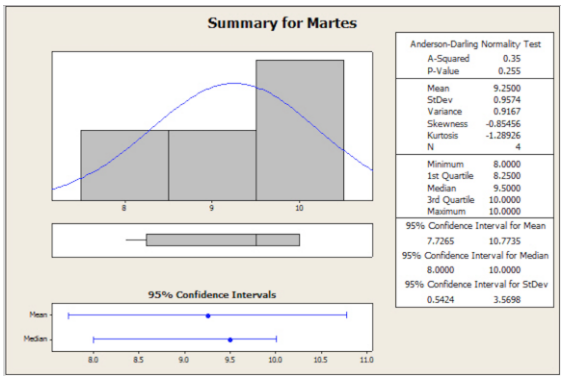

Figure 6- Descriptive Statistic – Tuesday

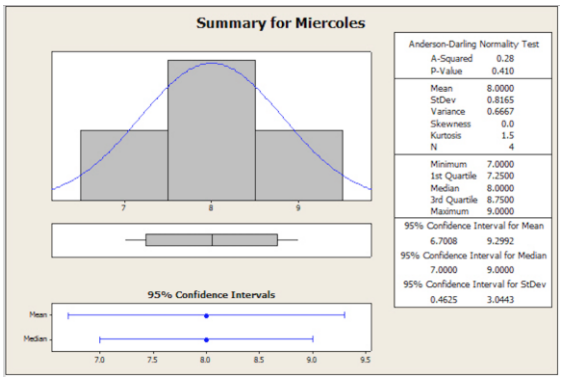

Figure 7- Descriptive Statistic – Wednesday

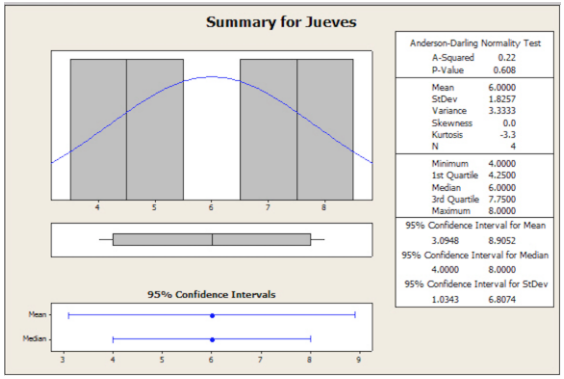

Figure 8- Descriptive Statistic – Thursday

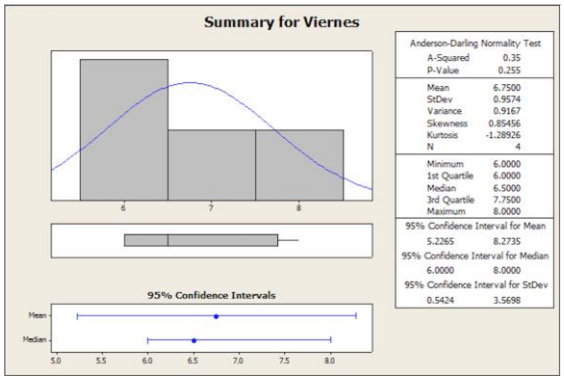

Figure 9- Descriptive Statistic - Friday

The analysis of employer rotation during the product process shows that that the best day to implement the cross-training program in manufacturing process is on Monday (Figure 5) because is the slowest due to the fact that the orders are processed the next day.

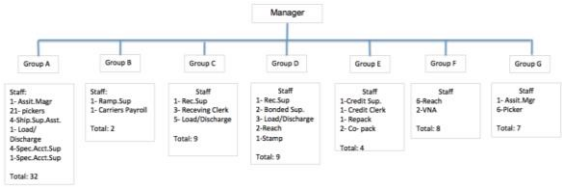

Figure 10
Organizational Diagram

A brainstorming technique with the manager, performed to analyze possibilities to reduce the "MRA" and the possibility of the rotation of the workers. The Organizational Diagram (Figure 10) shows the actual work force of the warehouse and the workers that are under each division. This graph demonstrates that the pickers are the major work force inside the warehouse ascending to a 36%. With the proper re-distribution of the employs some problems related to "bottleneck" can be solved like White, Tommy explain in "A New Way to Find Bottlenecks"**.**

Improve Phase

During the improve phase, the team decides to send another employee to assist the areas that are slowing the process or have problems with the material handling. This worker will be selected by the Assist Manager from one of the piking are that do not have a high volume of work during that day. This will help to eliminate the bottleneck problem that is happening in that station and the "MRA" in that area. The rotation of the employs will not only be for the repack area but also to the piking area. The employs will always be selected from the pikers due to the high volume of personal that this area have (31). In order to reduce the "MRA" the workers will have to follow the new process of material handling in order to reduce the waste related to their respective area. Due to the variety of the orders that the company receives during the week it is possible to have some employees rotating in different stations in order to help the station that is in high demand. By sending extra personnel to those areas the probability of breaking or damaging the products is reduced. The employee that will be designated to help order stations will be the ones of the group A. The installation of the additional personnel represents an opportunity to double the quantity of products that can be process at the same time and reduce the bottleneck on the process line [3]. Instead of testing two (2) pikers at the same time, now this step will have three (3) to reduce the delivery time and the possible defects related to the poor movement of the inventory. The second strategy implemented during the project was performed on the entry point of the goods. The strategy was the addition of another employee that will be designated to this area as part of the new rotation system proposed. By implementing it the damage product in this area will be reduced.

Implementing a new security system to ensure the safety of the merchandise and the employee can reduce the physical problem that represents the "MRA". This can be achieved by an ergonomic strategy philosophy that shows the proper handling of the material in a graphic illustration. By implementing this type of diagram in the warehouse the employee will always have a constant remainder to do the proper procedure of the material handling. In terms of physical protection to the merchandise, every pallet must be in good working conditions in order to guarantee the safety of the merchandise as well as the employee. Once the pallet is broken it should be decommissioned and substituted with a new one preferable a plastic one because it will not deteriorate as fast as a wood one and will have a better resistant to fire hazards. The pallets that are in the higher levels of the warehouse must have a metal deck. This will protect the pallet from falling due to a broken pallet. The merchandize on the upper part of the rack storage must have a cardboard that covers the complete top of the pallet in order to reduce the dust in the merchandize and prevent some water damage in case there is water filtration. The rack storage must have a protection guard in every corner of the base in order to protect the merchandize that

is moved from one area to another from possible share damage among others.

The new warehouse line SOP process to be followed by of the employ is illustrated on Figure 11.

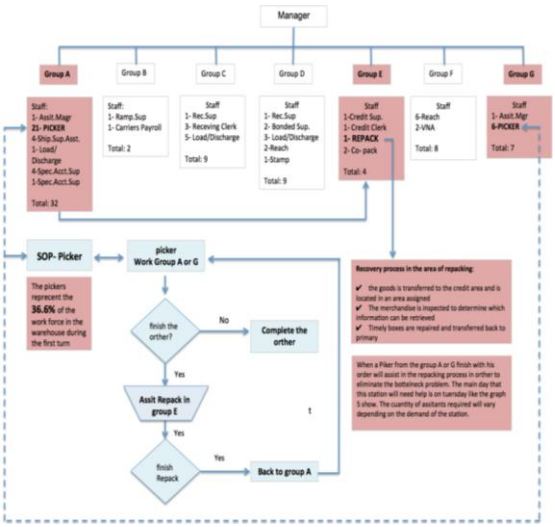

Figure 11
Proposed Process Diagram – Part 1

This illustrates the new relationships that the new areas will have and also the new SOP and conditions of the picker in order to help the repacking area. The new SOP of the pickers is oriented to satisfy the demand of personnel in other areas as a backup like the repacking and the area of receiving merchandise. This new organizational layout will bring more flexibility to the company in terms of the employee rotation and distribution. During the implementation phase, the product output of the manufacturing process will be monitored in order to compare the initial product output with the new product output speed and damage detection after the implementation of the changes in the manufacturing line.

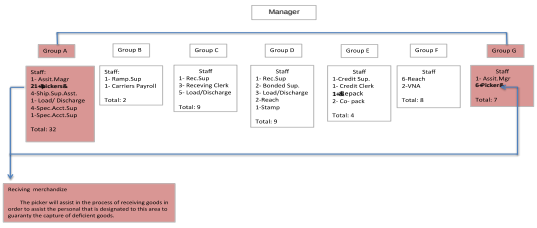

Figure 12
Proposed Process Diagram – Part 2

The supervisor of this area will request the assist to the personnel of the receiving area. This must be consulted with the others supervisor in order to maintain the management aware of the rotation of the day. This propose will come more in handily when the company is receiving new merchandize for the first time because by implementing a 5s system and have more assist the new product will have the majority of the possible defects reported and documented.

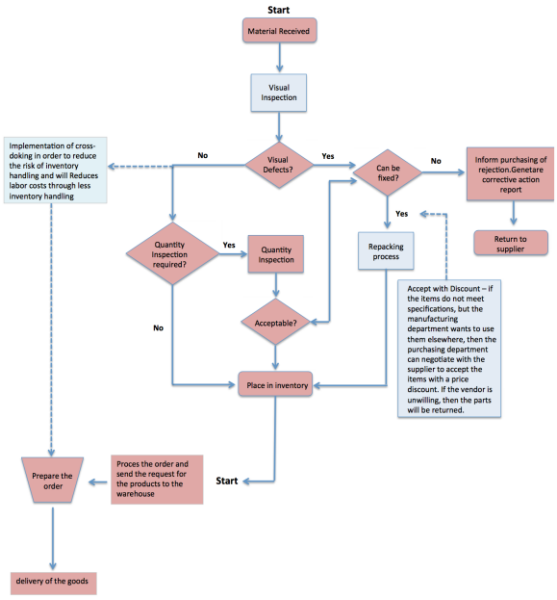

Figure 13
Proposed Process Diagram – Part 3

This diagram shows the implementation of cross docking in order to minimize the interaction with the operators and merchandize and also will reduce the waiting period of the costumer witch is a part of the critical to quality aspect.

Control Phase

Standard Operating Procedures (SOP) was created to satisfy the demand in some areas for the assembly process. The SOP is used as a tool to train the operators to performs the manufacturing process in a standardized way in order to prevent that the process is performed incorrectly. The implementation of Guidelines in the new "SOP" of the new process was created as a tool for the "picker" to fill the need of an area that currently is lacking of support. Finally, the production line procedure was revised to incorporate the recommendations of the workforce movement and to train the operators in

different stations in order to facilitate the process that will be performed after the implementation of the changes.

As part of the control phase, a metric about the product output on the manufacturing line was revised. The new target of waste reduction is to lower it to 20% less than the actual amount.

For the receiving area it is recommended a visual control like a "5S" and guide lines to minimize the defects that enters to the warehouse and develop some visual aid with the information of the common defects that it recommended to develop in order to attack the problem instead of dealing with it later in the process. All these tools are part of the control plan of the detection and mitigation of damage goods of the company.

Another possible opportunity will be to develop a chart of the most common damages in the goods inside the warehouse in other to attack the actual one. In terms of the control to the personnel the manager and supervisor will develop a strict guideline that will show the disciplinary actions that will be taken with the employee that break any merchandize or broke any rule. This will have at some point a recommendation of re-training following the OSHA procedure recommended and if the incidents keep happening then the manager will have to layoff the employee.

CONCLUSION

The manufacturing line capacity using Lean Manufacturing on a warehouse Company can be improved by using tools of Lean and a DMAIC as systematic approach. By using this approach, sources of muda on the process were identified. In the process, sources of waste were associated to the interrupted flow of the manufacturing process due to a bottleneck and "MRA". Improvements performed to the warehouse process were performed on the distribution of personnel to improve the manufacturing flow and the addition of new equipment to improve and guarantee the quality of the product. By performing the improvements, the goals of the projects are expected to be achieved.

The first goal of the project was to develop a plan to reduce the "MRA" with out compromising the quality of the goods and make the plan less dependable as possible from the employee. This can be achieved by implementing more cross-docking systems and improve the design safety methods

The second goal of the project was oriented to decreasing manufacturing damage merchandize that the company receive and speed up the receiving process with new guidelines and security methods without compromising the quality of the product. To achieve this goal, the company will have to purchased new security equipment and invest in cross tainting the employees. The new rotation and safety methods will help to reduce the waste of $125,000 annually in the warehouse and without having to hire new personnel.

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