Packaging Process Improvement in a Manufacturing Environment

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Abstract *— A manual filling, packaging and labeling process implicates significant labor intensive tasks that will result in non- standard process with high variability. This non-standard process has resulted in more than 20 complaints in the last 2 years. This manual process requires 2-3 employees per batch. This project will focus on the reduction of cycle time for the pack out process and reduce and or eliminate complaints due to discrepancies. This project will also address the ergonomic concerns related to repetitive movements. In order to standardize and automate this process Lean Six Sigma Tools and methodologies (Define, Measure, Analyze, Improve and Control) were used to identify the problem and improve the process. As a result we were able to recommend the implementation of equipment and waste minimization. This recommendation would imply at least a 13% improvement in productivity.*

Key Terms *— Cycle Time, DMAIC, VOC, VSM.*

INTRODUCTION

Packaging is the technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging can be described as a coordinated system of preparing goods for transport, warehousing, logistics, sale, and end use. When looking at a manual pack out process multiple sources of waste are exposed. The current pack out process at Company X consists of 3 steps: filling, closing the lid and labeling.

Packaging automation is needed in order to reduce unnecessary waste and have a standardized process.

There are 8 types of waste: over production, defects, inventory, over processing, transportation, waiting, motion and unutilized people. This project will focus on reducing waste of motion, defects and waiting.

Defects waste is when a task/ product needs to be reworked. Multiple defects occur during the packout process such as incorrect labeling, label alignemnt, weight discrepancies among others.

Waste of waiting is when an employee or customer is waiting for the next step or a product. During the pack out process there normally 2-3 employees. During the complete process the tasks for the operator are not evenly distributed.

Waste of motion, which is the unneccessary movement of people. This manual tasks involves a lot of repetive tasks and unneccesary motions.

By reducing these wastes we would expect an improvement in the cycle time of the pack out process.

When automating a process you start to have a more standardized process. Automation saves labor. It is used to improve quality, accuracy and precision. These improvements will help address and meet the Voice of the Customer (VOC).

The customer wants to receive the material with the correct and aligned label. They have requested an accurate weight based on the order placed.

LITERATURE REVIEW

Company X has a manual pack out process. The pack out process is one of the most critical steps in the supply process for these paste products. Once these are packed out they are then cartonized prior to shipping to the Customer. This manual process has caused multiple complaints from internal and external customers.

In order to reduce the errors caused by manual processes. The pack out process has been divided

in 3 steps as mentioned above. When focusing on the labeling process which takes approximately 39 minutes of the 4 hours that the complete process will normally take. The filling process takes in average 75 minutes and the closing step 32min.

A packaging recipe specifies how the finished product gets to its final assembly. This addresses such things as containers, labels, etc. The finished product is usually produced in bulk, but is rarely delivered in bulk form to the customer.

Using lean six sigma approach to address this project will help address these focus areas. Lean and Six Sigma are complimentary, since Six Sigma eliminates variation and defects, both of which can create havoc when trying to eliminate waste and create continuous flow. This can also happen the other way around [1].

The DMAIC Methodology will be used. This methodology consists of:

- Define: Select and define the project VS
- Measure: Complete a current VSM to establish a baseline.
- Analyze: Analyze the VS to design a VSM with shortest lead time.
- Improve: Design, implement and debug continuous flow.
- Control: Ensure that the new VS meet / exceed goals and that the new design can be improved.

When trying to standardize a process, process stability is needed. Process stability means repeatability. We need to meet productivity, quality, cost, lead time, safety, and environmental targets every time. [2].

Some elements of standardized work are the Takt time, Work sequence and in process stock.
The takt time tells us our demand frequency, work sequence which is the best way to the process, and the having the correct inventory of in process stock.

In order to understand the best way of the process, the current flow of the process needs to be established. A lean tool which is used is the value stream map (VSM). The value stream map is the map that includes all the actions in the process that are done from order to delivery. This includes all actions that are or not value adding. A spaghetti diagram will a so be used to understand if the layout is correct and be able to identify unnecessary movements of the material and or technicians.

METHODOLOGY

Lean six sigma is the combination of the Lean and Six Sigma. Lean focused on reducing waste by streamlining the process and six sigma reduces defects by effectively solving the issues. The combination will result in solving problems and improving processes that will become more efficient.

Six Sigma's most common and well known methodology is its problem solving DMAIC approach. The DMAIC (Define-Measure-Analyze-Improve-Control) is the classic Six Sigma methodology. The DMAIC methodology takes an identified problem and uses a set of tools and techniques in a logical fashion to arrive at a sustainable solutions. The solution will minimize/eliminate the problem. [3]

The six sigma methodology reduces the number of defects in the manufacturing process and thereby improves customer satisfaction and business profitability. In order to stay competitive, organziations need to continuously improve their processes.

The DMAIC roadmap is as follows [4]:

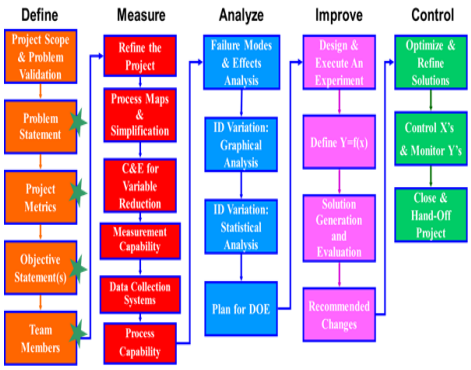


Figure 1
BMGI Six Sigma Method

The application of this methodology eliminates the use of opinion and drives the organization to a more scientific means in order to make a decision.

Key concepts for Lean Six Sigma are:

- The 5 core principles of Lean
- Define value-added and non-valued added activity
- Define the 7 most common types of waste and their causes.
- Review a systematic approach to discover
- Waste within a process.

RESULTS AND DISCUSSION

The results will be presented and discussed following de DMAIC methodology.

Define

The manual pack out process at Company X is an area where automation can be implemented throughout the process. The pack out process consists of 3 steps: filling the jars, closing the lid and placing the label. This process is done for a great variety of products. These products are packed out in at least 6 different jar sizes, pails and cans. Orders packed out range from 1 to 300 jars. Each pack out requires 1-3 employees per each batch.

Problem Statement

The complete pack out process for the pack out of 300 jar order takes approximately 4 hours. This process is not just made up of the 3 main steps which are filling, closing and labeling, this process include additional steps that do not add value to the process. This type of manual process depends on the operational discipline of the employees. During the last few years there have been multiple complaints regarding the standardization of the labeling process and final weights. This has included complaints and incidents in the pack out process that referred to non-alignment of the labels, mislabeling, missing caps and weight discrepancies. Also, ergonomic concerns have arised from this type of manual process and repetitive movements.

Measure

After defining the problem the baseline was defined. Data was collected for three days and 3 pack outs of 600kg batches. These batches consist of 300, 2kg jars. The baseline for this process consisted of the pack out of 3 lots of 300kg batches measured at different steps of the process. This baseline value indicates how the process is currently performing.

A data collection plan was created prior to starting the process:

Table 1
Data Collection

Data Collection Chart				
Process	Who	measurement	unit	sample size
Filling	Packing area technician	seconds (s)	jar	54
Closing	Packing area technician	seconds (s)	jar	54
Labeling	Packing area technician	seconds (s)	jar	54
Organizing	Packing area technician	seconds (s)	jar	54
Setup time for filling porcess	Packing area technician	minutes (min)	batches	3
Mixing setup step	Packing area technician	minutes (min)	batches	3
Supply preparation	Packing area technician	minutes (min)	batches	3

A VSM was completed in order to understand the complete process. See figure 2.

A graphical summary was completed for the different steps in the process. The pack out process starts with an order entered into the system. The planning system provides a recommendation to the Supply Chain team and they generate a pack out sheet that will provide instruction to the Packing area coordinator.

The packing area coordinator will assign a technician and he will start the process. The process starts when the technician mixes the material for 20minutes. After the mixing process has been completed the technician will get the jars, lids and caps needed for the pack out process. The packing order sheet indicates the amount of containers needed to start the process. For this task two technicians are working simultaneously on the preparation of the order.

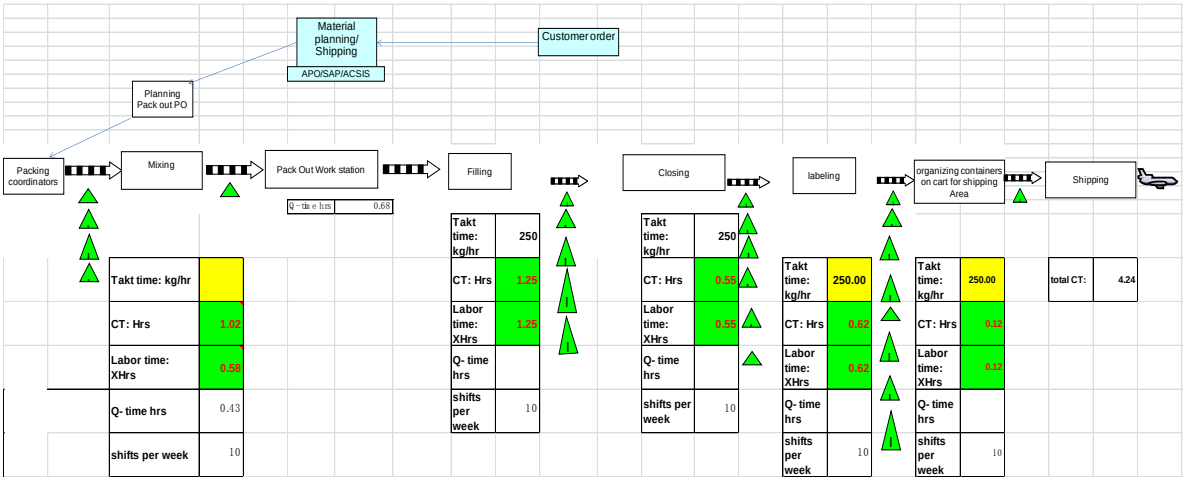


Figure 2
Current VSM- Pack out process

Once completed one technician will start to fill out each jar. The next technician will place the inner lid and close the jar. After closing the jar the second technician will process to place the labels on the jars. Once jars are labeled they are organized and placed on a cart that will be moved to the shipping area once material has been fully packed out.

The movements throughout this process have been documented by using a spaghetti diagram. See Figure 3.

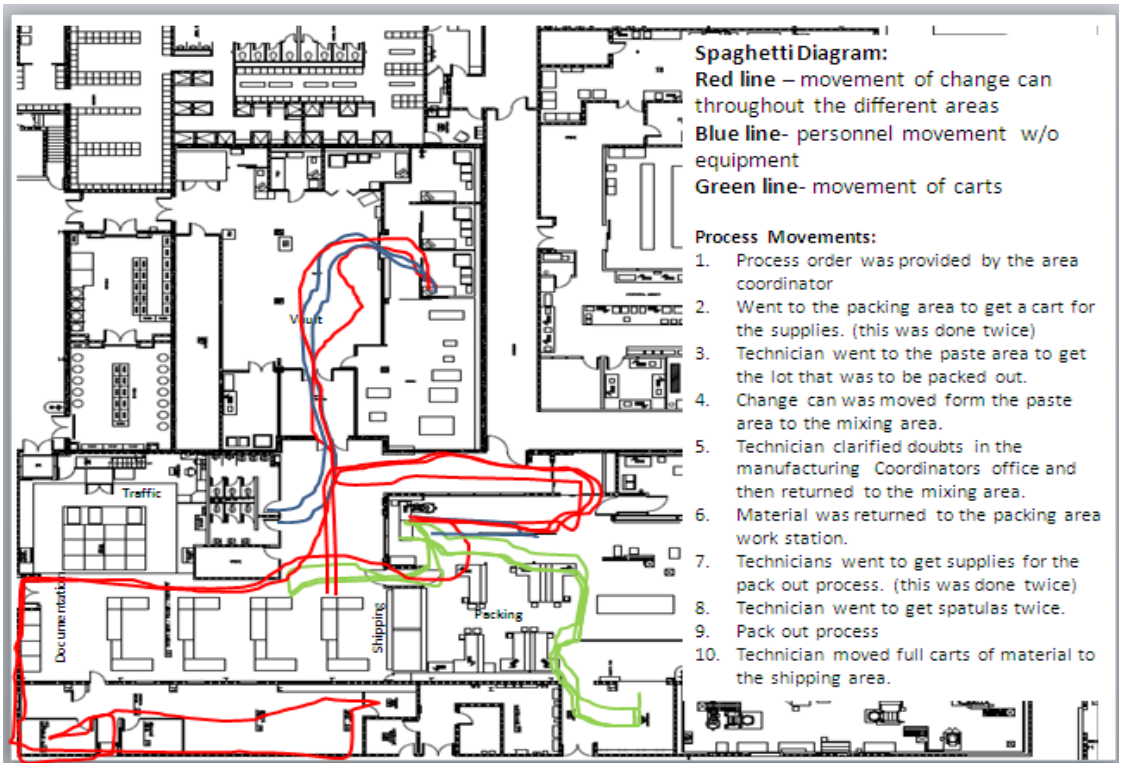
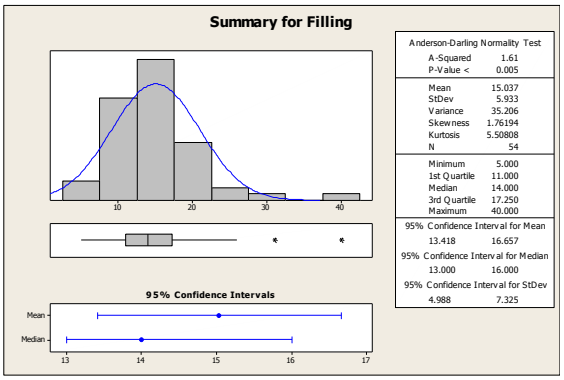


Figure 3
Spaghetti Diagram- Pack out process

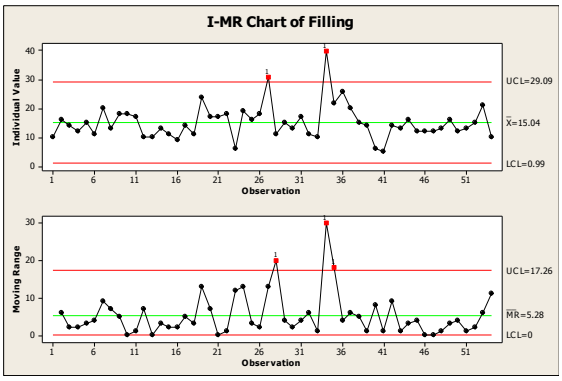
Summary and control charts of the data collected of the 3 major steps in the pack out process provided below.

Below is the filling summary here you can see that the average per each jar is approximately 15 sec per jar (2kg). This is the equivalent of 75 minutes for the complete 600kg.



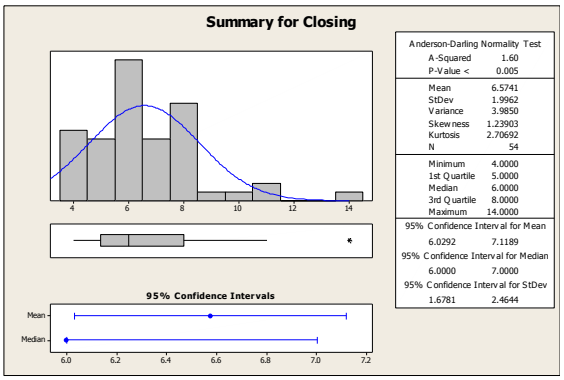
Graph 1
Summary for Filling

The out of control data points during the filling process were due to the variances that are present during a manual process. The weighing of the 2kg is manually controlled.



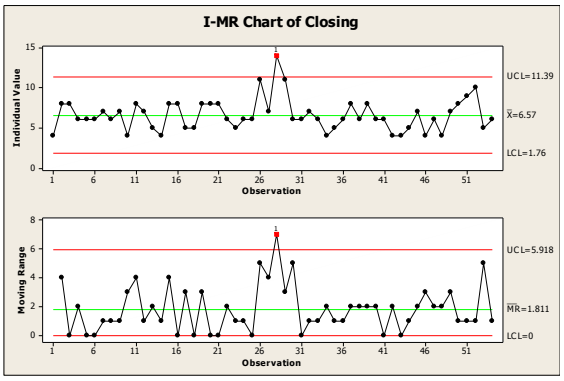
Graph 2
I-MR Chart of Filling

When looking at the closing summary you can see that the average per each jar is approximately 6.6 sec per jar (2kg). This is the equivalent of 33 minutes for the complete 600kg.



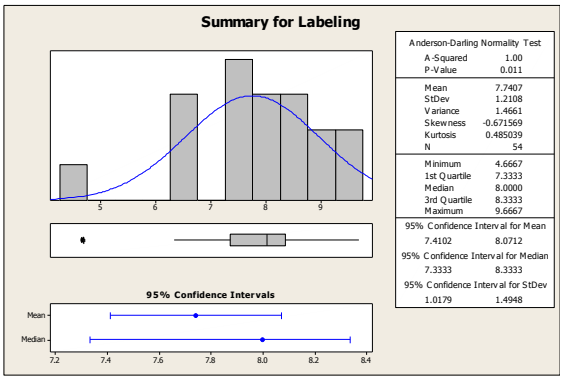
Graph 3
Summary for Closing

During this step there were a couple of out of control steps which were due to issues with lids, lid shortages and cleaning of the jar.



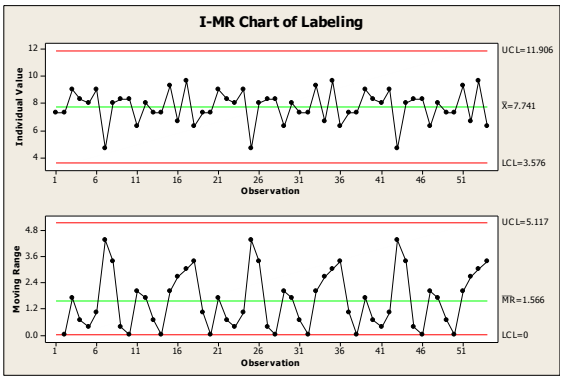
Graph 4
I-MR Chart of Closing

When looking at the labeling summary you can see that the average per each jar is approximately 7.4 sec per jar (2kg). This is the equivalent of 37 minutes for the complete 600kg.



Graph 5
Summary for Labeling

On multiple occasions during the labeling step labels needed to be adjusted and or removed.



Graph 6
I-MR Chart of Labeling

Analyze

When analyzing the VSM and the spaghetti diagram multiple wastes were found throughout the process. The VSM demonstrated that we have material waiting for it to be completed at all times. Since this is a manual process the change cans are waiting for the operator to be able to start mixing it. The estimated production is 5 lots per day but only 1 can be worked on per shift. This will cause Q time for the other 4 lots to be packed out. For the purpose of this analysis we will be counting the Q-time of one lot of 600kg, equivalent to 300jars throughout the pack out process. This was equivalent to 1.11hours per batch. If the expectation is to pack out the 5 lots we would then see the Q-time as practically one shift 5.55 hours. The takt time calculated was 250kg/hr. We are currently running at a rate of 141.5kg/hr.

The Spaghetti diagram will be discussed based on the color of lines. The red lines which describe the movements of the change can denote this heavy equipment is moved throughout most of the packing, shipping and vault area in order to complete the pack out of the material. Blue lines representing the movement of the employees were not very significant. Movements done by the employees were needed. The green lines represent the movement of carts that carry supplies and packed out jars was somewhat excessive. Each operator worked on cart at a time. Supplies are manually collected and counted for each pack out process order. At the moment this is done by two employees.

Wastes present throughout the process:

Waste of defects:

- This type of waste was captured during the labeling process. Labels were misaligned and needed to be removed and a new label needed to be placed.
- Discrepancies in the weight that needed to be adjusted per each jar.
- When placing inner lids and jars on multiple occasions the technician needed to clean the jar because material was on the walls of the jar where the label should be placed.

Waste of waiting:

- During both of these processes the two employees were not busy at all times and would wait for the other employee to complete the task at hand in order to begin the next one.
- There was additional waste observed when the mixing step was in process. The technician waited for the mixing step to be complete. This is an automatic process that is set up with a time and will shut down automatically.

Waste of motion:

- Waste of motion is seen throughout the complete pack out process. The filling step, closing, labeling and organizing step are all done approximately 300 times, one per jar.

All these wastes mentioned above are the differences seen in the summary charts in the measurement step.

Improve

After analyzing all the opportunities for improvement in this manual process various recommendations were proposed. The focus areas that would be most valuable and feasible at the moment were reducing number of employees per

pack out of the 600kg batch (300jars), the reduction of cycle time throughout the complete pack out process by removing waste, reducing repetitive movements and finally developing more standard process that will address the VOC (no complaints).

When focusing on the layout of the process. This is a manual process that requires two or three employees. When going through the VSM and spaghetti diagram it was noted that this operation could be done with one person. Not only can it be completed by one person but it can be done in an ergonomic manner.

The recommendations proposed were to install a labeling set up composed of Figures 4-6. This would require the purchase of a Round product labeling system (Figure 4). This equipment will label 12 jars/min. This will eliminate the variability in the labeling process.

Figure 4
Round Product Labeling System

As part of this improvement the feeder (Figure 5) will be needed in order to minimize the movement of the employee after filling out the jar.

Figure 5
Feeder Table

After the jar has been filled an accumulating table (Figure 6) would be added in order to combine these steps in the pack out semi-automatic process. The feeder will organize the jars as needed.

Figure 6
Accumulating Table

If all these recommendations are taken into consideration the new process should look as follows. See Figure 7.

By implementing the automated pack out process the following benefits will be seen:

Table 2
Expected Benefits

Expected Benefits	Before	After
Reduction of cycle time	4.24hrs	3.75hrs
personnel reduction per pack out	2	1
Increase in productivity	141.5kg/hr	160kg/hr (13% increase)
Waste minimization	1.waiting during mixing step 2.waiting of containers for labeling and organizing	1. organizing supplies during mixing step 2. eliminated
Ergonomics		minimization of repetitive movements
Standardization	defects during the pack out process	minimization of complaints: misaligned labels, mislabeling

The benefits mentioned above in the table are all those mentioned as part of the purpose of the project.

Waste minimization will be an ongoing improvement in this area.

Control

Successful implementation of any process requires a control phase. This will assure the sustainability of the improvement to be implemented. Appropriate documentation and training to employees will be needed to sustain the proposed improvements. [5]

Standardized procedures will need to be created for the use of the new equipment. This procedure should have detailed information regarding the operational functions, safety concerns or risks and troubleshooting guidelines.

Training documentation will need to be updated to create visual aids of the tasks to be performed and the expected way of executing them. Included below is the control chart, owners and time needed to implement these documents. Part of the documentation will also require updating the systems where they are to be held as controlled documents.

A control plan has been created and approved by the Area Supervisors and Unit Manager. Figure 8 includes the detailed control plan.

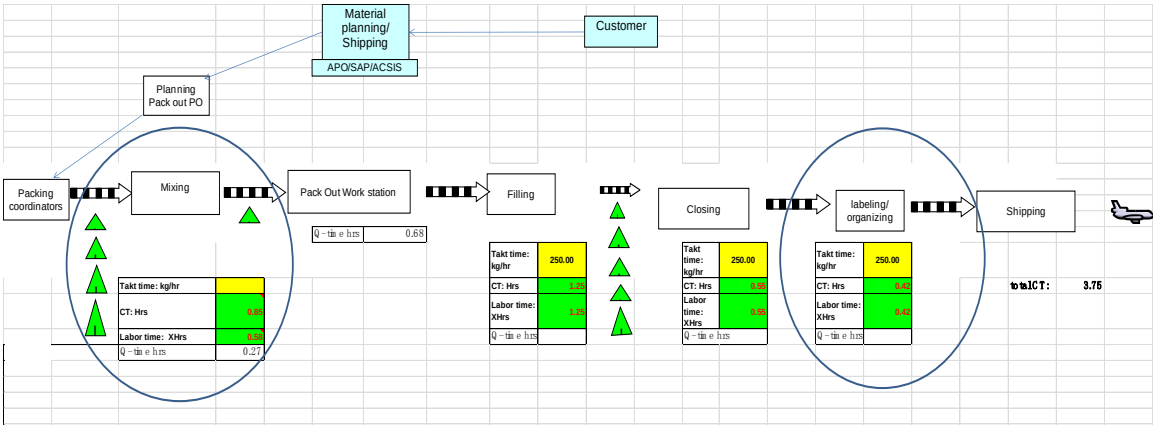


Figure 7
Future VSM Map

Process Control Input	Characteristic/ Parameter	Specification / Requirement	Measurement Technique	Who Measures	Where Recorded	Response Plan		
						Action	Timing	Owner
Create procedure for equipment use	Define Instructions for equipment use	completed	document	Packing Resource	Procedure/ ETQ system	• Create document • Submit document for Approval • Upload into ETQ system	6 months	Project Leader
Create preventive maintenance checks	Define critical parameters for equipment reliability	completed	document	Process Engineer	PM/ SAP system	• Create document • Submit document for Approval • Upload into SAP system	6 months	Maintenance Reliability Engineer
Retraining of employess filling and closing	Discuss and redefine new process	completed	document	Packing Cooridnator	Training documentation/ Area training documents	• Update training documents • Train Technicians	2 months	P&S resource

Figure 8
Control Plan

CONCLUSION

All industries are moving to become a World Class Manufacturing Company. For this project Lean Six Sigma was used because this is one of the Methodologies used to reach this type of goal. In order to be competitive continuous improvement is needed. Continuous improved is a constant upgrade of the process or technique being used. Continuous improvement includes constant changes that are beneficial.

When looking at all the benefits that were presented in the improvement phase we will meet the expectations of the customers and the employees.

A standardized process makes the job easier and consistent. Minimizing the mount of defects during the process minimizes reworks and complaints.

One of the greater benefits is the increase in productivity by 13% without increasing the head count.

Ergonomics is a great concern and the semi-automation of the process will reduce repetitive movements of the employee.

After successful implementation of the labeling machine this can be used for smaller batches of material that range from 100-200jars. When verifying the different machinery available other size jars can also be used in this machine with minor adjustments.

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