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Abstract

What she wants and when she wants it is the name of the game when it comes to manufacturing of any goods/products. Having the right product at the right time and with all the right options to meet her needs. This is a must have in any great manufacturing company if they want to keep growing and doing more business.

Company XYZ (this is not the real name of the company) did not have this in one of its new production lines. The research that was done showed the areas that needed to be done to improve the line to meet the customers expectation. Moreover, it showed the company where it could increase its output and reduce the companies overhead (OH) cost.

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Chapter I: Introduction

Company XYZ is a multi-national corporation that specializes in many different home furnishing products. Company XYZ has a clear vision statement of wanting to be the best. To do this the company has located factories in strategic countries to maximize the ability of meeting the customer's needs in the shortest possible time. Company XYZ prides itself on being ahead of the competition and thinking of new ways to grow the business. Over the past 50 plus years that the company has been in operations it has revamped the company 15 times. Bringing about new products for the customers and starting new manufacturing processes around the world.

With the company focused on growth and trying to be better than the competition the company will focus majority of the team to maximize square meter to output ratio. Putting the most equipment in the smallest amount of space to get the maximum amount of output per hour. This means there will be more machines, more workers and more product in a smaller area.

This process helps the company achieve lower costs of the finished goods by reducing its operating expenses. In 2019, the company built a new facility. In a short period of time the company has employed over 2,000 people and produces about 9,000 pieces per week. By the end of 2019 company plans to increase its headcount and equipment to support in doubling its output. By the end 2020 the company plans to increase its overall output to 36,000 pieces per week.

The process to create these products is considered a trade secret, but what can be mentioned are the basics. There are multiple different machines that will make many of the sub parts. This is done to reduce cost, so the company does not have to outsource this operation. After all the parts are made they will then need to be assembled. This is done with a

combination of human power and machine power. Some are automated and semiautomated operations while the rest must be done by 100% human power. That last operation will be packing. The actual packing of the finished goods is done by human power only. Taking the finished product off the assembly line and putting it into a box.

With the company's direction of maximizing the square meters, the one thing that will not increase as much as the rest will be the size of the building. The company has used all available space to build the current manufacturing buildings and all remaining space the company owns is designated for new business that is being developed.

Statement of the Problem

The current packing process at Company XYZ can produce 9,000 pieces/week. Next year the company will need to produce 36,000 pieces/week. All of this will need to be done in approximately the same square meters as the current process.

Purpose of the Study

The goal of this study was to develop an improved method of packing that would satisfy the increased output needs and simultaneously support in lowering the operating costs. Other objectives were to increase profit margins which would be a byproduct of lowering operating cost. Finally, having worker moral improved even with the increasing production output form 9,000 pieces/week to 36,000 pieces/week.

Assumptions of the Study

During this study of improving the packing process of Company XYZ there were key assumptions that were made. First, it was assumed that Company XYZ would continue with their growth plan. This meant that between the beginning of the year to the end of the year the growth from 9,000 pieces/week to 36,000 pieces/week would occur.

Secondly, Company XYZ had the financial capability to invest in the improvements that would be needed to increase the output of the process. This would include any staff, mechanical improvement, new machines or any automations needed to achieve the target.

Thirdly, that all improvement would be driven to increase output of the line rather than slowing the process down and adding in extra none needed steps into the process. This would include process that are also driven to increase cost rather than lower cost of the line.

Finally, Company XYZ would approve the needed changes that were found to increase the output and lower the overhead cost. This would include purchasing of the new machines or hiring of any new staff members needed.

Definition of Terms

This study contains key terms to elaborate on the topic and the study.

Bottleneck. It is the area in a process that flows slower than the rest of the process. When a streamlined process must slow down or stop because the bottleneck is impeding its normal smooth flow ("Bottleneck Analysis," n.d.).

5 Why. Refers to the process of asking "Why" 5 times. Each time a person asks "why" they will get a response. With this response another question will be able to be thought up and asked. This will repeat until a root cause is found (Paradies, 2019).

6M. Refers to Man, Machine, Method, Materials, Measurement and Mother Nature. These are all of the areas of focus where a root cause could be found (Hessing, 2019).

Limitations of the Study

There were a few limitations to this project with regards to cost, time and availability. This study was limited to improving only the packing process of the assembly line and not of the people or any other process in the line. All improvements that were made had to get approval

from the Board of Directors (BOD) before any purchases could be made. All purchases that were made needed to have a return on investment (ROI) of under two years. The time to get all the improvements done was by the middle of 2020 or before the end of 2nd quarter fiscal year. Lastly, any improvements that needed to be installed could not negatively impact current production, so all improvements had to be installed and tested when production was not working.

Methodology

To meet the goal of this study, the following methodology was used. A presentation was created that outlined the importance of improving the current process to meet the needs of the new target. The presentation showed the relevance of maximizing space and increasing output would have to our customers and to the business.

After the presentation review, the following methodology approach was used to determine which approach to increasing the current processes output would be. The first step involved evaluating the current process and finding any waste that was in the current process. Company XYZ had many different operations that was under the packing process. With this there was plenty of opportunity to review each step to determine if it was a value-added operation or if was just waste.

Next, the data was taken to be determine what key steps needed to be kept in the process to achieve the finished packaged product. The data was evaluated by all needed departments to determine the best next course of action to improve the process and not to impact the process negatively which would increase the cost or slow down the process.

This information was then used to determine what processes needed to be changed, eliminated or built. All investments that would have to be made were indicated at this point

based on the new machines that would need to be built or the new people that needed to be hired to increase the output to the previously stated target.

The last steps were implementation and testing of the new processes and equipment. All the new machines and processes were put into place and tested to show proof that they were a benefit to the process. Company XYZ would then confirm the process and make it the new standard of the company.

Chapter II: Literature Review

The current packing process at Company XYZ can produce 9,000 pieces/week. Next year the company will need to produce 36,000 pieces/week. All of this will need to be done in approximately the same footprint as the current process. Company XYZ will utilize Lean manufacturing combined with automations to improve this process. All will be verified utilizing financial overhead information.

Lean Manufacturing – Front Runner in Reducing Waste

Lean manufacturing has been around for a long time, but really did not start getting attention until after World War 2. Japan utilized this methodology to improve the production processes in many manufacturing industries (Liker, 2004). Lean has evolved into a system of processes to support manufacturing industries in reducing waste.

How lean has evolved. In the beginning there was Henry Ford and the assembly line. This was the first notable step in manufacturing where a flow production was seen (Hessing, 2019). During the early to mid-1900s this was the way production was done and it worked well. In 1950 a man named Eiji Toyoda, nephew of Sakichi Toyoda (founder of Toyota motors) went to Ford industries to learn about how they manufacture automobiles (Liker, 2004).

During the time that Eiji was training at the Ford Motors Company he began to understand how this process was not going to work in Japan (Skhmot, 2016). The reason that this would not work in the Japan as opposed to working well in United State (U.S.) is because the people in Japan wanted more options in their vehicles than what the U.S. wanted. With Henry Ford's line they would run the same model with the same options, giving the customer very little to choose from. With the inability of being able to copy the Ford process, Toyota would decide to create their own process. Over many years and by adding new processes,

Toyota was able to come up with a manufacturing approach that worked well in Japan. This is called the Toyota Production System (TPS).

The different kinds of lean to support in reducing waste in an organization. Lean manufacturing is the utilization of tools to find and reduce/eliminate waste. Waste is a loss of money to an organization. Liker (2004) wrote about seven different types of waste in an organization.

Overproduction. When a company has too much inventory then they will have less of what they actually need. (Liker, 2004). When a company has overproduction, they have an excess of work in process (WIP). Work in process or WIP is work that has begun but has not shipped. It could be anywhere between the beginning of the operations to the packing area. Until it gets out the door and the company receive money, then it is still considered WIP.

Waiting (time on hand). Whenever goods are not moving or being processed, the waste of waiting occurs (McBride, 2003). If the goods are not moving or if the workers are not doing anything, this would be considered waiting. Much of a products' lead time is tied up in waiting for the next operation or the next step in the process; this is usually because the flow of material is poor and cannot move onto the next operation. The production runs could also be too long and finally the distance between work centers are too great (Early, 2019).

Unnecessary transportation or conveyance. Having to move a product, person or any material from one location to another adds cost to the operation. This cost in lean terminology is called transportation waste. When the transportation does not add value (meaning the customer would not pay for it) then it is considered waste (Early, 2019). Transportation of the goods between each facility or operation is necessary and there will always be this need to move the product.

Over processing or incorrect processing. Refers to act of doing more work than is needed in an operation along with, adding more components, or having more steps in a product or service than what the customer needs or wants in the product (Skhmot, 2016). Doing more than what is necessary to complete the item, using the wrong equipment or adding in extra parts to give it more functions than what the customer requested. The customer does not pay for all this extra stuff or using fancy equipment. This is considered waste by over processing the job.

Excess inventory. Having too much inventory is something most people do not think as waste. People will normally think having a lot of inventory is being safe for the "just in case" situation. But having more inventory than necessary to sustain a steady flow of work can lead to problems including: product defects or damage materials, greater lead time in the production process, an inefficient allocation of capital, and problems being hidden away in the inventory (Skhmot, 2016). Excess inventory can be seen in the factory as having too much WIP either on the production floor or in the warehouse. In the warehouse is the most common and this is normally due to purchasing too much for what is being made or sold. Not watching the inventory levels or having the correct safety stock will create future problems for production and can become quite costly.

Motion. A step in the production process should be completed with the smallest amount of motion possible. Using more motion than is needed is a waste of resources (JM, 2015). In most cases people do not realize walking from one location to another could be considered wasted motion. If a person must take two steps to go from one work station to another, that is considered motion. If the company found a way to move the work stations closer to each other so the employee did not have to take any steps, then the company would get more output, have a cost savings and there would be a reduction in motion waste. Motion is one of the easiest wastes

to have in a company, but many people overlook it. They considered it as normal production instead of waste.

Defects. This is probably the easiest of all the wastes to understand. A defect occurs when product or service falls short of the customer's expectations (JM, 2015). If it is not made the way they want it, then it is considered defective or not correct. This will add high cost to either replace or repair it. Even higher costs could occur if the customer is not satisfied and decided to no longer order.

Different tools to reduce waste. With the development of lean there has been many strides to develop new tools to reduce waste in an organization. These tools focus on finding and eliminating/reducing the waste that is causing loss revenue, labor variance, quality issues and anything else that is waste in the organization (Liker, 2004).

5S or 6S. In the world of Lean, 5S or 6S is where many companies will start. 5S is defined as Sort, Set in Order, Shine, Standardize and Sustain ("5S," n.d.). When a company follows these five organization methods in order they can eliminate waste from poorly organized work areas. With 6S, some companies will add in safety to better promote safety in the workforce ("6S Information," n.d.).

Single-minute exchange of dies (SMED). Also known as a quick change over, this is the process to reduce the setup time of a machine or operation. In many cases companies will buy more machines to try to avoid doing change overs thinking that it will help the company. Many companies have opted to improve their quick changeover technology to the point where it is economically viable to have very frequent changeovers (Kobayashi, 1990). In the world of manufacturing, the more pieces per min you can get out the better. When a company can change the product fast in a machine, then it will be able to get more pieces per min.

Key performance indicatory (KPI). These are metrics that are tailored by all members of the company to track and encourage progress towards critical goals of the organization ("KPIs (Key Performance Indicators)", n.d.). When a company has KPI's and the members of the teams understand these KPI's then they will have direction and focus. Having this will give them targets to meet and clarity as to how they are doing. Having great KPI's that will give not only the BOD but all levels understanding of the performance of the company will greatly impact the finished results.

Lean supports in lowering costs in the company. Waste is defined as any activity that does not add value from the customer's perspective (Skhmot, 2016). Waste in a company is the same as saying loss of money. When there is waste in a company that means the company is not producing or working at its full potential. When there is waste in a company there is loss in money through the forms of scrap, motion, or any other of the 7 wastes explained.

Technology has Changed the Way Organizations Manufacture Products

From using basic tools to having robots build entire products, technology has changed a lot over time. By utilizing technology many companies are now able to produce faster, safer and have better quality than ever imagined.

Computerized systems are replacing the need for suppliers. Automated guided vehicle (AGV) are vehicles that can run without humans operating them. Commonly looked at as a forklift or pallet mover with no operator and following a designed programed path. In a normal operation, there is a person either driving a powered industrial vehicle (PIV), like a forklift or pallet mover, or the company could have a person moving the product by cart or pallet jack. All of this has changed with the invention of the AGV (Taglic, 2020).

The use of robots and automated equipment is eliminating manual processes. Increasing labor productivity is one factor as to why automations is an improvement over normal production methods (Csanyi, 2016). Needing less labor and having consistent outputs are a main factor to why automations is so great. Next would be the mitigation of labor shortages. Even if your workers are great and are fast, they will inevitably want to go on vacation or will get sick, robots do not get sick. Improve quality by reducing the need for people in repetitive tasks.

Technology is paving the way in lowering costs in manufacturing. Reduction in labor, less quality issue and improved output are just a few of the ways that technology has found its way into many manufacturing companies (Csanyi, 2016). Looking at the reduction in labor a company would be able to see different ways of saving money, such as less recruitment costs, workers comp cases and high wages for people who do repetitive jobs. All of these are ways technology can reduce a company's costs.

Overhead (OH) Cost

The overhead costs are something that might be overlooked but are extremely important to know when operating a company. Knowing all the costs and how they affect the bottom line, or the finished product can be the determining factor between a successful company and a failed company. There are quite a few different types of overhead that are in a manufacturing company. Indirect labor such as suppliers, warehouse staff or office personnel are an example of overhead. Plant depreciation, insurance, property taxes and rent of manufacturing facilities are also common types of OH. If the company has any facilities there will also be power, heating, natural gas and other utilities consumed by manufacturing (Jan, 2019).

Dollar per square meter and the importance in an organization. Typically, the facility is one of the most expensive assets for a company; the organizations goal is to safely get

as many sales dollars into the building as possible (Stevens, 2016). When a company really wants to make money, they will look at the space and figure out how to maximize it. Manufacturing, or service industry that has a brick and mortar facility will look at this to make sure that the OH costs stay low and maximize the amount of revenue made.

Summary

This chapter was a literature review that covered Lean Manufacturing through the Define, Measure, Analyze, Improve and Control (DMAIC) principle. The chapter discusses how automations has improved manufacturing. It also shows how overhead costs directly affect the finished product.

The next chapter will look at the methodology of these three main topics and how to systematically use them to improve the processes throughout the study. Each process will go into greater detail as how they could be used to improve the process.

Chapter III: Methodology

Company XYZ has been growing in an exponential manner. Taking on new products and expanding so fast that the space is no longer enough to pack all finished goods. Company XYZ needed to expand without expanding. To do this, 36,000 pieces per week needed to be packaged in the same square meters as 9,000 pieces per week.

This could only be made possible by group coordination. The Board of Directors (BOD) told all the higher ups the goal and when it needed to be achieved. After this, the managers and directors got together to build the team that would be handling the project from beginning to finished. The leaders in each of the fields were picked to take on this monumental task. A combination of engineers, production, planning and facilities were brought together.

With the team picked and explained the goal and timeline they would then have to make the plan of attack. This plan was formatted in the DMAIC model. DMAIC stands for Define, Measure, Analyze, Improve and Control (Terry, n.d.). With utilizing lean methodology, the team had a starting point and a direction as to how they will complete the BOD's goal.

Define

In the past year, Company XYZ has grown from 9,000 pieces per week to 36,000 pieces per week. This represents 289% growth that customers are demanding. If this growth could not be met, customer satisfaction would have dropped do to the missed on-time delivers or cancelled orders. To reduce the chance of customer dissatisfaction the company needed to increase the pieces per hour to meet the customer demand. The requirement from the Board of Directors (BOD) was the team needed to increase the pieces per hour without increasing the needed square meters for packaging.

Measure

To understand which direction to go, the team first needed to understand where the starting point was. Knowing the measurements that will be tracked and knowing where to start was the first step to improving the scenario. With the direction from the BOD of not being able to increase the total square meters used, this was the first measurement that the team needed to take. The team worked with production and calculated the space that was currently being used to pack 9,000 pieces per week. With the current production and packing process being spread out between 4 different locations. Each area was calculated and then added together to complete the baseline square meters used.

The next measurement that was needed was the pieces per hour that the packing line was currently doing when running 9,000 pieces per week. Understanding what the current situation was, and how the process worked in each step gave the team the necessary numbers to work out what would need to be improved, reduced, eliminated or automated. The measurement for time was taken as an overall of the main process and each individual subprocess. Giving the team clear picture of what to review when working on the main project.

To make sure that the cost of the new process did not exceed the old process, the team needed to calculate the direct, indirect and Overhead (OH) costs. Having the financial information will confirm if the newly created process creates a better profit margin than the old process. This will be an indicator for the team to determine if the process will need to be improved at a lower cost.

To support with the OH costs, the team will need to know what the starting headcount for the packing area. This will include all the indirect labor that are not tied to the finished goods. As the packing process is not considered to be production, the entire staff who does the packing

and the staff supporting this department are all considered indirect labor. The members of the departments at 9,000 pieces was the starting point. The ratio of headcount to output at 36,000 pieces needed to be the same or better than the ratio at 9,000 pieces per week.

Main things that the team needed to remember is that the goal for pieces per week was 36,000. This was the main target and needed to be reached without increasing the space. The space used for 9,000 could only be used for 36,000 pieces. Lastly, it could not cost more to operate. The OH cost needed to be equal or lower than the OH cost at 9,000 pieces per week.

Analyze

After the team was able to get the baseline information for all the measurements needed to start the project, they were then able to create a plan to analyze the problem.

- Engineer will calculate the max pieces/hr. of the current packing line
- Engineer will breakdown the process to each individual operation of the process and sub processes
- Production and Engineer will evaluate each process and determine what can be improved, reduced or eliminated based on pieces per hour and OH cost comparisons
- Utilize the 5 whys and the 6M's tools to find root cause analyses (ROA)
- The root causes will be evaluated to determine if the effect negatively or positively the OH, square meters or pieces per hour
- If the ROA is shows positive results the process will stay and continue to be monitored and improved
- If the ROA shows negative results the process will be tested again and after will determine in the process will need to be improved, reduced or eliminated

- The Continuous Improvement team will do a line balance to combine operation that are in order of each other and under the target combined time.

Improve

When all areas were finished being analyzed the engineering and production team was then able to start making changes to improve the processes. The improve phase is completed in the following steps:

- First the team will do small scale tests of each process after being changed
- Each test will be reviewed on how it impacts each process and how it impacts the end goal
- Breakdown the small-scale test into sub processes to evaluate the data
- Do tests on the sub processes to narrow down the root causes
- Each sub processes were reviewed on how it could be improved
- Lean methodology was used to improve each sub process
- Automations were used to support in improving and eliminating processes
- Put together all processes to do live test to evaluate if any bottlenecks
- Recalculate new max pieces/hr.
- Max pieces/hr. meets the target then Engineering will do large scale production run
- Max pieces/hr. does meet target then the team will review the bottlenecks and repeat the process until the bottleneck is improved
- Put together all processes to do live test again
- Repeat process until the goal was achieved

Control

After everything was completed the team needed to make sure that the operators and leadership maintained the new processes. To do this the team needed to create ways for easy management of the process. Utilizing lean methodology, the team created a 6S standard operating procedure (SOP) to maintain the process. This ensured that the area had everything in its proper places and the workers had everything they needed. Making sure that the working area was clear and had clear visibility for management to see any issues that could arise.

Having a proper preventative maintenance (PM) schedule was needed to maintain the machines and not negatively affect production. With having maintenance team go through each motor, belt and part of the machine while production was not working supported them with less downtime from machine breakage.

Having key production targets or key performance indicators (KPI) was a must when guaranteeing the new process was followed. This was done with a few different methods. First, having daily output tracking. Understanding the numbers of what you need and what you are getting each day, shift and hour was important for all leaders and workers. The team could utilize this info to certify that they were reaching their quota or target. Knowing the target always and know exactly what number the team is at each moment supports staying on track. Next, with utilizing the daily output tracking the team was able to compile data to show scheduling compliance. This data was used as a lagging measurement for the management to understand if production was following the schedule, if they did not follow the schedule they would be able to ask why and then improve the process with the information found. For finance department, OH tracking would be used to make sure the teams followed the headcount, square meters allocation and pieces per hour targets that were specified by BOD. Lastly, Perfect Order

Index (POI) is a measurement that the company using to determine if they are shipping what the customer needs and when then need it.

Utilizing all the measurements listed in the control phase is what makes up the implementation plan. This is the plan that is created by engineering and continuous improvement (CI) teams to ensure that all processes were followed correctly by production when starting the new process. This is the step by step training that will need to be followed along with the measurements that will need to be tracked. This is used and done so that everyone knew how to do the job correctly and how they are performing with the new process.

Constraints

This project was kept on strict guidance and was monitored heavily from day 1. With the BOD needing this project to be a success, there was very little (to no) room for error. Even with this project needing to be a success, there were still guidelines that needed to be followed and restrictions that could not be broken.

First and most important limitation that the team had was space. This was a requirement from the BOD in the very beginning of the project. The team was not allowed to utilize more space with the new process than what the previous process was using. Meaning, the space that was utilized at 9,000 pieces per week would have to be the same space that would be used at 36,000 pieces per week.

Another limitation that was directed to the team was cost. Cost of the project and cost after completed. This was defined as the investment cost and the finished OH cost. With the finished OH cost, the team needed to make sure that the new process would be equal to or less than the current process. If the process that was implemented increased the OH cost, then the team would have to find a way to lower this cost below the target number.

Investment cost is all the cost that was spent to finish the project. The team had to determine between simple operations and automations. Each step of the process needed to be calculated based on space, headcount, movement and repetition to determine what investment was need. With simple operation the team could look at adding headcount, conveyors, basic tools and new processes. With automations, the team could look at mechanical assisted machines, automated conveyors, robots, and anything else that could support the project.

Time was the last main factor the team needed to worry about. As they were working on the project, the production team was still growing. Each week production would increase their output and would get closer to their target. With each passing week the team would feel the pressure from production. With the growth of production, the space that they were using was getting tighter and tighter. It was getting harder for production to do basic function with all the work in process (WIP) in the way.

Summary

With a project this large and diverse, all the teams had to come together to work through the problem. After coming together with all information gathered and testing multiple solutions the team was able to devise a solution that would improve the process and lower the overall cost of the operation.

Chapter IV Results

The goal of this study was to find the best way possible to improve the output and to lower the cost of the production process at Company XYZ. The focus was utilizing automatic or semi-automatic processes to improve the process and to lower the overhead cost. Utilizing lean manufacturing and the DMAIC process was there to support in keeping the team focused on the tasks and largely used at the end of the study to support in the standardization and sustainment of the new processes.

Base Line Data

Base line data or starting data was collected to determine where Company XYZ is currently so to better understand what steps needed to be taken to improve each process. The base line data showed at the current pieces per hour (pieces/hr.), what the total square meters was being used to perform all the operations. Also, included in this data was headcount, scrap, workstations used, machine downtime.

Costs were also taken in the form of dollar per square meter. This number is used to associate how much money the company is making per square meter used. In this study, all the costs were fictitious as the actual data could not be used. For the point of this study we associated numbers to each area that involved costs and based the success of each improvement on the increase or the decrease of the potential money. Other cost numbers that were used would include headcount salary and scrap costs.

Results of 1st Test

The first test consisted of reviewing the manufacturing process and find waste in each operation that could easily be removed. The study was centered around utilizing 5S methodology to clean up simple operations to better streamline the movement of the processes.

During this test the demand was not increased so that they could have less variables when doing the test.

With the below chart it is notable that not much has changed except the headcount has reduced by two people. This was accomplished by improving the efficiency of the workers and reducing the steps needed to each operation.

Table 1

Direct Labor was the Only Change in 1st Results

Metric Measured	Base Line	Metric 1	1st Result
Square Meters Used	3000	3000	-
Pieces/Hr.	79	79	-
Direct Labor	36	34	6%
Working Location	6	6	-
Quality Headcount	12	12	-
Scrap Per/100pieces	2	2	-
Training Hrs./person	20	20	-
Downtime Hrs./shift	4	4	-
Warehouse Staff	6	6	-

Note. Results are based on (%) increased or decreased in comparison to the Base Line Measurement taken before test started. Positive (%) is good for the company Negative (-%) is bad for the company.

With the reduction of headcount, the below chart shows the savings in headcount cost.

Table 2

Headcount Cost Reduced, All Other Fields had Zero Change

Cost Metrics	Base Line	Metric 1	1st Result
Dollar/ Square Meter	$ 300	$ 300	$ -
Headcount Cost	$ 18,000	$ 17,000	$ 1,000
Indirect Labor Cost	$ 9,000	$ 9,000	$ -
Scrap Cost	$ 18,000	$ 18,000	$ -

Note. Results are based on dollar value $ increased or decreased in comparison to the Base Line Measurement taken before test started. Positive $ is good for the company Negative ($) is bad for the company

Results of 2nd Test

During the second test Company XYZ increase the demand from 9,000 pieces/week to 18,000 pieces/week. With this large increase of demand the team needed to test automations. The automations that was tested was a conveyor system. This conveyor system was used to convey the finished goods after being packed from each station to one location. With the current processes being in six different locations, utilizing a conveyor to move all the finished goods to one location supported in eliminating unnecessary movement for the packing department and the warehouse department.

The chart below will show the reduction in both warehouse headcount and direct labor headcount. The warehouse no longer needed to go to each of the six different locations to pick up the finished goods and now only needed to go to one location. This improvement resulted in the company being able to reallocate 2 people from the warehouse department to another department. Same with the direct labor, this was because no one needed to sort or load finished

goods onto pallets, so each work station was able to reallocate one person. Since the efficiency improvement was made in the previous test this was the reason why only four people were reallocated total from the direct labor column during test 2.

Table 3

Square Meters Used Exceeded the Acceptable Limits

Metric Measured	Base Line	Metric 2	2nd Result
Square Meters Used	3000	4500	-50%
Pieces/Hr.	79	158	100%
Direct Labor	36	30	12%
Working Location	6	6	-
Quality Headcount	12	12	-
Scrap Per/100pieces	2	2	-
Training Hrs./person	20	20	-
Downtime Hrs./shift	4	4	-
Warehouse Staff	6	4	33%

Note. Results are based on (%) increased or decreased in comparison to the Base Line Measurement taken before test started. Positive (%) is good for the company Negative (-%) is bad for the company.

The cost chart below shows changes in all four-cost metrics. With the dollar per square meter. This was increase due to the demand increase. Even with the total square meters used being increase the total demand increase was greater and made it possible for the dollar per square meter to increase. Both headcount cost and indirect labor cost had a savings from the headcount reduction from direct labor and from warehouse (which warehouse is considered

indirect labor) Lastly the scrap cost increase since the demand went up and the test did not result in any means to reduce the scrap that was occurring.

Table 4

Scrap Cost Increased

Cost Metrics	Base Line	Metric 1	1st Result
Dollar/ Square Meter	$ 300	$ 400	$ 100
Headcount Cost	$ 18,000	$ 15,000	$ 2,000
Indirect Labor Cost	$ 9,000	$ 8,000	$ 1,000
Scrap Cost	$ 18,000	$ 36,000	$ (18,000)

Note. Results are based on dollar value $ increased or decreased in comparison to the Base Line Measurement taken before test started. Positive $ is good for the company Negative ($) is bad for the company.

Results of 3rd Test

In the 3rd test Company XYZ continued with automating the processes and added in more conveyor and an automated packing machine. The extra conveyor was put in place to support in the packing process at the end of the line. The automated packing process supported the workers to put the product into the box with less effort and faster than the manual process.

The way the process stands now is there are two employees at the machine and support in packing the finished goods into the box. Then the box will go onto a conveyor system towards the end of the line. When it gets close to the end of the line, all the conveyors from each station will converge into one main conveyor where a few people will finish the packing process before the finished goods are put onto the pallet.

With the 3rd test results shown below, Company XYZ was able to reduce the square meters used from the previous test even with increasing the total output per week. With the output per week up another 9,000 pieces per week now totaling 27,000 pieces per week the improvements made at Company XYZ were still able to reallocate direct labor, lowering the needed labor to do the same function as previously needed for only 18,000 pieces per week.

Simplifying the process by utilizing automations has lowered the training needed to perform each task. With the ability to locate employees to specific tasks and standardize their operations, it has become easier for employees to understand their role and learn it. This standardization has also made its way to the scrap area. Reducing the complicated and unrepetitive nature of the job previously, the scrap rate has lowered with more simplified methods and standardization practices being put in place.

Table 5

Square Meters Used Exceeded the Acceptable Limits

Metric Measured	Base Line	Metric 3	3rd Result
Square Meters Used	3000	3500	-22%
Pieces/Hr.	79	237	200%
Direct Labor	36	28	18%
Working Location	6	6	0%
Quality Headcount	12	12	0%
Scrap Per/100pieces	2	1	50%
Training Hrs./person	20	6	70%
Downtime Hrs./shift	4	4	-
Warehouse Staff	6	4	33%

Note. Results are based on (%) increased or decreased in comparison to the Base Line Measurement taken before test started. Positive (%) is good for the company Negative (-%) is bad for the company.

After the 3rd test the cost chart below shows the dollar per square meter has increased. This is directly due to the increase demand and the lower space needed to perform that task that was previous done at only 18,000 pieces per week. Also, with the reallocation of employees and the standardization of the process, both headcount cost and scrap cost are showing improved numbers.

Table 6

Indirect Labor did not Change, All Other Fields Show Positive Results

Cost Metrics	Base Line	Metric 1	1st Result
Dollar/ Square Meter	$ 300	$ 514	$ 114
Headcount Cost	$ 18,000	$ 14,000	$ 1,000
Indirect Labor Cost	$ 9,000	$ 8,000	$ -
Scrap Cost	$ 18,000	$ 27,000	$ 9,000

Note. Results are based on dollar value $ increased or decreased in comparison to the Base Line Measurement taken before test started. Positive $ is good for the company Negative ($) is bad for the company.

Results of 4th and Final Test

The 4th test resulted in the final steps needed to complete the study. With more standardization being done and reallocation of the machines, all the efforts accumulated to the final test needed to complete the study to the satisfaction of Company XYZ. By utilizing standardization, the team took the automated packing machines and relocated them closer to the final conveyor where all product accumulates. This made it possible for less machines needed as the product came directly to the workers.

With the machines being moved out from the space they were previously needed, now there was not a need for employees to be at the machine. The product would come out of the machine and go directly onto a conveyor. This conveyor would take the product to the workers that were operating the packing machines. After the packing process was completed, the boxes would go onto the main conveyor where a few employees would finalize the boxes before being put onto the pallets.

With the demand meeting its target of 36,000 pieces per week the process was able to handle all the demand and as shown in the chart below, with less square meters needed than the previous operation. With all the finished product now being in one location instead of being spread out over six separate location, the quality department was able to centralize their operation to one location which gave them the ability to reallocate their headcount to other needed areas in the facility.

Finally, with the machines being standardized and the operations and movement of product being simplified, the downtime that occurred previously was able to be reduced which supported in the increased output from the process.

Table 7

Square Meters Achieved Target of Being Less Than or Equal to the Base Line

Metric Measured	Base Line	Metric 4	4th Result
Square Meters Used	3000	2800	7%
Pieces/Hr.	79	316	300%
Direct Labor	36	14	59%
Working Location	6	1	83%
Quality Headcount	12	6	50%
Scrap Per/100pieces	2	0.5	75%
Training Hrs./person	20	4	80%
Downtime Hrs./shift	4	2	50%
Warehouse Staff	6	4	33%

Note. Results are based on (%) increased or decreased in comparison to the Base Line Measurement taken before test started. Positive (%) is good for the company Negative (-%) is bad for the company.

The cost metrics below show the results of the 4th test. As stated, the study has succeeded in supporting the target of increasing the output and reducing the square meters needed to

process the demand. All of this was done while still being able to reallocate headcount from both the direct labor and indirect labor as well as reducing the scrap cost by standardizing and simplifying the processes.

Table 8

All Fields Show Positive Results

Cost Metrics	Base Line	Metric 1	1st Result
Dollar/ Square Meter	$ 300	$ 1,286	$ 771
Headcount Cost	$ 18,000	$ 7,000	$ 7,000
Indirect Labor Cost	$ 9,000	$ 5,000	$ 5,000
Scrap Cost	$ 18,000	$ 18,000	$ 9,000

Note. Results are based on dollar value $ increased or decreased in comparison to the Base Line Measurement taken before test started. Positive $ is good for the company Negative ($) is bad for the company.

Summary

The study began with utilizing basic lean principles to simplify and standardize processes to reduce the waste in each operation. Later tests would implement mechanical and automated processes to reduce the complexity of the process while also eliminating much of the wasted motion in the process.

The next chapter will discuss about all chapters that were done during the time taken to do this study. It will also draw a conclusion as to the results of the study and what Company XYZ will be doing. Finally, recommendation was made to Company XYZ based on the testing that was done.

Chapter V: Discussion, Conclusion and Recommendation

Making improvements in any company need to happen to keep up with the competition. Knowing the best methods and how to execute these methods to improve a company is essential in keeping giant companies at the top and getting smaller companies to compete with the giants. It is imperative to know where the company is currently, and what direction the company wants to go.

Discussion

This was a large-scale project that encompassed multiple different departments and a large-scale production operation. The goals and targets given by the Board of Directors (BOD) were set with the growth of the business and competing with other global giants in mind. Growing from only 9,000 pieces per week to 36,000 pieces per week in less than a year is simply unheard of in many different production industries.

When the team was given this goal, they knew right away that it would not be easy. In fact, most companies would think that it was not possible. But, with this company and those teams it has turned into the norm. For this company, doing unimaginable things and having wildly important goals was a standard.

After the project started and the team got into it, the great ideas started flowing in. Many people had ideas as to how they would want the end to look but did not quite know how to get there. Getting all the teams together was the best thing that could have happened. It made each department who normally do not work with each other, get all the ideas put into a room and discussed amongst them all.

When automations were put on the table as a plausible option the BOD would invest in, the maintenance department came alive with excitement and fear. This was something many of

them dreamed of but were not prepared to handle. It meant learning new skills and new machines to support production and the team to achieve the goal.

When the project started its second and third test, the team knew that they had to find new ways to minimize the space that was being used. For both phases took up more space than the base line test. This was a key target that the BOD set that could not be broken. When the 4th test came up, it was decided to take all ideas from the past tests, along with a few new ideas to improve them and combine all together. This is how the team was able to achieve the target for space.

When it came to overhead (OH) cost, the engineering department was the only team that really understood this amongst the team. So, when the teams wanted to add more headcount to get more pieces per hour, this was a hard no by the engineers. Engineering had to explain that when adding headcount meant adding OH cost. Even with getting more pieces per hour, many times this would not cost out well for the company. With that explained, the teams worked out alternative ideas so to keep headcount the same or reduced.

In summary, the teams worked quite well together and enjoyed the challenge. Many of them learned parts of the company or processes that were previously unknown to them. This supported the growth of each individual and the company alike. After the goal was achieved, the teams have already started looking for the next big project that will support in improving the company and building the giant.

Conclusions

The main goal of this study was to focus on implementing methods to improve the pieces per hour of the operation while still reducing the cost associated with running the operation. This goal was done by utilizing lean manufacturing techniques and automations.

In the literature review, it showed that by utilizing lean techniques a company would be able to reduce the waste in the process by simplifying the operations and standardizing the steps. Lean methods were also utilized in how the study was performed but incorporating the DMAIC process.

The literature review with automations showed that utilizing auto or semi-automated processes support companies by doing repetitive jobs without making waste or scrap. Automations also reduce or eliminate the need to stop working and can continuously make the same part over the course of the day.

Some of the drawbacks of lean and automations are the starting point. With automations, the starting cost usually stops most companies. Machines, even as basic as conveyors, cost a lot of money and unless you have a good revenue stream or a good plan to get your return on investment, it is hard to justify the cost. With lean, it normally takes someone with the knowledge of lean methodology to be able to manage the project and the processes to make it work. Humans also have bad habits of wanting to do it the way that in the norm or not change. This can put lean in a difficult spot when trying to make big changes in a company.

Recommendations

As a result of completing this study, recommendations were made to Company XYZ. First, the importance of space utilization. Company XYZ needed to grow but without growing in size. This meant the need to improve the current space that they used. Planning on how to use the space and what space could be used by each person needs to be done to ensure that the space is not wasted.

Next, it is being recommended to Company XYZ to utilize Lean Manufacturing and 5S methods to improve the company. Utilizing these methods support in eliminating waste in the

processes and standardizing operations. Utilizing these methods help simplify processes for employees and lower the time it takes for new employees to understand the tasks that are being required of them. It also reducing the opportunity for making mistakes which helps in reducing the scrap an employee could make.

Finally, it is being recommended to Company XYZ that automations should be incorporated into the facility and the processes. Putting automations in the form of conveyors and machine assisted technology reduces people and product movement. The reduction in movement reduces the wasted steps and increases the output of each person. This increased output of each person supports in lowering the overhead cost or any other wasted costs that could be put into an operation that is not running at full potential. With that, the recommendation is that Company XYZ follows the methods of the 4th test that was done during this study.

With the 4th test, the company was able to lower all costs and increase the dollar per square meter. This was all being done at max demand based on Company XYZ's goal. The 4th and final test was an accumulation of all previous tests and resulted in the positive final results.

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