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Hill, Jonathan, F. *The Application of Lean Tools and 5S to Improve a Production Area*

Abstract

The objective of this research paper was to reduce the square footage of Department 1A. Achieving this, the project required the application of lean tools and 5S. The project applied lean and 5S to clean and organize the department. The comparison of the original state to the new environment showed that the space that Department 1A had been using was excessive.

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I would like to thank the following people for their support and guidance in my life during my time in graduate school.

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Chapter I: Introduction

Company X, (the name not given due to confidentiality) initiated plans to assemble kits for windows beginning in 1903. These kits are no longer being produced, the windows and doors are now completely assembled and sold ready to install. Company X has 20 different facilities, employing thousands of people. The manufacturing facilities are located both in the United States and Canada. The headquarters is based in Bayport, Minnesota. There are many different divisions within this corporation, each having their own management teams. One specific division in the state of Wisconsin assembles a mid-priced window, which is sold in the east coast region of the United States. In efforts to maintain this site as profitable, principles such as lean are being used by all levels of employees within the organization, from the shop floor to the office personnel.

Department 1A installs exterior grilles on FX units, custom order non-operational units. This department is staffed with two employees that preform the required tasks. Equipment used within this space included four routers, a miter saw, two computers, two sanders, and a tip table. The amount of equipment required excessive floor space, forcing individuals working within this department to do unneeded walking to navigate in and around the equipment, in order to complete the required tasks. The supplies needed for this department were in two different locations within the work space and another location outside of Department 1A, in a remote work center that produced double hung windows. Multiple storage areas for supplies resulted in an inefficient and time consuming processes for this department when valuable time was wasted looking for supplies needed to add grilles to the windows.

With this excessive space and disorganization the window units the employees were

producing took more time to produce than expected, resulting in lost production, late shipments to the customers and a higher labor cost, than were originally planned for this department.

Statement of the Problem

The lack of organization and spacing of equipment and supplies in Department 1A was causing excessive and unnecessary movement by the department employees. This movement resulted in wasted time and lost production. This department required 5S and the application of lean tools to improve this area. The implementation of 5S will provide an effective and productive work space that reduces the movement of the people and increase the output of the product.

Purpose of the Study

The purpose of this project was to develop a new layout for Department 1A. This will effectively decrease the floor space for equipment and supplies, and increase the efficiency and effectiveness of the production employees. The new layout will provide freed up space from the reorganization that would be assigned to an adjourning department that is in need of the extra space to handle increased sale volume.

Assumption of the Study

It was assumed that the existing space that Department 1A was utilizing included wasted space and employees' time. This project focused on decreasing the utilized area for production in Department 1A. It is also assumed that the reorganization would improve the flow of production through the department. The freed space would be an effective solution for storage of additional supplies needed for production to be kept closer to their origin of use.

Definition of terms

5S - Stands for sort, set in order, shine, standardize and sustain. A lean manufacturing process to organize and manage manufacturing operations (Chapman, 2005).

FX Department - A department in company X that produces stationary windows all multiple sizes that can either be shipped to the customer or to another department for use.

Muda – This describes waste in and organization using lean manufacturing.

PDCA –Is the abbreviation for Demming's Plan Do Check Act cycle (Hojjati, 2011).

Red Tag – A process of marking an item that is not needed in an area used while performing the sort stage of 5S (Chapman, 2005).

Spaghetti Diagram – Is a diagram that is put on paper and drawing lines to show the process. This process could be the product, information or the movement of people (Gjeldum, 2011).

Value Stream Mapping – A visual tool that allows the user to see the waste throughout the process. The map shows a future state that more closely resembles lean (Lovelle, 2001).

Limitation of the Study

This project was limited by the existing space and location of Department1A. This study was limited to the existing equipment being used in the installation of grilles. No new processes or no additional employees would be added, due to the sales volume remaining at the consistent level, during the course of the study.

Methodology

Literature was reviewed to identify the current best practices to determine how to reduce movement and improve space utilization. Application of lean tools and a Spaghetti Diagram was created to identify the waste within the system. In this project the wastes that were being

reviewed included motion, time, and space. The Spaghetti Diagram also specified that the production supplies required were kept at a location away from where they were needed.

The future layout of the area was then designed and presented to other employees that work within Department 1A. The employees reviewed the future design of the space and were consulted as to their opinion of any unforeseen problems with the new layout, and provided suggestions to resolve any issues.

Before the reorganization of equipment, 5S was initiated, and became a new standard for the department. The first step in the 5S process is sort. This is the process of going through and red tagging everything that was not a necessity for production. Items were tagged if not used in a six month time span. The red tagged items were then planned for disposal or recycling to other departments.

After red tagging unneeded equipment and supplies the set in order stage was implemented. This stage required placing the machines, computers and tools at placement of usage. Equipment within the area is taped off in the placing and labeling location. Taping off and labeling was done so any employee could enter the work area and effectively locate the tools and supplies that were required and replace it in the appropriate location. The set in order stage is also effective in ensuring that the warehouse personnel placed and organized the supplies where they are to be utilized.

The shine stage was originally initiated in the first stage by red tagging items and removing them. Each machine was wiped down and the area was deep cleaned. This will effectively help employees observe any malfunctions in the equipment and machines.

Sustain is the final stage of 5Sis hardest to both accomplish and maintain. It required consultations with the supervisors and leads for Department 1A. Standardization needs to be

followed by Department 1A Supervisors and Leads. This is a requirement to monitor usage of tools and supplies that may be removed from the department, and maintain Department 1A clean and clutter free. Following the development of the Spaghetti Diagram and the application of 5S the layout of Department 1A was reviewed for waste, the development of a new layout would reduce waste and improve productivity.

Summary

Department 1A was not efficient in terms of labor to produce a unit and in terms of space utilization. The machines in the area were too far apart and the supplies were stored in more than one location. The Value Stream Mapping determined that steps were being wasted by the employees in the work area and time was wasted by all of the extra movement. 5S was used to make the area more organized and condensed in size, with the accomplishment of a more productive Department 1A. The literature review conducted during the study indicated that this type of scenario is not specific to Company X. The literature review in Chapter II presents multiple occurrences where lean principles application reduced waste and improved organizational effectiveness.

Chapter II: Literature Review

The lack of organization and spacing of equipment in Department 1A has caused wasted motion by the employees in the department. Thus time was wasted moving from one piece of equipment to another and productivity was then required. To develop solutions to decrease waste, a review of literature on topics related to lean manufacturing has been done.

Lean Manufacturing

Lean manufacturing was commonly believed to have been started in Japan, but Henry Ford had been using parts of Lean as early as 1920's (Venda & Sakthidhasan, 2010). Production is lean because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product. Also it requires keeping far less than half the needed inventory on site, resulting with many fewer defects, and produces a greater and ever-growing variety of products (Acharya, 2011). Research from the Lean Enterprise Research Centre says that in a typical manufacturing company the breakdown in the time that a product is being manufactured breaks down like 60 % waste, 35% non-value added and the other 5% is value added to the product (Hines, Found, Griffiths & Harrison, 2008).

Lean Manufacturing also includes these additional tools:

1. 5S
2. Cellular Manufacturing
3. Just In Time
4. Kanban
5. Total Productive Maintenance
6. Setup time reduction

7. Total Quality Management
8. Visual Management
9. Standard processes (Acharya, 2011).

To make a lean system with no slack – no safety net – work at all, it is essential that every worker try very hard (Womack, Jones, & Roos, 1990). The workers need to pay attention to details instead of having their minds on non-work related things. If this is the case this could be very detrimental to a lean system. Companies need to have managers who walk the walk and talk the talk in order to get their employees on board.

There are numerous methods and tools that organizations use to implement lean production according to Ravikumari, Marimuthu, & Chandramohan:

1. Kaizen Rapid Improvement Process this involves the project team members to meet and brainstorm ideas and solutions to problems.
2. 5S involves sort, set in order, shine, standardize, and sustain.
3. Total Productive Maintenance is where the employees working in the area are capable of noticing changes in the machine and taking proper precaution to have them fixed before they breakdown.
4. Cellular Manufacturing is machines are placed closer together to help in the production.
5. One-piece Flow Production System is where one window would be worked on a time, instead of the person working on several at a time.
6. Just – in – time Production is where the windows show up just in time for the employee working in the area to need them.
7. KANBAN is a system that uses signals to orders parts and supplies.

8. Six Sigma did not use in this project
9. Pre-Production Planning did not use in this project
10. Lean Enterprise Supplier Networks (Ravikumari, Marimuthu, & Chandramohan, 2009).

With these implementations managers can reduce the amount of steps that an employee will need to make in order to complete the task at hand. These methods will also help engineers reduce the actual size of some locations to help reduce the numbers of steps an employee needs to take.

True lean is about people improving their own work through problem solving with the support from management and in accordance with company goals and objectives (Badurdeen & Gregory, 2012). Thinking about it, people will begin to understand that the two main objectives in lean manufacturing are continuous improvement and the respect for the people doing the job, their ability to solve quality issues that arise. People need to look at the company culture to understand whether or not lean will work.

When operating independently, lean processes can create a fragmented business approach that hurts the company's core quality standards (Strouse, 2008). Lean processes need to be implemented with all of the quality standards and processes that the company has already set as standards. Companies should not just drop models or frameworks that have been successfully working in order to use the current fad business philosophy. Lean can join what is already there and make it more efficient and profitable. Toyota would later develop Kanban from lean manufacturing (Stouse, 2008). This process works like a pull system and parts or product are not pushed down the line. If a quality problem occurs the line shuts down and everybody on the line and supervisor works to get this problem resolved (Strouse, 2008). The goal of the new lean

system is to streamline work effectively and efficiently with whatever resources you have at your disposal.

Eight tips for lean integration according to Strouse (2008) include the following:

Create a Quality Planning Procedure*;* the lean manager must develop a quality planning process that dictates how to implement new initiatives such as 5S or Kaizen. This documentation will become the guide for future initiatives (Strouse, 2008).

Don't Forget the Rules; lean does not mean that your business is starting fresh. Use the methods that were developed when you first registered your management system. Referencing the basics, such as introducing formal procedures and forms and identifying where records are kept will ensure you have not jeopardized your ISO registration (Strouse, 2008).

Write it down; changes usually require some form of adaptation. If this is the case, revise and update the applicable documentation in a timely manner, especially before your next scheduled audit. Most importantly, define and measure every process involved with the new lean system (Strouse, 2008).

Set Goals and Track them; it may appear redundant to state that a business should record the goals and objectives of its new lean system. However, it is a step that often is overlooked. Additionally, the company must implement a measurement system to gauge this new initiative's successes or failures. This ensures the company is on a continuous quality-improvement cycle (Strouse, 2008).

Remember Who Comes First; it is one of the oldest sayings in the business world, but there is merit in repeating it here: The customer always comes first. Changes to a QMS can positively affect the bottom line but ultimately should never impact the company's capability to

serve its customers. Always remember that the focus is on the customer, and the rest should follow (Strouse, 2008).

Assign Responsibilities; senior management must assign responsibilities to all those who oversee continuous quality improvement. The lean manager must develop a plan that uses the existing management system as a starting point. In turn, the internal audit process must police the initiative to ensure it has been integrated (Strouse, 2008).

Focus Internal Audits on the Initiative; internal audits should be scheduled appropriately for a newly implemented lean system or any new initiative for that matter. Internal audits must take into account status and importance and assess the system's effectiveness and whether it plays by the rules of the QMS (Strouse, 2008).

Be Disciplined; ISO registration can be a time-intensive, tedious, and bureaucratic process. Regardless, you can't cut corners and take shortcuts. The QMS must be kept current, and this may include revising or adding documentation and updating control plans (Strouse, 2008)These eight principles provide for a meaningful and organized lean implementation to help save company's time and money, by not just abandoning what processes they already have in place and working. The most important tip here is that employees must always remember who comes first, because if there are no customers no matter what a company does, there will be no business (Strouse, 2008).

Cellular layout is one of the main ideas of lean manufacturing. Companies are reducing a lot of muda by getting rid of all the walking that is taking place, moving equipment closer so that each piece takes less time to make. The main benefit from a layout like a U will be the decrease in the amount of time that a product spends in the work center (Pattanaik, & Sharman, 2009)

The significant benefits of cellular manufacturing are a reduced setup time, reduced work-in-process inventory, reduced throughput time, reduced material handling costs, improved product quality and simplified scheduling (Pattanaik & Sharman, 2009).

During the mid-1990s, the value stream concept evolved and was seen to extend beyond manufacturing or the single company, and stretch from customer needs right back to raw material sources. By looking at this and seeing what people considered to be waste and non-value, may be completely different then the customers point of view. (Hines, Matthias, & Rich, 2004) The four stages of lean thinking:

1. Cells and assembly lines
2. Shop floor
3. Value stream
4. Value systems

Top management must be on board for any lean program to succeed. If you do not have top management support this type of program will not succeed and no one will even try to make it work.

Lean is a way of thinking; whole systems approach, focus on adding value, and focus on removing waste from processes. Lean can help reduce the spaced needed for an area or production line. It also looks at the non-value added work that is being done on the product (Landry, 2010).

5S

5S is systematic to lean production, a business system for organizing and managing manufacturing operations that requires less human effort, space, and capital and time to make

products with fewer defects. 5S stands for sort, set in order, shine, standardize and sustain (Chapman, 2005).

In the sort stage employees are going through the whole area and red tagging items that are not needed or have not been used for a long time (Landry, 2010). After red tagging an item that is not being used nor needed it is removed from the area. This allows only the tools or supplies that are needed to complete the task to be in the area only.

During the set in order stage employees are placing all the tools and supplies in locations where they are needed (Landry, 2010). At this time each tool or supply is marked where it belongs by either drawing around each item or marking it someway. By doing this anyone person that comes into the area they will be able to find or tell if something is missing.

Shine is the process of cleaning everything in the area and checking all of the machines or tools (Landry, 2010). By checking the machines or tools, the employee that uses them on a regular basis will be able to notice if something is wrong. This will help the employee keep an eye and ear on machines to catch any possible maintenance issue before it happens.

Standardize is the process of keeping everything in its place (Landry, 2010). This should be done at the end of every shift that way tools and supplies will not be missing. This will allow anyone to access the tools or supplies as needed.

Sustain is the hardest step in 5S. The previous four steps need to be checked on a regular basis. This can be done multiple ways by doing an audit on a regular basis, having assigned task for each employee, giving time at the end of the shift to work on 5S and by having a check off or sign off sheet. If managers, supervisors and employees would just stop and think about doing the things that are more natural and use their common sense these things can and will help any company make a profit. All of 5S is common sense, employees need to be educated in the way

of lean thinking and people need to go back to the basics. These are common sense efficiencies, anybody can do cleaning, labeling, organizing, marking, follow-up and making more efficient. But companies have a very hard sustaining these (Payne, 2004).

5S works as a cycle and never stops. This cycle is like PDCA Demming cycle (Plan, Do, Check and Act) and this cycle in 5S is changed to Sort, Set on Order, Shine, Standardize and Sustain (Hojjati, 2011). There may be many benefits to a company for using 5S no matter their size. Some of these could be greater employee morale, less safety incidents, cleaner facilities and better quality and production.

Value Stream Mapping

VSM (Value Stream Mapping) allows the user to see waste throughout the value stream and imagine a future state that more closely resembles lean. It is necessary to understand the seven elements that do not contribute to the value of the production (Lovelle, 2001). These seven elements are overproduction, inventory, transportation, waiting, motion, over-processing and re-work (Lovelle, 2001). For any changes that the Value Stream Mapping future state shows, will cost money and needs full support from upper management. These changes can decrease the amount of time that it takes an item to move from the beginning of the value stream to the end. It will have an effect on inventory, not just the raw materials but also the work in process. It will even help determine where the bottlenecks stand in the value stream. Most companies can get better benefits out of the Value Stream Mapping by going upstream to the customer and going downstream with the suppliers of the raw materials (Duranik, Stopper, & Ruzbarsky).

Necessary but non-value adding operations may be wasteful but are necessary under current operating procedures (Hines & Rich, 1997). Value-adding operations involve the

conversion or processing of raw materials or semi-finished products through the use of manual labor. The following are the seven categories that production wastes are grouped into (Liker, 2004):

1 – Overproduction

2 – Waiting

3 – Transport

4 – Inappropriate processing

5 – Unnecessary inventory

6 – Unnecessary motion

7 – Defects

An eighth type of waste added by Toyota is the underutilized people (Badurdeen & Gregory, 2012). If managers would look at these eight wastes and define them and then look for them they will find them. These exist in any manufacturing, service or possibly office buildings. If managers think about overproduction this would be the worst of all the seven waste (Hines & Rich, 1997). This would be building extra product that there is no need for, this can happen in the service and office situation also. Waiting occurs in all types of businesses including waiting for raw materials, waiting for parts to be used in the service industry and in the office waiting for important documents to print off or get delivered by messenger. Transport in the manufacturing plant involves moving product from one location to another, but in the service you might need to move something out and bring in something else. (Hines & Rich, 1997) Inappropriate processing occurs in situations where overly complex solutions are found to be simple procedures such as using a large inflexible machine instead of several small flexible ones. Unnecessary inventory can happen anywhere at any given time. In a manufacturing building you

may go into the warehouse area and find product that has been there for a long time. This will happen in the service industry and also office buildings. (Hines & Rich, 1997) Unnecessary movements involve the ergonomics of production where operators have to stretch, bend and pick up when these actions could be avoided. Then there is defects, these are direct costs to any company. These defects happen in any factory all the time and cost a company more money to throw away or time and money to possibly repair if possible. This can happen in any type of business, or even in one's own home.

Process activity mapping comprises a group of techniques that can be used to eliminate from the workplace waste, inconsistencies and irrationalities and provide high-quality goods and services (Hines & Rich, 1997). There are five stages to this process which includes:

1 – The study of the flow of processes

2 – The identification of waste

3 – A consideration of the whether the process can be rearranged in a more efficient way

4 – A consideration of a better flow pattern, involving different flow layout or transport routing

5 – A consideration of whether everything that is being done at each stage is really necessary and what would happen if superfluous tasks were removed.

There are also these other tools to go along with the process activity mapping. These include supply chain response mapping, production variety funnel, quality filter mapping, demand amplification mapping and decision point analysis. These will not go into for this project.

Value Stream Mapping is an enterprise improvement tool to help in visualizing the entire production process, representing both material and information flow (Gjeldum, 2011). Using

this type of map will help determine how much extra movement is being used in the process of adding grilles to the window. This map will also show how much extra time is spent walking to get the skins for the FX department. This will also help show how time will be saved by moving the skins closer to the FX department. This type of map is also considered a spaghetti diagram.

A first design of Value Stream Mapping is realized according to the original data from production processes and the layout, identifying the key times of each workstation (Alvarez, Calvo, Pena, & Domingo, 2009). This design represents the starting point of improvement. Then after a few months a company may want to go back and revisit the Value Stream Mapping to see if any new changes can be implemented to cut down time and save capital. While revisiting the Value Stream Mapping companies may find that the time it takes to make a product will increase but the amount of work in process and inventory may have decreased which also will save capital.

Value Stream Mapping is a tool commonly used in lean continuous improvement programs to help understand and improve the material and information flow within organizations (Duranik, Stopper, & Ruzbarsky, 2011). In this part of the process making a Spaghetti Diagram will be useful. This can be useful to show the flow of information, the movement of the product through the area and the movement of the employees in the area. Use of a Spaghetti Diagram is helpful; it will show all the places a unit must go to, to get out the door. This would start at, the door where the raw materials come into the plant, then to the storage location throughout the plant. After this it shows how it gets to the line to be made into the unit, then it could go out the door or over to the grille area. Then after this process it may go out the door or over to the mull area to get connected to another unit before it goes out the door (Liker, 2004).

U-shaped Work Cell

U-shaped manufacturing cells eliminate a lot of the walking, work in progress and double and triple handling (Brandt, n.d.). Eliminating the walking has many of benefits, not just for the increase in production, but the employee will not get as fatigue and be able to be attentive longer throughout the day. This is important on an assembly line. All of the workers can then be crossed trained to assist when someone needs help. Also everyone can then watch for defects, by doing this employees should be able to keep defects from getting out the door or going to a different part of the company to have extra value added parts put on. This type of work cell should also cut back on inventory needed in the plant, because there will be less room needed. By using this type of work cell will lead to more profits by having less space taken up, less people needed to build the product, less work in process sitting around. This type of work cell would be a pull system, which means that a person cannot push as hard as they want to, but they have to wait until the person after them pulls the product before starting the next one (Chaneski, 2005).

Summary

Lean manufacturing is lean because it uses, less space, less people, and less human effort (Womack, Jones, & Roos, 1990). There are many different tools used in lean manufacturing like Total Productive Maintenance, Just in Time, One piece flow, and 5S. There are many more tools that can be used to help lean become successful. 5S is one tool in lean manufacturing the S stands for sort, set in order, shine, standardize, and sustain. Companies must do each step in order starting with the easiest and working through the hardest. Value stream mapping helps the person see where wasted movements are being made. This is human movements, supply movement or product movement. U-Shaped work cells decrease the amount

of human walking, space needed for a work center where people can stop and help each other out. The U-shape work also eliminates the double and triple handling of product.

The literature reviewed included topics on lean, and tools used to increase efficiency such as 5S, and waste reduction. Through the Value Stream Mapping and Spaghetti Diagrams was also discussed. In the following chapters these process improvement tools will be put to use, to improve Department 1A.

Chapter III: Methodology

The lack of organization and spacing of equipment and supplies in Department 1A caused excessive and unnecessary movement by the department employees. This movement resulted in wasted time and lost production. This department required 5S and lean manufacturing to help organize the area. The implementation of 5S will provide an effective and productive work space that reduces the movement of the people and increase the output of the product.

The purpose of the study in Department 1A was to decrease the square footage required and increase the efficiency and effectiveness of the production employees. Decreasing the amount of excessive steps being taken by employees working in the area this will help increase the output of the department, which in turn will help manage any extra, demand put on the area. The current design of the department was studied and the need for a change in the layout was noticed.

Data Collection

The project began with documentation of the current process; measuring square footage, and existing process tools. Data was collected through direct observation of the employees who work in the area. There were meetings with the other employees on how the area should be set up and where things needed to be kept. The communications were among the employees and those that directly worked in that area including three people that worked in the area, a lead, and an engineer. Everyone was kept up to date throughout every step of the process. During the data collection, measurements were taken, maps were drawn, and ideas were written down. The lead in the area was involved in assisting with the measurements, and drawing of the map. Employees were asked to write down comments and concerns that came to them while

preforming the job duties. The employees working in Department 1A were instructed to follow normal procedures in help keep the data collected accurate. An example of the layout distance worksheet that was used in Figure 1 below.

Layout Distance Worksheet		
Activity	Time (in mins.)	Distance (in feet)
From computer to computer		
Tip table to router 9		
Supplies in work center		

Figure 1 Example of a Distance Tracking Worksheet

Examination of the Process before the Project

The objective of this project was to use lean practices to shrink the square footage of the department to better utilize the space within the factory. In the beginning the machines being used were spread out too far from each other. Supplies were just thrown anywhere they could be set down, whether near the location of use or somewhere else in the work area. The supplies were not always placed in the same location, because the employees that worked in the area were not always there. Most of the time the supplies were put away by someone from outside the area and they were just trying to get done as soon as they could this indicated a work area that was in need of a 5S implementation as shown in Figure 2.

5S

In order to improve the work place organization the area will go through a 5S implementation. The first step in 5S is to sort. During this step the work is to determine what tools, supplies and pieces of equipment were needed. The items that are not needed are considered muda. The excess items would then be red tagged and removed from the location.

These items were either stored in the warehouse for future use in Department 1A or another department in the plant. This would be done by employees and the lead that used this area. When this was being completed employees were red tagging any item that had not been used for at least six months.

Figure 2 Picture of an area in need of 5S

The next phase is the set in order stage. In this stage employees place tools, supplies, and machine where they will be the most utilized. Then tools and supplies are labeled and this becomes their home, where they are to remain unless in use at the time.

This is so that every tool has the right spot to be in and is easily located. Marking can be done in many different ways by drawing around an object, to taping them off. This is done so that anybody that comes into the area can see if all the proper tools are where they need to be. After each tool and supply locations were taped off, next was labeling off each location. This was done so that everything was easily identified and would easily notice if it was missing.

After the order stage the project would address the shine stage. In this stage machines and tools would be deep cleaned. Each piece of equipment would be wiped down. Supplies are put into storage neatly; tools are all hung where needed. By doing these employees will be able

Figure 3 Picture of Supplies Labeled

to notice if a machine is not operating properly. This will help keep the area cleaner and more organized. This also defines what the area was designed to look like.

Standardization was the next step in the process. This was done by having every employee doing the job follow the same procedures. Whether it is how the grilles are put on a unit, to where every tool is kept. This process is not only for the employees working in the area, but also for the warehouse workers that are bringing supplies into the area for storage. With every location labeled they will put supplies in the right location every time.

The final stage of the 5S process is sustained. This is the hardest of the five steps to accomplish and maintain. This had to involve the supervisors, leads, and employees working in the area. A 5S checklist audit sheet will be developed to ensure this is achieved and maintain.

Spaghetti Diagram

A Spaghetti Diagram is a tool that places a process on paper drawing lines to show the process steps and flow. This process could be the product, information or the movement of people (Gjeldum, 2011). The project area was drawn on paper, each machine was laid out, and

lines are then drawn from the first step of the process through the final step. This diagram will be used to help determine if there are any unnecessary movements being made.

The first step taken was to measure the area in feet. The measurements also include where each of the machines stood in comparison to each other within the area. After this was done then a map of the area was drawn out with all of the dimensions and where each pieces of equipment was located. By doing this the employees working on this project were able to determine that there was too much space being underutilized.

The map of the area was important in many different ways see Figure 4. One way it helped was for the development of a spaghetti diagram. This diagram was used in determining that there was excessive amount of steps being taken by the person or persons working in this area. This diagram was used to determine where the best location for each piece of equipment would be. Figure 4 is an example of a Spaghetti Diagram.

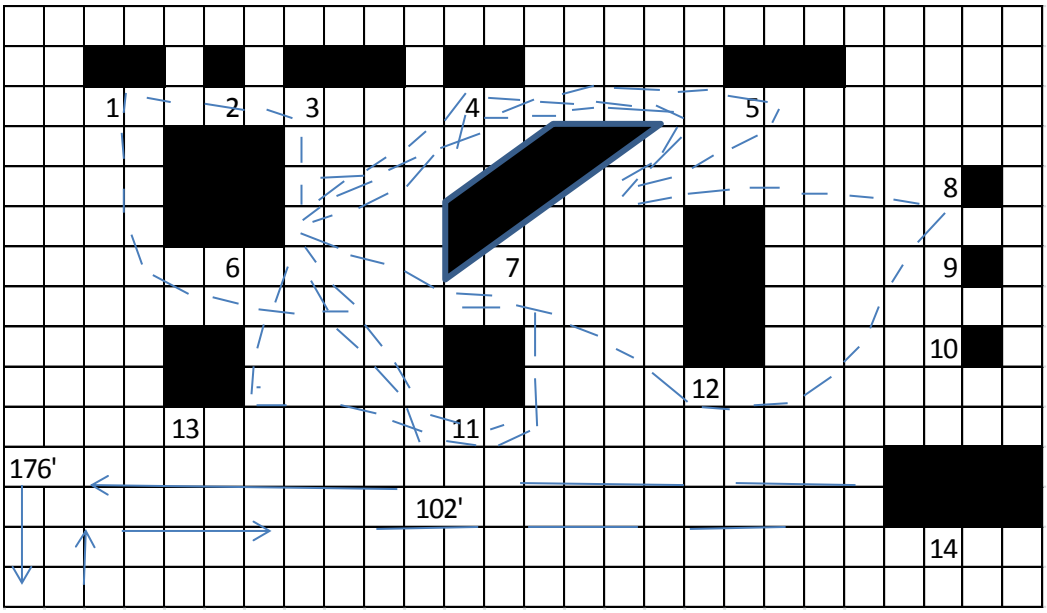

Figure 4 Example of a Spaghetti Diagram

This will identify the waste of motion going on with in this process.

U-shaped Work Cell

In the design of the area a U-shaped work cell would be considered. Shown in Figure 5 is an example of what a U-shape work cell looks like. The value that this type of work center would add is a decrease in the amount of steps that an employee working in this area would be required to complete this process. The machines and supplies would be closer together, taking a step or two in any direction and an employee would be along another machine or able to get to tools needed. The supplies would be loaded from the outside of the U and employees could help other employees easily. This would also benefit the warehouse personnel, instead of going into the work center to put the supplies away; the warehouse workers will also will be able to do this from the outside.

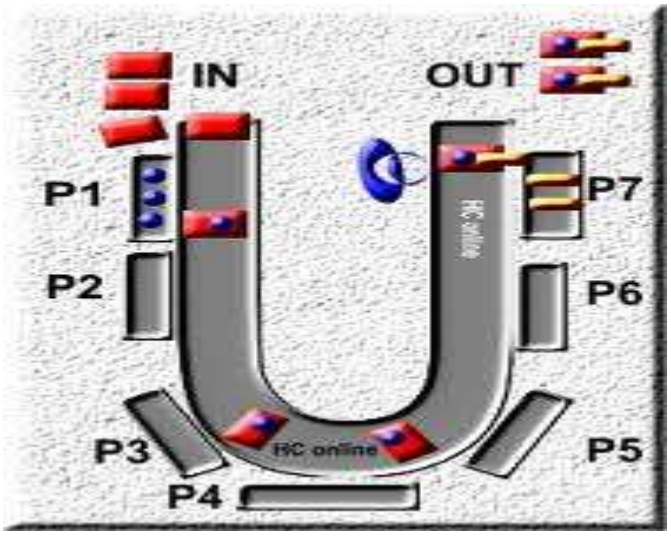

Figure 5 Example of a U-shaped work cell

Summary

This chapter defined the methods that were used to address the problems in the work area. The specific lean tools that would be utilized include spaghetti diagram and 5S. In Chapter IV results of this work will be described. Employees were involved in the design of the work

area. The process was watched to see how the employees did the work and what machines were being used. The spaghetti chart was used to see how much walking each employee would take during the production of a grilled unit.

Chapter IV: Results

The lack of organization and spacing of equipment and supplies in Department 1A was causing excessive and unnecessary movement by the department employees. This movement has resulted in wasted time and lost production. This department required 5S and lean manufacturing tools to help organize the area. The implementation of 5S has provided an effective and productive work space that reduces the movement of the people and increased the output of the product.

The purpose of the study in Department 1A was to decrease the square footage that it required and increase the efficiency and effectiveness of the production employees. This decreased the amount of steps being taken by employees working in the area and to increase the output of the department, which in turn will help manage any extra, demand put on the area. The current design of the department was studied and the need for a change in the layout was noticed.

Current State

The existing area was measured in at 1,456 square feet. The machines, supplies, and tools are scattered throughout the area. The equipment being used on all grilles are:

1. Tip table
2. Computer 1
3. Computer 2
4. Saw
5. Router (place grilles on window, flip window over)
6. Router (place grilles on window)
7. Place on rack

The two computers that were required to be used on each window to be grilled were kept at different ends of the area; this was addressed in the current layout. The routers were kept clear to one end of the work area and the tip table was located in the other half of the area. The processes were spread out which consumes excess space and inefficient work.

Data Collection

The data that was collected was used to analyze the current lay out, and to create the new layout for Department 1A. This data was collected by direct work observation of the employees as they worked in the area. They were informed that they needed to follow standard processes and procedures. That project was not intended to change any of the processes that were not part of the project .Data was collected in the first stage of the project, to determine if the area could be made smaller. The data was collected three different times during the project. The communication was among the employees working the area and any impacted employees. Through this communication and the observation of these employees an Activity Tracking Worksheet was filled out to help with identifying any wasted movement. The process steps to produce the product include:

1. Scan tag
2. Start window on laser computer
3. Align window with laser
4. Measure, cut and router grille pieces
5. Place grilles on windows
6. Flip window over either using tip table or manually
7. Measure, cut and router grille pieces
8. Place grilles on window

9. Put window in box

10. Place on flat to be shipped

11. Label and scan window tag

After the completion of the Layout Distance worksheet and the new setup for Department 1A the distance between the two computers went from 28 feet to four feet with a reduction of 86% in distance. The steps that were saved will help increase the output of the employees working this area.

Distance Tracking Worksheet		
Activity	**Time (in mins.)**	**Distance (in feet)**
Computer 1 to computer 2		34 feet
Computer 2 to tip table		12 feet
Tip table to saw		16 feet
Saw to router		18 feet
Router to tip table		36 feet
Tip table to saw		16 feet
Saw to router		18 feet
Router to tip table		36 feet
Place on flat to be shipped		6 feet
Acquiring FX skins	30 mins.	239 feet

Figure 6. Before Layout Distance Worksheet

In the original set up of Department 1A the employee that was working in the department would walk and average of 192 feet to put the grilles on one window. In the new layout for the department, the employee traveled 66 feet for a savings of 126 feet. The total number of feet the employees were walking is shown in Figure 7, 8, and 9. The increase in productivity is approximately about 66%.

Distance Tracking Worksheet		
Activity	**Time (in mins.)**	**Distance (in feet)**
Computer1 to computer2		4 feet
Computer 2 to tip table		12 feet
Tip table to saw		8 feet
Saw to router		8 feet
Router to tip table		6 feet
Tip table to saw		8 feet
Saw to router		8 feet
Router to tip table		6 feet
Place on flat to be shipped		6 feet
Acquiring FX skins	15 mins	20 feet

Figure 7. After Layout Distance Worksheet

Distance Tracking Worksheet		
Activity	**Reductions (in mins.)**	**Reductions (in feet)**
Computer 1 to computer 2		30 feet
Computer to tip table		0 feet
Tip table to saw		8 feet
Saw to router		12 feet
Router to tip table		4 feet
Tip table to saw		8 feet
Saw to router		12 feet
Router to tip table		4 feet
Place on flat to be shipped		0 feet
Acquiring FX skins	15 mins	219 feet

Figure 8. Results in savings

5S

5S was decided to be implemented in this department, by going through the five steps sort, set in order, shine, standardize, and sustain to help with organization and cleanliness of this department. In the sort stage the employees will tag items that are no longer needed Figure 9

show items that have been red tagged. Then the set in order stage supplies were put in their proper storage location and labeled. This not only helps the employees in the area but also the employees that work in the warehouse that are required to come into the area to put supplies away. Implementing 5S in this department got the employees to do a deep clean; this is very beneficial for many reasons, as explained later. The standardization stage has always been in the area with the employees following the proper work procedure for the department.

The sort stage employees placed the extra tools and unneeded supplies onto a cart. Then these were taken and stored in the warehouse for further use in the work center or another if needed. Employees were informed that anything that was not used in the last six months needed to be removed. They discovered that there were six boxes of extra supplies being stored in the area. Discovered during this phase was nine tools in the area did not even belong there.

Figure 9. Tools red tagged ready for removal

The next phase set in order stage tools, supplies and equipment were placed where they would be needed or to be stored. Each item was then labeled and locations for storage racks or supplies were taped off. This was intended to make it easier for warehouse personnel to know where the supplies were kept, also when an employee went into the area they would know if there was anything was missing. Employees would be able to tell if there were enough supplies to do the job at hand or if they needed to have more brought to the area. Figure 10 shows the

area following the set in order phase, there is a location for each item and each location is also labeled for easier identification by all employees entering the area.

Figure 10. Supplies labeled

The shine stage followed the set in order phase. All machines were wiped down, floors swept, tools cleaned and supplies put where they belonged. This stage is an important one, not only because of the cleaning, but now if a piece of machine is not working properly or leaking any fluids. This will help all of the employees coming into the area to identify any potential breakdown. An employee will be able to see if there are enough supplies to do the job on hand or if they need to get more. The employees working in the area will also know what the department should look like before they leave, the will help the next employee coming into the area.

Standardization was already being done in the area. All employees were to follow standard procedures when working in the area. The change involved proper placement of supplies and tools. Every employee working in the area will know where everything belongs and if anything is missing. As a result of the changes that were made to Department 1A, the results are a more clean and organized work center, with the ability of other employees coming into the

area and finding what is needed. The impact of the reduction of square footage installed the need of the implementation of 5S.

The final stage of 5S is sustain. This is the hardest stage to obtain. It requires that all employees needed to follow standards and procedures that were put in place. The leads and supervisors need to check the work of employees to make sure all standard procedures are being followed. To help the department sustain 5S the employees are required to clean the area after each day that windows are to be grilled. The lead of this area is to make sure that this is being done.

Spaghetti Diagram

With a new map of Department 1A a new spaghetti diagram was created, to see how much of a reduction in travel that these employees did. This diagram showed that the area's size could be reduced by 42% in amount of space utilized with all of the machines still able to be utilized. Spaghetti diagrams help to show the inefficiencies in the work center, it can help to increase safety, tells the number of trips a person makes to the same machine and a way to better allocate a person time.

The original spaghetti diagram shown in Figure 11 for Department 1A 1,456 square feet was utilized. Figure 12 shows the new layout of square footage of 840 feet, after the rearranging of Department 1A. This reduction allowed the factory to save 616 square feet, a reduction of 42%. This new area has become the FX skin warehouse.

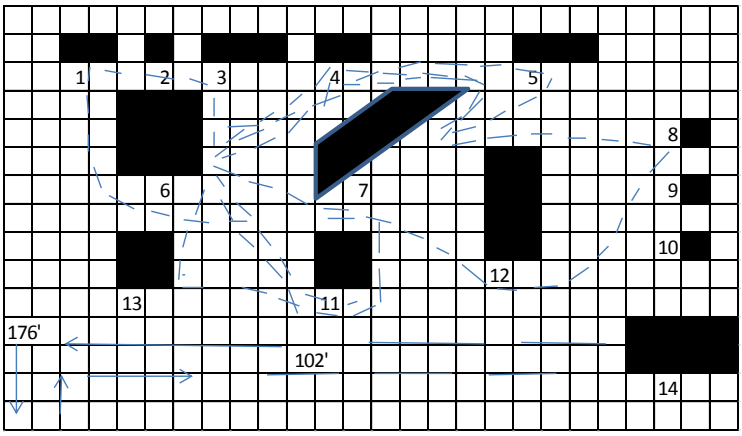

Figure 11. Original Spaghetti Chart

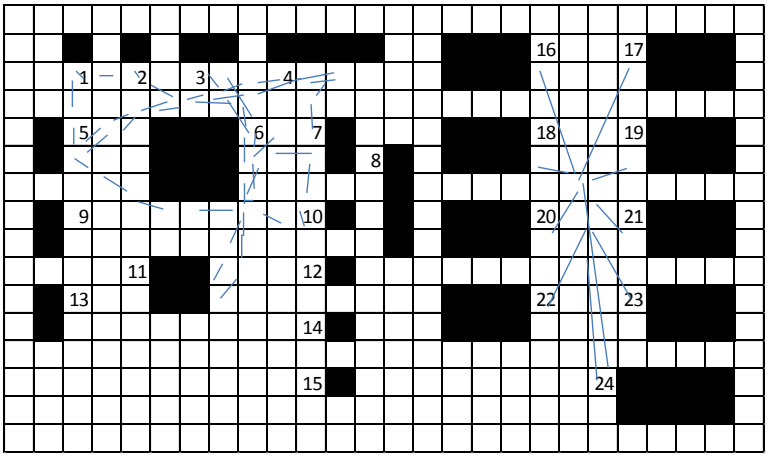

Figure 12. New Spaghetti Chart

Other Benefits

After the rearrangement of Department 1A the project freed up 616 square feet. The project then moved the FX skin warehouse into this area. As shown in Figure 12 there was of room for this to be accomplished. The service person that was pulling the skins for the FX department was walking 478 feet to take the skin cart to fill it and bring it back to the line and in 30 minutes. With the movement of the FX skin warehouse to its new location there was a time savings of approximately 15 minutes or a reduction in time of 50%.

U-shaped Work Cell

This design was to put the machine around the tip table in the form of a U as shown in Figure 13. This provided a reduction of 42% in the spaced utilized. The employees in this area will travel a few steps to get to any of the machines that will be needed. Doing this will increase the production volume of these windows in the future.

Figure 13. The work center as a U-shape work cell

Summary

The revised Department 1A utilizes 840 square feet; this represents a 42% reduction from the prior condition. The reduction decreased the travel distance between the machines. This also benefitted the supplies that are now stored within the department. The revised Department 1A is more compact and easily accessible so that an employee working in this area will only need to take a few steps between machines, placed next to each other to make the beginning steps quicker. With the routers closer to the tip table this has allowed for any adjustment that needs to be made to a grille to be done with minimal movement.

5S was used to benefit the department, not only by reducing the size but also providing organization. After the new layout was implemented a new map of the area was created and with this a spaghetti diagram was done. This spaghetti diagram showed that fewer steps were needed to reach any machine.

It was noted that the employees that was working in the area was doing a lot of walking from machine to machine. It was also noted that this was causing extra time to be spent on each unit that was being grilled, decreasing the units produced per person in the area. As a bonus to saving travel time inside the work center, distance was also saved for the service person pulling the window skins for the FX department. This was person was traveling 239 feet to get to these skins. With reduction in the square footage of Department 1A the FX skins were moved to this open location in the department.

In Chapter V the discussion will go into what needs to happen next. What the project still needs to accomplish and any other issues that may arise.

Chapter V Discussion

The project examined the amount of space that Department 1A was utilizing. A project was initiated to determine if the space could be reduced to help with the process of installing external grilles to non-operational windows. Applications of lean tools were used along with 5S to provide a result of 42% reduction in the space of Department 1A. As an added benefit from this project the FX skins were moved out of the warehouse and placed close to the point of use.

Chapter I defined why Department 1A was in need of 5S and the application of lean tools to reduce and to better organize the area. Chapter II reviewed literature of the application of lean tools and addressed how an area would benefit from 5S reorganization. Chapter III discussed how the application of lean methodology and 5S were used to obtain data, and how the use of a Spaghetti Diagram would benefit the project. Chapter IV explained the results of applying lean methodologies and the benefits of 5S.

Limitations

The results from this project were limited to the specifications that were required for Department 1A. The results of this project cannot be widespread or deduced from evidence outside of the scope of this paper, due to the specialized nature of Department 1A. The creation of a Spaghetti Diagram was essential to identify excessive space and movements by the employees in this department.

The project was limited to no addition in equipment, processes, and employees working within Department 1A for the installation of grilles. The project applied only lean tools as this was a chosen directive of the company and could provide results within the time frame assigned for the project.

Conclusions

The project in Department 1A was a success in terms of the introduction of lean procedures and 5S methodologies. The detection of wasted space and movement of employees warranted the applied use of 5S. Through the use of lean methodologies along with a Spaghetti Diagram, a reduction in the square footage used by Department 1A was made. The square footage went from 1,456 square feet to 840 square feet for a 42% saving. This saving in square footage had other benefits, by allowing FX skins to be placed closer to their origin of use. The service person for the FX department was traveling 239 feet to acquire the skins, pushing a cart in both directions. These components are within 20 feet, providing a reduction 219 feet of travel to acquire these components. The result of this move saves an average of 1,095 feet traveled each day.

Recommendations

The use of lean processes and principles were focused only at Department 1A. In the future, further processes and applications of lean maybe looked at to help with the efficiencies of other departments within Company X.

The application of 5S was successfully applied to Department 1A. There is less clutter and more organization. A 5S check list needs to be designed so that the employees are more aware of their responsibility at the end of the shift to provide the sustainability step of the 5S process.

The project has proven that putting into practice the philosophy of lean has been a success within Department 1A. The education of lean principles and tools may encourage other employees in different departments to look into how these tools maybe a benefit in other areas.

This project showed the results of the application of lean and 5S within Department 1A. Teams from the other areas should also be trained on the benefits of a successful 5S execution.

The management team should keep searching for ways to continually improve processes in all areas of the plant. The management team should look to the employees that are actually performing the jobs for their inputs and ideas for improvements.

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