Lean Tools in a Machine Shop Company

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Abstract *— A machine shop company has been identified due to lack organization in the workplace, deficiency by not labeling and storing used tools; workplace preventive maintenance, machines and workflow. The decision-making process comes from a dialogue about standardization of process, which builds understanding among employees of how should do the work. Another problem was how to meet with the specifications of product from customer by meeting with the demand per days and adding value to the product. The tools selected to resolve the situations of the company was to perform lean manufacturing process by getting the results per Kaizen events (the cycle of Kaizen, known as the Shewhart cycle, Deming cycle, or PDCA) and 6S (Sort, Set in order, Shine, Schedule, Score and Safety). Contributions of lean approach to business improvement will be used to improve safety, reduce lead time, raise employee morale, identify problems more quickly, develop control through visibility, establish convenient work practices, and increase the workflow in the workplace.*

Key Terms *— 6S, Kaizen Events, Lean Manufacturing Process, Standardization.*

INTRODUCTION

Although perhaps under-studied in the research literature, anecdotal accounts indicate that kaizen events are becoming a popular problem solving and continuous improvement tool for manufacturing process. Kaizen events are essentially well-structured, multi-day problem solving sessions involving a cross-functional team, who is empowered to use experimentation as they see fit to derive a solution. This article details the application of 6S by using the kaizen event methodology for a manufacturing process. The 6S methodology is another universal technique that can be applied to all types of businesses and organizations, both in shops and in offices, even those that apparently are sufficiently neat and clean. This technique can bring excellent results for its simplicity and effectiveness. The aim is to improve and maintain organization, order and cleanliness in the machine shop. It aims to improve working conditions, safety, working environment, staff motivation and efficiency, quality, productivity and competitiveness of the company. The machine shop operator, under study, works daily with many tools and machines depending of the job, and receives suppliers on different time, which requires having a clean and uncluttered viewing area to expedite the process and avoid accidents. The state of machine shop is a clear disorder; tools and machines out of place and no visual controls are not used to facilitate the searching of tools, and machineries. There was a high level of inventory, which meant that had more movement and useless transfers within different areas in the machine shop.

PROBLEM STATEMENT

Industrial Project is a machine shop company that provides various services like warehouse maintenance, welding, forklift- housing tire and trailer reparation; rebuild engines; design and create several parts for different application and orders from customer. By using lathes, milling machines, drill press and other kind of machinery permit to offers those kinds of services. One of the problems and situations that originated this work is how to maximize customer value while minimizing waste and how to create process that need less human effort, less space, less capital and less time to make products and service at less costs and with much fewer defects. It is very important to do this

research in order to investigate how can increase the quality of products, add value to any activity or process for the customer and how improve the manufacturing process by using lean philosophy.

RESEARCH DESCRIPTIONS

The research is about how to establish facts, solve new or existing problems, prove new ideas, or develop new theories for manufacturing process by using lean manufacturing tools to the company. It is very important to develop this study because it allows the identification of research problem, literature review, and specify the purpose of research. Data collection and analysis of information could increase understanding of any problems and situation relate to manufacturing process.

RESEARCH OBJECTIVES

The objectives of this research are the following: implement lean manufacturing tools to increase quality and reduce or eliminate waste in the manufacturing process. Create process that need less human effort, space, capital and time to make products and services by minimizing cost and defects. It is expected to add value by producing goods or providing a service that meet the specifications of customers. It should be done by implementing lean manufacturing tools like Kaizen event methodology, 6S and visual control.

RESEARCH CONTRIBUTIONS

The research will provide several contributions. The main contributions with the development will identify problems, issues and situations that have a main impact into the manufacturing process, products and customer service. Once they are corrected, the competitiveness of the company will increase.

LITERATURE REVIEW

The research area selected for the design project is the implementation of a lean manufacturing process in a machine shop company. The selection was done due to the disorganization into the workplace and lack of quality.

Kincaid [1] defined waste as anything not essential to the process like overproduction, unnecessary motion, inventory, waiting, transportation, defects, underutilized people and extra unnecessary processing. Lean manufacturing is defined by The Lean Manufacturing Guide as "A systematic approach to identifying and eliminating waste through continuous improvement by flowing the product at the demand of the customer" [2]. It is derived from Toyota Production System and its objective is to increase the value-added work by eliminating wastes and reducing unnecessary work. The technique often decreases the time between a customer order and shipment, and it is designed to improve profitability, customer satisfaction, throughput time, and employee motivation. When this process is implemented right, better ways to do most productive work with the least expenditure of time and materials are found, and accident prevention benefits will be obtained as a side effect.

One of the tools to perform a lean manufacturing process in the machine shop is Kaizen. It refers to a philosophy or a set of practices that focuses on the continuous improvement of processes in manufacturing or any other organizational environment. It can be applied to both manufacturing and business processes, such as logistics, engineering, and supply chain. Kaizen refers to activities that continually improve all functions, and involves all employees from the shop workers and engineers. In other words, Kaizen is “a system of continuous improvement in quality, technology, processes, company culture, productivity, safety and leadership [3].

Another of the tools to perform a lean and safe manufacturing process in the machine shop is 6S. The name 6S comes from the six Japanese words that make up the six stages of 6S, each one starting with the letter “S”. The 6S methodology uses six principles: Sort, Set in order, Shiny-clean, Standardize clean-up, Sustain and Safety. The 6S principles [4] are the following:

- Sort - divides things into the necessary and the useless or out-dated categories; then it discards the useless things.
- Set in order - means to neatly arrange and identify parts, processes, and tools for ease of use. It eliminates waste like searching, walking human energy, excess inventory, and unsafe conditions. Visual controls are used to communicate information such as where items belong.
- Shiny-Clean - is a one-time step to make everything clean and set that as the standard. Standardized clean-up is the ongoing and regular task of keeping the facility clean to meet the "Shiny-Clean" standard.
- Standardize - It is the method to maintain the first 3S- sort, set in order, and shine.
- Sustain - Maintain and review standards. Maintain focus on this new way and do not allow a gradual decline back to the old ways.
- Safety - Eliminate hazards. This sixth "S" has been added in order to maintain the focus on safety within the lean events and embed safe conditions into all improvements.

METHODOLOGY

In order to implement the 6S on workplace, the Kaizen events methodology should be used. The first step is to organize a program committee responsible for develop a plan and a budget per Kaizen events. This program committee is compound by the manufacture engineer and operators. Once the program is developed it is recommended to make an introduction announcement to the employees before starts the program. Then program committee will give some training and support to employees to discuss the purpose, mission, objectives and goals for the event. Those new procedures will be implemented in the machine shop area. After closely observing the actual application of the 6S plan, evaluations will be made regarding its effectiveness. Once it has been completed the corrective actions will take place if there is any inefficiency. All of these procedures should be implemented on details per Kaizen events.

The cycle of kaizen activity can be defined as:

- Standardize an operation and activities.
- Measure the standardized operation (find cycle time and amount of in-process inventory).
- Gauge measurements against requirements
- Innovate to meet requirements and increase productivity.
- Standardize the new, improved operations
- Continue cycle ad infinitum.

This is also known as the Shewhart cycle, Deming cycle, or PDCA. PDCA (plan–do–check–act or plan–do–check–adjust) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. It is also known as the Deming circle/cycle/wheel, Shewhart cycle, control circle/cycle, or plan–do–study–act (PDSA) [4].

It is a technique of four steps to implement any lean tools like 6S and visual control. Both tools 6S and visual control will be implemented in the machine shop area by using the Kaizen.

The PDCA is a project methodology with four phases as show in Figure 1:

Figure 1
PDCA

By implementing the PDCA technique mentioned above will help to implement the 6S methodology in the machine shop.

The steps in each successive PDCA cycle [4] are the following**:**

- Plan- Establish the objectives and processes necessary to deliver results in accordance with the expected output (the target or goals). By establishing output expectations, the completeness and accuracy of the specification is also a part of the targeted improvement.

- Do-Implement the plan, execute the process, and make the product. Collect data for charting and analysis in the following "CHECK" and "ACT" steps.
- Check- Study the actual results (measured and collected in "DO" above) and compare against the expected results (targets or goals from the "PLAN") to ascertain any differences. Look for deviation in implementation from the plan and also look for the appropriateness/completeness of the plan to enable the execution. Charting data can make this much easier to see trends over several PDCA cycles and in order to convert the collected data into information. Information is what you need for the next step "ACT".
- Act- Request corrective actions of significant differences between actual and planned results. Analyze the differences to determine their root causes. Determine where to apply changes that will include improvement of the process or product.

A summary of the activities to be performed as part of the implementation is detailed below:

Sort

The Red – Tag strategy showed on Figure 2 is a simple method for identifying unneeded items, evaluate their usefulness, and deal with them appropriately.

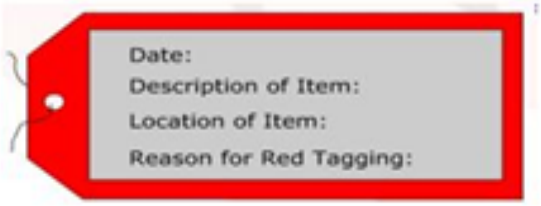


Figure 2
Red-Tag Examples

A team will perform the red tag analysis in one or two days. It helps to identify what items are required in the machine shop area like supplies, materials, tools and paper work to do the required task or project. Each red –tagged item is dated and moved to a central holding area. This system is the way to free up valuable floor space by determining the minimum and maximum quantities that should be stored in the work area and determining the off-line storage location for items that are seldom used.

Set in Order

Organizes the machine shop area for the maximum possible efficient. It means arranging needed items so that they are easy to use and labeling them so that anyone can find them and put them away. The ideal is economy of time and motion. When orderliness is implemented, there is no wasted human energy or excess inventory. Visual controls like showed on Figure 3 is used to communicate information such as where items belong. Storage areas, cabinets and shelves should be properly labeled. By using signboard strategy help to identify what, where, and how many should be in area of work. Clean and paint floors facilitate to make it easier to spot dirt, waste material and dropped parts and tools. Outline areas on the floor help to identify work areas, movement lanes, storage areas and finished product areas. Put shadows on tool boards, making it easy to quickly see where each tool belongs.

Figure 3
Visual Control

Shine

Keep everything swept and clean. The purpose is to keep everything in top condition so that when someone needs to use something, it is ready to be used. It is not only sweeping floors and wiping off machinery, cleaning also means inspection. Shine

in the machine shop area can be implementing by choosing targets, performing five minutes shine and incorporating systematic inspection procedures to the shine procedures. In addition, a cleaning schedule is performed in which an area is assigned to each operator to maintain clean, organized and in order the work areas.

Standardize

It is the method to maintain the first 3S- sort, set in order, and shine. The purpose is to prevent setbacks in the first 3S, to make a daily habit, and to maintain fully implemented. It should be completed by assigning 3S responsibilities. Integrate 3S duties into regular work duties-visual 6S (everyone should distinguish between abnormal and normal conditions). It should be use a checklist in order to check the 3S maintenance level in the machine shop area. Other kind of visual management that can be implemented is signboard in area of work.

Sustain

Without commitment to sustain the benefits of 6S activities quickly falls apart. For this reason some kind of role should be implemented. Involving the management department can help to educate, create teams, allow time, provide resources, and encourage involvement in the company. Educating to the coworkers by using training program help to meet with the sustain process. A good way to continue educating employees, and for maintain standards, is to use 6S poster and signs. It helps to remind employees of the proper procedures, and of the benefits that come from following plan.

Score

In order to display the performance metric a radar chart showed on Figure 4 should be implemented to evaluate the workplace after the completion of each process. It helps to show how a team has evaluated a number of organizational performance areas. It is essential to provide an overall realistic and useful picture of performance.

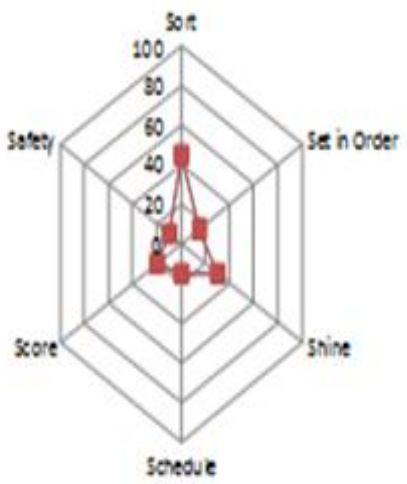


Figure 4
Radar Chart

Safety

It is necessary to perform a safety evaluation by reviewing every action and each area ensuring that there are not overlooked and potential hazards. A series of meetings, visits to the equipment and machining area are conducted to evaluate the manufacturing process, facilities and utilities.

PROJECT EXECUTION AND RESULTS

To get ready for the event, the machine shop area has been visited in order to identify what things the customer wants to improve. This is an important step in order to know the customer idea of how the work process in the target work area need to improve and what business benefits that improvement should produce. On this step the expectations of the customer can be confirmed. It can be evaluated in order to be sure that 6S can be used to accomplish the purposes the customer has expressed and provide the improvement that employees feel will be meaningful. It helps to see the possibility that 6S will take out enough waste travel, transport, and excess materials to justify its cost. To complete this step a project charter has been created in order to specific the problem statement in the machine shop company. See Table 1 for Project charter.

Table 1
Project Charter

Project Charter			
General Information			
Project Title:	Lean Tool In A Machine Shop Company		
Brief Project Description	Industrial Project is a machine shop company that provides various services like warehouse maintenance, welding, forklift- housing tire and trailer reparation; rebuild engines; design and create several parts for different application and orders from customer. By using lathes, milling machines, drill press and other kind of machinery permit to offers those kinds of services. One of the problems and situations that originated this work is how to maximize customer value while minimizing waste and how to create process that need less human effort, less space, less capital and less time to make products and service at less cost and with much fewer defects. In order to increase the quality of product and improve the manufacturing process the lean philosophy should be implemented.		
Prepared By:	Omar Acevedo Concepcion		
Date:	3/30/2012		
Project Team Member			
Manufacturing Engineer	Technician	Operator	
Project Objective:			
Implement lean manufacturing tools to increase quality and reduce or eliminate waste in the manufacturing process. Create process that need less human effort, space, capital and time to make products and services by minimizing cost and defects. It is expected to add value by producing goods or providing a service that meet the specifications of customers. It should be done by implementing lean manufacturing tools like Kaizen, 6S and visual management.			
Sponsor Approval:			
Rafael A. Nieves Castro, PharmD, MS, RPh			

Cross Functional Team ("Plan" from Kaizen Events)

In order to identify the people and areas for the event a meeting should be performed to identify the volunteers and areas that could work in this project. The team should be people working in the setting that will 6S. This meeting is a good opportunity to welcoming everyone and explains what the mission for the 6S event is. Propose the schedule by showing a Gantt chart like showed on Figure 5 and provide some pre-event materials to read and understand the scope of the event.

Once the team has been selected another meeting should be setup to provide training on lean principles, concepts, techniques, and explain what it is, how it is done, and showing some examples of "before" and after" including pictures of other work areas where 6S has been implemented. This meeting can be used to share what things are good and no good about its work area and list the concerns and ideas. This kind of ideas can be used as part of the information to analyze in detecting waste due to workplace disorganization and the lack of visual information.

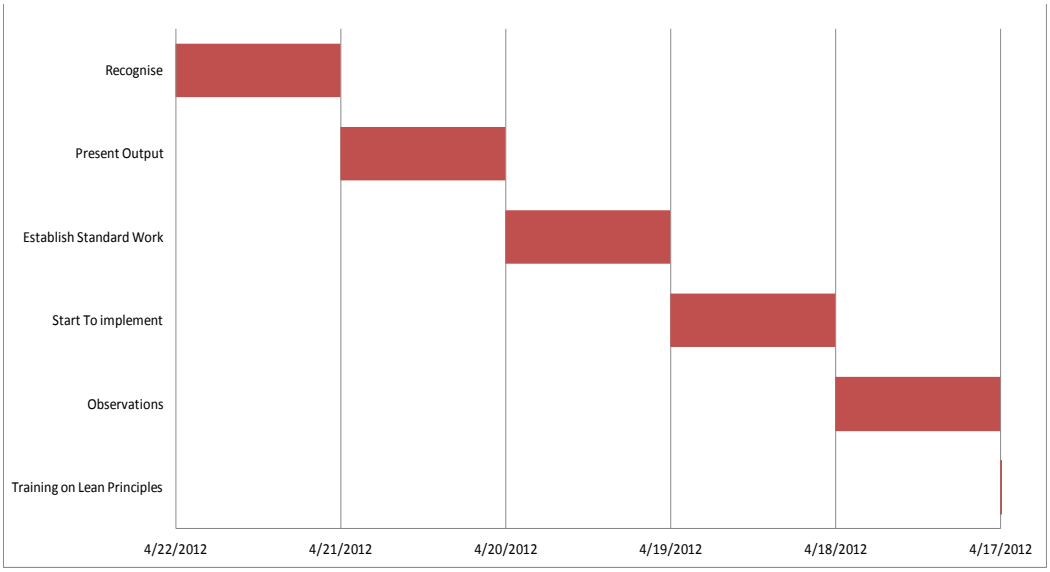


Figure 5
Gantt Chart

Get Fact ("Do" from Kaizen Events)

This is the data collection step. The team decides on what should be measured and how to measure it. This forms a data collection plan. It is usual for teams to invest a lot of effort into assessing the suitability of the proposed

measurement systems. The following task should be completed in order to get this data: do a process flowchart, take "before" pictures of the machine shop, make observations of waste in the workplace, and complete a 6S evaluation form. One team member should be selected in order to do the process flowchart and another to do the pictures using the digital camera. On Figure 6 shows the process flowchart for one job done in the machine shop. It is the reoperation process for the forklift-tire.

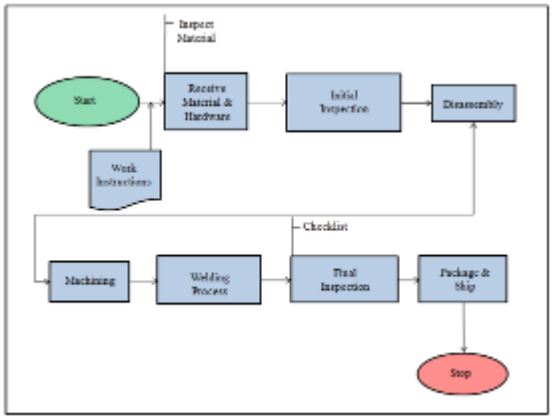


Figure 6
Current Process Flow Chart for the Reoperation Process on Forklift-Tire

Pictures before to implement 6S in workplace ("Do" form Kaizen events): See Figures 7 and 8.

Figure 7
Machine Shop with Multiple Waste Items

Figure 8
Machine Shop with Multiple Waste Items

Next step was to complete the checklist of 6S evaluation form; the time spent on setup time and searching tools before to implement 6S in the workplace, ("Do" from Kaizen events). See Tables 2 and 3.

The score measure has been established of the following: 2 = More than two problems have been found on areas inspected. 1 = One to two problems have been found on areas inspected.

Table 2
6S Evaluation Form

6S Evaluation Form			
6S Area: Manufacturing Process		Item score	
		Before 6S	After 6S
Sort	**Distinguish between what is needed and not needed**		
	Have all unnecessary items been	2	
	Are walkways, work areas, locations clearly	2	
	Does a procedure exist for removing unneeded items?	2	
Stabilize	**A place for everything and everything in its place**		
	Is there a place for everything?	2	
	Is everything in its place?	2	
Shine, (Cleanlines)	**Are locations obvious and easy to identify?**		
	Cleaning and looking for ways to keep it clean	2	
	Are work areas, equipment, tools, desk clean and free of debris, etc?	2	
	Are cleaning materials available and accessible?	2	
	Are all aisle marking, location indicators, etc., clean and unbroken?	2	
	Cleaning schedules exist and are posted?	2	
Standardize: (Adherence)	**Maintain and Monitor for adherence**		
	Is all necessary information visible?	2	
	Are all standards known and visible?	2	
	Are all visual displays current and up to date?	2	
	Is there adherence to existing standards?	2	
Sustain Self-(Discipline)	**Following the rules to sustain**		
	Are procedures being followed?	2	
	Does an on-going audit and feedback system exist?	2	
	Does a system exist to respond to audit feedback?	2	
Safety	**Maintaining a safe work place**		
	Is a green tag system in place?	2	
	Are appropriate controls in place to identify safety equipment?	2	
	Is all safety equipment unobstructed and accessible?	2	
	Total Score	40	
Evaluator Name: Omar Acevedo		Scoring: 0= No problems, 1= One to Two problems, 2= More than two problems	

Assess Waste ("Check" from Kaizen Event)

After the digital pictures were taken in the machine shop area, the observations of waste that derived from how the workplace was organized were documented. Also the 6S evaluation form was used before to implement 6S in order to get the

rating on each stage (Sort, Set in order, Shiny-clean, Standardize clean-up, Sustain and Safety). It permits to evaluate each stage of 6S methodology and use these to test whether the mission and goals for the event are valid, given the facts in the workplace. After revised the pictures and the 6S evaluation form several waste have been found. For example, due lack of organization into the machine shop the operator needs to walk more than is required to perform the reoperation. Also the operator spent more time in looking for the required tools to complete each step of the reoperation process for the forklift tire. Before to consider how to eliminate the wastes, some measurements were taken. For example, the time spent in setup and searching for tools in the during reoperation process. This measure allow to calibrate which type of waste most affect the performance during the reoperation process for the forklift tire. In order to get these data a measure has been done to the operator during the reoperation process for the forklift tire before to implement 6S.

Table 3
Time Spent on Setup Time and Searching Tools

(Time spent on Forklift Tire Process)	Description	Time before 6S Implemented
Initial inspection	Set up time	15 min
	Searching tools	5 min
	Total time before to start the inspection process	20 min
Disassembly	Set up time	20 min
	Searching tools	8 min
	Total time before to start disassembly process	28 min
Machining	Set up time	15 min
	Searching tools	8 min
	Total time before to start machining process	23 min
Welding	Set up time	8 min
	Searching tools	6 min
	Total time before to start welding process	14 min
Final inpection	Set up time	5 min
	Searching tools	5 min
	Total time before to start final inspection process	10 min
Total Process Time	**Time &min)**	**95 (min)**
	Time (hr)	**1.58 (hr)**

Make Improvements and Measure Results ("Act" From Kaizen Events)

On this step the team takes each goal, looks at the observations associated with it, and generates ideas to eliminate the waste and improve workplace organization and the display of important information. In order to do the improvements in the workplace the 6S methodology has been selected.

Implementing 6S methodology as improvement:

- Sort: The team may propose removing unnecessary items in the work area by using red tag. The Red – Tag strategy is a simple method for identifying unneeded items, evaluate their usefulness, and deal with them appropriately. See Figure 8 for red tags process.

Figure 8
Different Items have been selected by the Machine Shop Operator and Marked with Red Tags

- Set in Order: Organizes the machine shop area for the maximum possible efficient. It means arranging needed items so that they are easy to use and labeling them so that anyone can find them and put them away. The ideal is economy of time and motion. When orderliness is implemented, there is no wasted human energy or excess inventory. It eliminates waste like searching, walking, excess inventory, and unsafe conditions. Visual controls have been used to communicate information such as where items belong. Storage areas, cabinets and shelves have been labeled. By using signboard strategy help to identify what, where, and how many should be in area of work. Clean and paint floors facilitate to make it easier to spot dirt, waste material and dropped parts and tools. Outline areas on the floor help to identify work areas, movement lanes, storage areas and finished product areas. Put shadows on tool

boards, making it easy to quickly see where each tool belongs. See Figures from 9 to 10 in order to see the implementation of this step in the workplace.

Figure 9
Visual Controls have been used to Communicate Information

Figure 10
Visual Controls on the Floor and Parts Ordered

- Shine: Keep everything swept and clean. The purpose is to keep everything in top condition so that when someone needs to use something, it is ready to be used. Shine in the machine shop area has been implementing by choosing targets, performing shine and incorporating systematic inspection procedures to the shine procedures. In addition, a cleaning schedule is performed in which an area is assigned to each operator to maintain clean, organized and in order the work areas. See Figures 11 and 12.

Figure 11
Visual Shine Step Implemented in the Machine Shop

Figure 12
Visual Shine Step Implemented in the Machine Shop

- Standardize - It is the method to maintain the first 3S- sort, set in order, and shine. The 6S evaluation form has been used as checklist in order to check the 3S maintenance level in the machine shop area. On Table 4 the 6S evaluation form has been completed after 6S has been implemented. No problems were found after implementation of 6S in the workplace.
- Sustain: Involving the management department can help to educate, create teams, allow time, provide resources, and encourage involvement in the company. Educating to the coworkers by using training program help to meet with the sustain process. A good way to continue educating employees, and for maintain

standards, is to use 6S poster and signs. It helps to remind employees of the proper procedures, and of the benefits that come from following plan. A master schedule showed on Table 5 has been created to verify that each activity is completed for each operator at the end of the process.

Table 4
6S Evaluation Form

6S Evaluation Form			
6S Area: Manufacturing Process		Item score	
		Before 6S	After 6S
Sort	**Distinguish between what is needed and not needed**		
	Have all unnecessary items been		0
	Are walkways, work areas, locations clearly		0
	Does a procedure exist for removing unneed items?		0
Stabilize	**A place for everything and everything in its place**		
	Is there a place for everything?		0
	Is everything in its place?		0
Shine, (Cleanlines)	**Are locations obvious and easy to identify?**		
	Cleaning and looking for ways to keep it clea		0
	Are work areas, equipment, tools, desk clear free of debris, etc?		0
	Are cleaning materials available and accessil		0
	Are all aisle marking, location indicators, etc clean and unbroken?		0
	Cleaning schedules exist and are posted?		0
Standardize (Adherence)	**Maintain and Monitor for adherence**		
	Is all necessary informatio n visible?		0
	Are all standards known and visible?		0
	Are all visual displays current and up to date		0
	Is there adherence to existing standards?		0
Sustain Self (Discipline)	**Following the rules to sustain**		
	Are procedures being followed?		0
	Does an ongoing audit and feedback system exist?		0
	Does a system exist to respond to audit feedback?		0
Safety	**Maintaining a safe work place**		
	Is a green tag system in place?		0
	Are appropriate controls in place to identify safety equipment?		0
	Is all safety equipment unobstructed and accessible?		0
	Total Scor		0
Evaluator Name: Omar Acevedo		Scoring: 0= No problems, 1= One to Two problems, 2= Mor than two problems	

- Safety: Building awareness into all activities is the focus of this step. Zero accidents and injuries will be attained when accident prevention, identifying and eliminating hazards, becomes an integral part 6S program. Once the assessment has been done on previous step ("Do" from Kaizen event") into the workplace some measures have been implemented. One of the measures was to use all the security equipment necessary per OSHA regulations before to start any jobs. A manufacturing engineering has been selected in order to be responsible of any security regulations into the workplace. All employees will be inspected before to start any job into the workplace in order to verify that meet with the OSHA regulations. Some security equipments most used and have been implemented in the machine shop are the following: ear protective, eyewear, face shier, safety gloves, safety labels and signs, welding gloves, welding jackets, and clothing depending of the job. In order to maintain it into the workplace the visual control of security has been used as required in the workplace to remind it to any employees before to start any job. See Figure 12 for examples of safety equipments.

Table 5
Master Squedule

Master Schedule							
Month: April 2012							
Workplace: Machine shop							
	S	Mo	Tu	We	Th	Fr	Sa
Week 1	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
		Operator	Operator	Operator	Operator	Operator	
Week 2	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
		Operator	Operator	Operator	Operator	Operator	
Week 3	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21
		Operator	Operator	Operator	Operator	Operator	
Week 4	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28
		Operator					
Week 5	Day 29	Day 30					
		Operator					
Legend							
Perform 6S							
Days of Week							

- Score: All the activities in the machine shop area have been measured before and after the 6S event and the score system has been implemented. Once each operator has been completed the 6S check list evaluation form to evaluate each activity before and after the implementation the score system has been used

to evaluate the results. The scores were obtained from the 6S check list evaluation form. The radar chart showed on Figure 13 has been used to visualize the results before and after the 6S event in machine shop

Ear protective

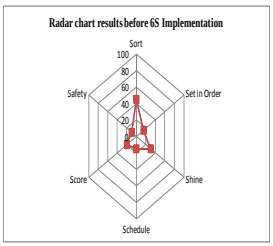
Eye Wear

Safety Gloves

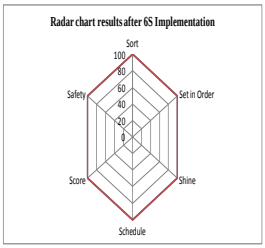
Safety Labels

Fire Extinguisher

Figure 12
Safety Equipments



Before 6S



After 6S

Figure 13
Radar Chart Before and after 6S Implementation

Time Spent on Setup and Searching Tools after 6S Implemented ("Act" from Kaizen Events)

After 6S has been implemented the time spent on setup and searching tools for the reoperation process for the forklift tire were documented. It is good test in order to compare the results after implemented 6S in the machine shop. On Table 6 show the result obtained before and after implementation of 6S methodology.

The total time reduction before to start each step for the reoperation process is 1.58 hrs - .90 hr = .68 hrs per Table 6. The customer demand is 1 reoperation/day and the cycle time is 7.0 hrs /reoperation. Before to implement the 6S methodology in the machine shop the original cycle time was 7.0 hrs + 1.58 hrs = 8.58 hrs per reoperations. After implementation of 6S 0.68 hrs/reoperation was found of not value added to the customer product. See Table 6 the total process time after 6S implementation.

Table 6
Time Spento on Setup Time and Searching Tools for the Reoperation Process

Type of job (Forklift Tire)	Time before 6S Implemented	Time after 6S Implemented
Disassembly Process	10 min	5 min
	35 min	15 min
	45 min	20 min
Housing Reoperation	60 min	30 min
	90 min	60 min
	145 min	90 min
Welding Process	15 min	7 min
	5 min	5 min
	20 min	12 min
Total process time	3.5 hr	2 hr
(Time spent on Forklift Tire Process)	Time before 6S Implemented	Time after 6S Implemented
Initial inspection	15 min	12 min
	5 min	2.5 min
	20 min	14.5 min
Disassembly	20 min	12 min
	8 min	2 min
	28 min	14 min
Machining	15 min	10 min
	8 min	5 min
	23 min	15 min
Welding	8 min	5 min
	6 min	2 min
	14 min	7 min
Final inpection	5 min	2 min
	5 min	2 min
	10 min	4 min
Total Process Time	95 (min)	54.5 (min)
	1.58 (hr)	0.90 (hr)

Saving after Implementation of 6S

Below is a Table that show the annual total cost of the overtime done during the reoperations process for the forklift tire before to implementation of 6S. To complete the reoperation process three operators are required in the workplace. On Table 7 shows a total annual cost of overtime per $835.20 without the implementation of 6S.

Table 7
Savings after Implementation of 6S

Quantity of operators per shift	Total overtime including the three operators (hrs)	Days	Total overtime before 6S Implementation (Hrs)	Rate / Hour ($)	Total cost of overtime before 6S Implementation	Annual Cost of Overtime ($)
3	1.74	5	8.70	10.00	87.00	835.2

Per Table 7 the total annual cost of overtime was $835.20 before to implement the 6S. After implementation of 6S the overtime for the three operators is not required therefore the company could have savings of $835.20 on average by

keeping the customer the same demand/day of the reoperations.

CONCLUSIONS AND RECOMMENDATIONS

After Kaizen event and 6S methodology implementation in the machine shop considerable improvements has been observed as show on Figure 13 and Table 7. The implementation of 6S has changed the mindset of employees by increasing morale, helping to identify problems more quickly and promoting better communication between staff working in the area. Therefore, the implementation of 6S had result satisfactory by improve safety, reduced down time, increase the time and quality products. One objective was to reduce the lead time for each step of the reoperation process. Per Table 6 the total time reduction before start each step for reoperation process was 0.68 hrs. It means that the previous reoperation process had 0.68hrs of not value added to customer's product. By implementing 6S methodology the not value added has been eliminated from the customer's product increasing the quality. Also the current shift before to implement the 6S was the 8.58 hrs on average and due this situation each operator need to stay 0.58 hrs more than current time per shift in the machine shop in order to complete the reoperation/day for the customer. It means that the company needs to pay more money to complete each reoperation/day with not value added to the final product. After implementation of 6S this overtime by each operator is not required therefore the demand/day can be completed with less money and value added. Per Table 7 the company could have savings of $835.20 on average by keeping the customer the same demand/day of reoperations. Recommendation that may take in consideration is the application of DMAIC to specific product. It may analyze each detail step during the reoperation process in order to eliminate any cause of defects during the process that can decrease the quality of the product. Another recommendation is the implementation of 5 Whys to determine any root cause of a defect or problem in the product.

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