Reduction of Scrap in Manufacturing Line B-1 Using Six Sigma Manufacturing Methodology

Saynel Estévez Merced
Manufacturing Engineering
Carlos González, PhD.
Department of Industrial Engineering
Polytechnic University of Puerto Rico

Abstract *— In this research, the focus was in a manufacturing production line of receptacles assembly. The receptacles are the finish good of this production line. In this process the receptacle is build completely starting with the bridge assembly and finishing in the top assembly. DMAIC is the methodology used in this research as Define, Measure Analyze, Improve and Control. DMAIC is a popularized continuous improvement method. Although there is considerable literature available with the Six Sigma implementations, there is very little research published about the experiences implementing step by step some tools. The goal of this research is to minimize 45% the amount of scrap in the process and as a consequence reduce the amount of money that the company is losing due this reason. In this research were used different techniques to maintain a continuous improvement, demonstrating that the DMAIC methodology is a useful one to have an incremental improvement.*

Key Terms *— B-1, DMAIC, Scrap and Six Sigma.*

INTRODUCTION

In this research, the interest is to identify a great opportunity for improvement based on business objectives and the needs and requirements of the customer. Global economy imposes very rigor conditions. If an enterprise wants to achieve and sustain competitive advantage, it has to fulfill those conditions. One of the conditions concerns the care for customers and their introducing into the enterprise, not just through respecting and taking care of their complaints, but through listening to the voice of customers and building their demands into product and process specifications. It's not impossible to provide satisfying results in all dimensions of customer satisfaction. The company, in this case Hubbell Caribe Limited, a manufacturing company that is based in Vega Baja, Puerto Rico, and is dedicated to manufacture electrical receptacles and other electrical devices. It will focus on Plant 2 which has eight different areas: Banco 2, New Jack, Receptacle, B-1, Size 1 & 2, Hubbellock, Manual Valise and Wirecom. This project is going to determine what area has a high monetary scrap. The main focus is based on B-1 line process, where the process leaves a specific amount of residues that is known as scrap. Scrap is a term used to describe recyclable materials left over from every manner of products consumption. Often confused with waste, scrap in fact has significant monetary value. This scrap comes from different components that would be studied. The final goal of this project is find the real causes of scrap to attack them and reduce the scrap of the line.

RESEARCH DESCRIPTION

The assembly of receptacles in B-1 occurs in Plant 2. The amount economical of scrap in this area causes an impact to the business, also excess the labor cost. The scrap affects directly to the productivity, efficiency affects the OEE completely. This research is focus to reduce the scrap in this line improving the process giving excellent results using a useful DMAIC methodology.

RESEARCH OBJECTIVES

This research has the main objective that is a business basis objective that considers and studies the impact in terms of productivity, efficiency and scrap reduction after the establishment of this specific DMAIC Methodology. The specific objective of this main objective is to reduce product waste by 45% in production line B-1 increasing the line throughput and the elimination of the amount of scrap after application of Six Sigma principles. Different tasks will be performed to reduce the scrap and optimize line productivity.

RESEARCH CONTRIBUTIONS

Although there is a body of literature that presents the nature and advantages of Six Sigma implementation; there is lack of quantitative data-based research that specifically examines whether the implementation of Six Sigma combined results in improvements in reduction of scrap. This research pretends to determined and gives some numerical basis for the Six Sigma implementation. Understanding the different economical aspects within an electrical industry after the implementation of Six Sigma principles following the DMAIC (Define, Measure, Analyze, Improve, and Control) approach. Regarding the business contribution, the principal idea is to reduce scrap and in parallel increase productivity and increase at the same time the probabilities to bring new products as results of a decrease in the standard product cost and the space consolidation.

LITERARURE REVIEW

Six Sigma is a disciplined, data-driven methodology for eliminating defects in any process. To achieve six sigma quality, a process must produce no more than 3.4 defects per million opportunities. According to Devane [1], six sigma's basic value proposition is that principles for process improvement, statistical methods, a customer focus, attention to processes, and a management system focusing on high-return improvement projects result in continuous improvement and significant financial gains.

The prominent Six Sigma objective is to achieve greater revenue and profit for the business and high customer satisfaction. Properly executed, Six Sigma will achieve this through lower costs. However, achieving Six Sigma goals may require significant changes to the system. Change is perceived as a major source for disruption and higher costs. Although every associate in the organization should be a good change agent; Six Sigma assigns special roles to realize effective change. An executive-level manager in the role of champion acts as the official change agent, facilitating the management plans and change process.

According to George [2] Motorola recognized there was a pattern for improvement (and use of data and process tools) that could naturally be divided into the five phases of problem solving, usually referred by the acronym DMAIC. Phase I (Define) this phase is to clarify the goals and value of a project. Phase II (Measure) the purpose of this phase is to gather data on the problem. Phase III (Analyze) this phase is to examine the data and process maps to characterize the nature and extent of the defects. Phase IV (Improve) is to eliminate defects in both quality and process velocity. The last one is Phase V (Control) that the purpose of this phase is to lock in the benefits achieved by doing the previous phases.

The following Figure 1 tell us where is the must ammout of scrap in what plant .

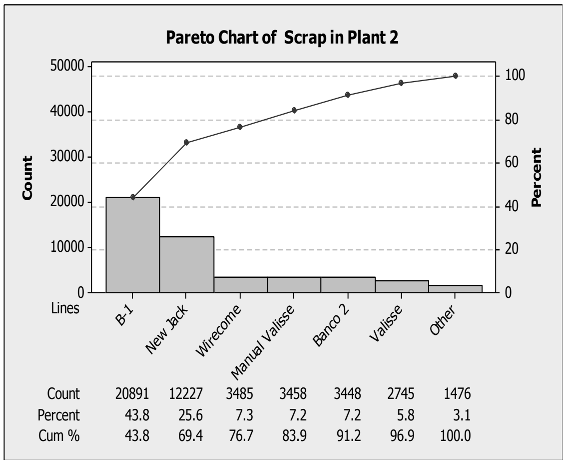

Figure 1
Pareto of Scrap by Plant

The most scrap is concentrated in B-1. This line is the one that is would be analyzed. Actually the line of B-1 has a quantity of scrap of 20,891 units that is equivalent of $39,617 in loss. In this research the historical data will be collected to be measured and analyzed. Once the data is measured and analyzed it will make various recommendations to decrease the quantity of scrap.

Lean Manufacturing Philosophy

This research consists of the design, explanation of the tools to be implemented and the reason for the implementation. It also established the type of analysis and how the data was collected. This research is intended to implement different six sigma tools in order to reduce scrap especially in a specific production line (B-1) where is the must percentage of scrap. The methodology of Six Sigma basics in essence creates improvements by managing variation and reducing deficits in the processes of an enterprise. DMAIC these five elements focus on significant process improvements. You may ask how this process relates to the everyday man or woman. Using data from every conceivable source, the statistical formulas used by the process of the Six Sigma methodology can effectively calculate this data into productive applications. From the time allotments for pizza delivery, to the analytical processes used by insurance companies, statistics play a large part in daily affairs, and this approach enables productivity and profit for businesses without neglecting consumer input. The processes of Six Sigma with its statistical perfections that allow increased profits, less defective products, and millions in the bank, is impressive to those that gain such windfall, but the lingering question to ask may be too little, too late[1]. Six-Sigma is a 21st century concept. It represents a process-focused, resource-based and customer-driven concept. Enterprises implement the Six Sigma business concepts to achieve processes and activities perfection. The essence of Six Sigma concepts is that customers' satisfaction can be provided by increasing the quality of products. The quality of products can be increased by increasing the quality of processes. Finally, the quality of processes depends on resources and capabilities and on their combination. Six-Sigma is more than just a business concept. It is a management philosophy that signifies how expensive defects are. Six-Sigma can be implemented through Six Sigma projects, which involve five phases shown in Figure 2. However, the mentioned phases of improvement in Six Sigma ways include very detailed, concrete measures, instruments and techniques. This makes it possible to call them methodology. Six Sigma methodology (DMAIC) helps to improve any process. It suggests that it is usually possible to improve processes' efficiency, not by changing the combination of resources and capabilities, but by eliminating variation and defects, which appear as a consequence of variation. In summary, the Six Sigma basics of statistical findings for business and consumer advancement, heralds as the ultimate process for achievement, yet leaves the mind to ponder its effectiveness upon the human race [2].

Figure 2
DMAIC Methodology

Methodology

In this competitive world, each organization needs to fight for a place at the top. To sustain competitiveness, each organization needs to produce and deliver defect free products. In order to do so, organizations follow many different business management strategies witch one of the most popular strategy is six-sigma. Six-Sigma is a business management strategy that involves betterment of the organization's existing products, to make them defect free. The following paragraphs will help you understand this methodology in detail.

DMAIC Methodology Tools

DMAIC is an acronym which stands for Define, Measure, Analyze, Improve and Control. These are tools of DMAIC, and are used in order to find and eliminate defects in the product. A team of experts is formed which uses the DMAIC methodology to find and eliminate the root cause of defects. This team has a leader with a six sigma black belt certification. Other members of the team hold six sigma certifications too. These are experts who look at processes and the products. The outcome of their study helps the organization to raise its position in the market, and cut off competition by producing defect free products. Let us proceed to understand the DMAIC methodology [1].

1. D - Define

The team is formed with a specific purpose in mind. This is what the define stage is all about. The team needs to sit together and define the scope, goal, budget, duration and the problem. The leader of the team makes a charter document where they mention all the above aspects in complete detail. Then, work begins. The team defines the problem and then sets about finding the root cause and finding ways to eliminate that cause. The understanding of business process management helps the team at this stage of DMAIC methodology [2].

2. M - Measure

Here, the performance of the process is measured. The feedback of people who manufacture products, feedback from customers who use the products and the way the product is processed, are all measured. The team also takes a look at business growth strategies. At this phase, the problem statement and project contract are commonly refined as a result of establishing an accurate baseline for the metrics being targeted. This can be known as the data collection step too. All relevant data, important to the product, and the processes followed to manufacture the product is collected at this stage [2].

3. A - Analyze

The next step in DMAIC process, analyze, as the name suggests, is analysis of the data collected in the previous phase. It is important to analyze the feedback given by customers, as they are the end users of the product and the product needs to match their needs. In this stage, the root cause of the problem is identified. A process chart, here, helps the team in understanding where the process of manufacturing the product has gone wrong.

4. I - Improve

The process chart helps the team in redesigning the process, after elimination of problems. A complete new process chart is then made, which highlights the changes and improvements to be incorporated, in order to do away with defects. The concepts of total quality management and lean manufacturing are used in this stage. Documentation accompanies the new process chart, which provides the changes made in the process, in detail. Work at this stage becomes easy, if the team has collected enough data [2].

5. C - Control

This is the last stage in DMAIC model. After the new process is designed, the organization replaces the old process with the new one. The team closely monitors the working of the new process and ensures that there are no problems in the new process. They monitor the performance of the new process and ensure that products manufactured are defect free. If there are any further changes to be made, the team makes changes and again measures the performance of the process. Under proper guidance and observance of the team, new process is adopted by the organization [2].

RESULTS AND DISCUSSION

This section discusses all the stages of DMAIC methodology to go to the entire process and capture all the variables using the Six-Sigma Manufacturing Principles.

Define

The Project Team Charter (Table 1) was filled to understand all the variables of scrap of receptacles. The Project Charter contains all the metrics to be impacted with the scrap reduction in line B-1. In addition, all the requirements, scope, resources are identified to facilitate tasks delegation and teamwork. The schedule is important to develop the research organize and in time.

Table 1
Project Team Charter

Project Title	**Reduction of Scrap of Manufacturing Line B-1**
Total Saving Identified	$ 20,000 Monthly
Project Leader	Saynel Estevez Merced
Project Start Date	November 2011
Project End Date	May 2012
Element	**Team Charter**
Process : The process in which the opportunity exist	Receptacle Assembly Process.
Problem Description: Describe the problem that need to be solved, or the opportunity to be addressed	Actually the line of B-1 has a quantity of scrap of 20,891 units that is equivalent of $39,617 in loss. In this research the historical data will be collected to be measure and analyze.
Objective: What improvement is targeted?	The objective of this research is to reduce the Scrap 45 %, focus in eliminating everything considered as scrap.
Metrics: What are the measurements that quantify program process and success?	Metric: Scrap of components; Baseline: 12.6 %; Goal: 6.9 %
Element	**Team Charter**
Team Members: Names and Roles of Team Members	Antonio Quiles – Elec. Engineer Ribbet Vázquez – Ind. Engineer Milagros Ortega – QA Engineering
Benefit to External Customers:	Customers will have lower lead time to get the product.
Schedule: Give the key milestones and dates	**Key Project Dates** Define: November 2011 Measure : January 2012 Analyze: February 2012 Implement: March 2012 Control: May 2012
Budget: What financial resources are required for the team?	Assistance

After fill all the information presented in the Project Charter, many opportunities exist with actual scrap of B-1 line. The Figure 3 shows us the product of defect.

Figure 3
Scrap Product

- **VOC**

Every business needs to know the customer needs and expectative about the product or service for what they are paying for. Table 2 shows what we need to know to identify the expectative, requirements and needs from the point of view of the customer.

Table 2
Voice of Customer

VOC	Complaint	Critical Customer Requirement
No cosmetic error	Product has other color or scratch	Visual Inspection
Functional	Other voltage	100% Functional & correct voltage
Package	Package broken	Correct Package, without damage
Documentation	Incorrect documents included	Correct documents required
Top Clean	Top not clean	100% Clean
Wrong Catalog in package	Catalog isn't the required	Correct catalogs
Component missing	Component not included	All Components included
Wrong accessories included	Accessories don't match with catalogs	Correct accessories included
Broken	Damage of any components	Perfect Condition

Measure

In this phase all types of data will be collected in order to understand and identify were the root cause for the scrap generated is located in the process. In this process we will measure the numbers in terms of percentage that is coming out of the process, known as the process output, the final product. This metric in Figure 4 tell us the quantity of scrap by month and the quantity of production of receptacles by month in the Line of B-1. Currently the scrap of the receptacle is 12.6% according to the historical data.

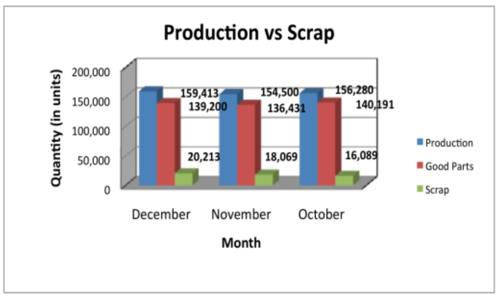

Figure 4
Scrap vs. Production Metric by Month

The receptacle has different components to make the finish good in this case the receptacle. The components to scrap the receptacle are for washer, bridge, top, ground clip, contact, screws, rivet and base. Figure 5 tells us the quantity of scrap of why the receptacle was scraped.

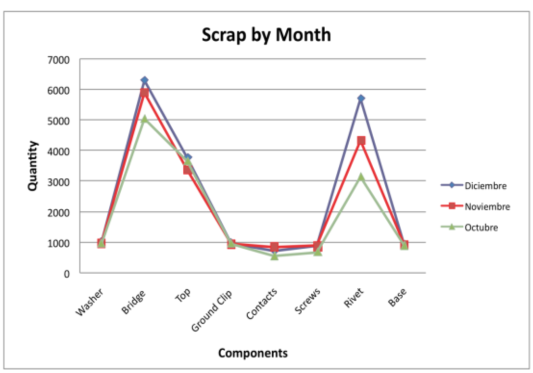

Figure 5
Scrap of Components by Month

The Figure 6 is the data collected in the month of October, November and December that show the major offenders in the scrap of receptacles that are bridge, rivet, top and washer.

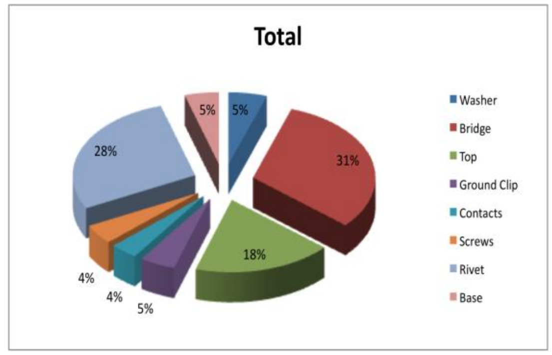

Figure 6
Percentage of components in October November and December

- **FMEA**

The Table 3 shows us the Failure Mode and Effect Analysis review the process step by step. These three criteria, Severity, Occurrence, and Detection, are rated on scale of 1 to 10, with a 1 representing only the minor incidence and 10 represent catastrophic event [2]. The product of these three criteria ratings becomes the risk priority number. The higher RPN prioritize the need to eliminate the cause, reduce the frequency. In this case are three high RPN values stand out, with value of 384-392-405, particular attention should be given to which one has the high severity.

Table 3
FMEA Analysis

Process	Potencial Failure Mode	Severity	Potencial Cause	Ocurrence	Current Control	Detentions	RPN
Emthech	Operators Errors	Misfit Wire	Lack of Training	3	Training	9	81
Bridge Assembly	Bridge Malfuntion	Damage Bridge cannot be used in the Assembly	Bent or Broken	9	PM of Equipment	5	405
Bridge Assembly	Rivets Malfuntion	Malfunctioning Receptacles	Unformed Rivets	8	Inspection	7	392
Bridge and Final Assembly	Screws Malfunction	Misfit Contact	Screws without thread	6	PM of Equipment	8	144
Bridge and Final Assembly	Ground Clip Malfunction	Non Function Clip to the Receptacle	Close Clips	5	PM	6	120
Final Assembly	Washer Malfunction	Cannot be Assembly with other components	Without Holes	7	PM	5	175
Final Assembly	Incorrect Top	Cannot reach customers requierments	Damage or Wrong Color	8	PM of Equipment	6	384
Final Assembly	Base Malfunction	Other Components cannot beAssembly to make a Funtional Receptacle	Damage or Wrong	4	PM	4	112
Final Assembly	Contact Malfunction	Misfit Screws	Unformed Contacts	5	None	6	120
Inspection	Lack of Ilumination	Operator cannot detect all Defects	Don't have the requierd Ilumination	5	None	4	120

Analyze

In this phase of analyze a different tools are to be made to identify the root causes of the offenders of scrap. A Value-Added Analysis is a method in which a process is stripped down to its essential steps, it was important to develop a value added analysis because it gives more detail about each individual task that is being performed per workstation and the time related to that particular task. In this analysis each activity is evaluated to determine the contributions to the customer requirements.

- **Potential Roots Causes**

The team, based on the causes of major scrap, identifies the potential root causes of each one. In the Table 4 the causes of mayor scrap are identify and are: rivets, the tops, the washers and the bridges. Each one of these causes has some potential root causes that cause the problem in each one. From the data collected and the analysis that the team did to each potential cause of scrap the following potential root cause were identified:

Table 4
Potential Roots Causes

Offender	Potential Root Cause
Bridge	Bent
Top	Paint
Washer	Dirty
Rivets	Bent

Historical data was analyzed through Pareto Charts shown in Figure 7. The following Paretos were performed by causes of scrap on receptacles. Were the result was:

° The potential root cause in washer is that they are dirty with a 80%.

° The potential root cause in rivet is that they are bent with a 93%.

° The potential root cause in top is that the paint is bad with a 87.

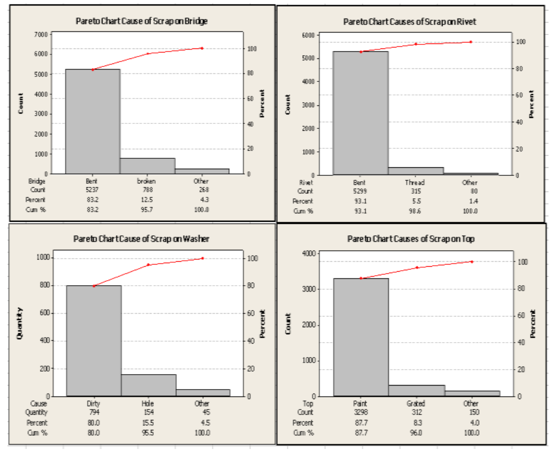

Figure 7
Potential Roots Causes

- **Cause and Effect Analysis**

The cause-and-effect analysis generates possible causes of defects, in this case the major offenders that are: the bridges, the rivets, the tops and the washers. The Cause and Effect Diagram is also known as Fishbone Diagram and shows the potential causes for which the bridges, tops, rivets and washers are causing the damages receptacles. The following Figure 8 shows the possible causes in the different categories that make a defective receptacle.

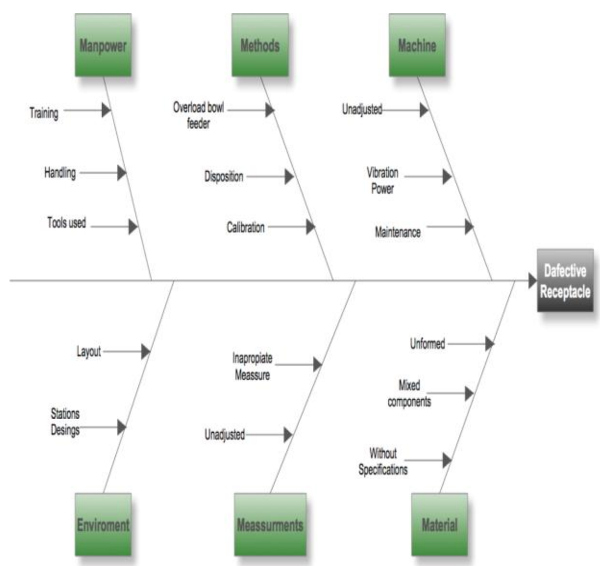

Figure 8
Cause and Effect Analysis of Receptacle Defect

Improve

In this phase of improve a different tools are used to make action of the possible root of causes of scrap. This phase is important to prove that the possible causes of the problem are the correct one. It is used to identify potential failure modes, determine their effect on the operation of the product, and identify actions to reduce the failures. In resume this phase is going to show the implementation of the different tools to make sure that the real causes that is found in the previous phase is the correct and to show the difference of before and after that tells us the causes of the problem was resolved.

In the Analyze Phase the team identified the major potential root causes for the causes of scrap of B-1 line. After the explication here are the solutions for the root causes:

• **Bent Bridges** – The place where most of the bridges are bents is in the guides because the most of the time the guides are unformed because of the wrong utilization of the tools. In the bowl feeder when the operators overload the bridges get sock and therefore bent.

• **Top painting** – When the plates are worn the paint does not reach the point of operation and therefore the tops badly painted. Also some times the tops come to the stamping machine dirty and the top is painted wrong. Some times when there are accumulation of production the operators put the finished receptacles in buckets and when they need those receptacles they throw all of them in the area to be packed, and this cause that the paint gets striped.

• **Dirty Washer** – The major problem is when the nests are unadjusted the washers' fall to the floor and therefore gets dirty.

• **Bents Rivets** – The rivets get bent when the machine has the wrong pressure. When the guides are unformed because of bad decision of the operator, also cause that the rivets get bent. And when the supplier sends rivets out of specification they get bent in the machine.

These major root causes are the responsible of more than the 80% of the scrap of B-1 line. Where these major root causes the team recommended some solutions for the process. Another tool used to prioritize is the Failure Mode and Effect Analysis (FMEA) shown on Table 5. It also helps in the reduction of failure. The Risk Priority Number (RPN) identifies the order in which the issues need to be addressed. After the recommendations the second RPN score has low value, meaning the risk will be minor.

Table 5
FMEA of Potential Roots Causes

Process Step/Input	Potential Failure Mode	Potencial Failure Effects	Severity	Potential Causes	Ocurrence	Potential Solution	Detentions	RPN
Bridge Assembly	Bent Bridges	Bent bridge cannot be used in the assemby or can cause malfuntion to the receptacles	9	Unformed guides	9	Rectification of the guides	7	**567**
				Overload bowlfeeder	6	Sensor	5	**270**
				Unadjusted nests	7	Preventive maintenance	8	**504**
Bridge Assembly	Bent Rivets	Malfunctioning receptacles	7	Wrong machine pressure	9	Monitor settings	9	**567**
				Unformed guides	7	Rectification of the guides	8	**392**
				Out of specification	5	Inspection	7	**245**
Final Assemly	Dirty Washers	Cannot be assembly with others components	5	Unadjusted nests	8	Preventive Maintenance	8	**320**
				Supplier	6	Inspection	7	**210**
Final Assembly	Top painting	Cannot reach customers requirements	8	Worn plates	9	Preventive maintenance	8	**576**
				Production accumulation	8	"Porta buckets"	7	**448**
				Dirty tops	7	Clean tops	8	**448**

After doing the analysis a root of causes was founded and the team does recommendation to improve the problem of scrap of receptacles. The Table 6 before present shows the different solution for the scrap that the company has.

Table 6
Solution of the Root Causes

DEFECT	Root Cause	Recommended Solution
Bent Bridge	Unformed Guides	Rectification of the guides
	Overload Bowl Feeder	Sensor
	Unadjusted Nests	Preventive maintenance
Top painting	Worn Plates	Preventive maintenance
	Accumulation of Production	"Porta buckets"
	Dirty Tops	Clean tops
Dirty Washer	Unadjusted Nests	Preventive Maintenance
	Supplier	Inspection
Bent Rivets	Wrong Pressure	Monitor settings
	Unformed Guides	Rectification of the guides
	Out of Specification	Inspection

Table 7 shows the implementation matrix of the solutions presented throughout this research. Target completion dates were established keeping in mind the approvals required by manufacturing director and engineering department.

Table 7
Implementation Matrix of the Solutions

Process Input	Causes	Area of improvement	Strategy	Action	Responsible
Bridge assembly	Bent Bridges	Guides	TPM and Mistake Proofing	Rectification of the guides	Manufacturing Engineering
		Bowl feeder	Mistake Proofing	Sensor	Supply Chain
		Nests	TPM	Preventive maintenance	Manufacturing Engineering
	Bent Rivets	Setting	Standar Work and Visual Control	Monitor settings	Production Engineering
		Guides	TPM and Mistake Proofing	Rectification of the guides	Manufacturing Engineering
		Supplier	Standar Work	Inspection	Quality Department
Final Assembly	Dirty Washers	Nests	TPM	Preventive Maintenance	Manufacturing Engineering
		Supplier	Standar Work	Inspection	Quality Department
	Top Painting	Plates	TPM	Preventive maintenance	Manufacturing Engineering
		Before stamping	Mistake Proofing	Clean tops	Quality Department
		Packaging area	Visual Control	"Porta buckets"	Production Engineering

- **Photos of Before & After The Implementation**

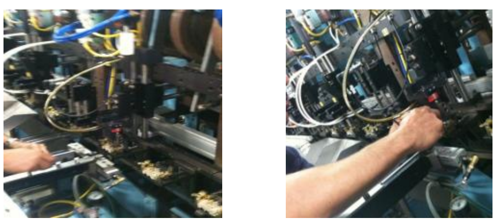

Figure 9
Before and After adjusting Nests

Figure 9 shows us the adjusting of the nest that reduces the problem of the dirty washers.

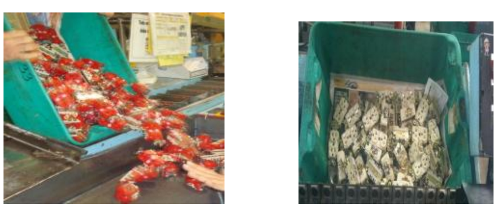

Figure 10
Before and After installing a Porta Buckets

Figure 10 demonstrated the installation of Porta Bucket reduce the problem of damage paint in the top.

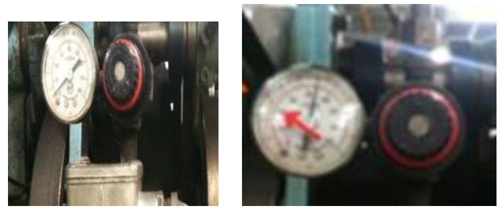

Figure 11
Before and After changing the Pressure of the station

Figure 11 shows the change of the pressure that decreases the amount of bent rivets.

Figure 12
Before and After stalling the brush on painting top station.

Figure 12 shows the installation of a brush that help to clean the top after the top goes to the operation of paint the point

Figure 13
Before and After the rectification of the Guides

Figure 13 shows the rectification of the guide that reduces the bent of the bridge.

Figure 14
Before and After the Sensor was installed on the Bowl Feeder.

Figure 14 shows the installation of the sensor that detect when the bowl feeder is full, avoiding the bent of bridge.

Control

The main goal of this phase is to hand off and delivers to the management the control of the improvement done. An implementation plan was prepared as a guidance to complete several tasks. The before and after analysis compare how the project began and the current state of the project. The main problem identified were the scrap of receptacle that are caused by bridge bent, rivet bent, washer dirty and bad painted top are the offenders of the scrap.

Table 7
Control and Sustain Plan

Defect	Process Input	Control	Responsible	Frecuency
Bent Bridge	Unformed Guides	Rectification of the Guides	Tool Maker Department	Monthly
	Overload Bowl Feeder	Install Sensor	Mechanics	N/A
	Unadjusted Nest	Adjust Nest	Mechanics	Monthly
Top Painting	Worn Plates	Change Plates	Mechanics	Monthly
	Accumulation of Production	Install a Porta Buckets	Tool Maker Department	N/A
	Dirty Tops	Install a New Brush	Mechanics	Monthly
Dirty Washer	Unadjusted Nests	Adjust Nests	Mechanics	Monthly
	Supplier	100% Visual Inspection	Quality Department	Each Batch
Bent Rivets	Wrong Pressure	Fill a Form to Indicate the Pressure	Operator	By Catalog
	Unformed Guides	Rectification of the Guides	Tool Maker Department	Monthly
	Out of Specification	100% Visual Inspection	Quality Department	Each Batch

This plan in Table 7 is used to ensure the team is making satisfactory progress to the project goals. After the implementation of the strategies presented in the implementation plan, it is important to monitor the progress of the line after these improvements are in place and running. The goal of the monitoring, control and sustain plan is to ease data gathering in order to attain improvement plan's due dates. Implementation can't take place before monitoring how the line is going to be affected by these changes.

Conclusion

During this research the team identifies the real causes of scrap in the line of B-1 and the improvement was done giving satisfactory results to the company decreasing the scrap more than 45%. The main problem identified were the scrap of receptacle that are caused by bridge bent, rivet bent, washer dirty and bad painted top are the offenders of the scrap. With the help of additional data the potential causes for these defects were the following: Bridge– guides unformed, Rivet – Wrong pressure, Washer – Unadjusted nest, Top – Bad painted. Then, improvement suggestions were presented, addressing the causes mentioned above, including the development of an improvement plan, where the causes were strategically organized, based on the results of the prioritization matrix developed in the improvement phase. It is important to monitor the progress of the line after these improvements are in place and running. After six (6) months of project the goal in terms of scrap reduction was achieved the Table 8 shows the reduction of scrap in each components.

Table 8
Before & After Results

Machine	Cause	Solution	Before	After	Reduction	Scrap Reduction
Bridge Assembly	Bridge	Rectification of the Guides	5742	3770	1972	
		Sensor in the Bowl Feeder	5742	5047	695	
		PM Nest	5742	5251	491	
	Total Scrap Reduction				3158	45%
	Bent Rivets	Monitor Setting	4382	3350	1032	
		Rectification of the Guides	4382	3526	856	
		Inspection	4382	3948	434	
	Total Scrap Reduction				2322	47%
Final Assembly	Dirty Washer	Preventive Maintenance	969	618	351	
		Inspection	969	768	201	
	Total Scrap Reduction				552	43%
	Top Painting	Preventive Maintenance	3586	2804	782	
		Porta Buckets	3586	3107	479	
		New Brush	3586	3055	531	
	Total Scrap Reduction				1792	50%

References

[1] Devane T. "*Integrating Lean Six Sigma and High-Performance Organizations: Leading the charge toward dramatic, rapid and sustainable improvement*". Wiley Imprint. 2004.

[2] Maxey J.; Price M.; Rowlands D.; George M. "*The Lean Six Sigma Pocket Tool Book*". New York, NY: McGraw-Hill. 2005.