Broken Bases Scrap reduction in FD line

Bryan Lee Medina Cuevas
Master in Engineering Management
Dr. Héctor J. Cruzado
Graduate School
Polytechnic University of Puerto Rico

A key reference point to verify the efficiency of a production line is its scrap performance. The FD breaker production line of company "ABC" is currently facing challenges due to broken nubs and corners defects of 3-pole bases impacting the scrap metric with an estimated 4.9K dollars per month. By using the Six Sigma DMAIC methodology, it was determined in which workstations was occurring the highest frequency of breakages. A 28% breakage rate reduction was obtained by improving fixture conditions, defining proper positioning methods and stricter WIP levels that improved the material flow.

Key Terms *— Pareto, Problem-Solving, Scrap, Six Sigma.*

INTRODUCTION

Background

The electrical devices manufacturing company "ABC" located in Haina, Dominican Republic, is seeing a high impact of scrap related to "broken bases" defects in its FD 3Pole Industrial Breaker production line, with an impact of $4.9K per month affecting the scrap metric, as shown in Figure 1. In some cases, the defect can occur or be detected in the final stages of the assembly process, which means it represents an impact to the productivity metric as well.

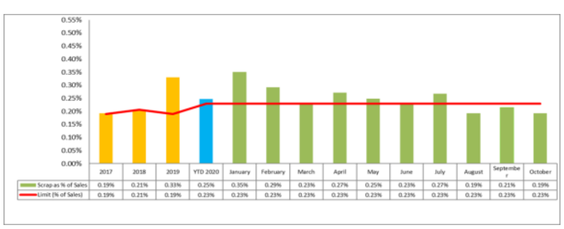

Figure 1
Scrap Metric FD Line (YTD 2020)

Problem Statement

The problem the line is facing is that the year-to-date scrap metric is out of target at 0.25% vs a goal of 0.23% of sales. A Pareto analysis of the top 5 offenders shows that the #1 detractor is the 3Pole base, which accounts for 39% of the total scrapped parts, as shown in Figure 2. This means that an estimated $4.9K dollars are scrapped per month due to broken 3Pole bases (a rate of 1.25% vs the total bases used in production).

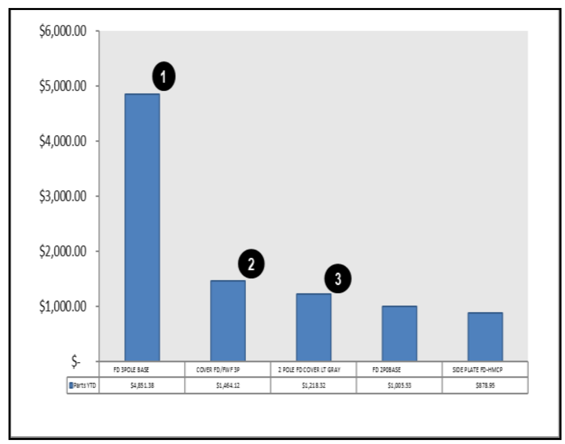

Figure 2
Pareto Scrap FD Line Parts (YTD 2020)

This project aims to reduce at least 15% of the overall scrap rate of 1.25% due to broken 3Pole bases. By following the Six Sigma DMAIC Methodology (Define – Measure – Analyze - Implement – Control) guidelines, the project team performed a thorough evaluation of the process flow, identified the root cause and took corrective actions in order to meet or exceed this project objective.

LITERATURE REVIEW

Problem solving is using analytical methods to find the causes of a problem and come up with the means of eliminating it. The QC problem-solving approach is a good starting point, since is a “method of solving problems rationally, scientifically and effectively using the QC viewpoint, the QC Seven-Step formula and the QC tools” [1].

The DMAIC is the basic Six Sigma roadmap for problem-solving, providing the five stages to follow during the course of a project:

- D-Define: to provide a specific problem definition and scope.
- M-Measure: to gather accurate and sufficient measurements/data.
- A-Analyze: to analyze the measurements/data to see if its consistent with the problem and useful to identify a root cause.
- I-Improve: to implement the solutions and verify effectiveness with independent data.
- C-Control: to stablish verification processes to keep the solutions in control.

Each stage provides a set of tools to guide the team thru the process [2].

Some of the most important tools to take into consideration and use over the course of a DMAIC project are the following:

- Process Flow Map: it’s a diagram to show graphically each of the steps and material flow of the process to be improved by the project.
- Pareto Diagram: it’s a data analysis tool that helps to focus the efforts on the most critical defects by arranging them in decending order of frequency.
- Cause and Effect Diagram: it’s a diagram that helps the team brainstorm and list all the possible root causes into 6 categories (6M’s). [3]
- Measurement System Analysis (MSA): it’s a statistical tool used to verify if measurements obtained by the measurment system are accurate and reliable for decision making.

METHODOLOGY

Define

The FD production line builds around 4,000 units per month divided between 1, 2 and 3 poles. Currently, and for the past few years, the line is facing a scrap problem related to broken 3-poles bases during the manufacturing process, that is affecting the scrap metric accounting for 39% of the rejections, as shown in Figure 2.

The Process Flow Map in Figure 3 show the process steps the 3P base and subsequent sub-assemblies go thru and will be evaluated to verify the individual impact each one has over the defects.

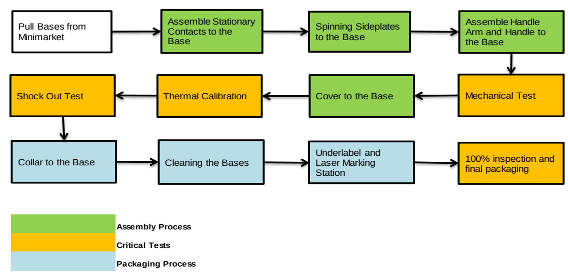

Figure 3
FD production line Process Flow Map

Measure

Using a pareto chart, shown in Figure 4, the main defects related to scrapped 3P bases were determined to focus the improvement efforts towards these select few critical issues. The “broken nubs” and “broken corners” were selected as targets. The “no re-use laser” rejection is one where the bases are not actually broken but were sent to scrap and can’t be reused because of the laser etched serial code.

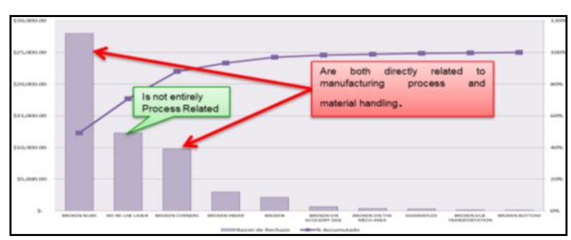

Figure 4
Pareto of top rejection reasons of 3P base

Furthermore, since the pass or fail criteria related to these rejections is attribute data (broken or not broken) dependent of the operator appraisal, a MSA study was performed to make sure "Data Collectors" are well prepared to identify the non-conformances under study. Results are shown in Figure 5.

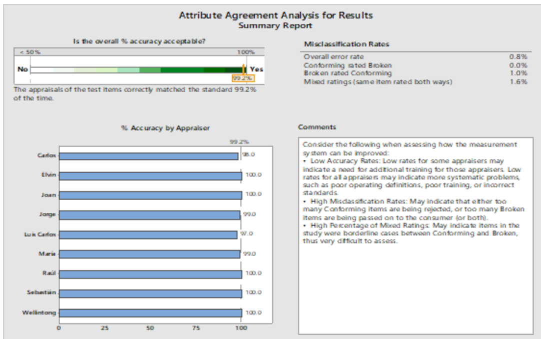

Figure 5
Attribute MSA of "Data Collectors"

These results lead to conclude the following:

- Kappa Value for all appraisers was above 0.75.
- 99.2% of the times all the appraisals matched the standard.
- MSA results indicate an acceptable inspection method is in place.

A data collection procedure was stablished, to have the process technician take 5 samples from the process, 4 times a day during 15 production days. This exercise led to the creation of the Pareto Chart shown in Figure 6, which evidences the workstations where most of the bases are getting breakages. Eighty percent of defective bases detected were clustered on 5 stations: Thermal Calibration, Shock Off Test, Collar to Base, Rack Brks for Packing & Rack Brks for Normalization.

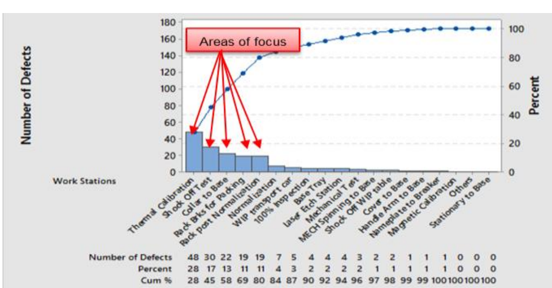

Figure 6
Pareto of broken bases per workstation

Analyze

As the project team went thru the measured data, a brainstorming activity was performed to identify all the possible root causes of the problem. These ideas were documented in the Fishbone Diagram shown in Figure 7.

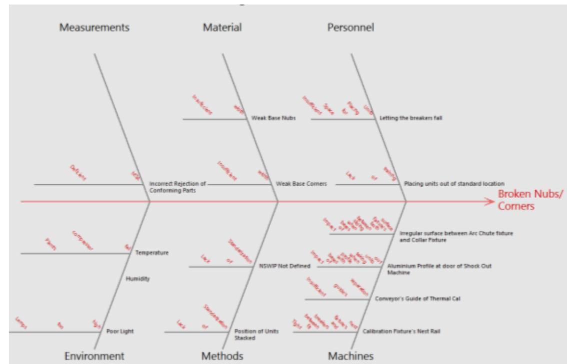

Figure 7
Cause-Effect diagram for broken nubs/corners

Improve

The list of actions seen in Table 1 were identified by taking a closer look into the different root causes listed under each category of the Cause-and-Effect diagram as well as the current condition of the fixtures in the workstations.

Table 1
Improvement stage action items

Category	Station	Finding	Action
Machine	Thermal Calibration	Nubs and corners are hit when placing units into conveyor's slot due to insufficient guide's separation	Create delrin guides and make them wider
Machine	Thermal Calibration	Nubs are hitting the rails at entrance into the fixture's nest	Mill the fixture nest entrance and make "a path" for the nubs to avoid friction
Machine	Shock Off	Entering and exit of units out of the fixture is impacting them with the aluminum profile.	Level up the profile and the fixture's nest to avoid the impact.
Machine	Shock Off	Base of the fixture provoke friction on the Bases	Make an extruded cut at the fixture base to allow free movement of the nubs without friction.
Machine	Collar	Fixture Worn provoke difference on level of join between arc chute detector fixture and collar fixture	Match the level of both fixtures to ensure smooth slide of units.
Method	Normalization Rack	Positioning of the breaker into Normalization and Packing Rack, joined with excessive WIP tend to weak or breaker corners and nubs of the base	Create Visual Aid and train personnel to respect WIP and place the units vertically one next to another, instead of stacked.
Personnel	Shock Off, Normalization	Placing the units out of the standard location and stacked due to lack of training. WIP definition is included on Standard Work Layout document already, but this is not explained to employees on certification phase.	Re-train current personnel and add Std WIP explanation to the certification format sheet.
Material	All	Base's nubs with insufficient width make them weak and vulnerable to breakages.	Increase base nubs width up to the maximum spec allowed that don't compromise functionality of the breaker

Control

The improved process was found to be stable with expected defects proportion in the range from 0% to 2.67%, down from 5.5%, as shown in Figure 8. This chart can help monitor the process to visualize and alert the departmental team of any abnormal conditions on daily production activities or defect spikes related to broken bases.

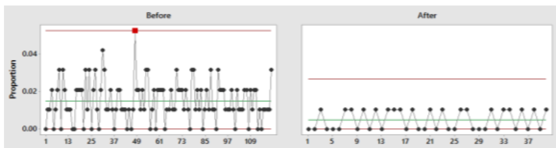

Figure 8
Before and After defective proportion control chart

Conclusion

With this project the team was able to identify the gaps in the process that caused the most broken bases defects (focused on broken nubs and corners). Out of all the process steps related to physical flow of bases, 3 stations were the top detractors, causing most of the breakages (on nubs and corners). By improving the fixture conditions on those stations, the material flow was made easier and smoother for the handling of the bases between workstations.

Defining proper positioning methods and stricter work in process (WIP) levels were also determined to be key elements to avoid handling issues that resulted in broken nubs and corners.

Finally, the project objective was achieved, as evidenced by the Broken Nubs and Broken corners defects rate got reduced from 1.25% (0.91% Broken Nubs and 0.34% Broken Corners) to 0.89% (0.57% Broken Nubs and 0.32% Broken Corners) which accounts for a 28.8% reduction, as shown in Figure 9.

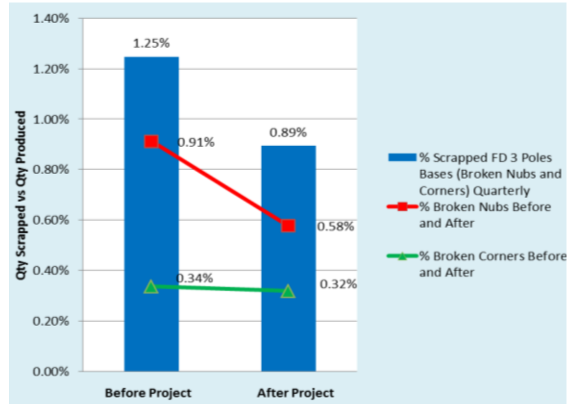

Figure 9
Before and After defects rate

References

[1] Hosotani, K., *The QC Problem-Solving Approach*, 1992, 3A Corporation.

[2] Brussee, W., *Statistics for Six Sigma Made Easy!*, 2004, McGraw-Hill.

[3] Eckes, G., *El Six Sigma Para Todos*, 2004, Grupo Editorial Norma