Increase of Manufacturing Process Output

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Abstract

Haemonetics Puerto Rico, a medical devices manufacturing site of blood filters, identified that approximately the 11% of the monthly plan of the manufacturing line #3 cannot be made using the available manufacturing time of the line. The objective of this project is to increase in at least 20% the manufacturing line output by identifying and eliminating the wastes in the manufacturing process of line #3. To achieve this goal, the DMAIC methodology will be used to identify the possible root causes and improve them adequately. After following DMAIC methodology and provide improvements, the line output increased in a 22%, which means that the line will only require 37 shifts per month to complete the manufacturing plan from the 40 shifts available. With this improvement, line #3 now can comply with the monthly plan.

Research Description

Line #3 of Haemonetics Puerto Rico is producing 11% less good blood filters than was required. According to this, the research tries to increase the output of the line per shift, to comply with the monthly manufacturing plan for the line, without incurring in extra labor hours.

Research Objectives

The objectives of this research are to identify the wastes in the manufacturing process of line #3 and after that developing solutions that increase the filters output per shift in at least 20%.

Methodology

The problem-solving methodology that will be used to increase the process output of line #3 is DMAIC, an acronym for Define, Measure, Analyze, Improve and Control. The American Society for Quality (ASQ) defines DMAIC as "a data-driven quality strategy used to improve processes" [1]. The five letters of the acronym represent the five phases used during the improvement process.

Results and Discussion

Define Phase

Problem Statement:
Currently, the manufacturing line #3 of Haemonetics Puerto Rico manufactures approximately 1,850 good filters per shift, with two shifts of 7.58 hours of manufacturing time per day. The monthly plan require a total of 82,800 good filters from this line, which mean that approximately the 11% of the plan cannot be made. This implicate that the operators need to work extra hours to comply with the monthly plan.

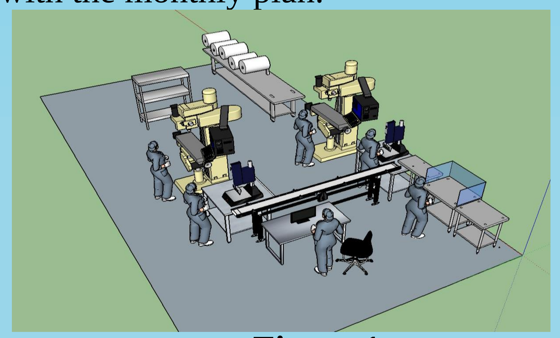

Figure 1
Line #3 Process Layout

SIPOC:
The SIPOC helps to understand the process by identifying the suppliers, customers, inputs, and outputs from the process, with the purpose of better visualize the process and those who collaborate in it.

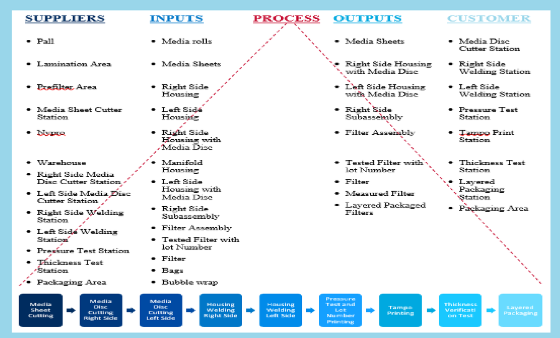

Figure 2
SIPOC Diagram

Results and Discussion

Measure Phase

As part of the measure phase, it was wanted to answer the following questions using historical data reports between August and November of the year 2019.

How much time take each step per station?
The time per station was collected and was concluded that the bottleneck of the process is the right welding with 11.68 seconds per filter.

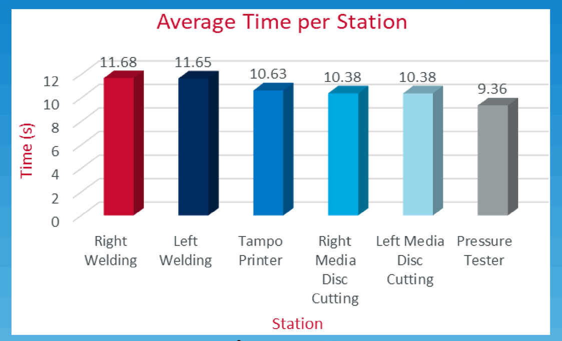

Figure 3
Average Time per Station Graph

How many filters per shift are packaged?
The 1st shift had more variation than 2nd shift. In addition, in average, the 1st shift, can packaged more filters than the 2nd shift.

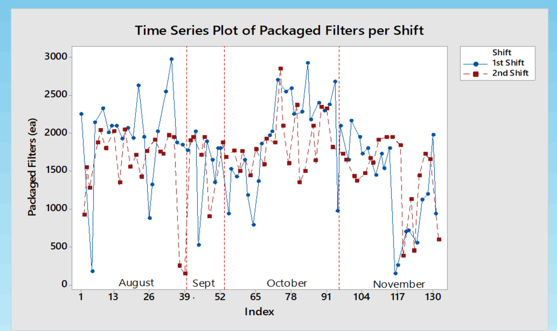

Figure 4
Time Series Plot of Packaged Filters per Shift

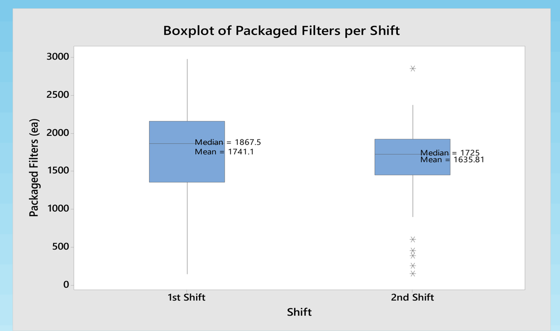

Figure 5
Boxplot of Packaged Filters per Shift

How many filters are scrapped per manufacturing shift and per defect?
The 1st shift had more variation than the 2nd shift. In addition, the 2nd shift, in average, scrapped less filters than the 1st shift.

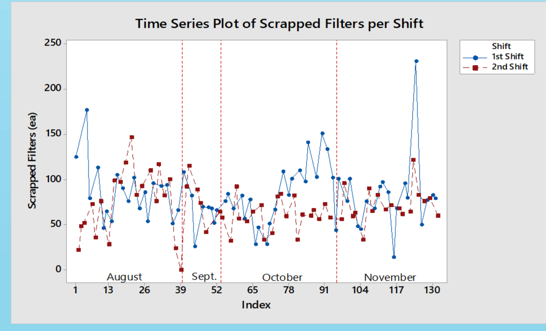

Figure 6
Time Series Plot of Scrapped Filters per Shift

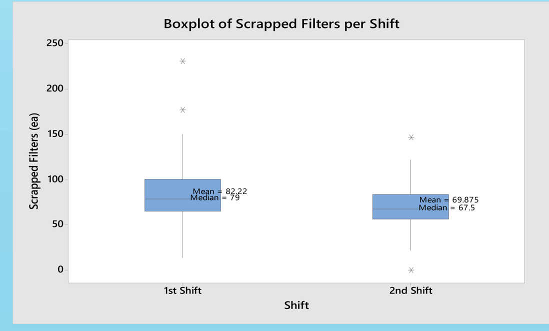

Figure 7
Boxplot of Scrapped Filters per Shift

The operators of line #3 scrapped 3,501 filters due to particles, followed by tampo print errors.

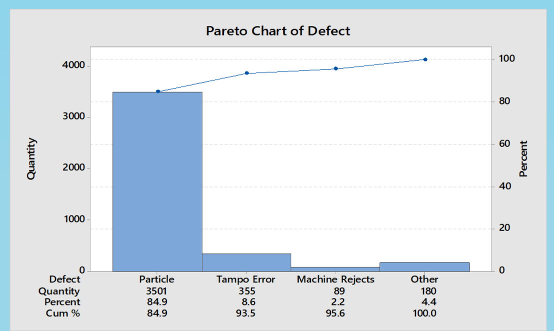

Figure 8
Pareto Chart of Defect

How much time the line is down due to equipment malfunctions?
The 20% of the total downtimes categories that cause the 80% of the downtimes counts are represented by seven categories as shown in Figure 9. And the 20% of the total downtimes categories that cause the 80% of the downtimes are represented by four categories as shown in Figure 10.

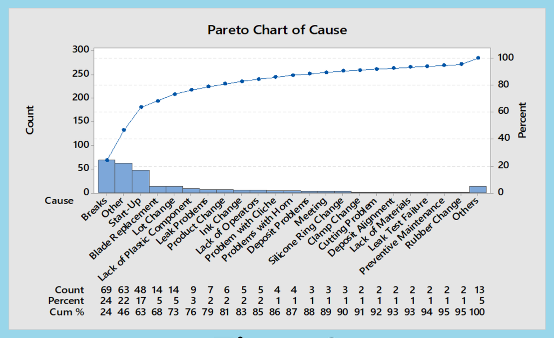

Figure 9
Pareto Chart of Cause

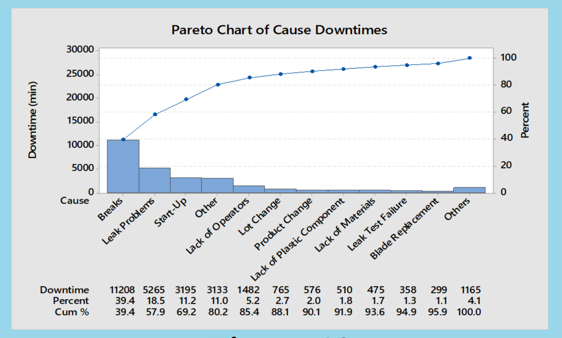

Figure 10
Pareto Chart of Cause Downtimes

Results and Discussion

Analyze Phase

Cause and Effect Diagram:
Twenty-six causes were identified for related to the low filters output effect where only six were taken to focus the investigation.

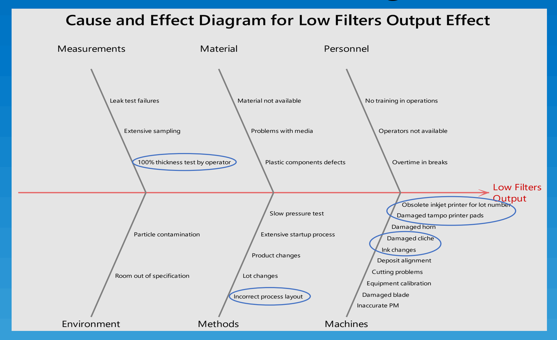

Figure 11
Cause and Effect Diagram

Hypothesis Test: Packaged Filters
The P-Values obtained was 0.051 with a confidence level of 95%. Since the P-Value is greater than 0.05, the null hypothesis is accepted. Therefore, there is a relationship between the variances of the first shift and the second shift.

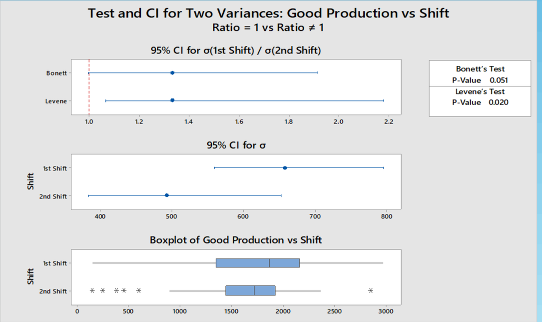

Figure 12
Hypothesis Test of Packaged Filters between First and Second Shifts

Hypothesis Test: Scrapped Filters
The P-Values obtained was 0.248 with a confidence level of 95%. Since the P-Value is greater than 0.05, the null hypothesis is accepted. Therefore, there is a relationship between the variances of the first shift and the second shift.

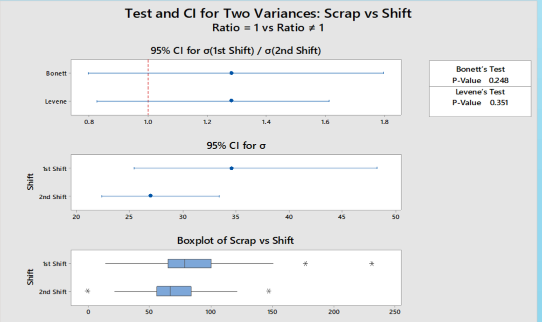

Figure 13
Hypothesis Test of Scrapped Filters between First and Second Shifts

Regression Analysis
The P-Value obtained was less than α of 0.05. This indicates that there is a statistically significant effect on the total number of filters discarded due to the rejections obtained at the tampo printing station. Therefore, if filters are discarded due to damaged tampo print, the total scrapped filters quantity is affected significantly. According to the R-sq obtained, 26.21% of the variation is represented by the rejections of the tampo printing station.

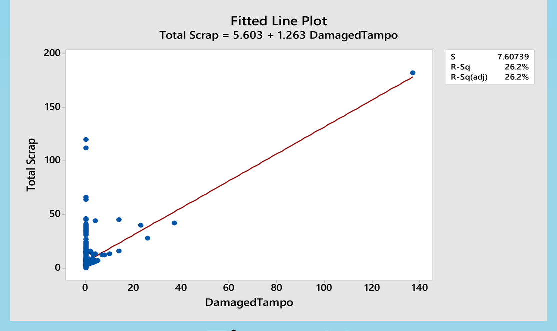

Figure 14
Fitted Line Plot for Regression Analysis

Improve Phase

To increase the output of line #3, the following improvements were proposed:

1. **Thickness Test Station:** Incorporate the test as part of the pressure test by designing nests that comply with the maximum height accepted for the filter thickness.
2. **Tampo Print Station:** Eliminate tampo print process and implement etched process to the plastic components at supplier level.
3. **Lot Number Printing Station:** Replace the current lot number inkjet printer by an automatic lot number printing station with a laser printer and eliminate the lot number defects.
4. **Pressure Test Station:** Replace the current pressure test station by an automatic pressure test station with capacity of four filters instead of two.

Results and Discussion

Figure 15
Current Pressure Test Station

Figure 16
Proposed Pressure Test Station

5. **New Layout:** Re-layout of line #3 that includes the elimination of the conveyor between right and left welding stations, the tampo print station, the current inkjet printer, the current pressure tester and the current thickness verification station. In addition, includes the introduction of the new lot number printing station and the new pressure and filter thickness tester and a relocation of each station. As a result the quantity of operator working in the line will be reduced from nine to seven.

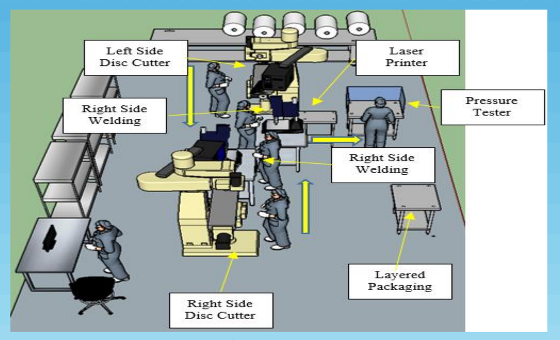

Figure 17
Proposed Line Layout

Control Phase

To maintain the improvements implemented in the Improve phase, the following were performed:

1. **5S:** To maintain the new layout after the implementation, 5S tool was used. The 5S tool consists of removing from the working area all those elements that are not necessary to carry out the work [2]. In addition, the equipment spaces were identified in the floor to sustain the correct position.
2. **Validation:** For the new equipment, an Installation Qualification (IQ) was performed. In addition, a Process Qualification (PQ) was required to validate the new process layout.
3. **Poke-Yoke:** The nests of the pressure tester were designed as a Poke-Yoke tool. If the filter does not enter in the nest means that the filter is higher than the acceptance of the thickness verification test and filter need to be discarded by the operator. If the filter entered in the nest, the filter is considered as a good unit for thickness verification test.
4. **Procedure and Training:** Standard Operating Procedures (SOPs) that support the manufacturing process of line #3 were revised to include the new equipment and layout. Visual aids were added to the SOPs to serve as a visual guide to the operators. In addition, training was provided to the applicable operators.

Conclusions

Once the data were collected, measured, and analyzed improvements to eliminate the possible root causes were proposed. With the improvements implemented line #3 was capable to increase the line output in a 22%. This means that the line only needs 37 shifts per month to complete the manufacturing plan from the 40 shifts available per month. It can be concluded that the DMAIC methodology helps in the achievement of the proposed improvement in the define phase after the project completion.

References

[1] American Society for Quality, "The Define, Measure, Analyze, Improve, Control (DMAIC) Process," 2020. [Online]. Available: https://asq.org/quality-resources/dmaic. [Accessed March 18, 2020].
[2] M. Bahena, P. Reyes Aguilar, "Curso de Seis Sigma," Universidad Interamericana, Santa Fe, Ciudad de México, Feb 2006. [Online]. Available: https://www.icicm.com/files/CursoSeisSigma.pdf. [Accessed March 24, 2020].