Filling Process Yield Improvements

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Abstract

Misus Winery is a wine making and distribution plant. Its main product is Cherry Blossom which is a pink wine. The high demand for its product has created the need to make improvements in their processes. As part of this research project, it was focused on the improvements in the process yield results in the filling in Misus Winery. The process yield is the metric use to measure a process performance. Currently, there was reported a variability in the process yield obtained per production lot. By the end of this project, the process yield will be improved and sustained above the target goal. In order to improve the process yield, a DMAIC (Define-Measure-Analyze-Improve-Control) methodology was conducted to achieve the project goal. DMAIC is conducted in well-defined steps that helps to understand a problem and solve it in a systematic way. The process yield will be improved by the standardization and optimization of the filling process.

Project Description

This project has been outlined with the purpose of analyzing current potting process for inductors, in order to determine key factors negatively affecting the operation; thus increasing potting operation yield and reducing scrap and rework expenses.

Project Objectives

The objective for this project will be addressed to:

- Improve the production yield of the filling process of the company main product.

Methodology

A systematic approach needs to be used as a methodology to achieve the goals of the project to be conducted. Since the purpose of this project is to improve and maintain the yield of the filling process of the Misus Winery main product, the DMAIC methodology tools to use will be determined as more convenient.

Results and Discussion

Define Phase

During the Define phase, it was developed the project charter (Figure 1). This tool helped in the definition of the Problem Statement, Project Scope, and Business Case. Also, it can be used to organize the different phases of DMAIC methodology in the project.

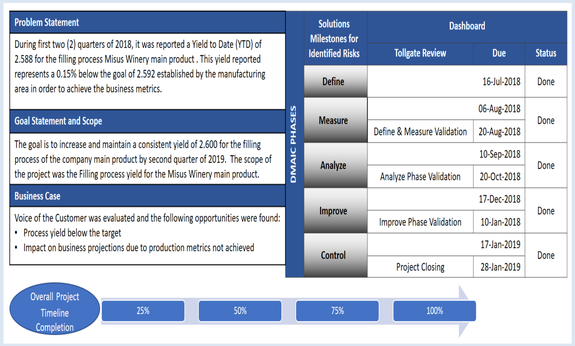

Figure 1
Project Charter

A SIPOC diagram (Figure 2) was developed to identify all elements of a process improvement project before work begins. It helps define a complex project that may not be well scoped by defining the boundaries of the process.

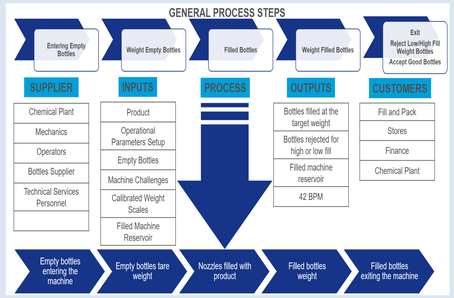

Figure 2
SIPOC Diagram

A Voice of the Customer (VOC) was performed to define what are the customers' needs and what of these needs can be achieved. The following is a summary of the results of the VOC:

- The process yields calculated from the lots manufactured were below the target goal.
- High incidence of High/Low fill bottles which are automatically rejected by the machine. The high/low fill bottles are flush into a carboy. This product is returned to the chemical plant for reprocessing.
- Filler machine setup variability between mechanics.
- High incidence of nozzles tips ruptures.
- Operational parameters uploaded by a validated recipe. There are fixed operational parameters and recommended operational parameters. To optimize the filling process, there is an operational parameter that requires the constant operator intervention in the machine. Each operator modified the operational parameter according to his experience.
- The Fill and Pack area operated in two shifts. In both shifts are new operators conducting filling process.

Measure Phase

The purpose of the measure phase is collecting the data needed to evaluate the current process the process yield of filling.

The process yield data was collected from the plan attainment of the production line. The process yield per month was graphically shown (Figure 3).

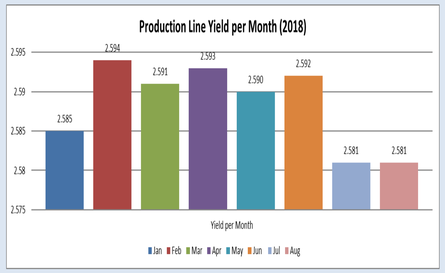

Figure 3
Production Line Yield per Month

Analyze Phase

The purpose of the Analyze phase is identifying the root cause of the situation detailed in the problem statement. After the evaluation of the data obtained, it was decided to perform the 5Why's Analysis.

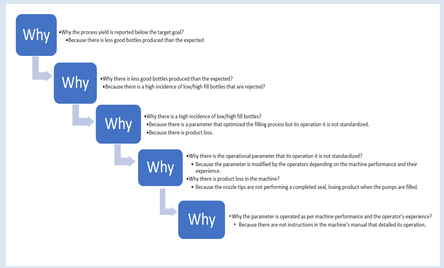

Figure 4
5Why's Analysis

After concluding the Analyze phase (Figure 4), it was found that there were two root causes for the variation in the process yield.

- Pump Stroke parameter operating instructions were not standardized causing process variations.
- Nozzles tips do not perform a proper sealed due to wear causing product loss.

Improve Phase

During the Improve phase, the possible solutions to the root causes identified during the Analyze phase were developed.

- For the standardization of the operation of the Pump Stroke parameter, it was developed instructions to standardize the pump stroke operation during the filling process. The instructions incorporated each operator's methodology to operate the pump stroke parameter. The instructions included pictures as guidelines for the operators. In addition, the instructions were in English and Spanish for easy understanding.
- A new nozzle tip design was proposed for the product loss cause. For the new nozzle tip, a Design of Experiment (DOE) was developed. After the DOE, a confirmation run and complete validation process (PQ) was conducted obtaining satisfactory results.

Three production lots were monitored during the exercise and the results obtained were satisfactory. Table 1 shows the results obtained.

Table 1
Performance Qualification Results

Bulk Lot Number	Period	Bottle per Minute Filled (BPM)	Quantity of Bottles Accepted*	Bottles Rejected (Low)	Bottles Rejected (High)	Product Splash	Bottles Rejected Unknown
S-18-035	Beginning	27	167	0	0	0	0
	Middle	27	2,900	0	0	0	0
	Last	27	1,720	0	0	0	0
S-18-036	Beginning	33	482	0	0	0	0
	Middle	33	2,768	0	0	0	0
	Last	33	5,000	0	0	0	0
S-18-037	Beginning	38	500	8	0	0	0
	Middle	38	3,080	0	0	0	2
	Last	38	5,405	0	0	0	0

In addition, to evaluate the fill weight of the bottles a total of fifty (50) bottles per lot were randomly sampled in order to verify its volume with a graduated cylinder (Table 2).

Table 2
Volume Measurements Analysis

Bulk Lot Number	Quantity of Bottle Sampled	Average Volume Filled ($\bar{X}$)	Standard Deviation (s)	Lower Limit (mL)	K	L + Ks	L + Ks ≤ $\bar{X}$	Pass / Fail
S-18-035	50	252.12mL	0.350mL	250mL	2.609	250.91mL	250.91mL ≤ 252.12mL	Pass
S-18-036	50	252.54mL	0.503mL			251.31mL	251.31mL ≤ 252.54mL	Pass
S-18-037	50	252.26mL	0.443mL			251.15mL	251.15mL ≤ 252.26mL	Pass

The yield was calculated since the purpose of the evaluation was to improve and maintain a process yield above the target goal (Table 3).

Table 3
Production Yield in the Filler Machine

Bulk Lot Number	Bulk Size (kg)	Total Accepted Unit in the Filler Machine	Yield	Manufacturing Yield Target
	A	B	C = B/A	
S-18-035	2,250 kg	5,833	2.592	2.592
S-18-036	2,193 kg	5,710	2.604	
S-18-037	2,295 kg	5,973	2.603	

Control Phase

During the control phase of this project the following actions were performed:

- Modification of the machine operating manual. Various modifications were performed for the operating manual.
  - It was incorporated detailed instructions to operate the Pump Stroke parameter which is directly related with the filling performance. The instructions were developed in conjunction with the operators to incorporate the actual steps to operate the machine.
  - For the instructions, it was incorporated pictures as guidelines for the operators.
  - The instructions were included in English and Spanish for easy understanding.
- It was established only the more capable operators in the filling operations. These operators were trained with the new instructions as in the field training.
- The machine operating manual was modified to incorporate the new operational parameters.
- The machine job plan and spare parts list was incorporated the new filler nozzles. The old filler nozzles were decommissioned.
- The Failure Mode and Effect Analysis (FMEA) of the filler machine was updated including the modifications performed during this project.

Conclusions

To improve the production yield of the filling process, a DMAIC methodology exercise was conducted. During the exercise the following opportunities areas were found: Pump Stroke parameter not standardized in the filling process. Product loss through the filler nozzles tips.

For the standardization of the operation of the Pump Stroke parameter, it was developed detailed instructions in conjunction with the filling area operators. In addition, the training process was reinforced to the filling operators. These actions helped to standardized the filling process and optimized the machine performance. For the product loss, it was validated a new design of filler nozzles that prevent the product loss. A DOE analysis was conducted to determine the operational parameters range that optimized the responses evaluated. After the determination of the operating range, the new parameters were validated obtaining satisfactory results.

After the modifications performed, it was obtained a process yield above the target goal of 2.592. These modifications improved the filling manufacturing process guarantying a standardized process that it is optimized complying with the manufacturing and customer requirements.

References

[1] George, M, L, Maxey, J. Rowlands, D. & Price, M. "The Lean Six Sigma Pocket Toolbook", *McGraw-Hill*, 2005, p. 5 - 41.

[2] Breakthrough Management Group, DeCarlo, N., "The Complete Idiot's Guide to Lean Six Sigma", *Breakthrough Management Group*, 2007, p. 183.

[3] Khan, R. "Six Sigma Statistics using Minitab", *17 Green Belt Edition*, Rehman M. Khan, 2016, p. 199.

[4] Montgomery, D. Runger, G. Faris Hubele, N. "Engineering Statistics" 3rd ed. *Wiley John & Sons, Inc*, 2004, p. 319.

[5] *What is Lean?*, 9-5-2019, Retrieved: http://asq.org/quality-resources/lean

[6] Breakthrough Management Group, DeCarlo, N. "The Complete Idiot's Guide to Lean Six Sigma", *Breakthrough Management Group*, 2007, p.2.f