Beer Filter Uptime Improvement

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Problem Definition

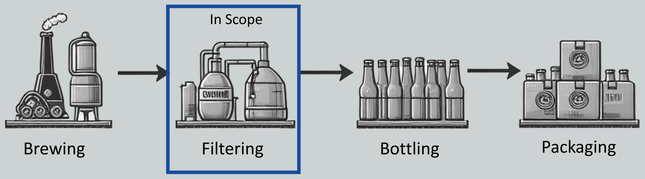
Problem Statement

The Labatt brewery is looking for a solution to improve the filtering process. It is currently experiencing worse downtime than its sister locations.

Objectives

- Reduce downtime by 10%
- Propose a framework for continuous improvement in the future.

Figure 1: Filter in the Carbonation room



Current State

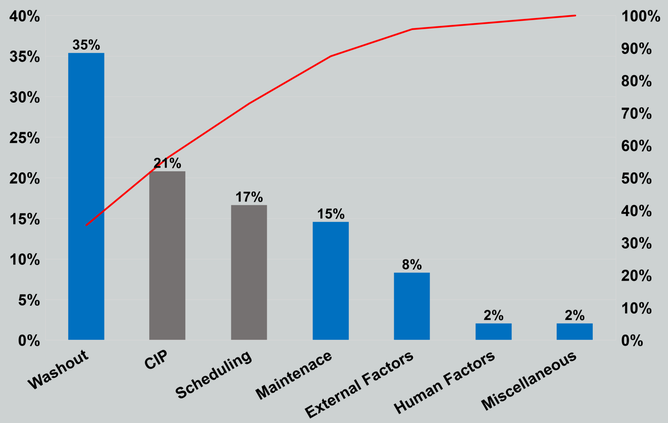
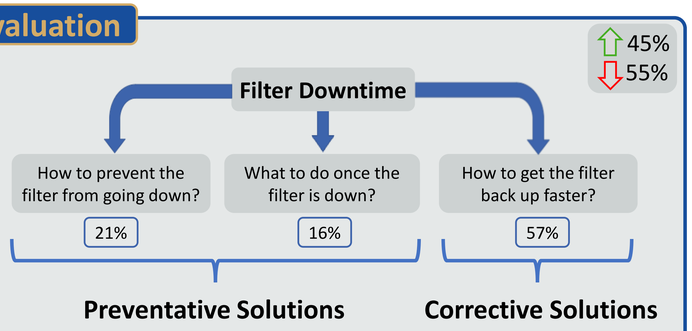


Figure 2: Pareto Analysis of Downtime Causes based on 88 data points

Evaluation



Methodology & Solutions

1. Analysis for Preventative Solutions (Downtime Process Improvement)

- Developed tools to aid staff in maintaining accountability and standardizing maintenance during downtime.
- Aimed at reducing the four lowest causes of downtime through proactive and preventive activities.

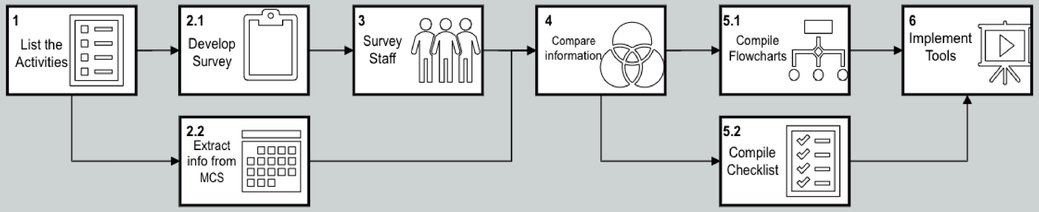


Figure 3: Procedure taken to develop preventative solutions

Preventative Solutions

Priority Zone	Area	Activity	Occurences	Day of Month 1	2	3	4	5	6	7	8	9
1	Vessel CIP	Clean Filter/DEG	Weekly									
1	Vessel CIP	Bottle Line Cleaning	Weekly									
1	Vessel CIP	Spicy Hop Inj	Weekly									
1	Vessel CIP	Hexahope Inj	Weekly									
1	Vessel CIP	Clean D12 and D13 tanks	Weekly									
1	Vessel CIP	Premix Tank & Line	Monthly									
1	Vessel CIP	Clean B1-B20	Monthly									
2	Vessel CIP	Transfer Hose CIP	Weekly									
2	B-Cellar	Clean and Refill Germ Bath B Ce	Weekly									
2	C-Cellar	Clean and Refill Germ Bath C Ce	Weekly									

Figure 4: Checklist for completing maintenance tasks each day

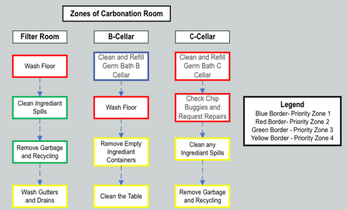


Figure 5: Flowchart for Weekly Tasks

2. Analysis for Corrective Solutions (Framework for Cycle Improvement)

- Minimize washout process runtime while maintaining filter cleanliness.
- Current state is three steps, totaling 45 minutes.
- Utilizes Design of Experiment and a mathematical model.

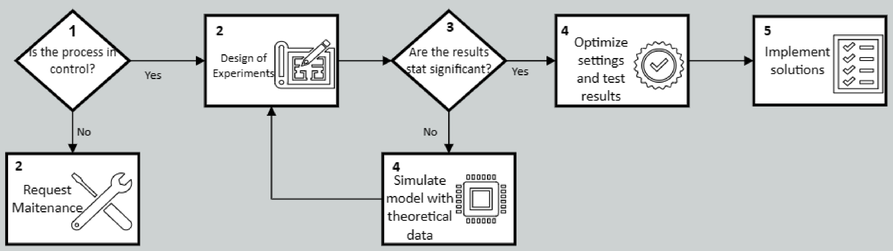


Figure 6: Framework for Cycle Improvement

Design of Experiments (DOE)

- Output variable: Post-washout cleanliness (1-5).
- Input variables: Washout step duration (cycles).
- Number of experimental trials: 8.

Step	Upper Limits: Cycle (qty)	Upper Limits: Total Runtime (minutes)	Lower Limits: Cycle (qty)	Lower Limits: Total Runtime (minutes)
1	5	4.6	4	3.7
2	11	17.6	9	14.4
3	24	23.2	19	18.4

Table 1: Design of Experiment Parameters

Mathematical Model

$$Minimize:\ Z = \sum_{i=1}^{3} \alpha_i x_i \quad [1]$$

s.t.

$$\hat{y} = \beta_0 + \sum_{i=1}^{3} \beta_i x_i + \sum_{i=1}^{2} \sum_{j=i+1}^{3} \beta_{ij} x_i x_j + \beta_{13} x_1 x_3 + \beta_{123} \prod_{i=1}^{3} x_i \quad [2]$$

$x_1 \geq 4$ [3] $\quad x_2 \geq 9$ [4] $\quad x_3 \geq 19$ [5]

$i \geq 0, Integer$ [6] $\quad x_i \geq 0, Integer$ [7]

Where:
$i \ \& \ j = Washout\ step$
$\alpha_i - Duration\ of\ washout\ step\ i$
$\beta_0 - Average\ effect\ coefficient\ of\ cleanliness$
$\beta_i - Effect\ coefficient\ of\ cleanliness\ for\ x_i$
$\beta_{ij} - Effect\ coefficient\ of\ cleanliness\ for\ interaction\ between\ x_i \ \& \ x_j$
$x_i \ \& \ x_j - Number\ of\ cycles\ for\ washout\ steps\ i \ \& \ j$
$\hat{y} - Predicted\ cleanliness$
$Z - Total\ washout\ time$

Simulation

Data Generation

- DOE results were not statistically significant (R^2 = 0.33).
- Monte Carlo simulation was used to generate 10,000 data points with cake space ranging from 80 to 95%.
- New R^2 = 0.61.

Washout Equation

$$y = \frac{\beta}{1 + e^{0.5\left(t - 22.5\left(\frac{\beta}{100}\right)\right)}}$$

Where:
y – % cake space during washout
β – initial cake space %
t – time (minutes)

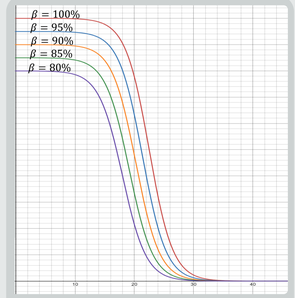


Figure 7: % Cake Space during Washout vs Time

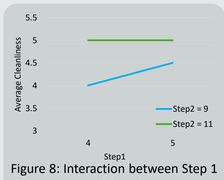


Figure 8: Interaction between Step 1 and Step 2

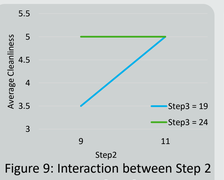


Figure 9: Interaction between Step 2 and Step 3

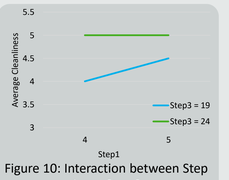


Figure 10: Interaction between Step 1 and Step 3

Implementation

Preventative Solutions

Tools were presented and reviewed by the Labatt team. Flowcharts were implemented as a dry-erase booklet for workers to check off completed tasks.

Corrective Solutions

Applying the simulation data to the mathematical model, the optimal number of cycles was determined to be 6, 9, and 19 for Steps 1, 2, and 3, respectively. A template for further Design of Experiments will be provided for staff to implement once the filter is in control.

Risk Analysis

Failure Mode	Potential Causes	Potential Effect	S	F	D	RPN	Action Recommended
Asset damage	Pressure increase	Screen and filter damage	5	3	5	75	Pressure to remain constant
Poor data collection	Lack of training	Inaccurate data recording	4	3	5	60	Create SOP
Production time loss	Failed washouts from parameter changes	Production loss	4	3	2	24	End-of-week trials, lower limit = 20%

Legend:
Risk Priority Number (RPN): Low (1-10), Medium (11-30), High (31-125)
Severity (S), Frequency (F), & Detection (D) on a scale of 1-5.

Table 2: FMEA Analysis

Results

Metrics	Corrective Solutions	Preventative Solutions
Current Downtime (%)	19.3%	14.7%
Target Savings (min/day)	14	20
Target Downtime (%)	18.3%	10.2%
Additional Throughput (HL/day)	49.7	71
Increase of Value made ($/year)	$150,770	$215,386
Total Value Added ($/year)	$366,156	

Table 3: Predictive Results after solution implementation