Six Sigma Project

Project at **Project under**

Streamlining Dairy Process (Pasteurization) for Energy Efficiency and Cost Effectiveness

Submitted By

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2. Introduction

2.1 Six Sigma

Six Sigma is a data-driven methodology and philosophy aimed at improving processes, reducing defects, and enhancing quality within organizations. Originating from Motorola in the 1980s and popularized by companies like General Electric, Six Sigma is founded on the principle of striving for near-perfect performance by minimizing variation and errors in production and service delivery.

At its core, Six Sigma is about achieving excellence through rigorous problem-solving and statistical analysis. The term "Six Sigma" refers to a statistical measure of process variation, specifically representing a level of performance that equates to only 3.4 defects per million opportunities. This level of precision underscores the methodology's commitment to reducing defects to an almost negligible level.

The Six Sigma methodology follows a structured approach known as DMAIC (Define, Measure, Analyze, Improve, Control) for process improvement:

1. Define: Clearly articulate the problem, project goals, and customer requirements.
2. Measure: Quantify current process performance using data and metrics to establish a baseline.
3. Analyze: Investigate the root causes of defects and variation within the process.
4. Improve: Implement solutions to address identified issues and optimize process performance.
5. Control: Establish measures to sustain improvements and prevent regression back to previous performance levels.

Moreover, Six Sigma employs various statistical tools and techniques such as process mapping, regression analysis, hypothesis testing, and control charts to identify areas for improvement and validate the effectiveness of implemented changes.

Central to Six Sigma's success is its focus on data-driven decision-making and the involvement of cross-functional teams trained in the methodology. These teams, often led by certified Six Sigma practitioners (e.g., Green Belts, Black Belts), collaborate to tackle complex problems and drive organizational transformation.

Ultimately, Six Sigma is not just a set of tools and methodologies but a cultural and organizational commitment to continuous improvement, customer satisfaction, and operational excellence. By systematically addressing inefficiencies and defects, Six Sigma helps organizations enhance product quality, increase customer loyalty, reduce costs, and drive sustainable growth in today's competitive business landscape.

2.2 About CP Milk Pvt. Ltd. (Gyan Dairy)

Overview

C.P. Milk and Food Products Pvt Ltd., embarked on its journey in 2007 as a Dairy Manufacturing and Bulk Distribution Company, marking the beginning of a trajectory that has seen remarkable growth and diversification. Initially focusing on two core products, Desi Ghee and Skimmed Milk, the company has since expanded its operations to encompass a wide array of business verticals.

Today, C.P. Milk and Food Products Pvt Ltd. stands as a multifaceted entity, with operations spanning Manufacturing, Distribution, Bulk Sales, Polypack and Retail Sales, as well as the innovative Gyan Fresh Stores and Gyan Fresh Home Delivery App. With a comprehensive product line boasting over 30 dairy offerings, the company caters to the varied needs and tastes of consumers across India.

The company's footprint extends across three strategically located manufacturing plants in Gudamba, Barabanki, and Varanasi, ensuring efficient production and distribution capabilities. Anchored by its Corporate Office in Lucknow, Uttar Pradesh, and bolstered by Regional Offices in Noida, Kanpur, Varanasi, and Allahabad, C.P. Milk and Food Products Pvt Ltd. has established a robust operational network to serve its growing customer base.

A testament to its commitment to quality and customer satisfaction, the company's Gyan Bulk Products are distributed nationwide, while its Home Delivery services are actively expanding across Uttar Pradesh, currently operational in Lucknow and Kanpur.

Under the visionary leadership of Founder C.P. Agarwal and his successors Jai Agarwal and Anuj Agarwal, C.P. Milk and Food Products Pvt Ltd. has experienced rapid expansion and success. Today, the company prides itself on offering a diverse portfolio of 17 meticulously crafted dairy products, all prepared using milk sourced directly from over 165,000 dairy farmers. Supported by a dedicated team of over 600 professionals and the unwavering backing of its dairy farming partners, the company aspires to earn the trust and loyalty of countless Indian families, striving to become the most beloved dairy brand in India.

2.3 DMAIC Process

The DMAIC (Define, Measure, Analyze, Improve, Control) process is a structured methodology widely used in Six Sigma and quality management initiatives to drive process improvement and problem-solving.

The first phase, Define, serves as the foundation, where the project's purpose, scope, and objectives are clearly outlined. It involves identifying the problem or opportunity for improvement, establishing project goals, and creating a project charter to guide the team's efforts.

In the Measure phase, data is collected to quantify the current state of the process under study. Key performance metrics are identified, and data collection tools are utilized to gather relevant information. This phase aims to provide a baseline understanding of the process's performance and establish measurable criteria for improvement.

Following Measure is the Analyze phase, where the collected data is analyzed to identify root causes of problems or areas for enhancement. Statistical tools and techniques are employed to uncover patterns, trends, and correlations within the data. This phase is crucial for gaining insights into the underlying issues driving process inefficiencies.

Armed with the insights gained from analysis, the Improve phase focuses on developing and implementing solutions to address the identified problems or optimize the process. This phase often involves brainstorming, experimentation, and pilot testing of potential solutions to determine their effectiveness.

Lastly, the Control phase ensures that the improvements achieved are sustained over time. Control measures and monitoring systems are established to track key process metrics and prevent regression to previous performance levels. Standard operating procedures and training programs may also be implemented to institutionalize the changes and ensure long-term stability.

Through the DMAIC process, organizations can systematically identify areas for improvement, implement targeted solutions, and achieve sustainable results, ultimately leading to enhanced quality, increased efficiency, and greater customer satisfaction.

3. Define Phase

3.1 Case Insight

The Define Phase of the DMAIC (Define, Measure, Improve, Analyse, Control) is the most important phase that the Defines the project objectives and customer needs, determines the project scope and develops the project plan. This phase also includes the formation of the project team and the selection of the team leader and Six Sigma Champion.

The business case mentions that Gyan Dairy Plant has recently invested in the latest technology for Plate Heat Exchangers (PHE) in their pasteurization process to enhance efficiency and reduce energy consumption. However, the plant still aims to further optimize energy usage and minimize costs associated with pasteurization. The primary objective of this Define phase in the DMAIC (Define, Measure, Analyse, Improve, Control) process is to clearly define the project scope for identifying opportunities to save more energy during the pasteurization process at the Gyan Dairy Plant.

The problem we are trying to resolve is bring down the variation rate (Current Standard Deviation 0.5) and Average Final Time Temperature (Current 5.41 degree Celsius) to set variation rate (<=0.3) and Average Final Time Temperature (4 degree Celsius, Margin +-2 degrees).

3.2 Project Charter

A project charter is a document developed by a project team that outlines the scope and purpose of a project. It provides a roadmap for the project and serves as an agreement between the project team, stakeholders, and other interested parties. The charter should include an overview of the project, an outline of the objectives and goals, a description of the project scope, and any other information that is necessary to define the project. It should also include a timeline of the project and a list of resources and stakeholders involved.

The project charter is an essential part of project management. It defines the project's scope and purpose and serves as the basis for all other project documents and activities. It also helps the project team to stay on track and to ensure that the project is completed on time and within budget. It also serves as a reference point for any changes that may be needed throughout the project

For problem statement we clearly defined the problem statement and then found the out the critical to process and critical to quality of the project and mentioned in the charter.

<table>
<tr><th colspan="4">PROJECT CHARTER</th></tr>
<tr><td colspan="4">Streamlining Dairy Process (Pasteurization) for Energy Efficiency and Cost Effectiveness</td></tr>
<tr><th colspan="3">Business Case</th><th>Opportunity Statement</th></tr>
<tr><td colspan="3">Significant energy loss during pasteurization process even after installing the latest technology for Plate Heat Exchanger.</td><td>Pain Point: Latest technology cannot be efficiently utilised.

Opportunity: Energy efficiency through streamlining process using more technology and control measures</td></tr>
<tr><th colspan="3">Goal Statement</th><th>Project Scope</th></tr>
<tr><th>Metric</th><th>Current Level</th><th>Goal/Target</th><td rowspan="3">Process under improvement: Pasteurization

Starts With: Silo Fill
Ends With: Dispatch

In scope: Packed Raw Milk
Out of Scope: Other Dairy Products like dahi, paneer, butter, etc.</td></tr>
<tr><td>Primary CTQ: Reducing Variation in Final Time Temperature (TT)</td><td>Approximately 0.5 standard deviation</td><td><= 0.3 standard deviation</td></tr>
<tr><td>Secondary CTQ: Reducing gap from average Final TT and Set Point of Final TT</td><td>5.41 degree Celsius</td><td>4.0 degree Celsius with margin +-2 degrees</td></tr>
<tr><th colspan="3">Project Plan</th><th>Team Selection</th></tr>
<tr><td>Phase</td><td>Start</td><td>End</td><td>Sponsor: KPMG</td></tr>
<tr><td>Define</td><td>January 23rd</td><td>January 29th</td><td>KPMG Mentor: Mr. Ankit Chandra</td></tr>
<tr><td>Measure</td><td>January 30th</td><td>February 7th</td><td>Faculty Mentor: Dr Kirti Nayal</td></tr>
<tr><td>Analyse</td><td>February 8th</td><td>February 16th</td><td>Company Guide (Gyan Dairy) : Ms Smita Dubey</td></tr>
<tr><td>Improve</td><td>February 17th</td><td>February 25th</td><td>Member: Rupanshi Rastogi</td></tr>
<tr><td>Control</td><td>February 25th</td><td>February 28th</td><td>Member: Satvik Singh</td></tr>
</table>

Figure 3.1 Project Charter

4. Measure Phase

In Measure Phase we completed following tasks:

a. As-is Process Map of Pasteurization
b. Data Collection Plan
c. Basic Statistic Plan
d. Process Capability Report for Final TT

4.1 As-is Process Map of Pasteurization

The as-is process map documents the current workflow of a specific process, illustrating sequential steps, decision points, inputs, and outputs. It provides a visual representation of the process flow, aiding in understanding and analysing the current state for potential growth.

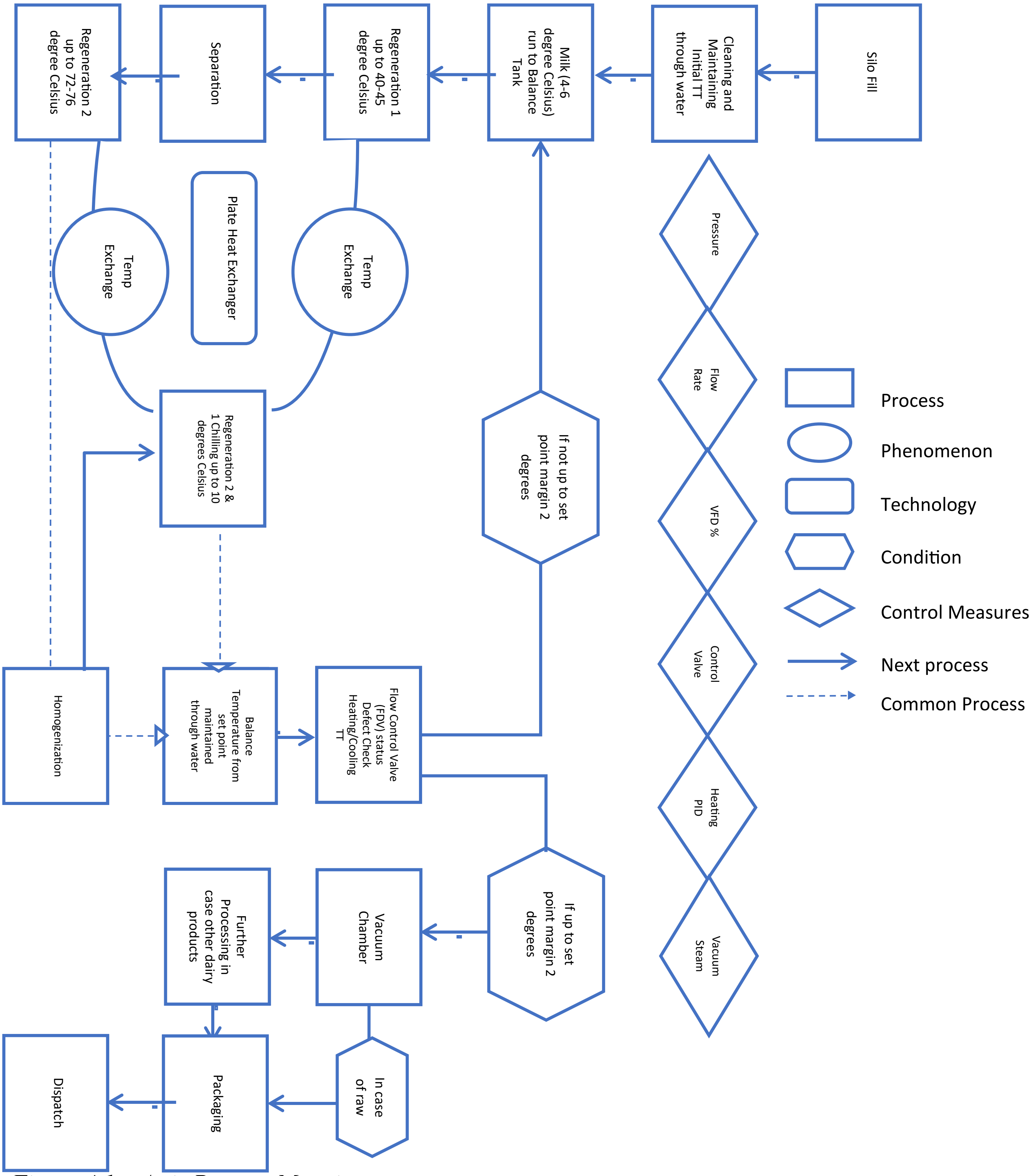


Figure 4.1.a As is Process Mapping

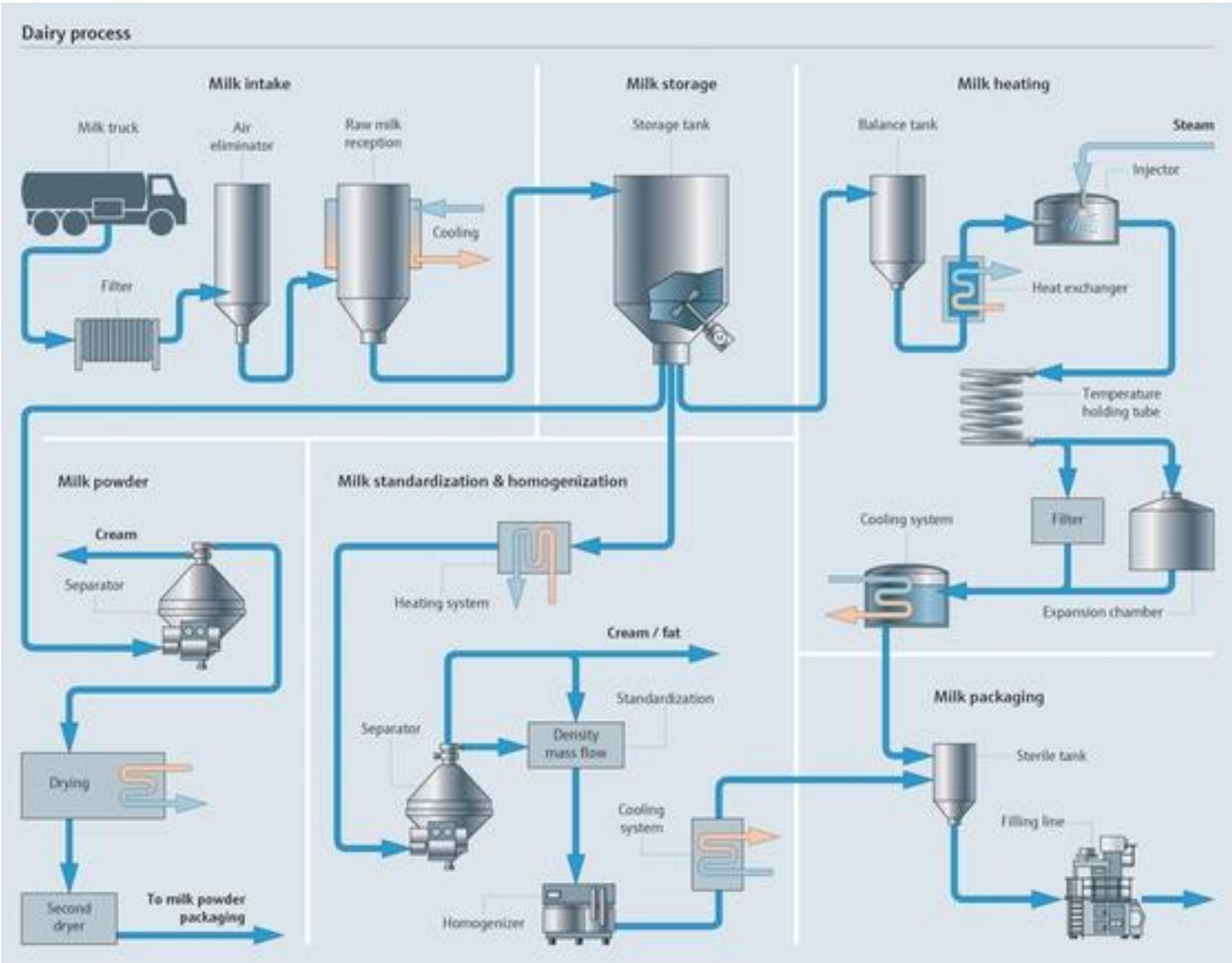


Figure 4.1.b As is Process Map Pictorial Representation

4.2 Data Collection Plan

Data was collected from the following sources:

a. Production Department
b. On call/Personal Interaction Data
c. Other sources online for analysis purpose

Type of Data Collected

a. Production Department Time Temperature monitoring data.
b. Other data involving – Capacity, Time, Process.
c. Data for check sheet for making Pareto Analysis.

CP MILK - LUCKNOW

10KL MILK PASTEURIZER-1 REPORT

Sr.No.	DATE & TIME	Date	STATUS	FLOW(L/h)	HOTWATER IN TT	HOTWATER OUT TT	HOLDING COIL IN TT	HOLDING COIL OUT TT	FINAL MILK OUT TT	AFTER BALANCE TANK	CHILLED WATER IN TT	HOT WATER IN PRESSURE	CHILLED WATER IN PRESSURE	AFTER BALANCE TANK PRESSURE	HEATING FDV STATUS	CHILLING FDV STATUS	HOMO INLET TT	SEP INLET TT	CONTROL VLV STATUS	VFD %	FLOW SET POINT	DESTINATION	HEATING PID SP	BEFORE VAC. TEMP	VACCUATOR STEAM PID	VACCUATOR STATUS
793345.0	2024-01-0101:06:01	2024-01-01	CIP	10194.4	81.5	79.0	80.8	83.1	67.3	57.0	62.4	1.2	11.8	6.5	FORWARD	DIVERT	79.0	75.5	100.0	100.0	11500.0	HMST	82.0	80.2	26.9	VACCUATOR INLINE
793346.0	2024-01-0101:07:01	2024-01-01	CIP	10226.9	83.3	80.3	81.8	81.3	67.6	57.6	62.5	1.1	11.8	6.6	FORWARD	DIVERT	77.4	74.4	100.0	100.0	11500.0	HMST	82.0	81.9	34.2	VACCUATOR INLINE
793347.0	2024-01-0101:08:01	2024-01-01	CIP	10231.2	82.2	79.3	81.0	82.6	69.2	58.5	62.6	1.1	11.8	6.6	FORWARD	DIVERT	79.0	75.9	100.0	100.0	11500.0	HMST	82.0	80.7	24.8	VACCUATOR INLINE
793348.0	2024-01-0101:09:01	2024-01-01	CIP	10252.9	83.3	80.4	81.7	81.3	69.6	59.0	62.8	1.2	11.8	6.9	FORWARD	DIVERT	77.3	75.9	100.0	100.0	11500.0	HMST	82.0	81.8	34.2	VACCUATOR INLINE
793349.0	2024-01-0101:10:01	2024-01-01	CIP	10257.2	82.2	79.4	80.6	82.3	70.7	59.9	63.3	1.2	11.8	6.8	FORWARD	DIVERT	78.9	76.2	100.0	100.0	11500.0	HMST	82.0	80.8	30.4	VACCUATOR INLINE
793350.0	2024-01-0101:11:01	2024-01-01	CIP	10287.6	83.0	80.2	81.5	81.1	71.3	60.4	63.8	1.2	11.8	6.8	DIVERT	DIVERT	78.6	77.1	100.0	100.0	11500.0	HMST	82.0	81.6	40.5	VACCUATOR INLINE
793351.0	2024-01-0101:12:01	2024-01-01	CIP	10231.2	82.9	79.9	81.2	82.8	71.8	61.1	64.3	1.2	11.8	6.8	FORWARD	DIVERT	79.2	76.8	100.0	100.0	11500.0	HMST	82.0	81.4	20.0	VACCUATOR INLINE
793352.0	2024-01-0101:13:01	2024-01-01	CIP	10252.9	83.1	80.4	80.6	81.5	72.9	61.7	64.7	1.1	11.8	6.7	FORWARD	DIVERT	78.9	77.7	100.0	100.0	11500.0	HMST	82.0	81.8	37.8	VACCUATOR INLINE
793353.0	2024-01-0101:14:01	2024-01-01	CIP	10213.9	83.4	80.4	81.4	82.2	73.0	62.2	65.3	1.1	11.8	6.8	FORWARD	DIVERT	79.6	77.6	100.0	100.0	11500.0	HMST	82.0	81.9	20.7	VACCUATOR INLINE
793354.0	2024-01-0101:15:01	2024-01-01	CIP	10242.0	82.4	80.2	80.9	81.7	73.8	62.6	65.8	1.3	11.8	6.6	FORWARD	DIVERT	79.5	78.5	100.0	100.0	11500.0	HMST	82.0	81.3	35.9	VACCUATOR INLINE
793355.0	2024-01-0101:16:02	2024-01-01	CIP	10289.7	83.3	80.7	82.1	82.2	73.9	62.9	66.3	1.3	11.8	6.8	FORWARD	DIVERT	79.5	78.1	100.0	100.0	11500.0	HMST	82.0	82.0	16.8	VACCUATOR INLINE
793356.0	2024-01-0101:17:01	2024-01-01	CIP	10276.7	83.4	80.8	81.3	82.3	74.7	63.4	66.7	1.2	11.8	6.8	FORWARD	DIVERT	80.0	79.0	100.0	100.0	11500.0	HMST	82.0	82.0	26.9	VACCUATOR INLINE
793357.0	2024-01-0101:18:01	2024-01-01	CIP	10268.1	84.1	81.3	81.7	82.0	74.8	63.6	67.2	1.2	11.8	6.9	FORWARD	DIVERT	79.1	79.0	100.0	100.0	11500.0	HMST	82.0	82.7	26.0	VACCUATOR INLINE
793358.0	2024-01-0101:19:01	2024-01-01	CIP	10211.7	84.1	81.0	81.8	82.4	75.4	64.1	67.5	1.1	11.8	6.5	FORWARD	DIVERT	80.2	79.2	100.0	100.0	11500.0	HMST	82.0	82.6	18.6	VACCUATOR INLINE
793359.0	2024-01-0101:20:01	2024-01-01	CIP	10307.1	84.2	81.3	81.5	82.2	75.6	64.3	68.0	1.1	11.8	6.5	DIVERT	DIVERT	80.3	79.8	100.0	100.0	11500.0	HMST	82.0	82.8	18.3	VACCUATOR INLINE
793360.0	2024-01-0101:21:01	2024-01-01	CIP	10285.4	84.5	81.4	81.8	82.3	75.9	64.7	68.3	0.9	11.8	6.8	FORWARD	DIVERT	80.2	79.5	100.0	100.0	11500.0	HMST	82.0	83.0	10.1	VACCUATOR INLINE
793361.0	2024-01-0101:22:01	2024-01-01	CIP	10255.1	84.4	81.4	81.4	82.3	76.2	64.9	68.7	1.1	11.8	6.9	FORWARD	DIVERT	80.3	80.0	100.0	100.0	11500.0	HMST	82.0	82.8	10.1	VACCUATOR INLINE
793362.0	2024-01-0101:23:01	2024-01-01	CIP	10255.1	84.7	81.7	81.9	82.3	76.2	65.2	69.1	0.9	11.8	6.7	FORWARD	DIVERT	80.3	79.7	100.0	100.0	11500.0	HMST	82.0	83.1	3.2	VACCUATOR INLINE
793363.0	2024-01-0101:24:01	2024-01-01	CIP	10296.2	84.6	81.5	81.8	82.5	76.8	65.4	69.3	0.9	11.8	6.9	FORWARD	DIVERT	80.6	80.3	100.0	100.0	11500.0	HMST	82.0	82.9	0.0	VACCUATOR INLINE
793364.0	2024-01-0101:25:01	2024-01-01	CIP	10278.9	84.9	81.8	81.9	82.3	76.7	65.6	69.7	0.8	11.8	6.7	FORWARD	DIVERT	80.0	80.0	100.0	100.0	11500.0	HMST	82.0	83.3	0.0	VACCUATOR INLINE
793365.0	2024-01-0101:26:01	2024-01-01	CIP	10237.7	83.8	81.1	81.8	82.5	77.2	65.9	69.9	1.1	11.8	6.8	FORWARD	DIVERT	80.8	80.5	100.0	100.0	11500.0	HMST	82.0	82.5	0.0	VACCUATOR INLINE
793366.0	2024-01-0101:27:01	2024-01-01	CIP	10281.1	84.4	81.9	81.4	82.1	77.2	66.0	70.2	1.1	11.8	6.9	FORWARD	DIVERT	79.7	80.4	100.0	100.0	11500.0	HMST	82.0	83.1	4.1	VACCUATOR INLINE
793367.0	2024-01-0101:28:01	2024-01-01	CIP	10244.2	84.6	81.5	82.1	82.5	77.6	66.3	70.5	1.1	11.8	6.8	FORWARD	DIVERT	80.9	80.5	100.0	100.0	11500.0	HMST	82.0	83.1	0.0	VACCUATOR INLINE

Figure 4.2.a Production Department Time Temperature monitoring data.

The data is of milk pasteurizer and it has following headers:

Sr. No., DATE & TIME, Date, STATUS, FLOW (L/h), HOTWATER IN TT, HOTWATER OUT TT, HOLDING COIL IN TT, HOLDING COIL OUT TT, FINAL MILK OUT TT, AFTER BALANCE TANK TT, CHILLED WATER IN TT, HOT WATER IN PRESSURE, CHILLED WATER IN PRESSURE, AFTER BALANCE TANK PRESSURE, HEATING FDV STATUS, CHILLING FDV STATUS, HOMO INLET TT, SEP INLET TT, CONTROL VLV STATUS, VFD %, FLOW SET POINT, DESTINATION, HEATING PID SP, BEFORE VAC. TEMP, VACCUATOR STEAM PID, VACCUATOR STATUS

Other data involves capacity – 600000 litre per day

Time – 13 hours functional per day, 11.5 hours in production, 1.5 hours downtime

Process – used for making as is process map

Reasons	Weightage	Variations in Flow Rate & Final Temp			Lack of latest Technology			Adaptibility to technology			Inadequate monitoring			Poor maintainence			Lack of Employee training			External Factors		
		Rank(Points)			Rank(Points)			Rank(Points)			Rank(Points)			Rank(Points)			Rank(Points)			Rank(Points)		
		1(3)	2(2)	3(1)	1(3)	2(2)	3(1)	1(3)	2(2)	3(1)	1(3)	2(2)	3(1)	1(3)	2(2)	3(1)	1(3)	2(2)	3(1)	1(3)	2(2)	3(1)
Head of Operations	0.3	3					1														2	
Head of Quality	0.25			1		2					3											
Plant Head	0.2	3								1											2	
Plant Supervisor 1	0.05	3																2				1
Plant Supervisor 2	0.05		2							1										3		
Plant operator	0.025			1		2											3					
Foodtech student 1	0.025			1	3				2													
Foodtech student 2	0.025				3					1											2	
Foodtech student 3	0.025		2				1	3														
B Tech dairy technology student 1	0.025							3								1					2	
B Tech dairy technology student 2	0.025		2		3																	1
Total Points	1	1.65	0.2	0.3	0.225	0.55	0.325	0.15	0.05	0.275	0.75	0	0	0	0	0.025	0.075	0.1	0	0.15	1.1	0.075
Total weighted points		2.15			1.1			0.475			0.75			0.025			0.175			1.325		

Figure 4.2.b Check Sheet

The Check Sheet is made by taking common problems that come up for not achieving better energy efficiency, this list was then given to certain survey takers related to issue to rank the issues as their top 3.

Each rank was given different points

Rank 1 – 3 Points

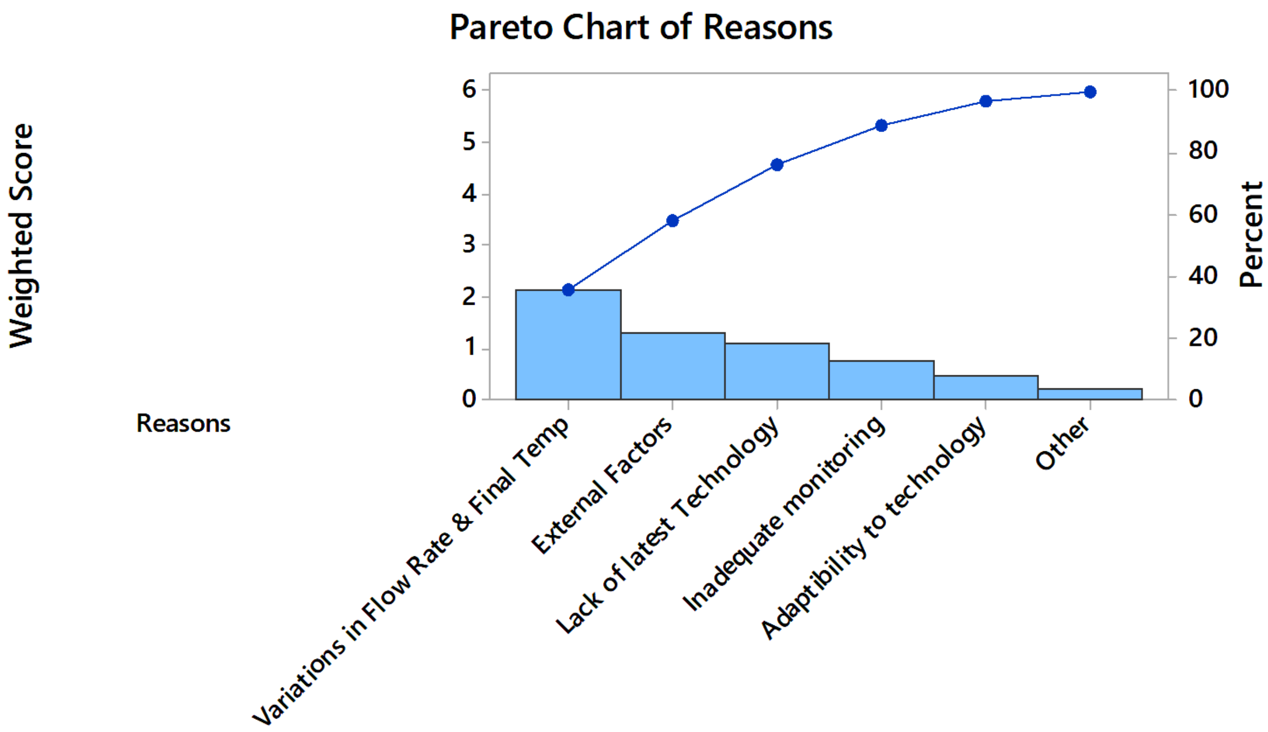
Rank 2 – 2 Points

Rank 3 – 1 Points

Then each stakeholder was given different weightage based on influence, knowledge, and expertise. Then final weightage score is taken out by taking out sum product.

4.3 Basic Statistical Plan

At first, we have converted our check sheet into a Pareto Chart to get a better of the major contributor to the issue.



Weighted Score	2.150	1.325	1.100	0.750	0.475	0.200
Percent	35.8	22.1	18.3	12.5	7.9	3.3
Cum %	35.8	57.9	76.3	88.8	96.7	100.0

Figure 4.3.a Pareto Analysis

Inference: It can be observed that Variations in Flow Rate & Final Temp cause the major issue which also follows the 80-20 rule of Pareto analysis as out of 6 issues only 2 is causing around 60% of the issue.

4.4 Process Capability Index

Now to test whether the Time Temperature data is normal or not we did an Anderson Darling test and found that the p-value is greater than 0.05 which means the data is normal.

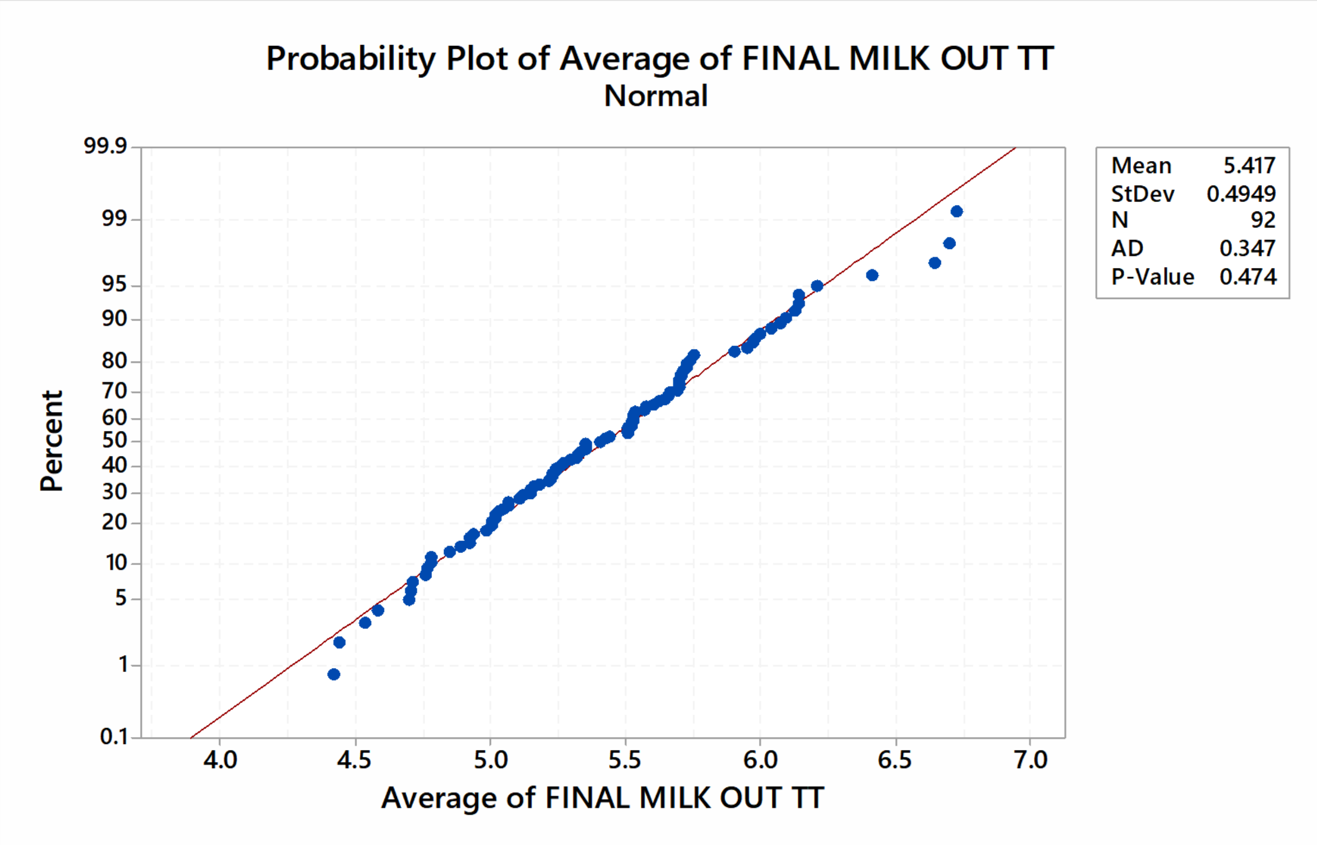


Figure 4.4.a Anderson Darling Test for normality

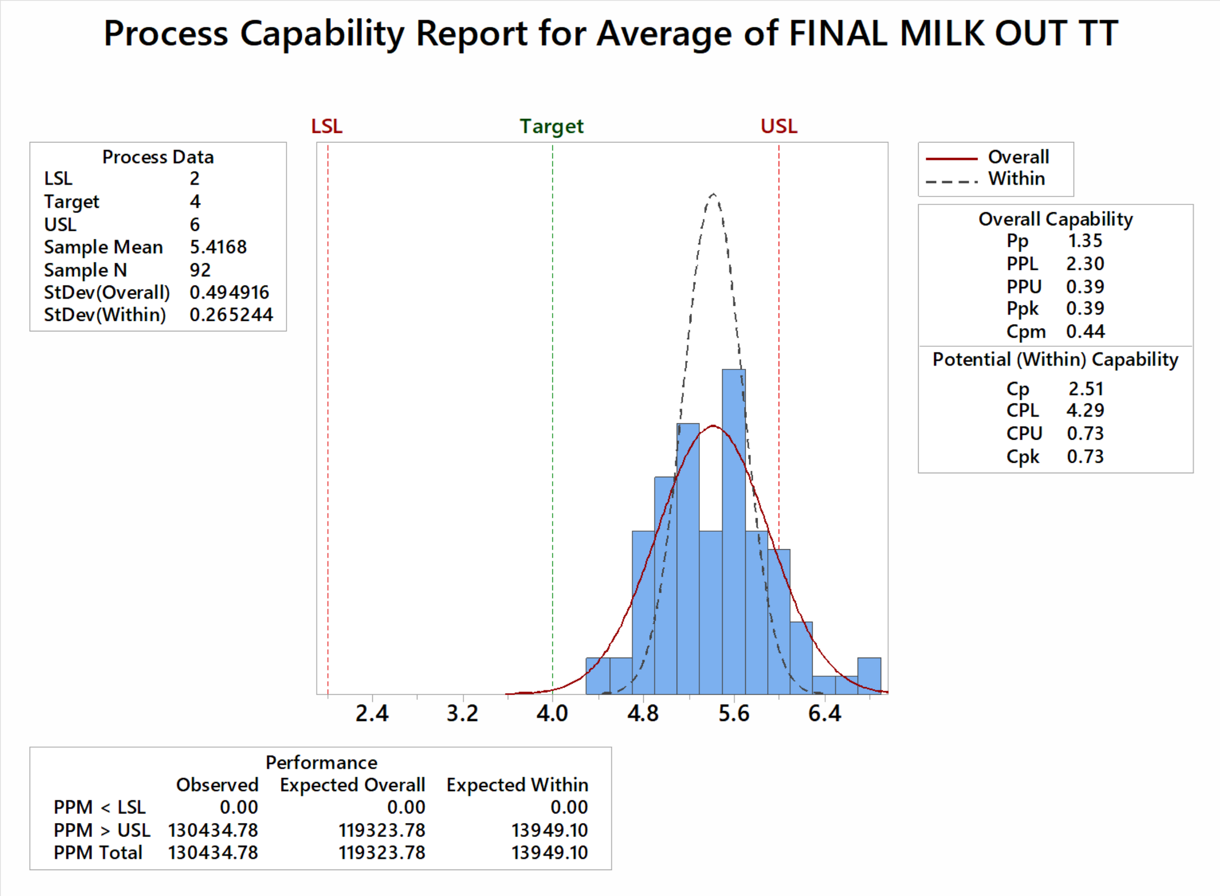


Figure 4.4.b Process Capability of the current process

Inference: Though Cp>Pp but difference is less so the data is not tempered and low Cpk value indicates we can centre the process.

These inferences were made with help of following understanding:

Situation		What can cause this situation	What is the correct action to take
Cp<Pp	Potential vs Capable	Normal use condition	No Action
Cp=Pp		Normal data is normally distributed and has not been manipulated	No Action
Cp>Pp		Data has been manipulated or tool wear is occurring but slowly.	Review For tool wear, review for data manipulation.
Cp<Cpk	Capable vs Capable Index	**This is impossible.**	**This is impossible.**
Cp=Cpk		The process is perfectly centered	No Change
Cp>Cpk		The process is not centered	Adjust the process toward the middle if Cpk is less than validation requirements and Cp is higher than validation requirements.
Situation		**What can cause this situation**	**What is the correct action to take**
Pp<Ppk	Potential vs Potential Index	**This is impossible.**	**This is impossible.**
Pp=Ppk		The process is perfectly centered	No Change
Pp>Ppk		The process is not centered	Adjust the process toward the middle if Cpk is less than validation requirements and Cp is higher than validation requirements.
Cpk<Ppk	Potential Index vs Capable Index	Normal use condition	No Action
Cpk=Ppk		Normal data is normally distributed and has not been manipulated	No Action
Cpk>Ppk		Data has been manipulated or tool wear is occurring but slowly.	Review For tool wear, review for data manipulation.

Figure 4.4.c Situation-Cause Analysis for Process Capability

5. Analyse Phase

The Analyse phase of the DMAIC process is the most critical stage in improving a process. It involves collecting and analysing data to identify the root cause of the problem and determine what needs to be addressed to improve the process. This phase also involves identifying the relevant data sources and gathering data from them.

At first, we embarked on a thorough exploration of the problem at hand. Utilizing the fishbone analysis technique, also known as Ishikawa or cause-and-effect diagram, we systematically identified potential causes contributing to the identified issue. This method allowed us to delve into various domains, including man, machine, method, material, measurement, maintenance, mother nature, and management, in search of root causes and contributing factors.

Following the fishbone analysis, we strategically chose one cause for further analysis, considering its perceived significance and potential impact on the problem. This selection process involved evaluating the effectiveness of addressing each cause against the resources and constraints of the project. Ultimately, one cause stood out as particularly critical due to its potential to address multiple root causes identified during the analysis. This strategic decision ensured that our resources were allocated effectively, focusing on the most impactful areas for improvement.

Subsequently, we delved deeper into the chosen root cause, conducting a detailed analysis to gain a comprehensive understanding of its underlying factors and mechanisms. This analysis involved gathering additional data, conducting interviews with relevant stakeholders, and utilizing various analytical tools to dissect the root cause and its associated contributing factors. Additionally, we employed a 5 Why analysis to systematically uncover the underlying reasons behind the identified root cause, peeling back successive layers of causation to identify fundamental issues.

Steps involved:

a. Listing causes through fish bone analysis
b. Choosing one cause for further analysis and reason for choosing it
c. Analysing root cause
d. 5 Why analysis

5.1 Fish Bone Analysis

Fishbone analysis, also known as Ishikawa or cause-and-effect analysis, is a methodical problem-solving technique utilized to identify and explore potential causes of a specific problem or effect. The process begins by clearly defining the problem or effect under investigation. A visual representation resembling the skeleton of a fish is then created, with a horizontal line representing the problem or effect and diagonal lines extending outward to represent different categories of potential causes. These categories often include aspects such as Manpower (People), Methods, Machines, Materials, Measurement, and Mother Nature (Environment), though they can be customized to suit specific contexts.

Fishbone analysis is an iterative process, and improvement efforts are often ongoing to ensure sustained progress and resolution of the identified problem. Overall, fishbone analysis provides a structured and systematic approach to problem-solving, facilitating the identification and mitigation of root causes to achieve lasting solutions.

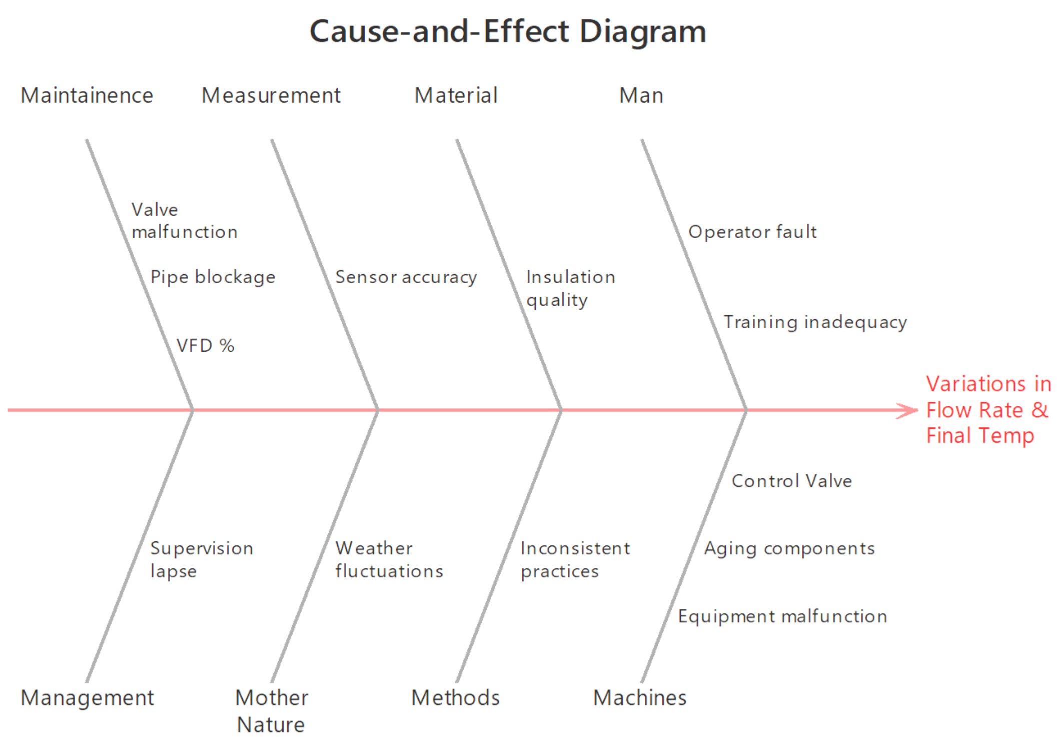


Figure 5.1 Cause and Effect Diagram (Fish Bone Diagram)

5.2 Cause to proceed and Why

Here under Maintenance category the VFD % is chosen.

VFD stands for Variable Frequency Drive, which is a type of motor controller that regulates the speed and torque of an electric motor by varying the frequency and voltage of the power supplied to it. VFDs are commonly used in industrial and commercial applications to control the speed of pumps, fans, compressors, and other motor-driven equipment. By adjusting the speed of the motor to match the required load, VFDs can help improve energy efficiency, reduce wear, and tear on equipment, and provide more precise control over processes. They are often integrated into automated systems and are an essential component of modern manufacturing and HVAC (heating, ventilation, and air conditioning) systems.

Here the VFD% indicates the speed of the motors which runs all these fans and pumps. So, it must be maintained under certain percentage to avoid under and over loading.

Reasons to choose VFD %

- Data Availability
- Quantifiable data
- Data Variations
- Relation to both Flow Rate and Final TT

5.3 Analysing root cause

Before proceeding with VFD% data we must do a process capability test to see that the data is capable or correct or not.

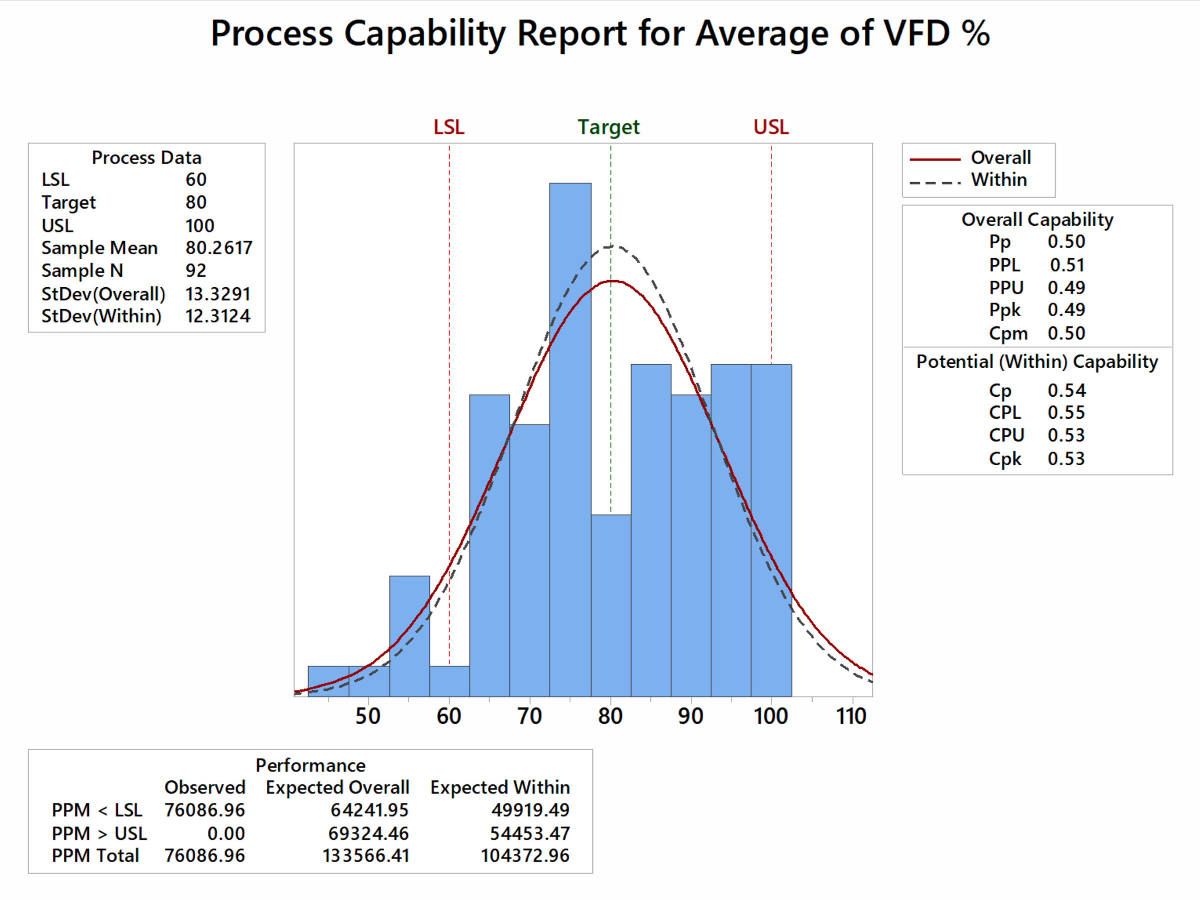


Figure 5.3 Process Capability for Average of VFD%

Inference: The same inferences can be taken as we got when we did process capability analysis Final TT. So, we can infer that Cp>Pp but difference is less so the data is not tempered and low Cpk value indicates we can centre the process.

Here we can also specify the LSL and USL from the data as we see most of the data lie between 60 to 100. Note that we will take different warning or ideal limits for better results.

5.4 ‘5’ Why analysis

DEFINE THE PROBLEM

Variations in Flow Rate & Final TT

WHY IS THIS A PROBLEM?

PRIMARY CAUSE

Why is it happening?

1 Inefficiencies in VFD%

Why is that?

2 A lot of variations in daily average VFD%

Why is that?

3 Lack of optimization & predictive analysis

Why is that?

4 Proper Technology and Tools

Why is that?

ROOT CAUSE

NOTE: If the final "Why" has no controllable solution, return to the previous "Why."

5 *Not required*

CORRECTIVE ACTION TO TAKE

CORRECTIVE ACTION

More investments could be done on Tools, Technology, & Systems like

- Advanced Control Systems
- PID Control
- Feedback Sensors
- Predictive Analytics
- Condition Monitoring
- Energy Management Systems (EMS)

PARTY RESPONSIBLE

R&D Dep, Operation Dep, Quality Dep, Finance Dep

DATE ACTION TO BEGIN

-

DATE TO COMPLETE

-

Figure 5.4 5 Why Analysis

The 5 Whys analysis is a problem-solving technique that aims to identify the root cause of an issue by asking "why" repeatedly. It begins with clearly defining the problem at hand, whether it's a quality concern, operational inefficiency, or another issue. Then, the team asks "why" the problem occurred, with each answer providing the basis for the next question. This process continues iteratively, typically five times, until the team reaches a point where further questioning is no longer necessary or possible. The final answer uncovered through this process represents the root cause of the problem. By systematically delving deeper into the underlying factors contributing to the issue, the 5 Whys analysis helps teams avoid merely addressing symptoms and enables them to develop more effective solutions that target the true cause. This approach fosters a thorough understanding of the problem and encourages thoughtful problem-solving, ultimately leading to sustainable improvements and long-term success.

6. Improve Phase

the Improve phase is a critical stage where identified solutions are implemented to address the root causes identified during the Analyse phase. This phase is centred around testing and implementing potential solutions to improve the process or address the identified problem effectively.

During the Improve phase, the focus shifts from analysis to action. The solutions identified during the previous phases are evaluated, refined, and prioritized based on their potential impact on the problem and feasibility of implementation. This may involve brainstorming sessions, pilot tests, simulations, or small-scale trials to assess the effectiveness of proposed solutions in a controlled environment before full-scale implementation.

This phase will include the following:

a. Plan Implementation
b. Technology, Tools, & Systems involved
c. Contribution Analysis
d. Improvement Analysis
e. Cost Benefit Analysis

6.1 Plan Implementation

The plan implementation stage will take the solution which we got from 5 Why Analysis. As our solution involves several technology and tools with taking account into different departments involved. This stage will focus upon how these departments will play their roles in implementing the plan.

The R&D Department plays a crucial role in the implementation of the plan by conducting research and development activities to explore the latest advancements in technology and systems relevant to the identified areas. They will collaborate with external partners, attend industry conferences, and stay abreast of emerging trends to ensure that the organization remains at the forefront of innovation. Additionally, the R&D Department will be responsible for evaluating potential tools and technologies, conducting feasibility studies, and developing prototypes or pilot projects to test their effectiveness before full-scale implementation.

The Operations Department will oversee the integration of the new tools, technology, and systems into the day-to-day operations of the organization. They will work closely with vendors and suppliers to procure the necessary equipment and ensure that it is installed and configured correctly. The Operations Department will also develop and implement training programs to familiarize staff with the new systems and procedures, as well as establish protocols for ongoing maintenance and support to ensure optimal performance.

The Quality Department will play a vital role in ensuring that the implementation of new tools and systems meets the organization's quality standards and regulatory requirements. They will conduct thorough testing and validation of the new systems to verify their reliability, accuracy, and consistency. The Quality Department will also establish metrics and Key Performance Indicators (KPIs) to monitor the effectiveness of the implemented solutions and identify areas for improvement.

Finally, the Finance Department will oversee the budgeting and financial aspects of the plan implementation. They will work closely with the other departments to develop cost estimates, allocate funds, and track expenses related to the procurement, installation, and maintenance of the new tools and systems. The Finance Department will also conduct cost-benefit analyses to evaluate the return on investment (ROI) of the implemented solutions and ensure that they align with the organization's overall financial objectives.

Overall, the successful implementation of the plan will require close collaboration and coordination among all departments involved, with each playing a unique but interconnected role in driving innovation, improving operational efficiency, and enhancing overall organizational performance.

6.2 Technology, Tools, & Systems

Technology involved:

a. Advanced Control Systems
b. PID Control
c. Feedback Sensors

Advanced Control Systems

These systems are designed to handle complex and nonlinear processes, provide enhanced performance, robustness, and flexibility in controlling various types of systems. Model Predictive Control (MPC), Adaptive Control, Nonlinear Control, Optimal Control, Robust Control, Fuzzy Logic Control, Neural Network Control are some of its examples.

- Model Predictive Control (MPC): MPC utilizes a dynamic model of the process to predict future behaviour and optimize control actions over a finite time horizon. It continuously updates predictions and adjusts control inputs, making it suitable for systems with complex dynamics and constraints.
- Adaptive Control: Adaptive control adjusts its parameters in real-time based on the system's response, allowing it to adapt to changes in operating conditions or uncertainties. It is particularly useful for systems with varying dynamics or environments where precise models may not be available.
- Nonlinear Control: Nonlinear control techniques are designed to handle systems with nonlinear dynamics, which cannot be adequately modelled using linear methods. They employ strategies such as feedback linearization, sliding mode control, or Lyapunov-based methods to stabilize and regulate nonlinear systems.
- Optimal Control: Optimal control seeks to minimize a cost function while satisfying system constraints, aiming to find the best control inputs over a specified time horizon. Techniques like dynamic programming, Pontryagin's minimum principle, or optimal control theory are employed to achieve optimal performance.

- Robust Control: Robust control techniques aim to ensure system stability and performance in the presence of uncertainties or disturbances. They design controllers that can tolerate variations in system parameters or external disturbances, providing resilience against modelling errors or environmental changes.
- Fuzzy Logic Control: Fuzzy logic control utilizes linguistic variables and fuzzy rules to mimic human decision-making processes. It allows for intuitive control strategies, particularly in systems with vague or imprecise information, and is robust to uncertainties and nonlinearities.
- Neural Network Control: Neural network control employs artificial neural networks to approximate complex nonlinear mappings between inputs and outputs in a control system. It learns from data and adjusts its parameters over time, making it suitable for adaptive control and nonlinear system identification.

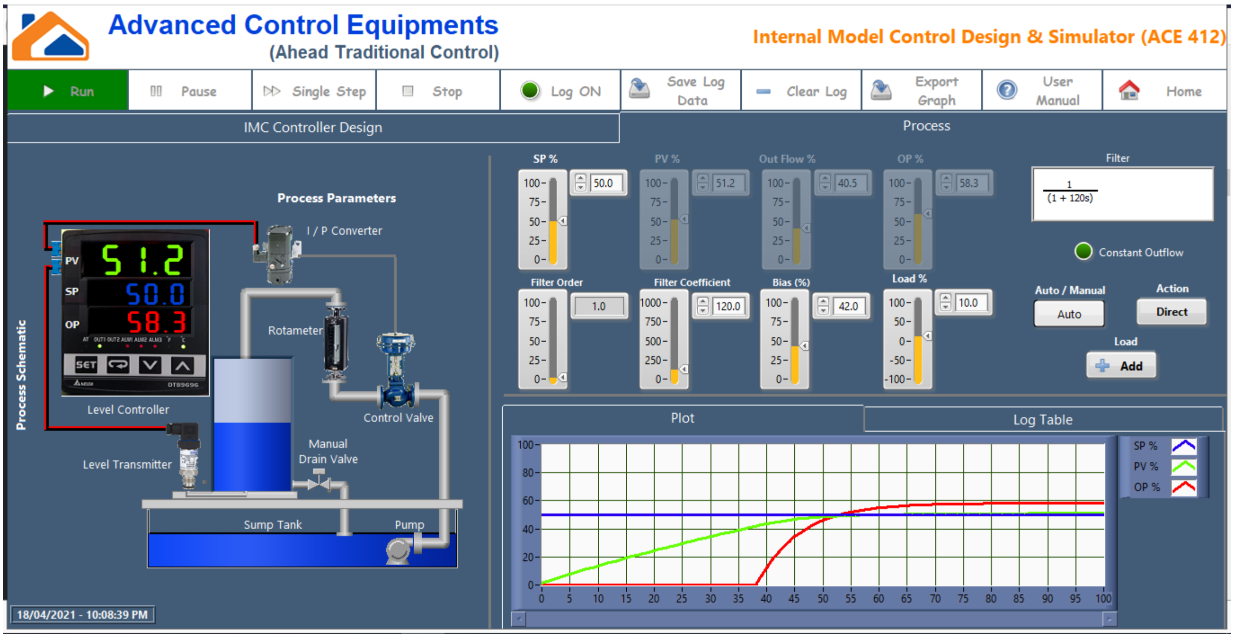


Figure 6.2.a Advanced Control Equipment Simulator

PID Control

PID control, or Proportional-Integral-Derivative control, is a widely used feedback control technique in engineering. It aims to regulate a process by adjusting a control variable based on the difference between a desired setpoint and the actual process variable.

Proportional (P) Term: The proportional term responds to the current error between the setpoint and the process variable. It produces a control output proportional to the error, which helps reduce steady-state errors and improves system responsiveness.

Integral (I) Term: The integral term integrates the error over time, allowing the controller to eliminate any remaining steady-state error and achieve precise control. It continuously adjusts the control output based on the accumulated error, helping to maintain stability and accuracy over long periods.

Derivative (D) Term: The derivative term predicts the future trend of the error by calculating its rate of change. It adds damping to the control action, helping to reduce overshoot and improve the transient response of the system.

By combining these three terms, PID control provides a balance between stability, responsiveness, and accuracy, making it suitable for a wide range of control applications. It is widely used in industrial processes, robotics, automotive systems, and many other fields where precise control is essential. Adjusting the parameters of the P, I, and D terms allows engineers to tune the PID controller to meet specific performance requirements and adapt to varying operating conditions.

Though this technology is already in use of the plant but more updating can be done in it.

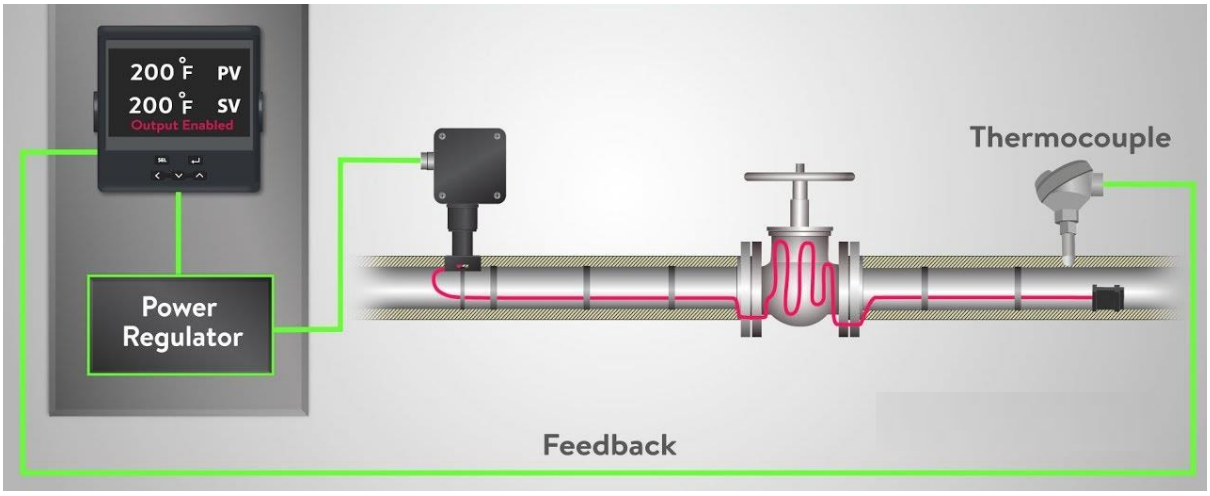


Figure 6.2.b PID Controller

Feedback Sensors

Some of the examples are:

- Position sensors,
- Velocity sensors,
- Acceleration sensors,
- Force sensors,

- Torque sensors,
- Pressure sensors,
- Temperature sensors,
- Flow sensors,
- Level sensors,
- Load sensors

Systems involved:

a. Predictive Analytics
b. Condition Monitoring

Figure 6.2.c Feedback Sensors

Predictive Analytics

Predictive analysis is the process of extracting insights from data to predict future outcomes or trends. It involves using statistical techniques, machine learning algorithms, and data mining methods to analyse historical data and identify patterns, relationships, and correlations. By leveraging these insights, organizations can make informed decisions, anticipate future events, and optimize strategies across various domains such as finance, marketing, healthcare, and manufacturing. Predictive analysis enables proactive planning, risk management, resource allocation, and performance optimization, leading to improved efficiency, productivity, and competitiveness.

Condition Monitoring

Condition monitoring is a proactive maintenance approach that involves the continuous monitoring of equipment or assets to assess their performance and detect any deviations from normal operating conditions. It typically involves the use of sensors, data acquisition systems, and analytics tools to collect and analyse data on various parameters such as temperature, vibration, pressure, and fluid levels. By monitoring these parameters in real-time or periodically, condition monitoring enables early detection of equipment faults, abnormalities, or signs of deterioration, allowing maintenance teams to take timely corrective actions before failures occur. This approach helps to minimize unplanned downtime, extend asset lifespans, optimize maintenance schedules, and reduce overall maintenance costs. Condition monitoring is widely used in industries such as manufacturing, oil and gas, power generation, and transportation to ensure the reliability, availability, and performance of critical assets.

Tools involved:

a. Energy Management Systems (EMS)

Energy Management Systems (EMS)

EMS stands for Energy Management Systems. It refers to a set of tools, technologies, and processes designed to monitor, control, and optimize energy consumption within an organization or facility. EMS typically involves the integration of hardware and software solutions to gather data on energy usage, analyse patterns and trends, and implement strategies to reduce energy waste and improve efficiency. Key components of EMS may include energy monitoring and metering systems, building automation systems, demand response capabilities, and energy conservation measures. By implementing an EMS, organizations can better manage their energy resources, reduce operational costs, comply with regulatory requirements, and achieve sustainability goals.

Figure 6.2.d Siemens EMS Portal

Figure 6.2.e Siemens EMS Dashboard

Note: The example for platform for EMS is taken as Siemens because the company is already using Siemens platform for their Plant Operations.

6.3 Contribution Analysis

The contribution analysis will show that how much in terms of percentage each of the technology, tool, & system will contribute to reduce the Standard Deviation (Currently at 13.25) of Daily Average VFD%.

Note that these numbers are approximate and are just assumption made from taking knowledge of companies in the similar industries. The actual numbers can be only obtained after implementing the solution.

Let us break down how each measure could contribute to reducing the standard deviation:

a. Advanced Control Systems:
- Reduction in standard deviation: 10% to 20%

b. PID Control:
- Reduction in standard deviation: 5% to 15%

c. Feedback Sensors:
- Reduction in standard deviation: 10% to 20%

d. Predictive Analytics:
- Reduction in standard deviation: 8% to 15%

e. Condition Monitoring:
- Reduction in standard deviation: 5% to 12%

f. Energy Management Systems (EMS):
- Reduction in standard deviation: 8% to 15%

Taking a Conservative approach forward:

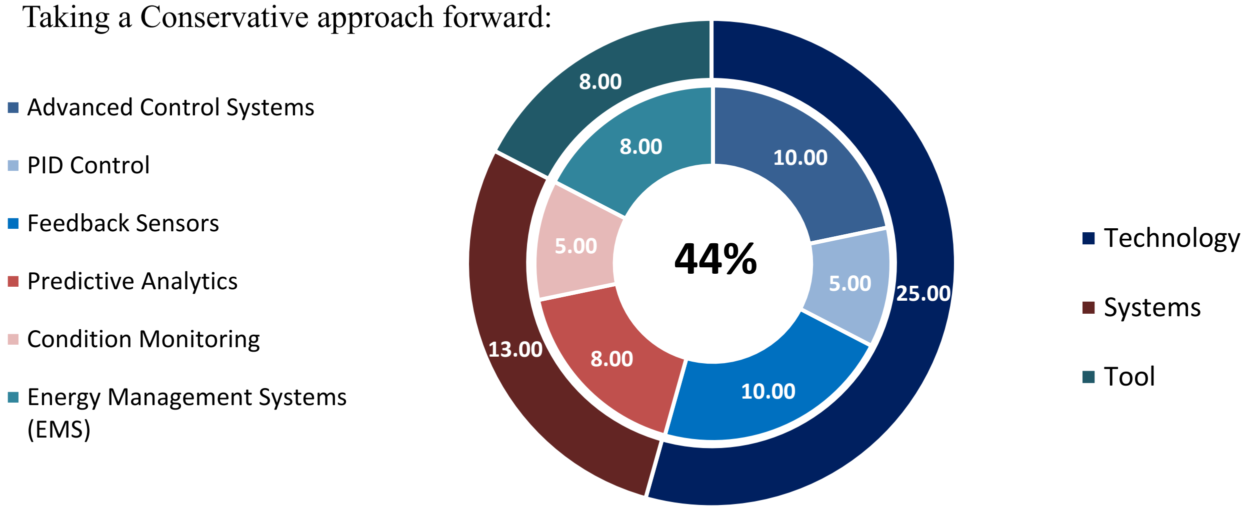


Figure 6.3.a Contribution breakdown

Inference: By taking a conservative approach a total of 44% deduction can be observed which gives us a new standard deviation as:

$$13.25 * \{(100\text{-}44)/100\} = 07.10$$

6.4 Improvement Analysis

The improvement happens in a flow effect as improvement in variation in VFD% improves variation in flow rate that ultimately improves Final TT variations.

For the sake of simplicity and lack of information about quantitative relation between these variables the other variable reduction in Standard Deviation is taken at the same rate that is 44%.

Note that a relative relation which is a direct one in this case can be established.

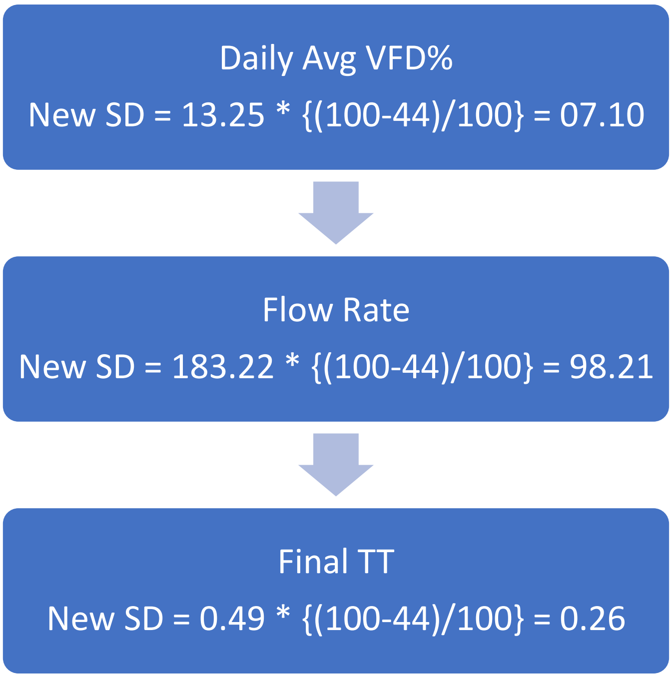


Figure 6.4.a New Standard Deviations

Now using this data, a Scaling Factor was established and all the three data were transformed.

$$\text{Scaling Factor} = \text{New Standard Deviation/Old Standard Deviation}$$

$$\text{Transformed Data} = \{(x-\bar{x}) * s\} + \bar{x}$$

Where x = Original variable data point

$\bar{x}$ = Set Point or Mean (Mean if Setpoint is not there)

s = Scaling Factor

After getting the transformed data and setting the UCL/USL, LCL/LSL, UWL, LWL, Setpoint or Mean we can compare and mark the improvements in all three variables through control charts.

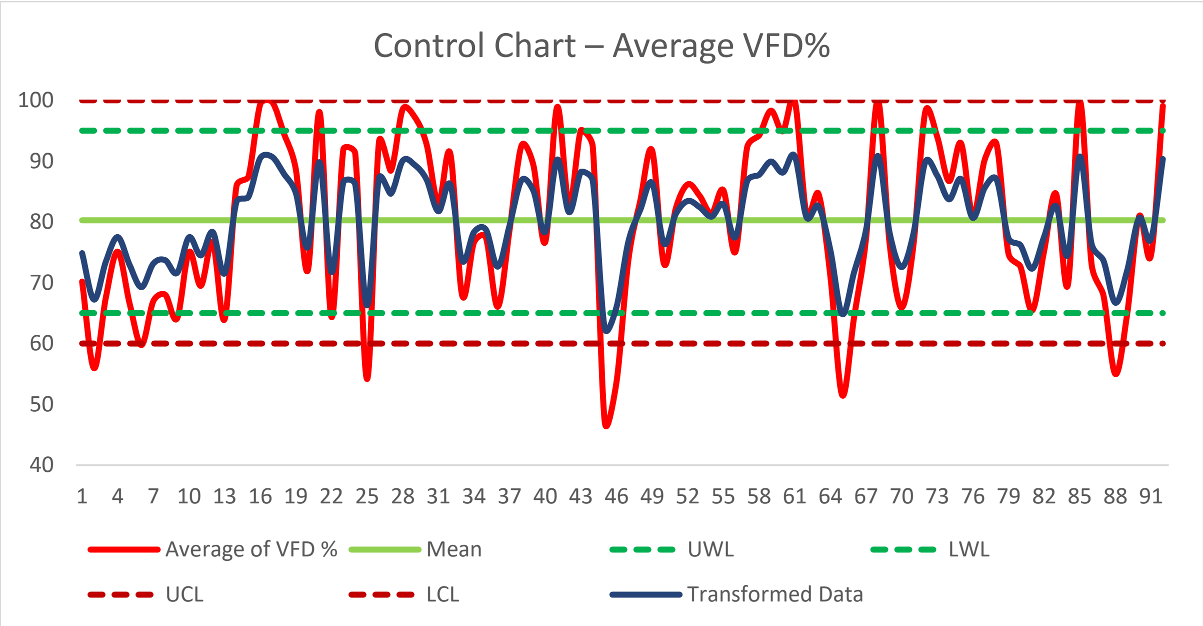


Figure 6.4.b Control Chart Average VFD%

Inference: It can be observed that after implementation of the variation will reduce and the Average VFD% will come closer to the mean (approx. 80) which is also the feasible percentage for VFD.

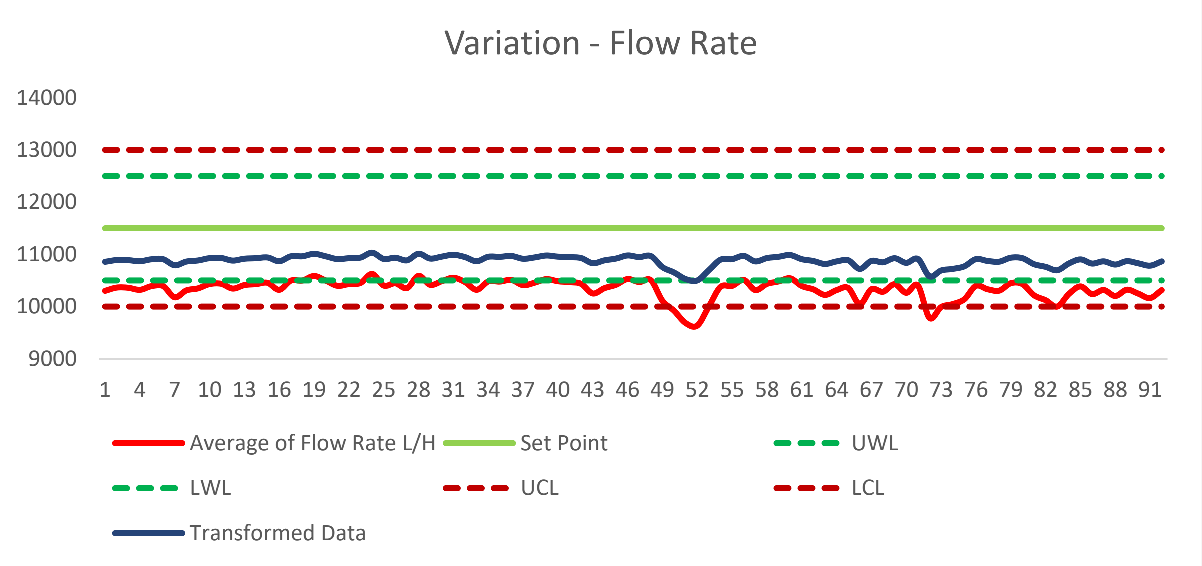


Figure 6.4.c Control Chart Flow Rate

Inference: Here also we can observe the variation change and more importantly before the rates were far from the set point which is 11500 L/H but now it is in a better position.

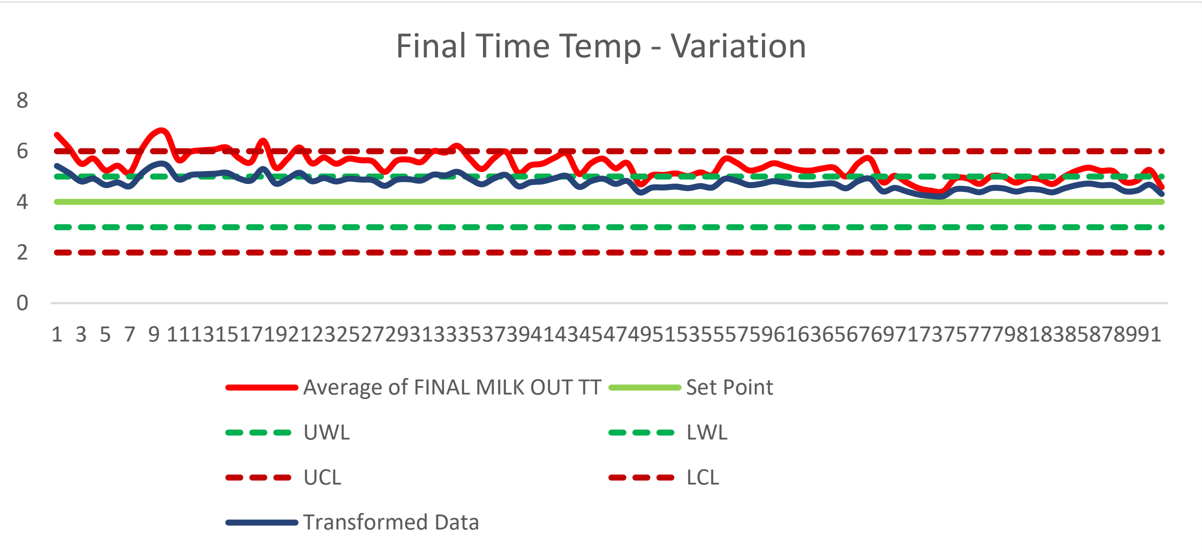


Figure 6.4.d Control Chart Final TT

Inference: Here again like flow rate we can see less variations and Time Temp coming closer to the Set Point which is 4 degrees Celsius.

6.5 Cost Benefit Analysis

This section will include:

a. Cost Breakdown of Technology implemented
b. Cost Breakdown of unit cost of production
c. Savings
d. Breakeven Analysis

Cost Breakdown of technology implementation:

Technology	Amount
Advanced Control Systems	₹ 7,00,000
PID Control	₹ 70,000
Feedback Sensors	₹ 35,000
Predictive Analytics	₹ 3,50,000
Condition Monitoring	₹ 3,50,000
Energy Management Systems (EMS)	₹ 14,00,000
Total	**₹ 29,05,000**

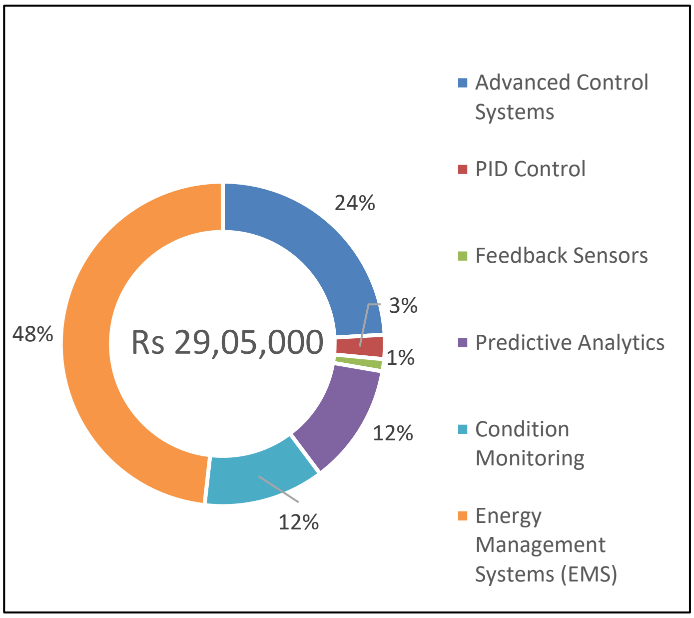


Figure 6.5.a Cost Breakdown of technology implementation

Cost Breakdown of unit cost of production:

- Raw Material Costs

Milk Procurement: ₹20 to ₹25 per liter (assuming bulk purchase from dairy farmers).

Packaging Materials: ₹2 to ₹3 per liter (including bottles, caps, labels).

- Processing Costs:

Labor Costs: ₹5 to ₹7 per liter (including wages for operators, technicians, and quality control personnel).

Energy Costs: ₹2 to ₹4 per liter (including electricity, fuel for pasteurization, and other processing activities).

Maintenance Costs: ₹1 to ₹2 per liter (for routine maintenance, repairs, and upkeep of processing equipment).

Depreciation: ₹1 to ₹3 per liter (amortization of capital costs for machinery and equipment).

- Overhead Costs:

Administrative Expenses: ₹1 to ₹2 per liter (for management, administration, and office operations).

Utilities: ₹1 to ₹2 per liter (including water, sanitation, heating, and cooling).

Insurance: ₹0.50 to ₹1 per liter (premiums for insurance coverage).

Taxes and Licenses: ₹0.50 to ₹1 per liter (payments for regulatory compliance, permits, and taxes).

- Distribution and Transportation Costs:

Transportation: ₹2 to ₹4 per liter (for transporting raw milk and distributing packed milk).

Storage: ₹0.50 to ₹1 per liter (for warehousing and cold storage facilities).

Quality Assurance and Compliance Costs:

Testing and Quality Control: ₹0.50 to ₹1 per liter (for laboratory testing and quality assurance programs).

- Marketing and Sales Costs:

Advertising and Promotion: ₹1 to ₹2 per liter (for marketing campaigns and promotional activities).

Sales Commission: ₹0.50 to ₹1 per liter (payments to sales representatives or agents).

Miscellaneous Costs:

Contingency Fund: ₹0.50 to ₹1 per liter (reserves for unforeseen expenses).

Research and Development: ₹0.50 to ₹1 per liter (investment in research and development).

Inference: It is observed that going by a conservative approach again the Total Cost of production is approximately Rs40 per litre and the maintenance cost is Re1 per litre.

Assuming 50% contribution from pasteurization, the cost would be

1 * (50/100) = Rs 0.5 per litre

Savings

Our research shows that the technology will reduce maintenance cost by 10%.

Now capacity of the plant = 600000 L/Day

Total maintenance cost per day = 600000 * 0.5 = 300000

Cost saved per day = 300000 * (10/100) = 30000 per day

Monthly Saving = 30000 * 30 = Rs 90000

Breakeven Analysis

Month	Cost	Savings Per Day	Saving - Cost
1	2905000	900000	-2005000
2	2905000	1800000	-1105000
3	2905000	3600000	695000
4	2905000	7200000	4295000
5	2905000	14400000	11495000
6	2905000	28800000	25895000

Figure 6.5.b Breakeven Analysis

Inference: It is observed that between 2-3 months the investment would be recovered and the savings will be doubles in just 6 months.

Other Benefits:

- Reduced Downtime
- Higher Productivity
- Better Quality
- Increased process efficiency

7. Control Phase

In the Control phase of DMAIC, efforts are directed towards maintaining improvements and preventing the recurrence of issues. This involves implementing control plans, establishing SOPs, training staff, and setting up monitoring systems to track performance. Regular reviews and audits ensure ongoing effectiveness, facilitating a culture of sustained improvement and efficiency.

Here the we can control our VFD% data and when the control is needed can be best monitored by I-MR chart as the data are recorded every minute and much grouping is not possible.

So, for continuous monitoring we can use the I-MR chart and we have displayed our transformed data of VFD% for reference.

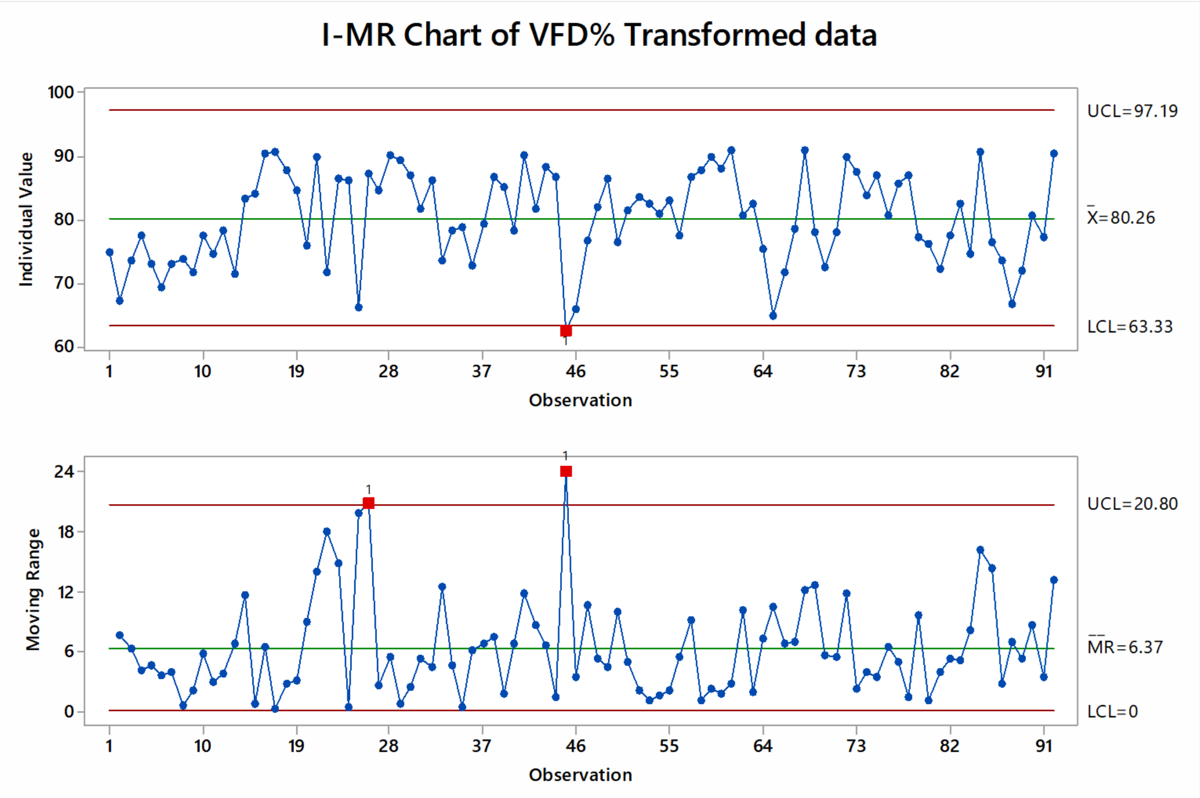


Figure 7.1 I-MR Chart for VFD%

Inference: We can see that after implementation the performance is expected to be much more in control both by mean deviation or by moving range.

8. Sources/References

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9. Moment of Student

Figure 9.1 Moment of Students