Scrap reduction in Capping Process in Personal Care Product

Shameer Ahamad A

ROADMAP

- Overview
- Define
- Measure
- Analyse
- Improve
- Control

OVERVIEW

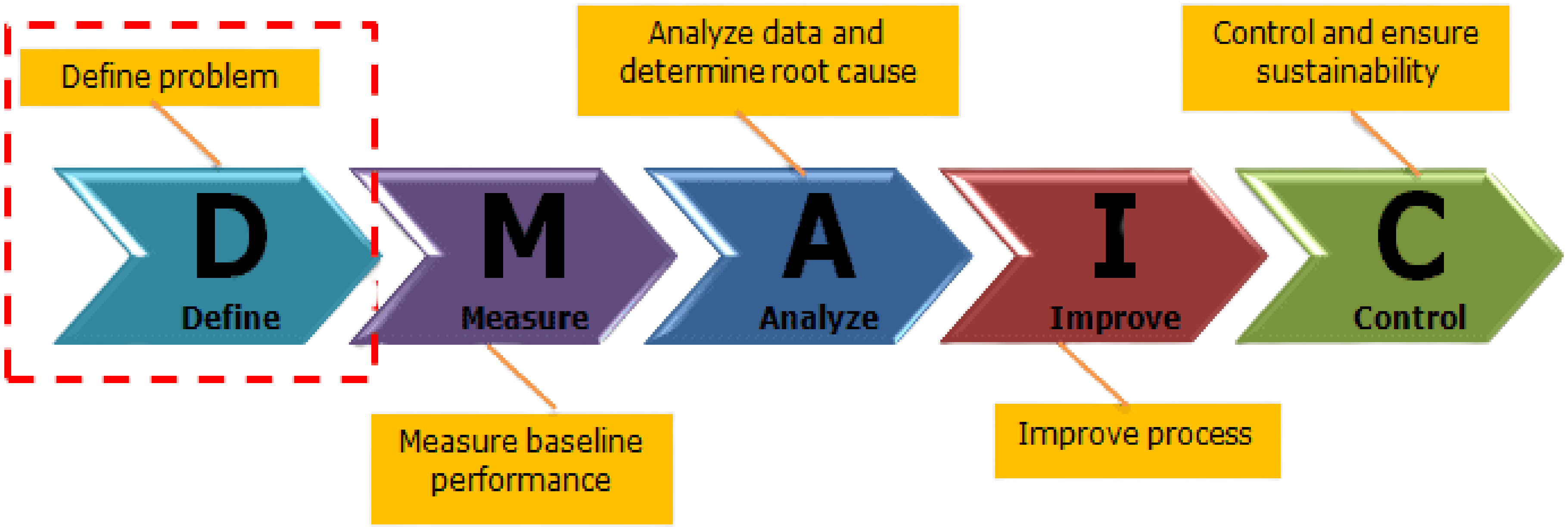
Background

The current issue of cap damages in the packaging process results in significant material loss, rework, and downtime, contributing to an estimated **annual loss of $20,000**. These recurring losses not only impact profitability but also hinder operational efficiency and production flow.

By implementing Six Sigma methodologies to reduce the cap damage rate to **≤3%**, the organization can realize an estimated **annual savings of $8,787**. This improvement will directly enhance process efficiency, reduce machine stoppages, and optimize overall packaging line throughput.

Furthermore, minimizing defects will ensure stronger **compliance with quality and regulatory standards**, reinforce **customer trust**, and **enhance the brand's image** in the market. Overall, this project aligns with the organization's strategic goals of cost reduction, process excellence, and sustainable quality improvement.

DEFINE PHASE



VOC & CTQ

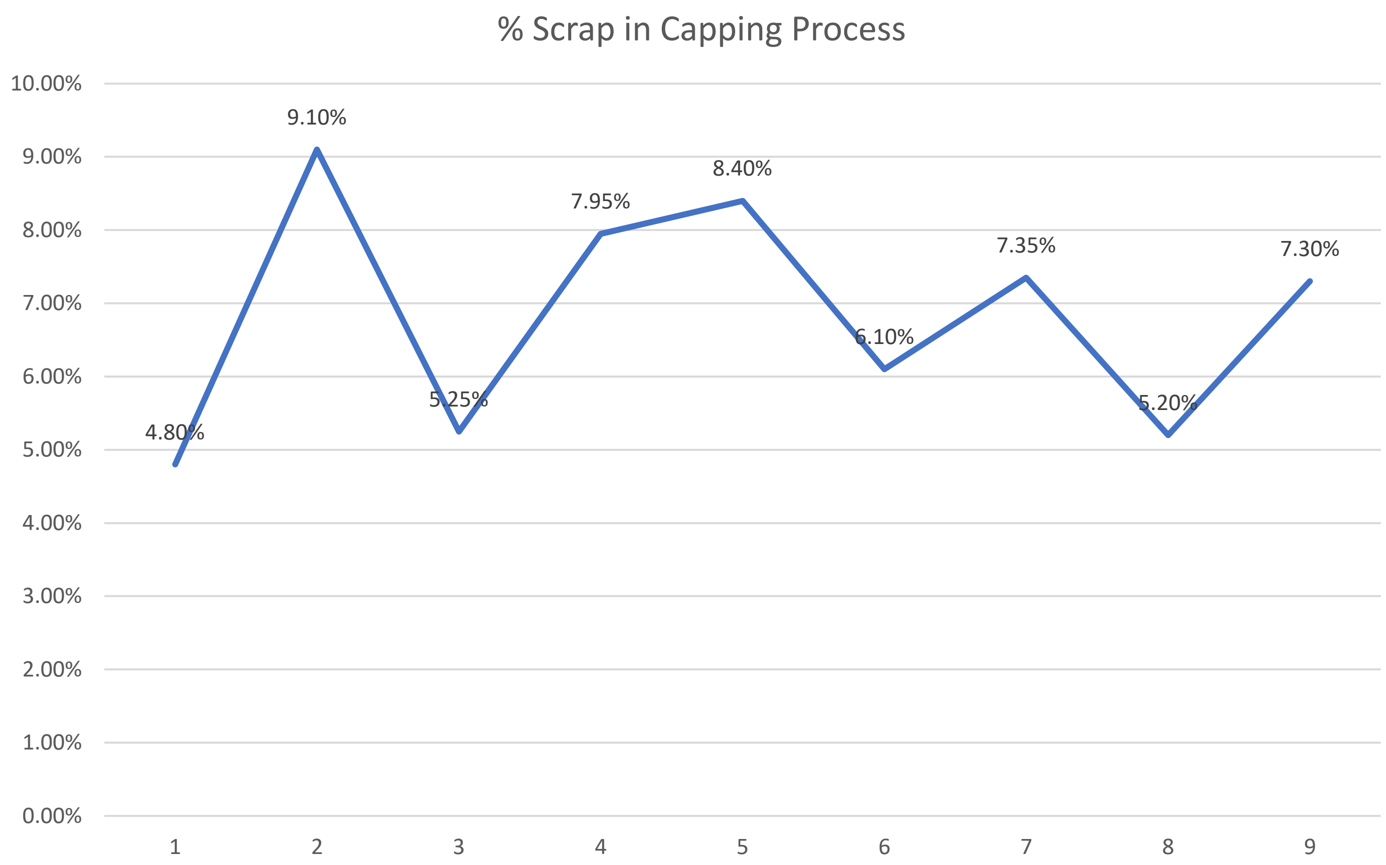
Voice of Customer:

"We want consistent product quality with no defects."

CTQ Tree :

Voice of customer	Critical to X	Primary Metric for improvement
"We want consistent product quality with no defects." ***."***	**CTC (Critical to Cost):** Reduced material loss, lower cost per unit, improved yield.	**Primary Metric -** Y = % Scrap in capping process **Secondary Metric -** Productivity

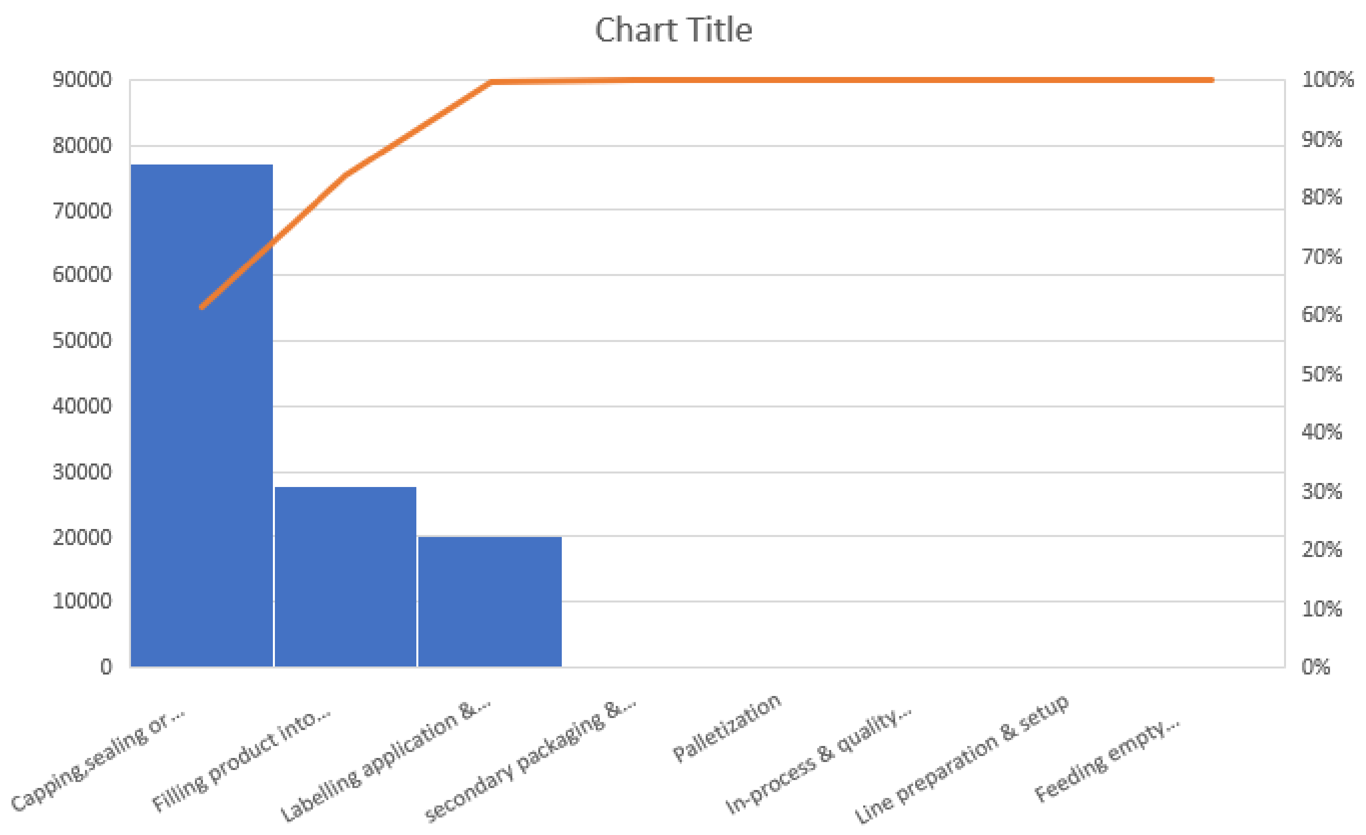
Baseline Performance of Primary Metric (9 months data as Line chart)



Inference :

- Last 9 months scrap percentage data shows a significant variation and hence ideal problem to be taken up as a Six Sigma Project.

Pareto chart



Inference :

- Capping Process is contributing higher to the scrap %

SIPOC

Suppliers (S)	Inputs (I)	Process (P)	Outputs (O)	Customers (C)
Cap Vendors (suppliers)	Caps, closures, pumps, seals	1. Line preparation & machine setup	Properly sealed, damage-free caps	Internal: Production, QA/QC, Maintenance, Warehouse, Sales, Regulatory
Bulk Product Manufacturing Team	Bulk-filled bottles, jars, tubes	2. Feeding bottles/jars to capping machine	Defective/damaged caps (scrap)	External: Distributors, Retailers, End Consumers, Regulatory Authorities
Maintenance Team	Packaging equipment (capping, sealing units)	3. Capping, sealing, or crimping	Efficiency data (cap damage % per shift)	
QA/QC Team	SOPs, work instructions, quality standards	4. In-process inspection & defect detection	Inspection reports, quality records	
Operators	Skilled manpower for operation	5. Rework/sorting of damaged units	Reworked products or scrap disposal	
Production Planning & Scheduling	Production schedules, batch records	6. Final QC verification & release	Approved, ready-for-shipment packaged products	

Project Charter

Project Title:	Reduction of Scrap% in Baking process from 16 to 1%
Project Leader	**Project Team Members:**
Project Leader (Black Belt): Process Improvement Manager – Sarah Johnson	Packaging Line Supervisor – Deo Quality Assurance Executive – Ben Maintenance Engineer – Brian Operator Representative – Lwanga Finance Analyst: Michael
Champion/Sponsors:	**Key Stake Holders**
Project Sponsor: Operations Director – John Smith	Production Team Quality Assurance (QA) Quality Control (QC) Consumers
Problem Statement:	**Goal Statement:**
The current cap damage rate in the packaging line averages 6.83% over the last 9 months	To reduce the cap damage rate from 6.83% to below 3% within 6 months
Secondary Metric	**Assumptions Made:**
Productivity	

Project Charter

Tangible and Intangible Benefits:

Current cap damages cause an estimated **annual loss of $20,000** (due to wasted caps, rework, and downtime). **Reduction to ≤3%** will generate approximately **$8787** in yearly savings.

Risk to Success:

In Scope:

Capping, sealing, and crimping processes on the packaging line. Cap material quality, handling, machine setup, operator training, and preventive maintenance

Out of Scope:

Issues related to upstream processes (filling, labelling). Damages caused during storage and transportation after packaging

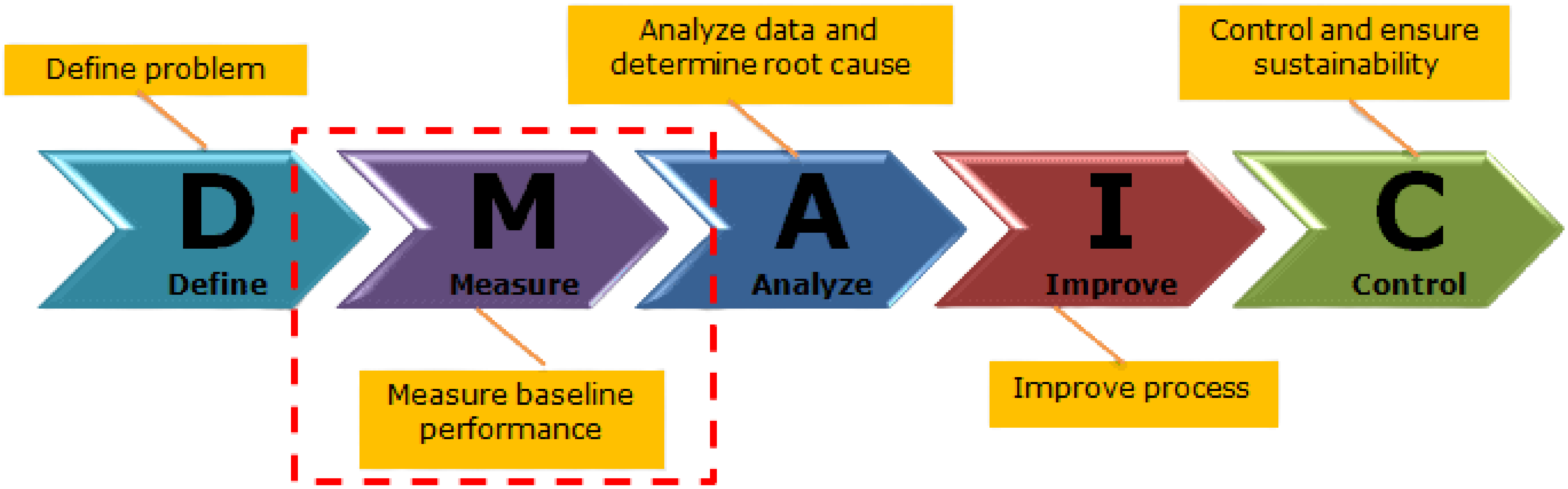
Signatories:

Project Timeline

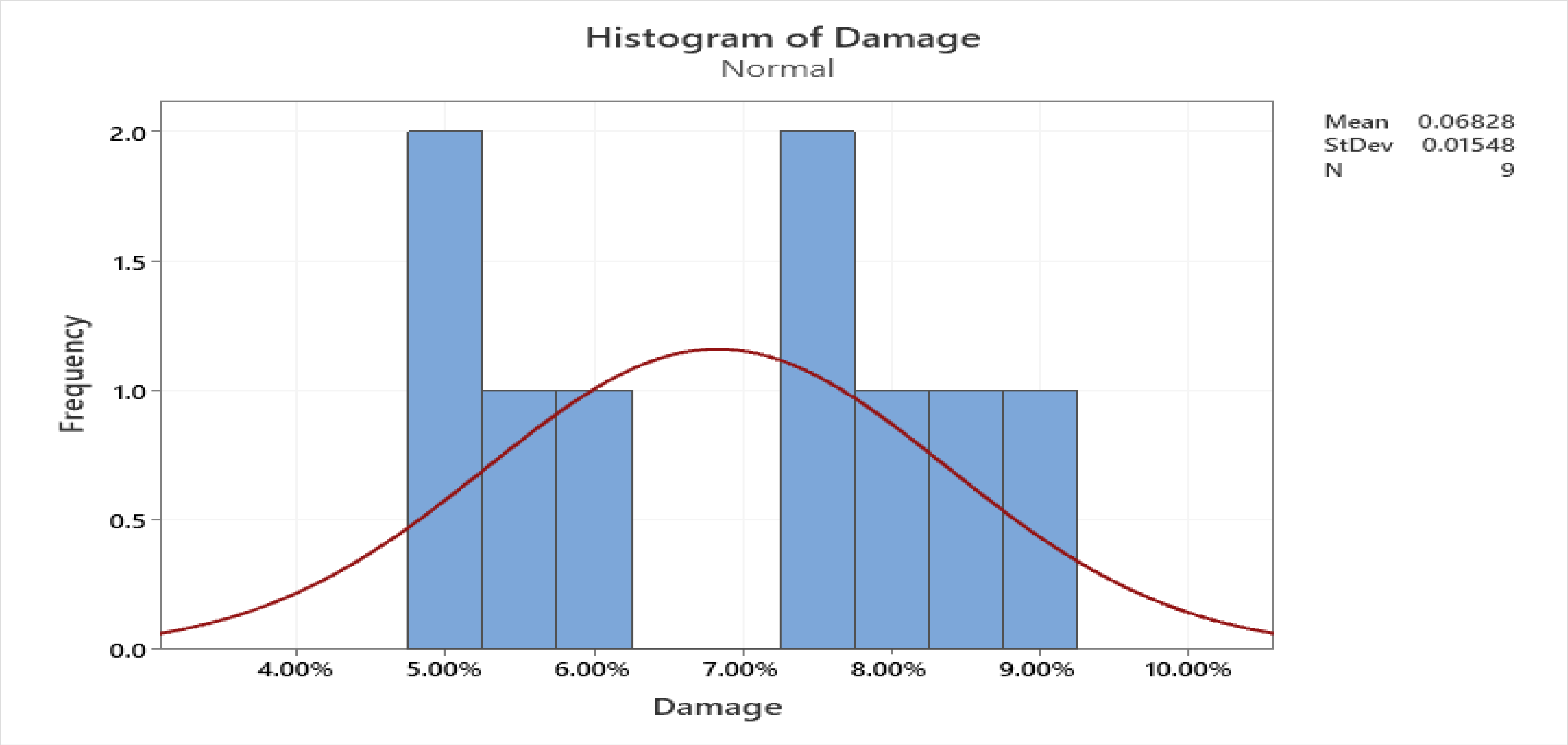
6 Months

Stages	Start	End
Define	1st March 2025	31st March 2025
Measure	1st April 2025	30th April 2025
Analyze	1st May 2025	15th July 2025
Improve	16th July 2025	25th September 2025
Control	25th September 2025	20th October 2025

MEASURE PHASE



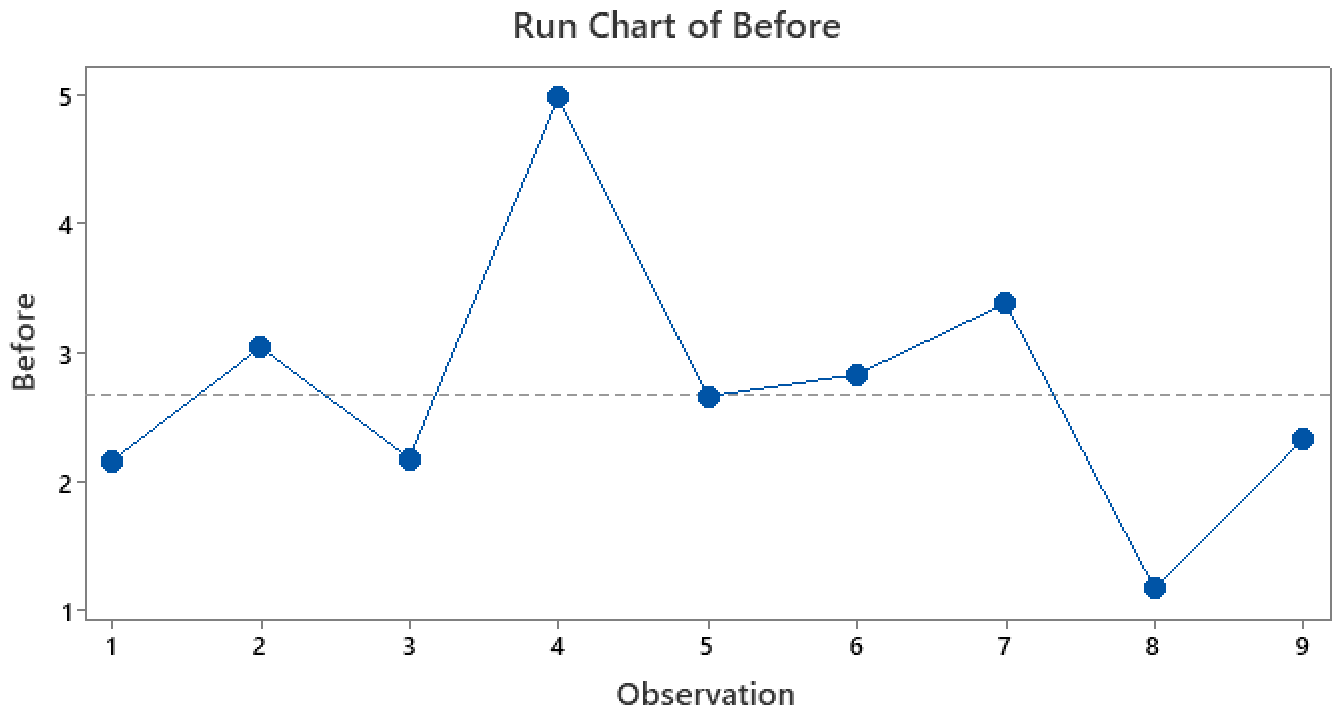
Data collection – Histogram (Before improvement)



Inference :

- Data is normally distributed over the mean

Data collection – Run Chart (Before improvement)

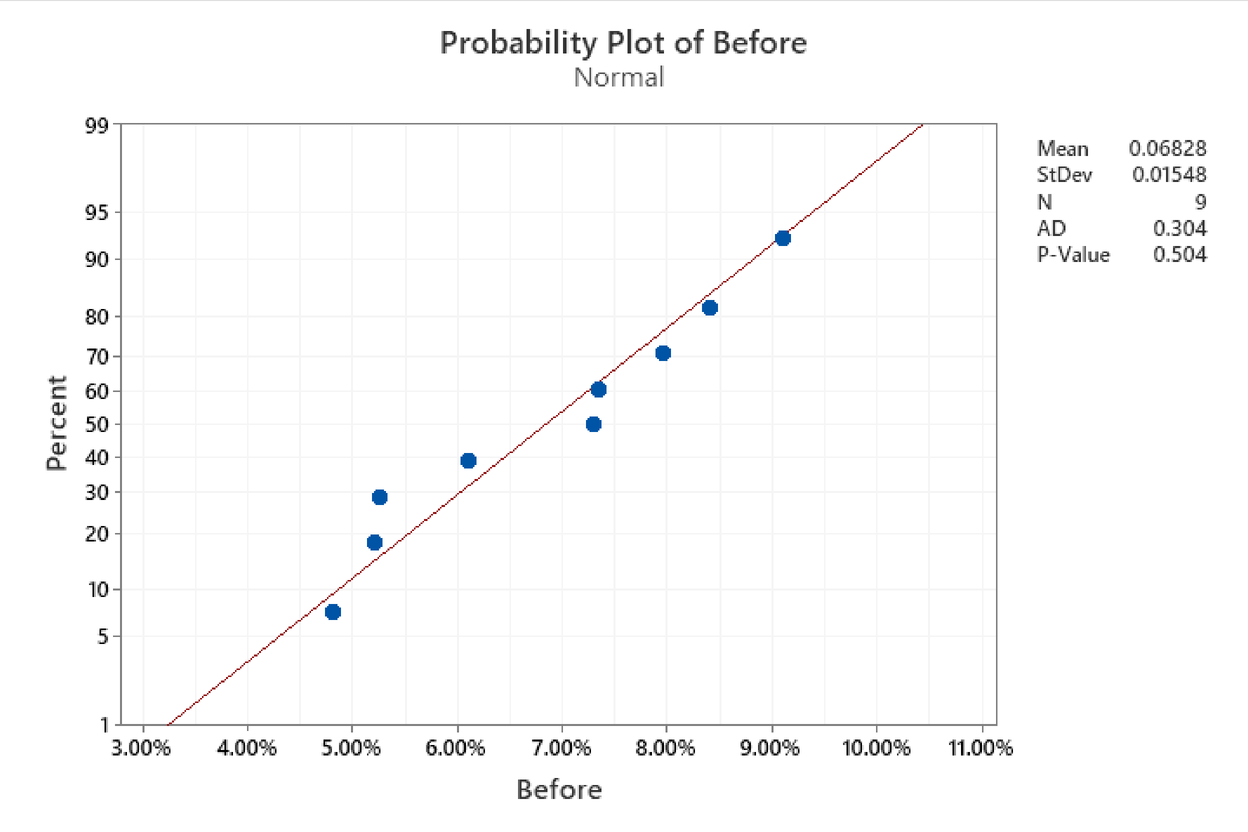


Number of runs about median:	7	Number of runs up or down:	7
Expected number of runs:	5.4	Expected number of runs:	5.7
Longest run about median:	2	Longest run up or down:	2
Approx P-Value for Clustering:	0.870	Approx P-Value for Trends:	0.881
Approx P-Value for Mixtures:	0.130	Approx P-Value for Oscillation:	0.119

Inference :

P > 0.05 – No special causes in the process. Data can be used for further analysis

Data collection – Normality plot (Before improvement)



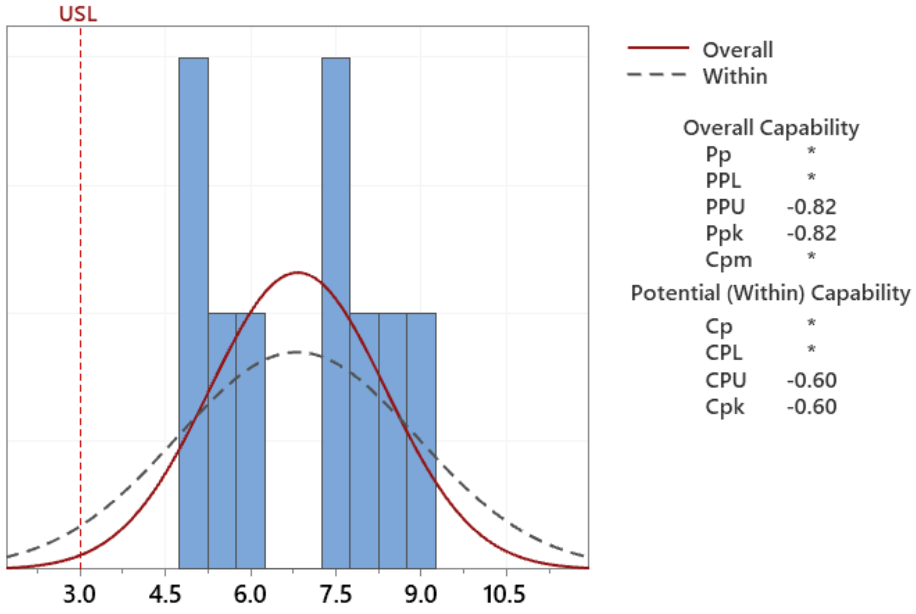
Inference :

- P > 0.05 in all scenarios, thus all the data is normally distributed

Data collection – Normality plot (Before improvement)

Process Capability Report for Before1

Process Data	
LSL	*
Target	*
USL	3
Sample Mean	6.82778
Sample N	9
StDev(Overall)	1.548
StDev(Within)	2.11658



Overall Capability	
Pp	*
PPL	*
PPU	-0.82
Ppk	-0.82
Cpm	*

Potential (Within) Capability	
Cp	*
CPL	*
CPU	-0.60
Cpk	-0.60

Performance

	Observed	Expected Overall	Expected Within
PPM < LSL	*	*	*
PPM > USL	1000000.00	993295.48	964733.67
PPM Total	1000000.00	993295.48	964733.67

The actual process spread is represented by 6 sigma.

Inference :

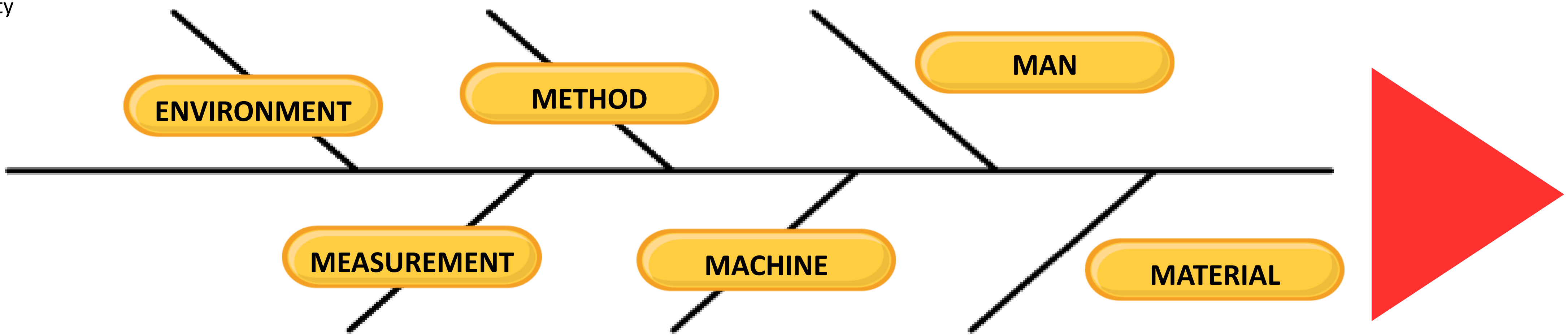
- P > 0.05 in all scenarios, thus all the data is normally distributed

Fish Bone Diagram

- High humidity weakening adhesive seals
- Temperature fluctuations affecting cap flexibility
- Dust particles interfering with sealing integrity
- Poor lighting affecting operator inspection accuracy
- Noise and vibration in the environment disturbing machine stability

- Lack of standardized SOPs for capping setup
- Improper line speed settings causing stress on caps
- Inconsistent torque application
- Poor changeover practices between products
- Inadequate in-process inspection steps

- Insufficient operator training on capping machines
- Improper handling of caps during feeding
- Fatigue due to long shifts
- Lack of attention to machine alarms
- High turnover leading to inexperienced staff



- No real-time monitoring of cap damage rate
- Inaccurate defect classification (mislabelling of damage types)
- Manual data entry errors during reporting
- Lack of root cause tracking in scrap reports
- No benchmark comparison with industry standards

- Poorly calibrated capping torque settings
- Misaligned sealing heads/crimping tools
- Wear and tear of capping jaws/chucks
- Frequent machine breakdowns
- Vibrations causing misplacement of caps

- Poor-quality caps (thin, brittle, or uneven threads)
- Inconsistent bottle neck dimensions
- Defective seals or liners inside caps
- Variation in supplier material quality
- Contaminated or warped caps from storage

3M Analysis for Waste

MUDA

- Scrap from damaged caps during sealing.
- Rework required for bottles with loose or misaligned caps.
- Excess motion when operators repeatedly adjust machine settings.

Mura

- Inconsistent torque application leading to over-tightened or under-tightened caps.
- Variation in machine speed causing irregular damage rates.
- Fluctuations in quality of caps from different suppliers.

Muri

- Overloading operators with continuous manual inspection of caps.
- Running machines at higher-than-optimal speed, stressing equipment and causing failures.
- Expecting one capping machine to handle multiple bottle formats without proper changeovers.

8 Wastes Analysis

Defects

- Damaged caps due to misalignment or poor sealing.
- Leaking bottles caused by improper crimping.

Overproduction

- Producing more capped bottles than the packaging schedule requires.
- Running trial batches larger than necessary during setup.

Waiting

- Line stoppages while waiting for maintenance after breakdown.
- Idle operators waiting for material supply (caps/bottles).

Non-Utilized Talent

- Not involving operators in root cause analysis.
- Underutilizing trained staff for machine setup and calibration.

Transportation

- Moving caps unnecessarily between storage and the line.
- Shifting damaged bottles multiple times for rework.

Inventory

- Excess stock of caps piling up near the machine.
- Holding too many spare parts without usage.

Motion

- Operators walking repeatedly to fetch tools or caps.
- Extra hand movements to manually realign bottles.

Overprocessing

- Rechecking every bottle instead of sampling due to lack of trust in process.
- Applying excessive torque settings beyond required standards.

Action Plan for Low Hanging Fruits

Special Causes (sudden failures / abnormalities)

Category	Observed Issue	Lean Tool / Approach	Action Plan	Expected Benefit (Low Hanging Fruit)
Special Cause	Misaligned sealing heads	Poka-Yoke / Jidoka	Introduce alignment jigs and machine auto-stop if misalignment occurs	Reduced cap damage instantly, less rework
Special Cause	Poor torque calibration	Standard Work + Calibration Checklists	Daily torque calibration before shift	Consistent sealing, reduction in defects
Special Cause	Inconsistent bottle neck dimensions	Supplier Quality Assurance (SQA)	Work with suppliers to introduce go/no-go gauges	Fewer rejects at line, improved incoming quality
Special Cause	Contaminated cap batches	5S + Incoming Inspection	Segregate cap storage area, implement incoming lot inspection	Elimination of defects from storage/transport
Special Cause	Humidity/temperature fluctuation	Environmental Control	Install dehumidifiers, monitor climate	Stable process, less warping of caps

Action Plan for Low Hanging Fruits

3M	Observed Issue	Lean Tool	Action Plan	Benefit
Muda (Waste)	Rework due to damaged caps	Kaizen + Standard Work	Implement in-line defect detection	Reduced scrap & rework
	Excessive motion fetching tools	5S	Place torque wrenches and gauges at point-of-use	Less operator fatigue, time saving
Mura (Unevenness)	Irregular capping torque	SMED + SPC	Set standardized machine parameters with control chart monitoring	Stable sealing performance
	Inconsistent line speeds	Heijunka (Line Balancing)	Level production runs to match takt time	Smooth flow, less variation
Muri (Overburden)	Operators manually inspecting all bottles	Automation + Jidoka	Use vision inspection for cap defects	Less operator strain, better accuracy
	Overrunning machines beyond capacity	TPM (Total Productive Maintenance)	Define max operating speeds and preventive checks	Reduced breakdowns, longer machine life

Action Plan for Low Hanging Fruits

Waste	Issue	Lean Action	Benefit
Transportation	Excessive movement of caps to line	Line-side cap feeders	Reduced handling damage
Inventory	Excess cap stock at line	Kanban system for cap replenishment	Less clutter, fresher stock
Motion	Operators walking to fetch tools	5S & Visual Management	Faster setup, less fatigue
Waiting	Idle time during breakdowns	TPM & Andon signals	Faster response, less downtime
Overproduction	Extra capped bottles beyond demand	Production scheduling (Heijunka)	No excess WIP, smoother flow
Overprocessing	Excess torque applied	Standard torque settings	Less stress on caps
Defects	Damaged caps & leaks	Poka-Yoke + Jidoka	Scrap reduction
Skills (Unused Talent)	Operators not engaged in problem-solving	Kaizen circles	Improved morale, practical solutions

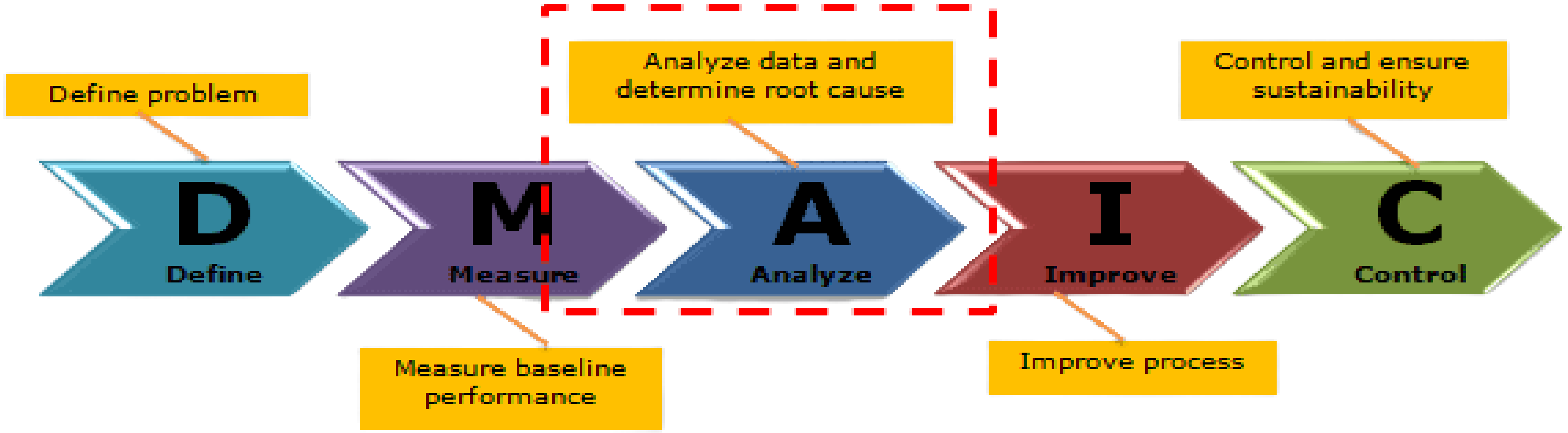
Top 12 Prioritized Root Causes (Based on Net Score)

Root Cause	Score
Poor quality caps from supplier	622
Inconsistent bottle neck dimensions	488
Improper cap handling	440
Misaligned sealing heads	330
Worn-out capping jaws/chucks	330
Poor torque calibration	288
Defective liners/seals	274
Operator training gaps	234
Improper line speed	234
Lack of SOPs	220
Poor changeover practices	140
No real-time monitoring	156

Data Collection Plan

Output / Input	Type of Data	Measurement Method	Unit	Frequency	Responsibility
Misaligned sealing heads	Continuous (numerical)	Alignment checks with gauge/visual jig	mm deviation	Daily	Maintenance
Worn-out jaws/chucks	Continuous (numerical)	Go/No-Go gauge / calliper	mm wear	Weekly	Maintenance
Poor quality caps (supplier)	Attribute (defect %)	Incoming QC sampling (AQL)	% defective caps	Per lot	QC
Poor torque calibration	Continuous (numerical)	Torque tester	N·m (torque)	Per shift	Production Supervisor
Inconsistent bottle neck dimensions	Continuous (numerical)	Vernier/micrometre	mm diameter	Per lot	QC
Defective liners/seals	Attribute (defect %)	Visual inspection	% defective	Per lot	QC
Operator training gaps	Attribute (count)	Training records audit	% trained vs. total	Monthly	HR + QA
Improper line speed	Continuous (numerical)	Machine display/PLC	Bottles per minute	Daily	Production
Improper cap handling	Attribute (count)	Observation audit / time study	# mishandled caps	Weekly	QA / IE
Lack of SOPs	Attribute (yes/no)	Document & floor audit	Availability	Quarterly	QA
Poor changeover practices	Continuous (numerical + attribute)	Stopwatch (time) + scrap count	Minutes & # rejects	Every changeover	Production
No real-time monitoring	Continuous (time)	Line logs / downtime record	Minutes delay	Per shift	QA + Production
Misaligned sealing heads	Continuous (numerical)	Alignment checks with gauge/visual jig	mm deviation	Daily	Maintenance
Worn-out jaws/chucks	Continuous (numerical)	Go/No-Go gauge / calliper	mm wear	Weekly	Maintenance

ANALYSE PHASE



Analyse – Hypothesis testing

Regression Equation

Scrap_Cap_% = 1.254 + 0.9596 Cap_Defect_Rate_% + 7.528 Neck_Dim_SD_mm
+ 0.5558 Handling_Defects_perK

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.254	0.295	4.25	0.000	
Cap_Defect_Rate_%	0.9596	0.0481	19.96	0.000	1.00
Neck_Dim_SD_mm	7.528	0.951	7.92	0.000	1.01
Handling_Defects_perK	0.5558	0.0381	14.57	0.000	1.01

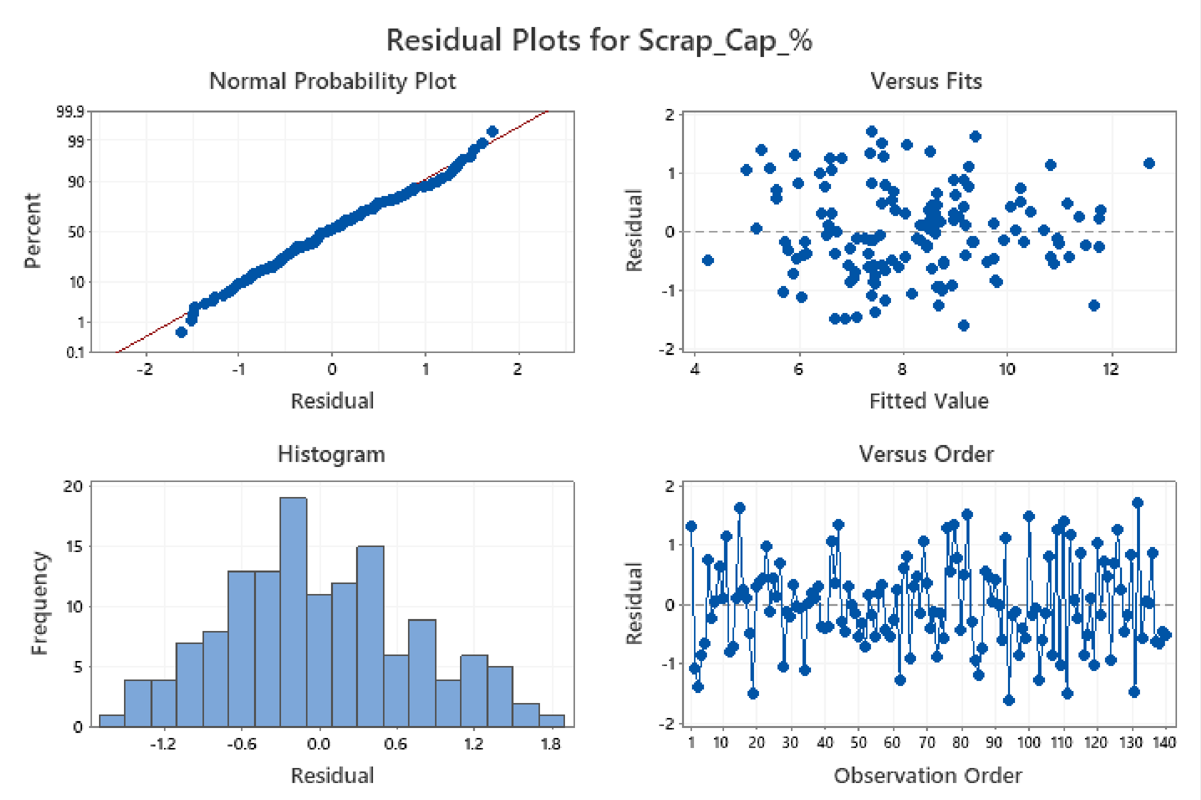
Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.754826	83.32%	82.95%	82.38%

Fits and Diagnostics for Unusual Observations

Obs	Scrap_Cap_%	Fit	Resid	Std Resid	
15	11.018	9.400	1.618	2.18	R
38	9.276	8.962	0.314	0.44	X
82	9.095	7.584	1.512	2.02	R
94	7.558	9.164	-1.606	-2.17	R
111	5.199	6.694	-1.495	-2.00	R
132	9.127	7.407	1.720	2.30	R

R Large residual
X Unusual X



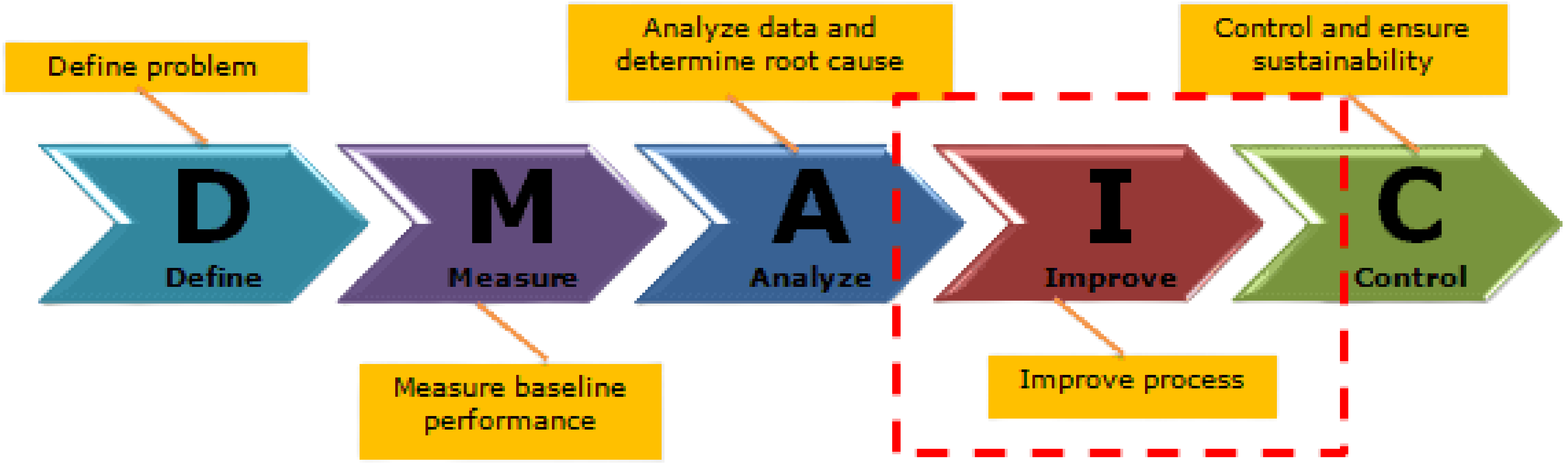
Inference :

- Since p < 0.05 Supplier cap defect rate %, Neck dimensions and Handling defects % are validated as critical root causes

Summary of Statistically validated Root causes

Supplier cap defect rate %, Neck dimensions and Handling defects % are validated as critical root causes

IMPROVE PHASE



Improve Design of Experiment

RunOrder	Type	A_CapDefect_code	B_NeckSD_code	C_Handling_code	Cap_Defect_Rate_%	Neck_Dim_SD_mm	Handling_Defects_perK	Scrap_Cap_%
1	Center	0	0	0	4	0.2	4.5	5.78
2	Center	0	0	0	4	0.2	4.5	5.57
3	Factorial	1	-1	-1	7	0.05	1	5.17
4	Factorial	1	-1	1	7	0.05	8	7.23
5	Factorial	-1	-1	1	1	0.05	8	3.04
6	Factorial	-1	-1	-1	1	0.05	1	1.06
7	Center	0	0	0	4	0.2	4.5	5.72
8	Factorial	-1	1	-1	1	0.35	1	3.89
9	Factorial	1	1	1	7	0.35	8	10.39
10	Factorial	-1	1	1	1	0.35	8	6.02
11	Factorial	1	1	-1	7	0.35	1	8.14

Improve

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		5.6373	0.0296	190.66	0.000	
Supplier defect	4.2300	2.1150	0.0347	61.00	0.000	1.00
Neck dim	2.9850	1.4925	0.0347	43.05	0.000	1.00
Handling defectt	2.1050	1.0525	0.0347	30.36	0.000	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0980657	99.89%	99.85%	99.74%

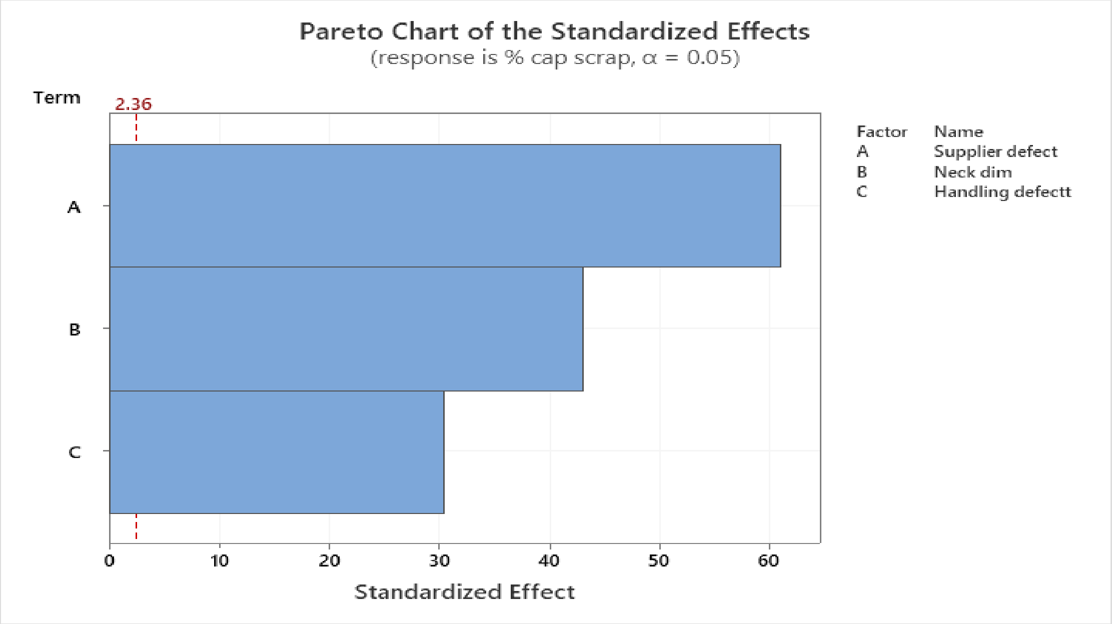
Analysis of Variance

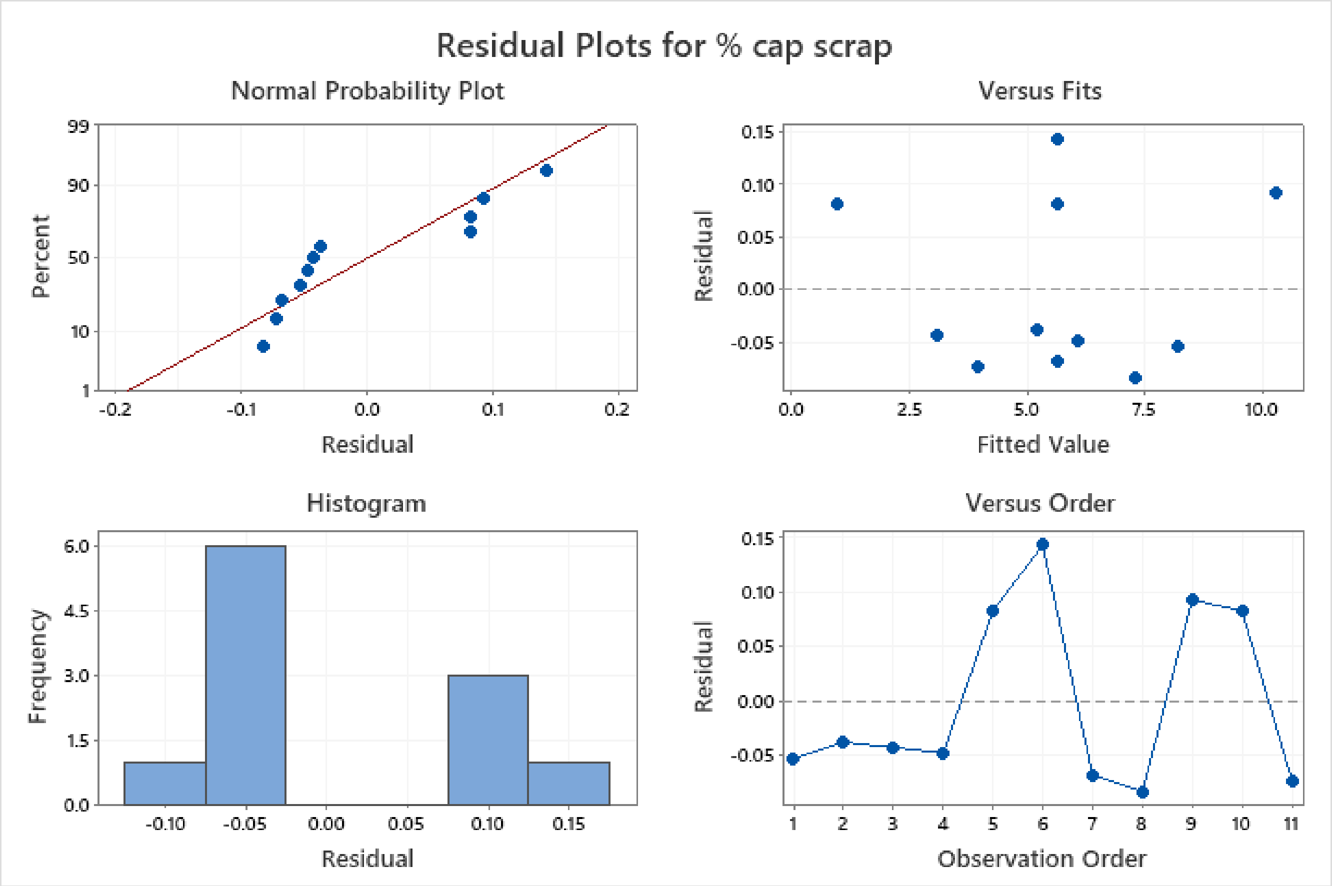
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	62.4683	20.8228	2165.23	0.000
Linear	3	62.4683	20.8228	2165.23	0.000
Supplier defect	1	35.7858	35.7858	3721.14	0.000
Neck dim	1	17.8205	17.8205	1853.04	0.000
Handling defectt	1	8.8620	8.8620	921.51	0.000
Error	7	0.0673	0.0096		
Curvature	1	0.0115	0.0115	1.23	0.310
Lack-of-Fit	4	0.0325	0.0081	0.69	0.662
Pure Error	2	0.0234	0.0117		
Total	10	62.5356			

Regression Equation in Uncoded Units

% cap scrap = -0.5259 + 0.7050 Supplier defect + 9.950 Neck dim + 0.30071 Handling defectt

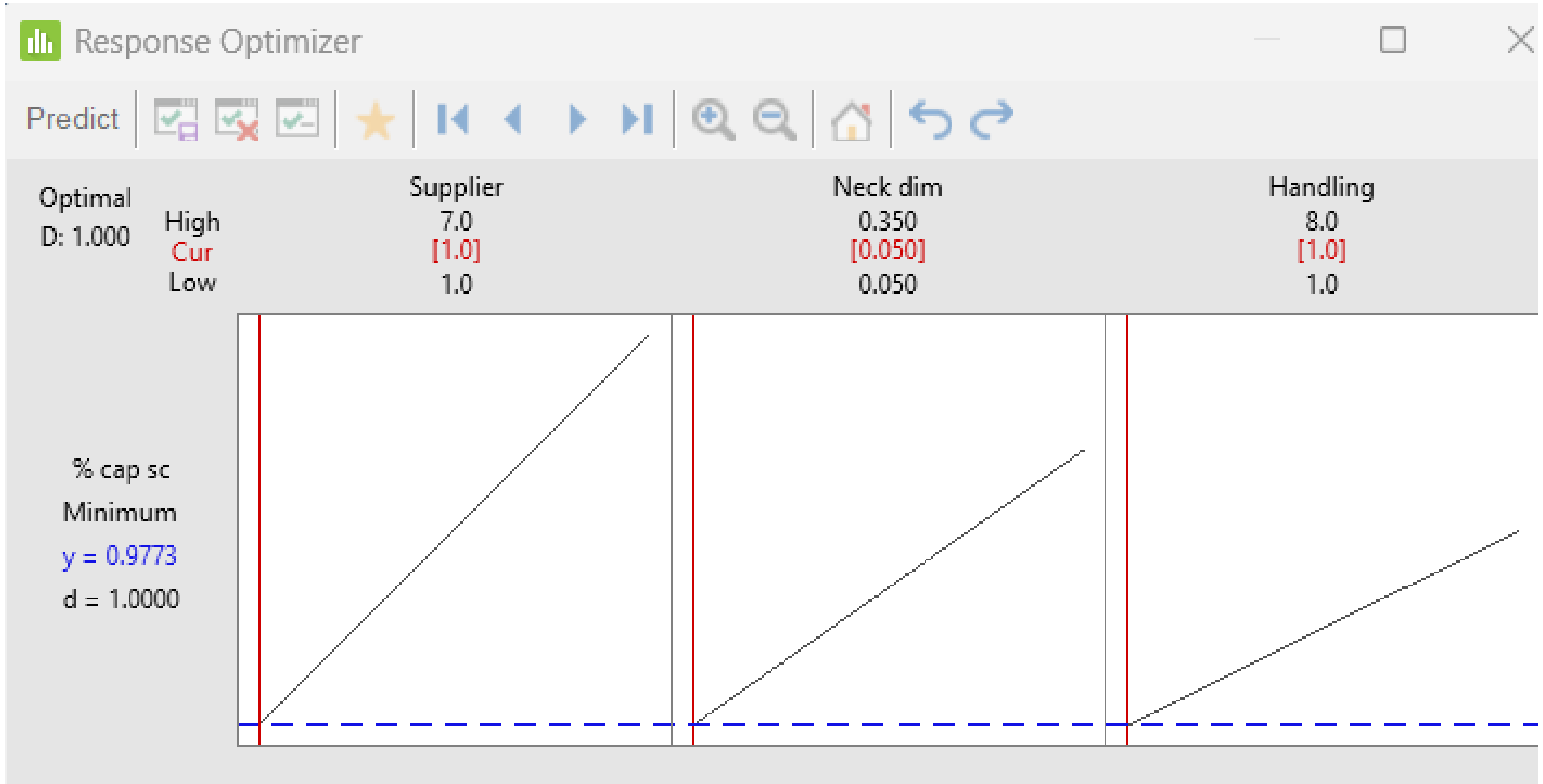
Improve





- Since it is passing all the validations, the equation as per previous slide is validated

Improve Design of Experiment – Response Optimizer



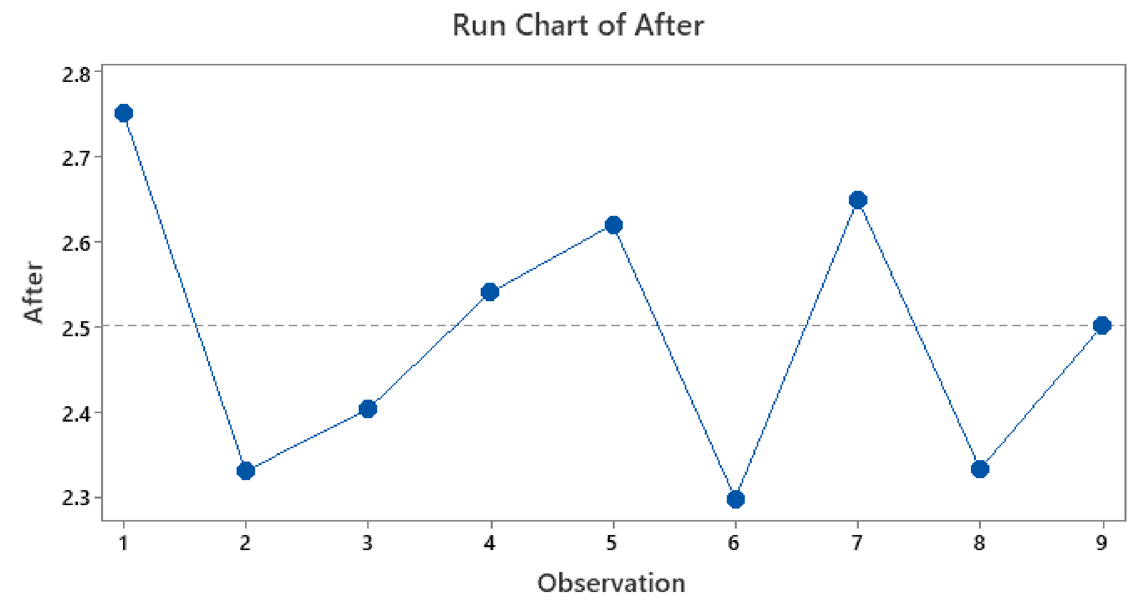
•**Inference:**

- Optimum values of the critical inputs were identified

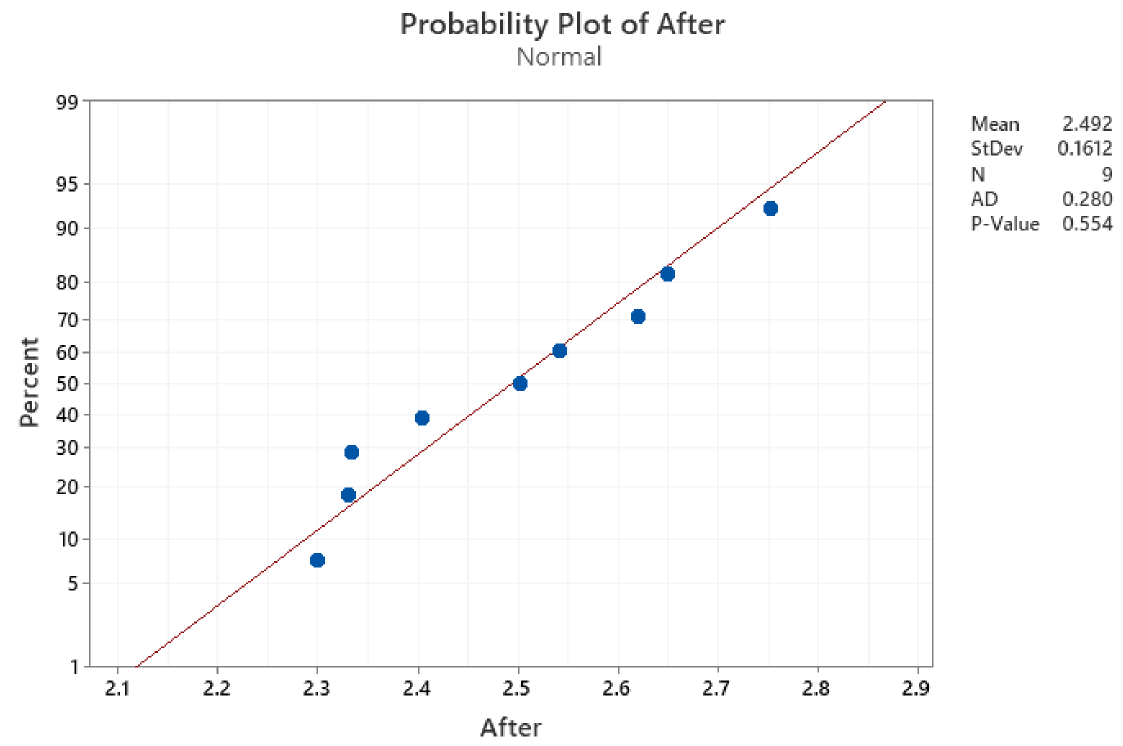
Improve

No.	Root Cause	Improvement Action	Responsible	Timeline	Expected Impact
1	Poor quality caps from supplier	Implement supplier quality agreement; introduce incoming inspection with go/no-go gauge and visual defect check for every batch	Procurement & Quality	Week 1–2	Prevent defective caps entering line
2	Inconsistent bottle neck dimensions	Conduct dimensional audit of bottles; communicate tolerance to moulding supplier; introduce in-line neck gauge inspection	Supplier Quality & QA	Week 2–3	Ensure consistent fit between cap & bottle
3	Improper cap handling	Provide lined trays or anti-static bins; train loading operators on correct handling and stacking of caps	Production Supervisor	Week 3–4	Reduce cracks and deformation during handling

Improve – Run chart and Normality Test (After Improvement)



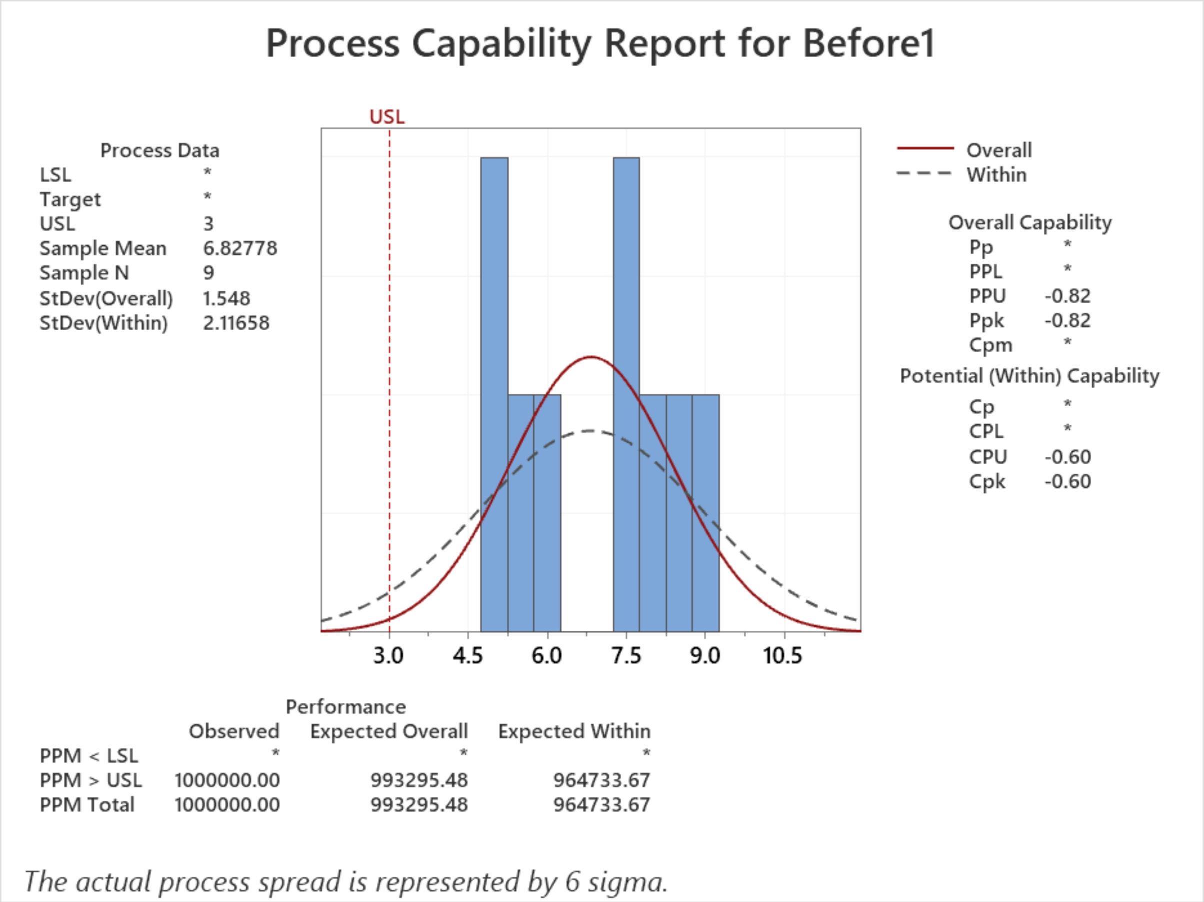
Number of runs about median:	6	Number of runs up or down:	6
Expected number of runs:	5.4	Expected number of runs:	5.7
Longest run about median:	2	Longest run up or down:	3
Approx P-Value for Clustering:	0.656	Approx P-Value for Trends:	0.616
Approx P-Value for Mixtures:	0.344	Approx P-Value for Oscillation:	0.384

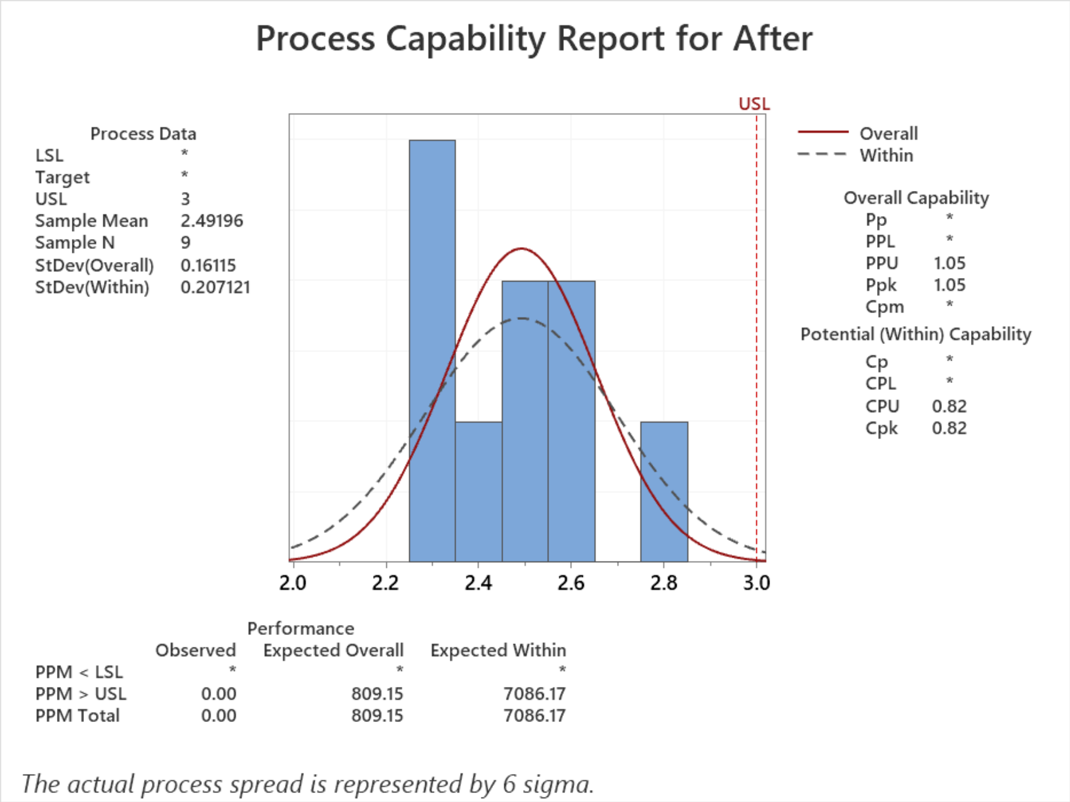


Inference:
- Run chart – process is stable there is no special causes in the process (p value > 0.05)

Inference:
- Normality test – Data are normally distributed

Improve – Run chart and Normality Test (After Improvement)





Inference :

- Before Cpk < After Cpk, which shows process is much more capable after improvement
- There is less variability in system since stdev reduced after improvement
- After improvement the data are normally distributed near the target within specified limit

Improve –After Improvement (Statistical validation for Improvement – Hypothesis Testing)

Two-Sample T-Test and CI: Before1, After

μ_1: population mean of Before1
μ_2: population mean of After
Difference: $\mu_1 - \mu_2$

Equal variances are not assumed for this analysis.

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Before1	9	6.83	1.55	0.52
After	9	2.492	0.161	0.054

Estimation for Difference

Difference	95% CI for Difference
4.336	(3.139, 5.532)

Test

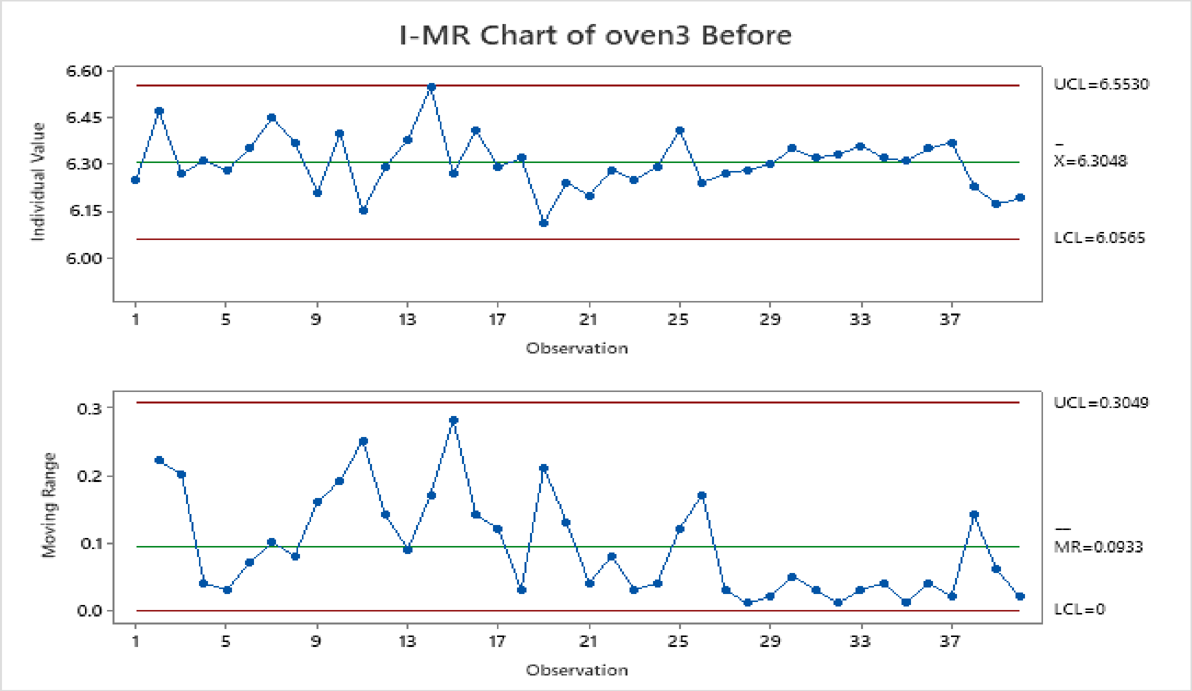
Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

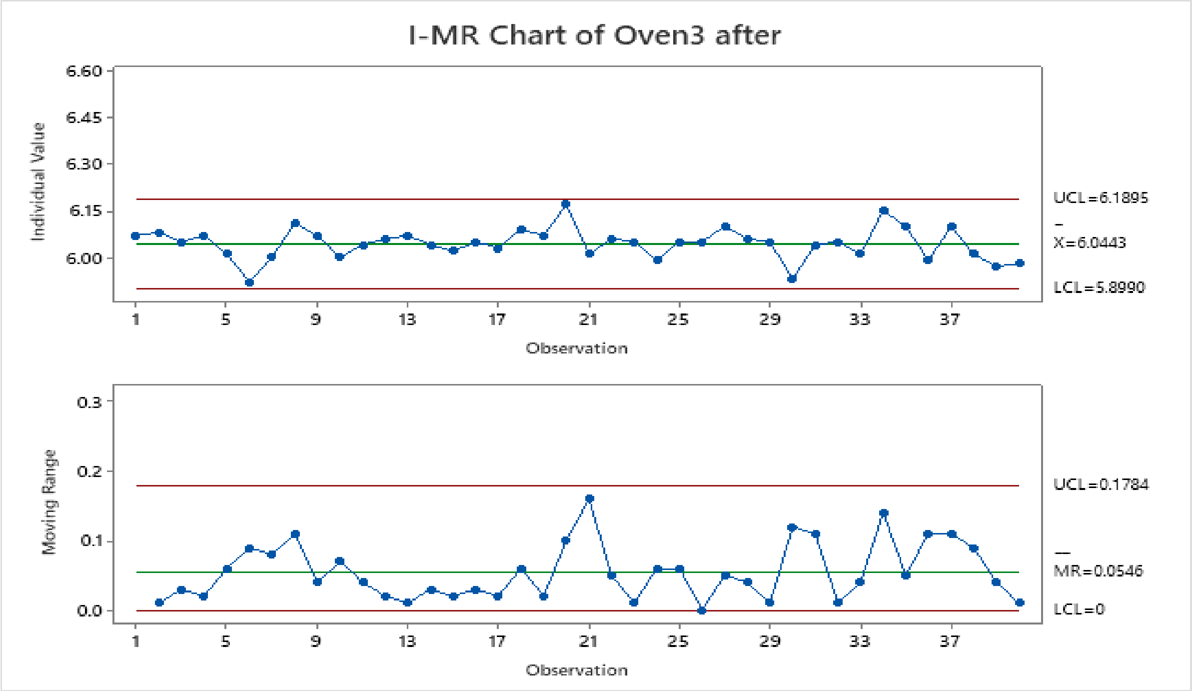
T-Value	DF	P-Value
8.36	8	0.000

Inference:
Since P value is less than 0.05, there is enough evidence to reject the null hypothesis and we can conclude that the difference between the population means is statistically significant.

Improve – (Statistical validation for Improvement – I-MR Chart)

I-MR Chart of oven3 Before, Oven3 after





Inference :

- Before Cpk < After Cpk, which shows process is much more capable after improvement
- There is less variability in system since stdev reduced after improvement
- After improvement the data are normally distributed near the target within specified limit

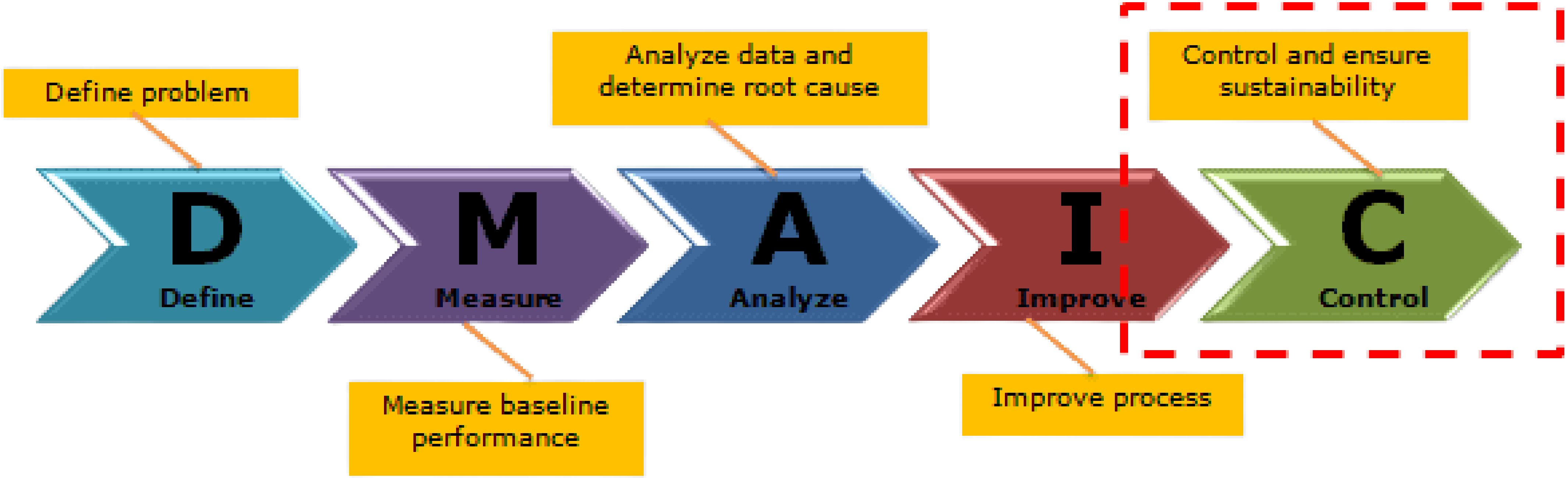
FMEA

S.no	Process / Action	Potential Failure Mode	Effect (what happens)	Cause	Current Controls	S	O	D	RPN	Recommended Action(s)	Owner	Target S, O, D	Target RPN
1	Incoming caps inspection (new vision system)	Vision system misses small cracks / false accepts	Defective caps enter line → increased cap damage & rework	Sensor not tuned; poor lighting or dirty lens	Manual sampling AQL	8	7	8	448	Calibrate vision system, daily lens clean, validation checks (sample 125 caps/day), redundancy: occasional manual sample; train QC on false-positive handling	QC / Eng	8,4,4	128
2	Supplier tolerance tightening	Supplier delays or rejects	Shortage of caps → line stoppage or use of non-conforming caps	Supplier capability gap	Incoming QC sampling	7	6	6	252	Supplier development: capability study, PPAP, contingency supplier, Kanban minimum stock level	Procurement	7,3,3	63
3	In-line neck gauge installation	Gauge fails to detect borderline bottles	Misfit caps applied → leakage or damage	Sensor miscalibration or wrong setpoints	Manual gauge checks sporadic	8	6	7	336	Validate gauge against lab calipers, set alarm thresholds, daily zero-check, operator quick-check station	QA / Maintenance	8,3,4	96
4	Cap feed & handling upgrade (lined chutes)	Caps still deform in chute or get orientation errors	Higher damage, jams → downtime	Incorrect chute geometry or wrong material	Visual checks	6	6	6	216	Prototype test, half-day run before rollout, install orientation sensors and shock-absorbing lining	Prod Supervisor / IE	6,3,3	54

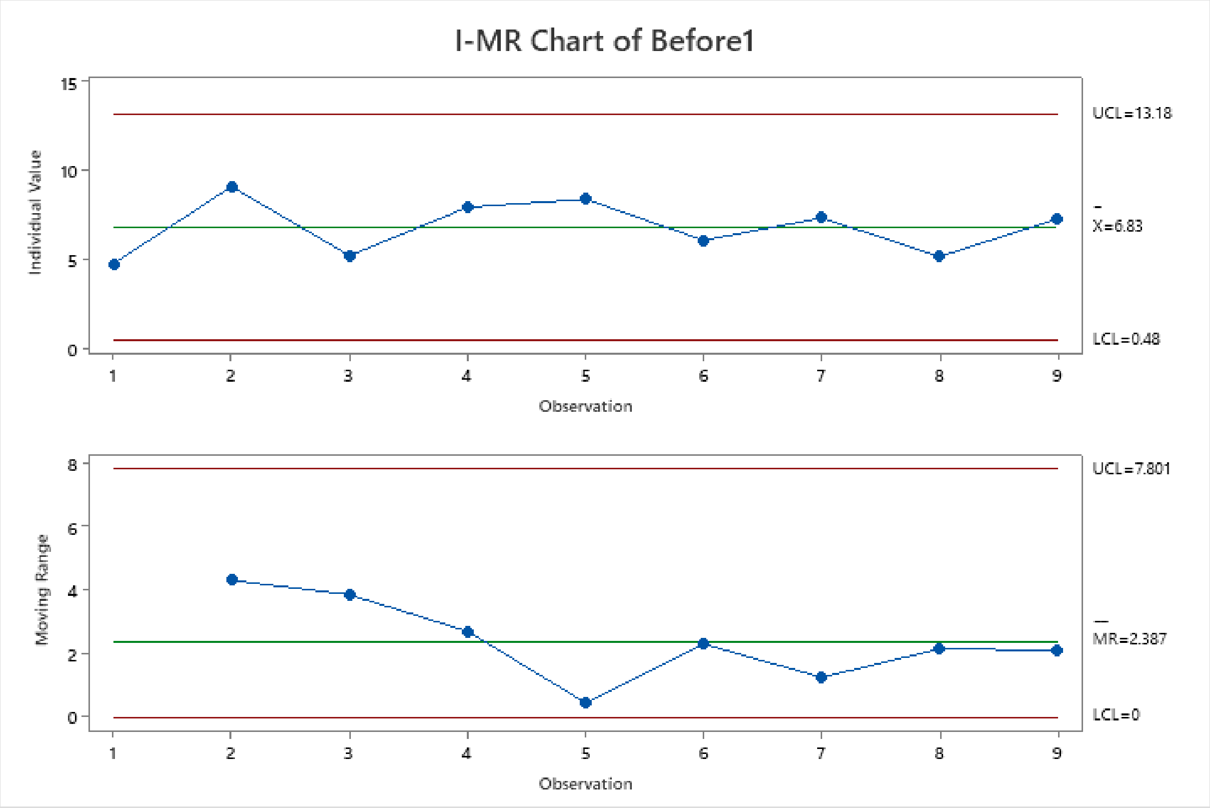
FMEA

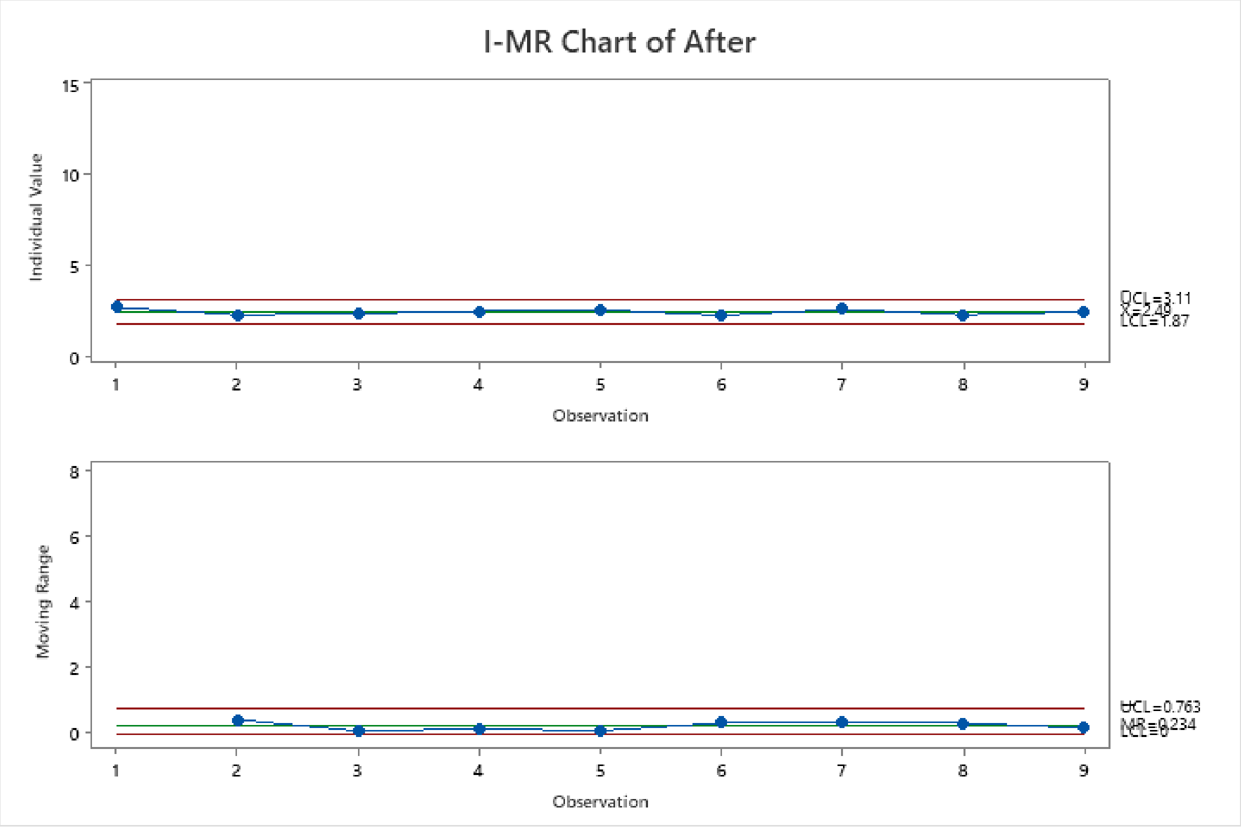
S.no	Process / Action	Potential Failure Mode	Effect (what happens)	Cause	Current Controls	S	O	D	RPN	Recommended Action(s)	Owner	Target S, O, D	Target RPN
5	Sealing head alignment procedure	Alignment procedure not followed or mis-measured	Off-centre sealing → cross-threading, cracked caps	Lack of adherence to SOP or inadequate jig	Ad-hoc alignment	9	5	7	315	Jigs with go/no-go fit, daily alignment checklist sign-off, torque/position sensor interlock	Maintenance / Line Lead	9,2,3	54
6	Replace worn jaws / PM schedule	Parts wear earlier than expected	Poor gripping → scratches, slippage, cap damage	Undetected wear, wrong usage life	Reactive maintenance	8	6	6	288	Cycle counter + auto-alert, spares kit, visual wear gauge, monthly inspection	Maintenance	8,2,3	48
7	Torque calibration & digital controllers	Controller calibration drift or bypass	Over/under torque → fractured caps or loose seals	Poor calibration frequency, bypassed interlock	Manual torque checks irregular	9	6	8	432	Install digital torque controllers with auto-lock, calibration log w/ QR scan, monthly calibration audit	QA / Maintenance	9,2,3	54
9	Line speed optimization (DOE)	Speed changes cause transient defects when implemented	Sudden spike in scrap during trials	Poorly planned changeover, lack of monitoring	Manual supervision	8	6	7	336	Run DOE on pilot line, phased ramp-up, real-time SPC, holdback sample batch and rollback plan	Process Eng	8,2,3	48

CONTROL PHASE



Improve (Statistical validation for Improvement – I-MR Chart)





Inference:

- Since P value is less than 0.05, there is enough evidence to reject the null hypothesis and we can conclude that the difference between the population means is statistically significant.
- It is also visible from the individual value plot & box plot, there is clear difference in mean after improvement.

Sustain Action Plan – 5S

5S Step	Key Activities in Capping Area	Expected Benefit
1. Sort (Seiri)	Remove damaged caps, old tools, uncalibrated torque wrenches, and unused jigs from the workstation.	Reduces mix-ups and accidental use of defective materials.
2. Set in Order (Seiton)	Label and mark storage zones for caps, bottles, torque tools, and lubricants; shadow boards for tools.	Faster retrieval and zero search time.
3. Shine (Seiso)	Daily cleaning checklist for cap chute, torque heads, and conveyors; assign cleaning ownership.	Prevents dust, oil, and particle contamination that causes capping slippage.
4. Standardize (Seiketsu)	Create visual SOPs for torque setup, alignment checks, and machine cleaning; use color codes.	Ensures consistency across all shifts and operators.
5. Sustain (Shitsuke)	Conduct weekly 5S audits, reward teams maintaining 90%+ scores, and update Kaizen board.	Builds accountability and culture of discipline.

Sustain Action Plan – Poka Yoke

Root Cause	Poka-Yoke Mechanism (Error-Proofing Solution)	Purpose / Benefit
1. Poor Quality Caps from Supplier	• Incoming Vision Inspection System – camera or sensor checks cap dimensions, cracks, and color before feeding. • Go/No-Go Cap Gauge for sampling each batch.	Automatically rejects defective caps and ensures only conforming ones enter the hopper.
2. Inconsistent Bottle Neck Dimensions	• Inline Neck Diameter Gauge (laser or mechanical probe). • Mechanical Stopper / Neck Locator to guide bottles to correct position.	Prevents misfit between cap and neck; avoids torque variation.
3. Improper Cap Handling	• Anti-jam Cap Chute Design with smooth lining to prevent scratches or deformation. • Cap Presence Sensor to detect if a cap is missing or inverted.	Reduces cap damage and misfeeds, ensuring correct orientation before capping.
4. Misaligned Sealing Heads	• Head Alignment Pin or Locator Guide that only allows correct seating of head after cleaning/maintenance. • Auto-alignment Sensor – stops machine if head not aligned.	Ensures consistent sealing pressure and prevents cross-threading.
5. Worn-Out Capping Jaws/Chucks	• Usage Counter / Cycle Counter triggers maintenance alert after preset number of cycles. • Torque Deviation Alarm when average torque drifts beyond limits.	Prevents defects caused by wear before they occur.
6. Poor Torque Calibration	• Digital Torque Monitoring with Lockout – machine stops if calibration date expired or torque outside range. • Color-coded torque wrenches with calibration stickers.	Prevents over-tight or loose caps and enforces calibration schedule.
7. Defective Liners/Seals	• Cap Liner Presence Sensor (vision or thickness detection). • Automatic Reject Mechanism for missing or double liners.	Ensures every bottle has a functional liner, preventing leakage.
8. Improper Line Speed	• Speed Interlock System – machine auto-adjusts torque head speed relative to conveyor speed. • Speed Alarm Indicator if variation exceeds ±5%.	Maintains consistent capping quality and avoids torque fluctuation due to speed changes.

Control Plan

Process Step	CTQ / Parameter to Control	Specification / Target	Measurement Method / Tool	Frequency	Responsible	Control Method / Reaction Plan
1. Incoming Caps Inspection	Cap visual defects (cracks, deformations)	0% defect acceptance	Automated Vision System + Manual Sampling	Every lot	QC Inspector	Reject defective lots, quarantine suspect batches, feedback to supplier immediately
2. Cap Dimensions Verification	Cap height, diameter, liner presence	As per supplier drawing ±0.05 mm	Vernier Calliper, Go/No-Go Gauge	1st lot of each shift	QC / Production	Stop line if out of tolerance; inform supplier; replace stock
3. Bottle Neck Dimensions	Neck diameter, thread pitch	28 mm ± 0.05 mm	Neck Gauge / Vernier	Daily check / batch start	QA Technician	Adjust filler height; quarantine batch; report to bottle supplier
4. Capping Head Alignment	Head-to-neck concentricity	Centred within ±0.2 mm	Dial Gauge / Alignment Jig	Weekly	Maintenance	Re-align using jig; record alignment in logbook
5. Torque Setting Verification	Applied torque on caps	0.8 – 1.0 Nm	Digital Torque Tester	Each shift	Line Operator / QA	Adjust torque controller; verify 5 caps after change
6. Cap Feed Handling	Orientation and chute movement	0 jams per shift	Visual check, sensor count	Continuous (sensor)	Operator	Stop line, clear chute, check orientation unit and feed angle
7. Jaw / Chuck Wear Check	Jaw wear / slippage	No wear lines or cracks	Visual + PM checklist	Weekly	Maintenance	Replace worn parts immediately; log usage life

Control Plan

Process Step	CTQ / Parameter to Control	Specification / Target	Measurement Method / Tool	Frequency	Responsible	Control Method / Reaction Plan
8. Sealing Head Pressure / Speed	Machine RPM / Sealing pressure	Standard setup sheet	HMI Display + Tachometer	Daily	Operator / Engineer	Adjust to standard; log deviation and cause
9. Line Speed Monitoring	Bottles per minute	40 BPM ± 5	Line Counter	Continuous	Operator	Reduce speed if damage > threshold; escalate to Supervisor
10. Liner Adhesion (Seal Check)	Peel strength	2.5–3.0 N	Pull Test	Once per batch	QC	Reject batch if below limit; investigate cap supplier
11. Operator Training & Certification	SOP adherence & skill competency	100% trained operators	Competency Checklist	Monthly audit	Production / HR	Retrain or reassign unqualified operators
12. Preventive Maintenance (PM)	Torque controller, heads, jaws	As per PM schedule	PM Logbook	Monthly	Maintenance	Replace worn components; recalibrate torque tester
13. SPC Monitoring (Control Chart)	% Cap Damage	Target ≤ 3%	$\bar{X}$–R Chart	Daily / Shift	QA Engineer	Investigate if point beyond UCL; document corrective action
14. Audit of Sustained Controls	Compliance to all above controls	≥95% checklist compliance	5S + Control Plan Audit	Weekly	Process Engineer / QA	Review non-compliance trends; report to Ops Manager
15. Visual Management / 5S	Workplace organization, SOP display	100% compliance	5S Audit Sheet	Weekly	Supervisor	Correct deviations; photo evidence before/after

Conclusion

Results after improvement

- **Project has achieved its intended results after improving by identifying the variation cause and reducing scrap rate.**