Reduction of Rejection Rate in Poor edge

Mohammed Anees

ROADMAP

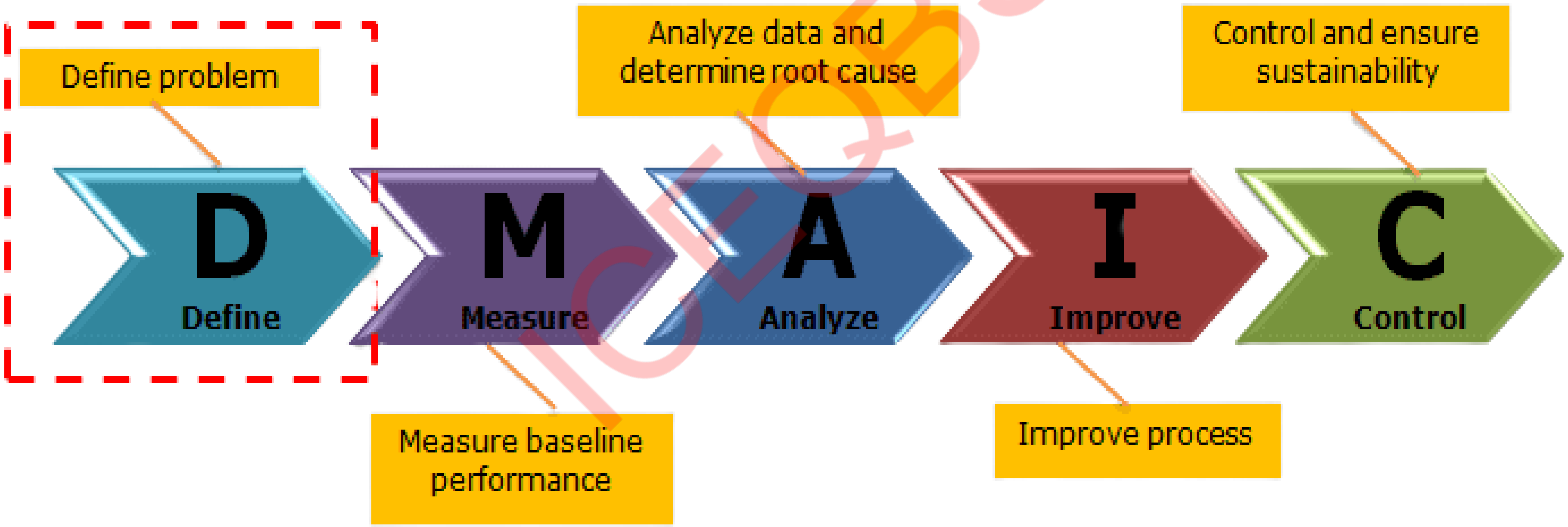
- Overview
- Define
- Measure
- Analyse
- Improve
- Control

OVERVIEW

Background

•The Edge Cleaning process in Conveyor Line-1 has an unstable average rejection rate of 5.11%, peaking at 7%, leading to material waste, production disruptions, tool breakage, and delivery delays. This results in a COPQ of ₹4.5 lakh per month. Reducing rejections to <2.5% and stabilizing the process will save approximately ₹27 lakh annually, improve production predictability, and enhance OEM customer delivery performance.

DEFINE PHASE

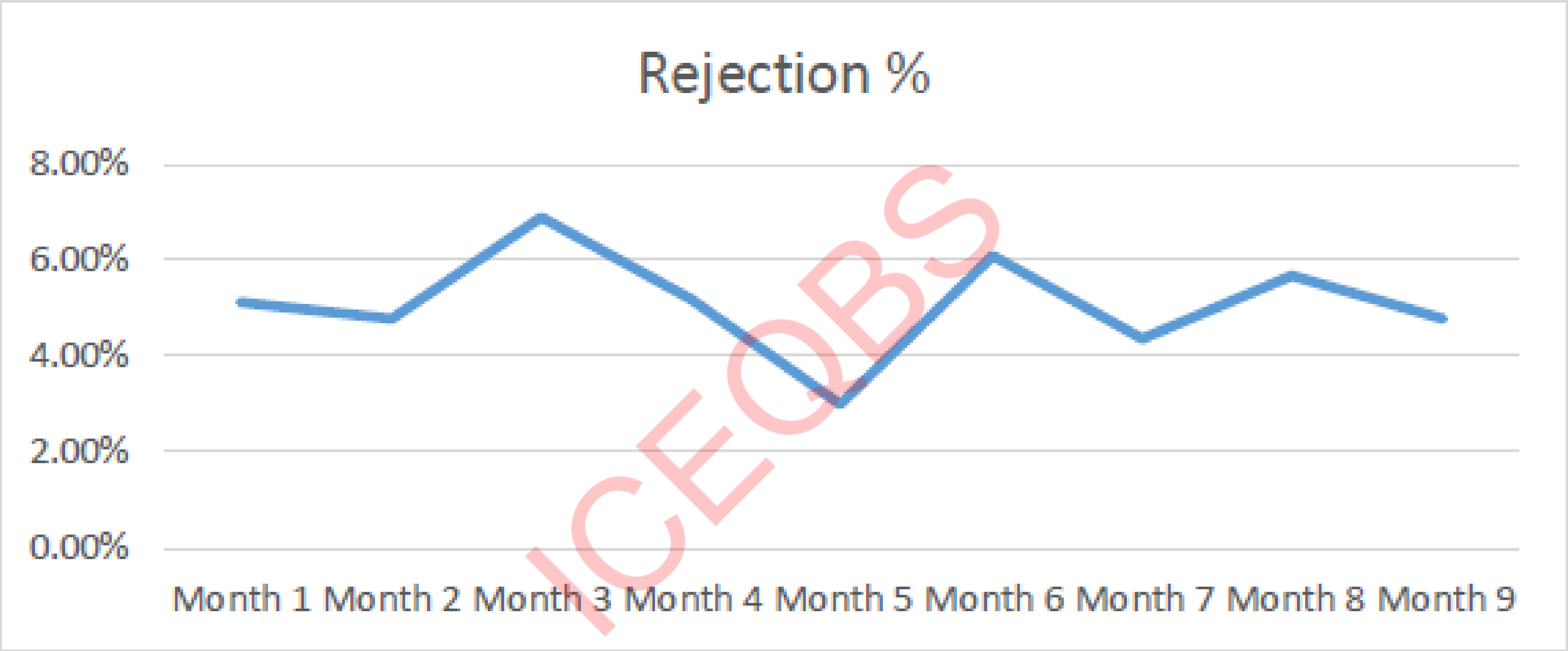


VOC & CTQ

CTQ Tree :

Voice of customer	Critical to X	Primary Metric for improvement
The Sole attached edges should be clear & free from adhesive & Dust"	Edge Cleaning Rejection Rate	**Primary Metric -** Y = % Edge Cleaning Rejection Rate **Secondary Metric -** Cycle Time / Lead Time

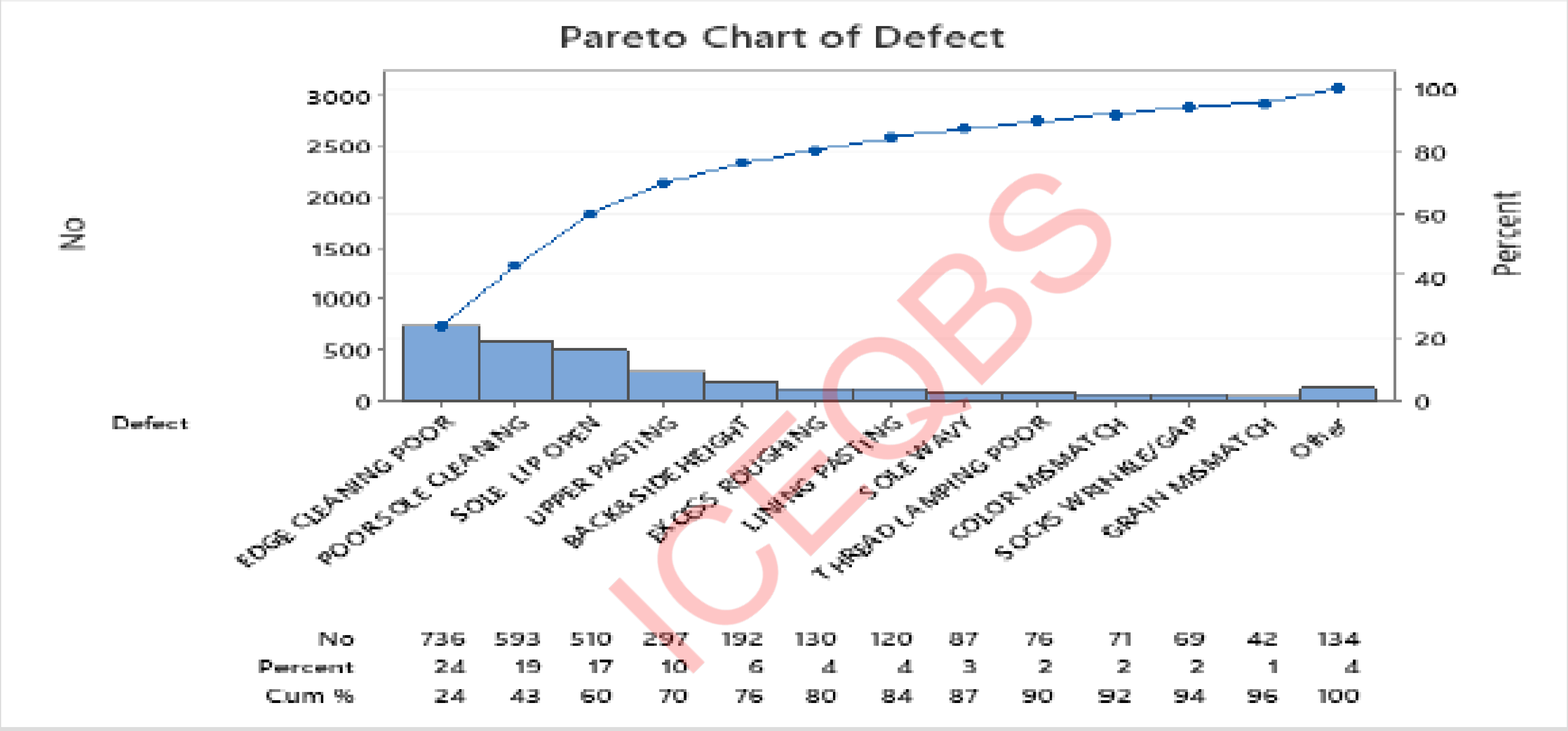
Baseline Performance of Primary Metric (9 months data as Line chart)



Inference :

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

Pareto chart



Inference :

- Edge cleaning contributes substantially and included in the scope of the project

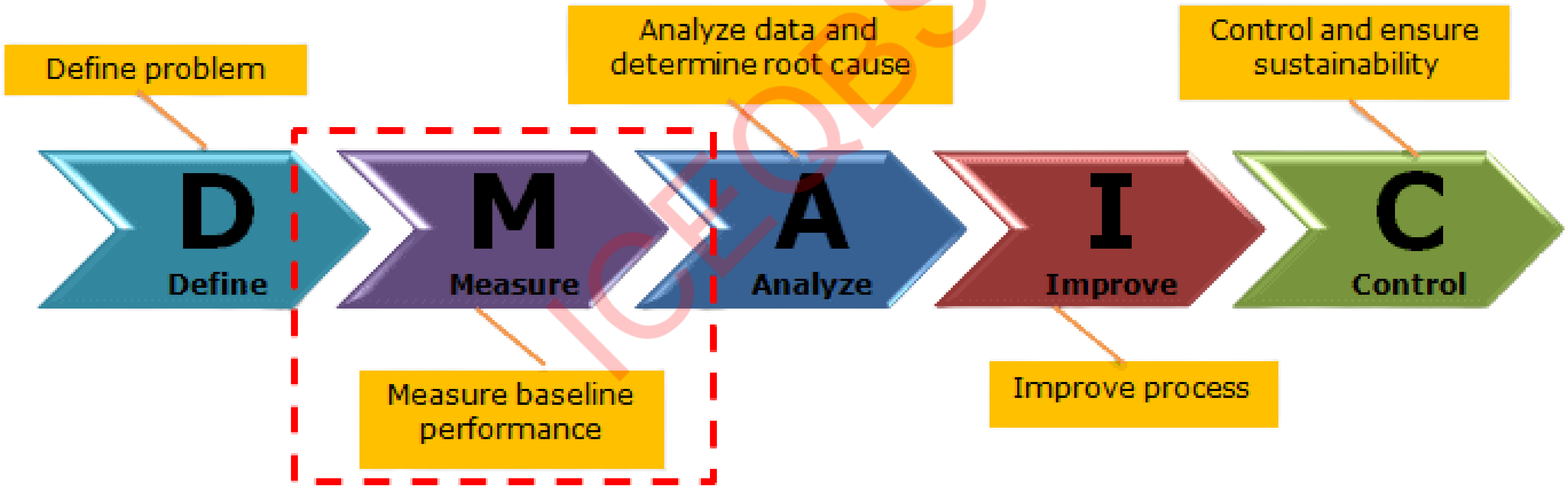
Project Charter

Project Title:	Reduction of Rejection Rate in Poor edge cleaning
Project Leader	**Project Team Members:**
Mohammed Anees	SPC Technician Adhesive Lab Technician Quality Inspector
Champion/Sponsors:	**Key Stake Holders**
Plant Head – Production	Finishing section 2nd stage inspection Final inspection
Problem Statement:	**Goal Statement:**
In the last 9 months, the Edge Cleaning Process in Conveyor line1 has experienced an average rejection rate of **5.11%** . The monthly rejection rate is highly unstable, peaking at 7%, leading to unpredictable production schedules and significant material waste	To reduce the average rejection rate of Edge Cleaning Process from **5.11%** to less than **2.5%** by the end of the next quarter (3 months).
Secondary Metric	**Assumptions Made:**
Cycle Time / Lead Time	Equipment capability is sufficient to achieve <2.5% rejection with optimized settings. Rejection data is accurate and consistently measured.

Project Charter

Tangible and Intangible Benefits:	Risk to Success:
~₹27 lakh annual COPQ reduction. Reduced scrap and tooling breakage. Improved process stability. Better OEM delivery confidence.	Operator non-adherence to revised SOPs. Upstream material variation affecting edge quality.
In Scope:	**Out of Scope:**
The Marking , Scoring , Adhesive application, Attaching, Pressing , Edge Cleaning Processes	Till lasting section end finishing section & packing
Signatories:	**Project Timeline:**
General manager Lasting Supervisor	6 months

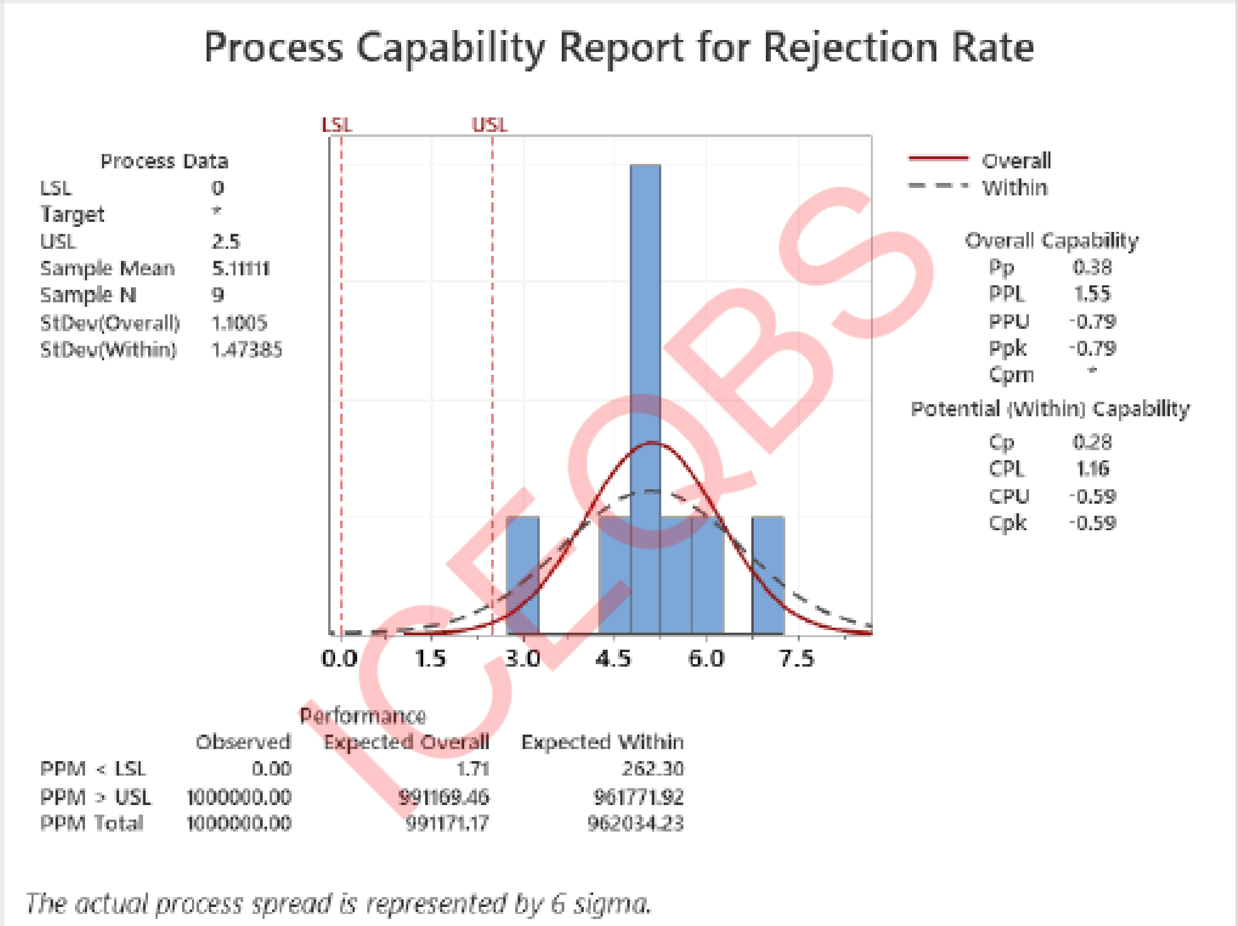
MEASURE PHASE



SIPOC

Suppliers	Inputs	Process (High-Level)	Outputs	Customers
Chemical Vendors	Suitable Adhesive, chemical & Mixture Ratio	Edge Rough & cleaning	Inspection Reports	End User.
Proess Tehnician	Pattern & Process Method	Standard method	Rejection Rate	Quality Dept
Maintenance Technician	Machine Speed & Control	Machine Setting	Correct samples	Supervisor
Tool Technician	Tool shape & Mateiral		Test Samples	Quality dept

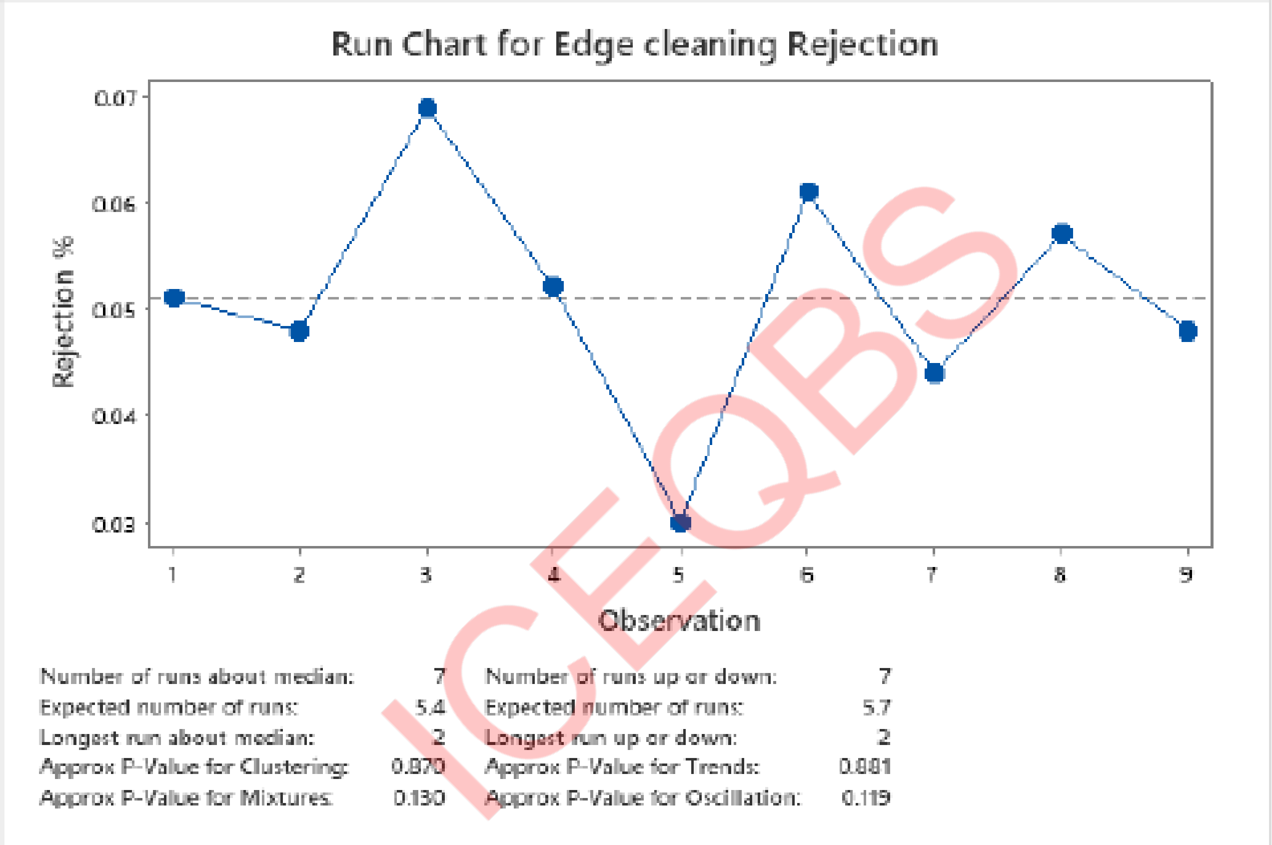
Data collection –(Before improvement)



Inference :

- The rejection rate process is incapable and not centered, with the mean exceeding the USL and negative Cpk, indicating a high likelihood of rejections and the need for immediate process improvement.

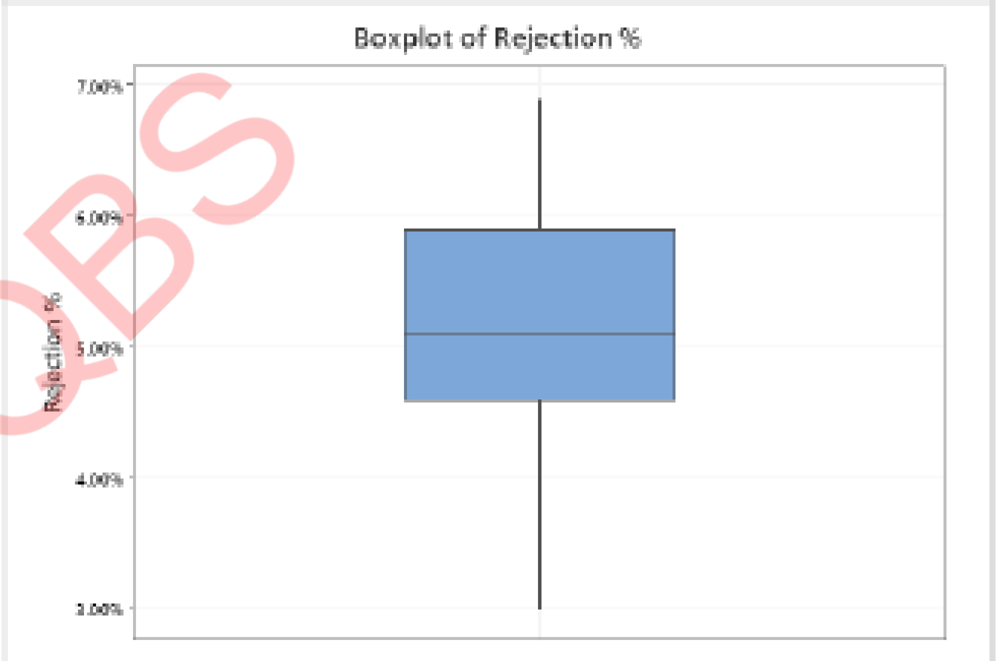
Data collection – Run Chart (Before improvement)



Inference :

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

Data collection – Normality plot (Before improvement)



Inference :

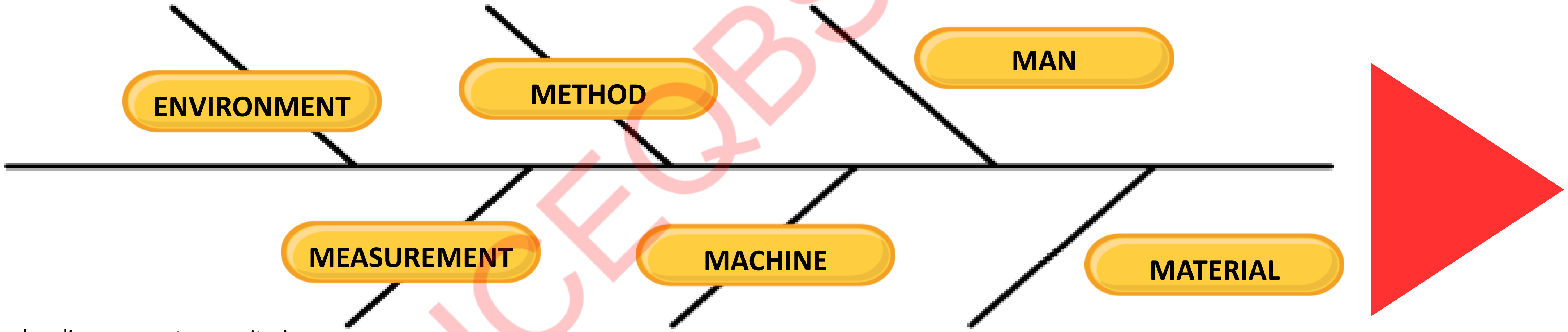
- P > 0.05 in all scenarios, thus all the data is normally distributed

Fish Bone Diagram

1. Poor lighting in the cleaning area
2. Dusty or dirty workplace conditions
3. High humidity affecting cleaning effectiveness

1. No standardized edge cleaning method defined
2. Incorrect sequence of cleaning operations
3. Insufficient cleaning time allowed

1. Insufficient operator training on edge cleaning process
2. Lack of skill in handling edge cleaning tools
3. Operator negligence or lack of attention to detail



1. No defined edge cleanliness acceptance criteria
2. Subjective visual inspection only
3. Inadequate inspection tools or gauges

1. Worn-out brushes or abrasive tools
2. Improper machine speed or pressure settings
3. Poor preventive maintenance of cleaning equipment

1. Excessive burrs on incoming material edges
2. Variations in material hardness
3. Oil, grease, or dirt present on edges

common and special causes

Common Causes

- Inadequate operator training
- Operator fatigue
- Lack of standard operating procedures
- Worn-out cleaning tools
- Poor preventive maintenance
- Incorrect machine settings
- Insufficient cleaning time
- Material hardness variation
- Excessive burrs on material
- Oil or contamination on edges
- No defined inspection criteria
- Visual inspection only
- Poor lighting in work area

Special Causes

- Machine misalignment
- Equipment vibration
- Inadequate machine capability
- Poor-quality raw material from suppli
- Outdated work instructions
- Inadequate inspection tools
- Inspection data not recorded
- Temperature variation
- Inadequate workspace ergonomics

3M Analysis for Waste

Muda (Waste)

1. Re-cleaning edges due to incomplete cleaning
2. Excessive Adhesive Application
3. Excessive Edge roughing in Cleaning process

Mura (Unevenness)

1. Variation in edge cleaning quality between operators
2. Inconsistent cleaning time per among pairs
3. Uneven hourly pair running

Muri (Overburden)

1. Operators required to clean edges manually for long periods
2. Machine operated beyond recommended speed or capacity
3. Operators handling heavy Weights

8 Wastes Analysis

Defects	• Parts rejected due to improper edge finish or hidden porosity revealed in final machining. • Rework caused by incomplete or uneven edge cleaning.
Overproduction	• Cleaning more parts than required due to poor rejection feedback loop. • Processing batches without confirming downstream acceptance readiness
Waiting	• Conveyor stoppages while rejected parts are segregated and inspected. • Operators waiting for quality clearance or rework instructions
Non-Utilized Talent	• Operators performing manual re-cleaning instead of focusing on value-added tasks. • Quality issues repeatedly occurring without using operator insights for improvement
Transportation	• Extra movement of rejected parts between edge cleaning, inspection, • Shifting parts to machining before detecting edge-related defects.
Inventory	• Accumulation of rejected or suspect parts near the conveyor line. • Excess WIP created due to unstable rejection rates
Motion	• Repeated manual handling and repositioning of parts for re-cleaning. • Operators walking frequently to fetch tools or gauges due to poor workstation layout.
Overprocessing	• Multiple edge-cleaning passes on the same part to meet acceptance criteria. • Additional inspection checks caused by inconsistent process output.

Action Plan for Low Hanging Fruits

Special Causes (sudden failures / abnormalities)

Issue (Special Cause)	Lean Tool	Action	Responsibility	Benefit
Machine misalignment	TPM	Align and calibrate edge cleaning machine	Maintenance	Consistent edge cleaning
Tool wear variation	Standard Work	Tool replacement standard & checklist	Supervisor	Reduced defects
Supplier material variation	Supplier Quality	Incoming material edge inspection	Quality	Fewer rework cases
Poor lighting	5S	Install focused LED lighting	Maintenance	Better defect detection

Action Plan for Low Hanging Fruits

Type	Action	Lean Tool	Benefit
Muda (Waste)	Remove re-cleaning loops, place tools at point of use	Kaizen / 5S	Reduced rework & motion
Mura (Unevenness)	Standardize cleaning time & method	Standard Work / Line Balancing	Uniform quality & cycle time
Muri (Overburden)	Introduce job rotation, ergonomic fixtures	Ergonomics / Workload leveling	Reduced operator fatigue & injuries

Action Plan for Low Hanging Fruits

Waste	Action	Lean Tool	Benefit
Defects	Edge guide to prevent missed areas	Poka-Yoke	Reduced rework
Overproduction	Clean only as per downstream demand	Pull System	Less excess work
Waiting	Place machine & inspection nearby	Layout Improvement	Reduced idle time
Non-utilized Talent	Involve operators in improvement ideas	Kaizen	Better engagement
Transportation	Create edge cleaning cell	Cell Layout	Less movement
Inventory	Limit WIP between processes	FIFO	Faster flow
Motion	Tool shadow boards at workstation	5S	Less fatigue
Over-processing	Define edge cleaning quality limit	SOP	Avoid extra cleaning

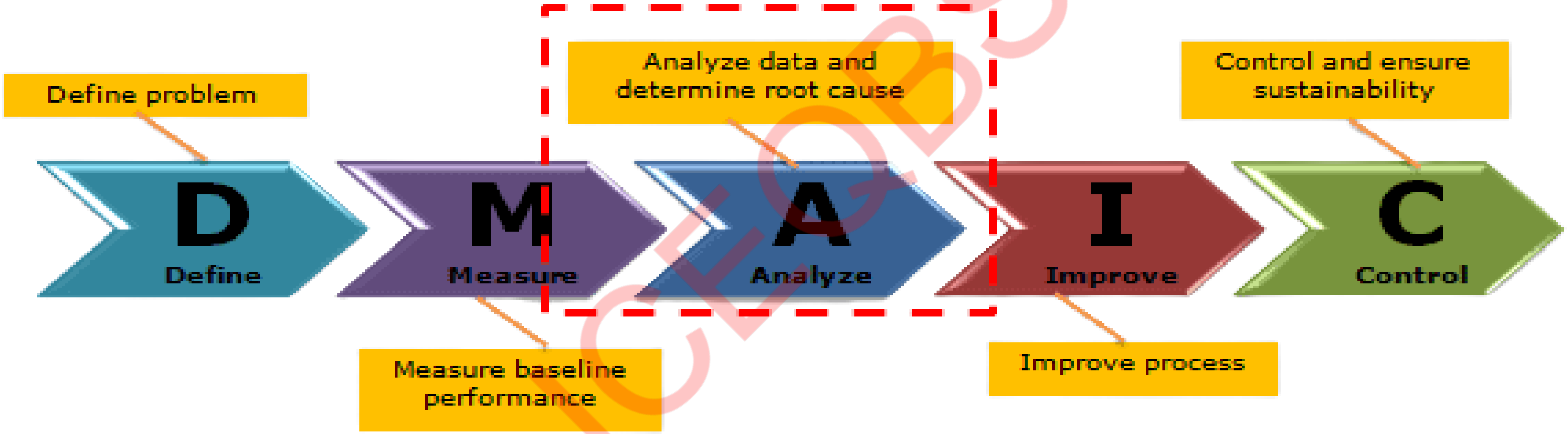
Top 12 Prioritized Root Causes (Based on Net Score)

Rank	Input (X)	Net Score
1	X3 – Operator skill	216
2	X1 – Machine misalignment	195
3	X2 – Tool wear	195
4	X5 – Improper method	195
5	X12 – Inadequate inspection	195
6	X7 – Material burrs	171
7	X9 – Oil / grease	171
8	X4 – Operator fatigue	144
9	X15 – Rework loops	135
10	X6 – Inconsistent cleaning time	129
11	X8 – Material hardness	81
12	X14 – Over-processing	81

Data Collection Plan

Data Item (X) / Root Cause	Output (Y) Affected	Type of Data	Unit of Measure	Frequency	Source / Tool	Responsible
X3 – Operator skill/training	Edge Cleanliness, Rework	Attribute & Process	Skill level (High / Medium / Low), Error count	Each shift	Operator assessment, checklist	Supervisor / Quality
X1 – Machine misalignment	Edge Cleanliness, Rework, Cycle Time	Continuous	mm deviation, defect count	Daily	Caliper, gauge, machine log	Maintenance
X2 – Tool wear	Edge Cleanliness, Rework	Continuous	Tool wear mm, defect count	Daily	Inspection, gauge	Maintenance
X5 – Improper cleaning method	Edge Cleanliness, Rework	Attribute	% adherence to SOP	Each shift	Observation checklist	Quality / Supervisor
X14 – Over-processing	Cycle Time, Edge Cleanliness	Attribute	# of extra cleaning steps	Each shift	Observation / SOP check	Supervisor
X12 – Inadequate inspection	Edge Cleanliness, Rework	Attribute	# of defects missed, inspection checklist compliance	Each shift	Inspection records	Quality
X4 – Operator fatigue	Operator Fatigue / Safety	Attribute	Fatigue level (1–5 scale), error count	Each shift	Observation / survey	Supervisor

ANALYSE PHASE



Analyse – Hypothesis testing

Regression Analysis: Rejection_% versus X1_Machine_Misal

Regression Equation

Rejection_% = 4.240 + 2.872 X2_Tool_Wear_mm - 0.1080 X3_Operator_Skill_Score_1t

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	4.240	0.400	10.60	0.000	
X2_Tool_Wear_mm	2.872	0.434	6.62	0.000	15.89
X3_Operator_Skill_Score_1to10	-0.1080	0.0274	-3.95	0.001	15.89

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0639614	98.48%	98.37%	98.03%

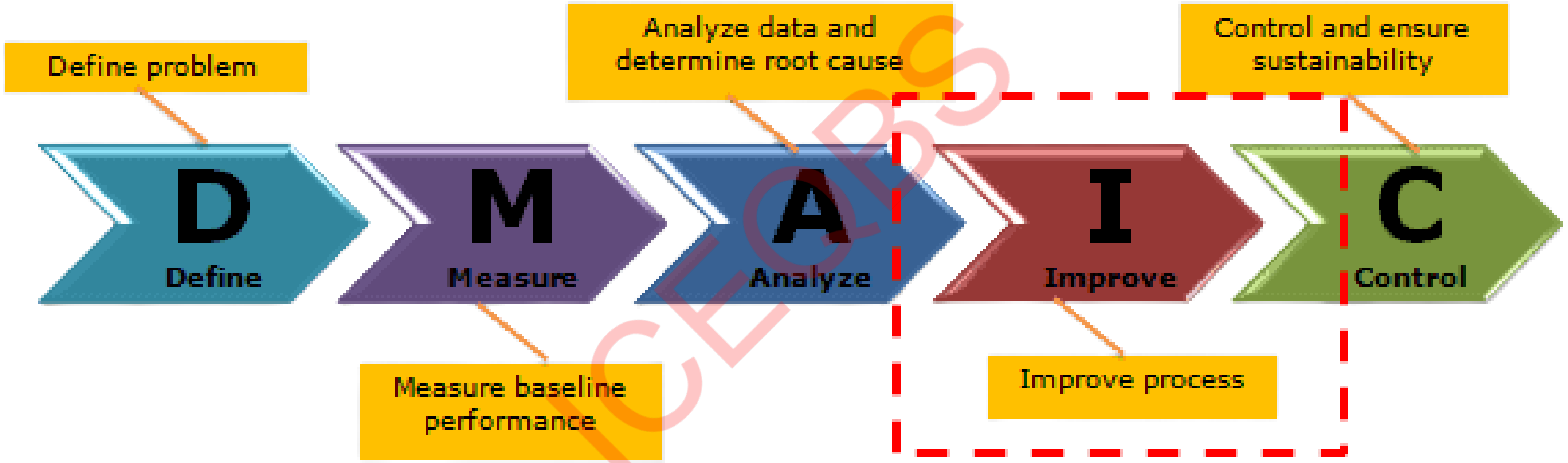
Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	7.15121	3.57560	874.00	0.000
X2_Tool_Wear_mm	1	0.17932	0.17932	43.83	0.000
X3_Operator_Skill_Score_1to10	1	0.06373	0.06373	15.58	0.001
Error	27	0.11046	0.00409		
Total	29	7.26167			

Summary of Statistically validated Root causes

The regression model is statistically significant ($p < 0.001$) with high explanatory power, showing that **tool wear increases rejection rate** while **higher operator skill significantly reduces rejections**, validating both as critical drivers of process performance.

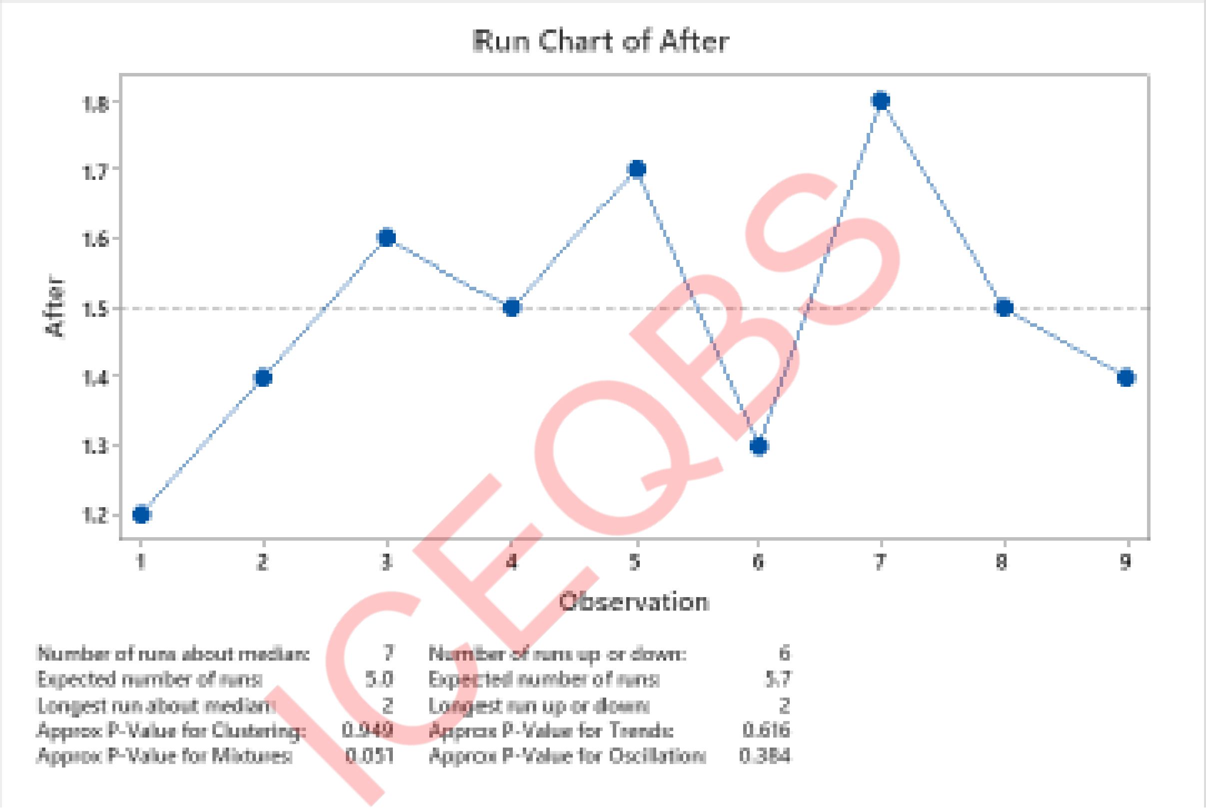
IMPROVE PHASE



Improve Design of Experiment

Sl. No.	Critical Root Cause	Improvement Action	Implementation Method	Responsible	KPI / Monitoring Metric	Expected Impact
1	Tool Wear (X2)	Implement preventive tool replacement based on wear limit	Define max wear limit (e.g., ≤ 0.55 mm); measure once per shift using gauge/microscope; replace before limit	Maintenance Supervisor	% tools replaced before limit ≥ 95%	Consistent edge finish; reduction in tool-related defects
2	Tool Wear (X2)	Tool condition checklist before each batch	Visual + dimensional checklist (chipping, rounding, vibration); operator sign-off mandatory	Line Supervisor	Checklist compliance = 100%	Early detection of worn tools
3	Operator Skill (X3)	Skill certification for edge-cleaning operators	Training on angle, pressure, feed rate; certification test with ≤2% rejection	Production Manager / Trainer	% certified operators = 100%	Reduced variation due to improper handling
4	Operator Skill (X3)	Display standard work with visual SOP at machine	Visual SOP with photos of correct method and defect samples	Quality / IE Team	SOP audit score ≥ 95%	Improved method adherence
5	Tool Wear & Operator Skill	Operator–tool matching and rotation plan	Skill matrix vs machine/tool condition mapping; rotate by output quantity	Production Planner	No rejection spike after shift change	Stable performance across shifts

Improve

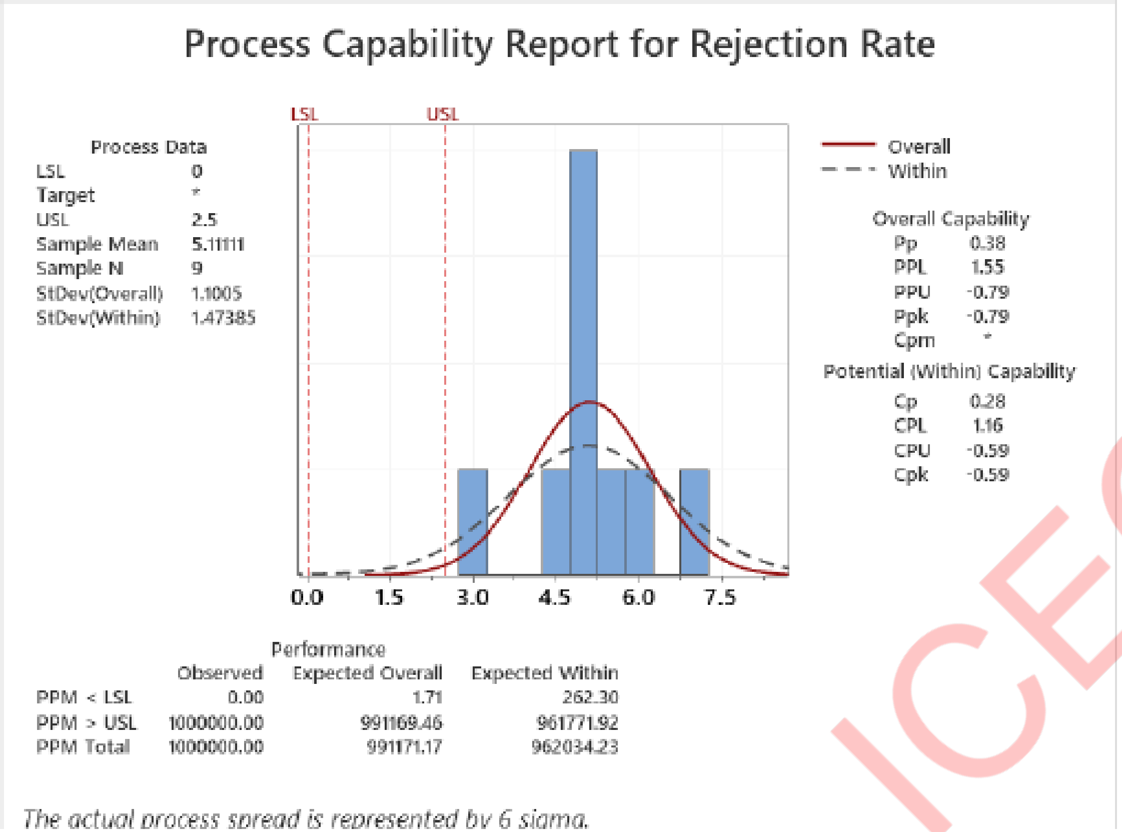


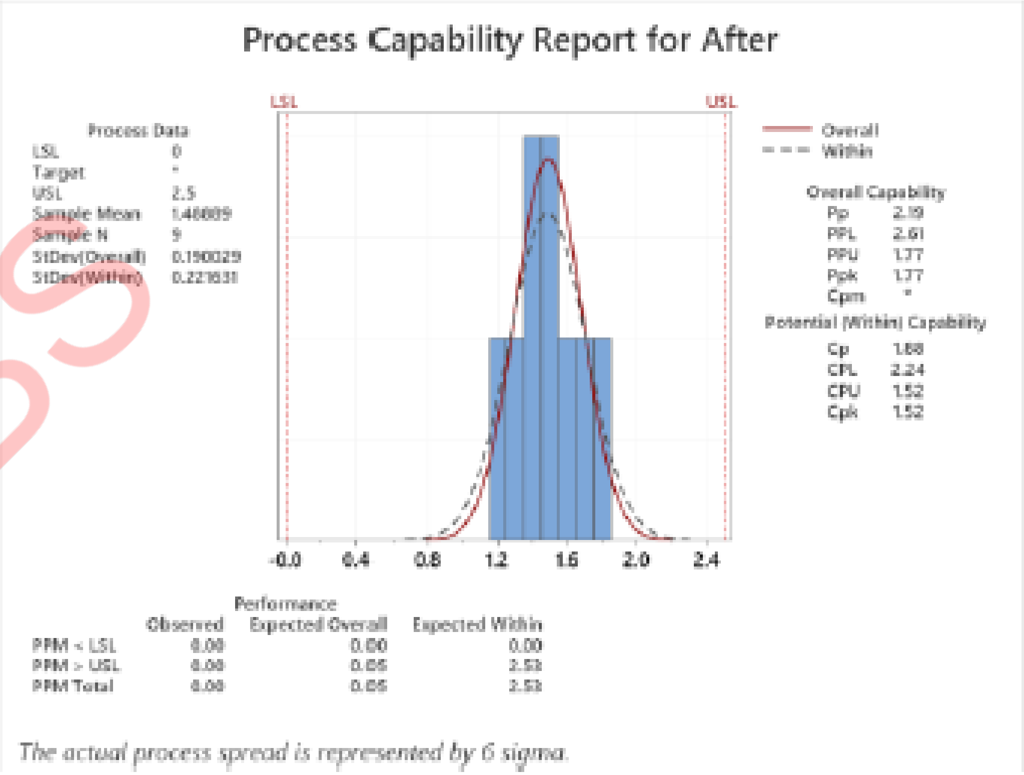
- The run chart shows no abnormal patterns or trends, indicating that the post-improvement process is stable and operating under statistical control.

Improve

•The probability plot shows that the post-improvement data follows a normal distribution (p-value > 0.05), confirming process stability and suitability for control chart monitoring.

Improve – Process capability – Before & After Improvement





Inference :

The capability analysis shows a clear improvement from an incapable process before (Cpk < 0) to a capable and well-centered process after improvement, with the rejection rate consistently within specification limits.

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

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

μ_1: population mean of Before
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
Before	9	5.11	1.10	0.37
After	9	1.489	0.190	0.063

Estimation for Difference

Difference	95% CI for Difference
3.622	(2.764, 4.481)

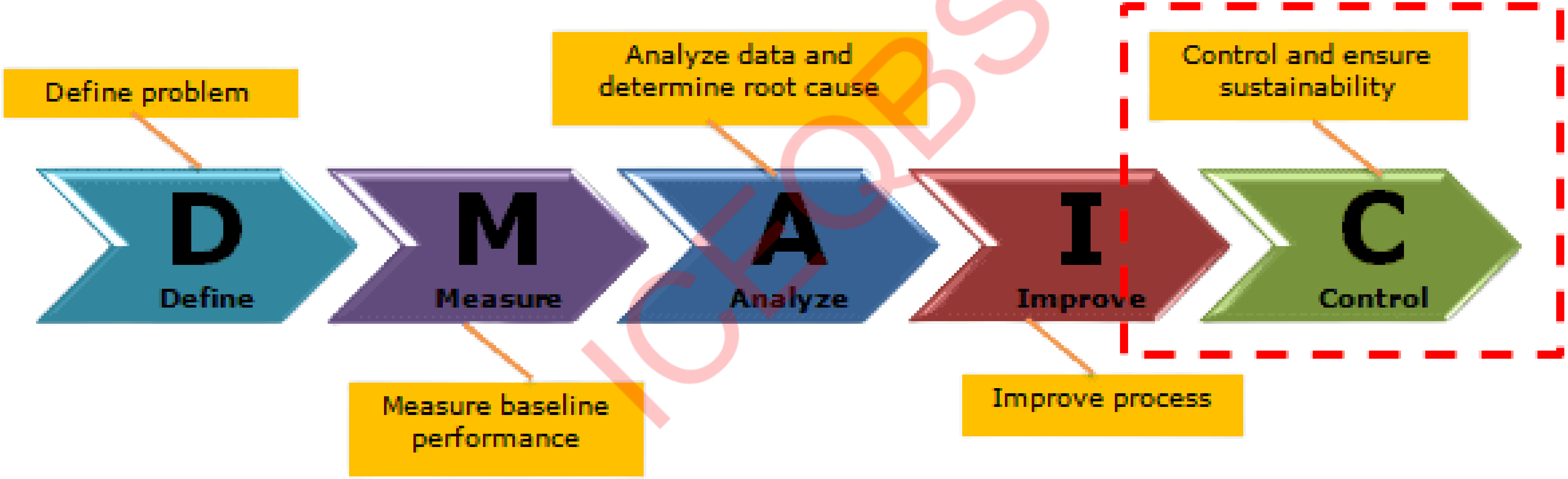
Test

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

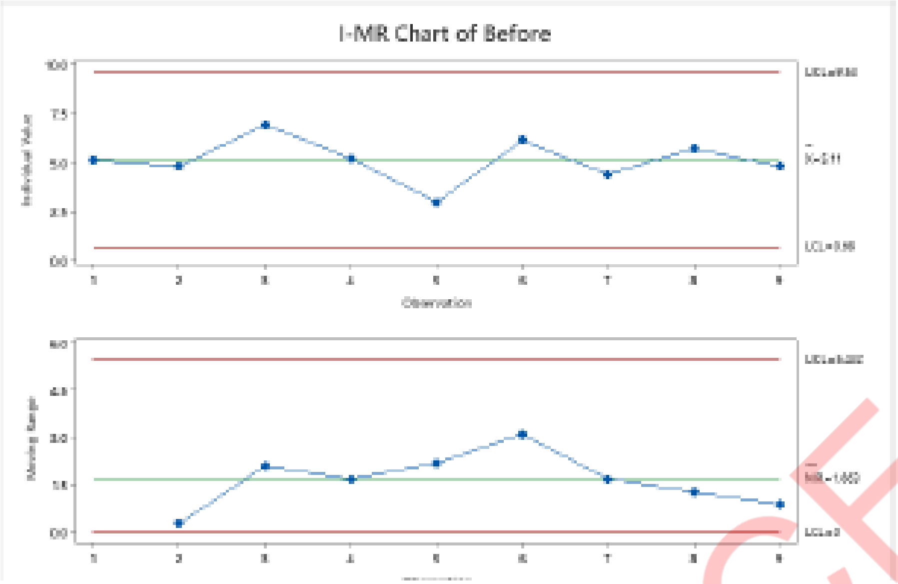
T-Value	DF	P-Value
9.73	8	0.000

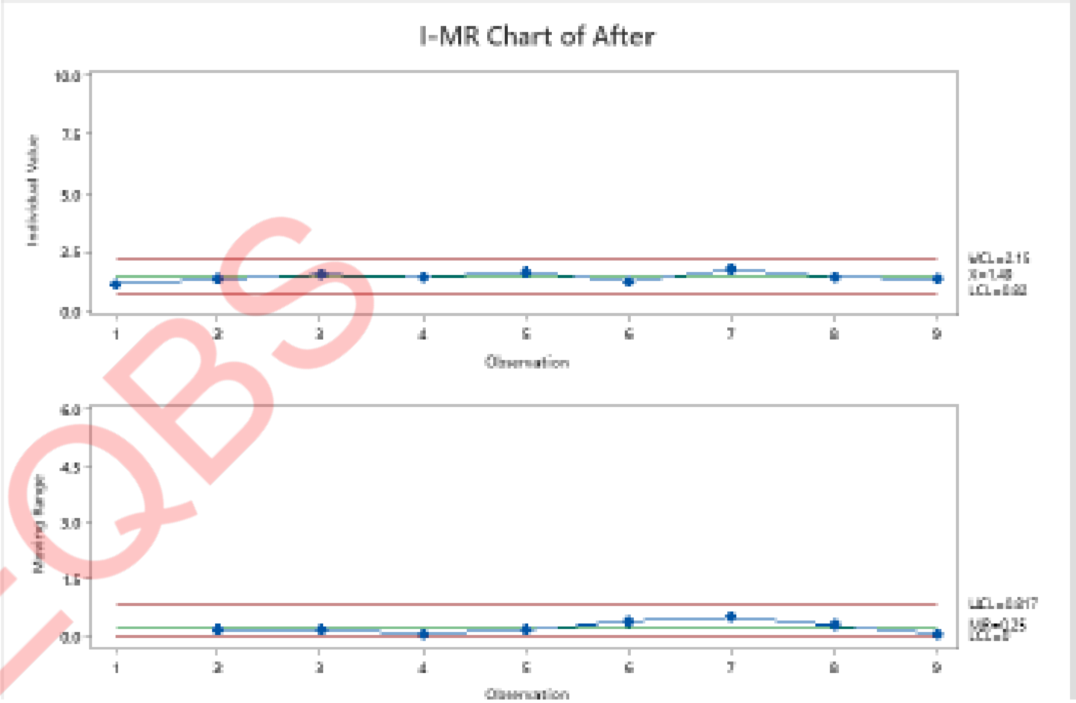
The two-sample t-test shows a statistically significant reduction in rejection rate after improvement ($p < 0.001$), confirming that the implemented changes led to a meaningful and sustained performance improvement.

CONTROL PHASE



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





Inference:

The I-MR charts indicate that the process has transitioned from an unstable, high-variation state before improvement to a stable and well-controlled state after improvement, with significantly reduced variation and all points within control limits.

Control Plan

Sl. No.	Type	Mechanism	What is Done	Error Prevented / Benefit
1	Poka-Yoke	Tool wear indicator mark on tool or holder	Mark maximum wear limit line; tool must be replaced once edge reaches mark	Prevents use of over-worn tools
2	5S (Set in Order)	Shadow board for edge-cleaning tools	Dedicated labeled slots for good tools, worn tools, and gauges	Prevents mixing of good and worn tools
3	Poka-Yoke	Interlock or checklist lock before machine start	Machine can run only after tool condition checklist is completed	Prevents production with unchecked tools
4	5S (Standardize)	Visual SOP at workstation with defect samples	Display correct method and typical reject edges	Prevents wrong technique by operators
5	Poka-Yoke + 5S	Color-coded tool life tags	Green = OK, Yellow = Near limit, Red = Replace	Prevents accidental reuse of expired tools

Control Plan

Sl . N o.	Proces s Step	Potential Failure Mode	Potential Effect of Failure	Potential Cause	Current Controls	S (Severity)	O (Occurrence)	D (Detec tion)	R P N	Recommended Proactive Action	Action Owner	Revised RP N
1	Tool replace ment as per wear limit	Tool not replaced on time	High rejection due to dull edge	Operator ignores wear mark	Visual check only	8	5	5	20 0	Introduc e color-coded tool tags + supervis or sign-off	Maintenance	64
2	Tool condition checklist	Checklist not followed	Defective tool used in production	Time pressure, shift rush	Paper checklist	7	6	5	21 0	Digital or stamped checklist before machine start (interlock)	Production	56
3	Operator certification	Untraine d operator assigned	Improper cleaning method	Manpower shortage	Informal OJT	9	4	6	21 6	Skill matrix + system block for uncertified operators	HR / Production	54
4	SOP adherence	Wrong tool angle or pressure	Edge damage, uneven finish	SOP not visible or outdated	Verbal instructions	7	5	5	17 5	Visual SOP with photos + monthly audit	Quality	49
5	Shift handover	Tool condition not communicated	Worn tool continues in next shift	No handover standard	Verbal handover	6	6	6	21 6	Tool status tag + shift handover log	Line Supervisor	60

Control Plan

Sl. No.	Process Step	CTQ / Control Parameter	Specificatio n / Target	Monitorin g Method	Frequenc y	Reaction Plan if Out of Control	Responsibilit y
1	Tool usage	Tool wear (mm)	≤ 0.55 mm	Measure using gauge / microscope	Once per shift	Stop machine, replace tool, inspect last 20 pairs	Maintenance Supervisor
2	Start of batch	Tool condition checklist	100% compliance	Signed checklist before start	Every batch	Hold productio n until checklist completed	Line Supervisor
3	Operator assignment	Operator skill certification	Only certified operators allowed	Skill matrix verification	Every shift	Replace operator or provide supervised operation	Production Manager
4	Method adherence	SOP compliance score	≥ 95%	Layered process audit	Daily	Retrain operator, review SOP at machine	Quality Engineer
5	Process output	Rejection % (edge defects)	≤ 2.5% per shift	Rejection tracking chart	Every shift	Trigger root cause review, check tool + operator	Process Owner

Conclusion

Results after improvement

- This project successfully reduced rejection rates, stabilized the process, and established effective controls to sustain improved performance and cost savings.