International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

Lean Six Sigma Implementation for Reducing Defects and Improving Productivity on the Cross Car Beam W610 Product Line: An On-the-Job Training Study at Belrise Industries Pvt. Ltd., Chakan, Pune

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Abstract **- Tier 1 automotive component suppliers operate under sustained OEM pressure for near-zero-defect delivery, and rework that is absorbed inside the process quietly erodes yield, capacity and cost. Contemporary literature positions Lean Manufacturing, Six Sigma and the DMAIC cycle as complementary approaches for exposing such hidden losses. This applied industrial study examined the Cross Car Beam (CCB) Assembly Line W610 at Plant B-39, Chakan, Pune, of Belrise Industries Pvt. Ltd., a line that integrates eight robotic welding cells, an AutoGauge station and a Firewall rework station. The primary objectives were to establish a quantitative First Time Yield (FTY) baseline, prioritise defect categories, assess error-proofing health through a Poka-Yoke audit, identify the cycle-time bottleneck, diagnose root causes, estimate the Cost of Poor Quality (CoPQ) and develop a DMAIC-based corrective-action and control plan. Conducted during an on-the-job training (OJT) assignment from 15 May to 15 July 2026, the methodology combined shop-floor observation, discussions with Quality, Production Engineering and Maintenance personnel, and analysis of daily FTY tally sheets (2,385 parts over 24 working days of May 2026), the Firewall rework register (46 events in 17 categories), stopwatch cycle-time observations and a 95-checkpoint Poka-Yoke audit.**

Of the 2,385 parts inspected, 926 passed first time and 1,459 were not OK, giving a pooled FTY of 38.83% against a target of at least 95%. Pooled FTY was 54.17% over the 13 working days to 19 May but fell to 14.44% over the 11 working days from 21 May, a collapse the plant attributed to a gauge calibration failure. Four of 17 defect categories accounted for 56.52% of rework events, and Shift B contributed 26 of 46 events (56.5%). The Poka-Yoke audit recorded 87.1% compliance, with 8 of 62 applicable checkpoints non-functional and 5 of them in Robotic Cell 2 (68.8% compliance). Robotic cell R3-A ran at 193 seconds against a line average of 174 seconds, driven by a 117-second welding phase. Estimated CoPQ was approximately ₹8.78 lakh per month. In conclusion, line performance is constrained by error-proofing reliability, gauge calibration discipline, weld-process stability and shift-level capability rather than by a single dominant defect. A ten-action corrective plan was developed; the gauge Standard Operating Procedure (SOP) and pre-shift checklist were completed during the OJT, while the remaining actions are proposals. It is recommended that management restore and interlock all Poka-Yoke sensors, enforce gauge calibration control, retrain Shift B on the leading defect categories, optimise the R3-A weld programme and institutionalise a daily FTY dashboard.

Keywords - Lean Six Sigma, DMAIC, First Time Yield, Poka-Yoke, Pareto Analysis, Cross Car Beam, Automotive Manufacturing

I. INTRODUCTION

The Indian automotive sector contributes approximately 7.1% of the national gross domestic product and about 49% of manufacturing GDP, and the auto-component industry was valued at roughly USD 69.7 billion in FY2023 [1], [2]. Within this ecosystem, Tier 1 suppliers deliver complete systems and modules directly to vehicle manufacturers and are expected to hold quality-management certification such as IATF 16949 [12]. One such module is the Cross Car Beam (CCB), a structural member that spans the cabin between the A-pillars and carries the dashboard, steering column, HVAC unit and airbag modules. Because the CCB is safety-relevant and is welded from many small brackets, dimensional accuracy, weld position and the presence of every nut and locator pin are critical to quality.

Belrise Industries Pvt. Ltd. is a Tier 1 automotive component manufacturer supplying OEMs including Maruti Suzuki, Tata Motors, Mahindra, Bajaj and Honda. At Plant B-39, Chakan, Pune, CCB Assembly Line W610 combines 24 sub-operations spanning sub-assembly, eight robotic welding cells (R1-A to R4-

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

B), an AutoGauge inspection station and a Firewall rework station. Despite this structure, the line's First Time Yield records show that most parts do not pass first time: during May 2026, Shift A inspected 2,385 parts, of which 926 passed without rework and 1,459 were recorded as not OK, against an FTY target of at least 95%. Rework of this scale forms a 'hidden factory' that consumes labour, inspection time and capacity without appearing in final-yield figures.

To address this problem, this study presents an applied Lean Six Sigma investigation of Line W610 using the DMAIC framework in three stages. First, a quantitative baseline was established from daily FTY records, the Firewall rework register, a robotic-cell cycle-time study and a Poka-Yoke audit. Second, the data were analysed through Pareto analysis, shift stratification, SPC interpretation and a 4M cause-and-effect analysis to identify the dominant sources of loss. Third, the findings were converted into a ten-action corrective plan, projected targets and a control framework. As the author's role during the OJT was diagnostic and advisory, implementation ownership remained with the plant's Quality, Maintenance, Production Engineering and HR functions.

II. LITERATURE REVIEW AND THEORETICAL BACKGROUND

A. *Literature Review*

Womack et al. [3] introduced Lean Production by examining the Toyota Production System, arguing that performance improves when activities that add no value are systematically removed, and Womack and Jones [4] later distilled Lean into the principles of value, value stream, flow, pull and perfection. Harry and Schroeder [5] presented Six Sigma as a data-driven management strategy for reducing process variation and defects, while Antony et al. [6] documented a Six Sigma case study in manufacturing quality improvement and drew guidance for managers from it. Shingo [7] contributed the Poka-Yoke concept of source inspection and mistake-proofing, Ishikawa [9] introduced the cause-and-effect diagram for structured root-cause analysis, and Montgomery [8] provides the statistical basis for control charts, including attribute charts suited to pass/fail data. Imai [10] framed continuous improvement as Kaizen, and Liker [11] described the Toyota practice of stopping to fix problems at source. IATF 16949 [12] embeds several of these tools, including SPC, FMEA and measurement system analysis, in automotive quality-system requirements. These sources are largely foundational and conceptual; this study applies them jointly, through FTY measurement, Pareto prioritisation, Poka-Yoke auditing and cycle-time analysis, on a live robotic welding and assembly line.

B. *Theoretical Background*

This study combines Lean waste elimination with Six Sigma variation reduction. Lean classifies non-value-adding activity into eight wastes (TIMWOODS): Transportation, Inventory, Motion, Waiting, Over-production, Over-processing, Defects and Skills under-utilisation [3], [4]. On Line W610 the dominant wastes are Defects, visible as rework, and Waiting, visible as downstream idle time behind the slowest welding cell. Six Sigma contributes the DMAIC cycle (Define, Measure, Analyse, Improve, Control), which structures the project from problem definition through to a sustaining control plan [5], [6].

The primary performance metric is First Time Yield, defined as the number of units passing a process step without rework, scrap or repair divided by the number of units entering that step, expressed as a percentage. FTY is preferred to final yield because it exposes the hidden factory: a process can ship every part and still consume significant labour and capacity in rework. Error-proofing is assessed through Poka-Yoke, which either prevents a defect (prevention type) or detects it immediately (detection type), using contact, fixed-value or motion-sequence methods [7]. A non-functional detection sensor therefore allows defects to pass undetected. Process stability is interpreted with Statistical Process Control, which separates common-cause variation, inherent to the process, from special-cause variation that demands investigation; a p-chart monitors the proportion of non-conforming units directly [8]. Root causes are organised with the Ishikawa diagram on the 4M basis (Man, Machine, Material, Method) [9], and defects are prioritised with Pareto analysis, one of the seven basic quality-control tools. Finally, Cost of Poor Quality expresses internal failure costs such as rework labour, re-inspection and lost capacity in monetary terms.

III. MATERIALS AND METHODS

A. *Research Objectives*

This study evaluates quality and productivity losses on CCB Assembly Line W610 at Belrise Industries to achieve six core objectives: (1) establish a quantitative baseline of FTY and defect incidence from the daily records of May 2026; (2) identify and prioritise the major defect categories through Pareto analysis and shift stratification; (3) assess error-proofing health through an audit of 95 Poka-Yoke checkpoints; (4) perform a cycle-time study across the eight robotic welding cells to locate the bottleneck; (5) diagnose root causes through 4M cause-and-effect analysis and SPC interpretation, and estimate the CoPQ; and (6) develop a DMAIC-based corrective-action plan with targets and a control framework.

B. *Research Design and Data Collection*

An applied, descriptive-diagnostic, non-experimental industrial case study was carried out during an OJT assignment (15 May to 15 July 2026). In the Define phase a project charter and a SIPOC (Suppliers–Inputs–Process–Outputs–Customers) map of the line were prepared. In the Measure phase, quantitative data were drawn from plant records [13]: daily FTY tally sheets from the Shift A log books (2,385 parts over 24 working days of May 2026); the Firewall rework register covering all available shifts (46 rework events across 17 defect categories); direct stopwatch measurement of loading, welding and unloading times in all eight robotic cells (five observations per cell per phase); and a Poka-Yoke audit checklist completed with the maintenance team for 95 checkpoints. Qualitative data came from floor observation and discussions with operators and shift supervisors. Secondary material included monthly quality reports, gauge calibration records and IATF audit reports. All data were cross-checked against the W610 shop-floor records held by the Quality Supervisor. The Analyse, Improve and Control phases are reported in the following sections.

C. *Analytical Framework and Limitations*

Data were tabulated and analysed in Microsoft Excel using descriptive statistics, Pareto analysis, shift stratification, cycle-time comparison against the line average and p-chart interpretation. Wastes were classified with the TIMWOODS framework, and root causes were analysed with an Ishikawa diagram on the 4M basis. The study has limitations: detailed

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

FTY was available only for Shift A, with Shifts B and C represented by rework-event counts; FTY is recorded in parts whereas the rework register counts events, so the two datasets cannot be reconciled directly; only one month of data was analysed, which cannot capture seasonal or model-change effects; the SPC interpretation relies on binary pass/fail data rather than raw measurements; the Poka-Yoke audit reports no checkpoints for Robotic Cell 4; CoPQ rests on assumed labour and capacity rates; and, as the author's role was advisory, implementation decisions rest with plant management.

IV. DATA ANALYSIS AND DISCUSSION

Document the Production Process Through SIPOC Mapping

TABLE I.
ROCESS MAP OF CCB ASSEMBLY LINE W610 AND POKA-YOKE AUDIT COVERAGE

Process Segment	Cells / Stations	Output	PY Points Audited
Sub-assembly	Tunnel Bkt, IP Bkt, End Bkts	CCB sub-assembly	Not itemised
Robotic Welding Cell 1	R1-A, R1-B	Welded CCB frame	43
Robotic Welding Cell 2	R2-A, R2-B	Intermediate assembly	24
Robotic Welding Cell 3	R3-A, R3-B	Welded assembly	26
Robotic Welding Cell 4	R4-A, R4-B	Complete CCB	Not reported
AutoGauge and Firewall Rework	AutoGauge; Firewall station	OK / rework-tagged CCB	2 (AutoGauge)

Table 1 summarises the SIPOC map of Line W610. Steel, fastener, coated and in-house stamped inputs feed a sub-assembly stage (Tunnel Bracket, IP Bracket and End Brackets), after which the CCB passes through four robotic welding stations, each with an A and a B cell, before AutoGauge inspection and the Firewall rework station, where parts are tagged OK or for rework. The finished CCB is supplied to Maruti Suzuki platforms. The Firewall register is therefore the single point at which defects are recorded by category, which is why it underpins the Pareto and shift analyses below. The audited Poka-Yoke checkpoints total 95 (43 + 24 + 26 + 2), and the audit does not itemise checkpoints for Robotic Cell 4, a coverage gap that should be closed in the next audit.

Establish the Baseline First Time Yield

TABLE II.
ASELINE QUALITY PERFORMANCE OF SHIFT A, MAY 2026

Metric	Value
Working days observed	24
Parts inspected	2,385
Parts OK first time	926
Parts not OK	1,459
Pooled FTY (926 ÷ 2,385)*	38.83%
Mean of daily FTY*	36.77%
Not-OK rate P	61.17%
Best daily FTY	83.33% (09 May)
Worst daily FTY	3.75% (23 May)
Days meeting target	0 of 24
Target FTY	≥ 95%

*The OJT working report states a headline FTY of 28.47%. Recomputation from the daily totals gives 38.83% (pooled) and 36.77% (mean of daily values); the recomputed figures are used here pending reconciliation with plant records.

FTY Before and After the 21 May Gauge Calibration Failure

Parameter	02–19 May	21–31 May
Working days	13	11
Parts inspected	1,464	921
Parts OK	793	133
Parts not OK	671	788
Average parts per day	~113	~84
Pooled FTY	**54.17%**	**14.44%**
Lowest daily FTY	34.72%	3.75%
Highest daily FTY	83.33%	35.00%

Tables 2 and 3 show that FTY is the primary quality gap. Of 24 working days, none reached the 95% target, and the best day (83.33% on 9 May) still fell short. Splitting the series at 21 May shows a sharp structural break: pooled FTY fell from 54.17% to 14.44%, a drop of 39.7 percentage points, while average daily inspection volume fell by about 26%. Interpreting the series as a p-chart on the not-OK fraction, with a pooled centre line of 0.612 and day-specific three-sigma limits (recomputed for this paper from the daily data), 17 of 24 days fall outside the limits: the seven days below the lower limit all precede 21 May, and 10 of the 11 days from 21 May exceed the upper limit, with 27 May the only exception. This pattern is a classic special-cause signal, consistent with the plant's finding that a gauge calibration failure was responsible, and the appropriate response was gauge withdrawal and recalibration rather than process overhaul. However, FTY before the failure was still 54.17%, about 41 points below target, so the gauge failure aggravated an already chronic problem rather than creating it.

Prioritise Defects Using Pareto Analysis

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ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

Pareto Analysis of Firewall Rework Events (46 Events, 17 Categories)

Rank	Defect Type	Events	Share	Cum. %
1	BIW M8 Nut Weld Shift / Missing	9	19.57%	19.57%
2	Tunnel Bkt Welding Shift / Mismatch	7	15.22%	34.78%
3	IP Bkt Broken / Shift	5	10.87%	45.65%
4	Channel Support Defects	5	10.87%	56.52%
5	HVAC Weld Shift	3	6.52%	63.04%
6	End Bkt Locater Pin Weld Miss	3	6.52%	69.57%
7	Fuse Box Welding Shift	2	4.35%	73.91%
8	Steering M8 Nut Missing	2	4.35%	78.26%
9–17	Other 9 defect types	10	21.74%	100.00%
	Total	**46**	**100%**	—

Table 4 confirms a concentrated defect profile. The top four categories (BIW M8 Nut Weld Shift/Missing, Tunnel Bracket Welding Shift/Mismatch, IP Bracket Broken/Shift and Channel Support Defects) account for 56.52% of the 46 rework events, and the top eight account for 78.26%, which supports a vital-few strategy in which resources are directed first at the leading categories. Notably, six of the eight leading categories (BIW M8 nut, Tunnel Bracket, HVAC, End Bracket locator pin, Fuse Box and Steering M8 nut) describe weld-position, missing-weld or missing-nut defects, totalling 26 events (56.5%). These are the failure modes that the line's Poka-Yoke sensors are meant to detect, which suggests, although the data do not prove, a link between non-functional sensors and the defects that escape to the Firewall station.

Stratify Rework by Shift

Shift-wise Rework Stratification

Shift	Rework Events	Share	Data Available
Shift A	7	15.2%	Daily FTY tally (2,385 parts)
Shift B	26	56.5%	Rework count only
Shift C	13	28.3%	Rework count only
Total	**46**	**100%**	—

Table 5 identifies Shift B as the largest contributor, with 26 of 46 rework events (56.5%), which is 3.7 times the count of Shift A and twice that of Shift C. An equal split across three shifts would be about 33%. The shift-level pattern is consistent with the fishbone finding that Shift B suffers absenteeism and replacement by less-trained operators. Two cautions apply: the counts are not normalised by shift output, so part of Shift B's share could reflect volume, and Shift A holds the only FTY series, so a full shift-wise FTY comparison remains outstanding.

Identify the Cycle-Time Bottleneck

Robotic Cell Cycle-Time Study (Seconds, Stopwatch Observations)

Cell	Load	Weld	Unload	Total	vs Average
R1-A	78	82	16	176	+2 s
R1-B	80	79	29	188	+14 s
R2-A	66	102	17	185	+11 s
R2-B	61	98	10	169	−5 s
R3-A	**52**	**117**	**24**	**193**	**+19 s**
R3-B	71	76	16	163	−11 s
R4-A	52	112	11	175	+1 s
R4-B	74	56	16	146	−28 s
Average	**67**	**90**	**17**	**174**	**Baseline**

Table 6 shows that R3-A is the bottleneck at 193 seconds, 19 seconds (about 11%) above the 174-second line average and 47 seconds slower than the fastest cell, R4-B (146 seconds). The phase breakdown locates the cause: R3-A's welding phase of 117 seconds is 27 seconds above the 90-second average, whereas its loading time of 52 seconds is among the shortest. The delay is therefore in the weld programme and robot motion rather than in material handling, which supports reviewing the weld programme and loading/unloading balance before adding capacity. R1-B (188 s, rated High) and R2-A (185 s, rated High) form a second tier, and the 29-second unloading time of R1-B is well above the 17-second average. The project estimated the resulting lost capacity at about ₹1.85 lakh per month.

Audit Poka-Yoke Error-Proofing Health

Poka-Yoke Audit Summary by Station

Station	Total	OK	Failed	N/A	Compliance
Robotic Cell 1	43	31	1	11	96.9%
Robotic Cell 2	24	11	5	8	68.8%
Robotic Cell 3	26	10	2	14	83.3%
AutoGauge Station	2	2	0	0	100.0%
Total W610	**95**	**54**	**8**	**33**	**87.1%**

OK = functional; Failed = not working. Compliance = OK ÷ (OK + Failed); N/A checkpoints are excluded.

Table 7 shows overall Poka-Yoke compliance of 87.1%, with 8 of 62 applicable checkpoints non-functional (overall risk rated Medium in the audit). Robotic Cell 2 is the weakest station and the only one rated High risk: it holds 5 of the 8 failures (62.5%), and 31% of its applicable checkpoints are not working, giving the lowest compliance (68.8%). Each non-functional sensor is a point at which a defect can pass undetected, and the line has no PLC-level interlock to stop operation when error-proofing is unavailable. A further observation is that 33 of 95 checkpoints

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

(34.7%) were marked N/A, including 14 of 26 in Robotic Cell 3, and that Cell 4 is absent from the audit; these classifications should be validated so that unavailable error-proofing is not hidden inside the N/A category.

Classify Wastes Using the TIMWOODS Framework

TIMWOODS Waste Classification and Shop-Floor Evidence

Waste	Observed Manifestation	Plant Evidence (May 2026)	Process Location
Defects	Parts failing first-time inspection and requiring rework	1,459 of 2,385 parts not OK; 46 rework events	AutoGauge; Firewall rework station
Waiting	Downstream idle time behind the slowest cell	R3-A at 193 s against a 174 s average	Robotic Cell 3 (R3-A)
Over-processing	Re-inspection, repeat rework and gauge re-testing	1,459 parts re-inspected at 15 min each; ~100 parts a day re-tested for 10 days after 21 May	Firewall station; AutoGauge
Skills under-utilisation	Untrained operators at critical stations; less-trained replacements	Shift B: 26 of 46 rework events (56.5%)	Critical welding and assembly stations
Others	Transport, Inventory, Motion and Over-production not assessed	No data collected	—

Table 8 shows that Defects and Waiting dominate the observed waste on Line W610, with Over-processing as a direct consequence of rework and re-inspection. The re-inspection and gauge re-testing figures are assumptions used in the CoPQ estimate rather than measured values. Transport, Inventory, Motion and Over-production were outside the data collected, so no conclusion is drawn on them.

Diagnose Root Causes Using Cause-and-Effect Analysis

Cause-and-Effect Matrix (4M Framework) for Recurring Defects PART-1

4M	Root-Cause Analysis	
	Root Cause Identified	Supporting Evidence
Man	Untrained operators at critical stations	Shift B: 26 of 46 rework events (56.5%)
Man	Shift B absenteeism and replacement by less-trained operators	Shift B share against a 33% equal-load benchmark
Machine	Eight non-functional Poka-Yoke sensors, concentrated in Robotic Cell 2	87.1% compliance; Cell 2 at 68.8%
Machine	R3-A weld cycle exceeds the line average	193 s against 174 s; welding 117 s against 90 s
Machine	No PLC-level interlock for critical Poka-Yoke sensors	Noted during the audit
Method	Gauge inspection not consistently mandatory; gauge calibration failure	Pooled FTY 54.17% to 14.44% from 21 May
Method	Pre-shift fixture checkpoints not documented	Weld-position defects in six of the top eight categories
Material	BIW bracket variation beyond stated tolerance	Related category: BIW M8 nut weld shift / missing (9 events)
Material	Tunnel Bracket supplier change and qualification activity	Tunnel Bkt welding shift / mismatch (7 events)

Cause-and-Effect Matrix (4M Framework) for Recurring Defects PART-2

4M	Root-Cause Analysis	
	Operational Impact	Recommended Countermeasure
Man	Defects escape at critical stations	Shift B supervisor training and standard-work audit (Action 5)
Man	Capability gaps during absenteeism	Multi-skilling programme and absenteeism buffer plan (Action 8)
Machine	Defects can pass undetected	Restore all eight sensors; recommission PY at BIW M8 nut station (Actions 1, 3)
Machine	Bottleneck and lost capacity	Weld programme optimisation at R3-A (Action 6)
Machine	Operation continues without error-proofing	PLC interlock for critical sensors (Action 1)
Method	Special-cause FTY collapse and re-testing	Gauge SOP and pre-shift checklist (Action 2, completed)
Method	Undetected fixture drift	Fixture check at Tunnel Bracket station; daily FTY dashboard (Actions 4, 7)
Material	Weld-position and nut defects	Weld audit at BIW M8 nut station (Action 3)
Material	Mismatch rework	Incoming Tunnel Bracket supplier qualification (Action 9)

Table 9 (Parts 1 and 2) points to four interconnected root causes: unreliable error-proofing, weak gauge-calibration discipline, a slow weld programme at R3-A, and capability gaps

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

concentrated in Shift B. The causes are mutually reinforcing: a non-functional sensor removes the defect-detection barrier, an uncalibrated gauge removes the inspection barrier, and untrained replacement operators increase the rate at which defects are created. The material causes, bracket variation and a supplier change, are supported by observation but not yet by incoming-inspection data.

Estimate the Cost of Poor Quality
Estimated Monthly Cost of Poor Quality

CoPQ Category	Basis	Cost (₹)	Share
Internal rework labour	46 events × 2.5 h × ₹150/h × 26 days	4,49,500*	51.2%
Re-inspection	1,459 parts × 15 min × ₹120/h	43,770	5.0%
Lost capacity (R3-A)	19 s/unit × 2,385 units × capacity rate	1,85,000	21.1%
Gauge failure impact (post 21 May)	10 days × ~100 parts re-tested × ₹200	2,00,000	22.8%
Total	—	**8,78,270**	**100%**

*As stated in the OJT report; the printed formula evaluates to ₹4,48,500 (total ₹8,77,270). The basis multiplies the 46 recorded events by 26 days; if the 46 events are a monthly rather than a daily count, this category would be substantially lower. Labour and capacity rates are assumed, so the figures should be validated against ERP data.

Table 11 puts the estimated CoPQ at about ₹8.78 lakh per month. Internal rework labour is the largest component (about 51%), and the single gauge-calibration failure accounts for a further 22.8%, showing that one special cause can cost almost as much as the lost capacity at the bottleneck and the re-inspection effort combined. Because the estimate rests on assumed rates and an unverified event basis, it is a decision-support figure rather than an audited financial value.

Develop the DMAIC Corrective Action Plan
Corrective and Preventive Action Plan PART-1

Corrective Action	Root Cause	Priority
1. Restore 8 non-functional PY sensors; add PLC interlock	Machine	High
2. Gauge SOP and pre-shift gauge inspection checklist	Method	High
3. Weld audit and PY recommissioning at BIW M8 nut station	Machine	High
4. Fixture check at Tunnel Bracket station	Machine	High
5. Shift B supervisor training and standard-work audit	Man	High
6. Optimise R3-A weld programme (bottleneck)	Machine	Medium
7. Daily FTY dashboard as mandatory Shift A KPI	Method	High
8. Multi-skilling programme and absenteeism buffer plan	Man	Medium
9. Incoming Tunnel Bracket supplier qualification	Material	Medium
10. Rework-threshold alert system (real-time containment)	Method	Low

Corrective and Preventive Action Plan PART-2

Action	Owner	Target	Status
1. PY sensors and PLC interlock	QA Manager + Maintenance	Jun-26	In Progress
2. Gauge SOP and checklist	QA Supervisor	Jun-26	Completed
3. BIW M8 nut weld audit	Production Engineer	Jul-26	Open
4. Tunnel Bracket fixture check	QA Supervisor	Jul-26	Open
5. Shift B training	QA Manager	Jul-26	Open
6. R3-A weld programme	Process Engineer	Aug-26	Planned
7. Daily FTY dashboard	QA Manager	Ongoing	In Progress
8. Multi-skilling programme	HR + Production Manager	Aug-26	Planned
9. Tunnel Bracket supplier	SQA Engineer	Sep-26	Planned
10. Rework alert system	QA Manager	Oct-26	Planned

Status as recorded in the OJT working report; to be updated against current plant records.

Projected Improvement Targets (Proposals, Not Achieved Results)

Metric	Current (May 2026)	6-Month Target	12-Month Target
First Time Yield (pooled)	38.83%	60–65%	80–85%
Monthly rework events	46	< 20	< 10
PY sensor compliance	87.1%	100%	100% + PLC interlock
R3-A cycle time	193 s	≤ 180 s	≤ 174 s
Monthly CoPQ saving	—	≈ ₹4–5 lakh	≈ ₹7–8 lakh
Shift B rework share	56.5%	< 40%	< 33%

Tables 12 to 14 outline a low-capital improvement roadmap arranged by priority. The high-priority actions address the defect-detection and inspection barriers first: sensor restoration with an interlock, the gauge SOP and the weld audit at the BIW M8 nut station, which together target the leading Pareto

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

category and the special cause behind the late-May collapse. Of the ten actions, only the gauge SOP and pre-shift checklist are recorded as completed. Sustaining control rests on a daily FTY dashboard, a Poka-Yoke audit checklist, weekly R3-A cycle-time review, a daily rework register and scheduled gauge calibration, each with a named owner and reaction plan. The targets in Table 14 are proposals; actual benefits must be verified through post-implementation baselines and sustained control-chart evidence.

V. FINDINGS, CONCLUSIONS AND SUGGESTIONS

A. Findings

The investigation of CCB Assembly Line W610 at Belrise Industries produced the following findings. Of 2,385 parts inspected over 24 working days of May 2026, 926 passed first time and 1,459 were not OK, giving a pooled FTY of 38.83% against a target of at least 95%; no day met the target. FTY fell from 54.17% (13 days to 19 May) to 14.44% (11 days from 21 May), a special-cause pattern attributed to a gauge calibration failure, although pre-failure FTY was itself about 41 points below target. Four of 17 defect categories accounted for 56.52% of the 46 rework events, led by BIW M8 Nut Weld Shift/Missing (9 events) and Tunnel Bracket Welding Shift/Mismatch (7 events), and six of the eight leading categories were weld-position or missing-nut defects. Shift B contributed 26 events (56.5%). The Poka-Yoke audit found 87.1% compliance, with 8 of 62 applicable checkpoints non-functional, 5 of them in Robotic Cell 2 (68.8%), and 33 of 95 checkpoints classified as N/A. Robotic cell R3-A was the bottleneck at 193 seconds against a 174-second average, driven by a 117-second welding phase. Estimated CoPQ was approximately ₹8.78 lakh per month, subject to validation. Of ten corrective actions, the gauge SOP and pre-shift checklist were completed during the OJT.

B. Conclusions

This study achieved its stated objectives. A quantified baseline, a Pareto-based defect hierarchy, a shift stratification, a cycle-time study, a Poka-Yoke audit, a 4M root-cause analysis and a CoPQ estimate together give a coherent picture of quality and productivity losses on Line W610. The analysis indicates that performance is constrained less by one dominant defect than by the reliability of the barriers that should prevent and detect defects: error-proofing sensors, gauge calibration, standard work and operator capability, together with a slow weld programme at R3-A. A single calibration failure proved as damaging as chronic process problems, which makes calibration control a critical special-cause response. By restoring and interlocking error-proofing, enforcing gauge discipline, retraining Shift B, optimising the R3-A weld programme and tracking FTY daily, the plant can reduce rework, recover capacity and build a foundation for sustained improvement. The conclusions are those of an applied OJT diagnostic study rather than a validated long-term Six Sigma implementation, and any post-OJT improvement claim should be supported by fresh production data and control-chart evidence.

C. Suggestions

To achieve tangible improvement across all stakeholders, the plant should execute a phased, collaborative roadmap:

For Quality and Plant Management: Restore all eight non-functional Poka-Yoke sensors, add a PLC-level interlock for critical sensors, maintain the Gauge Inspection SOP and pre-shift checklist as a mandatory control, and deploy the daily FTY dashboard as a visual management KPI.

For Production Engineering and Maintenance: Audit the weld process and recommission Poka-Yoke at the BIW M8 nut station, introduce documented fixture checks at the Tunnel Bracket station, and optimise the R3-A weld programme and robot motion toward the line average.

For HR and Production Supervisors: Deliver targeted Shift B refresher training on the four leading defect categories using physical defect samples, and build a multi-skilling matrix with minimum qualified coverage at each critical station.

For Supplier Quality: Complete incoming-quality qualification of the new Tunnel Bracket supplier through the appropriate PPAP process, and verify bracket dimensions against tolerance.

D. Implications of the study

The implications of this study provide strategic and operational benefits across all primary stakeholders:

- Plant Management: Restoring error-proofing and stabilising FTY protects capacity that is otherwise consumed by rework, and supports the zero-defect expectations of OEM customers.
- Shop-Floor Operators: Standard work, a pre-shift gauge checklist and targeted training reduce dependence on individual experience and make the work easier for replacement personnel.
- Quality and Maintenance Teams: Register-level data, the Pareto hierarchy and the Poka-Yoke audit give a factual basis for prioritising repairs and tracking whether corrective actions reduce recurring defects.
- Other Lines and Plants: The audit and dashboard formats can be replicated on other CCB and structural-assembly lines once validated on W610.

E. Future Scope of the study

The baseline established in this research opens several avenues for future inquiry:
Extended Baseline and Shift-wise FTY: Collecting at least three months of FTY and dimensional data for all three shifts would permit stronger SPC and capability analysis and a full shift-wise comparison.
Measurement System Analysis: Gauge R&R studies for the critical gauges would quantify measurement-system contribution to the observed variation.
Validated Cost Model: Quantifying CoPQ from ERP and validated labour and capacity rates would replace the assumed rates used in this study and confirm the return on the proposed actions.
Post-Implementation Verification: Comparing FTY, rework events and Poka-Yoke compliance after implementation, with

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 12, UCBO - 2026

control-chart evidence, would test whether the projected targets are achievable and sustained.

ACKNOWLEDGMENT

I express my sincere gratitude to Prof. Shrirang Sajanapwar, School of Business, Indira University, for his valuable guidance and encouragement, and to the industry mentor and the Quality, Production Engineering and Maintenance teams at Belrise Industries Pvt. Ltd., Plant B-39, Chakan, Pune, for their operational inputs and support during the study of CCB Assembly Line W610. I am also thankful to all those who, directly or indirectly, helped in completing this research study.

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