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REDUCING THE DEFECT (*NOT GOOD*) RATE TO IMPROVE PRODUCTION EFFICIENCY USING DMAIC: A CASE STUDY OF AN AUTOMOTIVE SEAT COVER MANUFACTURER

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Abstract

This study addresses a persistent quality problem at PT SSC, a second-tier automotive seat cover manufacturer in Indonesia, where the defect ratebreferred to internally as the Not Good (NG) rate for embossed leather and PVC products remained above the internal 2% target during July–December 2025, causing excess material consumption and reduced profitability. The study aims to identify the main factors causing the NG rate to exceed the threshold and to formulate strategies that reduce it and enhance production efficiency using the DMAIC framework. Drawing on internal production records and semi-structured interviews, the data were analyzed through Pareto analysis, Statistical Process Control (U-Chart), Fishbone analysis, and the Borda Count. The results show that the sewing process is the dominant NG contributor (76% for leather and 67% for PVC) and is statistically out of control, with two prioritized root causes which are the absence of a structured preventive maintenance schedule and the absence of a standardized pre-OJT operator training program. Accordingly, the study proposes an implementation plan combining a Preventive Maintenance Program and a Structured Operator Training Program, reinforced by a real-time monitoring dashboard and a re-evaluation protocol. Grounded in the company's own data, the projection indicates that the average NG rate can approach the 2% target and profitability can recover to about 85% of the expected margin. The study contributes an evidence-based, implementation-ready improvement roadmap for a sewing-intensive automotive component context that remains underrepresented in the DMAIC literature.

Keywords: *Defect reduction, DMAIC, Production efficiency, Root cause analysis, Statistical process control*

1. INTRODUCTION

The Indonesian automotive industry is one of the largest and most strategic manufacturing sectors in the national economy, with domestic motorcycle sales reaching approximately 6.4 million units in 2025 (Dananjaya, 2026). Within this high volume, Original Equipment Manufacturers (OEMs) dominated market, second and third-tier component suppliers such as seat cover manufacturers operate on thin margins under stringent quality standards. At such volumes, even a small defect rate or marginal material overconsumption produces substantial absolute losses, making process quality control and output consistency decisive determinants of profitability and of meeting OEM requirements.

In automotive component manufacturing, strict Acceptable Quality Limit (AQL) requirements make defect control a critical priority, as persistent defects reflect process instability and reduced reliability. Defects are widely regarded as one of the most critical forms of waste, directly generating rework, scrap, and excessive material consumption without creating customer value (Arunagiri & Gnanavelbabu, 2014). For seat cover manufacturers, therefore minimizing defects is an absolute requirement for remaining competitive and for sustaining the long-term partnerships binding suppliers to OEMs (Talib et al., 2013).

To address such issues, structured quality improvement methodologies have been widely adopted. The Define, Measure, Analyze, Improve, Control (DMAIC) approach has repeatedly demonstrated measurable defect reduction, including a decrease in rejection rate from 5.5% to 3.08% (Mittal et al., 2023), as well as an improvement in a car parts supplier's sigma level from 3.4 to 4 when paired with fishbone, Pareto, and Statistical Process Control (SPC) analysis (Condé et al., 2023). However, although this body of research primarily focuses on apparel, textiles, or other automotive parts, its application to motorcycle seat cover production within the Indonesian supply chain remains limited. This gap matters because seat cover manufacturing is not equivalent to general garment sewing or to other automotive components, it combines dissimilar materials (embossed synthetic leather and PVC) within a single product, relies on a sewing-intensive process whose stitching quality is judged against strict visual and dimensional standards set by OEMs, and operates under acute material-cost pressure where even minor overconsumption erodes already thin supplier margins. Whereas defect-reduction studies in apparel sewing emphasize productivity and rework, these combined material, visual, and cost constraints make the seat cover context distinct and warrant dedicated investigation, which is the focus of this study (Lingkon et al., 2024).

This study examines a seat cover manufacturer company, a Japanese invested second-tier supplier producing embossed synthetic leather and PVC seat covers. During July–December 2025, the company consistently recorded a defect or Not Good (NG) rate above its internal 2% target, causing excessive material consumption, higher costs, and reduced profitability. This study therefore aims to identify the main factors causing the persistently above threshold NG rate through a DMAIC-based analysis, and formulate improvement strategies to reduce the NG rate and enhance production efficiency.

2. RESEARCH METHOD

This study applies a single case study design that integrates qualitative and quantitative data, structured around the DMAIC framework as the primary analytical approach (Daniyan et al., 2022). The study was conducted at PT SSC, a second-tier automotive seat cover manufacturer, using operational data from the July–December 2025 production period for its embossed synthetic leather and PVC product lines. Specifically, this study uses a concurrent mixed-method approach within a single case study. Quantitative data, including production output, NG records, and material cost data, were used to measure the scale, location, and stability of the NG problem. At the same time, qualitative data from direct observations and semi-structured interviews were collected to understand the operational factors behind the problem. Both types of data were gathered in parallel and integrated during the Analyze phase, where quantitative findings were interpreted alongside expert insights to identify and prioritize the root causes. This integration ensured that the conclusions were based on both statistical evidence and practical understanding rather than on a single source of data.

Two complementary types of data were collected. Quantitative data consisted of secondary records obtained from internal production reports, including NG counts, total production output, material consumption, and material cost performance. Qualitative data were gathered through direct observation and semi-structured interviews with key production stakeholders, included of the department head, section head, and sewing line leaders, to identify operational practices and potential causes of NG occurrence. In addition, a structured ranking questionnaire was administered to three production experts to support root cause prioritization based on their experience-based judgment.

The analysis followed the DMAIC stages. The Define stage established the problem scope by quantifying the gap between planned and actual production performance. In the Measure stage, the NG rate was computed for each product line and evaluated against the company's 2% quality threshold, using Equation (1):

$$NG\ Rate\ (\%) = \left(\frac{Total\ NG\ Units}{Total\ Production\ Output}\right) x\ 100\% \tag{1}$$

Pareto analysis was then applied across the cutting, check panel, and sewing processes to identify the dominant contributor to NG following the 80/20 principle (Voehl et al., 2014). Process stability was assessed using a U-Chart control, selected because the NG data represent count-based defects with variable output across months (Mahesh & Prabhuswamy, 2010; Montgomery, 2009). The center line and control limits were obtained using Equations (2) and (3):

$$CL = \frac{Total\ NG\ Products}{Total\ Units\ Products} \tag{2}$$

$$UCL = \bar{u} + 3\sqrt{\frac{\bar{u}}{n}}, LCL = \bar{u} - 3\sqrt{\frac{\bar{u}}{n}} \tag{3}$$

where n is the number of units inspected in each period.

In the Analyze stage, a Fishbone diagram organized the potential causes across the Man, Machine, Method, Material, Measurement, and Environment (5M+1E) categories, drawing on the interview findings. The identified causes were then prioritized using the Borda Count method (Gharbi et al., 2025), in which each of the three experts ranked the causes and points were assigned using Equation (4):

$$Borda\ Point\ (BP) = n - r + 1 \tag{iv}$$

where n is the total number of causes evaluated and r is the assigned rank.

The total Borda score was obtained by summing the points across all respondents, with higher totals indicating stronger collective agreement. The Improve and Control stages translated the prioritized causes into improvement strategies and a monitoring mechanism, the outcomes of which are presented in the following section.

3. RESULTS AND DISCUSSION

3.1 Dominant NG Contributor and Process Stability

Pareto analysis of the average NG distribution across the cutting, check panel, and sewing processes during July–December 2025 identified the sewing process as the dominant contributor for both product lines. For leather, sewing accounted for 76% of total NG (464 units), followed by check panel at 21% and cutting at 3%. A consistent pattern appeared for PVC, where sewing contributed 67% (559 units), check panel 30%, and cutting 3%. In line with the 80/20 principle, this concentration confirms that the sewing process is the priority area for further investigation.

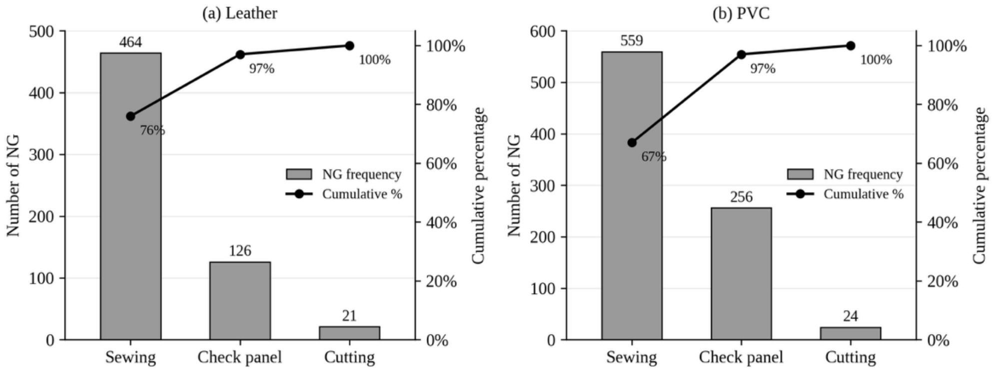

Figure 1. Pareto Analysis of NG (a) Leather Material and (b) PVC Material

Process stability was then assessed using a U-control chart. The control parameters derived from the defect data are summarized in Table 1.

Table 1. U-Chart Control Parameters for Leather and PVC Products

Parameter	Leather	PVC
U-Bar (process average)	9%	8%
Upper Control Limit (UCL)	12%	11%
Lower Control Limit (LCL)	6%	6%

For leather, the NG-per-unit rate peaked at 14% in July, exceeding the UCL and signaling an out-of-control condition, before declining through the period to 5% in December, which fell below the LCL. PVC followed the same trajectory, peaking at 13% in July and dropping to 4% in December. Both lines also touched the UCL again in October (12% and 11% respectively), indicating recurring instability. Because both materials behave almost identically under the same sewing conditions, the instability appears to be process-related rather than material-specific.

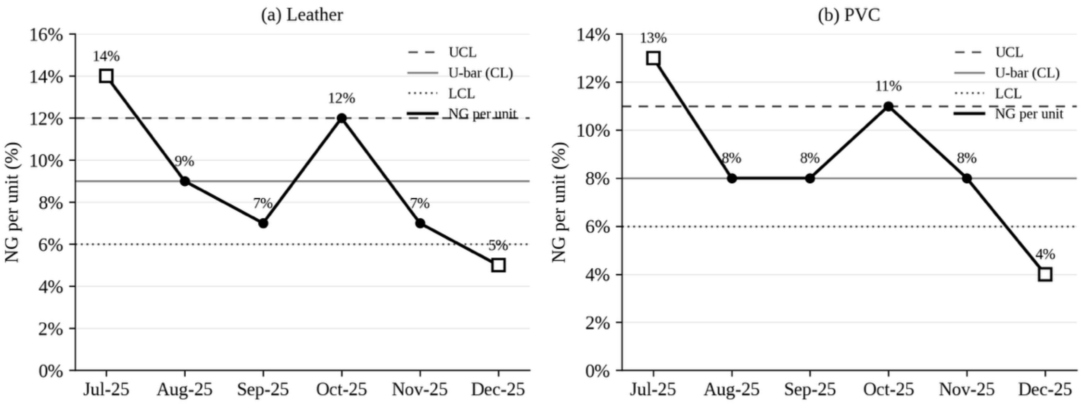

Figure 2. U-Chart for NG (a) Leather Products and (b) PVC Products

Two observations warrant emphasis. First, the recurring July and October spikes confirm the presence of special-cause variation requiring structured intervention. Second, although the rate trends downward and ends below the LCL, points beyond either limit still represent an out-of-control process; the late-period decline is therefore not yet evidence of a stable, capable process, and without structured corrective action it may be difficult to sustain.

3.2 Root Cause Analysis and Prioritization

A cause-and-effect using Fishbone analysis, built from the semi-structured interviews, identified eight potential root causes of sewing NG across the spanning machine condition, operator competency and workload, work-instruction compliance, NG recording practices, material characteristics, and workstation layout. Material type was excluded as a primary cause, since practitioners reported no meaningful difference between leather and PVC in sewing difficulty or handling. These causes were then prioritized through the Borda Count in Table 2.

Table 2. Total Borda Score and Final Ranking of Root Causes

Code	Root Cause	Category	Total BP	Rank
RC2	No preventive maintenance schedule (reactive maintenance only)	Machine	**22**	**1**
RC4	No standardized operator training program before OJT	Man	**22**	**1**
RC1	Uncertainty in repair time due to spare-part shortage	Machine	20	2
RC7	No guidebook for NG detailed classification and recording	Measurement	17	3
RC3	Workload imbalance among operators	Man	16	4
RC5	Low operator compliance with work instructions (IK)	Man	13	5
RC8	Long distances between sewing workstations with obstacles	Environment	12	6

Code	Root Cause	Category	Total BP	Rank
RC6	Several work instruction (IK) documents not yet updated	Method	10	7

These two dominant causes are mutually reinforcing the progressive machine wear under reactive maintenance produces the periodic out-of-control spikes, while inconsistent operator competency sustains an elevated baseline between those spikes. This finding is consistent with prior DMAIC studies in sewing-intensive manufacturing, which similarly trace elevated defect rates to maintenance and operator-skill factors (Mojumder & Saad, 2025).

3.3 Improvement Strategies and Projected Impact

The two dominant causes were translated into two targeted improvement strategies. First, a Preventive Maintenance Program that addressing in RC2, replaces the reactive culture with a scheduled regime of daily, weekly, monthly, and quarterly maintenance activities, a per-machine checklist, a designated maintenance Person-In-Charge (PIC), and a buffer stock of critical spare parts. Second, a Structured Operator Training Program that addressing in RC4, replaces informal OJT only onboarding with a competency-based framework comprising competency mapping, a pre-OJT training module, a certification assessment required before independent line assignment, and periodic reassessment. Both are reinforced by a Control mechanism: a real-time NG monitoring dashboard, implementable on accessible tools such as spreadsheets linked to a QR-code entry form, coupled with a closed-loop re-evaluation protocol activated whenever the NG rate remains above 2%.

To estimate the financial implication, NG reduction factors of 61.5% and 61% are drawn from a comparable DMAIC application in garment manufacturing were applied sequentially to the historical monthly data (Mojumder & Saad, 2025). Under this projection, the NG rate falls from the 6–17% baseline range toward the 2% target, material cost gradually realigns with the planned budget, and average profitability recovers to approximately 85% of the expected margin once a steady state is reached from March 2026.

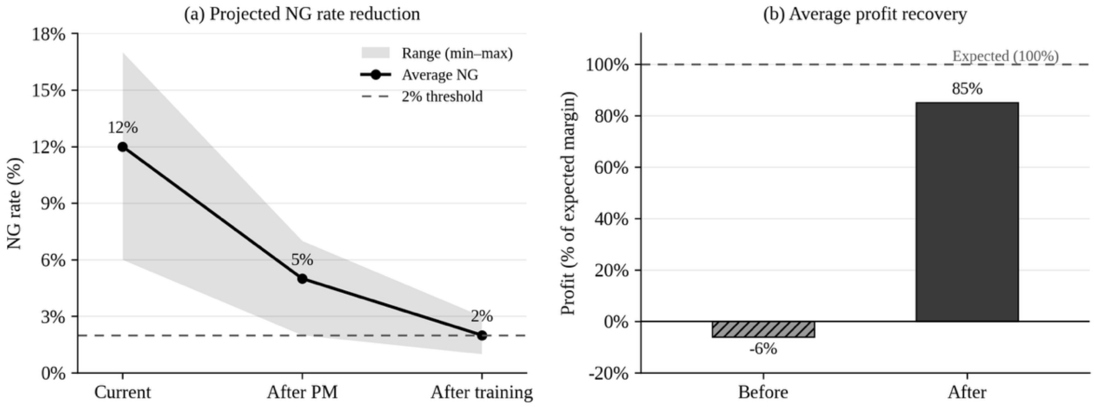

Figure 3. Projected NG rate reduction and average profit recovery after the proposed solutions

These results are presented as projections, consistent with the scope of this study, whose objective was to produce an evidence-based, implementation-ready improvement plan rather than to measure post-implementation outcomes. The projection is grounded in empirical data throughout the baseline NG performance, the dominant process, and the prioritized root causes were all derived from PT SSC's own production records and expert assessment, and the expected reduction draws on reduction factors reported for an analogous sewing-intensive manufacturing context (Mojumder & Saad, 2025). The close similarity in process characteristics makes these factors a reasonable basis for estimation, while the staged roadmap and control mechanism provide a concrete pathway for realizing them. The study therefore delivers a validated diagnosis and a structured, prioritized intervention whose projected impact offers PT SSC a defensible basis for implementation, with actual magnitudes to be confirmed through the monitoring system established in the Control stage.

DISCUSSION

The Sewin hjkbbpg Process as the Dominant Defect Source

The finding that sewing accounts for the majority of NG in both product lines (76% for leather and 67% for PVC) is consistent with prior DMAIC and lean studies in sewing-intensive manufacturing, where stitching operations are repeatedly identified as the principal locus of defects (Lingkon et al., 2024; Mojumder & Saad, 2025). It also reflects the broader view that defects are a primary form of waste, generating rework and material loss without adding customer value and concentrating NG in a single downstream process indicates that improvement effort is most efficiently directed there rather than dispersed across all stages. (Arunagiri & Gnanavelbabu, 2014). The near-identical behaviour of leather and PVC under the same sewing conditions further supports a process-centred rather than material-centred interpretation, distinguishing this case from material-driven defect studies and reinforcing the relevance of the DMAIC focus on process control.

Maintenance and Operator Competency as Mutually Reinforcing Causes

The two highest-ranked root causes are the absence of preventive maintenance and of a standardized pre-OJT training program that correspond to the Machine and Man categories of the 5M+1E framework and mirror the causal patterns reported in comparable case studies, where unscheduled maintenance and skill variation drive recurrent process instability (Condé et al., 2023; Mojumder & Saad, 2025). The U-Chart evidence adds a temporal dimension to this comparison, the recurring July and October excursions beyond the upper control limit are characteristic of special-cause variation in the statistical process control literature (Montgomery, 2009). Their coincidence with reactive maintenance supports the interpretation that progressive machine degradation, rather than random noise, produces the out-of-control signals. The interaction effect periodic machine-driven spikes superimposed on a competency-driven baseline is consistent with earlier observations that single-factor interventions tend to underperform relative to combined technical-and-human corrective programs, which is why the two strategies proposed here are designed to operate together rather than in isolation (Mittal et al., 2023).

Theoretical and Practical Contribution

Relative to existing DMAIC applications, which concentrate on apparel, textiles, or general automotive parts, this study extends the method to embossed-leather and PVC seat cover production, a sewing-intensive automotive component context that combines dissimilar materials, strict OEM visual standards, and acute material-cost pressure. The contribution is therefore contextual as much as methodological, it demonstrates that the established DMAIC toolset (Pareto, U-Chart, Fishbone, and Borda Count) transfers to this setting, while showing that root-cause prioritization must accommodate the dual material and cost constraints specific to it. Practically, the prioritized, evidence-based roadmap offers second-tier suppliers a transferable template for converting diagnostic findings into a staged improvement and monitoring plan, rather than a one-off corrective action.

4. CONCLUSION

This study aimed to identify the factors contributing to the persistently high NG rate at PT SSC and to develop improvement strategies to reduce defects and improve production efficiency. The findings showed that the sewing process was the main source of NG in both leather and PVC products, accounting for 76% and 67% of defects, respectively. SPC analysis also indicated that the process was statistically out of control, suggesting the presence of special-cause variation.

The analysis identified two key root causes which are the absence of a structured preventive maintenance schedule and the lack of a standardized operator training program. To address these issues, this study proposed a Preventive Maintenance Program and a Structured Operator Training Program, supported by a real-time monitoring dashboard and a re-evaluation protocol.

The proposed improvements are projected to reduce the NG rate to approximately 2% and improve profitability to around 85% of the expected margin. However, these results are based on projections, and the single-case design limits broader generalization. Future research should evaluate the actual implementation outcomes, explore additional root causes, and assess the long-term financial impact of the proposed improvements.

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