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Development of Defect Performance Analysis and Dashboard to Automotive Inward Quality Inspection Supplier

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Abstract *- In this study, the inward quality inspection framework and supplier quality management system of Belrise Industries Ltd., Chakan are investigated in order to find out the operational bottlenecks and to reduce non-conformities in incoming parts by the company in the automotive industry. The study is based on the operational challenge of avoiding the inclusion of defective parts in assembly lines, which is rooted in Total Quality Management (TQM), Crosby's Zero Defects philosophy, the Pareto Principle, and the Acceptance Sampling theory (ISO 2859). The aim was to assess the current inward inspection system, review supplier defects, determine if certain defects are common across different suppliers and develop an interactive, data-driven decision support tool. Over a period of three months (13 April – 13 July 2026), a combined descriptive and analytical research methodology was employed which included a scope of 17 suppliers, 137 part-number records and 246 inspected parts for the M110 and W610 vehicle platforms. The primary data collected from the field by observing the receiving workflows and inspection procedures was supplemented by company quality records and then processed, cleaned and analyzed in Microsoft Excel.*

The empirical study showed that 13.01% (32 defects) were found overall. The most common inspection methods were standard sampling (69.85%), Direct Online status (18.38%) and 100% inspection (11.77%). A significant discovery was that a small number of critical vendors had a large percentage of defects—five key vendors accounted for 84.38% (27 defects) of all non-conformities, with Vision Tools at the top with 21.88%. (18.75%), and V K Tools (18.75%). Tooling and dimensional control were identified as key failure modes by the Pareto analysis with the "Hole Under Size" (21.88%), "Manually Bend" (12.50%) and "100% Burr Present" (12.50%) representing almost half of the defect occurrences. Defects were similar across models (17 in M110 and 15 in W610), demonstrating that non-conformities are vendor process-focused and not platform-specific. The study concludes that the successful shift from a receiving inspection approach to a dynamic monitoring approach based on a supplier quality Excel dashboard is a critical part of Quality Assurance. Key practices recommended are supplier risk-based dynamic levels of inspection, supplier-specific Supplier Corrective Action Requests (SCAR) for tool maintenance and integration of dashboard metrics into executive sourcing review meetings.

The keywords used for this article are Inward Quality Inspection, Automotive Supplier Quality Management, Pareto Analysis, Defect Classification, Acceptance Sampling, Quality Control Dashboard, Tooling Non-Conformities, Automotive Component Quality, Risk Based Inspection, Process Capability.

I. INTRODUCTION:

The automotive industry is an intricate and interdependent manufacturing environment where the quality of the final product is critically dependent on the reliability, accuracy and performance of materials and components supplied from outside the system. The automotive Original Equipment Manufacturers (OEMs) and Tier-1 suppliers depend on a wide multi-tier supplier base for raw material, engineered parts and sub-assemblies. In this kind of environment, it is critical to keep the incoming material quality constant in order to ensure continuous manufacturing without any interruptions in production, reduce scrap and rework expenses, and avoid the spread of defects to the subsequent manufacturing processes. Sometimes referred to as Incoming Quality Control (IQC), Inward Quality Inspection is the first operational filter to ensure that the part received meets the strict engineering specification before it starts being produced. This function includes part identification, dimensional layout checks, visual checks, material property checks, and standard documentation. In addition to non-conformance detection, IQC produces vital operational data that reflects the broader supplier capabilities. These inspection records can be analysed systematically to identify defect patterns for each supplier, part number, material grade and failure mode and turn the raw inspection data into actionable business intelligence for Supplier Quality Management (SQM).

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There is growing emphasis in academic literature, and in industry practice, that physical inspection as a stand-alone solution is not sufficient to deal with systemic problems in supplier quality. Using only detection is a barrier to operation, while using inspection data to inform proactive and preventive measures is an opportunity to improve overall supply chain performance. This study investigates the inward quality operations of Belrise Industries Ltd. in Chakan, Pune to tackle this shift in defect detection to supplier development through data. The project is conducted as part of a 3-month operational internship and assesses the day-to-day incoming inspection activities including gauge verification, Pre-Dispatch Inspection (PDI) reporting, Standard Operating Procedure (SOP) compliance, and Initial Article Inspection, and incorporates these inspections into a centralized Supplier Defect Performance Dashboard. The study uses statistical quality control tools, such as Pareto analysis, supplier defect distribution and inspection method categorizations to transform a collection of individual inspection logs into unified performance indicators.
The last quarter is dedicated to literature review and theoretical background.

II. LITERATURE REVIEW:

Covaci, Țîțu, and Dragomir-Pânzaru (2026) suggest that incoming-inspection data should be connected to a supplier process control and predictive governance through a "Digital Quality Thread". The chapters 'A Study of the Quality Management Methods…' and 'An Investigation on Supplier Delivery Performance…' consider quality management practices in the automotive supply industry and the use of SPC in supplier monitoring. Ranking automotive suppliers using AHP is the subject of "Suppliers Re-evaluation…" and reduced inspection for automotive suppliers is the topic of "Developing a Skip-Lot Zero Defect Sampling Plan…". "Quality Control of Supplier Defects…" covers the analysis of defect categories, rejection trends, and 8D actions; "Application of SPC for the Assessment of Supplier Performance…" covers rejection and process capability; and "Beyond PPM…" explores the evaluation of supplier based on defect rate, risk and operational indicators. Optimizing Incoming Quality Control…" models inspection coverage and cost, and "Sustainability of Zero Contamination Defects…" reviews automated optical inspection and DPPM. "Statistical Monitoring of Supplier Performance…" discusses automotive quality-system monitoring, "Incoming Inspection Improvement…" presents supplier evaluation, and "Elimination of Incoming Inspection…" discusses supplier–manufacturer quality improvement. "Sampling Plan for Incoming Material Inspection at Sanden" is about how to make the sampling plan reliable in automotive, "Device and Method…" is about how to perform automatic part inspection and "Perancangan Dashboard Digital Quality Assurance…" is about how to design a digital QA dashboard. These include "Support Methodology…", "Dashboards…", "SPC-based Critical Parameters Monitoring…", and "Study of Practices…" all of which focus on aspects of visual and automotive quality reporting, as well as real-time vendor-part monitoring and a study of practices for logistics-dashboard adoption. Lastly, dashboard, defect, SPC, Pareto, and root-cause approaches are provided by "A Visually-Oriented Quality Improvement Data Management System," "Analysis of Selected Problems…," "Application of SPC in Automotive Manufacturing," "Quality Defects Analysis for Automotive Trim Parts," and "Leveraging Digital Dashboards…."

A. Theoretical Background:

Inward quality inspection and supplier quality management are based on the theoretical basis of the Total Quality Management (TQM) and Statistical Process Control (SPC). In contemporary automotive supply chain, inward quality control acts as the first line of defense to make sure that non-conforming parts do not enter into production lines, which is also in line with the concept of "Zero Defects" introduced by Philip Crosby. For Crosby, Quality is Conformance to Requirements, and in removing defects at the Receiving stage the Exponential Cost of Poor Quality from Downstream Line Stoppages, Rework and Warranty Claims are reduced. In parallel, Joseph Juran's Pareto Principle, the "80/20 rule", is an analytical tool used to assign non-conformances to a small number of "vital few" defect types and suppliers. In addition, Acceptance Sampling theory (as found in ISO 2859 / MIL-STD-105E standards) dictates the decisions for risk-based incoming inspections, weighing producer risk versus consumer risk in determining sampling plans versus 100% inspection or Direct Online (DOL) status. Continuous feedback loops are also necessary from the Plan-Do-Check-Act (PDCA) cycle advocated by W. Edwards Deming, which converts inward inspection data into actionable metrics, which are then used to conduct root cause analysis, supplier corrective action requests (SCAR), and continuous process improvement. Combined with state-of-the-art digital visualization tools, these theoretical models can help organizations move from being reactive in detecting defects to proactive in managing supplier performance based on data.

III. MATERIALS AND METHODS

A. Research Objectives

The study is of mixed type (descriptive and analytical) in order to assess the inward Quality inspection system of the Belrise Industries Ltd. Chakan. The study was carried out within a period of 3 months from 13 April 2026 to 13 July 2026. The target population included all incoming automotive components at the plant, specifically the M110 and W610 vehicles. A purposive sampling technique, a non-probability sampling technique, was used to select a defined scope of 17 suppliers, 246 parts supplied/inspected, 137 part-number records and 32 defects recorded.

Both primary and secondary data sources were used in the investigation. Primary data were collected by direct observation of receiving workflow, inspecting routines, quality checkpoints, and the use of measuring instruments on different levels of complexity of the components. Secondary data were obtained from company's quality records, inspection checklists, Standard Operating Procedures (SOPs), process control plans and pre dispatch inspection reports.
Data collected were cleaned, structured, and standardized in an Excel master data set to eliminate inconsistencies and duplicates. Quantitative data analysis was conducted to categorize the defects and group them by supplier, Pareto analysis was performed to identify critical non-conformities

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(causing the most issues), like undersized holes, manual bending and burrs. In the end, information was combined into an interactive KPI-driven dashboard in Excel, which enabled visualization of supplier performance, distribution of inspections and trends of their defects.

IV. DATA ANALYSIS AND DISCUSSION

The distribution of the Operational Baseline and Inward Inspection Methodology is shown in Table 1

TABLE 1: OPERATIONAL BASELINE AND INWARD INSPECTION METHODOLOGY DISTRIBUTION

Parameter Operational Metric				
	Scope / Sub-Category	*Record Count (**N**)*	*Distribution (%)*	*Operational Checkpoints & Focus*
Model Distribution	M110	69	50.36%	High feature density, complex length/hole checks
	W610	68	49.64%	Critical forming, slots, and bending verification

Table 1 data shows that sampling inspection is the main type of inspection for incoming inspection, with 69.85%, followed by 18.38% Direct Online and 11.77% 100% inspection depending on component criticality. A total of 137 part-number records and 246 inspected units have a defect rate of 13.01% (32 defects). M110 (50.36%) and W610 (49.64%) are spread evenly, with each one requiring different verification protocols because of the feature density, including hole diameters, slot positions and length dimensions. The direct impact of material grade diversity (MM21D, MM24 HSLA340, MS, STD and PLASTIC) on tool wear, gauge selection and inspection intensity are the primary factors to consider. Although the sampling method has provided an optimum throughput for routine parts, the 13.01% defect rate indicates a need to adapt the intensity of the inspection based on the supplier's capabilities and material characteristics.

The supplier quality performance and defect contribution analysis are shown in Table 2.

TABLE 2: SUPPLIER QUALITY PERFORMANCE AND DEFECT CONTRIBUTION ANALYSIS

Rank	Supplier Name	Total Defects	Share of Total Defects(N=32)	Parts Inspected	Defect Concentration / Performance Profile
1.	Vision Tools	7	21.88 %	High Volume	Primary defect contributor; requires process audit
2.	NextGen Engg.	6	18.75 %	Medium Volume	High defect concentration relative to supply volume
3.	V K Tools	6	18.75 %	Medium Volume	Frequent dimensional non-conformities
4.	Belrise Ranjangaon	4	12.50 %	High Volume	Internal inter-plant supply issues
5.	NexGen	4	12.50 %	Medium Volume	Forming and burr-related non-conformities
6.	Remaining 12 Suppliers	5	15.62 %	Varies	Minor/infrequent defect occurrences
Total	17 Suppliers	32	100.00%	246	Overall Defect Rate: 13.01%

The performance of suppliers is significantly different between the 17 suppliers assessed in the scope of the project. Incoming defects are mostly concentrated with five suppliers, accounting for 84.38% (27 out of 32) of all defects recorded. NextGen Engg. and V K Tools are the next highest single contributors with 6 defects each (18.75%) and Belrise Ranjangaon and NexGen with 4 defects each (12.50%). 15.62% of the defects came from the remaining 12 suppliers (4). When coupled with volume of supplies, the evaluation of defect volume will help to avoid the misjudgment of high volume suppliers. However, the high concentration of non-conformities from the top 5 vendors shows that targeted supplier audits, tool inspections and supplier development efforts targeted on these identified sources will provide immediate quality improvements.

TABLE 3: DEFECT FREQUENCY, PARETO CLASSIFICATION, AND MODEL BREAKDOWN

Defect Description /	Count	Individual Shar	Cumulative	Associated Mode	Root Cause Area /

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Category		e (%)	Share (%)	l (M110 / W610)	Quality Impact
Hole Under Size	7	21.88%	21.88%	M110 / W610	Punch wear, incorrect pin size, poor tool maintenance
Manually Bend	4	12.50 %	34.38%	W610	Secondary manual operation, bending gauge variation
100% Burr Present	4	12.50%	46.88%	M110 / W610	Dull piercing/trimming dies, improper clearance
Slot-Related Issues	3	9.38 %	56.26%	M110	Tooling misalignment, positioning error
Formation / Profile Defect	3	9.38 %	65.64%	W610	Press tonnage variation, material springback
Dimensional Out-of-Spec	3	9.38 %	75.02%	M110 / W610	Raw material thickness variation, gauge miscalibration
Other Non-Conformities	8	24.98 %	100.00%	M110 (17) / W610 (15)	Miscellaneous surface and visual defects
Total Recorded Defects	32	100.00%	-	**M110: 17	W610: 15**

Pareto analysis shows that there are a few major defects that cause quality non-conformities. The biggest defect category is "Hole Under Size", with a total of 7 (21.88%) defects. There are 4 occurrences of "Manually Bend" (12.50%) and 4 occurrences of "100% Burr Present" (12.50%). The three most common defect categories make up almost half (46.88%) of all defects observed. Model-wise distribution reveals that 17 defects are found in the M110 whereas there are 15 defects in the W610, indicating a balanced distribution of defects, meaning that the defects are not due to the specific design of the vehicle models but because of the manufacturing processes of their respective suppliers. The amount of hole undersizing and overburring is a direct indicator of tool wear and improper punch clearances along with insufficient vendor end gauge maintenance; these are definite areas of focus for corrective action.

V. FINDINGS, CONCLUSIONS AND SUGGESTIONS

A. Findings

This study has been carried out on the inward quality inspection system of Belrise Industries Ltd, Chakan on M110 and W610 models of vehicle by analysing 137 records of part number from 17 suppliers and 246 parts inspected while the overall inward defect rate is 13.01% (32 defect recorded). The results from the evaluation of sampling inspection methodologies identified that standard sampling inspection was the dominant methodology when it came to receiving control, 69.85% (95 records), followed by 100% inspection, 18.38% (25 records) and Direct Online (DOL) inspection at 11.77% (16 records). Supplier-wise Non-Conforming Items analysis found that a small number of suppliers had a high percentage of non-conforming items, with five suppliers accounting for 84.38% (27 Non Conforming Items) of all non-conforming items, namely Vision Tools (7 Non-Conforming Items, 21.88%), NextGen Engg. (6 Non-Conforming Items, 18.75%), V K Tools (6 Non-Conforming Items, 18.75%), Belrise Ranjangaon (4 Non-Conforming Items, 12.50%) and NexGen (4 Non-Conforming Items, 12.50%). The Pareto analysis of the non-conformances showed that dimensional and tooling-related errors were the most common causes of non-conformance, accounting for almost 50% of the total (46.88%), with "Hole Under Size" as the most frequent error type at 7 occurrences (21.88%). The defects were distributed fairly evenly between the vehicle platforms (17 in M110, 15 in W610), indicating that the platform design is not the primary cause of quality risks, but rather, is a result of manufacturing from the vendors and tool wear. Finally, a Supplier Quality & Inward Inspection Dashboard (SQID), an interactive Excel model, was developed to successfully combine all these metrics into one dynamic inspection management tool for risk-based inspection planning and targeted supplier corrective actions.

B. Conclusions

The study's results show that the incoming quality inspection system is an important preventive measure against compliance of the components supplied to Belrise Industries Ltd., Chakan, but it must move from a static inspection to a dynamic process with data driven supplier management. The overall incoming defect rate determined by analysis of receiving records was 13.01% of 246 parts examined, with most of the defects concentrated from a small number of vendors. In particular, five suppliers produce 84.38% of the total defects recorded – with Vision Tools, NextGen Engg. and V K Tools being the leading

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causes. Moreover, Pareto analysis shows that the main physical quality problems are not specific to any vehicle platform (such as the M110 or W610) but are mostly manufacturing and tooling related, and that the leading problems are undersized holes, manual bending deviations and too large burrs. Standard sampling inspection (69.85%) lack real-time supplier risk integration to prevent defects proactively. In the end, the interactive Excel-based Supplier Quality & Inward Inspection Dashboard provides the management with an analytical tool that enables them to enforce the correct inspection frequency based on risk assessment and to start targeted Supplier Corrective Action Requests (SCAR), avoid punch tool degradation at vendor sites, and improve incoming material quality continuously throughout the automotive supply chain.

C. Suggestions

The results give the following practical recommendations for key stakeholders to enhance inward quality and supplier performance:

For Belrise Quality & Production Teams: Establish an automatic inspection mechanism that raises high defect suppliers (such as suppliers Vision Tools, NextGen Engg.) from the normal inspection to temporary 100% inspection, and gives Direct Online (DOL) status to high-quality suppliers who always adhere to the quality standards to optimize inspection efficiency on the shop floor.

To External Suppliers & Vendor Development: Send targeted Supplier Corrective Action Requests (SCAR) for high frequency tooling problems, such as holes that are undersized and burrs are too large. Require preventive maintenance for piercing dies/punches and pre-dispatch gauge verification of dies/punches at vendor facilities before shipment.

Implement a Supplier Quality Dashboard in weeks review meetings and integrate the excel sheet into weekly review meetings to monitor the suppliers KPIs, to link the supplier quality rating with the purchase allocation in the coming weeks and to create joint quality improvement workshops with persistent low performing suppliers

D. Implications of the study:

D. Significant findings from this research for main stakeholders of the organization are:

Inward Quality Inspectors & Operational Teams: Offers a framework of structured, risk-based approach to move inspectors away from uniform sampling and towards dynamic checking, with the labour & gauge resources deployed where there is the greatest likelihood of a defect.

Suppliers & Component Manufacturers: Both establishes performance accountability and makes it transparent. Vendors have a clear view of their defects trends and are able to invest appropriately in preventing defects from tool maintenance issues (e.g., holes that are too small because of tool wear) and pre-dispatch quality control.

Plant Management & Executive Leadership: Provides a centralized real-time decision making dashboard for plant leadership, empowering them to allocate plant sourcing decisions with data, conduct objective supplier evaluations and minimize rework and line stoppage costs in the assembly line.

Vehicle Design & Assembly Stakeholders: Offers evidence that component quality issues brought in are not platform specific, thus allowing engineering teams to keep standardizing parts across multiple models without having to redesign parts for M110 and W610 lines.

E. Future Scope of the study

Further research needed

The scope of this study does not limit itself to the aforementioned but extends to several other aspects of improvement of the inward quality management process:

ERP & IoT Integration: Converting the old, off-line Supplier Quality Dashboard, which was dependent on stand-alone Excel, to a real-time module in the ERP/SAP system, that automatically logs defects, scores vendors in real-time & immediately blocks non-conforming batches.

Advanced Analytics & AI-Driven Inspection: Leveraging predictive analytics and machine learning algorithms for anticipating vendor defect risks, informed by past quality trends, material grade characteristics, and production batch sizes.

Automated & Computer Vision Systems: How to use Automated Optical Inspection (AOI) and vision-based measurement systems to inspect high-volume parts and eliminate visual & dimensional defects in a repeatable manner, such as burrs, hole undersize, or slot misalignments.

Supply Chain Expansion: Adding additional vehicle models to the M110 and W610, tier-2 sub-suppliers to be managed, and additional incoming inspection workflows for raw materials.

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