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Enhancing Supplier Capability Through Waste Minimization: A Quality Matrix Perspective

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Abstract

In the packaging sector, even minor deviations in product specifications can lead to increased waste, operational inefficiencies, and compromised product quality. This research focuses on addressing critical manufacturing challenges faced by Company A in maintaining ovality standards for polymer cans exceeding the acceptable threshold (≤3%) or 1.2mm which is pivotal for packaging integrity. Using a combination of advanced tools like the Hoshin Kanri X-Matrix methodology for strategic alignment and integrates tools like root cause analysis (Ishikawa), Pareto analysis, and experimental validation to identify key factors influencing deformation, including load, packaging, and temperature variations. The samples were analyzed, controlled experiments and correlation analyses confirmed that load management significantly reduces deformation, while temperature has minimal impact. By implementing improved packaging designs, including the use of 5-ply separators, floor rejections were reduced from 5% to 1.1%, reduced man-hours by 50%, yielding financial savings of 8.76 MN PKR annually and enhancing operational efficiency.

Keywords: Continuous improvement, Defect reduction, Lean manufacturing, Load management, Packaging quality, Supplier capability, Waste minimization.

Introduction

In today's industrial landscape, the need for precision, sustainability, and cost-efficiency in manufacturing processes has grown exponentially. For industries specializing in high-volume production, maintaining product integrity during production, storage, and transportation is critical to ensuring customer satisfaction and brand reputation. One such challenge is the ovality of polymer can an issue that directly affects the structural integrity and appearance of the final product. Ovality refers to the degree of deviation from a perfect circular cross-section. In the packaging industry, where products are transported and stored in bulk, maintaining a strict ovality threshold is essential for ensuring stacking efficiency, reducing material waste, and preserving product quality.

Company A, a leading manufacturer of polymer cans, faces a significant challenge in maintaining ovality below the industry standard of 3%. Failure to meet this threshold not only increases rejection rates during quality control but also compromises the efficiency of downstream processes like packing and stacking. Moreover, the financial implications of rejections, sorting, and waste accumulation create a pressing need for sustainable solutions. Despite advances in production technology, achieving consistent quality in polymer cans remains a persistent challenge for the packaging industry. Several interrelated factors contribute to ovality defects, creating a significant barrier to maintaining strict quality standards. Each of these factors, when left unaddressed, can exacerbate structural imperfections in the final product and lead to a host of operational, financial, and environmental consequences. These technical challenges create a cascading impact that extends beyond the manufacturing floor and into the broader supply chain.

The primary contributors to ovality defects include improper temperature control during molding can result in material deformation. Excessive stacking loads during storage and transit can lead to significant structural deformation. Loose or tumbled packing increases internal movement during transit, further induction of deformation. Variations in the polymer material used can influence the final product's ability to withstand stress during transportation and handling. These issues create a ripple effect across the supply chain. Polymer cans with high ovality are inherently weaker and more prone to cracking under external stress. Such failures compromise the integrity of the packaged product, leading to increased returns from customers. For instance, a cracked can not only results in product loss but also tarnishes the brand's reputation, as customers associate such defects with poor quality. Ovality defects involves additional sorting and inspection efforts during quality control, increasing man-hours and slowing down production lines. High rejection rates also disturb inventory levels, as more raw materials and production capacity are required to compensate for defects. The costs associated with defects are multifaceted, including the direct cost of rejected cans, the additional labor required for sorting, and the opportunity cost of wasted production time. Furthermore, the financial burden of customer dissatisfaction, such as product returns or loss of market share, can significantly affect the company's bottom line. The waste generated from rejected polymer cans poses a significant environmental concern. Discarded polymer materials, especially those that are non-biodegradable, contribute to landfill accumulation and environmental degradation. Recycling efforts, while beneficial, may not fully offset the waste generated, particularly if the rejected materials are contaminated or unsuitable for reuse.

This research focuses on bridging these gaps through a combination of structured methodologies and practical interventions, aiming to set new benchmarks for excellence in the packaging industry. The Hoshin Kanri X-Matrix serves as the backbone of the research methodology, aligning high-level strategic goals with actionable initiatives. This framework enables a clear linkage between organizational objectives (e.g., waste minimization and quality enhancement) and operational measures (e.g., process improvements and defect reduction). By visualizing the interplay between goals, actions, and performance metrics, the X-Matrix ensures that every intervention contributes directly to achieving measurable outcomes.

Goals and Objectives

The primary goal of this research is to enhance supplier capability and improve packaging quality by minimizing ovality-related defects in polymer cans. This involves leveraging advanced analytical tools and strategic frameworks to address root causes, optimize processes, and ensure sustainable improvements in manufacturing and supply chain practices.

- To achieve consistent conformity with ovality standards (≤3%) to enhance product integrity and customer satisfaction.
- To minimize material waste by decreasing floor rejections, optimizing resource utilization, and implementing sustainable practices.
- To efficient production and packaging processes to reduce sorting time,

man-hours, and costs.

- To address environmental concerns by minimizing the waste footprint and improving recycling potential for polymer materials.

These goals and objectives collectively aim to address industry challenges, contribute to academic knowledge, and provide practical solutions for achieving excellence in packaging quality and operational performance. It aims to set a standard for how academic research can drive meaningful improvements in real-world manufacturing practices.

Literature Review

In a packaging industry, raw material, production processes, and advanced technologies are involved in order to design, produce, and deliver the final product in the form of wrappers or container, across various sectors. Such industries focus to protect their products during storage and transportation, preserve the quality of the final product, and to enhance visual appeal in order to attract buyers.

As demands for quality and efficiency in packaging industry rise, the industries face challenges to deliver a quality product, due to some external factors. Moreover, reducing waste and maintaining a consistently high level of product packaging, are the main challenges. In order to improve the product quality, this literature study focuses on the role that lean manufacturing tools and Total Quality Management tools including Hoshin Kanri, X-Matrix as well as Why-Why Analysis, plays to uplift the product integrity. Although each concept has got its contributions, their interaction offers a comprehensive approach to goods and services improvement. As a result, in manufacturing sectors, advancements are made in the form of automating several process in order to convert a raw material into a final product, and delivering it to the end user. These developments should be able to improve productivity, reduce waste, and enhance product quality. However, productivity and product quality remained low, which results in low customer satisfaction, because it does not meet the quality criteria (1) . As a result, it is imperative for the companies, to focus on enhancing and preserving product's quality they produce by developing an appropriate quality system (2). Lean manufacturing is being applied in the production area to alleviate some of these issues. Since. the lean concept was first introduced in Japan when the manufacturing sector could not afford to incur large investments in redesigning their industries as, this concept helps to reduce cost by lowering waste percentage to a minimum level, and increasing the rate of production, because it was originated in order to maximize the utilization of resources by lowering waste (3) . It eliminate waste and cover its ideas and techniques such as pull-push production system, Total Quality Management (TQM), Continuous Improvement (CI), Just in Time (JIT), Total Productive Maintenance (TPM), and Value Stream Mapping (VSM) (4). Through the use of earlier business studies, this system sought to lower cost at every stage of the manufacturing process, from designing to manufacturing to finishing. Since the main goal of lean manufacturing is to eliminate waste in all processes, the maximum number of companies are attempting to apply this approach. While companies shown a notable improvement since it alleviated business performance which in turn helps to meet management and customer satisfaction (5) . As lean improves all the value added process by eliminating non- value added activities to reduce waste. The seven categories of waste identified by lean concept are, overproduction, excessive movement of parts, machinery or personnel, over-processing, excess inventory as it lowers product quality and effects customer service, extra movement due to bad layout, and defective products (6). It was first used in the automotive sector, but as it is a management strategy that can lower waste production in any process, it has since spread to all production and services sectors (7).

Organizations may encounter challenges when implementing lean practices because of their dependency on suppliers for inventory, the high cost of carrying inventory, poorly designed workspaces, and a lack of awareness of other factors that cannot be classified as waste like personnel safety, environmental risk and morale (8). While, implementing lean practices often fail to fulfill the organization’s desire of achieving sudden improvement. Therefore, applying lean and Total Quality Management is essential for improving quality and sustaining continuous improvement in an organization (9). Therefore, Total Quality Management, a collection of tools, methods, and techniques, that helps the organizations attain, improve, and maintain the quality in processes, goods, and services can also help to achieve the goal of maintaining quality and customer satisfaction. The concept of TQM (Total Quality Management) emerged between 1980s-1990s as an idea of quality management. Total Quality Management, usually abbreviated as TQM is a managerial philosophy which helps to improve the quality in all business aspects, continuously. Initially, this approach was restricted to manufacturing sector only, but now it has been implemented into services industries, including health-care, restaurants, government, and education. (10).

This approach helps to identify opportunities for improvements, implement changes, and monitor the results to ensure the current progress. The aim of Total Quality Management is to increase customer's satisfaction by enhancing the overall quality of products and services, and optimizing the resources (11) . It is a customer focused approach, which focuses to understand and meet the needs and expectations of customer in right time, right quality and at right cost. The organizations implement TQM approach in order to deliver their products and services, which best meet the desires, requirements, and expectations. Here, the customer's satisfaction and feedback are integral, which guides the organization's efforts and ensure that quality should be at top priority (12).

TQM (Total Quality Management) consists of three main components. One of the components is the core values, which are the basis for organization's culture. The second component of TQM is the way to carry out the objective of an organization, or in simple words, this component targets the techniques which are applied in order to achieve the desired goals and objectives. The third component, which is the most important component, consists of the tools which provides statistical basis that helps in decision making and data analysis within an organization (13). These three components of TQM are interdependent and support each other. It is important to classify the components according to Total Quality Management. Here, QFD (Quality Function Deployment) is often confused with QH (Quality House) (14) . However, QFD is defined as "a system which is used to translate consumer's requirements into company's requirement at each stage, starting from research and product development to engineering, manufacturing, marketing, sales, and distribution of the final product". Thus, therefore, QFD is a technique, not a tool. On the other hand, Quality House is a tool, used within Quality Function Deployment (15). Similarly, Hoshin Kanri is also a technique used in TQM. Hoshin kanri is a process used for policy deployment, and has been applied in 1970s within Japanese companies (16) . This methodology helps to ensure that the objectives set by the organization are capable to activate the actions of all team members at the hierarchical levels, resulting enhanced overall performance and continuous improvements. This policy deployment process aligns all strategic objectives, set and defined by senior management, with the help and contribution of middle management, the tasks carried out by the employees (17) . In this system, teams plays a fundamental role in achieving company's strategic goals and objectives, because this system is based on the linkages between goals and objectives, missions, and strategies as well as the coordination throughout the managerial (18). The Hoshin Kanri process is executed into four major phases which are summarized by an acronym FAIR (focus, alignment, integration, and review). Here, "focus phase" focuses on identifying and defining the main strategic objectives of an organization, "Align phase" correlate all available resources with objectives and strategic priorities through Hoshin policies. Similarly, "integrate phase" integrates the Hoshin policies with the current operational activities. While, during "review phase", the implemented Hoshin policies are assessed and their results are reviewed. This assessment is carried out once in a year, but could also be scheduled as per convenience or requirement (19).

As a result, the effectiveness of Lean Manufacturing TQM, Hoshin Kanri, and X-Metrix methodology has been proved by a significant number of research papers in manufacturing as well as service sector. However, in this research lean manufacturing and TQM's tools are implemented simultaneously, in order to decrease the quality problems by optimizing sewing process and reducing the defects percentage to a minimum level.

Methodology

A systematic and multi-phase methodology designed to address ovality defects in polymer cans through data-driven analysis, innovative interventions, and rigorous validation. The study leverages the Hoshin Kanri X-Matrix framework, which aligns strategic goals with actionable initiatives to achieve measurable outcomes. Complementing this, tools like cause-effect diagrams and Pareto analysis are employed to identify root causes and prioritize interventions. By systematically addressing root causes and validating solutions through real-world applications, the study offers a replicable model for other manufacturing industries facing similar challenges.

Statistical Sampling and Analysis

In the quantitative phase, numerical data is gathered and analyzed to determine rejection rates and ovality variations. Its main goal is to measure the ovality induction problems on rejection rates and the effectiveness of solutions that are put into place using statistical and numerical data. The general formula for sample size without population size adjustment is:

$$n = \frac{(Z^2 \times p \times (1-p))}{e^2}$$

Parameters such as minor and major diameters of all the sampled data were measured to calculate the ovality percentage. Where the use of statistical sampling methods for representative analysis, employing a Z-score of 1.96 for a 95% confidence level and a margin of error of 5 gives the initial sample size of 384.16, which would be the required sample size if the population were infinite. As the population is finite and known so finite population correction (FPC) will be used here. The formula for adjusting the sample size for a finite population is:

$$\check{n} = \frac{N \times n}{1+(n-1)}$$

The overall fact finding approaches and the numerical data collection and analysis techniques utilized to measure the influence of defect issues on rejection rates can more easily be distinguished by separating the research design and the quantitative phase. This study underscores the potential for scalable applications of the proposed solutions across industries. The ovality test has been conducted on all of the sampled data. The formula used to calculate the ovality percentage was:

$$\textbf{Ovality (\%)} = \frac{(\text{Max OD} - \text{Min OD})}{\text{Nominal OD}} \times 100$$

Where Max OD refers to the largest outer diameter of the can, Min OD refers to the smallest outer diameter and Nominal OD is the expected standard outer diameter. To see the trend of sampled data, with the value of 0% for lower control limit and 3% for upper control limit with average ovality value of 1.07%. The values of UCL and LCL were mentioned in product specification sheet shared by manufacturer (Cans supplier).

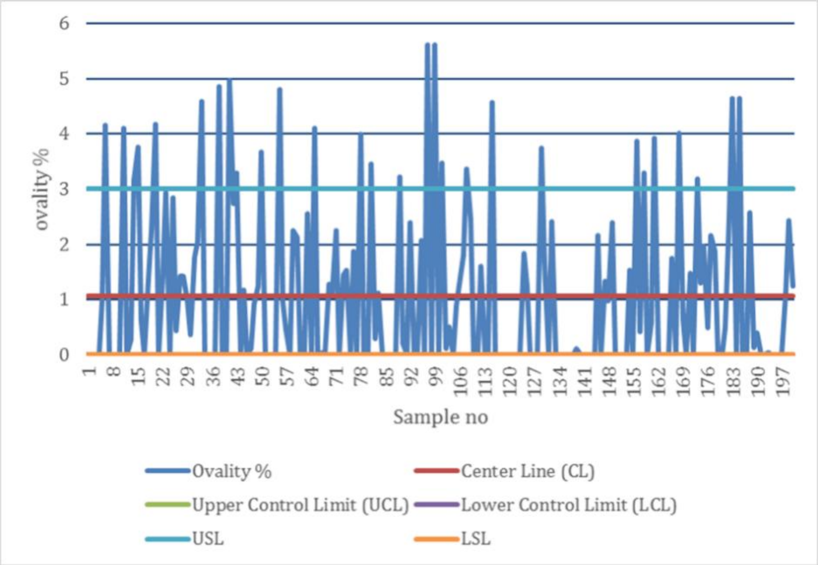

Figure 1 All the sampled data with ovality variation including LCL and UCL.

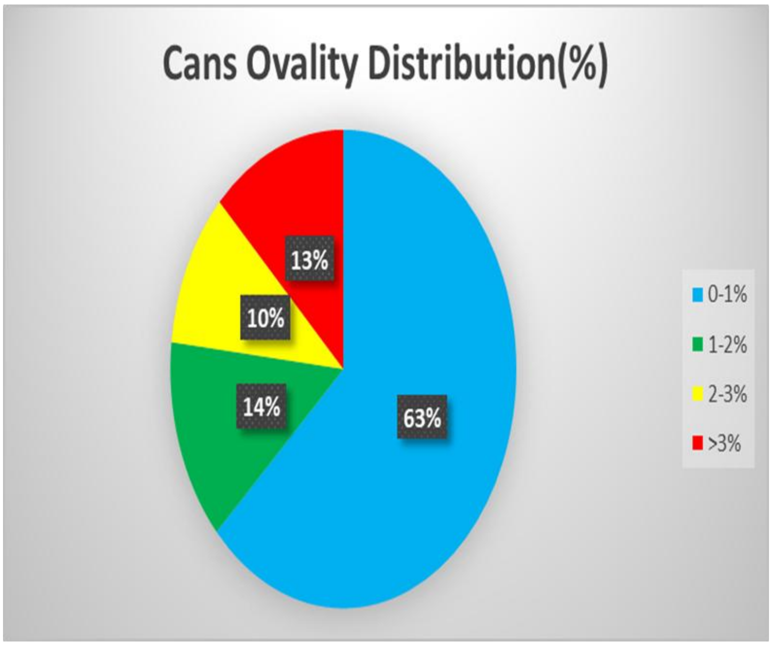

Figure 2 The total defect recognized was 13% as per ovality distribution chart.

The manufacturing and packaging process was modeled as an interdependent system where variables like temperature, stacking load, and packaging design influence outcomes. The analysis was designed to identify key operational bottlenecks and prioritize solutions using analytical tools such as Ishikawa diagrams, 80/20 rule, and statistical validation. This study employs a root cause analysis framework to identify factors contributing to ovality defects. It combines experimental data with qualitative insights to diagnose the problem and test solutions effectively. Fishbone Analysis approach categorized issues into four domains materials, methods, machinery, and environment providing a comprehensive map of potential defect sources. The data analysis reveals several key insights into the causes of can ovality. The primary issue appears to be related to packaging methods, particularly the use of tumbled packaging, which fails to provide adequate support for the cans during transportation.

While Pareto Analysis identifies primary contributors to ovality defects, highlighting packaging and load management. As the key findings from Ishikawa diagrams and Pareto analysis find packaging (Loose packing and insufficient load distribution led to deformation), temperature Variations (Improper molding and storage conditions causes ovality issues) and stacking Load (Excessive stacking during storage induced higher deformation rates). Experiments were conducted under varying stacking loads, temperatures and transit time to quantify their impact on ovality.

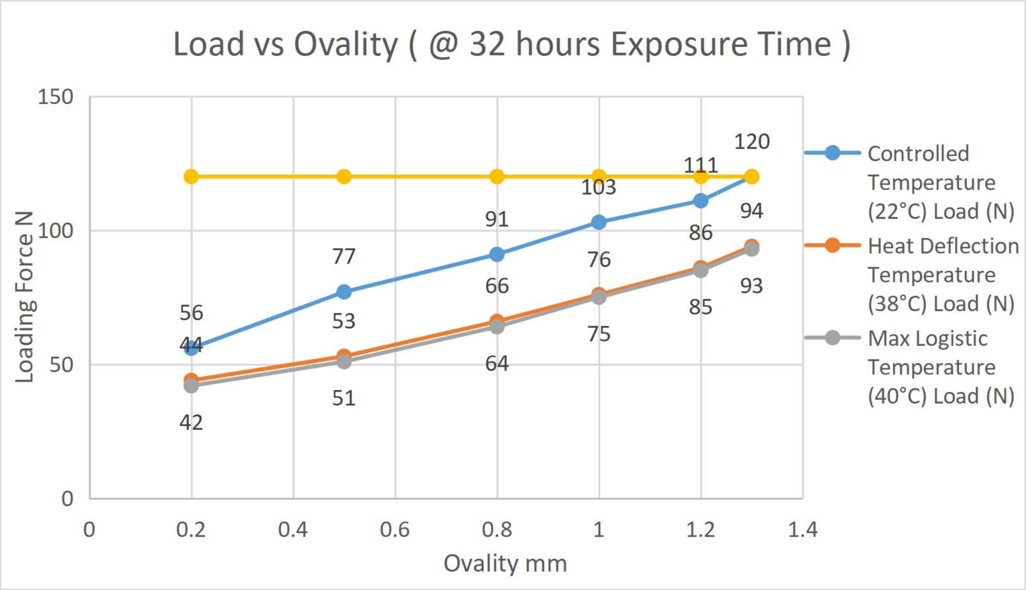

Figure 3 Load vs. ovality behavior at transit time of 32hrs and different temperatures highlights critical deformation thresholds.

The chart Fig 3 presents the relationship between loading force (in Newtons) and ovality (in millimeters) under various temperature conditions for an exposure time of 32 hours, with the maximum allowable ovality standard set at 1.2 mm. This shows that maintaining controlled temperatures is crucial for minimizing ovality under loading conditions. The data reveals that higher temperatures (38°C and 40°C) reduce the material's ability to withstand higher loading forces, leading to increased ovality compared to a controlled temperature of 22°C. The chart reveals that maintaining controlled temperatures is crucial for minimizing ovality under loading conditions. At 1.2 mm ovality, the loading force is highest at the controlled temperature of 22°C (120 N), indicating the material's optimal performance. However, at higher temperatures of 38°C and 40°C, the loading force required to reach 1.2 mm ovality significantly decreases to 94 N and 93 N, respectively. While the average loading force was of 140 N. This demonstrates the detrimental effect of increased temperatures and load on the material's structural integrity.

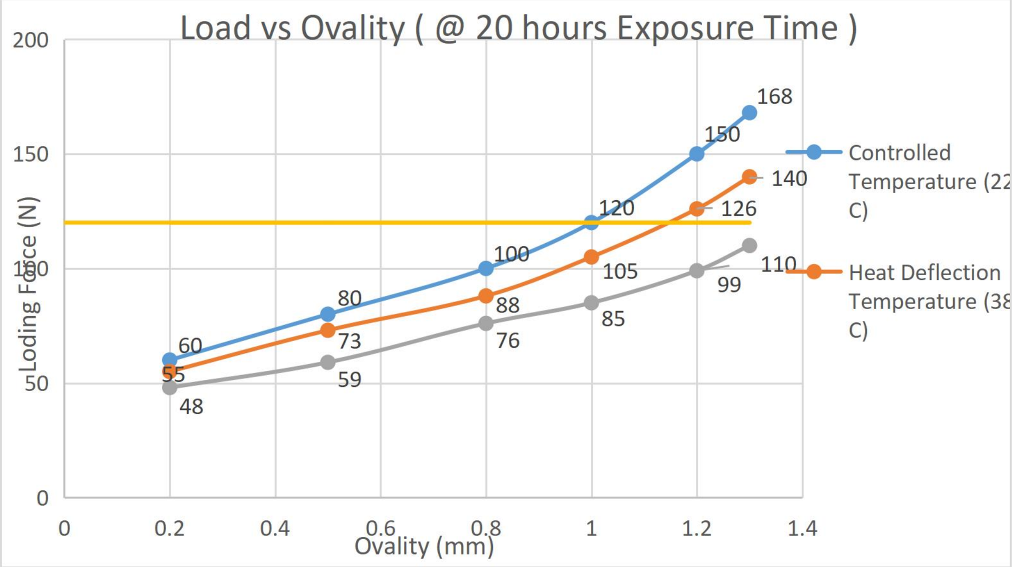

Figure 4 Load vs. ovality behavior at transit time of 20hrs and different temperatures highlights critical deformation thresholds.

The analysis on the basis of Fig.4 reveals that controlled temperatures (22°C) ensure the best performance of the polymer cans, with the loading force significantly elevated to 150 N the required standard at 1.2 mm ovality. While the average loading force was of 140 N. However, at elevated temperatures (38°C and 40°C), the material's resistance decreases, with forces approaching or barely meeting the allowable threshold. Correlation analysis was used to examine the relationship between can ovality and several factors, including transit temperature, stacking load, and packaging method d.

$$r = \frac{Cov(X,Y)}{\sigma x \,.\, \sigma y}$$

This analysis is crucial for understanding which factors are most strongly associated with increased deformation. There's a very strong positive correlation between ovality and load at both 20 and 32 hours under maximum logistic temperature conditions.

$$\textbf{Cov (X,Y)} = \frac{\sum_{i=1}^{n}(Xi-\dot{X})(Yi-\dot{Y})}{n}$$

Ovality (X) percentage deformation of the cans. Load (Y) stacking load applied during transportation, mean (Ẋ, Ẏ) is the average value of Ovality and Load, Standard Deviation (σX, σY) measures the dispersion of data from the mean, covariance (Cov (X, Y), Indicates the direction of the linear relationship between variables. Pearson correlation coefficient (r) measures the strength and direction of the linear relationship. This suggests that as the load increases, ovality increases nearly linearly. The correlation strengthens slightly at the 32-hour exposure, indicating that prolonged exposure may slightly enhance the relationship between load and ovality in these conditions.

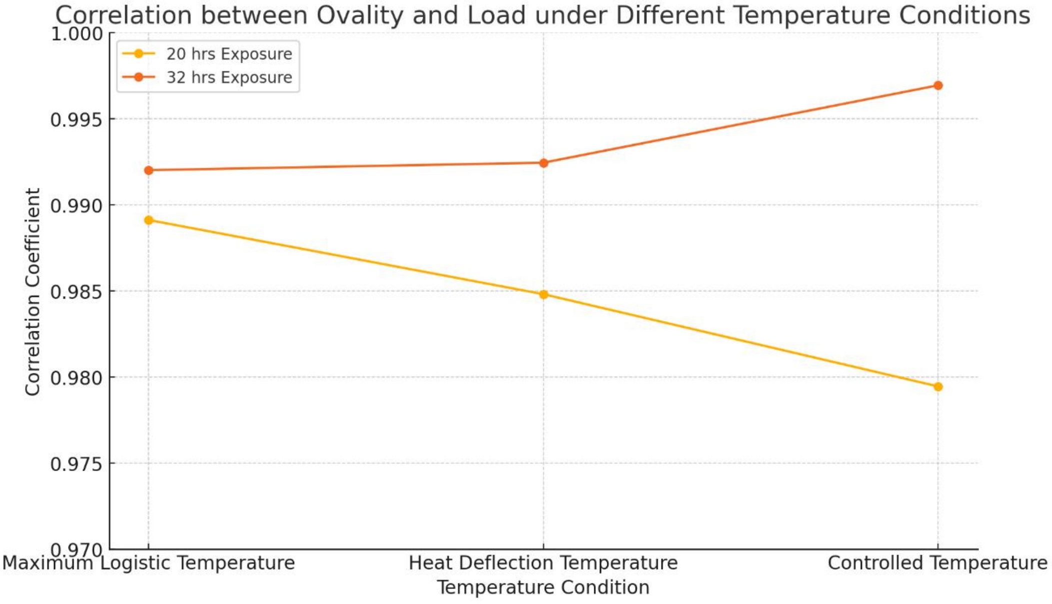

Figure 5 Exposure enhances ovality-load correlation under different conditions.

The Fig.5 reveals correlation coefficient values (ranging from 0.970 to 1.000) measure the strength of the linear relationship between ovality and load, with higher values indicating a stronger correlation. The controlled temperature condition shows a very strong positive correlation between ovality and load, with the correlation being highest (0.997) at 32 hours. This significant increase suggests that at controlled temperatures, extended exposure (32 hours) under load has an even stronger effect on ovality, possibly due to a consistent environment that allows the load-induced deformation to manifest more clearly over time.

By integrating a comprehensive suite of measurement techniques, including precise instrumentation for tracking ovality and loading forces under various conditions, this study captures high-resolution data essential for understanding the distortion behavior of polymer cans. Utilizing root-cause analysis tools such as Fish bone diagrams and Pareto charts, the research systematically identifies and categorizes the primary factors contributing to product deformation, including temperature variability, stacking loads, and material inconsistencies. Furthermore, through experimental validation, controlled tests were conducted to evaluate the interplay of these factors, simulating real-world conditions like prolonged exposure times and varying temperatures. To ensure the packaging design analysis the following X-Matrix framework within the Hoshin Kanri methodology supports strategic alignment and lean methodologies by connecting high-level goals with specific actions, measurable metrics achieving less than 3% defect rates or 1.2mm ovality.

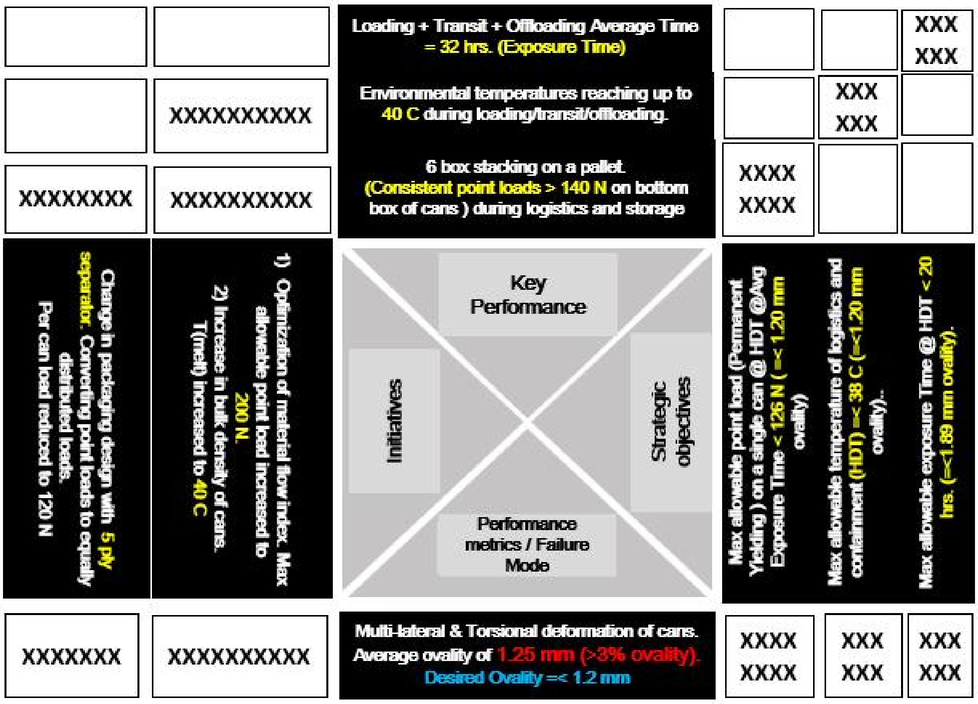

Figure 6 A strategic framework that connects various elements of the research.

The findings from Fig.6 highlight critical areas for intervention, with a particular focus on enhancing packaging solutions to improve load distribution and structural integrity. The proposed adjustments, such as the implementation of 5-ply separators, are designed to reduce internal movement and resist deformation during storage and transportation. Strategic objectives to minimize ovality in cans during transportation and storage. To maximize can integrity by improving packaging design and optimizing transportation methods.

- Key processes transportation methods and conditions (distance, load distribution, Packaging material strength, design, and cushioning).
- Performance metrics percentage of cans with ovality ≤ 3% or 1.2mm. Reduction in damaged cans during transit (measured in terms of waste percentage). Improved load distribution metrics to reduce compression and impact forces.
- Initiatives were basically the Implementation of separator packaging (5-ply). Optimization of load configurations in transportation to mitigate compression effects. Integration of temperature control strategies for long-distance shipments to avoid heat-induced deformation.

This matrix guided the research direction and ensured alignment between the transportation and packaging improvements, performance tracking, and strategic objectives. These enhancements aim to ensure that products consistently meet quality standards while maintaining resilience under varying operational stresses. To see Validation and Statistical Evaluation the trends, patterns, and relationships between ovality variations and rejection rates, quantitative data collected using control charts before and after taking interventions.

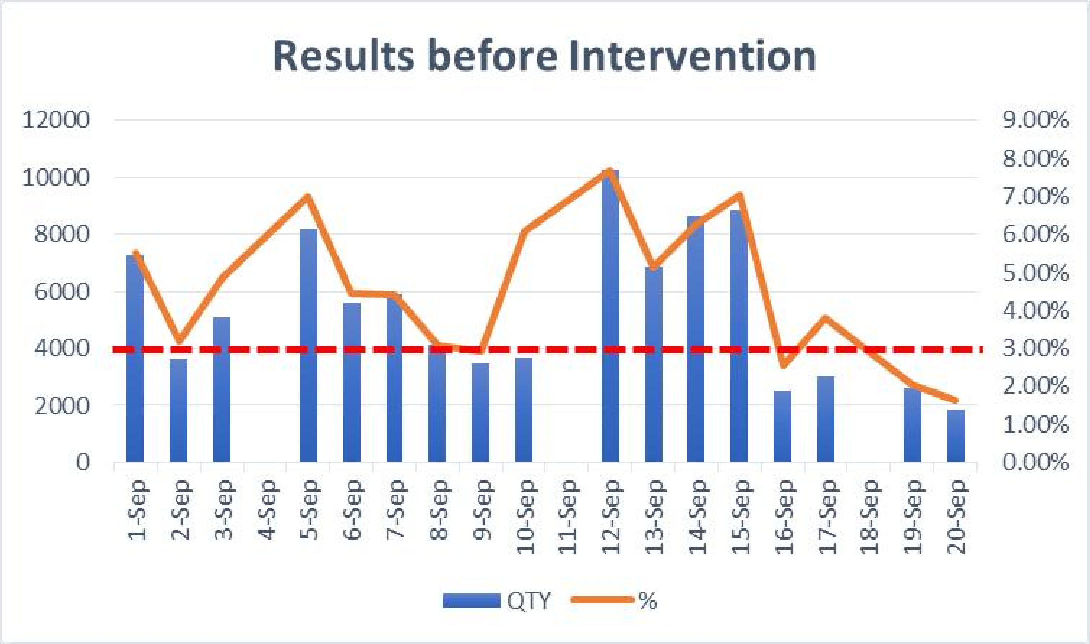

Figure 7 Pre-intervention results show high variability in defect percentages, with 5% average.

Statistical analysis has been done for evaluating the efficacy of interventions through control charts and defect rate comparisons. The trend Fig.7 shows inconsistent quality performance with periodic spikes in ovality percentages prior to the intervention. the daily ovality percentages, showing fluctuations above the red dashed line (representing the average defect percentage of 5%).

Intervention Strategies

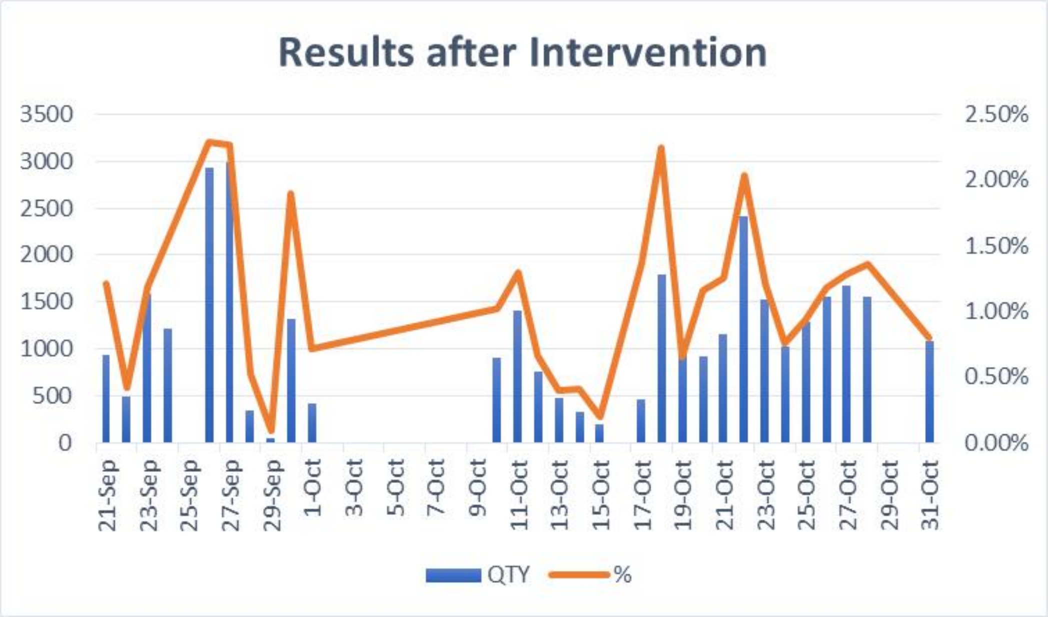

Figure 8 Post-intervention results show high variability in defect percentages, with 1.1% average.

As Fig.8 reveals that further enhanced structural support, minimizing internal movement during transport and preventing ovality. The 5 ply separator achieved an ovality defect rate of 1.1%, exceeding expectations. Developed strategy improve packaging practices to minimize stress on lower layers of stacks. Results verified the significance of packaging design and stacking practices as critical factors influencing defect rates.

Conclusion

This research shows that integrating strategic tools like Hoshin Kanri with experimental validation can effectively address ovality challenges in polymer cans. The methodology was verified through a real-world case study involving the manufacturing and packaging processes at Company A. The implementation of 5-ply separators, has yielded considerable improvements in operational efficiency, cost-effectiveness, and product quality. Firstly, the sorting process saw a 50% reduction in sorting time and man-hours, notably improving productivity and allowing resources to be allocated to other critical areas of the manufacturing process. The use of separator packaging to minimize direct contact between cans and reduce ovality. The optimization of load distribution during transportation to prevent excessive weight compression.

Additionally, floor rejections, which initially averaged 5%, were reduced to an impressive 1.1%, indicating a marked improvement in defect control and adherence to quality standards. This reduction in rejections not only highlights the success of the interventions but also ensures higher yields from the production process.

From a financial perspective, the improvements resulted in annual cost savings of 8.76 million PKR, achieved through decreased material wastage, reduced labor costs, and minimized operational inefficiencies. These savings contribute directly to the bottom line while reinforcing the financial viability of the adopted quality measures.

Further, the introduction of enhanced packaging methods significantly strengthens product quality and reliability. The findings commend for lean methodologies, emphasizing waste reduction, quality assurance, and resource optimization. Future research will focus on polymer quality improvement, optimized cooling processes, and automation in storage and handling to further mitigate deformation risks. These methods, designed to oppose variations in temperature and stacking loads, reduced deformation risks and ensured that products consistently met customer expectations and industry standards. Collectively, these achievements demonstrate the success of the intervention strategy in driving measurable and sustainable improvements across multiple facets of the production process. This methodology provides a vigorous framework for identifying and solving quality challenges in polymer manufacturing, demonstrating both practical and academic significance. By systematically addressing root causes and verifying solutions through real-world applications, the study offers a replicable model for other manufacturing industries facing similar challenges. This provide a roadmap for achieving higher manufacturing standards and sustaining long-term quality improvements.

References

[1] K. Yang and B. S. El-Haik, 'Design for Six Sigma: A Roadmap for Product Development,' 2009.

(2) 'Operational Research in Engineering Sciences – Theory and Applications.'

(3) G. C. P. Condé, P. C. Oprime, M. L. Pimenta, J. E. Sordan, and C. R. Bueno, 'Defect reduction using DMAIC and Lean Six Sigma: A case study in a manufacturing car parts supplier,'2022.

(4) M. Roncal-Coronel, F. Tarazona-Ballon, and J. C. Quiroz-Flores, 'Warehouse Management model to reduce return rate applying Lean Manufacturing Techniques and Multicriteria ABC in SMEs in the textile sector,' 2023.

(5) M. Tavana, A. Shaabani, and N. Valaei, 'An integrated fuzzy framework for analyzing barriers to the implementation of continuous improvement in manufacturing,' 2020.

(6) M. V. Ciasullo, A. Douglas, E. Romeo, and N. Capolupo, 'Lean Six Sigma and quality performance in Italian public and private hospitals: A gender perspective,' 2024.

(7) G. Ballard and I. Tommelein, 'Lean management methods for complex projects,' 2012.

(8) P. P. K., 'Productivity Improvement Through Lean Deployment & Work Study Methods,' 2014.

(9) 'The Analysis of Quality Control in Garment Company Using Statistic in Controlling Product,'2016.

(10) M. A. Daqar and M. Constantinovits, 'The role of total quality management in enhancing the quality of private healthcare services,' 2020.

(11) 'Lean Six Sigma Approach to Improve the Production Process in the Mould Industry: A Case Study,'2019.

(12) U. Hellsten and B. Klefsjö, 'TQM as a management system consisting of values, techniques and tools,' 2000.

(13) H. Leite, S. Williams, Z. Radnor, and N. Bateman, 'Emergent barriers to the lean healthcare journey: baronies, tribalism and scepticism,' 2024.

(14) 'Do TQM Instigate Sustainable Development: Identifying the Key Role of Green Innovation and Knowledge Management,'2023.

(15) J. K. Chen, 'Identifying critical success factors of total quality management via comprehensive assessment of soft and hard factors,' 2024.

(16) S. F. Faghidian and S. Mahmodi, 'Evaluation of total quality management enablers using the DEMATEL-ISM integration method in the steel industry,' 2024.

(17) A. Stavelin and S. Sandberg, 'Analytical performance specifications and quality assurance of point-of-care testing in primary healthcare,' 2024.

(18) K. E. Roche and R. J. Baumgartner, 'Development of a strategy deployment framework combining corporate sustainability and operational excellence,' 2024.

(19) P. I. D. Silva and S. M. C. Seneviratne, 'Lean Manufacturing and Operational Performance: An Empirical Study on an Apparel Manufacturing Company,' 2022.