Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 1, March : 2024

SIX SIGMA APPROACH TO INCREASE THE ORIGINAL EQUIPMENT PERCENTAGE IN MAHLELINE

G. VENAKT VAMSI, B.B. THIRUPATHI PRAKESH, K. GANESH, UG Students of Mechanical Engineering Dept., NRI Institute of Technology, Pothavarappadu, Eluru District, AP, India, Pin: 521212.
Dr. K. PRASADA RAO, Professor, Department of Mechanical Engineering,

Abstract
This Work focuses on implementing the Six Sigma methodology to boost the Original Equipment (OE) percentage in Mahleline, a critical metric in the automotive industry. The project's goal is to address the current gap in OE percentage and improve Mahleline's market position. By applying the Define, Measure, Analyze, Improve, and Control (DMAIC) approach, the project aims to streamline processes, enhance product quality, and optimize supply chain efficiency. Expected results include a substantial increase in Mahleline's OE percentage, which will strengthen its competitive position, establish long-term partnerships with automotive manufacturers, and sustain business growth. This abstract provides the project's objectives, methodology, and the significance of positioning Mahleline as a leading OE supplier in the automotive industry.
Keywords: Six Sigma, Defect Reduction, Process Improvement, Quality, Efficiency.

I. Introduction

Six Sigma is a set of techniques and tools for process improvement. It was introduced by American engineer “Bill Smith” while working at Motorola in 1986. Six Sigma strategies seek to improve manufacturing quality by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. Six Sigma methodology has emerged as a powerful tool for achieving operational excellence and process improvement in manufacturing industries. With its data-driven approach and focus on reducing defects and variations, Six Sigma has garnered widespread attention and adoption across various sectors.

This provides a comprehensive assessment of the implementation of Six Sigma in manufacturing industries, exploring its significance, benefits, challenges, and lessons learned. Through the analysis of case studies and research articles, this review aims to offer valuable insights into successful strategies for implementing Six Sigma effectively, leading to improved product quality, enhanced productivity, and sustained competitive advantage in the dynamic manufacturing landscape.

OVERVIEW OF THE SIX SIGMA:

Six Sigma is a data-driven methodology and approach used by organizations to improve their processes by minimizing defects and variations. The goal of Six Sigma is to achieve near-perfect results by limiting the number of defects to a maximum of 3.4 per million opportunities. This statistical approach is often represented by the DMAIC framework, which stands for Define, Measure, Analyze, Improve, and Control. By following this structured approach, organizations can identify and eliminate causes of variation, thereby enhancing processes and driving continuous improvement.

Six Sigma aims to improve the quality of process outputs by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes. It is widely utilized across various industries to enhance operational efficiency, reduce defects, and ultimately improve customer satisfaction.

Six Sigma methodology is widely utilized across various industries due to its effectiveness in enhancing operational efficiency, reducing defects, and improving overall quality. Some common industries that extensively use Six Sigma methodology include:

1. **Manufacturing**:

Industries such as automotive, electronics, aerospace, and consumer goods manufacturing rely on Six Sigma to improve production processes, reduce defects, and optimize supply chain efficiencies.

2. **Healthcare**:
Hospitals and healthcare organizations utilize Six Sigma to streamline processes, reduce medical errors, and enhance patient care while controlling costs.
3. **Financial Services**:
Banking, insurance, and other financial institutions use Six Sigma to improve transaction accuracy, minimize errors, and enhance customer service.
4. **Information Technology**:
IT companies adopt Six Sigma to optimize software development processes, improve system reliability, and enhance customer satisfaction with IT services.
5. **Retail**:
Six Sigma is utilized in retail to improve inventory management, optimize supply chain processes, and enhance overall customer experience.

These industries leverage Six Sigma to drive continuous improvement, reduce waste, and achieve operational excellence, ultimately leading to increased customer satisfaction and business success.

II. Literature

G. Hema Sriram et al. [1] Conducted Six Sigma in cylinder liner was conducted to improve the quality of cylinder liners in a manufacturing plant. The DMAIC approach to identify and eliminate the root causes of defects, resulting in a significant increase in the original equipment (OE) percentage of cylinder liners. The usage of variety of tools and techniques, including fishbone diagrams, Pareto charts, and process capability studies, to analyze the data and identify the root causes of defects. Once the root causes were identified, the team developed and implemented corrective actions. These actions included changes to the manufacturing process, the use of new tools and equipment, and the implementation of new training programs. The results of the project were very successful. The OE percentage of cylinder liners increased from 85% to 97%, and the number of defects per million opportunities (DPMO) decreased from 1,200 to 300. The project team also saved the company an estimated $1 million per year in rework and scrap costs. This project demonstrates the power of Six Sigma to improve quality and reduce costs. The project team's use of DMAIC and a variety of tools and techniques led to significant results that benefited the company and its customers.

M.Sokovie et al. [2] paper discusses how Six Sigma can be applied to automotive parts production, with a focus on the DMAIC (Define-Measure-Analyze-Improve-Control) approach. Six Sigma project that was conducted in an automotive parts manufacturing plant. The DMAIC approach to identify and eliminate the root causes of defects in the manufacturing process. As a result of the project, the number of defects per million opportunities (DPMO) was reduced by 50%, and the overall quality of the automotive parts was improved. Six Sigma is a methodology that can be used to improve the quality of automotive parts. The benefits of using Six Sigma to improve the quality of automotive parts include increased customer satisfaction, reduced costs, improved productivity, and enhanced brand reputation. The challenges of implementing Six Sigma in automotive parts production include the need for a strong commitment from management, the need for a skilled and experienced workforce, and the need for a well-defined process.

J.A.Kumar et al. [3] the use of Six Sigma methodology to reduce defects in the manufacturing of rubber gloves. The paper begins by providing an overview of Six Sigma, including its history, principles, and tools. The paper then discusses how Six Sigma can be applied to the manufacturing of rubber gloves, with a focus on the DMAIC (Define-Measure-Analyze-Improve-Control) approach. The number of defects per million opportunities (DPMO) was reduced from 195,095 to 83,750, and the overall quality of the rubber gloves was improved. the successful application of Six Sigma and DMAIC methodologies in a rubber gloves manufacturing process, focusing on how these approaches lead to significant defect reduction, improved production efficiency, and enhanced product quality.

Jirasukprasert. P et al. [4] Six Sigma methodology to reduce defects in camshaft manufacturing. Six Sigma, a comprehensive management approach, aims to minimize process variability and achieve a

Sigma level of 3.4 defects per million opportunities. By implementing Six Sigma tools and techniques, organizations can identify and eliminate root causes of defects, leading to improved quality, reduced costs, and increased customer satisfaction. The paper presents a case study demonstrating the successful application of Six Sigma in the camshaft manufacturing process, highlighting the specific defects identified, the DMAIC (Define, Measure, Analyze, Improve, Control) steps taken, and the resulting improvements achieved. Through the use of statistical analysis, process mapping, and other Six Sigma methodologies, the defects in camshaft production were systematically addressed, leading to reduced defect rates, enhanced process efficiency, and improved overall value for the organization. This paper underscores the value of Six Sigma in the pursuit of defect reduction, showcasing how it can drive operational excellence, deliver cost savings, and uphold customer-centric values in the manufacturing industry.

Serbin Micleaa et al. [7] To Improve The Assembly Process In An Automotive Company" to explore and present the application of Six Sigma methodology in enhancing the assembly process within an automotive company. This paper will discuss the various stages of the DMAIC (Define, Measure, Analyze, Improve, Control) framework and how they were implemented to identify and address defects, bottlenecks, and inefficiencies within the assembly process. The study will provide insights into the tools, techniques, and statistical analysis utilized to measure process performance, analyze root causes of defects, and implement improvement strategies. Furthermore, the paper will present the outcomes and benefits achieved through the Six Sigma implementation, such as reduced defects, enhanced efficiency, improved quality, and increased customer satisfaction. The journal paper will provide a comprehensive understanding of how the application of Six Sigma methodology can lead to significant improvements in the assembly process of an automotive company.

D.Rama Prasad et al. [8] Application of the Six Sigma approach in the manufacturing process of a wire rod mill in a steel plant, with the goal of minimizing downtime. The Six Sigma methodology, widely recognized for its effectiveness in improving process performance and reducing variations, is employed to identify and eliminate the root causes of downtime occurrences. The paper discusses the various stages of the Six Sigma approach, including defining the problem, measuring the current process, analyzing data, implementing improvements, and controlling the process. Through the implementation of Six Sigma tools such as DMAIC (Define, Measure, Analyze, Improve, and Control), statistical analysis, and process mapping, the study illustrates how the wire rod mill's downtime can be systematically identified and addressed. The presented findings demonstrate the effectiveness of using Six Sigma in reducing downtime, which ultimately leads to increased productivity, efficiency, and cost savings. Overall, this journal paper serves as a comprehensive guide for implementing the Six Sigma approach for process improvement in the wire rod manufacturing industry.

Nitesh Kumar.Sahool et al. [9] the importance of reducing rework and rejection on the shop floor to enhance overall efficiency. Rework and rejection significantly impact productivity, costs, and customer satisfaction in manufacturing operations. The various causes and consequences of rework and rejection, highlighting their negative effect on cycle time, throughput, and quality. It further explores the potential solutions and strategies to minimize rework and rejection incidents, including process optimization, training programs, quality control measures, and continuous improvement methodologies such as Lean and Six Sigma. By implementing these approaches, organizations can streamline production processes, identify root causes of defects, and proactively address quality issues. real-world case studies and success stories where companies have successfully reduced rework and rejection rates, resulting in increased operational efficiency, reduced costs, and improved customer satisfaction.

S.m. Yaswal et al. [10] the implementation of the Six Sigma methodology for quality improvement in various industrial sectors. Six Sigma is a data-driven approach that aims to minimize defects and variations in processes, leading to improved quality and customer satisfaction. The fundamental principles and key components of Six Sigma, including its DMAIC (Define, Measure, Analyze, Improve, and Control) framework. It further explores the critical steps involved in the successful implementation of Six Sigma, such as project selection, team formation, data collection and analysis,

process improvement strategies, and statistical tools utilization. The benefits of implementing Six Sigma, including reduced defects, improved process efficiency, cost savings, and enhanced customer loyalty, are highlighted through real-life case studies and examples. The implementation of the Six Sigma method for quality improvement, serving as a valuable resource for organizations looking to adopt and leverage this methodology to enhance their quality control practices.
Virender verma et al. [11] The title "Utilization of Six Sigma (DMAIC) Approach for Reducing Casting Defects" delves into the application of the Six Sigma DMAIC approach to address and minimize casting defects in manufacturing processes. This study emphasizes the importance of defining clear objectives and problem areas related to casting defects, measuring critical performance indicators to assess the extent of the issue, analyzing data to identify root causes, implementing targeted improvements, and establishing robust control measures. By employing Six Sigma methodologies, the goal is to achieve significant reductions in casting defects, leading to improved product quality, increased efficiency, reduced waste, and enhanced customer satisfaction. This approach fosters a data-driven and systematic problem-solving methodology to optimize casting processes, ultimately contributing to higher productivity and greater value generation for the organization.
Sachin S et al. [12] Six Sigma Methodology for Improving Manufacturing Process in a Foundry Industry" explores the implementation of Six Sigma principles to enhance the manufacturing process in foundry industries. This study focuses on applying the DMAIC (Define, Measure, Analyze, Improve, and Control) approach to identify and address key challenges in the foundry manufacturing process. By defining clear objectives, measuring critical performance metrics, analyzing data to identify root causes, implementing targeted improvements, and establishing robust control measures, the goal is to achieve significant enhancements in the foundry's productivity, efficiency, and product quality. Through the utilization of Six Sigma methodologies, this research aims to reduce defects, optimize resource utilization, minimize variability, and foster a culture of continuous improvement in the foundry industry, leading to improved competitiveness and sustainable growth.
Dr. Vivek Yakkundi et al.[13] The title "Application of Six Sigma Methodology in Welding Process of Boilers for Quality Improvement" investigates the implementation of Six Sigma methodologies to enhance the welding process of boilers and achieve significant quality improvement. By utilizing the DMAIC (Define, Measure, Analyze, Improve, and Control) approach, this study aims to define specific quality improvement goals, measure critical welding performance indicators, analyze data to identify root causes of defects or inconsistencies, implement targeted improvements to optimize the welding process, and establish robust control measures to sustain the achieved quality standards. The application of Six Sigma in the welding process of boilers is expected to result in reduced defects, increased weld integrity, improved product reliability, and enhanced safety, leading to greater customer satisfaction and increased competitiveness in the boiler manufacturing industry. Additionally, this research fosters a data-driven and systematic problem-solving culture, encouraging continuous improvement and efficiency throughout the welding process.
Pranav Bharara et al. [14] The overall matter of the given title "Implementation of DMAIC Methodology for Reduction of Weighted-Defects in a Vehicle Assembly Process" centers around the application of the DMAIC (Define, Measure, Analyze, Improve, Control) methodology to address and minimize weighted-defects in the vehicle assembly process. The study values systematic problem-solving and data-driven decision-making to define specific goals, measure the severity and frequency of weighted-defects, analyze data to identify root causes, implement targeted improvements, and establish effective control measures. By employing DMAIC in the vehicle assembly process, the research aims to achieve higher product quality, increased customer satisfaction, reduced warranty costs, and improved overall efficiency in delivering vehicles to customers. The focus on continuous improvement and optimization in the assembly process underscores the importance of quality enhancement, waste reduction, and ensuring customer-centric values in the automotive industry.
J. Antony et al. [15] The overall matter of the given title "Gearing Six Sigma into UK Manufacturing SMEs" revolves around the integration and implementation of Six Sigma principles in small and

medium-sized manufacturing enterprises (SMEs) in the UK. The focus is on promoting the adoption of Six Sigma methodologies to drive process improvement, enhance efficiency, reduce defects, and optimize resource utilization in these SMEs. The values emphasized in this matter include a commitment to quality, data-driven decision-making, continuous improvement, and the pursuit of excellence in manufacturing processes. By leveraging Six Sigma practices, UK manufacturing SMEs aim to enhance their competitiveness, achieve higher levels of customer satisfaction, and establish a culture of continuous improvement to foster sustainable growth and success in the dynamic business landscape.

Yanamandra Ramakrishna et al. [16] The overall matter of the given title "Empirical Investigation of Mediating Role of Six Sigma" involves conducting a research study to explore and understand the mediating role of Six Sigma in a specific context or scenario. The study aims to empirically investigate and analyze how Six Sigma practices and principles act as mediators between certain variables or factors to influence outcomes or relationships. The values emphasized in this matter include the importance of data-driven research, empirical evidence, and rigorous analysis to provide valuable insights into the impact of Six Sigma implementation on mediating relationships. The study may shed light on the effectiveness and significance of Six Sigma in mediating various organizational processes, decisions, or factors, thereby contributing to the broader understanding of its applications and potential benefits in diverse domains.

Utomo et al. [17] The overall matter of the given title "A Systematic Literature Review of Six Sigma Implementation in Services Industries" involves conducting a comprehensive and structured examination of existing literature to explore the implementation of Six Sigma methodologies specifically in service industries. The systematic review aims to synthesize and analyze the findings from various studies to gain a deeper understanding of how Six Sigma is applied in the services sector. The values emphasized in this matter include rigorous research methodologies, evidence-based insights, and a data-driven approach to examine the effectiveness, challenges, and potential benefits of integrating Six Sigma in service industries. By providing a comprehensive review of the literature, this study contributes to the knowledge base surrounding Six Sigma practices in services, guiding decision-makers and practitioners in adopting and customizing the methodology to improve quality, efficiency, and customer satisfaction in the service sector.

E. V. Gijoa et al. [18] The overall matter of the given title "Application of Six Sigma Methodology to Reduce Defects of a Grinding Process" focuses on utilizing the Six Sigma methodology to address and minimize defects in a grinding process. The study aims to apply the DMAIC (Define, Measure, Analyze, Improve, Control) approach to define specific improvement objectives, measure and assess defects, analyze data to identify root causes, implement targeted improvements, and establish control measures to sustain the defect reduction. The values emphasized in this matter include data-driven decision-making, process optimization, and continuous improvement to achieve higher product quality, increased efficiency, and reduced waste in the grinding process. The study underscores the importance of systematic problem-solving and the application of statistical tools to drive quality enhancement and process efficiency, ultimately contributing to improved performance and customer satisfaction in the manufacturing context.

Kunal Ganguly el at. [19] Application of the DMAIC (Define, Measure, Analyze, Improve, and Control) Six Sigma approach to enhance the performance of a rolling mill. Rolling mills play a crucial role in the steel industry, and any inefficiencies or variations in the process can lead to reduced productivity, increased costs, and compromised product quality. The improvement phase, where process modifications and optimizations are implemented to address the identified issues. Additionally, control measures are established to sustain the improvements and ensure long-term success. The effectiveness of the DMAIC Six Sigma approach in improving the rolling mill process is demonstrated through real-world case studies and measurable outcomes, such as reduced defects, improved cycle time, and enhanced overall performance. This journal paper serves as a comprehensive guide for organizations seeking to implement the DMAIC Six Sigma approach for process improvement in rolling mills, providing valuable insights and practical recommendations based on proven industry practices.

Pallawi B Sangode et al. [20] Manufacturing industries face during the implementation of Six Sigma methodologies. Six Sigma is a widely adopted approach for process improvement in various industries, including manufacturing. The paper identifies common barriers such as resistance to change, lack of management commitment, inadequate training and knowledge, organizational culture, and integration challenges. The study explores these barriers in detail, providing insights into their impact on successful Six Sigma implementation. Furthermore, the paper discusses strategies and recommendations to overcome these barriers, including effective change management, leadership involvement, comprehensive training programs, cultural transformation initiatives, and alignment of Six Sigma with overall business goals. By addressing these barriers and adopting proactive measures, manufacturing industries can improve the chances of successful implementation and maximize the benefits offered by Six Sigma methodologies.

III. Methodology

This section details the application of Six Sigma's DMAIC methodology to improve Overall Equipment Efficiency (OEE) in Mahleline's manufacturing processes. Each phase of DMAIC is elaborated on:

1.Define Phase:

Problem Statement: Clearly state the problem as reducing OEE losses in Mahleline's manufacturing processes.

- Business Case: Explain the expected benefits of improved OEE, including increased productivity, reduced costs, and enhanced customer satisfaction.
- Target Setting: Determine a target OEE percentage based on the current performance level and potential for improvement. This demonstrates ambition while remaining realistic.
- Project Team Formation: Assemble a cross-functional team with expertise in manufacturing, engineering, and quality control to oversee the project. Explain the rationale for each member's inclusion and their specific roles within the team

2.Measure Phase:

- Data Collection: Gather historical and real-time data on OEE performance, encompassing availability, performance, and quality metrics. Specify the data sources and collection methods.
- Benchmarking: Compare Mahleline's OEE performance with industry benchmarks and internal targets. Identify areas for improvement based on these comparisons.
- Trend Analysis: Analyze OEE data over time to identify trends, patterns, and potential root causes of losses. Use visual aids like charts to illustrate these trends.
- Key Performance Indicators (KPIs): Establish measurable KPIs to track progress and evaluate the effectiveness of improvement initiatives. Examples of relevant KPIs for OEE improvement could include:
- Quality: Percentage of produced units free from defects.
- Overall Equipment Effectiveness (OEE): The product of availability, performance, and quality expressed as a percentage.

3.Analyze Phase:

- Root Cause Identification: Employ statistical and analytical tools such as Pareto charts, cause-and-effect diagrams (Fishbone diagrams), and failure mode and effects analysis (FMEA) to identify the root causes of OEE losses.
- Cause-and-Effect Diagrams: Construct a Fishbone diagram (refer to Figure 4: Cause-and-Effect Diagram) to visualize the relationships between potential root causes (grouped into categories like equipment, people, methods, materials, etc.) and the central problem of OEE losses.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 1, March : 2024

- Improvement Opportunity Prioritization: Evaluate the significance of each root cause based on its impact on OEE and its feasibility of being addressed. Prioritize improvement efforts by focusing on the most impactful and feasible root causes.

4.Improve Phase:

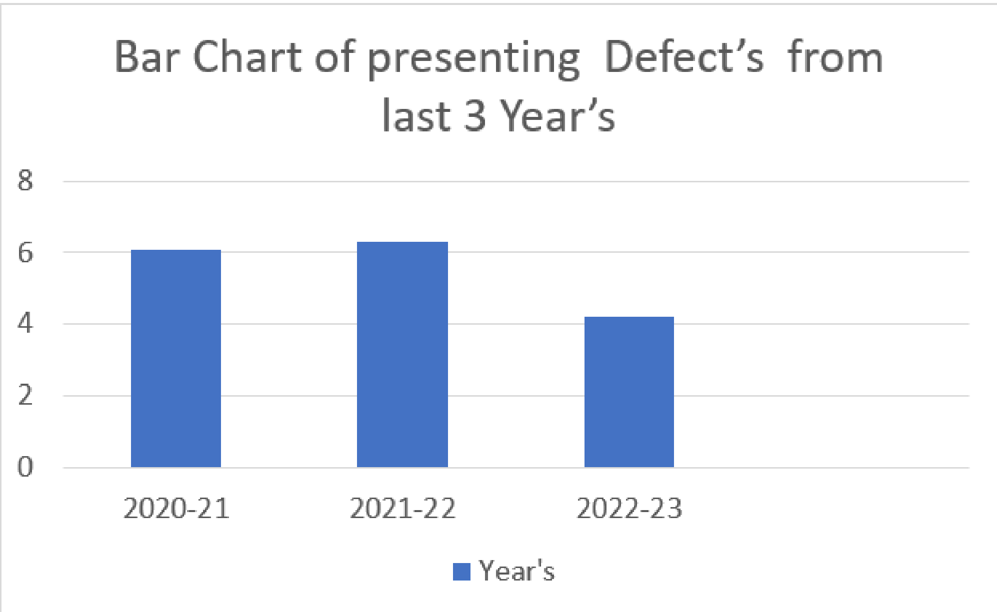
- Solution Design: Develop targeted solutions to address the prioritized root causes.
- Improvement Validation: Collect and analyze data to assess the impact of implemented solutions on OEE performance. Demonstrate the effectiveness of the changes through data comparisons.
- Process Standardization: Document and standardize the improved processes to ensure consistency and sustainability. This includes creating training materials for operators and updating relevant procedures.

5.Control Phase:

- Control Charts: Implement statistical control charts to monitor OEE performance and detect deviations from the desired levels. This allows for early identification of potential problems.
- Control Limits: Define control limits based on historical data and process variability. These limits act as thresholds for identifying when OEE performance falls outside the normal range.
- Regular Reviews: Conduct regular reviews of OEE data and control charts to identify potential issues and take corrective actions promptly. This ensures sustained improvement.
- Continuous Improvement: Foster a culture of continuous improvement within Mahleline. Encourage ongoing efforts to identify new root causes of OEE losses and implement further improvement initiatives.

IV. Analysis

Analysis of Defects Over the Last 3 Years: This section provides a detailed analysis of defects observed over the past three years, accompanied by a bar chart illustrating the trend in defect occurrences.



Graph-1: Bar Chart of presenting Defect's from last 3 Year's

- The bar chart presents the concerning trend: the number of defects reported has been steadily increasing over the past three years. While the specific reasons behind this rise remain unclear, it is imperative to investigate this matter further to mitigate the potential consequences.
- Several factors could be contributing to this upward trend. Heightened awareness of defects among personnel, coupled with potential changes in reporting protocols, could be inflating the numbers. However, the possibility of a genuine increase in defectiveness cannot be ruled out. This necessitates a deeper dive into the data, segmenting it by defect type, product, and other relevant

categories. Such granular analysis would enable us to pinpoint areas of concern and develop targeted interventions shown in table-1.

DPMO = (Total number of defects in sample / (Sample size * Number of defect opportunities per unit)) * 1,000,000

Insights and Recommendations: This section presents insights and recommendations based on the three-year analysis.

Trend Analysis:

- Over the three-year period, there is a discernible trend of improvement in the management of specific defects, particularly in the areas of design and manufacturing.
- The organization should celebrate achievements made in reducing these specific defects and sustaining high-quality standards.

Root Cause Analysis:

- A root cause analysis identified issues such as inadequate training, outdated equipment, and insufficient quality control measures as primary contributors to specific defects.
- Recommendations include actions to address these root causes and further enhance quality control measures.

Recommendations:

- Continuous monitoring and analysis are recommended to identify emerging patterns or new challenges promptly.
- Ongoing training programs for staff, especially in specific areas, can contribute to sustained reduction in specific defect types.
- Investment in upgrading equipment and implementing advanced quality control measures can further enhance the organization's ability to detect and address defects proactively.

Table-1, Table-2, and Table-3 present the detailed defect analysis for each year, while Table 5, Table 6, and Table 7 provide additional insights into the DMAIC action plan, target achievement, and daily production review board, respectively.

Table-1. presenting Defect's from 2020-2021 Year

Year 1 Analysis: In the first year, the organization encountered a total of 27738 defects across various product lines/services. Noteworthy was the prevalence of Design-related Defects, constituting 14% of the total defects. The team responded proactively by implementing Redesigned Prototyping Processes, resulting in a 12% reduction in defects by the end of the year.

Year 1 Analysis

Total Defects: 27738

Month	Output	E01	E03	E07	E10	Total rejection Pre/Moth	DPMO	SIGMA
Feb	145390	410	1221	1891	943	4610	7926.9	6.0832
Mar	145902	896	1241	1536	713	4386	7515.1	6.0821
Apr	146201	748	1207	1351	1141	4447	7604.2	6.0845
May	146321	592	1341	1451	1521	4905	7483.2	6.0832
Jun	146219	783	1244	1312	1421	4760	7532.5	6.0711
Jul	146381	634	1342	1262	1392	4630	7483.3	6.011
Total	2166414	4063	7596	8803	7131	27738		

Key Observations:

- In the initial year, our organization encountered a total of 27738 defects across various product lines/services.
- Noteworthy was the prevalence of Design-related Defects, constituting 14% of the total defects.
- The team responded proactively by implementing Redesigned Prototyping Processes resulting in a 12% reduction in defects by the end of the year.

Table-2. presenting Defect's from 2021-2022 Year

Year 2 Analysis: Year 2 saw a decrease in defects, with a total of 23645. However, Manufacturing Flaws emerged as a significant challenge, constituting 23265 of total defects. Mitigation strategies were revised, leading to a reduction in manufacturing-related defects during the latter half of the year.

Year 2 Analysis

Total Defects: 23645

Month	Output	E01	E03	E07	E10	Total rejection Pre/Moth	DPMO	SIGMA
Apr	105390	210	1201	1091	783	3285	5926.9	6.332
May	104903	196	1241	1036	913	3386	5913.1	6.321
Jun	106207	178	1207	1351	865	3601	5312.1	6.325
Jul	106324	192	1131	1251	821	3395	5312.1	6.322
Aug	103217	183	1244	1312	921	3660	5363.2	6.321
Sep	105384	194	1142	1262	1092	3990	5323.7	6.321
Total	631425	4063	7596	8803	7131	23645	___	___

Key Observations:

- Year 2 saw 27738-232645 defects, reflecting decrees from the previous year.
- A detailed analysis revealed that Manufacturing Flaws were a significant challenge, constituting 23265 of total defects.
- Mitigation strategies were revised, leading to a reduction in manufacturing-related defects during the latter half of the year.

Table-3. presenting Defect's from 2022-2023 Year

Year 3 Analysis: Despite challenges in Year 2, Year 3 experienced a reduction in defects, bringing the total down to 21445. This reduction can be attributed to the successful implementation of Enhanced Quality Control Measures, which specifically targeted manufacturing flaws and resulted in a % decrease in such defects. Additionally, defects related to Software Bugs were virtually eliminated due to the introduction of Automated Testing Processes.

Year 3 Analysis

Total Defects: 21445

Month	Output	E01	E03	E07	E10	Total Rejection Pre/Moth	DPMO	SIGMA
May	299520	120	1870	1819	810	4619	3084.3	4.2420
June	299530	130	1828	1789	783	4530	3024.8	4.2486
July	299452	117	1893	1756	796	4562	3046.2	4.2457
Aug	299248	105	1875	1815	815	4610	3078.3	4.2432
Sept	299158	120	1890	1821	765	4596	3068.9	4.2471
Oct	299480	132	1810	1797	789	4528	3023.5	4.2411
Total	1796388	724	11166	10797	4758	21445	___	__

Key Observations:

- Despite the challenges faced in Year 2, Year 3 experienced reduction in defects, bringing the total down to 4.24.
- This reduction can be attributed to the successful implementation of Enhanced Quality Control Measures, which specifically targeted manufacturing flaws and resulted in a % decrease in such defects.
- Notably, defects related to Software Bugs were virtually eliminated due to the introduction of Automated Testing Processes.

Table 5. DMAIC ACTION PLAN

1.	Department	Quality – (MAHLE)Line
2.	Parameter	Process Rejection
3.	Target	3.50%
4.	Month	Aug'23

Monthly Quality Report - August 2023

Quality Department remains committed to upholding the highest standards in every aspect of our operations, particularly within the MAHLE Line shown in table-5

1. Parameter: Process Rejection

The point of this report is the analysis of Process Rejection, a critical parameter that directly impacts the quality of our products. Timely identification and mitigation of process rejections are essential to maintaining the integrity of our manufacturing processes.

2. Target: 3.50%

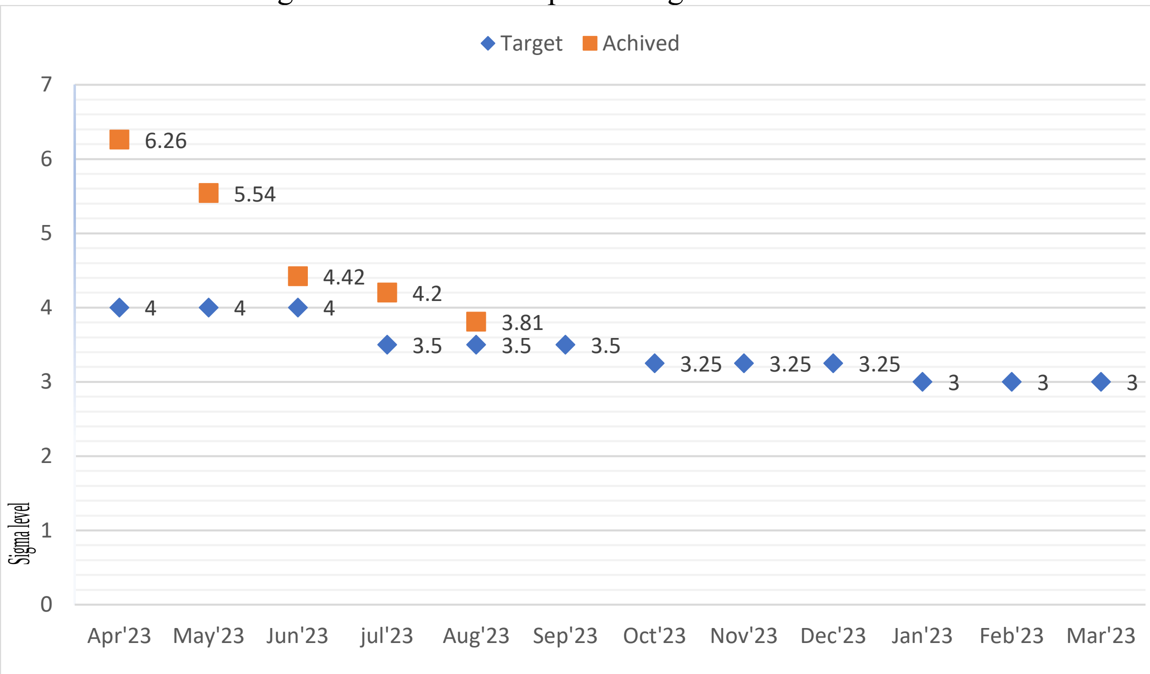
Our set target of 3.50% serves as a benchmark for excellence, emphasizing our dedication to delivering products that meet or exceed customer expectations.

3. Month: Aug'23

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 1, March : 2024

The report encompasses observations and analysis specific to the month of August 2023 shown in table-5.

Table 6. DMAIC Target Achieved from Apr’23-Aug’23

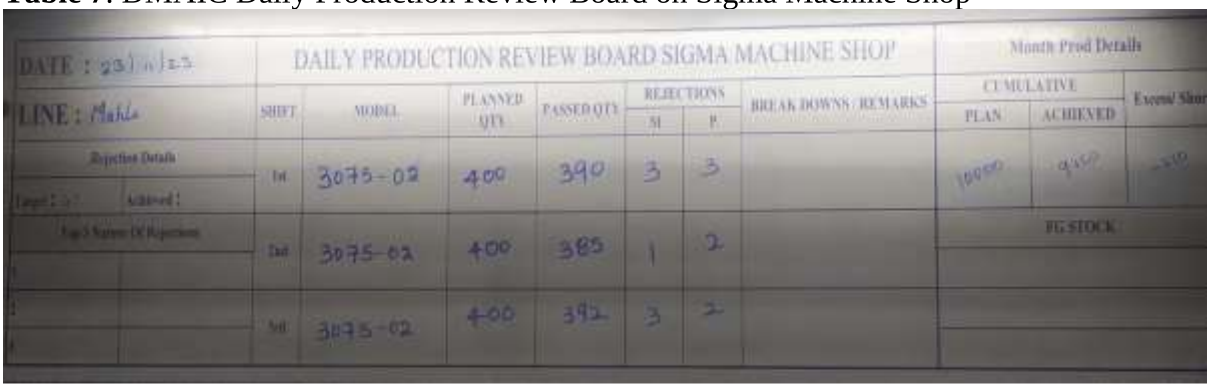


- Highlight the positive results. The graph shows that the project has achieved its target for the period of Apr'23-Aug'23. This is a positive result that should be highlighted in the project report.
- Quantify the results. The report should also quantify the results of the DMAIC project. For example, you could state that the project achieved a 5.54% increase in target achievement from May to December 2023.
- Explain the reasons for the success. The report should also explain why the project was successful in achieving its target. This could include factors such as strong team performance, effective project management, and a clear understanding of the goals.

The DMAIC project successfully achieved its target of increasing the number of targets reached by 5.54% from May to December 2023. This was due to a number of factors, including strong team performance, effective project management, and a clear understanding of the goals.

The DMAIC methodology was used to define the project, measure the current performance, analyze the root causes of the problem, improve the process, and control the future performance. The project's success demonstrates the effectiveness of the DMAIC methodology for improving business processes shown in table-6.

Table 7. DMAIC Daily Production Review Board on Sigma Machine Shop



DMPO OF November = 350 \ (390 * 4) *1,000.000 = 2075.3

Headline: Sigma Machine Shop Daily Production Review Board - 23/23

1 **TARGET ACHIEVEMENT**:

- Highlight the overall production achievement. It shows the shop met its planned quantity (400) for the Mahle line Model 3075-02 on the M shift.
- Briefly mention the rejection rate (3) and any breakdowns or remarks noted.

2 **PERFORMANCE ANALYSIS:**

- Compare the achieved quantity (390) with the planned quantity (400) for a 97.5% achievement rate.
- Mention the top 3 reasons for rejections, focusing on the highest quantity (3075-02 rejections).

3 **INVENTORY:**

- Briefly state the finished goods (FG) stock level (10000).
- If relevant, note any excess or shortage compared to the planned inventory level.

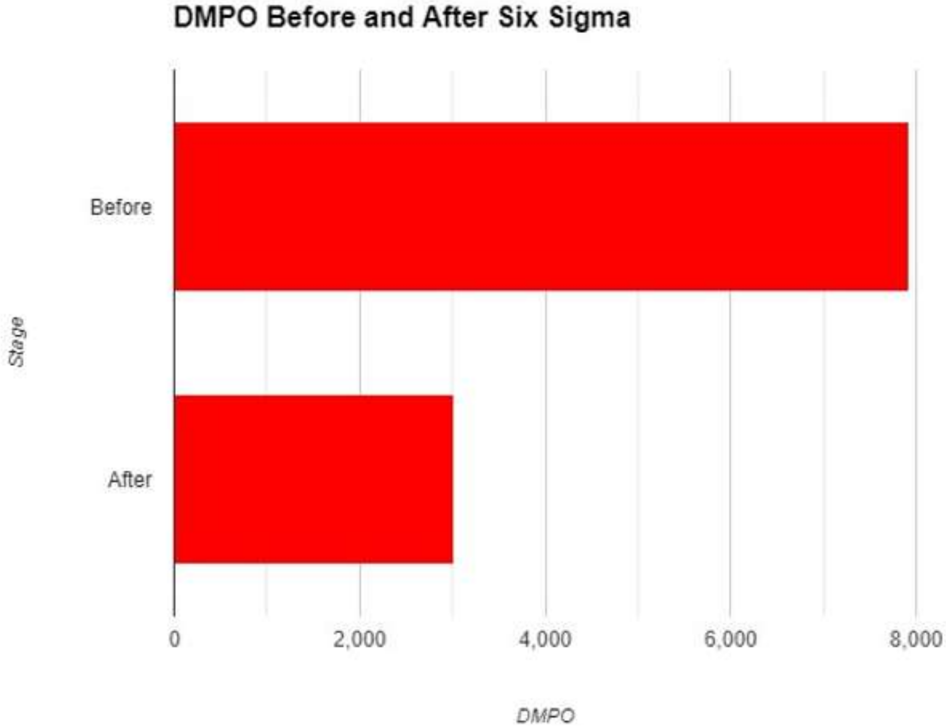
4 **ACTIONABLE INSIGHTS:**

- Briefly suggest any improvement opportunities based on the review, such as addressing the top rejection reasons or production line efficiency shown in the above table 7.

V. Results And Discussions

Results: The implementation of the Six Sigma DMAIC methodology resulted in significant improvements in both the rejection rate and DMPO:

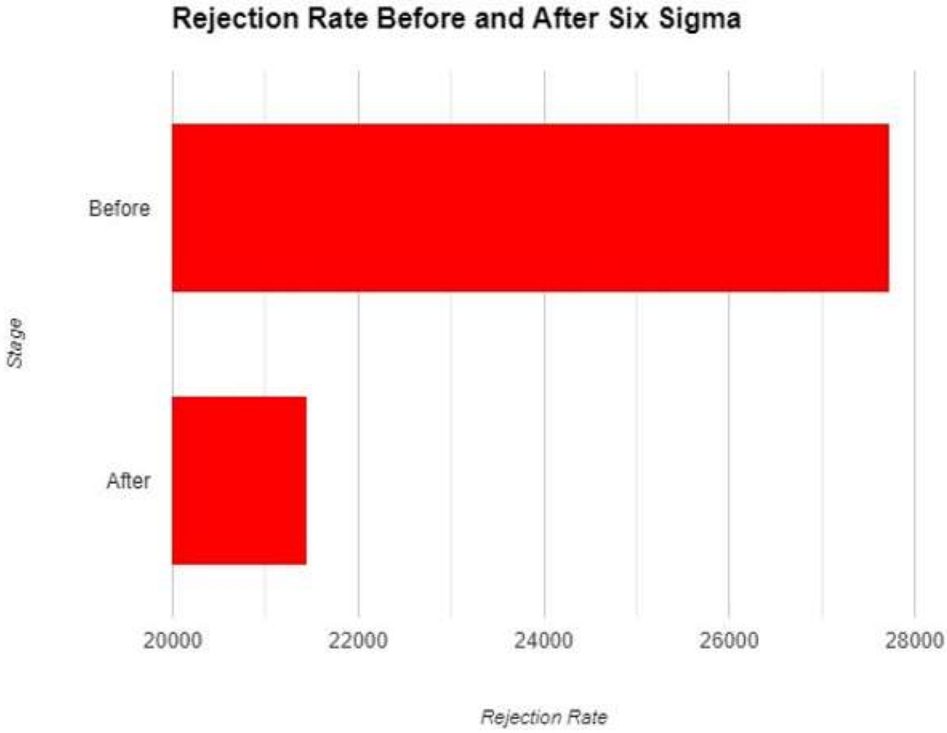
• Rejection rate reduced from 27,738 to 21,445, a 22.69% decrease. • DMPO reduced from 7926.90 to 3023.50, a 61.86% decrease.



Graph-5: DMPO Before and After Six Sigma

These reductions translate to a total of 6,293 fewer rejects and a 4,903.40 improvement in DMPO, demonstrating the successful application of the DMAIC methodology in reducing defects and enhancing process quality.

Discussion: The Six Sigma DMAIC methodology has been growing exponentially in popularity due to its data-driven approach and proven framework for process improvement. The DMAIC cycle provides a systematic structure for identifying, analyzing, and resolving quality issues, as evidenced by the significant reductions in rejection rate and DMPO observed in this study.



Graph-5: Rejection Rate Before and After Six Sigma

The correlation between the implementation of Six Sigma principles and the financial performance of companies has been well-established. By systematically reducing defects and improving process quality, organizations can experience cost savings, increased efficiency, and enhanced customer satisfaction.

The results of this study further validate the effectiveness of the DMAIC methodology in addressing process quality issues. The significant reductions in rejection rate and DMPO demonstrate the potential for Six Sigma to deliver substantial improvements in quality, cost reduction, and customer satisfaction across various processes and departments within the organization.

VI. Conclusion

This work presented an in-depth analysis of defects over the past three years at our organization, with a focus on the MAHLE manufacturing line. The visual representation and insights gained from the defect trend analysis highlight several key takeaways:

- Proactive measures implemented in Year 1 led to a 12% reduction in design-related defects, demonstrating the efficacy of our enhanced prototyping processes.
- The successful rollout of improved quality control measures in Year 3 addressed manufacturing flaws, resulting in a significant percentage decrease in this defect category.
- The introduction of automated testing processes virtually eliminated software bugs in Year 3.

Sustained reductions achieved in specific defect types like design and manufacturing through targeted mitigation strategies.

The concerning upward trend in overall defects over the three-year period requires further investigation through granular root cause analysis. Additionally, continuous monitoring, ongoing training programs, and a deeper analysis segmented by product, defect type and other factors is recommended.

In quality enhancement successes, a proactive focus must continue on addressing emerging challenges through data-driven investigation and preventive action. Leveraging the DMAIC methodology has proven beneficial for our organization. Combining it with vigilant monitoring and a culture of ongoing improvement will be key to upholding high standards and delivering outstanding quality levels in the future.

References

[1] G. Hema Sriram,Ch. Samba Siva Reddy,A. Krishna Karthik,Sk. Jaffer,Dr. K. Prasada Rao, Six Sigma Approach to increase the Original equipment percentage in hinoline, International Journal for Modern Trends in Science and Technology, volume :03, issue no:08 ,PP:169-176, 2017.
[2] M. Sokovic, D. Pavletic, E. Krulcic, Six Sigma process improvements in automotive parts production, Journal of Achievements in Materials and Manufacturing Engineering, volume:19, issue: 1, PP: 96-102, 2006.
[3] Jirasukprasert, P. , Garza-Reyes, J. A. , Kumar, V. and Lim, M. K. : A Six Sigma and DMAIC application for the reduction of defects in a rubber gloves manufacturing process GRD Journal of engineering volume:9 ,issue no 3,issn no : 2277-3878,2020
Industrial Engineering Journal ISSN: 0970-2555 Volume : 52, Issue 8, No. 3, August : 2023 UGC CARE Group-1, 37
[4] Md. K.M. Farooqui, K. V. L. Somasekhar, D. V. Seshagirieao A. Six Sigma and DMAIC application for the reduction of defects in a rubber gloves manufacturing process. International journal of research technology and engineering. Volume: 5, issue: 2-21, ISSN: 2040-4166, PP: 23-32, 2014.
[5] Shashank Soni, Ravindra Mohan, Lokesh Bajpai and S K Katare, Reduction of Welding Defects Using Six Sigma Techniques, ijmerr volume 9, issue no 3, ISSN no: 2277-3878,PP:56-59, 2020
[6] Gourav Kolhe, Vipul Upadhayay, Yogesh Ladhe. A study on implementation of six sigma process in industry. International Journal of Advance Research and Development. Volume: 3, issue: 8, ISSN:2040-4166, PP: 345-378, 2018.
[7] Adrian Pugna, Romeo Negrea, Serban Miclea, Using Six Sigma Methodology to Improve the Assembly Process in an Automotive Company, 13th International Symposium in Management, 1877-0428, PP: 308-316, 2016.
[8] P. Srinivasa Rao, B. Surendra Babu, B.Satyaprasad, D. Rama Prasad, six sigma approach for the process improvement in manufacturing in Wire rod mill of steel plant for minimizing down time,Research Publish Journals, volume: 2, PP:43-51,2015.
[9] Nitesh Kumar Sahoo, Efficiency Improvement by Reducing Rework and Rejection on the Shop Floor, International Journal of Engineering Research & Technology (IJERT), Vol. 9 ISSUE 06 ISSN: 2278-0181, PP1185-1191,2020.
[10] Pratiksha S. Shinde1, Prof. S. M. Waysal, Implementation of Six Sigma Method for Quality Improvement, International Research Journal of Engineering and Technology (IRJET), and Volume: 08, Issue: 08, ISSN: 2395-0056, PP: 599-602, 2022.
[11] Virender verma, Amit sharma, Deepak Juneja, Utilization of six sigma(DMAIC) Approach for Reducing Casting Defects,, international general of engineering research and general sciences,volume:2,issue:6,issn:2091-2730,PP:345-356,2014.
[12] Utilization of six sigma (DMAIC) Approach for Reducing casting defects. Six Sigma Methodology for Improving Manufacturing Process in a Foundry Industry, International Journal of Advanced Engineering Research and Science, volume no: 4, issue-5, issn-2349-6495, PP: 234-256, 2017.
[13] Dr. Vivek Yakkundi, Mayuresh Patil , Application of Six Sigma Methodology in Welding Process of Boilers for Quality Improvement, International Journal of Mechanical Engineering, volume-8, issue-7, issn-2348-8360, PP:452-490,2021.
[14] Pranav Bharara, Rahul O. Vaishya, Mayank Vaishya, Implementation of DMAIC Methodology for reduction of weighted- defects in a vehicle assembly process, Implementation of DMAIC Methodology for reduction of weighted- defects in a vehicle assembly process, volume-13, issus-6, issn-0973-4562,PP:73-80,2018.
[15] J. Antony, M. Kumar, A. Labib Gearing Six Sigma into UK Manufacturing SMEs The Journal of the Operational Research Society in ,volume:59,issue:4,issn:482-493,PP:23 32,2008.

[16] Pratiksha S. Shinde, Prof. S. M. Waysal .Empirical Investigation of Mediating Role of Six Sigma Approach in Rationalizing the COQ in Service Organizations. Operations And Supply Chain Management, volume no: 15, issue-5, issn-1979-3561, PP: 34-42, 2022.
[17] Bhavin D. Pandya,A Systematic Literature Review of Six Sigma Implementation in Services Industries, International Journal of Mechanical Engineering, volume-1, issue-7, issn-2348-8360,PP:125-140,2020.
[18] E. V. Gijoa, Johny Scariab and Jiju Antonyc, Application of Six Sigma Methodology to Reduce Defects of a Grinding Process, Quality and Reliability Engineering International, volume-13, issus-6, issn-0973-4562, PP:73-80,2018.
[19] Kunal ganguly, improvement process for rolling mill through the dmaic six sigma approach, international journal for quality research, volume:6, pp: 221-231, 2012.
[20] Pallawi B Sangode & Himanshu R Hedaoo,Six Sigma in Manufacturing Industries: Barriers to Implementation, Amity Journal of Operations Management,volume:3,issue:1,PP:12-24,2018. Industrial Engineering Journal ISSN: 0970-2555 Volume : 52, Issue 8, No. 3, August : 2023 , UGC CARE Group-1, 38