"Streamlining Operations: the 7 Quality Control Tools and Their Impact on Defect Reduction"

Vandit Buch, Jalpa Zalawadia and Prashant Singh Tomar

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1st Vandit D Buch
Department of Mechanical Engineering
Parul Institute of Engineering & Technology
Vadodara,India
2203052080001@paruluniversity.ac.in

2nd Jalpa Zalawadia
Department of Mechanical Engineering
Parul Institute of Engineering & Technology
Vadodara,India
jalpa.zalawadia@paruluniversity.ac.in

3rd Prashant Tomar
Department of Mechanical Engineering
Parul Institute of Engineering & Technology
Vadodara,India
Prashantsingh.tomar@paruluniversity.ac.in

***Abstract*— The utilization of seven Quality Control (QC) methodologies for defect reduction in the manufacturing business is examined in this study report. To better understand how important quality management is to both operational effectiveness and customer satisfaction, the study investigates how manufacturing processes might use techniques like Pareto analysis, Ishikawa diagrams, and control charts. The article illustrates the usefulness of these techniques in locating, evaluating, and reducing flaws across the production cycle with the use of actual case studies. The results demonstrate a transformative influence on product quality and organizational effectiveness, with notable increases in defect reduction. The report also presents a thorough framework with fifteen main goals, including improved defect discovery, standardized procedures, and quantitative measures. A culture of continuous improvement is promoted by the purposeful use of QC tools, with the goals of continued defect reduction, cost savings, and increased customer satisfaction. This study offers insightful information and a useful road map for businesses looking to achieve operational excellence by implementing QC tools.**

Keywords*— Pareto Analysis, Fishbone Diagrams (Ishikawa Diagrams), Control Charts, Histograms, Scatter Diagrams, 7 Quality Control Tools, DMAIC, SIPOC, Root Cause Analysis, Failure Mode, and Effects Analysis

I. INTRODUCTION

This study examines the application of the seven-quality control (QC) tools for defect identification and reduction across a variety of industries, with an emphasis on the Pareto Chart and Fishbone Diagram. The seven quality control tools provide a methodical way to find, examine, and reduce flaws in various operations. Based on the Pareto Principle, the Pareto Chart helps prioritize problems by emphasizing the critical few elements that have the biggest impact on defects. The Fishbone Diagram, also known as the Ishikawa Diagram, on the other hand, allows for a thorough examination of contributing elements by offering a visual depiction of explanations for a particular issue.

We will examine real-world applications, and useful implementations of these tools throughout this essay. We hope to demonstrate the usefulness of the Pareto Chart and Fishbone Diagram in defect identification and reduction, giving businesses insightful information to improve their quality control tactics.

As the foundation of organizational success, quality control is essential to operations in a variety of industries. Sustaining growth and reputation requires delivering high-quality products and services in a competitive environment where consumer expectations are rising. In operations, quality control refers to the systematic administration of procedures, goods, and services to fulfill or beyond established standards, ensuring dependability, consistency, and client pleasure.

In this context, using the 7- QC instruments are essential for every firm hoping to improve its quality management procedures. These instruments, created by the pioneers of quality management, offer an organized and thorough method for locating, evaluating, and reducing flaws in operational procedures. Every instrument adds a different viewpoint to the quality control procedure, which enhances the overall efficacy of continuous improvement and defect prevention.

II. LITERATURE REVIEW

Nikunj Parmar et al aims to review research work done by several researchers on quality management using the 7 QC tools in manufacturing industries to improve product quality. The author wants to provide an easy introduction to the 7 QC tools and their systematic use in manufacturing processes to enhance the quality level. The author conducts a literature survey to review different quality tools used in small-scale industries and emphasizes the importance of QC tools. The author concludes that most industries use the 7 QC tools because they are simple and effective, leading to improvements in quality, productivity, and profitability.[1]

Siti Holifahtus Sakdiyah et al emphasis on timely and precise information is essential for making decisions as it forms the basis for handling problems effectively and achieving organizational goals. To support accurate decision-making, the importance of appropriate data integration and trustworthy information from all divisions within a corporation is emphasized. The application of Root Cause Analysis (RCA) is described as a procedure that helps businesses avoid future failures by locating and understanding the fundamental causes of issues. Though it may require more time for deliberation and decision-making, the text recognizes the value of brainstorming as a technique to gather a variety of ideas and solutions for problem-solving. The significance of analytical and systematic thinking in decision-making is also highlighted, with an initial emphasis on determining the problem's core cause.[2].

Mr. Shajil Kumar P A et al aim to identify the several reasons for non-fee payment in college tuition fees during the Covid-19 pandemic period using a Causal Loop Diagram and Pareto Chart. They analyze the impact of the pandemic on educational institutions in India and the difficulties faced by student stakeholders in completing their tuition fees. The authors use the Causal Loop Diagram to visualize the interrelationships and cause-and-effect processes between different variables and the Pareto Chart to determine the relative importance of these variables. They find that financial issues due to the pandemic and the inability to access physical facilities and infrastructure are major reasons for non-fee payment. The authors suggest implementing effective fee installment methods and taking significant managerial steps to collect fees from students who are unwilling to pay.[3]

Novan Bastian et al highlights the shortcomings of J Corp's present internal audit planning process, pointing to the lack of a comprehensive, step-by-step protocol, inadequate documentation, and difficulties internal auditors have in identifying important risks and organizing their work. It emphasizes how important it is for internal auditors to have a deep grasp of the business and suggests collaborating with researchers to improve the procedure. It emphasizes how crucial documentation is to the internal audit planning process and how it helps auditors identify risks, evaluate internal controls, and put improvements into place.[4]

Khairun Nadiyah et al research focuses on the examination and correction of product flaws at SP Aluminum, a manufacturer that specializes in kitchenware. The study uses five quality control techniques—flowchart, check sheets, p-chart, Pareto diagram, and fishbone diagram—to accomplish this purpose. Super Wok Number 12 collects and uses a variety of methods to assess data on product problems. The intensity category of product defects is determined by the check sheet analysis; out-of-control data is identified by the control chart analysis; the most common types of defects are highlighted by the Pareto diagram analysis; and common causes of product defects are identified by the fishbone diagram. The report emphasizes the value of ongoing quality improvement and supports the detection and correction of product flaws through the application of quality control instruments. There is a focus on the ongoing need for companies to enhance their performance by minimizing defects and ensuring consistent product quality.[5]

Gheorghe Ilie et al focuses on the usage of the Fishbone diagram, commonly known as the Ishikawa diagram, to evaluate the risk of occurrences having many causes is examined in this research. It clarifies how effective the Fishbone diagram is at identifying and classifying the root causes of various problems that organizations face, such quality problems also there is a proposal in the paper to expand the range of applications for the Fishbone diagram. This entails integrating effect concerns and probabilities into the analysis. The suggested modification makes it possible to calculate risk scores for each cause category and to thoroughly assess total risk in relation to the phenomena under study by integrating these variables.[6].

A.A.A.H.E. Perera et al focusses on an automated powder filling and packing process, this research aims to identify the sources or categories of waste resulting from raw materials while investigating the underlying factors that contribute to this waste. To maintain product consistency, monitoring and control procedures have been put in place with the goal of cutting waste.[7].

Badiatud Durroh et al aims to evaluate the quality control of tea products at PT Candi Loka, addressing concerns that have been detected, comprehending the elements that impact tea quality, and suggesting ways to improve the quality of tea production. The study uses a qualitative technique in conjunction with a descriptive strategy. Fishbone charts, Pareto charts, check sheets, and stratification are all used in data analysis. With an emphasis on pekoe goods specifically, the Pareto diagram illustrates quality differences in dry tea items from March 2022.[8].

Hibarkah Kurnia et al focuses to lower the cost of cleaning agent purchases in an Indonesian paint manufacturing company by combining lean thinking with A3 problem-solving techniques. The corporation spent a lot of money on imported cleaning chemicals, according to their investigation into the unnecessary expenses related to buying cleaning supplies. The cost of buying cleaning supplies was lowered by 97.71% by the authors using lean thinking and the A3 problem-solving technique. Toyota frequently employs the A3 method, which offers a methodical and thorough approach to problem-solving. To find the underlying reasons of the issue, the authors also used the Fishbone Analysis tool to do root cause analysis. Both qualitative and quantitative methods are used in the study.[9].

Mario Coccia et al focuses of general-purpose technologies (GPTs) are methodically identified and analyzed in this research using a visual aid called the Fishbone diagram. The conceptual framework emphasizes the use of the Fishbone diagram in illustrating the interconnected drivers of complex technologies as it examines the persistent drivers of GPTs over time and geography. The figure illustrates GPTs, which are impacted by a variety of events, to help comprehend their origin and development. According to the study, determinants of GPTs are innate characteristics of human societies that support long-term human progress by serving as strategic hubs for a range of goods and activities. It also emphasizes how important coherence and simplicity are to the theoretical foundation of GPTs. And the goal is to provide insights into the factors that influence GPTs' regularity and determinants.[10]

Yudha Adi Kusuma et al discuss the problem of subpar products in the sugar industry and suggest methods for quality management. To evaluate and reduce manufacturing problems, they use fishbone diagrams, failure mode and effect analysis (FMEA), and control charts (p- and u-charts). The readings on the control chart show that the process of producing sugar is under control. While the FMEA detects high-risk sub-factors including operational neglect, subpar sugar cane sorting, timetable changes, incomplete repair areas, and unorganized layouts, the fishbone diagram is used to identify defect causes. The authors suggest developing standard operating procedures (SOP) and considering changes in raw material handling based on the data processing results to increase the quality of sugar production.[11].

Norhairin Mohd Saad et al study to promote Lean Product and Process Development (Lean PPD) in a knowledge-based environment by proposing a new A3 thinking method to problem-solving. With this method, the design team may understand the relationship between theory and practice and gather scientific knowledge in an organized manner. To gather best practices, obstacles to knowledge capture, and processes of problem-solving techniques, the authors performed an industrial field survey among designers and engineers in European manufacturing businesses. To overcome the shortcomings of the methods used in problem-solving today, the A3 thinking approach is suggested. It encourages designers to record and illustrate the knowledge that is generated when an issue is solved. Improving decision-making, stopping recurrence, and boosting product innovation are the objectives for following projects.[12].

S J S Velu et al focuses on using quality management techniques, the article addresses the first pass yield (FPY) metric's stagnating performance at ABC Semiconductor's manufacturing floor and suggests creative alternatives. The main goals are to identify effective corrective measures by applying the DMAIC technique and examining the causes behind the existing performance. The authors emphasize the significance of control in maintaining the process to minimize variation and defects and use the 7QC tools technique, notably failure pareto analysis, to identify and mitigate pre-identified failure modes. Minitab and full factorial design are two statistical techniques used to examine data and find important independent variables affecting yield losses. The application of Lean Six Sigma goals, waste detection, and removal on the manufacturing floor are also highlighted in the report. The findings show a noteworthy reduction in yield loss, from 17.4% to 3.52%, through the application of the Lean Six Sigma DMAIC approach.[13].

Eirin Loodgaard et al suggests a novel way to improve the product design process by fusing the A3 method of problem-solving with Failure Modes and Effects Analysis (FMEA). The authors contend that while the traditional FMEA method has its flaws, using FMEA alone is not enough to achieve effective improvement. It is feasible to conduct a deeper root cause analysis of prioritized issues during risk reduction by combining FMEA with the A3 approach of problem-solving. Toyota's A3 technique is praised for its capacity to clearly and illustratively convey problems that need to be solved, promoting efficient communication and decision-making. According to the authors, A3 thinking can solve flaws and traps in the FMEA procedure and offer a more practical tool for project reporting, particularly when dealing with lengthy projects. Together, the combined approach is positioned as a comprehensive strategy to achieve quality and reliability improvement in the product design process.[14].

Imdad Ali Memon et al refers to identify and reduce faults in the paint shop, the article presents a case study of the application of the Seven Quality Control (7QC) tools in an automotive manufacturing. At first, the plant had only used a portion of the tools, which produced subpar outcomes. Then, it was decided that the main goal would be to comprehend how each of the seven quality control techniques is implemented and to use them all thoroughly. To demonstrate process capability and variation levels, the article emphasizes the use of Histograms (QC tool 3), which has led to a notable decrease in paint defects. A key component of data collection was the use of check sheets (QC tool 2), which marked instances of defects and concentrated on attribute data between November 2015 and February 2016. To sum up, the purpose of the paper is to demonstrate the efficacy of applying the 7QC tools in controlling and reducing defects within the paint shop of an automotive factory.[15].

RanYan et al especially address the problems of over-drying of thin plates and impermeable drying of thick plates during combined drying of workpieces with varying thicknesses in their attempt to design suitable curing process parameters for powder coating. Additionally, they use differential scanning calorimetry (DSC) to study the ideal powder coating curing temperature range and create a test plan to ascertain the powder coating curing duration within this temperature range.[16].

Naol Dessalegn Dejene et al focuses on reduction of injection molding defects and increase overall equipment effectiveness (OEE). To systematically identify and analyze faults, the authors offer a combination technique that uses a hybrid Pareto chart and the Failure Mode and Effects Analysis (FMEA) methodology. The goal of the study is to improve the quality of the finished product by removing flaws from the injection molding process. It focuses on seeing faults, comprehending how they affect the finished product, and investigating the root causes behind these failures. The study also identifies key process variables that affect how PVC material behaves and offers mitigation strategies for errors. The study offers a detailed methodology.[17]

III. FINDINGS

A. Pareto Chart

- Known for its ability to prioritize problems by highlighting the most important few contributing components.
- Highlighted in literature for its ease of use and capacity to direct resource allocation decisions for optimal impact.

B. Fishbone Diagram

- Well-known for its ability to graphically depict problem underlying causes.
- Its use in fostering methodical approaches to problem-solving and facilitating cross-functional interactions is frequently highlighted in literature.

C. Root Cause Analysis

- Highlighted as an essential phase in processes for quality enhancement.
- Stresses how critical it is to locate and deal with the underlying causes of flaws or problems.

D. Failure Mode and Effects Analysis (FMEA)

- Often praised for its methodical evaluation of potential failure modes and their effects, FMEA takes an initiative-taking approach to risk assessment.
- Literature often discusses its application in preventing defects before they occur.

E. Histograms

- Recognized for their contribution to the visual representation of data distributions.
- Emphasized in the literature as a tool to help find trends, variances, and patterns in a dataset.

F. Measure, Analyze, Improve, Control, or DMAIC

- key to the Six Sigma methodology, which is well-known in the literature for its organized and evidence-based approach to process optimization.
- emphasizes how crucial it is to set control systems, measure essential elements of the project, analyze data, and implement adjustments.

G. The Lean Principles:

- The use of lean concepts, such as cutting waste, streamlining procedures, and boosting productivity, is frequently covered in literature.

- places a strong emphasis on client value and a mindset of continual improvement.

H. A3 Method for Solving Problems

- Acknowledged for taking a clear and systematic approach to problem-solving.
- The use of it to show information on an A3 sheet of paper is frequently discussed in literature, encouraging.

Overall, the literature highlights the necessity of an integrated, holistic strategy that frequently combines different quality control (QC) technologies to successfully manage quality concerns, minimize errors, and improve overall process performance. The precise conclusions might change depending on the sector, the setting, and how the literature on quality management develops. For the most updated information, always consult the most recent and pertinent sources.

IV. PROBLEM IDENTIFICATION

We have identified significant issues within our cup wheel production process, manifesting as various defects that compromise both product quality and operational efficiency. Our objective is to tackle these challenges strategically by employing Pareto charts as a tactical tool for defect analysis and resolution. Specifically, we aim to develop a Pareto chart that delineates the frequency and significance of different types of defects in cup wheel manufacturing. This visual representation will enable us to prioritize the most impactful flaws, which account for a substantial portion of quality issues. By focusing our improvement efforts on addressing these high-impact problems through targeted projects and resource allocation, we anticipate a notable enhancement in product quality, reduction in waste, and overall efficiency gains within the cup wheel value stream.

V. SCOPE AND OBJECTIVES OF RESEARCH WORK

The principal aims of this investigation are to methodically detect and classify flaws within the cup wheel value stream, with a particular emphasis on hook marks and their consequences for product excellence. The objective is to prioritize defects by using Pareto charts as a data analysis tool to identify key issues that require immediate attention. To address the underlying causes of quality problems, the study also aims to perform a thorough root cause analysis to understand why hook marks and other faults develop. To apply efficient Quality Control (QC) procedures and achieve the best outcomes, the exploration also entails identifying common factors that can facilitate reduction. Thorough literature reviews are essential to the study because they provide insightful information that helps to define the general goals of the research.

VI. SUPPLIES AND TECHNIQUES

The method of gathering data started with a thorough assessment of the value stream, which involved frequent visits and careful data entry on PPM data sheets. Defects found by visual inspections were carefully categorized into three groups: segment shifting, hook marks, and destructive testing. Defects that had an immediate effect on the product received special attention. To address and alleviate these problems, a monthly form was created expressly for using the cause-and-effect diagram technique to pinpoint the core reasons of faults. This technique showed to be especially successful in lowering hook mark flaws. Over the course of four months, data was collected consistently using the same structured methodology and PPM datasheet layout.

VII. TRIALS AND RESULTS

APPLICATION OF 7 QC TOOLS

1) Pareto Analysis:

- Derived from the Pareto Principle, this tool emphasizes focusing on the vital few factors that contribute significantly to defects, enabling organizations to prioritize and address the most impactful issues first.
- A Pareto chart is employed to analyze and prioritize the top three defects over a span of three months October(as shown in Fig.1),November(as shown in Fig.2) and December(as shown in Fig.3). The pareto charts are displayed below.

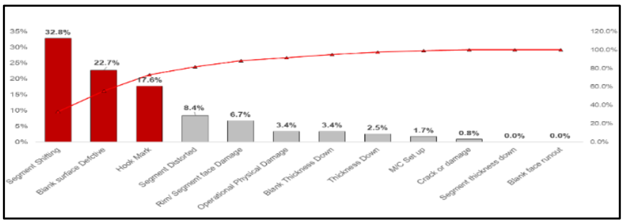

Fig. 1 Rejection Pareto Chart for October Month

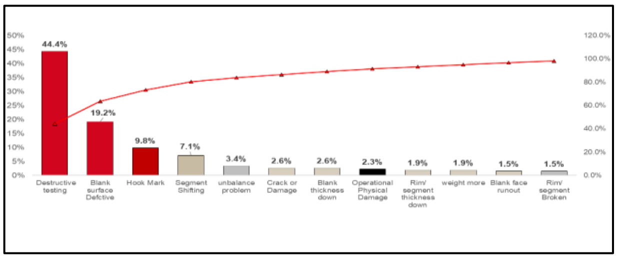

Fig. 2 Rejection Pareto Chart for November Month

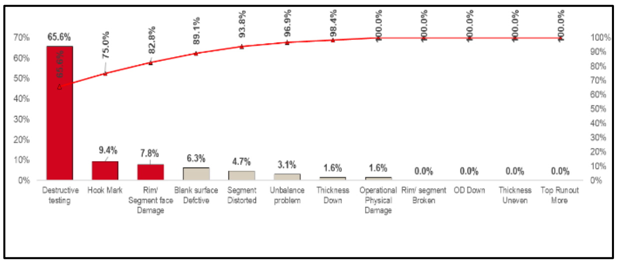

Fig. 3 Rejection Pareto Chart for December Month

2) Ishikawa (Fishbone) Diagram

- Used for root cause analysis, the Fishbone Diagram(as shown in Fig.4) visually represents potential causes of defects, facilitating a systematic exploration of contributing factors and aiding in problem-solving.
- A fishbone diagram was used as a methodical tool to address and remove hook mark problems in the cup wheel production process. The fishbone diagram, sometimes referred to as an Ishikawa or cause-and-effect diagram, made it easier to pinpoint the underlying causes of hook marks in an organized manner. Fishbone diagrams with their primary categories or "bones" represented elements including

personnel, material, equipment, process, and environment.

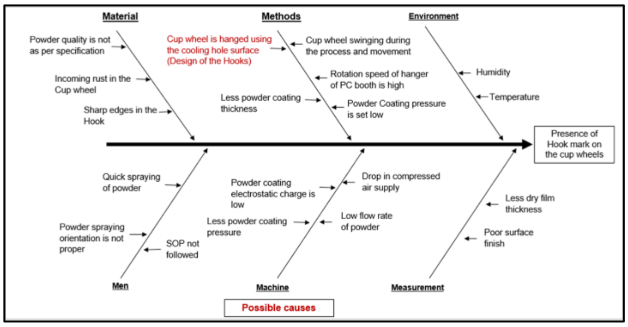

Fig. 4 Root Cause Analysis

Within these categories, team members engaged in the production process worked together to visually map out the sources of hook mark problems. The team was able to identify specific elements contributing to the flaws by using the fishbone diagram, which methodically explored and analyzed each potential cause. This cooperative strategy promoted a thorough comprehension of the underlying issues, facilitating the creation of focused remedies for defect reduction.

3) Histogram

- A graphical representation of data distribution, histograms provide insights into the frequency and patterns of defects, aiding in the identification of areas for improvement.
- Histogram (as shown in Fig.5) shows the monthly frequency of defect occurrences from November 2024 to February 2024 was represented graphically in the depiction.

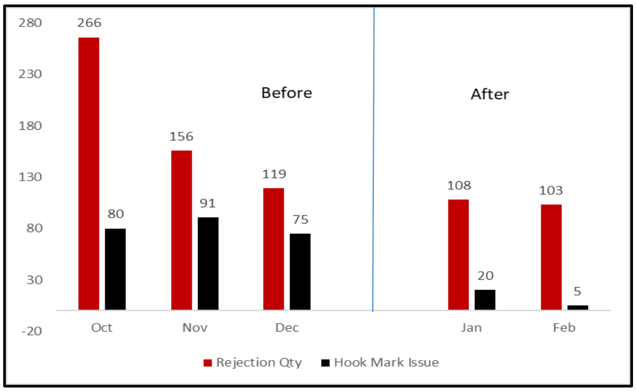

Fig. 5 Rejection Frequency

Table 1-Rejection Frequency

Month	Rejection Qty	Hook Mark Rej	Percentage
Oct	266	80	80%
Nov	156	91	91%
Dec	119	75	75%
Jan	108	20	20%
Feb	103	5	5%

Usage and maste0072y of these seven-quality control (QC) technologies enable firms to proactively address difficulties, improve operational efficiency, and achieve higher levels of quality and customer satisfaction as they traverse the complexity of current business environments.

VIII. CONCLUSION

This study focused on implementing the 7QC tools for reducing defects in a cup wheel manufacturing facility. The initial phase involved creating a flow chart and designing check sheets for data collection at various inspection points. Notably, higher frequency defects were identified in November and December 2024. Through the application of the cause-and-effect diagram, a substantial reduction in defects was achieved. By the fourth month (February 2024), total defects decreased by (86 Nos), dropping from (91) in the first month to 5. Each quality control tool played a significant role in defect reduction, with the cause-and-effect diagram proving particularly instrumental in identifying and addressing root causes. This study contributes by shedding light on potential defects and errors impacting production within the cup wheel manufacturing industry.

We have primarily focused on leveraging three of the seven basic quality control (QC) tools: the Fishbone (Cause-and-Effect) Diagram, Pareto Chart, and Histogram. These tools were specifically selected to address the complexities inherent in the cup wheel production process and to facilitate a comprehensive analysis of defects and quality issues.

Among the top three defects highlighted in the Pareto chart, the hook mark issue has been successfully addressed through conducted trials, showcasing a tangible resolution. However, it is noted that the remaining two defects are currently undergoing the process of resolution, indicating that their mitigation strategies are in progress. This conclusion underscores the effectiveness of employing Pareto analysis as a proactive defect identification tool, enabling targeted interventions to improve product quality and operational efficiency. As efforts continue to address the remaining defects, it is anticipated that our focused improvement projects will lead to sustained enhancements throughout the cup wheel value stream, ultimately resulting in optimized production outcomes.

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