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"APPLICATION OF QUALITY MANAGEMENT TOOLS FOR ENHANCING PRODUCT QUALITY AND OPERATIONAL EFFICIENCY IN THE RIM MANUFACTURING SECTOR"

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ABSTRACT
This study identifies how quality management tools can develop product quality and operational efficiency within the rim industry manufacturing sector—determining, analyzing, and rectifying key defects on the rims using some quality tools: Pareto charts, Ishikawa diagrams, and Trend Charts. They are predominantly used to evaluate scratches, edge bends, weld spatter, and misalignments. Using such tools, the current study successfully finds the root causes of inefficiencies and provides an environment for continuous improvement. The results illustrate how focused quality management activities greatly impact product reliability and customer satisfaction while reducing waste and production costs. Such a study is of extreme benefit for implementing quality control in similar industries; it contributes to research and actual advances in quality management.

KEYWORDS: -
Quality tools, Pareto Charts, Ishikawa diagrams, reduction in waste and cost.

1. INTRODUCTION
In today's competitive manufacturing landscape, effective quality management is crucial for maintaining product standards, reducing waste, and improving customer satisfaction. Quality management tools (QMT) are essential for organizations to identify and address defects, thereby streamlining production processes systematically. This research examines the use of QMT in the rim manufacturing industry, which frequently encounters issues like corrosion, misalignment, and surface scratches that can affect product reliability and operational efficiency.
This study explores the application of key QMT, such as Pareto charts, Fishbone diagrams, Check sheets, and Trend charts, to analyze and tackle significant defects in rim production. By pinpointing the root causes of inefficiencies, these tools provide valuable insights for improvement and promote a culture of ongoing enhancement. The goal of this paper is to illustrate how these QMT applications can not only lower defect rates and production costs but also elevate the overall quality of products, benefiting both manufacturers and consumers. The findings offer a detailed case study on quality management practices in industrial settings, especially for industries looking for effective, data-driven solutions to quality issues.

2. LITERATURE REVIEW
The purpose of this research is to study the application and effectiveness of quality control (QC) tools in Indian industries with ISO9001 certification. The main aim will be to study literature on the application of QC tools in these certified industries, mostly about how they can improve manufacturing processes and reduce defects, ultimately aiming at achieving a quality level. Through the years, various types of research have shown that QC tools play a vital role in defect reduction, process enhancement, and quality improvement. Table 1 shows key findings from the literature.

Table 1 Key findings of authors from the literature

Author(s)	Year	Industry/Application	Key Findings

Deepak, D., & Dhingra, D.	2013	Bicycle Industry	Implementing quality control tools like Pareto analysis significantly reduced defects, improving overall product quality.
Arya, S., Bhargava, M., & Singh, M. P.	2019	Bearing Industry	Quality tools identified the main causes of defects, including improper material handling, leading to corrective actions.
Erdhianto, Y.	2021	Sugar Packaging	Use of the seven tools method reduced packaging defects, especially related to sealing and labeling issues.
Sutrisno, B.	2022	General (Systematic Literature Review)	Highlighted the versatility of the seven tools across industries and their role in identifying and mitigating defects.
Sjarifudin, D., & Kurnia, H.	2022	Garment Industry (Men's Jackets)	PDCA combined with the seven tools method improved quality by addressing sewing and fabric-cutting errors.
Sambodo, P., & Cahyana, A. S.	2022	Manufacturing (CV. XYZ)	Quality Control Circle and seven tools identified key defect sources, leading to targeted process improvements.
Widodo, E., Hariyanto, A. L., & Haryudiniarti, A. N.	2023	Lubricant Bottles	Analysis using the seven tools method resolved leakage issues in 800ml bottles, enhancing product reliability.
Safitri, W., Sutrimo, A., Huda, M., & Erdi	2023	Honeycomb Board Machines	Seven tools methodology reduced defect rates in production by identifying process inefficiencies and material issues.
Mayuki, M., Lengkono, H. P., Chandra, J., & Sriwidadi, T.	2024	Printing Industry (CV. XYZ)	Implementation of seven tools minimized print alignment defects, leading to enhanced product consistency.
Rahma Dana, A. R., & Donorianto, D. S.	2024	Safety Belt Production	Seven tools method identified key causes of defects, such as machine settings, enabling a reduction in faulty products.

This research extends these findings, investigating a case study in an Indian industry context on the use of QC tools to address and prevent quality issues, thereby achieving broader goals of defect minimization and process improvement.

3. RESEARCH METHODOLOGY

1. Identify the problem
2. Collect data
3. Data analysis
4. Implement countermeasures

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5. Conclusion

3.1 Identification of Problem: - In the past year, the rim manufacturing department of Company XYZ has reported a tremendous number of defects. The main kinds of defects observed include corrosion, dents on the discs, hole misalignment, and scratches. All these reoccurrences in defects suggest inefficient production procedures and, consequently, the need for systemic improvement.
3.2 Collect Data: - The rejection data has been collected from the XYZ Company using daily inspection reports and rearranging the data defect-wise.
3.3 Data Analysis: - Two Quality tools namely a Check Sheet and a Pareto chart have been used for data analysis in the study.
3.4 Implement Counter Measures: - This research paper will employ trend analysis and fishbone diagrams as key tools for problem-solving.
3.5 Result/Conclusion: - Based on the research and data analysis provided by XYZ Company, this study will conclude the issues and countermeasures related to defects produced in rim manufacturing.

4. PROBLEM ANALYSIS

The paper presents actionable insights into quality management in manufacturing by analyzing 12 specific defect types that impact product integrity and customer satisfaction, including corrosion, improper hole alignment, and weld quality issues.
The study highlights the integration of various Quality Management Tools (QMTs), such as Pareto analysis and Statistical Process Control (SPC), demonstrating their individual and combined effectiveness in identifying and prioritizing critical quality issues.
Furthermore, the research underscores the importance of fostering a culture of continuous improvement and leveraging data-driven decision-making as foundational strategies for achieving competitive advantage in the manufacturing sector

Table 2 Production Data of industry

Name of Defect and Number of defectives Month wise.	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24
Corrosion	125	112	88	72	93	66	33	34	42	55	23	88
Dent on Disc	397	321	182	371	203	820	544	390	198	263	355	230
Incorrect hole allignment	116	75	71	88	45	57	32	81	77	39	40	23
Poor weld quality	204	160	201	134	122	168	100	65	142	58	150	72
Scratch	806	655	714	600	523	546	410	356	245	299	378	346
Rim Runout	65	55	61	34	45	61	71	44	39	28	53	37

Weld Spatter	168	433	281	399	288	622	420	370	352	431	620	321
Paint Run Out	188	160	44	172	199	209	302	288	299	302	172	201
Burr and sharp edges	900	625	712	342	294	256	188	170	155	136	166	121
Edges bend	426	322	823	502	289	310	366	622	549	789	334	433
Incorrect disc position	124	55	29	31	92	18	16	74	35	63	43	22
Grinding marks	320	272	234	291	302	236	233	196	155	140	170	163

The data presented in Table 2 outlines the manufacturing output for the period from July 2023 to June 2024, totaling 130,050 units. While the production volume demonstrates the plant's capacity for large-scale manufacturing, quality issues remain a significant challenge, with 34,281 defective units recorded during the same period. This translates to an average defect rate of approximately 26.35%, indicating that nearly one in four units produced exhibited some form of defect.

The defects identified include issues such as corrosion, dents, misalignments, and welding faults, highlighting critical gaps in quality control processes. These findings underscore an urgent need for enhanced quality management practices and process optimization to address these shortcomings effectively.

4.1 Prioritizing the Problem: - A Pareto analysis is initiated by identifying a problem area to focus on. First, it requires an accurate definition of the problem or particular area to be improved upon. Upon defining the problem, data collection takes place to gather relevant information regarding the causes or factors that are contributing to the problem. After collecting data, the subsequent step is to classify and categorize the data by type of cause or issue. The categories are listed in descending order of significance based on their frequency or impact. Several factors contributing the most are sought to solve the problem (Table 3). Once the causes are grouped, calculate the cumulative percent for each to determine how each is contributing to the larger problem. This can help you identify which small set of causes is responsible for the biggest portion of the problem.

Table 3 Cumulative Percentage

Name of Defect	Frequency	Cumulative frequency	Cumulative Percentage (%)
Scratch	5878	5878	17.15
Edges bend	5765	11643	33.96
Weld Spatter	4705	16348	47.69
Dent on Disc	4274	20622	60.16
Burr and sharp edges	4065	24687	72.01
Grinding marks	2712	27399	79.92
Paint Run Out	2536	29935	87.32
Poor weld quality	1576	31511	91.92
Corrosion	831	32342	94.34
Incorrect hole alignment	744	33086	96.51

Incorrect disc position	602	33688	98.27
Rim Runout	593	34281	100
	34281		

A Pareto chart is a visual representation of the data with each cause represented as a bar to represent how frequently each cause is serving as the reason and a line graph to show your cumulative percentage. The "vital few" causes usually appear on the left-hand side of the chart, accounting for most of the problem. The purpose of such analysis is to focus engineers on solving the critical issues, as their resolution will bring the most significant improvement.

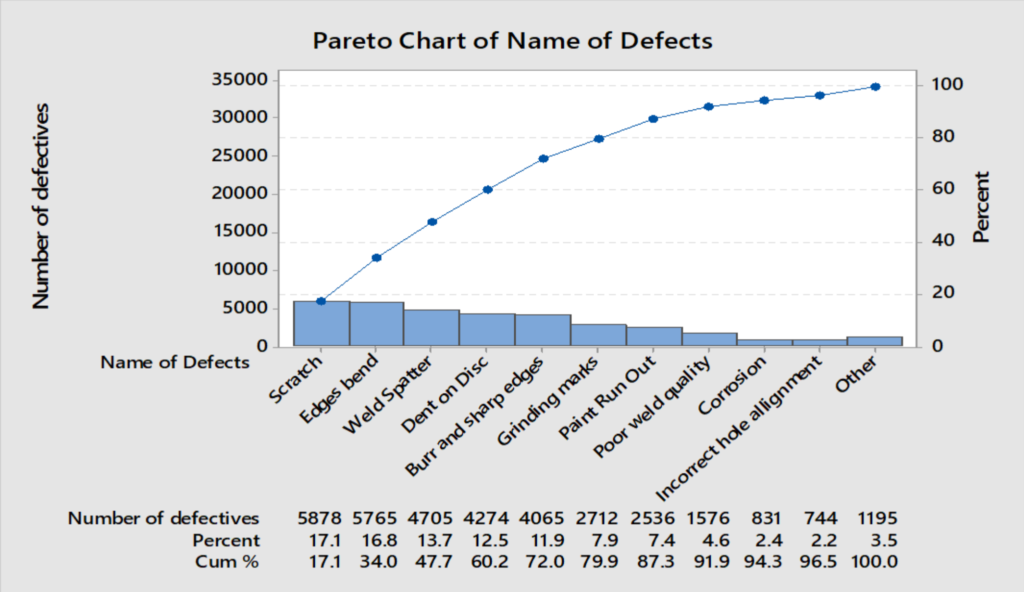

Figure 1 Pareto Chart

Based on the analysis, it can be concluded that Scratches, Edges bend, Weld spatter, dent on Disc, and Burr & Sharp edges, these defects account for approximately 72% of the total defects. By effectively addressing and controlling these key issues, we can significantly improve the production rate and substantially reduce the defect rate.

Based on the Pareto chart results, we will now carry out a trend analysis of the five defects that have been prioritized, followed by an individual trend analysis for each defect. Next, we will construct a fishbone diagram based on a structured brainstorming session guided by these trend analyses.

4.2 Trend Analysis: - Trend analysis is the reviewing of historical data to identify patterns or trends in the quality of products or processes that are over time. This method keeps an organization proactive in its handling of quality control because it detects deviations from the expected performance, giving room for correction before a problem occurs. We will conduct the trend analysis of Scratches, Edges bend, Weld spatter, dents on Disc and Burr & Sharp edges over the past 12 months (1 Year).

4.2.1 Trend Analysis of Scratches

The trend analysis plot for Scratch defects, indexed over 12 months, contains a fitted Linear Trend Model:

$Yt = 782.3 - 45.00 \times t$

This reduces to $Yt = 782.3 - 45.00 \times t$ meaning that there has been a reduction of 45 defects per time unit, with an initial defect count of 782.3. MAPE 15.7%, MAD 60.56, and MSD 4845.72, indicating modest prediction deviations. The chart is trending downwards, which would indicate reductions in defect reduction. However, variations from Months 6 to 12 reflect inconsistencies that need further scrutiny. Root cause analysis shall follow with a fishbone diagram to discern the factors that contribute to these variations.

Here is the Fishbone diagram for "scratches" on the rim, illustrating the various factors that can contribute to scratch defects during the manufacturing process.

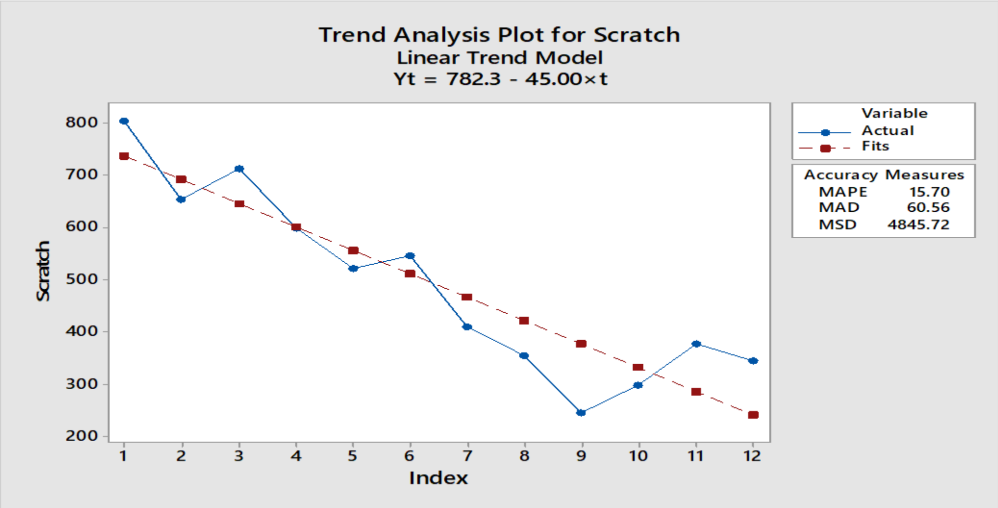

Figure 2 Trend Analysis of Scratch

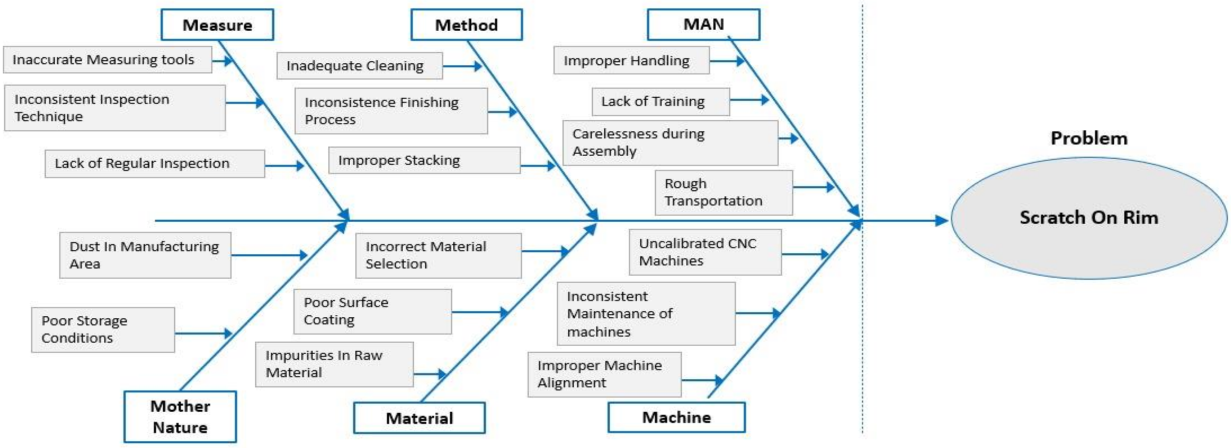

Figure 3 Fishbone diagram of Scratches on the rim

From the analysis of this fishbone diagram, it is noted that specific contributors to rim scratches in manufacturing are found and identified as areas of needed solutions. Human factors are issues such as mishandling and lack of training, which can be addressed by thorough programs to ensure proper assembly and transport and instill a culture of diligence and responsibility in workers. The machine-related issues, which include misalignment, are minimized by routine CNC machine calibration and maintenance to guarantee consistency in performance. Improvements in methodology, such as a strict protocol for cleaning, stacking, and handling of rims, will enhance uniformity and reduce scratches. Material factors can be further mitigated by strengthening quality control in the process of selecting the right material and proper surface coatings of the rims to avoid scratches that may be caused by impurities or inadequate protection. Implementing these solutions across human, machine, method, and material would effectively reduce scratches on the rims, improving product quality and customer satisfaction.

4.2.2 Trend Analysis of Edges Bend

The trend analysis for "Edges bend" defects is mostly variable with time, having the linear model

Yt = 452+4.3×t

which presents a small upward trend by 4.3 units per index, showing small increases in defects over time. Some key observations would be huge fluctuations on indices 3, 9, and 10, together with drops at 6 and 11, to show inconsistency, which can be as a result of irregular production factors. The fitted trend is almost flat and does not capture the high variability; the measures of high accuracy errors, such as MAPE at 32.2%, MAD at 146.1, and MSD at 30,470.3, are indicative of a poor fit. Major anomalies in the data series, like the spike at index 3 and the drop at index 6, also reflect potential changes in process or operation. Further research using root cause analysis or fishbone diagramming is scheduled to determine the causes.

Here is the Fishbone diagram for "Edges Bend" on the rim, illustrating the various factors that can contribute to defects during the manufacturing process.

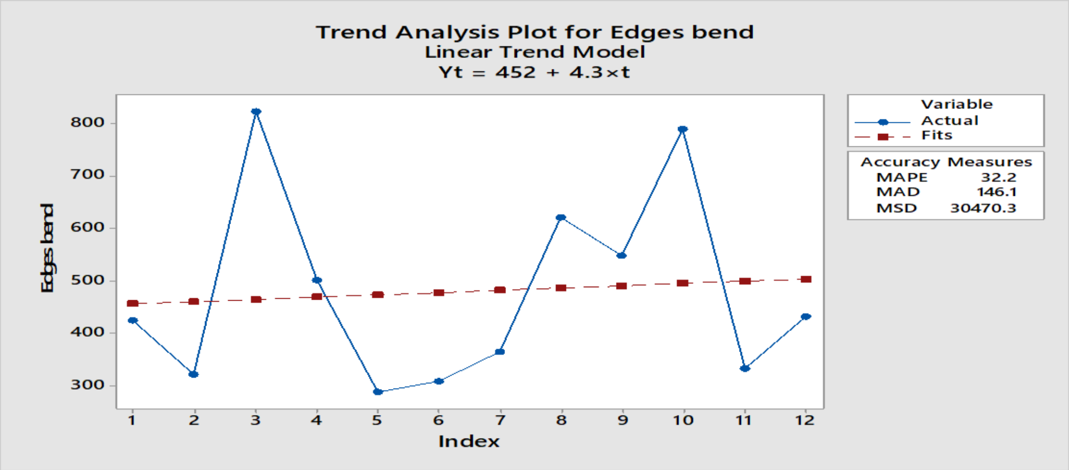

Figure 4 Trend analysis of Edges bend

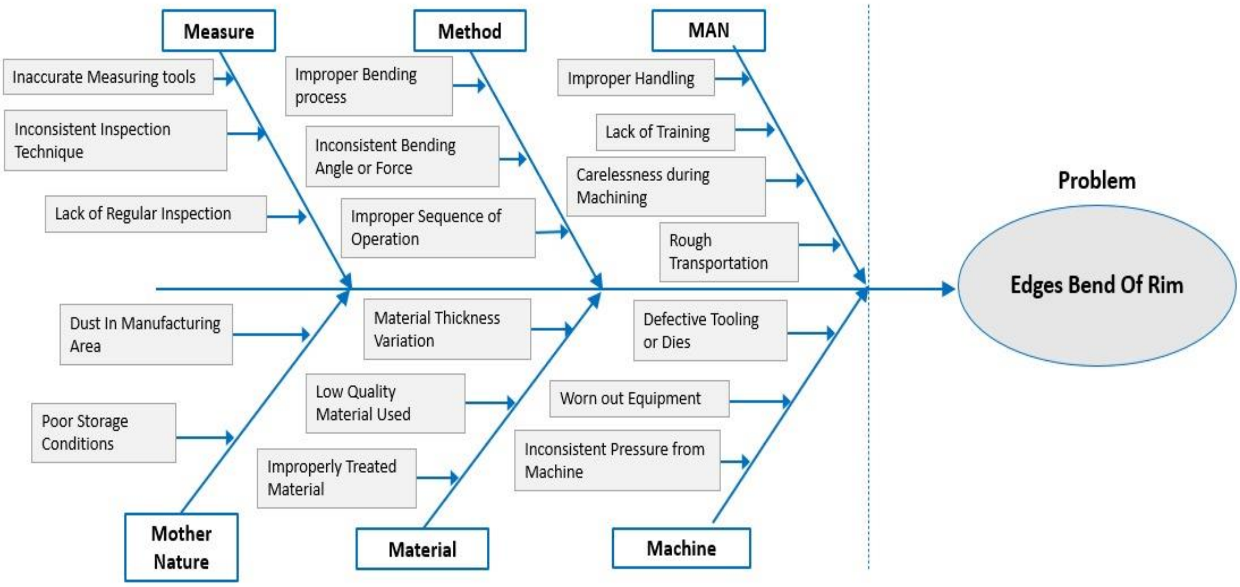

Figure 5 Fishbone diagram of Edges bend

The analysis of this fishbone diagram identifies the key factors that cause edge bending defects in rim manufacturing: a holistic approach is therefore necessary. Under "Man," improvement in the education of the worker in handling and machining reduces the errors in rim manufacturing. For "Machine," calibration, maintenance, and proper replacement of equipment ensure that pressure and performance are stable. In "Method," standardization of angles and sequences of bending reduces defects. Material-related defects can be minimized through quality control, proper material selection, uniform thickness, and close collaboration with suppliers. To have better defect detection, the "Measure" category suggests regular calibration and a constant inspection schedule. Lastly, under "Mother Nature," a clean storage environment and cleanliness protocols will protect materials from contaminants, thus minimizing defects. All these focused improvements across all categories could heavily reduce edge-bending defects. Therefore, overall quality improved.

4.2.3 Trend Analysis of Weld Spatters

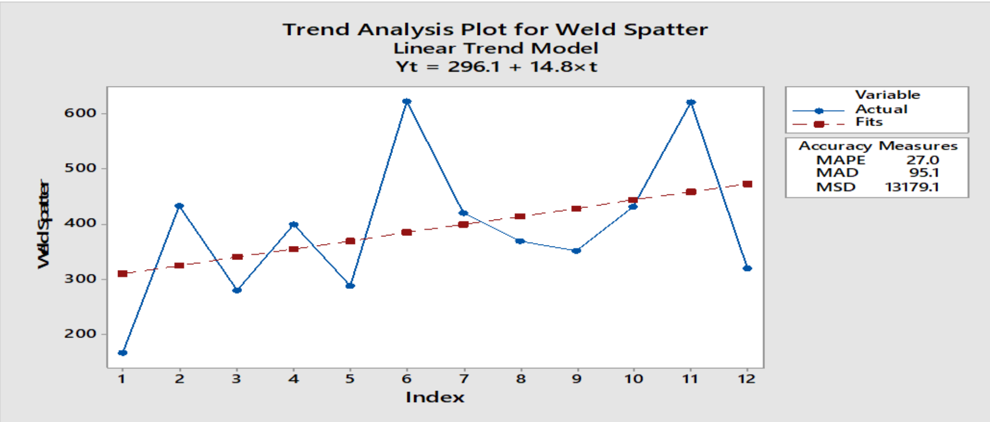

Figure 6 Trend analysis of Weld spatters

The Trend Analysis Plot for Weld Spatter is a curve that has an upward trend with a linear model Yt = 296.1+14.8t, shows an increase of 14.8 units per period. The data, however, is very volatile with peaks at Index 6 and 10 and troughs at Index 12, which the fitted trend fails to reproduce. The key accuracy metrics are MAPE: 27%; MAD: 95.1; MSD: 13,179.1, and in general, there is deviation, majorly spikes, and troughs. From this cyclic pattern of the data, the external or periodic sources may cause the factors under which these weld spatter levels take place. These non-linear fluctuations show more complex patterns, meaning further modeling techniques are needed. Such fluctuation in weld spatter will be further analyzed based on a fishbone diagram and root cause investigation.

Here is the Fishbone diagram for "Weld Spatters" on the rim, illustrating the various factors that can contribute to defects during the manufacturing process.

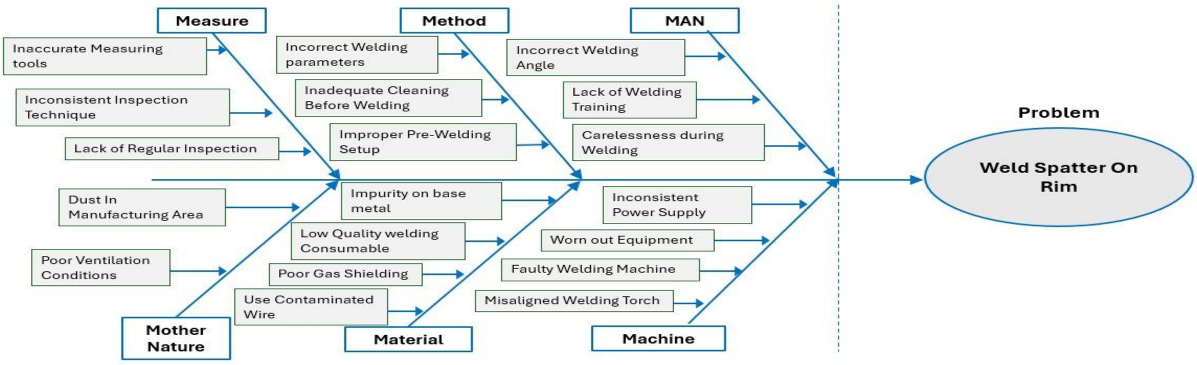

Figure 7 Fishbone diagram of Weld spatters

The major contributors to welding spatter on rims, according to the analysis of the fishbone diagram, should be approached holistically to reduce the defects. In the "Man" category, proper training for welders on angles and careful welding can reduce human errors. For "Machine" factors, maintaining a steady power supply, regular servicing of equipment, and timely replacement of worn parts will improve performance and reduce defects. This will ensure the consistency of the welding process by controlling "Method" problems through standard welding parameters and pre-welding arrangements. In the "Material" side, quality control measures must be strictly observed, while coordination with suppliers is in place to get only quality materials. Better "Measure" practice through standardized tools and periodic checks will catch the potential problem early. Lastly, "Mother Nature" can be controlled through cleanliness protocol and protective storage that prevent contamination, further minimizing spatter defects due to welding. Such integrated application of these strategies will improve the overall weld quality, thus minimizing spatter.

4.2.4 Trend Analysis of Dent on Disc

This trend analysis of dents on disc of the rim has a linear regression model showing that the frequency of dents decreases as time progresses, using the equation

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Y t = 391−5.4×t where the negative slope of -5.4 indicates the steady drop in the number of dents. In the chart, actual versus fitted values for the blue actual data line show the red dashed fitted trend. Deviation has been huge, mainly in two points: 6 and 7, with peaking around 800 after which the curve shows the decline. Accuracy measures -MAPE (38.2), MAD (121.5), and MSD (29,494.5) suggest moderate to high variation because a model cannot capture variations wholly, particularly around peaks observed at points 6 and 7. It could represent the effect of outside elements, like manufacturing and quality issues, causing periodic rises in dents. In short, this trend analysis indicates the likelihood of defect reduction. Analyzing the root causes will be tackled with a fishbone diagram and brainstorming to identify key factors for spikes in dent occurrences.
Here is the Fishbone diagram for "Dents on Disc" on the rim, illustrating the various factors that can contribute to defects during the manufacturing process.

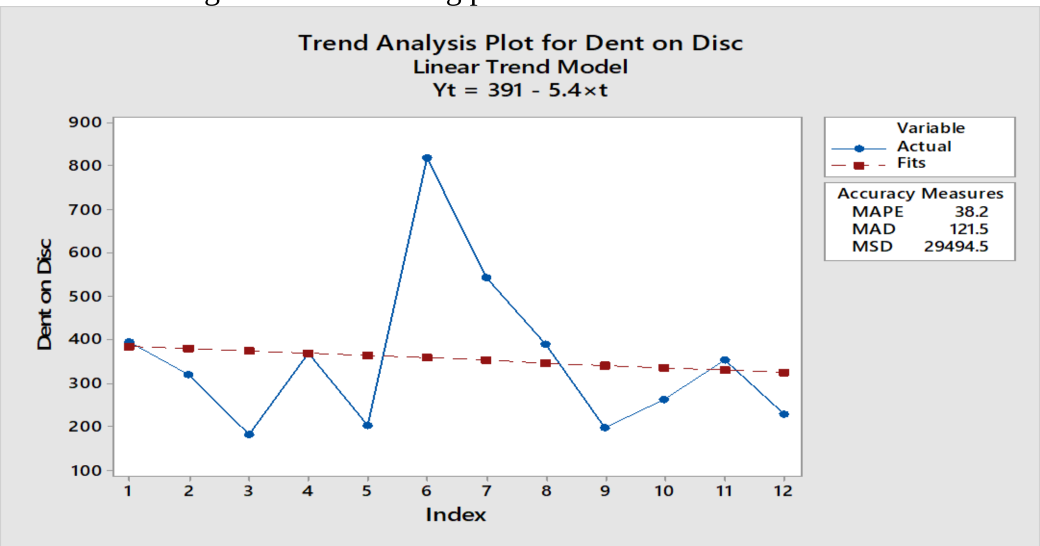

Figure 8 Trend Analysis of Dent on disc

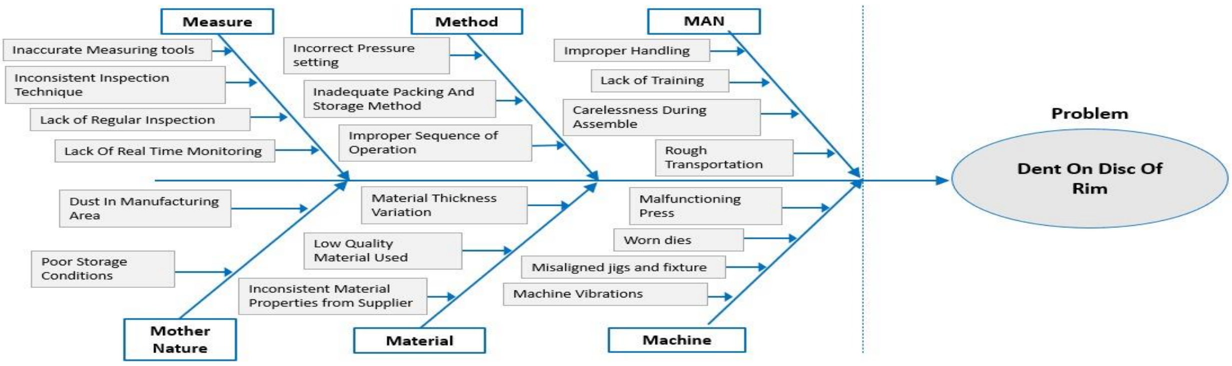

Figure 9 Fishbone diagram of Dent on disc

The analysis of the fishbone diagram indicated that the dents at the rim of the discs during the manufacturing process were caused by key factors as follows: The improvement measures needed to be focused there. For Man, human errors like mishandling and carelessness are mitigated through training programs that are upgraded in the production line. Machine problems demand proper maintenance, calibration, and replacement at the right times to guarantee reliability and decrease malfunctions. Method concerns need to have rigid protocols for sequences of operations, proper pressure setting, and better packaging to avoid defects. In Material control, proper quality checks and supplier relationships that ensure material thickness uniformity can avoid dents. In the Measurements aspect, regular calibration of measuring instruments and regular inspection schedules will improve the detection of defects. Lastly, by controlling Mother Nature factors, organized storage and cleanliness protocols prevent dents caused by dust or contaminants. All of these steps comprise a comprehensive approach to reducing defects in disc rims.

4.2.5 Trend Analysis of Burr & Sharp Edges

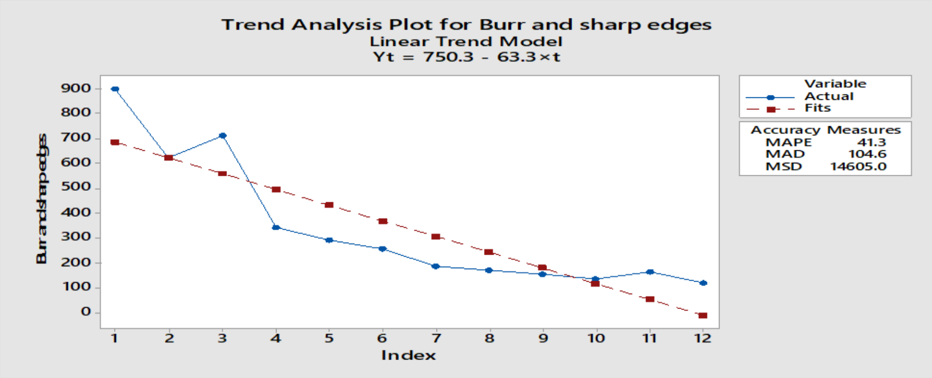

Figure 10 Trend Analysis of Burr & Sharp edges

Burr and sharp edges trend analysis follows a linear model defined by the equation as Yt=750.3−63.3×t, meaning that there is a steady decline at about 63.3 defects per time index. The graph demonstrates that from 750 defects, the negative slope of the line represents the reduction with time. The accuracy measures in the result reflect a moderate error in the prediction. For example, MAPE was at 41.3%, MAD was at 104.6, and MSD was at 14,605, meaning that there is a variability in the accuracy of the result. Observed values first above the predictions (Indexes 1-3), then below (Indexes 4-7), and lastly values fluctuate around the trend line, signifying stabilization. Overall, the trend is one of improvement in defect reduction; however, further analysis would be recommended to address the early spikes and maintain the downward trend, which means that the corrective actions do have a positive impact. Analyzing the root causes will be tackled with a fishbone diagram and brainstorming to identify key factors for spikes in dent occurrences.

Here is the Fishbone diagram for “Burr & Sharp edges” on the rim, illustrating the various factors that can contribute to defects during the manufacturing process.

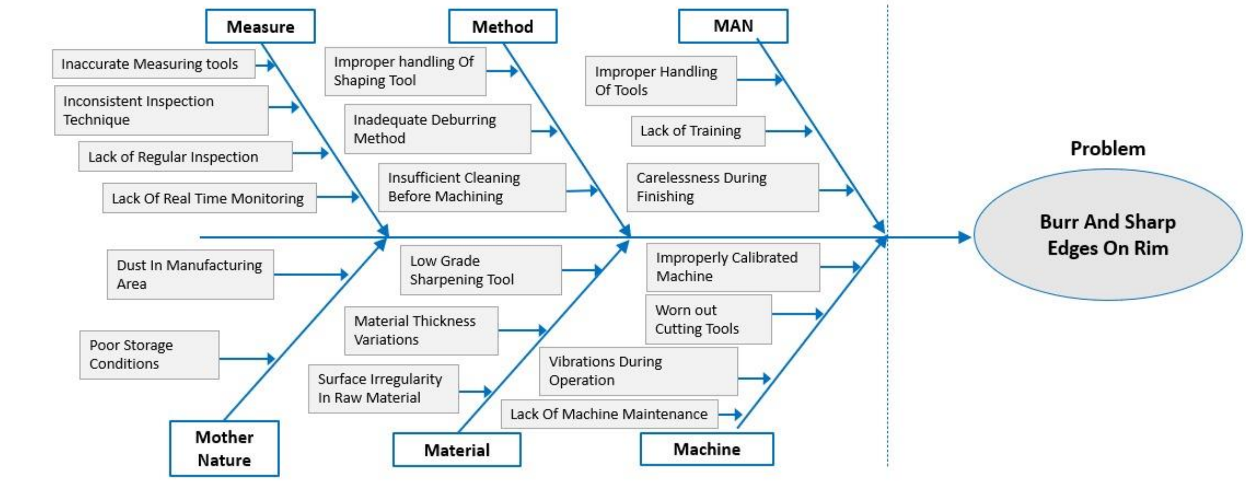

Figure 11 Fishbone diagram of Burr & Sharp edges

The fishbone diagram analysis identifies key factors contributing to burrs and sharp edges on rims during manufacturing, highlighting the need for a structured approach. In the Man category, enhanced worker training in tool handling and finishing techniques is essential to reduce human errors. For Machine issues, regular calibration, maintenance, and replacement of worn tools, along with minimizing machine vibrations, are critical for precision. Addressing Method concerns involves establishing standardized procedures for sharpening, burring, and cleaning processes to ensure consistency. Improving Material control through quality checks on raw materials and consistent

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supplier collaborations helps reduce defects. In the Measure category, frequent calibration of inspection tools and a consistent inspection schedule enhance early defect detection. Lastly, Mother Nature factors can be managed by maintaining clean storage environments to prevent environmental contaminants from affecting rim quality. Together, these targeted actions can significantly reduce burr and sharp edge defects, improving overall product quality and manufacturing efficiency.

5. RESULT/DISCUSSION

In this rim manufacturing case study, quality control tools were used to analyze the defects; it was then discovered that scratches, edges bend, weld spatters, dents on discs, and burrs and sharp edges are 72% of all defects. Thereafter, using the approach of root cause analysis referred to as the 5M, several contributions and their solutions were found in the system.

Man-related issues, primarily through improper handling of materials, lack of training, and carelessness, are the major causes of defects. Remedial measures include training skills and best handling practices that will be integrated into practice and a culture of responsibility and continuous engagement of workers.

Inconsistencies in production emerge from machine-related issues: poor maintenance, misaligned, and vibrating. In this regard, it would be advisable to implement preventive maintenance with scheduled checks of alignment to ensure machines work at their best, decreasing machine-related defects.

Deviations from SOPs and inadequate cleaning of incoming materials are those factors that lead to the generation of defect rates in the Method category. Proper adherence to SOPs and better cleaning processes for incoming materials can check the control of the process of production and prevent defects.

For Material issues, differences in grade and properties because of inconsistency in supplier material were among the largest contributors for defects. These issues could be greatly addressed by creating a proper procurement standard and through thorough checks of incoming materials to achieve quality and consistency.

Lastly, problems in Measurement include uncalibrated tools and inconsistent inspection practices. This prevents the early detection of defects. Thus, improving quality and detection of defects can be made possible if tools are calibrated on a regular basis and inspections standardized at each stage of production.

By targeting the root causes of these across all 5Ms, introducing solutions, and maintaining continuous monitoring with quality control tools, defects in the rim manufacturing process can be minimized. This will give way to high efficiency, quality product, and customer satisfaction.

6. CONCLUSION

This research paper concludes with the following (Shown in Table 4) countermeasures aimed at reducing defects effectively.

Table 4 Countermeasures

Defects	**MAN**	**MACHINE**	**METHOD**	**MATERIAL**	**MEASURE**	**MOTHER NATURE**
Scratch	Proper training in material handling could reduce scratches.	Regular calibration and maintenance will help to reduce scratches.	Strict protocols and consistent processes could help to reduce scratches.	Better quality control can prevent scratches.	Ensure that all measurement tools undergo calibration at regular intervals.	Implement a strict cleanliness protocol within storage areas.

Edges bend of Rim	Better training and handling could reduce edge bend defects.	Regular inspections of dies & Tools.	Automated bending tools to ensure consistent angles.	Proper inspection of incoming material from customers.	Ensure that all measurement tools undergo calibration at regular intervals	Utilize protective coverings and padded racks for rims during storage and handling
Weld Spatter	Proper training of the welding process and SOP.	Ensure a stable power supply, conduct regular maintenance on welding machines, and align the welding torch accurately before operation.	Set optimal welding parameters according to material specifications and establish a standardized pre-welding setup.	Properly check the base material before welding. (Avoid using rusty material)	Real-time inspection will help to reduce spatters on rims.	
Dents on disc	Proper training of material handling could reduce dents.	Set proper required pressure of press and reduce machine vibration by regular maintenance.	Provide cushioning material between rims while transportation.	Better quality control can prevent dents on the rim disc.	Time-to-time calibration of measuring tools.	Ensure routine cleaning of storage spaces to prevent accumulation of abrasive particles.
Burr & Sharp Edges	Use trained manpower for the finishing process.	Regular calibration of machines and maintenance will help to reduce dents.	Set a specific method or SOP for the finishing process.	Use high-grade finishing tools.	Real-time inspection will help to reduce the sharp edges defects.	Utilize protective coverings and padded racks for rims during storage and handling.

7. FUTURE WORK

Although quality control tools in this experiment have highly aided the clarification and minimization of defects in rim manufacturing, there are some cases wherein further research will help widen our knowledge regarding these technologies or their applications. Using state-of-the-art technology and industry-specific applications in future research, more complex methods can be utilized to:

Real-time Quality Monitoring System

It would be interesting to see how the use of IoT and AI facilitates real-time data monitoring on manufacturing lines. It is logical that such systems would reduce labor costs and predict rather than react to defects and maintenance solutions, but again, the source was not able to verify this.

Machine Learning for Defect Prediction

In the future, research might move forward toward building machine learning models based on production data for defect forecasting. It could identify the repeating patterns and know which parts would go wrong due to other historical defect data, and measures could then be taken by the manufacturer in advance.

Lean Manufacturing Integration

There is a need for more research in the expansion of the domain of quality control themes with Lean manufacturing principles. The above solution would address defects and waste reduction, thereby increasing the process flow and, hence overall efficiency in rim manufacturing.

REFERENCES

[1] Deepak, D., & Dhingra, D. (2013). Application of Quality Control Tools in a Bicycle Industry: A Case Study. International Journal of Research in Engineering and Technology, IJRET, eISSN: 2319-1163, pISSN: 2321-7308.

[2] Arya, S., Bhargava, M., & Singh, M. P. (2019). Case study on quality control tools for bearing industries. International Journal of Scientific & Engineering Research, 10(5), ISSN 2229-5518.

[3] Erdhianto, Y. (n.d.). Quality control analysis to reduce the number of defects in the packaging of PG Kremboong sugar products using seven tools method. TiBuana: Journal of Applied Industrial Engineering, 4(1), 28–35.

[4] Sutrisno, B. (2022). A systematic literature review of quality seven tools. Indonesian Journal of Industrial Engineering & Management, 3(1), 72-84.

[5] Sjarifudin, D., & Kurnia, H. (2022). The PDCA approach with seven quality tools for quality improvement in men's formal jackets in the Indonesian garment industry. Jurnal Sistem Teknik Industri (JSTI), 24(2), 159–176.

[6] Sambodo, P., & Cahyana, A. S. (2022). Product Quality Control in CV. XYZ Using Seven Tools and Quality Control Circle. In Proceedings of SENASAINS 5th, Universitas Muhammadiyah Sidoarjo, Procedia of Engineering and Life Science, 3, December 2022.

[7] Widodo, E., Hariyanto, A. L., & Haryudiniarti, A. N. (2023). Analysis of quality control of 800ml lubricant bottle leaks with seven tools method at PT. EFG. JUTIN: Jurnal Teknik Industri Terintegrasi, 6(4), 1260-1271.

[8] Safitri, W., Sutrimo, A., Huda, M., & Erdi. (2023). Seven tools as quality control to reduce defective products in the honeycomb board machine process. DEAL: International Journal of Economics and Business, 1(1). E-ISSN: 3026-2453.

[9] Mayuki, M., Lengkono, H. P., Chandra, J., & Sriwidadi, T. (2024). Analysis of printing product quality control using the seven tools method on CV. XYZ. Journal of Economics and Business Letters, 4(2), Article 275.

[10] Rahma Dana, A. R., & Donorianto, D. S. (2024). Safety Belt Product Quality Analysis to Analyze the Number of Defects Using the Seven Tools Method at PT. XYZ. Indonesian Journal of Computer Science, ISSN 2549-7286.