Quality Management: Application of the DMAIC Tool to Prevent Paint Rework on Excavator Buckets

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ABSTRACT

Purpose: This work aims to apply the DMAIC methodology to solve a problem of paint rework on buckets during the storage process at a heavy machinery company in the South of Rio de Janeiro.

Methodology/Approach: The technical procedures adopted for the research are based on the case study approach. This methodological classification allows for an in-depth and detailed investigation of a singular case.

Findings: With this solution, we were able to reduce rework and consequently cut the costs of re-painting parts, which can also be highlighted as the main applied contribution of this work, since these results can support other companies that will go through the same process.

Research Limitation/Implication: It is important to note that there was not enough time to collect results after implementing the device. For future research, it is suggested that the company continue to invest in continuous improvement processes, using methodologies with different approaches.

Originality/Value of paper: The need to avoid painting rework, due to the associated costs, highlights the importance of the structured approach proposed. Data analysis showed that more than 40% of the buckets produced by the company had paint scratches, generating 63 hours of rework and a cost of R$ 124,988.51.

Category: Research paper

Keywords: quality management; Lean Six Sigma; DMAIC; continuous improvement; zero defects

Research Areas: Quality Management

1 INTRODUCTION

Quality management plays a fundamental role in the quest for operational excellence and meeting customer expectations. In the industrial context, the occurrence of problems that lead to rework can result in delays, waste, and significant losses. It is therefore crucial to use effective methodologies to identify, analyse and solve these problems in order to minimise their impact and guarantee the continuity of the production process (Godina, Silva, & Espadinha-Cruz, 2021; Enache et al., 2023; Tsung & Wang, 2023). Quality management plays a fundamental role in ensuring that an organisation achieves high standards of excellence in its products or services. First and foremost, it aims to satisfy customers' needs and expectations. Through the implementation of practices and processes aimed at continuous improvement, quality management allows the company to identify and correct possible faults, offering reliable, durable products that meet the established specifications and requirements (Santos & Millán, 2013; Azevedo et al., 2019; Vieira et al., 2019; Silva et al., 2020; Chero Yenque et al., 2022; Talapatra, Santos, & Gaine, 2022; Makinde et al., 2022; Craveiro et al., 2023), to promote innovation (Santos et al., 2019; Zgodavova et al., 2020; Murmura, Bravi, & Santos, 2021; Yülek & Santos, 2022; Santos et al., 2023), towards sustainability (Santos et al., 2014; Rebelo et al., 2016; Rodrigues et al., 2020; Teixeira et al., 2022; Sun et al., 2023).

One tool that can be used for this purpose is Define, Measure, Analyse, Improve, Control (DMAIC), which is part of the Six Sigma methodology. DMAIC is a structured and systematic approach that seeks to improve existing processes by identifying opportunities for improvement, analysing root causes, implementing solutions and establishing controls to maintain the results achieved (Knop, 2022; Ramos & Rodríguez, 2022; Tsung & Wang, 2023). Once DMAIC has been defined as the tool to be applied to the problem, a project team will create a project charter to be followed during the process. It should contain all five phases of the cycle, which can be used with different tools because it is a flexible cycle, which will be fundamental to helping the improvement process (Knop, 2022; Ramos & Rodríguez, 2022; Tsung & Wang, 2023).

In a company, it is essential to eliminate problems that generate unnecessary costs. In this way, rework must be avoided, reducing the costs of materials and labour. Therefore, applying DMAIC as a solution to this problem becomes a relevant and promising strategy for improving efficiency and quality in an organisation's processes. By applying DMAIC, the company can obtain a structured, data-based approach to identifying the root cause and implementing effective solutions (Knop, 2022; Ramos & Rodríguez, 2022; Tsung & Wang, 2023). Thus, the research question that can guide the development of this work is: What impact does the application of the Six Sigma methodology using the DMAIC tool have on improving industrial processes in terms of operational efficiency, product quality and cost reduction? Therefore, the aim of this research is to explore the application of DMAIC as a quality management tool to prevent rework on bucket painting on excavator machines. The main concepts and stages of DMAIC will be covered, as well as its theoretical and practical framework in quality management. In addition, a case study will be carried out in an industrial company in the heavy machinery sector, with the aim of identifying the challenges and benefits of applying DMAIC in this specific context.

2 THEORETICAL REFERENTIAL

This section reviews the scientific literature with the aim of presenting the theoretical foundations of the central themes of this research: Quality Management, DMAIC and Lean Six Sigma (LSS). The approach adopted aims to provide an in-depth understanding of these concepts, highlighting their importance in process optimisation and the search for organisational efficiency.

Quality management is a set of practices and processes designed to guarantee excellence and customer satisfaction in relation to the products and services provided by an organisation. It involves planning, implementing and controlling quality-related activities with the aim of continuous improvement (Jirasukprasert et al., 2014; Ismail et al., 2023; Hamdan et al., 2024). A fundamental aspect of quality management is to define clear standards and specifications for products or services to ensure that they meet customer needs and expectations. The aim of quality management is to guarantee excellence, efficiency and consistency in all areas of the company, with a view to continuous improvement (Castro et al., 2020; Khalilinezhad et al., 2021; Solanki & Desai, 2021; Kumar et al., 2023; Escobar et al., 2023).

In addition, quality management involves the adoption of preventive and corrective measures to avoid problems and failures in products or services. This includes identifying and analysing risks, implementing controls and carrying out internal audits to check compliance with established standards (Mandal, 2012; Chen et al., 2023; Hannafin et al., 2023). Quality management also promotes the use of tools and techniques such as process mapping, root cause analysis and performance indicator management, which make it possible to monitor and evaluate the effectiveness of the actions implemented (Amitrano et al., 2016; Knop, 2022; Bai et al., 2023).

The DMAIC methodology, in which each letter is used in a phase, was used as a case study in this research to solve excessive painting rework on excavator buckets. This cycle is one of the Six Sigma tools. DMAIC is a continuous improvement approach, and its implementation in the organisation aims to reduce costs and waste. It solves problems related to failures, excessive costs and time, thus improving the quality of processes (Knop, 2022; Ramos & Rodríguez, 2022; Prado et al., 2023). Lean Six Sigma uses a set of Lean tools to increase productivity. While Six Sigma aims to reduce damage. DMAIC will help achieve these objectives. This methodology is used to improve quality and reduce problems in existing processes, where the cause of the problem is not well specified. This method points out the importance of analysing data before starting to solve problems and apply improvements. Through the five stages, this quality approach is applied (Enache et al., 2023; Pongboonchai-empl et al., 2023; Uluskan & Karşı, 2023).

DMAIC is contained in the Six Sigma methodology, which provides significant benefits for organisations, as it seeks to analyse process performance, aiming to increase performance, reduce costs, improve cycle time by reducing non-value-added steps and avoiding waste. In addition to improving the quality of the product or service and reducing errors that may appear in the process, this will generate customer satisfaction and improve employee morale. (Alshamlan et al., 2022; Pongboonchai-empl et al., 2023; Tsung & Wang, 2023). Continuous progression leads to better quality products and services, meeting customer expectations and increasing customer satisfaction. At the same time, when employees see the positive results of the improvements implemented, their motivation and engagement are strengthened (Uluskan, 2016; Adeodu et al., 2023; Uluskan & Karşı, 2023).

Applying DMAIC helps to solve problems, due to the organisation of the steps, techniques and tools that help to acquire diagnoses and generate and analyse decision alternatives. These tools help to collect and analyse data, diagnose problems and generate decision alternatives for improving processes (Escobar et al., 2022; Bonetti et al., 2023; Condé et al., 2023). DMAIC serves to develop or improve a process, reaching a high level of process capability and working on identifying and almost eliminating the main causes responsible for customer dissatisfaction, allowing the project team to develop effective solutions based on facts and data, rather than making decisions based on assumptions or subjective experience (Solanki & Desai, 2021; Gomes et al., 2022).

Toyota in Japan developed the Toyota Production System in the 1940s. This approach is understood as a management system that integrates specific techniques aimed at eliminating waste in both internal and external processes. Its purpose is to eliminate waste in production and improve efficiency, playing an essential role in improving an organisation's production and competitiveness. Its foundations are based on stability and standardisation. Companies that have adopted Lean Manufacturing have seen positive impacts on their commercial performance, as well as their financial and environmental performance (Tsarouhas, 2021; Achibat et al., 2023; Neeru et al., 2023). This approach encompasses various management techniques that complement each other and are coherent, such as Just-in-Time (JIT), Total Quality Management (TQM), Total Productive Maintenance (TPM) and Human Resource Management (HRM). In addition to the direct benefits, the implementation of Lean Manufacturing also brings indirect benefits to organisations, such as improved quality and safety, reduced tracking time, a positive change in corporate culture, as well as reduced fatigue and stress. There are various Lean Manufacturing techniques and methods used by companies, such as Seiri, Seiton, Seiso, Seiketsu, Shitsuke (5S), Single Minute Exchange of Die

(SMED), Kanban, Kaizen, Poka-Yoke and other relevant tools. (Hollingshed, 2022; Mittal et al., 2023; Tsarouhas & Sidiropoulou, 2023).

3 SCIENTIFIC METHOD

This section provides information on the research method adopted in this study. Initially, the classification of the research will be discussed, encompassing its nature, approach, objectives, and work procedures. Next, the stages of execution will be detailed, outlining the planning, data collection and analysis of the results. Next, the instruments used for data collection will be mentioned, highlighting their relevance in obtaining information. In addition, the methodological flow will be presented, describing the stages for the development of the research.

Scientific research encompasses various classifications related to its nature, approach, objectives and procedures (Kothari & Garg, 2019). In the context of this study, the classifications are highlighted in Table 1. This study was conducted by means of applied research, whose objectives were exploratory and descriptive, with a qualitative approach based on a case study. In this section, the definitions and particularities of these elements are presented, justifying the methodological choice adopted.

Table 1 – Research classification (Adapted from Cronin & George, 2023; Kothari & Garg, 2019; Reis et al., 2021)

Nature	**Objective**	**Approach**	**Research procedures**
Basic	Exploratory	Quantitative	Experiment
Applied	Descriptive	Qualitative	Survey
	Explanatory	Combined	Modelling
			Content analysis
			Case study

The research method adopted in this study is of an applied nature, given that its propositions seek applicability in a specific reality. As for the research objectives, they will be outlined in an exploratory and descriptive manner, allowing us to delve deeper into the elements of the investigation and, at the same time, observe, analyse, classify, and interpret the data impartially, without direct interference from the researcher. This methodological approach aims to ensure an understanding of the phenomena being studied, thus enabling an informed analysis (Miguel, 2018; Kothari & Garg, 2019).

The research adopted in this study is classified as qualitative, in which the aim is to understand and interpret the phenomenon under study through in-depth analysis of descriptive data. In this approach, the researcher plays a fundamental role as the main vehicle for conducting the research. Their role includes collecting information, analysing the data and interpreting the results in a contextualised way (Yin, 2017; Kothari & Garg, 2019).

The technical procedures adopted for the research are based on the case study approach. This methodological classification allows for an in-depth and detailed investigation of a singular case, with the aim of understanding, describing and analysing the phenomenon in its real context, aiming for the specificity of the case studied (Yin, 2017; Kothari & Garg, 2019). In this work, a case study was carried out in the heavy machinery sector.

This work was developed based on a problem encountered at a heavy machinery company in the southern region of Rio de Janeiro. The company specialises in the manufacture of heavy machinery, also known as the yellow line, as well as industrial vehicles such as forklift trucks. Its aim is to become a national industry that is fully integrated and adapted to the Brazilian market, offering excellence in service, sales, and technical assistance. The bucket is a fundamental part of excavator machines, playing an important role in their operations. It is designed to withstand the adverse conditions and challenges encountered in excavation environments. It is the part of the excavator that will dig, lift, and transport materials, as marked on Figure 1.

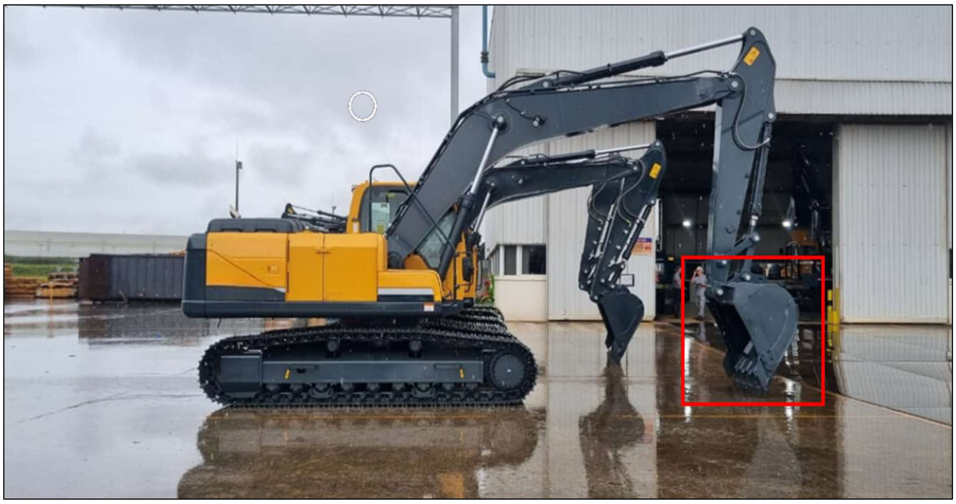

Figure 1 – Backhoe loader bucket

Its shape and size vary according to the specific application. This versatility makes the bucket a central part of the functionality of excavating machines, playing a crucial role in carrying out a wide range of construction and excavation tasks. The following is a flowchart as shown in Figure 2.

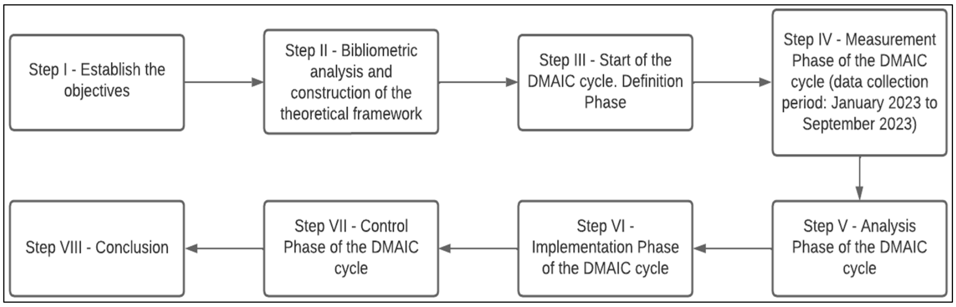

Figure 2 – Methodological flow

This study was divided into eight stages: Stage I – establishing the objectives; Stage II – bibliometric analysis and construction of the theoretical framework; Stage III – beginning of the DMAIC cycle. Definition phase; Stage IV – measurement phase of the DMAIC cycle; Stage V – analysis phase of the DMAIC cycle; Stage VI – improvement phase of the DMAIC cycle; Stage VII – control phase of the DMAIC cycle; Stage VIII – conclusion.

In stage I, the objectives of this work were defined, providing a purpose and direction to be followed. In stage II, Scopus searches were carried out to find articles on quality management and DMAIC. In this way, through bibliometric analysis, it was possible to build a theoretical framework based on published works with a good foundation. Moving on to stage III, the case study began. Using the DMAIC cycle, the definition phase began, with the aim of identifying opportunities for improvement and the project's expectations.

Stage IV was the measurement phase, where it was possible to collect data to measure the performance of the process. Then, in stage V, the analysis phase, it was possible to understand the problem based on the data causing this undesired effect. In stage VI, the improvement phase, it was possible to identify solutions to eliminate the problem. Proceeding to stage VII, the control phase, it is possible to look for opportunities for continuous improvement by monitoring the process. Finally, stage VIII discusses the achievement of the objectives proposed in this study and their main contributions.

4 RESULTS AND DISCUSSIONS

To ensure methodological clarity, the management tools used in each DMAIC phase were explicitly defined. In the Define phase, the Project Charter, Ishikawa Diagram, and GUT matrix structured problem identification and prioritisation. In the Measure phase, performance data were collected to calculate rework rates and associated costs, supported by KPIs. Additionally, a SWOT matrix was conducted at this stage to consolidate validated quantitative findings into a structured strategic diagnosis. In the Analyse phase, data interpretation identified pallet contact as the root cause of paint damage. The Improve phase applied a 5W2H action plan, leading to the implementation of a protective device. Finally, the Control phase established a formal Control Plan to sustain improvements through defined monitoring and corrective procedures. Initial analysis of the situation revealed that the collision between the heavy machinery bucket and the storage pallets was causing significant scratches. This resulted in substantial rework, where parts had to be repaired or repainted, increasing production costs and extending the time needed to complete each unit.

Through data collection, direct observations, and analysis of defective parts, it was possible to quantify the increase in paint consumption resulting from touch-ups and repainting. In addition, inspection of the affected parts demonstrated the recurring nature of the problem and its impact on product quality. To solve the problem, a protective device was created to prevent direct contact between the painted parts and the wooden pallets.

The continuous search for improvement has become a fundamental objective for companies. In this context, quality management plays a crucial role, providing a structured way to identify and resolve issues related to defects and failures and, at the same time, drive continuous improvement. DMAIC, a widely used analysis method in this context, offers a systematic approach to problem solving (Knop, 2022; Ramos & Rodríguez, 2022; Tsung & Wang, 2023). In the first stage, an Ishikawa Diagram was drawn up so that the possible causes of the problem could be identified more quickly and clearly (Figure 3).

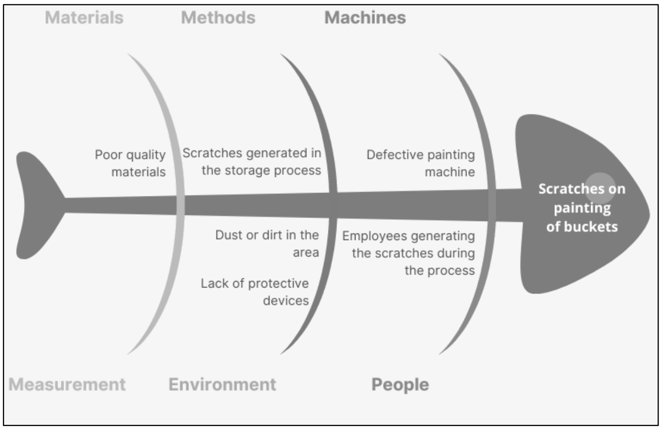

Figure 3 – Ishikawa diagram

In the second stage, a project charter was drawn up, as shown in Figure 4, in which the main definitions of the project were stated. In this way, it is possible to understand more clearly the objectives to be achieved, generating greater alignment between those involved.

Business Case Machine buckets often come into contact with wooden pallets during the storage process, resulting in unwanted scratches.	**Opportunity Definition** Develop a definitive solution to eliminate unwanted scratches.
Goal Setting Implement improvements to eliminate contact between the bucket and wooden pallets, reducing rework and excessive paint consumption.	**Project Scope** -Reduce paint failures; -Reduce rework costs; -Improvement of the zero defects indicator.
Team -Manufacturing team; - Maintenance team; - Parts painting team.	

Figure 4 – Project charter

In the third stage, the problems were defined, and their understanding made clearer. The GUT matrix was used as a prioritisation tool, assessing severity, urgency, and trend, according to Table 2.

Table 2 – The GUT matrix used

GUT Matrix					
#	Problem	Gravity	Urgency	Trend	Score
1	Devices/racks/pallets do not have protection	5	5	5	125
2	Need to create more devices to support the frames	4	4	3	48
3	Rework cost impact	5	5	5	125
4	Part of the team is being moved to carry out rework	3	3	3	27
5	Bad indicators	3	3	3	27

At the bucket storage stage, the wooden pallets result in scratches in the paintwork, which generates significant rework, as repainting must be carried out, causing an increase in paint consumption, directly affecting the efficiency and costs of the production process. To address this problem, a multidisciplinary team will be formed, made up of members from the quality, production, logistics, painting, and maintenance areas.

This team will analyse, propose, and implement solutions that minimise unwanted contact between the wooden pallets and the buckets during the storage process, reducing costs and rework, with a view to continuous improvement. In the last stage, a 5W2H was structured to define the tasks to be carried out and follow them up in a more practical and visual way (Table 3).

Table 3 – The 5W2H used

	ACTION PLAN				PROJECT	Scratches on heavy machinery buckets
WHAT?	WHY?	WHERE?	WHEN?	WHO?	HOW?	HOW LONG?
A protective device is required to assist with storage	- It is necessary to solve the problem of damage to painted parts during storage - Improvement in KPI	Location where buckets are stored	Immediately	Logistics, painting, quality, manufacturing, and maintenance	A device will be developed that has a resistant metal surface to suspend the buckets between drillings.	Estimated period: 1 month

The measurement phase acts as a fundamental pillar for the successful implementation of improvements and analysis in organisational processes. At this stage, data was collected using Microsoft Excel, so that a basis could be established for subsequent evaluations and improvements, as well as understanding the extent of the impact of problems. In this context, Table 5 presents data on rework on excavator model RB220C-9 buckets associated with painting problems, including the associated costs and the hours dedicated to these tasks, helping to identify opportunities for improvement and highlighting the relevance of this information to the success of process optimisation and cost reduction initiatives.

The data in Table 5 were collected over nine months, from January to September 2023. The number of machines reworked was determined using a production plan, according to Table 4, where each month contains several machines to be produced, and along with this, the percentage of defect history is multiplied to obtain the number of machines to be reworked. To calculate the total rework time, the chrono analysis method was used.

Table 4 – Production plan

Month	Quantity of machines	Failure history
January	109	42%
February	119	45%
March	105	48%
April	101	45%
May	115	41%
June	118	49%
July	104	47%
August	106	46%
September	110	44%

The average of five rework times resulted in 8.5 minutes, multiplied by the number of machines reworked. When calculating the cost of labour, the value of the factory painter's labour was taken as R$5.08. This value was multiplied by the total rework time and the amount of labour. Retouching is done with a brush, which implies moderate paint consumption. The amount of paint used was calculated based on the average monthly consumption, which is 0.45L of paint to touch up one machine. The cost associated with this amount of paint is R$12.22 per litre, and the total cost of the paint was obtained by multiplying these values. Finally, the total cost of the rework is the cost of the labour multiplied by the cost of the paint used.

Table 5 – Buckets rework

Issue data			**Rework**						
Month 2023	Class	Origin	Total	Labour	Total Rework Time (h)	Labour Cost 5,08	Quantity of Paint Used (L)	Cost of Paint Used 12,22	Total Cost in R$
Jan	Damaged Paint	Intern	46	1	6.5	32.9	21	251.74	8,295.56
Feb	Damaged Paint	Intern	54	1	7.6	38.5	24	294.47	11,350.45
Mar	Damaged Paint	Intern	50	1	7.1	36.3	23	277.15	10,054.38
Apr	Damaged Paint	Intern	45	1	6.4	32.7	20	249.93	8,176.39
May	Damaged Paint	Intern	47	2	6.7	67.9	21	259.28	17,598.98
Jun	Damaged Paint	Intern	58	2	8.2	83.2	26	317.95	13,232.75
Jul	Damaged Paint	Intern	49	2	6.9	70.4	22	268.79	18,914.13
Aug	Damaged Paint	Intern	49	2	6.9	70.2	22	268.13	18,821.38
Sep	Damaged Paint	Intern	48	2	6.9	69.7	22	266.15	18,544.49

Aiming for a clearer understanding and more precise analysis of organisational operations, Key Performance Indicators (KPIs) were implemented, as shown in Figure 5. With the purpose of simplifying complexities and offering a comprehensive view of process performance, KPIs are tools that allow for an objective and quantitative assessment of progress towards established objectives. These indicators provide a framework for working with previously collected data, offering insights that direct actions towards specific areas that require attention and improvement.

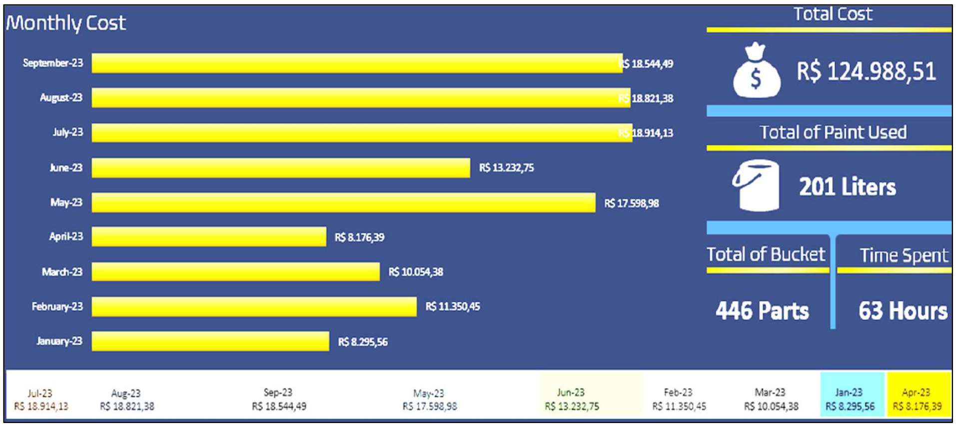

Figure 5 – Analysis of KPIs

Although the Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix is traditionally positioned within the Define phase of the DMAIC framework, this study deliberately applied it during the Measure phase to consolidate empirically validated findings into a structured strategic diagnosis. Rather than serving as an exploratory instrument, the SWOT analysis was grounded in statistically validated performance indicators, ensuring alignment between quantitative evidence and strategic interpretation. The data collected in Measure revealed consistent patterns in rework rates, operational costs, and process variability, establishing a robust empirical foundation for integrating internal organisational factors, such as process capabilities and structural constraints. Based on this diagnostic consolidation, the project seeks to significantly reduce rework rates and optimise the costs associated with corrective activities. By mitigating rework and its financial impacts, the organisation aims to enhance operational efficiency, improve resource allocation, and reinforce sustainable corporate growth. Within this methodological design, the SWOT matrix (Figure 6) functioned as a strategic synthesis mechanism, supporting the prioritisation of critical variables and guiding targeted improvement initiatives in the subsequent stages of the DMAIC cycle.

As far as strengths are concerned, because the team involved in solving the problem is multidisciplinary, it can result in members with diverse skills, which can bring different perspectives to the solution, making it a strength. There is also the fact that the painting team has experienced collaborators. On the other hand, weaknesses include inadequate storage of the buckets and insufficient quality control during the storage and painting process. As for opportunities, there is the possibility of developing appropriate storage procedures and providing additional training for the painting team. Finally, the threats include the increase in rework costs and the negative impact on customer satisfaction, as by increasing the costs of the process, the value of the product increases.

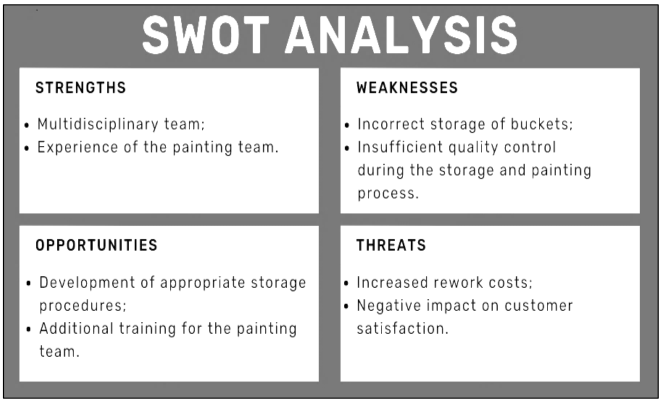

Figure 6 – The SWOT matrix used

This SWOT Analysis provides a comprehensive view of the internal and external variables that can influence success in reducing rework and its associated costs. By understanding the strengths and opportunities, while addressing the weaknesses and threats, the organisation can develop more effective strategies to achieve its goals. Previously, a challenge was identified related to the quality of paint on the parts of a heavy machinery company.

Figure 7 – Stored buckets

The buckets were showing paint problems during the storage and handling process, as shown in Figure 7. To solve the problem, we implemented a protective device designed to prevent direct contact between the painted parts and the storage pallets. This consists of a metal surface designed to support and protect the buckets. Its structure can support the weight of the buckets and suspend them between the holes in the bucket, preventing direct contact with the part that could cause scratches or damage to the paintwork.

After analysing the two-dimensional (2D) drawing of the bucket in Figure 8, here is the three-dimensional (3D) representation of the device using the SketchUp application, as shown in Figure 9. Using this tool made it possible to create a detailed and accurate virtual model. This will allow for a clearer and more in-depth visualization of the project, aiding in the design process, manufacturing, and communication with stakeholders, making it an important tool for product development.

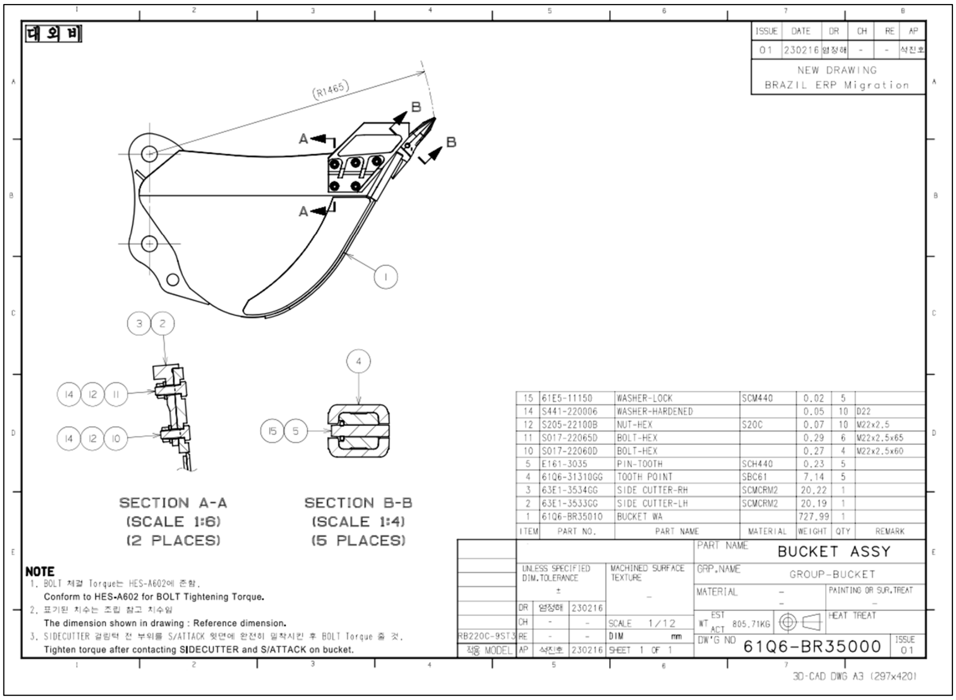

Figure 8 – Bucket 2D drawing

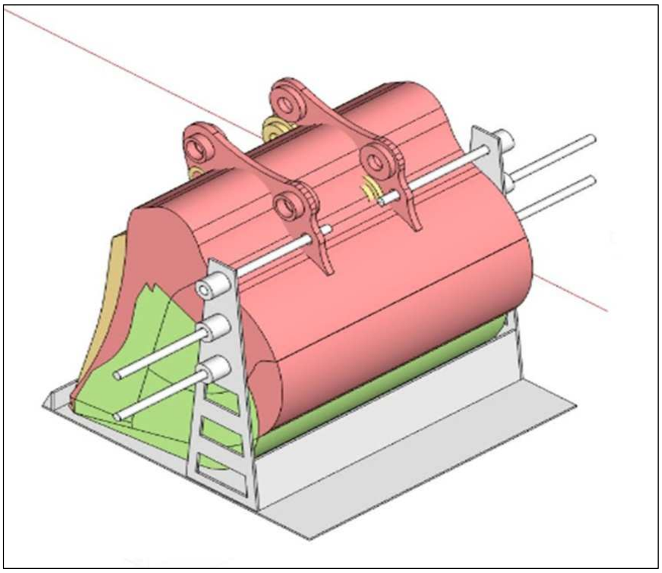

Figure 9 – Implemented device

In the Control phase, it is essential to ensure that the improvements implemented are maintained over time and that any deviations from the new process are promptly identified and corrected. To ensure this, a control plan was drawn up, as shown in Table 6, aimed at monitoring and maintaining the quality of the buckets and the efficient functioning of the support and protection system, whereby any scratched bucket must be immediately reported to the quality team.

Table 6 – Control plan

#	Measurements	Performance Standard	Description	Frequency	Responsible	Contingency pan	Where to Report?
	Indicator	Control and Specification Limits	What to check?	When to check?	Who will check?	Corrective action	
1	Number of buckets scratched	Every scratched bucket must be reported, regardless of quantity	If scratching occurred after storage	2 times per week	Quality team	- Bring together the team that participated in the project to analyse - Rework the paint	Quality team

5 CONCLUSION

This research set out to develop a solution to the problem encountered in a heavy machinery company using the DMAIC methodology. The analysis revealed that the collision between the wooden pallets and the buckets caused them to be scratched during the storage process. The data collected showed that the company had a high cost of rework. In each month analysed, more than 40% of the buckets had to go through the painting rework process, which generated 63 hours of rework and a cost of R$ 124,988.51.

By studying the problem using DMAIC and the quality tools, it was possible to develop a device that will protect the buckets of the excavators, preventing any kind of collision during storage, so as not to scratch the paintwork. With this solution, the company was able to reduce rework and consequently cut the costs of re-painting parts, which can also be highlighted as the main applied contribution of this work, since these results can support other companies that will go through the same process. It is important to note that there was not enough time to collect results after implementing the device. For future research, it is suggested that the company continue to invest in continuous improvement processes, using methodologies with different approaches. Furthermore, expanding the scope to identify and resolve other improvement points within the production chain could provide additional benefits.

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