Scrap Reduction on Anodize Area Treatment

Eliezer O. Fernández Rodríguez
Manufacturing Engineering
Carlos Pons Fontana, Ph.D.
Industrial and Systems Engineering
Polytechnic University of Puerto Rico

Abstract — *MD Company encounters significant challenges within its anodizing process, characterized by pronounced waste generation. Proposing an integrated approach merging Lean manufacturing principles with DMAIC methodology to mitigate this issue. Over a span of 110 days, the research extensively addresses waste reduction and enhancements in operational efficiency, employing methodologies such as Pareto analysis and the 5 Whys technique. Literature review underscores the criticality of efficient processes and the indispensability of Lean Six Sigma tools. The implementation of DMAIC serves to meticulously identify, analyze, improve, and control the problem. Noteworthy findings culminate in a remarkable 25% reduction in waste, underpinning MD Company's unwavering commitment to sustained operational excellence. This achievement further cements MD Company's position as a pioneering force within the industry, exemplifying its dedication to pioneering and perpetuating innovative manufacturing practices.*

Key Terms — *5S, DMAIC method, Scrap, Waste reduction.*

PROBLEM STATEMENT

MD Company, a global corporation dedicated to the creation, production and sale of a wide range of medical products and treatments, faces a critical issue in its production process. Despite its prominent global presence and pivotal role in the advancement of medical technologies, operational efficiency and waste reduction remain major challenges for the company. In particular, anodizing treatment, a crucial step in the production of high-demand units, is being affected by a major scrap generation problem.

In the last year, MD has experienced a considerable loss due to this problem, with a total of 6,090,716 units of scrap produced. This situation not only represents a significant economic loss for the company, but also jeopardizes its ability to meet market demand and maintain its competitiveness in the medical industry. It is therefore imperative to effectively address this problem and develop solutions that will improve the efficiency of the anodizing process and reduce unit waste, thus ensuring MD Company's sustainability and continued success in the global healthcare market.

RESEARCH DESCRIPTION

MD Company is facing a problem of high scrap rate in its Anodizing Treatment Area, which covers 70% of its surface treatment processes. This situation, caused mainly by the drop of units in the tanks, has generated a decrease in productivity, increasing production costs and having negative environmental impacts. To address this challenge, the integration of Lean manufacturing concepts and waste reduction techniques, together with the use of advanced technology and the DMAIC methodology, is proposed. These strategies will seek to provide a comprehensive solution that improves plant efficiency, optimizes resources and promotes environmental sustainability, facilitating the identification of effective solutions and the implementation of control measures to sustain long-term improvements in the Anodizing process.

Research Timeline

The project conducted using the DMAIC methodology (Define, Measure, Analyze, Improve, and Control), involved various phases spanning different durations. During the Define phase, the Voice of Customer was utilized to identify and define the company's problem. In the Measure phase, scrap data was collected and visualized in a Pareto diagram to identify the most significant scraps. The Analyze phase involved conducting a 5 Whys analysis to find the root cause of the problem, as well as creating an Ishikawa diagram to visualize possible causes of the scrap. In the Improve phase, identified solutions were implemented, and improvement was calculated based on scrap reduction. Finally, in the Control phase, trainings were conducted for employees and audits were performed to verify the proper implementation of solutions and the maintenance of established improvements. The project had a total duration of 110 days.

	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1	**Manual Scheduled**	**Δ Anodize Project**	**110 days**	**Wed 12/20/23**	**Fri 4/8/24**	
2	**Auto Scheduled**	**Δ Define**	**21 days**	**Wed 12/20/23**	**Tue 1/9/24**	
3	Auto Scheduled	VOC	21 days	Wed 12/20/23	**Tue 1/9/24**	
4	**Auto Scheduled**	**Δ Measure**	**20 days**	**Wed 1/10/24**	**Mon 1/29/24**	
5	Auto Scheduled	Scrap data collection	11 days	Tue 1/10/24	Sat 1/20/24	3
6	Auto Scheduled	Pareto Diagram	9 days	Sun 1/21/24	Mon 1/29/24	5
7	**Auto Scheduled**	**Δ Analyze**	**22 days**	**Tue 1/30/24**	**Tue 2/20/24**	
9	Auto Scheduled	5 whys	12 days	Tue 1/30/24	Sat 2/10/24	6
10	Auto Scheduled	Ishikawa Diagram	10 days	Sun 2/11/24	Tue 2/20/24	8
11	**Auto Scheduled**	**Δ Improve**	**29 days**	**Wed 2/21/24**	**Wed 3/20/24**	
12	Auto Scheduled	Implementation	24 days	Wed 2/21/24	Fri 3/15/24	9
13	Auto Scheduled	Calculation of the improvement based on scrap reduction	5 days	Sat 3/16/24	Wed 3/20/24	11
14	**Auto Scheduled**	**Δ Control**	**19 days**	**Thu 3/21/24**	**Mon 4/8/24**	
15	Auto Scheduled	Trainings	9 days	Thu 3/21/24	Fri 3/29/24	12
16	Auto Scheduled	Audits	10 days	Sat 3/30/24	Mon 4/8/24	14

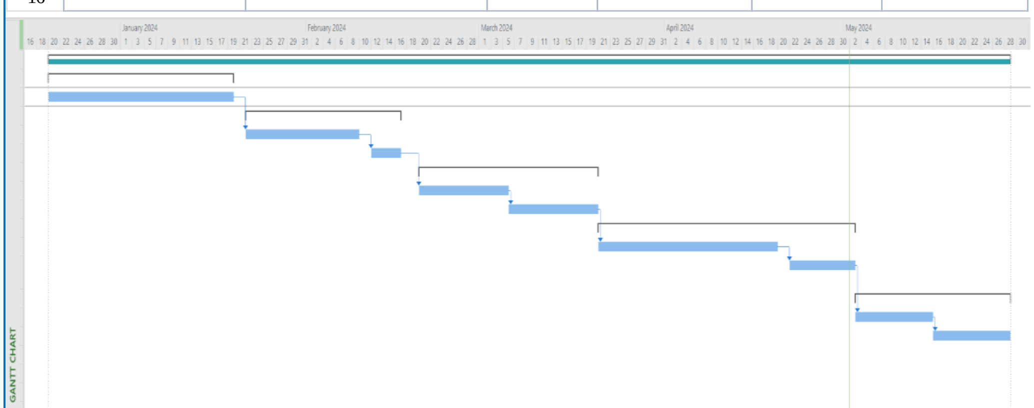

Figure 1

Project Timeline in December to April 2024

Research Contributions

By addressing the root causes of material waste, research aimed at reducing scrap waste can contribute to improved product quality. By improving the process flow, the amount of scrap waste can be reduced, which directly correlates to cost savings by reducing the consumption of resources and raw materials. A company's competitive advantage increases, its market position is strengthened, and it becomes recognized as a pioneer in efficient and ethical manufacturing methods as a result of all these efforts.

LITERATURE REVIEW

Manufacturing The Anodic Treatment Area is the backbone of industrial operations, providing anodic surface treatments to 70% of the company's product. In manufacturing, the efficiency of production processes is paramount to the success of the organization. Efficient operation is crucial to profitability and competitiveness. A major challenge facing manufacturers is scrap (defective or lost products). This literature review explores existing research on the causes, consequences and strategies to mitigate scrap in the anodizing processing area.

Organizations seeking to reduce waste in their production processes can use Six Sigma's DMAIC technique in combination with Lean concepts to create a solid foundation. DMAIC, with its organized approach of Define, Measure, Analyze, Improve and Control, helps identify the root causes of failures that lead to scrap. Organizations gain important insight into problems by setting clear objectives and collecting accurate data. Moreover, lean concepts provide useful tools for waste reduction, process optimization and continuous improvement.

METHODOLOGY

For the methodology of this study, the DMAIC (Define, Measure, Analyze, Improve and Control) approach will be followed to address the problem of scrap waste in the Anodizing Treatment Area of the MD company. In the Define phase, the Voice of the Customer will be used to understand the needs and expectations, thus providing a solid basis for problem identification. In the Measure phase, a Process Map will be used to visualize the process flow and specific data will be collected at each stage, allowing a detailed assessment of waste in each process. In the Analyze phase, the 5 Whys and an Ishikawa diagram will be applied to identify and understand the underlying causes of scrap waste, which will help develop effective solutions. In the Improvement phase, improvement will be measured through post-implementation testing of alternatives based on the identified needs, highlighting the importance of measuring the impact of the proposed solutions. Finally, in the Control phase, the most viable alternatives will be recommended to maintain the proposed improvement, thus ensuring a continuous and sustainable improvement in the Anodizing process. This structured and systematic approach will ensure a thorough understanding of the problem and facilitate the implementation of effective solutions to reduce scrap waste in the MD company. [1]

RESULTS AND DISCUSSION

It is essential to understand the needs and expectations of our customers throughout the definition phase. To do this, we must resort to the Voice of the Customer. This involves paying close attention to what our customers have to say about our products or services. The Voice of the Customer gives us a valuable first-hand view of customers, which helps us to better understand their preferences and concerns. [2]

In the Define phase, the Voice of the Customer provided by the packaging team has been incorporated, as can be seen in Figure 2. This communication highlights critical concerns related to the production of Product A in the anodizing area. Two main observations have been identified: first, the packaging team regularly reports receiving insufficient parts to complete scheduled Product A orders, resulting in production delays and negatively impacting the ability to meet customer demands. Second, they note that delays in the delivery of Product A parts lead to disruptions in the packaging process, resulting in unplanned downtime and reduced operational efficiency. To address these concerns, two key actions have been identified: reduce waste of Product A parts produced and improve communication between the areas involved. These customer observations not only underscore the urgency to act, but also provide clear direction for the ongoing anodizing project. By understanding the customer's needs and expectations, it is hoped to implement significant process improvements and optimize customer satisfaction.

VOC (Voice of Customer)

Dear Anodizing Area Team,

We are writing to express our concern regarding the parts demand fulfillment and scrap issues experienced in the production of Product A. In recent weeks, we have noticed a significant discrepancy between the quantity of parts supplied and the quantity required, as well as a noticeable increase in scrap levels on Product A parts received.

Specific observations:

1. Insufficient quantity of parts: We are regularly receiving less than the required quantity of parts to fill scheduled orders for Product A. We are receiving less than the required quantity of parts to fill scheduled orders for Product A. This is resulting in production delays and is ultimately negatively impacting the ability to meet customer demands for Product A.

2. Impact on our efficiency: Delays in the delivery of Product A parts are causing disruptions in our packaging process. This forces us to halt our operations, resulting in unplanned downtime and reduced operational efficiency in the Product A packaging area.

Required actions:

1. Scrap Reduction: It is requested to implement immediate measures to reduce scrap levels in the Product A parts produced. This is critical to ensure the delivery of high-quality parts that meet standards and allow for proper workflow in the Product A packaging process.

2. Improved communication: Smooth and proactive communication between the areas involved is crucial to address any Product A quality and supply issues in a timely and effective manner.

Next Steps: These concerns are expected to be discussed in a joint meeting to explore solutions and establish necessary corrective actions for Product A. The goal is to work together to ensure an efficient supply chain, with high quality Product A parts, and to optimally meet customer needs.

A prompt response is expected in order to schedule a meeting. We appreciate your attention and cooperation in this matter.

Cordially,

Packaging Area

Figure 2
Voice of Customer

Measure

In the measurement phase, the company focuses on collecting relevant quantitative and qualitative data to better understand the current state of the anodizing process. This allows it to establish a solid baseline and make informed decisions about areas in need of improvement. To this end, a variety of measurement tools and data collection techniques are used. [3]

As part of the measurement phase, a process map (Figure 3) has been created that details the various steps and activities of the anodizing process. This process map provides a clear visual representation of how the process is carried out, from cleaning to finishing. By mapping the process in this manner, areas of potential improvement, bottlenecks or inefficiencies can be identified. This process map will be used as a critical tool to measure and evaluate current process performance and to identify specific areas where attention can be focused to achieve the desired scrap reduction.

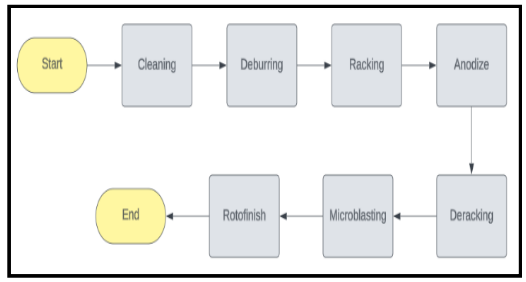

Figure 3
Process Map

To better understand the specific areas where scraps are generated in the anodizing process and identify opportunities for improvement, detailed data has been collected on scraps at each stage of the process, from cleaning to rotofinish. This data provides a clear picture of where the most waste is occurring and allows improvement efforts to be focused more precisely. The information that appears in Table 1 is a summary of the data collected in each of these areas, which will help determine the highest priority areas for scrap reduction. In addition, the information that appears in Table 2 shows the cost of scrap, total scraps units and total cost of scrap.

Table 1
Scrap in Anodize Treatment Process

Scrap in Anodize Treatment Process				
Process	**Total Scrap (Quantities)**	**Total Scrap (Percent)**	**Accumulated**	**% Accum.**
Tanks	2,436,292	40%	2,436,292	40%
Racking	1,827,219	30%	4,263,511	70%
Deracking	1,218,146	20%	5,481,657	90%
Rotofinish	304,539	5%	5,786,196	95%
Cleaning	121,808	2%	5,908,004	97%
Deburring	121,808	2%	6,029,812	99%
Microblasting	60,904	1%	6,090,716	100%
Total	**6,090,716**	**100%**		

Table 2
Scrap Information

Cost of Scrap	$6.05 per unit
Total Scrap (Units)	6,090,716 units
Total Cost of Scrap	$36,848,831.80

In order to analyze the data collected from scrap at each stage of the anodizing process and effectively visualize the areas that represent the greatest opportunities for improvement, a Pareto diagram has been created. This diagram is a graphical tool that allows identifying and prioritizing the most significant problems or causes, in this case, the most frequent types of scrap in the process. The Pareto diagram is shown below in Figure 4, which will help the company to focus its efforts on the areas that contribute most significantly to the total waste.

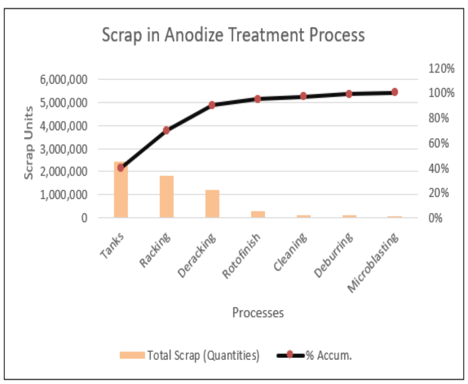

Figure 4
Pareto Diagram for Scrap in Anodize Treatment

Taking that in consideration, Table 3 summarizes the most significant rejects identified through the Pareto diagram, along with the most relevant waste data associated with each of them. This table gives us a detailed view of the types of scrap that represent the greatest opportunities for improvement in our anodizing process. We will use this information to prioritize our improvement actions and focus our efforts on the areas that have the greatest impact on waste reduction.

To better understand the nature and origin of each type of waste identified in the table, a brief definition of each is provided in Table 4. These definitions will help the company understand the underlying causes of waste and guide it in developing specific strategies to effectively address each type of waste.

Table 3
Summary of Most Significance Scraps

	Scraps	Units	Percent
Tanks	Rack Marks	556,464	18%
	Loss in Tanks	1,013,646	33%
DeRacking	Irregular Treatment	281,360	9%
	Derracking Loss Material	370,736	12%
Racking	Deformed Units	422,040	14%
	Coating Defects	411,547	13%
	Total	3,055,793	100%

Table 4
Scraps Descriptions

Scrap	Description
Rack Marks	Is when marks are generated on the product when it is removed from the rack.
Loss in Tanks	Is when the product is in the process of anodizing and falls off the rack which proceeds to fall into the tank and become scrap.
Irregular Treatment	Due to poor positioning when parts are not placed correctly on the racks, they may be damaged or not receive the anodizing treatment uniformly, resulting in scrap.
Derracking Loss Material	Is when material is lost when the product is removed from the rack because it is sometimes possible for it to become encrusted.
Deformed Units	During the racking process or when handling racks, some parts may become bent or deformed, rendering them unusable for their intended purpose.
Coating Defects	Is when bubbles, stains or lack of adherence are generated in the product.

In order to prioritize actions and focus efforts on the most significant problems, a Pareto diagram has been created showing the most relevant types of scrap in the anodizing process. The Pareto diagram is a visual tool that allows problems to be identified and prioritized according to their relative importance. Through this diagram, the company can identify the types of scrap that have the greatest impact on the process and focus on addressing them effectively. Bellow in Figure 5 is the Paret diagram, which will help focus efforts on the most significant scrap.

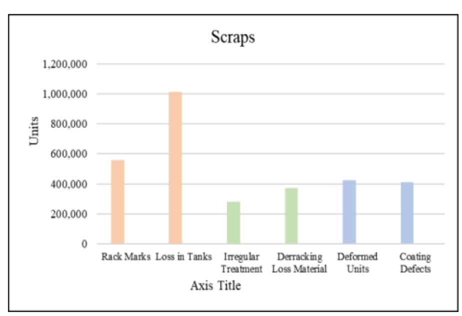

Figure 5
Pareto Diagram of Significance Scraps

Table 6
Most Relevant Scrap Data Collected

Total Scrap Units Per Year	
Scrap	**Quantity**
Loss in Tanks	1,013,646
Rack Marks	556,464
Deformed Units	422,040
Other Deracking and Racking Scraps	1,063,643
Scraps not in Scope	609,059

Below Table 6 contain the most relevant scrap data collected during one year in the anodizing process. These tables provide a detailed view of the amount of scrap that has been produced over time, allowing the company to identify trends and areas of focus to improve efficiency and reduce waste.

The company will use this information as a basis for further analysis in the Analyze phase and to develop specific strategies to address the most significant issues, in particular Loss in Tanks, which has been identified as the most significant scrap in the process.

Loss in Tanks represents one of the biggest challenges in the anodizing process, with an approximate loss of 1,380 units per shift. Rack Marks and Deformed Units also contribute significantly to waste, with approximately 765 and 586 units lost per shift, respectively. These data highlight the magnitude of the problem and underscore the importance of specifically addressing Loss in Tanks to achieve significant improvements in process efficiency and reduce waste.

Analyze

In the Analyze phase, the company embarks on an in-depth analysis of the data collected in the Measure phase with the objective of identifying the root causes of the problems identified and developing effective solutions. Following the analysis conducted in the Measure phase, it was determined that the main focus will be on scrap associated with Loss in Tanks, as it has been identified as the most significant type of scrap in the anodizing process. This comprehensive analysis will allow us to better understand the factors that contribute to the generation of this type of scrap, as well as to identify patterns and trends that will help us to effectively address this problem. Using analysis tools such as the Pareto diagram, cause and effect analysis, and other statistical techniques, the company will seek to identify critical areas that require attention and develop specific strategies to reduce the incidence of Loss in Tanks in our anodizing process. With a rigorous, data-driven approach, the company is committed to implementing effective solutions that drive continuous improvement and reduce the impact of this type of scrap. [4]

As part of the Analyze process, the 5 Whys tool will be used to thoroughly investigate the underlying causes of scrap associated with Loss in Tanks. This analysis tool, originally developed by Toyota, is based on the idea that by systematically asking a series of "why" questions, the root causes of a problem can be identified. As shows in Figure 6 by applying this tool specifically to Loss in Tanks scrap, we will seek to delve deeper into the root causes of this problem, exploring beyond the surface symptoms to address the underlying causes that contribute to its occurrence. This approach will develop a more complete understanding of the problem and guide the implementation of effective solutions that address the true causes of Loss in Tanks scrap.

In addition to the 5 Whys tool, an Ishikawa diagram, also known as a fishbone diagram or cause and effect diagram, will be used as part of the Analyze process. The Ishikawa diagram is a visual tool that allows the company to systematically identify and visualize the possible causes of a specific problem. In this case, as shown in Figure 7 the Ishikawa diagram will focus on the various categories that could be contributing to the scrap associated with Loss in Tanks. By examining categories such as people, processes, equipment, materials and environment, it will be possible to comprehensively explore the possible causes of the problem and develop a deeper understanding of its nature.

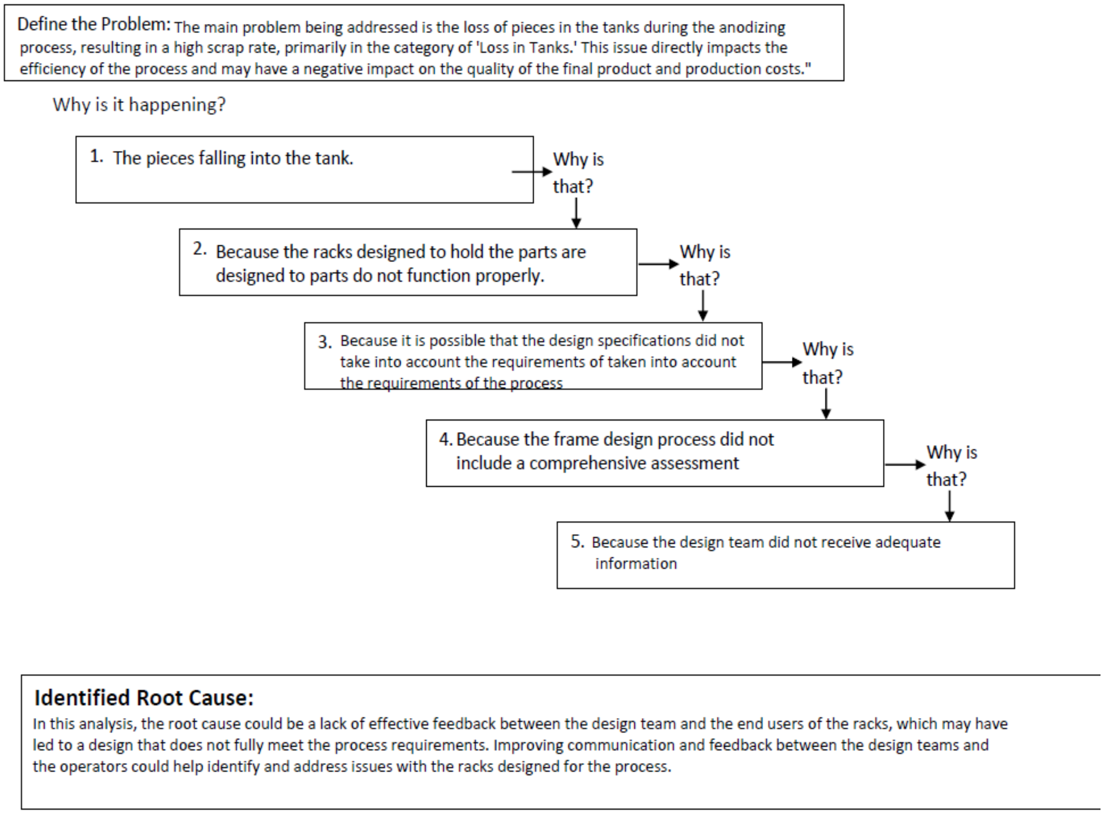

Figure 6
5 Whys for Loss in Tanks

This approach will help identify critical areas that require attention and guide the implementation of effective solutions to address Loss in Tanks scrap.

- Rack design: This cause refers to the evaluation of the design of the racks used during the anodizing process to determine if they provide adequate fixturing for the parts. Consider whether the racks are designed to ensure that the parts remain secure and stable in place throughout the process.
- Quality of construction: Examines whether the racks are constructed of high-quality, durable materials to effectively withstand the stresses and strains of the anodizing process.
- Part holding capacity: This aspect evaluates whether the racks can hold parts securely and stably during transport and handling. It considers whether the racks have the ability to hold parts in place without dropping or shifting during handling.
- Lack of effective restraint devices: Analyzes whether adequate retention devices have been implemented in the racks to prevent parts from falling. Verify whether additional devices or mechanisms have been installed on the racks to ensure the safety of the parts throughout the process.
- Wear or damage to shelves: Examine whether shelves are in good condition or show signs of wear or damage that may affect their ability to adequately hold parts. It is observed whether the shelves are in good condition or show signs of deterioration that could compromise their functionality.
- Inspection and maintenance of racks: This cause refers to periodically checking if the inspection and maintenance of racks is in good condition.

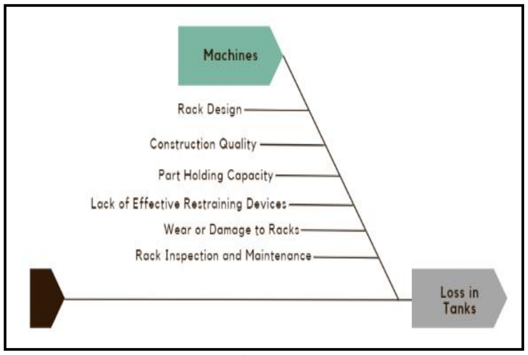

Figure 7
Ishikawa Diagram for Loss in Tanks

Figure 8
Rack

Figure 9
Basket

Improve

In the Improve phase, the company focuses on implementing effective solutions based on the findings and analysis conducted during the Analyze phase. After identifying the most significant scrap, Loss in Tanks, an action plan has been developed to specifically address this problem. The Improve phase represents a crucial step in the continuous improvement process, where changes will be implemented, and adjustments will be made to the anodizing process with the goal of reducing the incidence of scrap and improving overall efficiency. Through interdepartmental collaboration and a commitment to operational excellence, the company seeks to implement innovative solutions that will have a measurable positive impact on product quality and process efficiency.

After identifying in the Analyze stage that the rack (Figure 8) could be considered obsolete, the decision was made to implement equipment that would generate less scrap. In this case we decided to try the baskets (Figure 9). When these baskets are opened, the parts are placed in them, covered again by placing the clips on the sides and ready to be immersed in the anodizing tank. These baskets are used in another area that has nothing to do with the anodizing area, however, as the material is resistant to the chemical that contains the tanks, it was considered as a good option since it would not be necessary to invest in buying equipment. In addition, the area where these baskets are being taken from is not affected since there are plenty of baskets.

To prove that the basket is indeed a better piece of equipment than the rack, the scrap of three shifts was taken into consideration. That is to say, three shifts were performed with racks to collect the data of the most significant scraps "Loss in Tanks", "Rack Marks" and "Deformed Units". We then collected the data from three shifts using baskets in order to compare whether the baskets generated less scrap.

When collecting the data in those six shifts, it was observed that in the shifts that used baskets, two of the significant scraps were eliminated (Rack Marks and Deformed Units) since they were scraps caused by the rack as such. On the other hand, the "Loss in Tanks" scrap is still in force, but the amount of scrap generated previously was effectively reduced, as can be seen in Table 9, Table 10 and Table 11.

Table 9
First Shift Scrap Collected

	First Shift	
	Comparison Table	
	Rack	Basket
Loss in Tanks	1,190	892
Total	1,190	892

Table 10
Second Shift Scrap Collected

	Second Shift	
	Comparison Table	
	Rack	Basket
Loss in Tanks	1,236	927
Total	1,236	927

Table 11
Third Shift Scrap Collected

	Third Shift	
	Comparison Table	
	Rack	Basket
Loss in Tanks	1,372	1,029
Total	1,372	1,029

Control

As part of our commitment to ongoing improvement and operational excellence, we decided to put two crucial measures into place during the control phase of our anodization process:

- Training: The company is committed to ensuring that staff members are fully trained in the use of the new canastas and related procedures. Consequently, in order to ensure that every team member is ready to use these tools effectively and adhere to established procedures, exhaustive training is being provided. The company firmly believes that competent staff is essential to the success of any implementation.
- Auditors: The company understands how important it is to regularly check that established standards and procedures are being followed, as well as to identify any deviations or potential issues. Thus, in order to evaluate the performance of the process and ensure that the implementation is working properly, periodic audits are being carried out. These evaluations will provide useful information to provide opportunities for correction and continue to improve the anodizing process.

By putting these controls in place throughout the control phase, we are demonstrating our commitment to quality, efficiency, and ongoing improvement in every facet of our operations.

Conclusion

Based on a thorough analysis of the test runs performed, the organization is pleased to report that it has achieved a remarkable accomplishment by reducing the level of scrap by an impressive 25%. This result far exceeds initial expectations, demonstrating the effectiveness of the strategic measures implemented. This milestone not only leads to significant improvements in the efficiency of the anodizing process, but also generates positive impacts on cost optimization and overall customer satisfaction.

The ability to identify and address the underlying causes of scrap has been fundamental to this success. The implementation of innovative practices and tools such as baskets has allowed us to optimize workflow and minimize waste. This proactive approach to quality management and continuous improvement has proven to be critical to achieving the objectives set.

The organization's commitment to constant performance monitoring and agile adaptation of strategies to maintain and exceed scrap reduction standards is reiterated. This focus on operational excellence and collaborative work reinforces the company's leadership position in the industry and consolidates the organization's reputation as a benchmark in terms of efficiency and quality.

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