Optimization of shear testing

Author: Wilfredo Acevedo Liceaga
Advisor: Carlos Gonzalez, PhD
Department: Industrial Engineering

Abstract

Between 2022 and 2023, Lightspeed and the welding department manufactured 371 million contact arms for residential breakers. However, 207,132 were discarded due to the destructive shear test, resulting in a 0.029%(100,956 pieces) scrap rate. This project aims to replace the destructive test with a non-destructive alternative to eliminate the scrap due to shear test. Using the DMAIC methodology, we identified the problem, measured the waste rate, and analyzed data to identify root causes. The Olympus OmniScan MX2 ultrasonic system was chosen for its advanced inspection capabilities. Our analysis revealed a loss of $29,841 due to the current testing system. By implementing the OmniScan MX2, we anticipate eliminating 100% of scrap associated with the shear test, achieving an ROI of 1.34 years. This project offers a cost-effective solution to improve testing accuracy and efficiency, reducing waste in breaker manufacturing.

Introduction

This project addresses Lightspeed's challenge in manufacturing contact arms and the resulting scrap loss due to shear testing for residential circuit breakers. During 2022-2023, significant waste of contact arms occurred due to destructive shear testing. Our aim is to replace this with a non-destructive alternative, using the DMAIC methodology to identify root causes and assess options. Implementation targets reducing losses and enhancing efficiency in the manufacturing process.

Background

The shear test is fundamental in manufacturing components for residential circuit breakers, ensuring the durability of contact arms under operational stress. However, its destructive nature leads to substantial waste and increased non-conformance costs. Despite its crucial role in ensuring product quality, it is often seen as a cornerstone indicator, hampering timely corrective measures. Nonetheless, its utilization remains indispensable for identifying potential product vulnerabilities before distribution and mitigating failures and associated legal liabilities. Pursuing non-destructive alternatives remains paramount to enhance efficiency and reduce costs in manufacturing components for residential circuit breakers.

Problem

In this design project, we addressed the challenge of optimizing the shear testing process in manufacturing components for residential circuit breakers. The primary issue revolved around the destructive nature of the shear test, leading to high levels of scrap and increased non-conformance costs. Our main objective was to find a non-destructive alternative that would ensure the integrity of the components without incurring significant losses. Additionally, we aimed to identify the root causes of the existing problem, assess various options for non-destructive testing, and determine the feasibility of implementing a more efficient and cost-effective solution. This research was crucial because tackling this issue would not only enhance operational efficiency and reduce associated costs in producing residential circuit breakers but also guarantee the quality of the final products and bolster competitiveness in the market.

Methodology

Adopting a systematic DMAIC approach is crucial for achieving the project's objective of enhancing the audit process during the product realization phase. Specific DMAIC tools will be employed to increase audit yield and reduce defects.

In the Define phase, the Project Charter will outline the project's scope, objectives, roles, and responsibilities as a critical reference.

In the Measure phase, a SIPOC diagram will summarize the process's inputs and outputs, helping to understand all the variables and critical steps involved. Additionally, constraints will be validated using a thought map, and a Pareto analysis will identify the piece with the highest scrap rate.

During the Analyze, Improve, and Control phases, a fishbone diagram will examine all factors affecting the process, and a 5-why analysis will identify the primary factors impacting the welding test process. This comprehensive approach aims to address inefficiencies and issues systematically, improving process efficiency and effectiveness.

Project Charter

PROBLEM STATEMENT

From 2022 to 2023, Lightspeed and the welding departments processes manufactured 371 million residential breakers. A crucial functional test to ensure the proper functioning of these breakers is the shear test, a destructive testing method. During this period, the facilities discarded 207,132 contact arms due to the requirements of the shear test.
Out of the 371 million parts produced, Lightspeed accounted for 93% (346 million), resulting in a scrap rate of 0.029% (equivalent to 100,956 parts) due to shear testing. Notably, the Lightspeed department exhibited the highest shear test scrap rate. As a lagging metric, shear testing must be more precise and significantly contribute to the overall scrap percentage and the cost of non-conformance metrics for the Lightspeed department.

FINANCIAL BENEFIT

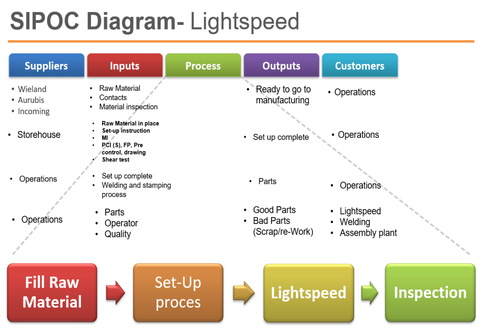
The welding (manual & automatic) and Lightspeed departments have a total annual loss of $81,367.68. Within that amount, Lightspeed contributes $29,841, equivalent to 36% of the total as compared to welding areas. The primary objective of the project is to completely eliminate these losses, reducing them to $0

METRICS

- Cost of non conformance (Conc)

OTHER BENEFITS

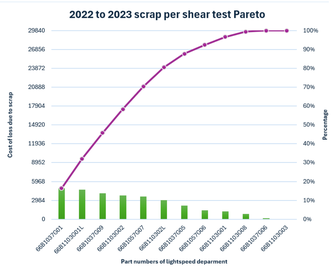
- Cost savings in rejection and rework.
- Improvement in operational efficiency.
- Reduction of material waste.

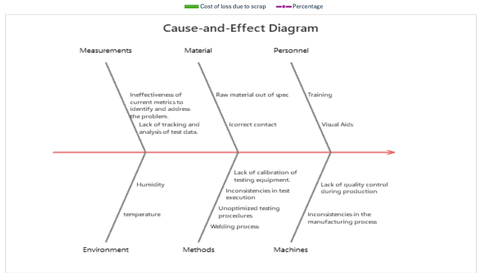


Results and Discussion

The project revealed that part number 66B1037G01 was the main contributor to scrap in the shear tests conducted by the Lightspeed department between 2022 and 2023, accounting for 100% of accumulated costs. This highlights the urgency of achieving a zero-waste margin by implementing a new non-destructive system. A deeper analysis using the fishbone diagram identified multiple factors contributing to the waste issue, such as inefficient test procedures and the destructive nature of existing equipment. These findings underscore the need to optimize the testing system with non-destructive methods to reduce scrap and improve process efficiency effectively. The conclusion confirmed that destructive shear testing is the primary cause of the high waste rate. A 5-why analysis further validated this root cause. A comprehensive study identified the Olympus OmniScan MX2 ultrasonic system as the best non-destructive testing solution, considering demand and business needs. Implementing this system will enable the identification of weld anomalies across all part numbers requiring shear testing, thus significantly reducing waste and achieving the project's main objective.

Pieces that has shear test									
Part number	Labor cost (FAC)/per hour	Piece cost	shear test 12 per hour	shear time in hour	run time	1Year Time it takes shear test	Time benefit	Run time*pcs with shear test (12 pc)	Total cost of shear test per piec
Lightspeed									
66B1103G01	14.25	0.199659	6 min	0.1	520.72	52.072	26.036	6248.64	1247.61
66B1103G01L	14.25	0.195833	6 min	0.1	1980.95	198.095	99.0475	23771.4	4655.23
66B1103G02	14.25	0.30296	6 min	0.1	1033.421514	103.3421514	51.7	12401.05817	3757.12
66B1103G02L	14.25	0.299134	6 min	0.1	844.74	84.474	42.2	10136.88	3032.32
66B1103G03	14.25	0.492263	6 min	0.1	1.029	0.1029	0.05145	12.348	6.078
66B1103G08	14.25	0.310422	6 min	0.1	228	22.8	11.4	2736	849.51
66B1037G01	14.25	0.278643	6 min	0.1	1467.55	146.755	73.38	17610.6	49.07
66B1037G05	14.25	0.477628	6 min	0.1	33.36	3.336	1.668	400.32	2149.33
66B1037G06	14.25	0.413575	6 min	0.1	747.81	74.781	37.3905	8973.72	165.59
66B1037G09	14.25	0.445903	6 min	0.1	764.22408	76.422408	38.2112	9170.68896	4089.23
66B1057G06	14.25	0.369294	6 min	0.1	317.2	31.72	15.86	3806.4	1405.75
66B1057G07	14.25	0.351564	6 min	0.1	847.67	84.767	42.3835	10172.04	3576.16





5 Why's		
Why	Question	Answer
1st why	Why does Lightspeed have a high scrap rate of 207,132 contact arms?	Because the shear test, a destructive testing method, breaks a significant number of contact arms.
2nd why	Why is the shear test being used despite its destructive nature?	Because it has been the traditional and accepted method for testing the strength and quality of the contact arms.
3rd why	Why has there been no shift from the shear test to a non-destructive testing method?	Because of a lack of awareness or understanding of alternative non-destructive testing methods that can effectively validate the quality of the contact arms
4th why	Why hasn't the organization sought alternatives to the shear test?	Because of a possible resistance to change and concerns about the initial investment or reliability of alternative testing methods.
5th why	Why is there resistance to changing the testing method even with the high scrap rate?	Because the shear test is deeply entrenched in the company's testing procedures and there might be a belief that no other method can provide the same level of quality assurance

Conclusions

The research concluded that the high scrap rate in testing contact arms for residential breakers at Lightspeed was primarily due to the destructive nature of the current shear testing method. Between 2022 and 2023, this testing resulted in significant waste, specifically for part number 66B1037G01. Using the DMAIC methodology, the study identified and analyzed the root causes of waste. This led to selecting the Olympus OmniScan MX2 ultrasonic system as a more efficient non-destructive testing alternative. Implementing this system is expected to eliminate 100% of the waste associated with shear tests, resulting in substantial cost savings and improved testing accuracy. The project demonstrates the feasibility and benefits of transitioning to non-destructive testing methods, offering a cost-effective solution to enhance efficiency and sustainability in breaker manufacturing.

Future Work

For the future, once the new system is implemented in the Lightspeed department, a promising next step would be to introduce the same system in the welding department. This would further optimize the testing processes.

Acknowledgements

In this section, I would like to express my gratitude to the team that helped carry out this project, whose support and guidance were essential for the completion of this research.

References

[1] Tanner, S. (2024, March 20). DMAIC Process: The 5 Phases of Lean Sigma You Must Know. Simplilearn. https://www.simplilearn.com/dmaic-process-article#:~:text=Define%2C%20Measure%2C%20Analyze%2C%20Improve,customer%20(internal%20and%20external).

[2] ASQ (n.d.). WHAT IS A PARETO CHART? https://asq.org/quality-resources/pareto

[3] What is a Fishbone Diagram in project management? | Wrike. (n.d.). [Online] Available: https://www.wrike.com/project-management-guide/faq/what-is-a-fishbone-diagram-in-project-management/

[4] Boogaard, K. (2021, February 3). Introducing the 5 Whys Technique of Problem Solving. Wrike. https://www.wrike.com/blog/the-five-whys-technique-problem-solving/

[5] Olympus (n.d.). OmniScan MX2. https://www.olympus-ims.com/en/omniscan-mx2/