Damaged Magnet Wire Solution for Boeing 787-10 Electric Motor Pump

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Abstract *— Damaged magnet wires is a problem that negatively affects the production of the 787-10 Boeing Airplane Electric Motor Pump. The major cause of damaged magnet wire during removal process is lack of adequate core protection. It was found that by implementing a plastic shim during this stage of the process, the defect was reduced by 100%, surpassing the initial goal of a reduction of 30% in PPM (Parts Per Million) and SRR (Scrap Rework and Repair) metrics.*

Key Terms *— Core, Nicked Wire, Polyester, Shim*

INTRODUCTION

Collins Aerospace operates in various segments, including commercial aviation, military and defense, business aviation, and helicopters. The company offers a wide range of products and services, including aircraft systems, avionics, mission systems, communication systems, cabin interiors, navigation solutions, and more. In the aircraft systems segment, electric motor pumps are manufactured at the Santa Isabel Site, Puerto Rico.

Airplane electric motor pumps are components used in aircraft hydraulic systems. These pumps are driven by electric motors rather than traditional engine-driven pumps. They play a crucial role in providing hydraulic power for various aircraft systems, such as landing gear operation, flight control surfaces, brakes, and other essential functions. The electric motor pumps consist of an electric motor demonstrated in Figure 1 and a hydraulic pump assembly. The electric motor converts electrical energy from the aircraft's power source, typically the electrical system or auxiliary power unit (APU), into mechanical energy. This mechanical energy is then used to drive the pump, which pressurizes the hydraulic fluid.

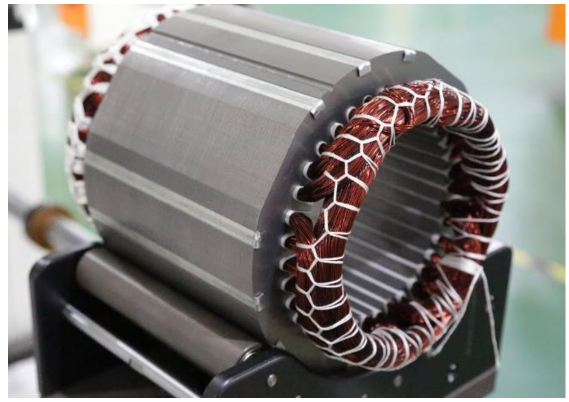

Figure 1
Finished Stator Example

The manufacturing process of electric motor pumps involves various complex steps to ensure the production of high-quality and efficient devices. However, one recurring issue in this process has been the occurrence of rejections due to nicked magnet wires during the removal of the top layers of the magnet wire from the core. This problem not only compromised the overall quality of the product but also led to financial losses and operational inefficiencies.

To address this critical concern, a project was initiated to find a viable solution. After careful evaluation and testing, it was determined that the implementation of a plastic shim in the manufacturing process could potentially solve the issue. A plastic shim, in this context, refers to a thin, flexible material inserted between the magnet wire and the core to prevent damage during the removal process. As primary objective, the solution will reduce by 30% the overall PPM's metrics for defect related directly to this condition of damaged magnet wires by May 2023. As a secondary objective, reduce by 30% the overall rework cost or SRR by May 2023.

CURRENT STATE

Before the implementation of the plastic shim in the manufacturing process of electric motor pumps, the company faced significant challenges. Rejections due to nicked magnet wires during the removal process resulted in a notable financial impact. The projected financial progress of the project was $52,700 by the end of May, but the without tool trendline indicated potential costs and rework expenses.

Furthermore, the project initially calculated a rework cost of 70%, equivalent to $9,045. This indicated the financial burden and inefficiencies caused by the occurrence of defects. These quality issues not only affected the company's reputation but also added to the financial strain. Operator feedback highlighted the ergonomic issues and manual-intensive nature of the removal process, impacting overall productivity and operator confidence. These challenges emphasized the need for a practical solution to streamline operations and improve the manufacturing process.

The analysis of the current state, considering both financial and operational aspects, revealed the urgency and importance of implementing a reliable and efficient solution. The introduction of the plastic shim aimed to eliminate defects, improve operator confidence, and achieve cost savings. By addressing these issues, the company aimed to enhance overall productivity, reduce financial losses, and ensure the production of high-quality electric motor pumps.

The implementation of the plastic shim in the manufacturing process of electric motor pumps had a significant impact on the aerospace parts customer of the product. Prior to the introduction of the plastic shim, the occurrence of rejections due to nicked magnet wires posed a risk to the quality and reliability of the electric motor pumps used in aerospace applications. The elimination of these rejections ensured that the aerospace parts customer received products of higher quality and reliability, meeting their stringent requirements.

METHODOLOGY

Root cause analysis (RCA) played a crucial role in analyzing rejection data and identifying opportunities for improvement in the manufacturing process. Cross-functional teams were formed to conduct a comprehensive RCA using a structured problem-solving tool known as the Cause-and-Effect Diagram, or Fishbone Diagram. This allowed for a systematic exploration of potential root causes contributing to the occurrence of rejections due to nicked magnet wires.

Through the RCA process, the teams discovered that the manual-intensive removal process itself was a key factor leading to the defects. This finding led to further investigation and brainstorming sessions, where the idea of protecting the magnet wires during the removal process emerged as a potential solution.

To validate this idea and trace opportunities in the manufacturing process, scatter diagrams were utilized. By analyzing the relationship between the occurrence of rejections and various process variables, the teams were able to identify a correlation between the absence of protection for the magnet wires and the occurrence of defects. This data-driven approach provided evidence supporting the need for a protective solution, leading to the concept of implementing a plastic shim.

Collaborative effort of different teams, combined with the use of analytical tools, facilitated the discovery and implementation of the plastic shim as a preventive measure during the removal process.

The implementation of the plastic shim as a solution for protecting magnet wires during the removal process brings several benefits, aiming to reduce the overall impact on customers and improve key metrics. Currently, the project has incurred a year-to-date rework cost of $31,000 due to damage occurring during the removal process of the top layer of magnet wire from the stator core slots.

The final dimensional thickness defined for the plastic shim was 0.015”, after trying different alternatives with different thickens such as 0.025”, 0.020”and 0.010”. The alternatives for the plastic shim thickness were reduced to those 4 due to the slot walls thickness of the stator space is less than 0.040”, therefore adding a plastic shim with a higher thickness would result in no magnet wire being removed from the slots due to high thickness or damaged plastic shims due to reduced thickness and overall strength. Each plastic shim will be discarded monthly due to wear and tear produced during the manufacturing process and overall cost of each is $0.05 (Quantity of 20 to be replaced monthly).

When comparing Kapton and polyester, it is evident that Kapton possesses superior strength characteristics. Kapton is a polyimide film known for its exceptional mechanical properties, including high tensile strength and tear resistance. Polyester is less durable, but more practical in terms of economical purposes for the manufacturing process. Therefore, the polyester plastic shim was used as it could be discarded frequently and economically.

RESULTS

The implementation of the plastic shim in the manufacturing process of electric motor pumps has yielded highly positive results. The primary objective of the proposed solution was to reduce the impact on customers caused by recurring non-conformance issues related to damaged magnet wires. The data collected thus far indicates a significant improvement in the rework and Parts Per Million (PPM) metrics.

Prior to the implementation of the plastic shim, the project had incurred a year-to-date rework cost of $31,000 due to damage occurring during the removal process of the magnet wire's top layer from the stator core slots. By addressing this issue, the project aimed to reduce the overall PPM metrics associated with damaged magnet wires by 30% in the upcoming months. This reduction would have a direct positive impact on the overall product quality and customer satisfaction.

In addition to the PPM improvement, the project set a secondary objective of reducing the overall rework cost by 30% in the upcoming months. The target was set at $52,700 by May 2023, with the current rework cost estimated at $62,000 if the solution was not implemented. By implementing the plastic shim, substantial cost savings were expected to be achieved, contributing to improved financial performance. The successful implementation of the plastic shim occurred on April 3, 2023, following a meticulous evaluation process that determined the optimal dimensional thickness of 0.015". This thickness was selected based on considerations of the slot walls' thickness in the stator space, ensuring effective protection for the magnet wires during the removal process.

Financial progress is greater than the projected 52,700$ by the end of May. Figure 2 demonstrates the actual financial progress vs the projected progress of the project. Initially, the project scope was to reduce 30% the overall recurrence of the incidence, but after implementation of the tool proposed, no incidence was currently recorded resulting in a 100% reduction after implementation. The differential between the without tool trendline and the actual cost trendline, by the end of April is $12,915.00 or the actual savings of the project. The project initially calculated a rework cost of 70% or $9,045 by the day of this report, but project results are a 100% reduction in defect and a $12,915 in overall cost avoidance.

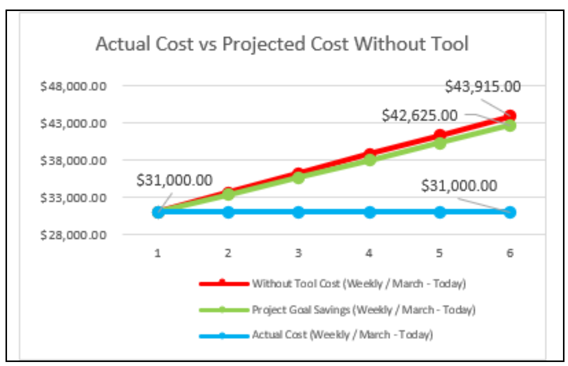

Figure 2
Actual Cost vs Projected Cost

Conclusion

The implementation of the plastic shim has successfully reduced the impact on customers caused by damaged magnet wires, leading to improved product quality and customer satisfaction. Additionally, significant improvements have been observed in rework costs and PPM metrics. The implications of these findings are twofold. Firstly, the implementation of the plastic shim has resulted in tangible benefits such as reduced defects, improved financial performance through cost savings, and enhanced customer trust. Secondly, the successful application of this solution highlights the organization's commitment to continuous improvement and adherence to quality standards.

Moving forward, it is recommended to continue monitoring the effectiveness of the plastic shim through ongoing data collection and analysis. Further optimization opportunities within the manufacturing process should also be explored.