Damaged cable solution on F-35 electric motor on Aerospace Industry

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Introduction

The electromagnetic engine of the F-35 aircraft is manufactured in Santa Isabel Puerto Rico and each unit costs about $6,000. This electromagnetic engine is one of the most complex to manufacture. Since this is a military electromagnetic engine, it has very high-quality standards and requirements. This electromagnetic motor is one of the most advanced in its category due to its relatively small size, which can generate large amounts of electricity. It should be noted that this electromagnetic engine, because of its difficulty, there is no other place where it can be manufactured. The F-35 aircraft has two of these engines inside, giving it the necessary power for a machine of this caliber.

An electric or electromagnetic motor is an electrical machine that transforms electrical energy into mechanical energy. It takes advantage of the fact that when a conductor through which an electric current circulates is within the action of a magnetic field, it tends to move perpendicularly to the lines of action of said magnetic field.

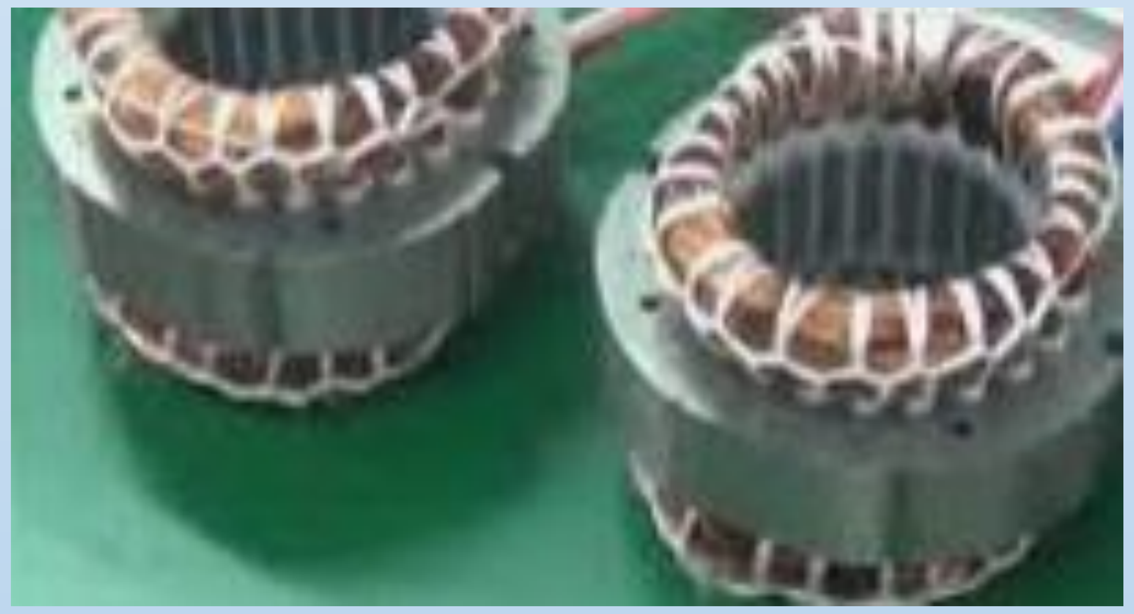

Figure 1
Example of electromagnetic motors

Objectives

The objective of this project is that these units Figure 1 are manufactured with the highest possible quality, attacking the major defect of this engine, which are the broken wires during manufacturing. To accomplish the objective, the DMAIC (Define, Measure, Analyze, Improve, Control) methodology was applied.

The expected benefits of this initiative are to:

- Decrease the incidence of broken wires.
- Decrease the manufacturing time of each motor.
- Decrease rework hours.
- Decrease scrap cost.

Methodology

To address this problem, the DMAIC methodology was used. In the Define phase, the voice of the customer was heard. This happens on the same production line during a GEMBA walk. The inspector was frustrated as he frequently found a damaged wire at the end of manufacturing the part. This defect, at this point, had a $6000 impact. The project goal was to reduce the failure rate from 35% (current) to 0% and a cost avoidance of $117,760.00 per year.

Also on the Define phase, the SIPOC tool was used to determine which process should be focused on. In the Measure phase, data was obtained that with this defect, 25 hours of work were lost, significantly impacting the production line in terms of delivery time. The Fishbone tool was used to visualize the possible causes in the Analyze phase. On the other hand, the Five Whys tool was used to precisely know the root causes of the problem.

In the Improve phase, a trial-and-error approach was applied. An advanced system of iterations was used, which consists of drawing and making prototypes in the shortest possible time using additive manufacturing technology known as a 3D printer. In the Control phase, the real cause of the cable breakage was clarified. The resin was lodged in the spaces between the copper and the cables, causing the cables to be irreparably damaged. They were causing an immediate loss to the company of $6,000.

The causes that were attacked to prevent the cables from breaking were to limit the movement of the cables with cable retainers. Another of the solutions was to protect the wires during the process with Teflon tape, and to add a special oil called McLube to prevent the resin from sticking near where it accumulated.

Manufacturing Process

The first operation or step to start manufacturing a motor is copper group as shown on figure 2. These will be fed into the core of the unit as shown on Figure 3

Figure 2
Example of electromagnetic coils

Figure 3
Example of core

An employee who places the coil groups within the core, following a specific pattern per grouping, called a Winding Diagram. The coil grouping follows the assembly design specifications as shown on Figure 4.

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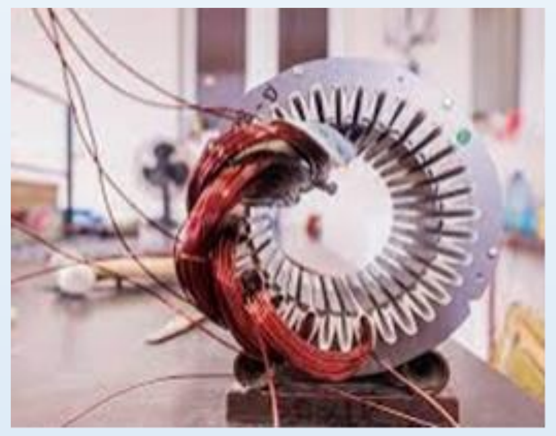

Figure 4
Example of insertion process

Next comes the forming process. Manufacturing process that configures, welds the wires, and joints, ties the ends of the wires, arranges them in a specific location and performs a forming process to control the dimensions as shown on Figure 5.

Figure 5
Example of laced unit

Next come the impregnation operation as shown on figure 6, which is a method or process that infuses a resin to fill the windings of the motor and electric generator components. It is in this process that the wires are broken. When the resin solidifies, it creates sharp edges that break the wires.

Figure 6
Example of impregnation process

At the end of the impregnation process, the unit is left with residues that need to be removed. The ultrasonic cleaning process is a process that uses a chemical or solvent, in different stages and equipment: agitation, resting and drying, to remove the particulate from the unit after the impregnation operation and in turn, remove any foreign material ("FOD") from the unit as shown on Figure 7.

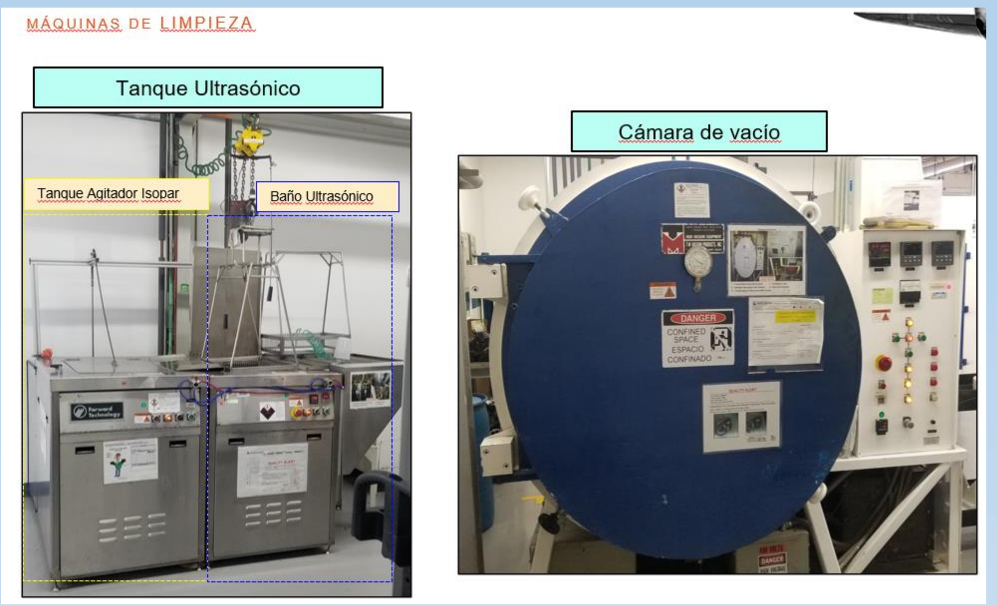

Figure 7
Cleaning machines

Finally, comes the last operation and that is the final inspection here, an inspector is the employee who validates that the product is in conformity with the engineering requirements and the customer's expectations.

Conclusions

After the evaluations and the use of DMAIC tools the implementations of these three solutions, the project was able to obtain a very significant improvement. This defect disappeared completely because the root causes that caused the wires to break were addressed. With the retainers shown in Figure 8, the wires could not move, thus helping the handling. With these retainers, space is also made, and the amount of resin build-up is drastically reduced because there is practically nowhere for it to stick to. The Teflon tape serves as a hardened resin protector. If any object touches the wires with the tape installed, it will not have as much chance of breaking them. And finally, the McLube oil, shown in Figure 9, plays a very important role because if resin falls on the oiled area, the resin will slide off and will not have a chance to damage the wires.

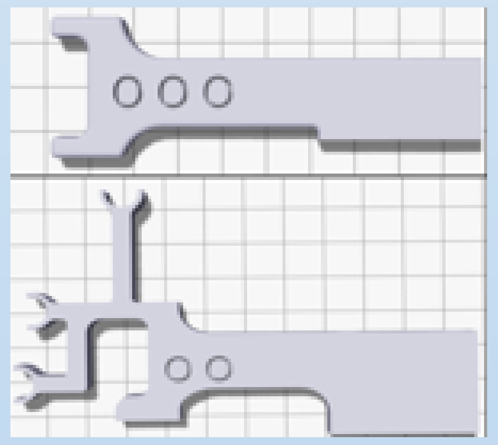

Figure 8
Cable retainers

Figure 9
McLube

The objectives were met only by improving the quality of the product and the quality of the process. One thing learned is that if quality can be improved, this can improve any metric, such as lead time, SRR and on time delivery.

Future Work

In future work, these solutions will be implemented on other electromagnetic motors or rotors that have already been impacted by this same defect. So far, given my experience, these solutions, with slight adjustments, could be applied to almost any winding product.

Acknowledgements

A big thank you to the following people who were instrumental in the realization and implementation of this project:

- Josue Perez Pierantoni (Product Line Supervisor)
- Hector Montosa (Manufacturing Engineer)
- Christian Barbosa (Machine Operator)
- Ernie Rodriguez (Machine Operator)