Case Study – Corrosion Djinn

Client

Figure 1 An F/A-18F Super Hornet

The U.S. Navy and Marine Corps comprise the world's second-largest air force, with a total of over 3,700 aircraft of all types. The Naval Air Systems Command (NAVAIR), headquartered in Patuxent River, Md., is charged with providing full life-cycle support for aviation aircraft, weapons and systems operated by Sailors and Marines. NAVAIR covers the spectrum from R&D, test, evaluation through to training, repair and in-service engineering with logistics support. Key objectives are to improve affordability by reducing operating and sustainment costs.

The Problem

Corrosion is one of the biggest degraders of readiness in Naval aviation[1], resulting in about 30 days a year, during which the aircraft is not mission-ready. Corrosion experienced by Navy and Marine Corps aircraft costs approximately $3.6 billion per year and accounts for almost one third of all maintenance costs. Indeed, this is part of a larger problem; a NACE study[2] estimated that 25-30% of corrosion issues could be avoided if optimum corrosion management practices were followed.

Figure 2 84-day corrosion inspection on an F/A-18E Super

There are many corrosion mechanisms, but evidence from aircraft teardowns[3] shows that 80% of corrosion costs related to structural damage stem from galvanic corrosion events. One particular issue is galvanic corrosion around fastener holes, a problem prevalent on the F/A-18F Super Hornet. The current fix for corrosion around fastener holes is to remove the corrosion and bring the hole dimension back into tolerance by opening it up and inserting a bushing. This is a lengthy and costly process, since even a single wing often has hundreds of corroded holes (Figure 3). The bushing material usually used is a stainless steel such as 15-5PH, because it is widely available in depots and easy to machine. Besides, when the depot maintainer consults the standard reference specification galvanic corrosion,

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[1] http://www.navair.navy.mil/index.cfm?fuseaction=home.NAVAIRNewsStory&id=6191

[2] NACE Corrosion Costs and Preventive Strategies in the United States - supplement. https://www.nace.org/publications/cost-of-corrosion-study/

[3] G. Shoales, et al., "Compilation of Damage Findings from Multiple Recent Teardown and Analysis Programs." Proc. of the 25th Symposium of the International Committee on Aeronautical Fatigue, held, May 27-29, 2009 (Stockholm, Sweden: ICAF, 2009).

MIL-STD-889, its galvanic tables tell him that stainless steel is a reasonable choice galvanically. Despite galvanic tables, stainless steel is a poor choice of materials, causing even more aggressive galvanic corrosion of the aluminum alloy airframe. Materials engineers have long known that titanium is a better choice than stainless, but could make little headway in the face of the MIL-STD-889 specification.

The Solution

The answer is to update the MIL standard and provide the maintainer with a better way of making materials choices. NAVAIR is doing precisely that. Under the Office of Naval Research Sea-Based Aviation program NAVAIR and Corrdesa developed a consistent, robust and validated method of assessing galvanic corrosion for mixed material couples, which Corrdesa has developed and commercialized as Corrosion Djinn™. Corrosion Djinn™ is a fast and easy-to-use software tool based on a growing database of validated, consistent electrochemical data for modern materials, coatings, and treatments. The science behind Djinn is the calculation of corrosion current (and directly the corrosion rate) rather than using galvanic potential tables, which are not sensitive to the actual corrosion kinetics. NAVAIR is in the process of updating MIL-STD-889 to base it on these galvanic current calculations, not galvanic potential differences.

Figure 3 Corrosion under F/A-18F wing panels

Impact

Many organizations implement MIL-STD-889 for assessing galvanic corrosion risk, and OEMs are often required by contract to use MIL-STD-889, so the updated standard will greatly improve galvanic corrosion in new aircraft, while Corrosion Djinn™ provides an easy way for manufacturers and maintainers to meet the updated standard.

Using Djinn we have demonstrated that bushings fabricated in a titanium alloy Ti6Al4V will produce significantly less galvanic corrosion, whereas, galvanic tables would incorrectly suggest the contrary. Titanium bushings can now be implemented, resulting in substantially lower galvanic corrosion and longer durations between maintenance cycles. Applying Corrosion Djinn™ to the numerous other galvanic interfaces that occur in aircraft will lead to significant reductions in corrosion and improvements in structural integrity.

Figure 4 Close-up of corrosion under F/A-18F wing panels