



Metalworking

Combating Corrosion in Aerospace Parts, from Start to Finish

Kip Hanson | Sep 17, 2024

Rusty signs and gates. Copper electrical terminals, slowly turning green. It's a sad fact of metallurgy that, with a few exceptions, all metals oxidize and—if left unprotected—corrode as a result.

You can blame oxygen, a highly reactive gas that plays a leading role in the phenomenon that eventually takes down even the tallest of buildings and sinks the most massive of ships.

Fortunately, some metals are at least corrosion-resistant, if not completely corrosion-proof. At the top of the list are noble elements like gold, silver and platinum, which are far less susceptible to oxidation, a process referred to as rusting in steel and other iron-bearing metals.

Then there are *aluminum*, chromium, *titanium* and nickel. Like their noble cousins, these form a thin layer of metal oxide when exposed to air, protecting their surfaces from further corrosion. That quality, combined with a high strength-to-weight ratio, extreme toughness or combination of the two, is why the metal alloys made from them are favorites in the aerospace industry.

Machining Corrosion-Resistant Alloys

Those same qualities make them notoriously tough to machine, a challenge on which John Giraldo, aerospace engineering projects manager for the Americas at Sandvik Coromant, can offer plenty of advice.

"Our expertise lies in the development of cutting tools that can efficiently and consistently machine these very tough materials and do so in the shortest time possible," he says. "Materials like Rene 41 and Inconel 718 are not only extremely corrosion-resistant but can withstand very high temperatures, which is why they're so popular with engine manufacturers, but there's also plenty of titanium as well as 300-series and PH stainless steel to contend with."

Of course, aircraft manufacturers use plenty of metals that are less robust than these heat-resistant superalloys, including alloy steels and aluminum.

Their level of oxidation resistance doesn't affect the actual machining process, except for the small adjustments made to finished part dimensions to compensate for plating or coating buildup after components leave the shop floor.

Plate, Paint, Coat and Powder

Here's a brief outline of the secondary processes used to enhance durability in some metals used in aircraft and jet engine components:

- Anodizing (which, ironically, is a controlled form of oxidation) is the go-to coating for all aluminum alloys, especially the Type III process used on critical aircraft components.
- Cadmium, nickel, chrome and zinc plating are found on everything from fasteners and brackets to the parts used in landing gear and hydraulic systems.
- Phosphate or chromate conversion coatings are typically used as a base for paints, primers and powder coating.
- Various physical vapor deposition (PVD) and chemical vapor deposition (CVD) thin films like those used on the cutting tools mentioned previously are sometimes applied to components that require additional wear or corrosion protection.
- Similarly, yttria-stabilized zirconia (YSZ), alumina oxide (Al_2O_3), silicon carbide (SiC), and other "nano" coatings are used on engine components, although increased heat resistance is more often the driving reason.
- Though not a coating or plating process, passivation is typically performed on stainless steel parts to remove surface impurities and promote the naturally occurring oxide layer. It is similar to electropolishing, which takes passivation one step further by smoothing and brightening part surfaces.

Here again, machinists are typically more concerned with meeting part tolerances than whatever finishes are applied.

Once workpieces are complete, the next step is giving them a good cleaning and judicious application of rust preventative before placing them into an egg crate or cardboard box, right?

Wrong, says Dean Richmond, global aerospace sales manager for Master Fluid Solutions. "Assuming you're running a high-quality, water-soluble or semi-synthetic cutting fluid, don't apply a rust preventative, don't put parts in solvent, and for that matter, don't even blow them off after machining. These fluids leave behind a thin layer that provides short-term protection for part surfaces. Hitting them with shop air removes this layer and replaces it with the trace amounts of oil and water found in any compressed air system, which can quickly lead to corrosion."

Richmond offers one caveat to his statement: The cutting fluid must be clean, well-maintained, and kept at the proper concentration level. Further, it should be checked periodically for the passivating compounds that help prevent oxidation in certain metals.

"If you've been machining large aluminum aerostructures nonstop for the past couple of years, chances are good that these compounds have been depleted and need a refresh, either with an additive or by changing the fluid out," he says.

Unseen Corrosion Risk

Richmond notes that *aerospace manufacturers* are just as concerned with the environmental corrosion discussed so far as they are with galvanic corrosion, which occurs when dissimilar metals—aluminum and stainless steel, for instance—are left in direct contact with one another, creating a battery effect that gradually destroys the softer of the two metals involved.

Greg Bruce, a senior technical marketing manager with ITW Pro Brands, agrees. He explains that aircraft require regular maintenance, much of which involves inspecting the myriad parts within for both types of corrosion. If corrosion is found, the components are cleaned and treated with a rust inhibitor or lubricant, or sometimes replaced. "If a part's critical to aircraft function, they'll just put a new one in," Bruce says.

Since most of the materials used in modern aircraft are naturally *corrosion-resistant*, they require little in the way of rust preventatives, he reiterates. The notable exception is where galvanic corrosion occurs, such as in bilge areas and an airplane's belly. Here, steel alloys are sometimes used, particularly on legacy aircraft like the C-5 Galaxy and C-17 Globemaster, military planes known for their load-carrying capabilities.

"Pretty much everything you can see on any aircraft is rustproof," adds Tony Reed, brand manager for the ITW Pro's LPS product line. "It's all the stuff you can't see that's most prone to corrosion, especially in environments that are high in humidity or near saltwater."

Choosing the Best Lubricant

Whatever the type of corrosion, whichever components are involved, Reed is quick to point out that using the correct lubricant to address the problem is crucial. "LPS 1, 2 and 3 are the crown jewels of the LPS line, and are often called out specifically by several well-known aircraft manufacturers," he says.

LPS 1 goes on wet but dries quickly, provides around 30 days of protection and "is really good at displacing moisture from niche areas and crevices, which is an important step before applying a true rust preventative like LPS 2, an oily, non-drying penetrating oil," he explains.

"LPS 2 is the jack of all trades—a lubricant, penetrant, and corrosion inhibitor that offers a couple years or more of protection," Reed says. "Then there's LPS 3. It has limited penetration ability but creates a soft, waxy, self-healing film that's great for areas where the metal is flexing a little bit, like the structural components I just mentioned. Whatever the application, though, it's important to choose the correct product, and be sure to reach out for help if you need a recommendation."

What are your best tips for overcoming corrosion risk? Tell us in the comments below.

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