(Image courtesy: OC Oerlikon)

Aerospace manufacturers turn to non-hazardous PVD coatings as regulations tighten on toxic hard chrome plating

Airframe manufacturers such as Airbus are expanding the use of PVD coating to broader applications, including copper bearings and bushings in landing gear assemblies.

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By Jeff Elliott

The search for a suitable replacement to hard chrome plating on aerospace components has been a key supply chain priority for aircraft manufacturers. This is because of the documented health risks to workers and the impact on the environment from exposure to hexavalent chromium, a carcinogen that occurs during the chrome plating process and the most toxic form of chromium.

Chromium is, as a result, a highly regulated chemical in major markets worldwide. In the European Union, hexavalent chromium falls under the domain of the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation, which establishes guidelines for the safe use of chemicals throughout the supply chain. Chromium is also closely regulated by the United States' Occupational Safety and Health Administration (OSHA)

> *"It has been a big task for the aerospace industry to replace hard chrome because it isn't as easy to find an exact replacement – every alternative will be a bit different," says Oerlikon Balzers Global Aerospace Segment Manager Toby Middlemiss. "So, manufacturers have had to go back to the drawing board and evaluate why hard chrome was used in the first place, what the application is and what the suitable alternatives are that might work.*

Learn more about hard chrome plating

Replacing hard chrome with a suitable alternative remains a significant challenge for the aerospace industry because of its widespread use as a surface coating on many components. Long prized for its hardness, ability to minimize sliding wear, corrosion protection and for extending the life of metal parts, it can be found on many aero structures, landing gears, engine mounts and air frames. In many cases, it is used on components where there is metal-to-metal contact between moving parts due to its low coefficient of friction.

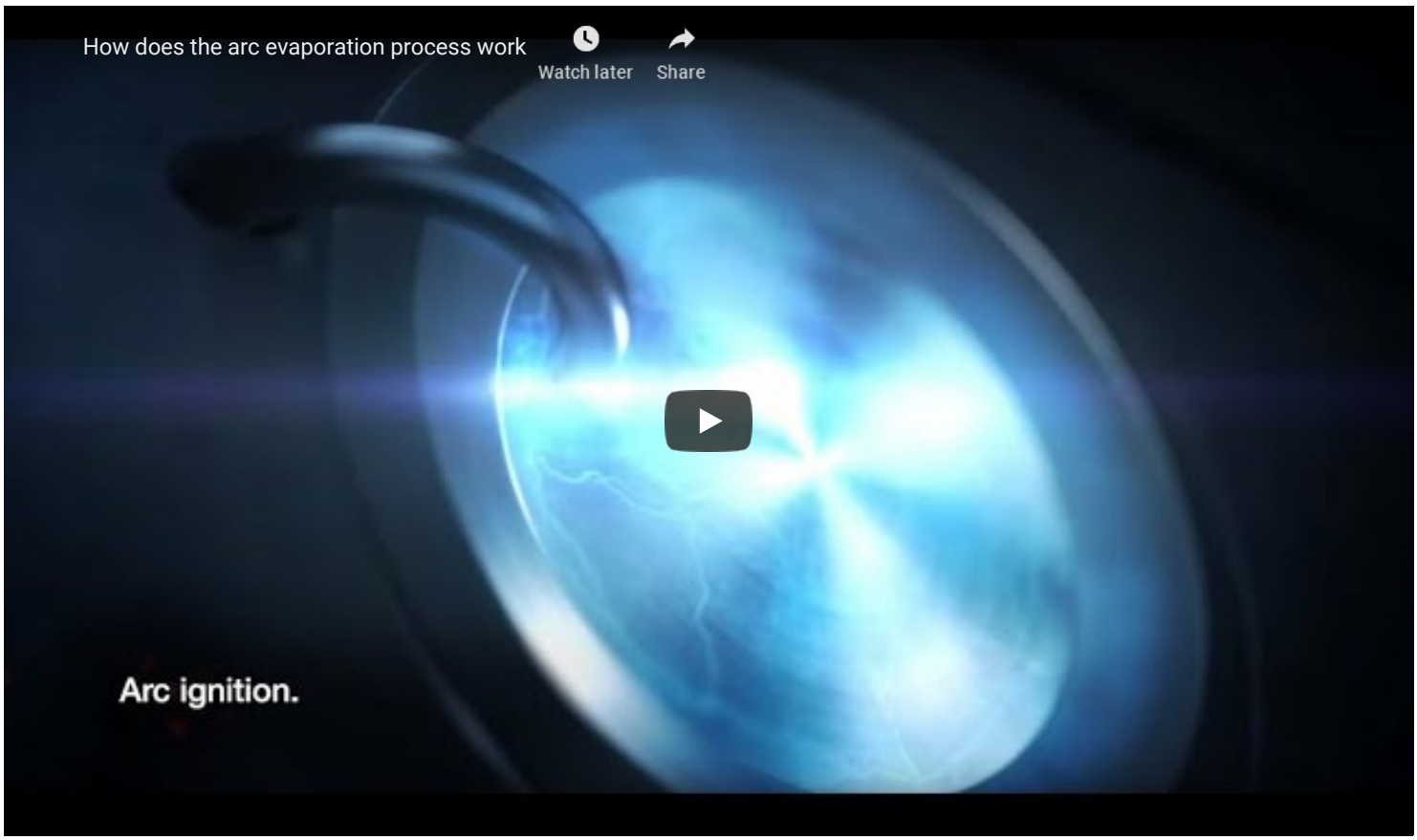
No exact replacement for hard chrome exists, so aerospace companies must identify and evaluate where and why they used hard chrome in the first place. It is a huge undertaking as each hard chrome-plated component needs to be reviewed for its functionality, connectivity to other parts, wear mechanisms, lubrication needs, and environmental operating conditions.

Aerospace companies can often achieve superior performance results with hard chrome alternatives. Despite its widespread adoption, hard chrome is not without its performance issues, including limits to its hardness and corrosion protection, difficulties with recessed and threaded applications, and the risk of pitting and spalling (flaking) under high-stress conditions.

PVD coatings

Physical vapor deposition (PVD) coatings are gaining traction in the aerospace industry as an alternative. PVD coatings offer many of the same benefits of hard chrome, but are REACH-conforming and non-hazardous.

PVD describes a variety of vacuum-deposition methods that can be used to produce thin coatings typically applied at relatively low coating temperatures of 160°C to 500°C. These application temperatures are ideal because they are below the tempering temperature of steels and would not alter a component's fundamental material properties.



Among the PVD options are several carbon-based coatings that provide a unique combination of extreme surface hardness, low friction coefficient, and anti-corrosion properties. For example, Oerlikon Balzers – part of the Swiss OC Oerlikon group – produces a coating called BALINIT C that has attracted the attention of some of the largest aerospace manufacturers in the world, including Airbus.

In November 2018, Airbus announced it was expanding its use of BALINIT C to include copper alloys – a substrate commonly used for bearings and bushings in aircraft landing gears and landing-gear-to-air-frame connections. Previously, Airbus had approved the PVD coating for use on steel, titanium, and Inconel substrates.

Learn more about PVD coatings

The technical qualification of BALINIT C as a non-hazardous and REACH-conforming option to hard chrome plating completes the Airbus Industrial Qualification Process for production centers at Oerlikon Balzers UK and Oerlikon Balzers France.

"Airbus has confirmed that our BALINIT C coating meets their technical and industrial requirements," says Oerlikon Balzers Global Aerospace Segment Manager Toby Middlemiss.

Oerlikon Balzers uses a mixture of metal and diamond-like carbon to create BALINIT C, a tungsten carbide/carbon coating. The coating is

applied to a thickness of 1 to 5 microns which enables it to be used on roller bearings and landing gear parts. It creates a bright, uniform finish, which eliminate the need for post-finishing and saves time and money. Hard chrome, on the other hand, needs to be ground and polished to achieve a uniform finish and proper tolerance.

BALINIT C also offers a stronger adhesion to metal substrates than hard chrome, a high load-bearing capacity, and a high level of scuffing resistance (adhesive wear). Due to its low friction coefficient, it reduces pitting and fretting corrosion on sliding or moving parts on an aircraft such as those found in actuators, flap track systems, and pumps – making the coating ideal for low lubrication and even dry running applications.

(Image courtesy: OC Oerlikon)

The coating is particularly suitable for case-hardening as well as ball- and roller-bearings, which suffer from severe and disproportionately distributed abrasive wear. BALINIT C can be applied to inner and outer races and cylinders and to the balls in ball bearings in a highly uniform coating thickness of 0.5 to 1 micrometer at temperatures below 200°C. The slight increase in roughness over hard chrome plating is offset by the burnishing qualities of BALINIT C, which smooth the raceway of the inner and outer rings and provide additional protection against scuffing and pitting.

With the increasing adoption of PVD coatings by industry leaders, such as Airbus, the opportunity to eventually eliminate hard chrome entirely from the aerospace industry is becoming more certain.

“It has been a big task for the aerospace industry to replace hard chrome because it isn’t as easy to find an exact replacement – every alternative will be a bit different,” Middlemiss says. “So, manufacturers have had to go back to the drawing board and evaluate why hard chrome was used in the first place, what the application is and what the suitable alternatives are that might work.

“It will continue to take a rigorous, evidence-based evaluation surface-by-surface, component-by-component to ensure that safety, performance, reliability, and cost criteria are all addressed,” Middlemiss adds.

Jeff Elliott is a Torrance, California-based technical writer. He has researched and written about industrial technologies and issues for the past 20 years.

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