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MACHINE DESIGN

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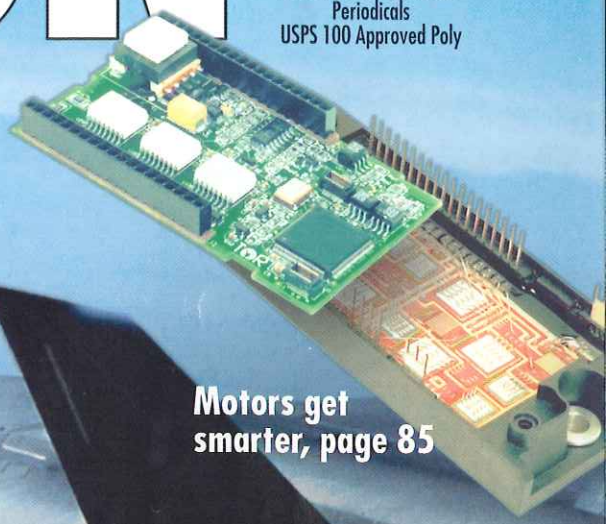

Motors get smarter, page 85

Coatings come out of the clouds

From aerospace to autos, page 52

Composite cylinders beat steel and aluminum, page 80

TOTAL DESIGN SHOW HITS THE MIDWEST

Total Design Show

Slick as a whistle, hard as a rock

Nibron, a coating of nickel, thallium, and boron, improves wear and hardness on aerospace and automotive components.

Several military jets, including the Air Force's new fighter, the F-22 Raptor, have engine components coated with Nibron to reduce wear.

Marshall Menachem
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A metallic coating of nickel, thallium, and boron, outperforms other aerospace coatings such as hard chrome and nickel-phosphorus when it comes to hardness and reducing wear. Classified as a tribologic thin-film coating and called Nibron, it extends the life of aerospace components, as well as improving their reliability and durability while increasing mean time between failures. In the Air Force, for example, maintenance crews were having a hard time with machine-gun mounts on certain warplanes. High-pressure loading and vibrations led to unacceptable levels of galling. After testing several friction-reducing coatings, the Air Force tested Nibron. It showed no signs of deterioration after 250,000 test cycles. The next-best candidate, hard chrome, showed significant wear after only 35,000 cycles.

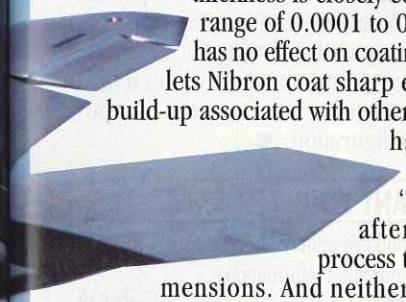
PLATING PROPERTIES

Nibron is deposited directly on a variety of substrates, including titanium, carbon, tool and stainless steels, Inconel, and most exotic alloys. But it isn't as compatible with some metallic substrates, including magnesium, aluminum, tungsten carbide, and those with high zinc and molybdenum

content. However, methods have been identified for successfully applying Nibron on aluminum and developments for coating magnesium are underway.

Nibron is usually applied using electroless plating. The process creates platings by reducing metals in a solution under controlled temperatures and pHs. Using a reducing agent containing boron, Nibron platings are "grown" at 0.0005 to 0.001 in./hr.

Nibron coatings are well suited to complex shapes, including those with intricate profiles, corners, grooves, and holes. The coating's uniform thickness is closely controlled over the range of 0.0001 to 0.010 in. Part size has no effect on coating thickness. This lets Nibron coat sharp edges without the build-up associated with other coatings such as hard chrome. It also eliminates "grinding back" after the plating process to restore part dimensions. And neither the plating nor plating process changes the substrates' tensile properties — an important attribute for aerospace applications. So far, however, no one is sure why it doesn't affect tensile properties like other electroless platings.



Nibron provides outstanding hardness and wear resistance along with good ductility. Typical as-plated hardness is over 58, and up to 74 Rockwell when heat-treated. Its low coefficient of friction minimizes galling and fretting and it produces no hydrogen embrittlement.

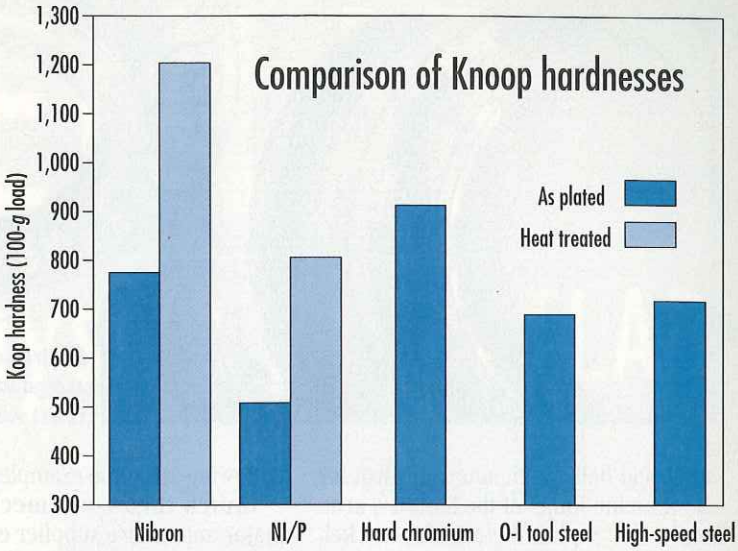
Nibron coatings are nodular and nodule size increases as the coating thickness increases. Therefore, as the plated surface gets thicker, the number of surface nodules decreases. The structure of the coated surface, even if it varies, does not affect surface finishes, which conform closely to the original substrates.

Because of its nodular surface, Nibron is a natural for impregnation. Its corrosion resistance and coefficient of friction, for example, can be improved by impregnating it with Teflon; impinging it with dry-film lubes, or by applying dry-film topcoats.

AEROSPACE AND BEYOND

Nibron is mainly used on components in high-performance military jet engines to extend life cycles. It conforms to PWA-259. Here are some examples of components and performance achievements.

Compressor bearing seal supports: Nibron has measurably increased the wear life of the seal groove, a major component in a jet-engine's compressor section. Nibron on the groove makes for a better seal and helps the seal resist wear from the chrome-plated seal ring. Extending the life of the seal found on F-14 Tomcats, F-15 Eagles, F-16 Falcons, and the new F-22 Raptor reduces costly and time-consuming replacements that involve tearing down almost the complete engine.



This chart shows that Nibron is harder than nickel-phosphorous alloys when electrolessly plated, and after heat treatment is harder than chrome.

Variable vanes: Another set of engine components that benefit from Nibron are Inconel trunnions and titanium vanes. They are in the rear compression inlet stage of jet engines and serve to control airflow, sending it through or around the afterburner. Nibron replaces electroless nickel on the vanes and trunnions and does a better job of reducing galling and wear. It is also used on the platform end of the vanes where harsh conditions previously called for tungsten carbide.

Augmentor nozzle mounting brackets: This component which anchors the link that moves the augmentor (also known as the afterburner) was wearing prematurely due to heavy chatter and rotation. Nibron on these components has increased their expected lives life dramatically and helps provide the free movement of the nozzle flaps. Previously, the complex geometry of the holes on the component prevented conventional machining of wear-resistant coatings.

Synchronization rings: These titanium rings control movement of the variable vanes and, subsequently, airflow through the engine. They have holes subject to heavy wear produced by locating pins riding on the surface and repeatedly dropping into them. In the past, the holes eventually become elongated to the point they needed to be plug welded, redrilled, and replated with electroless nickel. Nibron is now used inside and around the holes and wear, after more than double the number of hours, does not extend into the substrate. Repairs now consist of simply stripping and replating.

Shuttle manipulator arm: Nibron coats the

Electronic housings coated with Nibron resist wear.

Nibron evenly coats even the most complex structure, such as this engine bearing support for an airplane.

spherical ball which acts as a pivot for the knuckle joints of the Shuttle's arm. Again, this replaced electroless nickel, which had previously been used without success.

There are many other aerospace programs evaluating Nibron for use in areas other than the engine. These include landing gears, control systems, and other systems in which there is galling, fretting, or wear. And over the last few years, major efforts have been taken to use Nibron in the automotive industry. Following are some examples:

Clutch throw-out mechanism: A major automotive supplier experienced serious galling on the helical spline on its clutch release. The supplier thought his only solution was to redesign the assembly. Fortunately, they discovered Nibron and it is being used to reduce wear and galling, and is now specified for the part.

In the future, transmission shafts and gears, engine valves, rocker arms, axle components, and piston rings will benefit from Nibron. And the glass industry is already reaping benefits from Nibron coatings on tooling, while the machine-tool industry uses it on cutting and forming tools, jigs, and fixtures.

Nibron is part of a new generation in thin-film wear-resistant coatings and should be considered as an engineering component in the design process. Using it reduces friction and wear, but it also affects substrate selection and component configuration. ■

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