National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Oil-Free Lubricants

Revolutionary solid lubricants enable extreme applications

NASA's Glenn Research Center has developed high-temperature solid lubricant materials to reduce friction and wear in mechanical components, especially in extreme temperatures. The lubricant performs in temperatures from cryogenic levels to greater than 900°C. It has been formulated to provide higher density, smoother surface finish, and better dimensional stability than prior solid lubricant coatings. It can be applied either through plasma spraying as a coating, known as PS400, or as a solid composite material via powder metallurgy, known as PM400. Because of its ability to maintain thermal and chemical stability in higher temperatures, PS/PM400 enables efficiency increases of up to 40% in rotating machinery applications. Furthermore, PS/PM400 has proven durable in over 20,000 hours of turbine engine operation. PS/PM400 offers a substantial upgrade in wear resistance and efficiency for a vast range of aerospace and aeronautics applications. Its unique combination of good mechanical properties, long-term environmental durability, exceptional friction and wear-reducing characteristics, higher density, smoother finish, and better dimension stability establishes it in a class by itself among solid self-lubricating materials.

BENEFITS

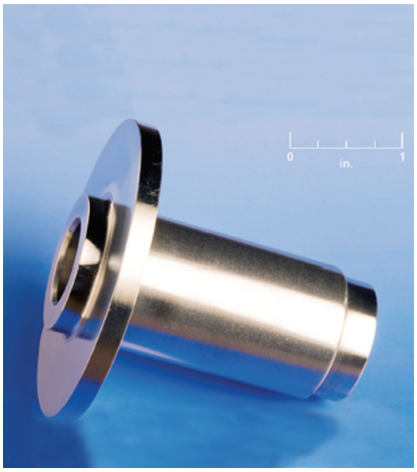
- Increased strength and durability: Use of a hardening agent improves the material's wear resistance without sacrificing flexibility in fabrication or lubricating ability
- Better oxidative and dimensional stability: The metallic binder eliminates the oxidative effects that often lead to dimensional swelling in other solid lubricants
- Improved surface finish: A denser coating results in a smoother finish and improved performance
- Reduced expense and complexity in fabrication: PS/PM400 does not require extra processes and uses less expensive silicon-carbide grinding
- Easily procured: Available in the marketplace from licensed vendors

THE TECHNOLOGY

In applying PS400 using the plasma spray-coating process, a 0.010 inch layer is deposited onto a metal surface. This composite coating often includes a metallic-based binder, a metal-bonded hardener, a high-temperature lubricant, and/or a low- temperature lubricant. PS400's improved metallic-based binder alloy greatly increases the structural strength and durability of the composite with respect to the operating temperature and the bearing load, and provides superior dimensional stability. PS400's metal-bonded oxide hardening agent provides additional hardness, wear resistance, and thermal stability, while also exhibiting a low coefficient of friction when used in sliding contacts. It is also significantly less expensive in terms of both acquisition and grinding processes.

Depending on the desired environment, high- and low-temperature lubricants may be added to the composite coating. The preferred high-temperature lubricant is a metal fluoride and the optional optional low-temperature lubricant is composed of metals, such as silver or copper, that are soft enough to provide lubrication at low temperature while maintaining oxidation resistance with a sufficiently high melting point. These qualities permit the materials to be used over a broad temperature range. Once the spray coating has been applied, the metal surface is ground and polished to produce a smooth, self-lubricating surface before use. Unlike some coatings that must be diamond-ground, PS400 is readily ground with a substantially less expensive abrasive, such as silicon carbide. This grinding process generally yields a coating thickness of 200 to 400 micrometers.

In instances when a coating is not convenient or possible, powder metallurgy techniques using PM400 can be used to make freestanding self-lubricating components such as bushings and wear plates.



Glenn's PS400 and PM400 lubricants can enable higher temperature operation

Glenn's solid lubricant materials are ideally suited for heavy machinery gearing applications

APPLICATIONS

The technology has several potential applications:

- Power generation
- Turbomachinery
- Valves
- Large engines
- Bushings, bearings, and races in extreme environments
- Turbines
- High-speed rotating equipment

PUBLICATIONS

Patent No: 8,182,741; 8,377,373; 8,753,417; 9,393,619

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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