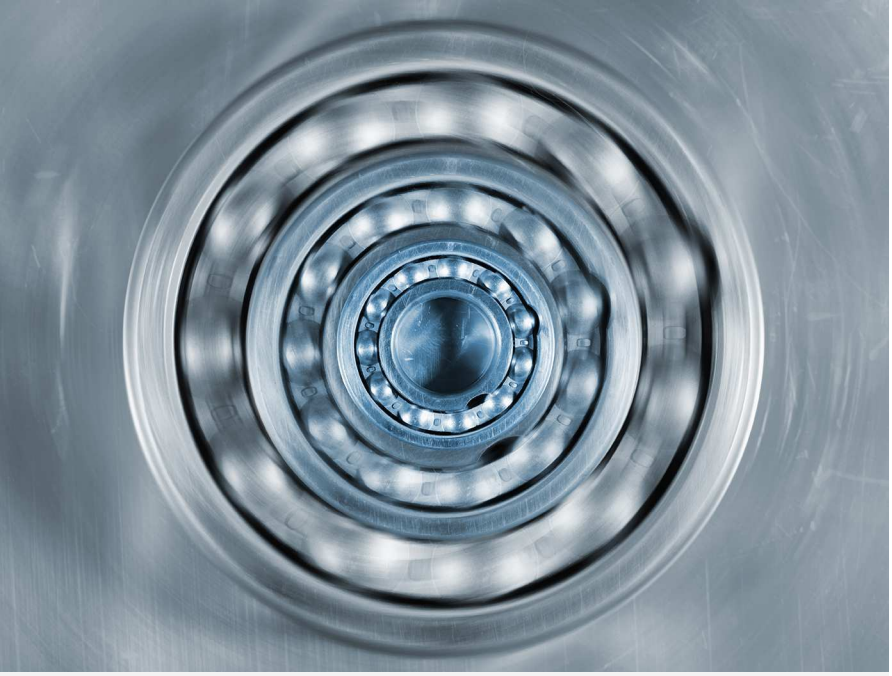


National Aeronautics and
Space Administration

technology solution

Materials and Coatings

Rare Earth Aluminate Composites

A multi-phase ceramic composite with excellent wear and reduced-friction properties

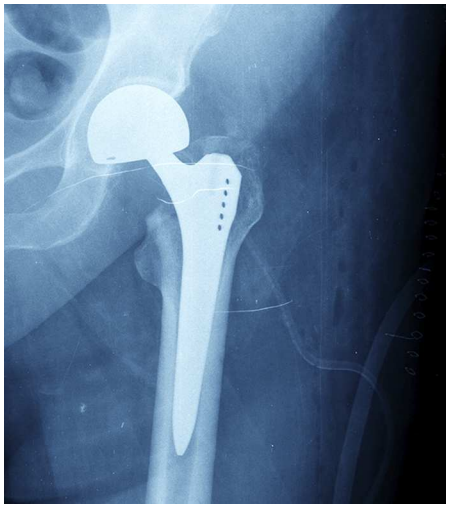
Bearing surfaces are typically either metal-on-metal (MOM), ceramic-on-ceramic (COC), or metal-on-polyethylene (MOP). MOM and MOP couplings have the drawback that metallic or polyethylene particles can sometimes separate from the couplings, which can cause significant problems, particularly in a hip or joint replacement. COC couplings are less likely to lose particles due to wear, which makes them more biocompatible, but they are more susceptible to fracture. COC couplings also have a tendency to squeak as they move. Innovators at NASA's Glenn Research Center have developed a technique using rare earth elements to fabricate a dual-phase ceramic composite that combines a wear-resistant phase and a solid-state lubricant phase. The result is a coupling material that, compared to currently used materials, exhibits a tenfold reduction in the friction coefficient, a sixfold reduction in wear, and a significant reduction in debris caused by wear. Glenn's groundbreaking rare-earth aluminate composite has considerable potential, not only in biomedical applications but also in commercial and industrial sectors.

BENEFITS

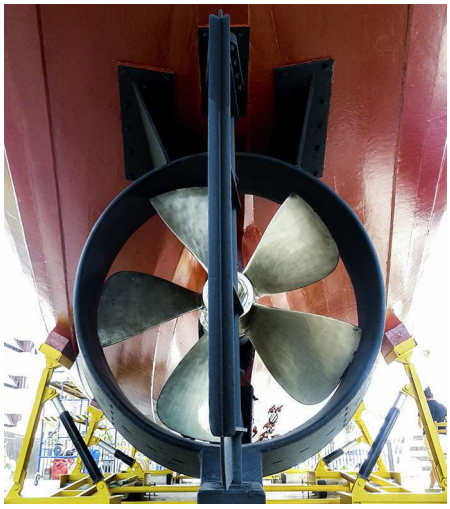
- Low-friction: Improves efficiency by reducing friction between moving components
- Wear-resistant: Lasts longer and does not shed wear particles under duress
- Strong: Offers hard material suitable for high-impact and heavy-load applications
- Corrosion-proof: Withstands harsh or acidic environments (e.g., marine applications)

THE TECHNOLOGY

Glenn's approach utilizes a combination of alumina (Al_2O_3) and specially defined ratios of rare earth oxides. These rare earth elements are typically either yttrium or gadolinium, although other rare earths may be substituted to produce different targeted effects, including generating a multi-phase composition instead of a dual-phase one. Glenn's method of adding rare earths to the alumina material produces a two-phase composite system that is optimized for the targeted mechanical properties of wear resistance and coefficient of friction. These composites can be formed by either casting from a melt with directional solidification or solid-state sintering of isostatically pressed powder preforms. In the latter process, the hot isostatic pressing both reduces the porosity of the ceramic material and increases its density prior to the sintering process. Glenn's revolutionary technique yields a composite with significant advantages over single phase ceramics. Single phase ceramics, although they display high strength and wear resistance compared to other materials and high performance alloys like CoCr, also have a relatively high friction coefficient. The incorporation of rare earths allows the fabrication process to introduce a continuous second ceramic phase and create tertiary phases at the interfaces, which greatly improves the material's friction properties without sacrificing the wear characteristics. This combination of sturdiness and reduced friction gives these materials great potential for use in a wide range of applications.



This new composite could eliminate many of the issues encountered by those who undergo hip or knee replacement surgery.



Large ships and small boats alike depend on corrosion-proof bearings in their propeller shafts both to save power and achieve their optimal speed in the water.

APPLICATIONS

The technology has several potential applications:

- Biomedical (e.g., hip and joint replacements)
- Ball bearings and hard face seals
- Oil drilling
- Automotive and marine engines
- Industrial machines

PUBLICATIONS

Patent Pending

More Information

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