Success Story

Near-Frictionless Carbon Coatings Offer Significant Industrial Benefits

Background

The many moving mechanical assemblies in advanced transportation vehicles present complex challenges for automotive engineers. These systems must operate under increasingly severe sliding conditions (such as high loads, speeds, and temperatures) that currently available materials and lubricants cannot tolerate. Engineers must improve the surface friction and wear characteristics of the mechanical system components by using hard, slippery surface films.

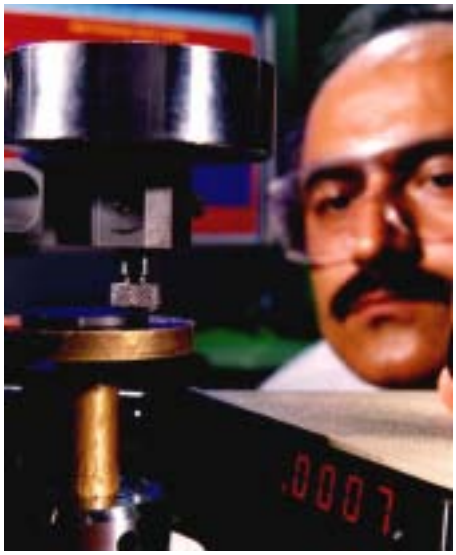
With funding from the U.S. Department of Energy's FreedomCAR and Vehicle Technologies Program, researchers at Argonne National Laboratory have developed and patented a smooth, wear-resistant carbon film that features an exceptionally low coefficient of friction (less than 0.01 in dry and inert sliding environments), enabling components to last longer and potentially reducing parasitic losses associated with friction. The film can also reduce friction and wear under starved (diminished) or boundary lubricated sliding conditions.

The Technology

Because of its extremely low friction coefficient and wear rate, Argonne's new near-frictionless carbon (NFC) film offers a way to make rolling, sliding, or rotating machine parts more efficient and long-lasting. NFC film reduces friction by factors of 20 to 100 below the levels feasible with existing low-friction materials, coatings, or lubricants. In aerospace and transportation systems, such reduction in friction translates directly into higher efficiency and better/quieter performance, while less wear results in longer lifetime and lower maintenance cost.

Key advantages expected from these carbon films in moving mechanical assemblies are extended wear life, reduced maintenance costs, improved reliability, reduced environmental emissions, and most importantly, increased energy efficiency resulting from decreased frictional losses.

Combining high hardness with ultra-low-friction diamond and diamond-like carbon films can provide long-term wear resistance and lubrication to reduce material and energy losses. The low friction of diamond and diamond-like carbon is associated with their very inert nature. These materials are very hard and do not stick to rubbing surfaces — because of the strong covalent bonding between carbon atoms, they have extremely low wear rates.



An Argonne researcher observes a sample of near-frictionless carbon (NFC) film that is 40 times slicker than Teflon™.

Argonne's NFC film possesses a unique combination of qualities that make it potentially useful for a wide range of applications. The film's friction coefficient is perhaps the lowest reported to date for a solid material and its wear resistance is the highest. In terms of durability, the film has an extremely long endurance life. In a recent evaluation, researchers tested a 1-micrometer-thick application of the film on H23 steel under dry sliding conditions in a clean test environment; it accumulated over 14 million sliding cycles without wearing through. In addition, the film

can be deposited at room temperature on any kind of substrate (i.e., metals, ceramics, and polymers) and at fairly high deposition rates.

While the most promising applications for this film appear to be those that operate in essentially air-free environments, such as bearings for ultrahigh vacuum instruments, certain mechanical seals, and selected cryogenic, space, and aircraft applications, the material's properties in air and on lubricated surfaces also are impressive. This new material is also well-suited to applications in automobile and engine parts such as turbocharger rotors, piston rings, gears and bearings, air-conditioning compressors, and fuel injector components, including possible applications in electronic and micro-electromechanical systems.

Commercialization

Argonne is working with several industrial partners to further develop the near-frictionless coating to increase engine efficiency, extend wear life, and reduce maintenance costs for motor vehicles.

Argonne anticipates that the uniqueness of this new material may lead to its use in a variety of commercial applications and the Laboratory is interested in finding ways for this near-frictionless carbon film to undergo wider study and evaluation.

Benefits

- Increases component life
- Improves performance in rolling, sliding, and rotating applications
- Can be applied at room temperature
- Usable with complex shapes on any kind of substrate
- Does not require post-application machining

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