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NASA TECH BRIEF

Lewis Research Center

Plasma-Sprayed Metal-Glass Fluoride Coatings for Lubrication to 1170 K (1650°F)

The Problem:

A need exists for the development of improved high-temperature, self-lubricating materials. In advanced aircraft, the aerodynamic heating at speeds of Mach 3 and higher can result in vehicle skin temperatures well above the temperature limitations of presently available airframe bearings.

Solid lubricants such as graphite, molybdenum disulphide, and graphite fluoride oxidize or dissociate below 770 K (930°F). Self-lubricating composites of a sintered porous nickel base superalloy, in which the pore structure is impregnated with calcium fluoride (CaF_2)-barium fluoride (BaF_2) eutectic, have been successfully tested for long duration in non-oxidizing atmospheres to 1170 K (1650°F). In air, however, usefulness is limited to 920 K (1200°F) for long durations and 1070 K (1470°F) for short durations, because oxidation of the sintered metal structure occurs and causes swelling and distortion of the part. Previously, considerable improvement was achieved by partially filling the pore structure of a metal matrix with oxidation-protective glasses. The lubricating fluorides were introduced in a second infiltration. The resulting composites had improved oxidation resistance and were self-lubricating at 1170 K (1650°F). However, the double infiltration was complex and time consuming.

The Solution:

The plasma spraying of a Nichrome matrix composite containing dispersed glass for oxidation protection and calcium fluoride for lubrication. The coatings can be applied to bearing journals and bearing bores.

How It's Done:

A special glass of the composition 21.2 w/o BaO - 7.8 w/o CaO - 13.0 w/o K_2O - bal SiO_2 is prepared. The glass is pebble milled to a fine powder. The powdered glass is then mixed with powdered Nichrome metal and CaF_2 to the desired composition - 67 w/o Nichrome - 16.5 w/o glass - 16.5 w/o CaF_2 for plasma spraying.

The substrate surfaces are grit blasted with coarse alumina grit. The composites are sprayed to a thickness of about 0.050 cm (0.02 in) and subsequently machined back to a thickness of 0.025 cm (0.01 in). During spraying, argon is used as the carrier gas and the arc gas. An arc current of 350 amperes is used.

The coating is machined at low speeds and with light cuts to prevent smearing of the Nichrome matrix metal. The surface is then enriched in the lubricant by heat treating the specimens in air at 1145 K (1600°F) for four hours. The heat treatment causes a solid state migration of fluorides along the surface and serves the added beneficial purpose of mildly preoxidizing the exposed metal. The surface becomes entirely covered with a combined fluoride-oxide film which is very desirable to prevent direct metal to metal adhesive contacts during sliding.

Bearings with a composite liner in the bore were in good condition and exhibited very good oxidation resistance after over 50,000 oscillating cycles. The bearing temperatures were controlled, and these temperatures were cycled between 300 and 1170 K (77 and 1650°F).

Notes:

1. During the sliding process, any wear that takes place exposes more lubricant thereby preventing an increase in wear rate or galling of the surfaces. The lubricating material prevents galling from room temperature to 1170 K (1650°F), but is especially effective from 810 to 1170 K (1000 to 1650°F) at which temperatures the glass and particularly the fluorides are soft enough to form a smear or glaze of lubricating film on the surface.
2. In general, better results were obtained with the coating on the bearing bore rather than on the journal surface. The coating was easily machinable and had excellent bond strength on the substrate metal.
3. In addition to aircraft requirements, other areas in which high temperature lubrication is needed include sliding contact seals for automotive turbine regenerators, shaft seals for turbopumps, piston rings for high performance reciprocating compressors, and lubricants for hot glass processing machinery.

(continued overleaf)

4. Further information is available in the following report:

   NASA TN-D-7556 (N74-16146), Self-Lubricating Plasma-Sprayed Composites for Sliding-Contact Bearings to 900°C

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10016

5. Specific technical questions may be directed to:

   Technology Utilization Officer
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   Cleveland, Ohio 44135
   Reference: B74-10016

Patent Status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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