NASA TECH BRIEF
Lewis Research Center

NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

Graphite Fiber-Polyimide Composite Rod End Bearings for High-Temperature High-Load Applications

The Problem:

Plain spherical bearings (also known as rod end bearings) are used in applications involving oscillating motion and requiring self-alignment. Aerospace applications include airframe bearings and bearings for engine control linkages. Airframe control surface bearings are a particularly difficult application because of the requirement for exceptionally high dynamic load capacity. Aerodynamic heating in supersonic flight, especially at speeds of Mach 3 or higher, will heat control surface bearings above the 436 K (325°F) service limit for the reinforced polytetrafluoroethylene (PTFE)-lined bearings currently used in many aircraft. PTFE bearings also are subject to cold flow under a combination of high loads and vibration.

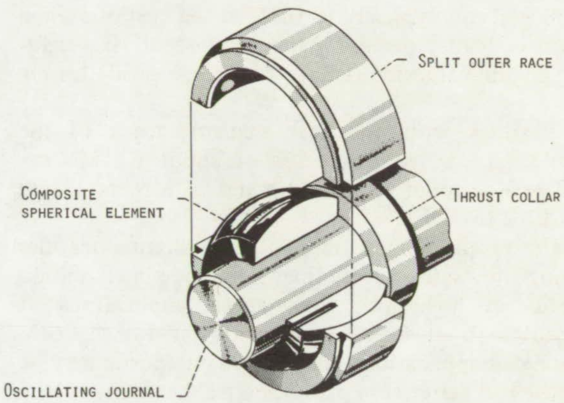
The Solution:

Self-aligning plain spherical and plain cylindrical oscillating bearings with molded graphite-fiber-polyimide self-lubricating elements composed of 50 weight-percent chopped graphite fibers and 50 weight-percent polyimide.

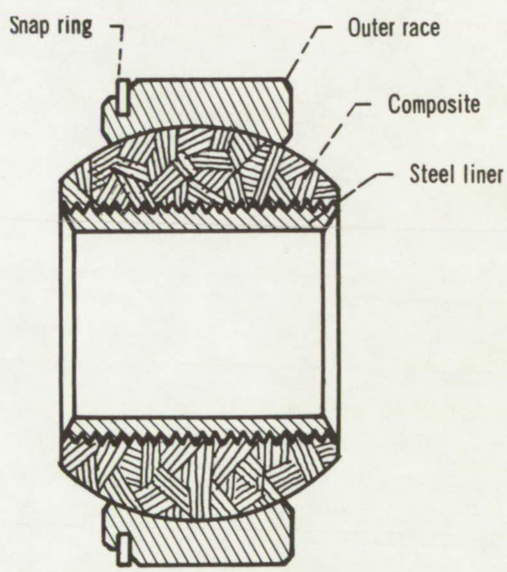
How It's Done:

The resin used in the composite bearing material is an addition-type polyimide. Addition polymers form void-free solids because they do not release gaseous reaction products during the final stages of polymerization. The graphite is in the form of chopped fibers. The composite has a yield strength of about 200 MN/m^2 (30,000 psi) and an elastic modulus of 4.4 GN/m^2 (640,000 psi). The outer races and the journal are made of 440-C-HT steel, which has a hot hardness of Rockwell C-57 at 617 K (650°F) and has good oxidation resistance in air to about 811 K (1000°F).

Dynamic load capacities and friction coefficients were determined for the three bearing designs shown in the figure. The composite was evaluated as a ball material and as a thin-wall bearing liner material. Dynamic load capacity tests consisted of step-wise increases in radial load at about 2200 N (500 lb) increments until bearing structural failure or a large and disproportionate increase in wear rate occurred. Oscillation frequency was 1 hertz at ±15° amplitude. Temperatures were: nominal room temperature (no external heat addition), 589 K (600°F), and 617 K (650°F).

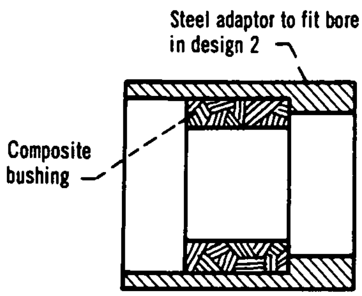


(A) DESIGN 1; MOLDED COMPOSITE BALL. JOURNAL OSCILLATES IN BEARING BORE.



(b) Design 2; molded composite ball with steel-reinforced bore. Ball oscillates in outer race.

(continued overleaf)



(c) Design 3; composite bushing and adaptor to allow testing to high unit loads. Journal oscillates in bore of bushing.

The principal results were as follows:

(1) Cylindrical steel bearings with thin-wall composite liners had dynamic load capacities of 280 MN/m^2 (40,000 psi) at nominal room temperature and 240 MN/m^2 (35,000 psi) at 589 K (600°F). Friction was reduced by about 30 percent, typically to 0.15, at the cost of a small reduction in load capacity by the addition of 10 weight-percent graphite fluoride $(CF_x)_n$ to the composite formulation.

(2) Bearings with spherical elements made of the composite had a load capacity of about 67 MN/m^2 (10,000 psi) at room temperature and 25 MN/m^2 (3600 psi) at 617 K (650°F).

(3) The results demonstrated that oscillating bearings employing thin-wall graphite-fiber-polyimide liners should be useful in high load, low speed applications at temperatures to at least 589 K (600°F). For light-to-moderate load applications, the molded composite may be used as the ball material in plain spherical bearings.

Notes:

1. Further information is available in the following report:
   NASA TN-D-7880 (N75-15052), Dynamic Load Capacities of Graphite-Fiber-Polyimide Composites in Oscillating Plain Bearings to 340°C (650°F)
   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: B75-10151
2. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B75-10151

Patent Status:

NASA has decided not to apply for a patent.

Source: H.E. Sliney and T.P. Jacobson
Lewis Research Center
(LEW-12514)