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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:

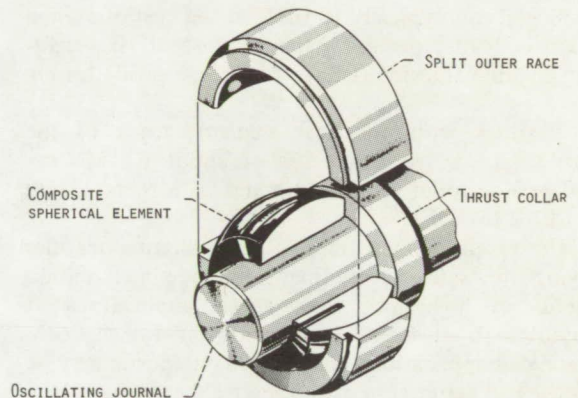
Self-aligning plain spherical and plain cylindrical oscillating bearings with molded graphite-fiber-polyimide self-lubricating elements composed of 50 weight-percent chopped graphite fibers and 50 weight-percent polyimide.

How It's Done:

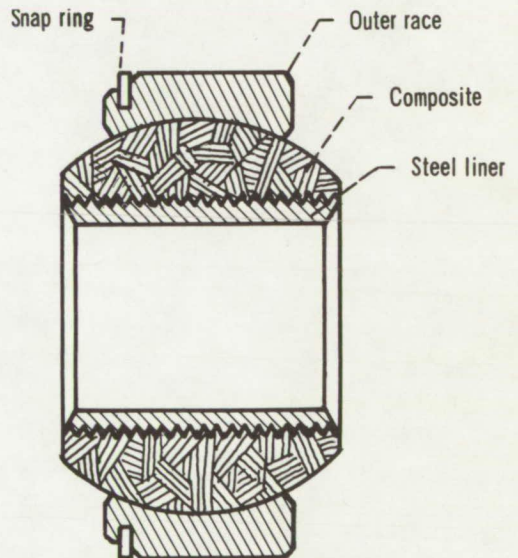
The resin used in the composite bearing material is an addition-type polyimide. Addition polymers form void-free solids because they do not release gaseous reaction products during the final stages of polymerization. The graphite is in the form of chopped fibers. The composite has a yield strength of about 200 MN/m² (30,000 psi) and an elastic modulus of 4.4 GN/m² (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).

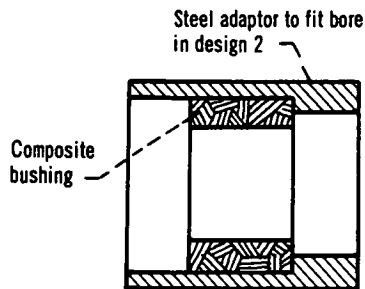


(A) Design 1; molded composite ball. Journal oscillates in bearing bore.



(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:

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 Reference: B75-10151

2. Specific technical questions may be directed to:

Technology Utilization Officer
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 Cleveland, Ohio 44135
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Patent Status:

NASA has decided not to apply for a patent.

Source: H.E. Sliney and T.P. Jacobson
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