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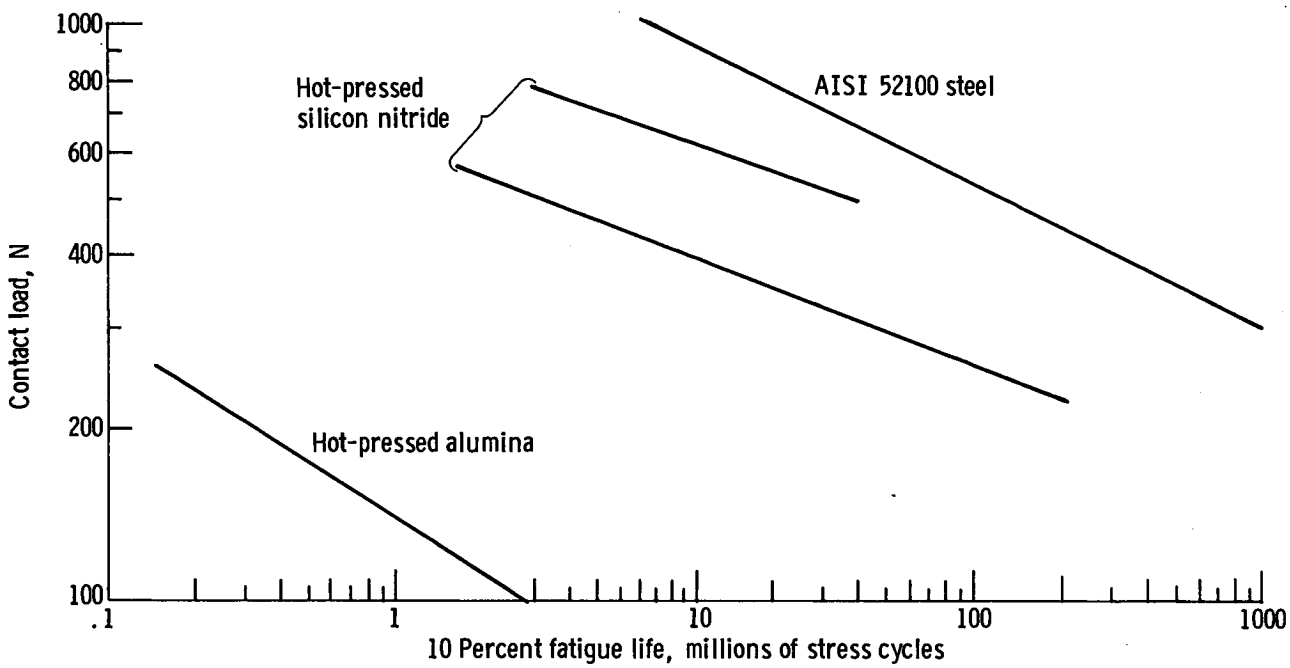
Silicon Nitride Used As A Rolling-Element Bearing Material



Fatigue life of hot-pressed silicon nitride approaches that of AISI 52100 steel.

For applications in which high temperature, or corrosive environment, or both are encountered, dry film lubrication and ceramic bearings may be a workable alternative to more conventional steel bearings. Also, with lower densities than bearing steels, ceramics used as balls for very high-speed ball bearings may contribute to good bearing life. The centrifugal forces on the balls increase outer race loads, promote fatigue, and thus shorten bearing life; ceramic balls, being lighter, may alleviate this problem.

Accordingly, rolling-element fatigue tests were conducted with hot-pressed silicon nitride to determine its ability to withstand the concentrated contacts in rolling-element bearings. A five-ball fatigue tester was used to test two grades of hot-pressed silicon nitride 12.7-mm diameter balls in contact with steel lower balls at several load conditions and at a temperature of 328 K (130°F). The lubricant was a super-refined naphthenic mineral oil. The fatigue results in the figure show that both grades of hot-pressed silicon nitride give at least three orders of magnitude greater fatigue life than hot-pressed alumina at the same contact load. Previously published data indicated that hot-pressed alumina had the longest fatigue life at similar conditions of any ceramic or cermet tested.

Further, the life of the more homogeneous, higher-strength grade of hot-pressed silicon nitride (upper line in figure) is approaching the life of a high quality, consumable-electrode vacuum-melted bearing steel, AISI 52100, at the same contact load.

A fatigue problem does arise, however, even though hot-pressed silicon nitride has only 40 percent the density of bearing steels. Silicon nitride has a very high elastic modulus, about 50 percent greater than bearing steels. Thus, for a given contact load, a steel race in contact with

(continued overleaf)

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a silicon nitride ball will experience a Hertz stress about 15 percent greater than the same steel race in contact with a steel ball. The fatigue life of a bearing race is extremely sensitive to changes in Hertz stress. Therefore, the usefulness of silicon nitride balls in contact with steel races, such as in a very high-speed ball bearing, is limited.

If hot-pressed silicon nitride is used for both balls and races, attention must be paid to fitting both the shaft and the bearing housing, because the thermal expansion properties are very different from those of currently-used shaft and housing materials. There has been some success with this problem.

Notes:

1. Further information is available in the following report:
   NASA TN-D-7794 (N74-34889), Rolling Element Fatigue Life of Silicon Nitride Balls
   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: B75-10134
2. Further information is also available in ASME Paper No. 74-Lub-12, "Fatigue Life of High-Speed Ball Bearings with Silicon Nitride Balls."
3. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B75-10134

Patent Status:

NASA has decided not to apply for a patent.

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