A BARDEN Precision Bulletin

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THE EFFECTS OF HIGH SPEED ON BALL BEARINGS

"High speed" — when referring to ball bearings — is a relative term. A bearing's operating speed can have a considerable impact on its performance. Generally, the effect of centrifugal ball loading can be seen at about 750,000 dN, where dN is the product of the bearing bore in mm x speed in RPM. (Note that the European community usually uses the term dm N, where dm is the bearing pitch diameter.) This centrifugal loading effect can be significant at 1.25×10^6 dN and will have a major impact at 2×10^6 dN.

HOW SPEED AFFECTS BEARING PERFORMANCE

Speed influences bearing performance in several critical areas:

Centrifugal forces. As a ball traverses the pitch diameter of the bearing, at roughly 40% of shaft speed centrifugal forces come in to play which propel the ball outward settling it deeper into the race groove. This centrifugal action changes the contact angle at both races. (The contact angle is the angle between the ball-to-race contact line and a plane through the ball center, perpendicular to the bearing axis. See Fig. 1.)

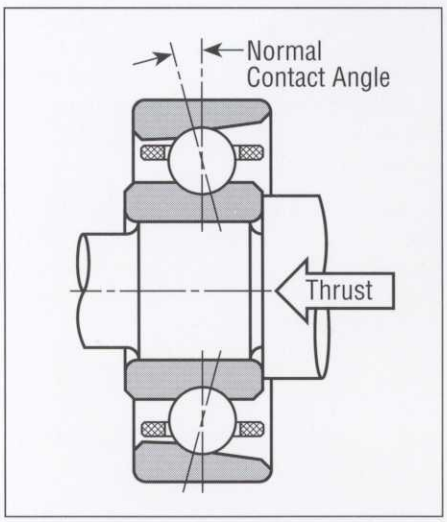

Figure 1. *Drawing shows the normal ball-to-race contact angle.*

At high speeds, centrifugal forces can be enough to change the ball/race contact points. The ball/outer race contact angle diminishes while the ball/inner race contact angle increases. (See Fig. 2.)

Since the ball can only rotate about a single axis, it must roll on one surface and skid or slip on the other. The greater the contact angle difference, the greater the slip. When this occurs, heat generation and surface distress result. Centrifugal forces also impart a higher load to the outer ring which can shorten material fatigue life.

At extremely high speeds where dN values approach or exceed 2×10^6, centrifugal expansion of the inner ring and shaft become significant and should be a consideration in determining shaft fits and radial play. As an example, a 50 mm bore bearing operating at 2×10^6 dN has an inner ring expansion of roughly .001" while a solid steel shaft has only expanded .00015". For the same dN value, expansions are significantly greater as the diameter increases.

Lubrication. Speed also has an affect on lubrication. The higher the speed, the more "viscous shear" occurs, increasing heat generation. High temperatures reduce lube film separation due to a drop in lube viscosity. The rate of lubrication degradation also increases. Centrifugal action at higher speeds throws lubricant outward which can contribute to lube starvation on critical surfaces, which is why the oil stream should be aimed at the inner race. Rotational cavitation within the bearing also resists lube entry and flow through the bearing. On the plus side, higher speeds do help develop a lube film separation between balls and races.

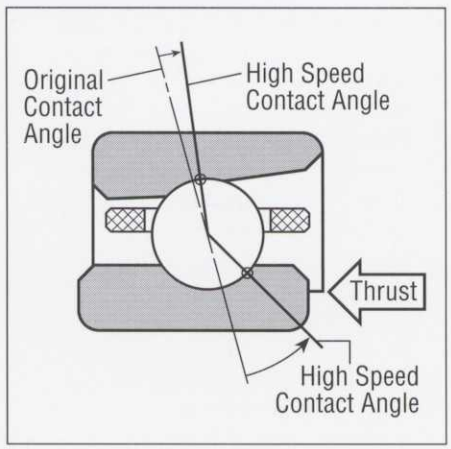

Figure 2. *Ball/race contact points shift on inner and outer rings due to centrifugal forces.*

Cages. Speed influences the performance of the bearing cage. At higher speeds, ball-to-cage forces and friction increase, resulting in higher torque, cage wear and elevated temperatures which could lead to cage deterioration.

Vibration. Bearings act as vibration generators, influenced by the number and size of the balls, the pitch diameter, the bearing's internal clearance, pre-load and, of course, operating speed. The frequencies generated may, at times, cause system resonance.

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DESIGN FEATURES

- Small ball design allows a greater number of balls for increased bearing stiffness (e.g. 22 balls per bearing vs. 15 in the case of the 107 size).
- A land of the inner and outer rings is relieved to provide:
  —optimum exposure and flow through characteristics for air/oil lube systems.
  —increased storage area for shielded, grease lubed bearings.
- Ceramic (silicon nitride) balls available as an option.
- Integral shields—single or double—available as an option.
  —Interchangeable with standard series bearings.
  —Factory controlled and filtered grease ensures clean, proper amount of lubrication.
- Available with 15° or 25° contact angle.

BENEFITS OF USING ZSB SMALL BALL BEARINGS

- Increased bearing stiffness allows enhanced workpiece finish and greater machining accuracy.
- Up to 20% or more increase in operating speeds possible.
- Lower bearing friction means cooler running temperatures.
- Grease life increased due to lower temperatures.
- Integral shields keep contaminants out, lubricants in, reducing risk of bearing failure.
- Bearing grease life prolonged, which increases production capacity, reduces downtime.
- The ceramic ball option offers further reductions in torque and increased stiffness as well as increased speedability.
- Direct interchangeability of ZSB series with other standard angular contact bearings.

SUMMARY

Barden ZSB angular contact series bearings can provide increased speedability due to lower torque and temperature characteristics while offering improved stiffness and extended grease life.

Barden ZSB series bearings offer several key design options including ceramic balls and integral shields.

Your Barden sales representative or Authorized Barden Distributor can provide you with more information on how Barden's ZSB series can improve your machining operation's productivity and performance. Or if you prefer send for technical specifications literature on all available sizes by calling or writing Barden direct.

ZSB NOMENCLATURE

Please refer to C-10 catalog for further explanation of preload and lubrication criteria.