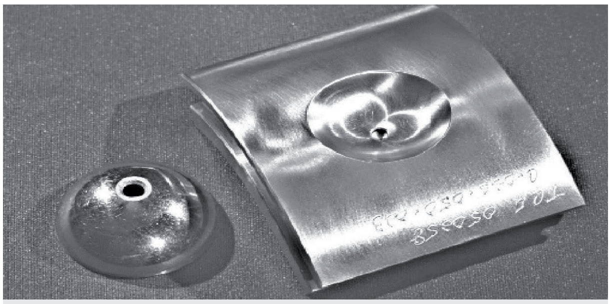
INDUSTRIAL BEARING JOURNAL

Benefits of ball and socket pivot design



A journal pad with spherical socket and its matched ball

In the 2nd Quarter 2003 issue of The Bearing Journal (Volume 5, Issue 3) Miba wrote about tilting pad joumal bearing pivot design. The article compared and contrasted the most common pivot designs, detailing the superiority of the ball & socket pivot.

The benefits of the ball & socket pivot (Figure 1) over „conventional" pivot designs include low stress pivots, high stiffness pivots, axial alignment capability and tight clearance control. Of course, as with any mechanical design, the benefits are only appreciated if the pivot is correctly designed for the application.

The article below pertains to industrial sized bearings (bores of about 10" and below). For larger bearings, heavily loaded bearings, and/or high speed applications, Miba utilizes specialized proprietary ball and socket materials, dimensions, and tolerances.

PIVOT STRESS AND STIFFNESS

Pivot mechanical designs can be compared by calculating the pivot stress and the stiffness of the pivot.

Pivot stress is the contact stress between the two mating surfaces. For rocker back pivots, a line contact exists between the pad back and the outer shell bore. As load is applied, this line widens to accommodate the load, resulting in a rectangular contact area. For point contact pivots (such as with a button in the pad mating with the outer shell bore) the contact area increases from a point to a circle as the load is applied. For ball and socket pivots the contact area is already accounted for in the design and is much greater than the point or line contact designs. This greater area results in lower stresses for a given load.

Likewise, since the load is transmitted though a greater area with the ball and socket pivots, the stiffness of the interface is also optimized. This is because there is a very small radial deflection as the load is applied. Since the deflection due to an applied load is small, the stiffness is high. High pivot stiffness is important since rotor motion should take place in the oil film where damping can contribute to the overall dynamics of the machine. When some motion takes place in the pivot (or other areas of the support stmcture for that matter) the oil film damping does not contribute in that area.

Figure 2 is a plot of the three pivot stresses and stiffness for a typical industrial sized bearing design. Note that the ball and socket design has both a low stress and a high stiffness.

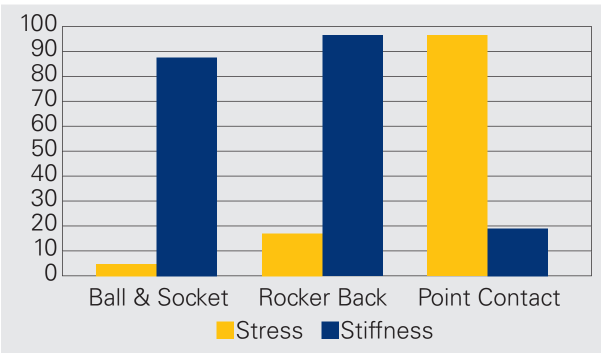
BALL MATERIAL

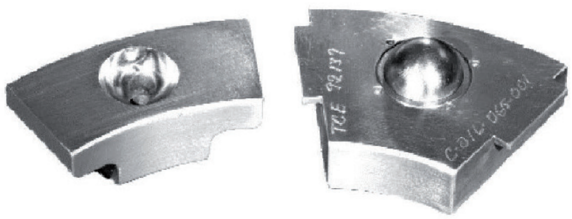
For most industrial sized bearings, Miba uses ball-bearing quality balls to manufacture the ball portion of the pivot. These balls allow us to achieve very close tolerances on diameter, sphericity, and surface finish, while utilizing the very high hardness synonymous with the ball bearing industry. Summarized below are values for grade 25 Chrome alloy steel balls made from alloy 52100:

Hardness: 60-67 Rockwell C
Sphericity: 0.000025 inches
Diameter tolerance: +/- .0001 inches
Maximum surface roughness: 2.0 microinches

For smaller balls (1 inch diameter and under) Miba uses case hardened steel balls, manufactured to grade 25 tolerances. These balls have a case hardness of at least 60 Rockwell C. This gives us the tight tolerances and high surface hardness but make tapping the balls easier since they are not through hardened (case hardened balls are only available to about 1 inch in diameter).

BALL MANUFACTURE





Thrust pad with ball and mating upper leveling link with spherical socket

Since these balls are very hard, cutting them to size presented a serious challenge. The balls are split by one of several state-of-the-art methods including wire EDM, or by utilizing an abrasive cutoff wheel. Once split, the flat is ground to hold a very tight ball height tolerance and the ball is tapped to accept the bolt that will hold it into the outer shell. For the larger through-hardened balls (more than 1 inch diameter), a special tapping process is used to thread the balls. The case-hardened balls can use conventional drilling and tapping since their core is still relatively soft.
It is recognized that the ball sphericity may go slightly out of grade tolerance once a ball is split, due to relaxation of stresses induced during manufacturing, tmncating, and modification. We find that the sphericity of each ball is still within acceptable tolerances for the application, but when a socket is generated it is fit with a ball and the pad and ball are kept as a matched set.

SOCKET GENERATION

As a standard, Miba generates the spherical socket into the back of each babbitted bronze joumal pad because a ball end mill or ball reamer is not accurate enough to yield acceptable socket diameter, sphericity or finish. As the socket is generated, the ball that stays with that pad is blued to the socket. For most industrial size bearings the ball to socket blue must be 75 percent or better and it must blue in the bottom of the socket. The „pad stack“ is the measurement from the ball flat to the babbitt bore; this dimension is held within 0.0005 inches. In special designs we may choose to use a separate hardened socket.

BALL SIZING

In the 1980s it was discovered that undersized balls will experience fretting corrosion and brinelling at the pad to ball interface. This has been adequately addressed at Miba since our inception in 1991 by utilizing ball sizing charts that account forHertzian contact stress levels. These charts utilize the bearing diameter and pad length and assumed dynamic loads to specify minimum ball diameters.
It is also important that the ball does not protmde too far into the pad, weakening the pad. Conversely, too shallow of a protmsion can result in the pad having to slide excessively in order to pivot, resulting in potentially undesirable behavior such as pad lock-up. Over the years Miba has upgraded many OEM ball & socket bearings because of this problem. Miba analyzes bearing loading and space limitations when selecting ball diameter, ball protmsion, pad thickness and pad material.

SUMMARY

Miba started in business with sound engineering, design and manufacturing processes for ball and socket pivots as used in upgraded tilting pad joumal bearings. Miba has been supplying ball and socket tilting pad joumal bearings for 15 years and we have not seen any come back for repair with pivot damage either caused by excessive contact stresses or application of undersized balls. Tilting pad thrust bearings (Figure 3) can also benefit from the ball and socket design, allowing the pad to tilt in all directions and to lessen the increase in float caused by pivot wear.

1 | Miba Industrial Bearings Germany
Göttingen, Germany

2 | Miba Industrial Bearings Germany Osterode
Osterode, Germany

3 | Miba Industrial Bearings US
Grafton, WI, USA

4 | Miba Industrial Bearings US
Columbus, NE, USA

5 | Miba Industrial Bearings US (Houston)
Deer Park, TX, USA

6 | Miba Industrial Bearings Brasil
Cataguases, Brazil

Miba Industrial Bearings U.S. (Houston) LLC
1800 W 13th St, Deer Park, TX 77536, USA
Cheryl Armitage
Cheryl.Armitage@miba.com