Technical Article

Timken® ADAPT™ Roller Bearings

in Vibratory Screens / Feeders

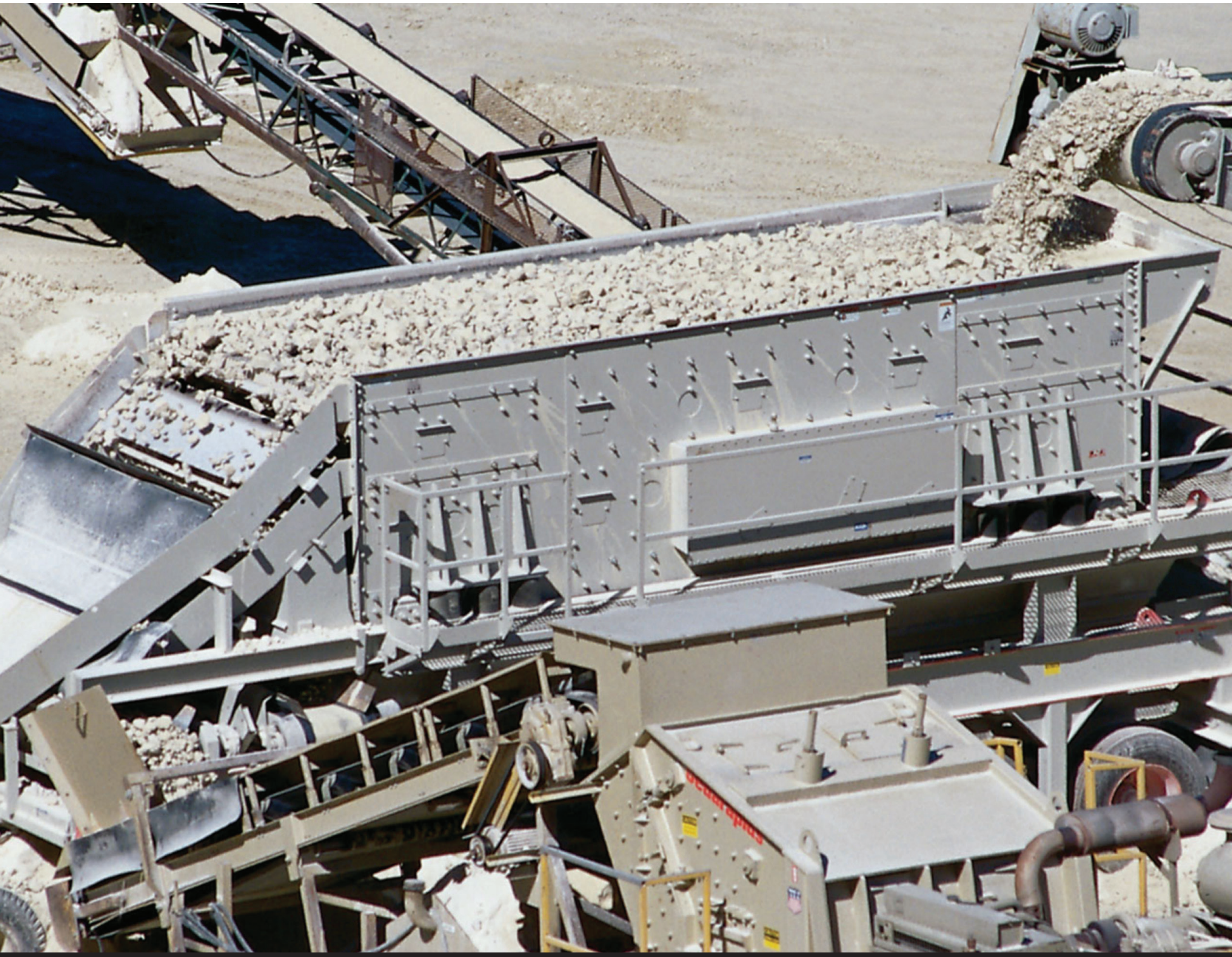

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Table of Contents

Timken® ADAPT™ Roller Bearings in Vibratory Screens / Feeders

Abstract

This paper discusses the Timken® ADAPT™ roller bearing and its specific use in vibratory screen and feeder applications. It outlines how the ADAPT bearing's features lead to creating more value for the Original Equipment Manufacturers (OEMs) and End Users (EUs).

The ADAPT bearing concept is illustrated, demonstrating the bearing's ability to handle both axial displacement and dynamic misalignment independently. The bearing mounting arrangement and means of lubrication are discussed.

Further, the paper details how the ADAPT bearing's features reduce operating temperatures for both the ADAPT bearing and adjoining bearings, and eliminate shaft fretting and induced axial loading, resulting in longer lubrication life and improved bearing life and performance, and in longer equipment component life with reduced maintenance time and costs.

Vibratory Screen / Feeder Application Characteristics

Vibratory screens and feeders play an integral part wherever mining ores or aggregates are processed. This equipment either sets the feed rate (feeder) through the downstream process or sizes the material for efficient processing further downstream.

Although vibratory screens and feeder applications subject the bearings to medium loads and speeds, they still create a challenging application for bearings compared with typical heavy industry applications. The eccentric masses that excite the equipment create the requirement for bearings to handle dynamic misalignment and a rotating load zone. The dynamic misalignment function is further challenging since the amplitudes of misalignment are high due to the relatively small diameter shafts, (typically 50 – 200 mm) used over a wide bearing spread (~2m).

Higher operating temperatures are typically seen on vibratory screens. Higher heat generation is seen from the bearing due to this dynamic misalignment during operation. Also, the vibratory motion will create oil churn and micro-movements inside the bearing, contributing to the higher operating temperatures. Thus, operating temperature becomes a critical parameter for vibratory screen performance. High temperatures may damage the equipment or be an indicator to how severely the equipment and bearings are working.

The eccentric masses further challenge the bearings with creep within the housing and on the shaft, resulting in fretting. This occurs due to the cyclic loading from the rotating load zone between components with a slight clearance. For example, fretting may occur at the loose fit between the bearing inner ring and shaft. The small clearance allows physical movement between the two surfaces as the load increases and decreases. During this interaction, material is removed from one surface and adheres to the other, and typically forms a rusted appearance due to oxidation. This is a typical occurrence on spherical roller bearings (SRB) used on vibratory screens.

Several challenging conditions develop due to the fretting; namely: induced axial loads, contamination, and early shaft wear. The induced axial loads, explained later, introduce axial bearing loads and reduce the bearing life. The contamination is a result from fretting wear particles breaking off and making their way to the bearing race surfaces, leading to premature bearing damage. The prolonged removal of these small particles over time reduces the shaft diameter, causing the shaft to be out of tolerance, at which point a replacement should be made. On all accounts, extra cost is incurred, initially with bearings and later with a shaft, not to mention the downtime and resource costs to replace these items.

Vibratory screens may employ either oil or grease lubrication. The oil lubrication is typically an oil sump that is splashed with a flinger. For ease of maintenance, grease may also be used where operating temperatures will allow for it.

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Typical Vibratory Screen Bearings

Spherical Roller Bearings (SRBs)

Spherical Roller Bearings (SRBs) have remained the bearing of choice for vibratory screens, particularly due to the high dynamic misalignment requirements of the application due to relatively long, small diameter shafts.

Since heat generation is high for this application, SRBs with a C4 radial internal clearance (RIC) are typically selected to account for the clearance reduction that occurs between mounted and steady-state thermal operating conditions. Furthermore, standard SRBs have been modified to help reduce the heat generation. These modifications typically consist of reduced RIC range and reduced fit ranges. These W800 modifications produce a bearing with greater precision, to reduce the opportunity for bore fretting, radial preload and overheating.

Cage type continues to be a contentious topic, with typical options of either a machined brass or steel material, chosen based on one's prior experience. The large section machined brass cage has historically been a stronger cage that holds up to the large cage forces brought about by the vibrations. New manufacturing methods have assisted in creating a strong thin section stamped steel cage that can similarly withstand the large cage forces. The steel cage has the benefit of being two-pieces, one per bearing element row. This allows the rows to rotate at different speeds, which is typical if the rows are loaded differently. Under radial loads this does not occur, and only axial loads will cause this to occur on an SRB. A vibratory screen does not typically see axial loads unless produced by an induced axial load condition described later.

Furthermore, Timken's EJ cage, which is stamped steel, has additional benefits, compared with other premium brands, that increase the lubrication flow into, through, and out of the rolling elements. This helps to reduce the operating temperature in SRBs. Timken testing has shown an operating temperature reduction of 5°C for a 22322 SRB compared with other premium brands, which equates to an 8% increase in bearing life.

Since an SRB is a unitized design, either the shaft / bore fit or housing / OD fit must be loose. Atypical compared to most applications, in vibratory screens the non-rotating component is tight fit to limit fretting and rotation in the housing. Unfortunately, some fretting regularly occurs on the shaft / bearing bore interface. The fretting is exponentially progressive unless either or both the shaft and bearing are replaced. This negatively impacts the float functionality of the SRBs as the shaft expands or contracts. The fretting creates an adhesion or 'stickiness' between the shaft and the bearing bore. This is further explained in Removal of Induced Axial Load.

Cylindrical Roller Bearings (CRBs)

Cylindrical Roller Bearings (CRBs) have been utilized where dynamic misalignment is less severe. Typically, this occurs in short shaft gearboxes. The short bearing spread limits the bending that can occur on the shaft.

From a performance perspective, the SRB performance advantage is due mostly to a higher capacity rating for the same size bearing. CRB performance is only slightly impacted by their lower tolerance for misalignment.

The CRB's non-unitized assembly allows the inner ring and outer ring to be separated so both components can be mounted with a tight fit, thus eliminating fretting from occurring.

Summary

Traditional roller bearing designs (i.e., tapered, cylindrical, spherical) meet most of today's application requirements for heavy industry. However, for vibratory screen applications, where dynamic misalignment (continuous misalignment of the shaft relative to the bearing during operation) and high axial displacement (movement parallel to the axis of the shaft) are encountered, a bearing that operates at a lower temperature, higher reliability, easier to mount and easier to maintain is desirable.

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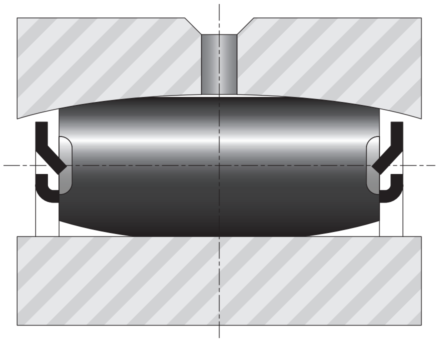

Figure 1: Cross Section of the ADAPT Bearing

ADAPT Bearing Design

A Brand-New Bearing

To meet increasing industry demands and customer needs, Timken engineered an entirely new bearing with a separable inner ring that simultaneously offers the internal float characteristics of a cylindrical roller bearing and the dynamic misalignment capabilities of a spherical roller bearing. This is the ADAPT bearing, and it is available with both steel and brass cage configurations.

A key feature is the bearing's ability to accommodate float and misalignment independent of each other. Specifically, the bearing's axial-float position does not affect its ability to misalign, and vice versa. The basic configuration is shown in Figure 1, albeit an animated picture with exaggerated profiles for ease of illustration.

Hybrid Bearing Innovation

The design of the ADAPT bearing combines a cylindrical inner ring with proprietary profiled rollers and outer ring. The combination of these profiles results in "three-point contact." Specifically, the inner ring to roller contact occurs at a single point, while the roller to outer ring contact occurs at two separate points. The outer ring contacts are symmetrically disposed at either side of the inner ring contact, creating inherently stable roller dynamics. This is represented in Figure 2. This three-point contact also means the roller is subjected to bending when under load. To accommodate this, ADAPT bearing rollers are manufactured from case-hardened steel.

During centered and aligned operation, the loads and reactions are balanced. In Figure 3, any axial movement (float) of the inner ring has no effect on load distribution. When an angular misalignment is introduced however, the initial roller to outer ring reaction becomes unbalanced. Figure 4 shows the load increasing at one end of the roller and decreasing at the other. Since the roller will always seek to balance the load, the axial component of the higher loads drives the roller over until stability is re-established as shown in Figure 5.

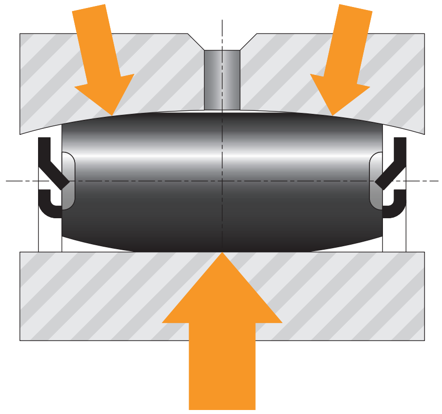

Figure 2: Balanced 3-point Contact of the ADAPT Bearing

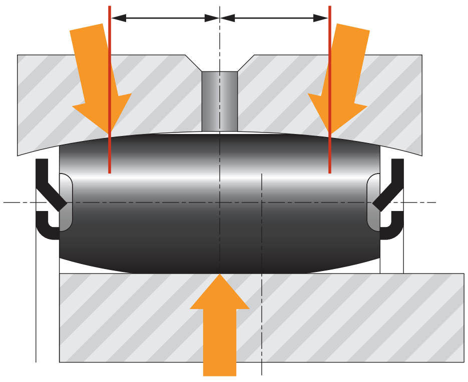

Figure 3: Internal Axial float of the ADAPT Bearing

ADAPT bearing roller and raceway profiles and surface finishes are also enhanced to maximize the load capacity and increase the relative oil lambda ratio (film thickness). The increased lambda ratio improves reliability in conditions where lubrication is marginal. A hardened steel cage (or brass cage) was designed to unitize the roller set. This allows for separation of the three bearing components (inner ring, outer ring and roller set), which offers flexibility for installation, removal and inspection.

This unique design allows the ADAPT bearing to misalign up to +/- 0.5° while simultaneously handling axial displacement, regardless of the initial bearing radial internal clearance. And because radial clearance is independent of axial float and misalignment, it can be reduced, resulting in an optimized load zone (more rollers sharing the applied load). Axial float capability is a function of the inner ring width only and is not tied to the bearing's misalignment position. Where required, bearings with wide inner rings can be specified in order to further increase the axial float capability beyond the standard +/-6mm.

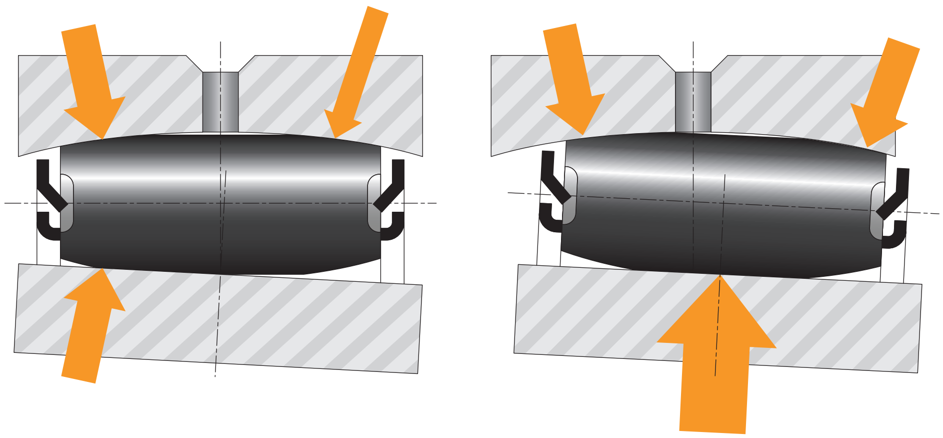

Figure 4: Momentary Load Imbalance Under Misalignment

Figure 5: Roller Adaption to Re-establish Balanced Loads

Means of Lubrication

Similar to spherical roller bearings, the center section of the ADAPT bearing outer raceway is lightly loaded, which allows the bearing to be supplied with an outer ring lubrication groove and holes (Figure 1) when required. The open design of the cage does not restrict lubricant flow in and out of the bearing. This ensures efficient lubricant distribution, heat removal and purging of old grease and contaminants.

Cage Type

The ADAPT bearing can be manufactured with both stamped steel and machined brass cages. The ADAPT steel cage is one piece (one bearing row), making it considerably stronger than the SRB stamped steel cage from a geometric perspective.

Same Improved Performance Modifications

The ADAPT bearing maintains the W800 modification code with a C4 RIC described earlier. This ensures that the benefits of lower operating temperature historically seen on SRBs are retained for the ADAPT bearing.

ADAPT and SRB System

The ADAPT bearing can only be incorporated as a float bearing. Therefore, another bearing type must be used in the fixed position to locate the shaft and to take any axial load the application may have. Typically, this fixed bearing is an SRB since it can also handle the dynamic misalignment.

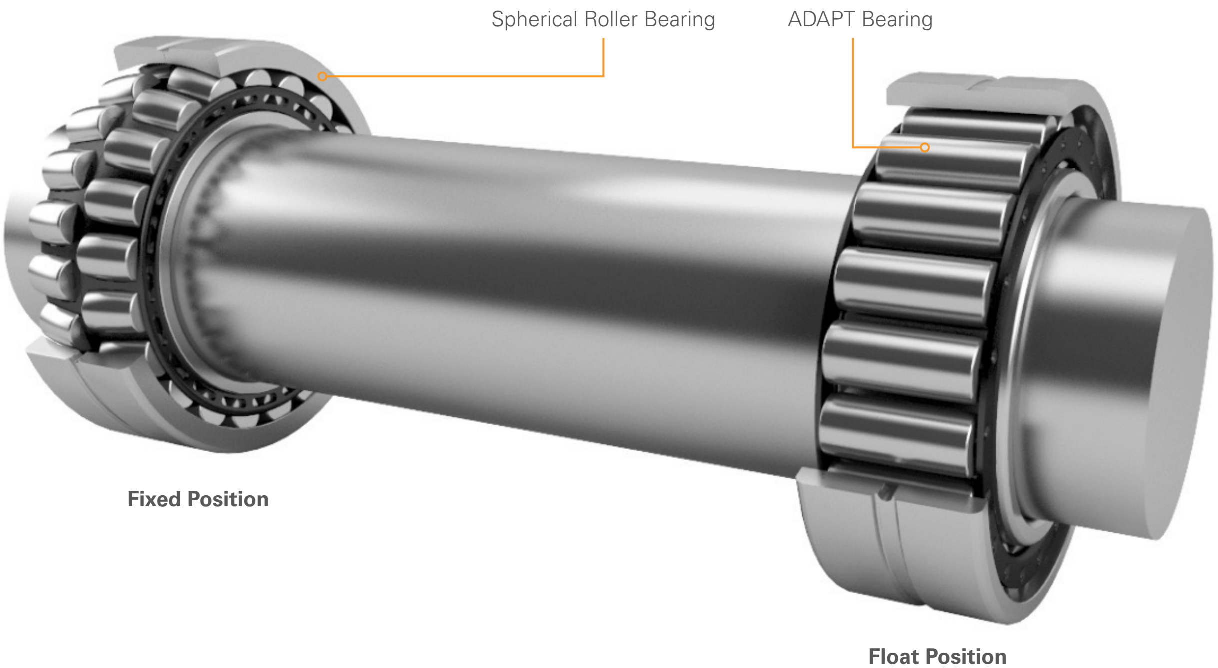

Figure 6: Arrangement of an ADAPT and SRB System

Application Success

Continuous Casters

Continuous casters are employed in the metals industry where hot formed steel is poured down a mold and is then rapidly cooled as the steel moves slowly along a continuous set of rollers. The rollers are supported by bearings seeing the slow rotating, high load conditions. The high loads create high misalignment and the heat of the material generates large axial expansion and displacement of the shaft. Application conditions are perfectly suited for the ADAPT bearing.

Paper Machine Rolls

On the opposite side of the application spectrum, a paper machine places fast rotating, moderate load conditions on the bearings. The forces to finish paper are moderate, while the speed is high to obtain high paper production rates. Furthermore, the machine widths dictate a wide bearing spread creating high misalignment requirements. High operating temperatures for drying of the paper creates high axial displacement requirements. Again, these are application conditions perfected suited for the ADAPT bearing.

Why Choose ADAPT for Vibratory Screens

In multiple ways, the ADAPT bearing improves the equipment performance via reduced downtime and component wear, which results in reduced maintenance cost and increased production time.

Lower Operating Temperatures

In SRBs, the spherical rollers exhibit a significant difference in roller radius across the roller width, which is exacerbated with longer rollers. This means that although the roller itself has one velocity, the surface velocity along the roller width varies. This velocity variance creates micro-slip when the surface velocity is higher than the roller velocity, and micro-slide when the surface velocity is lower than the roller velocity. When either of these occur while rollers contact the raceways under load, energy is lost. This energy loss is typically seen in heat generation of the system. The dynamics are further impacted by the contact angle of the rollers, which aligns the rollers such that the variances of raceway radius across the raceway width increases.

True rolling motion is when the surface velocity is equal to the roller velocity. The internal geometry of an SRB is designed such that two contacts of true rolling motion exist (indicated by 2 green dots in Figure 7). At locations furthest from these, the micro-slip and micro-slide, and thus heat generation (red Figure 7) is at its worst. This progression is shown in the contact ellipsis in Figure 7 and takes into account the variance in the raceway radius.

By contrast, the ADAPT's roller and raceway radius does not vary significantly. Similar to a cylindrical roller bearing, the roller surface has true rolling motion across the roller width. While there may be some variance at the rollers ends contacting the outer raceway, the difference is very slight and therefore will only cause minor micro-slide. This is shown in the animated view of Figure 8, where the contact ellipsis, utilizing the same SRB scale for the progression, shows the roller-raceway radius variance.

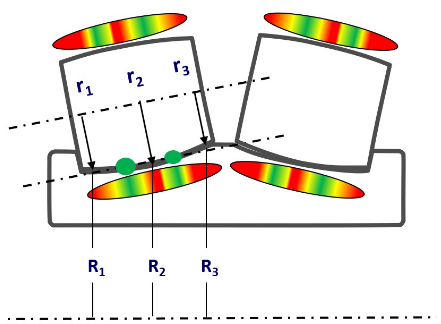

Figure 7: SRB Roller and Raceway Velocities

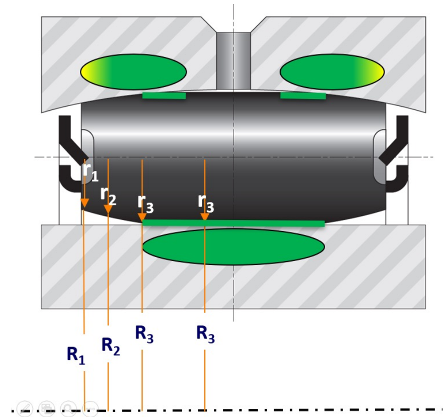

Figure 8: ADAPT Roller and Raceway Velocities (Animated Cross-section)

Figure 9 shows the actual cross section of the ADAPT bearing, which illustrates more precisely, just how little the roller and raceway radii vary, resulting in lower friction and heat generation and thus in a cooler operating bearing.

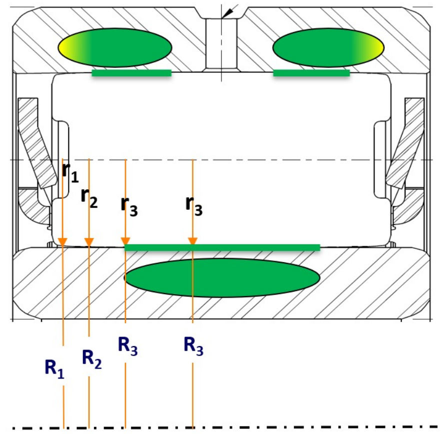

Figure 9: ADAPT Roller and Raceway Velocities (Actual Cross-section)

Elimination of Shaft Fretting

Fretting has been a continual issue for shaker screen applications. The potential negative effects are shaft deterioration culminating in added maintenance costs, induced axial load (discussed below), contamination from loose fretted particles and difficult disassembly and reassembly. To limit fretting, tight outer ring / housing fits and reduced fit ranges have been established. However, the former still requires a loose inner ring / shaft fit where fretting still occurs. The loose fit is a necessity for both mounting purposes and float requirements.

The float requirement can be met by the internal float capability of an ADAPT bearing. This allows the inner ring to now be clamped across the faces to create a typical fixed bearing. Otherwise, instead of clamping, the ADAPT inner ring or shaft tolerance could be adjusted to create a tight shaft / inner ring fit.

Figure 10: Shaft Fretting and Material Transfer to Bearing Bore

Removal of Induced Axial Load

Shaker screen applications do not impart any axial loads on the bearings, other than minor off-center loading. As described earlier, the shaft / inner ring fit is loose to allow axial displacement of the shaft relative to the bearing and housing. This is particularly important as the difference between mounted and operating temperatures increases, and for longer shafts. The shaker screen typically has both characteristics.

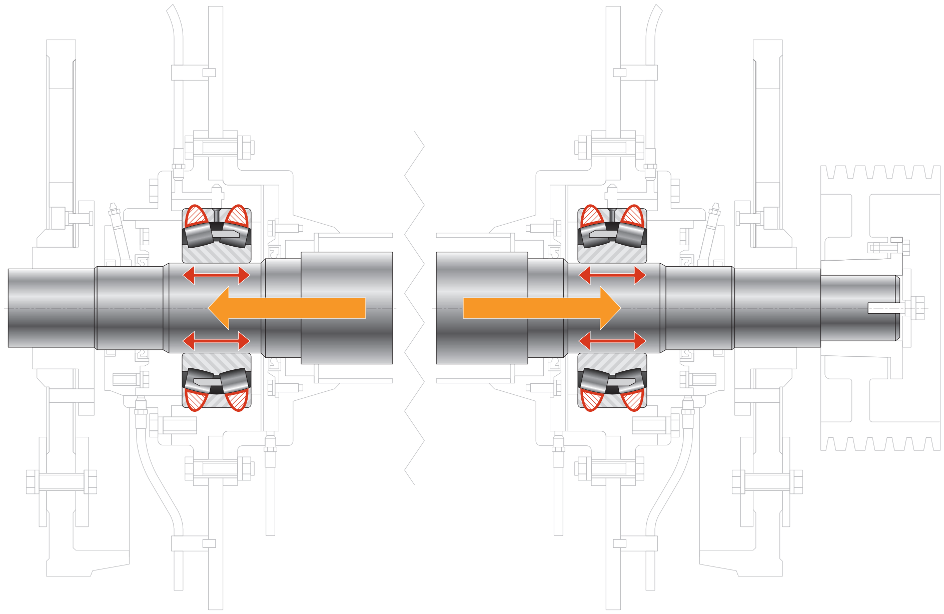

Figure 11: Appropriate Axial Displacement of SRBs System at New Equipment Installation

As the system operates and generates heat, there is thermal expansion, most prominent over the length of the steel shaft. With the axial thermal expansion, the shaft must grow within the bore of the inner ring. The friction between the shaft and the inner ring at first creates an equal and opposite force on the bearings, until the shaft moves. The onset of fretting causes a change in the surface finish of the shaft and the bearing bore. Over time, this changes the coefficient of friction, raising the force required to axially displace the shaft. In extreme cases, as the shaft tries to expand, the high friction induces an axial load on the outboard rows of each bearing while unloading the inboard rows. The higher load on the outboard rows decreases bearing life and increases heat generation.

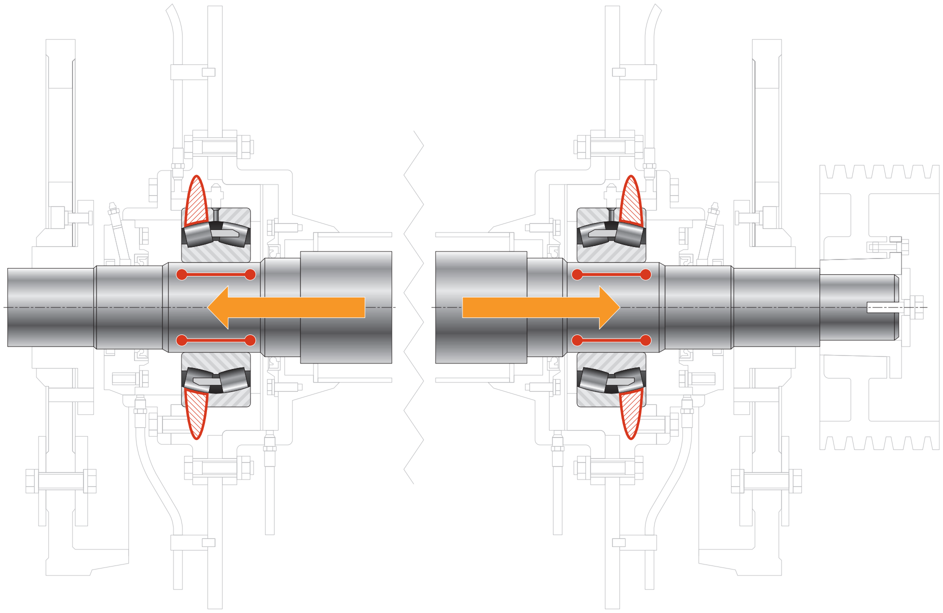

Figure 12: Little Axial Displacement of SRBs System due to Fretting

With the ADAPT bearing, the internal float capability will allow the shaft to expand with the least amount of force with no deterioration of this function. The benefit extends to the fixed SRB, since the ADAPT bearing cannot exert an axial load onto the SRB. To do this, the inner rings of both the SRB and ADAPT can be axially clamped (see blue in Figure 12). By keeping operating temperatures comparably lower for both bearings positions, the total system bearing life improves.

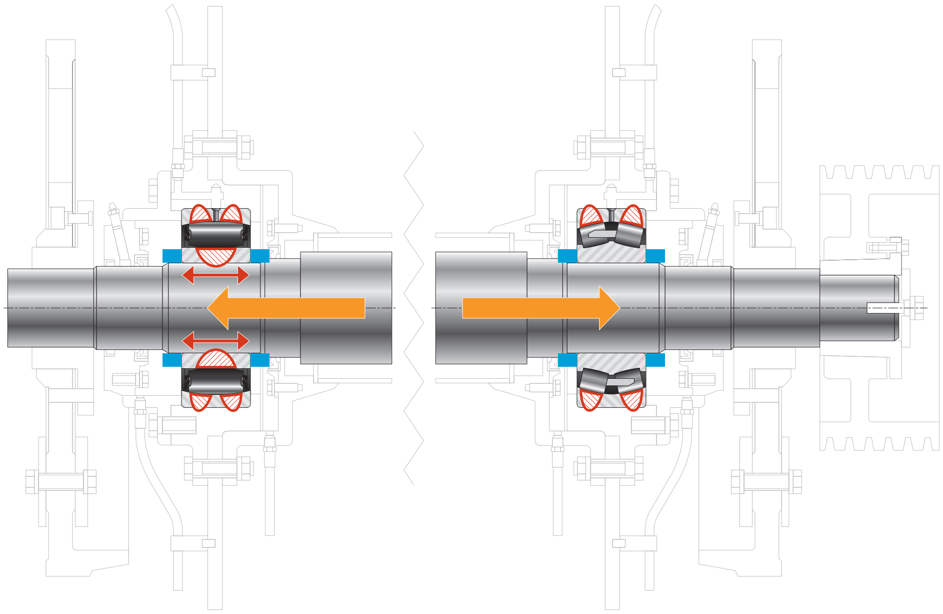

Figure 13: Continuous Axial Displacement of an ADAPT-SRB System

Improved Lubrication Films and Life

Lower operating temperatures will increase the operating oil viscosity, thereby increasing the oil film thickness for a given set of application conditions. The oil film thickness protects the bearing by separating the roller and raceway surfaces, preventing contact with each other. On a microscopic level, machined surfaces have asperities, as shown in the animation of Figure 14. The oil separation ensures that asperity peaks on the surfaces do not micro-weld, break off, or create contamination within the bearing, thus prolonging the life of the bearing. The ratio of the oil film thickness to the composite roughness of the surfaces is described as the lambda ratio. A value above 1 indicates the oil film thickness is greater than the height of surface asperities, leading to a positive scenario. A lambda ratio less than 1, indicates interaction / contact between the surface asperities.

$$\boxed{\lambda = \frac{\text{film thickness}}{\text{composite surface roughness of race and roller surfaces}}}$$

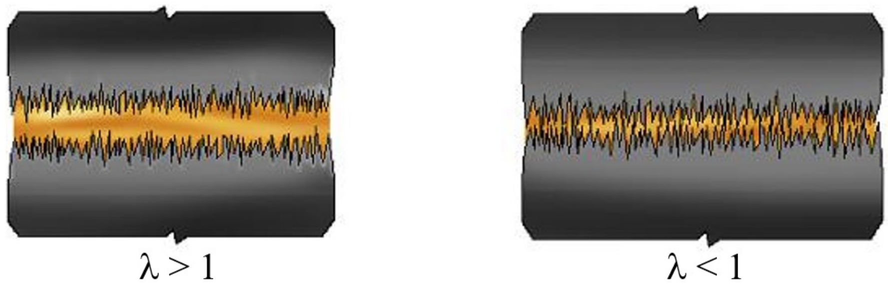

Figure 14: Lambda Ratio

The lower operating temperatures may allow an application to be moved to a relaxed maintenance regime, such as grease lubrication or extended oil change intervals. For example, by utilizing the ADAPT bearing, an oil lubrication is replaced with grease, but similar operating temperatures are maintained as shown in Figure 15.

Operating Temperature Above Ambient – Shaker Gearbox Test Data
SRB only in Oil vs. ADAPT & SRB in Grease

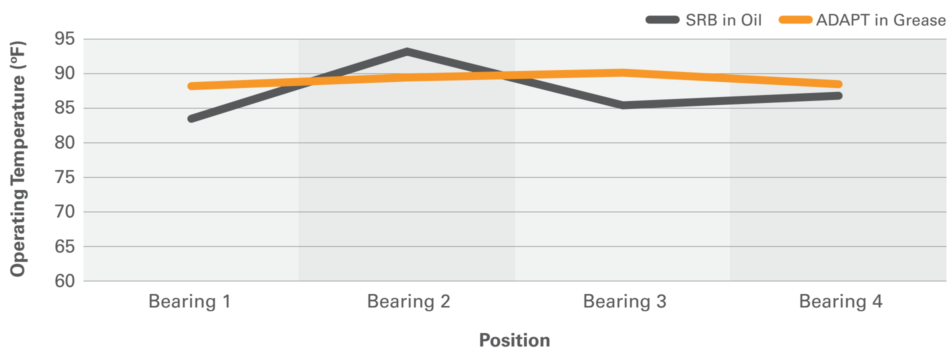

Figure 15: Cooler Operation with ADAPT

The lower operating temperatures simultaneously lower the oxidation rate of the oil, thereby extending the oil life. Using the Arrhenius Rate Rule, for every 10°C (~18°F) increase in temperature, the lubrication life has a 50% reduction. From Timken application testing, results indicate that the difference in operating temperatures between an ADAPT-SRB arrangement and an SRB-SRB arrangement with oil lubrication, would amount to as much as 22% longer lubrication life at the ADAPT position and 11% longer life at the SRB position.

Applying the same rule with grease lubrication, test results indicate that the difference in operating temperatures between an ADAPT-SRB arrangement and an SRB-SRB arrangement would amount to as much as 45% longer lubrication life at the ADAPT position and 11% longer life at the SRB position.

Longer Bearing Life

The ADAPT bearing life is extended compared to the SRB by several factors, including increased dynamic capacity, lower operating temperatures, increased oil film thicknesses and lower axial and radial bearing loads.

For example, in Figure 16, the comparison of the equivalent ADAPT to a 22322 SRB indicates the dynamic load capacity is 5% higher for the ADAPT bearing (TA2322). Using the catalog bearing life equations, this equates to an 18% increase in bearing life.

Dynamic Capacity Rating	
ADAPT (TA2322W33W800)	999 kN / 224,000 lbf
SRB (22322EMW33W800)	949 kN / 213,000 lbf
+5% load capacity = +18% bearing life	

Figure 16: Dynamic Capacity Comparison between ADAPT and SRB Bearings

The lower operating temperature will also increase the oil film thickness to help prolong the bearing life. From Timken application testing data, the (10°F) drop in operating temperature of the ADAPT bearing equates to an 8% increase in lube adjusted catalog bearing life.

Temperatures	
ADAPT (TA2322W33W800)	82.0°F
SRB (22322EMW33W800)	92.5°F
-10 °F = +8% bearing life	

Figure 17: Operating Temperature above Ambient Comparison between ADAPT and SRB Bearings

Lastly the lower axial loads of the ADAPT bearing extends the bearing life. SRBs inherently have axial loads internally opposing one row to the other. These loads are eliminated with the one row ADAPT bearing. As discussed earlier, the induced axial load will be eliminated, resulting in improved bearing performance.

Increased load capacity:	+18% bearing life
Reduced operating temperature:	+8% bearing life
Life increase over SRB	**+26% bearing life**

Figure 18: ADAPT Total Bearing Life Increase over SRB

Vibratory Screen Gearbox Testing

To verify the theoretical benefits of the ADAPT bearing over the SRB, Timken carried out testing on their inhouse vibratory screen (Figure 19). This test rig utilizes an eccentrically loaded gearbox (Figure 20) bolted to the screen frame. Baseline tests were conducted with SRBs in every position. Then ADAPT bearings were placed in float positions 2 and 4 (See Figure 20) and results compared.

The test was conducted at 900 rpm, with eccentric loads generating a 17,000 lbf (76kN) centrifugal force on each pair of bearings. Tests were conducted with ISO VG 150 lubrication for the bearings in the shaker screen and gearbox shown in Figures 19 & 20.

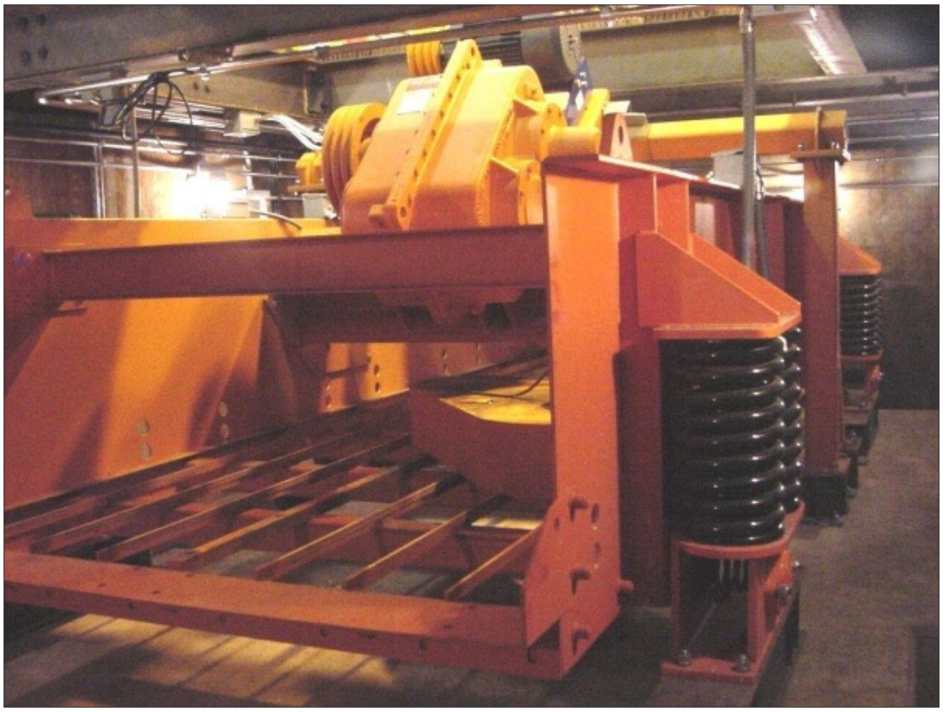

Figure 19: Application Test Rig

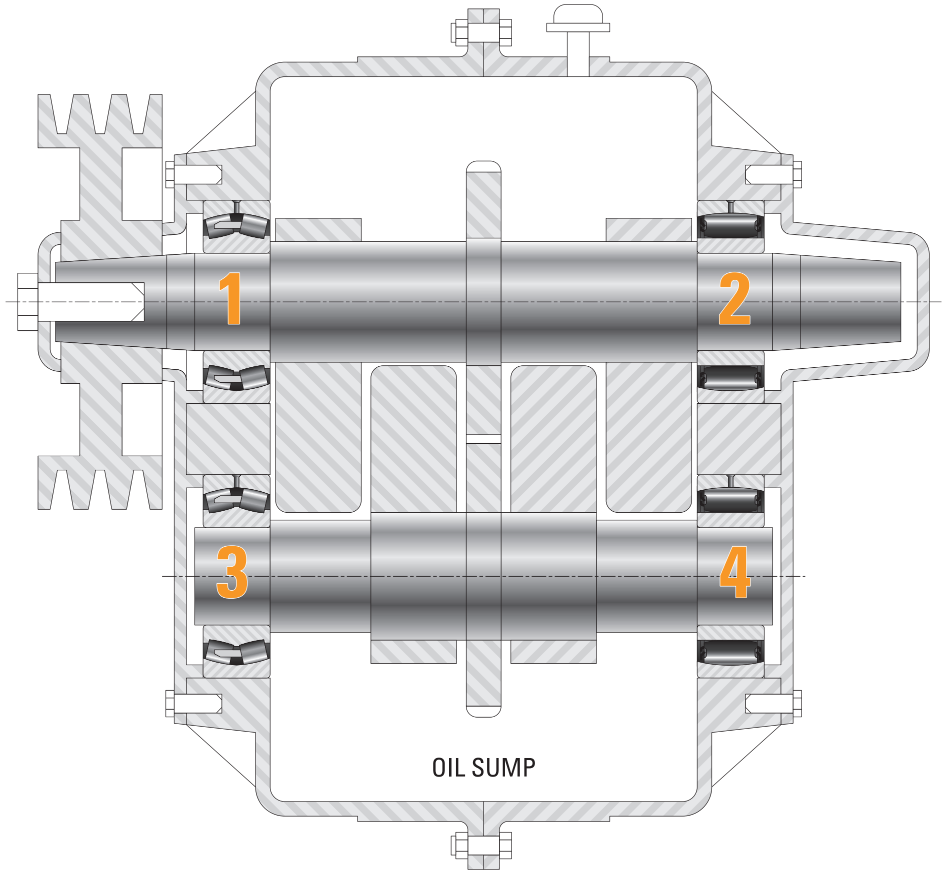

Figure 20: Test Rig Gearbox Layout and Bearing Positions

Oil Lubrication Test Results

The tests showed a reduction in bearing operating temperatures at the ADAPT positions of as much as 10°F. The ADAPT bearings also impacted the SRB performance by reducing their operating temperature by as much as 5°F.

Operating Temperature Above Ambient – Shaker Gearbox Test Data
SRB only in Oil vs. ADAPT & SRB in Oil

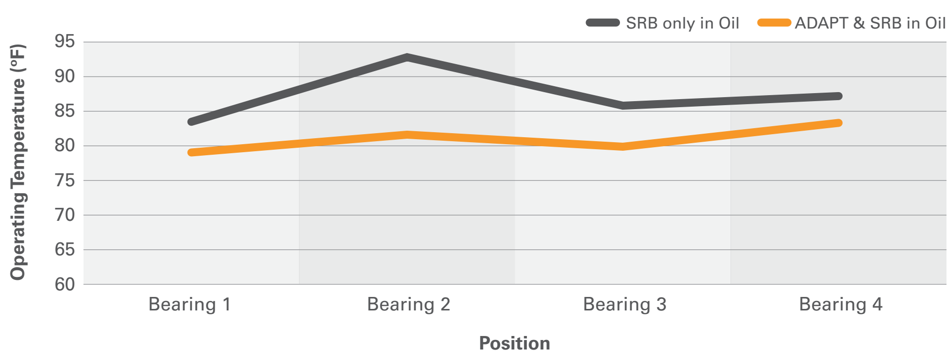

Figure 21: Test Rig Data – ADAPT Temperature Reduction in Oil

Lower Viscosity Oil Lubrication Test Results

With the lower operating temperatures when ADAPT bearings are used at the float positions, the oil operating viscosity and film thickness is improved. Under the improved conditions, analysis indicates that a lower viscosity oil can be used with the ADAPT bearings and a comparable Lambda ratio is maintained relative the SRB only baseline.

Test data indicates than an even greater reduction in operating temperature can be attained with lower viscosity oil. The ADAPT bearings operated at up to 15°F lower and the SRB up to 11°F lower in the reduced viscosity oil per Figure 22 below. Again, lower operating temperatures help further improve bearing, oil and seal life.

Operating Temperature Above Ambient – Shaker Gearbox Test Data
SRB only vs. ADAPT & SRB in Lower Viscosity Oil

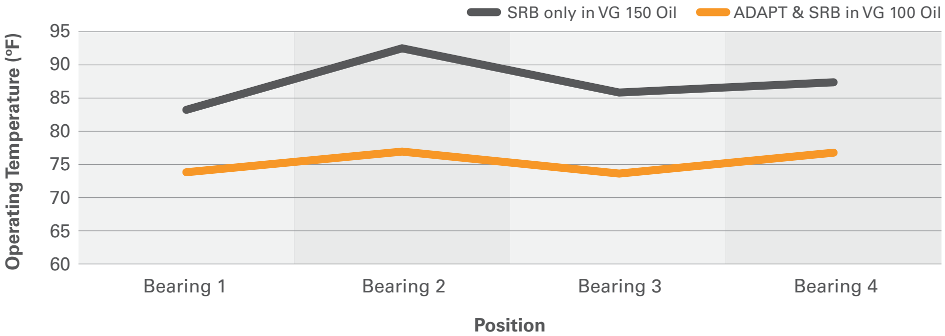

Figure 22: Test Rig Data – ADAPT Temperature Reduction in Lower Viscosity Oil

Grease Lubrication Test Results

Tests were also run with a modified gearbox to seal off the traditional oil lubricant. Bearings were lubricated with an ISO VG 150 grease.

In grease lubrication, the temperature reductions were even more significant, with the ADAPT bearing temperatures reduced as much as 20°F, and the SRB temperatures reduced by as much as 6°F. Test data results are shown in Figure 23 below.

Operating Temperature Above Ambient – Shaker Gearbox Test Data
SRB only vs. ADAPT & SRB in Grease

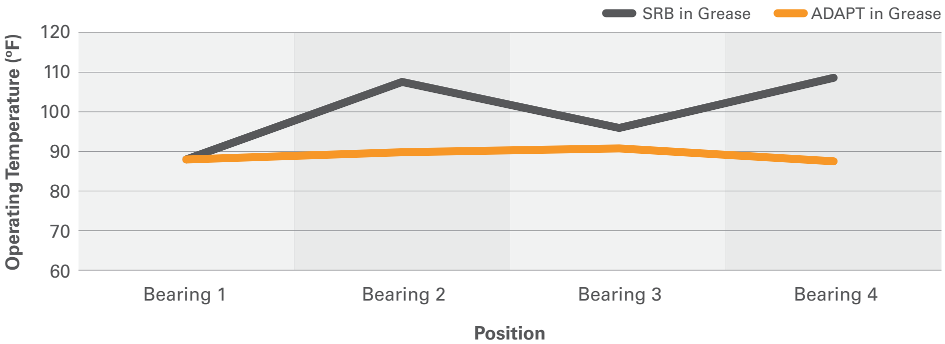

Figure 23: Test Rig Data – ADAPT Temperature Reduction in Oil

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Impact of Cage Type on Bearing Performance

The tests results show similar operating temperatures between cage types utilizing oil lubrication. However, in grease lubrication, results show that both ADAPT and spherical roller bearings with steel cages operate at lower temperatures. The ADAPT bearings with steel cages operate approximately 10°F lower than those with brass cages. In arrangements with SRBs only, the spherical roller bearings with steel cages operate an average of 15°F lower than those with brass cages.

Conclusions

The eccentric loads of vibratory screens and feeders create a challenging application for bearings. The bearings are subject to dynamic misalignment, a rotating load zone, and elevated operating temperatures causing axial thermal growth. The eccentric load also promotes fretting, leading to possible shaft damage and contamination.

Spherical roller bearings are typically selected by an OEM for screens and feeders for their ability to handle the dynamic misalignment. Timken provides SRBs with the W800 modification code to improve precision and guard against fretting, radial internal preload and overheating. Additional improvements include a robust machined brass cage or a highly engineered FNC hardened steel cage with excellent lube flow, both tolerant of the rotating load zone and contamination.

The ADAPT bearing further improves performance in a vibratory screen or feeder application. The design of the ADAPT bearing combines a cylindrical inner ring with proprietary profiled rollers and outer ring. It adjusts to +/- 0.5° of dynamic misalignment and can float internally for +/- 6mm of axial thermal growth, both independent of each other. Specifically, the bearing's axial-float position does not affect its ability to misalign, and vice versa.

A hardened steel cage unitizes the roller set, allowing for separation of the three bearing components, offering flexibility for installation, removal and inspection. And with a lightly loaded center section, the outer raceway is designed with an outer ring lubrication groove and holes. The open design of the one-piece stamped cage allows for optimum lubricant flow in and out of the bearing, ensuring efficient lubricant distribution, heat removal and purging of old grease and contaminants. And by design, the ADAPT bearing, with one row of longer rolling elements has less micro-slide and slip in operation, which further reduces operating temperatures compared to an SRB.

With an SRB-SRB arrangement, the float bearing allows for axial thermal growth of the shaft within the bore of the loose fit inner ring. However, should fretting occur at that interface, the thermally expanding shaft may not float within the inner ring, instead applying an axial force in the outer rows of each SRB and unloading the inner rows. Thus, one row of rollers will see heavy loads and the other lightly loaded row may be pulled along by the cage or see increased roller skewing and sliding. Both would cause premature damage to the spherical roller bearings.

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With the ADAPT bearing at the float position, an SRB at the fixed position will handle any axial load from the vibratory screen or feeder application. And with the capability to float internally between the rolling elements and race surface, the axial growth of the shaft, with the clamped inner ring, will not be impeded. Furthermore, a system with both the SRB and ADAPT inner rings clamped, minimizes fretting potential.

Application Test Results – Bearing Performance

The below summarizes the bearing performance improvements shown in application testing for both bearings due to lower operating temperatures by utilizing the ADAPT bearing at the float position.

Position	Lubricant	Temperature Reduction	Longer Bearing Life	Longer Lubricant Life
ADAPT	Oil	5°F - 10°F	4% -8%	12% - 29%
SRB	Oil	5°F	4%	14%
ADAPT	Grease	20°F	16%	56%
SRB	Grease	6°F	5%	17%

- In an oil application, the cooler operating ADAPT bearing allows for a lower oil viscosity which results in up to a 15°F lower operating temperature and 12% longer bearing life.
- A steel cage has a minor benefit over a brass cage when oil lubricated, but has a significant benefit when grease lubricated. The test results indicate lower operating temperatures for the following bearing arrangements with steel cages compared to brass cages in grease:

  a. SRBs - Steel is 15°F lower (12% longer bearing life)

  b. ADAPT - Steel is ~10°F lower (~8% longer bearing life)