O PAPEL vol. 82, No. 7, pp. 78 - 81 - JUL 2021

MODIFICATION STUDY OF THE BEARING ARRANGEMENT AND APPLICABILITY OF THE THREE-BARRIER SOLUTION IN WOOD CHIP CONVEYOR

Authors: Danilo Amorim da Silva[1], Edmilson R. de O. Santos[1], Marcelo G. Pereira[1]

[1] *SKF do Brasil LTDA. Brasil*

ABSTRACT

A chip conveyor belt return roller bearing installed in a pulp plant presented premature failures due to misalignment and contamination, causing a Mean Time Between Repair (MTBR) of around three months. The conveyor belt carries wood chips to process, therefore, great reliability and availability is required to avoid a decrease in production and high maintenance cost. In order to increase equipment MTBR, the original bearing arrangement was evaluated in terms of application, which comprised Deep Groove Ball Bearings and Cylindrical Roller. From that study, a change from the original bearing arrangement to two Sealed Spherical Roller Bearings (SSRB) was proposed, which presented less sensitivity to system misalignment compared to the original arrangement. A Three-Barrier Solution was also implemented, an efficient solution against solid particles contamination in those components. This approach has been widely and efficiently applied in several equipment, mainly in bearing conveyor belts. After implementation of the SSRB arrangement solution, bearing life reached 24 months and, so far, the system has not presented failures. Therefore, in operational equipment conditions, bearing relubrification of was eliminated, contributing to worker safety since the environment has solid particles in suspension; as well as increased equipment reliability and availability for production process.

Keywords: *Bearing arrangement, Three-Barrier Solution, sealed bearing, belt conveyor.*

INTRODUCTION

Nowadays, industries need to guarantee the reliability and availability of their assets to maintain productivity. In this context, this article will describe the improvement of conveyor belt housings, especially in return roll, where the bearings suffered a lot of failures in the past. This was due to bearing arrangement having suffered misalignment and a high-contamination environment, and therefore, causing premature failure in the system. The objective of this study was to increase equipment MTBR by replacing Deep Groove Ball Bearings and Cylindrical Roller Bearings for Spherical Roller Bearing, and application of Three-Barrier Solution, which is efficient against solid-particle contamination in these components. Figure 1 illustrates the bearings that were used before and after maintenance.

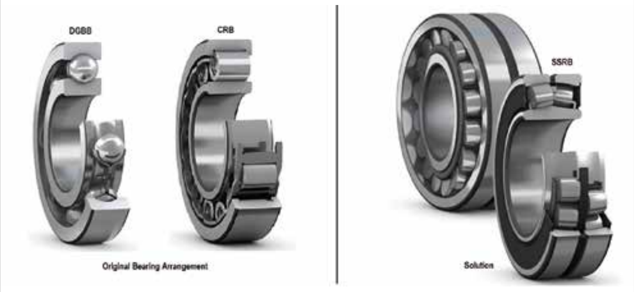


Figure 1. Arrangement bearings

Figure 2 shows the main application of this study with contamination environment present on the chip conveyor belt return roller housing.

Figure 2. Chip conveyor belt return roller housing

METHODS

Equipment Data

Table 1 shows data of the original equipment, which was applied to the Three-Barrier Solution, and also to evaluate the new bearing arrangement modification.

Table 1. Equipment data

Housing model	Original of equipment
Conveyor belt return roller bearings	(2x) NJ 214 ECJ (2x) 6214
Lubrication	Grease
Type	Mobilgrease XHP 222
Specification	Manual
Frequency relubrication amount	53 g/monthly/per housing
Roller mass + shaft mass	400 kg
Belt tension	96 Kgf/cm^2
Roller rotation	95.5 RPM
Operation temperature	50° C

Corresponding author: Danilo Amorim da Silva E-mail: amorim8silva@yahoo.com.br Phone number: (11) 99260-1708

Minimum load

The condition for the proper functioning of a given bearing is that it should be subjected to a certain minimum load [1].

In this study, this condition was evaluated for the return roller, where it was recommended to modify the arrangement for spherical roller bearings, where deep groove ball and cylindrical roller bearings were used in the past.

With this, the minimum load can be estimated according to the calculation of Equation (1).

$$Pm = 0.01 \times Co \qquad (1)$$

Where:

Pm – Minimum load (kN)
Co – Static load capacity (kN)
Pm = 0.01 x 240 = 2.40 kN

Applying the following mass: roller, shaft, and also belt tension, the bearing arrangement located on the return roller reached the minimum load.

Three-Barrier Solution

The Three-Barrier Solution consists of components against the entry of contaminants [2]. Figure 3 shows the main components of the barriers, according to numbers. The first component is the sealed bearing (1), then the grease inside bearing (2), which must be filled around 90% of the empty space and finally the external seal (3).

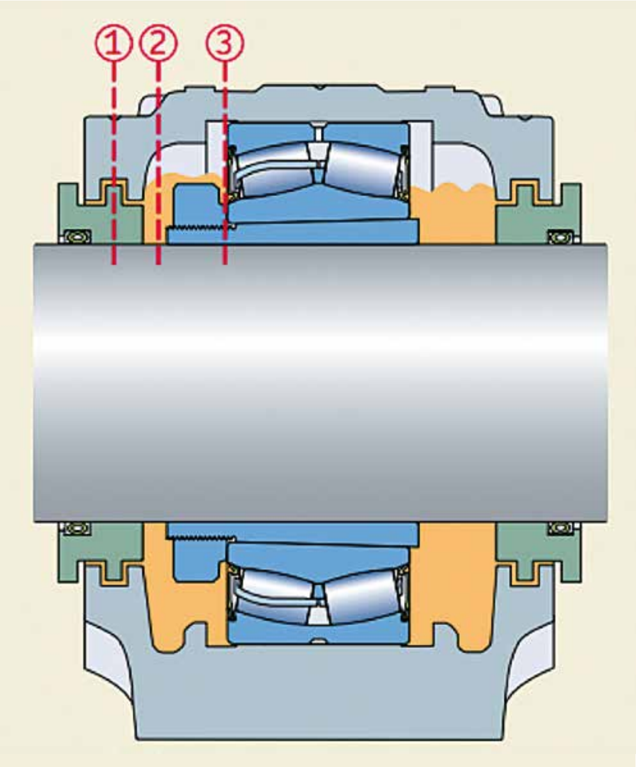
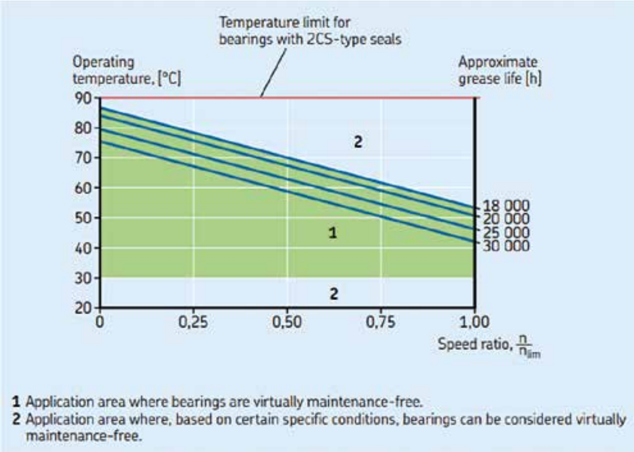


Figure 3. Three-Barrier Solution



1 Application area where bearings are virtually maintenance-free.
2 Application area where, based on certain specific conditions, bearings can be considered virtually maintenance-free.

Figure 4. Analysis of operational conditions diagram [2]

Evaluation of the equipment's operational conditions is essential to check the need for relubrication, therefore check the speed limit of the sealed bearing, in order to allow for proper functioning [4]. Among the parameters to be analyzed are operational temperature and the rotation described in Table 1. Figure 4 shows that respective bearing fits in the working region (1). This means that there is no need to relubricate them.

Calculation of belt tension force

Considering a smooth pulley and belt contact angle with pulley 180°, Figure 5 shows the forces considered [5].

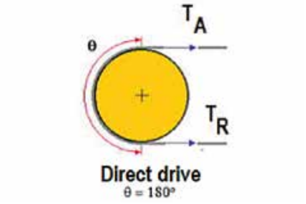


Figure 5: Illustration of belt-tension forces

Equation (2) to (8) shows the calculations of forces.

$$T_{ef} = \frac{P}{v} = \frac{37}{4} = 9.25\ kN \qquad (2)$$

$$T_R > T_{ef} \cdot \frac{1}{e^{\mu\theta} - 1} \qquad (3)$$

$$T_R > T_{ef} . U \qquad (4)$$

$$U = \frac{1}{e^{\mu\theta} - 1} \qquad (5)$$

$$T_A = T_R + T_{ef} \qquad (6)$$

Where:

Tef – Effective tension force
TA – Actuation tension force
TR – Resistive tensile strength
U - Drive factor (U = 1.66, considering smooth pulley and belt contact angle with pulley 180°)

According to Equation (7) and (8):

$$T_R = 9.25x1.66 = 15.355\ kN \qquad (7)$$

$$T_A = 15.355 + 9.25 = 24.605\ kN \qquad (8)$$

Considering the resulting force of the system, represented in Figure 6 and calculated based on Equations (9) and (10).

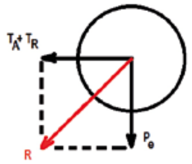


Figure 6: Resulting forces.

$$R = \sqrt{(T_A + T_R)^2 + P_e^{\,2}} \qquad (9)$$

Where:
Pe – Shaft weight
TA – Actuation tension force
TR – Resistive tensile strength

Finally:

$$R = \sqrt{(39.96)^2 + 4^2} = 40\ kN \qquad (10)$$

Shaft Dimension Calculation - ASME Method

For the assembly of the proposed bearings on the adapter sleeve, it is necessary to machine the shaft in 5 mm in diameter, for this, the dimensioning of the shaft was carried out using the ASME Method to verify this condition. Calculations are represented in Equation (11) below.

Formula for calculating shaft diameter:

$$d = \left\{ \frac{16}{\pi X \delta s} \sqrt{(KbxMb)^2 + (KtxMt)^2} \right\}^{\frac{1}{3}} \qquad (11)$$

Where:
δs = Admissible tensile
Kb = Factor that takes into account shock and fatigue, applied to the bending moment
Kt = Factor that takes into account shock and fatigue, applied to the torsion moment
Mb = Bending moment
Mt = Torsional moment

Considerations:
(1) Torsional moment not considered
(2) Stress Concentration Factor (Kb) Gradually Applied Load - flexion (Kb = 2)
(3) Admissible tensile (δs)

Considering SAE 1045 STEEL; δe = 531 MPa [3]. Calculation of Equation (12) to (13)

δs=0.3 x δe (12)
δs=0.3 x 531 MPa = 159.3 MPa (13)

Considering the keyway, multiply the value of δs by 0.75, shown in Equation (14).

δs= 0.75 x 159.3 MPa = 119.475 MPa (14)

(4) Calculation of the bending moment (Mb)

Bending moment (Mb = 22500 kN.mm) is represented in Figure 7.

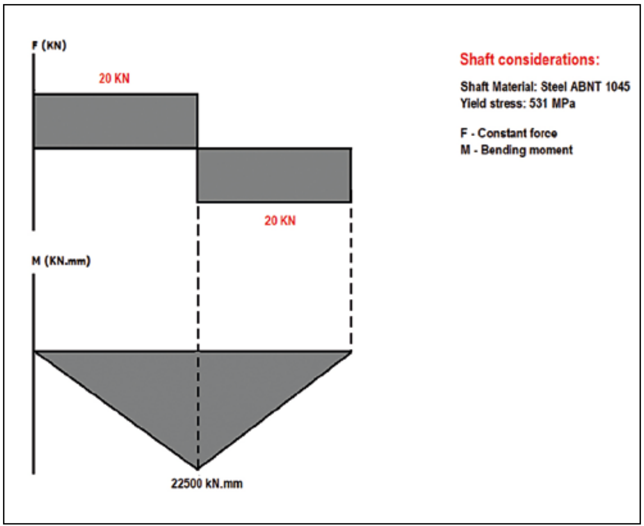


Figure 7. Free-body diagram of force and bending moment.

Finally, the calculation of minimum shaft diameter is shown in Equation (15) to (17).

$$d = \left\{ \frac{16}{\pi\, x \delta s} \sqrt{(KbxMb)^2 + (KtxMt)^2} \right\}^{\frac{1}{3}} \qquad (15)$$

$$d = \left\{ \frac{16}{\pi x 119.475 x 10^6} \sqrt{(2x22500N.m)^2} \right\}^{\frac{1}{3}} \qquad (16)$$

$$d \approx 12.5\ mm \qquad (17)$$

Since 65 mm diameter is larger than 12.5 mm, it is possible to machine the shaft and then mount the sealed bearing suggested.

RESULTS AND DISCUSSION

In this study, the bearing arrangement composed by Deep Groove Ball Bearings and Cylindrical Roller was modified. Such operation aims to eliminate premature failures caused due to misalignment of system and the Three-Barrier Solution was applied to eliminate the entry of contaminating agents inside the bearings. As a complement to the application, an additional quantity of 19 grams of lubricant was inserted into the bearing BS2-2215-2CSK/ VT143 (Figure 8), through the lubrication channel W33, knowing that it originally presents 25% to 45% of the internal empty space

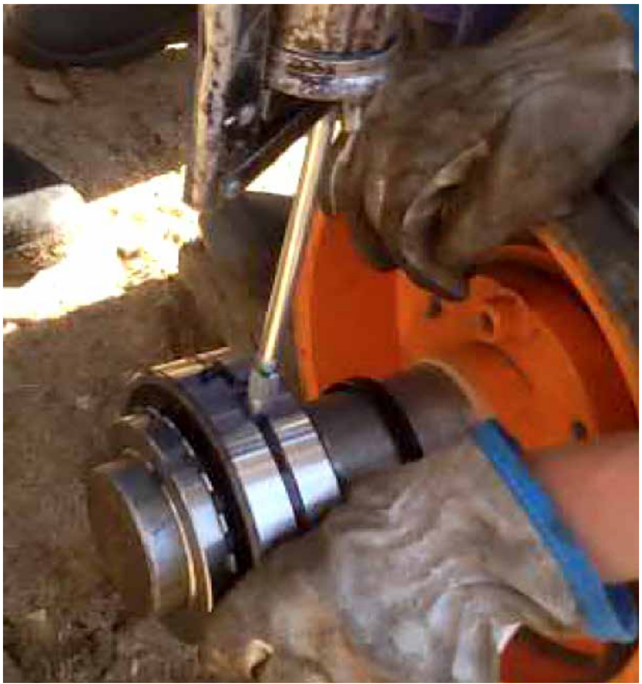


Figure 8. Grease added inside the sealed bearing

filled with grease. This way, with the additional addition of grease, the empty space of the bearing becomes 55% to 75% filled, helping to form a lubricating film in load zone.

During assembly of the bearing in question, the SKF Drive-up method was used, applying the values in Table 2 below. With preliminary verification of the dimensional tolerances of the shaft, with an h9 adjustment and IT5 cylindricity.

Table 2. Values for applying the SKF Drive-Up method.

Bearings	Pump Pressure (Initial Position)	Axial displacement (Dial Indicator)
SKF BS2-2215-2CSK/VT143	1.03 MPa / 149.5 psi	0.453 mm

The method consists of reducing the radial internal clearance by application of pressure by the pre-established hydraulic pump and axial displacement, according to Figure 9 [4].

The SNL 515-612 housing was mounted, filling 90% of the empty internal space with grease, after the bearing was positioned.

It was recommended that the bearing housing support have the following tolerances:

- Flatness: IT7
- Surface roughness: Ra ≤ 12.5 µm

CONCLUSIONS

In the context of a productive environment, asset reliability and availability are paramount. As such, this work adopted a bearing arrangement assessment that is less sensitive to misalignment and applied a Three-Barrier Solution to contain premature failures. Maintenance costs were reduced: where failures previously occurred every 3 months, after these changes, more than 24 months of operation have gone by without any failures. Additionally, the gains were the longest time without relubrication needs and safety. ■

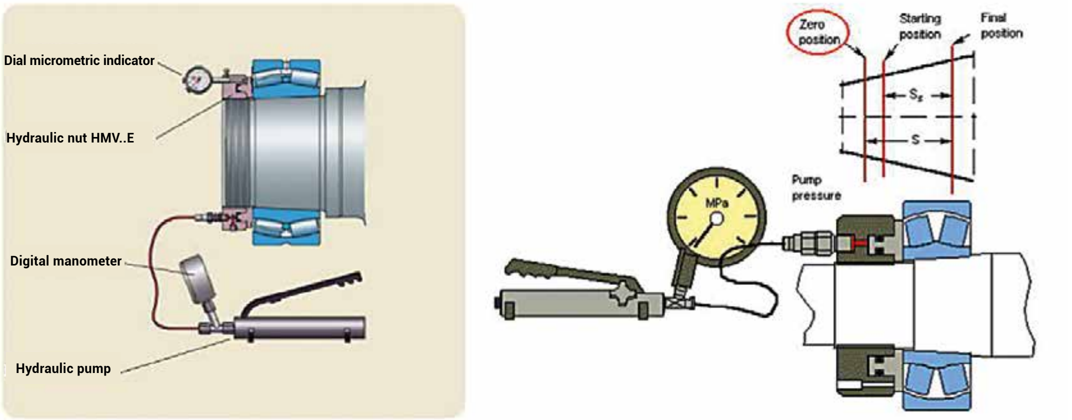


Figure 9. SKF Drive-up mount method

REFERENCES

1. SKF, Rolling Bearing Catalogue, PUB BU/P1 10000/1 EN, pp.1-1130. Published February 2013.
2. Sealed SKF Explorer Spherical Roller Bearings, Optimum protection against contaminants, downtime and high maintenance costs, pp.1-28, April 2013.
3. Norton, R.L. “Machine Design”, 3rd Edition, pp. 1-931, 2006.
4. Silva, D. A.; Massoti, J.G.B.; Pereira, M.G. “Eliminação de Falhas Prematuras de Rolamentos de Transportador Aplicando o Conceito Tríplice Barreira”. O Papel Magazine, pp. 83-84. November 2016.
5. https://www.ctborracha.com/borracha-sintese-historica/aplicacoes/correias-transportadoras/calculo-e-seleccao-de-correias-transportadoras/. Access in 01/10/2018.