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LIFETIME ANALYSIS OF SPHERICAL ROLLER BEARINGS ON ROLL MILL MACHINES AT PT. ABC

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Graphical abstract

Figure 1. Bearing 22315 EK

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Abstract

PT ABC is a wheat flour production company in Indonesia. Many sophisticated machines are used in the wheat flour production process, one of which is the roll mill machine. In its operation, the roll mill machine uses bearings to support the roll when it rotates and reduce friction that occurs so that the roll can rotate smoothly and avoid wear. If the bearing does not function properly, it can damage the machine and other components. Therefore, to predict damage to the bearing, it is necessary to analyze how long the bearing lifetime is. In the implementation of this Practical Work, research will be conducted to determine the lifetime and types of damage that occur to the bearings used so that solutions can be found to prevent damage to the machine and other components. Based on the results of calculations in this study, the life of the spherical roller bearing in the roll mill machine using the basic rating life method shows that the bearing life obtained is 36,696,343 operational hours, while the time required to re-lubricate the spherical roller bearing is every 9800 hours with the amount of lubricant given is 17.6 grams.

Keywords: spherical roller, bearing, Maintenance Schedule, Preventive Maintenance, roll mill machine.

Abstrak

PT. ABC yang merupakan salah satu perusahaan produksi tepung terigu di Indonesia. Dalam proses produksi tepung terigu banyak menggunakan mesin-mesin berteknologi canggih salah satunya adalah mesin roll mill. Dalam pengoperasiannya, mesin roll mill menggunakan bearing atau bantalan yang berfungsi untuk menyangga roll ketika berputar dan mengurangi gesekan yang terjadi sehingga roll dapat berputar dengan lancar serta terhindar dari keausan. Apabila bearing tidak berfungsi dengan semestinya, maka dapat merusak mesin dan komponen lainnya. Oleh karena itu, untuk memprediksi kerusakan pada bearing perlu dianalisis berapa lama umur bearing yang digunakan. dalam pelaksanaan Kerja Praktik ini akan dilakukan penelitian untuk mengetahui umur dan macam-macam kerusakan yang terjadi pada bearing yang digunakan sehingga dapat dicari solusi untuk mencegah kerusakan pada mesin dan komponen lainnya. Berdasarkan hasil perhitungan dalam penelitian ini, umur spherical roller bearing di mesin roll mill menggunakan metode basic rating life, menunjukkan bahwa umur bearing yang didapat yaitu 36.696.343 jam operasional, sedangkan Waktu yang diperlukan untuk melakukan pelumasan ulang pada spherical roller bearing yaitu setiap 9800 jam sekali dengan jumlah pelumas yang diberikan sebesar 17,6 gram.

Kata kunci: spherical roller, bearing, Maintenance, Preventive Maintenance, roll mill machine.

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1.0 INTRODUCTION

Many industries use rotor-bearing systems such as high-speed turbines and generators. However, the vibration of an antifriction rotor–bearings is a key factor in reducing the life of the bearings; thus significantly influencing the performance and working life of the whole power plant. [1]

Rolling element bearings are a precision, yet simple, machine element of great utility. A brief history of rolling element bearings is reviewed and the type of rolling element bearings, their geometry and kinematics, as well as the materials they are made from and the manufacturing processes they involve are described. [2]

The grain milling process, in which flour is produced, is very important since it radically changes the quality and quantity characteristics of products. The main milling machine used during the last two centuries in the leading branches of the food industry is a roller mill. [3]

One of the critical components in roll mill machines is the bearing system. **Spherical roller bearings** are widely used in such applications due to their unique ability to effectively accommodate misalignment and handle radial and axial loads. These bearings are specifically designed to endure the harsh operating conditions of roll mills, such as high temperatures, contamination, and frequent load variations.

A frictionless force transmission between the mechanical components of high production volume systems was accomplished by Rolling Element Bearings, which leads to being an imperative item of the condition-based maintenance (CBM). [4]

For any roller generator correction profile, the pressure distribution in the contact, and then to determine the contact capacity indicator. The diagrams of the contact capacity indicator as a function of Stribeck's unit load, obtained in the course of investigations, have been presented. It has been found that arch correction in the spherical roller bearing should only serve the purpose of ensuring a proper ratio of osculation coefficients for both races, which would allow obtaining the self-stabilization of the barrel and minimum friction losses. On the other hand, the barrel-race mating conditions can only be guaranteed by the simultaneous use of arch-logarithmic correction[5]

The adoption of spherical roller bearings in roll mill machines offers several advantages, including improved load capacity, extended service life, and reduced maintenance requirements. These benefits translate into enhanced operational reliability, minimized downtime, and cost savings for flour manufacturing companies.

However, challenges remain in optimizing the performance of spherical roller bearings in these machines. Issues such as improper lubrication, misalignment beyond tolerable limits, and excessive wear can lead to premature failure, compromising production efficiency. As a result, research in this area focuses on selecting appropriate bearing materials, improving lubrication systems, and developing predictive maintenance techniques to ensure the optimal performance of spherical roller bearings in roll mill applications.

This study aims to analyze the use of spherical roller bearings in roll mill machines at a flour manufacturing company, identifying key factors that influence their performance and exploring potential improvements to maximize operational efficiency and bearing lifespan.

Several methods are suggested for estimating the ε parameter using a real case with a finite element analysis load distribution accounting for structural ring deformation and ball-race contact angle variations. [6]

PT ABC is a wheat flour production company established in 2010 and started operating on October 20, 2011. Previously, PT. ABC was a joint venture between Turkey and Indonesia in October 2014. This company imports wheat from countries such as the United States, Canada, parts of the European continent, and most of Australia because wheat does not grow well in tropical countries such as Indonesia. PT. ABC, in carrying out its activities, has several certifications, such as the SNI 3751: 2009 certificate, namely regarding wheat flour products as food ingredients.

2.0 METHODOLOGY

The following are several methods used by the author in collecting data related to this research:

1. Operational Data Collection
   - Gather operational data from the roll mill machine, including load conditions, rotational speed, ambient temperature, and lubrication status.
   - Document the usage history and failure occurrences of the bearings, including operational time until failure.
2. Field Testing
   - Conduct on-site inspections of the bearings used in roll mill machines.
   - Measure wear on bearing components such as raceways, rolling elements, and cages using tools like profilometers or optical microscopes.
   - Examine signs of material fatigue, corrosion, or contamination.
3. Lubrication Analysis
   - Assess the quality and viscosity of the lubricant used in the bearings.
   - Analyze contamination and degradation of the lubricant using techniques like Fourier Transform Infrared Spectroscopy (FTIR).
   - Evaluate the impact of lubrication on bearing service life.
4. Failure Analysis
   - Analyze failed bearings using techniques such as Scanning Electron Microscopy (SEM)

or Energy Dispersive X-ray spectroscopy (EDX) to identify failure mechanisms (e.g., material fatigue, corrosion, or wear).
- Correlate failure analysis results with roll mill operating conditions.

5. Life Prediction Modeling
   - Apply theoretical models such as the L10 Bearing Life Theory to estimate bearing life based on operational load and speed.
   - Validate the model predictions with data from field and laboratory testing.
6. Development of Maintenance Strategies
   - Implement predictive methods like vibration analysis or thermography to monitor bearing conditions in real time.
   - Evaluate the effectiveness of condition-based maintenance (CBM) strategies to extend the service life of the bearings.

Spherical roller bearings can be optimized by a modification of the geometry of the rolling element, that is, the spherical roller.[7] Maintaining spherical roller bearings in roll mills is vital for optimizing performance, reducing costs, and ensuring safe and sustainable operations.

Implementing a robust maintenance program, including regular inspections, lubrication management, and predictive monitoring, is key to achieving these benefits. Proper maintenance of these bearings is essential for the following reasons:

1. Ensuring Operational Efficiency
2. Minimizing Downtime
3. Extending Bearing Life
4. Reducing Maintenance Costs
5. Maintaining Product Quality
6. Enhancing Workplace Safety
7. Improving Sustainability

At present, maintenance scheduling is typically per formed at predetermined time intervals. Predicting th e wear and degradation of the bearings, would ena ble operators and bearing manufacturers to 1) optimi ze the design and maintenance of the bearings, and 2) quantitatively determine the best time to replace the bearings.[8]

Figure. 2 Scratches on the surface of the rolling elements

As shown in Fig. 2, it is common knowledge that the surface layers of a material, if deformed, should be regarded as a separate structural level, where the evolution of deformation processes may considerably impact the condition of the material or the structure as a whole. This fact is connected with reduced shear stability in the surface layers of materials. Besides being weakened, the surface layer becomes subjected to localized macro- and micro-deformational effects caused by vibration, local strength overloads, etc. during friction. Hence, wear should be viewed as the result of the combined impact of several factors.[9]

3.0 RESULTS AND DISCUSSION

The type of bearing used in the roll mill machine at PT. ABC is a spherical roller bearing with type 22315 EK fabricated by SKF. This bearing has two rows of rollers that can withstand quite high loads.[10] The following is a picture and specifications of the 22315 EK bearing which can be seen in the Fig. 3 below.

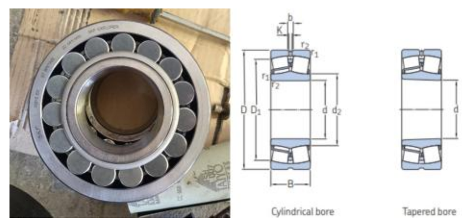

Figure. 3 Dimension of Bearing 22315 EK

Spherical Roller Bearings are designed to handle high radial and axial loads while accommodating misalignments between the shaft and the bearing housing. Their unique design and functionality make them ideal for the demanding conditions of a flour roll mill. Spherical roller bearings play a pivotal role in maintaining the efficiency, reliability, and durability of roll mills in flour production. Their ability to handle complex load scenarios, resist harsh environments, and reduce maintenance requirements makes them an indispensable part of the milling process. There are several steps to find the life for **spherical roller bearings** as follows:

1. Find the equivalent load acting on the bearing.

The following is a Free-Body Diagram (FDB) of the bearing on the C5-1 roll mill machine.

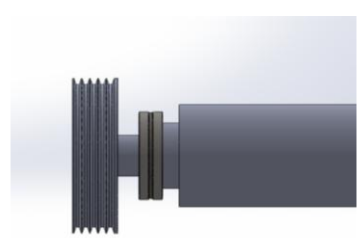

Figure. 4 Free-Body Diagram (FDB) of the bearing

Calculation of Equivalent Load

The axle or roll load that occurs on a spherical roller is:

$$W_{roll} = m \times g$$

$$W_{roll} = 600\ kg \times 9{,}81\ m/s^2$$

$$W_{roll} = 5886\ N$$

Because there are two bearings on one roll, the roll load is divided into two:

$$W_{roll\ each\ bearing} = \frac{5886}{2}$$

$$W_{roll\ each\ bearing} = 2943\ N$$

Load of *house bearing* of *spherical roller bearing*:

$$W_{house\ bearing} = 12\ kg \times 9{,}81\ m/s^2$$

$$W_{house\ bearing} = 117{,}72\ N$$

The pulley load on the roll is:

$$W_{pulley} = 20\ kg \times 9{,}81\ m/s^2$$

$$W_{pulley} = 196{,}2\ N$$

The total radial load that occurs on the spherical roller bearing in the roll mill machine is:

$$F_r = W_{roll\ each\ bearing} + W_{house\ bearing} + W_{pulley}$$

$$F_r = 2943\ \text{N} + 117{,}72\ \text{N} + 196{,}2\ \text{N}$$

$$F_r = 3256{,}92\ N$$

Find the axial load that occurs on the spherical roller bearing:

$$F_a = \frac{0{,}5 \times F_r}{Y}$$

$$F_a = \frac{0{,}5 \times 3256{,}92}{1{,}9}$$

$$F_a = 857{,}08\ N$$

After obtaining the axial load value, the next step is to find the ratio of the axial load value to the radial load and then compare it with the e value that is already in Table 4.1 (V = 1 for the rotating inner ring, V = 1.2 for the rotating outer ring):

$$\frac{F_a}{VF_r} \leq e$$

$$\frac{857{,}08}{(1)(3256{,}92)} \leq 0{,}35$$

$(0{,}26 \leq 0{,}35)$

Therefore, for the factor X = 1 and factor Y = 1.9. Then find the equivalent load using the following formula:

$$P = XVF_r + YF_a$$

$$P = (1)(1)(3256{,}92) + (1{,}9)(857{,}08)$$

$$P = 4885{,}38\ N$$

2. Bearing Life Calculation

Once the equivalent load work on the bearing is calculated, the next step is to find the bearing life using the following formula.

$$L_{10} = \left(\frac{C}{P}\right)^p$$

$$L_{10} = \left(\frac{462000}{4885{,}38}\right)^{\frac{10}{3}}$$

$$L_{10} = 3.853.116\ \times 10^6\ round$$

The above results are the bearing life in millions of rotations. So to find the bearing life based on the time of use in hours, you can use the following formula:

$$L_{10h} = \frac{10^6}{60\ x\ n} L_{10}$$

The rotation of the roll mill machine is not yet known, it is first searched using the following formula:

$$d_1\ x\ n_1 = d_2\ x\ n_2$$

$$n_2 = \frac{d_1\ x\ n_1}{d_2}$$

$$n_2 = \frac{21\ cm\ x\ 3000\ rpm}{36\ cm}$$

$$n_2 = 1750\ rpm$$

So we calculate the bearing lifetime, is:

$$L_{10h} = \frac{10^6}{60\ x\ n} L_{10}$$

$$L_{10h} = \frac{10^6}{60\ x\ 1750} 3.853.116$$

$$L_{10h} = 36.696.343\ hours$$

3. Lubrication Calculations

For the lubricant used in spherical roller bearing type 22315 EK in the roll mill machine is grease. The following is the data needed to calculate the lubrication:

Table 1. Bearing Lubrication Calculation Data

Data Types	Simbol	Spesification
Basic Dynamic Load	C	462 kN
Equivalent Load	P	4,885 kN
Rotation	n	875 rpm
Inside Diameter	d	75 mm
Outside Diameter	D	160 mm
Wide	B	55 mm
Bearing Factor	b_f	2

From the data listed in the table above, it can be used to find the relubrication time by first finding the load ratio using the following formula:

$$Load\ Ratio = \frac{C}{P}$$

$$Load\ Ratio = \frac{462\ kN}{4{,}885\ kN}$$

$$Load\ Ratio = 94{,}58$$

After getting the load ratio, then find the speed factor using the following formula:

$$Speed = nd_m b_f$$

$$Speed = 875(\frac{160+75}{2})2$$

$$Speed = 205.625\ mm/min$$

To find the amount of lubricant provided in debt repayment, use the following formula.

$$G_p = 0{,}002 \times D \times B$$

$$G_p = 0{,}002 \times 160 \times 55$$

$$G_p = 17{,}6\ gram$$

During re-lubrication, the grease applied is 17.6 grams.

4.0 CONCLUSION

Based on the analysis that has been done, the following conclusions can be drawn and at the same time answer the objectives of this report.

The calculating results of the lifetime of spherical roller bearings in the roll mill machine using the basic rating life method show that the bearing age obtained is 36,696,343 operational hours, and The time required to re-lubricate the spherical roller bearing is every 9800 hours with the amount of lubricant given of 17.6 grams.

Best Practices for Maintenance are:

1. Develop a Maintenance Schedule: Regularly inspect and service bearings based on manufacturer recommendations and operational demands
2. Train Staff: Ensure maintenance personnel are knowledgeable about proper handling, inspection, and lubrication of spherical roller bearings.
3. Use Quality Components: Employ high-quality bearings and lubricants designed specifically for roll mill environments.
4. Implement Monitoring Systems: Leverage condition-monitoring technologies to enhance predictive and condition-based maintenance.
5. Proper maintenance ensures longer service life, reduced downtime, and cost savings, making it a critical aspect of managing spherical roller bearings in roll mills.

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