International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 5, pp 209-213, May-2023

https://doi.org/10.47001/IRJIET/2023.705025

Analysis of Lifetime Drive End Bearing on Motor Conveyor C2

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***Abstract* - PT. X is a company engaged in the field of Steam Power Plant (SPP) with a capacity of 2x350. With a workload of up to 24 hours a day, periodic overhauls are required for the machines in the SPP environment, one of which is the bearing which functions to withstand radial and axial loads on the C2 conveyor machine. Bearing lifetime needs to be calculated to find out the estimated useful life of the bearing so that it is easier for the company to carry out scheduled maintenance according to the job plan. Based on the results of calculations carried out using the analytical method based on ABMA (American Bearing Manufacturers Association) the results are 5.9 years worth and 6.2 years worth of results using the bearing calculator. Based on the usage duration guidelines, the results of calculations using the analytical method and the results of calculations using the tools on bearing calculator show that both results meet the minimum usage duration threshold (40,000-50,000 hours).**

Keywords: bearing, lifetime bearing, maintenance, motor conveyor, bearing calculator.

I. INTRODUCTION

Electricity is one of the most important things in today's life. The need for electricity in Indonesia is always increasing every year. Power plants in Indonesia use various types of generators, including hydro, steam, diesel, gas, geothermal and others. In the power generation system, there are many applications and applications of science related to mechanical engineering. For example in equipment such as pumps, compressors, turbines, boilers, generators, heat exchangers, conveyor motors, and others [5]. There are several types of conveyor motors in SPP and are used according to their respective functions.

The C2 conveyor motor plays an important role in coal transportation activities at the SPP which functions to drive the belt conveyor that transports coal from the coal yard to the Transfer Tower (TT) building for further crushing of coal into smaller sizes (crushing). In the C2 conveyor motor, bearings have a vital function in the process of machine operation. Bearing is one part of the machine element which plays an important role because the function of the bearing is to support a shaft so that the shaft can rotate without experiencing excessive friction. Bearings must also be strong enough to allow the shaft and other machine elements to work properly according to their function [4]. There are two main aspects that determine bearing lifetime, namely the amount of loading (axial load and radial load), and the speed of the bearing. These two aspects have a direct impact on the performance of the bearings which hold the load when the engine is running. Bearing lifetime needs to be calculated to find out the estimated service life of the bearing according to the usage guide so that it makes it easier for companies to carry out scheduled maintenance according to the job plan [6].

II. RESEARCH OBJECT

In accordance with the definition of ABMA (American Bearing Manufacturers Association) what is meant by equivalent load is constant radial load acting on the rotating inner ring. In reality, bearings usually receive a combination of radial and axial loads and in a condition where the inner ring is fixed while the outer ring rotates [1]. So, the equivalent load equation (P) becomes:

$$P = X_2 \, V \, F_r + Y_2 \, F_a \quad (1)$$

Description :

P : Equivalent load (kN)

F_r : Radial load (kN)

F_a : Axial load (kN)

V : Rotation factor (constant)
(1 for inner ring, 2 for outer ring)

X_2 : Radial constant

Y_2 : Axial constant

How to choose X and Y value can be done with these following steps:

1) Calculating value of F_a/C_0
2) Calculating value of $F_a/(V.F_r)$
3) Comparating value of F_a/C_0 and value of $F_a/(V.F_r)$ for gethe value of e. The value of e is used to determine the value of components X_2 and Y_2 .
4) Calculating value of P

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5) Calculating the lifetime bearing L_{10}

Bearings that are analyzed are assumed to rotate with constant rotation, not contaminated by pollutant particles that are in the environment of PT. X, and lubrication is carried out using grease periodically, so the prediction of bearing life (expressed in hours) can be written with the following equation [3].

$$L_{10} = \left(\frac{C_{10}}{P}\right)^{b} \times \frac{10^6}{60 \cdot n} \quad (2)$$

Description :

L_{10} : Lifetime bearing (jam)

C_{10} : Dynamic load (kN)

P : Equivalent load (kN)

b : Load bearing constant (b=3 for ball bearing)

n : Shaft rotation (rpm)

2.1 Type and Specification of Motor Conveyor C2

The motor used is a high-voltage 3-phase induction electric motor which has a box-section construction using steel plates so that the weight of the motor becomes lighter. The two sides and top of the frame have holes for cooling. The motors have a laminated core which is compressed and mounted to the machine frame whereas the rotors are manufactured using cast-aluminum and welding. It also has IP44 and IP54 protection levels. C2 conveyor motor specifications can be seen in Table 1 below [7]:

Table 1: Specification of Motor Conveyor C2

Type of Motor	YKK 3551-4
Power Rating	185 kW
Frequency Rating	50 HZ
Rotating Velocity	1483 r/min
Mass	2110 kg
Type of Bearing	6222/Z1, NU222/P6

2.2 Type and Specification of Bearing

The bearings analyzed are those located on the drive end side of the motor, namely bearings with the type of 6222 - deep grove ball rolling bearings with specifications can be seen in Table 2 as follows:

Table 2: Specification of Motor Conveyor C2

Rolling/no	Rolling bearing
Amount of bearing	Single bearing
Type of bearing	Deep groove ball bearing
Design code	6222
Inner Temperature	70℃
Outer Temperature	65℃
Type of Grease	LGMT3
Cleaning code	-
Inner diameter	110 mm
Outer diameter	200 mm
Width	38 mm
Dynamic Load Rating (C)	151 kN
Static Load Rating (C_0)	118 kN
Reference Speed	6700 r/min
Limiting Speed	4300 r/min
Sealed Limiting Speed	2000 r/min
Mass	4,45 kg

*For F_a dan F_r values are 3,8 kN dan 3 kN respectively.

III. RESULTS AND DISCUSSION

The following is the calculation of the bearing lifetime on the C2 conveyor motor PT. X using the following analysis method:

3.1 Calculating Value of F_a/C_0

The calculation of the F_a/C_0 value obtained from the bearing details contained in Table 2 is obtained as follows:

$$\frac{F_a}{C_0} = \frac{3{,}8\ \text{kN}}{118\ \text{kN}} = 0{,}032$$

3.2 Calculating Value of e

The value of e is found by interpolating the values F_a/C_0 and e from the reference table for equivalent radial load factors on ball bearings. Calculations are performed using the equivalent radial load factor on the ball bearing. The equivalent radial load factor can be seen in Table 3 as follows:

Table 3: Equivalent Radial Load Factor in Ball Bearing [2]

		$F_a/(VF_r) \le e$		$F_a/(VF_r) > e$	
F_a/C_0	e	X_1	Y_1	X_2	Y_2
0.014	0.19	1.00	0	0.56	2.30
0.021	0.21	1.00	0	0.56	2.15
0.028	0.22	1.00	0	0.56	1.99
0.042	0.24	1.00	0	0.56	1.85
0.056	0.26	1.00	0	0.56	1.71
0.070	0.27	1.00	0	0.56	1.63
0.084	0.28	1.00	0	0.56	1.55
0.110	0.30	1.00	0	0.56	1.45
0.17	0.34	1.00	0	0.56	1.31
0.28	0.38	1.00	0	0.56	1.15
0.42	0.42	1.00	0	0.56	1.04
0.56	0.44	1.00	0	0.56	1.00

3.3 Interpolating to Find Value of e

$$\Leftrightarrow \frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$$

$$\Leftrightarrow \frac{0{,}032 - 0{,}028}{0{,}042 - 0{,}028} = \frac{y - 0{,}22}{0{,}24 - 0{,}22}$$

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$$\Leftrightarrow \frac{0{,}004}{0{,}014} = \frac{y - 0{,}22}{0{,}02}$$

$$\Leftrightarrow (0{,}285)(0{,}02) + 0{,}22 = y$$

$$\Leftrightarrow 0{,}225 = y$$

∴ Obtaining value of e = 0,225.

3.4 Calculating Value of $F_a/(V.F_r)$

$$\Leftrightarrow \frac{F_a}{(V.F_r)} = \frac{3{,}8\ \text{kN}}{(1.3\text{kN})} = 1{,}267$$

Because the value of $F_a/(V.F_r)$> e, therefore X_2 dan Y_2 table is used, because value ofX_2already listed 0,56, therefore calculating an interpolation against value ofY_2.

3.5 Interpolating to Find Value of Y_2

$$\Leftrightarrow \frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$$

$$\Leftrightarrow \frac{0{,}032 - 0{,}028}{0{,}042 - 0{,}028} = \frac{y - 1{,}99}{1{,}85 - 1{,}99}$$

$$\Leftrightarrow \frac{0{,}004}{0{,}014} = \frac{y - 1{,}99}{-0{,}14}$$

$$\Leftrightarrow (0{,}285)(-0{,}14) + 1{,}99 = y$$

$$\Leftrightarrow 1{,}951 = y$$

∴ Obtained value ofY_2= 1,951

3.6 Calculating Equivalent Load

$$P = X_2\, V\, F_r + Y_2\, F_a$$

$$P = (0{,}56)(1)(3) + (1{,}951)(3{,}8)$$

$$P = 9{,}093\ \text{kN}$$

3.7 Calculating Lifetime Bearing

$$L_{10} = \left(\frac{C_{10}}{P}\right)^b \times \frac{10^6}{60\ .\ n}$$

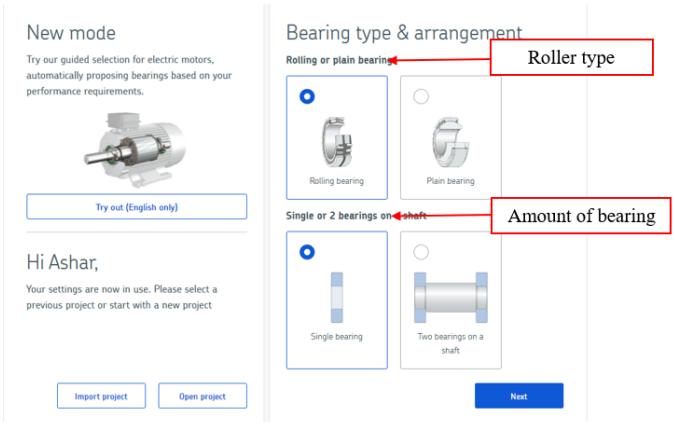
$$= \left(\frac{151}{9{,}093}\right)^3 \frac{10^6}{60(1483)}$$

$$= 51875\ \text{h}$$

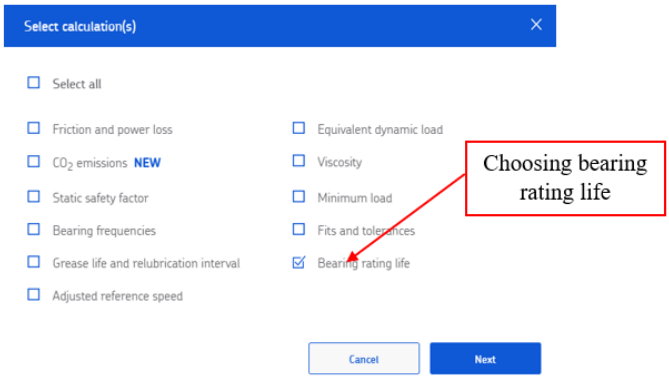
∴ Obtained lifetime bearing lifetime bearing is 51875 hours or about 5,9 years.

3.8 Calculating Lifetime Bearing Using Bearing Calculator

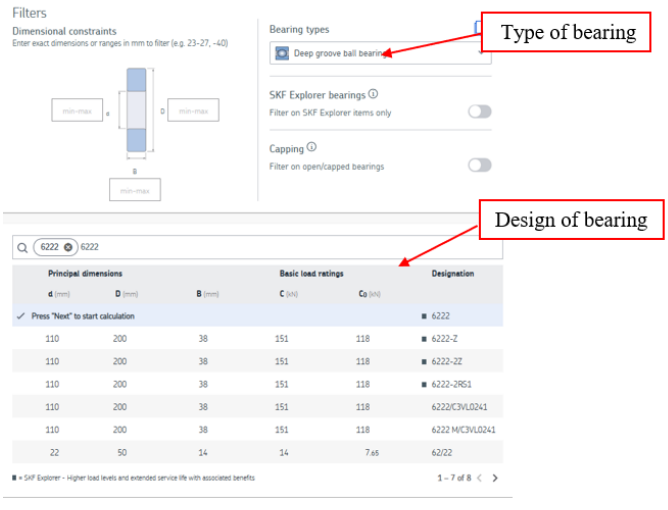
The bearing lifetime calculation can be calculated using the tool on the bearing calculator as follows:



Picture 1: Determining the Type and Number of Bearing



Picture 2: Determining the Bearing Rating Life Option



Picture 3: Determining the Type and Design of Bearing

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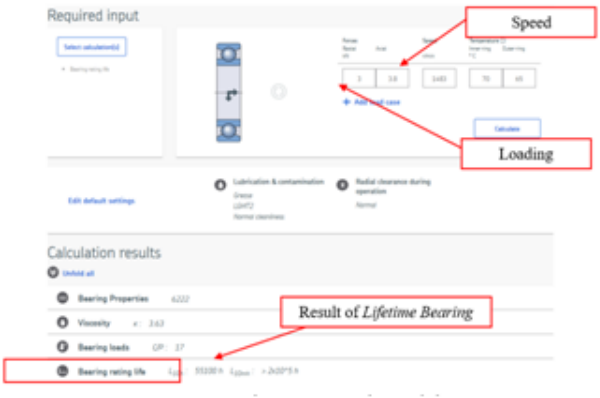

Picture 4: Inputting Speed and Loading

3.7 Guideline Operating Hours

At PT. X the use of bearings on conveyor motors C2 bearings have a guideline operating hours [8] for Bearing Life based on Specification and Machine Type, can be seen in table 4 below:

Table 4: Guideline Operating Hours

Guideline values of specification life for different types of machines

Machine type	Specification life Operating hours
Household machines, agricultural machines, instruments, technical equipment for medical use	300 ... 3 000
Machines used for short periods or intermittently: electric hand tools, lifting tackle in workshops, construction equipment and machines	3 000 ... 8 000
Machines used for short periods or intermittently where high operational reliability is required: lifts (elevators), cranes for packaged goods or slings of drums, etc.	8 000 ... 12 000
Machines for use 8 hours per day but not always fully utilized: gear drives for general purposes, electric motors for industrial use, rotary crushers	10 000 ... 25 000
Machines for use 8 hours per day and fully utilized: machine tools, woodworking machines, machines for the engineering industry, cranes for bulk materials, ventilator fans, conveyor belts, printing equipment, separators and centrifuges	20 000 ... 30 000
Machines for continuous 24 hour use: rolling mill gear units, medium-sized electrical machinery, compressors, mine hoists, pumps, textile machinery	40 000 ... 50 000
Wind energy machinery, this includes main shaft, yaw, pitching gearbox, generator bearings	30 000 ... 100 000
Water works machinery, rotary furnaces, cable stranding machines, propulsion machinery for ocean-going vessels	60 000 ... 100 000
Large electric machines, power generation plant, mine pumps, mine ventilator fans, tunnel shaft bearings for ocean-going vessels	> 100 000

From the table above it can be categorized if the conveyor motor is included in the category of machine types that operate for 24 hours, where for this type of machine it is estimated that the bearing life can operate for 40,000 – 50,000 hours.

IV. CONCLUSION

From the analysis and discussion of the lifetime drive end bearing on the C2 conveyor motor PT. X, the following conclusions are obtained:

1) The C2 conveyor motor used is a YKK 3551-4 motor and the bearing used is 6222 -deep groove ball bearing.
2) Based on the calculation results using the analytical method, the result is 51785 hours (5.9 years) while using the bearing calculator; the result is 55100 hours (6.2 years).
3) Based on the usage duration guidelines on the manufacturer website, the results of calculations using the analytical method and the results of calculations using the tools on the bearing calculator show that both results meet the minimum usage duration threshold (40,000-50,000 hours).

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Volume 7, Issue 5, pp 209-213, May-2023

https://doi.org/10.47001/IRJIET/2023.705025

Citation of this Article:

Nazaruddin Sinaga, Bambang Yunianto, Ashar Ali, "Analysis of Lifetime Drive End Bearing on Motor Conveyor C2" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 5, pp 209-213, May 2023. https://doi.org/10.47001/IRJIET/2023.705025

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