IJEIT
The International Journal of Engineering and Information Technology
journal homepage:www.ijeit.misuratau.edu.ly
MISURATA UNIVERSITY

Analysis of Double-Row Ball Bearing Used in TACCHI FTC 100 Machine (case study)

Mohamed Sawalem
Mechnical Engineering department -faculty of Engineering-Misurata university, Libya

Mustafa Aburwais
Mechnical Engineering department -faculty of Engineering-Misurata university, Libya

Abstract— **In one of the lathes (TACCHI FTC 100) used in the central workshop of the Libyan Iron and Steel Company, a number of bearings are used to support all the pieces to be turned. In this research, we tried to study the stresses arising in the bearings used in this lathe and the extent of their responsibility for the failure of the bearing, and the total deformation of the bearing under loading conditions was examined by using finite element analysis . Through the analysis, it became clear that the maximum resulting stresses in the bearings ($2.68673 \times 10^7 N/M^2$) did not exceed the yield stress of the bearing material (Chromium Stainless Steel 100 Cr6), and also did not produce significant deformations in the bearings (only 0.0376373 mm) , and this means that the resulting stresses were not the cause of the bearings failure, which is likely to occur for other reasons**.

Index Terms: **Double raw ball Bearing, lathe machine , contact stress.**

I. INTRODUCTION

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction.

Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts. Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it[1].

A lot of researchers have worked for improving the life of the bearing. Pushpendra [2] find out the effect of material of bearing: steel, Structural Steel, Si3N4 and SiC on its performance, František Pochyl et al [3] presented a modified Reynolds equation for studying the effect of fluid slipping at partially hydrophobic surface. Zhang Yongqi et al. [4] developed FEM of roller bearings by using Reynolds equation and considering the surface roughness. R. Pandiyarajan et al. [5] determined the contact stress of large diameter ball bearings using numerical methods.Through previous researches, no one addressed the problems that may occur to the bearings during their operation.

This work studied the stresses arising in the bearings used in the (TACCHI FTC 100) type lathe as shown in figure (1) located in the central workshop of the Libyan Iron and Steel Company and the extent of their responsibility for bearing failures. Finite element three dimensional model by using Finite Element Analysis software SolidWorks was built for design a model of double row angular contact ball bearing via optimization

Figure 1. TACCHI FTC 100 machine used as a case study

of material properties to have high natural frequency and least stress parameters of module considering an angular velocity of 1000 rpm.

SolidWorks is used for stress simulation due to its integration with CAD modeling, user-friendly interface, extensive material library, parametric modeling capabilities, a wide range of analysis options, visualization tools, and integration with design optimization.

When the work pieces (hollow shaft 640 mm diameter * 8 m length with 8000 kg weight) installed on the lathe machine (TACCHI FTC 100), it is fixed as a simply supported beam rests on two supports and is free to

Received 5 Oct , 2023; revised 13 Oct, 2023; accepted 5 Nov, 2023.

Available online 13 Nov, 2023.

rotate, the free end of the piece is supported by three double row ball bearings as shown in figure (3). Figure (2) shows the free body diagram of the shaft. The force acting due to the weight of the shaft was:

Total force 8000* 9.81= 78480 N

Force acting on each side 78480 / 2 = 39240 N

Force acting on each bearing

$$39240 * \cos 45^{\circ} = 27746.87 \text{ N}$$

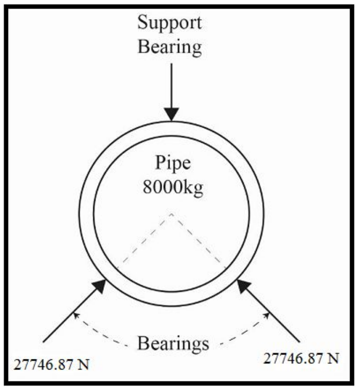

Figure 2. Free body diagram of the shaft

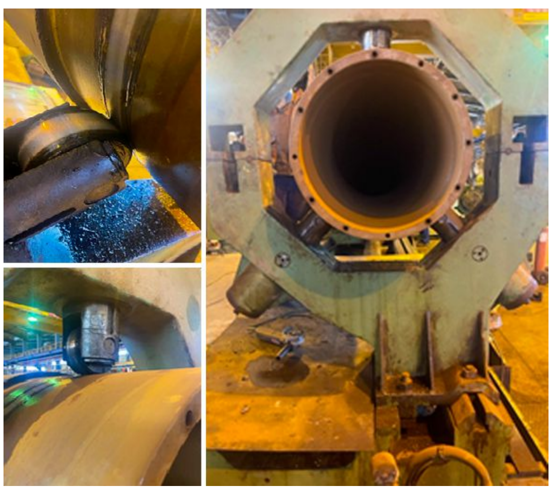

Figure 3. Installation of shaft on lathe machine

II. MODELING

A. Geometry of bearing

There are different types of bearing which are used for different speeds and applications but the main focus in this study is on Double Row Ball Bearing which used in the lathe under study, the geometrical parameters of the double row ball bearing is listed in Table1 and figure (4).

Table 1. the geometrical parameters of the double row ball bearing

PARAMETER	VALUE
Outer diameter (D)	80 mm
Inner diameter (d)	35mm
Width (B)	34.9mm
Nominal contact angle (α)	15°
No. of balls	12 Per row
Mass	0.79kg

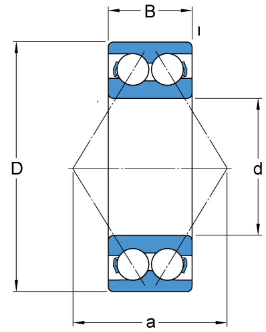

Figure 4. Gemmerry of bearing

The material of Double Row Ball Bearing used is Chromium Stainless Steel (100Cr6) and their properties are listed in Table2.

Table 2. the properties of bearing material.

Property	Value	Unit
Elastic Modulus	2e11	N/m^2
Poisson's Ratio	0.28	N/A
Shear Modulus	7.7e10	N/m^2
Mass Density	7800	N/m^2
Tensile Strength	413613000	N/m^2
Yield Strength	172339000	N/m^2
Thermal Conductivity	18	W/(m·K)
Specific Heat	460	J/(kg·K)

Double row angular contact ball bearings are units with solid inner and outer rings and ball and cage assemblies. Their construction is similar to a pair of single row angular contact ball bearings but they are narrower to a certain extent. Figure (5) shows the bearing used in the machine under study in this work.

Figure 5. The bearing used in the TACCHI FTC 100 machine

B. Bearing modeling

In this work the modeling was done using SolidWorks as shown in figure (6). It is one of the most popular design and engineering software on the market. Known for its range of features and high functionality.Then the model is imported to SolidWorks Simulation to complete static structural analysis.

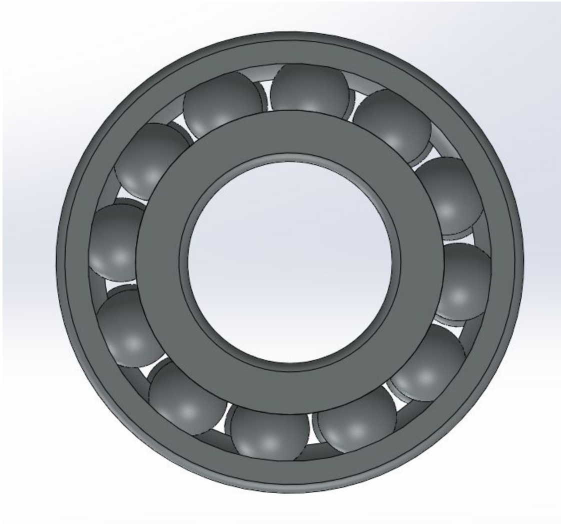

Figure 6. Geometry of ball bearing without defect.

C. *Bearing Meshing*

Before choosing meshing type and size, a mesh sensitivity test was conducted , where the different mesh sizes were applied as shown in figure (7) which produce different stresses as listed in table(3)

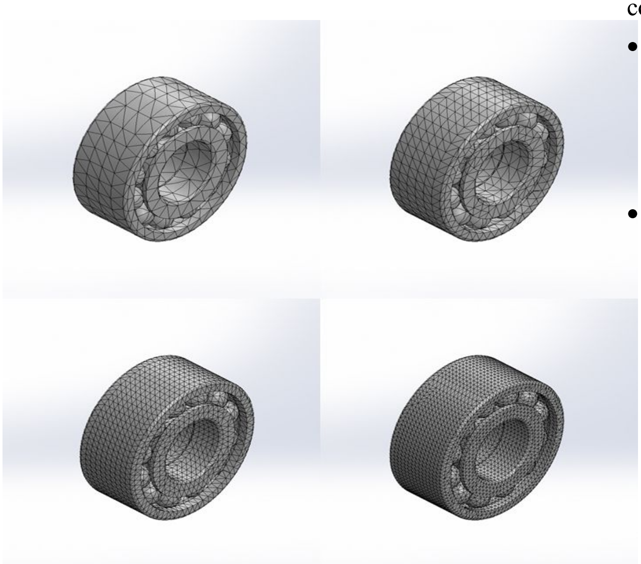

Figure 7. Different element size tested in sensitivity test

Table 3. Sensitivity test data

Element size (mm)	Tolerance (mm)	Stress (N/mm^2)
8.3	0.415	3.2436
7.3	0.365	3.0598
6.3	0.315	2.69558
5.3	0.265	2.6906
4.3	0.215	2.68673

By changing the element size, it became clear that the stress decreased when the element size decreased, and that it began to stabilize when small element sizes were reached.
Accordingly, meshing of the model was done using default meshing type tetrahedral method of contact size 4.30296 mm and tolerance 0.215148 mm. Number of nodes and elements are 24776 and 13442 are being created respectively as shown in figure (8).

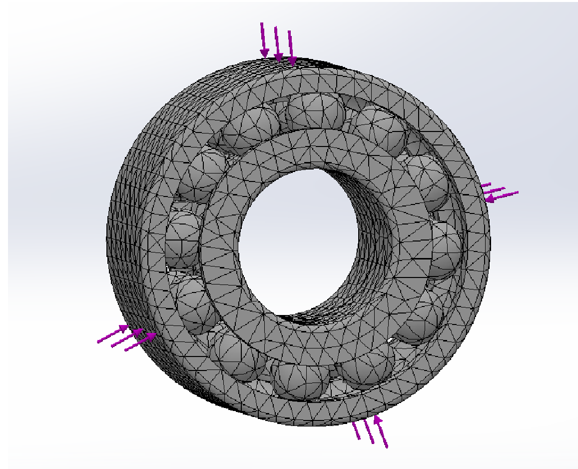

Figure 8. Meshing of ball bearing without defect

D. *Boundary Conditions*

During analysis two boundary conditions has been considered which on ball bearing are as follows:

- Applying Force of 27746.87 N on outer surface of ball bearing (Force acting on each bearing due to weight of the shaft), as shown in figure (9), where the arrows in blue indicate the force applied to the surface of the bearing,
- Fixed support of inner case of ball bearing shown as green arrows (because it dose not actually move)

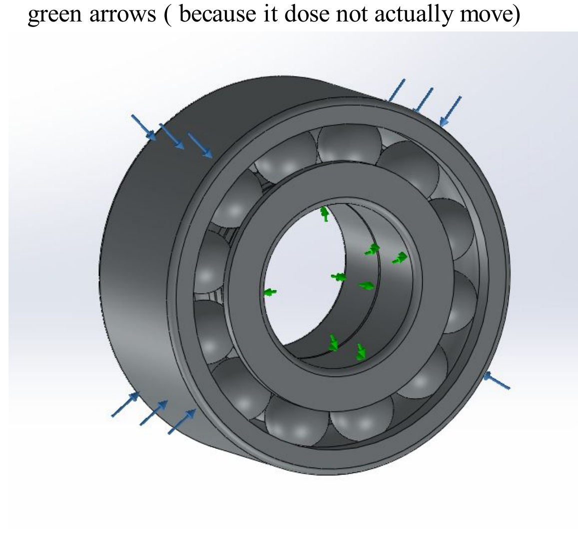

Figure 9. Boundary conditions appling on ball bearing.

III. ANALYSIS

Finite Element Analysis (FEA) is the simulation of physical phenomena using a numerical technique called the Finite Element Method (FEM).
As stated in the introduction, the finite element method is a numerical procedure for obtaining solutions to boundary-value problems, a finite element analysis of a

boundary-value problem should include the following basic steps:

- Create a geometry – Define geometry of a structure or object.
- Pre-process:
1. Meshing – Create mesh structure based on structure's geometry.
2. Set boundary conditions – Assign boundary, load, and initial conditions for the structure.
- Process: Numerical analysis – Perform numerical analysis of smaller mesh elements.
- Post-process: Post-process results – Organize and illustrate results for effective interpretation.

IV. RESULTS AND DISCUSSION

By analyzing the force applied to the bearing which is 27746.87 Newtons, the maximum stress value was $2.68673\times10^{7}N/m^{2}$, which is less than the yield stress of the bearing material used by 15.6% , while the maximum deformation resulted was 0.0376373 mm which was on the outer surface of bearing as shown in figures (10) and (11).

From these results , it can be said that by applying this load,there was no damage to the bearing and the very low deformation results did not reach the extent of plastic deformation

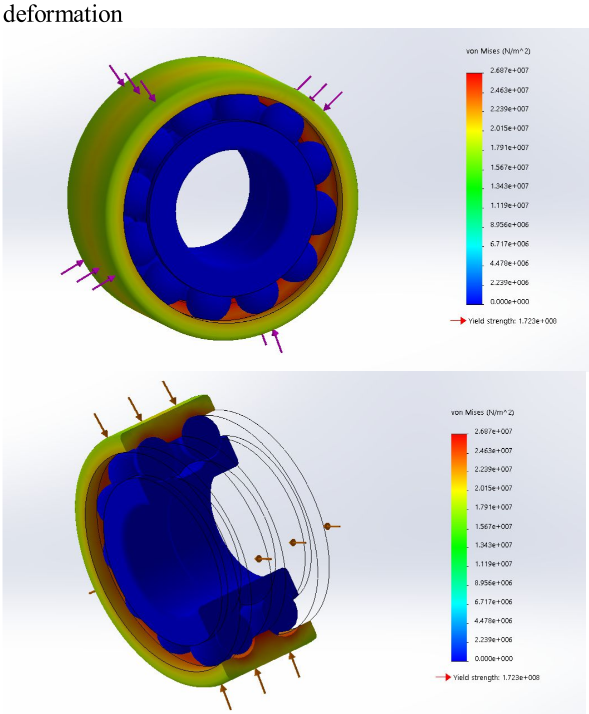

Figure 10. Resulted stresses of ball bearing

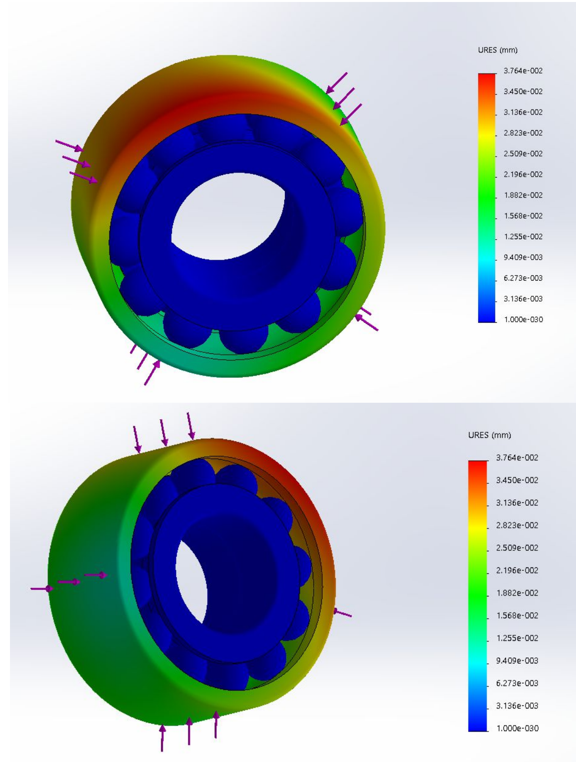

Figure 11. Deformation of ball bearing

V. CONCLUSION

It can be say that the shedding of these loads cannot be the main reason for the failure of the bearings, and what happened may be the result of one of the following two reasons:

- During investigation and questions the workers of the lathe in the central workshop of the Libyan Iron and Steel Company about the lubrication of the bearings, it became clear that the lubrication process does not take place periodically and for this reason we think that the failure of the bearings may be due to the lack of periodic lubrication, or used a certain types of coating the bearings to reduce the coefficient of friction. Martin Vicen etl [6] show that , in lack of lubrication, coating of bearing by CarbonX DLC reducing the friction of 100Cr6 bearing steel resulted in reduced wear and increase bearing lifetime.
- By observing the position of the pieces to be turned on the lathe, it became clear that most of them are not symmetrical in shape, and this is the reason for the unevenness of the force applied to the bearings and causes severe knocking at times, which may be the cause of their destruction

REFERENCES

[1] Khurmi.R.S,Gupta.J.K, A Textbooks of Machine Design, Eurasia Publishing House(PVT) LTD,2005, RAM NAGAR,NEW DELHI-110 055

[2] Pushpendra Tiwari, N. V. Saxena, Finite Element Analysis of Ball Bearing for Different Materials, International Journal of Trend in Scientific Research and Development, Volume 4 Issue 6, September-October 2020.

[3] František Pochyl,Journal Bearings with Hydrophobic Surface, Procedia Engineering. 39pp 76 – 83, 2017.

[4] Zhang YongqiTan QingchangZhang KuoLi Jiangang, Analysis of Stress and Strain of the Rolling Bearing by FEA method, Physics Procedia 24 (2012) 19 – 24.

[5] Pandiyarajan.R, Starvin.M.S, Ganesh.K.C , Contact Stress Distribution of Large Diameter Ball Bearing Using Hertzian Elliptical Contact Theory, Procedia Engineering 38 (2012) 264 – 269.

[6] Vicen.M, Bronček.J, Nový.F, Investigation of tribological properties of CarbonX coating deposited on 100Cr6 steel,Producion Engineering Archives 25(2019) 52-55

.