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Comparative Study of Static Stress on Bearing 6207: Analysis Based on Manufacturer Brands and Its Impact on System Performance

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Abstract

This research provides a thorough examination of ball bearings from various brands, with a specific focus on 6207 type bearings, using ANSYS simulation software. The bearings under study are sourced from five different brands: KOYO, NSK, Nachi, NTN, and SKF. The study includes a series of tests, with a primary emphasis on assessing static stress when subjected to a 1000 MPa pressure load. Key parameters evaluated in these tests encompass total deformation, equivalent stress, bearing life, and safety factor. The findings from the analyses reveal significant differences among the tested bearings. Notably, KOYO brand bearings demonstrate superior performance compared to their counterparts, characterized by reduced levels of deformation and stress. However, it's important to acknowledge that each brand of bearings possesses distinctive characteristics, comprising both strengths and weaknesses, contingent upon the specific application context. In conclusion, this study underscores the critical importance of thorough testing and analysis in the process of selecting bearings tailored to precise operational requirements. The research highlights the exceptional performance of KOYO bearings under the examined conditions, while also emphasizing the necessity for a nuanced decision-making process that takes into account diverse user preferences and varied application demands.

1. Introduction

Rolling-element" is one of the very important components for machines. In general, machines will have rotating components, ranging from wheels, shafts, pulleys, and similar components. Some of these moving components will require bearings to reduce friction and assist in the rotation that occurs. Rolling-element bearings are commonly found in domestic and various industrial applications [1]. Bearings are one of the critical mechanical components in the industrial world because of their function in assisting the rotation of components in a machine. The use of bearings is focused on reducing friction, so without bearings, friction increases as loading, support, working temperature, loading conditions, and shaft rotation increase [2]. Monitoring the condition of rolling-element machines is important to determine the right time for maintenance of the system and automation of the machining process [3- 4]. Many factors can lead to the failure of machine functions, but one of the causes of failure is damage and bearing failure [5]. One consequence of bearing failure is friction, but if the friction becomes too high, it can result in heat on the shaft and its seat [6]. This friction can lead to damage to parts around the bearing or to parts directly or indirectly related to the bearing. Predicting the service life and damage of ball bearings is important with high accuracy so that damage can be addressed before endangering operators and disrupting the production process. To predict the service life and damage of ball bearings, one analysis method that uses software ANSYS [7]. Static analysis in industrial applications is a common effort to gain higher certainty about the capabilities of components. This analysis is done using critical software and involves inspecting program code and considering various behaviors of products or components that may occur when a machine using these components operates [8]. Static analysis is used to identify defects in the digital design. Technology has evolved to produce systems that can perform deeper analysis, reveal more defects, and reduce false alarms. This testing system aims to provide a brief breakdown of static code analysis, features, and potential [9]. In general, Hertz's theory is one of the theories used as a basis for calculating contact pressure and radial stiffness that occurs in ball bearings [10]. However, Hertz's theory has limitations in its use, such as only being able to consider a small part of the contact surface of the bearing surface and not being able to analyze the overall structural deformation that occurs in the ball, outer ring, inner ring, and bearing housing. Additionally, with changes in load, material, boundary conditions, or other external factors, contact or separation will occur between these surfaces. When the load is zero, the contact zone will shrink to a point contact. However, as the load increases during operation, both the inner ring, outer ring, and moving elements will cause deformation in the contact area, changing the point contact into surface contact. Furthermore, the contact area will gradually become elliptical and produce residual stresses [10], [11]. This phenomenon is difficult to predict accurately. Additionally, the influence of friction on contact conditions is also a difficult factor to consider, and its effects can vary with changes in load. Zhu et al. studied the stress and deformation of deep groove ball bearings based on static finite element models, but they did not include defects in their research. Yin et al. studied the Mises stress of ball bearings with point defects and the non-linear dynamic characteristics of ball bearings with defects. To the best of our knowledge, little research has been done to assess the stress levels in the defect zone within rolling bearings [12], [13]. Based on this fact, static stress testing on bearings can be assumed as an effort to further explore and deepen the impact of loading on bearings in terms of safety factors, life, total deformation, and equivalent stress of bearings. The safety factor in bearings is the ratio between the load-bearing capacity of the bearing and the load applied to the bearing during operation [14]. The safety factor is used to ensure that the bearing will operate safely and will not experience structural failure or excessive wear during normal use or emergency situations. The purpose of the safety factor is to ensure that the bearing does not experience failure or damage that could endanger the operational system or equipment using the bearing. The life of a bearing is determined and influenced by many factors, such as the type of bearing, applied load, lubrication conditions, rotational speed, and operational environment [15]. Many methods can be used to determine or predict the life of a bearing, and one method that can be used is bearing life analysis using software such as ANSYS. Finite element modeling is generally used to model bearings and various applied load conditions. This modeling can then be used to predict bearing life by considering factors such as load, speed, lubrication, and bearing material properties. In practice, bearing life is a statistical estimate that cannot guarantee that every bearing will reach its exact life. Unforeseen factors such as fluctuating loads or extreme operational conditions can affect bearing life. Therefore, preventive maintenance and condition monitoring of bearings are often performed to avoid unexpected failures and maximize bearing life. This monitoring may involve routine inspections, lubrication maintenance, and monitoring of bearing vibration and temperature [16]. Total deformation in the context of bearings refers to the change in shape or displacement experienced by the bearing when subjected to a load. This deformation can occur in various parts of the bearing, including the balls or rollers in the bearing, the inner race, the outer race, and other components that make up the bearing. This deformation can impact the performance of the bearing and the overall system. Total deformation in bearings can be calculated and estimated using finite element analysis or mathematical modeling based on the material properties and geometry of the bearing [17], [18], [13]. Equivalent stress in the context of bearings refers to a single stress value used to describe the level of stress acting on the bearing due to the applied load. The use of equivalent stress helps in understanding the level of stress occurring in the bearing and comparing it to the allowable stress limits to determine if the bearing is safe under its operational conditions [11], [19], [20]. The load that must be borne by the bearing becomes very important to ensure longer operational life. The load is considered static in some cases, such as in stationary bearings, low-speed, low-vibration conditions, or sudden large shocks during rotation [11], [13]. The goal of this research is to analyze the impact of static stress on bearings using ANSYS, facilitating the scheduling of bearing replacement. This scheduling can prevent disruptions in ongoing production processes and potential losses.

2. Methodology

The research related to estimating damage and the service life of bearings will be conducted on several bearings from different brands but with the same type and size. This study will be carried out using data obtained from the official catalogs of each bearing brand. A comparison of bearings will be conducted by testing static stress on bearings with a loading of 1000 MPa, which is selected solely to compare the impact produced on bearings originating from each brand. The brands to be compared are SKF, NTN, NSK, and Nachi. However, due to the similar conditions and specifications of NSK and NTN, bearings from the KOYO Seiko brand will be added as a reference point.

2.1 Data Collection Method

The collected data consists of specifications for the bearings to be used and also pertains to the loading that will be applied to these bearings. The studied bearings are of the same type, with the distinguishing factor being the brand that manufactures them. There are five bearing brands that will be investigated: SKF, NTN, NSK, KOYO Seiko, and Nachi. Data related to the specifications of these bearings will be obtained from official sources, such as websites and catalogs published by the respective brands.

2.2 Data Processing

The design will be tested through a simulation process using Ansys. In this process, data related to the specifications of bearings from various brands will also be incorporated into the simulation. After all design stages are completed, the simulation will commence to assess damage and determine the service life of the bearings. Fundamentally, the goal of load optimization is to find the maximum load that can be applied to the ball bearings under static conditions. This is crucial to ensure that the ball bearings do not exceed the load capacity specified by the design or the manufacturer. The process of searching for the maximum load limit involves strength analysis, tolerance considerations, and the safety factor of the ball bearings. Numerical methods or simulations such as Finite Element Analysis (FEA) can be used to analyze and model the response of the ball bearings to the maximum load. The simulation results obtained will be observed to determine whether the data is valid and accurate. If it is not accurate, retesting will be conducted. The data will be considered valid if the placement of the load and its effects align with the expected values. Observations will be made regarding the position and direction of the load on the components. Valid data will be reanalyzed and compared with the test results of bearings from various brands to determine which bearings have the highest and lowest values.

2.3 Bearing Specification and Design

This research will be conducted using bearings from 5 different brands: NSK, Nachi, NTN, KOYO, and SKF. Testing will also be performed with the same load applied to each bearing, but variations in loading may be introduced to determine the maximum load capacity of the bearings. Here are the specifications of the bearings to be tested [14, 21-26]:

Table 1 *Bearing specifications*

Brand	Type	Boundary Dimensions (mm)			Load (N)		Speed
		d	D	B	Cr	Co	(RPM)
NACHI	6207	35	72	17	25700	15300	9800
SKF	6207	35	72	17	27000	15300	13000
NSK	6207	35	72	17	25700	15300	9500
NTN	6207	35	72	17	28400	15300	9800
KOYO	6207	35	72	17	25700	15400	9200

The bearings used have varying numbers of balls and structural details. However, all the bearings to be tested have similar specifications and the same code, which is 6207. The inner diameter of these bearings is 35 mm, the outer diameter is 72 mm, and the thickness is 17 mm. Below are the designs of each bearing to be used, shown from various angles:

Table 2 *Bearing balls specifications and dimensions*

Brand	Type	Dimension	Quantity
NACHI	6207	10.16 mm	11
SKF	6207	11.176 mm	9
NSK	6207	9.144 mm	11
NTN	6207	10.922 mm	9
KOYO	6207	11.176 mm	9

a b c

Fig. 1 *Design of Nachi 6207 bearing (a) Right view; (b) Front view; (c) Isometric view*

a b c

Fig. 2 *Design of NSK 6207 bearing (a) Right view; (b) Front view; (c) Isometric view*

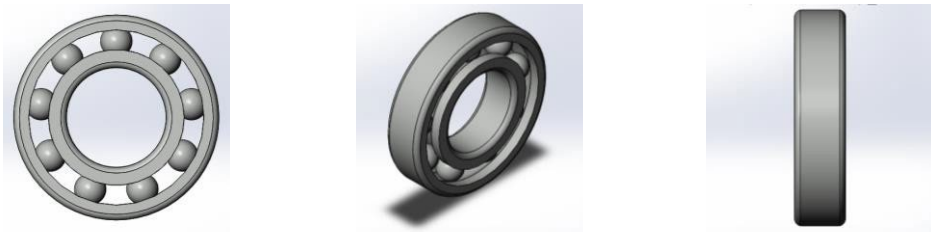

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Fig. 3 *Design of NTN 6207 bearing (a) Right view; (b) Front view; (c) Isometric view*

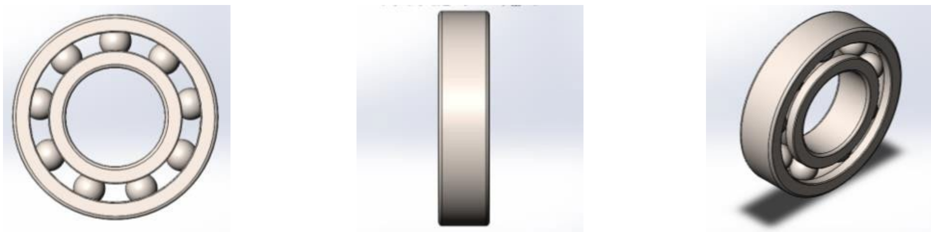

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Fig. 4 *Design of SKF 6207 bearing (a) Right view; (b) Front view; (c) Isometric view*

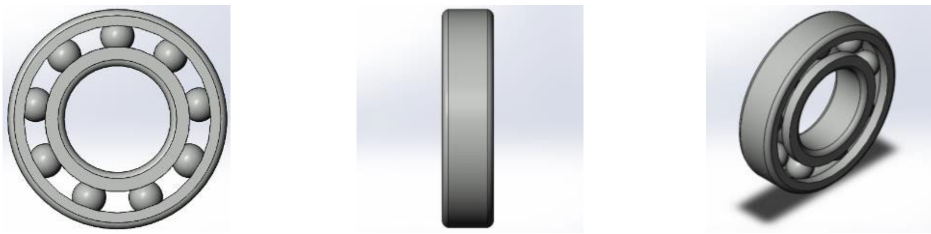

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Fig. 5 *Design of KOYO 6207 bearing (a) Right view; (b) Front view; (c) Isometric view*

Fig. 1 illustrates the front, right, and isometric views of the bearing design with type 6207 from the Nachi brand. This bearing has a total of 11 balls and is made of bearing steel as its material. Similar to Fig. 1, Fig. 2 to 5 also show the bearing designs viewed from the front, right, and isometric angles. Each bearing will have a different number of balls. The number and dimensions of the bearing balls for each brand will be presented in Table 2. However, all these bearings are made of bearing steel material.

3. Research and Analysis Results

The static structural testing is a simulation that involves applying pressure to the bearings. This pressure is applied while the bearings are in a static state. The pressure will be applied to one side of the bearing, and the impact of this pressure application will be observed. Pressure application testing will be carried out with a pressure of 1000 MPa. This static structural testing will yield simulation data related to total deformation, equivalent stress, service life, and safety factor. Each brand will be tested using the same method and conditions. This is done to compare the test results between bearings from different brands. In the Ansys simulation, the bearings will use structural steel with properties similar to and closely resembling bearing steel properties. The material density is 7.85 g/cm3.

3.1 Nachi

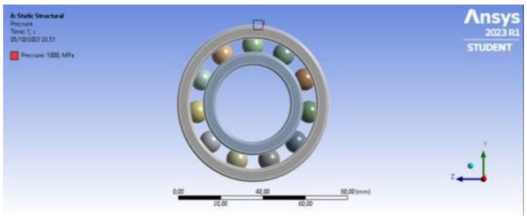

Fig. 6 *Pressure distribution applied to Nachi 6207 bearing (right view)*

Table 3 *Test results for Nachi bearing at 1000 MPa*

No.	Category	Value	
		Max	Min
1	Total Deformation	3.2628 mm	0.18981 mm
2	Equivalent Stress	8645.2 MPa	63.948 MPa
3	Life	1X106 cycle	0 cycle
4	Safety Factor	1.348	0.0099709

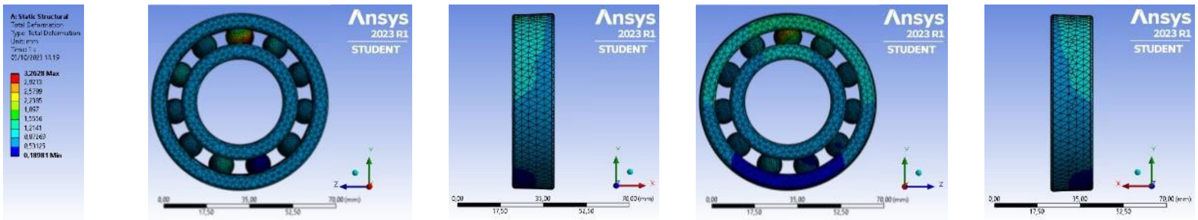

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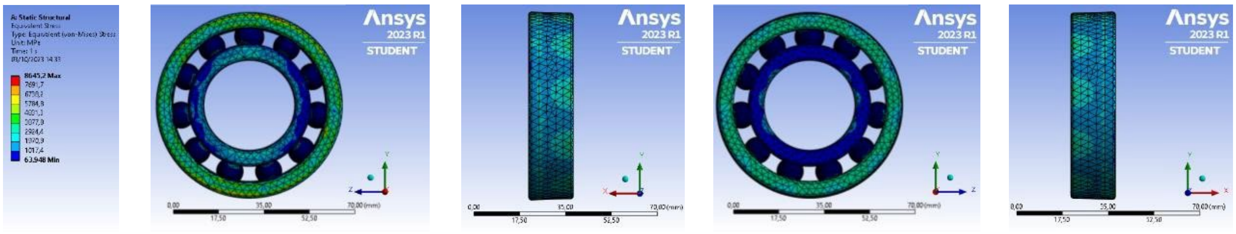
Fig. 7 *Impact of deformation due to 1000 MPa pressure applied to Nachi 6207 bearing (a) Total deformationvalue; (b) Right view; (c) Front view; (d) Left view; (e) Back view*

In Fig. 7, one of the simulation results for the total deformation of the bearing is displayed using Ansys with a pressure of 1000 MPa applied on one side. The colors seen in the simulation model indicate that areas with high stress are colored in red, while areas with low stress are colored in blue. The red areas are more susceptible to deformation compared to the areas within the range from orange to blue. The maximum total deformation in this test is 3.2628 mm, with a minimum value of 0.18981 mm. Fig. 7b to 7e show variations in color on each side, indicating that the load received by each area of the bearing is different. Some areas are more affected compared to others. The areas receiving the load will experience a more significant effect compared to other areas.



a b c d e

Fig. 8 *Impact of equivalent stress due to 1000 MPa pressure applied to Nachi 6207 bearing (a) Equivalent Stress value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation analysis using ANSYS, the results show the equivalent stress on components subjected to a pressure of 1000 MPa, as displayed in **Fig. 8**. The distribution of equivalent stress can be observed through the color map on the simulation model, where areas with high stress are colored in red and areas with low stress are colored in blue. The maximum value of equivalent stress in this test is 8645.2 MPa, and the minimum value is 63.948 MPa. These results help in evaluating the structural strength and understanding critical points that may experience high stress. In this analysis, equivalent stress is an important parameter for predicting the potential for failure and structural deformation.

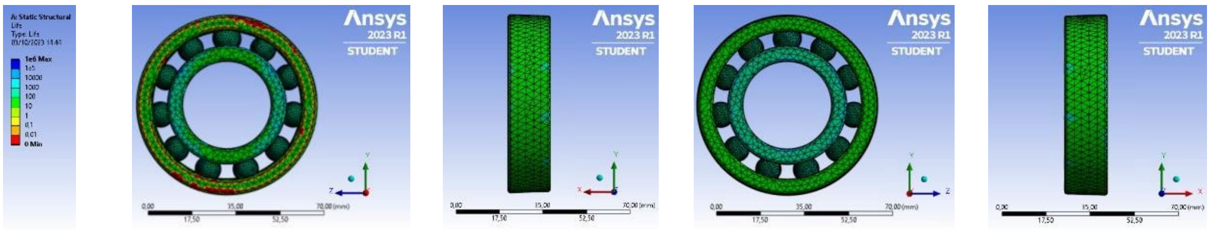


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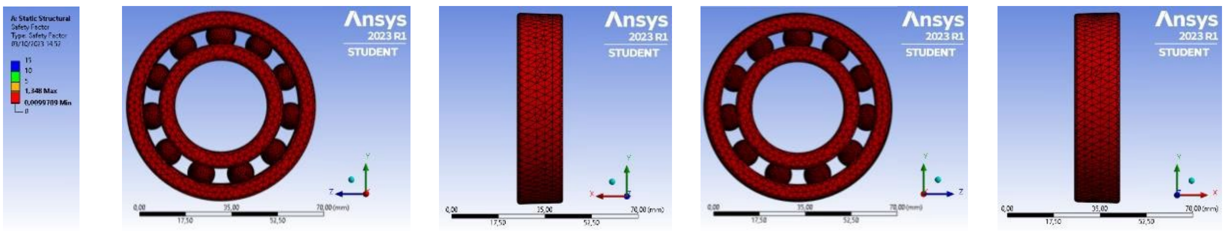
Fig. 9 *Impact of fatigue life due to 1000 MPa pressure applied to Nachi 6207 bearing (a) Life value; (b) Rightview; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using fatigue analysis within ANSYS, a fatigue life analysis was conducted on a specific component. The results indicate that the component has an estimated maximum fatigue life of around 1x106 cycles and a minimum of 0 cycles before failure occurs. The distribution of fatigue cycles on the component can be observed through the color map on the simulation model, with areas experiencing high cycles colored in red. These results provide valuable insights into the component's life and critical points that may experience fatigue. Knowing the fatigue life enables actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high stress, with the goal of improving the component's life and preventing unexpected failures.



a b c d e

Fig. 10 *Impact of fatigue safety factor due to 1000 MPa Pressure applied to Nachi 6207 bearing (a) Safety factor value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the fatigue analysis tool within ANSYS, a safety factor analysis was conducted on the component subjected to fatigue. The results indicate that the minimum safety factor for the component is 0.0099709. This means that the component has a capacity of at least 0.0099709 times the cyclic load applied before failure due to fatigue occurs. The distribution of safety factors on the component can be visualized through the color map on the simulation model, with areas having high safety factors colored in blue and areas with low safety factors colored in red. By knowing the safety factor, it can be evaluated whether the component meets the safety requirements that have been set. If the safety factor is too low, actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high cyclic loads can be taken to improve the safety factor and prevent undesired failures.

3.2 NSK

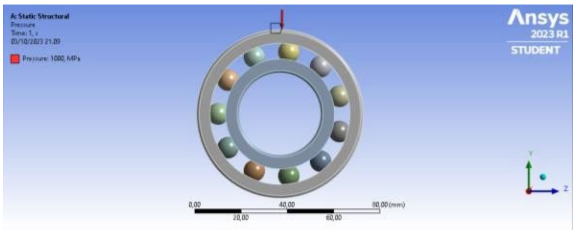
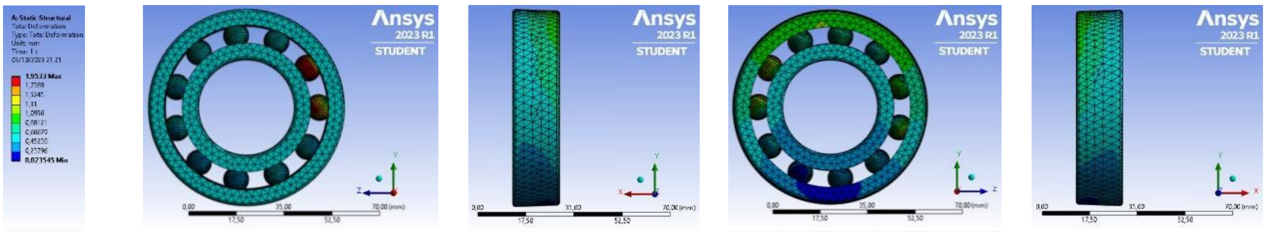


Fig. 11 *Pressure distribution applied to NSK 6207 bearing (right view)*

Table 4 *Test results for NSK bearing at 1000 MPa*

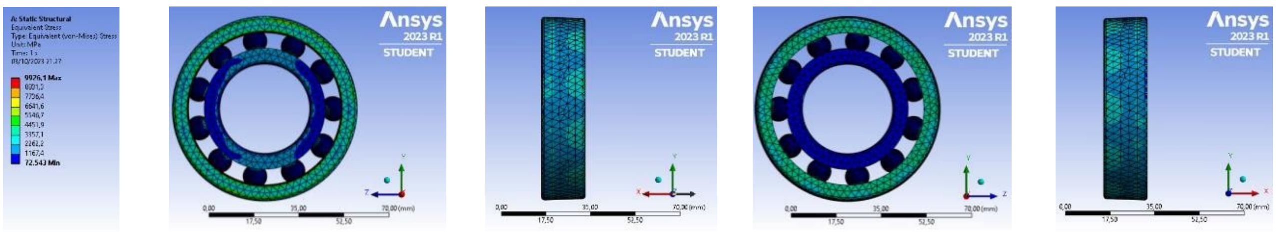
No.	Category	Value	
		Max	Min
1	Total Deformation	1.9533 mm	0.023545 mm
2	Equivalent Stress	9926.1 MPa	72.543 MPa
3	Life	1X106 cycle	0 cycle
4	Safety Factor	1.1883	0.0086842



a b c d e

Fig. 12 *Impact of deformation due to 1000 MPa pressure applied to NSK 6207 bearing (a) Total deformation value*

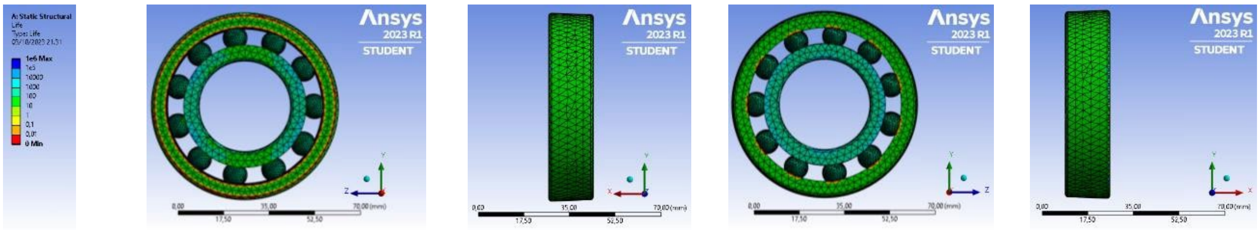
In Fig. 12, one of the simulation results for the total deformation of the bearing is displayed using Ansys with a pressure of 1000 MPa applied on one side. The colors seen in the simulation model indicate that areas with high stress are colored in red, while areas with low stress are colored in blue. The red areas are more susceptible to deformation compared to the areas within the range from orange to blue. The maximum total deformation in this test is 1.9533 mm, with a minimum value of 0.023545 mm. Fig. 12b to 12e show variations in color on each side, indicating that the load received by each area of the bearing is different. Some areas are more affected compared to others, and the areas receiving the load will experience a more significant effect compared to other areas.



a b c d e

Fig. 13 *Impact of equivalent stress due to 1000 MPa pressure applied to NSK 6207 bearing (a) Equivalentstress value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

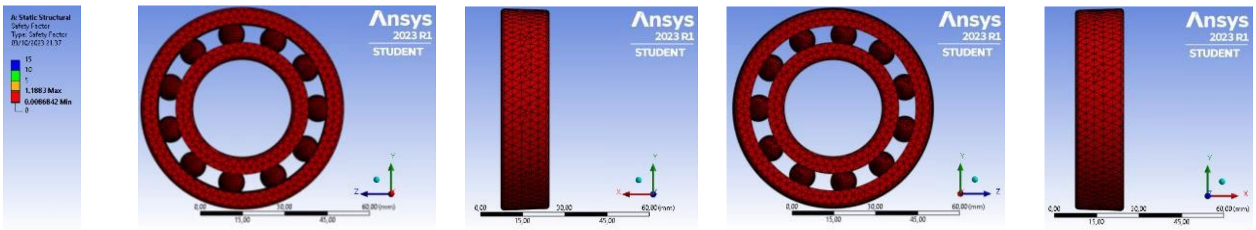
Based on the simulation analysis using ANSYS, the results show the equivalent stress on components subjected to a pressure of 1000 MPa, as displayed in Fig. 13. The distribution of equivalent stress can be observed through the color map on the simulation model, where areas with high stress are colored in red and areas with low stress are colored in blue. The maximum value of equivalent stress in this test is 9926.1 MPa, and the minimum value is 72.543 MPa. These results help in evaluating the structural strength and understanding critical points that may experience high stress. In this analysis, equivalent stress is an important parameter for predicting the potential for failure and structural deformation.



a b c d e

Fig. 14 *Impact of fatigue life due to 1000 MPa pressure applied to NSK 6207 bearing (a) Life value; (b)Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the fatigue analysis tool within ANSYS, a fatigue life analysis was conducted on a specific component. The results indicate that the component has an estimated maximum fatigue life of around 1x10^6 cycles and a minimum of 0 cycles before failure occurs. The distribution of fatigue cycles on the component can be observed through the color map on the simulation model, with areas experiencing high cycles colored in red. These results provide valuable insights into the component's life and critical points that may experience fatigue. Knowing the fatigue life enables actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high stress, with the goal of improving the component's life and preventing undesired failures.



a b c d e

Fig. 15 *Impact of fatigue safety factor due to 1000 MPa pressure applied to NSK 6207 bearing (a) Safety factor value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the fatigue analysis tool within ANSYS, a safety factor analysis was conducted on the component subjected to fatigue. The results indicate that the minimum safety factor for the component is 0.0086842. This means that the component has a capacity of at least 0.0086842 times the cyclic load applied before failure due to fatigue occurs. The distribution of safety factors on the component can be visualized through the color map on the simulation model, with areas having high safety factors colored in blue and areas with low safety factors colored in red. By knowing the safety factor, it can be evaluated whether the component meets the safety requirements that have been set. If the safety factor is too low, actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high cyclic loads can be taken to improve the safety factor and prevent undesired failures.

3.3 NTN

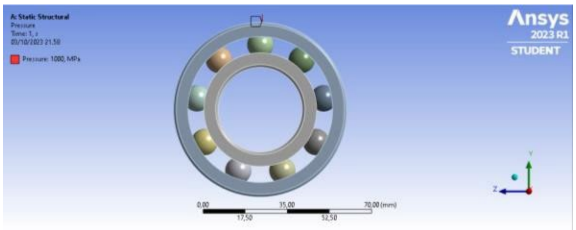


Fig. 16 *Pressure distribution applied to NTN 6207 bearing (right view)*

Table 5 *Test results for NTN bearing at 1000 MPa*

No.	Category	Value	
		Max	Min
1	Total Deformation	4.6197 mm	2.3235X10-4 mm
2	Equivalent Stress	8790.3 MPa	38.718 MPa
3	Life	1X106 cycle	0 cycle
4	Safety Factor	2.2254	9.8063X10-3

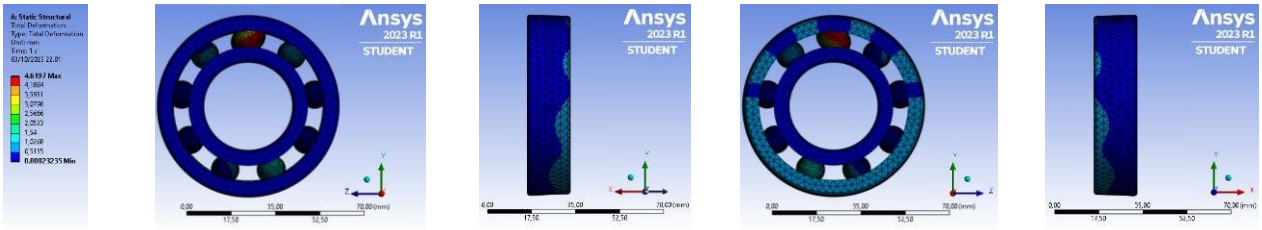


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Fig. 17 *Impact of deformation due to 1000 MPa pressure applied to NTN 6207 bearing (a) Total deformationvalue; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

In Fig. 17, one of the simulation results for the total deformation of the bearing is displayed using Ansys with a pressure of 1000 MPa applied on one side. The colors seen in the simulation model indicate that areas with high stress are colored in red, while areas with low stress are colored in blue. The red areas are more susceptible to deformation compared to the areas within the range from orange to blue. The maximum total deformation in this test is 4.6197 mm, with a minimum value of 0.00023235 mm. Fig. 17b to 17e show variations in color on each side, indicating that the load received by each area of the bearing is different. Some areas are more affected compared to others, and the areas receiving the load will experience a more significant effect compared to other areas.

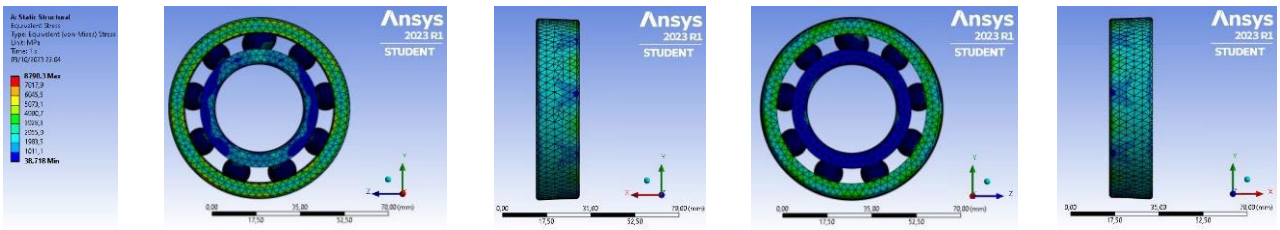

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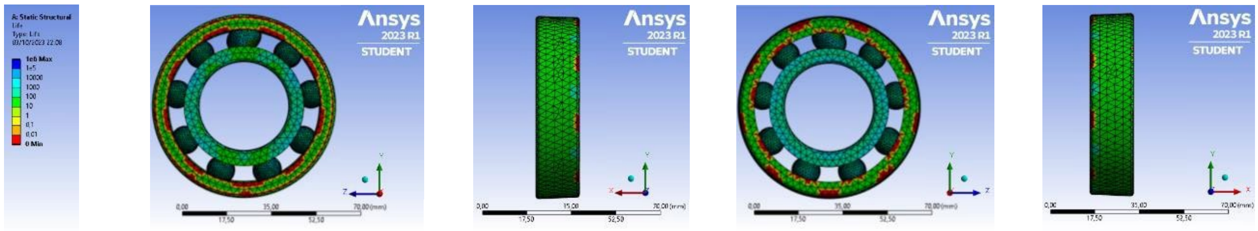
Fig. 18 *Impact of equivalent stress due to 1000 MPa pressure applied to NTN 6207 bearing (a) Equivalent stress value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

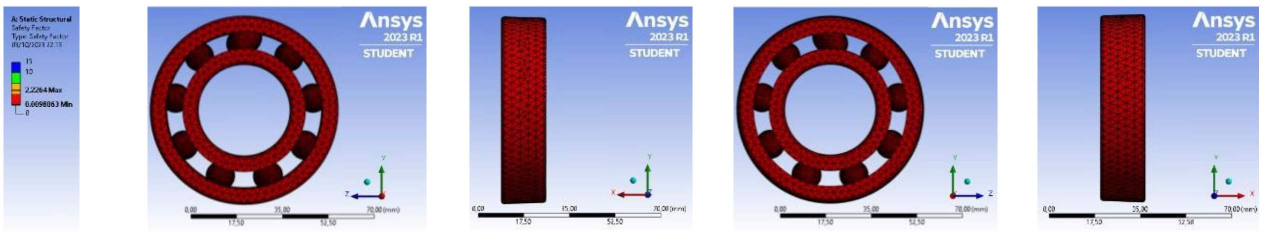
Based on the simulation analysis using ANSYS, the results show the equivalent stress on the component subjected to a pressure of 1000 MPa, as displayed in Fig. 18. The distribution of equivalent stress can be observed through the color map on the simulation model, where areas with high stress are colored in red, and areas with low stress are colored in blue. The maximum value of equivalent stress in this test is 8790.3 MPa, and the minimum value is 38.718 MPa. These results help in evaluating the structural strength and understanding critical points that may experience high stress. In this analysis, equivalent stress is an important parameter for predicting the potential for failure and structural deformation.



a b c d e

Fig. 19 *Impact of fatigue life due to 1000 MPa pressure applied to NTN 6207 bearing (a) Life value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the fatigue analysis tool in ANSYS, the analysis of fatigue life was conducted on a specific component. The results show that the component has an estimated maximum fatigue life of approximately 1x106 cycles and a minimum of 0 cycles before failure occurs. The distribution of fatigue cycles on the component can be observed through the color map on the simulation model, with areas experiencing high cycles colored in red. These results provide valuable insights into the component's life expectancy and critical points that may experience fatigue. Knowing the fatigue life allows actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high stress, with the goal of extending the component's life and preventing unwanted failures.



a b c d e

Fig. 20 *Impact of fatigue safety factor due to 1000 MPa pressure applied to NTN 6207 bearing (a) Safety factor value:(b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the safety factor analysis tool in ANSYS, the analysis of safety factors was conducted on a component subjected to fatigue. The results indicate that the minimum safety factor for the component is 9.8063 x 10-3. This means that the component has a capacity of at least 9.8063 x 10-3 times the cyclic load applied before failure due to fatigue occurs. The distribution of safety factors on the component can be visualized through the color map on the simulation model, with areas having high safety factors colored blue and areas with low safety factors colored red. By knowing the safety factor, it can be evaluated whether the component meets the established safety requirements. If the safety factor is too low, actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high cyclic loads can be taken to improve the safety factor and prevent unwanted failures.

3.4 SKF

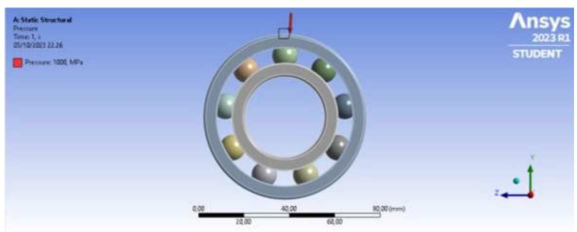
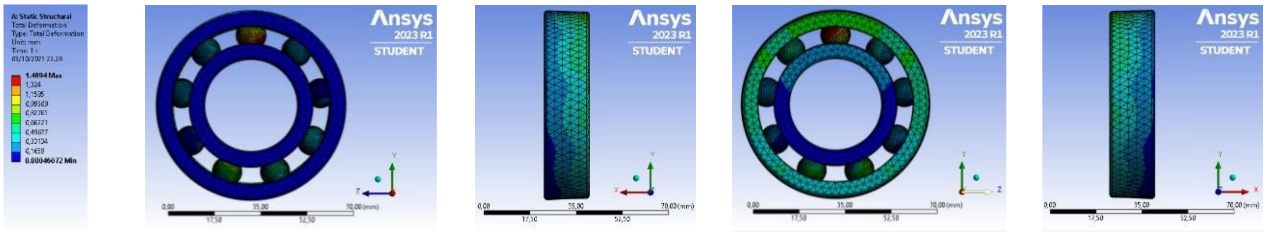


Fig. 21 *Pressure distribution applied to SKF 6207 bearing (right view)*

Table 6 *Test Results for SKF Bearing at 1000 MPa*

No.	Category	Value	
		Max	Min
1	Total Deformation	1.4894 mm	4.6072X10-4 mm
2	Equivalent Stress	9433.8 MPa	40.517 MPa
3	Life	1X106 cycle	0 cycle
4	Safety Factor	2.1275	9.1373X10-3



a b c d e

Fig. 22 *Impact of deformation due to 1000 MPa pressure applied to SKF 6207 bearing (a) Total deformation value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

In **Fig. 22**, one of the simulation results for the total deformation of the bearing is displayed using Ansys with a pressure of 1000 MPa applied on one side. The colors visible on the simulation model indicate that areas with high stress are colored red, while areas with low stress are colored blue. The red-colored areas are more susceptible to deformation compared to the areas in the range from orange to blue. The maximum total deformation in this test is 1.4894 mm, with a minimum value of 0.00046072 mm. Fig. 22b to 22e show color variations on each side, indicating that the load received by each area of the bearing is different. Some areas are more affected compared to others, and areas receiving the load will experience more significant effects compared to other areas.

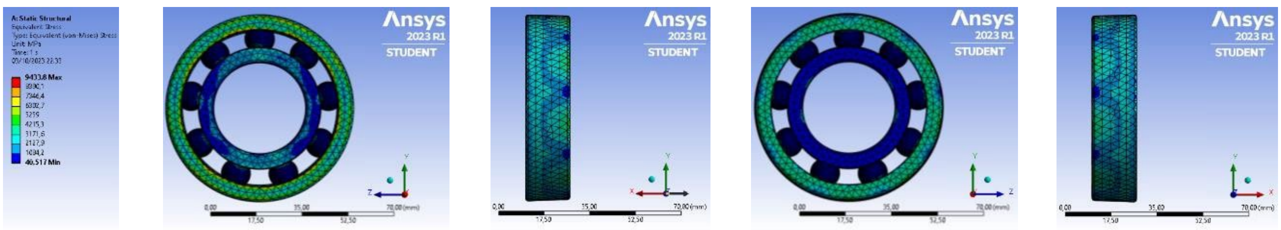


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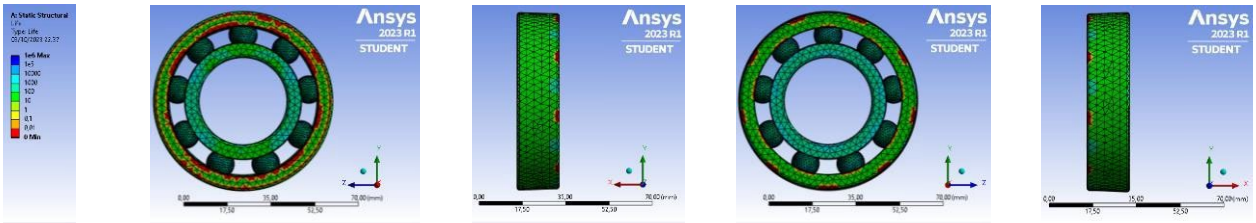
Fig. 23 *Impact of equivalent stress due to 1000 MPa pressure applied to SKF 6207 bearing (a) Equivalent stress value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

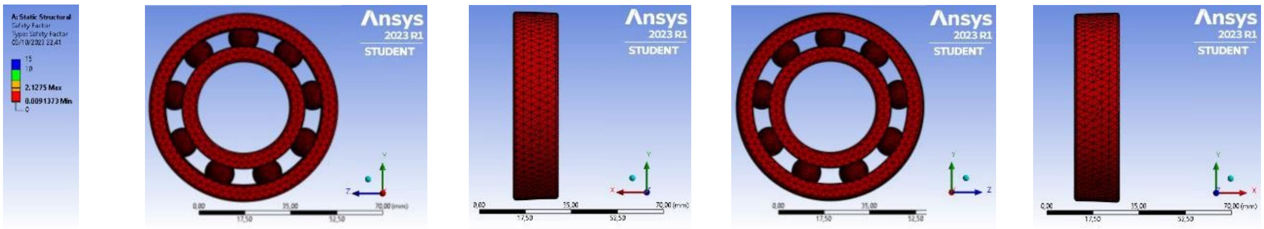
Based on the simulation analysis using ANSYS, the results show the equivalent stress on the component subjected to a pressure of 1000 MPa, as displayed in Fig. 23. The distribution of equivalent stress can be observed through the color map on the simulation model, where areas with high stress are colored red and areas with low stress are colored blue. The maximum value of equivalent stress in this test is 9433.8 MPa, and the minimum value is 40.517 MPa. These results help in evaluating the structural strength and understanding critical points that may experience high stress. In this analysis, equivalent stress is an important parameter for predicting the potential for failure and structural deformation.



a b c d e

Fig. 24 *Impact of fatigue life due to 1000 MPa pressure applied to SKF 6207 bearing (a) Life value; (b) Right view(c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the fatigue analysis tool in ANSYS, the analysis shows that the component has an estimated maximum fatigue life of approximately 1x10^6 cycles and a minimum of 0 cycles before failure occurs. The distribution of fatigue cycles on the component can be observed through the color map on the simulation model, with areas experiencing high cycles colored red. These results provide crucial insights into the component's fatigue life and critical points that may experience fatigue failure. Knowing the fatigue life allows for actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high stress, with the goal of increasing the component's life and preventing unexpected failures.



a b c d e

Fig. 25 *Impact of fatigue safety factor due to 1000 MPa pressure applied to SKF 6207 bearing (a) Safety factor value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the safety factor analysis tool in ANSYS, the analysis shows that the minimum safety factor for the component is 0.0091373. This means that the component has a capacity of at least 0.0091373 times the cyclic load applied before failure due to fatigue occurs. The distribution of safety factors on the component can be visualized through the color map on the simulation model, with areas having high safety factors colored blue and areas with low safety factors colored red. By knowing the safety factor, it can be evaluated whether the component meets the safety requirements that have been set. If the safety factor is too low, actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high cyclic loads can be taken to increase the safety factor and prevent undesired failures.

3.5 KOYO

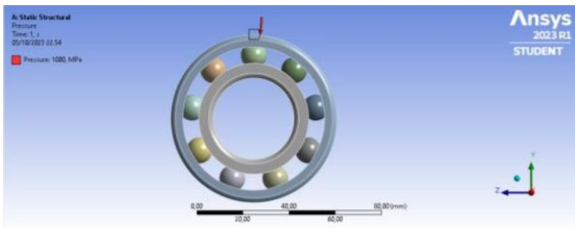
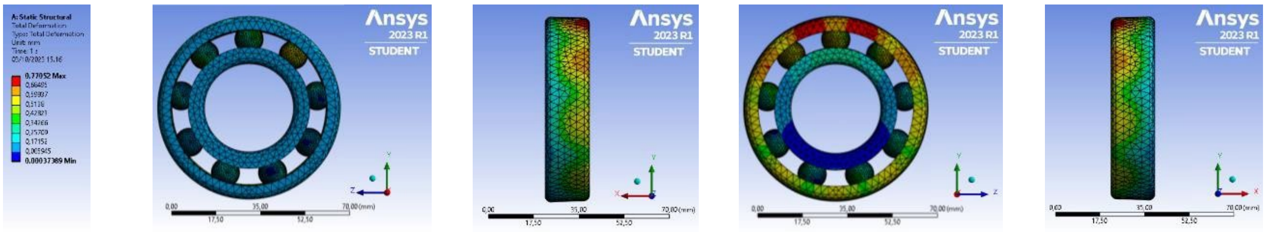


Fig. 26 *Pressure distribution applied to KOYO 6207 bearing (right view)*

Table 7 Test *results for KOYO bearing at 1000 MPa*

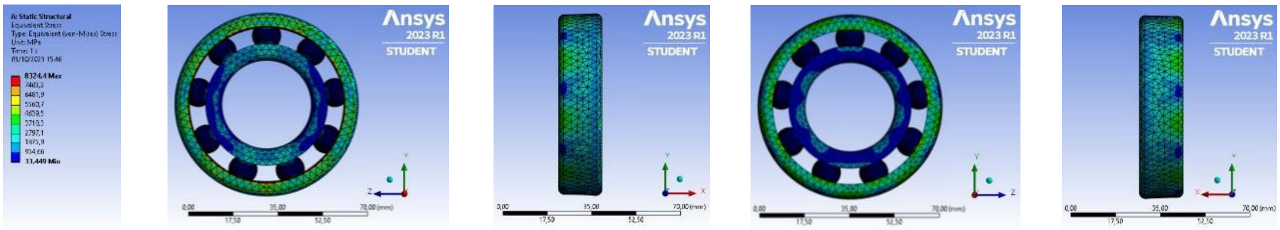
No.	Category	Value	
		Max	Min
1	Total Deformation	0.77052 mm	0.00037389 mm
2	Equivalent Stress	8324.4 MPa	33.449 MPa
3	Life	1X106 cycle	0 cycle
4	Safety Factor	2.5771	0.010355



a b c d e

Fig. 27 *Impact of deformation due to 1000 MPa pressure applied to KOYO 6207 bearing (a) Total deformation value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

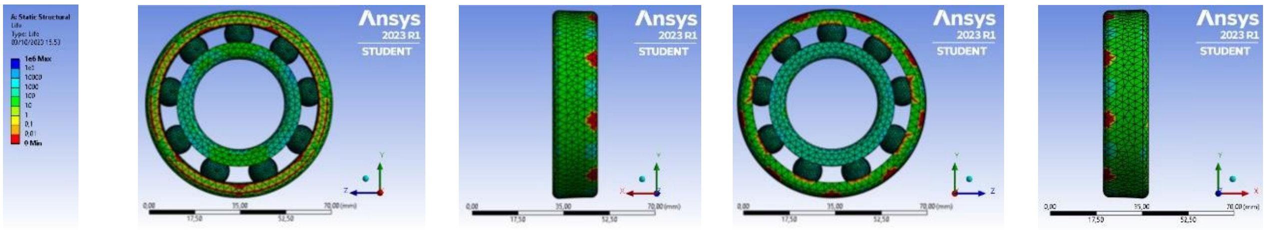
In Fig. 27, one of the results of the total deformation simulation of the bearing is shown using Ansys with a pressure of 1000 MPa applied on one side. The colors seen on the simulation model indicate that areas with high stress are colored red, while areas with low stress are colored blue. The red-colored areas are more susceptible to deformation compared to areas that fall within the range from orange to blue. The maximum total deformation in this test is 0.77052 mm, with a minimum value of 0.00037389 mm. Fig. 27b to 27e show differences in color on each side, indicating that the load received by each bearing area is different. Some areas are more affected than others, and areas that receive the load will experience a more significant effect compared to other areas.



a b c d e

Fig. 28 *Impact of equivalent stress due to 1000 MPa pressure applied to KOYO 6207 bearing (a) Equivalent stress value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

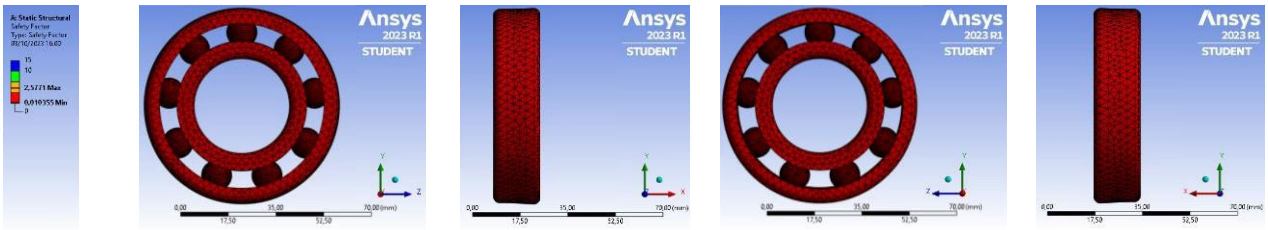
Based on the simulation analysis using ANSYS, the results show the equivalent stress on the component subjected to a pressure of 1000 MPa, as displayed in Fig. 28. The distribution of equivalent stress can be observed through the color map on the simulation model, where areas with high stress are colored red, and areas with low stress are colored blue. The maximum value of equivalent stress in this test is 8324.4 MPa, and the minimum value is 33.449 MPa. These results help in evaluating the structural strength and understanding critical points that may experience high stress. In this analysis, equivalent stress is an important parameter for predicting the potential for failure and structural deformation.



a b c d e

Fig. 29 *Impact of fatigue life due to 1000 MPa pressure applied to KOYO 6207 bearing (a) Life value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the fatigue analysis tool in ANSYS, the analysis shows that the component has an estimated maximum fatigue life of around 1x106 cycles and a minimum of 0 cycles before failure occurs. The distribution of fatigue cycles on the component can be observed through the color map on the simulation model, with areas experiencing high cycle counts appearing red. These results provide crucial insights into the component's fatigue life and critical points that may undergo fatigue. Knowing the fatigue life allows for actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high stress, with the goal of enhancing the component's life and preventing undesirable failures.



a b c d e

Fig. 30 *Impact of fatigue safety factor due to 1000 MPa pressure applied to KOYO 6207 bearing (a) Safety factor value; (b) Right view; (c) Back view; (d) Left view; (e) Front view*

Based on the simulation results using the safety factor analysis tool in ANSYS, the analysis shows that the minimum safety factor for the component is 0.010355. This means the component has a capacity of at least 0.010355 times the cyclic load applied before failure due to fatigue occurs. The distribution of safety factors on the component can be visualized through the color map on the simulation model, with areas having high safety factors appearing blue and areas with low safety factors appearing red. Knowing the safety factor allows for an evaluation of whether the component meets the safety requirements that have been established. If the safety factor is too low, actions such as redesigning, selecting materials more resistant to fatigue, or adding reinforcement to areas experiencing high cyclic loads can be taken to improve the safety factor and prevent undesirable failures. Based on the conducted tests and collected data, the following table provides a comparison of each bearing according to the tested categories.

Table 8 *Comparison of test results for each bearing*

No.	Brand	Maximum Value				Minimum Value			
		TD	ES	Life	SF	TD	ES	Life	SF
		mm	MPa	Cycle	-	mm	MPa	Cycle	-
1	KOYO	0.7705	8324.4	1X106	2.5771	0.000374	33.449	0	0.010355
2	Nachi	3.2628	8645.2	1X106	1.348	0.18981	63.948	0	0.009971
3	NSK	1.9533	9926.1	1X106	1.1883	0.023545	72.543	0	0.008684
4	NTN	4.6197	8790.3	1X106	2.2264	0.000232	38.718	0	0.009806
5	SKF	1.4894	9433.8	1X106	2.1275	0.000461	40.517	0	0.009137

Table 8 shows a comparison of each tested bearing brand under the same conditions and in similar pressure areas. Based on the test results, the largest total deformation value is owned by NTN with a value of 4.6197 mm, and the lowest value is owned by the bearing with the KOYO brand, which is 0.7705 mm. This value indicates that the bearing with the NTN brand can be said to be more at risk of deformation compared to other brands, while KOYO bearings have the lowest deformation value and can be considered safer for use. The equivalent stress values displayed in Table 8 indicate that NSK bearings have the highest stress value when subjected to a pressure of 1000 MPa, compared to bearings from other brands tested under the same conditions. This high stress value represents the possibility of bearing damage. Based on this equivalent value analysis, NSK bearings have a higher risk of damage compared to bearings from other brands, and KOYO bearings have the lowest risk of damage due to stress. The bearing life or lifespan analyzed based on the test results of applying a pressure of 1000 MPa to each bearing results in the same value for each brand, which is 1x10^6 cycles. This can be interpreted as bearings still being able to be used optimally for 1,000,000 cycles of use. The safety factor is essentially an important value to be tested on components to be used, and it is done to determine how safe the components are. The larger the safety factor value, the better the results, as a high safety factor value indicates a higher level of safety. In the test results, KOYO bearings have a higher safety factor value compared to bearings from other brands; therefore, KOYO bearings can be considered safer for use compared to other bearings.

4. Conclusion

The ball bearings used in this test come from 5 different bearing brands, each with different specifications. The ball bearings used are of the same type, which is 6207, with the same outer, inner, and width dimensions. This analysis is conducted using the ANSYS software. The testing performed on the bearings is static stress testing using a pressure of 1000 MPa, and it assesses total deformation, equivalent stress, life, and safety factor. The tested bearings are analyzed and compared with each other. Based on the test results and analysis, the ball bearings from the KOYO brand are considered superior to the 6207 bearings from other brands. However, all tested bearings also have their own strengths and weaknesses in various aspects. Therefore, the selection and use of bearings can be tailored to the preferences and needs of the user or potential user.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

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