

## **RESEARCH ARTICLE**

#### ANALYSIS OF DEEP GROOVE BALL BEARINGBASED ON STATIC, DYNAMIC AND FREQUENCY ANALYSIS USING ANSYS R3

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 Manuscript Info
 Abstract

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*Keywords: -*Bearings, Analysis, Ansys, Solidworks Bearings are used in various mechanical applications. These applications include automobiles, aerospace, shipping industries, etc. Based on the type of application the bearings are subjected to various radial and axial loading which leads to the generation of stresses and vibrations in the bearing. Continuous stresses and vibration-induced inside the bearing affect the life of the bearings which in turn leads to failure of these bearings before expected life. In this paper, an effort has been made to select the type of bearing used for standard medium speed electric motor. The type of bearing used is deep groove ball bearing of type and size 6312. A three-dimensional model was created with the help of Solidworks Software. Further, the model was subjected to pure radial loading to carry out static, dynamic and vibration analysis using Ansys simulation software to check the life of bearing. Thus, the obtained results are compared with the analytical method.

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**Introduction:-**

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least three races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling, they have a much lower coefficient of friction than if two flat surfaces were sliding against each other. Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races. Deep groove ball bearings are particularly versatile. They are suitable for high and very high speeds, accommodate radial and axial loads in both directions and require little maintenance. Single row deep groove ball bearings are the most widely used roller bearing type in the world due to their versatility and overall performance.

G. Lundberg and A. Palmgren established the primary relation between bearing geometry and bearing life. In the case of ball bearings, the bearing life is related to five variables [1]. The variables are ball diameter, the pitch diameter, the inner- and the outer-race conformities, the number of balls, and the contact angle. Except for the bearing contact angle, the relation between the parameters remains the same regardless of whether the bearing is a deep-groove ball bearing or an angular-contact ball bearing. The relations have been incorporated into both the ANSI/ABMA and the ISO standards to predict the bearing fatigue life as well as the current life prediction bearing codes. The theory only relates to the lives of the inner and the outer races and incorporates the ball-set life into their

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analysis by inference. It has since been recognized that the life of the ball set concerning the races is different for a deep-groove ball bearing and an angular contact ball bearing as well as being dependent on the relative contact (Hertz) stresses at the inner and the outer races. However, the standard does not distinguish between the deep-groove (radially loaded) nor does it separate the effect of the ball life from that of the raceway. Analysis report determined the effect of the ball-race conformity on the ball bearing life and considers the life of the ball set independent of the lives of the races

## Methodology:-

The methodology starts with the appropriate selection of ball bearing based on real-life applications. Initially, the ball bearings are classified and the simplest yet effective bearing i.e. DGBB is chosen. The next step is to select a suitable application on the selected ball bearing. The application is restricted to industry and accordingly, four major applications are found. The next step is based on the calculations of Static, dynamic and natural frequency on the given load conditions. Based on it the graphical calculations are performed on the software and it is compared with analytical results. The results portray the differences obtained in the software and the analytical calculations and based on it a suitable action is recommended in the conclusion.



Fig.2.1 Flow chart of methodology

#### **Software Introductions:**

#### Solidworks:

The Solidworks software is developed by Dassault Systems. The software has been advocating the convenience and efficiency of the 3D CAD software. It is a simple and effective user-friendly software used for designing process. In the process of design, using feature, size and constraint function, the model is designed. It is also used widely for modal analysis of various mechanical components. The designed model can be assembled with the help of assembly tool provided in Solidworks by applying number of relationship and constraints between mating parts.

#### **Ansys Software:**

ANSYS Mechanical Enterprise is the flagship mechanical engineering software solution that uses finite element analysis (FEA) for structural analysis using the ANSYS Mechanical interface [2]. It covers an enormous range of applications and comes complete with everything you need from geometry preparation to optimization and all the steps in between. With Mechanical Enterprise one can model advanced materials, complex environmental loadings and industry-specific requirements in areas such as offshore hydrodynamics and layered composite materials. Mechanical Enterprise can cover all needs for dynamic analysis, including — for linear dynamics — modal, harmonic, spectrum response and random vibration with pre-stress, and advanced solver options for rapid solutions. In the transient domain both implicit and explicit solvers enable you to model time dependent scenarios. The Rigid Body Dynamics capability lets you solve mechanisms rapidly. It also enables to include Component Mode Synthesis (CMS) parts to add flexibility to models while still accelerating the simulation. Acoustic simulations can be carried out to understand the vibroacoustic behavior of systems, with or without structural pre-loading. One can also create waterfall plots to more conveniently understand results over varying frequencies.

#### **Three-Dimensional Model:**

The 3-D model is created using Solidworks tools. The design specification is shown are shown in Table 4.1. The 3-D model for bearing is shown in Figure 4.1.



Fig.4.1:- 3-D Model of 6312 bearing.



Fig.4.2 Dimensional parameters of bearing

**Table 4.1:-** Dimensional parameter of 6312 deep groove ball bearing.

Parameters	Dimensions mm
Inner Diameter (d)	60
Outer Diameter (D)	130
Width (B)	31
Radius (r)	2.1

## **Analytical Calculation:**

For a given application the following standard data is considered of the maximum equivalent load ( $P_e$ ) that the bearing can sustain is 2.2 KN, the speed (N) of motor is 1440 rpm. This bearing is subjected to pure radial load thus no effect of axial load.

Standard data from PSG Design data book [3] for 6312 bearing is taken as given below:

Dynamic load (C) =6400 kgfStatic load (C<sub>0</sub>) = 4800 kgf

### Radial load (Fr) for given bearing can be calculated as:

 $\begin{array}{ll} \mbox{Pe=} (VXF_r + YF_a) \mbox{ S} & \dots (1) \\ \mbox{Where V= Ring rotating factor (as outer ring is fixed and inner ring is rotating) = 1.1} \\ \mbox{X=Dynamic Radial Load Factor (bearing subjected to pure radial load) =1} \\ \mbox{Y=Dynamic Axial Load factor (bearing subjected to pure radial load, no axial load) = 0} \\ \mbox{F}_r = \mbox{Radial Load} \\ \mbox{F}_a = \mbox{Axial Load} \\ \mbox{S = Service factor for medium duty = 1.2} \\ \mbox{Substituting the values in equation (1)} \\ \mbox{2900 = 1.1 (1xF_r + 0) 1.2} \\ \mbox{F}_r = \mbox{2160 N} \end{array}$ 

Calculating life for 90 % probability of success (L<sub>10</sub>):  $L_{10} = (C/P_e)^k$ Where  $L_{10}$ = life for 90% probability of success K= 3 for ball bearings  $L_{10} = (6400/220)^3$  $L_{10}$ =24619.083

Calculating life in hours (L<sub>h</sub>)  $L_{10}=(L_h \ge 0.000 \times 0.0000)/10^6$ 24619.083 = (L<sub>h</sub> \expression 1440 \expression 60)/10<sup>6</sup> L<sub>h</sub>= 284.94 \expression 10^3 hrs.

## Natural Frequency Analysis:



**Fig.6.1** Fixed Support at Outer ring.

Fig.6.2 Applying rotational velocity to Inner ring of 1440 rpm



Fig.6.3 Frequency at mode no 1



Fig.6.5 Frequency at mode no 3



Fig.6.7 Frequency at mode no 5



Fig.6.4 Frequency at mode no 2



Fig.6.6 Frequency at mode no 4



Fig.6.8 Frequency at mode no 6

# Static and Dynamic Analysis:



Fig.7.1 Fixed Support at Outer ring



Fig.7.3 Applying radial load of 2200 N



Fig.7.5 Total Deformation in static condition



Fig.7.2 Applying rotational velocity at Inner ring of 1440 rpm



Fig.7.4 Equivalent (von-mises) stress in static condition



Fig.7.6 Equivalent (von-mises) stress in dynamic condition



Fig.7.7 Total Deformation in dynamic condition

#### Results:-NaturalFrequency: Table 8.1:- Damped Frequency

Table 8.1:- Damped Frequency at 6 Nodes.



Fig.7.8 Fixed Support at Outer ring

Modo	Downod Engenory [11]	
Niode	Damped Frequency [Hz]	
1.	367.09	
2.	367.22	
3.	380.19	
4.	380.23	
5.	768.6	
6.	775.73	



#### **Static and Dynamic Analysis:**

Results	Total Deformation	Equivalent (von-mises) Stress
Static	0.0017748 mm	4.9209 MPa
Dynamic	0.30312 mm	38.453 MPa

## **Conclusion:-**

From the above results we can conclude that the maximum deformation in static and dynamic analysis is 0.0017748 mm and 0.30312 mm respectively and Equivalent (von-mises) stress in static and dynamic analysis is 4.9209 MPa

and 38.453 MPa respectively. The life obtained is in  $10^6$  cycle which much higher than the calculated life of 284.94x $10^3$  hrs. Thus, bearing is safe for the given load.

#### **Future Scope:**

This bearing can be replaced with deep groove ball bearing of type and size 6412, which has higher static and dynamic capacity. It can show less deformation and good vibration absorption capacity

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