iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** III **Month of publication:** March 2022

DOI: https://doi.org/10.22214/ijraset.2022.40791

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

A Study of Rolling Contact Fatigue in Bearings with Rolling Elements

Firdous Zia[1], Gouraw Beohar[2]
[1, 2]Department of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur

Abstract: Excessive noise levels from wheels and brakes, tire wear levels, bearing hub wear, bearing humming, undercarriage noise, and other factors are considered in this study. According to the study findings, better design and fatigue life prediction are urgently needed to prevent accidents. Because the hub assembly on the left side of the vehicle experiences the most deformation and has the shortest fatigue life, the behavior of the wheel hub ball bearing under duty cycle loading conditions affects deformations and bearing life.
Keywords: bearing, fatigue life, Wheel hub, duty cycle.

I. INTRODUCTION

The basic function of bearings is principally to reduce the mechanical friction. Reducing friction means: machinery will run more efficiently there will be less frictional wear, extending the operating life of the machinery preventing abrasion burn, avoiding a mechanical breakdown. Bearings also contribute to lower energy consumption by reducing friction and allowing the efficient transmission of power. This is just one way in which bearings are environmentally friendly." To bear," in the sense of "to support," and "to carry a weight," are two meanings of the term "carrying." Bearings are responsible for supporting and carrying the weight of rotating axles.

Bearings can be found in surprising abundance all around us. Consider automobiles: a typical car contains between 100 and 150 bearings. The wheels would rattle, the transmission gear teeth would not mesh, and the automobile would not drive smoothly without bearings. Bearings are utilized in a variety of machines, including trains, airplanes, washing machines, refrigerators, air conditioners, vacuum cleaners, copier machines, computers, and satellites, in addition to automobiles.

Bearings improve the operation of machines while also reducing energy consumption. Bearings work quietly, in harsh conditions, and are buried in equipment where we can't see them. Bearings, on the other hand, are critical for the smooth functioning and high performance of machinery.

Rolling bearings, also known as rolling element bearings, are widely employed in machinery for a variety of purposes. Rolling bearings were once referred to as antifriction bearings because they have substantially less friction than sliding bearings. Many different types of rolling-element bearings are available in a variety of designs that can be used to handle radial and thrust loads in most equipment configurations. Balls, cylindrical rollers, spherical rollers, and conical rollers are examples of rolling elements.

Between two raceways, an inner and outer race for radial bearings, or top and bottom races for thrust bearings, a ball bearing captures a number of hardened and ground steel spheres. To maintain the balls correctly spaced around the raceways, a retainer (also known as a separator) is utilized. Depending on their design and manufacture, ball bearings may handle combined radial and thrust stresses to varying degrees. For smaller diameters and lighter weights, ball bearings are less expensive. A deep grove or Conrad-type ball bearing, as shown in Figure 1.1, can withstand both radial and moderate thrust stresses.

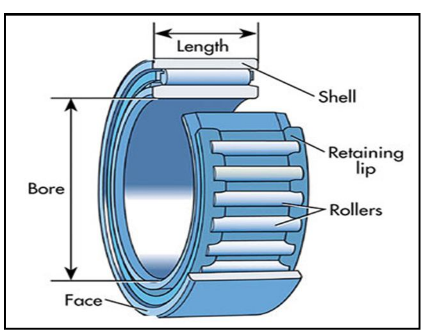


Figure 1. 1 Roller bearing

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

Rolling element bearings, in general, are designed to carry axial and/or radial loads while decreasing rotating friction by sandwiching rolling elements like cylinders or balls between the inner and outer races. There are many various types of rolling element bearings, but ball bearings are the cheapest since they are constructed with balls rather than cylinders. They're used in a multitude of applications in industry today, including production lines, electric motors, pumps, and gearboxes. Thrust, axial, angular contact, and deep groove ball bearings are among the several types of ball bearings. Deep groove ball bearings provide the majority of the measurement data sets used in this research. Figure 1.2 shows an example of a typical deep groove ball bearing.

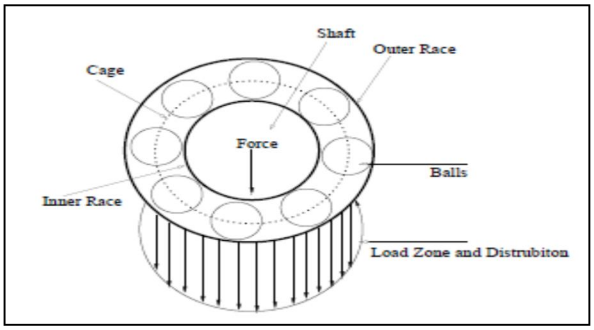
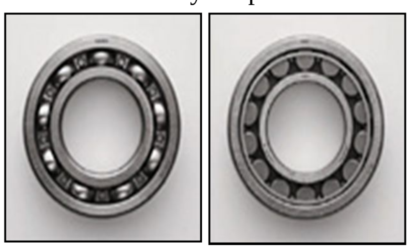


Figure 1. 2: Ball bearing components, applied force, load zone, and load distribution.

In comparison to other rolling-element bearings, ball bearings are smaller and have a lower load-carrying capability, but they can withstand both axial and radial stresses. The axial force is applied parallel to the shaft, whereas the radial force is applied perpendicular to the shaft. Correct alignment, positioning where it will be utilized, and enough lubrication are all critical factors to consider in order to extend the life of this equipment.
A ball bearing consists of an inner race, an outer race, balls, a cage holding the balls separate from each other, and a shaft, as shown in Figure 1.2. The loading zone and load distribution are also shown in the figure, together with the direction of applied force. The outer race is usually kept stationary while the inner race and the balls revolve. Because they are immediately under the applied stress, the majority of faults on the inner side of the outer race, such as fractures or pits, occur in the load zone. Inner race flaws, on the other hand, can occur everywhere since the race is not stationary.
Rolling bearings are made up of four simple parts and have a very simple fundamental structure.



(a) (b)

Figure 1. 3 (a)Ball bearing & (b) Roller bearing.

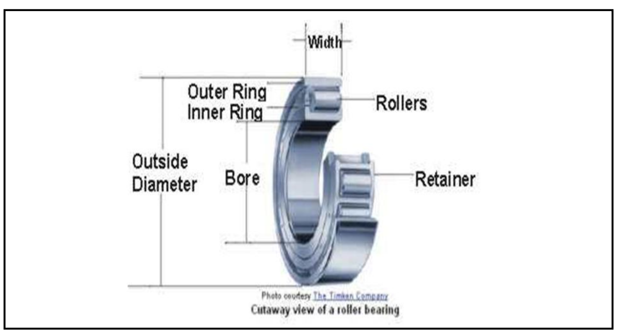


Figure 1. 4 Outer rings, Outer ring, Rolling elements & Cage

The huge ring of the outer race is known as the outer ring, the inner race's little ring, several balls or rollers that are enclosed in the area between the outer and inner races (rolling components), Cage: Used to keep the rolling components in place.

A. Classification of Rolling (Ball Bearing) Element Bearings

Because ball bearings have less friction than roller bearings, they can run at faster speeds. When rolling through oil or grease, the balls, in particular, have less viscous resistance. Ball bearings, on the other hand, have a lesser load capacity than roller bearings due to the high contact pressure of point contact. Manufacturer catalogs offer roughly 50 different types of ball bearings. Each one was created for a certain purpose and has its own set of traits. The most frequent kinds are described in the next section.

1) Ball Bearings

a) Deep-Groove Ball Bearing: The most popular kind is the deep-groove ball bearing (Fig. 1.5), which can withstand reasonably large radial stresses. Deep-gr**o**ove radial ball bearings are the most commonly used bearings in the industry, accounting for over 80% of all industrial rolling-element bearings. They can withstand significant thrust stresses because to the deep groove in the raceways (in the axial direction of the shaft)

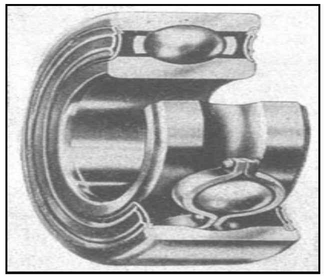


Figure 1. 5 Deep-groove ball bearing.

as well as radial loads A deep-groove bearing can withstand around 70% of its radial load in thrust. The bearing size and number of balls improve the radial and axial load capability. A filling-notch kind of bearing with a higher number of balls than a regular bearing can be utilized for maximum load capability. One of the race's shoulders has a notch in this design. More balls may be inserted into the deep groove between the two races thanks to the circular notch. If the outer ring is split, the maximum number of balls can be entered. External mechanisms must be supplied in that instance to hold and tighten the two ring parts together.

2) *Self-Aligning Ball Bearings:* Between the bearing and the shaft's center lines, it's critical to adjust for angular machining and assembly faults. Misalignment can also be caused by the shaft's elastic deflection. The misalignment creates a bending moment in the bearing and adds severe contact stresses between the balls and races in a normal deep-groove ball bearing. The spherical shape of the outer race in the self-aligning bearing (Fig. 12-3), on the other hand, allows for an additional angular degree of freedom (similar to that of a universal joint) that prevents any bending moment from being transferred to the bearing and prevents any additional contact stresses. Self-aligning ball bearings include two rows of balls and a common spherical raceway on the outer ring that allows for self-alignment.

Figure 1. 6 Self-aligning ball bearing.

For precisely identifying the rolling elements' route on the inner raceway, the inner ring is constructed with two restraining ribs (also known as lips), one on each side of the roller element. The exterior ring, on the other hand, is devoid of ribs to allow for self-alignment. A larger, spherical outer race allows for more self-alignment. Self-aligning ball bearings are commonly employed in situations where shaft misalignment is predicted owing to bending, manufacturing defects, or mounting issues. The design engineer must keep in mind that manufacturing tolerances will always exist. For radial loads paired with mild thrust loads, self-aligning bearings can be used. Because shaft bending creates imbalance and vibrations, the fact that self-aligning bearings do not exert any bending force on the shaft is especially significant in applications that need high accuracy (minimal radial run-out) at high speeds. All types of bearings, including sleeve bearings, benefit from the principle of self-alignment.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

3) *Double-Row Deep-Groove Ball Bearing:* This bearing type (Fig. 12-4) is utilised for radial loads that are quite high. It is more susceptible to misalignment issues than a single row and should only be used in applications where little misalignment is expected. A self-alignment bearing should be chosen if everything else fails. Double-row ball bearings have a similar design to single-row ball bearings. Because double-row ball bearings are bigger and feature two rows, they can accommodate more loads.

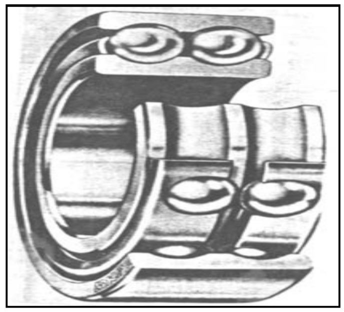


Figure 1. 7 Double-row deep-groove ball bearing.

Deep-groove ball bearing has two rows of grooves. carry radial loads that are higher Unlike deep-groove bearings, split ring designs (to accommodate the maximum number of balls) are not used, and each ring is constructed from a single piece. Double-row bearings, on the other hand, feature groups with bigger diameters and a greater number of balls to increase load capacity.

4) *Angular Contact Ball Bearing:* The radial and thrust loads are supported by this bearing type (Fig. 12-5). Some bearing manufacturers provide contact angles as high as 40 (from the radial direction), however 15 and 25 are the most common contact angles. The ratio of thrust to radial load is determined by the contact angle. Angular contact bearings, which are positioned in pairs against each other and preloaded, are extensively utilised for adjustable arrangements. Bearing clearances are reduced or even preload is induced in the rolling contacts in this manner. This is frequently done to harden the bearings so that the shaft may be supported rigidly. This is critical for lowering the amplitude of shaft vibrations when oscillating forces are applied. When accuracy is essential (for example, in machine tools), this design offers substantial advantages, as it lowers vibrations caused by imbalance. In high-speed applications, this is very crucial. Tapered bearings can also have an adjustable configuration; however, angular contact ball bearings have less friction than tapered bearings. Angular contact ball bearings, on the other hand, have a larger friction coefficient than radial ball bearings. In many key applications, such as high-speed turbines, including jet engines, angular contact ball bearings are the preferred choice.

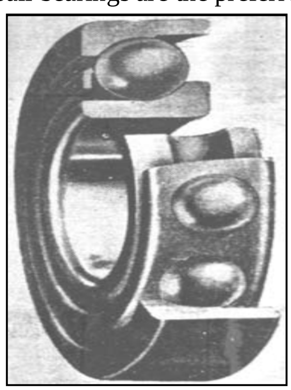


Figure 1. 8 Angular contact ball bearing.

Single-row angular contact ball bearings can handle significant radial and thrust loads in one direction. For two-directional thrust loads, prefabricated mountings of two or more single-row angular contact ball bearings are commonly employed. For heavy unidirectional thrust loads, two bearings in series can be employed, with two single-row angular contact ball bearings sharing the thrust load. To provide load sharing between the two bearings in series, precise axial internal clearance and a high-quality surface polish are necessary. Tandem arrangement refers to a bearing arrangement with two or more angular contact bearings facing the same direction. To maximize the thrust load-carrying capability, the bearings are positioned next to each other.

II. LITERATURE REVIEW

A V BORGAONKAR and I SYED (2020) et al In this paper, an attempt has been made to review for a clear understanding of the effect of these input parameters on the RCF life and tribological performance of coated rolling and sliding contact elements. It has been observed that the coating deposition process must be chosen based on technical and economic aspects. Among the different techniques, the thermal spraying technique is cost-effective, and it also provides better bonding strength, which improves the RCF life in comparison with other techniques. Similarly, the effect of other input parameters has been reviewed and possible combinations of the input parameters that help improve the performance of coated contacting elements summarized.

Linkai Niu and Hongrui Cao (2020) et al The better understanding of the vibration characteristics of a bearing with defects is crucial for the fault diagnosis of rolling element bearings (REBs). In the current paper, the vibration responses of a cylindrical roller bearing when a roller defect goes around outer and inner races are investigated. Firstly, an experiment was carried out and the experimental results are observed to discuss the multiple impulses which are generated when a roller defect goes around a race. Then a dynamic model is proposed for cylindrical roller bearings with roller defects. In the proposed dynamic model, the relative slippage, the finite size of a roller, and the change of contact force direction as a roller defect impacts with a race are all considered.

Zhang L, Xu H, Zhang S, Pei S. (2019) et al A radial clearance adjustable bearing is proposed in this study. The structure and working principles of the adjustable bearing are introduced. This adjustable bearing can change the dynamics characteristics of the bearing by adjusting the radial clearance. In this paper, a simple rotor-bearing finite element model is used to study the vibration response of the rotor system. When the rotational speed does not reach the critical speed, reducing the radial clearance can effectively reduce the vibration of the rotor, and the vibration suppression effect can reach 67%.

Mostafa El Laithya, Ling Wanga (2019) et al Rolling bearings are one of the most widely used components in industrial machinery. If suitably mounted, loaded, lubricated, and isolated from contamination, rolling contact fatigue (RCF) is believed to be the most probable mode of failure resulting in subsurface originated failures. Over the past several decades many researchers have studied the failure and microstructural alterations in bearings such as dark etching regions and white etching bands and how operating conditions such as pressure, temperature, and running time impact them during RCF. This paper aims to provide an overview of such alterations, their properties, formation mechanisms, and impact on bearing failure.

Sangram B. Kokate (2019) et al The paper covers the study and analysis of the Mahindra wheel hub using Finite Element Analysis (FEA). The current automotive industry trends towards speed acceleration of the vehicle by optimizing the weight with maintaining the same strength. studied various researches done so far in weight optimization. Our aim is to reduce the weight of the wheel hub by material optimization. We analysed various grades of materials viz. aluminium alloys in comparison with the current material. Aluminium with grade 7075 A6 was found to be the best alternative for the current material. Using FEA we proved that the new wheel hub is light in weight and can sustain the same load-carrying capacity along with the strength of the hub. We also focused on fatigue analysis of the wheel hub to find the life of the wheel hub.

Wei Xiong, You Wang (2019) et al In this study, a numerical simulation platform for the assembly of the hub bearing is established by the joint use of the static implicit and dynamic explicit algorithms. Based on the platform, the deformation process and deformation behavior of the inner ring are investigated, along with the interference assembly and riveting assembly on the loading process of the inner ring. Finally, relevant experimental verifications are carried out to consolidate the simulation results. The research findings could be used to guide the design and optimization of the axial clamping force and bearing clearance.

Piao Zhong-Yu, Xu Bin-Shi (2019) et al Rolling contact fatigue (RCF) of sprayed coating is a complicated process relating to materials, structures, loading conditions, etc. Herein, the research works over the past decades in RCF of sprayed coatings are summarized here to provide a guide to further explore the new

research interests. The impact of surface integrity on the RCF behavior of sprayed coating is discussed. The shear stress is recognized as the major contribution of the RCF fracture, and the sliding during rolling contact will deteriorate the lifetime of sprayed coatings. The according mechanisms are also discussed by fracture analysis, numerical calculation, and finite element method (FEM).

Bhushan Mohite (2018) et al This paper describes the weight reduction of the front wheel hub of COEP SUPRA SAE Formula car. Based on the obtained FEA result, an optimized and enhanced design for high strength – low weight was obtained. The topology optimization technique is used for performing optimization of the wheel hub. The structure of the wheel hub was modeled utilizing CATIA V5 software and analysis was performed using ANSYS Workbench software.

Wataru Kanematsu (2018) et al This paper describes Experimental and numerical analyses of the lifetime and crack propagation behavior of silicon nitrides under rolling contact fatigue (RCF) loading are surveyed. The influence of mechanical properties of test materials is also discussed in chronological order to trace the history of trends in the material development of RCF.

An observational study of propagation behavior from a natural flaw is also addressed. Future work to improve the reliability of ceramic bearings is discussed. The differences in the implications of the test results between the first three methods are explored by using a test specimen made of material from the same production batch. With an understanding of the differences, the influences of variables such as the state of lubrication and surface roughness on RCF behaviour is discussed.

Oscar O. Rodriguez, Arturo (2018) et al The hysteresis or phase lag occurs when cyclic loading is applied leading to the dissipation of mechanical energy. This paper presents an experimentally validated finite element thermal model that can be used to obtain temperature distribution maps of complete bearing assembly's in-service conditions. Different internal heating scenarios are simulated with the purpose of determining the bearing suspension element and bearing assembly temperature distributions during normal and abnormal operating conditions. The hysteresis heating is induced by the internal heat generation of the material, which occurs at the molecular level as it is being disturbed cyclically the commercial software package ALGOR 20.3™ is used to conduct the thermal finite element analysis.

Lihua Yang, Tengfei Xu (2018) et al In actual engineering applications, single-row tapered roller bearing is usually assembled into the double-row bearing to accommodate the heavy load conditions. The running safety and stability of types of machinery are highly determined by the characteristics of double-row tapered roller bearing. A comprehensive analytical procedure has been developed to study the bearing in the presence of combined external loads and accommodation of three degrees of freedom.

Li F, Hu W (2017) et al The cyclic contact stresses in cylindrical roller bearings are evaluated through the explicit finite element analysis with rolling the roller instead of moving a constant contact pressure in the computational domain. The coupling effect between the contact stresses and fatigue damage is investigated, and the effects of contact loading on the fatigue life are studied. Numerical simulations of crack initiation, crack propagation, and spalling are performed. Results are consistent with the previous experimental results. A new damage evolution equation in terms of the amplitude of octahedral shear stress is proposed, which considers the non-proportional variation of stress, and the material parameters in which are easily obtained from torsion fatigue testing data.

Vimal Kumar Pal, Dr Prabhat Kumar Sinha (2017) et al An integral shaft bearing is to reduce rotational friction and support, axial and radial loads which generate friction and increased temperature and vibration inside the bearings. If the generated heat and vibration cannot be properly removed from the inside bearing, the temperature might exceed a certain limit. That is why analyzing vibration in 10 steps, heat flow, the temperature distribution in a bearing system, a typical shaft bearing, and its environment has been designed and analyzed the system using the famous finite elements tool ANSYS workbench 14.0.

Songtao Xi, Hongrui Cao (2017) et al A Fortran language-based program has been developed for the spindle bearing system with the dynamic bearing models solved using the Runge-Kutta-Fehlberg integration method and the FE shaft model solved by Newmark-β. Based on the developed model, the effect of the FDB radial clearance, system preload, and spindle rotating speed on the system dynamics have been investigated. Based on the developed FDB dynamic model and Gupta ACBB dynamic model, a fully coupled dynamic model of the spindle bearing system combined with both ACBBs and FDB is developed.

Arakere, N.K. (2016) et al Modern bearing steels are critically important ultra-high-strength structural materials used in a multitude of industrial systems. They are unique among structural materials because of the localized nature of rolling contact fatigue (RCF) loading. The complex phenomena displayed by RCF from nanometre to millimetre length scales make reliable bearing life prediction in the gigacycle regime difficult. A comprehensive review is provided for cyclic fatigue loading experienced by the subsurface volume of RCF-affected material.

V Gowtham, A S Ranganathan (2016) et al In the existing design of the Wheel hub used for Student formula cars, the brake discs cannot be removed easily since the disc is mounted in between the knuckle and hub. A CAD model was developed based on the required fatigue life cycles of three different materials and the forces acting on the hub. The theoretical fatigue strength was compared with the stress obtained from the structural analysis for each material. The forces acting on the hub were calculated and linear static structural analysis was performed on the wheel hub for three different materials using ANSYS Finite Element code V 16.2.

Joijode V,rushabh Umesh (2016) et al While designing and developing any automobile the designing of the wheel assembly is critical. The Wheel Assembly is an important part of an automobile and its failure is hazardous endangering human life. The paper illustrates the forces acting on the components, the failure criteria, and the optimization of the components. It must also be noted that the components must be designed in such a way that they have a minimum weight at the same time care must be taken that they do not cross a certain stress value.

Zhigang Wang, Zeyu Weng (2016) et al Preloads have an important influence on working performance and service life of wheel hub bearing. The natural frequency of the bearing increases with preload increasing, but the increasing trend tends to slow as the natural frequency increases. The conclusion is got after testing on bearing swept-sine vibration tests with different preloads.

Bogdan Warda and Agnieszka Chudzik (2016) et al The influence of ring misalignment on the fatigue life of a radial cylindrical roller bearing is investigated. To anticipate the fatigue life, a technique was used that took into consideration bearing geometrical features such as rolling generator profiles, bearing radial clearance, angular tilting of rings, and complicated loads. The Boussinesq issue was solved numerically for the elastic half-space and with the FEM to derive the stress distributions required to compute the anticipated fatigue life. Lundberg and Palmgren's model were used to calculate the projected bearing life fatigue. The results of the computations were compared to roller bearing manufacturers' guidelines for permissible ring tilt angles.

III. KEY FINDINGS

The above review of literature guided the present research work in a definite manner with these findings. First, the overall safety of vehicles directly depends on safe driving and attached components. Wheel hub, axial, wheel housing, and ball bearing (inner race, outer race, and rolling element ball). Are the most crucial part that abrupt failure occurs. The deformations and bearing life of the wheel hub ball bearing under duty cycle loading circumstances are significant requirements for the vehicle's safety. The tight right cornering condition is shown to be the most severe of all the loading circumstances, as the hub assembly experiences the most deformation and has the shortest fatigue life on the left side of the vehicle.

The failure criteria for life calculations are predicted. The bearings' field data is based on excessive noise levels from wheels and brakes, tire wear levels, bearing hub wear, bearing humming, undercarriage noise, and so on.

IV. CONCLUSION

According to the literature research, certain essential aspects emerge, as well as some safety measures that can help reduce accidents and fatalities caused by breaking. The hub assembly encounters the highest deformation and has the lowest fatigue life on the left side of the vehicle. Better design and fatigue life prediction are urgently required to reduce accidents, according to the authors. Because the hub assembly encounters the highest deformation and has the lowest fatigue life on the left side of the vehicle, the behavior of the wheel hub ball bearing under duty cycle loading circumstances influences deformations and bearing life.

REFERENCES

[1] A V BORGAONKAR and I SYED., 2020, " Effect of coatings on rolling contact fatigue and tribological parameters of rolling/sliding contacts under dry/lubricated conditions: a review", Indian Academy of Sciences https://doi.org/10.1007/s12046-020-1266--volV).
[2] Linkai Niu a,b,⇑, Hongrui Cao c, Huipeng Hou a, Bing Wua,b, Yuan Lan a,b, Xiaoyan Xiong a.,2020, " Experimental observations and dynamic modeling of vibration characteristics of a cylindrical roller bearing with roller defects", Mechanical Systems and Signal Processing 138 (2020) 106553.
[3] Zhang L, Xu H, Zhang S, Pei S.,2019, " A radial clearance adjustable bearing reduces the vibration response of the rotor system during acceleration", Tribology International (2020), doi: https://doi.org/10.1016/j.triboint.2019.106112.
[4] Mostafa El Laithya,⁎, Ling Wanga, Terry J. Harveya, Bernd Vierneuselb, Martin Corrensb, Toni Blassb.,2019," Further understanding of rolling contact fatigue in rolling element bearings - A review", Tribology International 140 (2019) 105849.
[5] Sangram B. Kokate1, Gururaj R. Kulkarni.,2019," Material Optimization of Wheel Hub using Finite Element Analysis", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056/ p-ISSN: 2395-0072.
[6] Wei Xiong 1,2, You Wang 2,*, Xiao-Ping Li 1,*, Song Mei 3 and Zhu-Xin Tian 2.,2019," Study on the Forming Process and Deformation Behavior of Inner Ring in the Wheel Hub Bearing Based on Riveting Assembly", Study on the Forming Process and Deformation Behavior of Inner Ring in the Wheel Hub Bearing Based on Riveting Assembly.
[7] Piao Zhong-Yu, Xu Bin-Shi, Wang Hai-Dou & Yu Xiao-Xiao., 2019," Rolling Contact Fatigue Behaviour of Thermal- Sprayed Coating: A Review", Critical Reviews in Solid State and Materials Sciences, DOI: 10.1080/10408436.2019.1671798.
[8] Bhushan Mohite.,2018," Stress Analysis and Optimization of Front Wheel Hub", International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue X, Oct 2018.
[9] Wataru Kanematsu.,2018, " A review of rolling contact fatigue behavior of silicon nitride focusing on testing practices and crack propagation analysis", Wear 400–401 (2018) 10–20.
[10] Oscar O. Rodriguez, Arturo A. Fuentes, Constantine Tarawneh.,2018, " Impact of hysteresis heating of railroad bearing thermoplastic Elastomer suspension pad on railroad bearing thermal Management", Proceedings of the 2018 Joint Rail Conference JRC2018 April 18-20, 2018, Pittsburgh, PA, USA JRC2018-6209.
[11] Lihua Yang , Tengfei Xu , Haoliang Xu , Yao Wu.,2018, " Mechanical behavior of double-row tapered roller bearing under combined external loads and angular misalignment", International Journal of Mechanical Sciences (2018), doi: 10.1016/j.ijmecsci.2018.04.056.
[12] Li F, Hu W, Meng Q, Zhan Z, Shen F.,2017, " A new damage-mechanics-based model for rolling contact fatigue analysis of cylindrical roller bearing", Tribology International (2018), doi: 10.1016/j.triboint.2017.12.001.
[13] Vimal Kumar Pal*, Dr. Prabhat Kumar Sinha, Er.Nikhlesh N. Singh.,2017, "Modeling, simulation and stress Analysis of Integral Shaft Bearing Using Ansys Benchworks 14.0", IJARIIE-ISSN(O)-2395-4396.

[14] Songtao Xi, Hongrui Cao, Xuefeng Chen, Linkai Niu.,2017, " A dynamic modeling approach for spindle bearing system supported by both angular contact ball bearing and floating displacement bearing", Journal of Manufacturing Science and Engineering. Received March 25, 2017.

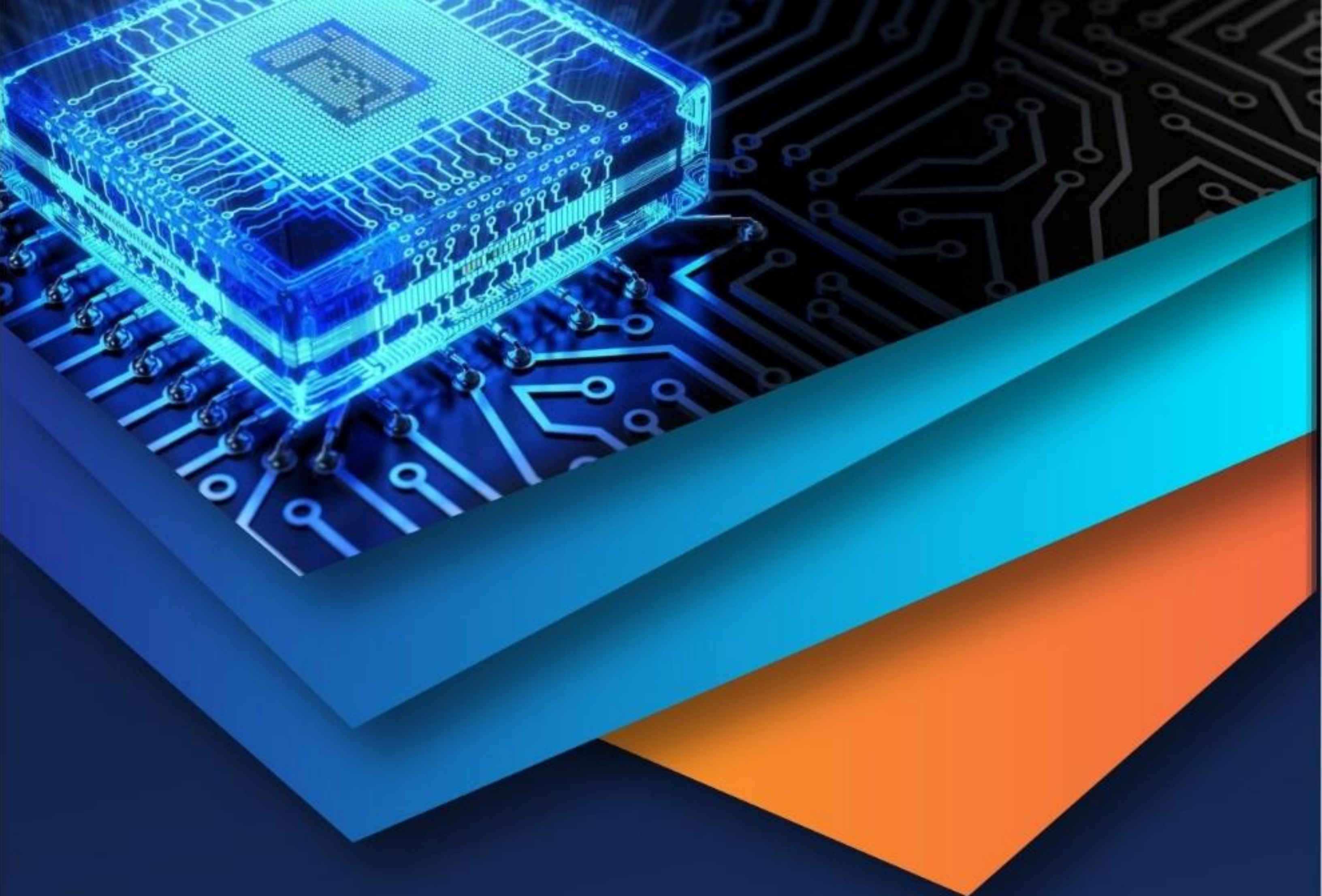
[15] Arakere, N.K.,2016," Gigacycle Rolling Contact Fatigue of Bearing Steels: A Review" International Journal of Fatigue (2016), doi: http://dx.doi.org/10.1016/j.ijfatigue.2016.06.034.

[16] V Gowtham1, A S Ranganathan2, S Satish3, S John Alexis4, S Siva kumar5.,2016," Fatigue based design and analysis of wheel hub for Student formula car by Simulation Approach" IOP Conf. Series: Materials Science and Engineering 149 (2016) 012128 doi:10.1088/1757-899X/149/1/012128.

[17] Joijode Vrushabh Umesh†* and Yadav Abhishek.,2016," Designing and Optimization of Wheel Assembly of a Formula Student Car", International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.

[18] Zhigang Wang1, a*, Zeyu Weng1, b, Qipeng Cao1, c, Jinhu Mei2 and Fuhong Zhu., 2016," Study on the Relation of Wheel Hub Bearing Preload and Natural Frequency by Dynamic Test", Advanced Materials and Manufacturing Technology II ISSN: 1662-9795, Vol. 693, pp 1453-1457 doi:10.4028/www.scientific.net/KEM.693.1453.

[19] Bogdan Warda and Agnieszka Chudzik.,2016," Effect of ring misalignment on the fatigue life of the radial cylindrical roller bearing", International Journal of Mechanical Sciences http://dx.doi.org/10.1016/j.ijmecsci.2016.03.019.



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY