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Fatigue Analysis of Deep Groove Ball Bearing Based on ANSYS: A Review

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Abstract

Ball bearing is the rotating assembly constitute with the four main components as bearing outer, bearing inner, bearing ball and bearing cage. This research study has been carried out for the steady analysis of deep groove ball bearing using ANSYS & analytical method is investigated. In this analysis the factors consider Fatigue life, hertzian stress, strain penetration. Through contact analysis, the changes could be showed in stress, strain, penetration, sliding distance, friction stress among the inner ring, outer ring, rolling elements and cage. Furthermore, the simulation results revealed that the computational values were consistent with theoretical values. The all showed that the model and boundary conditions were correct and rational, and it would provide a scientific basis for optimum design of rolling bearings under complicated loads.

Keywords: Deep groove ball bearing; Parameterize; Finite element analysis; Contact analysis, Fatigue life.

Introduction

Deep groove ball bearing's structure is simple and is widely applied. Its main failure mode is contact fatigue spalling of rolling elements. The contact finite element analysis can show bearings' information under contact, such as contact stress, strain, penetration and sliding distance, and so on, which play a significant role in optimum design of complicated rolling bearings. Contact is a complex nonlinear phenomenon, which involves not only change in state, but also accompanies with heat or electricity. Contact problem mainly includes two considerable difficulties at present. Firstly, before solving problems, the specific contact area isn't usually been known. With the change of load, between surfaces. That is hard to predict, even is a abrupt change. Secondly, most frictional effects on contact problems are needed to be considered. They may be disordered as well as nonlinear. ANSYS gives a good blue print for contact analysis which can take friction heat and electrical contact into account. It also has a special contact guide which is conveniently for creating contact pairs. The internal expert system of contact analysis does not require any settings of related contact parameter in a general contact analysis. So it can easily establish contact analysis.

A bearing may have to sustain severe static as well as cyclic loads while serving reliably in difficult environments. An angular contact thrust ball bearing better supports "combined loads" (loading in both the radial and axial directions). The larger the contact angle, the higher the axial load supported, but the lower the radial load. It can take greater thrust load than maximum capacity of the ball bearing from only one direction.

Literature review

There are some papers which have been studied and referred on my work:

Pandiyarajan.R, Starvin.M.S, Ganesh.K.C (2011) A bearing may have to sustain severe static as well as cyclic loads while serving reliably in difficult environments. An angular contact thrust ball bearing better supports "combined loads" (loading in both the radial and axial directions). The larger the contact angle, the higher the axial load supported, but the lower the radial load. It can take greater thrust load than maximum capacity of the ball bearing from only one direction. There are lots of researches developed to study the contact mechanics problems due to its nonlinear properties. This analysis used to study the

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failure behaviour at the contact zone and improving the contact behaviour to increase its service life. Basically the study starts with the components failure as static contact also to simplify the Hertzian contact problems the frictional effects in the analysis are not considered.

The commercial numerical analysis packages like ANSYS, Abaqus, etc. are strongly proven its ability to predict the failure of component and the results can be justified through relevant experimental or mathematical models. The failure initiation, maximum load carrying capacity, life of components can be approximately predicted. Especially fatigue analysis to predict the minimum service life on bearing is carried out by various researchers and the load carrying capacity and corresponding service life are the important area of research to understand the component behaviour.

TANG Zhaoping, SUN Jianping (2011)

Deep groove ball bearing's structure is simple and is widely applied. Its main failure mode is contact fatigue spalling of rolling elements. The contact finite element analysis can show bearings' information under contact, such as contact stress, strain, penetration and sliding distance, and so on, which play a significant role in optimum design of complicated rolling bearings. Contact is a complex nonlinear phenomenon, which involves not only change in state, but also accompanies with heat or electricity. Contact problem mainly includes two considerable difficulties at present. Firstly, before solving problems, the specific contact area isn't usually been known. With the change of load, material, boundary condition or the other factors, touch or separation will take place between surfaces. That is hard to predict, even is a abrupt change. Secondly, most frictional effects on contact problems are needed to be considered. They may be disordered as well as nonlinear. How to simulate the similar contact problems quickly and exactly is one of the heat problems that scholars care. ANSYS gives a good blue print for contact analysis which can take friction heat and electrical contact into account. It also has a special contact guide which is conveniently for creating contact pairs. The internal expert system of contact analysis does not require any settings of related contact parameter in a general contact analysis. So it can easily establish contact analysis. The paper took deep groove ball bearing 6200 for an example, discussed bearing contact, and built its finite element 3-D parameterized model by using the APDL (ANSYS Parametric Design Language) of ANSYS. Based on that, the nonlinear contact state was researched and analyzed.

Ayao E. Azianou1, Karl Debray, Fabrice Bolaers, Philippe Chiozzi, Frédéric Palleschi (2013)

Studies considered that the bearings are mounted in a rigid housing. This assumption is not realistic when we consider the case of a new generation of alternator where the housing is complex and deformable. This paper assesses the influence of housing deformation on load distribution in the bearing by two different approaches' a finite element approach and a semi-analytical approach where the rolling elements are replaced by user elements. A prior study has been done by using these two approaches in the case of rigid housing.

The geometry of ball bearing is important in load distribution modelling, especially curvature radii of the raceways of the inner and outer ring. These values are not indicated by bearing suppliers and they are difficultly determinable by conventional measurement methods. We have developed a new methodology to measure these values using a three-dimension measuring machine.

In this study, two approaches: a FEM and a semi analytical approach are used for load distribution calculation in statically radial loading. These results are consistent and closer to analytical formulations in the case of rigid housing. Semi-analytical approach is seen to be cheaper in term of computation time.

Using FEM, a complex deformable housing is numerically integrated in a ball bearing to study the load distribution considering. The numerical results show that housing deformation has effect on load distribution. Be-cause load distribution is an important parameter in ball bearing durability; the housing has to be considered in fatigue lifetime analysis.

Yujuan Xu, Mamtimin·Geni, Rahmatjan Imin, Bo Lu (2013)

In terms of design of bearing products structure, raising bearing loads, extending bearing life, increasing strength and rigidity, reducing friction and wear, reducing noise, reducing the volume, reducing weight and absolving maintenance have always been used as unremitting goal.

The design method of deep groove ball bearings is mainly contain the original design principles and coefficient of the bearing, but for design formula there is no new breakthrough.

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The most of the related research literature show that, the research of the affect of curvature coefficient of inner and outer ring on the performance of deep groove ball bearings is not enough at present. Therefore, the design of the contact interface structure parameters of deep groove ball bearings mainly rely on the experience and it is difficult to achieve the optimum design.

In this study, firstly the three-dimensional model of deep groove ball bearings is established, and numerical analysis are carried out for the contact stress near to the contact interface of deep groove ball bearing with the finite element software. Then the 156 finite element models are made and numerical analysis are carried out separately, on the basis of ensuring that the parameter of the curvature coefficient of inner and outer ring, the number and diameter of the rolling element has only one parameter changing each time, and the remaining parameters held constant. The changing relations between curvature coefficient of inner and outer ring, the number and diameter of the rolling element and contact stress are established, by analyzing the affect law of each parameter and contact stress.

In the study, the 156 finite element models are made and numerical analysis are carried out by changing the effective contact interface structure parameters such as curvature coefficient of inner and outer ring, the number and diameter of the rolling element. The contact stress under different structural parameters are analyzed in detail and the changing laws of curvature coefficient, the number and diameter of the rolling element and contact stress are discussed.

Rajnikant Nagarbhai Anjara, Milan J Pandya (2014)

In research study the bearing weight has been reduce by keeping constant temperature generated in bearing. To reduce the failure of bearing, static temperature of bearing should be less than critical temperature of bearing. Rotational speed, oil viscosity and thermal boundary conditions as the critical parameters which should be considered to avoid the thermal failure of the ball bearings. Corroboration with the energy dissipation criterion offers a better evaluation of the bearing performance related to scuffing. The predicted trends of increasing temperature and heat generation with increased shaft speed and of decreasing temperature and increasing heat generation with increased lubricant flow rate were verified by the experimental data. The temperature gradient through the bearing increases with increasing effective mounted contact angle.

Ball bearing is the rotating assembly constitute with the four main components as bearing outer, bearing inner, bearing ball and bearing cage. This research study has been carried out for the optimization of the deep grooved ball bearing. The optimization of the bearing means, to reduce the output of the bearing among the stresses generated due to load and the overall weight of the bearing. In this research work the bearing weight optimization has been performed by keeping the results of the stresses has been same as the generated in the existing bearing design. The weight is the most effecting parameter which is affecting on the life of the bearing and cost of the bearing. The saving in the weight of the bearing means reduction in the overall weight of the bearing.

Sumit Kumar Dahiya and A.K. Jain(2013)

In this study the steady analysis of deep groove ball bearing using ANSYS & analytical method is investigated. In this analysis four factors consider Fatigue, wear, stress, penetration. The main goal is to providing displacement in inner race by 0.01mm & 0.06mm & to get change in stress and penetration take place. All the result is based on specific dimensions. By providing displacement in inner race by 0.01mm & 0.06mm and coefficient of friction from 0.05mm & 0.025mm with 5 degree of rotation in clockwise direction with 500 rpm through which four cases obtained using ANSYS tool. An increasing the displacement value Hertzian stress value also increases with penetration. Then by using analytical method through Hertzian contact stress theory using & find out contact stress by this contact analysis through which change showed in stress penetration & fatigue life is to be calculated.

By using ANSYS to numerically simulate and analyze on stress and penetration during deep groove ball bearing contacts , the ANSYS solution got, which had good consistency with the Hertzian theory solutions, The contact analysis of this method can easily and intuitively get the stress and strain values as well as their images, which can efficiently understand the parts running information, such as contact penetration, contact stress also.

Method and software used

FEA

The finite element analysis (FEA) is a computing technique that is used to obtain approximate solutions to the boundary value problems

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in engineering. It uses a numerical technique called the finite element method (FEM) to solve boundary value problems. FEA involves a computer model of a design that is loaded and analyzed for specific results .

ANSYS

ANSYS is being used by designers across a broad spectrum of industries such as aerospace, automotive, manufacturing, nuclear, electronics, biomedical, and many more. ANSYS provides simulation solutions that enable designers to simulate design performance directly on desktop. In this way, it provides fast, efficient and cost-effective product development from design concept stage to performance validation stage of the product development cycle. ANSYS package help to accelerate and streamline the product development process by helping designers to resolve issues related to structural deformation, heat transfer, fluid flow, electromagnetic effects, a combination of these phenomena acting together, and so on.

Conclusion

By using ANSYS to numerically simulate and analyze on stress and penetration during deep groove ball bearing contacts, the ANSYS solution got, which had good consistency with the hertzian theory solutions, The contact analysis of this method can easily and intuitively get the stress and strain values as well as their images, which can efficiently understand the parts running information, such as contact penetration, contact stress also.

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