Deep Groove Ball Bearing Contact Stress Analysis Based on ANSYS, While Exfoliation Exists in Groove

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Abstract. Using finite element analysis software ANSYS deep groove ball bearing on the contact stress and the distribution while the exfoliation exists in groove. According to the simulation results, some phenomenon could be found out, and resolved. The result would have a great effect for the dynamics analysis and the vibration about rolling bearing.

Introduction

In 1935, many technicists already noted the exist of vibration, and replace the sliding bearing in the electric motor. There have a series of technical breakthrough on the study of bearing vibration since 1989. Vibration exist in every mechanical motions, and would affect personal health when the value reach the critical. For the mechanical equipment, these machining precision would be influenced seriously if the value of vibration is comparatively large. Moreever, bearing performance is one of the most important factors about the equipment.

At present, there have a lot of fundamental theories about the analysis of bearing based on ANSYS. Liu and Zhang, from the University of Shanghai, modeling with the software of UG, and processing the simulated analysis depending on the data interface between the software of UG and ANSYS, then compared the analysis result with Hertz valued in order to determine the veracity of this analysis method [1]. Those studies researched the distribution trends of the contact stress and strain while loading, which built up a part of theoretical knowledge about the dynamics analysis of beraing [2-4]. Xin established a 3D nonlinear contact model of a deep groove ball bearing with ANSYS Workbench software, and contrasted the computational values and the Hertz values [5]. The 3D model of deep groove ball bearing could be built up with the APDL language embedded in the finite element software ANSYS [6-7]. The research found that the bearing’s radial displacement occurred fluctuation while the load increasing [8-9]. Kostek observed a number of phenonena associated with non-linear dynamics, and provided an opportunity to select failure models [10].

In this paper, depend on the simulated analysis for exfoliation based on FEM; the exfoliation would be incarnated by the through-hole in the plane of symmetry of groove. The variation of contact stress and distribution would be found during the increasing of the diameter of exfoliation, that have a significant of contact stress and bearing vibration.

Processing of Simulated Analysis

The analysis would explained the form of simulated analysis based on ASNSYS as example as deep groove ball bearing of 6300. Under the condition that the model should be simplified as far as possible, so that the process of time could be shorten, simply and accurately reflects the mechanical property of solid model.

The major parameter of 6300 would be shown in Table 1, and the diameter of exfoliation in this simulated analysis would be shown in Table 2.

Table 1 The major parameter of 6300(mm)

D	d	B	Dw	Ri	Di	Re	De	a	Z
35	10	11	6.350	3.270	17.150	3.334	29.850	0	7

Table 2 The diameter of exfoliation (mm)

d	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5

Preprocessing. On the basis of the trim size, the coordinates of the keypoint of the inner\outer ring and centers could be calculated, then modeling with the operation of GUI or the parameterization of APDL. The element type is defined by brick 8 nodes solid 185. The material is ball bearing steel, the elasticity modulus is 2.07E5 MPa, the Poisson’s ratio is 0.3. The meshing type is free, and smart size is on. The part of contact areas and some details should be refined, as shown as Fig. 1. The model is 1/4 of the solid model because of the symmetry and the loading, as shown as Fig. 2.

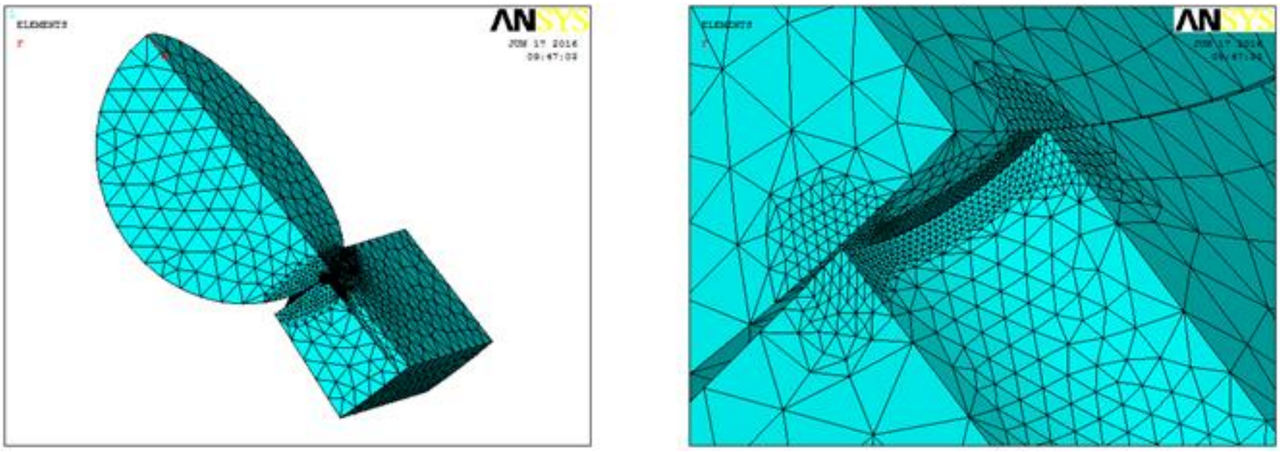

Figure 1. 1/4 analysis model, the load and the refine of contact areas

There are two methods, contact wizard and the APDL parameterization, to define the contact pairs after modeling. The element of contact surface is CONTA 174, and the target surface TARGET 170. Then the boundary conditions of this model could be confined as describing that: all DOF of the nodes belong to the outside surface of outer ring should be confined, and the plane of symmetry should have a symmetrical constraint because of the Poisson effect. The node of steel ball’s peak would be load with a force as 500 N, as shown as Fig. 2.

Results of This Analysis. (1) Nodes’ contact stress of the intersecting line between the exfoliation and the groove, from the inside to out.

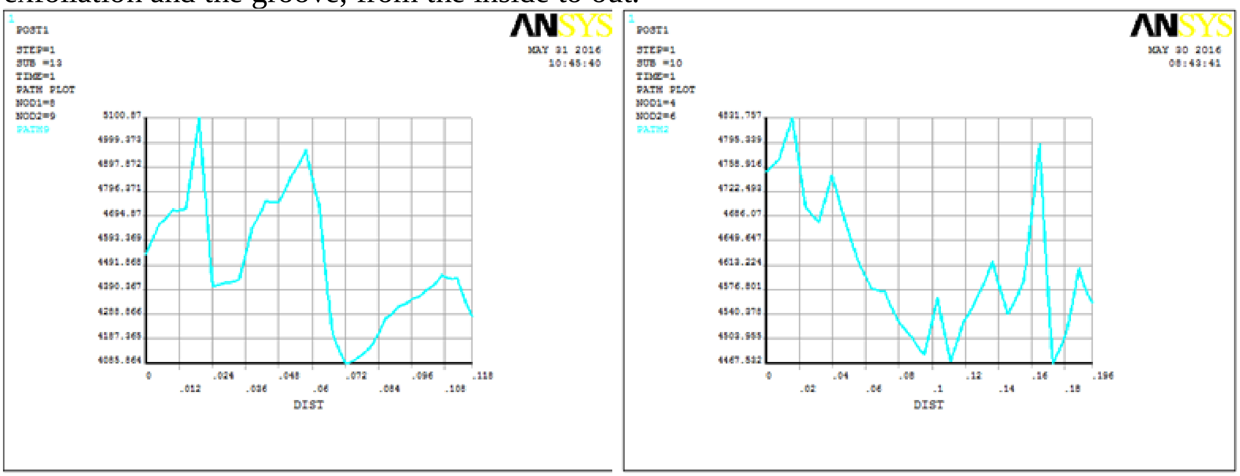

Figure 2. The contact stress of nodes while the diameter are 0.15 and 0.25 mm.

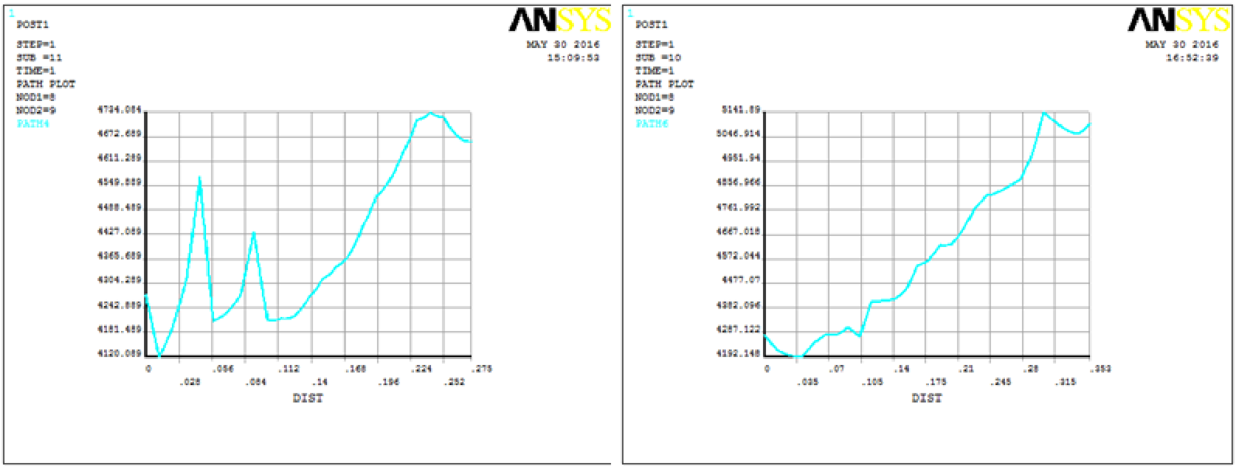

Figure 3. The contact stress of nodes while the diameter are 0.35 and 0.45 mm.

.(2) The distribution of contact stress on the groove while precessing.

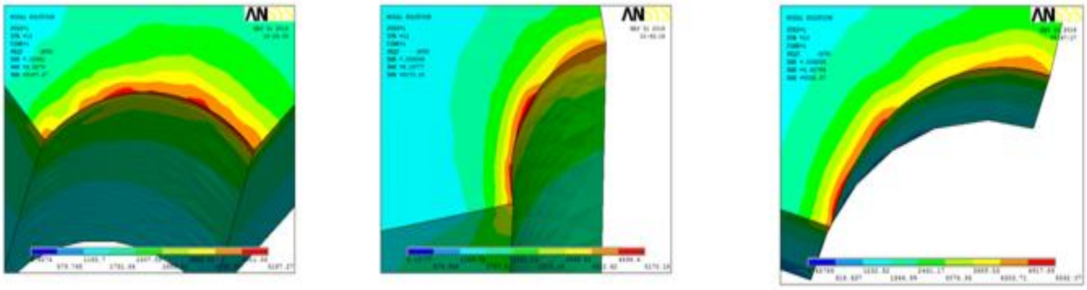

Figure 4. The distribution of contact stress while the diameter are 0.1, 0.15, 0.2 mm.

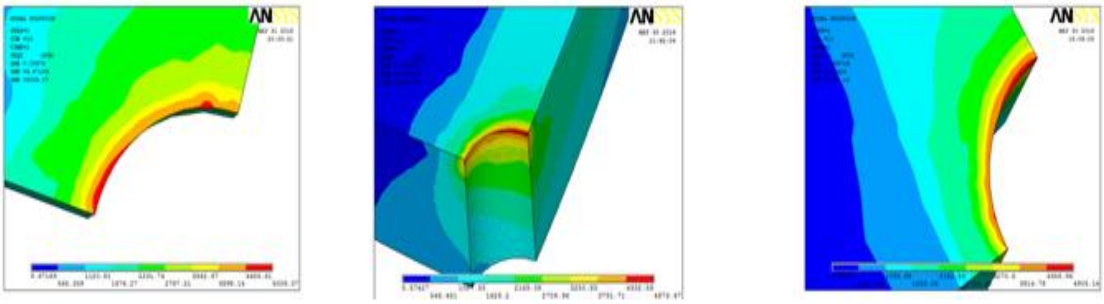

Figure 5. The distribution of contact stress while the diameter are 0.25, 0.3, 0.35 mm.

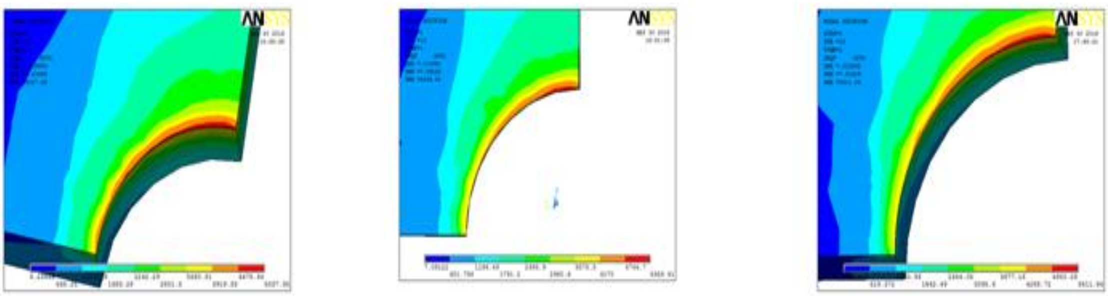

Figure 6. The distribution of contact stress while the diameter are 0.4, 0.45 0.5 mm.

(3) The maximal stress on the groove while processing for different diameter of exfoliation.

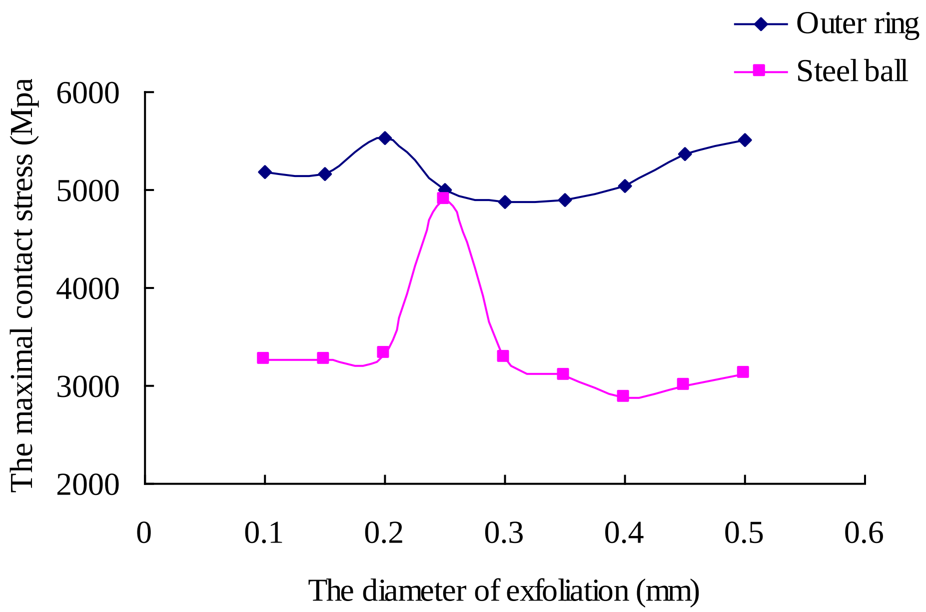

Figure 7. The distribution of maximal contant stress while the diameter incresing

According to the result, the phenomenon would be found as that:

(1) During the diameter of the exfoliation increasing, the major contact areas would diverge from the plane of symmetry about the groove to the long axis on the intersecting line nearly.

While the diameter is comparatively small, the curvature of the false surface is tiny extremely, the major type of contact is as common as the major contact areas happens on the bottom. However, the curvature increasing obiously, the major have a great change, and diverge to the long axis, during the diameter increasing.

(2) The unimodal distribution could be determined to the maximal contact stress, as shown as Fig. 9.

From Fig. 7 to 9, the contact form could be distinguished to the lineal contact and the surface contact. When the diameter is comparatively small, the major contact type is the surface, and the lineal as secondary. The long axis of contact areas is a = 0.903 mm, the minor axis b = 0.15 mm in the normal condition, during the diameter Delong to [0. 1, 0. 2], the contact form is both. While the diameter increasing, the area of the surface contact would decreased faster than the lineal, and eventually the lineal becomes the major contact type. When the diameter of exfoliation is 0.2 mm, the lineal become as the major contact type, the phenomenon of stress concentration is the most obvious, and after that the contact stress would be decreasing because of the growing of intersection line.

(3) The maximal contact stress of outer ring is greater than the steel ball all the while.

The exfoliation happened in the working of bearing. There are a lot of concave-convex parts on the nearby intersection line, that casue the stress concentration readily. So the outer ring’s is greater.

Summary

From the above, while the diameter of exfoliation increasing, the major contact areas have a great skewing, and eventually centralize the endpoint of long axis nearby. The distribution of the maximal contact stress between the outer ring and steel ball is unimodal, and the maximal value exists the diameter of 0.2 mm. moreover, the contact stress of outer ring is greater than the steel ball’s because of the stress concentration. The result could provide a few of original ideas, and would have a significant assistance for the dynamics analysis about the vibration of bearing.

Acknowledgements

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