A Review of Research on Stresses Induced in Cylindrical Roller Bearing

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Abstract: - A detailed investigation of stresses imposed on cylindrical roller bearings is presented in this review paper. The evaluation stresses in cylindrical roller bearings are the subject of a literature study. The present work and past development of assumptions on stress distribution of roller bearings are discussed in this study, followed by an investigation of bearing deformation and life.

Key Words: —*Cylindrical roller bearings, Stress, Deformation.*

I. INTRODUCTION

A. Cylindrical Roller Bearing

Cylindrical roller bearing are extremely used for medium speed and heavy loading conditions. This speed is recommended from 900 – 2200 rpm depending upon application. The use of cylindrical roller bearing could be seen in various machinery like shaper machine, rolling machine, dragline, heavy earthmovers, etc. The life of bearings depending upon various factors namely, equilateral load, reliability factor, and specific dynamic capacity. However, no one can predict the instantaneous failure of bearing which may occurs during operation of machine. Even the dynamic involved is transient and complex, which require in-depth understanding of the cylindrical roller bearing. The transient dynamics leads Fig.1 Cylindrical roller bearings (1w). The to time varying stresses and repetitive stresses due to which fatigue phenomenal occurs. Therefore, it is essential to evaluate the stress pattern under dynamic loading condition. On the flip side the temperature variation in cylindrical roller bearing will also leads to spalling of roller. Hence, it is also needed to investigate the effect of temperature variation in roller of the bearing.

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Fig.1. Cylindrical Roller Bearing

B. Phenomenon of stresses induced in cylindrical roller bearing

If one considers a roller moving in the raceways as shown fig. 2. Due to preloading and load which is coming on the roller from the shaft is represented as W. This W can be divided into two parts load due to static force and dynamic force. The static load include weight of the shaft, weight of component, which are to be placed on the shaft. Whereas the dynamic load will include tooth force of gear, belt tension of pulley, misalignment forces, etc. Due to W, a normal reaction (RN) will be induced by inner race of roller. The line of action of normal reaction will not be exactly equals and opposite but it has certain deviation from the line of action of load W. This is due to continuous wear and tear of the component. This time varying load will induced time varying reaction. A probable pattern of time varying reaction is shown in fig. free due to this time varying reaction what will be the stresses induced in the rolled is needed to identify.

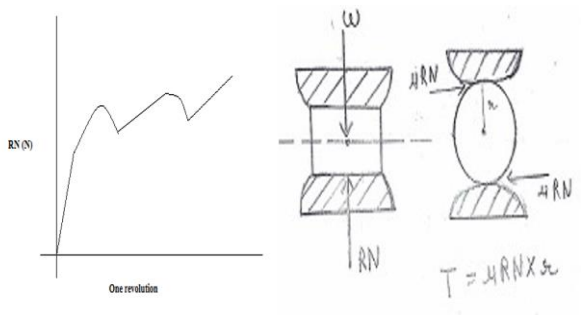

Fig.2. Stresses induced in cylindrical roller bearing

II. LITERATURE REVIEW

Stress and displacement distributions on cylindrical roller bearing rings using FEM. Necdet Demirhan, et.al. In this paper, FEM was used to study the stress and deflection distributions in the bearing's internal and outer races, taking into account the deflection of elastic rings. The stresses and displacements on the inner and outer races of the rings were found to have different distribution characteristics. It could also be the root cause of bearing spalling. Stress and displacements are no longer equally distributed along the tops of the rings in a radial pathway due to significant stresses at the point of contact.

*Hertz contact stress of deep groove ball bearing***.** Suresh Babub, et.al. In this paper, Analytical and MESYS tool analysis were used to calculate the hertz contact stress between the deep groove ball bearing and the inner race. The calculation procedure entails using analytical formulas to calculate maximum contact pressure at various loads and comparing the results with the MESYS tool to predict the contact pressure between the inner race and the ball of a single row deep groove ball bearing, with the contact between the inner race and the ball being treated as an elliptical contact. It was obvious from the results that the variation in MESYS results is extremely small, less than 5%.

Effects of tilted misalignment on loading characteristics of cylindrical roller bearings. Zhenhuan Ye, et.al. In this research paper author said, using the quasi-dynamic method and the FEA technique, the effects of tilting misalignment between the inner and outer rings on the distribution of loads on roller bearings are explored. In the operating process, the impacts of unbalanced misalignment on load and contact pressure changes are also evaluated. The data demonstrate that when the slanted misalignment grows, the maximum contact pressure in bearings slowly rises, and the fluctuation progressively lowers before significantly increasing. On the roller profile, pressure concentration occurred in the cross section of curves. The maximum load gradually decreased, then slightly increased as the deflection angle between the inner and outer raceways increased, and the maximum contact stress in the loading zone gradually increased, then stabilised after the deflection angle between the inner and outer raceways reached a certain angle. With varying loads and speeds, the maximum contact pressure between rollers and inner raceways under deflection between inner and outer raceways.

Analyzing Hertzian contact stress developed in a double row spherical roller bearing and its effect on fatigue life. Dhaval B. Shah, et.al. In this paper author, say that, for large size spherical double roller bearings, a method based on the Hertz theory was used to calculate contact stress. For contact stress, a finite element model was built and validated. The results achieved using both strategies were compared. The contact stress has a maximum relative error of 2.8 percent, indicating that the results of the finite element model are complementary. The highest stress concentration was detected using a finite element model, and it was discovered that under static loading, the maximum stress occurs at the start or end of the contacting arc. The fatigue life of a spherical roller bearing was determined using a verified finite element model.

Contact stress distribution of large diameter ball bearing using hertzian elliptical contact theory. Starvin M. S., et.al. Said the purpose of paper that, analytical and numerical approaches to determine the contact stress of large diameter ball bearings. The Hertzian Elliptical Contact Theory is used to calculate the contact stress in the analytical manner. The calculation technique entails using an in-house created programme to calculate the maximum contact pressure on the rolling element, as well as a complete finite element analysis of the contact between the ball and the raceway. The contact pressure in the ball and raceway was also predicted using finite element analysis.

Analysis of stress and strain of the rolling bearing by FEA method. Zhang Yongqi, et.al. According to the paper, a finite element model of roller bearings was developed using the Reynolds equation and taking surface roughness into account. After that, the stress in the roller and raceway was computed and solved under varied loads to determine the bearings' maximum stress and strain. Finally, the maximum stress and strain acquired from the pre-tightening were used to examine the influence of the pre-tightening on the work property of the bearings. The finite element analysis not only calculates the

maximum and minimum shear stress in rolling bearings, but also displays the locations of stress concentrations.

An analytical study of contact stress and contact zone analysis of cylindrical roller & spherical ball bearings in epicycloid condition. HARRSH K. DUBEY, et.al. in brief states of paper, The M. F. Spots analytical equation for epicycloid condition was used to explore contact stress and contact zone analysis of cylindrical roller and spherical ball bearings. To calculate the compressive stresses and the contact zone on the surfaces of the ball and roller bearing, various combinations of outer and inner radius ratios, as well as the elasticity of material, were used. Ball bearings are suitable for low-speed applications, whereas roller bearings are suitable for higher-speed applications, according to the analytical study of contact stress and contact zone analysis of roller and ball bearings in epicycloid condition. As a result, cylindrical roller bearings more efficient than ball bearings.

A new damage mechanics based model for rolling contact fatigue analysis of cylindrical roller bearing. Fukai Li, et.al. the author reported in that paper that, FE model was created for cyclic contact stress analysis in which the roller moves alongside the contact surface. This model suggests that contact loading varies as fatigue damage progresses. A new damage evolution equation is devised, which is defined in terms of the amplitude of octahedral shear stress. This equation also takes into account the non-proportional variation of the stress components in the rolling contact. Torsion fatigue testing results can simply be used to estimate the material parameters in the equation. Then, using the VUMAT function in ABAQUS, a numerical simulation was run to calculate the accumulation of fatigue damage in the material. The effects of contact stresses and fatigue damage on each other were explored.

Effect on stress and thermal analysis of tapered roller bearings. S. Senthil Kumaran, et.al. author said that, the stresses created between the roller, inner, and outer races of a taper roller bearing are calculated using the ANSYS software. On the inner ring, the maximum deformation occurs. Because of the stress created is less than the yield stress of the material, the resulting deformation will not break it. Internal crakes will still occur as a result of the high temperatures generated by these forces. The deformation was found to be concentrated on the inner ring's surface. The point of contact of roller bearings with the cone and cage is highly stressed.

New stress based fatigue life models for ball and roller bearings. Pradeep K. Gupta, et.al. as regards to this paper for calculating dynamic stress capacity in roller bearings life models was developed. In this study, life equations for single rolling elements for contact races were created initially, and then integrated to estimate the life of the inner and outer races roller bearings, as well as the entire part bearing. The contact stress range from 2 to 3 GPa. This life model gives increase life of bearing at low contact stresses.

III. CONCLUSION

We may conclude that cylindrical roller bearings are employed for high-speed applications based on the above review of studies on stresses caused in cylindrical roller bearings. The stress created at the point of contact between the roller and the raceways of the bearing is higher, and deformation occurs at the bearing's inner surface. By increasing the number of bearings, the bearing's life will be extended, and by carefully assessing the contact stresses, bearing spalling will be reduced.

REFERENCES

[1]. Necdet Demirhan, "Stress and Displacement Distributions on Cylindrical Roller Bearing Rings Using FEM", Mechanical Engineering Department 08 October 2014 Turkey.

[2]. Junning Li, Wei Chen, "Experimental study on skid damage of cylindrical roller bearing considering thermal effect". Mech Part Engineering Tribology 2014 China.

[3]. Suresh Babub, Vishwanath.A.K, "Hertz Contact Stress of Deep Groove Ball Bearing", Department of mechanical engineering,NIT, Warangal, India.

[4]. Zhenhuan Ye , Liqin Wang , Le Gu , Chuanwei Zhang, "Effects of tilted misalignment on loading characteristics of cylindrical roller bearings", University of California, San Diego, La Jolla, CA 92093-0401, USA.

[5]. Bogdan Warda, "Effect of ring misalignment on the fatigue life of the radial cylindrical roller bearing", Lodz University of Technology, Department of Vehicles and Fundamentals of Machine Design, Lodz, Poland.

[6]. Dhaval B. Shah Kaushik M Patel Ruchik D Trivedi, "Analyzing Hertzian contact stress developed in a double row spherical roller bearing and its effect on fatigue life", Industrial Lubrication and Tribology, Vol. 68 (2016).

[7]. Alin Marian Puşcaşu, Octavian Lupescu "Analysis of cylindrical roller bearings design in order to optimize the classical process using FEM", Department of Machine Manufacturing and Industrial Management, Iași, 700050, Romania.

[8]. Starvin.M.S, Ganesh.K.C, "Contact Stress Distribution of Large Diameter Ball Bearing Using Hertzian Elliptical Contact Theory" Tirunelveli, Kerala, India 2011.

[9]. B. Ramu, V. V. R. Murthy, "Contact Analysis of Cylindrical Roller Bearing Using Different Roller Profiles", Nov - April 2013.

[10]. Zhang Yongqi, Tan Qingchang , Zhang Kuo ,Li Jiangang , "Analysis of Stress and Strain of the Rolling Bearing by FEA method", China 2012.

[11]. Harrsh K. Dubey1, Satish P. Lokhande & Rajat G. Kawalkar, "An Analytical Study of Contact Stress and Contact Zone Analysis of Cylindrical (Roller) & Spherical (Ball) Bearings in Epicycloid Condition", Nagpur, Maharashtra, India Dec 19, 2018.

[12]. Fukai Li, "A new damage-mechanics-based model for rolling contact fatigue analysis of cylindrical roller bearing" School of Mechanical and Aerospace Engineering, Nanyang Technological University, 639798, Singapore 2018.

[13]. Yongcun Cui, Sier Deng, Yanguang Ni, Guoding Chen Xi'an, "Effect of roller dynamic unbalance on cage stress of high-speed cylindrical roller bearing", China 2018.

[14]. Joseph V. Poplawski, "Effect of Roller Profile on Cylindrical Roller Bearing Life Prediction—Part II Comparison of Roller Profiles", University of Regina, Bethlehem, Pennsylvania 25 Mar 2008.

[15]. Pradeep K. Gupta & Erwin V. Zaretsky " New Stress-Based Fatigue Life Models for Ball and Roller Bearings", NY, USA 05 july 2017.