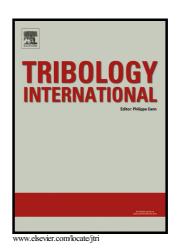
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ACCEPTED MANUSCRIPT

Dynamic modeling and vibration response simulations of angular contact ball bearings with ball defects considering the three-dimensional motion of balls

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ABSTRACT

A dynamic model to investigate the dynamics and vibration responses of angular contact ball bearings with ball defects is proposed. In the proposed model, each ball has 6 degrees of freedom (DOFs), meaning that the three-dimensional motion of balls is considered. The results show that whether a ball hit a race and the frequency property of the envelope spectrum largely depend on the geometrical characteristics and operating conditions. This increases the difficulty in diagnosing the ball defect when using vibration-based monitoring techniques. The current investigation suggests that the vibration response simulations should be carried out to investigate the vibration mechanism and to diagnose the ball defect more effectively.

Keywords: Angular contact ball bearings; ball defect; bearing dynamics; fault diagnosis

Nomenclature

a, b: Lengths of the semi-major axis and the semi-minor axis of the contact ellipse.

A, B, C, D: Four orbital positions of a ball.

 A_1 , A_2 : The left and the right ends of the contact ellipse.

 c_y , c_z : The damping coefficients of the bearing housing along the y_i and z_i directions.

 d_m : Pitch diameter of the bearing.

D: Ball diameter.

 f_{bdf} : Ball defect frequency.

 f_i : Groove curvature factor of inner race.

 f_o : Groove curvature factor of outer race.

 f_s : Rotation frequency of the bearing.

 F_{hy} , F_{hz} : The forces acting on the bearing housing along the y_i and z_i directions.

F: Force vector.

J : Principal moment of inertial.

 k_y , k_z : The stiffness coefficients of the bearing housing along the y_i and z_i directions.

K: Hertzian contact stiffness coefficient.

m: Mass of a bearing component.

 m_h : Mass of the bearing housing.

M: Moment vector.

 P_{\max} : The maximum Hertzian contact stress at the contact ellipse.

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