On the thermally–induced failure of rolling element bearings

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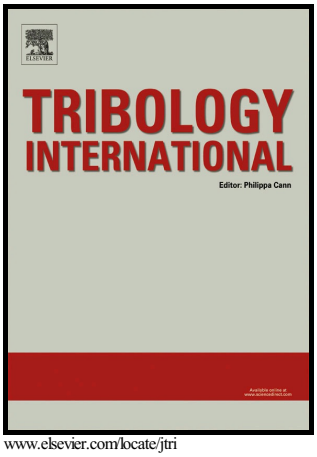

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Abstract:

A comprehensive investigation of two types of thermal failure of rolling element bearings is carried out both experimentally and analytically. The first type is concerned with the thermal failure of rolling bearings that can occur at high rotational speeds and large radial loads, and the second type deals with spindle bearings of high–speed machine tools. Developed in the present study is a simulation technique that considers the thermal expansion of the bearing elements in the dynamic simulations of the rolling bearings during the thermal failure. The results of dynamic simulations for the first type of thermal failure show that the unstable motion of the cage can lead to an ultimate bearing seizure because of the cage failure due to the large rollers/cage contact forces and high wear rate of the cage. However, the surface damage and wear at the roller/raceways interface are not considerable. On the contrary, for the second type of thermal failure of rolling element bearings, the simulation results reveal that the minimum film thickness at the roller/raceways interface drops and mixed lubrication regime prevails. Subsequently, a severe surface damage and wear occur at the rollers/raceways contact surfaces and eventually the bearing fails. The cause of this failure is the thermal seizure of the spindle bearing due to the rapid rise of the thermally–induced preload inside the bearing assembly with no sign of cage instability.

Key words: thermal failure; thermal instability; rolling element bearing; thermally-induced preload, dynamic model.

Nomenclature

a	Semi-major width of contact area (m)
b	Semi-minor width of contact area (m)
d	Roller/ball diameter (m)
d_p	Pitch diameter of bearing (m)
E	Elastic modulus (Pa)
E'	Effective modulus of elasticity $\left[0.5[(1-\nu_1^2)/E_1+(1-\nu_2^2)/E_2]\right]^{-1}$
F_{ip}	Initial preload (N)
F_r	Radial load on the bearing (N)
F_{th}	Thermally–induced preload (N)