Novel Tribo-Dynamic Methodology of Deep Groove Ball Bearing under Extreme Speeds of Electric Drives

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INTRODUCTION
More stringent automotive emission legislations introduce new technical challenges to the engineering and scientific community. In order to meet these legislations, many manufacturers introduce hybrid or pure electric powertrain systems. In order to maximize the efficiency of electric part and optimize its packaging, modern electric drives are designed to operate at ultra-high rotational speeds in excess of 10000 rpm and consequently, relatively lighter load. This new range of operating condition brings new challenges in terms of efficiency, durability and Noise-Vibration and Harshness (NVH). New experimental techniques and numerical methods are required to analyze tribological conjunctions under abovementioned conditions. This paper presents a novel combination of experimental measurement and multi-physics numerical methods to study the tribo-dynamic behavior of deep groove ball bearings under operating conditions of modern electric drives. Using the proposed methodology, the effect of axial preload on the tribo-dynamics of the bearing is investigated.

ABSTRACT
Rolling element bearings are critical components of modern electric drives. The elastohydrodynamic (EHL) contacts of these bearings significantly change their tribological performance under high-speed and light-load conditions. They should also operate under a wide range of conditions, promoting different NVH phenomena such as whine. Hence, a multi-physics approach comprising dynamics and tribology is required. In-situ experimental measurement of tribological conjunctions under these operating conditions is challenging, if not impossible. From computational point of view, it is time consuming to couple dynamic model with detailed tribological models to capture the highly transient conditions.

In this study, a novel combination of dynamic experimental measurement and tribological simulations is proposed for deep groove ball bearing. The experimental measurement is performed using a specially designed component level test rig, being able to reach 32000rpm. The rig can apply external excitations up to 2000Hz. The instantaneous position of the inner and outer races are obtained using laser vibrometer and accelerometer respectively. Figure 1 shows an example of obtained inner race displacement.

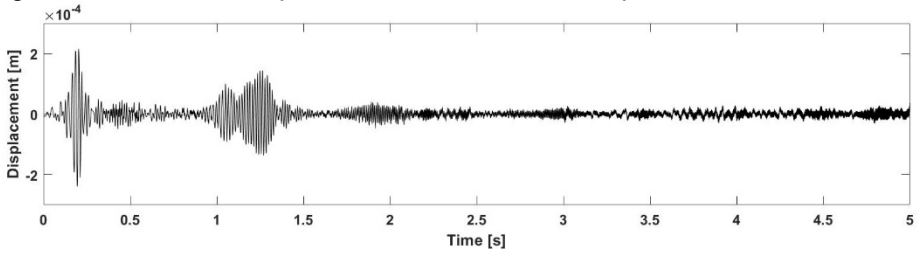

Figure 1: Experimentally obtained inner race displacement of deep groove ball bearing.

These experimental values form the boundary condition for the tribological model. The model can calculate the pressure, film thickness and temperature distributions [1]. Using the presented approach, the effect of preload on the tribo-dynamic performance of deep groove ball bearing is investigated. The results show that by applying higher preload, the dynamic response of the system can be effectively suppressed; but it has adverse effects on the efficiency of the system.

REFERENCES
[1] Mohammadpour, M, et al., (2015), “Roller Bearing Dynamics under Transient Thermal Mixed Non-Newtonian Elastohydrodynamic Regime of Lubrication,” *Proc. IMechE, Part K: JMBD*, **229** (4), pp. 407–423.