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The Dynamic Behaviour of Ball Bearings

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In cooperation with SKF, a research project was started on the dynamics of ball bearings. The research is motivated by the demand for silent bearings in noise sensitive applications, especially in the household appliance and automotive industry. The investigations should bring a clear understanding about the role of the bearing in the application with respect to the design, the quality and the way it is mounted.

The dynamic behaviour of a ball bearing application is studied by means of predictive modelling. The application consists of a flexible shaft supported by two deep groove ball bearings mounted in flexible housings. The housings, the shaft and the bearing outer rings are modelled with the finite element method. To solve the equations of motion by means of time integration, the large finite element models are reduced with component mode synthesis (CMS). To account for the flexibility of the bearing outer ring a new CMS method has been developed (reference [1.]). The stiffness and damping of the elastohydro-dynamically lubricated contacts between the balls and the guiding rings are modelled with spring-damper models. Their constitutive behaviour has been predicted with the help of transient contact calculations (reference [2.]).

The present work focuses on two sources of vibration. Due to the rotation of the lubricated contacts, the stiffness and damping in the bearing become time dependent, hereby generating parametric excitations. Furthermore, vibrations are generated due to form deviations of the individual bearing components. The form deviations, which are on nanometer scale, are caused by irregularities during the grinding and honing process.

The developed 3D ball bearing model has been successfully validated with measurements on a vibration test spindle. The predicted resonances and the vibrations generated by parametric excitations and form deviations of the rings and the balls agree well with the measured ones. It was found that in the audible range, most of the vibrations generated by the bearing can be related back to form deviations of the balls. It is concluded that the presented 3D model enables a fast and accurate evaluation of the influence of ball bearings on the dynamical behaviour of applications.

References

[1] Wensing, J.A. (1998) On the dynamics of ball bearings, Ph.D. thesis, University of Twente, Enschede
[2] Wijnant, Y.H. (1998), Contact dynamics in the field of elastohydrodynamic lubrication, Ph.D. thesis, University of Twente, Enschede