Dynamic modelling of cage flexibility in Ball Bearings

Karine Petuya [1), 2)], Daniel Nelias [1)] and Alexandre Leblanc [3)]

[1)] Univ Lyon, INSA-Lyon, CNRS UMR5259, LaMCoS, F-69621, France
[2)] Safran Aircraft Engines, Villaroche, France
[3)] Univ. Artois, EA 4515, LGCgE, F-62400 Béthune, France
*Corresponding author: karine.petuya@insa-lyon.fr

The present work models in dynamics a three-dimensional high-speed ball bearing. Its particularity is to consider a flexible cage with both global and local deformations. This model takes into account ball-to-pocket EHD lubrication, shocks, friction and damping. Its purpose is to study the influence of 3D-elastic cage on ball bearing motion depending on operating conditions. Final goal is to know if other cage material than steel or metallic alloys could be used.

Keywords: ball bearings, dynamics, tribology, EHD lubrication, cage flexibility

1. Introduction

Aeronautical industry is currently developing ball bearings with cages made of lighter but softer materials. These high-speed bearings experience three-dimensional ovalization of the cage and local impacts at ball-to-pocket contacts. These are produced during acceleration and deceleration phases, and also during cruise under combined thrust and radial loading. However, few ball bearing models consider today global and local cage elasticity, especially in three dimension. This is why this study aims at developing a dynamic model of ball bearing accounting for a 3D-flexible cage.

2. Methods

2.1. Flexible cage modelling
To model elasticity, the cage is divided into finite elements centred on the bridge as illustrated Figure 1. To compute stiffness, each element is considered as a 3D beam.

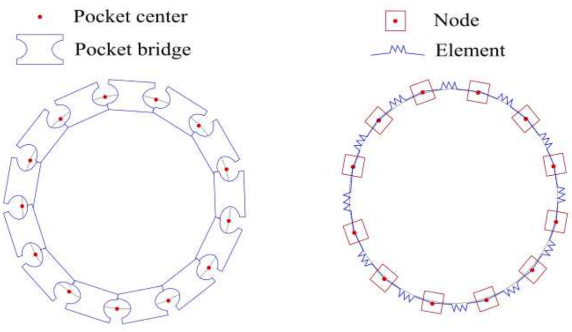

Figure 1: Finite Element cage discretization.

2.2. Ball-to-cage pocket interactions
Afterwards, as schematised Figure 2, ball-to-pocket forces are implemented. These ones differ whether there is contact or not. Indeed, if there is not contact, friction is computed applying barrel-plan and short journal bearing theory [1]. On the contrary, if there is contact, traction law applies to compute shear forces [2]. As well, Nijenbanning's model provides normal load adapted to the lubrication regime [3].

2.3. Dynamic problem
Then, accelerations and additional forces, as lubricant damping, are added to transpose the whole system in dynamics. To solve it numerically, the Runge-Kutta method is used.

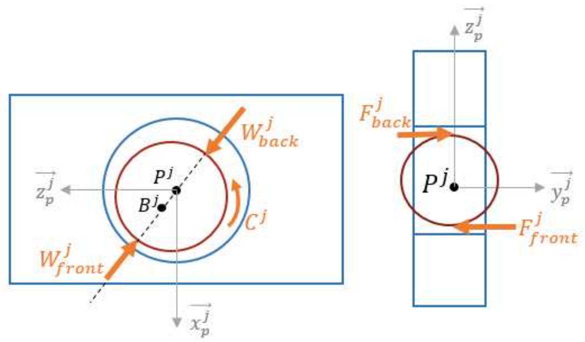

Figure 2: Ball-to-cage pocket interactions.

2.4. Results
This program provides pocket impact loads, cage center motion or cage global deformation depending on the ball bearing operating conditions. It is shown that these variables increase with combined applied forces, rings misalignment or transient operating conditions such as acceleration or deceleration.

3. Discussion

Finally, this study enables to analyse the influence of 3D-flexible cage on ball bearing dynamic behaviour. Nevertheless, improvements could be done to this model which includes different hypotheses. For example, surfaces are assumed perfect whereas ball or raceway flaking is common and tends to modify importantly bearing motion.

4. References

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