# Development and validation of an efficient model for bearing strain creep prediction

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**Abstract**. This contribution presents a novel reduced-order modelling approach for the efficient simulation and prediction of outer ring strain creep in ball bearings. The approach combines analytical modelling of the rolling element interactions with reduced-order finite element modelling of the outer ring and housing. A parametric model-order reduction technique specifically tailored for bearing creep prediction is applied to reduce the computational complexity of the model and allows rapid yet accurate assessment of multiple design iterations. The accuracy of the model reduction technique and overall modelling methodology is validated with numerical simulations and experimental measurements.

## Introduction

Rolling element bearings in modern drivetrains are subjected to high and dynamic loadings. To prevent early bearing failures, predictive tools are used in the early design phase to identify and avoid detrimental loading conditions in the final design. A particularly challenging failure mechanism to predict is outer ring strain creep. This phenomenon occurs when the induced shear stresses at the outer surface of the outer ring locally overcome the static friction force between the outer ring and the housing it is assembled in, causing the outer ring to rotate and eventually wear out the housing bore. Outer ring strain creep has been succesfully modelled using the Finite Element (FE) method by various researchers [1,2], with planet bearing creep in wind turbine gearboxes receiving considerable attention in the last years [3]. However, these modelling approaches rely on commercial FE software combined with high-performance computing clusters, and are thus not suited for repeated design iterations. In this presentation, the main challenges in developing an accurate yet efficient numerical tool for the prediction of bearing strain creep are discussed. These challenges relate to the high number of Degrees of Freedom (DOFs) in the FE representation of the outer ring and bearing housing (see Fig. 1), the relatively long simulated times needed to draw conclusions on bearing creep severity and velocity, and the accurate computation of stick-slip friction forces throughout the large convex-concave contact area between the bearing and the housing.

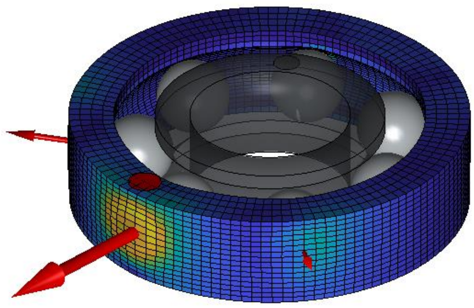

Figure 1: Hybrid reduced-order bearing model used to predict outer ring strain creep velocity.

## Results and discussion

As strain creep is dominated by frictional contact between the deformed outer surface of the bearing's outer ring and the inner bore of the housing, FE discretization is applied only to the outer ring of the bearing, with internal contact interactions being modelled by an analytical lumped-parameter method based on Hertzian contact theory (see Fig. 1). In order to reduce the number of DOFs, a configuration-dependent model-order reduction scheme is applied that is based on a small set of a priori static contact analyses. In order to further increase computational efficiency in dynamic analysis, a separation is made between dynamic and quasi-static DOFs. Finally, frictional contact forces in the interface between outer ring and housing are computed based on a continuous friction model that differentiates between regions of (elastic) stick and (constant or elastic) slip. In doing so, bearing creep predictions in agreement with full-order model simulations and experimental measurements are obtained in a matter of seconds-minutes, rather than hours-days.

## References

[1] Maiwald, A., & Leidich, E. (2013). FE simulations of irreversible relative movements (creeping) in rolling bearing seats–influential parameters and remedies. In Proceedings of the World Congress on Engineering and Computer Science (Vol. 2).

[2] Schiemann, T., Pörsch, S., Leidich, E., & Sauer, B. (2018). Intermediate layer as measure against rolling bearing creep. *Wind Energy*, *21*(6), 426-440.

[3] Gnauert, J., Schlüter, F., Jacobs, G., Bosse, D., & Witter, S. (2021). Simulative investigation of ring creep on a planetary bearing of a wind turbine gearbox. Forschung im Ingenieurwesen, 85(2), 219-227.