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A 360-degree model of lubricant distribution in rolling bearings

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This paper presents the simulation of lubricant distribution in a roller bearing allowing investigation of flow regimes influenced by gravitational, viscous and centrifugal effects at the same time. The efficient application of general-purpose CFD software is adapted to a cylindrical rolling bearing to develop a method applicable for industrial R&D processes. This approach with some simplified details has proven itself in daily usage during the design and engineering process even if the simulation result quality is below of those of scientific publications, but much more time- and cost-saving is.

Keywords: Computational fluid dynamics, full bearing model, rolling bearing, lubricant distribution

1. Introduction

Nearly all kinds of (rolling) bearings need some lubricant to allow separation of the surfaces of the bearing's components from each other. Friction and hence frictional torque of the bearings rise without or with insufficient lubrication whilst too much lubricant means also an increase of frictional torque due to churning losses. Such behaviour is usually described by Stribeck curve [1].

Additionally, the lubricant often fulfils also the function of cooling the bearing itself. This means that there must be a continuous throughput rate through the bearing which is in reality not necessarily the case depending on the application.

2. Chances and challenges of a 360-degree model

Experimental tests can basically show whether the basic design meets the origin specification. Local effects and internal details cannot be visualized in such tests because such areas cannot be "seen" by the engineer and are therefore to be regarded as black boxes. Numerical flow simulations open the view into these zones. Spatial details, resulting volume flow rates and also volumes with over- or undersupply can be determined, visualized, evaluated, and assessed. The advantage of such a process is, e.g., illustrated in [2]. However, the described regime is dominated by centrifugal forces and can hence be solved by a so-called segment approach as it is used also by [3]. Simulation of systems which are also influenced by gravitational effects requires a full 360-degree model, which means an increase of model size and simulated time. Hence, to provide a method allowing results for such a model not only in an academic but an industrial research environment, is extremely challenging.

3. Features of the 360-degree model

In the present paper, a pragmatic grid approach is derived in an efficient process to enable the 360-degree model for industrial applications. The advantages of so-called hanging node approach will be combined with purpose-made strategies to tackle the special needs of bearing simulations. These needs are particular caused by the multiple scales of magnitude present in the flow domain of a rolling bearing. In addition, measures to overcome the effects of the multiple time scales will be discussed.

4. Results

Two aspects of results will be presented from the new approach.

Firstly, results for individual rollers will be presented and compared with existing solutions as well as with basic theoretical approaches such as Reynolds equation. Furthermore, sample 360-degree result is given and discussed showing the interaction of gravitational, viscous and centrifugal forces in details.

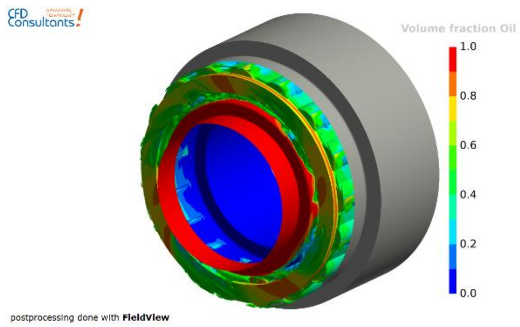

Figure 1: Oil Volume fraction - 360-degree model

5. Conclusions

Not only the bearing itself can be resolved with the help of a 360-degree model but further such areas that are necessary for the actual lubricant supply such as boreholes and inlet channels. This results into possible design evaluation beyond the bearing and thus represents an added value compared to tests and other modelling methods. Details will be shown in this presentation at WTC 2021 and the value added will be demonstrated by means of examples.

6. References

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