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INTERPOLATION STRATEGIES FOR NON-LINEAR PARAMETRIC MODEL ORDER REDUCTION IN GEAR CONTACT SIMULATION

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Abstract:

The need of faster and reliable dynamic simulation of complex, possibly lightweight machines brought in recent years to the quickly growing expansion of the fields of Model Order Reduction (MOR)[6], Parametric MOR (PMOR)[1, 2] and Non-linear MOR (NLMOR) [4]. One particularly challenging problem to be addressed within this field is the solution of contact problems as e.g. in gear simulation. Due to the use of lightweight materials and increasing required performances, flexibility of gear bodies and tooth flanks can no longer be disregarded [5]. This is especially true when quantities like the dynamic stress field are of interest. MOR techniques though inherently show limitations when dealing with problems in which the loads acting on the system can vary their location in time as it appears in gear simulation [3]. This contribution proposes to address this issue by making use of flexible multibody (FMB) simulation coupled with a novel non-linear parametric model order reduction (NLPMOR) strategy, see fig.1.

At first a description of the NLPMOR is briefly presented to highlight its main advantages regarding accuracy, computational performances and flexibility with respect to different applications. One of the key issues when dealing with PMOR and NLPMOR is related to the choice of a proper interpolation strategy used to interpolate between several pre-computed reduced order models [1]. When dealing with gear contact problems in FMB systems, the interpolation strategy has to be applied to the different matrices of the reduced model. A correct interpolation of the reduction space is needed for accurate contact detection while the reduced mass, stiffness and mass-invariants should be properly interpolated for a detailed assessment of the dynamic behavior of the gears both on a global and local level. It is nonetheless unclear how to interpolate these quantities in such a way that issues such as mode veering and crossing are avoided but also consistency between different interpolated quantities is retained. This work shows that for gear applications a parametric reduction space can be found that does not suffer from mode veering and

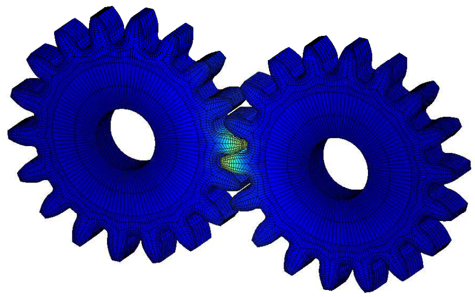

Figure 1: Gear pair in contact

crossing. The base in which the reduction space is represented is selected based on physical considerations. Other more general approaches such as the one in [1] are compared to show advantages and disadvantages of both strategies.

Finally the issue of consistency between interpolation strategies of the different building blocks of the reduced model is studied. It is shown that for a simple linear interpolation of the parametric reduction space, the reduced mass, stiffness and mass invariant matrices should be interpolated quadratically. Nonetheless the consistency of the interpolation strategy does not necessarily lead to more accurate results especially when the sampling of the precomputed reduced order model is performed on a coarse grid.

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