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Time-dependent Parametric Model Order Reduction for Material-Removal Simulations

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Machining of thin and lightweight structures is a crucial manufacturing step in industries ranging from aerospace to power engineering. Practical problems include machining of frame components, milling of blades for aircraft propellers or turbines and many more. The applications demand high geometric accuracy and excellent surface finish. The elastic workpieces, however, deform due to acting cutting or clamping forces. For numerical simulations, typically, Finite-Element-(FE)-based simulations are required to accurately predict the deflection of complex workpieces during machining.

To consider elastic effects as well as rigid body motions, elastic multibody systems (EMBS) are used. In order to enable efficient simulations and solve typical tasks, like the prediction of process stability, reduced elastic models have to be determined by linear model order reduction, [2]. Thereby, the system matrices need to be constant, which cannot be assumed for elastic bodies with varying geometry due to material removal. In [3], parametric model order reduction methods based on the interpolation of reduced system matrices [1, 4] are extended and applied for systems with moving loads, with the restriction that the FE mesh remains constant.

In this presentation we propose a technique to generate reduced elastic bodies for systems with varying geometry and their application in time-domain simulations. Therefore, the interpolation of the reduced system matrices, which are calculated for certain parameter samples individually, is applied. Based on these systems, interpolated reduced systems are calculated and used during the time-domain transient simulation. Due to the fact that the integration scheme in the multibody code has to be adapted, the software package Neweul-M^2 [5] is used. The adaption enables the generation of time-dependent parametric system matrices and the solution of the nonlinear differential equation of the EMBS. Results of the simulation of the material removal are illustrated for the model of a T-shaped plate.

References

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