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On the integration of tuned multi-mass dampers into a topology optimization method for machine tool structural dynamics

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Abstract

Topology optimization is becoming an integral part of the design process in various industrial fields in order to keep up with the continuous drive to increase productivity and efficiency. In the field of machine tools, the dynamic behavior of a machine tool's structure is largely responsible for its overall performance. Thus, topology optimization methods targeting the optimization of Eigen frequencies are often used in industrial practice.

A machine tool's structural frequency response (e.g. to external excitation during cutting processes) is also dependent on its damping properties. Therefore, the dynamic behavior of machine tools can be significantly influenced by utilizing one or more vibration suppression systems like tuned mass dampers (hereinafter called TMDs) to target specific vibrations. Although TMDs are often used to solve problems during operation, they are in some cases utilized during the engineering phase, becoming an integral part of the machine design.

By combining both optimal utilization of vibration suppression systems and topology optimization within a structural optimization framework, potential synergetic effects of both approaches can be utilized.

During the presentation, the recently started development of such an optimization framework including the automatic optimal positioning and analytic tuning of multi-mass dampers (MMDs) is described. The advantages of MMDs include robustness and easy implementation. Besides initial simulative results presented in the paper, practical results using a MMD attachment device prototype will be presented for discussion.

The described optimization framework in development addresses issues like manufacturing constraints for the topology optimization and restrictions on the MMDs physical properties. These constraints will be discussed in the presentation. Also, the challenge of deriving a suitable coupling scheme between the MMD placement and tuning and the topology optimization modules will be described.

The presentation will conclude with a brief outlook on the consideration of constraints for additive manufacturing and the volumetric distribution of multiple MMDs embedded inside those structures.