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Pose-Dependency of Machine Tool Structures: Appearance, Consequences, and Challenges for Lightweight Large-Scale Machines

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Abstract : Large-scale machine tools for the manufacturing of large work pieces, e.g. blades, casings or gears for wind turbines, feature pose-dependent dynamic behavior. Small structural damping coefficients lead to long decay times for structural vibrations that have negative impacts on the production process. Typically, these vibrations are handled by increasing the stiffness of the structure by adding mass. That is counterproductive to the needs of sustainable manufacturing as it leads to higher resource consumption both in material and in energy. Recent research activities have led to higher resource efficiency by radical mass reduction that rely on control-integrated active vibration avoidance and damping methods. These control methods depend on information describing the dynamic behavior of the controlled machine tools in order to tune the avoidance or reduction method parameters according to the current state of the machine. The paper presents the appearance, consequences and challenges of the pose-dependent dynamic behavior of lightweight large-scale machine tool structures in production. The paper starts with the theoretical introduction of the challenges of lightweight machine tool structures resulting from reduced stiffness. The statement of the pose-dependent dynamic behavior is corroborated by the results of the experimental modal analysis of a lightweight test structure. Afterwards, the consequences of the pose-dependent dynamic behavior of lightweight machine tool structures for the use of active control and vibration reduction methods are explained. Based on the state of the art on pose-dependent dynamic machine tool models and the modal investigation of an FE-model of the lightweight test structure, the criteria for a pose-dependent model for use in vibration reduction are derived. The description of the approach for a general pose-dependent model of the dynamic behavior of large lightweight machine tools that provides the necessary input to the aforementioned vibration avoidance and reduction methods to properly tackle machine vibrations is the outlook of the paper.

Keywords : dynamic behavior, lightweight, machine tool, pose-dependency
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