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Multidisciplinary Multi-Body Modeling of Machine Tools

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Abstract: This paper deals with a multi-body modeling of machine tools with actuators. The aim of this paper is demonstration of a multibody dynamics during design process of the machine tool and choice of an optimal actuator. The modern machine tool is a mechatronic system and usage of simulation modeling is a necessary step in the development process. The model-based design of the several modern machine tool assemblies is presented in this paper. This modeling technique can be used to determine the force of interactions of individual machine parts, dimensional drives, modal and harmonic analysis, etc.

Introduction

This abstract presents a modelling and a mechatronic development process in branch of machine tools. The modern machine tool is complex mechatronic system with integrated adaptronic systems. The development process of modern machine tools uses several modeling techniques and tools for design (CAD environment), multi-body dynamic analyses, finite element method computations, thermal analyses and electronics design techniques. The main aim is prediction of behavior of the developed machine tool and its optimal design with respect to customer requirements. A virtual prototype of machine tool is useful tool [1] for specification of its performance before it is built up. The accuracy of the prediction depends on complexity of the virtual prototype model.

The presented development process is based on multi-body model in MSC.ADAMS environment. The multi-body model represents mechanical parts of the machine tool assembly. This model allows to introduce connections to other multidisciplinary actuator system or adaptronic model and co-simulation of both models in other simulation environment like Simulink. The presented assembly of machine tool is created with rigid and flexible bodies of the machine tool. The analyses of this model are very useful for choice of actuators and for development of active damping systems.

The mechanical model is created in several development steps. The initial mechanical model with rigid parts is used for dynamic analyses of force interaction. As a next step, the CAD models are created and used for finite element analyses. The results of reduced finite element analyses are imported to the model and the improved mechanical model with flexible parts is used for static, harmonic and transient analyses. Furthermore, the model of mechatronic actuator or other developed adaptronic system is included [2]. The presented approach will be shown for a spindle, which is the key element of several types of machine tools.

Task formulation and spindle model

The spindle is very important part of machine tool and its operation affects quality of a workpiece and lifetime of tools. The spindle design has to respect accuracy and performance requirements; it means high the static and dynamic stiffness and stable thermal properties. The spindle stiffness characteristics are usually determined using finite element method with calculated or predicted boundary conditions.

The presented model use multi-body model of the spindle, where the flexible parts are used for direct calculation of the spindle stiffness characteristic, the results compared with measurements. The model is useful for choice of suitable actuator for high performance cutting and complex dynamic analyses. The verified model will be used for design of an active damping system for high performance cutting process.

The spindle model is shown in Fig. 1. This model was developed in several steps [3] and was compared with real measurement. The complex multi-body model consists of flexible mechanical parts which were created from CAD models on the basis of Craig-Bampton reduction. These parts are placed in models of bearings with radial and axial stiffness and damping. The mechanical parts are connected with an actuator. The model includes preloads of actuator and bearing assemblies. A cutting force is applied to the tool; it provides the real model of cutting process. The cutting velocity is assumed during simulation, the displacement of the spindle is observed for static and dynamic analyses of the spindle behavior. The simulation results together with measurements are shown in Fig. 1. The left graph plots the dependence of displacement of the spindle on applied force, whereas the right graphs shows the same plot for stiffness of the spindle. .

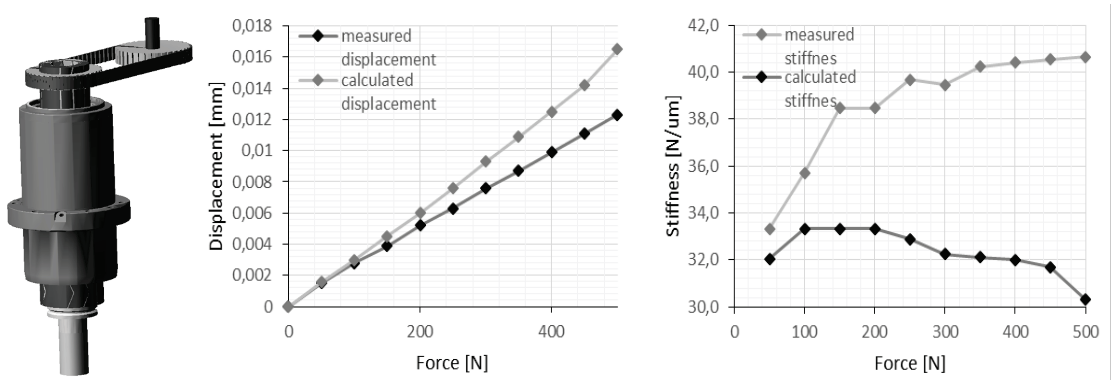

Fig. 1: Spindle model and verified static analyses of displacement and stiffness

Summary

The presented verified mechatronic model of the spindle provides a useful tool for actuator optimization study and the development of active adaptronic system for increasing of the cutting performance of a machine tool. The full paper contains more detail results and analyses.

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References

[1] Y. Altintas, C. Brecher, M. Weck, S. Witt, Virtual Machine Tool, CIRP Ann. - Manuf. Technol., 54 (2005) 115–138.

[2] Z. Hadas, T. Brezina, O. Andrs, J. Vetiska, L. Brezina, Simulation modelling of mechatronic system with flexible parts, in: 15th Int. Power Electron. Motion Control Conf., pp. LS2e.1–1–LS2e.1–7, Sep. 2012.

[3] VDI - Association of German Engineers, VDI 2206 - Design methodology for mechatronic systems, Design. p. 118, 2004.