TORNOS

Diploma Thesis proposal

Tornos SA
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Thermal Drift Correction through use of Thermo-Mechanical FEM and Model Order Reduction

Company profile

Tornos is a manufacturer of swiss-type automatic lathes and multi-spindle lathes, whose headquarter is located in Moutier (Switzerland). The company's history dates back to 1880, placing Tornos at the beginning of Swiss-type lathe technology. With its 728 employees (FTEs), Tornos Group generated sales of CHF 214.9 million in 2018.

Problematic

At start-up, our machines experience a warm-up phase during which the Tool Center Point (TCP) moves with respect to the machined bar due to thermal deviations, which might give rise to out-of-range machining parameters and parts rejection during quality control. Most of the time customers counteract these situations by dedicating a warm-up phase during which the machining program is launched without bar feeding.

Our interest in improving our Machine Overal Equipment Effectiveness (as well as in environmental friendliness) encourages us today to implement Thermal Drift Correction strategies in order to reduce the time needed to reach a stable machining process.

Project Description

A bibliographic survey oriented our reflection on using Finite Element Modeling (FEM) in order to represent the underlying physics in this problematic. FEM allows most of the time to rewrite the discretized set of equations into the form :

$$\begin{cases} E(t)\dot{x}(t) = A(t)x(t) + B(t)u(t) \\ y(t) = C(t)x(t) \end{cases}$$

The main challenge in for modeling machine tools is the dependance of the system's reponse function to the machine configuration (position of axes, on/off systems, etc.) which has been depicted with time dependency.

Such systems moreover usually contain hundred of thousands of nodes, which makes them practically impossible to simulate in real-time on a machine CNC. The following topics should therefore be addressed :

- Design of Experiment (DoE) for simulating the machine structure in all relevant configurations
- Model Order Reduction (MOR) of time-varying dynamical systems in order to reduce the size of the problem's matrices

And if time permits, going further on:

- Implementating a Digital Twin with feedback loops (observer/estimator based), typically relying on data returned by the machine NC (axis motor consumptions and trajectories, etc.) as well as temperature measures (ambiant, machine components, cooling and cutting oils, etc.)
- Test the resulting Thermal Drift Correction strategy

Foreseen development platforms

- ANSYS Mechanical (and/or MAPDL) : mandatory
- Meshparts : optional
- Scilab, Octave : wished (Matlab : optional)

Addressed topics

- Thermo-Mechanical FE modeling
- Model Order Reduction of Time-varying Dynamical Systems
- Simulation of Dynamical Systems and Control Theory
- (Programmation of Real-Time Operating Systems)

Motivated candidates interested in these topics are highly recommended to submit their application.

Bibliography

Lang, N., Saak, J., & Benner, P. (2014). Model order reduction for systems with moving loads. *at-Automatisierungstechnik*, 62(7), 512-522.

GALANT, Alexander, BEITELSCHMIDT, Michael, et GROßMANN, Knut. Fast high-resolution FE-based simulation of thermo-elastic behaviour of machine tool structures. Procedia CIRP, 2016, vol. 46, p. 627-630.

Benner, P., & Faßbender, H. (2015). Model order reduction: Techniques and tools. *Encyclopedia of Systems and Control*, 722-729.

If you are interested or have questions, please contact Dr. Lars Penter directly / bei Interesse oder Fragen melden Sie sich bitte direkt bei Dr. Lars Penter vom LWM/TU Dresden:

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