RELIABILITY OF THE TURNING PROCESS. MODELS IN MACHINING PROCESSES.

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Abstract: The concept of virtual production (VP) involves reproducing a complete virtual model of the machine tool, its processes and auxiliary devices. This allows the feasibility of the process to be visualized without the use of real tests.

Keywords: mathematical model, virtual machines, software platform, intelligent utility.

Introduction

Today, digital manufacturing is based on the integration of computer-aided design (CAD)/automated manufacturing (CAM) applications on PLM tools.

In this way, CAM allows you to move "virtual cutting tools" across digital surfaces of the part, creating code that the CNC uses to move "real tools" in the workpiece. Currently, virtual simulation tools can create virtual models of (I) the machine tool; (II) the workpiece; and (III) the cutting tool, and simulate machine movements and subsequent material removal, allowing a quick check for interference, excessive tool meshing, and collisions. The risk of collision caused by an incorrect machining operation is a constant nightmare for any machine tool programmer, worker, and managing director. The concept of virtual production (VP) involves reproducing a complete virtual model of the machine tool, its processes and auxiliary devices. This allows the feasibility of the process to be visualized without the use of real tests. If the evaluation is positive, the operations are transferred to a real production facility. Following the ideas of digital and virtual manufacturing, the Virtual Machine Tool (VMT) concept is a software platform with multiple approaches in which users can interact to evaluate different machine tool architectures.

For example, complex operations can require hours of preparation for machine setup, during which time the machine runs unproductively; using expensive production machines to form operators is another example of lost productivity. Many companies try to exhaustively utilize (around the clock) their production capacity, so using "virtual machines" is a good way to eliminate downtime. However, whenever machines are on, it is important to have 100% confidence that no collisions, interference or excessive tool engagement with the workpiece will occur. Instead of the traditional step-by-step verification of CNC programs, the WPT verifies them on conventional PCs [9]. The VPT is a set of software components: A 3D machine model with machining simulation software and a machine/human interface (MHI). The organizational logic of the virtual system is divided into two functional axes. One axis characterizes the machine design under certain conditions (loads, temperature, etc.), and the other is related to machine element movements and associated errors. The programmed movements, possible errors, deformations caused by process forces, and heating from multiple sources result in relative motion between tool and workpiece, which forms the final surface of the workpiece. A high quality VPT must predict cutting forces, temperature fluctuations, and the end result, which will be the size/sharpness of the machined parts. During postprocessing, the VPT graphically simulates and verifies programs. To date, the process models included in the WPT have been very simple, without the use of deep process models; this lack of deep process models is what prompted the present approach.

Internet-based manufacturing improves communication between manufacturers, customers and suppliers, and plays a key role in shortening time to market. Information integration is now called Industry 4.0, a high-tech strategy promoted by the German government that promotes the computerization of conventional industries such as manufacturing. The installation is the SmartFactory, which is characterized by adaptability, return on resources and ergonomics, and integration of buyers and business partners in business processes and price creation. Future wireless networks in the factory are expected to remotely control manipulators and robots, as well as CNC machines.

On the other hand, remote monitoring is already offered by some major machine tool manufacturers. For example, the e-Tower machine from Mazak® offers a virtual assistant to set up and support maintenance in or out of the office, targeting control functions, work scheduling, mobile alerts, etc. DMG-MoriSeiki®'s WebMonitor connects any machine to a Web-based platform. In both cases, users can log into the control system to access this information remotely from any Internet-connected device and see the current status of their machine.

The work presented here describes a new utility for predicting, evaluating, and monitoring machining processes in manufacturing plants. The modular software includes the ability to predict key quantities in machining processes based on models that include the static and dynamic behavior of the machine/workpiece system. It also works with experimentally derived signal data to make a priori decisions or in-process decisions. Because of this multiple concept, the software can be used at different stages of production, whether at the process definition stage (designing the workpiece clamp, choosing the machine tool architecture), at the machine tool programming stage, or even on-site by the machine tool operator. In this way, it can become an important "intelligent utility" for structuring process steps.

The aforementioned state of affairs raises the need for simulation packages that represent the performance of the production system. Although most of the common processing problems have been partially solved in the literature, it seems that the available solutions are more often used in the academic or scientific community, rather than being adopted by the industrial sectors. To bridge this gap, or more simply, to achieve the goal formulated as "make the models work!", there has been a vigorous effort in recent years. Solutions can be classified according to whether optimal cutting parameters are selected before (prediction, out of the process) or during cutting (in the process, i.e., reactively).

On the one hand, predictive or autonomous methods can help determine chatter-free machining conditions. They are applied before cutting, but require experimental information about machine/workpiece dynamics and cutting parameters. For example, Cutpro®, developed by Prof. Altintas, is a well-known chip removal simulation software that solves the process stability equation in the frequency domain. Recently, this lab released a new, more sophisticated software called MACHpro®, which allows the integration of a given system fit into a CAM module aimed at optimizing the toolpath (both trajectory and cutting parameters) from a dynamic perspective. On the other hand, in-process methods monitor the processing of significant quantities, such as energy consumption or vibrations, which are analyzed in real time, acting through a rapid change in the speed of the machine spindle. The onset of debouncing is identified by comparing it to a threshold value. The main disadvantage of this reactive approach is that traces of chatter/vibration are imprinted on the workpiece before the command to change cutting parameters is given. For example, AccordMill® records an audio signal during cutting, which is then filtered from noise and post-processed before being converted to the frequency domain. The optimal spindle speed is calculated based on the measured vibration frequency, the system's own frequency, the initial spindle speed and the number of teeth of the end mill. However, when the cutting depth is too great or in finishing operations, where the vibration modes vary noticeably (in magnitude and direction over time), this solution is difficult to converge.

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