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Virtual High Performance Machining

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Abstract

The goal of current research is to develop digital models of all steps in the manufacturing of parts. This paper presents an overview of digital machining of parts in virtual environment. It is based on research and development of digital models in machining parts. The tool – part intersection along the tool path is evaluated at discrete steps, which are then used to calculate chip area, cutting load, torque-power-energy drawn from the machine and the detection of chatter occurrence. The dynamics of the CNC system are incorporated to the digital model in order to estimate the true tangential feed and machining cycle time. The tangential feeds are automatically optimized by considering the tool breakage, spindle torque-power, and tool deflection limits set by the process planner. The virtual machining system can be used independently or as an integral part of CAM systems such as Siemens NX. Sample applications of the virtual high performance machining system in aerospace industry are presented.

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Keywords: Machining; machine tools; virtual

1. Introduction

The aim of present research is to create a complete digital factory that allows the simulation of product design, manufacturing and testing in the virtual environment [1]. While some of the simulation models are mainly based on geometry, such as visualization of features and motions, a realistic digital model must be able to predict the machining process states such as force, vibration, surface quality and machine errors. Presently, these process states are measured during costly physical trials. This paper presents a brief overview of High Performance Virtual Machining technology developed at the University of British Columbia – Manufacturing Automation Laboratory (UBC MAL). The system consists of machining process simulation kernel, machine tool controller kernel and graphical system to display the results and interact with the user. The scientific details of the simulation algorithms for each module have been published in the literature. However, the overall architecture of the Virtual High Performance Machining system is given as follows.

2. Process Planning for Optimal NC Programming

The tooling and machining tool paths are currently selected by process planner who rely on their past experience and intuition. When the parts are costly, like in aerospace industry, the planners tend to select conservative material removal rates to avoid chatter, tool failure or overloading of the machine tool. UBC MAL developed an advanced machining process simulation software (CUTPRO™©) which predicts the chatter free depth-width of cut, feed and speed by considering the work material properties, tool geometry, machine tool's structural dynamics [2]. The planner can select a chatter free cutting condition and virtually simulate forces, torque, power, surface form errors and vibration amplitudes to check if the selected parameters would lead to acceptable performance without violating the machine's torque-power and part's tolerance limits as shown in **Error! Reference**

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source not found.. The selected optimal cutting conditions are used in setting the speed, depth, width and feed in generating the NC program in CAM environment.

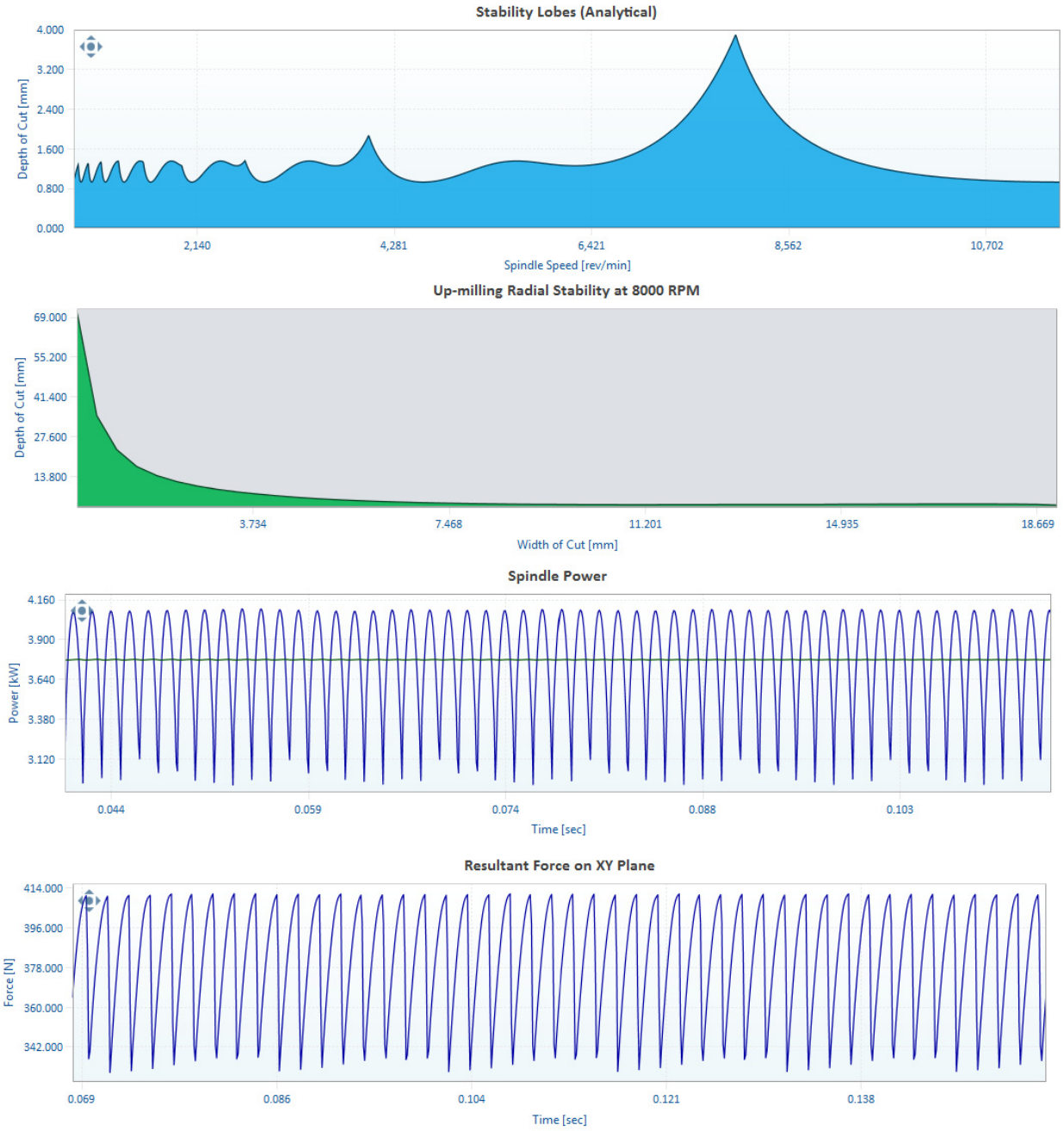

Figure 1: Stability lobes give the chatter free depth of cut, width of cut and speed. The process can be simulated at a desired cutting condition.

3. Virtual Machining System

Once the NC program is generated in CAM environment, its performance needs to be evaluated either physically on the machine tool which is costly, or in a virtual environment. UBC MAL has developed MACHPRO™ stand-alone virtual machining system and its derivatives which are embedded to commercial CAM platforms [2]. MACHPRO receives the raw workpiece geometry in the form of STL file and NC tool path in standard APT format. It uses CUTPRO tool, work material and process simulation engine to predict the cutting process states such as force, power, torque, surface form errors and chip area at discrete stations along the tool path. Alternatively, MACHPRO can re-produce a new NC program by varying