Mechanical Engineering

April 2008

CUT CORRECTLY

BYLINE: Thilmany, Jean.

By Jean Thimlany, Associate Editor

SECTION: FEATURE FOCUS MANUFACTURING; Pg. 24 Vol. 130 No. 4 ISSN: 0025-6501

LENGTH: 2140 words

ABSTRACT

Tony Schmitz, mechanical engineering professor at University of Florida, has an interest in manufacturing research and is looking to minimize machine chatter, which can cut the effectiveness of machine tools. His work toward this end is part of the Smart Machining Platform Initiative. The smart machine, which may be ready for its debut by mid-2010, would save manufacturers time and expense by greatly reducing waste and by speeding the machine-cutting process, Schmitz said. Software will collect machining and part information and use that information to automatically make adjustments to the cutting process. The goal is to marry hardware and software to create a machine that constantly monitors itself and conveys vital information to the operator and process planner. In order to make predictions about the best operating parameters, temperature, and flow for each part, the smart machine will need a way to simulate many different scenarios.

FULL TEXT

A metal-cutting machine that helps program itself, and trim manufacturing costs, is only a few years out.

Tony Schmilz is concerned about chatter. He's okay with idle chitchat, mind you. But the University of Florida mechanical engineering professor has an interest in manufacturing research and is looking to minimize machine chatter, which can cut the effectiveness of machine tools. His work toward this end is part of the Smart Machining Platform Initiative. It was founded five years ago, when a number of machine-tool manufacturers, commercial software developers, researchers, and government agencies joined forces to create a computer numerically controlled machine that would make parts within tolerance the first time out. Organizations involved in the initiative include the National Institute of Standards and Technology of Gaithersburg, Md.; the National Coalition for Advanced Manufacturing in Washington, D.C., and **TechSolve** of Cincinnati. The Cincinnati organization serves as a catalyst to integrate different commercial technologies into a smart-machining whole.

The smart machine, which may be ready for its debut by mid-2010, would save manufacturers time and expense by greatly reducing waste and by speeding the machine-cutting process, Schmitz said.

"Manufacturers have really been squeezed these past few years and are looking for ways to be more competitive," he said. "I really think smart machining offers that hope."

Those in the know often refer to the Smart Machining Platform Initiative's goal in shorthand coined by NIST: first-part correct. In other words, the machine would eliminate the trial and error that can be a way of life for machine operators when machining a part to exact tolerances.

The objective is to provide a CNC machine tool that can make parts better, faster, and at lower cost than today's machines.

"Lots of folks talk about the smart machine being autonomous," Schmilz said. "Software will collect machining and part information and use that information to automatically make adjustments to the cutting process."

Yes, metal cutting today is automated, but much about the cutting process depends on the machinists, who learn the ins and outs of their machines and best programming practices after years on the job. They tend to bring their own biases to the job, bringing a uniquely human element to an otherwise automated process.

"The operators who program these machines are pretty smart, but they might choose conservatively or they might get machine chatter that affects the part. So then, after seeing the part, they need to readjust parameters," Schmitz said. "With smart machining, we hope to avoid having to change operating parameters and part programs after making that first part. We don't want to make it and see what happens. We want to know what's going to happen beforehand and do it exactly right from the get-go."

A SMART MACHINE KNOWS

The goal is to marry hardware and software to create a machine that constantly monitors itself and conveys vital information to the operator and process planner. If the smart machine knows-based on its software algorithms and past experience-that it can't make a part to tolerance without vibrating, it can convey that information to the operator, said John Snyder, program manager for smart machining at **TechSolve.**

The smart machine that results from these efforts will make decisions about the manufacturing process in real time. It will understand how to best make a part. It will diagnose and correct deviations. And it will learn from past experience to optimize cutting in the future. It will also give operators feedback about the remaining life of cutting tools, spindles, bearings, and other parts so they can replace parts before quality degrades, Snyder said.

Surprisingly, much about what happens technically inside the machine or during cutting isn't yet well understood or can't be depicted with software simulations. The machine plays out many different physical scenarios as it does its job. Metal cutting involves disciplines ranging from metallurgy to thermodynamics and mechanics. The cutting process creates fluctuating temperatures, and re lies on coolant flows that have to be modeled to be understood. NIST is working toward those models.

The machine itself is subject to vibration and chatter. In order to make predictions about the best operating parameters, temperature, and flow for each part, the smart machine will need a way to simulate many different scenarios. It will then automatically choose the best one, Schmitz said. This is where his work comes into play.

Machines are subject to chatter and vibration that can disrupt part production. The smart machine will need simulation tools and information to find the cutting route that avoids chatter.

SYSTEM OF INTELLIGENCE

While the Smart Machining Platform Initiative is expected to result in an actual machine, the initiative itself is really an attempt to bring together all the disparate aspects-the predictive models and the hardware-that would make up the machine. The goal is to develop a smart system, a whole made up of individual parts. In some cases, software, hardware, and sensors must be fashioned from scratch or programmed to operate in a certain manner. Integrating everything is yet another challenge, Snyder said.

"An individual smart component is only so smart," Snyder said. Putting a smart component together with others can create a smarter system. According to Snyder, the Smart Machining Platform Initiative is trying to do that. "The concept is to take what's out there and modify it, creating it where we need to," he said.

Thanks to its on-board software, the smart machine will know the best way to make a particular part. It will generate its own cutting tool path based on that information and its own tool list.

Sensors will continuously monitor the machine to ensure that vibration, chatter, or tool wear isn't creating a part that's out of tolerance. In such cases, it can adjust operating conditions as necessary, Snyder added.

While those at work on smart machining expect to bring in the software and hardware from various vendors, and perfect it to their needs, they'll need to create a mechanism that controls the overall process. A kind of digital supervisor, Snyder termed it.

"That's the missing component we do have to develop," he said. "There are supervisory systems, but they're designed for certain processes, and ours doesn't fit."

The search for a smart machine is now in its second phase. During the first phase, members surveyed technologies to find the right applications for their needs. They fit the technologies into a test-bed platform at **TechSolve,** identified their capabilities and limits, and-when necessary-started the process again.

During phase two, the focus is on developing the supervisory system. According to Snyder, this second phase could be complete by September.

"Then we'll integrate everything and bring it together into a full system by the end of the program," Snyder said.

The program is set to end in two and a half years, and Snyder said he expects a fully integrated system to be assembled by then.

TOOL SOFTWARE

Although **TechSolve** acts as the project integrator in some way, the initiative is a concerted effort, with various players each contributing a part.

Schmitz at the University of Florida, for instance, is creating process and structural dynamics simulation models. Design and manufacturing can't be decoupled, he said. A process planner would use the models to simulate various scenarios before manufacturing begins.

According to Schmitz, "The models will show you: If I tell it to move around some path, how well does it do that? IfI have a cutting tool and holder combination in the spindle, what's the frequency response function? And that information can lead you toward selecting operating parameters that would give you this chance for first-part correct."

Schmitz's application would also simulate how a tool path would actually move during the machining operation rather than how an operator expects it to move.

"Say you've got some cutting tool you're using to remove material from a workpiece. If everything were rigid and the tool moved where you told it to, it'd be great. But that's not the case," Schmitz said. "In many cases, there's some error between the tool path you commanded and the one you actually got."

The nonrigid cutting tool can vibrate and affect the machining process. High vibration rates can cause the chatter that disrupts machining.

"We're trying to predict how those vibrations affect the cutting process," he said.

"If I know how the tool wants to vibrate, I could select machining conditions that offer small vibration but high removal rates," Schmitz said. "The process planner, with those models in hand, can see: I can select this spindle speed and axial depth to avoid chatter."

When Schmitz combines his process models, which depict the cutting away of material, with his dynamics models, which show how the machine would operate under certain conditions, he comes up with an even more powerful overall tool for the process planner who carries out the CAM programming.

But there's still more work to be done in terms of offering help to the process planner. The models Schmitz is perfecting will have to be integrated with other aspects of the smart-machining system. Take the tool-condition monitoring software. This application alerts operators when a tool shows wear. Schmitz's models could demonstrate how wear would affect that cutting process.

According to Schmitz, "That's the point we're at now: How do they best work together and how do you pull it off?"

Similarly, at the University of British Columbia in Vancouver, Yusuf Altintas, a virtual machining professor, and his team are developing mathematical models of the milling process, mechanics, dynamics, spindle dynamics, CNC performance, and vibration stability. As part of the project, his team has integrated these models into a virtual machining system that can take the standard part geometry and the numerically controlled program and automatically simulate the process along the tool path in CAM software.

The team's virtual machining system predicts forces, torque, power, vibration, and CNC and tool deflection error, and optimizes the cutting conditions along the tool path for the shortest production time for successful manufacture.

SELF-AWARENESS

But how can software developed at these two institutions become aware of such operating conditions as tool wear?

The overall smart machining challenge now is to develop sensors that will monitor a machine and give vital feedback to the process models that need that information.

"The current sensors are either impractical to mount or have low bandwidth to measure forces at high spindle speeds," Altintas said. "The lack of practical cutting force sensors is the fundamental obstacle in implementing a number of very advanced smart machining, adaptive algorithms developed in academia."

And one other major issue is what Altintas called the commercial challenge. How would CNC machine makers gain access to the software and hardware? Who would sell the smart machine?

That's another road to cross.

"We're not sure how customers would get it yet," Snyder said.

A number of Smart Machining Platform Initiative advisory groups are at work on the problem. Schmitz is glad to contribute his part to the plan without a role in the commercial challenge.

"The SMPI program and **TechSolve** have many commercial partners that are thinking: How do we work together to commercialize this?" Schmitz said. "But I'm just Tony at the University of Florida. I work on my models."

SIDEBAR

Even a state-of-the-art machine floor like this one might benefit from the advent of the smart machine, which will further automate the cutting process and could save manufacturers time and money lost to rework.

SUBJECT: MACHINE TOOLS (91%); RESEARCH & DEVELOPMENT (91%); MECHANICAL ENGINEERING (90%); COLLEGES & UNIVERSITIES (90%); ENGINEERING (90%); METALWORKING EQUIPMENT MFG (90%); FACTORY WORKERS (89%); SOFTWARE MAKERS (78%); INDUSTRIAL AUTOMATION (78%); COMPUTER PROGRAMMING (76%); SYSTEMS INTEGRATION (75%); US FEDERAL GOVERNMENT (75%); STANDARDS & MEASUREMENTS (69%) Cutting tools; Research & development--R&D; Machine tool industry; Systems integration; Automation; Simulation

PERSON: Schmitz, Tony

GEOGRAPHIC: CINCINNATI, OH, USA (71%) FLORIDA, USA (94%); MARYLAND, USA (79%); DISTRICT OF COLUMBIA, USA (79%); OHIO, USA (71%) UNITED STATES (94%) United States--US

CLASSIFICATION: 9190 United States; CLASSIFICATION: 5400 Research & development; CLASSIFICATION: 8670 Machinery industry; CLASSIFICATION: 5240 Software & systems

LOAD-DATE: April 28, 2008

LANGUAGE: ENGLISH

ACC-NO: 28788

GRAPHIC: Photographs

DOCUMENT-TYPE: Feature

PUBLICATION-TYPE: Magazine

JOURNAL-CODE: MEG