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Machine SMARTS

An array of tools allows machine tools to work smarter—not harder.

The numbers say it all. For the past year, the capacity-utilization percentage has been stubbornly stuck in the low 70s. In April, machine tool orders reached a 20-year low.

Larry DuFord, vice president of operations for machine tool distributor Ellison Mfg. Technologies, Santa Fe Springs, Calif., said his "customers don't necessarily need another machine tool or spindle or even another distributor. What they're really telling us they need are ways to save money and cut costs on a continuous basis, every year."

One way to cut costs is with "intelligent machining." This is accomplished by integrating machine tools with sensors, monitors and advanced controls to allow manufacturers to machine parts quickly, accurately and efficiently.

Progress on this front has come in fits and starts. Part of the reason, said Brian Ferguson, applications engineer for Hardinge Inc., Elmira, N.Y., is it simply hasn't been worth the trouble to optimize processes for the growing small-lot environment in machining. Hardinge contributed to intelligent machining in the early '90s, when it introduced the Automatic Thermal Compensation System. Standard on all of its SP (Super Precision) machines, the system can sense minute movements of machine tool components caused by thermal expansion and automatically compensates for them through the control.

GE Fanuc

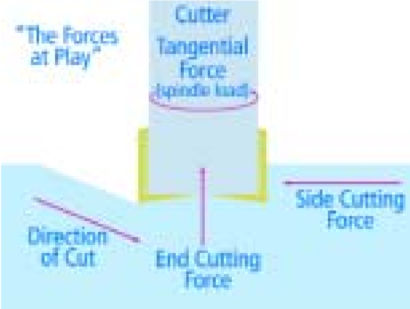
Naturally, the prime mover behind intelligent machining is computer technology. Smooth integration of computers and machine tools is key.

However, Sam Marinkovich, president of Active Automation Inc., Elk Grove Village, Ill., said computers and machine tools have not always been a good fit. He said the power of computers has outstripped that of machine tools, and the question today is how to make machines more compatible with advanced computers.

Today, progress in intelligent machining comes from recent developments in adaptive controls, machine tool optimization software and other software solutions that contribute to more efficient and smarter machining. To that end, let's take a look at what they are and their benefits.

Adopting Adaptive

While the concept behind adaptive controls is not new, implementing them certainly seems new, at least to Bill Griffith, Charlottesville, Va.-based GE Fanuc Automation Inc.'s CNC products manager. Though the technology has been around since the early '70s, it didn't catch on because the hardware was too slow. Back then, the real action was



CG Tech

Figure 1: CG Tech says spindle load, or tangential force, is not greatly affected by end cutting. Because adaptive control uses spindle load to control feeds, it may not detect poor cutting conditions and slow the feed when necessary.

integrating CNCs and machine tools.

The idea of intelligent machining with adaptive controls was somewhat ahead of its time. "The problem was controls weren't really fast back then, and you couldn't 'close the loop' fast enough to do a good job with adaptive," Griffith said. "Today they are."

The main factor that makes adaptive controls more feasible today is open-architecture controls. Nonproprietary systems allow for much greater flexibility in selecting software to run them. "They really opened up adaptive for third parties to get in and do a good job," said Griffith.

For Wayne Kotania, Fanuc's open-systems product manager, another factor is the attitude of today's end users. "They have very high incentives to get into lean manufacturing and increase productivity," he said. That is bringing adaptive controls and other related products to the forefront and making the customer's existing assets work smarter and better.

Griffith said modern adaptive controls must be able to read the spindle load quickly. The adaptive control then runs an algorithm that calculates the spindle load and the programmed feed and applies the result to modify the actual feed rate and maintain a constant spindle load.

In GE Fanuc's *i*Adapt adaptive control product, the adaptive algorithm is embedded in a PID (Proportional, Integral, Derivative) loop within the module. A PID is a means by which a constant condition is maintained despite changing variables. For instance, a home's programmable thermostat or a car's cruise control are forms of adaptive controls. The former turns an air conditioner up or down, according to the ambient temperature, and the later maintains a car's speed by activating the accelerator on an incline.

Putting a PID loop within the module is a significant improvement, Griffith said, because older adaptive controls couldn't react, or close the loop, fast enough. In other words, as the spindle load changed, the adaptive mechanism couldn't respond fast enough to change the feed rate. Griffith said *i*Adapt, however, can respond to spindle load changes within milliseconds.

The primary means by which adaptive controls operate is through feed-rate overrides. On some machine tools, Griffith said a feed-rate override switch can be set up to 120 percent of the programmed feed. In general, the overrides can be set in 10 percent increments.

The Fanuc *i*Adapt can override the programmed feed by up to 255 percent. In addition, the *i*Adapt can be adjusted in 1 percent increments, which provides improved feed-rate control.

By adjusting feed rates on the fly, Fanuc says cycle times can be reduced by up to 40 percent when rough milling. The company adds that the time savings start from the very first part. Therefore, claims Fanuc, there is no need to run test parts to fine-tune the cycle.

Automation, of course, is the handmaiden of adaptive controls. Andy Winzenz, product manager for Bala-Dyne Corp., Ann Arbor, Mich., a manufacturer of adaptive controls for balancing spindles, said, in many cases, shops are organized so that one operator watches over 10 to 15 machines. "There's not a dedicated operator anymore."

Like many adaptive controls, Bala-Dyne's balancing system is tied in directly to the machine control. After a certain number of parts are machined, the control checks the balance on the wheel. If the spindle's out of balance, sensors signal the control to make a correction.

Kotania pointed to *i*Adapt's ability to engage automatically when necessary. "It has a switch that you set. When you get up to a certain percentage of spindle load, it engages the adaptive control automatically."

The Optimized Option

Adaptive controls are not a total panacea. According to Jeff Werner, marketing and communications manager for CG Tech, the Irvine, Calif., provider of Vericut machining-simulation software, machine shops should carefully consider certain issues before adopting the controls.

Werner said adaptive controls behave differently on different machines and different CNCs. And, as with any electromechanical system, adjustment, reliability and maintenance can be ongoing concerns.

Another concern with adaptive control is the fact that it's a "reactive" system, said Werner. According to CG Tech, adaptive controls adjust feeds, based on feedback received from the spindle-drive motor, to maintain a constant load on the spindle drive. The company concedes this kind of optimization may be ideal for very rigid cutters that can sustain a heavy load, such as facemills or large endmills, but said spindle-load optimization cannot always provide optimal feeds for a wide variety of metalcutting tools.

Using a low-spindle-load operation, such as ramp milling, as an example, the company says that while the load is increased on the axial motors feeding the tool, this does not mean the spindle load increases equally.

In addition, CG Tech said high-performance carbide inserts are designed to cut as freely as possible, so they don't require much horsepower to work at high metal-removal rates. The company also says that spindle load is a poor indicator for determining maximum feed rates, because the increased spindle load is negligible, even if the feed rate is too high.

Werner said the toolpath-optimization module of Vericut, OptiPath, automatically adjusts feeds based on specific cutting conditions for each segment of the toolpath—before the cutter engages the workpiece. It makes its determination from verification of the solids model. Rather than react to feedback from the spindle, Werner said, the software assigns the optimal feed beforehand, based

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on cutting conditions, such as mrr, DOC, width of cut and cutting angle.

Instead of striving for constant spindle load, OptiPath maintains a constant cutter load. In the ramping example, maintaining a constant cutter load would result in safer feeds, said Werner.

Intelligent Software and Hardware

An integral element of intelligent machining is data collection. Like people, a tool can't take an "intelligent" action unless it knows in advance the informational context of that action and it's likely outcome.

The predictive module of the company's software monitors certain characteristics and signatures of the machine. "Machines today are capable of looking at their own accuracy and being able to predict, over time, if it's within tolerance," he said.

David Welsh, president of DLoG Inc., Elgin, Ill., a provider of JobPack, a DNC software package with a set of modules designed to eliminate paper from the factory floor, said up to 30 percent of machines in a given shop are not running, due to setup requirements. The machine tool and process-monitoring module of the JobPack system, for example, can measure the length of the setup process and provide an accurate picture to management.

"The reports define the action that needs to be taken," he said. This is critical when it comes to billing customers, because the shop can then provide an accurate statement of machine usage.

Advanced data-collection capabilities, in conjunction with adaptive controls, can also relieve programmers from performing unnecessary calculations, said Martin Roderick, applications engineer for Mazak Corp., Florence, Ky. The company's Mazatrol Fusion 640 control, with its added adaptive-control capability, has a Navigation function that graphically displays the spindle load for each cutting cycle, as well as speed, feed and DOC. In addition, it collects cutting data and stores it in a database.

Armed with this data, the Navigation feature can recommend more efficient cutting parameters and immediately recalculate cycle times.

No Monopoly

Clearly, intelligent machining cannot be neatly defined by a single product or company. Rather, it's a drive to fully integrate the computing power of today's high-powered, though low-priced, digital technology with traditional metalcutting processes. This means more data and computing power can be brought to bear on machining. The result is that shapes of mind-boggling complexity can be produced out of an array of advanced materials with minimal effort.

Soon enough, we will recall the days when humans had to stop and look up information in handbooks or record data on clipboards—and wonder how money was ever made so inefficiently.