Die/Mold Shop Joins Constant Velocity Revolution

According to machine tool supplier GBI Cincinnati, data processing inefficiency inherent in many CNCs can cause actual feeds and speeds to vary significantly from those called for in the part program, leading to acceleration and deceleration during the cut. GBI's Revolution machine, which features a high speed control designed to keep feeds and speeds closer to programmed rates, has helped this shop significantly improve cycle time and tool life on demanding prototyping applications.

Case Study from: Modern Machine Shop
Posted on: 3/16/2009

Shops typically take one of two paths for prototyping and die/mold work: EDM or machining. Grinding, 3D imaging and offshoots of EDM have gained some prominence, but one manufacturer says it has taken typical machining processes to a new level. A general-purpose, die/mold VMC equipped with a high speed control has reduced cycle time enough to readily accommodate stringent customer demands for quick turnaround. The key is the control's 50,000-block-per-second processing speed, which enables the company to avoid the variable feeds and speeds that can result from slower processing of complex part programs.

The machine, a Revolution CV4020 from GBI Cincinnati, was recently installed at W.L. Gore & Associates' Landenberg, Pennsylvania facility, which is just one of the company's 45 plants and sales offices worldwide. Founded in 1958 by Wilbert L. and Genevieve Gore, the privately-held firm is headquartered in Newark, Delaware and has 8,000 employees. While the company is most widely known for its Gore-Tex fabric, it also manufactures products used in consumer goods; electronic and electrochemical materials; fibers; geochemical services; cables and cable assemblies; medical products; sealants; and more. Manufacturing operations are clustered primarily in the United States, Germany, Scotland, Japan and China.

The approximately 500 employees at Gore's 106,000-square-foot Landenberg plant comprise the bulk of the company's Electronic Products Division. Machinist Ed McCracken says he has done "just about everything" during his time with the company, but he now spends most of his time making dies and molds for the division's prototype parts. These typically small, complex components incorporate materials ranging from plastics, delron, Teflon, norel and nylon to aluminum and steel. Although many shops may choose to EDM these prototypes—a capability also available at the Gore facility—Mr. McCracken uses the Revolution machine exclusively. "When I can put a part in the VMC, and the finished prototype meets the specified tolerances or better, why would I use another technology?" he asks.

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The Revolution CV4020's control is capable of simultaneous, eight-axis, 50,000-block-per-second data processing. The result is constant velocity machining, which GBI Cincinnati says can reduce cycle times by as much as 50 percent.

Mr. McCracken says the primary reason for implementing the machine was to improve efficiency and get products to customers as quickly as possible. "This is what customers demand today," he explains. "Everybody wants quick turnaround despite greatly compressed lead times. If you can't deliver to their expectations, they'll look elsewhere."

During an evaluation of various VMCs that could help improve delivery time, Mr. McCracken attended the Revolution CV line's official launch last year at GBI headquarters in Cincinnati, Ohio. One of the first things he noticed was that the machine appeared to be very quiet and stable during a Mercedes test, even with the test block at a 45-degree angle. At an appropriate break, he asked to see the test run on another model that was being set up in the back, away from the main display area. "I was really impressed—the machine wasn't even leveled up, and it was flawless," he recalls. "That basically sold me on the Revolution."

At W.L. Gore's Electronic Products Division, the machine has provided not only the short cycle times needed to please customers, but also the quality surface finishes required to successfully produce dies and molds for prototype parts, Mr. McCracken says. This is largely due to the machine's control, which features a high speed multiprocessor developed by Essex, Ontario-based Miceli Technologies (MTI). While processing speeds on standard controls range from 600 to 3,000 blocks per second, or even 5,000 on higher-end models, the Revolution control can achieve processing speeds of 50,000 blocks per second for eight simultaneously controlled axes, the developer says.

The control's ability to handle the high volume of data describing tool paths in detail enables the Revolution to achieve "constant velocity" machining, in which the cutting head continuously maintains programmed feeds and speeds. According to the developer, constant velocity along the cutting path eliminates the disruptive acceleration and deceleration often experienced with conventional CNCs as the tool moves through complex contours. These speed variations can result in stress that can dull or even break a cutting tool.

Thus, in addition to providing faster cycle times and quality surface finishes, constant velocity machining has eliminated many of the shop's previous problems with tool breakage. This was a common occurrence on the shop's previous machine, especially because the shop uses very small cutting tools, Mr. McCracken says. On average, its end mills measure 0.0625 inch in diameter, and some are as small as 0.01 inch. A cutter measuring 0.125 or 0.25 inch in diameter is considered a large tool at the plant, Mr. McCracken says. Plus, these tiny, thin tools are generally long, ranging from 6 to 10 times the cutter diameter.

Mr. McCracken stands at the Revolution control. Unlike conventional systems, this CNC calculates look-ahead before program start and adjusts cutter movement as the machine runs.

At constant velocity, small end mills can better withstand the cutting depths and high speeds required for the shop's complex, prismatic parts.

He notes that he was "shocked" after successfully using the Revolution to run a 0.01-inch end mill at 12,000 rpm and a 0.1-inch cutting depth through delron. "At that speed and depth, end mills can't survive changes in the tool path," he says. "But at constant velocity, they can easily handle complex, prismatic work."

Now, tool changes are more often a result of cutters becoming dull rather than breaking, Mr. McCracken says. Nonetheless, regardless of the reason for the tool change, the Revolution control makes the process easier. Able to run any CAD/CAM package that is compatible with a Windows XP environment, the control is said to handle mid-program restart without difficulty. In fact, such restarts can be handled in four different ways: by line number, block number, percentage of program run or by having the operator

position the cutter over the workpiece before program start. "When we were using a different machine, going back in the program to the point where the tool broke meant wading through code to find that point," Mr. McCracken says. "We can now go straight in and pick up right where we removed the tool."

The Revolution control has 80 smart data buffers for data transfer, as opposed to the four or five buffers included on most conventional controls, the developer says. While conventional look-ahead systems rely on feedback as the machine operates, the Revolution control calculates look-ahead before the machine starts and adjusts cutter movement as it runs. Its data-processing capability enables it to monitor operations and update tool paths in real time. Additionally, the 50,000-block-per-second processing speed is the minimum when interpolating eight axes—in a three- or four-axis system, the control is even faster.

The machine itself is a Revolution CV4020, a 40-taper VMC with a 15,000-rpm, 20-hp spindle (8,000-, 10,000-, 12,000- and 24,000-rpm models are also available). Other features include a 24-tool magazine and double-arm toolchanger that delivers a 1.9-second chip-to-chip tool change. The X and Y axes feature linear guides, while the Z axis incorporates a boxway design. X-, Y-, and Z-axis travels are 39.4 by 20.5 by 19.9 inches, and rapid traverse rates are 1.417 ipm in the X and Y axes and 1.102 ipm in the Z axis. Positional accuracy is 0.0003 inch, and repeatability is ±0.00012 inch.

Mr. McCracken says the Revolution would make a "great" production machine, and a single one could probably replace a number of conventional VMCs. However, many of its features are not needed for the shop’s prototype parts. "We don’t need all the speed, the very high rpms and a tool change in less than 2 seconds—in fact, we had to dial the ATC down," he explains. "What we do need is the constant velocity, the accuracy, repeatability and the designed-in rigidity and stability. With this single purchase, we’ve slashed prototype times by hours, if not days."

CNC Enables Fast, Constant Feed Rate

New Product from: Modern Machine Shop
Posted on: 12/29/2008

Miceli Technologies offers the constant velocity controller (CVC), a CNC incorporating a new approach to toolpath algorithms that produces a processing speed of 50,000 blocks per second. According to the company, this enables fast, constant feed rates for machining complex geometries. In contrast, CNCs with lower block-read speeds might not be able to consistently push machines at programmed feed rates. The resulting inconsistent tool motion can load flutes differently, adversely affecting accuracy and surface finish, and can shorten tool life by not moving the cutter fast enough to maintain minimum chip load, causing it to rub rather than cut.

Smooth, constant tool movement can result in less wear, better finishes, longer cutter life and faster cycle times, so retrofitting the CVC can be an economical alternative to purchasing a new machine tool, the company says. Capable of interpolating as many as eight axes, the control features 80 high speed buffers to control and monitor tool motion, 4 million maximum (servomotor) encoder counts per second, 15-digit motion control accuracy and a minimum resolution of 0.001 micron.

The Case For Constant Velocity

Constant Velocity Technology uses high speed computer hardware and creative algorithms to enable machine tools to achieve fast, consistent feed rates across complicated 3D surfaces.

Article from: Modern Machine Shop
Posted on: 6/17/2008

A machine tool's control can be a barrier to reducing the machining cycle time and improving the finish of complicated 3D molds, aerospace parts or medical-device components. When the processor can't keep up with the program, the drives starve for information, slowing tool progress, increasing cycle time and inducing inconsistent tool motion. This causes inefficient use of the spindle, which increases benchwork finishing time in addition to the number of trips to the tool crib to replace worn, overloaded tooling. GBI Cincinnati and MTI Technologies worked together on this problem and came up with a series of machine tools called Revolution. These machines are said to combine the quickness of modern control technology and precision in machine tool motion to yield true constant velocity.

Click Image to Enlarge

The CNC on this VMC uses constant-velocity technology to maintain high average machining speeds.

Savvy manufacturing engineers and CNC programmers know that programming at a feed rate of 100 ipm does not guarantee that the tool moves at 100 ipm. In fact, it is almost always less than the target feed rate. The reason for this is that the control's ability to generate the position of the tool in space given the part geometry, tool height offsets, tool radius offsets, common offsets and workpiece offsets requires complicated algorithms that must generate every point in the tool path as the tool moves across the part. The control also must calculate approach and escape motions as well as acceleration and deceleration.

Most controls in use today trace their roots to architecture that is 30 or even 40 years old, when among other things the download speed of the RS-232 connection was a bottleneck. Controls of this type can yield block-read speeds of up to 5,000 blocks per second. While this is sufficient for many part programs, complicated parts can require much more than that. When MTI's Carlo Miceli began to work on his own control, he started with a fresh approach to PC machine language logic and efficient information processing. The product was a CNC control based on modern PC hardware coupled with a new approach to toolpath algorithms that produces a read speed of more than 50,000 blocks per second. GBI Cincinnati says the result is "constant velocity" machining, which yields fast, constant feed rates. When the velocity (feed rate) is not constant, several problems can result.

The uneven motion of the tool loads the flutes differently as the tool passes through the part, adversely affecting accuracy and surface finish. Inconsistent motion can also shorten tool life by not moving the cutter fast enough to maintain minimum chip load, causing it to rub rather than cut. Such motion can also create small breaks in the tool's edges, creating heat and dulling the tool. However, by using constant velocity, the average speed of the cutter moving across the part is more uniform and more accurate, reducing finishing time and prolonging tool life.

On the Revolution series of machining centers, the MTI control does not create the excessive stress sometimes associated with high speed machining, allowing fluid tool motion for complicated part geometries.

The MTI control can also be retrofitted to an existing machine. The retrofit kit uses a series of control parameters to determine the maximum allowable G-force loading and safe operating limits. Standard kits are available now for many Fadal machining centers, with kits for other machines to become available in the future.

One result of the high block processing speed is that the control-follow error is constantly monitored and adjusted to achieve uniform tool motion and surface integrity during program execution. The system uses more than 80 high speed buffers to control and monitor tool motion, which can be adjusted instantaneously if the follow error becomes excessive.

The sum of the control quickness, drive tuning and efficient handling of the tool path is said to yield fast and accurate program execution even when working with complicated shapes. GBI Cincinnati plans to have three Revolution machining systems ready by IMTS 2008. Each will offer machine design features with MTI's control technology to solve problems in the moldmaking, aerospace and medical device industries.
