



Helical Solutions, Celeritive Technologies, and GateWay Community College Research Shows Massive Gains in Milling Productivity

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Cutting tool and machine tool technologies have become more sophisticated over the years, but some experts believe full productivity gains have not been made because of the inherent shortcomings in the off-line generation of toolpaths.

Ongoing research at GateWay Community College (GWCC) in Phoenix, Ariz., involving toolpath software provider Celeritive Technologies and high-performance tool manufacturer Helical Solutions, clearly shows that a high-quality cutting tool driven by innovative toolpath programs can increase metal removal rates by as many as 10 times.

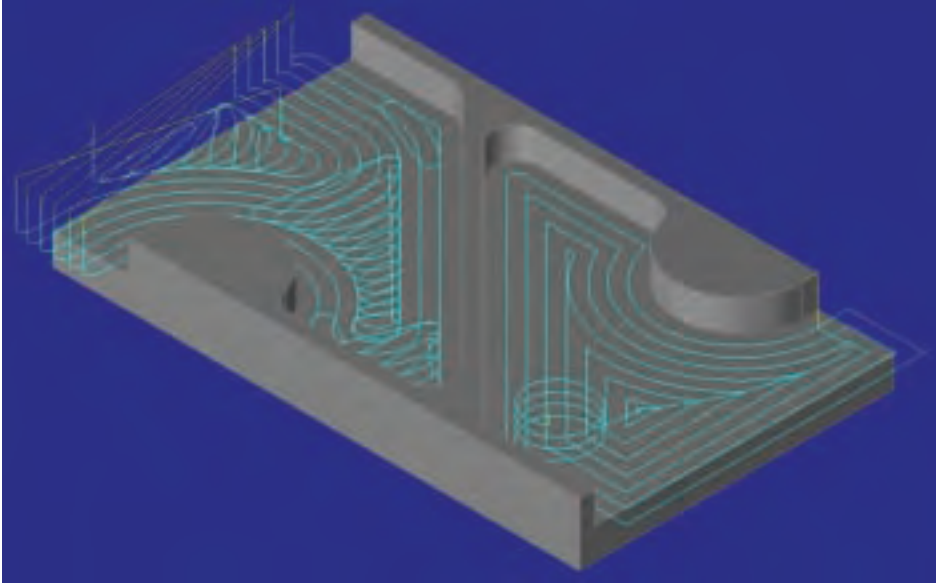
"No matter how sophisticated a machine tool is, it can't do anything without a tool and a toolpath," says Glenn Coleman, chief product officer and co-founder of Celeritive Technologies, designers of the VoluMill™ toolpath software used in the GWCC testing. "The toolpath has always been the weak link in the chain, typically forcing the use of cutting parameters that err on the side of caution rather than productivity."

According to Scott Tiehen, Helical Solutions' national sales manager, "These cautionary tool parameters are detrimental to the tools' performance and fate. High-performance geometries

are designed for optimum speeds and feeds and ensure the customer receives a heightened return on their cutting tool investment. With the use of VoluMill, we have discovered that not only does our tooling experience all of these characteristics, it also takes on a whole new aspect of affordability, consistency, and predictability, allowing for maximum return on investment."

When numerical control came along some five decades ago, programmers tried to replicate what a skilled machinist could do turning crank handles. Problems become obvious every time there was a sharp corner in the toolpath, where the load on the tool increases because the tool is bearing into more material.

"There have been many attempts over the years to improve upon the traditional toolpath," Coleman says. "Most of those, however, are still based on the fundamental pick-geometry-and-offset-it method. There are detect-and-adjust approaches out there that try to help along a path that has flaws, but the



Side-by-side illustration of a VoluMill™ toolpath (left) and a traditional toolpath (right).

VoluMill approach is to generate the toolpath so that the flaws are never there in the first place.”

There are four problem areas that limit machining throughput when using traditional toolpaths:

1. The initial full cut
2. Stepping over between cuts
3. Feeding into new areas of the part
4. Overloading in corners

Celeritive Technologies’ VoluMill is a revolutionary new programming toolpath technology that catches up with the cutting tools and machine tools. VoluMill utilizes existing CAD/CAM functionality for geometry and input/output functions, allowing customers to continue using their CAM system of choice. It dynamically manages cutting strategies, feedrate, and depth of cut, and minimizes force and heat build-up in both the part and the tool by maintaining the programmed material

removal rate. VoluMill is 100 percent compatible with all geometries and part/stock boundaries, cutting styles, materials, and cutting tools with support for an unlimited number of islands, tapered walls, variable pocket depths, and variable island heights found in the most widely used CAD/CAM software.

“What we have done with VoluMill,” Coleman says, “is devise a different way of driving the tool through the material. We’ve developed a path that will ensure a consistent load on the cutting tool. We’ve embedded ways to address all instances of the problem areas indigenous to traditional toolpath technology. As necessary, VoluMill makes dynamic adjustments to the depth of the cut and/or the feedrate so as to never exceed the pre-set volume of material being removed at any given time,” he continues. The results are metal removal rates that are five or 10 times faster than traditional toolpaths.

To prove VoluMill’s claims, Celeritive Technologies joined forces with Helical Solutions, a Maine-based manufacturer of high-quality, high-performance cutting tools at GWCC, where the two-year-old Manufacturing and Design Technology Department prides itself on being available to the industry for research of this type. “We call our program ‘integrated technology’ as

“There have been many attempts over the years to improve upon the traditional toolpath. Most of those, however, are still based on the fundamental pick-geometry-and-offset-it method. There are detect-and-adjust approaches out there that try to help along a path that has flaws, but the VoluMill™ approach is to generate the toolpath so that the flaws are never there in the first place.”

Glenn Coleman, chief product officer and co-founder of Celeritive Technologies

it combines the disciplines of design, CAD/CAM, CNC programming and operations, tool holding, and work holding," says GWCC's program director Dave Zamora. "We are fortunate to have a variety of machine tools to work with, ranging from two-axis to simultaneous five-axis models. We enroll approximately 300 students each year, primarily in our technology certification programs for new students and those interested in upgrading their manufacturing skills.

"With these resources, we're able to benchmark machining technology more than others in the industry because they're hard-pressed to make parts every day," continues Zamora. "We are an educational research facility for area companies to benchmark manufacturing processes and tooling, and my students learn extreme material removal parameters and they learn variations in work holding to create an optimal setup, which can then be transferred to the production shop. We love this environment to be able to share this technology with our students and our industry.

"VoluMill and Helical challenged us to use the new high-speed machines that we have and we wanted to push the machining envelope," Zamora adds. "We found the VoluMill software to be straightforward and highly productive for generating part programs. Helical Solutions advised us on how aggressive we could be in speed and feeds and provided the coated carbide test tools."

Milling Test #1 — 304 Stainless Steel

Machine: HAAS® EC400 Horizontal Machining Center with 20 HP (14.9 kW), 12,000 RPM spindle, and 1,000 IPM maximum feedrate.

Tool Used: Helical Solutions' HEVR-SR five-flute, variable-pitch carbide end mill (1/2 x 1/2 [G1] x 1 x 3 – edp#34272) with Aluminum Titanium Nitride (AlTiN) coating for heat resistance plus a .030" corner radius.

TOOLPATH	TYPICAL	VOLUMILL™
SFM	250 ft./min.	1,144 ft./min.
RPM	1,910	8,800
Feedrate / IPM	19	110
Chip Load / Tooth	.002"	.0025"
Axial DOC	.500"	.500"
Radial DOC	.100"	.0625"
MRR	.955 cu.in./min.	3.44 cu.in./min.

"The VoluMill toolpath allowed us to pocket (rough mill) with a five-flute Helical tool," says GWCC's Zamora. "We could also utilize the same tool for the finishing pass, allowing a combination that may help customers reduce their tool inventory by roughing and finishing with a single cutter."



A completed 304 Stainless Steel part cut by a Helical Solutions HEVR-SR five-flute variable pitch carbide end mill with Aluminum Titanium Nitride (AlTiN) coating for heat resistance plus a .030" corner radius and a VoluMill™ toolpath. This was achieved with an SFM of 1,144, RPM of 8,800, IPM of 110, and 3.44 CIM MRR.

Milling Test #2 — 17-4ph Stainless Steel

Machine: HAAS® Super VF3, #40 taper, 20 HP (14.9 kW), 12,000 RPM spindle, and 1,000 IPM maximum feedrate.

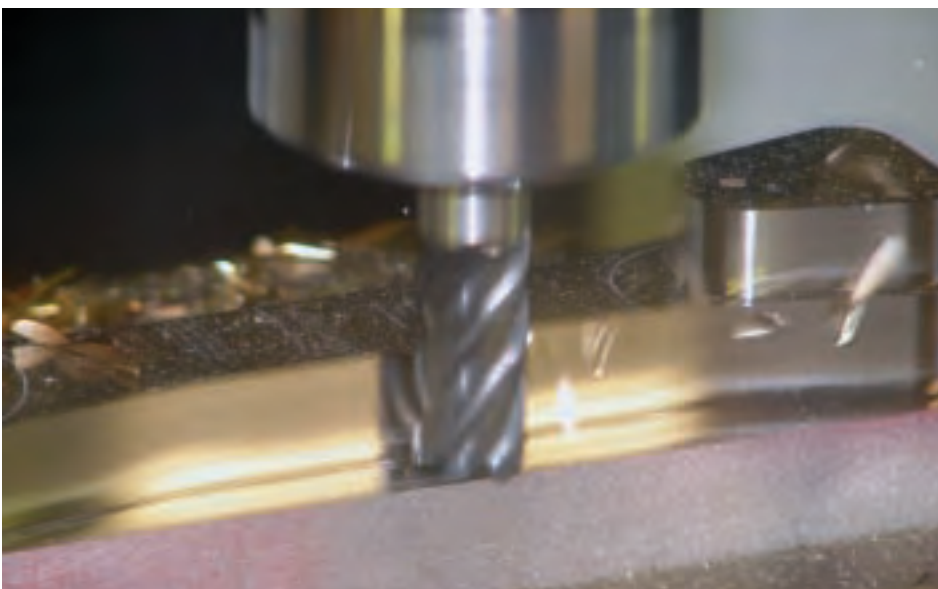
Tool Used: Helical Solutions' HEVR-SR five-flute, variable-pitch carbide end mill ($1/2 \times 1/2$ [G2] x 1 x 3 – edp#34272) with Aluminum Titanium Nitride (AlTiN) coating for heat resistance plus a .030" corner radius.

TOOLPATH	TYPICAL	VOLUMILL™
SFM	260 ft./min.	780 ft./min.
RPM	1,986	6,000
Feedrate / IPM	18.8	80
Chip Load / Tooth	.0019"	.0026"
Axial DOC	.500"	.500"
Radial DOC	.100"	.0625"
MRR	.94 cu.in./min.	2.5 cu.in./min.

Zamora recalls, "Despite the fact that his test was conducted without coolant, Helical's cutters and cutting parameters ran smoothly and the heat was carried off in the chips, keeping the part cool."



Helical Solutions' HEVR-SR five-flute, variable-pitch carbide end mill with AlTiN coating and a .030" corner radius.



Helical Solutions' HEVR-SR five-flute, variable-pitch carbide end mill with AlTiN coating and a .030" corner radius directed by a VoluMill™ toolpath cuts stainless steel without the need for coolant.

Milling Test #3 — 6061 Aluminum

Machine: HAAS® EC400 Horizontal Machining Center with 20 HP (14.9 kW), 12,000 RPM spindle, and 1,000 IPM maximum feedrate.

Tool Used: Helical Solutions’ HAL-C-SR three-flute, carbide end mill ($1/2 \times 1/2 \times 1 \times 3$ – edp#29390). As a standard, this tool has a serrated edge for breaking chips, a .030 corner radius and is considered a roughing/semi-finishing tool.

TOOLPATH	TYPICAL	VOLUMILL™
SFM	1,400 ft./min.	1,560 ft./min.
RPM	10,696	12,000
Feedrate / IPM	192	1,000
Chip Load / Tooth	.006"	.0277"
Axial DOC	.500"	.500"
Radial DOC	.200"	.200"
MRR	19.2 cu.in./min.	100 cu.in./min.

“We ran this test at the maximum feedrate the machine tool would allow,” Zamora says. “Still, the spindle load meter registered only 10 percent of the available horsepower, a testament to the productivity of well-designed cutting tools and an efficient toolpath.”



Helical Solutions’ HAL-C-SR three-flute carbide end mill. This tool has a serrated edge for breaking chips and is considered a roughing/semi-finishing tool.



A completed 6061 aluminum part cut by a Helical Solutions’ HAL-C-SR three-flute carbide end mill with a Zirconium Nitride (ZrN) coating for improved lubricity and a VoluMill™ toolpath. This was achieved with an SFM of 1,560, RPM of 12,000, IPM of 1,000, and 100 CIM MRR.

The Productivity Equation

Lasting productivity improvements in metal cutting encompass all of the disciplines at work at GWCC's Manufacturing and Design Technology Department. There is no "silver bullet." Helical Solutions is application-driven, knowing that a single carbide substrate with a common coating material won't achieve the best results every time. The right combination of tool length, rake angles, clearance angles, edge sharpness, and a multitude of coating processes are needed and provided by the company.

Celerative Technologies' product, VoluMill, is a new way of thinking about machine tool programming. By using a machine's optimum metal removal rate, it can increase productivity while removing unnecessary stress and strain on the machine, cutter, tool holder, and fixture. These benefits lead to longevity of equipment, cutting tools, increased cutting precision, and more. Moreover, there is no need to "tweak" part programs on the machine, and one-off runs become productive as well.

"Don't overlook other items such as coolant, high-quality, balanced tool holders, and well-designed fixtures," offers Helical Solutions' Tiehen. "Eliminating vibration and adding lubricity go a long way toward higher metal removal and longer life. In all, testing at GWCC proved that milling efficiency can be increased by 75 percent or more by using the right tools and programming techniques. Depending on how much milling the work-piece requires versus drilling, tapping, boring, and so on, overall cycle times can be reduced by one-quarter or more. That's a great payback for a small investment in quality cutting tools and efficient programming."

Helical Solutions, LLC

Helical Solutions supplies high-quality, high-performance cutting tools for aerospace, energy, medical, and other industries. Founded in 2001, Helical specializes in tools for hard-to-cut materials such as inconel and titanium and in tools customized for particular customer applications. Among the tools Helical offers are coolant-thru tools, form tools, chamfer end mills,

corner-rounding end mills, double-angle cutters, dovetail cutters, lollipop cutters, radius end mills, and taper end mills. Helical is headquartered in Gorham, Maine.

Celeritive Technologies

Celeritive Technologies was founded in 2007 to develop and commercialize advanced CAD/CAM technologies. Starting with a blank sheet of paper and leveraging the more than 75 years of combined machining, software design, software development, and business management experience of the founders, the company released its first product – VoluMill. This innovative and powerful toolpath engine extends and enhances the capabilities of today's CAD/CAM software systems, integrates seamlessly into PLM systems, and significantly improves productivity and throughput in the production environment.

For more information and to take advantage of the 15-day free trial offer, visit the VoluMill™ Web site at www.volumill.com

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