John Sulaiman, co-owner of Michael Tool & Mold, Oldcastle, Ont., Canada, with one of his two Fadal VMC4020 vertical machining centers retrofitted with constant velocity cutting (CVC) machine tool controllers built by Miceli Technologies Inc. (partially visible at right). Picture courtesy of Michael Tool & Mold.

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BEATING BUSINESS VOLATILITY IN AUTO TOOLING

Miceli Constant-Velocity Cutting Offers Low-Cost, High-Tech Option To Hand-Finishing EDM Electrodes

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Michael Tool & Mold – CVC for Miceli Tech
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In tooling for injection-molded plastic components, little things mean a lot. For moldmakers, these little things require the slowest metal-removal process, which is electrical discharge

machining (EDM). At Michael Tool & Mold (Windsor) Ltd. in Canada, machining blocks of graphite into EDM electrodes was one of the mold-build stages they wanted to improve.

All that changed when Michael Tool retrofitted a key production machine with a new constant velocity cutting (CVC) control. Developed by Miceli Technologies, CVC is a quantum leap over conventional numerically controlled machine tools. Both companies are based near Windsor, Ont., Canada. Michael Tool is in Oldcastle and Miceli Technologies is in Essex. For further information, see *www.miceli-technologies.com* and *www.michaeltool.com.*

Michael Tool makes tooling for automotive interior and exterior components such as consoles, instrument-panel components and door panels. Known to automakers as "trim," these parts are highly visible. Their appearance and fit are big factors when customers compare vehicles in dealer showrooms. Michael Tool also makes tooling for under-the-hood components such as, air cleaners and automotive lighting.

All these molded parts have sections that are too complex and intricate to be machined. Tiny features with extremely tight surface-finish specs must be "burned" into the steel with EDM.

Typical molds for trim panels at Michael Tool have highly styled textured surfaces on the visible outer sides. The non-visible inner sides have gusset ribs, mounting bosses and clip towers for fasteners, many with inside corner radiuses too tight to be machined.

Some molds require a series of graphite electrodes for these impossible-to-machine details. Mold "cavities," which form the visible sides, usually require three sets of electrodes. In the mold's "core," which forms the non-visible side, complicated, closely spaced features may require four and sometimes five electrode sets.

The number of electrode sets needed varies with the number of areas to be burned, the complexity of the geometry, the required accuracy and the depth of the burn. Some molds require no EDM work and thus no electrodes.

Since EDM is one of the most time-consuming stages of moldmaking, anything that gets cores and cavities and graphite electrodes in and out of EDM machines' oil-filled tanks faster boosts productivity.

The shop's owners— John Sulaiman and Andy Hui—have found that their Miceli CVC retrofit has considerably reduced most of the tedious and costly hand finishing that was such a big part of electrode production.

Sulaiman and Hui also are finding that these productivity gains help offset unprecedented volatility in orders and ever-tighter delivery schedules. "It is common for customers to change their minds, starting jobs and stopping them," said Sulaiman.

"Often the customer abruptly reschedules a previously stopped job, yet wants to maintain the original delivery dates," he added. "That forces us into unexpected set-up changes. We have been compelled to change not only our way of thinking, but also the way we manufacture."

Michael Tool & Mold's response to this volatility is to boost flexibility and its ability to respond to sudden change. Because machining EDM electrodes is such a crucial stage, a big portion of the gain is due to the two Miceli CVCs. The faster a job can be completed, the less likely it will be disrupted by changes in deadlines and priorities.

One Miceli CVC was retrofitted to an existing 4020 Fadal vertical machining center in 2008. That machine and two similar Fadals run almost continuously, machining blocks of graphite into EDM electrodes. Based on the initial CVC success, a second Fadal 4020 was retrofitted early in 2009.

The 30-year-old family owned company designs and builds tooling, generates prototypes and offers short-run production. It employs a modest-sized staff and has six computer-controlled machine tools in an 18,400-square-foot plant. Toolpaths are generated with a CAM package from the UK.

Graphite Gains At A Glance

Benefits in electrode machining attributable to the Michael Tool & Mold retrofits of a constant velocity controllers (CVCs) from Miceli Technologies:

- A 3-fold increase in finish machining.
- A 5-fold increase in rough-machining.
- A 7-fold tightening in tolerances for programming, to 0.0001 inch.
- Eliminating semi-finish machining.
- On-the-fly toolpath offset updates—a big need amid volatility.

Challenge and Opportunity: Electrode Machining Solutions

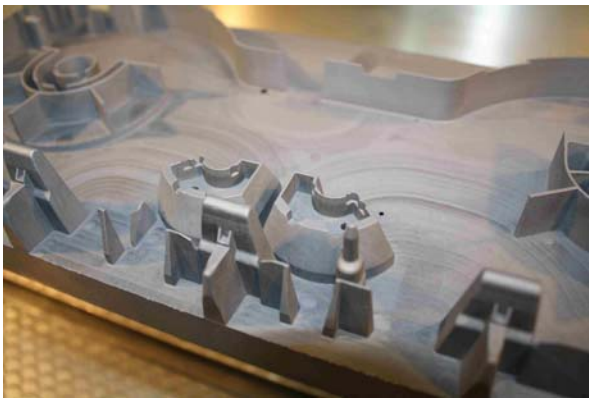
Both Fadals were originally equipped with relatively simple, stock numerical controls. Those controls had tiny buffer memory—where machine tool programs are stored as they run—held a very limited amount of code—approximately 250 lines. That's enough for only the shortest, simplest and least precise programs. Due to the complex geometry and intricate machining, almost any toolpath had more lines of code than the controller could handle.

That limitation meant that the original, stock numerical control was constantly reloading code while the machine tool itself ran short of data during cutting. Sulaiman said this is commonly known as "buffer overload." To the machine tool it is data starvation. The machine operator wa`s forced to reduce the programmed feed rate, wait for the machine to catch up, and then reset the feed rate back to its original setting. The result was an endless cycle of slowing down and speeding up. These inconsistent feed rates dealt sizeable blows to machining productivity and cutting tool life.

The other option was to run at a non-optimal feed rate that the controller could handle, but issues of time, productivity and surface finish arise.

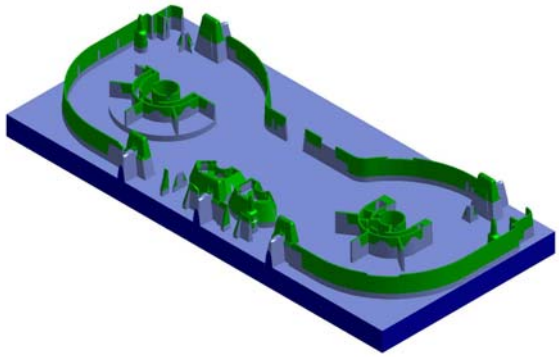
With the MTI controllers, Sulaiman said, "we have read in up to 750,000 lines of code have been read in with no information processing problems. "This is where we get the constant feed rates," Sulaiman pointed out. "This is one of the great advantages of the MTI controllers, their ability to read in vast amounts of data, almost limitlessly and at high speed." In fact, MTI controllers can read in about 3 million lines of code.

Since the retrofits, the Fadals have become workhorses. "Machining electrodes has jumped five-fold in roughing and three-fold in finishing," Sulaiman said. "We have upgraded nearly every aspect of graphite machining," though some tool-wear factors such as step-downs, stopovers, numbers of passes and spindle speeds remain unchanged. The increased feed rate has hiked overall shop productivity and boosted Michael Tool's on-time delivery performance.



Three close-up views of graphite electrode for a mold core shoe that makes part of an instrument cluster (dashboard) and CAD rendering (lower right). In the rendering, green areas represent the molding surface or area to be burned. Light blue areas indicate clearances to avoid interfere with other areas in the tool. This job is for an automotive customer.

Images courtesy of Michael Tool & Mold.



"It was obvious to us," said Sulaiman, "that with today's unstable business climate, offshore competition and ever increasing demands from automotive customers, we had to re-evaluate our machining technology and the way we build molds. As we reviewed investing in new machining centers early in 2008, Carlo Miceli [MTI founder and president] approached us with a retrofit proposal."

He continued, "to keep abreast of new technologies and using these technologies is one way we remain competitive and advance our company's ability to provide the best service."

The retrofit was an easy decision as the alternatives were unappealing at the time. They were:

- Continuing to use an older controller and being left at competitive disadvantages in quality and on-time delivery.
- Remaining at a cost disadvantage because of hand finishing.
- Buying a new or late-model used machine.

Moreover, getting a new machine tool fully into production takes several weeks. There is digging or modifying a foundation pit, followed by installing rigging and setting. Only then can the machine's systems—electrical, electronics, hydraulics, and lubrication—be connected. Finally there is tooling, post-processors, communications and training.

A typical retrofit costs much less but can be nearly as slow if the machine has to be shipped out. Either way, Sulaiman felt his customers would not appreciate anything that might cause a missed delivery date. *See Sidebar No. 1, "Catching a Break in Oldcastle."*

"Carlo [Miceli] demonstrated a CVC-retrofit Fadal destined for another customer and that convinced us," Sulaiman said. "We would get a machine at a considerable cost savings that in some cases would outperform new high-end units. Given the financial benefits of retrofitting, this approach made the best business sense."

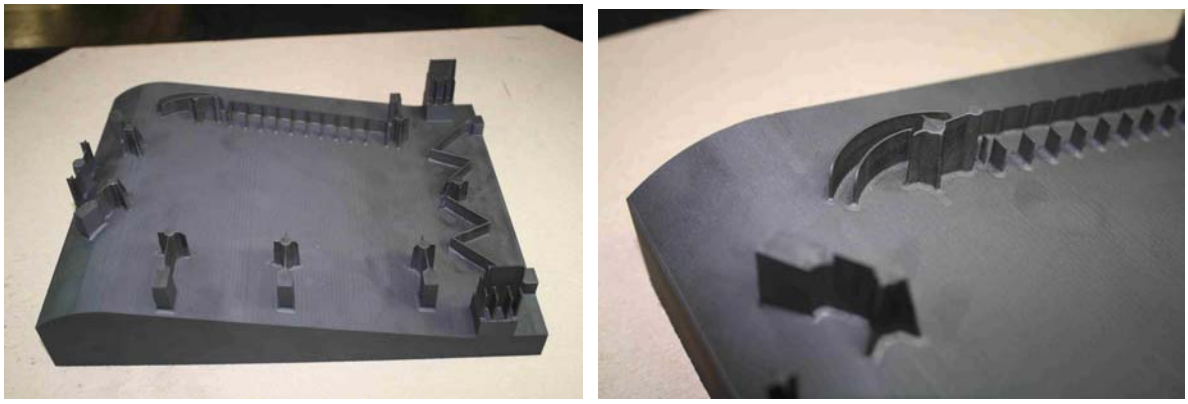
Opting for the CVC retrofits has turned into a strategic decision for Michael Tool. Each retrofit was done start to finish in under three weeks right in Michael Tool's shop.

Results: More Productivity in Machining Electrodes

In electrodes, Michael Tool's gains from the CVC retrofit were dramatic—the ability to program to as little as 0.0001-inch instead of 0.0007. "That is a drastic tightening in programing tolerances," he said, "and it reduced hand-working electrodes except final polishing." Summing up the retrofit results, Sulaiman observed that "the MTI controller provides better accuracy, more consistent cutting speeds and higher quality surface finishes. In electrodes, constant velocity eliminated hand finishing on some electrodes completely and reduced the remainder by 50 percent,"

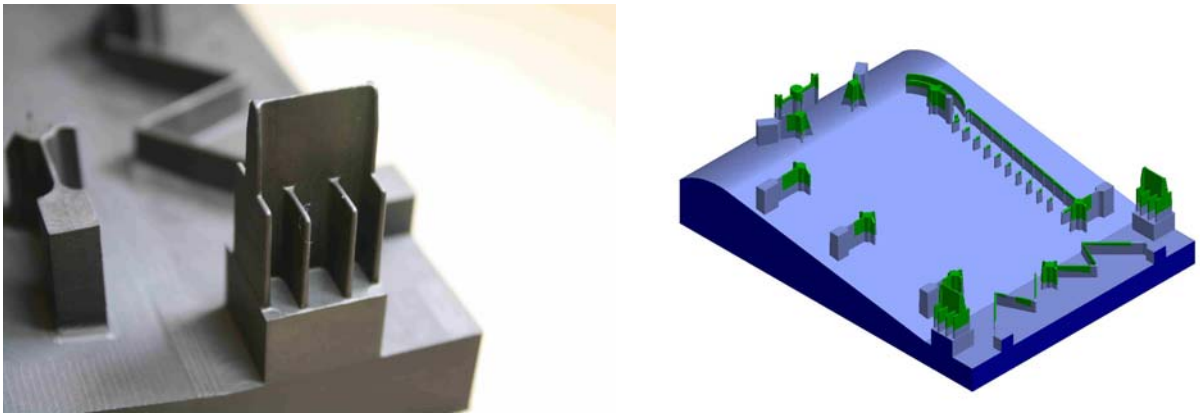
He added that "constant velocity even around corners gives us smooth machine-tool movement, and in electrodes that is critical in finish machining" and getting EDM work started quickly.

CVC capabilities have taken electrode machining from a three-stage process to just roughing and finishing; semi-finish machining was eliminated. "We now have the capability," Sulaiman said, "of roughing a graphite block to +0.010-inch stock and then directly finish machining to -0.004 inch." (The negative four-thousandths accommodates for EDM's characteristic spark gap and finish tolerances.)



Three close-up views of graphite electrode for a mold core slide that makes part of a between-the-seats console and CAD rendering (lower right). In the rendering, green areas represent the molding surface or area to be burned. Light blue areas indicate clearances to avoid interfere with other areas in the tool. This job is for an automotive customer.

Images courtesy of Michael Tool & Mold.



In addition, the operators of the retrofitted Fadals can now:

- Change tool and fixture offsets on the fly, as when a set of toolpaths is being blended into the toolpaths for an adjacent surface.
- Pull out in the middle of running a program and then go back in—to change cutters or even entire jobs, for example—without having to reload the entire program.

Both were impossible with the existing stock control's command-line interface. *For a rundown of MTI CVC capabilities, see Sidebar #2, "Advances MTI builds into its CVCs."*

Michael Tool is also getting much better cutting-tool life. "Our diamond-coated cutters and end mills now last up to six times longer than the coated-carbide cutters we were using," Sulaiman said. "The longer life is due to the greater wear resistance of the diamond coating and the constant feed rates the MTI controllers provide us."

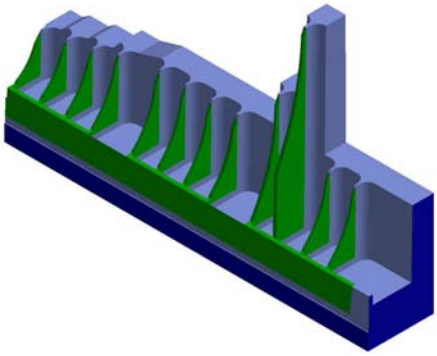
Benefits: Meeting Tighter Deadlines

"Basically," Sulaiman said, "we are manufacturing electrodes faster, with the same amount of people and all the while reducing time and cost. The time savings in machining and hand finishing of electrodes is a considerable benefit, both in the overall build time and in our ability to meet and in some cases exceed our customers' lead time expectations."

Two related benefits:

- The company has gained the ability to more effectively machine smaller P-20 steel core and cavity shoes, using the Fadal.
- Excessive stress on the Fadal that comes with the abrupt acceleration and deceleration of conventional machining is avoided. "Less stress on the machine means less wear and tear," Sulaiman pointed out, "and that ultimately equates to less downtime due to repairs."

Downtime for machine-tool maintenance is generally not a short-term business consideration but any loss of production time is. "In automotive moldmaking you cannot afford to be down," Sulaiman pointed out. "Time lost at any stage can affect the build schedule and, ultimately, whether we meet the delivery date."



Above left is a CAD rendering of a graphite electrode for a mold cavity that makes an automotive air-cleaner housing. Green areas represent the molding surface or area to be "burned" with EDM. Light blue areas indicate clearances to avoid interference with other areas in the tool. Above right are Michael Tool's two Fadal 4020VMCs retrofitted with Miceli CVC controllers.

Images courtesy of Michael Tool & Mold

Michael Tool & Mold expects to recoup its CVC investments in less than one year—a solid investment in an uncertain economy.

"With the new MTI controllers and the new cutting tools, Michael Tool is achieving tighter programming tolerances and best surface finishes our customers demand," Sulaiman summed up. "And we are doing it considerably faster than in the past."

The time they save in machining graphite electrodes has proven to be pivotal in remaining competitive and reducing lead times. "You get the job into the EDM tank sooner, and that helps reduce overall build time," he continued. "Tighter tolerances, better surface finishes and reducing cycle times are all crucial objectives when machining mold components."

Michael Tool has also seen something of a culture change. "Our operators always prefer the retrofitted Fadals," he said. "They are indicating a keener interest in achieving the best possible quality and now they know they have the latest in controller technology. They create higher quality programs, and their toolpaths run more efficiently and with greater consistency and repeatability."

He concluded, "doing it right the first time helps us stay competitive."

As a technology focused entrepreneurial company, Miceli Technologies is building its business with closely integrated partners. They are machine tool developer GBI Cincinnati Inc. and distributor Velocitech CNC, Independence, Ky. F or further information contact Kevin Bevan, president, GBI Cincinnati, at (513) 841-7391 kbevan@gbicincinnati.com and Tom Johnson, Velocitech, at (859) 801-3966 tom@velocitechcnc.com. The companies' Websites are www.gbirevolution.com and www.velocitechcnc.com.

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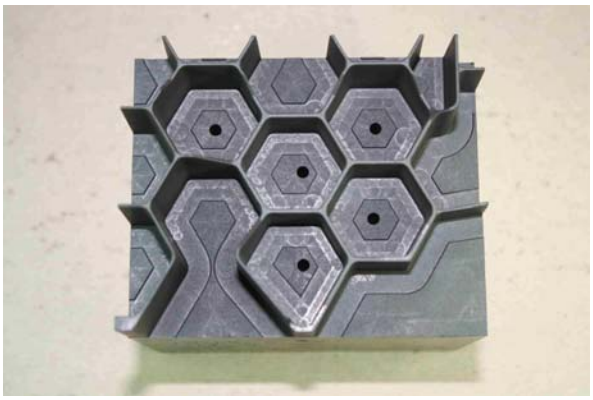
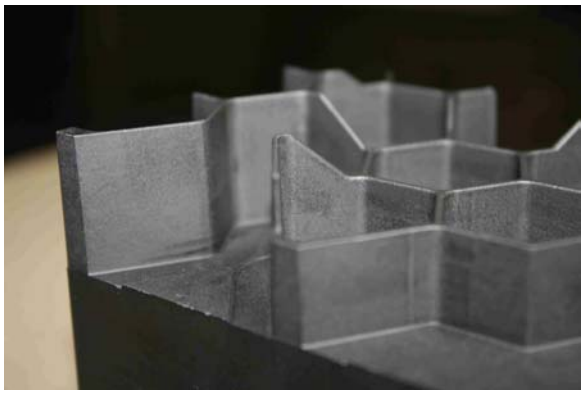
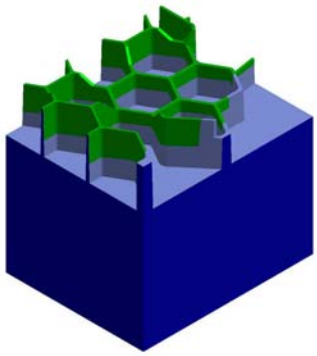




Above, two more close-up views of another graphite electrode for a console component. Below left, a CAD rendering of that tool. In the rendering, green areas represent the molding surface or area to be burned. Light blue areas indicate clearances to avoid interfere with other areas in the tool. This job is for an automotive customer.

Images courtesy of Michael Tool & Mold



S I D E B A R #1
Catching a Break in Oldcastle

Michael Tool caught a major break in retrofitting due to location. The mold shop and Miceli Technologies are both in the Windsor, Ont., Canada, area—Michael Tool in Oldcastle and Miceli in Essex. MTI did the retrofits right on Michael Tool's shop floor, so no rigging, no freight bills, and minimal disconnects and reconnects.

"The installations went smoothly," said Michael Tool co-owner John Sulaiman. "When the inevitable surprises did arise, Carlo [Miceli] and his team addressed them seamlessly. Relative to the amount of work they did for us, downtime was minimal. We would have lost a lot more time if we had bought a new machining center."

Miceli Technologies "was always professional and very willing to accommodate our shop schedule when it came time for the installations," Sulaiman added. "They understand how unpredictable our industry is and the time and budget constraints we face."

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S I D E B A R #2
Technical Advances Built into CVCs by MTI

Most programming and machine-tool cutting discussions are in terms of "speed," which translates into how many cubic inches of metal can be removed per minute. In finish machining, and in moldmaking in particular, raw speed is less important than accuracy and surface finish.

The constant velocity cutting (CVC) breakthrough at MTI cranks up the speed of machine tools, even of older models. CVC dramatically boosts average speeds at which X-, Y- and Z-axis drives push cutters around workpieces at 300 and 500 inches per minute. That speed can be traded off for extreme accuracy, as Michael Tool & Mold.

Most machine tools were designed for that and more but almost none ever achieve it. This is the dirty little secret of conventional numerical controls. "Programmed feeds are reached only under near-perfect conditions and then for only a few seconds at a time," Carlo Miceli pointed out. "There average machining speed is only 30% to 40% of what the programmer specifies." So much for productivity promises.

"CVC technology typically attains average speeds of 80% to 90% of what is programmed, which is two to

three times faster," Miceli added. Equally important for surface finishes and tool life, the speed stays constant, even around corners.

Major advances that MTI builds into its CVCs include:

- 8 interpolated axes.
- 50,000 block-a-second program execution versus 2,000 to 3,000 blocks a second in even the best conventional numerical controls.
- 80 high-accuracy smart buffers for look-ahead algorithms versus the conventional numerical control norm of a few dozen lines of code—in effect, just one buffer.
- 4 million maximum (servomotor) encoder counts a second, a measure of maximized closed-loop feedback, and far more than what is offered in even the best conventional numerical controls
- 15-digit motion control accuracy and a minimum resolution of 0.001 micron. Very few industrial systems offer any accuracy and resolution below one micron.

Other pluses of the MTI controller are its operator-friendly layout, full-sized keyboard, color LCD monitor, and Microsoft Corp. Windows-based applications. A hand-held pendant is standard on all Miceli controllers. Using the pendant, operators can pick up part coordinates, update toolpath offsets on the fly, and incrementally jog the machine tool spindle around the workpiece.

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This handheld remote comes standard with every CVC from Miceli Technologies.

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