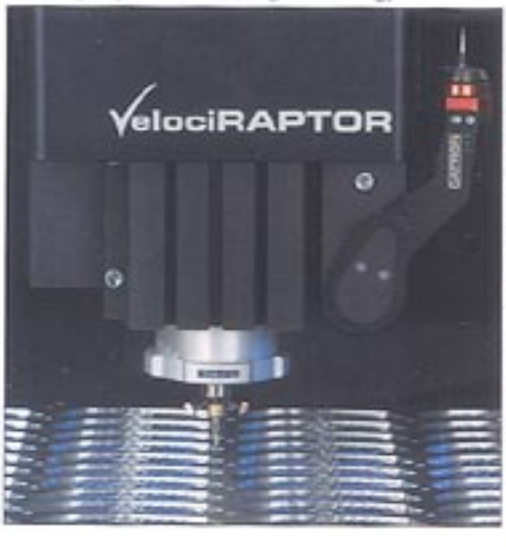
Small-Scale Machining with LARGE-SCALE PROFITS

Miniaturization in manufacturing really demands change. Three elements must be revisited as workpiece sizes decrease and part versions increase – micro-tooling design, low-viscosity coolant, and high-speed machining.

Competing in the high-speed world of micromachining presents many challenges. Conventional CNC machines attempting to use micro-tools smaller than 1/2-in dia at 10,000-rpm or less typically produce unfavorable feed rates with costly tool breakage.

Running slower with these fragile tools doesn't work either, because they require higher rpms than most conventional spindles can achieve. Improper chip evacuation causes much tool breakage. Chips must be removed from the cutting channel to minimize breakage. Small tools requiring high spindle speeds need to go even faster to kick chips out.

Efficiently machining with small tooling involves three interrelated elements: micro-tooling design, low-viscosity coolant, and high-speed machining technology.



The VelociRaptor™ uses 3mm Beamer Reamer tooling to batch machine three-dimensional, Harley-Davidson knife handles, 40-up from 6061 aluminum.

DESIGN DITTOS

Smaller tool diameters and higher spindle speeds change tooling requirements. Increased rpms require a properly balanced tool with significantly increased chip room to allow proper chip removal and prevent chip burn-up. Combined with high speed spindles and proper coolant, proper micro-tooling geometry can totally eliminate de-burring as a secondary operation.

A spindle mounted in the machine spins a microtool with the micro-volume Ethanol coolant spray mist illuminated.

KEEP IT COOL

Though high-speed machining employs technology to reduce heat, an efficient coolant system is still necessary for certain applications. Coolant eliminates heat and lubricates the tool so it can move swiftly across the surface.

Consider how cutting a cold block of butter becomes easier with a heated knife. The knife effectively melts some of the butter, which lubricates the blade so it moves easily across the block. The same principle works with high-speed machining. Micro-tooling needs a lubricating agent with a lower viscosity than water because the coolant must coat the cutting edge of the tool at very high spindle speeds.

One example of this is ethanol, a form of alcohol ideal for non-ferrous metals and some plastics. Although flammable, the low evaporation point makes ethanol a very efficient cooling and lubricating agent for high-speed machining. As a coolant, Ethanol doesn't leave any residue on the machined parts. This eliminates the costly secondary task of de-greasing those parts.

However, steel-based materials demand an oil-based coolant because carbide tooling on steel surfaces can cause sparks. Sparks can create a highly dynamic situation if exposed to an alcohol-based coolant.

THE NEED FOR SPEED

The smaller the tooling, the higher the spindle speed needed to efficiently machine parts. High-frequency spindles with speed ranges from 6,000-rpm to 60,000-rpm are ideal for milling, drilling, thread milling and engraving with micro-tooling.

Approximately 60 percent of heat created during the machining process dwells inside the chip. High-speed machining tries to evacuate the bulk of the heat by reducing the chip load to less than 0.005-in. This low chip load greatly reduces the forces between the tool and the material. High-speed/low-force machining creates less heat, reduces tool deflection, and allows machining of thinner-walled workpieces. The result is a better surface quality, cooler machining, easier workholding and better accuracy.

THE NATURE OF IT ALL

All these interrelated elements are possible because of the dynamic nature of machines that perform high-speed machining with micro-tooling. These machines are relatively lightweight, giving them a wide range of motion, agility,

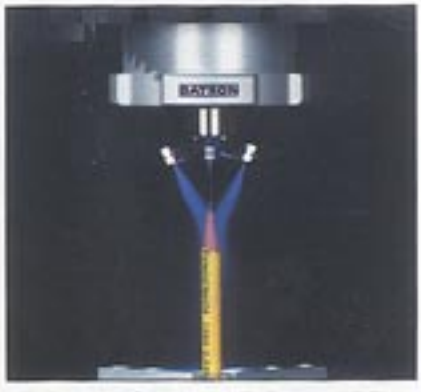


Illustration of the micro-drilling capabilities of a VelociRaptor™ using a #78 drill (0.0160-in) with Ethanol coolant at the tip of a pencil.

Ross parts 161LH and 160RH feature a main component milled out of engineering grade Delrin.

tion challenge and its impact on cycle time," states Brenneisen.

During a benchmarking session, Bill King, vice president of Datron, programmed the Aluminator to machine the Ross part 50-up. Fifty pieces were completed in an hour – the same time it took Ross's vendor to produce 8 to 10 parts. Brenneisen walked away with his own Aluminator.

BIG TIME RESULTS

The Aluminator brought all Ross production in-house and maintains a 500 percent increase in throughput – 50 parts per hour, compared to 8 to 10 parts per hour produced on the other machine in 2002. The cost per part dropped from $8 apiece to only $.50 each, a profit margin 16 times higher (a 1600 percent increase). Annual production costs fell from $64,000 to $4,000.

"The workholding almost eliminates set-up time and allows batches of parts to run unattended. We finished what was once a year's worth of parts in a couple of months. I programmed other jobs to get the biggest bang for the buck – that's how easy and flexible the software is," remarks Brenneisen. "This has improved our 'Made in America' product and dramatically increased revenue."

GREAT EXPECTATIONS

It all comes down to the right tools for the right job. Conventional machines retrofitted with high-speed spindles cannot approach the high standards required for high-speed machining. Only a machine built originally for high-speed machining with micro-tooling can satisfy the exacting expectations. BM

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Ross Custom Switches, 45 Church Street, Norwich, CT 06360, 860-886-6800, 860-886-8088, www.rossswitches.com

flexibility, and versatility, coupled with impressive speeds. Conventional heavier machines don't possess the same speed and maneuverability. They are suited for larger tooling.

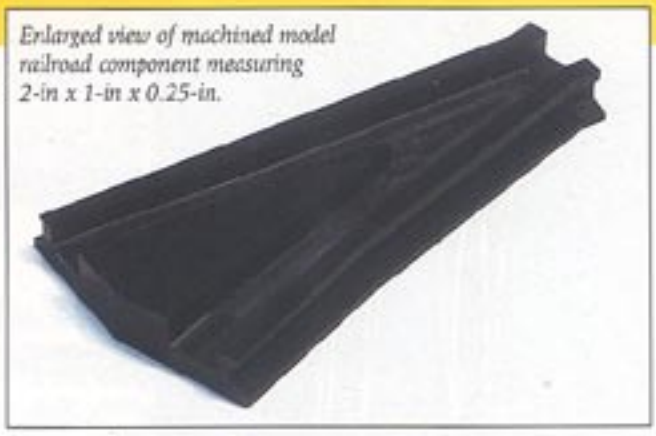
A high-speed spindle retrofitted onto a clunky conventional machine cannot be expected to efficiently accomplish high-speed machining with micro-tooling. A machine properly designed for high-speed machining with micro-tooling inherently encounters less machining force. It can achieve speed and nimbleness without needing a large motor to drive it.

THIS CAN'T GO ON

Ross Custom Switches (Norwich, CT) manufactures model railroad components used to switch model trains from one track to another. Ross discovered a way to increase margins while producing their custom track switches and turnouts in the U.S.

Machining these tiny 2-in x 1-in x 0.25-in parts was outsourced for years to local shops, but the high cutting force of the shop's conventional CNC machine couldn't hold the small part securely during production. So each part was manually set-up and clamped to an oversized piece of substrate on the machine bed. Eight to 10 parts were produced per hour.

Facing high production costs and foreign competition, owner Steve Brenneisen decided to make a change. "I wanted to have the total control of manufacturing parts in-house, quickly and with less cost, not having to depend on other shops," he says.



Enlarged view of machined model railroad component measuring 2-in x 1-in x 0.25-in.

FINDING THE FUTURE

Brenneisen attended the 2003 EASTEC trade show with his sights set on leasing the same CNC machine that his supplier used to produce parts. While there, he saw his future in the tiny parts being held to the bed of a Datron Aluminator™ High Speed CNC Machine with Vacumate™ workholding.

These machines feature a high-rpm spindle, produce a low cutting force and minimize side load. Even a part with very little surface area can be held securely on the vacuum table. "There was no clamping or fixturing and the set-up time was seconds instead of minutes. I immediately saw this translate my produ-