CNC MACHINING

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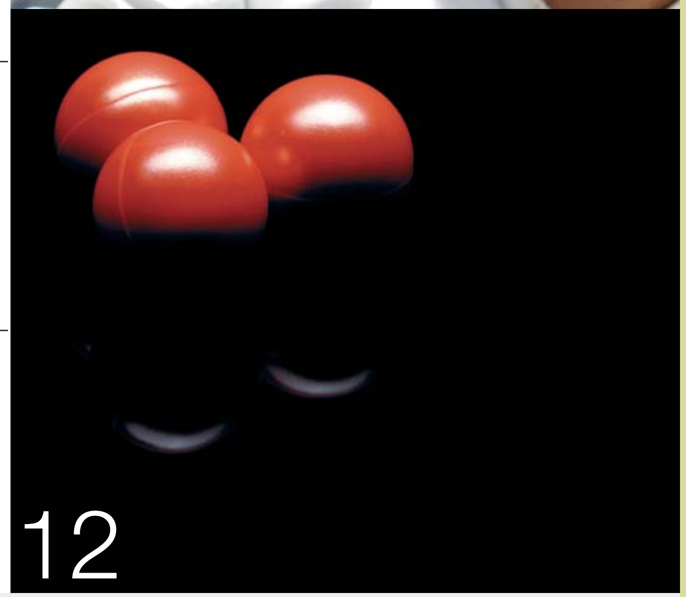


CNC MACHINING is published by Haas Automation, Inc., 2800 Sturgis Road, Oxnard, CA 93030, 805-278-1800, Fax 805-988-6918. Postmaster: Return invalid addresses to Haas Automation, 2800 Sturgis Road, Oxnard, CA 93030-8933 postage guaranteed. *CNC Machining* is distributed free of charge by Haas Automation, Inc., and its authorized distributors. *CNC Machining* accepts no advertising or reimbursement for this magazine. All contents of *CNC Machining* are copyright 2006 and may not be reproduced without written permission from Haas Automation, Inc. *CNC Machining* is distributed through a worldwide network of Haas Automation distributors, and by individual subscription request. Contact Haas Automation headquarters via mail or fax to be added to the subscription list. Haas Automation, Inc. & *CNC Machining* Magazine names ©2006. Designed and printed in the U.S.A. CPC # 40675626. www.HaasCNC.com.
Haas Automation Europe, ++32-2-522-9905 | United Kingdom, ++44-1603-760 539 | Haas Automation Asia, ++86 21 5046 2202

On The Cover

The ultimate weapon for recreational urban warfare: The DYE DM6 paintball marker.

Photo by Richard Berry

In This Issue

I resolve to exercise more, lose weight, quit [smoking, drinking, gambling – insert vice of choice here], treat my employees better . . .

. . . and do whatever it takes to compete in the world market.

It's another New Year, and time for another rash of New Year's resolutions – resolutions that may or may not be kept, but that have the best intentions behind them.

Why do we make New Year's resolutions, anyway? Because the New Year represents a new beginning, a chance to start afresh and try new things, a time for new ideas. It's a distinct point from which to embark upon a new journey. The old year– with its mistakes, regrets and misfortunes – is gone, and the New Year lies before us, a clean slate on which to create a new, and better, reality.

Yada, yada, yada. Most of us make New Year's resolutions because there are things in our lives or our businesses that we want to change. We really do have the best intentions, but most of us fail miserably. Maybe it's because we don't resolve to *do* the things on our lists. Rather, we resolve to *try* to do the things on our lists. Well, as Yoda instructed Luke Skywalker in the second Star Wars flick: "Do or do not. There is no try."

Sage advice, that.

Those who are successful in life and in business don't just try – they do. And they don't wait until the New Year to implement changes or try new ideas. If something isn't working, they fix it. If they have an idea for a new product or service, they go for it. Sure, sometimes they fail, but they never stop doing.

The subject of our cover story this issue is a man – and a company – who epitomizes the art of doing. Dave DeHaan, driven by a need to improve his personal performance in the recreational-urban-warfare arena known as paintball, came up with an idea: use modern gun-making methods and materials to build a better barrel for his paintball gun. One barrel led to 100, 200, 800 . . . Today, DeHaan's company, DYE Precision, is one of the top manufacturers of paintball guns, aftermarket barrels and accessories in the world, and he's definitely staying competitive.

Halfway around the world in India, another company, Bharat Forge Ltd. (BFL), wanted to expand its customer base from the Indian market to the world market, so they invested heavily in new forging equipment, automation and the latest manufacturing techniques. BFL now is a world leader in forging production, supplying virtually every global automotive OEM and Tier 1 supplier.

Bringing things closer to home, we've got an interesting piece on gearmaking. We take you inside America's leading machine tool builder to see how, and why, Haas Automation manufactures all of the gears for its products in-house.

As for education, we're pretty heavy on the subject in this issue, but for that we will not apologize. The shortage of skilled labor in the United States – and in much of the world – is real, and without a steady flow of qualified engineers, designers and machinists entering the workforce, domestic manufacturing firms will have an even harder time competing in the world market. We show you a school in Maine that is using the latest machine tools and software to give students real-world experience in a job shop environment. Then we hit the other coast for a college in Washington State that not only is educating the workforce of tomorrow, but also helping those already in the industry upgrade their skills to modern levels.

To show you that all this training actually works, we hit the Midwest for a story of two friends: one who recently graduated from, and the other who is still attending, Henry Ford Community College. They've parlayed their newly learned skills into a budding machine shop that specializes in precision-built custom components for a variety of industries. It definitely beats flippin' burgers at the local fast-food joint!

If that isn't enough to keep you on the throne (admit it, that's where you do much of your reading), we've also got an in-depth article on 3-D machining that provides valuable tips and tricks for getting the best results from your programming. And be sure to check out the Answer Man, for solutions to an assortment of applications problems, and Cycle Time, for the latest news and information about Haas Automation.

It's another new year, and another full issue. So pull up a chair, sit back, relax and enjoy!

Business and industry journalist Matt Bailey took the short flight from Mumbai to Pune recently to visit one of India's – and the world's – most successful forging manufacturers.

Bharat Forge

Story and photos by Matt Bailey

Passing through the imposing gates of Pune-based Bharat Forge Ltd. (BFL), the roads become smooth and well tended. Immaculate lawn edges and trim hedges border the long driveway leading to the car park, where small cars and scooters form orderly lines.

As a company, BFL has grown from its origins as a humble hammer manufacturer 40 years ago, into one of the largest, most accomplished and technically advanced forging operations in the world. It is the flagship company of the $1.25 billion (US) Kalyani Group, and describes itself as a "full-service supplier" of engine and chassis components. BFL is also India's largest exporter of automotive components, and has manufacturing facilities spread across six locations: two in India, three in Germany and one in North America.

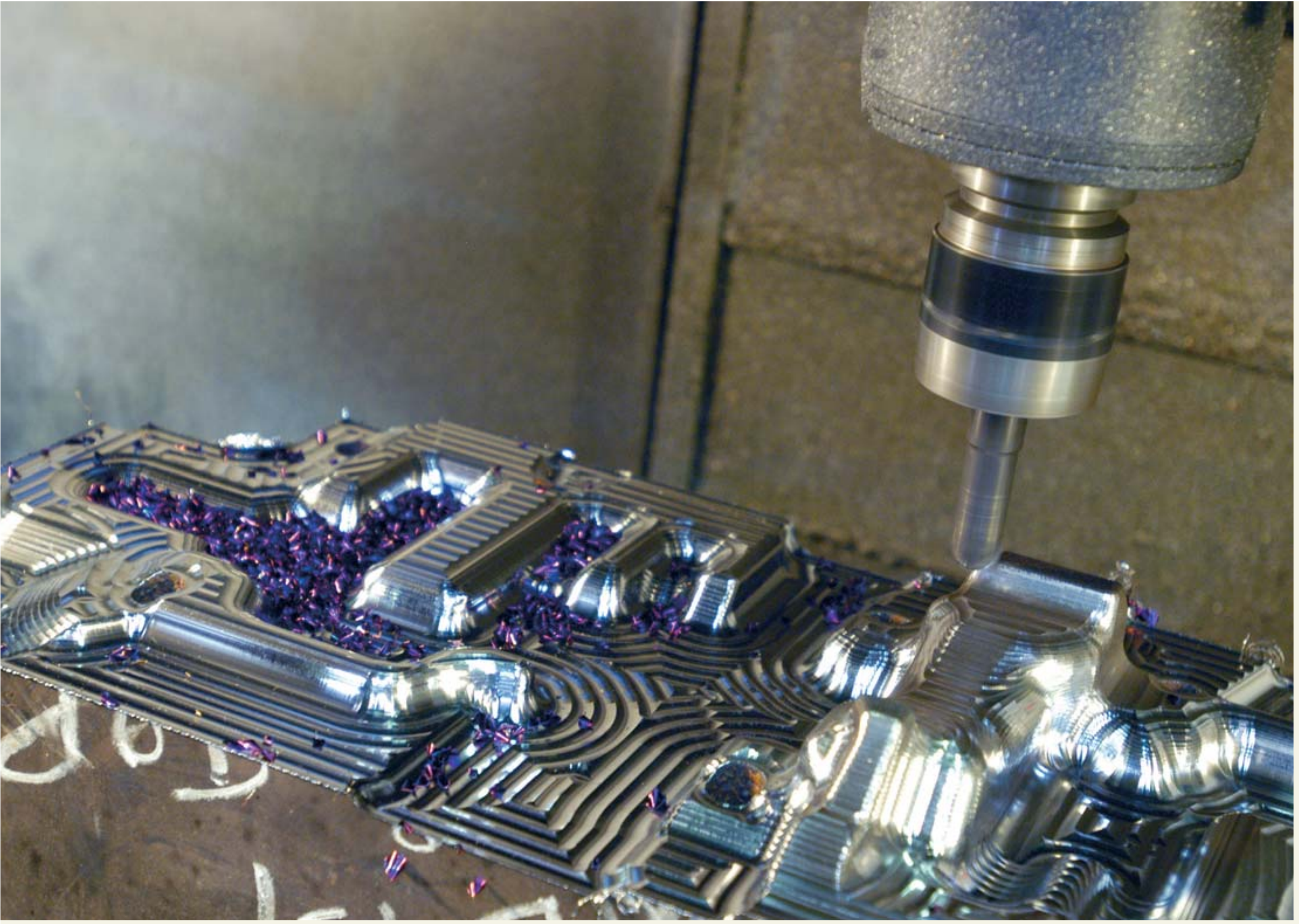
Over the years, BFL has invested to create state-of-the-art facilities and world-class capabilities, such as fully automated forging and machining lines comparable to the best in the industry. The company's customer base includes virtually every global automotive OEM and Tier I supplier, including: DaimlerChrysler, Toyota, BMW, GM, Volkswagen, Audi, Renault, Ford, Volvo, Caterpillar, Perkins, Iveco, Arvin Meritor and Cummins. Annual turnover of the 4,000-employee, publicly traded company is in excess of $600 million.

The turning point for BFL came in the late 1980s, when management at the company (then only selling to the market in India) decided to replace the ageing plant, which it originally bought second-hand from a U.S. supplier, with modern technology that would be the envy of forging shops the world over. The investment included new presses, new automation and the adoption of new manufacturing techniques, such as 5S and Kaizen. It was a bold strategy designed to make BFL a world leader in forging production.

Mr. B.P. Kalyani – a relative of the company's chairman – was given the task of implementing the new practices. To tackle the challenge effectively, BFL created a Forge Modernisation Division, and today Mr. Kalyani is its Senior Vice President.

"Our biggest challenge was to absorb the technology," he says. "It was all very new to us, but somehow we had to learn how to get the most from it – fast."

Word soon spread about the company's investment, and new customers sought out the company. One such customer



was U.S.-based axle-assembly manufacturer Arvin Meritor, which duly placed an order for 1,000 forged axle beams per month.

"We were able to offer them a product 20 percent cheaper than their previous supplier," says Mr. Kalyani. "Suddenly, the hard work and investment began to pay off."

Over the subsequent decade, the influx of orders accelerated, but despite the success, a problem began to surface: The die machining shop was struggling to keep pace with the forging lines.

"We knew we had to start looking at high-speed CNC machining centres," explains Mr. Kalyani. "At first, we only looked at various Japanese, German and Swiss models – the ones we had heard of. But the quotes were very expensive. We thought that must be the going rate, but then we came across Haas."

Mr. Kalyani admits he had not heard of Haas previously, but says the machine specification-to-price ratio was a real surprise. Only company policy, which demands that benchmarking tests take place between prospective supplier products, prevented him from placing an order immediately.

"We needed to prove that the Haas machines could produce a die within the cycle times and quality requirements we expected," he says. "At that time, we wanted to machine a connecting rod die from H13 tool steel (50HRc), so we passed the challenge to Haas. The result was really impressive. In fact, the results were no different than a set of benchmarking tests we had done on a Japanese machine that cost several times the price."

That was in 2001. Today, BFL owns 23 Haas machine tools: 16 VF-4 CNC vertical machining centres (the five most recent delivered in September 2005), two VF-7 machining centres, two VF-2 models, one EC-1600 horizontal machining centre, one Toolroom Mill and one Toolroom Lathe.

All of the Haas machining centres are fitted with 10,000- or 15,000-rpm spindles, as well as through-spindle coolant and high-speed machining options. In fact, BFL claims to have specified every available option on each of the machines it has purchased.

"We work the Haas machines very hard – 24 hours a day, seven days a week," says Mr. Kalyani. "Temperatures in the factory often can exceed 40°C (104°F), but none of our machines cope as well as the Haas machines."

Working around the clock, the Haas machines, run by five operators, produce a total of approximately 550 dies per month for forgings weighing up to 350 kg. Typical end products include crankshafts, connecting rods, front-axle

"All of our dies are now machined complete in a single setup on a single machine."

beams, rocker arms, steering knuckles, transmission parts and hubs. In fact, BFL claims to be the largest manufacturer of crankshafts in India, and the second largest worldwide, with annual production well in excess of 100,000 units.

"We are immensely pleased with the performance of our Haas machines," says Associate Vice President Mr. S. Rangan. "Before they were installed, the cycle time for a typical crankshaft die was 40 to 50 hours, now it is 14 to 15 hours. Similarly, a die for a connecting rod previously was machined in 40 hours, whereas now it takes just four. Add to this the fact that there is no bench or polishing work, no tool marks or cracks, and it is easy to see why we are so pleased. The days of separate roughing and finishing are also behind us. All of our dies are now machined complete in a single setup on a single machine."

Mr. Rangan states that two additional forging lines are planned for 2006, which will subsequently require yet more die-machining capacity. The company is also considering the acquisition of two more plants, one in Europe and one in China. He says that this ambition is targeted toward improving "speed to market." A decade ago, the time taken from receipt of a drawing to delivery of a hard-forged sample was around two months. Today, it is a couple of weeks. BFL's two-year target is to reduce it to just three days!

In the company's training division, a Haas Toolroom Mill and Toolroom Lathe are used daily by roughly 30 BFL trainees undertaking one-and-a-half year apprenticeship programs.

"We've never been afraid to invest," says Mr. Kalyani. "From the very beginning, the chairman invested the majority of profits back into the organisation. It's become a culture at BFL. Every company has the ability to define its own culture, and this is ours."

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the Perfect Gear

Story by Richard Berry

Photo: Scott Rathburn

"**More than any other type of machining,** gear making relies on a perfect mix of science and art," says Bill Tandrow, Director of Mechanical Engineering at Haas Automation. "I have a lot of respect for anyone who makes gears," he adds, in a noticeably reverent tone. "As much as any of our other efforts, the quality of our gear making defines the quality of our final product."

The science part of gear making is evident – it is well established in theory, with books full of formulas. But it's the less-apparent half that makes the dramatic difference. The real art of gear making, according to Tandrow, lies in careful observation and skillful control of the machining process itself. There's no "black magic" required, only complete and dogged attention to detail.

Gears don't make themselves. While that statement may seem obvious, the fact is that both cylinders and spheres, the most common bearing surfaces in mechanics, often do make themselves. Although a machinist's skill is required to consistently produce them in exact sizes and finishes, these shapes exist naturally, and their geometry can be machined accurately using only the most basic implements and setups. Chuck almost any shape stock into a lathe, run the cutting tool parallel to the turning axis, and you've made yourself a perfect cylinder.

Spheres are formed just as easily, except in three axes. Early machinists found they could make precision ball bearings with nothing more complicated than two rotating grooved plates, a suitable abrasive and lots of patience. The random rolling of rough blanks placed in the grooves automatically produced precise spheres. Perfectly spherical rocks have even turned up in riverbeds, created by nothing more exotic than a combination of the river's current and a hollow depression in the hard bottom.

But, while cylinders and spheres are natural shapes, the involute gear tooth is anything but. Even with modern CNC machines to tackle the problem, skill and careful attention are required to get it right.

"From the beginning," Tandrow continues, "this company's success has been built on attention to detail – not just being detail-oriented, but having the observational talents to see and understand what's wrong, and then having the know-how to make it right. That is the single bona fide secret to producing perfect gears."

Haas Automation approaches gear making seriously. The company machines every high-precision spur gear, worm and worm gear for its extensive product line in-house at its huge manufacturing facility in Oxnard, California. Out of more than 600 skilled machinists and assembly specialists, only a handful are assigned the task of making these demanding parts.

Consummate machinists Boris Klebanov and Edik Beginian have been with the company for about as long as anyone can remember. They purportedly learned most of what they know about gears from company founder Gene Haas.

"Years back, when we first started making mills," recalls Edik, "Gene wasn't completely happy with the gears we were getting from vendors, so he purchased a Reishauer RZ-80 and started making the gears himself. He did a lot of experimenting and testing to figure out exactly what was going on. He not only solved all of the performance problems, but he learned how to repair and maintain the machine himself. Then he taught us."

"We use those same perfected techniques today," Boris adds. "We're making essentially the gears that Gene evolved, along with 70 or 80 other kinds of gears. We're still doing everything in-house, and we're still solving all of our problems ourselves."

With schedules demanding different machine setups daily, maintaining process control is just one of many demands facing these highly talented machinists – but it's a big one.

"Spur gears were never intended to be precise," Tandrow remarks. "Until recently, nobody had equipment to make them precise. Machinists were often happy if they just fit together. If you open a *Machinery's Handbook* to the section on spur gears, you'll find a lot of tables for backlash and things. Those tables weren't based on a desire to make a bad gear," Tandrow says. "It's just that when those tables were written, back around World War II, that was the state of the art. CNC gear-hobbers and grinders obviously didn't exist then. You just couldn't expect to hold 30 millionths of an inch on a grind. But now we have equipment and processes that can hold down in those ranges repeatedly. We can literally produce an oil-film fit. We manufacture smoother running gears than anyone could even have imagined back then."

Why does Haas insist on making its own gears? "Because," says Tandrow, "quite simply, it allows us to precisely control the outcome. There are so many little tricks and subtleties in the hobbing and finish grinding, that we just would not succeed by having them done externally. We build our own gears to get exactly the right thing for us, at the highest precision possible."

Straight-cut spur gears are the basis for all of Haas Automation's gearboxes. The company started out buying complete assemblies, but they just weren't as perfect as the engineers wanted them, explains Tandrow. "Finally, we just designed our own gearbox. Now we make every part ourselves.

"When you buy gears from someone else," he continues, "you effectively have to buy through a middleman. Even if their shop is just across the street, you've got to build a relationship with them. You've got two different companies, two different cultures, and you probably have a pretty big disjuncture between the process of using the gears and the process of making them.

"But when you make a gear in-house, you can build things into it that they can't do across the street. For example, you can preassemble the gears in a rough state on a single mandrel, put them into a hobber or a grinder, and finish-grind them perfectly. The gears are as exact as you can measure them, and they're already on the shaft they'll run on. 'Across the street' is just not close enough to ensure this kind of quality," Tandrow says. "For most of our gearbox operations, the operator who hobbed or finish-ground the gear is literally within a hundred yards of where we assemble the gearboxes.

"For a manufacturing environment, that's the ideal. We can make the gears in very tight batches of 10 or 20, and quickly process them through. It's more cost-effective than ordering big batches, and if there are any issues, we're only looking at a small number of reworks to get production flowing again. That's if there are any issues," Tandrow emphasizes. "Honestly, we've not had one since we adopted this approach."

In the same area where the spur gears are cut and ground, Haas also machines precision worm gears and worms for its rotary products. This is where the dedication to tight process control really pays off.

"The aluminum-bronze worm gears at the heart of our rotary products are actually quite mature concepts," explains engineer Thomas Velasquez, who has been designing these products for more than a decade. "The inherent accuracy is assured by the single-lead hobbers that we use, and by the preassembly we do before cutting. We place the shrink-fit gear blank onto the spindle, mount it on the fixture and actually tram it in. The guys (Boris and Edik) try to shoot for a runout of about 50 millionths." This procedure ensures that the pitch diameter of the finished gear is perfectly concentric with its mounting diameter.

Again, the inherent accuracy of the setup is translated into actual product accuracy through the skill of these machinists, and through their careful control of the process. "Every third or fifth one is checked on the Klingelnberg gear analyzer against a master worm," notes Velasquez. "We can verify tooth-to-tooth and overall pitch accuracies on both the worm and the gear at the same time. We also have special worms that we use to check the gears as we're cutting them, for more immediate feedback. We need to know that they're coming out of the machines right."

"That's another very important aspect," adds Tandrow. "You can't compete at the level just described without having some of the best equipment in the world: like the Reishauer RZ-362A hobber, the Studer S40 grinders and the exceptional inspection equipment we have on the floor. You have to have the best tools to generate these results repeatedly."

"We also have new Mitsubishi GC15 and GC40 gear hobbers," adds Velasquez, "as well as high-quality carbide hobs, and a real passion for maintaining the equipment so that it stays accurate."

Another factor critical to the accuracy of the gears is the careful process of heat-shrinking the worm gear to the spindle before cutting it. "That all but eliminates concentricity errors," says Velasquez, "and it simply could not be done if the gear was jobbed out. In a nutshell, we keep tabs on everything: We know where we're going and how to get there."

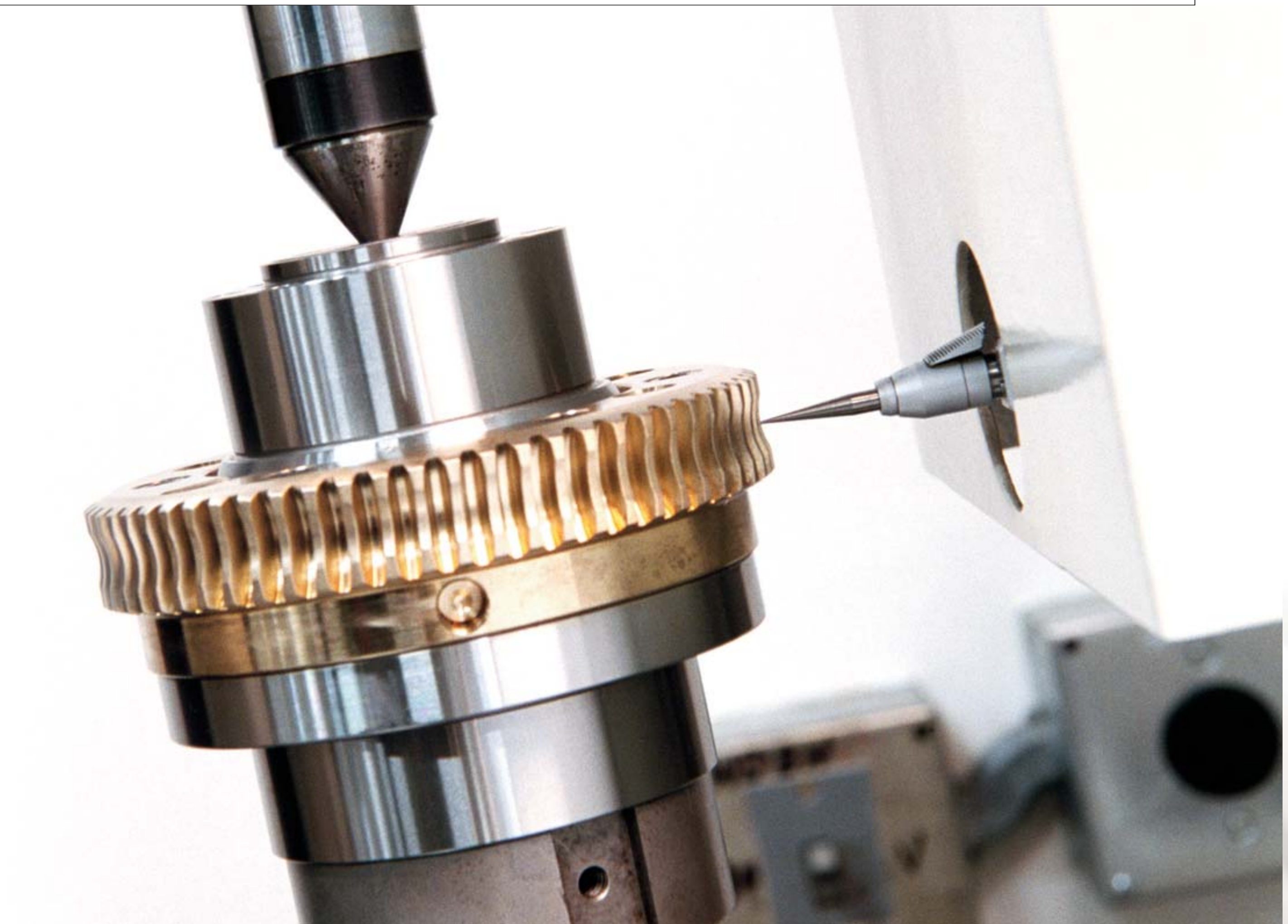
"That's the complimentary part," says Tandrow. "We have an assembly staff that can inspect as they build. Since the parts are made in a controlled process, and the assembly staff knows all aspects of it, including the tolerance bands for testing the parts, we have complete control of the quality."

A key member of that assembly staff, Misha Brkic, uses a proprietary inspection setup to verify the accuracy of each final product. With his years of experience, though, he can tell almost as much with his hands during the assembly process. He knows perfectly the subtle feel of an exactly machined worm and gear, and can stop the assembly process almost before it starts if he finds anything unusual.

"This level of skill and experience is the final key to the success of the process," says Tandrow. And while Brkic performs his duties on the opposite side of a long wall separating the machine shop and assembly areas at Haas, he's still only a hundred yards from Boris and Edik. There's a large doorway conveniently located midway between them.

"It's perfect!" Tandrow exclaims with a smile. "Just like the gears."

Haas rotary gears are pre-assembled to the spindle, and then trammed-in to a maximum runout of 2.5 microns before hobbing. This all but eliminates concentricity errors.



Bur-rup -rup-rup -rup-rup -rup!

The burst is impossible to ignore as it turns your whole world bright yellow. Your splattered mask marks a loser, and no degree of head hanging can hide it. Given that your shame came courtesy of a titanium Boomstick,® it might be possible to salvage *some* pride.

Then again, it might not.

Paintball is not now, nor has it ever been, a sport for the easily resigned.

Story by Richard Berry

Shop Photos: Richard Berry
Action Shots: Courtesy Dye Precision

Do or DYE

The Evolution of Dave Youngblood Enterprises

We never cease to be amazed when "an idea whose time has come" appears on the horizon . . . and steamrolls everything in its path. Mere mortals don't get it. We pay lip service to early birds and worms, or mothers of invention, but the power of "the big idea" lies outside our bounds of the barely imaginable. For a gifted thinker named Dave DeHaan, however, the powerful forces behind these tired clichés all converged one night in his garage, and propelled that modest owner of a single lathe and mill to the head of a multimillion-dollar manufacturing marvel.

Dave DeHaan turned pro at age 16. His sport of choice: paintball – and before long he was a well-known champion. It was the mid '80s, and even professional players didn't wear nice uniforms with their names on the backs. Nicknames ruled the day, and for obvious reasons, but not particularly to his liking, the teenage Dave DeHaan became known as "Youngblood."

Unless you've been hibernating for the last few years, you've most likely heard of paintball. You may not know the details of the game, but you have at least some inkling of its basic premise. While you've been napping, this game of high-tech hide-and-seek has become a cultural phenomenon, and the fastest growing extreme sport on the planet.

Fundamentally, paintballers shoot at each other with guns (the politically correct term is "markers") that fire paint-filled plastic balls to prove who shot whom. And, yes, it hurts! Other equipment is needed as well, including protective clothing, eye shielding and a tank of pressurized gas. Beyond that, the sport is difficult to describe. As few as two people or as many as 500 can play, and the game can last from mere minutes to a day or more. The objective is to *take* something, *find* something or just be the last shooter standing. But regardless of the particulars, one thing is certain: The game is a guaranteed adrenaline rush.

After several years of tournament success, Dave "Youngblood" DeHaan became everyone's favorite target. Adrenaline rush or not, he seriously needed to better his game. That spawned an idea: He'd make a better barrel for his gun. In fact, as the concept gelled, he imagined a much better barrel: one machined more accurately than any existing designs; one made using precision gun-drilling and honing techniques; one that would turn a simple plastic and aluminum paint-marker into a highly accurate, stainless-steel shooter. And that's exactly what he built.

As it turned out, the technological history of the sport was on DeHaan's side. Paintball's roots reach back to the '70s, when a small manufacturer adapted a Daisy® BB-gun design to make a pistol-shaped, industrial paintball marker. That little gun worked off of a 12-gram CO_2 cartridge and shot a paint-filled, 68-caliber ball. It was designed specifically for the U. S. Forestry Service to allow their field rangers to quickly and easily mark trees. Clever cattle ranchers quickly picked up on the idea, too. "A lot of those guys worked on horseback, and they found it was simple to shoot trees to mark them for cutting, or to mark cattle that needed to be separated from the herd for some reason," explains Dave. "And somehow, between that, and a bunch of guys kind of getting a little carried away, a sport was born."

Before long, all the established BB-gun manufacturers, including Daisy®, were manufacturing guns for the sport, alongside hundreds of other specialty manufacturers both large and small. That first marker lacked both range and accuracy, but it set the manufacturing standards for the soon-to-be sport. All paintball guns that followed used the same sized balls, and had barrels bored to a standard diameter. This fortunate turn of events allowed DeHaan to retrofit the special barrel he built to almost any paintball gun on the market.

"... the 200 run became 400, and the 400 run became 800, and before you know it, we were running several thousand at a time. Our name was becoming known, and people were calling constantly, wanting more."

Competitors, seeing Youngblood win tournaments with his spectacular stainless-steel barrel, wanted one too. “You know,” says DeHaan, “in so many sports, people assume that any success you have must be due to your equipment. But that’s okay,” he smiles, “that assumption helped us start a business. With so many people asking, ‘Where can I get a barrel like that,’ I decided to go in with a friend and make some more, and see if we could sell them.

“Really, there was no predetermined marketing plan,” remembers DeHaan. “I just picked the number 100 – it seemed almost possible that we could eventually sell that many. I was busy working as a part-time police officer, and also working for my father-in-law, so we subbed-out all the machining and just did the inspection, cleaning and packaging ourselves. I was really moonlighting it, out of my garage.

“We figured it would take us maybe a year to sell those 100 barrels,” DeHaan continues, “but by the time we got them assembled, we had them all sold! So we thought, ‘Well, let’s try just another 200.’ These barrels were really expensive for the time, so we thought maybe only 200 people – at most – would buy them. But, again, we sold out as quickly as we could turn them around. And the 200 run became 400, and the 400 run became 800, and before you know it, we were running several thousand at a time. Our name was becoming known, and people were calling constantly, wanting more.

“Before long, we couldn’t make barrels fast enough to keep up, so I thought, ‘We’ve got to get some good CNC equipment.’ I visited a local Haas dealer and explained our situation. They were very helpful, and really made it as painless as possible.”

Extensive use of rotary indexers allows DYE to perform multiple operations in a single setup – increasing productivity and precision.

With little machining experience and a product demanding tight tolerances, the Haas dealer recommended that the fledgling company start with a simple CNC lathe and a Haas VF-3 vertical machining center. “That was scary,” admits DeHaan. “I didn’t even know how to program that first machine we got. I tried – and crashed it several times. The Haas dealer spent a lot of time holding my hand those first couple of weeks.” But, with a lease for a 1500 sq-ft commercial space, one lathe and one Haas mill, Dave “Youngblood” Enterprises was officially launched. DYE Precision, as it would soon be known, was off and running.

Quickly, the steamroller gathered momentum. Despite the efforts of a couple competitors, demand for the superior DYE barrels grew every month. Soon, 1500 square feet wasn’t enough.

“When the guy behind us left, we knocked down the wall and brought in a couple more machines. Then a couple more after that, and then even more,” says DeHaan. They continued to go through walls and add equipment until, finally, DYE Precision occupied as much of the building as they could get: 16,000 square feet – most of it crammed full with Haas machines. Eventually, they were forced to move everything – lock, stock and barrel, so to speak – to a new building.

Today, DYE Precision operates from a purpose-built, 60,000-square-foot building just north of San Diego, California. “And still,” says DeHaan, “we’re crammed!” Already, the company is planning a new 120,000-square-foot facility a few miles away and hoping it will be big enough.

Explosive growth led the enterprise in some different directions. After buying out an established paintball gun company in 2003, DYE completely redesigned their existing product line and introduced a complete gun set to complement their aftermarket barrels and accessory products. About the same time, they also expanded into "soft goods" and began producing a wide-ranging line of clothing and protective gear for the game. The DYE brand is now known and marketed around the world, with active dealer networks spread from North America to Europe to Asia. Their catalogs list more than 10,000 different items. "It's still kind of amazing," muses DeHaan, half smiling, "there's no end in sight."

The big San Diego facility employs 140 people, and nearly a third are full-time machinists. "We need them," explains DeHaan. "All told, we're now up to about 40 Haas machines." Just about every product in the Haas line can be found on the floor, from a TL-1 Toolroom Lathe to a row of small SL-10 lathes to a bank of EC-400 horizontal machining centers. At first glance, the floor could be mistaken for a giant Haas showroom.

Working in materials as varied as 303 stainless steel, 6061 aluminum and even titanium, the machinists carry out a broad range of precision turning and milling operations, as well as honing, deburring, tumbling, bead blasting and polishing. All the metalwork except anodizing is done in-house, and you'd be hard pressed to find an idle moment.

"I've never seen a shop running machines like we run them here," says DeHaan. "We work them around the clock, 24 hours a day, 7 days a week. They run like crazy, and every second of machine time is accounted for," he emphasizes. "That's because in just the two gun lines alone, not including our barrels and accessory items, we need to produce more than 70,000 different parts each month to manufacture the final product."

Their catalogs list more than 10,000 different items. "It's still kind of amazing," muses DeHaan, half smiling, "there's no end in sight."

"You know," adds General Manager Brian Benini, "each gun kit has up to 35 unique parts that have to come together at exactly the right time to build a complete unit. You begin looking very closely at the machine run-times, the capacity issues, and you try to stay 'layered.' It's lean, just-in-time manufacturing, and it's dicey."

When asked about all the "do or die" clichés they must have heard, Benini adds, "Well, we do cut it close sometimes, but it's certainly the most efficient way to manufacture. And to stay efficient, we've always got to be very close to that narrow window of having all the parts come together just when we need them. Yeah, 'do or die' describes it."

Considering all the production going on, the shop floor doesn't seem over-crowded with people. "It's a big place, and the machinists are spread out," notes Hung Pham, the shop manager. "We use fixtures and multiple setups as much as we can, so the machines run in pretty long cycles, and an operator can look after more than one machine. We do multiple operations with rotaries on many mills, and multiple parts on tombstones whenever we can," he says. "Machining four or five parts at a time isn't unusual. We save lots of loading time, and it's more precise when we do it that way, instead of with separate operations."

DYE's horizontal machining centers – three Haas EC-400s and an older Haas HS-1RP– are dedicated to initial operations on the gun bodies and handle assemblies. "We load up the tombstones with four blocks of 6061 aluminum on each face," Hung explains, "and we do three ops at one time. We get lots of work done with these machines." The accuracy required for these components is tight: The front, back and bottom faces have to be flat within 2 thousandths. The HMCs also machine the cross hole, the bore, the thread and the pocket in the bodies.

When they come off the machines, though, they're still basically just aluminum blocks. The contour machining that defines the gun's beautiful, curvaceous shape is done on a small army of Haas Super-Speed vertical machining centers. Output from the four horizontals feeds a total of 11 Haas VF-2SS and VF-4SS verticals – all running 24/7 to keep up with demand.

DYE's famous two-piece barrels, on the other hand, are, by necessity, produced one at a time. They start as aluminum, steel or titanium bars, which are first gun-drilled for the bore. Next, they are turned down to shape, cut to length and threaded on Haas SL-10 or SL-20 CNC lathes. The logo and detail machining is typically done on Haas Mini Mills or VF-2 VMCs equipped with Haas 5C indexers for full fourth-axis work. "We have a lot of different machines we can schedule for these ops," says Hung, "so we have some welcome flexibility in this area."

A major feature of the DYE barrel, besides its precision bore, is the engraved logo, says Hung. "The engraving is very deep," he explains, "but with our setups, we can do it in a single op with a single tool. We hold tolerances within plus or minus two thousandths on both the turning and milling operations – even in the logo cuts. The engraving is so deep," he adds, "that its precision is critical to the strength and performance of the barrel."

And precision and performance are what DYE is all about. "Other turned parts, especially internal gun and regulator components, are very critical," Hung stresses. "The bolt, for example, needs to be held within two to three tenths. But we do that consistently – in large-quantity, around-the-clock production. Still, we're constantly improving, and learning how best to set things up."

The beautifully contoured bodies that define a DYE gun's shape are sculpted on a small army of Haas Super-Speed vertical machining centers.

DYE guns require a number of precision turned parts. Here, a DM5 fuse-bolt nears completion. The use of bar feeders on their Haas lathes keeps production flowing.

"We'll have a production meeting," says DeHaan, "and Hung will say, 'I'm doing good in my milling area, but we're running the lathes like crazy, and still slowing down completion of the product.' So we'll say, 'Let's add a machine, let's try to speed that up.' That's how we got into bar feeders on nearly all of our Haas lathes. It's a simple addition that has really helped production. And keeping things simple," he continues, "is always a good thing, no matter what you're making. There are a lot of turned parts on the guns, and of all the machines we have, the lathes run absolutely the most. We have some Haas lathes that have run only one part since the day they were installed. We load material in them and they just run around the clock. They're just amazingly reliable production machines."

But Hung's production planning can never get too comfortable, as the flexibility of DYE's machining cells is tested again and again. Every year, DYE introduces new models, and fights a release-date backlog of new orders. "We have to keep changing," adds DeHaan. "The people who buy our stuff expect it of us. We listen to the paintball players, we note their suggestions and we change." Virtually all the managers and top people in the company go to the tournaments and attend the industry's trade shows. Many are active professional players, and have been for years.

General Manager Brian Benini fits that description perfectly, and also wears the hats of Advertising Director and Research and Development Manager. He stays as closely integrated with the game as possible. "When you're face to face with your customer, you take it personally," he notes, "both their satisfaction and their problems." Designs have to change, and production has to change with them.

"We can't afford to lose touch," adds DeHaan, "that's why we stay in the game. Not losing touch is a big issue around here, and maybe that's why we're successful. We live, breathe and sleep paintball."

"Successful" seems a barely adequate word to describe the DYE phenomenon: from a simple idea to a garage business to the largest high-end manufacturer in the industry – in less than a decade. Now at the top of the pyramid, the pressure is on DYE to stay there, to continue the growth, to constantly perform better. Like the "Youngblood" tag from the beginning, the "do-or-die" cliché will always be there.

"The way I look at it," says DeHaan philosophically, "we'll make, or break, ourselves. Whether there's competition pressure or not, we're always going to improve our product, we're always going to grow in what we do, and we're always going to have the new idea. That's just the way we approach business – like the way we approach the game."

DYE Precision, Inc.
www.dyeprecision.com
858-536-5183

TIPS AND TRICKS FOR 3-D PROGRAMMING

By John Nelson, Applications Manager, Haas Automation, Inc.

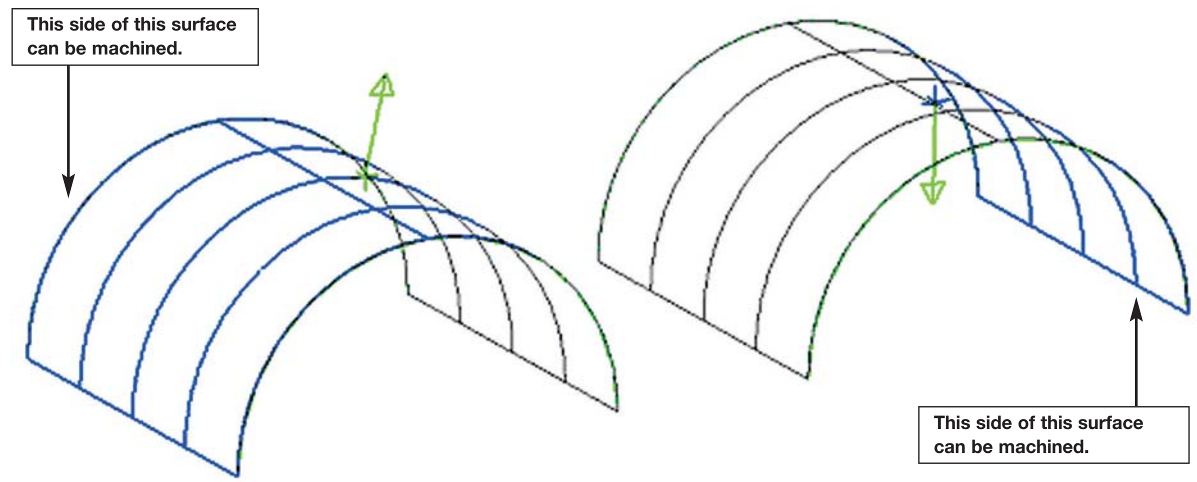
This article has some tips and tricks to use when programming complex 3-D surface toolpaths. All of my experience in 3-D programming has been with Mastercam® software. Many of the terms I will be using will be specific to Mastercam®, but most all CAM systems have similar features. Although the names of the features may be different, your system should still have them.

Modeled Surfaces

To get a good surface toolpath, you must start with good surfaces. If the surfaces you are using were created in a software program different from the software you are using to generate the toolpaths, it will be well worth your time to do some checks on the surfaces provided.

You need to determine the direction of the **positive surface normal**. A surface normal is a vector (direction) that is perpendicular to the tangent plane of a surface at the point of tangency. It is an attribute that is attached to each individual surface, and not to a specific part shape. In the following diagrams, the green arrows represent the vector that is perpendicular to the surface at the point where the vector intersects the surface, and they point in the direction of the positive surface normal.

Each surface has two normal vectors, which point in opposite directions. One is referred to as the positive (front, outward) direction; the other is referred to as the negative (back, inward) direction. The positive surface normal side of the surface should always be the side you are machining. When a surface is created, the direction of the default positive normal is based on the relative directions of the curves defining the surface. This becomes a problem if you are machining a model that has several surfaces, and some positive normals point inward and some point outward. The normal direction must be "flipped" so that all of the positive normals point in the same direction. In the graphic on the top of page 25, the surface on the left has the positive surface normal pointing outward. The surface on the right has the positive surface normal pointing inward.



It is important to know the surface normal direction, because it affects the way offset surfaces are created, curves are projected onto surfaces, and fillet surfaces are created between two sets of surfaces.

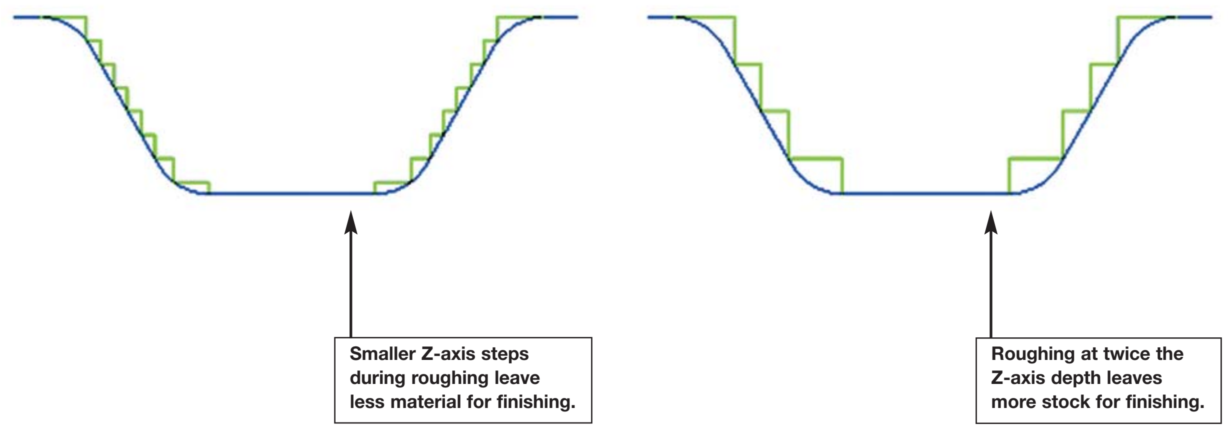
Also, check the **surface creation tolerance** or the **maximum surface deviation tolerance**. This will determine the maximum distance by which a surface can be separated from its generating curve. If the tolerance is too large, the final machined surface may not be desirable.

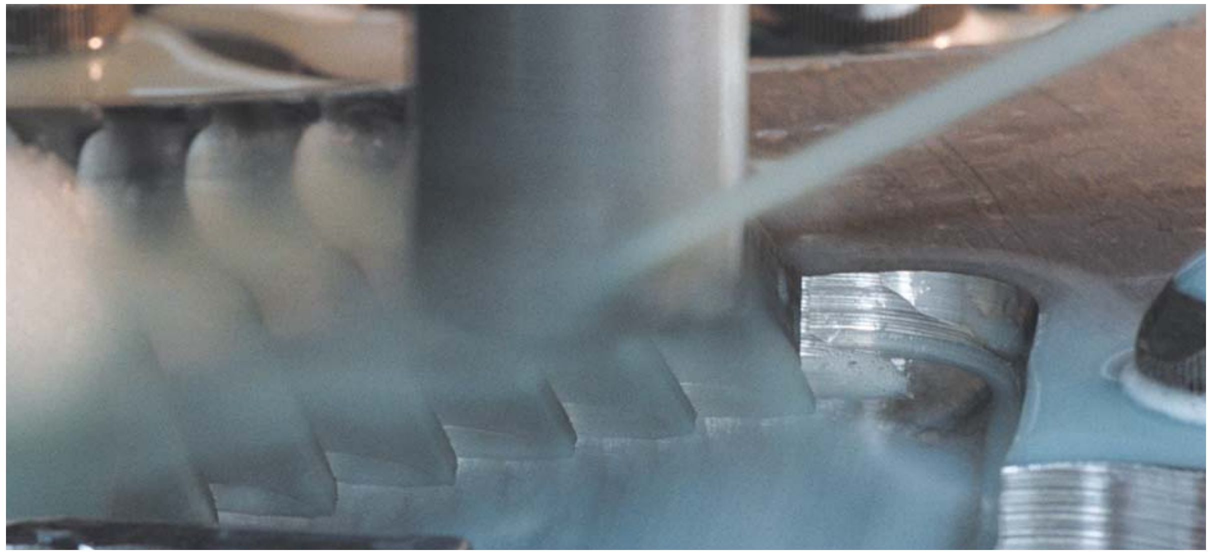
Tip: I usually set my maximum surface deviation tolerance to 0.00005" (0.0013 mm).

Choosing The Correct Surface Toolpath

All CAM systems provide a variety of surface toolpaths. For **surface-roughing toolpaths**, the shape of the finished part and the stock you are starting with will help you decide which path to choose. If you are removing material from inside a workpiece – in other words, cutting a cavity – a surface-pocketing toolpath is usually the logical choice. If you are cutting a core, or removing material from the outside of a workpiece, a surface-contour path may be best.

Most surface-roughing toolpaths will step down to constant Z-axis depths, and rough the stock leaving a specified amount of material on the designated surfaces. The depth of the steps in the Z-axis during roughing will affect the amount of material left for finishing. Larger steps in the Z-axis leave more material for finishing. Smaller steps in the Z-axis leave less stock to be removed during your finish cut.





Obviously, roughing with smaller Z-axis steps will increase cycle time, so there are three main factors to consider during programming. They are: material type, the size of your finish cutter and the required surface finish. If you are machining soft material, like aluminum or mild steel, the larger "chunks" of stock will not have much affect on your finish cutter. If you are machining hard or tough materials, your finish cutter may deflect when becoming engaged in uneven amounts of leftover stock. The result could be an uneven surface finish.

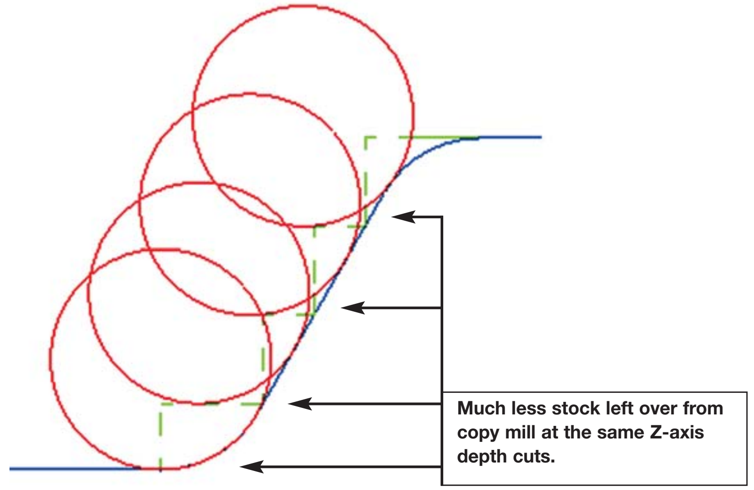
The two common solutions for this problem are to use smaller Z-axis steps during roughing, or to add a **semi-finish** path. The semi-finish path should be created with a larger stepover than the finish path, and using a different tool. It can be the same size as the finish tool, but should be a separate tool. This way, the finish tool does not wear out as fast as it would if it were used for both semi-finishing and finishing.

TIP: Typically, a semi-finish path will leave 0.005" to 0.015" (0.127 mm to 0.381 mm) stock for the finish cut.

When using smaller Z-axis steps during roughing, you can reduce cycle time by using a **copy-mill cutter**. A copy-mill cutter is an insert endmill with round inserts, but is not spherical like a ball endmill. The round inserts allow you to cut at higher feedrates, because they create a variable chip thickness. The entering angle of the cut varies from 0° to 90°, based on the depth of cut, which gives a very smooth cutting action. Copy-mill cutters are also very strong, because the cutting action takes place over a larger area than other insert geometries, allowing higher feedrates and reducing roughing cycle time.

The round inserts also allow you to remove material much closer to the true surface on non-vertical walls, when compared to cuts from a 90-degree endmill at the same Z-axis depth cuts. Most carbide insert tooling manufacturers make this type of cutter in various diameters and insert sizes.

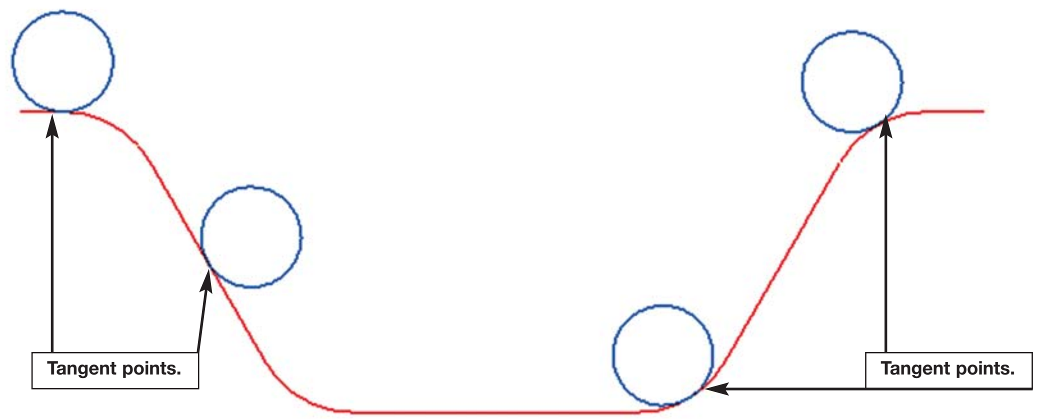
This is a round insert endmill, also known as a "copy-mill" or "button" cutter.



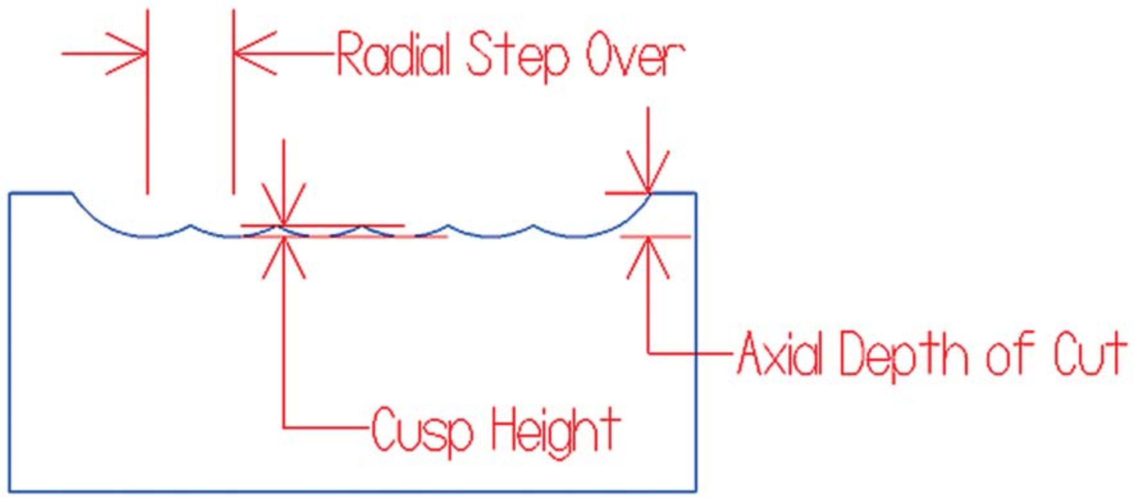
Surface-Finish Toolpaths

Surface-finish toolpath selection can be more difficult. There are a few basic concepts that must be understood in order to produce an excellent-quality surface-finish toolpath. In 99% of cases, a finish toolpath will be created using a spherical, or ball, endmill. The shape allows it to move over all surfaces and cut at any point around the sphere. For example, think of a ball bearing placed in a bowl. You can roll the ball over any part of the bowl and it will make contact with the surface in different points around the sphere, depending on the location of the ball in the bowl. The point of contact is called the tangent point. In the drawing below, the radii of the bowl are 0.250" (6.35 mm) and the radius of the ball bearing is 0.125" (3.175 mm).

The next concept to understand is called **radial stepover**. Radial stepover is the distance between centerlines of successive, parallel cuts. When the radial stepover is increased, the **cusp height** will increase. The cusp height is the primary factor that will determine the smoothness of the machined surface. A cusp height of 0.00003" to 0.00005" (0.00076 mm to 0.00127 mm) will produce a very fine finish. Since the cusp height is controlled by the radial stepover and the tool diameter, the following formula can be used to calculate the cusp height on a flat surface:



$$\text{Cusp Height} = \sqrt{(\text{Tool Diameter}/2) - ((\text{Tool Diameter}^2 - \text{Radial Stepover}^2) / 4)}$$



When selecting a finishing toolpath, your first consideration should be the required surface finish. If you are creating a mold and the surface finish must be extremely smooth, you will have to make different choices than if you are cutting sculpted surfaces with a large surface-finish tolerance.

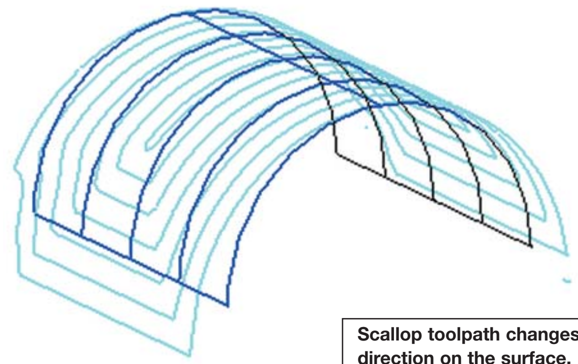
The first type of finishing toolpath is called a **parallel path**. It moves the tool across the surfaces in straight, parallel cuts. These straight cuts do not need to be parallel to a machine axis. They can be produced at any angle, but all passes over the surfaces will be parallel to each other. This toolpath usually produces the best finish, in most situations. Parallel toolpaths are cut using one of two methods: **zigzag** or **one-way**.

A one-way parallel toolpath takes a pass, rapids up in the Z-axis, rapids back to the beginning and takes another pass in the same direction at the specified radial stepover. All passes are made in the same direction.

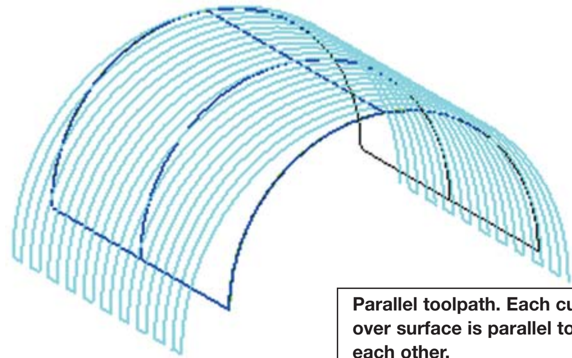
Zigzag cutting moves the tool back and forth across the part, stepping over at each change in direction.

TIP: It has been my experience that a one-way toolpath will produce a better surface finish, but will take longer to run because of the rapid moves at the end of each pass. Zigzag toolpaths have a tendency to climb-cut while moving in one direction across the part, but conventional-cut while moving in the other direction. This usually produces uneven surface finishes, and can cause premature cutter wear on hard or abrasive materials.

Another common toolpath is a **scallop** toolpath. Scallop-finish toolpaths create consistent scallop heights over an entire set of surfaces. The toolpath consistently touches the surfaces and minimizes retract motion. This path works very well, because it can start from the outside and collapse in toward the center, or start in the center and expand outward. The drawback to this toolpath is that, as it expands outward or collapses inward, it changes the cut direction on the surfaces. When the cutter changes direction, it leaves visible "seams" on the finished surface. This toolpath is very useful as a semi-finish toolpath to get rid of the steps from the constant Z-axis surface-roughing toolpath. It also works great when a very fine surface finish is not required.



Scallop toolpath changes direction on the surface.

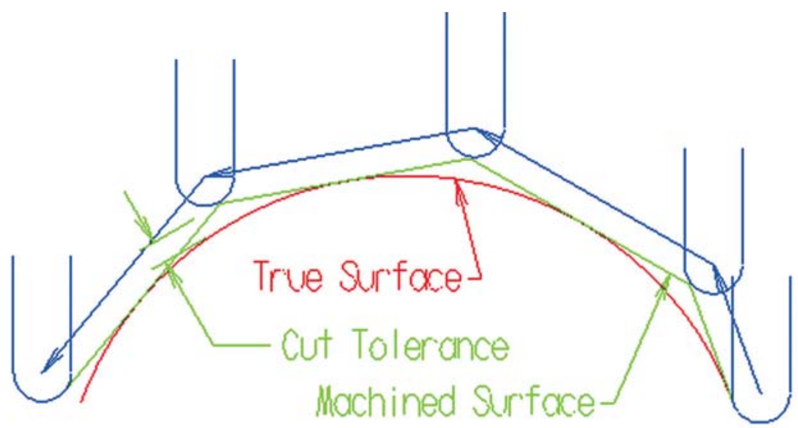


Parallel toolpath. Each cut over surface is parallel to each other.

Toolpath	PRO	CON
Parallel - One-way	Best surface finish; more consistent cut direction (climb vs. conventional)	Longer cycle times with rapid motion at the end of each pass
Parallel - Zigzag	Shorter cycle time; cutter stays on work-piece in cycle	Uneven surface finish and premature cutter wear
Scallop - Expand	Shorter cycle time; cutter stays on work-piece in cycle; excellent for semi-finish	Toolpath plunges into the center of the stock and expands outward; visible seams on the surface
Scallop - Collapse	Tool starts on outer edge of stock; shorter cycle time; cutter stays on workpiece in cycle; excellent for semi-finish; best Scallop path	Visible seams on surfaces where cutter path changes direction in the cut

Cut Tolerance

In all cases with surface toolpaths, the **cut tolerance** controls the precision with which the cutter follows the surface. This is sometimes referred to as **linearization tolerance**. The cut tolerance determines the accuracy of the surface using chordal deviation (the distance between the toolpath and the true curve, surface or solid face). The cut tolerance linearizes the toolpath and controls how closely the tool follows the true curve, surface or solid face.



Since the toolpath is linearized (all toolpath moves are G01, linear interpolation), the cutter cannot always be in absolute contact with any surface that has curvature to it. Therefore, the toolpath leaves the actual surface by an amount specified in the cut tolerance. When the cutter has deviated from the true surface by the cut-tolerance value, a block of motion is output to bring the cutter back in contact with the surface. When the cutter is back on the surface, another block of motion is output to avoid violating the surface.

Because of this linear toolpath, the machined surface is actually a series of flat surfaces called facets. Think of a diamond. It is round and conical, but is truly a series of flat surfaces. If the cut tolerance on a finishing surface toolpath is too large, the resulting surface will have large facets. And, because the toolpath is deviating from the true surface, you will see gouges in the machined surface. These gouges do not violate the true surface. They are only gouges in the uncut stock left over from the linearization process. This is because the tool will not always deviate from the true surface by the same amount in the same position along the true surface on successive stepover passes. To solve this problem, I have found that a very small cut tolerance will greatly reduce the gouging and the size of the facets.

TIP: For the finest surfaces, I recommend setting the cut tolerance to a value of 0.00002" (0.0005 mm).

In the photos above, the same shape was cut with the same cutter at the same spindle speed, feedrate and stepover. Everything was the same except the cut tolerance. The shape in the left photo was machined with the cut tolerance set to 0.00033" (0.008 mm). The shape in the right photo was machined with the cut tolerance set to 0.00002" (0.0005 mm). The difference in surface finish is like night and day.

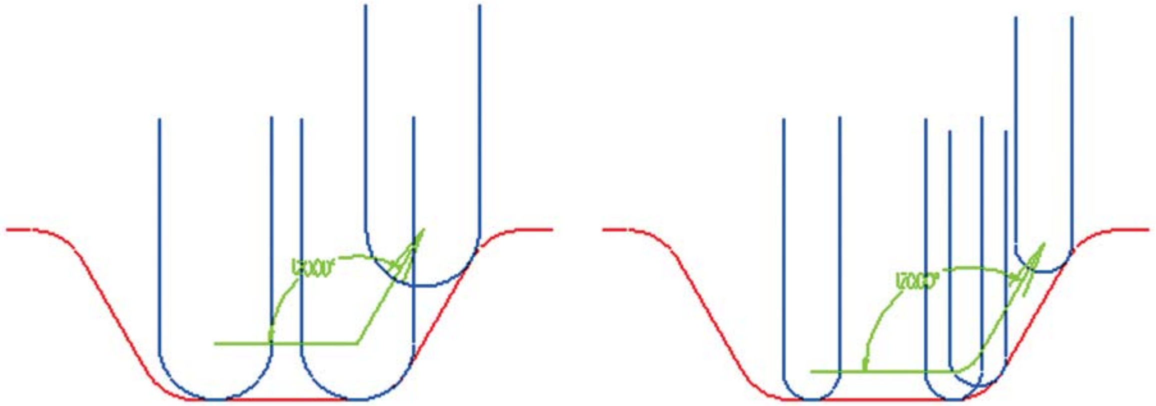
Filtering Toolpaths

Filtering toolpaths is a great way to reduce the size of the G-code file used to produce complex three-dimensional surfaces. When you filter a toolpath, the CAM system replaces straight-line toolpath moves that lie within a specified tolerance with a single toolpath move. This is contrary to the purpose of setting the cut tolerance to a small value discussed above, but if you set the cut tolerance and the filter tolerance to the same value, you can now set the arc filter to reduce the amount of G code without reducing accuracy.

With the toolpath filter, you can replace multiple linear tool moves with a single arc move of a specified minimum and maximum radius. You can select to create arcs in the XY, XZ and/or YZ planes, but the tool motion must be parallel to a machine axis to get the arc output. Setting the arc filter parameters allows you to smooth the faceting that is typical of linearized surface toolpaths, and create a single arc move out of several linear moves to reduce the amount of G code produced.

High-Speed Machining

The High-Speed Machining option in the Haas control works by analyzing the change in vector direction, or change in angle, from one block to the next. When the change in vector direction is very small, as with code produced by using a small cut-tolerance value, the control can interpolate the motion at a higher feedrate than when the change in vector direction is greater. The greater the change in vector direction, the more the control must slow the motion to stay on the programmed path. For this reason, you should never drive your cutter into a sharp internal corner. At such a sharp angle, the machine motion must come to a nearly complete stop to change direction in the span of one block of motion. In that brief period of hesitation in a sharp corner, any tool pressure or tool deflection will be reduced and may result in small gouges at the surface intersections. You should always model a fillet radius larger than the radius of the cutter being used, or select a cutter with a smaller radius than the required fillets. This allows the machine to make the large change in direction over more blocks of code. The machine motion will be much smoother and faster, and produce better finishes in those areas.



The graphic above shows the cutter machining into a sharp corner. The 120° change in vector direction in one block of code (left) causes the machine to slow down dramatically. If the cutter can interpolate a more gradual change in direction (right), it will result in a noticeable reduction in cycle time.

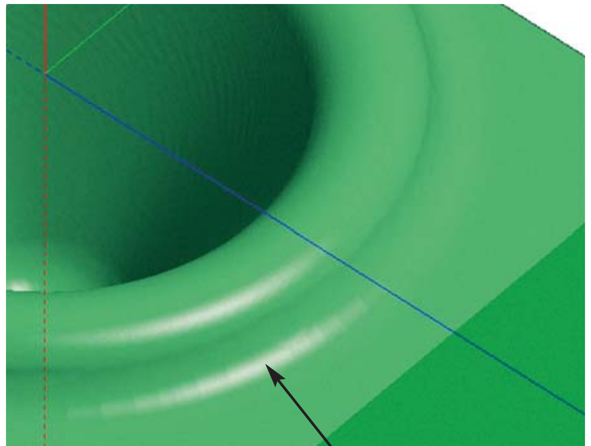
The Haas High-Speed Machining option can process at a speed of 1000 blocks per second. That is 1 block every millisecond. In order to maintain smooth, fluid motion, your program should not contain any block of code that takes less than one millisecond to execute. For example, if your feedrate is 150 inches per minute, the commanded speed is 2.5 inches per second (150 / 60 = 2.5). If you divide 2.5 inches per second by 1000, you will find that you travel 0.0025 inches every millisecond at 150 inches per minute. You can determine the three-dimensional distance traveled in a linear block of code by using the following formula:

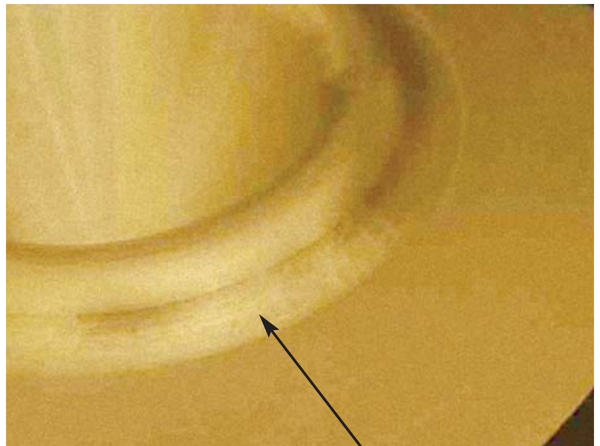
$$\sqrt{(X\ distance^2 + Y\ distance^2 + Z\ distance^2)}$$

G-code Verification

The best tip I can give on 3-D surface machining is to get a G-code verification software package. Every CAM system has toolpath verification built in. The problem is that you are verifying the CAM operation, but the machine is reading the G code. Many things can happen in the posting process, especially if you are applying the toolpath filter at that stage as described above. All of the applications engineers at Haas Automation have a copy of Metacut Utilities® on their computers. Metacut® is an inexpensive software program that produces a solid-model graphical representation of precisely what your programmed part will look like.

We sometimes hear complaints that a customer's machine is leaving a gouge in a part, but when the G code is analyzed with Metacut® the gouge shows up in the graphical representation.

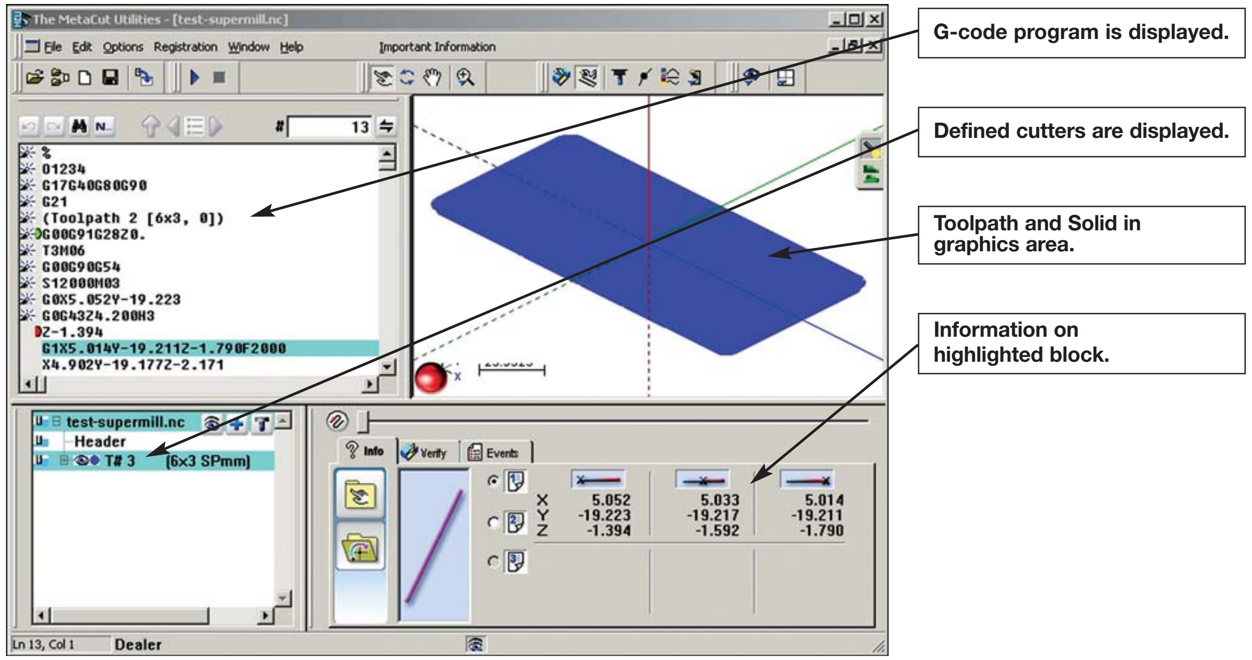


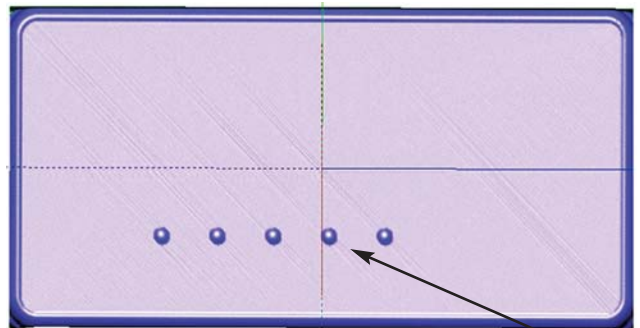


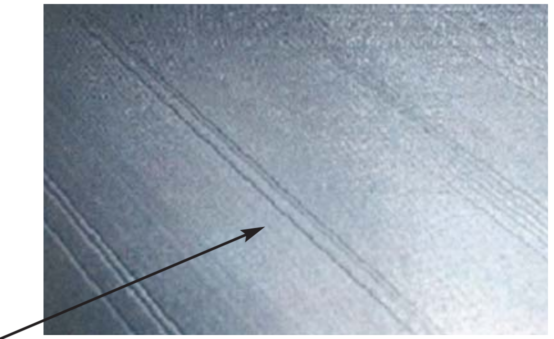
These photographs show a customer's part with faceting. Metacut Utilities® was used to produce a solid model representation of the customer's G-code program to show that the problem was with the program, and not the machine.

Metacut® software has functions such as graphical editing, verification, file and entity analysis, backplotting and graphical file comparison. The software gives you the ability to click on any block of code in the program and instantly analyze it. Metacut® will give you the X, Y and Z coordinates at the start point, midpoint and endpoint of each block. It calculates the two-dimensional distance traveled in each axis, as well as the three-dimensional distance traveled in all axes combined.

You can download a copy for a 30-day free trial at www.metacut.com. The software is very helpful in determining if there is a major problem with your program, such as a machine crash. But it is even more useful for determining the surface finish you can expect from your 3-D surface-milling program.







The same lines that appear in the photograph appear in the graphical representation generated by Metacut Utilities®.

Summary

1. Check your surfaces to make sure they can be machined.
2. Investigate copy-mill roughing to see if it is the right approach for your parts.
3. Finish with a ball endmill and set the stepover to produce an acceptable cusp height.
4. Set the cut tolerance appropriately for the desired surface finish.
5. Filter to arcs when possible.
6. Verify the G code before you cut a part.
7. If the result is not what you expected, verify the G code again, and zoom in on the area that doesn't look right. This will help you determine if the problem is in the program or caused by some other factor.
8. For questions, contact a technical representative from your CAM system supplier, tooling manufacturer or machine tool builder. If you own a Haas machine, you can contact me directly: John Nelson, Applications Manager, Haas Automation, Inc. jnelson@haascnc.com

A High-Tech Dream

By Brad Branham

When Kofi Ogoe was 16 years old and working as an automobile mechanic, he marveled at how precisely the metal parts of engines and transmissions fit together to work so smoothly. But he soon discovered he was less interested in how the parts worked than in how they were made to such exactitude. He dreamed of turning out highly precise, complex parts of gleaming steel and aluminum in a high-tech machine shop – a machine shop that was his.

Numeric Concept and Design, LLC, is based in Dearborn Heights, Michigan. It's small, but it's high-tech and very efficient. Here, as Kofi Ogoe programs the CNC mill and prepares to start the production cycle, his partner, Shaun Tuttle, solves a customer's design challenge at his CAD station. The best aspect of the shop, Kofi and Shaun will tell you, is that they are the owners.

The partners met ten years ago at the William D. Ford Career and Technical Center in Westland, Michigan, and became good friends. Kofi was enrolled in the CAM class and became fascinated with CNC machining, but he never forgot his other goal. "I'm an entrepreneur at heart," he says. "I wanted my own CNC machining company."

Getting caught in the seasonal Detroit-area machinist layoffs a year or so ago kindled Kofi's motivation to pursue his dream. A chance meeting with his friend Shaun led to the partnership. "I ran into Shaun at a restaurant in Westland and explained what I wanted to do," Kofi says. "Shaun became interested, and the rest, as they say, is history.

"The hardest thing getting started was coming up with the capital – we had to risk everything," explains Kofi. "It's tough starting out at 27. A lot of guys my age haven't got that kind of drive.

"Most start-up shops purchase 'just-get-by' equipment, and don't use the latest technology. From the beginning, we wanted a high-tech shop. We have a computer network, 3D CAD capabilities and fully programmable CNC equipment. Our machines are high-tech and capable of precision production, and we can alter the programming 'on-the-fly' from our laptops."

Numeric Concept and Design, LLC, specializes in precision-built custom components. "Our company provides services for anyone – from the government to auto companies to a regular person with a sketch wanting a specialized part for his or her own use," says Kofi. "The parts we make can range from cell phone covers to auto parts. We deal with parts starting with the engineering aspect, and take them all the way to the finished product."

"We're small, but we provide quality," adds Shaun. "We do custom parts and small production runs. There are also many opportunities outside the automotive industry. We're finding ways to expand our capabilities every day to incorporate a variety of work that will eventually include the medical and aerospace industries."

To start their business, Shaun and Kofi chose the Haas TM-1 Toolroom Mill and the Haas TL-1 Toolroom Lathe, because they wanted affordability and utility. "They were excellent choices," says Kofi. "They had the capabilities and the precision we wanted, and the machines are very well built and extremely dependable. We've never had a problem or a service call. The TM-1 mill and the TL-1 lathe use the same control logic, so programming one is the same as programming the other."

Kofi also recognizes another excellent advantage of the Haas machines. "One of the most important things is that Haas helped us out with great financing," he says. "Financing was one of our biggest start-up concerns."

Kofi recently graduated from the Manufacturing Productivity Systems Program (MPSP) at Henry Ford Community College (HFCC). Shaun is currently enrolled at HFCC, working on Associate Degrees in Manufacturing Productivity Systems and Computer-Aided Design. Kofi and Shaun give a lot of credit to HFCC and to Ken Wright, MPSP instructor.

"The program is first class," says Shaun. "Ken's a great instructor. He is very knowledgeable and has a great talent for sharing that knowledge. HFCC is great, too, and I would not consider training anywhere else. We learn on the latest and best equipment, and it's updated regularly."

Kofi agrees. "The training was very realistic, very close to real life – not just operating the machines. We learned how to quote jobs, estimate job times, manage stock – everything."

Ken Wright says that he takes a no-nonsense approach. "It is not the kind of class where someone gets up and reads to you out of a book – we work on the real machine," he explains. "Everything we make is aluminum or steel, and we use only carbide tools. This gives the students real-world experience they can use. We teach them to use every aspect of the machine. We use a lot of hands-on instruction – there's no substitute for working with the real thing."

Ken takes his job very seriously. "I've got to make my students smarter," he says. "Then they work smarter and faster, and that's how we will stay ahead of the curve."

The students at HFCC learn their skill on high-tech manufacturing equipment in the college's Haas Technical Education Center (HTEC). The HTEC – one of more than 60 in North American – is a unique partnership between Haas Automation, Inc., headquartered in Oxnard, California; the local Haas Factory Outlet (a division of Gerotech, Inc.), in Flat Rock, Michigan; and HFCC. The HTEC at HFCC currently houses more than $200,000 worth of high-tech manufacturing tools.

In addition to teaching at HFCC, Ken Wright is also very active in the manufacturing industry. He is National Chair of the Haas Technical Education Center Council, and teaches a "summer school" for instructors who want to get current with the latest technology. Ken also has developed a CNC certification program that is being used at HFCC and many other colleges.

Kofi and Shaun are busy with their operation, but they're not ignoring what lies ahead. "In the future, I think we're going to need more space," explains Kofi. "I want to do bigger production runs, and I want to get into some five-axis work. There are a lot of opportunities out there, so I think that it's going to happen."

Numeric Concept and Design, LLC
www.numericconcept.com
313-363-9022

Machining Technology Draws In Northwest Students

Story and photos courtesy Clark College

For many, the sparkling, blue rivers full of salmon and the lush, green forests of towering timber are what draws them to the Pacific Northwest. But at southwest Washington's largest community college, officials have discovered that machining technology is a big draw, as well.

Enrollment in the Machining Technology program at Clark College in Vancouver, Washington – just a stone's throw across the Columbia River from Portland, Oregon – was up 110 percent last year. In fact, classes are being added regularly to keep up with the demand, and the machine shops at the 70-year-old school are busy from 8 a.m. to 10 p.m., five days a week. To meet the growing need, the school recently completed a $4 million building renovation to house the new Applied Arts facility.

A big draw for the Clark program is the fact that students can enroll for a complete two-year course of study, or just take one or two courses to beef up their portfolio of skills.

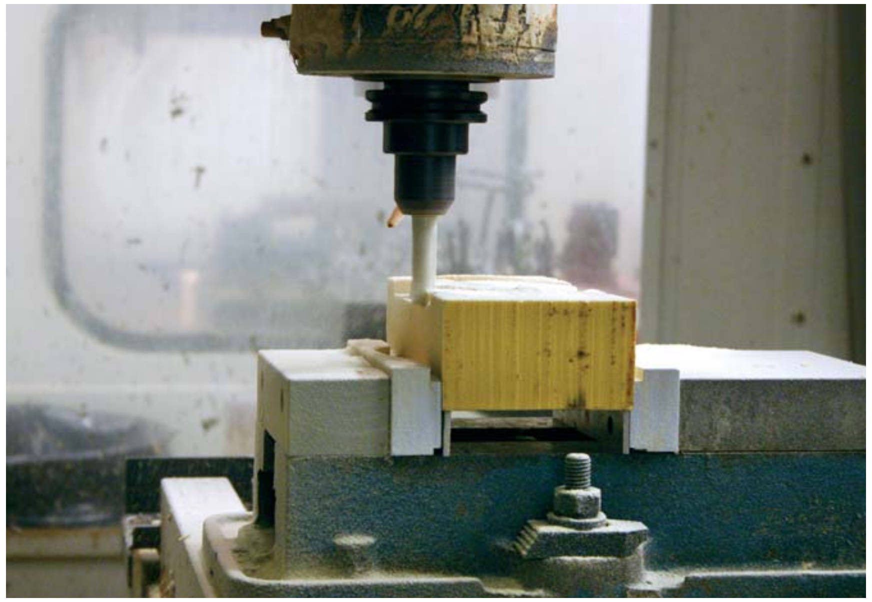
"You can pick and choose whether you want the two years, or just a course in high-speed machining, for instance, or manual machining," says department head Dale Waliezer, a former tool-and-die man turned mechanical engineer, and now a full-time educator. "Any class you want is now available every quarter."

In large measure, Clark has been able to establish itself as one of the nation's most extensively equipped college machining-technology facilities through the generosity of another Pacific Northwest mechanical engineer and machinist: Roy G. Andersen.

When he died in 1996, Andersen left $28 million to the Clark College Foundation, earmarking the funds to help further develop Clark's various vocational training and education programs.

The money has gone to purchase a plethora of machinery and equipment: a dozen manual mills, a dozen manual lathes, two CNC lathes, a high-speed machining center, a wire EDM machine, four surface grinders, two CNC mills and countless general shop tools. Two Haas VF-0 vertical machining centers play a particularly valuable role.

"These Haas mills are the basis for the first half of all of our CNC classes," says Waliezer. "The students learn the manual programming on the machines, and then they learn to use Mastercam. The machine is the foundation."



This year, they plan to add a third Haas mill – a VF-1 – which Waliezer says will allow students to get more real-life, real-world application in their studies. The college purchased its first Haas 10 years ago, and then upgraded it a few years later. Another was purchased three years ago.

Real-world experience on equipment like Haas machines is significant, as graduates of the Clark program regularly find work with highly respected firms. Waliezer notes that a large segment of Boeing Co. machinists currently working on the new 7E7 plane in the Portland plant received their training at Clark.

Despite the growing trend of shipping manufacturing jobs overseas to save labor costs, Waliezer says there will always be a need for skilled workers in the industry.

"Yes, a lot of the high-volume production is going overseas," he says, "but design work and prototype work is here to stay." As evidence, he cites a Clark graduate who last year started in a position paying $22 an hour.

One quarter of Clark's machining-technology students are already employed in the machining industry; they are in classes to upgrade their skills and keep up with technology as it advances. One student, Waliezer notes, travels weekly from Medford, Oregon – nearly a five-hour drive one way – for training in a specific software program. Clark College is the only West Coast college offering the instruction.

With the emphasis on new technology, Waliezer notes that most course work for a student in his or her second year focuses on CNC machines. "In their second year, students spend two-thirds of their time on a computer, because the reality is that, today, three-quarters of any part is built before it leaves the computer," he says. "Parts are designed, tools have been determined, cuts have been made, materials have been selected, and speeds and feeds have been set."

At the end of 2004, the Machining Technology program relocated to a larger, remodeled facility on campus – a location that includes new quality-control work areas, more space, better layout and a more true-life manufacturing setup, says Waliezer.

Meanwhile, Mike Tischendorf, who manages the model shop for Hewlett-Packard in Vancouver, stresses that skilled metalworking industry workers are vital to much of today's manufacturing efforts. He echoes Waliezer's observations about the quality of the Clark College Machining Technology program: "I think their equipment is among the best in the country."

When he hires a machine-shop worker, Tischendorf says, he looks for employees with solid foundational skills, like those taught at Clark College. Because of his work in the industry, Tischendorf serves on an advisory board for the Clark College Machining Technology program.

Individuals and firms interested in learning more about Clark College's Machining Technology program may contact Dale Waliezer or Bruce Wells in the Machining Technology program, or the college's Business and Industry Training Center, which works with employers to provide training and education.

Clark College
360-992-2000.

Maine-taining Manufacturing Technology

Story by Jacqui Higgins, DP Technology Corp.

Six new faces entered the manufacturing world this past May, and they are hot to get onto the shop floor.

Northern Maine Community College (NMCC), in Presque Isle, recently started a Precision Metals Manufacturing Program – more commonly known as Manufacturing Technology – and the first students recently graduated.

NMCC's Manufacturing Technology program centers around the school's Haas Technical Education Center (HTEC): a state-the-art facility featuring the latest CNC machines from Haas Automation, Inc., and ESPRIT CAM software from DP Technology Corp.

"When we developed the program," says Tim Crowley, NMCC president, "we were looking for innovative ways to ensure that our equipment would be kept current."

Dean Duplessis, instructor and coordinator of the program, says they have a total of four Haas machines: an SL-20 lathe, two Mini Mills (one with probing and one with a fourth-axis rotary) and an SL-10 lathe. The shop also has six Haas control simulators.

The equipment puts the students right in the driver's seat of the manufacturing world, Duplessis says. The students spend the first half of the program learning everything longhand in a "conventional" machine shop. They do not get into the CNC environment until their second year.

"After they learn how to program manually," Duplessis explains, "they are then introduced to the ESPRIT CAM system from DP Technology. We integrate that [longhand] knowledge into learning the CAM software, so the students understand that, at the end of process, it all boils down to how to cut materials."

Andrew Drost, a recent graduate of the program, says that learning to program a machine tool longhand gave him a better understanding of the process, and made the transition to learning CAM much easier. "I came out of the college with the ability to run a CNC machine," he says. "When I started out, I knew nothing about machining metal, and now I know how to take a raw piece and turn it into something valuable."

With the knowledge and skill he and his fellow students have gained from NMCC's Manufacturing Technology program, Drost says he knows they have an excellent shot in the workforce. Training with state-of-the-art machine tools is key – allowing the students to mimic in the classroom what will be expected of them on the job.

"If you are going to put students in this type of program," Duplessis says, "you want to emulate real-life projects. There are no restrictions. Students are learning, and developing projects, in an actual job shop environment."

Following the success of the first class to graduate from the Manufacturing Technology program, Duplessis says he's excited about the long life he and President Crowley foresee for the curriculum. The graduated students are already in the job market, and many already have had job interviews.

"The future employers of these students, I am hoping, will look to us as a valuable resource," Duplessis says. "We are really out there trying to forge relationships. Our needs match closely with Haas Automation's HTEC concept, and with the support offered by DP Technology. The two companies are making an investment in education, knowing that it will produce great dividends down the road."

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Haas Automation Tops 1 Million Square Feet with New Expansion

Haas Automation, Inc., the largest machine tool builder in North America, is nearing completion of a new 211,000-square-foot building at its headquarters and manufacturing facility in Oxnard, California. The addition represents the third expansion for Haas in 9 years, and will push facility size past the 1-million-square-feet mark.

Although similar in design to existing buildings at the Haas facility, the new building is considerably taller, with a 34-foot clear-ceiling height to accommodate 26-foot-high interior racking. It also has precision flat floors to allow for high-density, narrow-aisle racking equipment. The building will feature 10 loading bays (up six from the current four), and house a high-tech data center to support the company's extensive information systems.

"The new building will be dedicated exclusively to inventory," explains Haas Director of Operations Richard Mountan. "It will serve as a warehouse for component parts, as well as finished machines, freeing existing space for additional manufacturing capacity."

Over the last two years, Haas Automation's sales have more than doubled, driving production to record levels. With demand for the company's products reaching an all-time high, Haas produced, sold and shipped more than 10,000 machines in 2005, arguably more than any other machine tool builder in the world.

Currently, more than 57,000 Haas CNC machines are in service worldwide, and with regional headquarters in Europe and Asia further extending the company's reach, this latest major expansion is not likely to be Haas Automation's last.




One Year, One Facility – 10,000 Machines

Compared to the automotive and consumer-products industries, which deal in yearly sales well into the millions of units, the machine tool industry is a relatively low-volume proposition.

Unit volume, however, is a relative term. In an industry where many companies struggle to build 100 machines per year*, producing 10,000 machines in a 12-month period is a major feat.

That's exactly what Haas Automation, Inc., did in 2005. The company built – as well as sold and shipped – more than 10,000 high-quality Haas CNC machines at its manufacturing facility in Oxnard, California. That's an increase of more than 22% over 2004, and more than 200% over 2003.

"I know of no other machine tool builder in the world that has done this," remarks Haas General Manager Bob Murray, adding that the company reached this goal during a period of widespread plant restructuring and expansion.

"Increasing production by 200% over just two years," says Director of Operations Richard Mountan, "required a lot of hard work from a lot of people. Every area of the company contributed," he says. "But it's what we do. We set a goal and we make it happen. People have always worked hard at Haas, and that's not going to change. We are constantly implementing more and more technology, and continually reviewing our processes. It's not just a matter of taking what we do and multiplying it by some factor. It's about innovation.

"Through innovation," Mountan continues, "we expect our efficiencies to continually grow. The opportunities are there, and it's our responsibility to figure out the right way to make things happen."

**According to UCC filings for 2005 – which report the number of machine tools financed in the U.S., a rough estimate of units sold – more than 90% of the world's machine tool builders sold fewer than 50 machines each during 2005. The top five builders accounted for more than one third of all U.S. sales, with Haas nearly double the volume of its closest competitor.*

TRADESHOW CALENDAR

Want to see Haas machines at a trade show in 2006? Find your location and mark the day on your calendar.

Indianapolis, USA	January 24–25	Racing/Performance
Pordenone, Italy	February 9–13	Samumetal
Kortrijk, Belgium	February 15–18	Metapro
Bari, Italy	February 23–26	Bimu-South
Cluj-Napoca, Romania	February 28–Mar 6	Intern. Tech Fair
Chennai, India	March 3–6	DIEMOULD
Bilbao, Spain	March 6–11	BIEMH
Stuttgart, Germany	March 7–9	Medtec
La Roche, France	March 7–11	Simodec
New York City, USA	March 12–14	Jewelry Mfg
Utrecht, Netherlands	March 14–18	Techni Show
Brescia, Italy	March 18–21	Muap
Modelacao, Brazil	March 21–24	FERRAMENTARIA
Los Angeles, USA	March 27–30	WESTEC
Paris, France	March 27–31	INDUSTRIE 200
Shenzhen, China	March 28–31	SIMM
München, Germany	April 4–7	METAV
Chongqing, China	April 11 -14	CWMTE
Seoul, Korea	April 12–17	SIMTOS
Novi, USA	April 25–26	Moldmaking Expo
Zagreb, Croatia	April 25–29	Biam
Helsinki, Finland	April 25–28	Finntec
Shanghai, China	May 8–12	Die & Mold China
Moutier, Switzerland	May 9–13	SIAMS
Prague, Czech Rep	May 10–12	Mach 2006
Belgrade, Serbia/Montenegro	May 10–14	Technical Fair
Birmingham, England	May 15–19	MACH, UK 2006
Budapest, Hungary	May 16–19	INDUSTRIA
Montreal, Canada	May 22–24	Machine Tool Show
Moscow, Russia	May 23–27	Metallorba
São Paulo, Brazil	May 23–27	MECANICA
Guangzhou, China	May 23–26	Intl. Machinery
West Springfield, USA	May 23–25	EASTEC
Vilnius, Lithuania	May 23–26	Balttechnika
Athens, Greece	June 1–4	Metallon
Beijing, China	June 12–16	CIEMS & CMTF
Poznan, Poland	June 19 -22	Mach-Tool
Düsseldorf, Germany	June 20–24	METAV
Shandong, China	July 24–26	CIEF
Shenyang, China	Aug 29–Sept 2	CIEME
Oslo, Norway	September 12–13	Technical Fair
Istanbul, Turkey	September 14–17	Imak Tatef
Stuttgart, Germany	September 19–23	AMB
Plovdiv, Bulgaria	September 25–30	ITM
Besancon, France	September 26–29	MICRONORA
Bucharest, Romania	October 3–7	TIB
Brünn, Czech Rep	October 2–6	MSV
Shanghai, China	October 10–12	Metalworking China
Vienna, Austria	October 10–13	INTERTOOL
Milano, Italy	October 5–10	BIMU
Krakow, Poland	October 12 -14	Eurotool
Dnepropetrovsk, Ukraine	October 11 -14	Mashprom
Frankfurt, Germany	October 17–20	AIRtec
Moscow, Russia	November 7–10	Intertool
Dongguan, China	November 8–11	DMP
Porto, Portugal	November 14–18	EMAF
Basel, Switzerland	November 14–18	Prodex
Frankfurt, Germany	November 30–Dec. 3	EUROMOLD

First Haas Factory Outlet Opens in India

This past October, Haas Automation, Inc., officially launched its first Haas Factory Outlet (HFO) in India – an important milestone in the company's presence in the Asia-Pacific region. Located in the central-western city of Pune, the new HFO (a division of Omira Marketing Pvt Ltd) will provide dedicated sales, service and applications support for Haas customers in northern India.

"This is a world-class facility that sets the example for other HFOs in Asia," says Haas General Manager Bob Murray. "India has a large, technically educated and highly motivated general population, and the country represents a huge emerging market for Haas products. Our goal is to provide the same high level of industry-leading service in India that we provide in the United States."

Haas has sold its products in India for more than 10 years, through two established dealers: Omira Marketing Pvt Ltd in Mumbai, and Manav Marketing Pvt Ltd in Bangalore. Machine sales have more than doubled during each of the last 2 years, and are projected to reach the 600-plus range in the coming year.

To ensure that customers receive a rapid service response and have access to extensive in-stock inventories of spare parts, Haas will continue to expand its support in the region. HFO-Bangalore (a division of Manav Marketing Pvt Ltd) will open in the southern region early in 2006, and HFO Delhi (a division of Omira Marketing) is on schedule to launch in northern India before year's end.

New Haas Technical Education Center Opens in Michigan

The latest addition to Haas Automation's nationwide network of Haas Technical Education Centers (HTECs) officially opened in Warren, Michigan, this past September. The new facility is the result of a unique educational partnership between Macomb Community College, the local Haas Factory Outlet (a division of Gerotech Inc.) and Haas Automation, Inc. It is one of five HTECs currently operating in Michigan.

Known as the Haas Technical Education Center–Warren, the facility is located on Macomb Community College's beautiful, 160-acre South Campus. The HTEC houses an arsenal of state-of-the-art Haas CNC machines, including an EC-400 HMC, a VM-3 Mold Maker, a VF-3 VMC, an SL-20 turning center and several Haas Toolroom machines. Macomb's new CAM Training Lab, where students learn to program and operate Haas machines using PC-based Haas CNC Emulation Software, is located at the HTEC, as well.

Through the HTEC partnership, Haas Automation and the local Haas Factory Outlet (HFO) placed machines at Macomb on a matching basis with the college, essentially doubling the school's resources for manufacturing technology education. In return, the local HFO may utilize the HTEC as a satellite demonstration and training center for current and future Haas machine tool owners and users.

Haas Factory Outlets are a worldwide network of locally owned and operated businesses dedicated exclusively to the sales, service and support of Haas CNC machine tools. The goal of every HFO is to deliver a consistent, professional and high-quality ownership experience for all Haas customers at the local level, while providing access to global service and support.

Macomb Community College is one of the nation's leading community colleges, serving more than 30,000 students each semester, and reaching more than 350,000 persons each year through cultural and community service programs.

Changes at Haas CNC Racing for 2006

Haas CNC Racing approaches the 2006 NASCAR season with a hard-earned mantle of maturity, and a fresh slate of new opportunities. Significant changes will affect this year's team structure.

Former Busch Series champion Jeff Green will take over the NEXTEL Cup Series slot, piloting a Chevrolet Monte Carlo for sponsor Best Buy (at press time, the new number for the car had not been released). The 43-year-old ran in Cup competition last year driving the No. 43 Dodge for Richard Petty. Green arrives with strong credentials, including the 2000 Busch Series championship, which he won by the biggest points margin in Series history – posting six victories and a record-breaking 25 top-five finishes.

Johnny Sauter, the 27-year-old son of short-track racing legend Jim Sauter, will drive the Haas Busch Series car this year, with Yellow Transportation, Inc., as the primary sponsor. Sauter dominated ASA racing in 2001, taking both the series championship and Rookie-of-the-Year honors. Last season, Sauter drove the No. 1 Dodge in Busch Series competition for James Finch's Phoenix Racing, finishing 12th in points and 6th in overall winnings.

The 2006 season also will bring a new home for Haas CNC Racing. Construction of a new 140,000-square-foot office and garage facility in Kannapolis, North Carolina, is slated to begin in January, and scheduled for completion by November. The new 23-acre site will offer three times more space than the team's current home in nearby Harrisburg. The facility will provide much-needed room for expansion and growth, yet allow the team to remain close to world-famous Lowe's Motor Speedway.

the answer man

Dear Applications:

Hello, in reading your Operator's Manual, I see the words modal and non-modal used quite often. Can you please give me a definition of modal?

Jan

Dear Jan:

When a code is modal, it means the code stays in effect until it is cancelled by another code or another action taken by the operator (pressing the Reset key, etc.). When a code is non-modal, the code is only in affect for the block in which it is commanded. For instance, a G00 Rapid Motion Position command stays in effect until it is cancelled by a G01, G02 or G03 command. An example of a non-modal code is a G53. This code, Non-modal Machine Coordinate Selection, cancels all active offsets for the block with the G53. All offsets in effect on the block before the G53 block become active again in the block after the G53 block.

Sincerely,
Haas Applications

• • •

Dear Applications:

Is it possible to get manuals for the VF-3SS, VF-4SS and VF-7 in PDF format? Also, can you provide additional information on macro programming? Thank you.

Kelsey

Dear Kelsey:

The PDF manuals are not available to the public at this time. You may order additional manuals from the Haas Service Department if you require them.

There are many sources of information on macro programming. The Haas Operator's Manual has many pages on the subject, but because of the variety of things that can be done with macros, not everything is covered in our manuals. The Haas Applications Department recommends the following web page for more detailed information on macro programming:

http://www.programmingunlimited.com/

Sincerely,
Haas Applications

• • •

Dear Applications:

How do I determine the actual torque required for a given cut? For example, I am looking to purchase a Haas machine with a 12K spindle, and want to know if it will work for my application.

Brian

Dear Brian:

There are many factors that affect the required torque for a given cut. These factors include the type of material, the type of tool and the lead angle of the tool. It is very difficult to determine the required torque from a mathematical formula, and many tool manufacturers make it very clear that the values they supply in charts are just estimates. I have, however, found that the best way to determine the required torque is to call and ask the cutting tool manufacturer. They have spent many years engineering each particular tool, and have a wealth of information from real-world testing with the tool. They should be able to tell you how much torque is required at the cut and at the spindle for any given material.

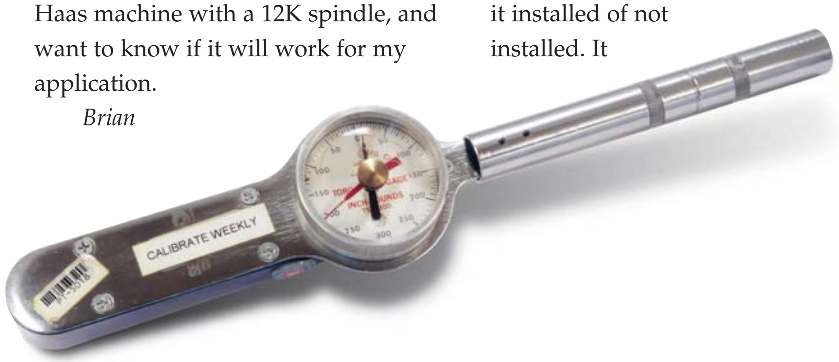
Sincerely,
Haas Applications

• • •

Dear Applications:

I own a TM-1. I am the second owner, so I do not know exactly what options were installed. On the parameter page with rigid tapping and so forth, next to each item there is either a 0 or 1. But on some items, there is a 0T. What does that mean? Is it installed of not installed. It says this on the rigid tapping parameter, and on some others, as well. Thanks,

Mike



Dear Mike:

If a parameter is set to 1, it is enabled. If it is set to 0, it is not enabled. If the parameter is 0T, this means you can enable the option for 200 hours for a free trial, but the option will be disabled after the 200 hours have expired. To enable an option for 200 hours, turn setting 7 off and push the Emergency Stop in. Then, change the parameter bit for the desired option to 1 by typing in the number 1 and pressing the Write/Enter button while the desired parameter is highlighted. The T will disappear and the 0 will change to a 1. If, after 200 hours, you decide you would like to purchase the option, you can contact your local Haas Factory Outlet for a code to permanently enable the option.

Sincerely,
Haas Applications

• • •

Dear Applications:

How does a person change the offset values for the tool probe, and the centerline of the machine (F2)? After touching tools off of the probe, I always have to adjust the offsets in the same direction for all of the tools. And I have to adjust the offset for F2 Centerline. Thanks,

Kris

Dear Kris:

The tool probe can be adjusted via settings 59, 60 and 62. If you cut an outside diameter and it is 0.001" oversize, then make setting 59 0.001" bigger. For example, if setting 59 is 3.1250", change the setting to 3.1260". If, after turning an inside diameter, the diameter is oversize 0.001", then increase setting 60 by 0.001". If, on the other hand, either diameter is undersize, then make the value in setting 59 or 60 smaller by the amount of the undersize condition. As far as adjusting the centerline value for the F2 button, this must be adjusted by a service technician from your local Haas Factory Outlet.

Sincerely,
Haas Applications

• • •

Dear Applications:

We just purchased a VF-2 CNC mill and are in the process of setting up our post processor. We hard-wired it to the machine and are using Surfcam. I have one problem, at the end of the program the machine will move up in Z to 1" above the part, and then it will move back down to the Z pick-up surface of the part before going up to the tool change position. That could be a problem in some cases. At the end of the post there is a G80 followed by a G28 Z0, and ending with an M30. How do I send the Z up to the Home position without it moving back down to the Z pick-up depth?

Arnie

Dear Arnie:

Instead of using G28 Z0, use the code G28 G91 Z0, followed by G90 on the next block. The G90 is to ensure that the machine goes back to absolute mode after the G28 G91 Z0. An even simpler way to program this is G53 Z0. G53 temporarily cancels all offsets and uses the machine coordinate system. G53 X0 Y0 Z0 will send each of the specified axes to their home positions; that is, the position they move to when you zero the machine when it is first powered on.

Sincerely,
Haas Applications

• • •

Dear Applications:

We are investigating the purchase of a Haas VMC with the High-Speed Machining option. Are special G codes needed for HSM, i.e., G05, G06, G06.1 as used in a GE control for NURBS interpolation? HSM hardware is typically faster, i.e., speeds, feeds, etc. What would be the difference in software?

Leo

Dear Leo:

No special G codes are needed for the Haas control to utilize high-speed machining. The HSM option is enabled electronically via a code entered into your control. This means that no special software is required for the HSM option. Shorter cycle times will be realized for surfacing programs that use shorter strokes at higher feedrates. The Haas control achieves this by utilizing the ability to look ahead up to 80 blocks. The control anticipates vector changes and decelerates and accelerates more efficiently, thus reducing cycle time.

Sincerely,
Haas Applications

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HMC I 15 models	5-Axis & Profiling
Lathe I 12 models	Large-Capacity
Rotary I 40 models	High-Speed
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All-New Model The 2006 EC-400PP HMC with integrated 6-station pallet pool, 20" x 20" x 20" travels, 20-hp vector dual-drive system, 8000-rpm inline direct-drive spindle, belt-type chip conveyor and 70-pocket side-mount tool changer.