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CNC MACHINING

the Ultimate Mercedes

CNC MACHINING

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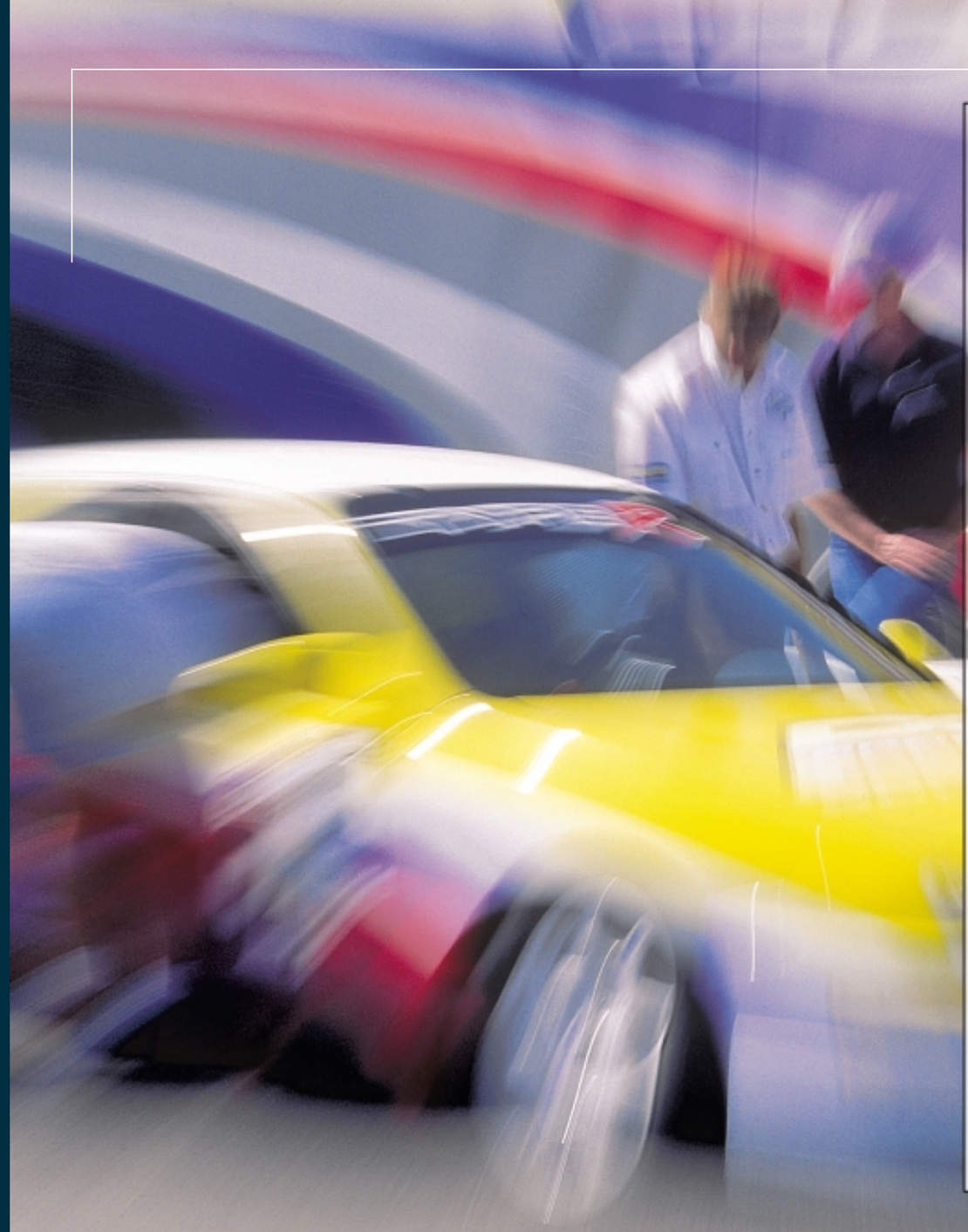


photo courtesy DC Sports

Another year is behind us and the New Millennium lies before us . . . man, life can be such a blur. In this issue of CNC Machining, things definitely get a little blurry, but bear with us, we always bring them back into focus.

For our cover story we feature Ilmor Engineering. They supply the Mercedes-Benz engines that put the blur in CART and Formula One racing. We visit the new Ilmor Tech Center in Plymouth, Michigan, for a look at what it takes to build high-performance race engines.

Then we move from the race track to the street for an inside view at DC Sports, a company that has experienced a blur of rapid growth over the past few years. Brothers Darrell and Darrick Contreras (the DC in DC Sports) have ridden the leading edge of the Sport Compact Car wave to become one of the top manufacturers of performance parts for Hondas and Acuras in the world. We show how they grew from producing five or ten exhaust headers a week to pumping out more than 400, in addition to manufacturing a full line of suspension components, intake systems and other performance accessories.

In our story about Mindrum Precision, we look at how this unique company has blurred the line between traditional CNC machines and precision grinders. You'll see how they use Haas VMCs and lathes to machine such exotic materials as glass, quartz and ceramic.

Then it's on to college. We follow a group of women engineering students from California State University, Northridge, as they "Shadow an Engineer" at Haas Automation to see what engineering is like in the "Real World." We found their views quite interesting.

Also interesting is the blur of high-speed machining. It's all the rage these days, but there's still a lot of confusion about exactly what it is, when to use it and just how much benefit to expect. We've come up with the definitive answer: It just depends! To clarify the subject – bring it more into focus if you will – we perform a head-to-head comparison of standard machining versus high-speed machining under different cutting applications.

But wait, there's more! You'll also find a piece on virtual manufacturing, a look at the newest Haas products, the latest Race Report and more.

So, sit back, relax and enjoy!

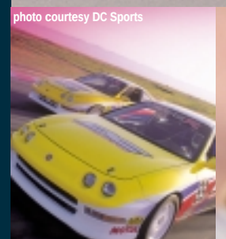
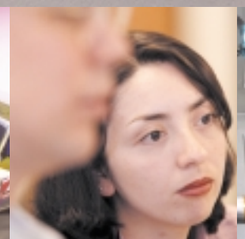
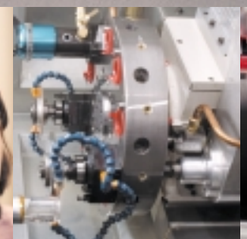
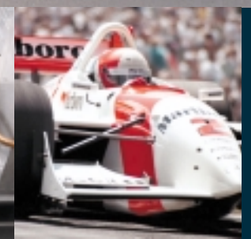


photo courtesy DC Sports







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INSIDE:

DC Sports takes performance seriously. The company got its start making exhaust systems for American Honda's race team. Today, they bring race-proven performance to the street with products for Hondas and Acuras.

by Denis Dupuis

A Look into the New Millennium

It is that time of the year again. Time to take stock of what we did last year and make our plans (budgets) for the new year. As I write this article, having just attended the Haas dealer council meeting, I am reminded of how tough 1999 must have been for you. Our customers wanted lower prices, our dealers wanted more margin and our employees wanted raises. It seems that we were squeezed from every direction. All-in-all it was a tough year for our industry, with the bottom line suffering the most. While we were able to remain profitable, it is difficult to be positive when every time we turn around the value of another ".com" rockets through the stratosphere, seemingly with little effort.

Ok, enough complaining, next year can only get better… right? It's planning time! As I try to peer into our future, I am persuaded that the new millennium will be better and brighter for the machine tool industry, and especially for Haas. I look at the new products we have on the drawing board, and know that they will be great additions to our product line. More high quality products, made in the USA, to help our customers solve their manufacturing problems – that's something very positive to look forward to.

Last year's launch of the Haas Factory Outlet concept of distribution is moving along as scheduled. The programs these HFOs open up to our customers – with their clear focus, improved services and dedicated employees – are positive affirmations that the new millennium is starting off well.

The quality program that Haas launched in 1999 has produced some excellent rewards, as well, in the form of higher reliability and reduced costs on the products that we manufacture. Our goal of achieving ISO certification is on target, and as we continue this program into 2000 and beyond, everyone will benefit – our customers, our distributors and our whole company.

We are blessed with so many things: good health, great friends, a good economy, the best quality of life and some of the best and brightest people to work with every day. What more could we ask for? I think I'll upgrade that budget for 2000.

Five-Axis Capabilities Dedicated

Haas Automation president Gene Haas recently visited Klune Industries, Inc., for the inauguration of the company's newest additions to their stable of machine tools. Klune purchased a new Haas VB-1 five-axis bridge mill (the second VB-1 off the production line) and a VR-11 five-axis vertical machining center. Both machines are hard at work helping Klune capitalize on the growing advantages of five-axis machining. Located in North Hollywood, CA, Klune Industries, Inc., specializes in manufacturing and engineering for the aerospace, communications and related industries.

2000 TradeShow Calendar

Show Name & Location	Dates	Information
HOUSTEX, APEX Houston, TX	Jan. 25 – 27, 2000	Held at the George R. Brown Convention Center, this show attracts buyers from the oil, high-tech, aerospace & shipping industries. Haas products will be shown in booth #1101.
SOUTH-TEC. APEX Charlotte, NC	Feb. 29 – Mar. 2, 2000	This event attracts over 13,000 attendees to the largest Southeast machine tool show. Haas Automation will be located in booth #2202A.
WESTEC, APEX Los Angeles, CA	Mar. 20 – 23, 2000	North America's largest annual metalworking and machine tool exposition with 35,000 attendees and 725 exhibitors. Haas Automation is in booth #3229.
EASTEC, APEX W. Springfield, MA	May 23 – 25, 2000	This is New England's leading machine tool show that attracts more than 25,000 attendees. Haas Automation will be located in booth #2448.
IMTS Chicago, IL	Sept. 6 – 13, 2000	This is the largest biennial trade show in the Americas, attracting over 120,000 attendees and 1,400 exhibitors. Haas Automation will be in booth #8232.

Haas Automation's involvement in the racing community is a beneficial association that recognizes the close bond between precision driving and precision machining. Through technical partnerships and sponsorship agreements, Haas provides race teams with the latest CNC equipment. In return, Haas gains access to a network of cutting-edge racing facilities where prospective customers can see Haas equipment making the parts that win races.

Hendrick Motorsports

Winston Cup Series

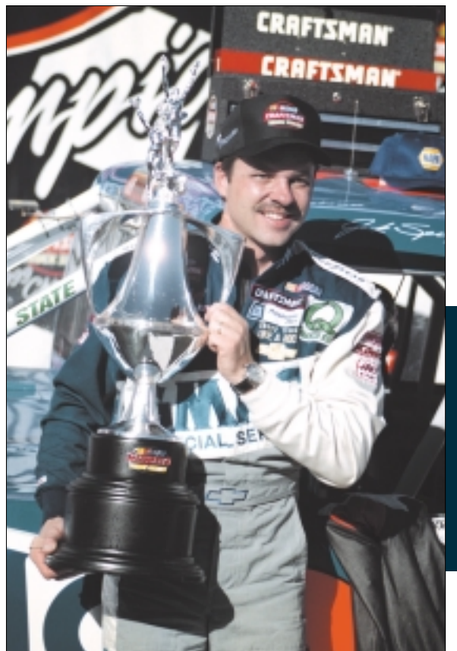
Major changes took place with car #24's Rainbow Warrior team during the last quarter of the '99 NASCAR season. Jeff Gordon finished out the year driving under new crew chief Brian Whitesell. With longtime former crew chief Ray Evernham – and five members of his "Rainbow Warriors" pit crew – leaving the team to take on new challenges, fans wondered how Jeff was going to take the split. He responded by winning the next race. Even though Gordon had the most wins for the season (7), he just missed winning his fourth Winston Cup Championship, finishing an uncharacteristic sixth in the points standings. In an interesting strategy move, Gordon even ran one race (Homestead) without stopping for fuel in an attempt to improve his standings, running dry as he crossed the finish line!

Hendrick drivers Terry Labonte (#5) and Wally Dallenbach (#25) finished out the season in 12th place and 19th place, respectively. Jerry Nadeau will replace Dallenbach in the #25 car for the 2000 season.

Craftsman Truck Series

Following a year of closely fought battles, Jack Sprague (#24), driver of the Hendrick Motorsports Chevrolet Silverado pickup, roared past his competitors with two laps to go at Fontana, the final race of the season. With help from fellow Chevy driver/rival Ron Hornaday, Sprague went on to win the race by a scant 0.266 seconds, capturing his second consecutive Craftsman Series championship.

Prior to rolling into the winner's circle, Sprague and Hornaday parked side by side at the finish line to salute the crowd. Then Sprague jumped back into the cab, lit up the rear tires and obscured his Haas logo (located just behind the rear wheel arch) with smoke as he signed his autograph on the finish line with a series of smokey "donuts." Congrats to Sprague and his Hendrick Motorsports crew!



Jack Sprague finished out the year with a win at Fontana and yet another overall championship title. Driving his Chevy Silverado pickup truck for Hendrick Motorsports, Sprague wins with parts machined on Haas CNCs.

PacWest Racing Group

CART Champ Cars

After another disappointing season, both Mark Blundell and Mauricio Gugelmin have re-signed with PacWest for the 2000 series. Transmission and coolant maladies kept the PacWest boys off the podium, and Blundell was sidelined for eight races with a neck injury, but they finally got some points late in the championship, finishing 16th and 24th respectively. Let's hope they see better luck next year.

CART IndyLights

Didier Andre (#18) drove his Motorola/PlayStation/PacWest Lola to a 3rd-place finish in the final race of the year, leading a total of 23 of the 50 laps in the race. Teamate Tony Renna – who just signed with PacWest as the new full-time driver for the Indy Lights Championship – crossed the line in 6th, driving for the injured Boris Derichebourg. Renna will also serve as the new Champ Car testing and development driver in 2000. Welcome aboard Tony.

Ilmor Engineering

CART Teams

Haas technical partner Ilmor and the racing world lost one of its most talented and likable drivers with the crash-related death of Greg Moore during the final race of the season at Fontana, CA. Moore, the youngest winning driver in CART history, had been the top-ranked Mercedes-Benz driver in CART points, and had racked up victories during each of the last two seasons.

Formula One

On a brighter note, Ilmor earned another Driver's Championship with Mika Hakkinen driving the Ilmor-powered Mercedes team car, leading the final race of the Formula One series (Osaka, Japan) from start to finish.

For a detailed feature story on Ilmor Engineering, turn to page 18.

All American Racers (AAR)

CART Champ Cars

AAR finished out the season with two American-built Eagles running in the CART series. Team Gordon (Robby Gordon, no relation to NASCAR's Jeff) switched over to the Toyota-powered chassis to finish out the '99 season.

At the final race of the season in Fontana, Gordon brought in his Eagle in 11th place, the highest finish for the Toyota engine, while Raul Boesel brought his All American Racers Eagle home in 17th.

However, late breaking news finds the long-running Toyota sponsorship of AAR coming to an end, and powerplant choices up in the air for the 2000 CART season. The AAR team is still dedicated to fielding at least one car, and rumor has it there may be a F– – – in the future for the American Eagles.

Precision Preparation Inc. (PPI)

CART Champ Cars

Scott Pruett (#24) and 1998 PPG-Dayton Indy Lights champion Cristiano da Matta (#25) spent the year pushing

Please see RACE REPORT page 35

Pruett picks up a wheel as he winds down through the "Corkscrew" at California's Laguna Seca Raceway. He also put his Toyota-powered, Haas-sponsored CART racer on the pole at Fontana, a first for the team's engine development program.

Pipe Dreams

Every generation has its vehicle of choice, the one every hormone-addled, high school gearhead just has to have. It is the epitome of cool, the picture of performance.

Story & Photos Scott Rathburn

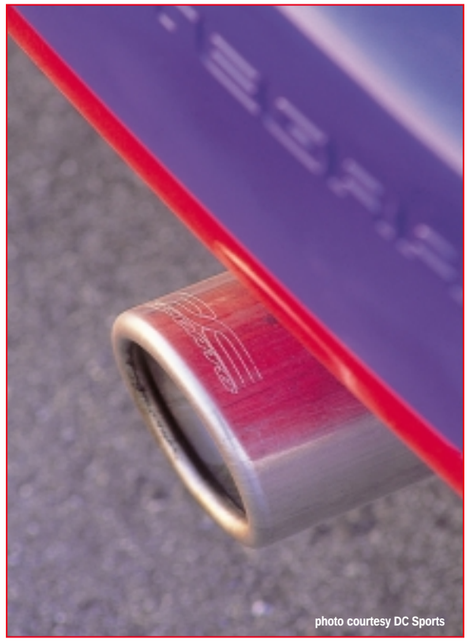


photo courtesy DC Sports

Back when fuel conservation was a non-issue, Detroit muscle cars from the Big Three were all the rage. Monstrous V-8s were a must, and straight-line performance was the measure by which they were judged. The more cubic inches the better, and the more fuel you could stuff into those cubic inches the more power you could squeeze out. The secret to higher performance was a fist full of dollars, a good set of wrenches and some bolt-on horsepower.

Then came the fuel crisis of the '70s and the ever-tightening EPA regulations of the '80s. No longer politically correct or environmentally friendly, gas-guzzling hot rods were pushed aside by economical imports from Japan.

Each year, the shrinking noose of environmental regulations forced automakers to employ increasingly complicated and expensive means to satisfy governmental pipe sniffers. But as the price for clean air continued to rise, advances in close-tolerance manufacturing and precision machining techniques – once the realm of limited-production vehicles and race operations – brought the cost of high performance down. Seemingly at odds, these two objectives soon reached economic parity and became practical in a production environment.

Enter the '90s. No longer content with gutless econo-boxes, the American public in general, and next-generation gearheads in particular, once again demanded performance, but this time they also wanted economy and a little sense of environmental responsibility.

Japanese automakers responded with vehicles that not only boasted high-performance, but did so with style and refinement, all while running cleaner and more economically than ever before. Thus was born the Sport Compact car. These vehicles featured race-bred technology wrapped in affordable packages, and nobody did it better than Honda and Acura.

Despite the performance these vehicles offered straight out of the box, it still wasn't enough. Ego driven one-upmanship, combined with the desire to stand out from the rest of the pack, created an instant market for products to make them faster, better handling and more stylish.

Seeing a rapidly growing customer base that was largely untapped by U.S. manufacturers, Darrell and Darrick Contreras formed DC Sports and stepped into the aftermarket fray. Their specialty? High-performance exhaust headers for Hondas and Acuras.

Headers are historically one of the easiest and most economical ways to boost engine performance. As an added benefit, this same modification usually adds to the "style" aspect of the vehicle by altering the sound.

The Contreras brothers had been building exhaust components for the motorcycle industry for some time, manufacturing high-performance product for the likes of Yoshimura and Pro Circuit Racing. But they wanted more control over their own destinies than this private-label work allowed.

CNC machined flanges are what set DC Sports headers apart from the rest of the aftermarket pack.

With DC Sports, they were able to take their future into their own hands. They cut off their private-label work and focused exclusively on manufacturing their own product for Hondas and Acuras.

"Our very first part," says Darrick, "was a header and exhaust for American Honda's race team. They were running their own CRX race program at the time, and bringing in some headers from Japan, but they wanted to source out the headers here."

The grapevine led American Honda to Darrell and Darrick's door. Having established themselves as a high-quality supplier through their work for Yoshimura and Pro Circuit Racing, they were a natural choice. And Honda wasn't disappointed.

"When we made the first part," notes Darrick, "they were really surprised at the quality and workmanship, and that just opened up a whole new door. That's basically how DC Sports started."

DC's product line continued to closely follow the Honda race program. "The next car they chose to race was the Prelude," says Darrell, "and I purchased one in '92 to help R&D product. Then we just kept doing another car, and another, and going through the line."

Then came Acura's flagship NSX, a Ferrari-eating two-seater that was a racecar wolf in street-car clothing. Again, DC was the natural choice to prototype the exhaust for Honda's racing effort.

What made DC Sports stand out was the quality of their product. "When we started making our very first header," explains Darrell, "we wanted it to be really high quality in order to meet Honda's tolerances. At the time, the parts from our competition were very crude – they had flame-cut flanges. We were the first to implement CNC-machined flanges and drill all the holes rather than flame-cutting them out. When we gave them to Honda they said, 'Man, what a great idea. You guys do a really nice job all the way through. Everything is very precise.'"

But there's a difference between building one-off prototypes for racing and manufacturing enough product to meet the demands of the general public. Darrell and Darrick soon found themselves overwhelmed with orders.

"When we started building our own headers – at that time it may have only been five or ten a week – we continued to have the flanges CNC made outside," says Darrell. "Then it got to the point where we could produce more headers than they could supply flanges, and we decided we needed to buy a machine.

"One of the guys a couple doors down from us had one of the early Haas machines, and he was telling us how, for the price, they're unbeatable, they're great machines. So we went to Ellison (the local Haas distributor at the time) and they really kind of jumped through hoops to help us finance a machine, since we were still a new company. We scraped up a fair amount down and bought one machine."

That first machine, a Haas VF-1 vertical machining center, gave DC the capability to machine flanges in-house. The brothers quickly discovered, however, that a machine doesn't make parts on its own.

"We bought the machine, then realized, Wow, it doesn't make any parts unless you know how to run it," says Darrell. "We were stuck."

"We had the welders needing parts, and we had a machine to make the parts," explains Darrick, "but we didn't

"When we made the first part, Honda was really surprised at the quality and workmanship, and that just opened up a whole new door. That's basically how DC Sports started."

know how to use it. We decided it was sink or swim – go to school, get a crash course on how to run this thing, and get it into production as fast as we can. We both went to the school, and I kind of took on the responsibility of running the machine and getting it up to speed."

Darrell, on the other hand, didn't fair quite so well. "I tried to do the school," he says, "and made it through one day, then I had X-Y-Z fever and checked out."

But having Darrick at the helm was enough, and within a month they were cranking out CNC-machined flanges of their own. "I ran it for three months, maybe," says Darrick, "then we hired a person to run it who had no machining skills whatsoever. I showed him what I had learned at the school, and gave him the manual. He just started trying new ideas, and we let him run with it."

That employee was Leonard Garcia. "We couldn't afford to go out and hire a twenty-dollar-an-hour machinist," explains Darrell. "So we looked within our employees for someone who was talented enough, and eager enough, to give it a go. Although Leonard had just graduated high school, he was pretty sharp and was ready to handle some responsibility."

Leonard rose to the challenge and today manages the entire CNC machining department at DC Sports, supervising several other employees, and running two shifts a day.

The Contreras brothers credit much of their success to the ease-of-use of the Haas machines. "If they had been hard to use we would have failed," says Darrick. "We would have been stuck with an expensive machine that no one knew how to use, and gone belly up. Fortunately, they were very easy to use, and right away we were able to get going, which is a huge plus."

Darrell agrees, "Two people who weren't machinists by nature were able to run them and get them into production. They've been nothing but our heart at this point," he adds, "and no matter what we throw at them, they seem to make it."

Header flanges are machined in two operations. First, the mounting holes and center of each exhaust port are drilled, then the mounting holes are used to fixture and locate the flanges as the outside profile is cut and the exhaust ports are interpolated to size.

Within three months of buying their first CNC machine, DC purchased a second Haas VMC, this time a VF-2. Darrell and Darrick felt surely that would be enough to make all of their parts. But as production continued to increase, there was a need for a third machine, so they purchased another VF-2. The added capacity not only allowed them to meet the increased demand for header flanges, but allowed them to develop new products.

At that time, DC Sports was known primarily for their headers; but as the company's reputation grew, distributors began asking for more. Darrell explains, "Our dealers said, 'You know, we can sell your headers all day long, but we need something to accent them. You need to branch off and find other parts to make, so that when a person comes in for your header, I can sell them your cat-back exhaust or your strut tower bar.' So, little by little, we just created other products to help sell what we currently had."

"So we decided to purchase a lathe to bring the shifters in-house. We felt that if we bought the Haas lathe, we could make the shifter, we could make an oil cap . . . "

The purchase of a Haas HL-2 lathe allowed DC Sports to bring their turning operations in-house, and branch out into new product lines.

New products brought new machining challenges. "We started making a short-throw shifter out of billet aluminum," says Darrick, "and we were farming those out to little independent machine shops. But we had a problem with supply: We could never get the parts when we wanted, and the quality wasn't always there. So we decided to purchase a lathe to bring the shifters in-house. We felt that if we bought the Haas lathe, we could make the shifter, we could make an oil cap . . . "

Darrell adds, "We just said, All right, what can we make on this lathe that we're currently out-sourcing, and what else can we make on it in the future? How can we make this machine pay for itself?"

According to Darrell, the Haas CNCs were crucial as DC Sports expanded its product line. Another key element was Steve Schmidt, who today provides much of the engineering behind DC's products.

Steve was just a sophomore in high school when he met Darrell and Darrick. They were working out of a small 1,440-square-foot shop in a multi-tenant complex, and he was working for a company across the parking lot. One day Steve spied a Honda RC 30 racing motorcycle – a fairly rare bike – in the window of the brothers' shop. Intrigued, he decided to stop in.

"We were making products for Yoshimura at that time," recalls Darrick, "and he was interested in motorcycles and saw the RC 30. He just became a kid who walked into the shop every day and looked around at what we were making. A few years later he was working for the company!"

Steve worked for DC on a part-time basis for about seven years, helping them with their computer system, drawing basic designs and doing some prototype fabrication. He came on board full-time shortly after DC got the first two Haas CNC machines. At that time, they were out-sourcing all of the machine programming, but they wanted to bring the process in-house. Steve was the logical candidate to take over the task.

"Darrell said he would send me to school to learn how to program the machines if I was interested," explains Steve. "I got the manual and started reading the G codes, then started learning how to work the machine and

"It seems our competition has found that our design is very attractive to our customers, so you can find a lot of headers on the market, now, that are very similar to ours."

change the tools. I started out by just kind of cheating, looking at some of the existing programs, copying the G codes over and putting in my own geometry. I essentially learned to program on the Haas machine. The control's like heaven; it was easy for me to learn on." Before long, Steve was writing all of DC's programs in-house.

"The Haas has been really flexible," Steve continues. "I guess one of the biggest benefits is that the control is the same on the lathe and the mill. When a new operator comes in, he doesn't have to learn separate controls, or where the keys are located. He can easily work the lathe and the mill, because it's the same control."

Today, Steve spends much of his time designing products and providing the technical drawings and programming for the DC Sports machining department. He also oversees the company's computer system, and is heavily involved in the company's racing program. He has nearly completed his Bachelor of Science degree in mechanical engineering, and is looking for areas where his engineering skills will be beneficial to the company.

DC Sports has now grown to 19,000 square feet in two buildings – a bit larger than their original shop. Their current catalog includes a full line of products to complement their trademark headers, including cat-back exhaust systems, suspension strut tower braces (front and rear), air intake systems, short-throw shift levers, and an assortment of billet aluminum engine dress-up pieces, like battery tie-downs, sparkplug covers and oil filler caps.

Handling the machining duties at DC are a Haas VF-1 VMC, two VF-2s and an HL-2 lathe. The VF-1 and one of the VF-2s are dedicated exclusively to machining header flanges five days a week, and the other VF-2 turns out the strut tower bars and all the other aluminum accessories. Anything round is machined on the HL-2 lathe, including parts for the air-intake systems, ends for the strut tower bars, and an assortment of threaded pieces and connectors. The shop currently runs two shifts per day, from about 6 a.m. to 11 p.m.

To increase production and reduce setup time for the header flanges, DC has fitted a manual pallet changer system (an SMW Setup Switcher) to one of the VF-2s. This allows the operator to load and unload parts offline while another setup is being machined. Tooling for each specific header flange is left on the individual pallets to speed changeovers, and the pallets are stored on nearby racks.

Header flanges begin as lengths of 3/8"-thick by 3"-wide cold-rolled steel. These are sheared to size, then fixtured four or five to a pallet for machining. The first operation drills the mounting holes for the header and drills out the center of each exhaust port. The mounting holes are then used to locate and mount the flanges on another pallet for the second operation. At this point, the port holes are interpolated and opened up to proper size, and a 1"-diameter indexable endmill is used to cut the flange profile. All operations are done in one pass to reduce cycle times. According to Steve, "This includes a full-diameter cut with the 1" indexable end mill, and that's running at about 60 inches per minute."

He says that the challenge now is to optimize the processes to increase the ratio of run time to power-on time.

They've done this on the HL-2 lathe by adding a turret-mounted bar puller. This allows the operator to load a three-foot length of bar through the chuck, then program the tool turret to pull a specified length of stock for the next part. In this way, multiple parts can be run without the operator having to load material.

The HL-2 has allowed DC to bring most of their round parts in-house. "We used to buy a lot of these round components from outside sources," explains Steve. "Some of them are threaded, so we would have to buy nuts and then have additional operations done on them before they were ready to use, which increased the cost.

"One part in particular is an EGR (exhaust gas recirculation) nut," he says. "It's internally threaded with a metric thread, and about 20 millimeters down it has an inverted flare with a hole all the way through the part. I talked to several outside sources and they said there was no way to make it in one part. They would have to do the inverted flare, then weld the threads onto it."

Darrell and Steve decided to take a closer look and see if they could make the part themselves on the HL-2. They

Leonard Garcia, above left, uses a manual pallet changer system to change fixtures on the Haas VF-2. Tooling for each specific header flange is left on the individual pallets to speed changeovers, and the pallets are stored on nearby racks. Above, all DC Sports headers are TIG welded by hand. At right, the Haas HL-2 lathe allowed DC Sports to bring this EGR valve in-house. What used to cost a dollar to buy now costs pennies to make.

contacted several different tooling manufacturers for a solution, but were only able to come up with special tools, which are always expensive. Undaunted, they continued to search, and finally came up with a standard tool that would do the job.

"That right there," says Steve, "cut our costs tremendously. I think we were paying a dollar per nut, and now we can make them for pennies."

Such solutions are typical of the DC Sports team. When they encounter a roadblock, they knock it down and go on. This philosophy has elevated them to the top of the aftermarket hill.

Being at the top is a great place to be, but it also gives the competition a clear target to aim for. And, although imitation may be the sincerest form of flattery, in the aftermarket world, it is usually an attempt to steal market share.

"It seems our competition has found that our design is very attractive to our customers," says Steve. "So you can find a lot of headers on the market, now, that are very similar to ours. So we're doing little things to distinguish our products from everybody else. One of those is taking advantage of the fact that we have the Haas CNC machines. A lot of the other manufacturers don't CNC machine their flanges, they use laser or waterjet. With the CNC equipment we can do extra detailing with just a minimal amount of added time, and it really distinguishes the part."

If the past is any indication, DC Sports will continue to rise to the challenge. They are always ready to take things to the next level. As Darrel says, "Everything we do, we attack it and try to do it at 100 percent. We want to be known as the company to call if you want to buy a Honda and Acura product. We'll do everything we need to do to keep it that way."

"People ask us how we made it to where we are today," muses Darrick. "And it's funny, I don't really have an answer. Just a lot of hard work and dedication. We don't give up."

DC Sports
909-734-2030

Kevin Young sets up suspension tie-bars for machining on a Haas VF-2, then inspects the finished parts as they come off the machine.

Breaking Through the Smog Barrier

DC Sports was the first aftermarket manufacturer to produce stainless steel exhaust systems for Hondas and Acuras. They were also the first to meet the strict regulations of the California Air Resources Board (CARB), thus making their systems legal in all 50 states.

According to Darrick Contreras, many manufacturers don't even attempt to meet CARB standards, preferring to label their products "For Off-Road Use Only." But he says the DC Sports headers didn't have any problem passing on the first try. "That either goes to say that we did our homework very well," he says, "or that our product was a quality piece, and that just made it easier to pass all the emission standards. Our header was a thicker gauge than what everybody else was using – we use 16-gauge material – and the stainless steel helped retain the heat, which just helped all the way around."

"Our competition was using slip-fits for the primary to the secondary, which leaked exhaust gases," adds Darrell Contreras, "and there was no way to control that. We CNC machined our flanges so the tolerance was real tight, and TIG welded all joints. We cut in O-ring grooves and supplied an OE-quality O-ring, so there was absolutely no leaking. I think all of these little engineering qualities just helped us pass with flying colors."

"The location of the oxygen sensor was another big plus," states Darrick. "Putting it in the right spot on the header so that it reads all of the cylinders was one of the factors in passing on our first try. That's more accurate than putting it in a single tube to read one cylinder and hoping that it's enough to compensate for the three cylinders that aren't being read."

DC Sports also designs their headers as direct replacements for the stock items, retaining all of the stock mounting points and using original equipment-style O-rings between the flanges. Even the factory nuts and bolts are used. "It's essentially a factory replacement part," says Steve Schmidt.

"We feel that Honda went through a lot of work to engineer the stock exhaust system," explains Darrick, "and they put the brackets on there for a reason. Therefore, we use the same principals and put the brackets back on our system. Some of the other manufacturers may take shortcuts: They'll leave different mounting brackets off, or use gaskets instead of O-rings. They won't thread the flanges, they'll just use a nut and a bolt, and maybe 10,000 miles down the road, the parts start leaking because the gaskets blow out. We just took it to the next level"

"Even when we researched the Haas machines," remarks Darrell, "we specifically bought them with rigid tapping in mind. We knew we wanted to tap all of our holes, instead of using nuts, so the customer wouldn't have to put a nut on the backside of a bolt in a hard to reach area."

This attention to quality and detail is what makes DC Sports products stand out. But the headers don't just look good and fit right, they also work well. Each design is thoroughly tested in-house on an engine dyno to optimize performance. Unlike some manufacturers, Darrel and Darrick aren't content with boosting just high-end performance. Rather, their goal is to produce a header that gives performance gains throughout the rpm range.

The latest R&D project for DC Sports is the new Honda S2000 Roadster. Only 5,000 of these luxury sports cars are scheduled to hit U.S. shores, but Darrell and Darrick already have one, and they're hard at work developing a performance header and dual-exhaust system for it.

Not only are DC Sports headers and other components CARB legal, they are designed to be direct replacements for the stock parts, making installation easier.

In stock trim, the Honda S2000 has the highest power-per-liter ratio of any naturally aspirated production automobile in the world, generating more than 240 horsepower from a mere two liters. What makes this even more impressive is that Honda achieved such performance while meeting California's stringent Low-Emission Vehicle (LEV) standards.

The addition of a DC Sports header and exhaust system to the S2000 will surely push the power ratio even higher. And since gearheads can never leave well enough alone, it's a sure bet that demand for the DC Sports components will be high.

And, in kind of an interesting twist, DC Sports will soon be getting back into the private-label business with some of their components – but this time for Honda directly. The company has been asked by Honda's Optional Equipment division to manufacture a line of engine dress-up pieces for sale by Honda dealers. The trio of billet aluminum pieces – battery tie-down, sparkplug cover and oil filler cap – will carry the *Powered by Honda* logo.

The Benefits of VIRTUAL MANUFACTURING

Story
Vaiti
Nathan

The goal of every manufacturer is to produce error free parts on time and within budget. Imagine having the ability to simulate the machining process and verify the accuracy of your parts before they get to the machine.

Virtual Manufacturing employs the latest computer technology to graphically reproduce the manufacturing process, including the CNC machine and associated operations. There are four interactive components of Virtual Manufacturing:

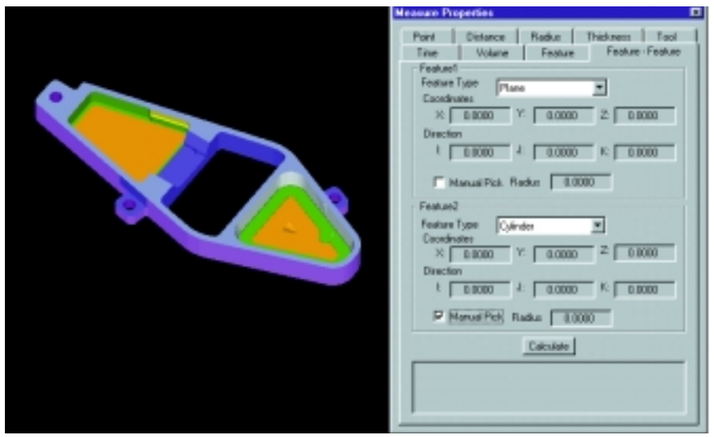
1. NC verification simulates the material removal process for various machining operations to detect part program errors.
2. Machine simulation graphically represents the movements of the machine tool and its components as the NC part program is executed to detect collisions.
3. Reverse post-processing enables the Virtual Manufacturing software products to interpret and simulate NC code written for a wide variety of CNC controllers.
4. NC optimization properly adjusts feeds and speeds to reduce machining time and maximize machine tool utilization.

Recent advances in PC computing capabilities and 3D graphic technologies have enabled wide usage of these solutions by the manufacturing industry. Manufacturers are now able to detect and avoid part gouges, program errors and machine component collisions, resulting in accurate, ready-for-market products on the very first run.

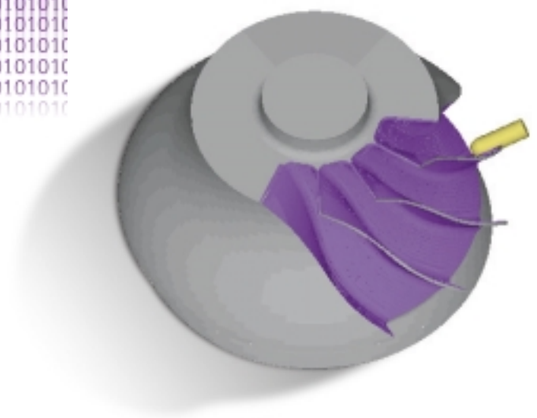
Virtual Manufacturing Benefits

Machinists and NC programmers can use virtual manufacturing to:

- Improve quality of the machined part
- Detect NC program errors, gouges and leftover material
- Ensure conformance with design specification
- Reduce machine and tool wear
- Increase machine tool utilization and productivity
- Reduce manufacturing costs
- Serve as a powerful presentation and visualization tool
- Train machinists and programmers
- Enhance shop floor documentation



Images courtesy of Sirius Systems.



NC Verification

NC verification software graphically simulates the material removal process by continuously updating the solid stock shape as the cutter moves along the toolpath to produce the final part. The software accepts NC G code, APT-CL or other CAM toolpath file formats as input and simulates the entire machining process.

Benefits of NC verification

- Detect NC program errors and bad or rapid cuts
- Machine parts correctly the first time
- Eliminate expensive and time consuming dry runs and proofing
- Reduce material scrap and overall cost

Important factors in selecting an NC verification product

1. Solid-based simulation: The software should provide an accurate solid-based representation of the machined part for the user to inspect with rotation, zoom and measurement functions.
2. Performance: Simulation speed is critical for quickly verifying the large NC programs normally associated with the mold and die industry.
3. Support for various input formats: Verification software must be flexible enough to handle all of the file types used in your manufacturing environment, from APT/CL to the many G-code formats for each of your machine tools.
4. Manufacturing operations: Verification software should support machining operations such as 3-5 axis milling, 2-4 axis turning, mill-turn and grinding.

Machine Simulation

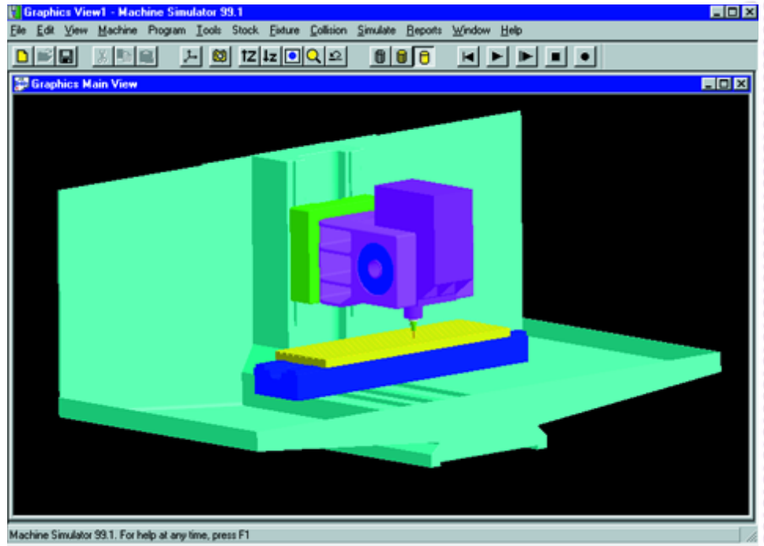
Machine tool simulation software uses 3D graphical technologies to model and animate the complete NC machine and its environment on the computer. The software processes the actual machine input and simulates all movements of the machine components, including the axes, heads and tools, to detect collisions between any moving or stationary components.

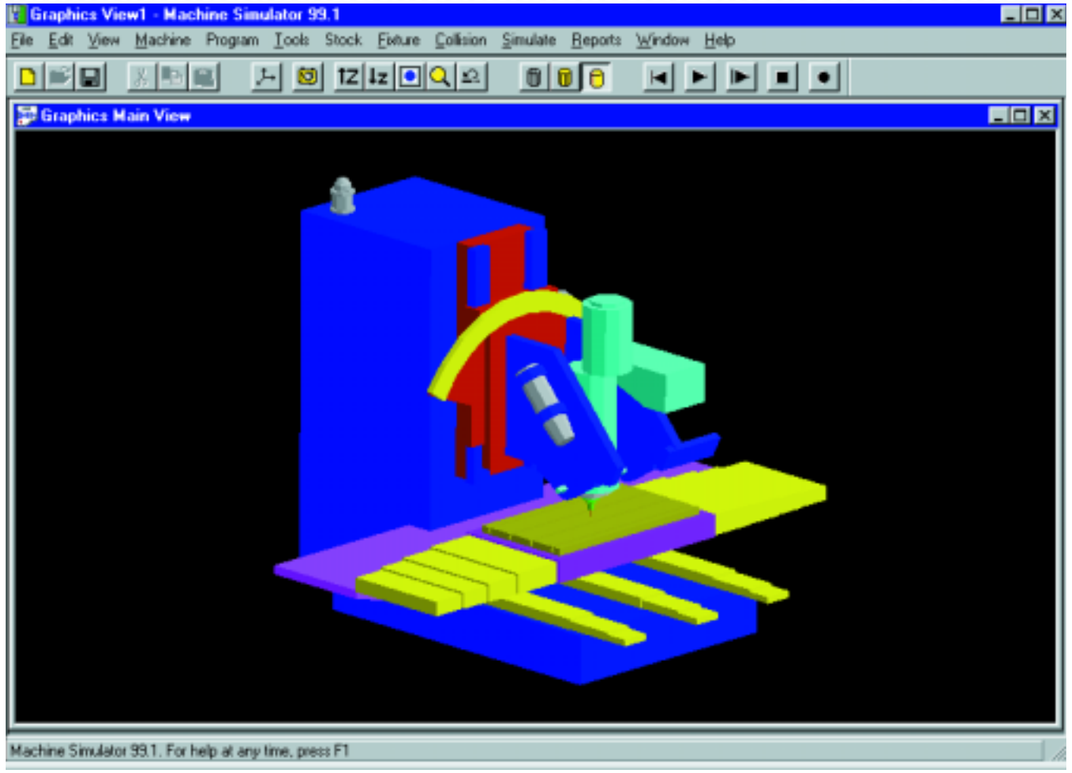
Benefits of machine simulation

- Detect collisions between all machine components including heads, axes, pallets and tables
- Preview machining operations by simulating movements of all machine components
- Train new programmers and operators
- Validate post processor configurations
- Use as a presentation and demonstration tool

Important factors in selecting a machine simulation product

1. Multi-window viewing capability: It will be important for you to visualize and check the machine movements with respect to the current machined stock shape. Without this, the collision detection will be incorrect. The software should perform simultaneous, single-window material removal and machine simulation.
2. Easy and non-programmatic interface: The machine modeling capabilities should be simple and flexible. Look for software which can accept standard 3D CAD models as the machine components or which provides a non-programmatic interface for machine definition.
3. Fast and smooth animation: For a realistic simulation of the machine tool, the software should support smooth animation using advanced 3D graphics capabilities.





Reverse Post Processing

This software accepts machine-specific NC G & M code CAD/CAM program input, and reverse post-processes the data into a neutral format such as APT/CL. This process allows Virtual Manufacturing products to accurately simulate the toolpath and animate a wide diversity of CNC machines.

Benefits of reverse post processing

- Simulate the actual machine input and ensure accuracy of CNC controller emulation
- Reverse post process NC programs from one machine controller for re-posting to another CNC controller. This is important during the retrofit of old machines with new controllers, and provides manufacturers with the ability to move the same part program between a multitude of machines

Important factors in selecting a reverse post processing system

Make certain that your reverse post processing software has an established library of CNC controller configurations and that the software has the flexibility to allow users to tailor an existing configuration or build a new controller configuration.

NC Optimization

NC optimization software analyzes NC programs to adjust the feeds and speeds, reducing machining time by up to 50% or more. The software analyzes machining parameters such as depth of cut, width of cut, volume of material removed, tool area of contact and tool sizes to determine optimum feeds and speeds.

Benefits of NC optimization

- Substantially reduced total machining time
- Better machine tool utilization and more efficient NC programs

Important factors in selecting an NC optimization product

1. Standard plug and play libraries: Standard CNC controllers as well as feed and speed libraries should be included to enable immediate operation of the software. Both user-defined and commercial feed and speed tables should be supported.

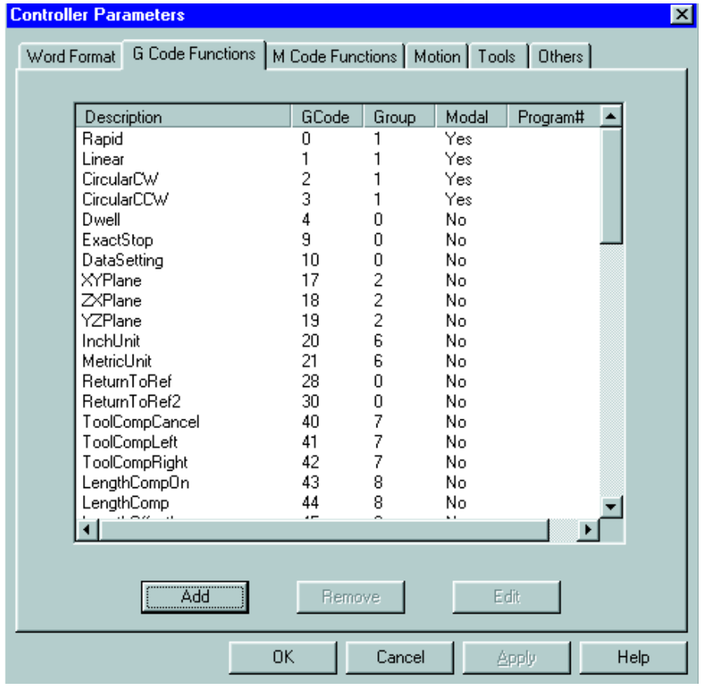
2. Speed and reliability: It is important that optimization be performed quickly and accurately to ensure optimum improvements to the manufacturing process.

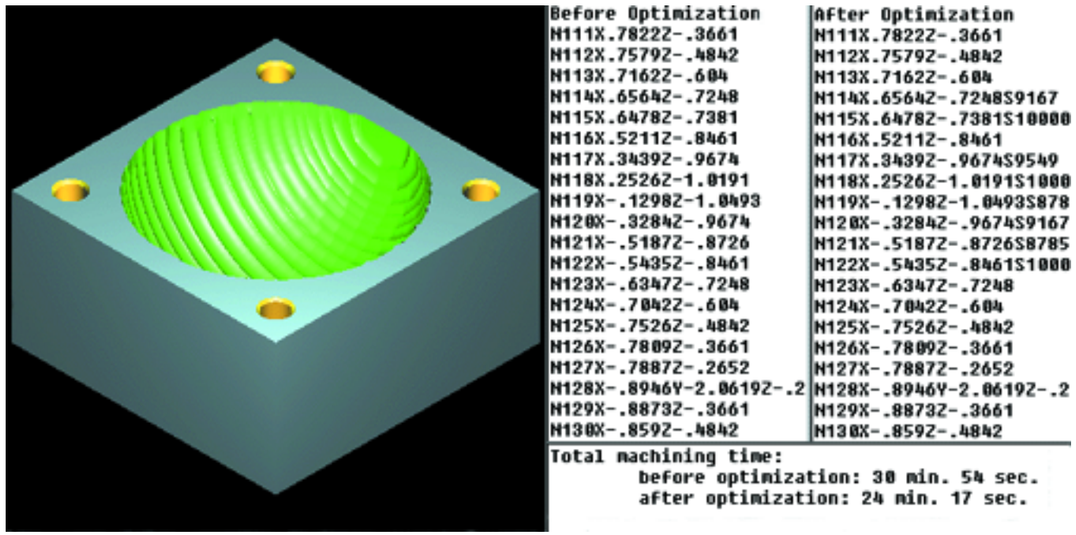
3. Other optimizations: Make sure the product has provisions and extensions to optimize other parameters such as: tool wear, tool life and inefficient tool movements.

More Information

Vaiti Nathan is the President and founder of Sirius Systems Corporation. Sirius designs and develops leading-edge software solutions for the manufacturing industry.

For more information, please contact Sirius Systems at 408-723-6510.





Extending a Winning Legacy into the Next Millennium

story and photos by Preston Gratiot

Racing improves the breed, and nowhere is this more evident than in the constant improvements in performance and reliability tracked by the typical racing engine.

photo courtesy Scott Desfor

Notes from Paul Ray on the new facility/engine:

"The fact that the fastest engines from the CART Spring Training event were built here at the new Ilmor Tech Center was no accident. It was a concrete example of the capabilities of our new state-of-the-art facility. But most importantly, it emphasized the excellence of the personnel we have on our team.

"Building an engine that can withstand the extreme heat, friction and vibrations developed at more than 240 miles per hour is not a glamorous job. It takes immense concentration and dedication to fit all of the more than 4,000 parts in our engine. There is no margin for error: There are no gaskets anywhere in our engine and many tolerances are measured to less than one-tenth the width of a human hair. Failure of any one of those parts can mean disaster.

"Each engine takes more than 120 man hours to build, and it is delicate, painstaking work. The pressure can be immense – and not just on race day.

"What makes this all worthwhile? Winning."

Paul Ray, Vice President, Ilmor Engineering

The initial batch of Mercedes racing engines assembled in the new Ilmor Technology Center in Plymouth, Michigan, were not only fast, they were reliable and fuel-efficient, as well. In the first outing of the season at Homestead, Florida, Mercedes-powered cars garnered three of the top four qualifying positions and led 126 of the 150 laps in the race. The new engine's fuel efficiency also allowed Greg Moore to make one less fuel stop than most of his competitors and win the race. It was an impressive first showing for the engines built at the new Ilmor facility: a pole position, a victory and a dominating performance overall, as three different Mercedes-powered cars led the race.

"We can never again have a 'First Race' for our new home," said Ray in retrospect, "and we were thrilled to win it."

On Mario Illien and Paul Morgan

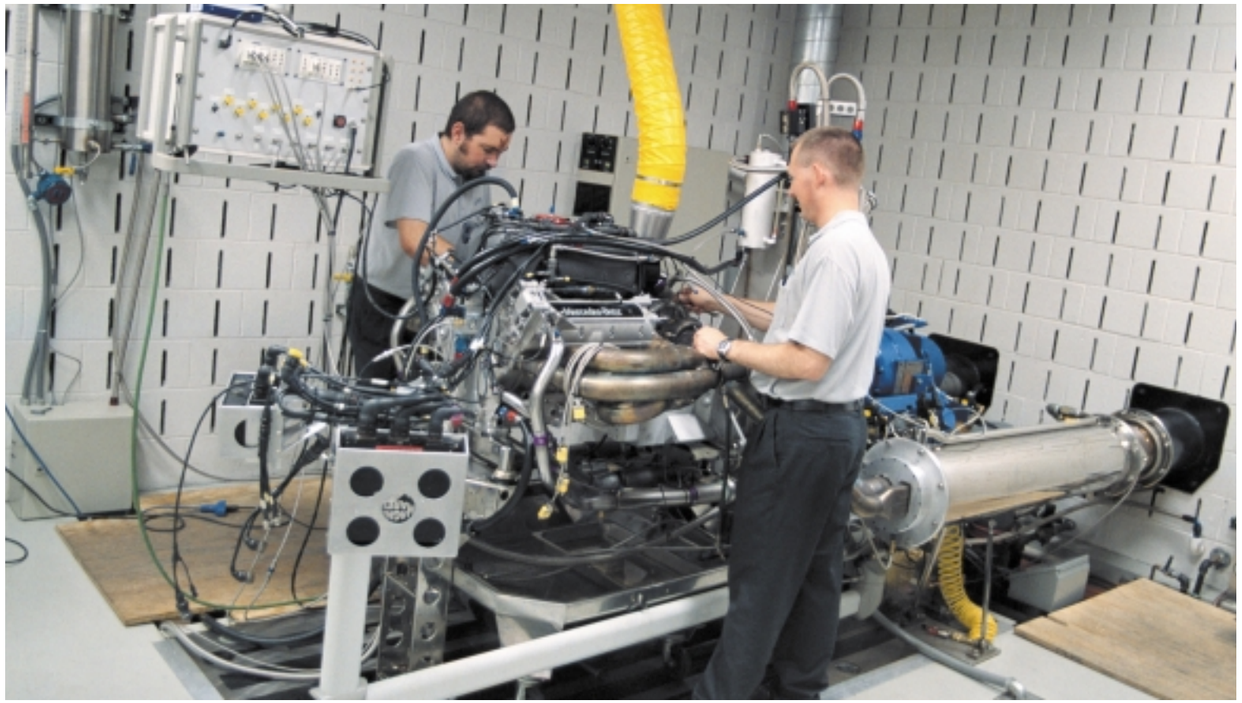
However, winning takes more than a new building and a 25-gigabyte hard drive full of high-tech designs. The staff has to have a very special mindset and a desire to work together as a team. The two founders of Ilmor, Mario Illien and Paul Morgan (the "IL" and "MOR" of Ilmor), created the kind of company they would like to work in: a company where ideas are respected and valued; where politics and bureaucracy are abhorred; where communication is encouraged; where work and play are both at full throttle; and where the way results are achieved is as important as the results themselves.

At Ilmor Engineering, the designer's goal is to either devise new ways to make an engine more efficient within the existing parameters, or step away from accepted technology and find a new way to take the checkered flag.

Winning Partnership

While the Ilmor name has only been in racing a relatively short time (formed in 1983), it is already well entrenched in the record books as a builder of winning engines. The engine-design/build specialists can boast of winning seven Indy 500 races and powering six CART Championship winners. Since 1986, Ilmor has won 116 out of 228 CART races, a winning record of more than 50 percent!

The two founders credit much of this success to their choice of subsequent partners – including racing great Roger Penske. It was with Penske that the group's partnership with General Motors and the first foray into Indy racing came into being.



Ilmor Engineering maintains the CART Mercedes-Benz racing engines. This means doing more than 300 rebuilds annually. Because the engines are leased to a number of teams, each is run on the dyno to ensure absolute equality when it gets to the track.

The result was an era of dominance that could only be compared to that of the Offenhauser of old, or its inevitable successor, the Ford-Cosworth. In 1991, Chevrolet ran ads that boldly stated, "You can't win Indy without one." In that season of 17 races, the Ilmor-Chevrolet took 17 pole positions and 17 victories. It doesn't get any better than that!

Then, in 1993, Chevrolet pulled the plug. Critics accused GM of deserting the field just as Ford was bringing in a new challenge. But GM IndyCar spokesman Wally Reese countered by saying: "I honestly don't think Chevrolet's afraid to race anybody on even terms. The bottom line is that Chevy is in business to sell cars and trucks."

New Star on the Horizon

"Without Roger Penske I don't think we would have survived," reflected Mario Illien. "Roger had a major input to the fact that we have a deal with Mercedes-Benz." By designing a new pushrod engine to maximize the existing rules, Ilmor – with new partner Mercedes-Benz – was ready to go racing with the introduction of the latest Ilmor/Mercedes-Benz powerplant.

Ilmor picked a good year to have its own name on the engine. Penske's costly yet ambitious three-car team cut a swathe through the 1994 season and took Al Unser Jr. to the PPG-sponsored IndyCar championship. In the runner-up positions were Penske's other two drivers, Emerson Fittipaldi and Paul Tracy. During the season, they had an incredible five 1-2-3 finishes. Never before had a team so dominated the IndyCar season.

"The winning Ilmor engine in the 1994 Indy 500 – the Mercedes-Benz 500I – went from drawing board to victory lane in 26 weeks," says Paul Ray. "The engine was the first since 1911 to win the pole position and the race in its debut appearance at Indy."

CNC Those Heads

The Indy engine was to have only two valves per cylinder, a design dedicated builders of competition engines – engines normally fed by at least four valves

Many of the 4,000-plus parts used to build the Ilmor IC108-series racing engine are replaced at every rebuild. The majority, such as this piston being cut on the Haas HS-1R, are machined from raw or forged billets at the Ilmor facility.

per cylinder – had long considered dead. Illien decided not to look at anybody else's pushrod designs. Instead, he and his team studied the problems, and engineered their own solution from scratch.

The engineers had to optimize the port shapes for maximum flow while still providing room for the valves, spark plugs, pushrods and, of course, the studs that would hold this compact head to the block.

The final layout of the valve gear and cylinder head was a tribute not only to CNCs and the value of CAD, but also to CAM: computer-aided manufacturing.

To set up equipment to machine such a head in the traditional manner would have been so time-consuming as to be out of the question. With CAM, the engine's sophisticated design could be realized – and repeated – with absolute accuracy.

The result was an engine so successful that it was doomed to over-regulation. USAC reduced the boost limit on engines like the Ilmor by 12.7-percent, effectively handicapping the Ilmor-Mercedes engine into oblivion – at least until the new IC108 roared to life.

Enter the IC108

"The goal in designing the new IC108 [Indy Car 1 (1st Generation) 08 (Eight Cylinders)] was to make it as small and as light as physically possible by minimizing the number of parts," explains Ray. To accomplish this downsizing, it was necessary to package components in much closer proximity to one another than ever before.

"The CART Champ car races take us to short ovals, high-speed super-speedways, natural-terrain road courses and temporary road circuits through the streets of cities like Long Beach and Toronto," Ray continues. "No other series in the world offers such a diverse schedule, which pressures our engineers and technicians to produce a single powerplant that is suitable for all of these distinct tracks."

To Build and Maintain

Ilmor not only builds the engines that meet these demands, it also maintains them on a race-by-race basis. In addition, each Ilmor/Mercedes engine comes with a walking, talking instruction manual: an Ilmor engineer.

These specialists are present each time the engines are started – tracking and enhancing their performance by electronically charting the engine parameters, adjusting the metering systems to conform to track and weather conditions and, in general, making sure the engines meet the high standards of the Mercedes-Benz reputation. This remote support is enhanced through the use of Ilmor's portable, on-site engineering facility: a full-function technical center that is housed in a double-slide-out trailer and towed track-to-track.

Mercedes Moves to Plymouth

Ilmor recently opened its new 26,000-square-foot technology center in Plymouth, Michigan, some 20 miles west of Detroit. This self-contained facility, which

Every Ilmor engine comes complete with a full-time, team-dedicated technician – onsite at every race or practice session to monitor engine performance. Computer input is downloaded in the pits (right) and then analyzed in the Ilmor Mobile Technical Center to provide optimum performance on race day.

serves as the technical headquarters for the Mercedes-Benz championship-winning "CART FedEx Championship Series" program, houses the administrative offices, an 18,000-square-foot engine assembly/rebuild facility, three dynamometer testrooms and a machine shop, all on a spacious 5.5-acre parcel of land.

The machine shop is fully equipped with the latest CNC machining centers and lathes from Haas Automation. Haas is listed as an Ilmor Star Partner company, a group of select "sponsors" that assist Ilmor in its quest for the engine-builders championship in CART.

When you consider that the present Ilmor-Mercedes CART engine consists of more than 4,000 individual parts, and that the engine is assembled without gaskets, absolute accuracy and repeatability is an undeniable necessity in order to build a consistent powerplant. CNC technology is the only way to ensure this accuracy, and Ilmor chose the Haas family of machine tools to provide this perfection.

Why Plymouth, Michigan?

While most of the CART racing teams have located in areas with large testing facilities nearby, such as Indianapolis, Ilmor chose to build, fittingly, just outside the "Motor City."

"One of the most important reasons for our locating here in Michigan is that it allows us to share a few hours of the working day with the main offices in England," says Jade Gurss, manager, marketing and communications. "So one of the things we did was build in the Eastern time zone and put in a fairly high-tech conferencing system.

"Through the ISDN line, we can connect directly to our headquarters in Brixworth, England. We have a lot

of intercontinental engineering meetings, and the system is configured so a person here can send engineering data or drawings back and forth on the same line," he continues. "Because of this, we can share all data and information with the England office in real time."

Engineered for Engines

The entire building is designed and focused to provide absolute efficiency. However, creativity is encouraged through surroundings that literally bend the strict angular architectural components so typical of the engineering world.

Official hanging artwork in the building consists of historical photos by Jesse Alexander, the famous Formula One photographer. "Our feeling was, A: We love his work, and B: The tone of his work gives a sense of the historical background of what we do," explains Gurss. "We think it's very important for all of the employees to understand the lineage of where we are now and what Ilmor and Mercedes have been through. We decided to have a little more of a sense of history."

Behind the glass doors that lead down the hall to the manufacturing/test cells, you find the typical look of a highly technical engine building facility, where perfection is the goal, and absolute repeatability is demanded by the customer.

This repeatability was assured with the order of three Haas CNC machines: a VF-4 vertical machining center, an HS-1R horizontal machining center and an HL-4 lathe. This facility was designed to build winners.

Chris Economaki, international television sportscaster and editor emeritus of National Speed Sport News, called the Ilmor facility, "no doubt this country's finest motorsports facility."

Building Design

When the present-day headquarters were built in Brixworth, England, Ilmor bought a big plot of land and put a nice building in the center. They then made the mistake of selling off all of the surrounding land. As the company grew, they were unable to buy back the land around it. When it came time to build the Plymouth facility they decided not to make that same mistake!

"We've built a modular building here in Plymouth that fits our current, and future, specifications," says Gurss. "The architecture, facilities and all of the master plans were designed for about triple our current capacity. That is why the building is surrounded by acres of grass. It's a little overkill for now, but this time we have plenty of room to grow."

Clean and Build

"On this particular engine (the current IC108E CART powerplant), we have about 4,000 individual parts," says Gurss. "So, rather than have each engine builder become an expert on all 4,000 parts, we've broken it up into what we consider are strategic modules, or what we call sub-assemblies."

Each of these sub-assemblies goes on a rolling cart which ends up holding all of the parts for a particular engine. Magnetic numbers are assigned to each part that corresponds to a specific engine block, or engine number, so each part can be tracked both internally and for later evaluation.

"Some parts are used only one time, and then others, like the engine block and crank, are reused. Following teardown, they end up in the Inspection/ Cleaning area," says Gurss. "We inspect every piece that is going back into an engine to make sure that we don't have any cracks or points of fatigue.

"In the Inspection Room, we have cleaning machines for every different part and piece. Obviously, different metals require different solvents, and the residue must be properly handled. We have a special machine for this process – it's basically like a huge industrial dishwasher. We can almost put an entire engine in there. It cleans all the residue and fluids off using a high-pressure wash, and then it superheats all the remaining waste and turns it into a powdery ash that we can just dump into a bin. It's an environmentally friendly way to clean and treat all solvents and oils."

Immaculate working conditions (above) are the "norm" at Ilmor. The facility is designed to allow for growth, while adhering to a specific workflow. With multiple teams running Ilmor engines, the Haas machines often run multiple shifts (opposite) to meet race deadlines.

Machining

Today's technology is so competitive that you have to build everything right on the absolute edge. Engine builders joke that your engine should first cross the finish line . . . then explode! Not only would this be a perfect example of power verses reliability, but it also doesn't leave much evidence of any bending of the rules.

"If it didn't have to be there," says Gurss of the thousands of parts found in the present day IC108 engine, "it wouldn't be there. So that's one of the things that we emphasize with the Haas machines, if we finish pieces with those machines, they are all critical, no matter how small they are. If any of those fail, it's not a good result for us or for any of our teams."

One area where the Haas machines have been instrumental is in machining the IC108's pistons to reduce the reciprocating mass.

"When I first heard about trying to save an ounce or two ounces per piston head, it didn't seem like much," explains Gurss. "But when you multiply one ounce times eight cylinders, and factor in as many as two million crankshaft revolutions from start-to-finish of a typical 500-mile race, that one ounce per piston certainly adds up (approximately 500 tons of rapidly moving mass).

"This adds up to a massive amount of inertia that must be overcome by the energy developed in the powerplant. Weight is directly related to an object's ability to alter its trajectory or speed. So successful racecars, by nature, must weigh as little as possible. That's why there are some components that are designed with maximum attention to weight. It's the reality of staying competitive."

Please see Ilmor page 34

Grinding Out a New Niche With a Mix of Haas Hybrids

Mindrum Precision is one of a limited group of manufacturers capable of fabricating shapes in highly technical glass, quartz, ceramic and other exotic materials.

Story & Photos
Preston Gratiot

What makes Mindrum even more specialized is the fact that the company is willing – and able – to modify traditional CNC machines to optimize new techniques in the working of these unconventional materials.

Started 43 years ago by Paul Mindrum, Mindrum Precision was the first major non-vineyard manufacturer in Rancho Cucamonga, California. Today, the company is a leader in sub-angstrom (smaller-than-an-atom) surface-roughness technology.

Changing Times

Originally specializing in the redrawing of glass shapes (heating and then stretching tubes or extrusions to reduce the dimensions while retaining the original shapes), Mindrum adapted through the years, meeting new challenges while introducing and refining new technologies.

Paul's daughter, Diane, has been President of the company for eight years, a challenging time that has included the major scaling back of the Defense Department's budget. Mindrum had been doing mostly Defense work, yet quickly redirected efforts toward commercial and developmental customers, especially in super-finishes and the machining of complex shapes.

In order to meet the demands of this constantly changing market, the company looked to monopolize on some of the latest CNC technologies, only to find that the choice of machining centers devoted to their niche of working with advanced glass, quartz and ceramics was rather limited, or prohibitively expensive.

Dennis Winegarner, General Manager, was called upon to apply his background in machine shops and gemology to meet these new challenges with new – sometimes hybrid – ideas and machines.

Hybrid Haas

"In our business of machining hard materials, we sometimes are forced to re-configure traditional metal machining tools into grinders. In the Haas machining centers, we have found a reliable and accurate base machine that allows us to make this transition," explains Winegarner. "With our modified Haas CNCs, we have made holes in complex ceramic shapes with a true position tolerance of .0001" at a distance of eight inches, with each part repeating every time. We have been very happy with our overall experience concerning Haas."

Winegarner also credits the Haas control with adding to the versatility of the Mindrum workforce. "My background as a machinist helps me appreciate the Haas control's layout. The control, and its commonality from one machine to the next, is easy to explain to others. New operators can learn the necessary functions in a short time.

"There have been a few times that I wished that I could buy a Haas control to attach to another piece of our existing equipment, because I was unhappy with the other control's performance. The Haas control is logically laid out and has many features that make the user's work easier."

He also notes that by having a quality graphics display, verifying a program is easy and often a source of relief on a complex program for an expensive material. "It's nice to be able to hit five key strokes or less and then watch your program running," he explains. "I personally have had times when that virtual run-through feature alone has saved me from disaster. In a part that may be thousands of dollars apiece at 80 to 85 Rockwell C, this is an important feature."

His familiarity with the Haas control goes back quite a few years. "My first contact with a Haas was back in Sunland," says Winegarner. "In fact, I was involved with the 30th VF-1 ever built. [To date, Haas has shipped more than 22,000 CNC machines worldwide.] Today, by incorporating CAD/CAM software, we have been able to make parabolic, aspheric and other complex shapes. The Haas machining centers have the memory space needed at these times."

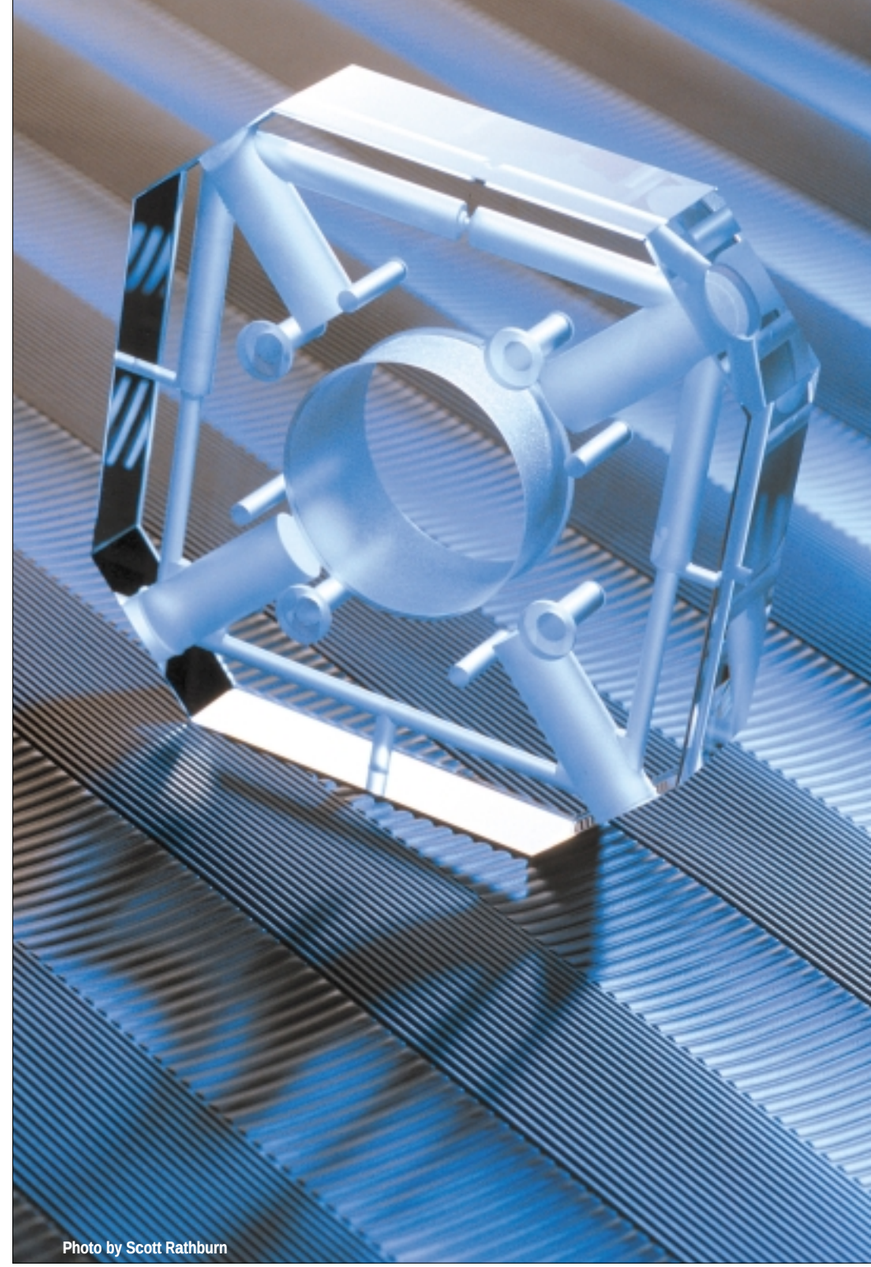


Photo by Scott Rathburn

Glass & Kilns

Building on its experience with redrawn parts, the company still employs a wide variety of different kilns. "We use them for a number of different processes, such as the annealing of glass or quartz," says Winegarner. "Some of these kilns will go up to about 3,000° Fahrenheit, which is the temperature you need to cure ceramic. In layman's terms, that is Pretty Damned Hot!"

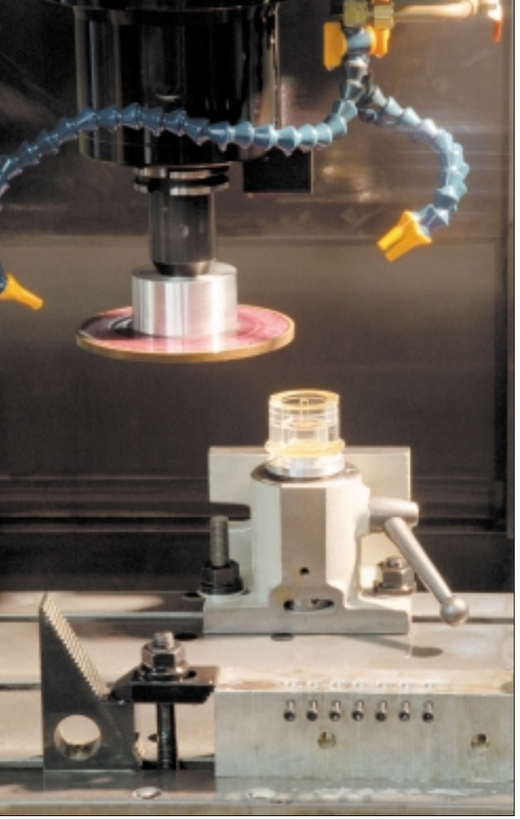
By redrawing, you can make any number of minute precision shapes. "We make some glass tubes or shapes that are so small that you can actually wrap them into a knot. That enters into the realm of fiber optics," he explains. "It is amazing the number of things that you can do with redraw. It's not uncommon to make prisms held within, say, thousandths; we can hold it within millionths. Whereas, if you hold it within five-thousandths, and then you shrink it down 25-to-1, you get a pretty accurate piece.

"Sometimes we'll get people at the shows who will ask us how small we can drill. We love to show them one of our redrawn rods with a twenty-thousandths hole," says Winegarner. "That generally gets them interested.

"We don't have a specific product that we build; we don't have a specific thing that we do. But we're a job shop that specializes in very diversified parts."

CNC Operations

"Literally every one of our departments has some form of CNC



operations," says Winegarner. "I couldn't get a CNC surface grinder for what I wanted, so I took a class that centered on taking existing equipment and modifying it, and it worked.

"For instance, we've taken this Haas SL-20 lathe with live tooling and turned it into a grinder. I had to do a lot of rearranging to get it to work, but it was a learning thing. One of the most important options we added to the machine, in addition to the live tooling, was the Haas auxiliary coolant filtration system. Grinding produces very fine particles, and the 25 micron filter is crucial to extending tool life and protecting the machine. In fact, we just had one tool on the turret fail after 1,300 hours of use – it was only rated for 200 hours. I think Haas could find itself selling these soon enough."

Start to Finish

"It's amazing how well it can hold tolerances," says Eric Bradford, CNC technician, referring to the Haas VF-4. "It gets us off to a good start, and if you get off to a good start, you are going to end up with a good finish. With the resolution that we have now, it gives us the ability to machine some of these more intricate patterns without breakouts as the two holes intersect. That has made our job much easier. You wouldn't think you would need such a large machine to do such small parts, but just having the rigidity there seems to help."

Winegarner agrees, "All around, our Haas CNCs have been very competitively priced, capable and have proven to be reliable machines. Not only would I recommend these machines to others, but I have even recommended them to my competitors."

Diamond Grinding

Because of the relative hardness of the materials Mindrum usually works with, most CNCs are fitted not with inserts, mills or drills, but with diamonds. "Everything is being ground with diamonds," says Winegarner. "Everything. It's the only material that will go through this stuff, and because of the challenging jobs we take on, we frequently have to design and build our own tools."

The fact that there are people on staff capable of performing this type of task is illustrative of the adaptability of the Mindrum workforce. "I would say that the number one strength Mindrum has, obviously, is its employees," says Winegarner. "Second is its diversity, and the fact that the employees are so well cross-trained. Everybody here does multiple tasks, or is trained to be able to do a number of different jobs. And most of the people we have here can do either all of their own programming or at least most of it."

When you are cutting ceramics, quartz or glass, the coolant/cutting fluids play an important part in making sure that the parts are kept cool and the residue is carried away to the filter. "Believe it or not, Mindrum uses straight oil," explains Winegarner. "You never have to dilute it. Going back to my years in metal machining, you would go into a shop of this size with this many cabineted machining centers on Monday, and the smell of the rotting bacteria between the layers of oil and water would make you want to run! You wouldn't want to work there, especially in the summertime!"

Stock & Stuff

"Unlike metals, where I can call my supplier and request an immediate shipment of aluminum right now, rapid order fulfillment is usually not the case with some of our so-called typical materials," explains Winegarner. "Consequently, we have to store a lot of our raw stock on site so we can meet our customers' needs in a timely fashion."

One of the more specialized materials Mindrum works is called Zerodur®. "It has a zero coefficient of expansion," notes Winegarner. "Most people react to that statement by saying, 'That can't be, everything has an expansion or contraction.' But this is a glass/ceramic composite that, from about a -50° to about +300°, has no measurable difference or change."

Now you might ask, why would this be so important?

"They use materials like this for items that must retain their designed shape through all types of temperature and pressure changes, such as the primary mirror replacements for telescopes," explains Winegarner. "It used to be that you'd have your mirror polished in town, then take it up the mountain about 4,000 feet and it would undergo some distortion. It wouldn't be as good, but it would be better than nothing.

"But now, with materials like Zerodur®, you can have your mirror polished in the Phoenix summer heat, and then bring it up to Big Bear where it is snowing, and still have no worry about deformations.

"There is also a big call for this absolute stability in the defense market. We did literally 100% of all HARM missile windows, and we had zero rejects.

"There is another material that is rarer to acquire than platinum. It is called T-19 Quartz. Only one place in the world – located in Germany – will make it, and they only make it when they want to! That's why the platinum is cheaper and easier. One time it took us nine months to get an order filled, and then at the last minute they shipped it to us by boat!" exclaims Winegarner.

Sticky Stuff

However, working materials such as glass or ceramics presents an interesting problem. "Back in my earlier days when I was a machinist and metalist, I would have loved to have known about blocking with wax," says Winegarner. "With metals, if you are having a problem with a part slipping in the vice you simply tighten the vice. If you try to do that with a glass part, it will shatter."

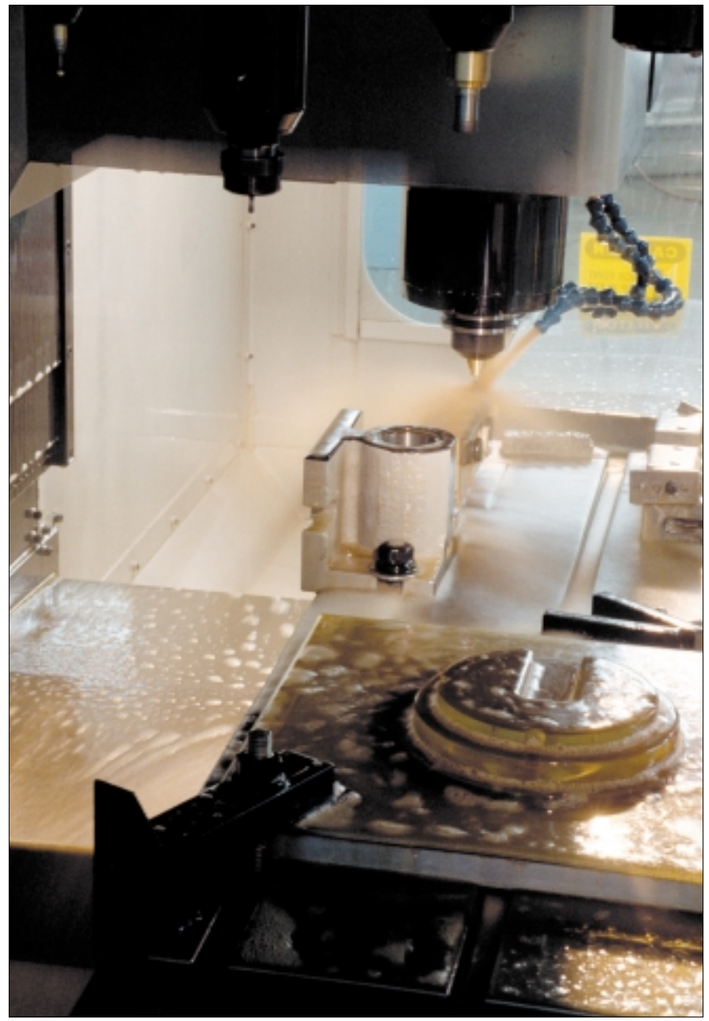
The solution is one that may surprise, but various types of wax are used to hold the parts in place. "Some of the waxes we use here are so strong that even Superman couldn't get them off. And that's how a lot of these workpieces are held onto turning spindles or machining fixtures. There is no way to grab onto them otherwise.

"Many of the pieces that we work with are so fragile that sometimes just trying to inspect these parts with verniers or micrometers will damage or scratch them," explains Winegarner. "So we have optical inspection devices that allow you to measure and check parts without having to touch them with any tactile devices. This machine is accurate to 50 millionths in the Z and 10 millionths on the X and Y. So you can indicate the points on the monitor and it will read out the distances."

Sub-Angstrom Shine

Because many of the parts manufactured by Mindrum Precision include comparatively miniature machining techniques, the technicians frequently make use of their atomic force microscope. "It reads in sub-angstrom," says Winegarner. "We can polish in sub-angstrom tolerances. What that equates to is this: 1-2 angstroms is the orbital path of the single electron of the hydrogen atom as it circles the nucleus."

Please see MINDRUM page 35



Machining glass, plastics or quartz presents a number of problems, with part-holding ability being one of the most important challenges. In many grinding applications, Mindrum Precision uses special "blocking" waxes to literally stick the workpiece to the fixture.

“Shadow An Engineer” is Practical Application

Story & Photos
Scott Rathburn

Most would agree that college is a world of its own. Fairly isolated from the concerns of “real” life, students go to class, they listen, they memorize, they move on to the next class. The cycle repeats itself daily. At regular intervals, they are tested to prove their mastery of each subject. After four years (give or take), the students venture out into the world to seek employment.

Often missing from the above equation, however, is the practical application of those learned concepts in a true work environment. This is particularly the case with regard to engineering.

Engineering is a highly competitive and demanding field. It is also traditionally dominated by men. Because of this, women engineering students often face additional challenges that their male counterparts might not.

California State University, Northridge (CSUN), injects a dose of reality into its engineering curriculum by taking students out of the classroom and into local industry to find out what working engineers really do. The program is called “Shadow an Engineer,” and it is co-sponsored by the Society of Women Engineers (SWE) and the Engineering Honor Society, Tau Beta Pi.

Haas Automation recently participated in the “Shadow an Engineer” program by hosting three members of the Society of Women Engineers for a day. CSUN students Mercedes Ibarra (Electrical Engineering sophomore), Faviola Lupercio (Mechanical Engineering senior) and Helen Avila (Mechanical Engineering junior), teamed up with Haas engineers John Ramadan (EE), Luman Burton (ME) and Andrew Harnett (ME) for a look at engineering in the “real world.”

The students began their visit with a tour of the Haas facility under the direction of Kurt Zierhut, director of electrical engineering, then each student split off to “shadow” their respective engineer.

We caught up with the three women later to get their impressions of their visit, and to discuss some of the difficulties faced by women in engineering today.

Mechanical engineer Andrew Harnett shows CSUN engineering student Helen Avila how to check for surface wear on a worm shaft.

CSUN students Helen Avila, Faviola Lupercio and Mercedes Ibarra, from left, visited Haas Automation for a look at what engineers do in the “Real World.”

CNC – What did you think of your time at Haas?

Mercedes *– It was interesting. I didn't really know exactly what electrical engineers did. So to see how they go through the process of designing something and then building it and testing it, was interesting.*

Helen *– I'm in mechanical engineering right now, but it's just my second year, so I don't really know what I definitely want to do. I was looking into manufacturing. I feel lucky to have seen the manufacturing side, and seen the importance of accuracy and tolerances. I learned a lot today, that's for sure.*

Faviola *– Well, as a student who had doubts about the major, I think it was really nice to see the breakdown of what mechanical engineers do. It helped me visualize the steps that a project goes through. It was really interesting, and it makes me appreciate my classes. I can start seeing what I would like to do in a company. This was very helpful for me.*

CNC – Mercedes, as the president of the CSUN chapter of the Society of Women Engineers, what can you tell me about the organization?

Mercedes *– Our emphasis is to get women involved in engineering. As we've seen, there aren't a lot of women working in the industry. We would like to encourage more women to do something with a science major, engineering major or computer science major. SWE lets them know that they don't just have to be teachers, there are other things they can do. Engineering is fun, and sometimes our little hands work a lot better than guys' hands.*

We also try to get the community involved with the school. It's mostly recruitment for women, letting them know that there is somebody in the organization they can talk to. There's a lot of difference between being a woman engineer and being a male engineer. Sometimes men don't take women very seriously, and that's a problem that we have. Sometimes you don't know who to talk to. The organization gives women the support.

CNC – What are some of the difficulties faced by women engineering students?

Faviola *– Men are competitive, and when they see a woman excelling, or even trying to take charge in a field that is predominantly men, they feel like they have to always be better than us. There were times in my freshman year when we would be studying, and I would know the answer, and they wouldn't listen to me. In a way, that kind of oppressed me a bit. I've been moving from study group to study group because of that. For a long period of time, the Society of Women Engineers was not available to me. It was reestablished last year. So it was really hard for me to find a group that I could relate to.*

I think we're getting better at it, and I think guys are starting to get better at it too, but it was hard for me at the beginning. My freshman year, there were six women, and I'm the only one left from my class. So it's really hard.

Helen *– Unlike Faviola, I've never experienced the oppression she mentioned from men. I haven't experienced that, yet. I know there are people who are like that, and I've observed students who are like that to the female professors, but now it's getting better, and I know it will get even way better than that.*

Mercedes *– I suppose the difference is that men always want to have power. They always want to be the leader, while women, we try to work together. Women have to learn how say, 'I want to do this; let me do this; I can do it myself.' And if we do it wrong? Oh well, that's how we learn. That's the opportunity of being an engineer, you're always learning. As long as you're willing to try, you'll always succeed.*

CNC – Are more women students coming into engineering?

Faviola *– Yes, and I'm really glad there are. We're getting fewer drops from the women who are entering these fields, and I think it's partly because there are a lot of us out there promoting the fact that we could do it. I think also that the high schools are doing a good job of letting their female students know that they can do whatever they want.*

Above, Faviola Lupercio looks on as mechanical engineer Luman Burton explains how sub-assemblies must be designed to work together as a part of the whole. Below, electrical engineer John Ramadan shows Mercedes Ibarra rhe inner workings of a Haas axis drive.

CNC – Where do you want to go from here? Has your visit to Haas changed where you want to go?

Faviola *– I think that it's clearing up doubts. It makes it easier, at least for me, to start picking the right paths. I've made a lot of mistakes in the past just because I didn't know, and I think this will definitely lead me in the right direction so that I can become a successful engineer.*

CNC – What would you say to other women about engineering?

Helen*– It's challenging, but it's worth it.*

Mercedes *– Don't ever think something can not be accomplished, you should always try it. Don't believe what other people tell you unless you've tried it yourself. Don't ever stop trying.*

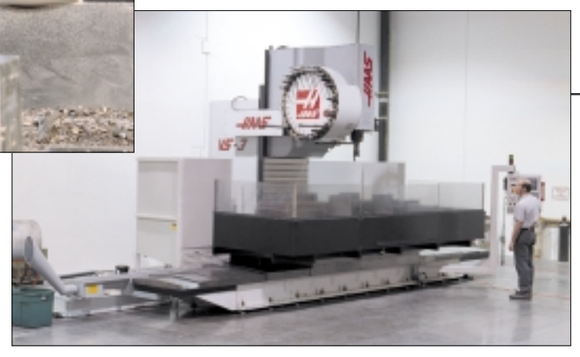
Faviola *– Don't ever think that you can't do something. You'll always have good days and you'll always have bad days, but as long as you keep to your goal, it doesn't matter how you get there, or how long it takes to get there. The important thing is that you get there.*

New Mini Mill on the Horizon >>

Good things often come in small packages, and the new Mini Mill under development at Haas Automation proves the point. This ultra-compact machine features travels of 16"x12"x10" (xyz), a ten pocket automatic tool changer and a footprint of just five feet by six feet. And, unlike other small machines, the Haas Mini Mill features a standard 40-taper spindle, so no special tooling is necessary.

VS-3 Reaches Production

The new Haas VS-3 extra-large travel VMC is now available for delivery. This 50-taper, geared-head machine features travels of 150"x150"x50", and the X axis is fully supported along its entire travel to handle extremely heavy loads with ease. A 30-hp vector drive spindle provides 450 ft-lb torque for serious metal removal, and a 28-tool side-mount tool changer keeps tools out of the work envelope for unobstructed machining.



Full C-Axis Option for SL-Series Lathes >>

This new lathe option provides high-precision bi-directional spindle motion that is fully interpolated with X and / or Z motion. Driven by a 5 hp servo motor through a 10:1 gear-reduction drive, the C axis yields high torque and rigidity for a variety of live-tooling second operations, such as flatting, slotting and grooving. The accurate 0.01 degree spindle positioning capability lends itself to intricate milling and drilling operations. The C axis offers speeds from 0.1 to 60 rpm, and it is engaged and disengaged via the part program.

ILMOR continued from page 25

Of course, most sanctioning bodies dictate a minimum weight allowed for cars competing in any specific class. But if you can minimize the weight of the required parts and get below the minimum, you can then add back weight into areas that will improve the handling of the car.

Shop Talk

Machine Shop manager Robert Mills says that this ability to precisely machine the many parts that make up a modern racing engine falls on the accuracy of the milling machines and the expertise of his crew.

"We service more than 300 engines per racing season," says Mills. "They are usually brought in for service based on the mileage on the components, and with CART's formula of everything being leased (because of the immense amount of engineering and expense in a modern racing engine), the team engines are maintained out of service centers like us. So we do more than 300 rebuilds during the average year. That adds up to a lot of machining."

However, whenever you remove mass from a high-performance component, you also stand the chance of removing a significant amount of reliability and resistance to fatigue. Enter the Haas CNC machining centers and the talented machinists who turn the designers' blueprints into the parts that attain that tenuous balance between weight and reliability.

"We machine everything from tiny little 2-3 mm pieces all of the way up to engine blocks and cylinder heads," explains Mills. "The Haas CNC machines are incredibly versatile. I look forward to getting to work every day to use them.

"The repeatability, once it's warm and settled in for the day, is unbelievable! We run an M-99 loop in the morning on a certain cycle to warm it up while we're getting ready, but the machine just comes in so quick, and once it's there, it's there all day."

While machinist Neil Tebbutt is usually at the Haas HL-4 lathe machining engine components, he frequently finds himself running either the Haas VF-4 vertical or the HS-1R horizontal. "I'm primarily on the lathe, but I also work on the other two machines."

He is able to do this versatile dancing act not only because he is a competent machinist, but because of design of the Haas controls. They are virtually identical on the vertical and horizontal machining centers, and only slightly different on the turning center to address the different axes controlled.

Program Loads?

"We load most of our files with our RS-232 cable, and we also do off-line programming," says Mills. "We can also load via wire or floppy, that's very versatile."

Another versatile feature is Quick Code. "That's a very valuable tool," says Mills. "Even when you have a CAM system, you tend to use Quick Code to do your editing on the console, and then you load that back to your computer. We also run the program in graphics, but there's always some little editing you'll want to do afterwards, and Quick Code is such a useful tool for all of that. It's a very valuable thing to have. I couldn't recommend it higher to anybody."

Dyno Detectives

"All of the engines built here make the long trip down the hallway to one of our two identical dyno rooms," explains Gurss. "Before they leave the building, each unit has to meet certain performance parameters to within one percent of the other engines of that specification. So, again, we keep coming back to the precision and the tolerances that have to be met along with the reliability." And the dyno doesn't lie. If something is a bit askew, the dyno techs will see it.

"Our dyno complex consists of three main rooms," he continues, "the two active units in use now, and a room which will eventually house our transient dyno. It will be a little bigger than the other two and will run the engine through a full gearbox, delivering an almost complete replication of any specific racing condition on any of the tracks we run."

The dyno cells are also used for durability testing. "It might sound strange," states Gurss, "but we might want to really push or even damage a series of parts. That can all be done here. Although some of our drivers have been known to find even more new and inventive ways to accomplish the same thing!"

Ilmor Engineering Inc.
734-456-3600

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ang•strom: a unit of length, equal to one tenth of a millimicron, or one ten millionth of a millimeter, primarily used to express electromagnetic wavelengths. Also used as angstrom unit.

"We can do surface roughness in less than an angstrom. One millionth of an inch is approximately 250 angstroms. Now we're getting into less than an angstrom. A lot of the stuff has been done with a Haas."

Med to Mod Applications

Mindrum also machines a hip replacement inspection device (a glass-like rod with a rounded socket end) used by surgeons to check the recipient hip socket for proper fitment and condition. "The doctors don't like to cut you open twice," says Winegarner, "so they will insert this device into the exposed hip socket to see what size prosthesis is needed, and to check where the new ball is going to rub in the socket. This allows for a more perfect match."

As a job shop, Mindrum is occasionally asked to modify existing products to fit new needs. "These projector lamp housings can be modified at a cost cheaper than what it would have cost the customer to make the required new tooling," says Winegarner. "They can buy the existing housing for 29¢, or whatever, then we modify it to new specs and still give it to them at a competitive price."

From Vino to Viability

What this all comes down to is that Mindrum Precision is a company with staying power. Starting in 1956, they have grown in size and built a reputation as a company willing to stretch their existing limitations to meet a customer's needs. Now, as the next generation takes the helm, even more daring technologies are being developed and optimized to satisfy newly discovered needs.

"We were the first building out here back when there was probably one stoplight in town," remembers Paul Mindrum. "There were 17 operating wineries, with wine being the major industry in Rancho Cucamonga. Gradually, the vines have been replaced with concrete and asphalt. Of course, other things have changed, too. When we bought this property, it was sold per acre. Now it is sold per square foot, and the area lives on the advancement and distribution of technology!"

Mindrum Precision Incorporated
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RACE REPORT continued from page 5

their Toyota-powered CART entries toward the front with Scott Pruett putting his Panasonic Reynard on the pole for the Fontana race.

But Pruett will move over to the NASCAR Winston Cup cars for 2000, driving the new Cal Wells entry. This opens up the Panasonic ride for Cristiano da Matta, who placed 2nd in the Rookie of the Year competition (Juan Montoya, overall series points winner was the only rookie to outperform Christiano). Pruett, in a symbolic gesture, turned over his steering wheel at the PPI open house a few nights before the last race.

Atlantic Series

However, the big news at PPI is the Kool/Toyota Atlantic series win. Anthony Lassaro (#25) and Andrew Bordin left the competition behind and claimed the series championship ahead of schedule at Laguna Seca Raceway, with Lassaro and Bordin crossing the line in 1st and 3rd, respectively.

SCORE Off-Road

In related racing efforts – but in a much more gritty way – Ivan "Ironman" Stewart whomped his way to a third-place finish at the Baja 1000 in the latest version of his Baja-dominating, V-8 powered Toyota Tundra off-road pickup.

Stewart probably would have finished higher, but it seems some of the locals decided to roll some boulders into a wash about 20-minutes downtrack from the starting line – just to see what would happen! The first truck made it through, but the second truck jammed between the boulders, causing a 20-minute blockage. Ivan was truck number three in that parking lot. While he finished only 5 minutes behind the class winner, he was heard to lament, "Well I guess I can't win them all!"

C&C Motorsports

Consistency is the name of the game in both successful machining and racing. Troy Cline grabbed third place in the overall SCRA points race and won the MSRA Series.

Dividing their driving chores among various race vehicles – SCRA Sprint Car circuit, NASCAR Winston West sedan racing and the SCORE off-road racing championships, where they placed second – Troy and partner Joe Custer are running hard, keeping the Haas name out in front of the racing privateers and parts manufacturers of the Southwestern states.

Haas Offshore Racing

Bill Bowen, General Manager of Haas Factory Outlet, Torrance, captained his Unlimited Warlock 32-foot E-Class power boat to yet another victory at the Ventura Offshore Grand Prix. This win pushed the rookie pilot over the top in the Pacific Offshore Power Boat Racing Series points race and earned the Haas Offshore Racing team its first championship. Notable is the fact that it did so during its first year of competition.

Driving with High-Speed Machining

text and photos by Scott Rathburn

What is high-speed machining?

Well, it depends who you ask. To some, it means high spindle speeds. Others think it means high feedrates. Still others define high-speed machining as a high "block per second" rate. The most important feature for high-speed machining, however, is arguably "block look-ahead." But what exactly is look-ahead? Maybe a few analogies will help.

Look-ahead is like driving a familiar twisty road in a high-performance sports car. You know the road like the back of your hand. Every corner is mapped out in your head, and you know exactly what is coming up next and when. You know how fast you can go at any point, where to brake and where to accelerate. You can get from point A to point B quickly and smoothly.

Not having look-ahead, however, is like driving that same twisty road for the very first time. You have no idea what is ahead of you. You don't know where the corners are, how fast you can go, where to brake or where to accelerate. If you want to get from point A to point B smoothly, you have to drive very slowly, allowing enough time to accurately negotiate each corner as it comes up. If you try to drive quickly, you end up heading into corners too fast, having to brake hard to get through. Because you don't know what is ahead, you dive into corners too soon, or run wide and have to correct. To make up for lost time, you accelerate hard on the straights, only to have to brake hard again for the next corner. The result is a very inaccurate and jerky ride.

Complex parts are much like a twisty road. The goal of high-speed machining is to cut complex parts accurately, smoothly and quickly. With a full 80 blocks of look-ahead, the Haas High-Speed Machining option turns even the most complex toolpath into a familiar road, making the journey from point A to point B a smooth and fast ride.

Machining Times >>
***normal machining*: 78 minutes**
***with High-Speed Machining*: 67 minutes**

The total cycle time for this part when machined without HSM is 78 minutes, as compared to 67 minutes with the HSM option. That's a time savings of 11 minutes per part. Assuming seven parts are machined per day, the total time savings per week using HSM will equal 6.42 hours. This translates into a weekly monetary savings of $481.50. At that rate, the HSM option will pay for itself in just 12.45 weeks.

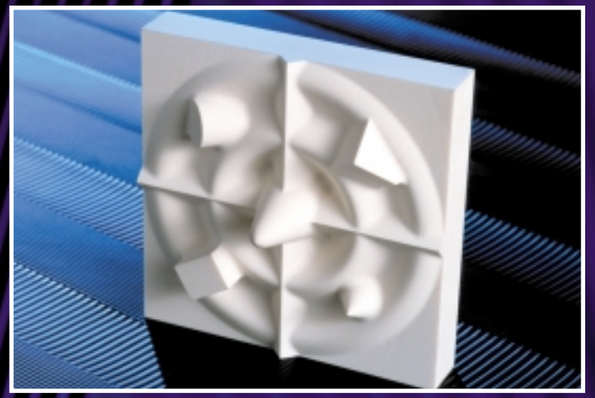
Actual time savings, however, depend upon the type of machining being done. We've all seen the disclaimers stating: "Actual Results May Vary." Well, when it comes to high-speed machining, this is very much the case. There is no set formula to determine how much time savings any particular shop will realize.

To help you determine what to expect, we performed a head-to-head comparison of cycle times for three different types of parts when machined with and without the Haas High-Speed Machining option. Then we calculated the return-on-investment time for the option based on the savings realized on each application. For simplicity, we based our calculations on a standard eight-hour work day, a five-day work week and an hourly shop rate of $75.00. We used the suggested retail price of $5,995 for the HSM option, and each comparison was based on the part being machined under the exact same conditions, with the same tooling and to a comparable surface finish and accuracy.

Machining Times >>
***normal machining*: 131 minutes**
***with High-Speed Machining*: 78 minutes**

The total cycle time for this part when machined without HSM is 131 minutes, as compared to 78 minutes with the HSM option. With this type of part, the advantages of HSM are even greater, with a time savings of 53 minutes. We'll assume that six parts can be machined per day, which leads to a weekly time savings of 26.5 hours. At $75 per hour, that's a savings of $1987.50 per week, which will pay for the HSM option in a mere three weeks!

Machining Times >>
***normal machining*: 97 minutes**
***with High-Speed Machining*: 42 minutes**



This is the kind of work that really benefits from the High-Speed Machining option. The total cycle time for this part without HSM was 97 minutes, as compared to 42 minutes using HSM. That's a time savings of an incredible 55 minutes per part! With that kind of cycle time, a total of 11 parts could conceivably be machined per day. But let's give the operator time off for good behavior and keep it to ten parts per day. By the end of the week, the HSM option will have saved 45.833 hours of cycle time, which amounts to an extra $3437.50 on the plus side of the weekly balance sheet. With that kind of savings, the High-Speed Machining option will pay for itself in just 1.74 weeks.

As you can see, the results of the Haas High-Speed Machining option are variable: They depend greatly upon the type of work being done. But even with relatively small time savings per part, the return on investment is short, making it well worth the price of admission. We think the results speak for themselves.

DESIGN ADVANCEMENTS FOR THE YEAR 2000.

HIGH SPEED MACHINING

Using a motion algorithm called "acceleration before interpolation," combined with full look-ahead of up to 80 blocks, the new High-Speed Machining option provides very high feedrates – up to 500 inches per minute – without risk of distortion to the programmed path.

The HSM option provides a powerful tool for reducing cycle times and improving accuracy for many applications, including tool & die, molds, patterns, electrodes, aircraft components and other 3-, 4- and 5-axis parts.

Thorough testing shows that cycle times for even the most basic parts are reduced considerably. And, as part complexity increases, the HSM option's time savings benefits will make you even bigger profits.

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