CNC MACHINING

Volume 8 Number 31 FALL 2004

“Please remove all tags before giving this toy to a child.”

Blasphemy! *Thou shalt not remove thy tags! Thou shalt honor and cherish thy tags, care for them lovingly and protect them faithfully. Removing thy tags shalt reduce thy value and make thyself less than before.*

But that’s what it says. Right there on the back of the tag. In small black type. Really.

And that’s the first thing I do when I buy a stuffed animal – take off the tags. In my view, stuffed animals are supposed to be cuddly little things that a child can hug and hold and sleep with – without being poked and prodded by cardboard tags with sharp corners, and little plastic fasteners with pointy ends. Of course, I don’t buy stuffed animals for any other reason than to give them to loved ones. I have no interest in collecting them, or making sure I have every one of a particular set.

Cut the tag off, say, a Beanie Baby® in front of a serious collector, though, and you’re liable to get shot, or at the very least, be subjected to a whimpering groan of anguish. After all, one person’s stuffed animal is another person’s obsession.

And one person’s obsession is another person’s business opportunity.

For our cover story this issue we visited a shop in Massachusetts that specializes in tooling for the thermoforming industry. J&R Plastics is the creation of Joe and Randy Amarello, two brothers who are so in tune with each other and their business that they routinely finish each other’s sentences. Engineers by profession, they spent years working for other thermoforming companies – learning the ins and outs, the rights and wrongs, the do’s and don’ts – before deciding to start their own business. And while it’s their combined knowledge and experience that have made them successful, it was the world’s fascination with understuffed little beanbag animals that provided the resources for them to go out on their own.

From the east coast we ventured a couple inches to the left and down a bit (on the map, that is) to a company in Milan, Ohio, that manufactures anthropomorphic test devices (ATDs). Denton ATD is a world leader in the design, development and manufacture of . . . crash test dummies. The company’s products are used by major manufacturers around the world to make cars, motorcycles, child seats and even thrill rides safer for the human body. We show you just what goes into making these important devices, and prove they’re not so “dumb” after all.

On the international front comes a story out of South Africa about a Johannesburg engineering company that produces jet engines for radio-controlled model aircraft. Andre Baird started the company, he says, as “an outlet for his pent-up desire to make something.” And make something he did. Baird Micro Turbines is one of only a handful of companies that manufacture such diminutive gas turbines. Although the RC market is small, and doesn’t offer much promise of large-scale growth, Baird is courting several multi-national companies that have “real-life”

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applications for his mini turbines. What once was a hobby may soon become a budding aerospace company.

Spinning at upwards of 120,000 rpm, turbine engines necessarily require components with a high degree of accuracy. Maintaining that accuracy requires precise control – of designs, of processes and, above all, of the movements of the machine tools. For an up-close look at machine tool motion control, we contacted our friends at Steinmeyer – a major manufacture of precision ballscrews, lead screws and differential roller screws – for some insight. Ballscrews, guide ways, controllers, friction, stick-slip, backlash, rigidity, single nut, double nut, high pitch, low pitch . . . it's all here in this informative piece.

For our education story this issue we visited Cal State University at Northridge for a look at how, in the words of Professor Stewart Prince, they "take students who have no machining experience and make an entire Formula car, where 90% of the parts are made on Haas CNC machines." Apparently they're doing something right, because CSUN's 2004 team finished in the top 10% in the Formula SAE Collegiate Design Series competition put on by the Society of Automotive Engineers.

Also inside, you'll find a report from IMTS 2004, the Race Report, information on new products, valuable tips from the Answer Man, and much more.

It's another action-packed issue. So sit back, relax and enjoy!

ON THE COVER

The ultimate protection racket: Tag protectors for collectible toys. Heart-shaped clamshells of thermoformed plastic keep the tags of these collectibles pristine.

Cover Photo: Scott Rathburn

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Election Talking Points

For those of you who might not be aware, this is a U.S. Presidential election year. The conventions are over, and the bashing is running at full speed. I am writing about this because, come November, U.S. citizens will elect "the leader of the free world" for the next 4 years. No matter what your politics are, this season must be as distressing to you as it is to me.

In trying to make an informed decision, we used to be able to read the papers and / or watch the news on television to find out where the candidates stood on the majority of the issues. Unfortunately, it seems to me that, in today's media world it is impossible to find non-partisanship where it ought to be. Forget the thousands of TV commercials we are being inundated with. We expect them to be unabashed pieces, skillfully crafted to sway our opinion for or against an issue or candidate. They *are* marketing pieces, after all.

What I am struggling with is all of the news organizations that follow up the candidate's speeches with talking heads who have to dissect and opine on almost every word. They usually have people from both political parties, each trying to further sway our opinions. Do we really need this dissection? Do the news organizations feel we are so ignorant that we cannot listen to a speech and understand it, or glean the facts from fiction ourselves? Personally, I find this pandering insulting.

Photo courtesy Corbis Images

One would think the print media would be above this fray, as they are not trying to compete with dozens of other news channels to grab your viewership and sell their sponsors' products. But I am finding more and more that even our newspapers are partisan in their reporting, making it difficult to fairly gauge what is fact and what is opinion. Come to think of it, it is the news media who anointed the President of the U.S.A. as the "leader of the free world" in the first place.

If you are anything like me, you are probably fed up with all the politics long before election day. You struggle with voting along party lines, because you agree with some areas of both parties, and disagree with some philosophies of both parties. So, where does that leave you? Voting for the person you hate the least? It seems a shame – doesn't it? – that elections have come to this.

I guess I will continue searching for the unbiased facts in the issues that are important to me. I will keep my head down, catch up on my reading of both non-fiction and fiction books to avoid the mind numbing deluge of politicking, and, come November, vote based on the candidates who make the most sense on the most number of issues. But vote, I will.

I suppose I should be happy that I have an opportunity to be a part of electing "the leader of the free world," as compared to billions of the world's other inhabitants who have no say. The leaders of the world's other free countries must feel slighted, as they work hard to improve the lives of their citizens. Maybe it is not our leaders who alienate our friends, but our media.

If we have ventured into partisanship in any way in this issue of our magazine, please accept my apology. It was accidental.

Serving the Industry for 100 Years

The Haas distributor in western Canada, Thomas Skinner & Son Ltd, celebrated its 100th birthday this year. Open-house centennial celebrations were held at Haas Factory Outlets in Vancouver (B.C.), Calgary and Edmonton (Alberta), and Winnipeg (Manitoba). In addition to live machine tool demos, Alberta Regional Sales Manager Dave Fawcett noted that "People seemed quite interested in our history" as well.

Thomas Skinner was a Scottish immigrant, a professional marine engineer who had worked on many a sailing vessel. When T. Skinner Company opened its doors a century ago, it was as a distributor of equipment and supplies for the maintenance of ships and shipyards. In 1947, 10 years after Mr. Skinner's death at age 81, his brother sold the company to Ideal Iron Works, a machine shop. Ideal sold the business to Max Krainer three years later. His son Paul, the current owner and president, has been with the company for 25 years. The staff members all agree that "We look forward to serving the industrial metalworking industry in our next century."

The Yorkshire Building (c. 1936 in this photo), on Seymour Street in Vancouver, was home to the T. Skinner Company in earlier days.

Haas Helps Student Win Title

Tyler Pack from Mansfield (Ohio) Comprehensive High School won the precision machining technology competition at the SkillsUSA national championships last June in Kansas City. Pack earned the gold medal by demonstrating his skills and knowledge in manual machining, manual turning and CNC programming during the competition.

The event was organized by SkillsUSA, a national organization serving more than 264,000 high school and college students who are enrolled in training programs in technical, skilled and service occupations. The national championships are a showcase for the best career and technical students in the nation, who compete in one of 77 different events ranging from cabinetmaking to machining.

It was Pack's second trip to the national championships. As a junior, he won the Ohio state title in 2003, and then finished fourth in the finals. This experience helped him win the gold medal as a senior. Pack won't be eligible to win a second title, but can compete next year at the college level. He was this year's valedictorian and will be attending Ohio State University in Columbus, where he will major in engineering.

"We are really proud of Tyler. He's just an awesome kid," said Marvin Harlan, one of Pack's instructors and also his coach in Kansas City. "He was really happy to win because he accomplished one of his goals. Yet when he won he said, 'We did it,' because he recognized that it just wasn't himself winning, but the entire program winning."

The Precision Technology / CNC Technology program at Mansfield Comprehensive High School has a Haas VF-2 VMC and an SL-10 lathe for students to learn about CNC machining. "Our Haas machines are powerful teaching tools, and the kids love to use them," said Harlan. "Our students have won the state competition four years in a row. A big part of our success is because of Jim Thompson, who teaches the juniors and does a tremendous job. Without him, we wouldn't be where we are today, " shared Harlan.

Harlan will miss working with such a gifted student as Pack, but he is confident that the program will continue to shine in state and national competitions.

For a complete 2004 - 05 Trade Show Calendar, head over to http://www.haascnc.com/news/trade_show.asp

Leffler Leads Team to Victory Lane

It's been a long time coming, but the Haas CNC Racing team finally celebrated its first NASCAR victory when Jason Leffler won the Federated Auto Parts 300 in June at Nashville Superspeedway. It was the first win on either the Busch Series or Nextel Cup Series for the three-year-old race team. Leffler's previous best finish in the No. 00 Haas Automation Chevy was fourth place in the CarQuest 300 in May.

"Wow!" Leffler exclaimed after the win. "What else can I say? We've been working all year for this day, and now that it has actually happened, I'm speechless. This team has given me their best every week, and we knew that we'd get what was due to us soon enough."

Winning often depends on being in the right place at the right time, and that surely was the case for Leffler. His first Busch Series win came after race leader Kyle Busch ran out of gas with four laps remaining.

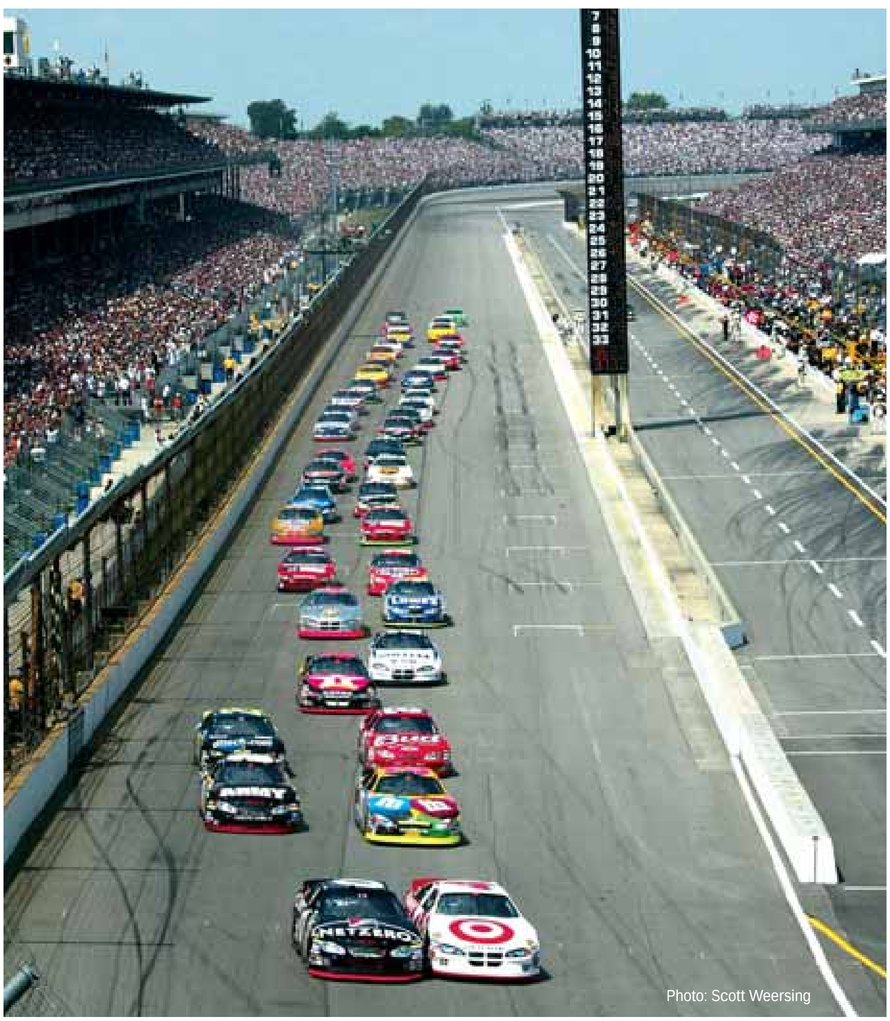


Photo: Scott Weersing

"It's not the way I wanted to win," said Leffler, "but I knew I couldn't catch the number five car (Busch)."

Leffler started the race in the second position, but by lap 6 he was at the top of the leader board, where he enjoyed a comfortable margin. When the time came for scheduled pit stops on lap 60, Leffler complained only of tight conditions from the center off. He entered the pits in first position and left in third.

With rain in the forecast, Leffler knew he had to get back to the front before the halfway point of the race, in case it ended early. *(In NASCAR, if a race is stopped by rain after the halfway point, the race is ended. If the race is stopped by rain before the halfway point, it is delayed and finished after the rain stops.)* But Mother Nature couldn't wait; the race was red flagged when rain hit just 17 laps shy of the halfway point.

After a three-hour rain delay, Leffler was able to regain the second position on lap 166. He was set to finish there, until Kyle Busch ran out of gas and spun out in the wet infield grass, leaving Leffler in the top spot. The race ended under the yellow caution flag and Leffler coasted to his first victory.

"At the end, I was sure I was going to finish second again," commented Leffler. "Our crew chief, Bootie Barker, was on the radio telling me to slow down. I don't think I've ever been told to slow down on a racetrack before. The next thing I knew, Kyle was spinning on the front stretch and I was in the lead under a caution/checkered finish. I hate it for Kyle, but I'll take my first win no matter how it comes. This might be our first win, but it definitely isn't our last."

A string of top-5 finishes after the win have kept the team near the top, with Leffler sitting in third place in the point standings after 23 races. Leffler's best run came in July when he finished third in three consecutives races – at New Hampshire International Speedway, Pikes Peak and Indianapolis. The strong finishes have definitely been a team effort, as the pit crew is leading the McDonald's Drive-Thru Pit Championship, a competition which scores pit crews on pit times, qualifying and finishes.

Nextel Cup

While the Haas Busch Series team moved up in the standings, the No. 0 Nextel Cup team continued to move down, with numerous finishes outside the top 30 – the team finished 31st, 39th and 37th in three consecutive races. Bad luck and misfortune continue to plague the No. 0 NetZero Chevy, despite some great qualifying runs. Ward Burton earned the team's highest-ever starting position when he qualified second for the Brickyard 400 at Indianapolis Motor Speedway. But soon into the race, the car had problems with the alternator, requiring an unscheduled pit stop. Burton fell back to 39th place when a multi-car accident knocked him out of the race.

"I saw the No. 10 car at the very last moment," said Burton following the accident. "I thought the No. 15 had just pulled out and we were going to get a run. There was just too much momentum going, and there was a wreck in front of me. It was a bad deal for us. We had an alternator cut out on me to begin with, and that's how we got there in the back, but we were starting to get the car back in shape. It was just a bad day."

Hoping to change their luck, the No. 0 team switched crew chiefs in July, with shop foreman Bill Ingle replacing Tony Furr. "Essentially, we just swapped their positions," said Joe Custer, general manager of Haas CNC Racing. "We originally asked Tony to join our team last year as shop foreman, and about halfway through the season we had the need to fill the crew chief role. Both Tony and Bill are more than capable of handling both of these roles, and we're hoping that having Bill at the track might help us achieve the results we think we're capable of. Obviously, this team is not performing as well as we would like, and we are very lucky to have the kind of depth we have here at Haas CNC Racing."

The change atop the pit box, however, failed to alter the misfortune of the team. In the New Hampshire 300 – the first race with Ingle at the helm – the No. 0 car qualified 12th, and ended the race in 29th place. The team's best finishes over the summer were 17th place in the Pocono 500 and 19th in the Tropicana 400 at Chicagoland Speedway. Burton is in 28th place in the Nextel Cup Series standings after 23 races.

Hendrick Motorsports

Hendrick Motorsports continues to have another great year in its 20th season, with both Jeff Gordon and Jimmie Johnson winning races. Consistent top-5 finishes have propelled Gordon and Johnson to first and second place in the standings, and make them the favorites to win the Nextel Cup Championship. It will all come down to the last 10 races of the year, as NASCAR uses a new points system that determines the champion based on finishes in the final 10 races of the season. The Chase for the Nextel Cup began at New Hampshire International Speedway on September 19.

While the number four usually isn't terribly significant in racing – obviously, number one carries more weight – this summer, four was a magic number for Jeff Gordon. When he won the Dodge/Save Mart 350 at Infineon Speedway in June, it was his fourth Cup victory on the challenging road course. When he took the number one spot in the Pepsi 400 under the lights at Daytona International Speedway, it was his fourth win of the 2004 season. And when he won the Brickyard 400 at Indianapolis Motor Speedway in August, not only was it his fourth Brickyard triumph, but it made him the fourth driver in history to amass four wins on the 2.5-mile oval. With his Brickyard win, the 34-year-old Gordon joins racing legends A.J. Foyt, Al Unser and Rick Mears as four-time winners at Indy.

Gordon also won four consecutive poles, has started first in five different races this year, and has five wins after 23 of 36 races.

When Gordon wasn't winning a race, it seemed teammate Jimmie Johnson was. Thus far, with 23 races down, Johnson has four wins to his name, including both races at Pocono Raceway over the summer. Johnson's first victory on the Pennsylvania tri-oval came in June, when he raced away from the rest of the field to win the Pocono 500. Then in August, Johnson completed the sweep by leading 124 of the 200 laps around the 2.5-mile speedway, including the final 38."We were just fast all the way through," Johnson said after the Pennsylvania 500. "The pit stops were fast, the race car was fast, the driver was fast . . ." Johnson, who also scored second-place finishes in the Pepsi 400 and the Tropicana 400, moved to the top of the Nextel Cup standings in June and remained there for nine consecutive weeks, until Gordon took over in August.

Brian Vickers continues to have a productive rookie campaign, with three top-10 finishes and one pole. Vickers

Please see RACE REPORT on page 36

Photo courtesy: Corbis Images

What a Dummy!

Story & Photos by Scott Weersing

There's nothing like slamming into a concrete wall at 35 miles per hour. Or getting hit from the side with enough force to rip the limbs from your body. It's such a thrill. The crunching metal, the breaking glass, the exploding airbags – it all contributes to the experience.

But such adventure is not for everyone. It takes a special individual: One with an acute awareness of the surroundings . . . who can sense every force, every action, every reaction as their body is tossed about like a rag doll . . . who can record every facet of the experience in complete, graphic detail . . . and recount each detail with extreme precision and accuracy.

Such individuals aren't born, they're made . . . or, more accurately, they're manufactured.

Denton ATD is a company that manufactures such "individuals" for use around the world. Located just off a country road in Milan, Ohio, Denton ATD is a world leader in the design, development and manufacture of anthropomorphic test devices (ATDs) – that's crash test dummies to you and me.

Just about every automaker you can think of uses dummies built by Denton. Ford, Honda, Chrysler, Porsche, Volkswagen – the company's customer list reads like a Who's Who in the automotive world. The Insurance Institute for Highway Safety and the National Highway Traffic Safety Administration (NHTSA) also use Denton products.

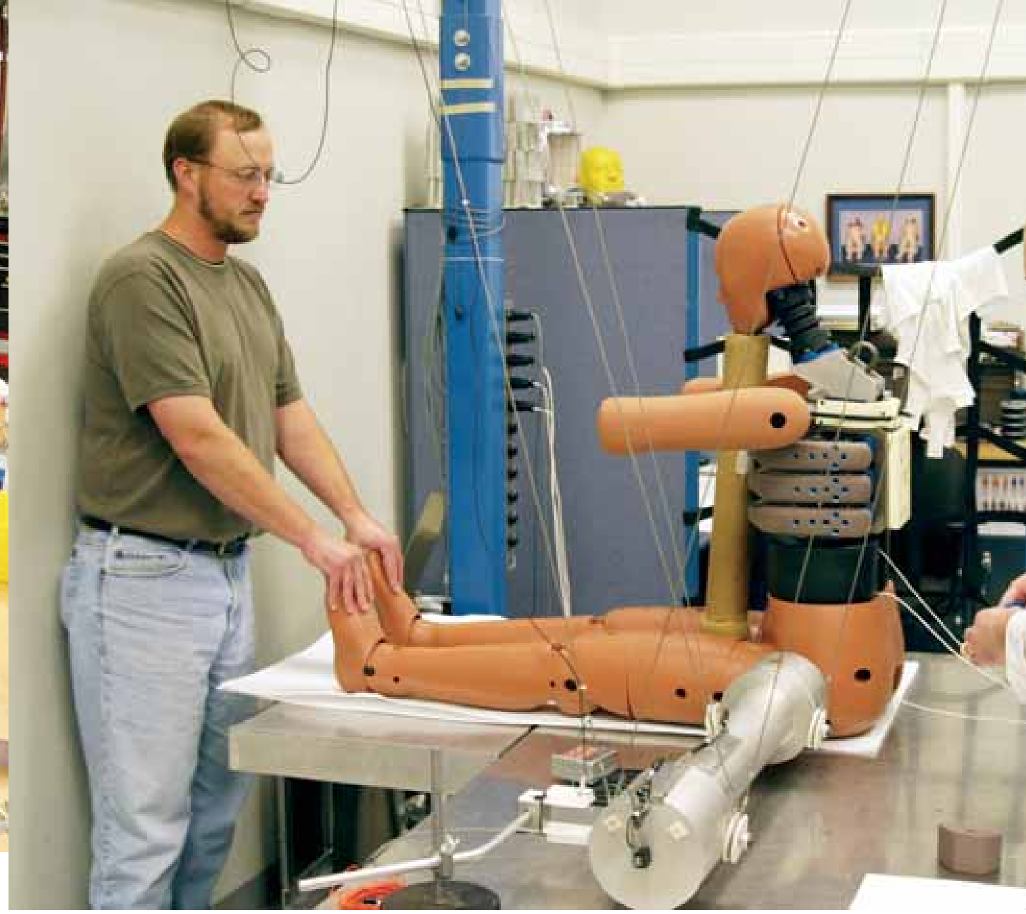
The NHTSA operates the National Crash Analysis Center in Ashburn, Virginia, where new cars are tested and then awarded safety ratings. Automakers routinely brag when one of their vehicles receives the coveted five-star rating from the NHTSA's New Car Assessment Program. But the unsung heroes of the program are the crash test dummies, which are crucial to determining those ratings.

The mission of a crash test dummy is simple: to simulate how a human body responds during a crash. To do this, a crash test dummy must, understandably, represent a human body very closely. So they have skeletons and joints and limbs, and they're constructed with simulated muscles and soft cartilage. Unlike humans, however, who don't fare too well during repeated vehicular collisions, anthropomorphic test devices are built to survive – crash after crash.

That longevity comes with a steep price, however, as a full-size ATD equipped with sensors can cost more than $130,000. But Denton's customers don't have much problem with the cost: There is no price too high for safety, because safety sells cars.

Not all ATDs spend their lives going from one car crash to another, though; some choose other careers.

"Crash test dummies aren't just used in car testing," says Rick Burkholder, machining center supervisor at Denton. "They're used to test roller coasters, such as the Top Thrill Dragster here in Ohio. They're being used by motorcycle manufacturers to develop an air bag that activates when a motorcycle hits a car. We've also built kid-size dummies to test school buses and child seats. Anything a human can get into, we're working on."



It's an exciting life for a crash test dummy, but that life gets its start in a very hot place – an oven, in fact. It begins with liquid polyvinyl being poured into a mold for a body part, such as an arm, leg or head. The mold is then placed in an oven to bake. "They're all baked at 375 to 400 degrees, just like a cake," says Burkholder. "We use a temperature probe, and when the mold reaches a certain temperature, we know it has formed a skin. We dump out the excess vinyl – which is recovered for use on other things – and then the mold goes back in the oven to cure."

Cured body parts are taken out of the molds and set on racks to cool. Once they reach room temperature, some of the parts are filled with expandable foam to give them better resiliency and durability during tests. Employees called trimmers then cut off the flash and remove any imperfections from the vinyl. "This part is all hand work, like you would do in a craft store," notes Burkholder. "So we have a lot of people working here that are very skilled with their hands." After trimming, the skin is rubbed with sandpaper, and then heated to its melting point to smooth out any remaining irregularities.

The different body parts are then attached to the crash test dummy's skeleton. The skeleton is made of different types of metal and plastic, depending on how much strain will be on that particular body part.

"We machine a variety of materials, from polyurethane all the way through to titanium," says Burkholder. "And now we're even getting into tungsten. For example, the spine is made of steel and urethane. In the dummy there are also cast aluminum pieces, urethane pieces and then Delrin pieces, which simulate the ligaments and tendons, and give a little movement in the shoulder joints."

Once assembled, each crash test dummy must be calibrated and tested. "The crash test dummy gets hit with a probe, and then we tweak the sensors until we get a reading for that part of the dummy," says Burkholder. "Then it gets shipped to our customers."

Burkholder is one of 16 machinists at Denton who work in two shifts to produce parts for the ATDs. To meet the auto industry's growing demand for crash test dummies, the company purchased its first CNC machine (a Haas VF-0) in 1994. Today, Denton has four Haas vertical machining centers – the original VF-0, two VF-1s and a VF-3.

"I enjoy my job," relates Burkholder. "It's fun. We make a product that no one else is making, and I get to put my hands on materials that other machinists don't have a clue about. How many people get to work with ninety-five percent tungsten? Or titanium? Or plastics?" he asks.

Denton started using titanium in its side-impact dummies because other materials would break during testing. "The nodding joint on the dummy is made of 7075 aluminum," says Burkholder, "and it was breaking off. So the engineering department came up with a process where we took that same part and melded it with a new titanium part. Now we don't have breakage."

Parts for the skeletons are usually manufactured in lots of 5 or 10, but more common components are manufactured in lots of 50. Denton makes so many different types and sizes of crash test dummies that they use a special database to hold all the programs, which are then drip fed to the Haas VMCs. "We have a database of about sixty-three hundred programs," says Burkholder. "Once the program is loaded in the machine, all the operator has to do is follow the setup information, load the parts and tools, touch them off and let it roll."

The machine shop is also responsible for making molds – out of 6160 aluminum – for the different body parts. "We had always sent the molds out," says Burkholder, "but since we have the Haas machines, there is no reason to. We're doing molds for new parts that are being revised, and we're replacing old molds that we made 10 to 12 years ago that are getting worn out. We use 3D Virtual Gibbs software to do the programming, and the Haas machines receive the programs like they were made for them."

But there's always room for improvement, and Burkholder and his staff have been able to increase their productivity in a rather unique way: by using the Haas Automation website. "I go to the Haas website (www.HaasCNC.com) and look at the frequently asked questions section," says Burkholder. "There's a lot of new stuff there you can learn. We can view the website while the machines are running, and find great tech tips, control tips and control shortcuts. All this leads to better processing on the Haas.

"For example, we changed our programs to eliminate turning off the coolant before a tool change, because the Haas automatically does that. So it takes five seconds out of tool change time. If I have twenty tools in a machine, and save five seconds each tool, that's a lot of time saved. So we changed our programs."

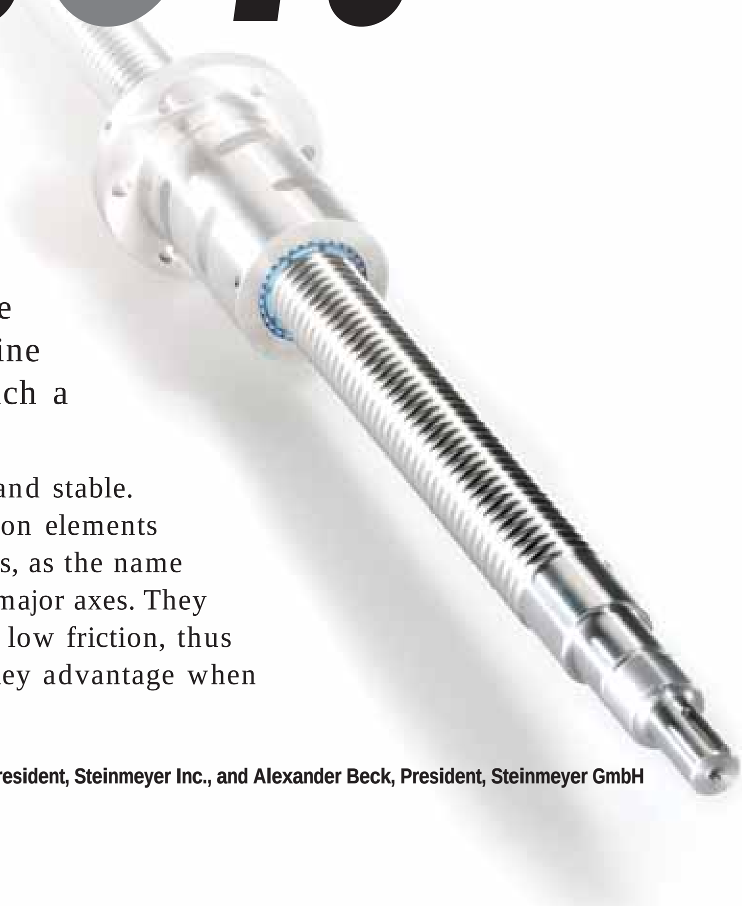
Such changes may seem insignificant at first glance, but when combined with the reliability of the Haas machines, these tips have allowed Denton to reduce delivery times and increase quality. "We've improved our lead time in the last year and a half," says Burkholder. "Our customers were happy when we delivered in 15 weeks. Now we're delivering in 8 weeks, and they're ecstatic.

"Our goals are: better quality, better fit, better finish. That's what sells this product," Burkholder says. "When I see a customer from Honda come in here and tell us how much our quality has improved over the last year, it makes me smile. It makes it worth getting up and coming in here at four o'clock in the morning."

Denton ATD
419-625-5200

Machines in

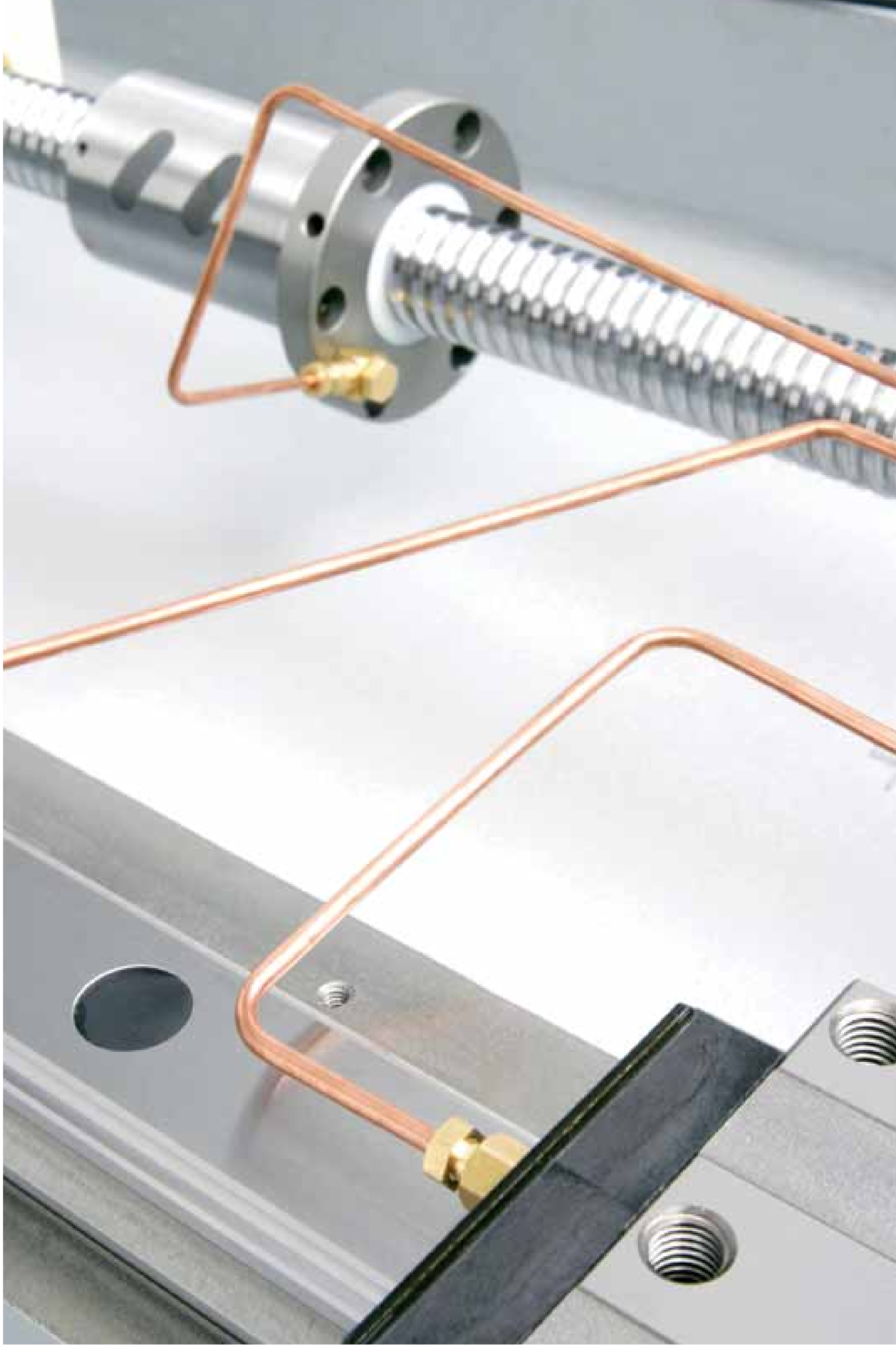
Motion



Ever wonder what kinds of components enable a Haas machine to perform as well as it does? To begin with, a precision machine tool needs a robust, high-quality spindle, as well as a powerful and flexible controller to handle complex programs. But how does the machine move the spindle or the workpiece with such a high degree of accuracy and repeatability?

Obviously, the machine's base must be rugged and stable. Another key ingredient is the choice of linear motion elements such as guideways and ballscrews. Linear guideways, as the name implies, control the straight-line motion of the three major axes. They also offer high load-carrying capacity together with low friction, thus enabling high-speed motion with no stick-slip – a key advantage when compared with designs that use box ways.

Story by George Jaffe, Executive Vice President, Steinmeyer Inc., and Alexander Beck, President, Steinmeyer GmbH



Decades ago, machine tools were guided by sliding ways and driven by lead screws – elements with relatively high friction (lead screw efficiency is about 60%, depending on pitch, lubrication and thread profile). To convert the rotary motion to linear motion, the lead screws were attached via couplings to DC servo motors (and before those, DC stepper motors) to power the machine axes. The controller converted the program commands into coordinated moves by the machine's three or more axes. Since speeds and accuracies were much lower then (the typical rapid traverse was 100 to 200 ipm, with required repeatability of 0.001 inch), these higher-friction components were acceptable.

As productivity demands required increased speed and accuracy, however, lead screws could not keep up. They were soon replaced by more efficient recirculating ballscrews (ballscrew efficiency typically approaches 90%). Concurrently, sliding box ways were replaced by rolling-element guideways, except on very large machines. Today's machine tools are often required to achieve rapid-traverse speeds in excess of 1000 ipm and accelerations greater than 1g – as well as demonstrate repeatability down to 0.0001 inch or better.

Several years ago, some builders announced machine tools that used linear motor drives to achieve rapid speeds in excess of 2000 ipm. Linear motors are a direct-drive element, using a combination of electric coils passing over permanent magnets. As the magnitude and phase of the current in the coils is varied, the coils move with respect to the magnets – with high speed and acceleration capabilities, because there is no contact and thus no friction between the drive elements. Despite their relative mechanical simplicity (they replace the ballscrew, coupling, support bearings and nut block), linear motors continue to be quite expensive, especially larger ones that can sustain the high forces required in some applications. Those larger ones also generate a tremendous amount of heat.

Hence, the precision ballscrew remains the drive of choice for most machine tool builders, who find it to be the best solution for providing high-accuracy, high-efficiency, high-speed motion, together with good stiffness (or rigidity) and long life – all at a reasonable cost. Ballscrews come in different shapes and configurations – single nuts, double nuts, tube ball return, ball deflector return, single-start thread, double-start thread, with backlash, anti-backlash, etc.

In a typical Haas machine, the screw (connected to the fixed motor via a steel disk coupling) rotates and the nut moves down the shaft. As the screw turns and the nut moves forward or backward on the shaft, the balls inside also move (between the shaft thread and nut thread), and must be recirculated somehow. Ball recirculation is accomplished either externally, via a return tube, or internally, via ball deflectors that guide the balls over the thread. Return tube designs are simpler to produce, larger in diameter and typically less expensive. Nuts with ball deflectors are more compact, and offer higher speed ratings and smoother motion. In both cases it is the balls that carry the (axial) load, and typically these are the first parts to wear due to material fatigue. Ballscrews are not designed to withstand significant side or radial loads – those are sustained by the guideways, which generally exhibit equal load capacity in any direction.

By definition, screw pitch is the distance between one thread and its neighbor, while a screw's lead is the distance the nut advances when the screw is rotated one complete revolution. For a single start thread, the pitch is equal to the lead. Lower pitches (e.g., 5, 6 or 8 mm) offer a good compromise between efficiency, load capacity, speed, resolution and motor torque. To increase speed on any axis, increasing the pitch is usually the first step – provided the motor has sufficient torque to overcome the reduction in mechanical advantage and the encoder has sufficient resolution. Higher pitches (e.g., 10, 15, 20 mm) are more commonplace now, as speed requirements increase and motor, amplifier and encoder technologies advance. For machines such as the Haas gantry routers, extra-large leads (40 and 50 mm) are used to achieve even higher speeds. Because the loads are much lighter compared to a VMC or HMC, the mechanical advantage of a smaller lead is unnecessary.

Machine tools require a high degree of repeatability to consistently produce precision parts – implying the use of play-free elements with good rigidity. Eliminating play is relatively easy in recirculating guideways: Just use precise oversized balls (or rollers) to achieve the required degree of rigidity. However, high preload can adversely affect fatigue life while delivering enhanced rigidity. Thus, many machine builders opt for a medium preload – combining good stiffness with an acceptable lifetime.

With ballscrews it gets a little trickier. When ballscrews first appeared, more than 50 years ago, the popular way to preload the assembly and eliminate any play was to use two ball nuts connected yet opposed to one another – the classic double-nut configuration. This effect is similar to the load path in a preloaded duplex bearing set. Later, this same effect was achieved in a single-piece design by just slightly offsetting the nut thread. In both cases we have what's known as two-point contact, which is characteristic of any double nut. Preloaded single nuts, on the other hand, eliminate play by using oversize balls to achieve four-point contact between screw and nut threads. As ball nut technology developed, preloaded single nuts became more popular – they were smaller and often less expensive, yet offered similar load capacities and comparable life. Double nuts still have an edge in terms of reduced friction torque and thus running smoothness, a result of fewer points of contact. They are favored for longer screws, whose length-to-diameter ratio is greater than 20:1. Haas machines use both types, depending on the application and desired characteristics.

Ballscrews are typically supported at both ends – on the motor end by a duplex set of angular contact bearings, and on the back end usually by a single radial bearing. Supporting both ends of the screw enables higher-speed operation and reduces vibration.

Since they are friction devices, both linear guideways and ballscrews must be lubricated regularly. Lubricant reduces heat build-up, eliminates micro-welding and prevents corrosion. The optimum method is one in which the machine's control signals an auto-lubrication system that is connected to the guideways, ballscrews, support bearings, etc. Haas uses such a system on all of its machines, and it has proven to be the most reliable – far more so than depending on a local service tech to periodically lubricate the machine manually.

On the Haas gantry router machines, which are subject to excess contamination due to their open-frame design, the ballscrews are specified to include combination wipers for added protection. These rugged wipers include:

- *one part external to the nut, made from durable plastic, that keeps contaminants out; and*
- *one part internal to the nut, made from felt and saturated with oil, that provides a steady and greatly reduced lubricant flow, for reduced maintenance.*

Haas has had very good success with ballscrews and linear guideways on its entire line of machine tools. This can be attributed to at least two factors – conservative, knowledgeable design and high-quality component suppliers.

Size Matters.

(But not the way you might think.)

Johannesburg engineering company Baird Micro Turbines – designer and maker of jet engines for model aircraft – is using small-scale CNC machines to tackle sizeable engineering problems. Business and industry writer and photographer Matt Bailey investigates. >>

>> ENGINEERING THRUST

In the first floor room of a small, unassuming end-of-block industrial unit on the outskirts of Johannesburg, Andre Baird fires up a miniature jet turbine mounted on a miniature test-bed by an open window.

It may only be "ticking over," but standing next to it, Baird's creation seems just as ear-splittingly loud as a full-size version. When he hits the throttle, I may as well not be wearing ear defenders.

With a grin, Baird holds the rev' gauge up for me to see the LED numbers jump to a staggering 120,000 rpm. Just as 12 kg of thrust forces the test-bed to start creeping forward – but before the banshee breaks its mounting and embeds itself in the wall opposite – he pokes the kill switch, much to my relief and, I suspect, that of the neighbours.

MODEL COMPANY

Before starting his company in 1998, Andre Baird made a living as a professional IT and electronics engineer. In his spare time he built radio-controlled model aircraft. The company, he claims, was started as "a hobby" – an outlet for his pent-up desire to make something.

"The original intention was to build one of the best model turbines available," he says. "I wanted to combine my hardware and software knowledge into one product. The turbine idea seemed like a good one."

And indeed it was. Just a few years on and Baird Micro Turbines is shipping its miniature power plants to enthusiasts all over the world.

But, before it could do so, there were a few engineering problems to overcome. Despite the small scale of the product, some of them were large-scale challenges.

MACHINE TOOL INVESTMENT

Originally, Baird Micro Turbines – like many small start-up companies – never had any intention of undertaking its own machining. The plan was to "farm out" most of the actual manufacturing, and concentrate on the design and development of the product.

"That didn't really work out," Baird says. "In the early days, we had to make a lot of prototypes – high-precision prototypes, at that. Most of the subcontract companies we approached weren't really interested. One-off prototypes are expensive to produce and time-consuming. These guys had other priorities, and we often found ourselves at the back of the queue."

Frustrated, Baird considered buying his own CNC machines and doing the work in-house. On the face of it, not such a big deal for someone of his technical ability, but never having programmed a CNC before, he was understandably cautious.

"We looked around for something that was simple to program and operate, but very productive, precise and reliable," he says.

And it had to be small, too; the company's ground floor office / workshop measures less than 20 square meters.

"We bought a Haas Mini Mill CNC machining centre," Baird says, "because

it met all of our criteria, and it had a lot of performance for a machine of its size."

In fact, the machine measures just 1981 mm by 1981 mm, but has a 6000-rpm spindle and a work envelope of 406 x 305 x 254 mm. Since the company introduced the mini machine concept two years ago, it has sold some 3000 to customers all over the world.

"It's small," says Baird, "so we were able to squeeze it in without too much trouble. It's also very easy to use. We were running it the same day it was installed."

Inspired by his investment, Baird bought a second Haas machine just a year later: an SL-10 CNC turning centre.

"By investing in these two machines we became pretty much self-sufficient in parts manufacture and for prototyping," says Baird. "The ability to do R&D on the premises is a great advantage. Apart from saving time, we can also ensure that the manufacturing procedures we've developed are used. For example, we've put a lot of thought into how we hold a part while it's being machined. This directly affects the quality of the component. If it's held incorrectly you can introduce stresses and distortions, which will cause it to fail."

When parts are spinning up to 120,000 times a minute, stresses and distortions can have spectacular consequences.

"We're working to high tolerances, too," Baird adds. "We wanted more control over those tolerances. We used to get parts back, test them and find that they hadn't been machined to our specified tolerances. It was a waste of time and money."

INJECTORS

One of Baird's biggest challenges was perfecting the fuel supply to the turbine.

On a full-scale engine, the fuel is often supplied by gear-driven pumps. Because weight is much more critical on a model aircraft, the fuel has to be delivered via injectors. To achieve the target of 20 grams of atomised fuel a minute, the company had to design and manufacture extremely fine injectors: a task that, ordinarily, wouldn't be attempted on a CNC milling machine.

"When we did some research into the very accurate mist injection we would need, we found that other manufacturers were either making the injectors by hand or were using some kind of etching system. I wasn't convinced that we couldn't do it using a milling machine."

Through a specialist supplier in Germany, Baird obtained a selection of very small diameter drills – some as fine as 0.2 mm!

"We set the Haas Mini Mill up to do the job, and I'm happy to say, we've had 100 percent success! Of course, we break

a drill occasionally, but far fewer than you might imagine."

Baird claims that the development process was made quicker by the fact that the company had the machines in-house.

"Having our own machines meant we were able to constantly try new designs," he says. "We could machine a new part, try it, and make any modifications quickly and with minimum expense."

THE FUTURE

No matter how fascinating and appealing a finely engineered mini-turbine is at ear-splitting full throttle, the market for Baird's creations is small, even on a global basis.

"Most of the demand for our product comes from the USA and Europe," he says. "It's steady demand, but it's never going to be enough to enable us to grow to any great extent."

The key to the company's future is more likely to be found in what it has learnt from designing and building its jet engines. Baird talks enthusiastically about a number of big, multi-national companies that he's in contact with, and how his mini-turbines can be used in "real-life" applications.

"For starters, defence companies are interested in using them in small, pilot-less drone aircraft," he says. "They're also considering them for use in missiles, which traditionally use comparatively inefficient rockets."

Clearly, Baird Micro Turbines is an organisation in transition: from start-up hobby-shop to fledgling aerospace company.

www.bairdtech.com

ther•mo•form:

to shape (esp. plastic) by the use of heat, vacuum and pressure.

Story & photos by Scott Rathburn

In a way, it all started with a bunch of stuffed animals.

Not that Joe and Randy Amarello cared much about the tiny, under-filled beanbag toys themselves. But their wives did. Their mother did. Other family members did. In fact, many of the Amarello kin were thoroughly enamored with the diminutive playthings. They collected them, traded them, traveled far and wide to find them . . . . Like millions of others across America and around the world, they'd fallen victim to the inexplicable allure of the Beanie Babies®.

The brainchild of H. Ty Warner, the eponymous founder of Ty Inc., Beanie Babies descended upon the toy market in 1993. Designed specifically to appeal to children, the palm-sized plush toys were inexpensive enough that kids could buy them with their allowance, and small enough that they could carry them in their pockets. But above all, they were cute.

Perhaps it's this inherent "cuteness" that made the Beanies so popular – not only with children, but with adults. Or perhaps it's because they were unlike any other plush toys on the market at the time. Whatever the reason, the little stuffed pets caught on, and they caught on big.

It wasn't until 1996, however, that the craze really took off – when Ty retired 11 Beanies from the company's line-up. The fact that certain Beanies were no longer available instantly made them more desirable – and more valuable. They weren't just cute toys anymore; they were serious collectibles.

As with most things collectible, the better condition a Beanie is in, the more it's worth on the secondary market. But it's not just the condition of the toy that matters; the condition of the original hang-tag (the heart-shaped tag attached to the toy's ear or other extremity) is also very important. A damaged hang-tag can reduce a Beanie's value considerably, and if the tag is missing completely, the value can drop by as much as 50%. With some rare Beanies fetching upwards of $2500 on the secondary market – about 500 times the original retail price – it pays to protect those hang-tags.

And that's where Joe and Randy Amarello come in. They're machinists – engineers, really – who, between them, have nearly 30 years of experience in the thermoforming industry. Thermoforming is the process of using heat, vacuum and pressure to form a sheet of material, usually plastic, into a particular shape. It's used to form such things as the plastic trays for holding electronic components, medical instruments or cookies; the plastic clamshells for holding muffins, fruit or take-out food; and those clear plastic – often nearly impenetrable – blister packages that many of today's consumer goods come in.

Back in 1997, surrounded as they were by a family of Beanie-holics striving to keep their hang-tags pristine, Joe and Randy had an epiphany: “Let’s design a heart-shaped plastic clamshell that snaps over a Beanie’s hang-tag and protects it.”

To them, it was a no-brainer. They worked for a custom thermoformer. They built thermoforming tools every day. They knew what they wanted to make, and they knew how to make it. Joe and Randy went to their boss and asked: “If we make the tool, will you run the parts for us?”

Their boss agreed, so they went to work. “We designed and built the tool on the weekends,” says Joe, “and when it was done, we gave it to the company we worked for to make the blisters for us.”

“We purchased the blisters from our employer and resold them out of our house,” Randy adds. “The first order we placed was for fifty thousand pieces, just to see if it would fly.”

And fly it did. Before long, says Randy, “We were placing million-piece blanket orders and selling them all in three months. It was unbelievable. We had five or six wholesale distributors buying from us; they would order a hundred thousand at a whack!”

“In just a short time,” says Joe, “we landed more than two thousand retail customers. The orders would come in sometimes thirty, forty, fifty thousand a day. We ended up selling almost ten million blisters!” he exclaims.

Yet, despite the standout success of the tag protectors, Joe and Randy kept their day jobs: They liked what they did, and they liked where they did it. “It was a privately owned company with about 30 employees,” says Joe. “It was small; it felt like family.”

But things changed when the company sold. “They became corporate,” says Joe. “And when they became corporate, they didn’t want to invest in equipment, in engineers, in people . . . .”

Which was not good for Joe and Randy, who were responsible for designing and building all of the company’s thermoform tooling. They could see the industry was changing – molds and tooling were getting larger – and they knew they needed new equipment to keep up. “We were trying to run a tooling department with old equipment that didn’t have any capacity,” says Joe.

“We were trying to do big plates, or even big molds,” explains Randy, “and sometimes we’d have to make eight programs to run them. We’d have to do half of the plate in four quadrants, and then flip it around and run the other half in four quadrants. It was getting frustrating.”

Despite the new owner’s reluctance to invest in the company, the Amarellos went in search of new equipment. Or, more accurately, in search of a quality used machining center, because they wanted to keep the investment cost low.

Through a used-machinery dealer they found a Haas VF-3 that was only a year and a half old. “It was in beautiful shape, and had lots of options,” says Randy. “We’d heard a lot of good things about Haas, and we talked to some people who owned Haas machines. They said that, for the value – the capability for the money – they couldn’t be beat.”

Thoroughly impressed, Joe and Randy pitched the VF-3 to corporate, but to no avail . . . at which point they had another epiphany. “We looked at each other and said: It’s time; let’s buy it ourselves,” says Joe. “We decided to turn the table and open our own tooling shop.”

For most people, giving up a full-time job and a steady paycheck to start their own business is a major decision, but the Amarellos didn't lose much sleep over it. "We knew engineering, we knew thermoforming like the back of our hands, we knew 3D mold making . . . it was time to do something different, to move forward," says Randy.

Thanks to the world's continued fascination with Beanie Babies, the Amarellos had the wherewithal to step out on their own. "The success of the tag protectors gave us the guts and the financial backing we needed to get started," says Joe.

Joe and Randy put down a deposit to hold the used Haas VF-3, and went in search of a building. In October 1999, they rented a 2,500-square-foot building near their homes in Acushnet, Massachusetts, purchased the VF-3 and moved it into the building. For the next two months, they spent their nights and weekends fixing the place up, painting it and getting it ready for business. They also purchased another machine – a used Haas VF-1 – and moved that into the building, as well.

On January 2, 2000, the day after the dawn of the new millennium, the aptly named J&R (Joe & Randy) Plastics, Inc., opened its doors. The Amarello brothers were ready for business, and they had work waiting for them.

It seems their previous employer had yet to find replacements for Joe and Randy, despite having a month's notice. They still needed someone to do their engineering work, and the Amarellos were more than happy to oblige.

"We knew that was going to happen," says Joe, "We were the only two engineers over there, and when we left, they didn't have anybody to do the work, so they farmed it out to us. For the first month, we basically did engineering work for them. But, I tell you, three weeks to a month into it, and people just started calling: 'Hey, I heard you guys started your own business. You want to quote this?'"

"Everybody in this business knows each other," adds Randy. "It's a very tight-knit business."

"So once they heard that the Amarello brothers had gone out on their own," Joe continues, "the

phones started ringing. It's such a small niche that word got out. It spread fast – like wildfire, actually. It snowballed from there."

The Amarellos attribute their immediate – and continued – success to their extensive knowledge of thermoforming tools and the thermoforming process.

"We have, from start to finish, the experience to make a tool – right from the prototype stages, all the way through to the complete assembly," explains Joe. "We take it all the way through the process, and that's what makes us so successful. We're not just offering machining of a part; we're offering the service of designing and building thermoforming tools. What's critical here is to offer . . ."

". . . every station of the machine," finishes Randy. "In an inline thermoforming machine, the plastic gets heated. It goes into a form station. There's an upper assembly and a lower assembly in the form station. We have full capabilities to design and machine and manufacture the whole package. Then it goes to the trim station. We can do that. Then it goes to the stacker station. We know the entire process. We know the shrinkages. We know what it takes."

It wasn't long – "probably six to eight months into the business," says Randy – before J&R needed additional capacity and capability to handle more, and larger, work.

"In our type of business," explains Joe, "tool size can run thirty by thirty five (inches), and the twenty by forty travels of the VF-3 just weren't big enough. And now they're coming out with thermoformers that are capable of doing a forty-inch-wide tool."

"We had plenty of jobs that were twenty-five inches one way," continues Randy, "and we could do them half and half in the confines of the machine. But we had one job that was thirty by thirty, and we had to take off the doors."

"It was a nightmare," says Joe. "We were losing work because we didn't have the table size. We needed a bigger machine."

As luck would have it, Randy came across a Haas VF-6 demo machine for sale on the Haas Automation website (http://www.haascnc.com/pre-owned/). The 64" x 32" x 30" travels of the machine were exactly what they needed, so Joe and Randy contacted Frank Kirbus, their sales rep from the local Haas

Factory Outlet, and began negotiations. According to Randy, the VF-6 was up and running in the shop around July 2000.

Despite a depressed economy and a serious downturn in manufacturing, J&R Plastics thrived and continued to grow. By fall 2002, they had more work than they could handle, and were ready to expand again. Subcontracting their work, however, was not an option.

"Because of the type of work we do," says Joe, "and the quality that we offer, we won't farm out our work to another vendor. They don't know the details of thermoforming, and no matter how good you go over it with them, there are always issues when the job comes back."

"We're very fussy about the quality we give to our customers," Randy explains, "and we don't want to have to rely on other people to produce what we expect."

"If we can't do it, we don't take it on," says Joe. "We were at a point where we were maxed out here. We needed three things to expand our business: We needed more equipment, more people and more space."

Once again, Lady Luck intervened. A local machine shop owner "was a bit under the gun with finances," says Randy. "He was in a very high-tolerance type of industry – working in tenths – and couldn't find qualified people to work for him. He was trying to do it all alone."

The shop had a couple of Haas machines – a VF-2 and VF-5 – but, thanks to the depressed economy, finding enough work to keep them running was difficult. Hearing that J&R had plenty of work, and hoping they might send some his way, the shop owner rang them up.

"But we don't farm out our work," says Joe. "So we made him an offer to buy out his whole company . . . "

". . . and also bring him aboard here," finishes Randy.

"It worked out for everybody," says Joe. "By buying out the other company, we got two of the three things we needed to expand: We got two machines – we were only expecting to buy one – and we got another person in here." As an added benefit, J&R also picked up the other shop's existing customer base.

Space, however, was still an issue. Luckily, the Amarellos were able to lease additional space from the business next door to house the new machines. By the end of 2002, they were hard at work.

With five CNC machines in-house, says Joe, "Our biggest problem is keeping up with the machines. It's very difficult to keep five Haas machines running without doing

production, and we don't do production here. Our type of work is very engineering involved. We have a lot of setups; it's not uncommon to do ten setups in a day."

To simplify and speed up the process, the Amarellos have installed nearly identical multi-vise fixturing systems on three of their five machines. "Our VF-1, VF-2 and VF-3 are vise setups," says Joe, "which allows us to do pieces twenty, thirty and forty inches long without taking a vise off. They're all the same size vise, and they're all on 10-inch centerlines. They're perfectly in line and they stay there, which allows us to do changeovers more quickly."

J&R's other two machines, the VF-5 and VF-6, are reserved for larger work, such as tooling plates and multi-cavity molds. "We kind of set it up for our industry," says Joe, "to utilize the capabilities of the machines, especially the bigger machines."

The tooling plates are primarily 2D work, which is faster and easier to machine. The thermoform molds themselves, however, are predominantly 3D, which requires the most engineering work and machining time.

According to Joe, jobs come to J&R in one of three ways. "Lots of times the customer will just send us the product: 'Here's my product; make me a package,'" he explains. "We'll sit down with them, do some sketches, and design the package from scratch. That is the safest way to do it, and it puts 100 percent of the responsibility on us."

From the product, Joe and Randy will design the package, build the CAD model, create the machining surfaces and generate the toolpaths for machining. Then they'll machine a prototype mold out of plastic, and actually pull a sample blister on their in-house thermoforming machine.

"Instead of having just a mold cavity," says Randy, "the customer can have a plastic blister, and try their parts in there to make sure everything fits the way it's supposed to. Today's sophisticated software gives a good representation, but it's not the same as feeling the real thing, and seeing how your product's going to work inside of it."

"That's one of the ways we work," continues Joe. "Another way is that they will send us a hard copy, a blueprint. But most people don't have the thermoforming experience. They draw a nice, pretty picture on paper, but they don't know the do's and don'ts of thermoforming. Right away, just by looking at that blueprint, we can say, There could be problem areas here, or, this is fine, go ahead and make it."

Drawing on their experience, the Amarellos work with the customer to refine the design and create the best blister for the product, and the best mold for the type of plastic being used.

"It's really hard to get anything true off a blueprint, though," says Randy. "It's okay for two-dimensional trays, where they can give you elevations, but in the three-dimensional world, you really need to go to the next level, with electronic files."

"And that's the third way," says Joe. "The customer will actually do a CAD drawing – either a solid model or a wire frame – send that to us and say: 'Here, this is what I want; make us the part like that.' We'll take the solid model or wire frame, create our curves and surfaces – all the drawing we need for the CAM system – and create, design and build that mold. Once we do that, then we'll make the prototype on the machine, pull samples and send them to the customer.

"But the best way is to have the physical product," he emphasizes, "because a lot of times the product doesn't match what they drew. Having the physical product is the most important thing. That way, we can make the blister – design and build the mold, manufacture it, pull the samples, put it together – and send it to the customer. The customer loves to get their product in the package."

Regardless of how the jobs come in, however, the approach the Amarellos use for the machining is the same. Rather than machine the entire 3D surface of the mold in one fell swoop, like many shops do, "We break up our surfaces to utilize the best machining direction," says Randy. "We won't just create one surface and say: Machine it all. We try to make the machine . . . "

". . . travel the least number of axes possible," finishes Joe. "Machining in one axis gets the best finish, in two axes is the second best, and when it's moving in all three, sometimes you may get more facet-y finishes than nice, smooth arcs. What sets us apart is the way we create and build our molds," he says, "the actual machining process of the mold."

While this may seem like extra work, given that today's software can easily generate a 3D program to surface the entire part – and today's machine tools can easily cut them – Joe and Randy feel it's the best way to do the job.

Their reasoning is twofold: They want the best surface finish they can get, and they want to reduce the wear and tear on the machine.

"A lot of guys who solid model, they just let the machine go crazy," says Randy. "They make pretty pictures and let the software do all the calculations, but many times the machine's running hog-wild, and they're beating up their machine."

"Our software (EZ-CAM) allows us to break the surfaces up," says Joe, "and with our experience in machining, we can pick and choose how we want to machine each surface. We literally break up each section of the part and program it the best way for each section of the mold.

"We'll rough it out at 100 inches a minute to get rid of all the stock. Then we'll use a tapered endmill – a lot of our molds are tapered – to contour mill, not 3D, the shape as much as we can, letting the side of the endmill do the work. Then we use a 3D ball endmill, but only where we have to," Joe says.

"And we'll try to keep that in a linear direction," says Randy. "Any time we can go in a single axis, we do, instead of coming in at an angle and going up and down. It creates amazingly smooth finishes. We also use very small stepovers to reduce the need to polish. A lot of companies may use ten or fifteen, twenty thousandths stepover, where we'll very commonly use three, four, five thousandths. We very rarely go over five thousandths, because of the finishes we're looking to get . . ."

". . . right out of the machine," finishes Joe. "The smaller the stepover, the better the finish, the less polishing, the nicer the part."

"It's like carving an ice sculpture," says Randy. "You just do a little, tiny bit at a time, and the machine runs for miles and miles and miles. We'll let the machine run fifty, sixty, eighty hours, but we're very picky about machining direction, and the toolpath that the machine uses over those sixty hours. If we're going to run for sixty hours, we want the finish to come out as good as it possibly can, with the least wear and tear on the machine.

"We run lights-out here, 24 hours a day, when a job requires it – which is most of the time," he continues. "Four out of five days a week, we're running at night – and over the weekends. We'll set up a job on a Thursday or early Friday, and we'll run all the way to Monday."

For this reason J&R needs equipment they can rely on. "Longevity is a key factor," says Joe. "We need machines that we can depend on, that are going to run lights-out, 24/7. That's critical for us."

"Running lights out has enabled us to keep our staff low, " says Randy, "because we're allowing the machine to do the work without having a physical body there. And people are expensive. If you've got three or four of those big jobs going at the same time, you're duplicating your time."

Of course, running 24 hours a day and duplicating your time only goes so far when business is booming. By 2003, it was apparent that J&R needed a larger facility, so Joe and Randy went in search of real estate. They purchased a piece of land nearby – about a mile down the road – in May of 2003, and by August, construction was under way. Ten months later, in June of 2004, the new home of J&R Plastics opened its doors.

Purpose-built to suit their exact needs, the building "is nearly four times the size of our old plant," says Randy. At 9,500 square feet, it has a dedicated machine shop, an engineering room, private offices, a conference room and even a cafeteria. All five Haas machines are now comfortably ensconced in surroundings more befitting a medical facility than a machine shop: spotlessly clean, neatly plumbed electrical and air, white and gray floor and walls. There's even a spot set aside – complete with air and electrical drops – for their next machine: a Haas VF-8.

And to think it all started with a bunch of stuffed animals. The Amarellos couldn't be more pleased.

J&R Plastics, Inc.
508-995-0893
www.jrplastics.net

BUILD IT
and they will run

Every spring, engineering students from universities around the globe descend upon the Detroit area to participate in the Formula SAE Collegiate Design Series competition. Put on by the Society of Automotive Engineers, FSAE is the culmination of a year-long program in which students conceive, design and fabricate a formula-style racecar.

The completed racecars compete in static and dynamic events, such as technical inspection, cost, presentation, performance trials and high-performance track endurance. This year, a record number of teams – nearly 2000 students – participated in the event.

One of those teams was Matador Motorsports. Like every student racing team, Matador is made up of highly enthusiastic engineers-to-be who put in workaholic hours to build a car that will outperform the competition's. Unlike the average student team, however, Matador has finished in the top 11% in more than a third of the Formula SAE races in which they have competed. Matador hails from California State University at Northridge (CSUN) and, except for a break during the years 2001-2002, has been competing since 1995. The 2004 team finished in the top 10% this past May.

Story: Linda Dorr Photos: Scott Weersing

"That's how we can take students who have no machining experience and make an entire Formula car, where 90% of the parts are made on Haas CNC machines."

BUILDING ON SUCCESS

In 2003, Matador's team placed an impressive 10th overall out of 140 entries, landing them in the top 7%. They didn't revel in their success for long, however. With the school year ending immediately after the race, Matador set about assembling a new team for the 2004 competition. Tin Bui, now a graduate student, worked on the engine of the 2003 car and then became the 2004 Project Manager. Aspirations were high for the coming year. "Our tenth-place finish really had the new team motivated to beat that placing," said Tin.

Heading into summer, the team had a lengthy to-do list, which included reading all the documentation on and then repairing the 2000 racecar (the last car CSUN built before the '03 one). This introduced new team members to the principles of racecar design. Once they had the fundamentals down, they turned their attention to redesigning the '03 car for 2004.

"The plan," explained Tin, "was to model a new, unrestricted intake system and new engine cover, and adapt it to the 2003 car's fuel injection system." One Saturday there was a huge turnout in the lab to build the new components. "Our momentum was at its peak," Tin said. Unfortunately, "the momentum abruptly died when the 2003 car came back in pieces after an accident."

Needless to say, seeing the team's best-placing car reduced to a pile of damaged parts was quite a shock. Not much got done that summer. But by the time the new school year started, Matador had regrouped. Given the time they had lost, Tin felt the team "needed a conservative design goal. I wanted an evolution of the 2003 car . . . just optimizing the current designs would reduce the time needed to remodel everything."

Other students on the 15-member 2004 FSAE team had different ideas. "They wanted more drastic changes," noted Tin, "and they understood what needed to be improved." In the end, the only components that didn't undergo a design change were the driveshafts, stub axles, jack shafts, hubs, spindles and body.

The rest of the car saw major modifications. The biggest change was replacing the rear chassis with an aluminum monocoque, using the engine and drivetrain housing as a stressed member. The chassis size was greatly reduced, so "the suspension was redesigned to have a smaller track and wheelbase, and also different packaging constraints," Tin reported.

The team began manufacturing parts during the fall semester. CSUN happens to be Gene Haas' alma mater, and back in '98 he entrusted a couple of Haas CNC machines to the school's College of Engineering and Computer Science. The Gene Haas Engineering Lab has an HL-2 lathe and a VF-2 vertical machining center (with plans to add both a Toolroom Mill and Toolroom Lathe in the coming year). Professor Stewart Prince is the lab administrator.

"We have the latest and greatest machines in our lab," noted Dr. Prince, "and the machines are so user-friendly now that we can take a mechanical engineering student who knows nothing about machining – but lots about machine design – and have him or her design parts using CAD, and of course use the analysis tools, and go straight from there to CAM and generate the G code.

"I give them an introduction to the CNC machines: 'Here's the machine, here's how the control works, don't drill any holes in the table. When it's time to run your part, come and get me.' Then I run it in Graphics to make sure it's going to work right, and if it does, then off they go.

"That's how we can take students who have no machining experience and make an entire Formula car, where 90% of the parts are made on Haas CNC machines," he said.

Now, while that's the condensed version of how CSUN students learn to run Haas machines, it's really not that far off. Jason Frick is a graduate student who was this year's chief drivetrain engineer. "I just kind of dove in," he said. "This project forces you to get things done! During 2002-2003 we didn't have anybody with any manufacturing experience. So John Mason [another

> ". . . we have higher build quality, and more accurate parts that we can trust."

drivetrain engineer, who designed the rear monocoque] learned to weld, and he became our welder. Well, I stood next to Dr. Prince and learned the controller on the Haas machine, and I already had some experience with CAM, so I became the CNC machinist. I did all the parts for our 2003 car, and then this year I had help." Mike Stackhouse, Matador's 2004 chief chassis engineer, had been machine shop supervisor at Edwards Air Force Base. Mike was at Officer Training School at press time, and hence unavailable for comment, but "He had good things to say about the Haas machines," according to Jason. "He loved that Quick Code stuff."

"And," added Tin, "Mike knew what type of tools to use, the speeds and feeds, all that stuff." Needless to say, Mike's skills and experience were a very welcome addition to the team's knowledge base.

Jason and Mike machined "all kinds of aluminum – 7075, 6061, 2024 – and a lot of steel, too. A lot of alloys – 4130, 4340, some mild steel," Tin continued. "Some of our competitors buy their parts. But we design everything for our application, which makes our car much lighter and faster than most of our competitors' cars. And we have higher build quality, and more accurate parts that we can trust. There are a lot of high-tolerance parts, especially in the drivetrain and the suspension."

Another recurring theme among Matador's student engineers is the quality of this educational experience. "You're not given these kinds of skills in a classroom," noted suspension engineer Katrina Finley. "The Formula racecar project is one of the most prestigious ones; it's just got a great reputation within the Engineering building. It gives you a lot more hands-on experience than most of the other design projects." Jason concurred: "I've learned more in the last two years, just from this project, than I have from my classes."

It's a phenomenal amount of work, but Matador team members are – as the saying goes – in it for love, not money. "We're the ones who are in the lab on Friday nights," Katrina said, laughing. "We're there early in the morning, late at night – it takes a lot of motivation. You really have to have a heart for it." In Jason's estimation, "Those of us who spent the most time on the project were here in the lab probably 50 to 60 hours a week. That's not including our other classes."

The result is a racecar with impressive specs. "We have a really good engine development program at CSUN," Tin reported, "so we have a massive amount of horsepower. It's fun!" With a wet weight of 467 pounds, length just under 104 inches, and a 64.5-inch wheelbase, the car generates 85.2 bhp, for a 0-to-60 time of 3.7 seconds, a top speed of 102 mph, and an FSAE Skidpad Event tally of 1.25 g of lateral force. Out of 140 FSAE entries this past May, Matador placed 8th in the Acceleration Event, 9th in the Autocross, 14th in the Skidpad Event (as well as 14th overall), and took the 3rd place Powertrain Award.

"This is racing," said a philosophical Tin, "where everyone is disappointed except the winner! We're in the top 10% worldwide, and we know that CSUN is a contender to win."

Even more important, though, is that a project like the FSAE car not only makes engineers out of the students who work on it – it can also inspire students who don't know yet that they like engineering. Katrina, the only woman on this year's CSUN team, hadn't planned on an engineering major when she started college. As a small girl with three brothers, she "wasn't really into Barbie dolls – I was into putting train sets together and getting my hands dirty and stealing my brothers' toys." Although she continued taking more advanced math and science classes as her education progressed, "I thought I'd be a cinematographer, or an English major. Then I heard about engineering from my classmates. So I started looking into it, and found out engineering is not just textbooks and formulas. You have to have an imagination and creativity. I have an affinity for art and for science, and how they combine – and I get to use both skills as an engineer."

Which is really the point of getting an education: finding a career where you enjoy what you have to do every day. Now that's the hallmark of a winner.

“The New Manufacturing Age”

Only Chicago, the self-proclaimed City of Broad Shoulders and home of the enormous McCormick Place Convention Center, could claim the title of “fitting host” to the largest industrial show in the Americas – IMTS.

Everything about this spectacular biannual event is, well – big! With its thousands of exhibitors, the International Manufacturing Technology Show of 2004 drew enthusiastic attendees from all over the world. Executives, engineers, shop owners, and machine operators alike gathered on the western edge of Lake Michigan to meet the manufacturers and compare their products head to head.

Arriving early and sneaking through a side door pays off for one IMTS visitor (above). Most visitors to the Haas booth had to deal with major crowding every day (opposite).

From the first day, large crowds spread out through the exhibition halls with both enthusiasm and curiosity. People seemed genuinely interested in what they were seeing, and actively intent on learning all they could. As might be expected, some booths at IMTS drew more visitors than others, and the Haas Automation booth with its new front-row location in South Hall was one of the busiest at the show. With a whopping 17,000 square feet of exhibition space and an unprecedented 40 CNC machines making parts and cutting chips, it was apparent that Haas went all-out to present the largest display of operating machines ever seen at IMTS. That array of machines, along with the special lighting, custom carpeting, and well-presented demonstrations, all made for great theatre, and the attendees loved it. They saw, they touched, and they asked countless questions.

Throughout the main exhibition buildings, an additional 20 or so Haas machines could be found attracting similar attention in other manufacturer’s booths; and virtually every place there was people, there was a sea of “Haas Genuine USA” show bags. The largest machine tool manufacturer in America was well represented.

In addition to the wide selection of standard machines from each product line, Haas, as usual, presented a number of brand-new production machines. The first products most visitors inspected on entering the Haas booth were the new OM-1 Office Mill and OL-1 Office Lathe. These units are the smallest CNC machines Haas has ever produced, designed to fit into spaces where ordinary CNC machines could never go. They’ll fit through a standard 36" door, and they offer full CNC capabilities, quick setup, and the famously friendly Haas control.

The PC-305 Plasma Cutter, another completely new model, greeted visitors with a spectacular fiery show. This single-arm-style, CNC mechanized torch featured a Hypertherm Powermax 1000 cutter, a big 3' x 5' table, a fume extraction system, and a well-designed open platform layout for easy access to large parts.

The new TL-3 Toolroom Lathe, with a functional range from manual to full CNC and a max part capacity of 20" x 60", also generated a lot of interest, and not just because of its size. The entire series of Toolroom Lathes was on display in the Haas booth, and demonstrated to the crowds how the user-friendly Haas control has gotten even friendlier. With the Haas Intuitive Turning System

at IMTS 2004

(ITS) – standard on all Toolroom Lathes – machine operators saw how they could generate parts programs even if they don't know G code. By simply choosing an operation, entering basic machining information as prompted, and pushing the Cycle Start button, the Haas ITS generates the G-code program and executes the desired operation.

Existing customers know that Haas Automation's commitment to innovation was not new to this landmark show – only the machines were. And hopefully the new customers acquired at IMTS '04 will come to understand as well that, for this forward-looking company, "The New Manufacturing Age" has just begun.

Compact CNC Office Mill and Lathe

As more and more specialized industries discover the advantages of machining parts in-house to control quality and scheduling, many are also discovering they can't fit a "normal" CNC machine into their facility. Their answer may be the new OM-1 Office Mill and OL-1 Office Lathe from Haas Automation, Inc.

The innovative Haas Office Mill features an ample work envelope of 8" x 8" x 8" (xyz) and a 20" x 10" T-slot table. It comes standard with a 50,000-rpm brushless micro motor spindle that accepts tools up to 0.25" shank size. The OM-1's unique spindle head also accepts a variety of other high-speed electric spindles (30 mm diameter). Brushless servos on all axes of the Office Mill yield cutting feeds up to 500 ipm and rapids up to 757 ipm for short cycle times. The user-friendly Haas control makes operation and setup a breeze.

The equally compact Office Lathe features a 5-hp (peak) spindle that turns to 6,000 rpm. The threaded 5C collet spindle accepts a number of optional chucks. The high-speed cross slide features travels of 12" x 8" (xz), and accepts a variety of gang-style tools in addition to the standard tool package that is included.

The Office Mill and Office Lathe are easily the most compact CNC machines Haas has ever built; yet, they offer all the high-performance features that make Haas the best selling machine tools in America.

the answer man

Dear Applications:

I need to do circular milling on my VF-3. I would like to know about I and J moves – how are they calculated? Are I and J arc segments of the circle?

Rod Lewis

Dear Rod:

The optional I, J and K commands represent the distance from the starting point to the center of the circle: I is the distance along the X axis; J is the distance in Y; K the distance in Z. (Typically, I and J are used in mill programming, while I and K are used with lathes.) Depending on your application, the R command may be used instead.

If you're cutting an arc of less than 360 degrees, you should use X, Y, Z and R commands. The X, Y and Z values define the endpoint – which is different from the starting point – and the R value is the distance from the starting point to the center of the arc. Note that if R has a positive value, the control will generate a path of 180 degrees or less; to generate an arc of greater than 180 degrees, you must specify a negative R.

To cut a complete circle – a 360-degree arc – you must use I, J, K commands (if only one of these values is specified, the others are assumed to be zero). In this case, the starting point and ending point are the same, so you don't need to specify X, Y or Z values.

Sincerely,

Haas Applications

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Dear Applications:

I just got a Mini Mill with rigid tapping. What kind of tap holder should I buy? My supplier offers a tension-only holder or a tension and compression holder, as well as a rigid tap holder. Should I just get the rigid one? I will be cutting 6 mm and 8 mm tapped holes, and also 1/8 NPT and 1/4 NPT. Thanks!

Josh Paulson

Dear Josh:

It's not necessary to use a tension/compression type toolholder with rigid tapping on a Haas. You can run the tap in a rigid holder. Remember, your feedrate must be precisely computed for the thread you're tapping (rpm x thread pitch = feedrate). The Haas control's calculator can help you do this, or, if you're using a CAM system, it should automatically do the calculation for you. Otherwise, please consult your Operator's manual for details about programming tapping cycles on the Haas control.

Sincerely,

Haas Applications

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Dear Applications:

We recently purchased a VF-5 and a TRT-210 two-axis tilting rotary table. This option required the additional purchase of a 4th-axis drive, and included the separate servo unit that can also be used on non-Haas machines. I have been assigned to do the programming for this, and would like an example of how to program the 4th and 5th axes. Since we do not have true 5th-axis capabilities with this configuration, is the 5th axis controlled by M code in the program, with a separate sub-program?

Ken Miller

Dear Ken:

With a full 4th axis and semi 5th axis setup, 4th-axis positioning is done with a standard A address code. There are two ways to "position" the 5th axis. One method, as you suggested, is by assigning it an M code from the spare M-function user interfaces. An alternative method, which adds a lot more functionality, is to use Setting 38, Auxiliary Axis Number. This setting is used to select the number of external auxiliary axes added to the system. (Up to four may be added: C is a rotary axis, and U, V and W are linear.) When you use Setting 38, the auxiliary axes must be connected through the CNC mill's second RS-232 port (the bottom one) to the rotary servo control unit.

If Setting 38 is set to 1, a C axis is assumed, so you can control the 5th axis by using C address codes in your program. In addition, using Setting 38 allows you to move the C axis with the jog handle on the mill control, and the mill Position display will show the current position of the C axis.

Please consult your VF Operator's manual for more detailed information about auxiliary axes.

Sincerely,

Haas Applications

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Dear Applications:

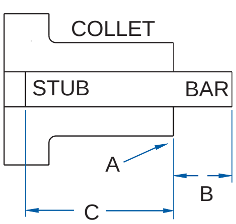
We just got an SL-20 lathe with a Servo Bar 300. I set macro variables 3100, 3101 and 3102 to zero, because a coworker told me I should remove the bar feeder settings so that we won't have any problems with our existing programs. Are these the only variables I need to worry about? Enclosed is the first program I want to run. What else do I need to check or verify before I run it?

Rick Schumacher

Dear Rick:

You're using I, J and K commands on the G105 (Servo Bar Command) line in your program. These IJK codes will override the macro variables, so – although it certainly doesn't hurt – it is not necessary to set the variables to zero.

Please check the numbers in your program, however. Macro variable 3100 corresponds to the letter J, variable 3101 corresponds to the I value, and 3102 is the letter K. Make sure that these values are in the right order.



A = reference position (macro var #3112)
B = initial push length (macro var #3101)
C = minimum clamp length (#3102)

Regardless of whether you use macro variables or IJK values, you still need to use G105 Q4 and G105 Q2 commands to set a reference position. The best method for setting a reference position uses a known location such as the chuck or collet face. Before you begin, check for proper spindle liner size, bar clamp adjustments and transfer tray alignment.

Macro variable #3112, REFERENCE POSITION, is established during setup but is not entered by the operator. Once the reference position is set, it remains the same for any other bar diameter or part length. It only needs to be reset if the bar feeder is moved or if it must be changed to fit a new collet or chuck setup.

You must enter values for the three bar feeder macro variables described below. (You can zero them later if you want to.) You'll find them in the Current Commands display; PAGE DOWN to the "Haas Servo Bar" screen, then use the up or down arrow keys to highlight the variable. Type in the value and press WRITE/ENTER.

#3100, PART LENGTH + CUTOFF, is the bar length pushed out at each G105 command after the bar is loaded. It's equal to finished part length plus cut-off and face clean-up allowance.

#3101, INITIAL PUSH LENGTH, is the distance past the reference position to which each new bar will be pushed when it is loaded.

#3102, MIN CLAMPING LENGTH, is the bar length required to support the length that will be pushed out past the chuck or collet face. This depends on bar diameter, part length and initial push length.

Here are the steps for setting reference position.

1. Enter a value for macro variable #3101.
2. Enter a value for macro variable #3102.
3. Place a bar on the charging tray.
4. In MDI mode, enter G105 Q4 and then press CYCLE START. The machine will load the bar, pushing it into the lathe so the lead end is about 4 inches away from the cutting area.
5. Press RESET, to enable bar feed using the jog handle.
6. Select the V axis by pressing the V key; then press HAND JOG. Using the jog handle, push the bar up to the chuck face or collet face to be used as the reference point.
7. Clamp the bar.
8. In MDI mode, enter G105 Q2 and then press CYCLE START. The machine will use the bar position to enter a value in macro variable #3112, unclamp the bar, push it out by the amount set in variable #3101, and reclamp.

Please read your Servo Bar Operator's Manual for more detailed instructions.

Sincerely,

Haas Applications

finished ninth in the DHL 400 at Michigan Speedway and ninth at Daytona in the Pepsi 400. With 23 races behind him, Vickers is in third place in the rookie standings, 76 points behind Kasey Kahne.

Terry Labonte, a two-time Cup champion, has six top-10 finishes so far; his best showing was a sixth place at Chicagoland Speedway in the Tropicana 400. Labonte is 23rd in the Nextel Cup Series standings through 23 races.

In the Busch Series, rookie Kyle Busch, 19, has proven that age and experience aren't required to be successful; he has won five times on the 2004 Busch Series. At Indianapolis Raceway, Busch won the Kroger 200 by beating Jimmy Sauter to the finish line by 0.896 seconds. "I kept watching my mirror, seeing (Sauter) get closer and closer, and I was like, 'Man, I don't know how I'm going to hold him off,'" Busch said. "So then I just started looking ahead of me and not worrying about the mirror. That's what fixed it right there was not worrying about him, just worrying about my own car and how to get around the race track better."

Busch, who has ten top-five and 14 top-10 finishes this season, also managed to gain ground in the Busch Series championship standings. With 11 races remaining, he sits just 97 points back from points leader Martin Truex Jr.

NHRA

The J&B Motorsports Top Alcohol Funny Car team continued their phenomenal year by winning the K&N Filters Supernationals at legendary Old Bridge Township Raceway Park in June.

"During qualifying, the weather was hot and humid – not at all favorable conditions for racing," said team owner Jeff McGaffic. "But on race day, the fantastic air that is common at Englishtown (New Jersey) returned, which meant that we had to completely change our tune-up from qualifying. Luckily, we made the right decisions and ran consistently fast all race day."

In the second round, the team faced veteran driver Bob Newberry. The J&B Motorsports crew tuned in the Firebird to earn their quickest time of the season thus far, and beat the legend in a great drag race. This set up a semifinal match with current NHRA national points leader Jay Payne. Payne had been gunning for the J&B Motorsports team since the final round at Atlanta, where Paul Lee defeated Payne for his first win. Nevertheless, Lee was ready and ran another consistent 5.67 ET to beat Jay and earn their third final-round berth of the 2004 season

The J&B Motorsports Top Alcohol Funny Car team is currently in seventh place in the NHRA point standings. With three wins in national event competition and two semifinal finishes at the divisional level, Lee and the Firebird have accumulated 413 points.

A Haas CNC lathe that fits through an office door – brilliant idea.

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