THE PUBLICATION FROM MAKINO FOR ADVANCED TECHNIQUES IN AEROSPACE MANUFACTURING

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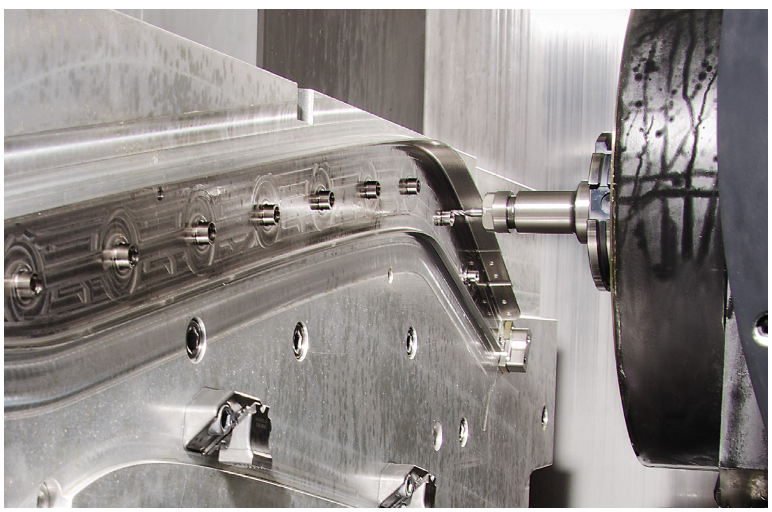

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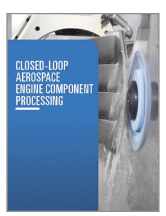

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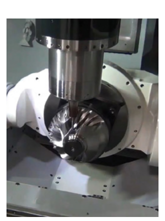

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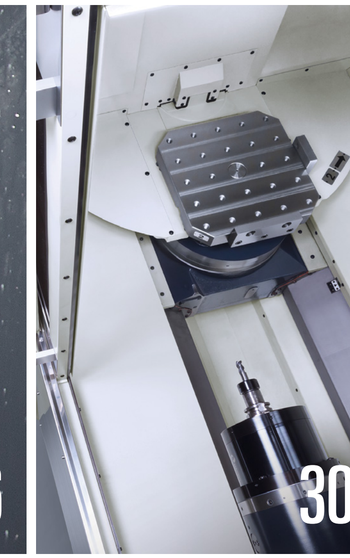

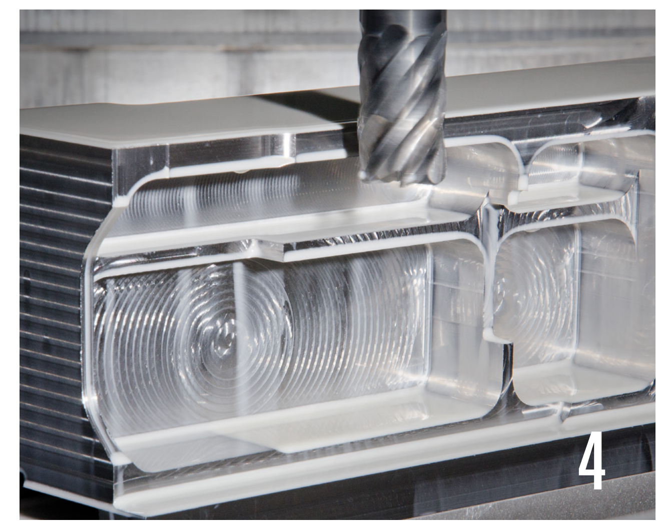

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T1 5-AXIS MILLING MACHINE ADDS FLEXIBILITY TO HARD-METAL MACHINING AT DYNAMIC NC

"In today's aerospace industry, we know we need to use every available advantage to lower our part costs because our customers are counting on us to help them lower their costs," said Jim Gibbs, president of Dynamic NC. "What we do impacts everything moving up the supply chain—a lower cost per part on an aerospace component reduces aircraft costs, which ultimately helps lower prices at the ticket counter so the airline can be more profitable. That means that to competitively produce aviation equipment in North America today, we need every tool at our disposal to thrive. For us, flexible process optimization through advanced technologies has been the big differentiator."

View additional video content at radical-departures.net/dynamicNC

Dynamic NC in Rose Hill, Kan., has a true handle on how to control costs. The builder of structural components for the aerospace industry knows its operating expenses and what kind of impact its equipment can have on an engineer's ability to perfect the production process. It also understands how this ultimately provides the competitive costs necessary to help the company win the next job.

"Counter to popular belief, being a low-cost leader has little to do with investment costs, but has everything to do with life-cycle costs," said Gibbs. "We employ high-performance technology to lower our unit price. With investments in new technologies from Makino, such as our T1 5-axis milling machines, we've been able to cut our cycle times in half, extend tool life and reduce labor hours, providing our customers with the lowest achievable part costs in challenging part applications."

Dynamic NC recently won a bid to machine hard-metal (13-8 stainless steel) 5-axis structural components and needed to purchase equipment to handle this work. Because of the pressures inherent in the aerospace industry, it needed a machine that could help it lower costs for that order.

The high-mix, low-volume production requirements of the aerospace market require manufacturers to maintain a process-oriented mindset at all times. This means continuous process research and development is a necessity, driving demand for flexible technology solutions.

"We've been able to cut our cycle times in half, extend tool life and reduce labor hours, providing our customers with the lowest achievable part costs in challenging part applications."

WEIGHING LONG-TERM PERFORMANCE

Gibbs started Dynamic NC in 2007 to specialize in the production of complex structural aircraft components and engine-mount components. He knew there was a niche for working with hard metals on jobs others didn't want to tackle. Gibbs was optimistic, building the facility to accommodate future growth. And thanks to its mission of providing its customers with the best quality part at the absolute lowest cost, Dynamic NC has doubled its sales each year since it began.

The company went in search of the equipment that would best fit the package.

"We do a lot of research to determine how to lower costs," said Kyle Gakeler, director of operations at Dynamic NC. "While we wanted technology to achieve greater flexibility in hard-metal machining applications, we also wanted equipment that would keep costs low through improved cycle times, greater perishable tool life, equipment reliability and reduced labor."

"When researching machine technologies, we have little interest in comparing equipment based purely on price and specifications. We want to know about the actual long-term performance, associated costs and process flexibility. It doesn't matter what the machine can do, but what we can do with the machine," said Gakeler.

"In our industry they used to have a saying, 'Good, cheap and fast—pick two.' But you can't do that anymore," said Gibbs. "To be cost-effective, you have to provide all three. Good refers to the quality, which has to be there. And fast and cheap go together because the faster you can make a part, the cheaper it is. We needed a machine that could accomplish all of this, and a high-performance machining center typically has a design and construction that improve key aspects of operation, including cycle time, tool life, part quality and reliability."

Mike Jones, director of engineering at Dynamic NC, agrees. "We believe you get what you pay for. Sure, we could spend less money on another machine, but that equipment would be more labor intensive, have longer run times and the efficient process would not be there. All of that translates to higher costs, which leads to fewer contracts and a smaller bottom line. It makes more sense for us to spend money on a high-performance machine that delivers quality parts in a shorter cycle time. All worries are eliminated concerning waste, labor, repair, downtime, tooling and maintenance—these are the hidden costs of ownership that factor into the overall purchase price. Many companies don't even consider these up front like we do."

NEW TECHNOLOGY DRIVES DOWN COSTS

In 2013, Dynamic NC purchased a Makino a92 horizontal machining center and F9 vertical machining center to begin introducing hard-metal applications into its production environment while expanding on current capabilities as well. That experience, along with Makino's reputable presence in the Wichita area, factored into the company's decision about new equipment for its hard-metal machining applications.

"Makino is highly regarded with our customers," said Gibbs. "We believe them to be in the upper echelon of machine tool builders in the U.S. We were already familiar with Makino from our own machining experience, and a few of us had worked with the Makino MAG-Series and T2 horizontal machining centers at previous companies. So we felt that the T1 5-axis milling machine would deliver the quality and reliability we needed for this job. In early 2014, we purchased the first two T1 machines sold in North America to use for our hard-metal machining [13-8 stainless steel] of 5-axis structural components."

Dynamic NC favored the T1 for the machine's rigidity, stability and unique kinematic structure, which offered a higher degree of flexibility in its process design and labor requirements. The 155-degree tilting A-axis and deep-chest column provide full 5-axis milling capability for parts up to 1,500 mm in diameter. The Z-axis travel and ability to reach way over the table have proven to be very versatile for all of the company's applications.

"We have found that the T1 is all about process flexibility," said Jones. "Part accessibility has been really helpful to us. We always consider kinematics when producing our parts because it helps us be more efficient. It opens up more options on how to machine a part and access part features. The machine's range of motion can help reduce the number of setups. Not only does that reduce labor, but we also know that parts are much more accurate the less they are moved."

Being a very process-oriented culture, Dynamic NC examines the tools it uses in its applications and how best to use them to optimize processes. Engineers recognize that the cost associated with tooling for hard-metal machining isn't cheap, thus tool life is critical to its goal for lowest part costs.

In late 2014, Dynamic purchased two MAG3.EX 5-axis HMCs to begin producing complex monolithic aluminum structural parts.

"A lot of people measure tool life in minutes, but we measure them in hours or days," said Gakeler. "Due to the T1's rigidity and active damping system, we have found that even in hard metals and roughing, we can better predict tool life. We are also able to use a wider variety of tooling that we would not have been able to use in a competitive machine. Even when burying a 1-inch endmill into a part for roughing, there is no vibration whatsoever."

The rigid design, power and accessibility of the T1 machines have enabled Dynamic NC to effectively cut hardened materials without limitation. Gibbs likens their hard-metal machining processes to that of a surgeon, using the exact instruments in the precise manner for efficient and accurate results. "The construction of the T1 provides a solid foundation for fixtures and all other machine components. With this level of stability, we find that cutting titanium is like cutting butter."

The machine's high-pressure, high-volume through-spindle coolant has also been essential in delivering coolant precisely to the cutting zone, effectively cooling the tools while evacuating chips to prevent recutting.

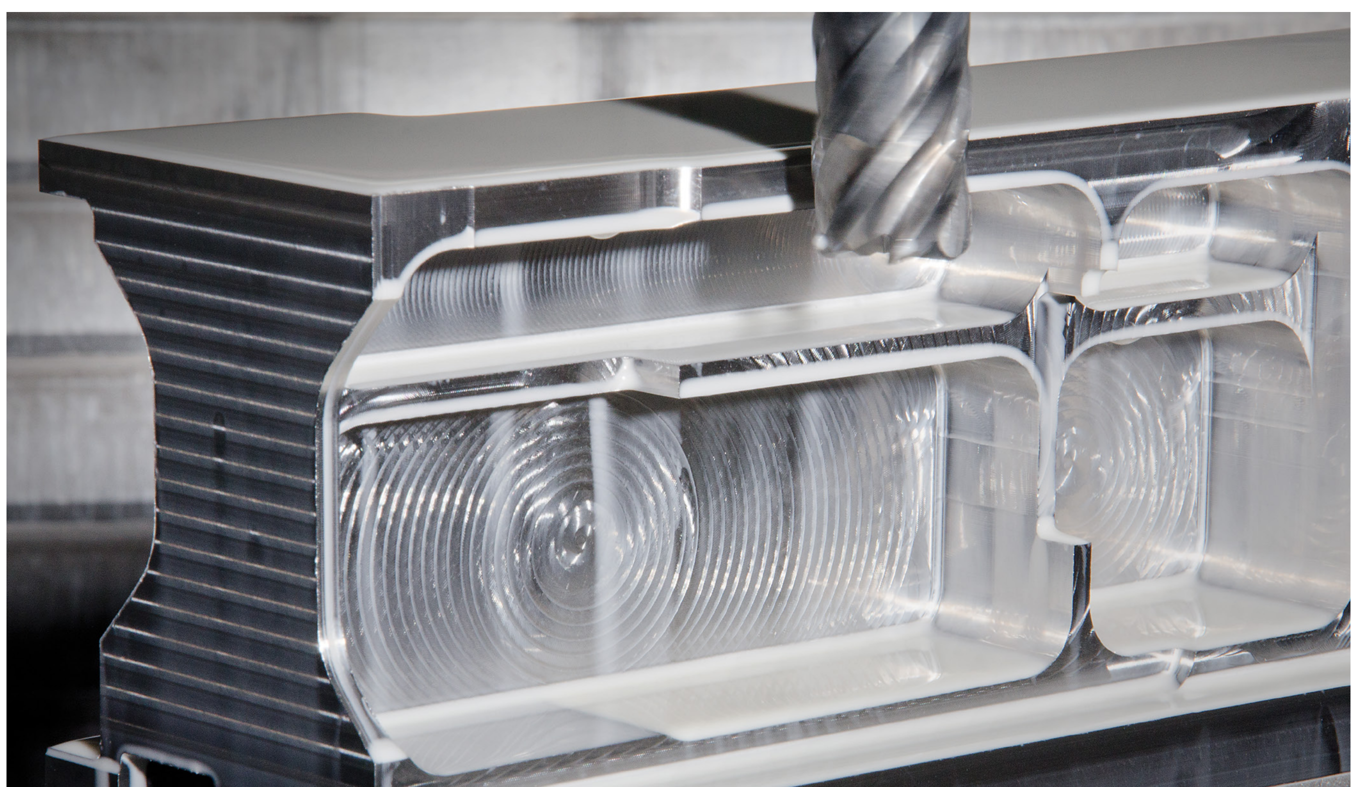
"The T1 gets coolant to the deep pockets, no matter the size of the tools," said Jones. "These features have led to significant improvements in tool life across all applications. The T1 can handle whatever we throw at it. We regularly test the limits of the machine, and the active damping helps the machine adjust itself to the cutting conditions. We get great reliability and virtually no downtime. The capabilities of the machine are beyond comparison to most machine tools out there.

"In fact, recently in a flap-track component, we have achieved a 50 percent reduction in cycle time, five to six times greater tool life and an 80 percent reduction in machining labor with the T1. Similar results have been seen across many of our other applications."

These process capabilities have enabled Dynamic NC to assert itself as the low-cost leader in hard-metal applications.

"For us, it's not about the tool life or productivity," said Gakeler. "It's total cost of the product that's important. What goes into the cost of the product? Capital expenditures, labor and perishable costs. We strive to minimize those. We need quality first in a product, but then the lowest cost is important. If I buy a premium machine that allows me to make parts in five minutes versus 20 minutes, then that is the most cost-effective. It's not about the spec sheet's listing of how much or how fast you remove material. It's about what it actually costs to remove it."

"It's not about the spec sheet's listing of how much or how fast you remove material. It's about what it actually costs to remove it."



MOVING FORWARD WITH THE ENTIRE PACKAGE

Seeking a similar level of flexibility as it had achieved in its hard-metal parts, Dynamic NC also wanted to expand its capabilities into the larger structural aluminum aerospace market. In late 2014, the company purchased two MAG3.EX 5-axis horizontal machining centers to meet these needs.

"The MAG3.EX machines have helped us become an exceptional resource for complex monolithic aluminum aerospace parts," said Gakeler. "We have been able to reduce the total cost of operation, including labor, cycle time and tooling costs. With a competitive machine, the part would have cost more to make. We would have had to perform more setups, and that variation would cause us to produce a lesser-quality part. With the MAG3.EX, we are getting the speed, accuracy, tool variety, chip evacuation and a 33,000-rpm spindle. A lot of machines look like they have the entire package but don't have the spindle speed this machine does."

Gibbs agreed. "I liken it to racing cars. The whole car is a system, and it takes the entire package to make the car go fast. If one part of the system goes down, it's not going fast. The MAG3 has it all—with no limiting factors. I believe that it's the most capable aluminum machine that Makino has. And though we've just put it on our floor, we are looking forward to seeing where it takes us."

The T1 machines' unique kinematic structure provides Dynamic with improved part accessibility that eliminates setups and enables full five-face machining.

"Recently in a flap-track component, we have achieved a 50 percent reduction in cycle time, five to six times greater tool life and an 80 percent reduction in machining labor with the T1."

As Dynamic NC steers its course toward future growth, the success that it has seen with these machines has led it to make plans to add an automated pallet-handling system to the T1 and a92 equipment, and to purchase two more T1 machines. The company also expects to install an MMC2 pallet-handling system across the existing MAG3.EX cell, and to add a third MAG-Series machine in the near future.

"This kind of technology has allowed us to not only reduce costs across the board but to also be the kind of resource that our customers can count on," said Gibbs.

"What matters most to Dynamic NC is building a reputation for taking care of those around us—whether they be customers, colleagues or the local community. For us, it's all about making each day valuable and bringing meaning to what we do. We want to impact lives and reduce the stress on the people we work with by completing quality projects that no one else can at the lowest cost per part," said Gibbs.

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PCX AEROSTRUCTURES

FEEDS GROWTH WITH T1 5-AXIS HMC ADDITION AT CAM-TECH MANUFACTURING DIVISION

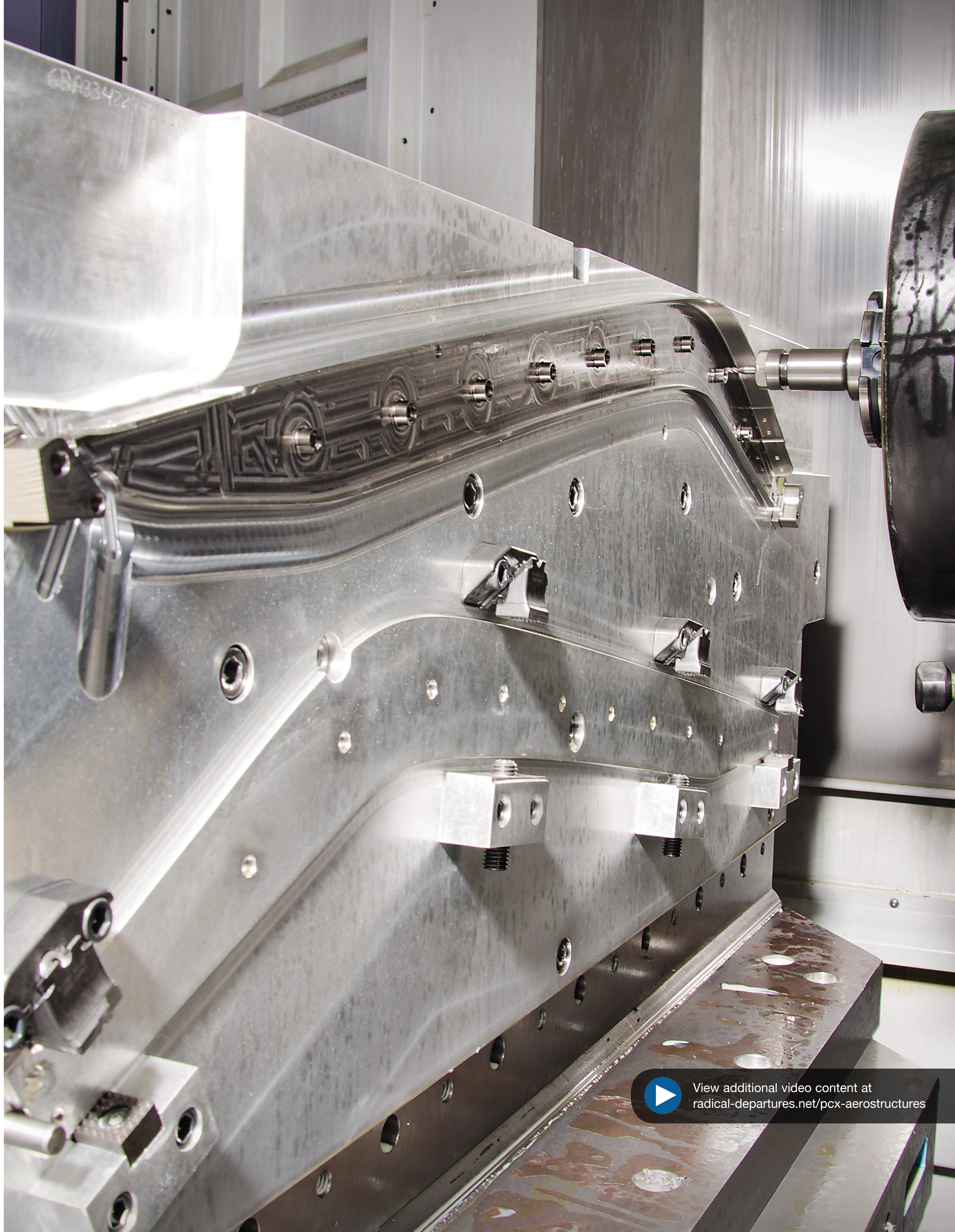
Walk into Cam-Tech Manufacturing's Mansfield, Texas, operation and you can't ignore that the company is poised for growth. The visitors' entrance leads to a mezzanine overlooking the manufacturing floor. Directly in front sits a new Makino T1 5-axis horizontal machining center.

"Sits" is perhaps not the best word to describe a mill that cuts commercial and military aircraft parts from titanium at 12,000 rpm and 32 inches per minute throughout two 10-hour shifts, including Saturdays. Cam-Tech's management strategically located the impressive T1 to ensure it was the first thing seen upon entering the 80,000-square-foot facility—and for good reason.

Precision machining of large structural airframe components is central to the company's strategy to compete for work globally. Not only did the company invest in advanced T1 technology, but they also designed an expansive, state-of-the-art assembly area to support rapid growth as a premier fabricator of wing and fuselage components.

As a supplier to major OEMs and Tier 1 integrators, Cam-Tech caught the eye of Newington, Conn.-based PCX Aerostructures LLC, a global leader in highly engineered, precision machining of complex parts from both aluminum and hard alloys. PCX ultimately acquired Cam-Tech in December 2014, increasing their breadth of services in the aerospace manufacturing arena. It was a perfect fit.

"Our customers are not going to wait for us to develop the capabilities. We've got to be ready when they have opportunities to make a part and parlay that into an entire subassembly," said Trevor Hartman, vice president of sales and marketing for PCX. "The T1 certainly is a great capability. When they see that, our customers in the detail part procurement business understand PCX and Cam-Tech are committed to investing in technology to manufacture parts more cost-effectively and with higher quality."



GROWTH THROUGH ACQUISITION AND INVESTMENT

PCX funded the T1 following its purchase of Cam-Tech, another signal to help convince industry OEMs and Tier 1 suppliers that the combined company is investing to expand its capabilities and to grow with them.

The return on the T1 investment makes Cam-Tech very competitive. Ribs for a Boeing application initially were produced 40 percent faster compared to the company's existing commodity machines. The company worked with engineers from both Makino and Single Source Technologies (SST) to improve tooling, work holding and programming. Ultimately Cam-Tech was able to reduce cycle times by 50 percent.

"PCX looks for a return on our investment in 24 to 36 months. With the programs we're running on the T1 and how well they're running, we're certainly going to realize a payback on the short side of that period," Hartman said.

The company purchased the T1 to produce 28 part varieties, supporting production of three aircraft a month. The OEM has since raised its manufacturing rate to four aircraft a month.

Cam-Tech's ability to machine parts and complete full assemblies in-house provides an advantage to its OEM and Tier 1 customer base.

Purchased initially for precision machining of titanium, the T1 is now used for about 40 percent of the parts Cam-Tech manufactures.

"We were already exceeding our original expectations based on the time studies provided by SST, and now we have the capacity for an additional 25 percent. With the assistance of the Makino applications engineers, we're able to go to an unattended situation to keep the machine continuously running," stated Cam-Tech General Manager Roger Hagger.

SETTING UP FOR MORE GROWTH

About two years ago, Cam-Tech's leaders decided that the way to remain competitive as a supplier of critical structural parts for large commercial aircraft and military contracts was to become a subassembly provider. Parts such as center wing-box frames, blocker doors, leading-edge ribs, bulkheads and fittings would be produced and assembled at Cam-Tech and ultimately shipped to OEM and Tier 1 integration centers.

Cam-Tech subsequently built a 65,000-square-foot building in 2011 and added another 15,000 square feet in 2015 to make room for additional machines and structural assemblies. The employee base grew by 30 percent.

Now operating as a wholly owned subsidiary of PCX Aerostructures, the company invested in Makino's T1, the most advanced equipment they owned that was capable of machining titanium—a hard alloy used in approximately 40 percent of the company's parts.

"PCX brings financial and technological resources for Cam-Tech to become a go-to shop for the aerospace industry for their complex assemblies that other shops have not been able to succeed in. A lot of the parts we have bounced around the world and ended up landing here and stay here because we've got the know-how to get it done. With the right vendor base and the right machine capabilities now, that will continue to happen," Hagger said.

Cam-Tech's leaders teamed up with SST and Makino to leverage the unique features of the T1 to win a Boeing contract for a military jet-door stiffener rib. Hagger visited engineers at Makino's North American headquarters in Mason, Ohio, and traveled to Makino's factory in Japan with Steve Neidigk, the company's local SST representative.

> "PCX looks for a return on our investment in 24 to 36 months. With the programs we're running on the T1 and how well they're running, we're certainly going to realize a payback on the short side of that period."

SST prepared accurate time studies that demonstrated Cam-Tech could produce parts faster and with better quality on one T1 machine versus two of its existing machines. SST and Makino offered engineering application support and on-site training far beyond anything Cam-Tech's team had received from previous machining center providers.

"We didn't want to just buy a machine. We wanted to change processes. We were really looking for a partner to help open our eyes to new technologies and new ways of approaching problems," Hagger said. SST and Makino "really got down to brass tacks with our programmers, explaining this is when to speed up the machine and when to slow it down. SST and the Makino application engineers shared what they've learned about where you can really hog and when you just need to lighten the cuts."

In addition to a week of on-site training included as part of the T1 investment, Cam-Tech opted to purchase an additional two weeks of support, enlisting the expertise of both SST and Makino engineers. Together they assisted shop employees with the initial setup process, fixture implementation and programming adjustments.

"Their big concern was, 'OK, we're buying this great machine, but we are used to doing it this way. We needed a new way.' We brought in Makino's aerospace group to work alongside Cam-Tech's operators and share knowledge about everything from fixturing to programming techniques," Neidigk said. "Cam-Tech had a successful implementation and good success with the T1 because of that engineering support."

HIGH PERFORMANCE; TIGHT TOLERANCES

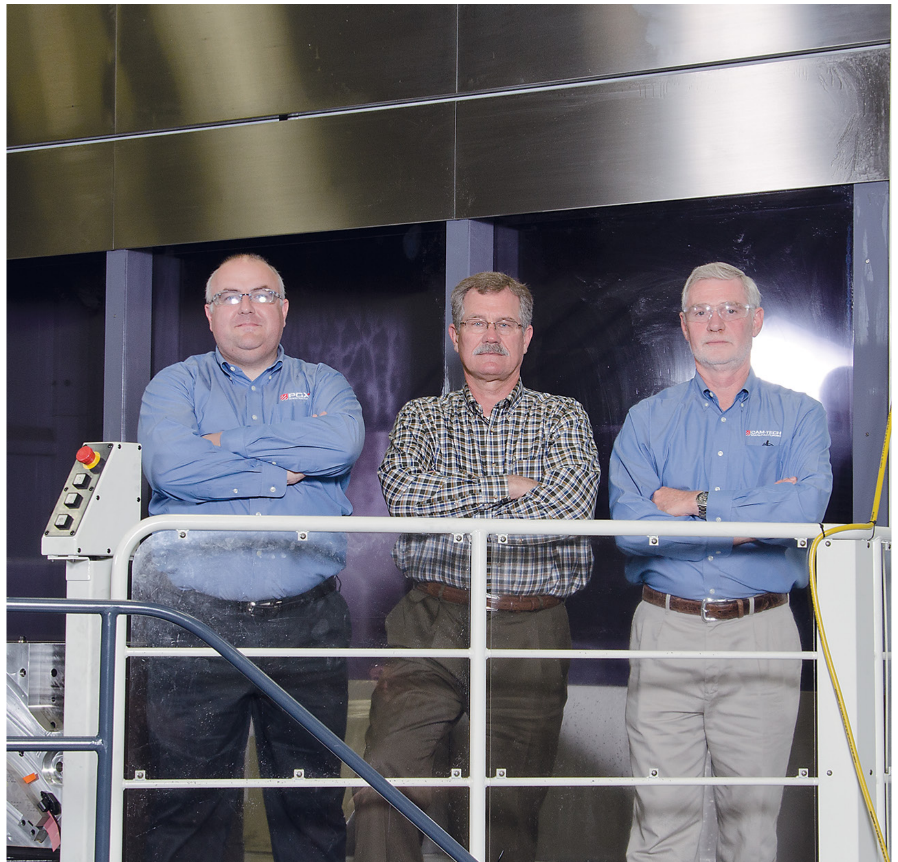
The T1 mills large aircraft structural components with ease, some starting out as titanium billet weighing up to 2,500 pounds. The T1 hogs out as much as 1,600 cubic inches per minute on structural parts for military jets, including one that Cam-Tech had originally produced on one of its commodity machines.

"It took 12 hours to cut the part on existing equipment. On the T1, it takes six hours," Hagger said.

Based on the proven speed and efficiency of the T1, Cam-Tech began transferring numerous jobs over from other machines. Operators didn't change existing programming, but simply moved them from an existing machine onto the T1. As a result, Cam-Tech reduced the cycle time for a complex, thin titanium fuselage component by half, while holding tolerances of plus or minus 0.00014 inch and positional hole tolerances of plus or minus 0.0010 inch.

With the T1's laser-equipped tool setter, Cam-Tech is able to check tool length and automatically replaces worn tools to ensure the highest level of accuracy and finish.

Featured Company: Cam-Tech Manufacturing, LP / A division of PCX Aerostructures / Mansfield, Texas / (817) 583-8820 / camtechaero.com



From left to right: Trevor Hartman, vice president of sales and marketing, PCX Aerostructures; Steve Neidigk, sales engineer, SST; Roger Hagger, vice president, Cam-Tech.

The accuracies evidenced by the T1 also helped Cam-Tech save on inspection costs by requiring only sample testing. The same parts historically produced on the company's existing machines all require inspection because the mills cannot hold the required tolerances with consistency. The T1's laser-equipped tool setter checks tool length and automatically replaces worn cutters and end mills before affecting tolerances and surface finishes. Currently 35 tools are stocked in a 120-tool magazine, with multiple backups for high-usage cutters and finishing tools.

"We have other machines that cut titanium, but the T1 is becoming our go-to machine because it's reliable and accurate, and it's so much faster than anything in our shop now," Hagger said.

MAKE WHAT MATTERS

What matters most to Cam-Tech's leaders is growing their business into a build-to-print shop, manufacturing and assembling large structural components for commercial and military applications. To accomplish that, they're investing in advanced machining technology—and people.

Hagger has made it his mission to reshore work lost to Southeast Asia, because he believes American workers can make aircraft parts competitively with the right equipment and training. The company started in 2000 with 16 workers and six machines in 15,000 square feet. They have now grown to more than 60 employees, 21 machines and 80,000 square feet.

CONTINUED ON BACK COVER

RADICAL DEPARTURES
ADVANCED TECHNIQUES IN AEROSPACE MANUFACTURING

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ALCOA CONQUERS THE COMPLEXITIES OF TITANIUM MACHINING

Remaining a leader in the titanium aerospace market requires continuous improvement to meet customer demands for service, quality, delivery and cost.

For manufacturers to thrive in this market, it is critical for them to steadfastly pursue the best people, processes and technologies. Careful management and integration of these attributes is the key to securing a long-term position within OEM supply chains.

"Aircraft OEMs are looking for ways to simplify their supply chain. They want to work with high-performing, vertically integrated suppliers. Our combination of materials expertise and advanced manufacturing capabilities positions us to succeed in meeting those demands," said Christian Ouimet, managing director of Alcoa's facility in Laval, Quebec, Canada.

A global leader in lightweight metals technology, engineering and manufacturing, Alcoa innovates multi-material solutions that advance the world. The company purchased the Laval manufacturing facility in 2015 as part of its acquisition of RTI International Metals.

With RTI, Alcoa expanded its reach into titanium—the world's fastest-growing aerospace metal—and added advanced technologies and materials capabilities for greater innovation power in aerospace and beyond. High-velocity machining at the Laval facility is one example of how Alcoa's downstream manufacturing processes enable Alcoa's businesses to produce some of the largest, most complex and finished aerospace components without having to outsource any part of the process. And that makes customers' lives simpler and saves costs.

ESTABLISHED LEADERSHIP IN TITANIUM MACHINING

The Laval facility is part of the company's Alcoa Titanium & Engineered Products (ATEP) business unit, which supplies advanced titanium and other specialty metals, products and services to the commercial aerospace, defense, and oil and gas markets. Alcoa's aerospace businesses, including ATEP Laval, will form part of the value-add company, to be named Arconic, following Alcoa's separation in the second half of 2016. Arconic will be a premier innovator of high-performance, multi-material products and solutions in attractive growth markets, including aerospace.

ATEP Laval specializes in the precision machining and assembly of complex titanium aircraft components, such as seat tracks, body chords, spars, doorframes and wing attachment components, for the likes of Airbus, Boeing and Bombardier.

Due to titanium's unique material properties, it is widely recognized as a material that is challenging to machine cost-effectively. However, ATEP Laval identified titanium-engineered products as a significant growth market. For more than a decade, the facility has been recognized as an established expert in the field.

"Early machine-tool investments helped us break ground within the titanium market, but increasing customer demands for cost reductions and faster delivery soon required us to take a new approach to titanium machining," said Ouimet. "General-purpose machine platforms were unable to provide the rigidity, flexibility or control necessary to fully optimize our processes. The Makino T-Series machines provided us with a purpose-built solution for titanium that has enabled us to reduce cycle times by more than 60 percent while simultaneously reducing tool costs by 30 percent or more."

PURPOSE-BUILT FOR TITANIUM MACHINING

Prior to its strategic pivot toward titanium-engineered products, the Laval facility primarily focused on the machining of large aluminum aircraft structural components. Investments in several Makino MAG-Series machines had been made to mirror the type of aluminum machining technology used by OEMs. So when ATEP Laval began exploring titanium machining technologies, this familiarity with Makino equipment led the company to explore Makino further, in addition to several other machine suppliers.

ATEP Laval's acquisition of Makino T-Series machines has enabled the company to reduce cycle times by more than 60 percent while simultaneously reducing tool costs by 30 percent or more.

To meet customers' demand for cost reductions, ATEP Laval continuously optimizes process through new tooling and real-time machine process monitoring.

"Around this time period, Makino was launching its first T-Series machine, the T4," said Christian Perry, CNC programmer team leader, technical services, at ATEP Laval. "They invited us to visit their manufacturing facility in Japan to see how the machine was designed and built, which was an eye-opening experience. The cutting demonstrations featured parts similar to those we were producing, and the quality was outstanding."

After returning from Japan, ATEP Laval began working with Makino to perform a series of test cuts on the T4 using two of its current production applications. Research engineers from ATEP Laval and Makino worked side by side in Makino's Mason, Ohio, facility to optimize processing methods and explore the features of the machine. Together, they produced a stable process that was nearly three times faster than the company's previous methods.

> "Working closely with Makino's titanium research and development team gave us confidence in the abilities of the equipment to deliver on the promises of performance that we make to our customers."

ATEP Laval's selection of machine suppliers involved a close evaluation of full life-cycle costs amortized over the duration of the contract. Through test-cut results, the company determined that the T4 was the best investment to offset costs while maintaining requirements for quality and delivery. According to Christian Sauvé, vice president and general manager, engineered products, ATEP, the benefits of acquiring a machine that could improve processes and avoid any non-quality costs outweighed the burdens of the long-term investment.

"Working closely with Makino's titanium research and development team gave us confidence in the abilities of the equipment to deliver on the promises of performance that we make to our customers. The test procedures were a good exercise in demonstrating the capabilities of the equipment and gaining a clear return on investment," Sauvé said.

Since its initial T4 acquisition, the Laval facility has expanded its titanium machining investments with a second T4 and the smaller T2 model. The company is also currently investing in a late-2016 delivery of the first-ever T5 machine to support production of some larger titanium doorframe components.

VALUE-ADDED BENEFITS

As OEMs seek to simplify their supply chains, Alcoa is well positioned to add value to the supply chain.

"ATEP is a fully integrated supplier of titanium and other specialty metals products, with the capabilities to deliver a complete solution from raw material to finished part," said Sauvé. "Customers that are in the process of consolidating their supply chains will bring us parts from other suppliers, where they have been struggling with getting parts that consistently meet quality requirements. We've been very successful at getting good parts right from the beginning. It's a mix of our engineering approach, having a solid team, and investing in the right equipment to face the challenge and deliver a good product."

> "A lot of manufacturers pretend that they can machine titanium, but to understand how titanium behaves and how to efficiently machine the material is something completely different."

Featured from left to right: Christian Ouimet, managing director of machining and integrated structures operations; Patrick Deschenes, CNC programmer; Christian Perry, CNC programmer team leader, technical services.

ATEP Laval is one of Alcoa's largest and most extensive machining operations. The facility shares knowledge and efficiencies with other Alcoa facilities, enhancing the company's overall capabilities and enabling Alcoa to conquer the complexities of titanium machining on a global scale.

"A lot of manufacturers claim they can machine titanium, but to understand how titanium behaves and how to efficiently machine the material is something completely different," said Louis Marc Pinard, director, strategic planning and business development at ATEP Laval. "That's where we make a difference. We work with titanium from raw material to finished part and understand the material intimately. We have a team of engineers, machinery and suppliers that we are proud to put in front of customers."

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- Real-Time Machine, Process Control and Data Management

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A RICH HISTORY OF MANUFACTURING EXCELLENCE AND INGENUITY

Through decades of transformation, ATEP Laval has built a reputation for superior customer service that continues today and is the foundation for a bright future.

Originally founded in Saint-Leonard, Quebec, Canada, as Claro Precision in 1966, ATEP Laval possesses a rich team history in the manufacturing, assembly and finishing of aerospace components. These capabilities expanded in 2004, when RTI International Metals, a leading producer of titanium mill products and fabricated metal components for the global market, acquired the company. As part of RTI, the company set forth on a strategic path to become a leader in advanced titanium and other specialty metals products and services for the commercial aerospace, defense, oil and gas, and medical products markets. The company's success in these markets brought tremendous growth, including the construction of a new, expanded machining facility in Laval.

When Alcoa acquired RTI in 2015, the acquisition expanded Alcoa's advanced manufacturing technologies and materials capabilities for greater innovation in aerospace and beyond.

Laval is part of the company's Alcoa Titanium & Engineered Products (ATEP) business unit. It is one of five ATEP facilities across three countries providing expertise in machining and extrusions. This combination of extrusions know-how and machining expertise has helped deliver solutions that reduce cost and lead-time for Alcoa's customers.

Today, ATEP Laval carries forward its tradition of excellence, combining the ingenuity of its people with cutting-edge, advanced manufacturing to deliver quality, highly engineered products that ensure customer success. The 180,000-square-foot facility and its 290-plus team members were named an Alcoa "Machining Center of Excellence" for exceptional performance in the precision-machining and assembly of titanium, aluminum and other specialty metals parts and components, and for providing machining expertise and support to other business units. Components produced at ATEP Laval fly on the world's most advanced aerospace platforms, including the Boeing 787, Airbus A350 and Bombardier C Series.

Alcoa is on track to separate into two industry-leading, publicly traded companies in the second half of 2016. The upstream company will operate under the Alcoa name; and Alcoa's aerospace businesses, which include ATEP Laval, will form part of the value-add company, to be called Arconic. Arconic will be a premier innovator of high-performance, multi-material products and solutions in attractive growth markets, including aerospace.

WHEN PRECISION MATTERS, DELIVER IT WITH ADVANCED LASER-EDM COMBO

By Brian Pfluger, Makino EDM Product Manager
and Jacques Coderre, Synova U.S. Sales Manager

As aerospace manufacturers strive to improve engine performance and reduce fuel consumption, they need high-quality hole drilling on turbine engine components.

New jet engines are designed to operate at higher temperatures, which places greater importance on cooling film hole airflow. To minimize hot spots in the engine during operation, designers increase the number of cooling holes with complex geometries for improved airflow. Special ceramic thermal coatings also insulate the alloy turbine parts from extreme heat. Moreover, new materials are being introduced that improve engine performance and longevity—all of which present additional challenges to traditional hole-drilling approaches.

To meet these demanding requirements, a revolutionary system combines laser-cutting technology guided by a water jet with advanced, high-speed electrical discharge machining (EDM) in an automated cell to precisely drill pre-coated blades and vanes.

WHAT'S NEEDED: HIGH-EFFICIENCY, METALLURGICAL QUALITY

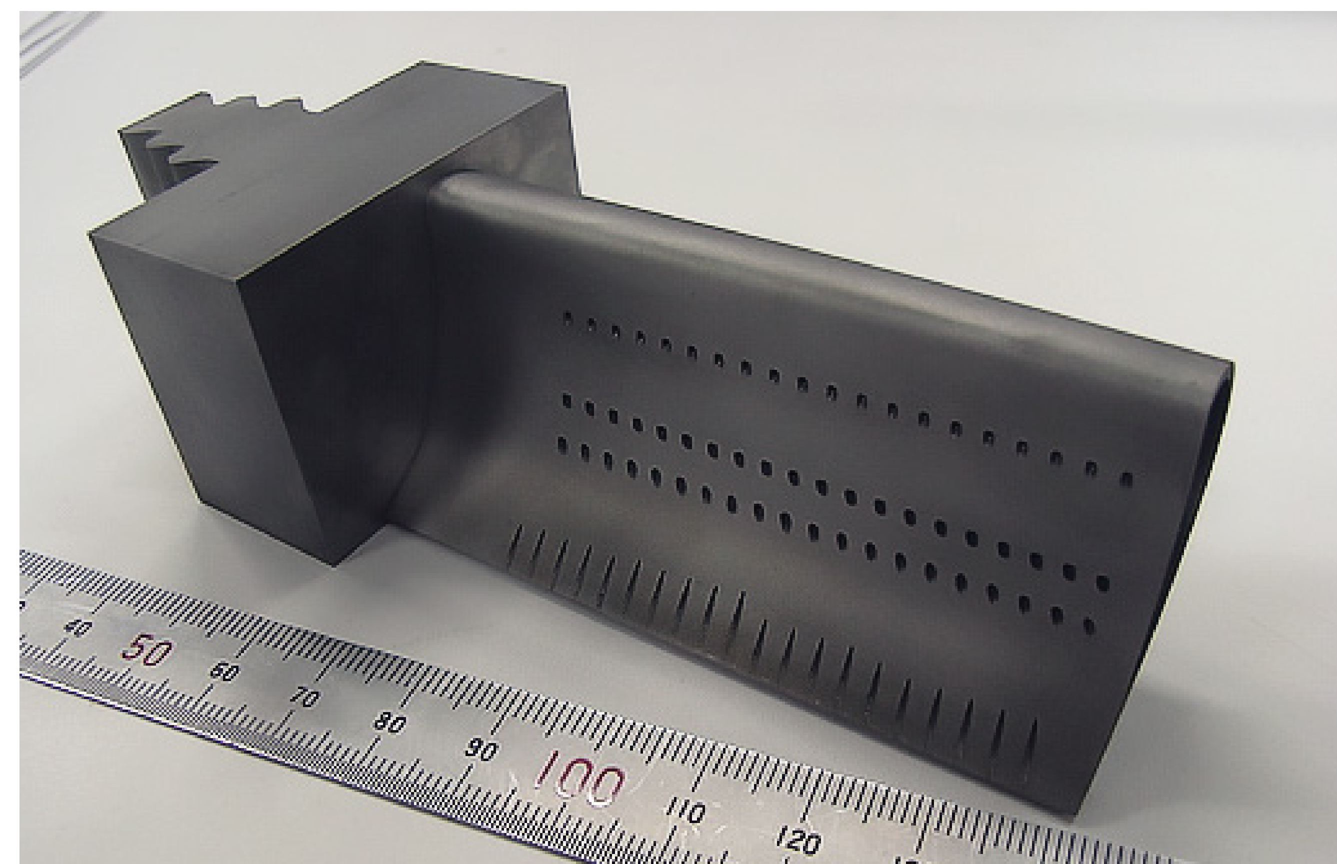
Although the use of round cooling holes is prevalent, aerospace designers increasingly use more complex geometries such as diffuser holes. To enhance airflow, diffuser holes vary in shapes and depth in order to blend into the 3-D shape of part details. Their geometries can range from tapered, round cones to squares or rectangles. The final through hole is often not centered to the outer diffuser shape.

In aerospace turbine parts, metallurgical quality is critical. Two areas can impact the operating life cycle of the engine component:

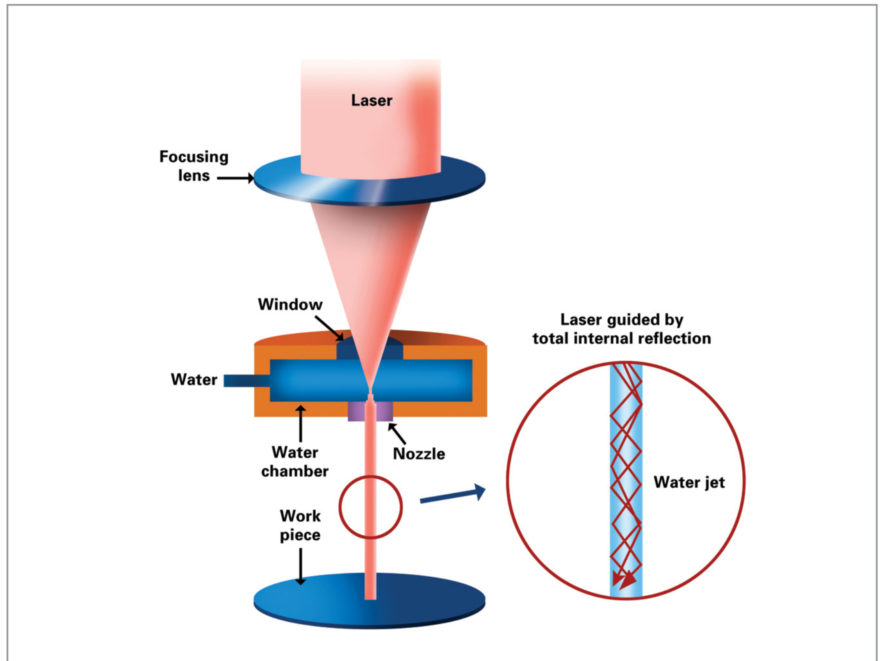
- The recast layer is formed by molten material that adheres to the part during machining.
- The heat-affected zone alters the microstructure of the base material by heating as the result of machining.

To address these concerns about overall efficiency and metallurgical quality, hole-drilling processes require maximization of machining speed while improving control of the machining depth and location accuracy of each detail. Machining of the cooling film hole features is commonly performed before the ceramic thermal coating is applied, as the EDM process cannot machine the coating material. This means the features have to be EDM machined to an estimated larger size to accommodate the thickness of the final thermal coating. Such a traditional processing method may not provide the best possible cooling film-hole accuracy or location, which can result in lost engine performance and efficiency.

In response, Makino and Synova developed an automated cell comprised of Synova's Laser MicroJet® MCS-500 series of 3- and 5-axis cutting machines along with Makino's EDBV3 and EDBV8 EDM hole-drilling machines that process a pre-coated blade or vane detail. The laser system cuts diffuser shapes in the coating



Diffuser hole sizes and shapes can vary. Typical values are 0.060 inches by 0.032 inches by 0.040 inches deep (1.5mm by 0.8mm by 1.0mm), with a final 0.020-inch (0.5mm) through hole.



Synova's Laser MicroJet guides a cylindrical laser beam along a hair-thin water jet, resulting in perfectly parallel walls, tight kerf widths, smooth sawing surfaces and sharp edges.

layer, and the EDM is used to drill the through holes. The EDBV system has an innovative solution to handle difficult-to-image "non-line-of-sight" holes. A sophisticated data-transfer scheme is also part of the cell, enabling high-accuracy hole drilling on both machines to produce complete components.

"The Laser MicroJet offers unique laser-cutting capabilities that complement our extensive machining and engineering portfolios. For example, coupling it with our EDBV series of EDM machines enables users to drill a complete blade with optimum output, including the drilling of non-line-of-sight holes," said Mark Logan, director of Makino/SST (Single Source Technologies).

HIGH PRECISION: SYNOVA'S LASER MICROJET® FOR COMPLEX PARTS

Synova's Laser MicroJet MCS-500 machines guide a cylindrical laser beam along a hair-thin water jet, resulting in perfectly parallel walls, tight kerf widths, smooth sawing surfaces and sharp edges. The technology has been used successfully for more than a decade for high-quality and high-precision micromachining of complex parts across a wide range of market segments. More recently, 5-axis machining systems have been developed to address needs in hole drilling in turbine machinery.

The water jet eliminates the complexity and process variations of maintaining the laser in focus typically associated with laser systems. Using water to guide the laser to a workpiece yields the following advantages:

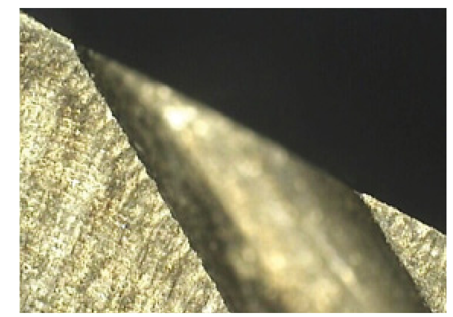
- Water guides the laser – The application becomes insensitive to the focal plane of the laser. A cylindrical laser beam is created, resulting in perfectly parallel walls, tight kerf widths and enabling the user to cut thick or non-flat parts, without having to worry about being in focus.
- Water cools the material – Heat is generated during laser ablation. When using a conventional laser system, the surrounding material absorbs a lot of the laser energy, creating an unwanted heat-affected zone. With the Laser MicroJet, much of the energy dissipates into the water. There is little heat-affected zone on the workpiece. Stress-induced conditions such as micro-cracking, thermal damage or deformation are greatly reduced.
- Water cleans the surface – When using a conventional laser, a portion of a laser-ablated material tends to redeposit and solidify, creating unwanted slag. With Laser MicroJet, the water displaces that material before it solidifies, translating into a much cleaner entrance, wall and exit surfaces without particle deposition or burrs.

The MCS-500 laser system offers full 5-axis capability. Synova integrates its Laser MicroJet system in a base machine manufactured by Makino. The resulting MCS-500 offers high-accuracy 3-D micromachining for a wide range of applications.

The MCS-500 offers high-accuracy 3-D micromachining for a wide range of applications.

MAKINO'S EDM SOLUTION FOR HOLE DRILLING

The drilling of diffuser shapes on Makino EDBV3 or EDBV8 EDM machines is performed using a tube electrode for the final through hole. If needed, a contouring tool-path pattern, similar to that of a milling process, can be used to machine funnel diffuser shapes. To accomplish this, the process involves performing a series of changing X- and Y-axis contours while stepping down in the Z-axis.



Cutting through thermal barrier coating layers as well as the underlying metal is achieved in a single step accomplished with the MCS 500 Laser MicroJet.

Blade and vane components, which are commonly casted, typically feature a hollow interior for saving weight and increasing the internal airflow. During the EDM drilling process, the cooling holes break into these internal cavities. To preserve the correct airflow, it is critical that no back wall impingement or back-striking takes place during the drilling process. Back-striking occurs when the drill/electrode comes in contact with the opposite internal cavity wall, which can cause disruptions in airflow and subsequently the cooling efficiency of the engine component.

To ensure best part quality, the EDBV is equipped with advanced control technologies to improve depth accuracy and prevent back-striking. To improve geometric form accuracy, the EDBV uses a highly sensitive dynamic feedback circuit within its electrical generator to sense when the tube electrode is in the correct position for machining. This intelligent processing minimizes the non-value-added "air cut" time that is commonly seen when processing high-engagement angles of 3-D diffuser shapes. The EDBV automatically self-optimizes and increases the machine feed rate when it detects areas of non-machining or air-cut time when processing diffusers. When this occurs, the machine also disables the electrode wear depth compensation, which results in improved 3-D form accuracy.

The EDBV machines also employ dedicated detection circuitry to sense when the electrode penetrates through the material and into the inner cavities of blades or vanes to prevent back-striking. This dedicated detection is achieved through the enhanced generator control and improved flushing that is provided by the EDBV's fully submerged operation. The machine is able to detect breakthrough within 1 second or within 0.040 inch (1.0mm) of depth, allowing for proper levels of quality control and safety while operating at maximum machining speeds.

The EDBV machines are designed around Makino's proven EDM platforms, incorporating a programmable rise-and-fall drop-tank design that has open and easy access for operators or automated equipment. A dielectric water reservoir has been integrated into the base casting of the machine, which saves on valuable floor space and offers greater thermal stability for improved accuracy.

Onboard filtration and resin systems consist of two large-capacity filters and a separate deionization resin cylinder to control water conductivity. These

All EDM drilling on EDBV machines is performed fully submerged under water. This approach enables faster machining speeds, improves part quality, and creates more stable and consistent conditions during cavity wall penetration.

"The Laser MicroJet offers unique laser-cutting capabilities that complement our extensive machining and engineering portfolios. For example, coupling it with our EDBV series of EDM machines enables users to drill a complete blade with optimum output, including the drilling of non-line-of-sight holes."

proven systems ensure consistent water quality, to further enhance the reliability and repeatability of machining results.

All EDM drilling on EDBV machines is performed fully submerged under water. This approach enables faster machining speeds, improves part quality, and creates more stable and consistent conditions during cavity wall penetration. The most significant improvement is seen in the machining speed, which in recent test validation has demonstrated up to 10 times faster processing than conventional technologies.

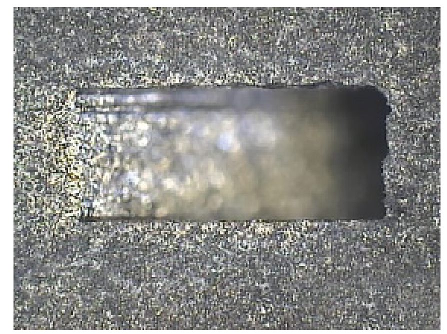
An additional benefit to submerged machining is the elimination of water splashing and potential slip hazards common in other EDM drill designs. To further improve productivity, EDBV machines use a single-electrode processing approach, which avoids the high cost of custom multi-electrode holders and standardizes the tool holders with a more flexible, cost-efficient system.

COMPLEX HOLE DRILLING: TWO MACHINES BETTER THAN ONE

Combining the Synova MCS500 Laser MicroJet with a Makino EDBV3 or EDBV8 in an automated cell leverages the strength of each machine and its underlying technologies to deliver a superior hole-drilling solution. The unique combination of machining processes gives manufacturers new capabilities to produce pre-coated turbine engine components with exacting details that achieve near-perfect levels of engineered cooling airflow. However, it is critical to combine the attributes and capabilities of both machining processes to achieve a reliable, practical solution. Advanced data transfer between the two machines ensures high precision with minimal setup. The result: a flexible automation cell in which work can be shared between laser and EDM machines in an optimum way for each product.

The MCS-500 Laser MicroJet can be used to remove any non-conducting thermal barrier coating, serving as a path to pre-coat parts with a thermal barrier layer. It can also be used as a stand-alone solution for complex piece-cutting applications of non-conductive materials.

The EDBV3 or EDBV8 can be used for drilling through holes, diffusers and also non-line-of-sight holes. The key limitation to the EDM process is that the workpiece surface must be electrically conductive, which has limited the EDM process to the machining of uncoated thermal barrier components.



The MCS-500 can also be used for diffuser shaping, as can be seen in the above photo.

As part features become deeper, the EDM process gains a significant speed advantage over Laser MicroJet.

By combining Makino's breakthrough EDM technology found in the EDBV-Series of machines with Synova's innovative MCS-500 Laser MicroJet, customers benefit from eliminating process steps typically associated with pre-coating drilling. By using each machine for what it does best, an optimum cell throughput is achieved, overall costs are improved and processes are simplified.

CLOSED-LOOP PROCESSING:

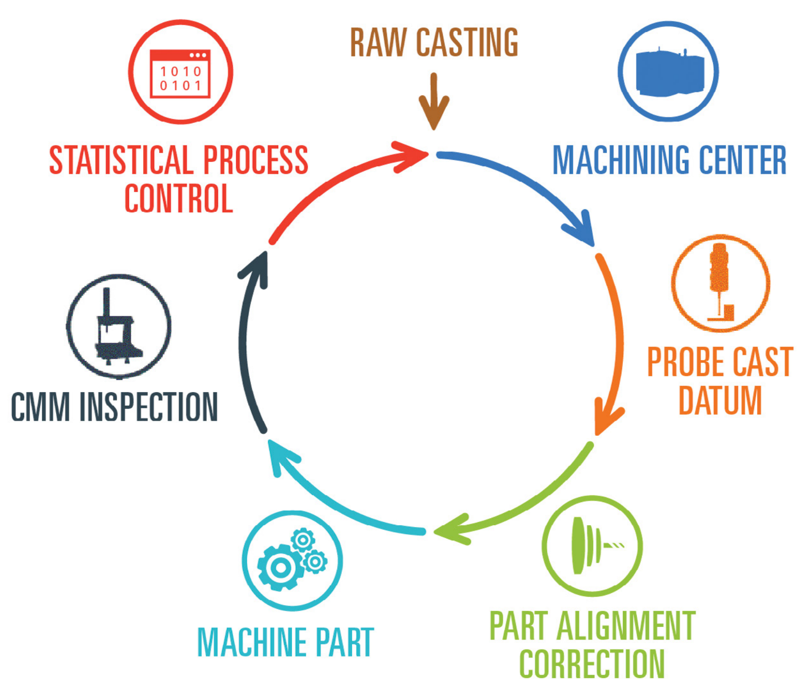
HOW TO IMPROVE JET ENGINE PART QUALITY

By Billy Grobe, Manager of Aero Engine Technology, Makino

As the commercial jet market continues to grow with orders and deliveries at record levels, production rates are soaring to historic highs to satisfy demand and reduce the backlog of aerospace engine orders. To meet these projections, manufacturers are putting equipment in place and proving out processes in advance, all while engaging in full production on the orders already coming through. This environment has led to the growing adoption of closed-loop manufacturing processes to help maintain strict quality and accuracy requirements while making large quantities of aircraft engine parts with little to no scrap.

Closed-loop processing establishes a mechanism that helps manufacturers become more efficient without needing much operator intervention. The quality and accuracy of the parts are improved by correlating between measuring devices and manufacturing devices. The machines communicate and react to each other, correcting any errors and making improvements without human intervention while also keeping the process on track.

Probing to secure a best fit before machining the part ensures quality. Then the data from the probing is processed and checked before loading another part. The feedback that occurs throughout the process creates the closed loop.



THE MOST IMPORTANT DECISION: SELECT THE RIGHT PARTNER

The planning, specification and implementation of closed-loop manufacturing is a complex process, making it crucial for manufacturers to identify a supply chain partner with deep planning and engineering experience in the development of these systems.

A strong supplier must be able to execute a turnkey package, managing the automation, software, mechanical and electrical engineering, and provide localized support. The supplier should be highly experienced in statistical process control and familiar with all critical technologies incorporated within the system, including the machinery, probes, coordinate-measure machines (CMM) and software. By selecting the right supplier, manufacturers can have confidence that the application is programmed and configured appropriately, the process is debugged, and on-site training is provided post-installation.

LAY OUT AND AUTOMATE THE CELL

Next, manufacturers must decide whether to implement a closed-loop process into an automated or non-automated cell.

Automated machining systems have been key to global competitiveness for many manufacturers and are configured to meet a variety of needs across nearly all industries. While the automated systems may have a slightly higher initial cost, they can dynamically improve output at a lower cost per part. In fact, some companies use automation to increase machining efficiency and capacity to gain extra revenue potential, to save direct labor costs and setup times, or to improve quality by eliminating scrap.

In a closed-loop environment, it is important to choose a provider with proven experience in automation. Moreover, when it comes to machine selection, with floor space at a premium in most shops, the automation cell design should optimize square footage. Other considerations to be made include equipment stacking, maintenance access and workflow through the cell.

TEST AND CHECK THE PROCESS

Integrating a closed-loop system requires more than just the right equipment; it demands detailed engineering support before and after equipment installation to conduct testing and process checks.

Process checks should be established during the system design process to manage the quality of parts, and to make sure every part detail and requirement is achievable. Manufacturers should rely on their supplier to provide recommendations on the best machine package and tooling package to meet production requirements, as well as programming of coolant trajectories and development of fixture designs. A quality supplier should be able to help manufacturers model and predict outcomes through proper process and fixture testing, 3-D modeling and time studies.

CONCLUSION

Ultimately, using closed-loop manufacturing technology not only reduces machining time but also increases accuracy and quality. In today's global environment, manufacturers must gain every competitive advantage they can.

The right supplier partnership can make designing and implementing a closed-loop process less complicated. How do you know when you've found the right technology provider? Be sure to ask whether they can provide:

- A single source for engineering and the capability to plan and execute the entire design and implementation process
- Machines that include milling, grinding and electrical discharge machining (EDM), along with 5-axis capability
- Turnkey processes with the reliability and stability to reproduce parts day in and day out with minimal adjustments
- Testing, 3-D modeling and time studies prior to setting up the machine and running parts
- Automation software and hardware that smoothly integrate with your machines
- Monitoring of key machining processes to maintain the closed-loop process

By having the proper resources in place to execute this type of solution, manufacturers can ensure a smooth and accurate process.

Learn more about the process of defining a closed-loop manufacturing process and what to look for when selecting the right supplier in Makino's complimentary white paper, "Closed-Loop Aerospace Engine Component Processing."
Visit makino.com/whitepapers/closedloop

The Newly Updated a51nx and a61nx HMCs: BETTER PRODUCTIVITY, BETTER VALUE

What happens when you take a top-performing horizontal machining platform and make enhancements? You have the opportunity to expand upon its best features for unmatched productivity and performance.

That's exactly what has been done with the newly updated Makino a51nx and a61nx horizontal machining centers. The familiar highly rigid casting and axis design of these industry-leading machines remains in the bed, column, table, linear guides and ballscrews. What has been improved are the machines' expanding list of technology features, including increased spindle torque, innovative tool monitoring and advanced motion controls. These and other productivity improvements, such as the new Professional 6 control and better ergonomics, have been added to improve productivity and reliability at no additional cost.

"When it comes to uptime, reliability and productivity, aerospace manufacturers won't find a more robust set of horizontal machining centers," said David Ward, horizontal product line manager at Makino.

HIGH-TORQUE, HIGH-POWER SPINDLES

Industry-leading spindle reliability continues with the new a51nx and a61nx models, featuring a standard 14,000-rpm (30 kW) spindle that has been upgraded to deliver 303Nm of duty-rated torque. This enables the machines to accelerate and decelerate from full rpm in 17 percent less time. When compared to previous models, the additional torque reduces rigid tapping time by 20 to 25 percent per hole. Large-diameter angular contact bearings ensure the highest level of rigidity for a variety of applications and processes.

An optional 24,000-rpm (80/60 kW) spindle is available on the a61nx model for extremely high metal-removal rates in aluminum structural aerospace parts. A new 20,000-rpm (30/18 kW) spindle with direct inject air-oil lubrication is also available, providing improved reliability and greater power for enhanced productivity.

REDUCING NONPRODUCTIVE TIME

Several enhancements have been made to reduce non-cut time on the new a51nx and a61nx machines. A vision-type broken-tool sensor (Vision B.T.S.) comes standard, supporting unattended operation by quickly validating the condition of cutting tools after each tool change. By creating a silhouette of the cutting tools, Vision B.T.S. is also able to detect the length, size and approximate weight of the tool. This information can then be applied to automatically set the tool-change speed to the appropriate setting (fast, medium or slow). The Vision B.T.S. system has fewer moving parts and requires no physical contact with the cutting tool, allowing for enhanced long-term reliability and less risk of chipping delicate tool materials, such as polycrystalline diamond (PCD).

Inertia active control (IAC) technology has also been expanded on the updated a51nx and a61nx machines to provide additional efficiency. In addition to optimizing positioning motion of the rotational B-axis, IAC technology is now able to improve acceleration and deceleration rates along the Z-axis. This is important for improving productivity because the Z-axis moves more than any other axis during the cutting process. IAC has also been added to the rotation of the ring-type tool magazine. Each time tools are loaded into the magazine, IAC quickly evaluates the total weight held in the ring. Acceleration of the ring rotation is then adjusted to match the total load. Faster ring acceleration means reduced tool-magazine seek times.

PROFESSIONAL 6 CONTROL

The Professional 6 (Pro6) control on the updated machines is designed to move operators fluidly through machine setup, empower them with easily accessible information and protect them with enhanced safety. Cycle-time saving and dynamic-control capabilities have been added to the new control's Geometric Intelligence (GI) functions to help lower costs per part.

With a perfect blend of the proven stability of the FANUC hardware and Microsoft Windows Embedded Standard 7 OS, the cutting-edge Pro6 offers these benefits:

- Streamlined operation – The screen layout matches the operator's process flow from setup to production.
- Operator assistance – Guidance functions, parameters, code and manual search function are available on screen to provide assistance when and where it's needed.
- Fully equipped – Thousands of dollars of options are now standard on Pro6, making it ready for any job.

- Productivity focus – New functions raise the standard for machine control, including its GI, which provides 2-D corner control and optimized canned cycle indexing.
- Enhanced safety – Dual-check safety (DCS), 3-D graphic viewer, maintenance screens and easy access to machine information are included.

Two forms of advanced motion-control GI are included with the Professional 6 control. GI Drilling is a unique G-code drilling cycle that allows the spindle and tool to arc from hole to hole instead of following a square path. This simple change reduces non-cut time by as much as 15 percent on common hole-pattern drilling. GI Milling, the second new, advanced motion control, is designed to improve performance in 2-D milling. GI Milling lets the user define a corner rounding tolerance on each milling path. Even a small tolerance enables the machine to quickly flow through the cut path, completing milling paths in less time. On complex 2-D paths, testing has shown cut time reductions as high as 35 percent. Not every tool will use these new features, but on typical production components the advanced motion control GI is reducing overall cycle time by 3 to 8 percent. This provides substantial cost reductions in both high-volume and low-volume production environments. In a high-volume production environment, that degree of cycle-time saving can reduce the number of spindles required. Reduced cycle times open up machine availability, enabling lower volume manufacturers to take on more work.

OPERATOR ENHANCEMENTS

The exterior of the machines has evolved in an effort to make maintaining the machine easier for the operator. The new L-shaped door, when open, allows more light to enter the machine and prevents fluid from dripping onto the operator during inspection and maintenance. The wide opening on the pallet-loading station (PLS) doors provides easy access for loading of fixtures and large workpieces. This type of accessibility is crucial for part loading and unloading in robot automated environments.

Chip and coolant management has been improved with the addition of a standard hydro-cyclonic filtration system. This system cleans coolant down to a 20μm level, extending the maintenance life of the coolant.

MAKINO

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Cam-Tech's goal is to build another 40,000 square feet to add assembly capability, more machining centers and another 40 employees. The addition is designed to house component subassembly for projects now in development for business-class jets from Embraer and Gulfstream. This expected growth relies on the performance of the existing T1 and the addition of two Makino MAG3.H horizontal machining centers. Built for high-productivity machining of complex aluminum parts, the MAG machines are going to share a linear pallet pool system—as Cam-Tech adds automation for the first time.

"We've designed the expansion of our facility in Texas to accommodate large aerospace subassemblies. We're trying to stay ahead of the needs of our customers with capability that they're hopefully going to help us fill up," said Hartman.