THE PUBLICATION FROM MAKINO FOR ADVANCED TECHNIQUES IN AEROSPACE MANUFACTURING

RADICAL DEPARTURES

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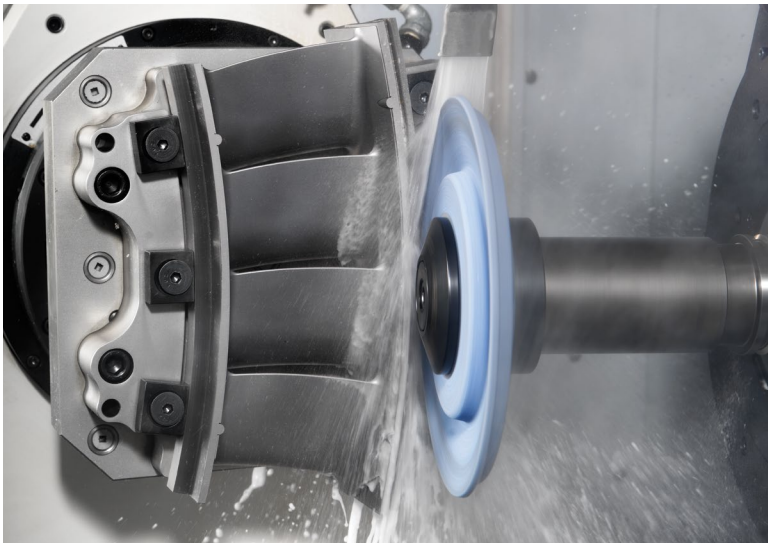
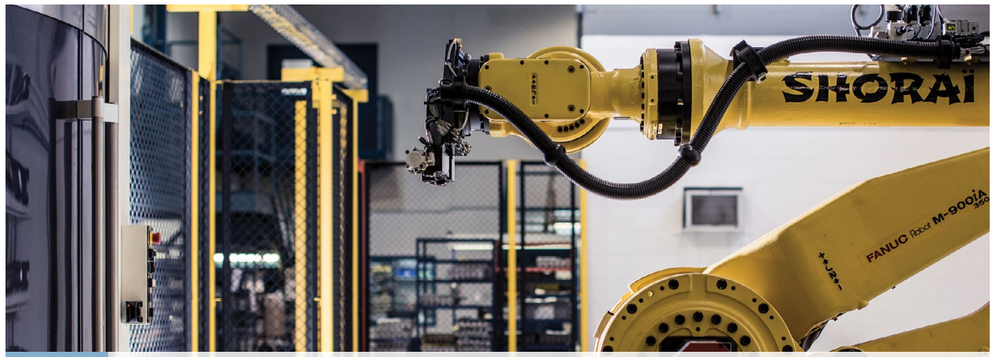
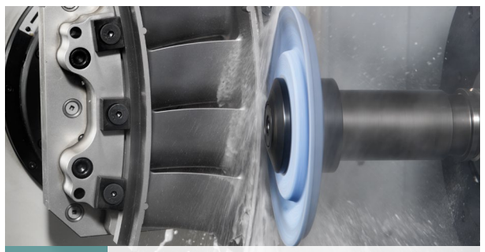


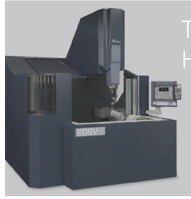
- ABIPA CANADA FORMULATES COMPETITIVE FUTURE
- FORECAST FOR GLOBAL AVIATION SOARS
- NEW GROUP ESTABLISHED TO DEVELOP AEROSPACE ENGINE MACHINING PROCESSES

CONTENTS

VOL.12 / NO.1







TECHNI-GRIP™ WORK-HOLDING SYSTEMS

Techni-Grip™ Work-holding Streamlines Workflow and Production

Years ago, Techni-Grip was established within an aerospace manufacturing facility that was trying to solve a number of internal work-holding challenges inherent to CNC mill work. Some of these situations included part stability when in the cut, dimensional repeatability, reducing raw material requirements for work-holding purposes, running multiple workpieces on the same fixture, reducing set time with quick change through repeatable locating and the ability to swap fixtures from machine to machine without complications.

To solve these problems, Techni-Grip came up with a work-holding system having a pin-and-hole design that would enable consistent positive location and that works by centering two 60-degree dovetails on the locating pin. The dovetail cut provides exceptional gripping strength with minimal clamping pressure. By minimizing material requirements to hold a workpiece and by reducing clamping pressure typically needed for traditional vises, Techni-Grip decreases the likelihood of material distortion and reduces scrap rates from parts coming loose.

Varying clamping points on the Techni-Grip system allow a much broader range of raw stock that a single fixture can hold, and enable multiple operations and various parts to be set up on a single fixture. This flexibility contributes to more versatility and the ability for this product to be applied to a variety of applications. The centered locating pins also let customers easily move a job from one fixture to the next, or one machine to the next, with consistent and repeatable positive location. This solution is made possible because all of the Techni-Grip systems use the same self-centering dovetail clamps and locating pins with equal distances. This pin-and-hole design ultimately reduces setup times and has been shown to provide up to 57 percent reduction in direct machining and fixturing costs.

> "The Techni-Grip system simplified my job by reducing obstacles in toolpaths ... Our tooling design requirements have been reduced by 80 percent. I wish I had this 10 years ago."

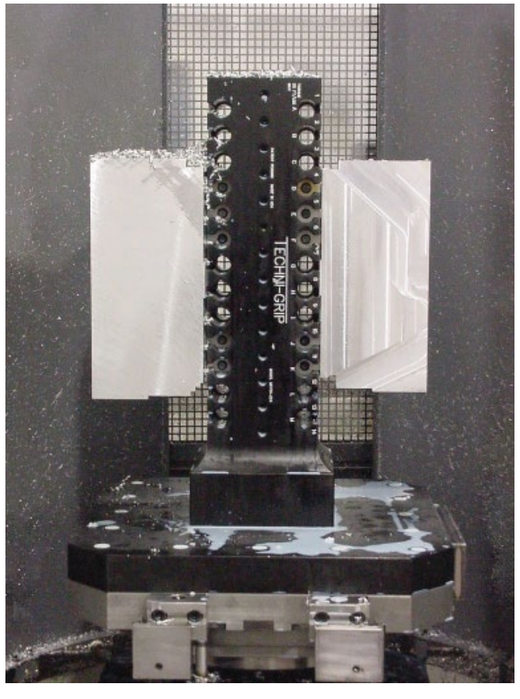
The dovetail clamps and locating pins protrude 0.085 inch above the base. In most cases, it is recommended that only 0.125 inch of excess stock be required to hold even large parts, with some applications using as little as 0.100 inch. This leaves 0.015- to 0.040-inch clearance between the bottom of the material to the top of the clamps and pins, reducing obstacles in the toolpath and allowing the part to be milled completely through in one operation without ever coming in contact with the clamps and pins. Unlike a fixture with a fixed dovetail, if a mistake is made where the endmill comes in contact with a clamp, Techni-Grip's unique self-centering feature allows for individual clamp assemblies to be replaced, as opposed to having to replace the whole fixture.

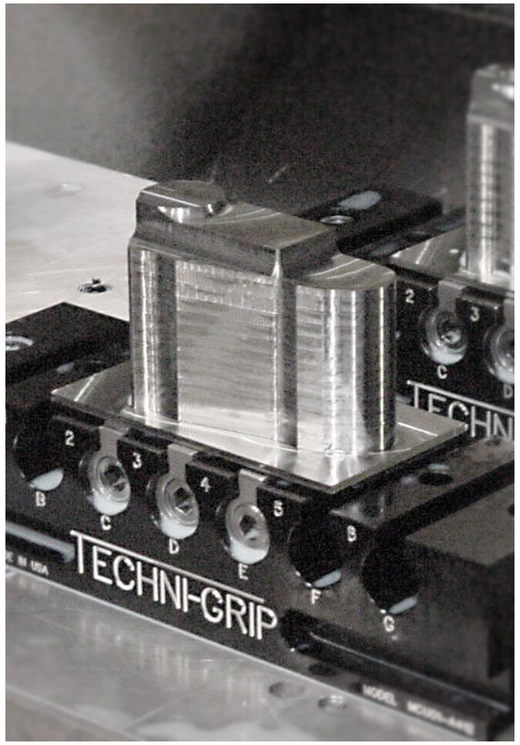
Lean manufacturing environments appreciate the standardized processes afforded by the Techni-Grip system. All stock is prepped using the same methods, all jobs are set up the same, and all parts are held the same. With fewer operations, reduced tooling design requirements and lower fixturing costs, overall expenditures are reduced. Although some may view prepping a 0.125-inch dovetail as an additional operation, even when using a traditional vise, the stock must be squared prior. With Techni-Grip, one is simply changing the prep operation versus adding an operation.

After completing the system and testing it over a year's time, Techni-Grip began receiving requests from manufacturers and in 2000 the owners patented and marketed the Techni-Grip system design.

"The Techni-Grip system simplified my job by reducing obstacles in toolpaths," said Doug St. John, programmer at JWD Machine. "I gained the ability to be much more aggressive about cutting—parts won't come loose. Our tooling design requirements have been reduced by 80 percent. I wish I had this 10 years ago."

The Techni-Grip system works well in aerospace applications where tight-tolerance requirements are required, but it can be used in many other industries, including automotive, medical, oil/energy and marine, to name a few. If a manufacturer is milling any type of metal or plastic and has 0.125 inch of excess material, the Techni-Grip system can be implemented. Techni-Grip offers various fixtures to be utilized in different applications and multi-axis operations. Its expansive line of universal fixtures can be used individually or in multiples using different configurations, such as side by side or in a string for larger jobs.





ABIPA CANADA
Formulates Competitive Future

COMPANY STREAMLINES OPERATION WITH AUTOMATED 5-AXIS MACHINING CELL

Becoming a world-class supplier for today's leading aerospace original equipment manufacturers (OEMs) requires a steadfast determination to remain focused on the future. Abipa Canada Inc. of Laval, Quebec, is always looking forward as it continually strives to improve its processes.

Abipa recently streamlined its operation with a new automated 5-axis machining cell it purchased to adapt to industry pricing realities and customer expectations for a low-cost content strategy. It is now able to produce parts at a ratio of at least 3-to-1 compared to previous processes, without adding labor.

"We are continuously looking to improve our processes and to be better than we were yesterday, and this means seizing opportunities to become more competitive," said Rui Cabral, general manager at Abipa. "What matters most to us is developing new innovations that add value to our customers, shareholders and the aerospace industry as a whole."

While this successful integration has helped Abipa stand today as a leading Tier 2 supplier of small to mid-sized aircraft engine and structural components for the likes of Bombardier Aerospace and Pratt & Whitney Canada, the path

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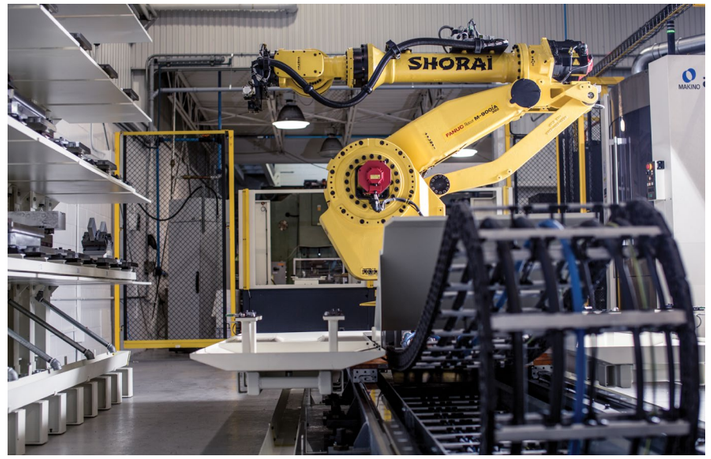
Abipa made its move into automation with an investment in an MMC-R fixture plate distribution system and a61nx-5E 5-axis horizontal machining center.



to its success was paved with several difficult learning experiences.

Following the recession of 2009, although Abipa was recognized for its quality and agility performance, it found itself frequently ranking as one of the pricier suppliers in its bidding efforts. It was this eye-opening experience that led Abipa to reevaluate its manufacturing processes with a forward-looking mentality.

"When we took a close look at the situation, we realized that low machine run-time ratio due to multiple setup operations was the single biggest differentiating factor in our cost equation," said Cabral. "Similar to the local suppliers, our shop floor was composed of stand-alone machining centers with an operator stationed at each machine."

While the answer to improving Abipa's competitiveness was clear, its leadership team did not take the investment decision lightly. Driven by a thorough strategic plan process, they defined a clear mission and vision, and identified the core activities for development. The company determined that in order to become truly cost competitive, the right automation solution would have to produce parts at a ratio of at least 2-to-1 compared to previous processes, without adding labor. Additionally, the technology needed to be modular in order to aggressively expand and pursue further cost reductions in the future.

Abipa made its move into automation with the purchase of a Makino robotic fixture plate distribution system, known as MMC-R, equipped with 20 fixture plates and an a61nx-5E 5-axis horizontal machining center. The success of this automated 5-axis machining cell quickly created enthusiasm and interest among the staff at Abipa, who aptly named the cell's robot "Shorai," which translates to "the future" in Japanese.

"Looking back now, it's odd to think that we were concerned about finding a solution that would meet our 2-to-1 production ratio requirement," stated Éric Deconninck, director of production. "It hasn't even been a full year since the cell's installation, and we are already exceeding those expectations without fully optimizing all of our processes to take advantage of the a61nx-5E's full capabilities. Based on the current performance of this automated 5-axis machining cell, we are now looking to gain the same level of productivity as three of our previous machines, without the need for additional manpower."

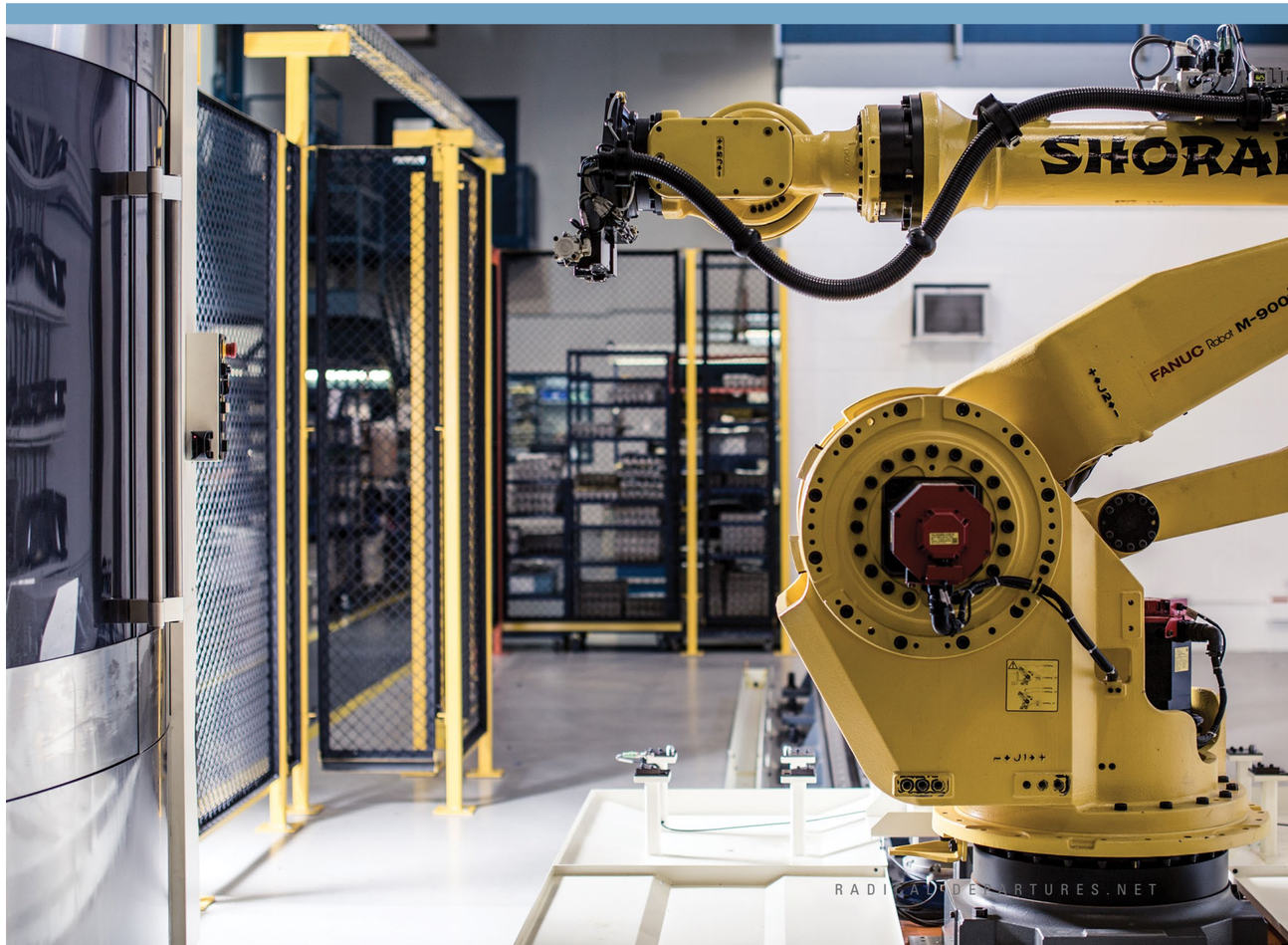
Despite its current size and market position, Abipa has spent much of its history as a small single-ownership company. Founded in 1982, the company got its start as a sheet-metal fabricator. In the 1990s, it performed assembly, welding and low-volume part production for the aerospace market. This expansion continued over the next decade, and by 2004, Abipa was growing by 20 percent year over year as orders from Pratt & Whitney Canada and Bombardier Aerospace grew. At this point, the company began investing in milling and turning machines to help boost production capacity, and in 2006 the shop expanded to double its original floor space.

PROVING OUT THE PROCESS

"Justifying the cost of automation was critical," said Cabral. "We needed to demonstrate that automation would help us save jobs by becoming more competitive, not eliminate them. It was important for us to share how we could maintain current employment and allow workers to become better trained and more tech savvy—potentially advancing their careers from operators to programmers or inspectors."

"Depending on the part design and material, we've seen productivity increases ranging anywhere from 85 percent to 525 percent."

The MMC-R system has enabled Abipa to fully automate 5-axis processes, leading to production ratios of 3-to-1 compared to previous technologies.



> "Production ratios are up to 3-to-1, and the more material that needs to be removed, the more productive we are."

The first priority for Abipa was to search for an automation and machine tool supplier, which was carried forward with a focus on finding the right technology and the best value proposition in order to ensure that the best solution was identified. The company weighed several machine characteristics, including cutting speed, rigidity and tool capacity, to meet its 2-to-1 production ratio benchmark. Several members of Abipa's leadership team had prior experience working with Makino's larger MAG-series machines for structural aerospace components.

While Abipa currently has 85 parts programmed into the MMC-R cell, it expects to grow that number to 500 different parts in the future.

Through this experience, they knew that the company and its regional dealership, Single Source Technologies–Canada (SST–Canada), offered deep knowledge and experience in aerospace applications.

"From application engineering support to the build quality of the machines themselves, it's clear that Makino and SST–Canada have a deep understanding of this market," said Nicolas Girard, director of methods and technologies, Abipa. "When we first saw the a61nx-5E, it reminded us of a smaller version of the MAG-series machines, offering exceptional levels of material removal and productivity. Additionally, the MMC-R system offered the flexibility we needed in a small enough footprint that could work within our available floor space."

Cabral and his colleagues evaluated the productivity of their current technologies. Through their analysis, they found that approximately one-third of all available production hours were currently being consumed by setup and maintenance processes. At 5,760 production hours per year, this meant that Abipa was achieving just 3,745 hours of available machining time.

"Based on test results coming in from Mason, Ohio, we calculated that the setup and maintenance hours for a stand-alone a61nx-5E were roughly equivalent to that of our current technologies; however, the machine's cutting performance was capable of increasing productivity by 80 percent—the equivalent of 5,949 production hours on our current equipment," said Deconninck. "These production figures grew exponentially when factoring in the impact of the MMC-R system. By eliminating setup hours and increasing spindle utilization to 95 percent, the productivity gains of the a61nx-5E were extended, reaching what would be the equivalent of 9,850 machining hours on our existing systems."

> "Of the parts currently undergoing tap testing, we've been able to double and even triple feedrates to achieve higher material-removal rates. In one application, average material-removal rates increased four times."

Abipa also took note of several new capabilities afforded by the automated 5-axis machining cell, including lights-out production scheduling and a larger machine work envelope that would enable the company to expand the work envelope and consequently offer larger part sizes to the market.

"There were many tangible and intangible considerations that went into building our case for 5-axis machine automation," said Cabral. "The justification covered every detail, evaluating actual cutting performance, return on investment, customer service, applications support and anticipated business growth. The Makino cell fulfilled each and every aspect without question, and our senior management team agreed to move forward with the plan immediately."

PUTTING THE PLAN INTO ACTION

Working closely with Makino and SST–Canada application engineers, Abipa's manufacturing team began to develop an implementation plan including not only the installation of the equipment but also design and fabrication of the modular fixturing, tool holders, cutters, probing routines, presetter integration and the development of CNC programs for three parts that would represent the various parts targeted for the machine that would also serve as acceptance tests. The MMC-R cell with a61nx-5E was assembled at Makino's Mason, Ohio, headquarters to prove out performance expectations on the three parts designated by both parties.

The automated 5-axis machining cell was installed in September 2013, and within weeks the company was loading orders into the cell and producing parts in a fraction of its previous processing times.

"The performance of the a61nx-5E has not only met but exceeded expectations on several occasions," said Deconninck. "Depending on the part design and material, we've seen productivity increases ranging anywhere from 85 percent to 525 percent. Production ratios are up to 3-to-1, and the more material that needs to be removed, the more productive we are. For example, the cycle time for one of our smaller parts dropped from 58 minutes to 26 minutes; meanwhile, the cycle time for one of our larger, more complex parts was reduced from 300 minutes to just 48 minutes."

According to Cabral, current performance enhancements are scratching only the surface of the a61nx-5E's full potential. Today, Abipa is working to perform tap testing on each part program in order to optimize cutting processes based on the a61nx-5E's capabilities. Equipped with Makino's unique 107-horsepower, 24,000-rpm spindle, the company expects to see significant performance gains from the a61nx-5E that go beyond initial expectations.

"Of the parts currently undergoing tap testing, we've been able to double and even triple feedrates to achieve higher material-removal rates. In one application, average material-removal rates increased four times. The biggest contribution to this growth was during the roughing process, where rates increased up to 20 times," said Girard.

Other process optimization activities in development at Abipa include setup alterations to support reductions in out-of-cut time. The company

> "Our customers have already begun to recognize the changes and advancements that we are making, and they see us as a viable, cost-effective solution and very competitive alternative to outsourcing their production to other countries."

is evaluating how it can better use the larger work zone in a way that is unique for small to midsize components.

"One of the unique capabilities that we have is our ability to apply prior experiences and methodologies from experience with the MAG-series machines to the production of smaller parts," said Girard. "With our previous equipment, it was difficult for us to produce hole features with tight tolerances for circular interpolation. These features required us to use a honing machine or boring head, which led to additional setups, teardowns and transfers between equipment. With the a61nx-5E, we are now able to machine-bore features complete using 180-degree indexing. Diameters are held within plus or minus 0.0006 inches with matching alignment within plus or minus 0.0002 inches."

STANDARDIZING AND SIMPLIFYING SETUP PROCEDURES

While Abipa currently has 85 parts programmed into the MMC-R cell, it expects to grow that number to 500 different parts in the future. In 2014 alone, the company is anticipating 100 new aluminum part orders—most of which are to be added to the cell's production queue.

"By choosing to go with the optional 218-tool capacity magazine for the a61nx-5E, we've gained a higher degree of production flexibility," said Girard. "This expanded capacity not only allows for a wider selection of on-board tooling but also affords space for redundancy to keep the cell running unattended longer. We're also actively developing a standardized approach to tooling and fixturing for quicker, easier setup routines."

Girard and other team members are currently engineering new processes to simplify operators' procedures when running the cell, making the technology easily accessible for operators at any skill level. This approach is particularly helpful in growing operators' versatility.

The company has established several fail-safe processes using a sophisticated probing routine within the machine to read what fixture, part number and fixtured part quantity have been loaded for processing.

"When humans are involved at any point in a production process, errors or incidents can and will happen regardless of operator skill level," explained Deconninck. "The addition of these fail-safe probing routines ensures that no matter how many parts are loaded into the cell, the machine can read and react appropriately to the job at hand. Even if a billet is accidentally fixtured incorrectly, the machine will stop and move on to the next pallet. It's a highly intuitive process that is just one of the many ways that we are continuing to innovate and improve."

HELPFUL INSIGHTS FROM ABIPA CANADA

For manufacturers who are looking to make their first move into automation, I want to reinforce the importance of proper preparation.

Push yourselves to do as much research and planning in advance before the equipment is delivered. Every company possesses a different degree of tech savviness and engineering capabilities, but don't underestimate successful implementation of automation and the learning curve of the manufacturing team. In our case, we worked closely with Makino for many months to plan out our goals, objectives and necessary steps to get there. They provided us with a dedicated project manager to help ensure that no detail was overlooked and every milestone was achieved on time.

Having the support of an experienced supplier can make a big difference in the pursuit of automation. There's much more to the process than simply placing a robot on your floor to load and unload parts. Every step of the production process has to be fine-tuned to guarantee reliability and optimal performance, from robotic interfaces to fixture design and programming adjustments. Most importantly, you should be sure to select a supplier that you know will support you even after the installation is complete. We still look to Makino for support today, and our production processes are improving continuously as a result.

Successful automation is all about preparation, and the supplier that you select can have a dynamic impact on how well you plan ahead.

— Rui Cabral, general manager, Abipa

The 24,000-rpm spindle and improved part accessibility of the a61nx-5E have improved cycle times by 80 percent over previous technologies.

BUILDING ADDITIONAL VALUE

Despite the overwhelmingly successful integration of its new automated 5-axis machining cell, Abipa continues to look toward the future. With the MMC-R's modular expansion capabilities, the company intends to add more machines and pallets to the system as it transfers parts to the cell and adds new orders. For phase 2 of Abipa's automation plans, the company is expecting to add a second a61nx-5E to the cell that is designed to handle harder materials such as steel and titanium. A third and fourth machine are also in the plans to complete the cell as part of a phase 3 expansion.

"For every two a61nx-5E machines placed in the cell, we expect to gain productivity equivalent to at least five of our previous machines," said Cabral. "By the time that phase 3 is completed, the cell will have provided us the productivity of more than 10 machines. Our customers have already begun to recognize the changes and advancements that we are making, and they see us as a viable, cost-effective solution and very competitive alternative to outsourcing their production to other countries."

With a growing volume and variety of part orders, Abipa looks forward to taking full advantage of the production scheduling and reporting capabilities of the MMC-R's MAS-A5 control software. Cabral and other managers intend to use the software's functionality to improve production workflow and optimize the shop's inventory for further price reductions.

The company also plans to eventually replace much of its previous technologies to further cut down on part costs and create additional floor space for more automation.

"Every day we are looking for opportunities to become more cost competitive and provide value that our customers can't get elsewhere," said Cabral. "We're working to maintain and grow our reputation as a world-class Tier 2 supplier for aerospace OEMs, Tier 1 integrators and equipment manufacturers through continuous innovation. So while we are excited to share all of our recent accomplishments in 5-axis machining and automation, our ambitions will never be satisfied by the accomplishments of today."

FORECAST FOR GLOBAL AVIATION SOARS

The world's leading aircraft manufacturers are forecasting blue skies ahead for the aviation industry over the next two decades. The 2014 market-outlook reports from Boeing, Airbus, Bombardier and Embraer predict the world's aircraft fleet to double in size over the next 20 years. Virtually every major manufacturer has recently revised its forecasts upward.

Boeing estimates the world's passenger and freighter fleet to expand from 20,910 to 42,180 aircraft, with 36,770 new airplanes over that time period valued at $5.2 trillion.

Most of this growth is expected to be in single-aisle airplanes, which are predicted to comprise 70 percent of units over the next 20 years, according to Airbus. Boeing estimated its production of 25,680 new single-aisle airplanes over that time period with a market value of $4.4 trillion, whereas Bombardier forecasts 22,000 business aircraft deliveries over the next 20 years.

CONTRIBUTING TO GROWTH

One reason for this boost in the recent forecasts is the replacement of aging aircraft, especially in North America. Airbus projects a 20-year demand for nearly 11,000 passenger aircraft to be replaced, largely in the single-aisle segment. Most of this replacement of an aging fleet of commercial aircraft is due to operating efficiency and the revenue requirements of the operating airlines. Emerging environmental concerns, new regulations and airspace modernization have also contributed to the retirement of older jets, according to Bombardier. Similarly, Airbus says it is likely to replace two-thirds of its existing fleet for being less eco-efficient, code words for fuel efficiency.

SOURCES:

Airbus:
Future Journeys Global Market Forecast 2013-2032

Boeing:
Current Market Outlook 2014

Bombardier:
Market Forecast 2014-2033

Embraer:
News Release – Embraer Releases 20-Year Market Outlook Projecting 6,250 New Jet Deliveries in the 70- to 130-Seat Segment

Boeing estimates the world's passenger and freighter fleet to expand from 20,910 to 42,180 aircraft, with 36,770 new airplanes over that time period valued at $5.2 trillion.

Therefore, the new engine programs will also see dramatic growth during this same period. All major jet-engine manufacturers are developing more efficient and eco-friendly engines for these new aircraft. Coupled with historically low interest rates, many airlines have gone on a buying spree recently, contributing to an even larger backlog of aircraft orders.

ECONOMIC GROWTH

World urban population is likely to reach 5 billion by 2030, with the global middle class predicted to more than double, according to Airbus. In the next two decades, there will be more people in the world, with more wealth, living in urban areas. Airbus predicts the urban population to, in fact, grow from 51 percent today to over 60 percent. Billions of people are going to want to travel by air, which means that worldwide demand will drive industry growth. According to Embraer, demand is estimated to increase by an average of 4.8 percent annually through 2033.

Boeing sees a future with passengers flying where they want and when they want. Airbus estimates that 27 percent of all trips during the upcoming 20-year period will be for visiting friends and relatives and will also reflect immigration flow. Similarly, the number of international students has nearly doubled since 2000, which has also contributed to aviation travel.

Economic growth drives wealth creation, which influences worldwide demand for commercial air travel. Boeing and Airbus report that over the last decade, 67 percent growth has been seen in the aviation industry, despite multiple world crises, the 9/11 attack, the SARS near-pandemic and the financial crises. Much of this expansion has mirrored the growth of the world economy. According to Bombardier, when the world economy has historically grown by an annual rate of 3 percent or more, the aviation industry also typically experiences growth. Expanding passenger traffic usually continues with resilient growth in a difficult but improving economic period, according to both Airbus and Boeing. In fact, Boeing says its 20-year forecast shows strong long-term growth due to world economy (up 3.2 percent), number of airline passengers (4.2 percent), airline traffic (5 percent) and cargo traffic (4.7 percent).

WORLD REGIONS LEADING THE PREDICTED GROWTH

All of the reports predict that emerging markets are going to be the source for much of the projected growth occurring during the next two decades. In fact, according to Boeing, emerging markets are likely to lead aircraft travel and expansion. Airbus predicts emerging economies to represent 50 percent of new-aircraft demand over the next 20 years. For example, it is estimated that two-thirds of the population of emerging countries are going to take one trip per year in 2032. These emerging countries include South Asia, China, Southeast Asia, Africa, Asia-Pacific, Latin America and the Middle East.

Airbus predicts Asia-Pacific to lead the world in aircraft traffic by 2032, followed by Europe, North America, the Middle East, Latin America, the Commonwealth of Independent States (CIS) and Africa. Embraer sees the Middle East and China as drivers, with an annual revenue passenger kilometers (RPK, which is a measurement of worldwide demand for air transport) of 7.1 percent and 6.8 percent, respectively, followed by Latin America (at 6 percent), CIS and Africa (at 5 percent).

More first-time flyers are likely to come from an expanding middle class, which is predicted to grow from 2.2 billion people today to 5.2 billion, according to Airbus. By 2025 it is projected that emerging markets are going to capture just over half of the world's gross domestic product (GDP). Embraer predicts that by 2033 Asia-Pacific and China will be the largest

World urban population is likely to reach 5 billion by 2030, with the global middle class predicted to more than double.

FACTORS HELPING THE INDUSTRY TAKE FLIGHT

There is a 20-year demand for 11,000 to 15,000 passenger aircraft to be replaced, largely in the single-aisle segment.

Annual growth in world economy of 3%.

Airbus says that two-thirds of the world's existing fleet will be replaced for being less fuel efficient and eco-friendly.

Emerging economies are expected to represent 50 percent of new aircraft demand over the next 20 years.

REPLACEMENT OF AGING AIRCRAFT

Aircraft replacement is expected to boost efficiency.

FUEL EFFICIENCY

Emerging environmental concerns, new fuel economy regulations and airspace modernization have also contributed to growth.

ECONOMIC GROWTH

Economic growth drives wealth creation, which influences worldwide demand for air travel.

THE CHANGING LANDSCAPE

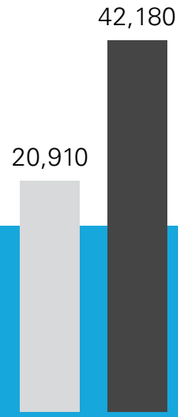
The volume and frequency of passenger air travel are increasing.

Growth in the world economy, particularly emerging markets, will drive growth.

Airlines are adapting new strategies for improved capacity and frequency.

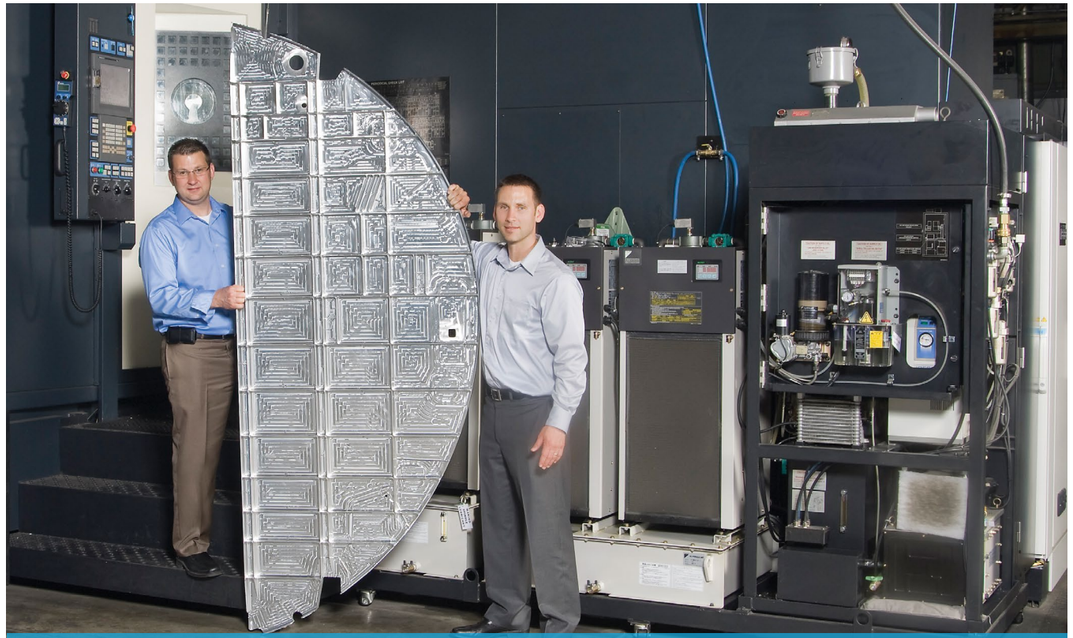
Improved affordability is enabling passengers to fly where they want, when they want.

The volume of cargo traffic is increasing.



WHERE WE LAND

Boeing estimates the world's passenger and freighter fleet to expand from **20,910** to **42,180** aircraft, with 36,770 new airplanes over that time period valued at $5.2 trillion.



With the world's leading aircraft OEMs predicting a doubling of the world's aircraft fleet over the next 20 years, aerospace manufacturers are positioned to see business orders soar.

Boeing and Airbus report that over the last decade, 67 percent growth has been seen in the aviation industry, despite multiple world crises ...

air-travel markets in the world, with a combined 40 percent of total global RPK.

North America and Europe are considered mature markets that grow more slowly but still generate 36 percent of world demand. According to Bombardier, North America is going to have a modest fleet-growth rate due to its more established market, but it is forecasted to receive the greatest number of new business-jet deliveries between 2014 and 2033, with 8,760 units. In contrast, China has a very small business-jet fleet and is now entering a rapid growth phase, according to Bombardier.

For planning purposes, the top three current programs are the Boeing 737 Max, Airbus A320 Neo and Boeing's 787 series. In addition, other civilian aerospace markets are also expected to grow, like rotorcraft, which will only add to total aerospace part production demand.

As long-term prospects for aviation remain strong, the time has come for Tier 1 and Tier 2 suppliers to invest in the technologies that provide for the capacity to handle rapidly increasing demand. Now is the time to take advantage of this projected growth and invest in new machining technologies.

For more information on new developments within the aerospace industry, visit us online at Radical-Departures.net.

NEW GROUP ESTABLISHED TO DEVELOP AEROSPACE ENGINE MACHINING PROCESSES

Aerospace manufacturing continues to grow rapidly in North America, with many aerospace suppliers working at capacity and building up a substantial backlog of aircraft orders in the process. With this in mind, Makino has established a new process development group to help satisfy growing production demands for newer, more fuel-efficient jet-engine technologies. Composed of highly specialized engineers with decades of experience in the manufacture of aircraft engine components, this group's goal is to help customers meet demands for increased production efficiency and quality.

Makino's Aerospace Engine Technology Group supports the grinding, EDMing and machining of exotic aerospace alloys specifically for the jet-engine market. The group's expertise encompasses a full range of innovative manufacturing solutions, including the machines, processes and engineering solutions necessary to produce complex jet engine and turbo machinery components with the highest quality, greatest throughput and lowest cost per part.

In coordinating its projects, the Aerospace Engine Technology Group employs grinding, 5-axis milling and EDM processes using innovative machine technologies such as the G-Series 5-axis horizontal machining and grinding center, and the new EDBV-Series EDM machines designed specifically for the production of cooling holes and diffuser shapes in turbine blades and vane segments.

"Today's aerospace industry demands greater capacity, efficiency and quality," said Billy Grobe, manager of Makino's Aerospace Engine Technology Group. "Our new group can provide detailed proposals for specific applications and deliver robust, reliable manufacturing solutions for virtually any engine component. It's an exciting opportunity for me to lead this talented team of professional engineers during perhaps one of the most significant periods of growth in aviation history."

To take advantage of the expertise from Makino's Aerospace Engine Technology Group in order to improve the efficiency of your aircraft engine production, contact **Billy Grobe at (513) 573-7375.**

G7 5-axis grinding machine producing an aerospace vane segment

IDENTIFYING BETTER MACHINING PRACTICES

"In our evaluation, Third Wave Production Module was the only package with the capabilities to optimize 5-axis toolpaths."

— Mark Larson, Makino Titanium Process R&D Manager

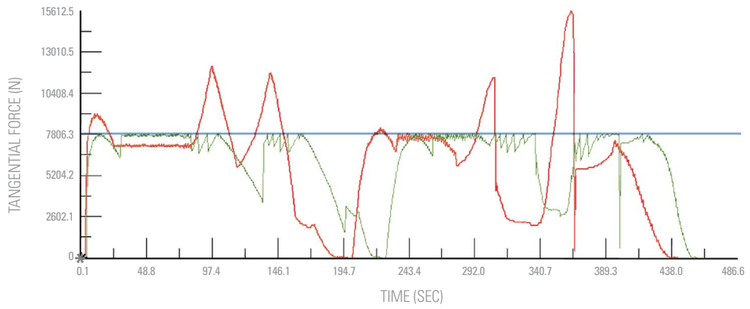
THE BACKGROUND

As one of the world's largest machine tool manufacturers, Makino is proud to partner with customers to build and sustain a metal-cutting business that thrives by making the parts that matter for the customers that matter the most. As part of this partnership, the company frequently machines sample parts for potential customers to demonstrate the advantages of Makino milling machines. The company is always on the lookout for technologies and tools that help them machine these sample parts more effectively and efficiently, not only to prove the benefits of Makino machines but also to promote better machining practices and tools to their customer community for a worldwide impact.

THE PROVE-OUT

Makino engineers used Third Wave Production Module to optimize a 5-axis pocket operation in a customer-provided test part similar to a landing-gear link.

BEFORE AND AFTER BALANCING TOOLPATH FORCES BY SETTING LIMIT OF 7806.3 N (BLUE LINE) WITHIN PRODUCTION MODULE



The 900-mm test part is machined from Ti-5-5-5-3, and Makino engineers wanted to identify the 5-axis toolpath that would achieve balanced loads. Tangential force limits were set at 7806.3 N within Production Module, and the toolpath was then optimized line by line to balance forces on the cutting tool.

THE TECHNOLOGY

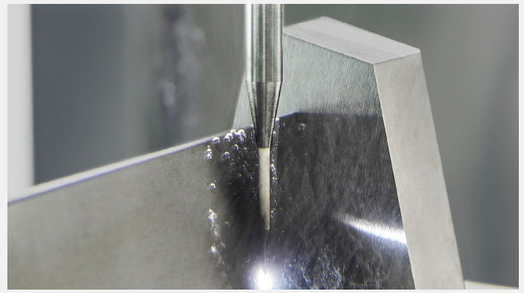
Third Wave Production Module is NC program optimization software integrating physics-based material models, CAD/CAM inputs and machine dynamics. The technology empowers users to make better informed decisions on tooling and toolpath strategies, creating processes that machine dramatically faster while improving tool life and part quality.

THE NEW EDBV8 FAST HOLE EDM DRILLING MACHINE

EDM Drilling Machine for Film-Cooling Holes and Diffuser Shapes

Modern product designs and production requirements can make EDM hole-drilling challenging, especially in complex applications such as film-cooling holes and shaped diffuser holes in blades and vane segments. Makino's new EDBV8 is ideally suited for large turbine engine component machining for the aerospace and power-generation markets, particularly as these manufacturers improve engine performance and reduce fuel consumption.

The EDBV8 is equipped with a 2-axis rotary table for enhanced workpiece positioning. The development of this machine marks the first expansion of the EDBV-Series (electrical discharge blade and vane) product line, and it gives blade and vane manufacturers the flexibility to accommodate a wider range of part sizes for any high-volume, fast hole EDM drilling application.



The EDBV8 fast hole EDM drilling machine provides manufacturers with the speed, flexibility and reliability to effectively produce a wide range of hole shapes and sizes with a single-electrode process. This approach significantly reduces tooling costs while improving cycle time, part quality and production efficiency. Its uniquely designed tooling system integrates the electrode and die guide into a common assembly for quick and reliable automated exchanges, and provides programmable control over electrodes and electrode diameter size changes.

The EDBV8 offers X-, Y-, Z- and W-axis travels of 800 mm, 600 mm, 750 mm and 500 mm (31.5 inches, 23.6 inches, 29.5 inches and 19.7 inches), respectively. The machine is also equipped with a 2-axis rotary table that can accommodate a maximum workpiece size of 500 mm (19.7 inches) diameter by 635 mm (24.96 inches) long, and a maximum payload of 150 kg (330 lbs.). Its rotating C-axis head features an EROWA compact chuck that enables automatic changing of electrode diameters from 0.2 mm (0.008 inch) up to 6.0 mm (0.236 inch) with rotation speeds up to 1,000 rpm.

With 5-axis table and automatic guide change, the EDBV8 is perfectly suited for long hours of unattended cooling hole and diffuser shape burning operations.

The EDBV8 uses a rigid guide-arm assembly to hold, locate and support the die guide, which can be alternately used as a programmable axis (W-axis) that runs parallel to the Z-axis. An integrated “middle guide” system is also contained within the W-axis and is used with long small-diameter electrodes to prevent whipping, bending and vibration of the electrode. Additionally, the middle-guide “fingers” automatically retract as the electrode tube reduces in length, maximizing the productive useful length of the consumed electrode.

The EDBV8 features improved flushing through fully submerged machining, greater machining stability and part accuracy, and faster cycle times with the equipped 10 MPa (1,450 psi) flushing capability for higher productivity of deep-hole features. The machine also contains a fast-response breakthrough detection circuit to prevent back-striking or back-wall impingement (damage to the inner cavity) during blade and vane cavity wall penetration. This highly sensitive breakthrough detection circuit, which uses a combination of different adaptive process-monitoring techniques, is accomplished while delivering maximum speeds.

An advanced EDM generator technology produces excellent metallurgical quality and integrity on high-nickel alloys such as Inconel®. Reliable and repeatable machining results are maintained using the machine’s on-board water quality control system that consists of a filtration system to clean the water, a deionization system to control water conductivity, and a chiller unit to maintain the water temperature at the same level as the machine casting.

The EDBV8 has been designed for easy operation, and it offers the operator unparalleled access to the work tank.

For unattended burning of varying film-cooling hole diameters, the EDBV8 features automatic tool change (ATC) and automatic guide change (AGC) systems. The patented tooling system combines the electrode holder and die guide together into a common assembly, providing enhanced reliability with simple and precise automated exchanges. Together, these features enable ATC and AGC exchanges in less than 1 minute, and they offer a unique combination of process flexibility while minimizing non-value-added machine motions.

The EDBV8 employs several proven software technologies used in Makino’s fine-hole sinker EDM machines. Makino’s Model Plan system is integrated into the controller, providing user-friendly input screens with direct G- and M-code programming formats. An electrode length management system provides electrode wear tracking and automatically exchanges electrodes when lengths become too short. The controller contains several canned cycles for hole drilling and simple diffuser shape machining, and custom G-code profiles can also be imported and easily used in the machine.

The EDBV8 has been designed for easy operation, and it offers the operator unparalleled access to the work tank with its three-sided rise-and-fall work tank. The EDBV8 is also capable of on-machine probing to determine workpiece locations and offsets. Electrical touch-sensing probing or a conventional mechanical touch probe can be used to capture location data points. The standard configuration of the EDBV8 includes a 24-station tool carousel and 24 tool assemblies to fully stock the machine for maximum productivity.

Together, these features enable the EDBV8 to provide solutions for larger, heavier workpieces while improving productivity and part quality.

PRODUCT PROFILE

MAKINO

RADICAL DEPARTURES

ADVANCED TECHNIQUES IN AEROSPACE MANUFACTURING

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