

More Axes Mean Greater Productivity for All: 5-Axis Machines for Every Shop Size



INTRODUCTION

The metalcutting industry has long understood 5-axis technology as a transformative technology, one that allows for the creation of parts that would be impossible to cut with conventional machines. Many shops have even invested in the technology without clear part-production goals in mind, as it can be a valuable way for a job shop to set itself apart from its competitors or expand its customer base. Others choose to continue using stable 3-axis processes, believing they do not need or cannot afford 5-axis capabilities.

In reality, 5-axis machining – especially full simultaneous 5-axis machining – can provide significant value to nearly any shop, and the range of equipment available today allows nearly any manufacturer to experience the benefits of the technology. From repeatability and precision to savings on workholding and setup time, 5-axis machining makes ordinary parts even faster to machine, in addition to allowing for more complex parts. Furthermore, improvements in control technology and offline programming have made these machines much more accessible to program and use.

A BRIEF HISTORY OF 5-AXIS MACHINING

Although many manufacturing professionals discuss 5-axis technology as a relatively new innovation, multi-axis machining predates even numerical control, let alone the sophisticated CNC machines seen in today's shops. As with screw or Swiss-style machines, early versions of this equipment required substantial setup time, in exchange for quick mass production of relatively complex parts. However, digitization made 3-axis mills and lathes much more practical for most general machining, particularly when the programming requirements for eventual 5-axis CNC machines appeared prohibitive for many shops.

To achieve the lowest possible cost of ownership, your investment should match your anticipated needs as closely as possible, even while you consider a range of other factors specific to 5-axis machines.

Many machine tool OEMs addressed this problem with so-called “3+2” machining, in which the machine executes a 3-axis milling program after locking the cutting tool in a tilted position with its two rotational axes. Also known as 5-axis positional machining, this style of machining is not capable of creating the complex contours that 5-axis technology is known for, but it provides other advantages, such as removing the need for fixturing to drill angled holes. Many shops saw this as a bridge technology between conventional and full 5-axis machining because of its somewhat lower prices, but as the cost of more advanced equipment has fallen, the need for a cheaper alternative to full 5-axis machining has also decreased.

Mazak machines focus on simultaneous 5-axis technology, where the rotating and tilting table operates independently from the three linear axes, allowing them to move in concert to produce unique part shapes and features. This reduces the need for fixturing even further, contributing to higher throughput and shorter lead times. The high-precision tilting and rotating tables ensure repeatable, predictable positioning without the need for additional manual part movement.

SELECTING AND APPLYING 5-AXIS TECHNOLOGY

A wide range of 5-axis machines ensures that all shops have access to the technology, as well as solutions that can meet their unique needs. But it also makes choosing the correct machine that much more critical. To achieve the lowest possible cost of ownership, your investment should match your anticipated needs as closely as possible, even while you consider a range of other factors specific to 5-axis machines.

From an application standpoint, for example, the expanded range of angular motion requires a larger work envelope than one might expect. To machine a cubic foot of material, you may need 1.5 cubic feet of clearance. Likewise, tools must often be longer to accommodate various angular machining applications, which might prompt shops to select a larger taper or more advanced toolholding, such as shrink-fit or hydraulic solutions.

Programming for 5-axis machines has also become much easier, particularly with modern CAM solutions, but the use of CAM software remains necessary. MAZATROL Smooth controls and associated SMOOTH TECHNOLOGY software packages can simplify this, as they are designed to work with a complete range of CAD/CAM environments. With MAZATROL TWINS and SMOOTH Project Manager, for example, programmers have full access to virtual machines from their office desktop computers, and a seamless program management system speeds up later program distribution and execution.

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VC-300A/5X

ACCESS, ACCURACY AND AGILITY

At its core, 5-axis technology offers very simple advantages that can make it valuable in nearly every shop environment, despite its additional complexities. With 3-axis machines, shops often must stop production to turn or re-clip a part into a custom-built fixture so they can handle a compound angle or diagonal part wall. A 5-axis machine can simply be programmed to tilt the table, allowing the same degree of access with the benefit of error-free, machine-controlled movement that can be relied upon across many jobs.

As a result, shops that integrate even entry-level 5-axis technology see its benefits quickly. What required multiple setups can often be finished in two, as these machines can work on five faces of a given part at once. The setup-time improvements alone can contribute to much shorter lead times, while increased repeatability prevents damaged or scrapped parts from impacting productivity. These advantages are especially potent in shops with high-mix, low-volume production environments, where agility is critical to keep up with the fast turnaround times their customers expect.

VC-300A/5X

Simple, innovative and designed to fit into any shop environment with ease, the VC-300A/5X brings advanced 5-axis technology and production value to high-precision small-parts processing for a variety of industries. Its rotary/tilt table features roller gear cam technology to fully eliminate backlash, while a wide range of spindle configurations makes it applicable to most shops' material and application requirements.

SPECIFICATION		VALUES
Capacity	Maximum Workpiece Diameter	6.290 in / 160 mm
	Maximum Workpiece Height	6.100 in / 155 mm
Spindle	Spindle Taper	40
	Maximum Speed	12,000 rpm
	Motor Output (5-minute rating)	25.0 hp / 19 kw
Magazine	Number of Tools	30
Rotary Axes	Table Indexing (C axis)	360.0000 degrees
Feed Axes	Travel (X Axis)	11.81 in / 300 mm
	Travel (Y Axis)	11.81 in / 300 mm
	Travel (Z Axis)	18.70 in / 475 mm

A given component might require 15 to 20 different parts, all with tight tolerances for fit and geometric complexities necessary for final assembly. With 5-axis technology, none of this becomes necessary.

EXPANDED CAPABILITIES

The phrase “complex contours” can be found in nearly every description of 5-axis technology for a reason – this approach makes many parts possible that could not be produced with conventional machines. Nevertheless, 5-axis machines can also expand a shop’s capabilities in a variety of other ways that may be more surprising. In addition to the kinds of process consolidation discussed above, these machines can also vastly improve the manufacturability of various products.

These capabilities were pioneered in the aerospace industry, where complex assemblies are common. A given component might require 15 to 20 different parts, all with tight tolerances for fit and geometric complexities required for final assembly. With 5-axis technology, none of this becomes necessary. Contouring, compound angles and innovative approaches to machining make it possible to produce these assemblies as single pieces. Every industry now has access to this kind of streamlining, and given the costs of maintaining large part families, 5-axis capabilities can result in significant savings.

VORTEX SERIES

When shops need unsurpassed accuracy for the production of large, heavy parts, they often choose from the VORTEX Series, robust machine models built around highly symmetrical base-and-column designs and/or tilting spindles with rotating tables. This allows for outstanding precision for cutting even large and complex titanium, aluminum and steel components such as jet engine casings, air frame components and gearboxes.

VORTEX i-630V/6S

Perfect for job shops and advanced manufacturers alike, the single-table VORTEX i-630V/6S offers standard, high-speed and high-torque spindle specifications to successfully meet a wide variety of application requirements.



VORTEX i-630V/6S

SPECIFICATION		VALUES
Capacity	Maximum Workpiece Diameter	49.210 in / 1250 mm
	Maximum Workpiece Height	55.120 in / 1400 mm
Spindle	Spindle Taper	50
	Maximum Speed	10,000 rpm
	Motor Output (30-minute rating)	50.0 hp / 37 kw
Magazine	Number of Tools	43
Rotary Axes	Table Tilt (B axis)	150 degrees
	Table Indexing (C axis)	360.0000 degrees
Feed Axes	Travel (X Axis)	56.10 in / 1425 mm
	Travel (Y Axis)	41.34 in / 1050 mm
	Travel (Z Axis)	41.34 in / 1050 mm



VORTEX HORIZONTAL PROFILER 160 XP

Many Mazak machines offer 2-pallet configurations that enable machining to continue while workpieces are loaded and unloaded on the other pallet.

VORTEX HORIZONTAL PROFILER 160 XP

With a massive 157" x 49" vertically oriented rotary/tilt worktable that accommodates up to 6,615 pounds, this rugged machine and its high-speed spindle options bring unmatched power, speed and accuracy for medium and large-sized parts.

SPECIFICATION		VALUES
Capacity	Table Right/Left	157.480 in / 4000 mm
	Table Longitudinal	62.990 in / 1600 mm
Spindle	Spindle Taper	HSK-A63/80mz
	Maximum Speed	30,000 rpm
Magazine	Number of Tools	60
Feed Axes	Travel (X Axis)	165.35 in / 4200 mm
	Travel (Y Axis)	59.06 in / 1500 mm
	Travel (Z Axis)	21.65 in / 550 mm

5-AXIS MULTI-TASKING

In many ways, 5-axis technology matured in tandem with Multi-Tasking technology, the other major form of process consolidation that took place in the metalcutting industry's recent history. It therefore comes as little surprise that the two solutions can be combined for even greater processing versatility – particularly given the popularity of the INTEGREGX Series, Mazak's flagship line of Multi-Tasking machines.

These complementary technologies are what make DONE IN ONE® machining possible. Part handoff between spindles prevents the need for nearly all manual workpiece handling, as it allows access to the unmachined sixth side. An INTEGREGX machine can act as a horizontal 5-axis solution with ease, even for shops that rarely need its turning capabilities – and the same holds true for Mazak's other models of larger 5-axis machines that also offer turning capabilities.

While many manufacturers leverage the capabilities of an INTEGREGX as a way to integrate bar-feeding automation into non-turning applications, Multi-Tasking technology allows for many similar forms of simple in-machine automation. But 5-axis machines also work well with other kinds of automation. Many Mazak machines, for example, offer 2-pallet configurations that enable machining to continue while workpieces are loaded and unloaded on the other pallet. More advanced solutions, like the Multi-Pallet Pool (MPP) and PALLETECH systems, enable full unattended, lights-out machining.



INTEGREX i-200H ST

INTEGREX i-200H ST

Designed to offer the highest level of single-setup part-production versatility available today, the INTEGREX i-200H ST Multi-Tasking Center features a second turning spindle (S) and lower parallel-style turret (T) with optional rotary tool capabilities to minimize fixtures, tools, handling and non-cut time. It also includes the next-generation MAZATROL SmoothAi CNC, which provides exceptional programming and production efficiency thanks to advanced features such as MAZATROL TWINS.

SPECIFICATION		BED LENGTH - 850U MM
Capacity	Maximum Swing	23.62 in / 600 mm
	Maximum Machining Diameter	23.620 in / 600 mm
	Maximum Bar Work Capacity	2.6 in / 65 mm
Main Spindle	Chuck Size	8 in
	Maximum Speed	5,000 rpm
	Motor Output (40 ED Rating)	30 hp / 22 kw
Second Spindle	Chuck Size	8 in
	Maximum Speed	5,000 rpm
	Motor Output (40 ED Rating)	25 hp / 19 kw
Milling Spindle	B-Axis Travel	240°
	Magazine Capacity	38
	Maximum Speed	12,000 rpm
	Motor Output (40 ED Rating)	16 hp / 12 kw
Turret (Lower)	Number of Tools	12
Feed Axes	Travel (X Axis)	21.06 in / 535 mm
	Travel (X2 Axis)	8.27 in / 210 mm
	Travel (Y Axis)	8.27 in / 210 mm
	Travel (Z Axis)	35.43 in / 900 mm
	Travel (Z2 Axis)	35.43 in / 900 mm
	Travel (W Axis)	35.43 in / 900 mm

CASE STUDY: SPORT TRUCK USA

Change was on the horizon for Coldwater, Michigan-based Sport Truck USA, a division of Fox Factory Holding Corp., in 2015. The shop received a project for the new model year Ford F150 pickup truck, but the vehicle's new design required a more complex steering knuckle, one with a compound-angle design. This prompted Sport Truck to turn to its long-time Mazak distributor, Addy Machinery, to help identify a solution.

The shop knew it wanted an easy-to-use 5-axis machine that would combine operations and reduce setup times so it could quickly and efficiently deliver products to market and keep up with the trend of more sophisticated – and frequent – vehicle suspension design changes. That solution turned out to be a Mazak VARIAXIS i-800 5-axis Vertical Machining



VARIAXIS i-800

Thanks to 5-axis technology, Sport Truck USA was able to eliminate three operations, reduce production lead times, improve machining accuracy and lower operating expenses.

Center with rotary/tilt table and 50 taper spindle. It was perfect for the shop because of its advanced multiple-surface, simultaneous machining capabilities that include milling, drilling and tapping – ideal for the knuckles' profiled surfaces. As a result, the shop was able to eliminate three operations, reduce production lead times, improve machining accuracy and lower operating expenses.

“We were already using the 4-axis Mazak HCN-6000 Horizontal Machining Center,” said Design Manager Jared Ball. “One of the good things about it is that it’s the same machine that our other suppliers use when they make parts for us. And it’s the reason we got the 5-axis VARIAXIS – we already trusted Mazak machines and knew they’re reliable and user friendly in addition to being able to make quality parts.”

The shop saw immediate boosts in production efficiency and accuracy. According to Ball, competitors were using a horizontal plane, three chuckings and multiple operations to produce a single knuckle. On its VARIAXIS i-800, Sport Truck now machines the same part, completed and ready-to-ship, in one setup made possible by Mazak’s DONE IN ONE technology. Operators only touch parts twice – once to load and again to unload – as opposed to moving parts around the shop to multiple workstations.

“For us, this is a huge deal. I’ve been on the technical support side in the years I’ve been at Sport Truck, and something you never, ever want to hear from a customer is that a part isn’t meeting their expectations,” said Ball. “One of the things about Mazak machines, and the VARIAXIS i-800 in particular, is that they can make the same identical part every single time, without quality issues, which results in a better customer experience.”

CONCLUSION

Manufacturing professionals have always understood that 5-axis technology represents the future of metal cutting – but that future is now. Retaining old processes, however reliable they may be, is counterproductive when it has become trivial to find productivity and quality-enhancing 5-axis solutions within the reach of any shop, including several best-in-class Mazak models. As many manufacturers have discovered, there has never been a better time to expand their capabilities as they prepare for the next wave of product development and production.

Learn more about Mazak’s comprehensive catalog of 5-axis machining solutions at [MazakUSA.com](https://www.mazakusa.com) or by contacting your local Mazak distributor.

About Mazak

Mazak Corporation is a leader in the design and manufacture of productive machine tool solutions. Committed to being a partner to customers with innovative technology, its world-class facility in Florence, Kentucky, produces over 100 models of turning centers, Multi-Tasking machines and vertical machining centers, including 5-axis models. Continuously investing in manufacturing technology allows the Mazak iSMART™ Factory in Kentucky to be the most advanced and efficient in the industry, providing high-quality and reliable products. Mazak maintains eight Technology Centers across North America to provide local hands-on applications, service and sales support to customers.