cover story

➤ BY ALAN RICHTER, EDITOR

This EMAG multitask machine for producing large parts features a chuck with a trunnion set up for turning and milling. EMAG

Big Parts, One Setup

Multitask machining large workpieces can increase worker safety and part accuracy while reducing idle time.

While micromachining may be a hot topic in the media, manufacturers are also making advances in "macromachining"—especially large part production. Whether it's mud-pump bodies for the oil patch industry, staging rings for jet engines, construction equipment lift arms or planetary gear carriers to help generate wind energy, manufacturers continue to produce more large parts, which are increasingly done in single setups on multitask machines.

The definition of a large part varies depending on who you ask, but this

Learn more about multitask machining large parts

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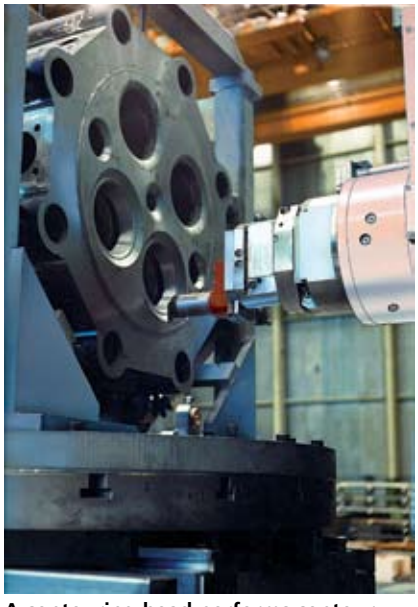
article looks at workpieces with at least one dimension measuring 500mm (19.7") or larger.

The term "multitask machining" is also open to interpretation. "I define multitasking as a machine that's able to perform dissimilar operations," said Ken Campshure, director of sales for MAG Giddings & Lewis, Fond du Lac, Wis. These operations include turning, milling, drilling, tapping, perimeter scalloping, boring, hobbing, grinding and even phonographic finishing, which creates a groove via a turning tool that spirals from a surface's outer edge to its center, similar to a groove on a long-playing phonographic record.

To perform these dissimilar operations via multitasking, MAG Giddings & Lewis offers vertical turning lathes with a spindle for live tooling and horizontal boring mills with a contouring head for facing and turning, as examples. The machine tool capacity available from the company starts at approximately a 1m cube. Campshure noted that about 80 percent of its VTLs have live spindles, and roughly half of its boring mill customers order a machine with a contouring head.



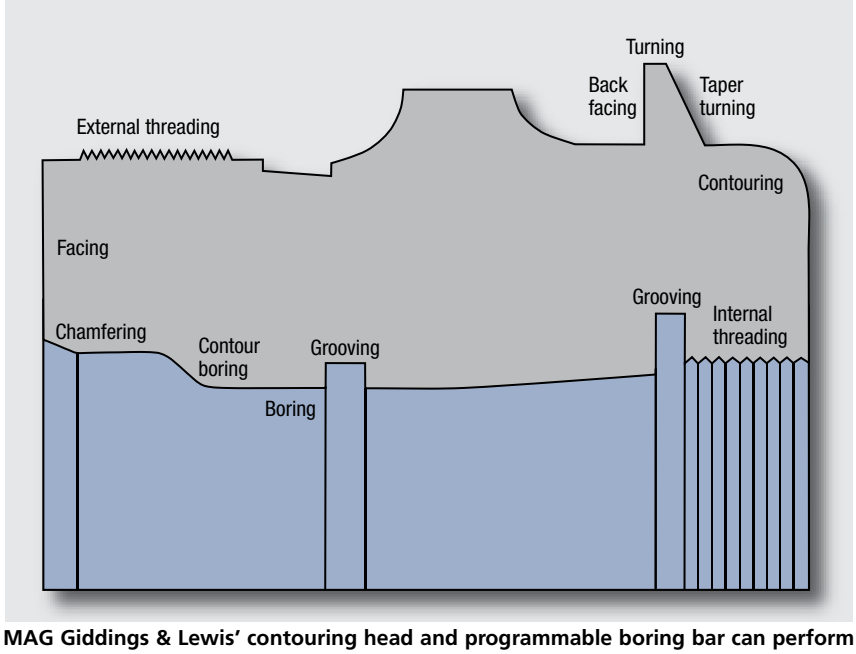
MAG Giddings & Lewis

A contouring head performs contour boring.

Safety First

One of the difficulties in machining a large workpiece that requires milling and turning, for example, is moving the awkward and heavy mass from one machine to another. That movement may require using a forklift or a crane with a set of hooks to swing the part from one place to another. "Any time I'm moving a big part around, there's a chance for that part to be out of my control," said Gary Hulihan, president of EMAG LLC, Farmington Hills, Mich., adding that a lack of control can be unsafe.

A multitask machine eliminates the need for such movement because the machine can produce all the required features in one setup. (See sidebar on



MAG Giddings & Lewis

MAG Giddings & Lewis' contouring head and programmable boring bar can perform multiple operations when added to a horizontal boring mill.

Searching for single setups

Knowing when and how to expand machining capabilities to include multitask machining to meet customer demands is a constant challenge. At John G. Wilson Machine Ltd., Princeton, Ontario, that challenge is even more significant because of the company's diversification and the large number of customers it serves. John G. Wilson Machine manufactures some 3,000 to 4,000 different parts per year for about 300 customers. In addition to full-service machining, the shop offers tube forming, punching, laser cutting and welding.

According to CEO Randy Wilson, the manufacturer's success lies in its diversity. "One of the strong components of our business has been the flexibility that our company has because of the type of machines we use and because of the type of diverse work that we are willing to do," he said. "If a customer's job is going to continue to grow, that's when we look to change the technology we are using to try and make that more cost competitive for our customer's benefit and also for ourselves."

Already owners of 18 Okuma machines, company management turned to EMEC Machine Tools, Mississauga, Ontario, Okuma's distributor for eastern Canada, for a solution to job growth demands. Brendan Cunningham, sales representative at EMEC, recommended an Okuma MacTurn multitask machine to improve the machining throughput of complex parts. By virtually eliminating the need to handle and fixture complex parts multiple times, the MacTurn reduces cycle times and part-handling times. A range of options in the 9-axis turn/mill machine includes an expandable automatic toolchanger, subspindle or tailstock, full B-axis or 1° H1 turret and a lower turret with optional milling capability.

"John G. Wilson Machine Ltd. was the ideal candidate for the MacTurn series machine," Cunningham said. "Because the company machines such a diversity of parts in a range of materials, they needed a high level of flexibility. The MacTurn machine allows producing many of these parts on a single machine in a single setup. The flexibility of the automatic toolchanger and the ability to hold up to 44 tools in the upper turret also provided the capability to run an unmanned third shift, effectively adding to production capacity."

The Okuma MacTurn multitask machine reduces cycle times and part handling by virtually eliminating the need to handle and fixture complex parts multiple times.

Reg Henry, operations manager at John G. Wilson Machine, described one job involving an 8620 high-carbon steel bearing stud for a lift truck. The part required a varying taper along its OD's full length and along the length of a hole hollowed in its center. "We produce 30,000 of these parts per year, and we were producing them using multiple operations on existing machines. It was costly and time consuming," said Henry. "The shop saved 90 seconds per piece by switching the part to the MacTurn."

The machine's full B-axis allows the cutting tool to be positioned at any angle. This, in addition to the B-axis' full milling capability with 15 to 20 hp, gives the shop the ability to produce a range of part geometries from even materials hardened up to 60 HRC.

Another part transferred to the multitask machine was a tension shaft that has a 0.001" tolerance between two milled surfaces, a 0.003" tolerance on its square edge and a 0.003" tolerance on the hex. The shop now makes the shaft in a continuous operation, with 1,000 pieces produced in each run. The scrap rate for the dimension between the milled surfaces went from 15 percent to zero after switching to the multitask machine. Before acquiring the multitask machine, broaching and finishing operations were done separately after the other machining operations, adding 3 minutes and 50 seconds to overall production time, which totaled 6 minutes and 35 seconds. Production time on the MacTurn is 4 minutes and 35 seconds.

The machine's rigidity enhances the company's capability to hold the tight tolerances, and that capability helped reduce the need for secondary finishing operations. Also, it takes about 6 minutes to change from one part in a family to another.

"Because we can produce a part from start to finish in one setup, we can satisfy a customer's delivery needs quickly, reducing queuing time to a minimum," Henry said.

John G. Wilson Machine now owns two MacTurns and manufactures dozens of parts running on both machines. "The machines give us the capability to grow our business in terms of capacity and build on our reputation for precision machining." Henry said. "In today's job shop business, if you don't buy into the technology, you're left behind."

—Jolyn Key, Communications Analyst, Okuma America Corp., Charlotte, N.C.

page 44.) EMAG builds a standard mill/turn line called the MT platform, which Hulihan described as modular. "Building blocks can be added to allow machining of different characteristics on a part than what you would typically do on a straight turning machine," he said.

Hulihan emphasized that safety is the most important factor in a manufacturing environment even if manufacturing professionals speak mostly about the need to productively make high-quality parts. "There's a qualifier to that, and that qualifier is safety," he said. "What did you accomplish if you ran 100 parts and somebody broke his leg or worse—heaven forbid? Eliminate those [part movement] opportunities and have it so you can produce the best, closest-tolerance parts you can possibly make at the lowest cost per piece and in the safest manner."

MAUS

Maus offers a frontal (top two images) or lateral pallet changer for loading and unloading parts.

Part Load/Unload

Even loading and unloading a large part into and out of a single fixturing can be a safety issue. "With the bigger parts, it's always a problem because you're loading to a chuck where you're going to clamp the part and that's time consuming; it takes people to be in the machine to do it and it increases the possibility of slipping and falling," Hulihan said.

To minimize that risk, end users will typically load large parts onto some type of roller or through-feed, cross conveyor. "The EMAG platform machine is designed to eliminate that risk. It's out in the open, so you have the ideal situation for loading the part," Hulihan noted. "You have a lot of control on how you can place a part because you have clear access to where you're going to set it."

Depending on the machine configuration, MAUS USA Inc., Calhoun, Ga., offers frontal and lateral pallet changers to load and unload parts for its multitasking machines. According to Alberto Fabris, the company's vice president, the choice of which type of pallet changer is most appropriate also depends on material flow, such as whether the workpiece is manually loaded or coming from a robot, conveyor, gantry or some other piece of equipment. "It could be much more convenient to have it in front of the machine or on the side," he said.

Fabris added that the two-position pallet changers enable a changer to be used to reposition a workpiece after an operation within the same machine to perform an additional operation instead of refixturing the workpiece in

another holder. "You reduce part handling," he said, "or you can machine two different parts, one right after the other."

MAUS offers its MTM series of multitasking machines in four platforms: 300, 500, 1,000 and 1,500 for producing parts from 200mm to 1,600mm in diameter. The largest platform enables machining of parts weighing up to 3 tons.

Part Positioning

When multitask machining a large workpiece, especially an asymmetrical one, it's best to avoid rotating the work in order to have a tool reach where needed, said Detlef Streichert, NT product specialist for Mori Seiki USA Inc., Rolling Meadows, Ill. "The part mass is pulling down its position because if you have an asymmetrical part, for example, the left side is heavier than the right," he said. Mori Seiki offers platforms within its NT series of multitask machines for producing large components, such as the NT5400, which comes with a 400mm, 500mm or 600mm chuck.

To multitask machine a part complete without rotating it, Streichert emphasized that a machine must have a high-enough Y-axis stroke, noting that the Y-axis travel is ±255mm on the NT5400. "With our machines, you don't have to rotate the part," he said. "You lock the spindle, leave the part in position and move the tool to where you need it.

When multitask machining a large workpiece, especially an asymmetrical one, it's best to avoid rotating the work in order to have a tool reach where needed.

It is difficult to image a machining center with two linear axes—X and Z—and a rotary axis to turn the features to be machined in the Z-X plane. However, that is exactly what the outdated mill/turn machines had, as they did not have enough Y-axis travel to machine many features and bolt patterns without rotating the work."

Streichert also emphasized the importance of having a machine with "an original Y-axis" to achieve Y-axis movements instead of interpolating X-axis and Y-axis movements. With two axes interpolating the Y-axis movement, there's greater positioning error because each axis has its own kinematic characteristics, he added. Moreover, if the tool is on the top or bottom of the part, the Y-axis stroke is reduced when creating a Y-axis movement from two different axes because one of the axes is no longer able to move due to its limited position.

Overcoming Inequality

Being able to machine a large part complete in one setup eliminates any tolerance buildup that might occur when refixturing a partially machined part into a different machine, but that doesn't necessarily mean the individual operations performed in a multitask machine will be quicker or more accurate than doing them in other types of machines. "Multitasking machines are not utopia," said MAG Giddings & Lewis' Campshure. "While a turning machine can do milling, drilling and tapping, it can't necessarily do all of those functions as well as a boring mill, for example."

He added that the tradeoff is the time it takes to remove the part from one machine, move it to another machine and refixture and redatum it vs. having one machine perform all the operations. "If you can adequately do the job to the quality levels that you need on a multitask machine, you're way ahead," Campshure said. "On the other hand, if you can't hold the tolerances required, it may force you to move the part to another machine."

Nonetheless, even when an individual operation takes significantly longer on a multitask machine, the end user may save much more time by not moving the part to a machine optimized for that task. For example, Streichert said one customer requires engraving a part, which takes 1 minute on a lathe compared to 8 minutes on a multitask machine equipped with a 25,000-rpm auxiliary spindle. But the setup time for the engraving on the lathe is significantly longer than 7 minutes, and it may take hours if the part is big. "One would need to carry the large part with a crane or forklift," he said. "Compared to the time required to do so, 7 minutes is nothing."

Even with differences in the time required to perform some operations, the quest is to make the machine's dissimilar capabilities compatible. "When I'm looking for a multitask machine, I expect a machine with milling performance like a milling machine and turning performance like a turning machine," Streichert said. He added that this is the case with NT multitask machines, where an NT machine with a 250mm chuck, for example, can remove about 555 liters per minute of chips compared to Mori Seiki's ML2500 lathe's rate of 560 liters per minute and its comparably sized horizontal machining center's rate of 500 liters per minute.

EMAG's Hulihan concurred that a multitask machine's dissimilar operations shouldn't have unequal performance. "If the cutting time changes dramatically on a multitask machine, getting longer to do the same amount of machining as it did across stand-alone applications, then obviously you're sacrificing something," he said. "Maybe the milling cutting doesn't have enough horsepower, so I can't do it in the optimal time. With the EMAG design, our cutting time will be as fast as on the stand-alone applications or even faster."

Fabris said the same holds for MAUS' offerings, depending on the application. "MTMs are best suited for low and medium production volumes," Fabris said, adding that one

Keyword

multifunction machines, multitasking: Machines and machining/turning centers capable of performing a variety of tasks, including milling, drilling, grinding, boring, turning and cutoff, usually in just one setup.

—CTE Metalworking Glossary

customer cut total machining time in half by switching production from two lathes and one HMC to a MTM series machine.

The MTMs are equipped with a semiautomatic loading and unloading system and an automatic toolchanger with up to 100 positions, enabling an end user to perform an array of operations. "You have full power for turning and full power for drilling, milling and so on," he said, adding that the MTM machines are primarily for turning. "They are complete machining centers, but the main operation needs to be turning."

This is because the MTMs are vertical machining centers, even when they have tilting heads for inclined operations, and having a turning operation is essential, Fabris noted, especially for round parts such as ring gears, bearings and hubs. "All the others are demanding and important operations, too," he said, "but are complementary to turning."

In addition to machining operations, multitask machines often can be tooled with probes for in-process measuring, which is the case for MAUS' MTM series. "The probing system is like having a CMM inside the machine."

Streichert indicated that about half the NT machines that Mori Seiki delivers have a metrology probe, which costs considerably less than an independent CMM capable of handling a large part.

Streichert also pointed out that a multitask machine may be able to reduce the total number of operations and tools to produce the required part features. In addition to time, that also saves money because the tools for big-part applications are usually large and therefore expensive.

Campshure said use of programmable boring bars or contouring heads are ways to reduce the number of tools required to make a part, enabling one tool to bore multiple diameters instead of having individual tools to rough, semi-finish and finish each bore size.

With all their advantages, multitask machining centers—for producing parts of any size—are generally more complex to operate, cost more than a lathe or a milling machine and are not for every metalcutting facility—at least not yet. "This [type of] machine is opening the door for the future," said Streichert. "I believe strongly that, maybe not in 5 years, but in 10 years, this machine type will replace all of the other machines." △

Editor's Note: A case study on multitask machining of a large landing gear component at Goodrich Corp. is available on www.ctemag.com. Please click on Interactive Reports.

MAG Giddings & Lewis

A MAG Giddings & Lewis vertical turning center drilling with two live heads.

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