Machining the BIG Stuff

A circa 1890 manufacturing plant's investment in new five axis milling leads to big productivity boost

Imagine manufacturing powerful motors and generators up to 100,000 hp weighing as much as 75,000 lb, measuring in the range of 17 ft wide by 17 ft high with an order-to-delivery cycle of 55 weeks for final customer delivery.

Then imagine cutting that delivery down time to 32-35 weeks and reducing machining time on critical components by more than two thirds.

It would be a tremendous challenge, but that's exactly what GE Energy's Motors and Generators division did when it decided to revamp part of its 750,000 sq ft manufacturing plant in 2008 and install a new Okuma double column machining centre, the MCR-BII.

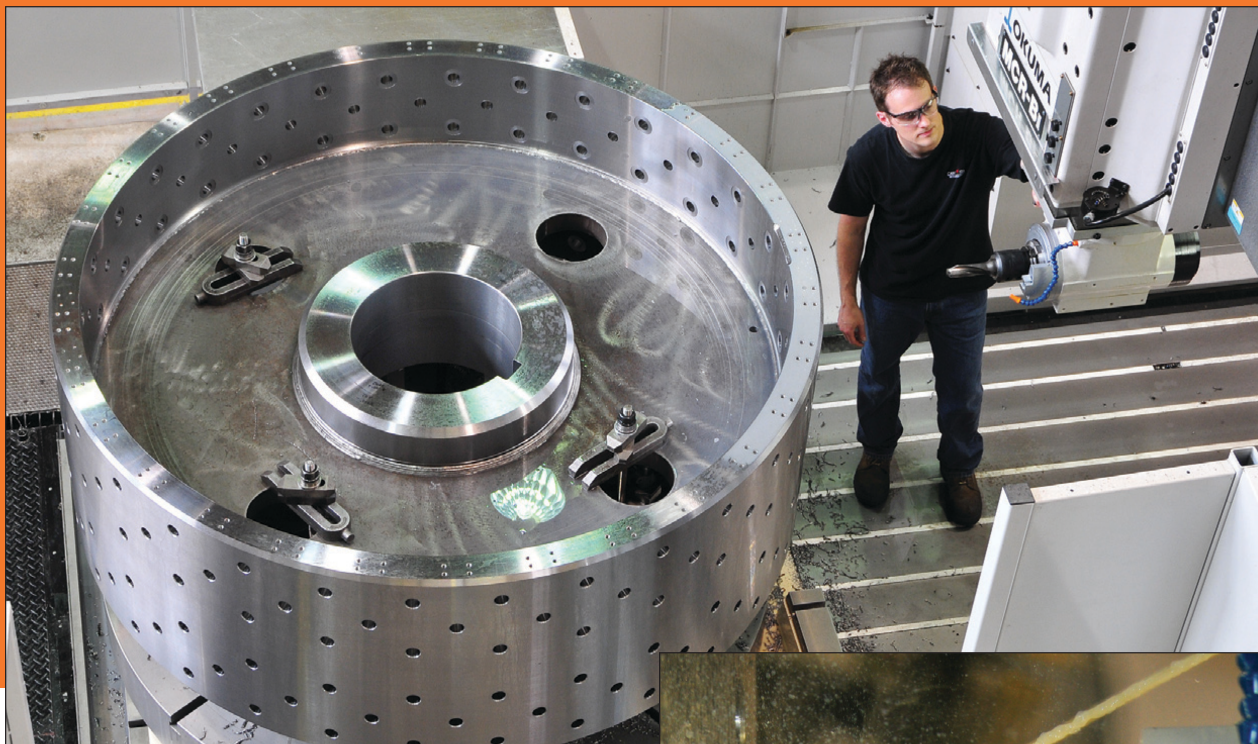
The new machining centre was a big change for this GE plant. Established circa 1890 as the Edison Electric Company, the manufacturing plant's 40-plus machine tools—lathes, horizontal boring mills and vertical boring mills—are decades old.

The older machine tools can handle forgings on lathes that weigh more than 35 tons, are 350 in. in length and 60 in. in diameter. Horizontal boring mills can handle parts over 350 tons, longer than 500 in. in length, 100 in. in height and W or Z axis travels of 40 in. The vertical boring mills handle parts that weigh more than 100 tons, measuring 120 in. high and 130 in. in diameter.

GE Energy's Peterborough plant manufactures synchronous high speed and low speed motors, induction (asynchronous) motors and generators. The major markets that use its motors include the oil and gas, power and energy, and mining industries. The high speed and low speed motors are produced in one machine shop on the east side of the plant, while the induction motors and generators are produced in another machine shop in the west side of the sprawling 1.5 million sq ft manufacturing facility. As well, large motors, including induction, are produced on the east side of the plant while AC traction motors for rail applications are produced on the west side.

Up until 2006, the machine shop that manufactures the synchronous low and high speed motors operated with few hiccups, delivering products around the world. (Approximately 80 per cent of the motors produced in the machine shop are exported, with a significant proportion destined for China and the Middle East.)

Part of the GE Energy team involved in selecting and planning the installation of the Okuma mill. From left to right: Oliver Schafranek, manufacturing engineer, Bill Nobes, supervisor, manufacturing support, and Russell Nash, productivity leader for motors and generators.



Top: One of the rotor spiders sitting on the table of the Okuma mill.

Right: A close-up view of a cutting tool on the Okuma mill machining a part.

Then management noticed a change in the demand for motors.

"What we were seeing was that between 2006 and 2007 the product mix completely flip flopped," says Tom Sayer, strategic growth leader for manufacturing at GE Motors. "We went from 65 per cent of our product being high speed motors and 25 per cent being low speed to the exact opposite, with 65 per cent of the products we were making being low speed machines."

He adds that the change occurred because of an upsurge in mining, which tends to use low speed motors versus the oil and gas industry, which typically uses high speed motors for its operations.

While both high speed and low speed motors are machined in the same shop, different machine tools are used to manufacture each type, and GE wasn't confident that its existing machine tools could accommodate the growing demand for low speed machines.

At the same time, there was growing competitive pressure to reduce cycle times and get machines out the door to customers faster.

"We were talking about going from one machine every three to four weeks to one machine every ten days for our quadratorque machines," says Sayer.

Bill Nobes, supervisor, manufacturing support, was one of the key people entrusted with figuring out how GE could accommodate the growing demand for low speed motors. To do that, he and his team zeroed in on the machining processes for the rotor spiders, the heart of the low speed rotor.

The process started with large steel rolled rim that was first placed, by overhead cranes, into the vertical boring mill to begin the cutting process. From there the crane would move the part to the layout area, a manual operation to plan out where holes and the keyway on the rotor spider would be machined, a process that would take about four hours. The next crane move would be to the slotter, a singe point vertical shaper, that would create the keyway with multiple small vertical cuts, then on to a horizontal boring mill that would drill and back spot face the radial holes. From there the part would be moved with the crane to the radial arm drill that drilled and tapped the top holes. The part was then flipped over with cranes for drilling and tapping of the bottom holes. The last step in the operation was to transport the part via the crane to the deburring area to remove sharp edges and wash.

The touch time cycle was 90 hours.

Nobes says the process was not efficient as there was a lot of downtime "You'd have to cue up each machine. So if a machinist wanted to put a part on the radial drill, he'd have to wait until the part sitting on the machine was gone and so you could have a part sitting a day or two. We found that three quarters of the time was just sitting and waiting to get on another machine."

To accommodate the growing demand for low speed motors, GE's aim was to reduce this cycle time so it could get more products out the door.

From the start, GE decided that the best solution would be a vertical machining process. Nobes and his team, which included Oliver Schafranek, a manufacturing engineer in the plant, spec'd out machines and visited suppliers of double column bridge mills to see the machines in operation to determine if these machines would suit GE's manufacturing needs. Okuma and SNK were among the early choices. The SNK mill was ruled out as it couldn't overcome some technical problems.

GE selected the Okuma double column machining centre with five axis capability, the MCR-BII. The mill was purchased through one of Okuma's exclusive distributors in Canada (Manitoba, Ontario, Quebec and the Maritimes), EMEC Machine Tools Inc., Mississauga, ON, and installed in March 2009.

While the return on investment for this multi-million dollar machining centre is 1.4 years, the dramatic benefits it has achieved in just a few months are worth it, says Nobes.

"We've gone from six operations to machine the rotor spider down to two and a half operations. And our machining time has dropped down to 24 hours from 90 hours. And material removal rates for some components, such as those machined on the slotter, is now 50 times faster on the Okuma machining centre."

Today, after the rotor spiders leave the boring mill, they're transported via cranes into the Okuma machine, which drills and taps top and bottom holes and the keyway all in one set-up.

An added benefit to the process is the reduction in setup time and the elimination of human error, says Tom Sayer.

"In the past, our machinists spent a lot of time laying out the holes and now these settings are in the computer. We don't have to redefine the data each time it moves to a new operation because we now have four setups programmed in the Okuma machine. So now we're not only faster we're also more accurate."

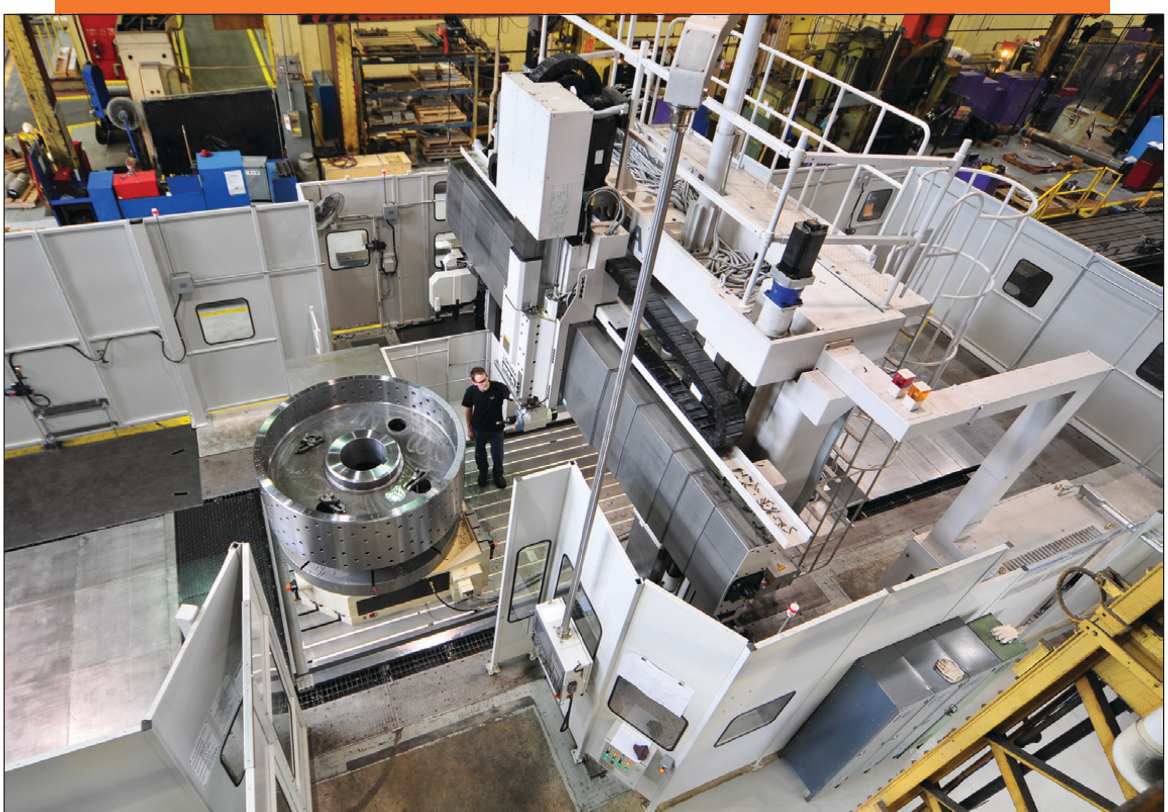
A new machining centre also means new tooling. GE uses several tooling suppliers. Among the major suppliers is Sandvik Coromant. Sandvik Coromant and its other tooling suppliers have equipped the Okuma machining centre with the latest high shear light cutting tools.

Russell Nash, productivity leader for large motors and generators says the tooling on the machine opened the door to new opportunities.

"At the end of the day, we were limited with what we could do with new tooling on existing machines because of the spindle speeds. Now with new tooling featuring the latest technology on the Okuma mill, it provides us another avenue of increasing productivity."

Despite the size of the mill—it's Okuma's largest double column machining centre that can accommodate up to 50 tools and handle a payload of 94,600 lb—installation, including the machine's foundation, went smoothly and maintenance has been minimal, says Nobes.

The Okuma machining centre in GE's plant weighs just over 67,000 lb with a floor space measurement for the machine only of 7,970 mm (313.78 in.) by 15,800 mm (622.05 in.). The effective width between columns is 3,050 mm (120.08 in.), while the table to spindle nose measurement is 150 to 2,450 mm (5.91 to 96.46 in.). The table measures 2,500 mm (98.43 in.) by 6,600 mm (259.84 in.) and features an X axis travel of 6,500 mm (255.91 in.).



One of the big challenges was trying to figure out the best location for the machining centre which, because of its size and open concept, needed to be in an enclosed cell. The team identified seven possible locations based on a number of parameters, with the most important factor being material flow. The location selected for the mill meant that GE could eliminate five machine tools, most of which were at the end of their life anyway and would not have been worth retrofitting, says Nobes.

Nobes adds that the machinists have taken to the Okuma machining centre. While there was a learning curve—for most of the young machinists it was their first experience with five axis/five sided machining—now that they're comfortable with the machine, GE is planning to expand the use of the machine tool for other products.

"We're just touching the surface of the capabilities with this machine," says Sayer. "As the product mix shifts again, it's our intention to begin machining the high speed motors on it too. And then the other possibility is that we can introduce new products with different designs on it. So it will allow us to become more efficient in machining and expand what we can do."

Design, adds Nash, is an important part of GE's success. Indeed, its business is geared to custom-made motors and introducing innovative designs.

A good example of a GE innovation is the quadratorque motor the company designed for its mining applications. The idea behind it, explains Sayer, is to take the stress off bull gears that have to turn big pieces of ore in a mill. GE created a design that features two synchronous motors working together on the same mill.

"We came up with the idea of two synchronous motors that have a second winding that changes the flux inside the rotor. Controlled by a quadramatic drive and combined with a clutch that you can jog, you perfectly match the rotation of those two motors, taking the stress off the gear," explains Sayer.

Another advantage of GE's quadratorque motor is its accessibility if something fails. Unlike the standard ring motors where the mill is part of the rotor and the stator is built around it on site, the quadratorque motor is designed in such a way that if you have a problem with a rotor or a stator you can simply drop in a spare and get the motor up and running faster.

GE Energy's Motors and Generators division has been making products for more than a 100 years and has the experience and know-how to make the best products in the market. But as competitive forces and market demands continue to change, Sayer says the Okuma machine is the right tool that will help the company gain a competitive edge by producing innovative products faster and more efficiently than its competitors. CM

GE Energy www.gemotors.com
EMEC www.emecmt.com
Okuma www.okuma.com
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PRODUCTIVITY INNOVATION

In order for GE Canada to process their workpieces on the Okuma MCR-BII bridge mill, some additional machine tool accessories were required.

The primary requirement was a heavy duty rotary table with the ability to support the rotor spider workpiece weight of 65,000 lbs. with the table mounted horizontally (as pictured in this article). Also required was a special right angle head to mill a keyway in the I.D. of the rotor spider, and a right angle head to drill & tap additional features on the rotor spider.

To fulfill these requirements, **EMEC Machine Tools Inc.** partnered with **Koma Precision, Inc.**, the North American importer for **Tsudakoma** rotary tables and **Romai** angle heads.

Tsudakoma designed and built a special 2,000mm diameter rotary table in compliance with GE Canada specifications. The rotary table was built at Tsudakoma in Japan, outfitted with Okuma servomotors, and wired to Okuma specifications. The table was shipped directly to GE Canada for a "Plug & Play" installation. An additional requirement for the rotary table was the ability to support a rotor shaft weighing up to 65,000 lbs. with the table in the upright position. Tsudakoma designed and built a special tailstock which is used with additional work supports to fulfill this rotor shaft requirement.

For the right angle heads, Romai designed and built special length right angle heads for the keyway milling operation and provided standard right angle heads for the drilling & tapping operations. All of these right angle heads have the ability to be automatically tool changed and were designed to use the existing anti-rotation block on the Okuma bridge mill.

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