JUNE 2004 / VOLUME 56 / NUMBER 6

▶ BY BILL KENNEDY, CONTRIBUTING EDITOR

TURNING THE BIG STUFF

Companies share ideas about turning long, large, heavy workpieces.

Despite the buzz, manufacturing today isn't all about micro- and nano-machining. There are *really* big parts being produced out there. Some are 100' long and weigh 100 tons. And, shops are turning these mega-workpieces to surprisingly close tolerances.

Conversations with representatives at a number of these facilities reveals how turning large parts is different from—and similar to—machining smaller ones.

What's Big?

Dave Ewing, president and chairman of Grand Valley Manufacturing Co., Titusville, Pa., categorizes the big parts GVM turns into three groups: long, large (diameter) and heavy. The horizontal lathes at GVM's Warren, Pa., facility can handle workpieces up to 100' long that have diameters to 116" and weigh as much as 198,000 lbs.

Typical of the long parts GVM turns are riser components used in the systems that transport oil and natural gas from the sea floor to offshore oil platforms. GVM machines specially engineered riser joints measuring 20' to 60' in length, with diameters from 10" to more than 24". In most cases, GVM machines the components from solid forgings.

Camco Machine

Camco Machine turned this 24'-dia. steel ring, part of a set for an autoclave door, on one of its Osaka Machine Tool VTLs.

B. Kennedy

Operator John Taydus at the NUM CNC that was retrofitted to the Farrell lathe at Grand Valley Manufacturing.

"We'll put a hole in it, finish-machine the contours and precision-thread it," Ewing said, adding that the risers are "not incredibly heavy—usually under 20 tons."

Parts in GVM's large-diameter category include 30"- to 96"-dia. casing pipes for the construction industry. An example is a 59"-dia. rolled and welded shell of low-carbon steel. The 20'-long casing's patented male and female connectors, which eliminate the need to weld casing pipes together, require GVM to hold tolerances of ±0.005".

A recent job at the company involved repairing an 82"-dia., 20'-long steel pressure vessel. GVM performed OD turning to evaluate the vessel's condition and then modified features on the 143,000-lb. part.

According to the owner of Machine Craft Co., Kim Jennison, machining big parts consumes big chunks of time. Truly large parts are quoted in "hours, sometimes days, instead of minutes," he said.

The Concord, N.H., company makes power-generation components, such as gas and steam turbine casings. "Some exhaust casings we've machined consumed about 350 man-hours," Jennison said. "High production" runs of such parts amount to just one or two pieces a month.

The investment of time, along with workpiece size, makes part handling a crucial element of the production mix. "Every part has to be rigged," explained Jennison. "If you're dealing with a piece that weighs 10,000 to 15,000 lbs., or more, and you've got several hundred hours already into it, you handle it very cautiously, for both safety and economic reasons."

The plant manager at GVM's Warren facility, Duane Baker, said, "Our average part is probably 40,000 lbs. You don't pick it up by hand; you use a crane." But it's still important to pay attention.

"Your load has to be level," Baker continued. "You don't just hook onto something and lift it. You lift it straight." GVM uses basket hooks and nylon straps capable of hoisting 100,000 lbs. in a straight pull.

Baker said, "Most everything is lifted with nylon straps. I don't like to see chains on anything because chains can slide."

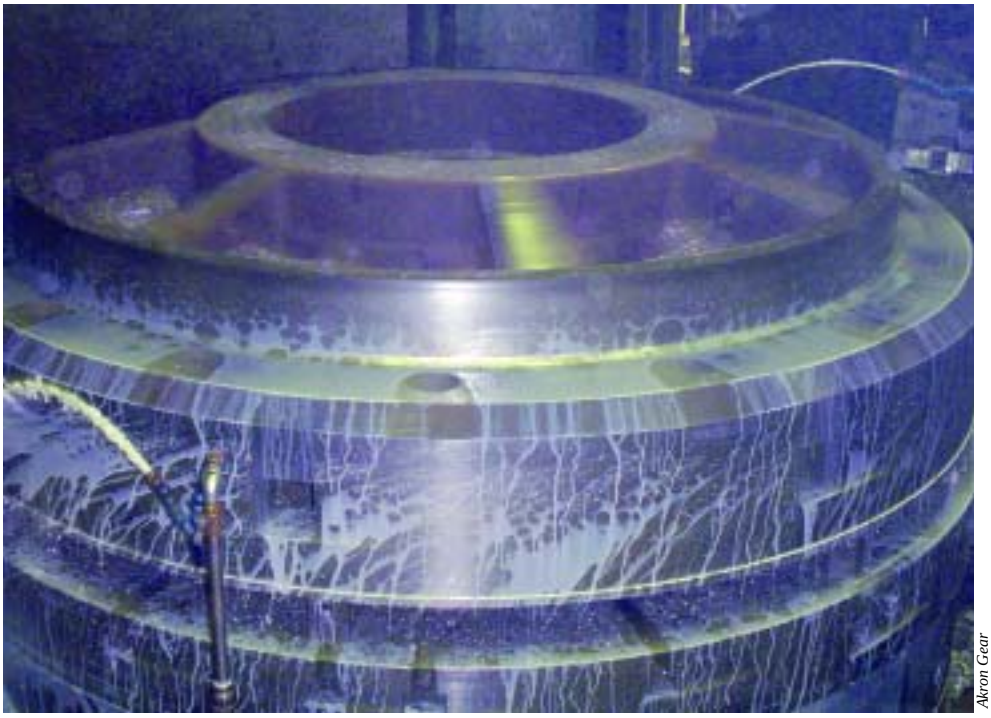
Big Machines

It takes big machines to produce big parts. But not all big machines are big in the same way.

For example, the vice president of Camco Machine Inc., Steve Weaver, said his company's Morando vertical turning lathe can support up to 400 tons and turn a part 17' in diameter and 18' high. ("It is most likely the largest and most capable of the precision, heavy-machining lathes in the West," he said.) One of the company's Osaka Machine Tool VTLs, on the other hand, lacks the weight capacity of the Morando but can turn parts 40' in diameter and 8' high. Another of the company's Osaka VTLs has a part-height capacity of 10'.

The mix of machines enables Camco to tailor machine usage to part size, Weaver said. "You wouldn't want to put something small on the Morando when we have other verticals that can handle the job."

Machines that turn large parts often are customized to fit the application.



Akron Gear

It took 30 hours to OD- and ID-turn and counterbore this 109"-dia., 24"-high, 18,000-lb. casting on a Bullard Dynatrol VTL at Akron Gear & Engineering.

GVM's horizontal lathe for big diameters is an older, Russian-made Stanko machine that can handle 116" diameters and has 33' between centers. For truly long parts, the company's 40-year-old Farrell lathe boasts 88' between centers and a 77" swing. Both machines have been retrofitted with NUM CNCs, which enable them to produce complex contours and tapered threads.

Baker said GVM also upgraded other areas of the machine. For example, the Stanko's lead screws were replaced with ballscrews, and a W-axis was added parallel to the Z-axis to boost accuracy. Before the upgrades, Baker said the lathe could comfortably maintain a tolerance of ±0.010." Now it routinely holds ±0.001" or better.

Adding options at the time of manufacture can help optimize a machine tool's ability to process large parts. One company that understands this is Black Clawson Converting Machinery Inc.

The Fulton, N.Y., company is a global provider of converting and pelletizing equipment. The machines it engineers and manufactures are used by the labeling, packaging, coating and converting industries to make products such as labels, stretch film, flexible packaging and personal-hygiene products. The equipment incorporates a variety of large, precision rolls.

Black Clawson's machine shop manufacturing supervisor, George Fox, said some rolls are larger than 30" in diameter, and lengths may exceed 160". Most of the large rolls are made of steel and are turned on a Binns & Berry lathe. The machine can handle parts up to 40" in diameter, 315" in length and that weigh as much as 24,000 lbs. (when supported by two steady rests).

Fitted with a Fanuc control, the lathe is a standard model. However, Fox said, "it started out as a basic package, but [ended up being] custom-built for our needs." Black Clawson's specifications included a live-tooling capability so features such as longitudinal grooves and keyways could be machined while the rolls were still chucked in the lathe.

B. Kennedy

Operator Charlie Fiely uses a crane to load a large rolled and welded steel casing pipe into the Stanko lathe at Grand Valley Manufacturing.

"In the old days, you took a round part off the lathe and brought it over to a mill to machine the keyways," said Fox. "In today's world, we do all the turning, then use the live tooling to mill the keyway while the roll is still on the lathe."

Balance is a crucial consideration in the production of rolls. "Today, everybody's trying to do more," Fox said. "The faster our customers can run their lines, the more product they can make. All our rolls are balanced so they don't vibrate when run at high speeds."

Balancing is a multistep process. First, on the lathe, a skim cut is taken on the roll's OD. The roll then is moved to rollers, where the amount of imbalance, in terms of weight, is determined. A formula tells how much the roll must be offset in the lathe's chuck to remove the off-axis weight.

After turning, a precision-balancing machine ascertains the exact degree of balancing necessary to permit a roll to operate at the requisite speeds. At that stage, Fox said, "you're talking about adding or subtracting a very small amount of weight (through drilling out weight or adding plugs) to get rid of any vibration."

Cutting Parameters

Surprisingly, perhaps, the cutting parameters and tooling applied to large parts probably are familiar to shops that machine smaller workpieces. For example, achieving sufficient cutting speed is usually not a problem when turning a large-diameter part. Jennison said, "If you have a 120" diameter, it doesn't take much rpm to get 700 surface feet, which is what we'd normally run on steel with most coated carbides."

Nor do big parts necessarily require big tools. Ewing said GVM "pretty much uses regular coated carbide. If we are roughing and removing a lot of stock, that's when we get into larger inserts. For finishing work, where we don't need a lot of muscle, we use smaller carbide." Normally, a CNMG 643 is the biggest insert the company uses.

For contouring cuts, GVM applies a ⅛"-wide parting tool run at a DOC of about 0.010" that's held in a 60mm, quick-change modular toolholder. The modular tooling, Baker said, "gives us repeatability."

The following companies contributed to this report:

Akron Gear & Engineering
(800) 258-6608
www.akrongear.com

Black Clawson Converting Machinery Inc.
(315) 598-7121
www.bcconverting.com

Camco Machine Inc.
(909) 823-0657
www.camcomachine.com

Grand Valley Manufacturing Co.
(814) 827-2707
www.gvmco.com

Machine Craft Co.
(603) 225-0958

B. Kennedy

Turning an ID at Grand Valley Manufacturing.

He added that the company mostly uses inserts with standard edge preparations, but on occasion, it applies modified tools. Larger edge preparations can increase cutting forces, so "with thin-walled material, a 0.008" or 0.005" edge prep might be too much, so we'd use a sharper edge," he said. In some materials, though, an insert with a standard edge prep might chip, so one with a honed edge is used.

Fox said Black Clawson generally sticks with an all-purpose grade. The low volume of parts it runs minimizes the importance of optimizing tool performance. "We're not like some large production place that will run 3,000 parts and get a vendor in to work with several different grades to get the maximum output from the insert," he said.

Akron (Ohio) Gear & Engineering Inc. machines gear blanks up to 109" in diameter on a Bullard Dynatrol VTL. The company's vice president of manufacturing, Mike Stohovitch, said that for heavy metal removal, the shop generally employs standard negative-rake, coated-carbide inserts. "We can feed up to 0.050 ipr; roughing feeds are usually in the 0.030- to 0.040-ipr range. The machine will do 130 rpm, and we try to set a baseline of 300 sfm for roughing and maybe 350 sfm for finishing in steel. You'd be amazed how slow it has to run to maintain 300 sfm."

Tight Tolerances

Some might be amazed at the tolerances held by shops that machine large workpieces. Ewing said tolerances of ±0.001" to ±0.005" are typical at GVM. A common operation is cutting a tapered thread at the end of a 30'- to 60'-long riser component. Those usually are held to ±0.0015".

Baker added that extra support, in the form of steady rests, is essential when turning long parts.

Jennison maintains it is not difficult to attain tight tolerances on large parts if the proper equipment and techniques are employed.

"Actually," he said, "the biggest issue probably is the ability to inspect." Shop temperature is a factor. "You're dealing with a micrometer that is 60" to 70" long, and you get thermal expansion and contraction in the micrometer and in the part itself."

Machine Craft doesn't have a controlled atmosphere. "We just try and do all the inspecting at the same time and temperature and keep it uniform," said Jennison. "It's tougher in the wintertime. Even if a machine is 100' from the overhead door, if somebody opens it for 4 or 5 minutes and drives a vehicle in, you can have a difference. You can put an indicator on the part and watch it grow or contract," he said.

GVM uses large ID and OD micrometers that enable operators to measure around the quill on the tailstock. It also uses Pi Tape—a precision diameter-measuring tape for gaging part ODs.

When close tolerances are required, GVM makes test cuts at a number of different locations along the part's length. A cut might be taken at a 0.030" DOC, then the operator would gage the part and set his offset accordingly.

"It gives him a starting point," Baker said.

No Big Deal

He also said that the key to turning big parts efficiently is the knowledge that comes from experience.

In some respects, noted Stohovitch, turning big parts is no different from any other machining. "It takes proper training of the operator and proper machine shop practices."

The operator's attitude is critical, said Camco's Weaver. "Whether you're machining a tiny part or a big part, the need for confidence on the part of the operator is the same." To that end, Camco schedules weekly training sessions for all its operators.

One way big- and small-part production differs, though, said Baker, involves the "fun" factor. "Making thousands of small parts can get monotonous. Even though the part prints for two big parts may be the same, they can machine completely differently. This is a fun job."