Large Ultrasonic Unit Makes a Big Splash in Immersion Inspection

Oceangoing ships, power plants and steel mills use large, powerful gearboxes—up to 100,000 horsepower. To make the gearboxes' pinions and shafts, a gear manufacturer may start with bar stock and stepped steel forgings up to 160 inches in length and 18,000 pounds in weight. Also, the bar stock may be up to 22 inches in diameter and the forgings up to 40 inches in diameter.

To make the gearboxes, the company machines the forgings and bar stock with keyways, holes, teeth or other features. But, before it can do that, the company has to inspect the parts for defects.

Lufkin Industries' new immersion ultrasonic inspection unit can handle bar stock and stepped steel forgings up to 160 inches in length and 18,000 pounds in weight. The bar stock also can be up to 22 inches in diameter and the forgings up to 40 inches in diameter.

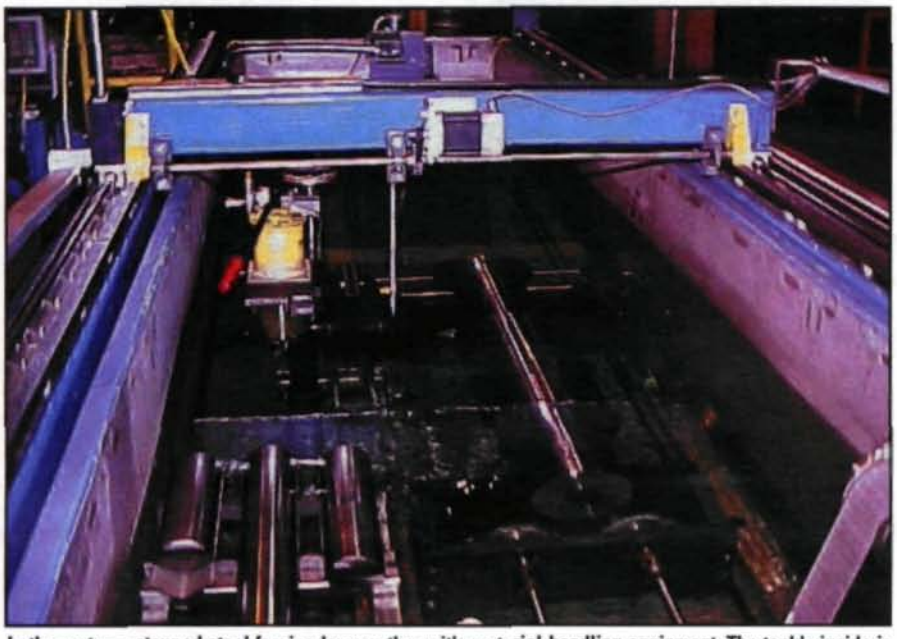
"The big investment in machining is about to take place," says Walter Wozniak, president of Innovative Test Systems Inc. of Baton Rouge, LA. "You want to find any defects in the forging before you begin the expensive final machining."

Lufkin Industries builds large, powerful gearboxes. Until recently, it inspected its forgings and bar stock manually, with a hand-held transducer probe. But, Lufkin now has a new device to inspect its parts—an ultrasonic inspection unit capable of handling parts up to 40 inches in diameter, 204 inches in length and 18,000 pounds in weight.

Specially made for Lufkin, the unit is the first one of its size built by Innovative Test. Such large units can also be specially built by other companies, like Matec Instrument Companies Inc. of Northborough, MA, and Panametrics Inc. of Waltham, MA.

The unit consists of a scanner, tank and material-handling equipment. Parts are lowered into the water-filled tank and are laid on the material-handling equipment.

The tank's inside is 214 inches long, 55.5 inches wide, and 40 inches tall. It can hold about 2,000 gallons of water. Lufkin fills the tank with about 1,500 gallons, which reaches about 29 inches up the tank's walls. The remaining space is for the parts, which displace water inside the tank.



In the water, a stepped steel forging lays on the unit's material-handling equipment. The tank's inside is 214 inches long, 55.5 inches wide, and 40 inches tall and can hold about 2,000 gallons of water.

The scanner uses ultrasound to look for irregularities—cracks and voids—in the parts. The ultrasound signal reflects irregularities back to the unit's operator via the ultrasonic instrument display. The signal's reflected amplitude and time to return allow the operator to determine a defect's location on a part, its size, and its depth from the part's surface.

Wozniak designed the scanner and tank by scaling up one of his existing scanners and tanks. He also created the material-handling equipment himself.

The equipment uses powered, horizontal rollers to rotate parts inside the tank. According to Wozniak, the rollers' ability to handle 18,000 pounds was unusual for ultrasonic inspection units—"To me, that was what made it unique."

Wozniak explains the equipment couldn't have a fixed geometry because each Lufkin forging can have segments with different diameters and lengths.

"It had to adapt," Wozniak says of the equipment. "It's just a feature that makes it more versatile."

An operator can adjust the rollers for diameter and length and the probe for pitch and yaw. Also, the unit has four computer-controlled, motorized axes,

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allowing for rotation along the W axis and linear interpolation along the XYZ axes.

Using an operator pendant with a liquid crystal display screen, the operator teaches the forging's shape to the unit, calibrating the ultrasonic instrument for the thickness of each forging's different segments. The operator then pushes the "cycle start" button, and the unit takes over from there.

Delivered in September, the unit is now part of Lufkin's power transmission division, located in Lufkin, TX. The unit will be used daily once it's fully added into Lufkin's production process, replacing its old inspection method.

That method used manual contact ultrasonic testing, which was performed after final heat treatment and turning, but before the part was machined with keyways, holes, teeth or other features—inspecting a part with features would be difficult because of its irregular shape. The part was turned to have a smooth surface finish, placed in a lathe between centers and coated with oil.

The part was then rotated very slowly while an operator held a transducer probe against the part, the oil serving as the coupling between them. With the probe against the rotating part, the operator moved the probe slowly down the part's length and checked the ultrasonic-testing instrument for indications of defects.

Mark Townley, Lufkin's project coordinator for the unit, says the company got the new device to improve its inspection process. He explains that Lufkin bought several multi-tasking turning centers for the division's facility. The turning centers can take a raw forging and perform multiple operations, like turning, milling keyways and drilling holes.

But, to inspect parts, Lufkin had to either stop the turning centers after turning but before milling and drilling, or find another way to inspect parts before they were put in the turning centers.

"Of course, we didn't want to stop production," Townley says. So, they found another way: immersing the parts for ultrasonic inspection.

"The immersion inspection unit allows you to have a rougher surface finish on the part," Townley says.

Innovative Test created the unit to inspect parts that haven't yet been turned. Besides eliminating that pre-turning, the new unit improves on the old method in other ways:

- Inspection is automated and more efficient;
- Parts with rougher surface finishes can be inspected because immersion testing provides better coupling between part and probe than contact testing;
- The unit's automated scan stops and sounds an alarm when it finds a defect, eliminating the need for quality-assurance technicians to constantly watch the ultrasonic-testing instrument, as required in contact testing; and
- Lufkin no longer has to pre-turn parts before inspecting them because the unit

can inspect parts after heat-treating and before final turning.

The unit uses as many employees as the old method used, though it has added a step to Lufkin's production process.

During heat treating, parts can form scales on their surfaces. The unit could read those scales with pockets of trapped air as though they were defects. Lufkin now removes those scales by shot-blasting each part. The parts can then undergo immersion testing in the unit.

Still, Townley says Lufkin expects the unit to provide a faster and more thorough inspection than the old method. The company has limited experience with the unit and parts can vary widely in size, but Townley explains Lufkin expects an average-sized part would take about 30 minutes to inspect compared with about 90 minutes using the old method.

He adds that Lufkin also expects to save money through the reduced inspection time.

Circle 300

Spline Rolling Takes a New Form

Spline rolling with rack-shaped tools has long been one of the fastest and most economical methods of manufacturing splined, toothed or threaded parts, especially in high-volume industries, such as automobiles, trucks and marine and off-road vehicles.

Equipment manufacturers have recently introduced new machines in North America that may provide even more advantages in certain applications. Several manufacturers now offer vertical spline rolling machines in addition to the traditional horizontal models, and some of the machines now employ servomotors instead of hydraulics to drive the rack-shaped tools.

According to those manufacturers, the result is machines with more flexibility and programmability in smaller, more efficient packages.

Nachi Machining Technology Co. (formerly National Broach & Machine) of Macomb, MI, demonstrated its servo-driven PFM/NC vertical roll forming machine at IMTS 2000 in September. Although the servo drives are a recent addition, building vertical machines is nothing new to Nachi, which has provided them for more than 30 years.

The advantages of a vertical machine are numerous, according to Nachi. On a horizontal machine, any flex in the machine causes the upper slide to move more than the lower slide, says product manager Harvey Yera. On a vertical machine, the slides move equally, Yera says, and you get more consistency in the rolling of the part.

That consistency results in greater control over tooth-to-tooth variation in the spline, adds Nachi account manager Nick Carene.

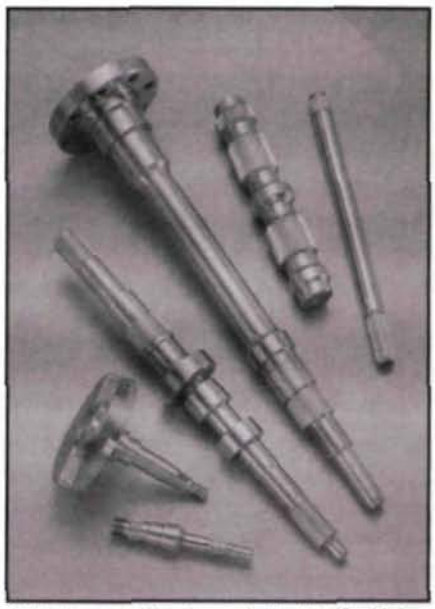
But the vertical machines' greatest advantage over horizontal machines of the same capacity may be their reduced size. "One huge advantage is floor space and cellular manufacturing," says Craig Everlove, president of Anderson-Cook Inc. of Fraser, MI. The company's newest machine is the servo-driven Marand 340V vertical spline roller.

Floor space is a primary selling point for other manufacturers as well. For example, the Nachi PFM/NC machines use 50 percent less floor space than a horizontal machine of the same capacity, says Raymond Wagner, vice president of marketing and sales for Nachi.

West Michigan Spline Inc. of Holland, MI, also manufactures vertical spline rolling machines. According to president Gary Hill, "the only advantage, in reality, is the floor space." Hill estimates that his company's vertical machines save approximately 25 percent to 30 percent of the floor space typically used by a comparable horizontal machine.

In addition to going vertical, many of the machines are going digital. Instead of the traditional hydraulic pumps, motors and cylinders to drive the motion of the rack tools, the newer machines employ electronically controlled servomotors.

Eliminating the hydraulic units reduces the size and weight of the machines even further than simply going vertical, but there are many other advantages, the manufacturers say.



Rolled parts. Courtesy of Nachi Machining Technology Co.

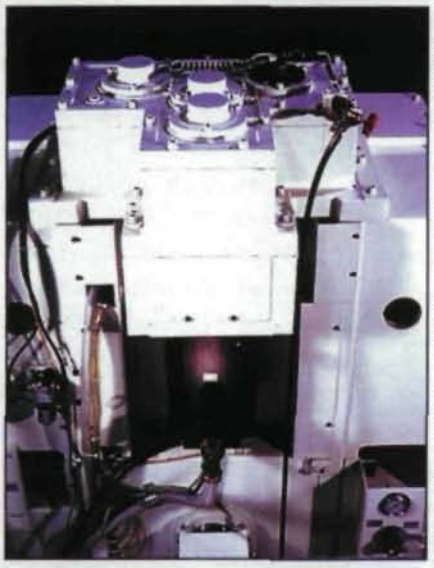
For example, with no hydraulic pumps or motors, the Nachi PFM/NC machines use 66 percent less energy than their hydraulically driven predecessors, Wagner says. "A byproduct is that it's also a much quieter machine. The servo-driven machines are 5-10 dB quieter than a typical hydraulic machine."

However, hydraulic machines are also getting quieter, says Hill. Today's hydraulically driven spline rollers typically operate within OSHA standards at well below 80 dB, he says.

Another advantage to the servo drives, Everlove says, is that they give the manufacturer more control over the motion of the slides that carry the rack tools. The servo drives make it easier to adjust the speed and synchronize the slides, he explains.

Yera agrees, and he points to that control as one of the main advantages of the servo drives. Although you can change the speed and force with a hydraulically driven machine, AC servo drives provide for easy programmability, Yera says. "With AC servo drives, you can vary the speed at any point in the rolling process."

The first three-quarters of the roll determines the quality of the part, Yera says. Slowing down the roll at the beginning reduces impact, minimizes oscillation and prevents slippage, which results



The PFM/NC machines from Nachi roll parts vertically (top). The machines are servo-driven (middle), and complex parts are "taught" via a handheld pendant (bottom).

in improved tooth-to-tooth spacing and composite index measurements, he adds. The programmability of the CNC machine allows the manufacturer to experiment and modify speeds to produce a better part.

In addition to the companies already mentioned, General Broach & Engineering Co. of Morenci, MI, uses servo drives on both its horizontal and vertical rolling machine models, according to the company's Website.

Because of the push toward cellular manufacturing, most of the spline rolling machine manufacturers have begun producing vertical machines, but not all have jumped on the servo drive bandwagon. Despite some apparent advantages of the new servo-driven vertical machines, some manufacturers have stuck to the traditional hydraulically driven models.

For example, West Michigan Spline manufactures vertical spline rolling machines, but their machines use hydraulics. The advantages gained by adding servo drives and CNC controls are simply not worth the price tag, says Hill.

A builder of only horizontal machines, Micromatic Textron of Holland, MI, uses servo technology for headstock positioning only. Instead of designing a completely new machine, the company has focused on improving the technology of its traditional models and finding other ways to increase productivity, says Bob O'Connor, sales manager for gear machinery. For example, O'Connor says, horizontal machines are getting longer and longer strokes, which allows the manufacturer to produce multiple splines on one part, larger diameter parts and parts with coarser pitches. While most of the vertical machines on the market have a maximum rack length of 48 inches, some of the horizontal machines allow racks as long as 60 inches or more.

Also, O'Connor says, the company is still waiting to see how well the servo-driven machines will hold up over the years. "The loads are fairly heavy in spline rolling," says O'Connor, who also suggests that some of the components needed in a servo-driven system may not hold up as well as their hydraulic counterparts. "Our concern was for the long run."

According to Hill, a user periodically will have to rebuild the hydraulic cylinders on a hydraulically driven spline roller. "If the machines are built correctly and the cylinders are lined up properly, they will last for seven to nine years," he says.

The engineers at Nachi say that their servo-driven system will hold up at least as well as a similar hydraulic system. "We know that the ball screws have a service life of at least 10 years," says Wagner.

Each type of machine has advantages and disadvantages, and both will require some kind of maintenance and refurbishing over their useful life. All the manufacturers agree that the customer should consider those issues carefully before deciding on one type of machine over another.

Despite the reservations of some manufacturers, the combination of servo drives and the vertical machine orientation seems to be a hit with customers, says Wagner. According to Wagner, Nachi has sold approximately 45 of the PFM/NC machines worldwide since the model was introduced about two years ago, with about 10 of those machines sold in the United States.

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