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Better Production

As the search for hydrocarbons expands into deeper areas of the world's oceans, components of offshore petroleum production and distribution systems are subject to ever-higher operating pressures. In recent years, dimensional specifications for accuracy have tightened as much as tenfold to enable these parts to withstand the demands of deepwater drilling and production. While deviations of a few thousandths of an inch were acceptable in the past, today's customers often demand tolerances of a few ten-thousandths of an inch.

Fortunately for America's energy industries, manufacturers of machine tools, shop tooling and fixturing have kept pace. And shops like Longhorn Machine Inc. have been successful enough to fund capital investments in new machining technologies and develop advanced processing methods to make maximum use of these investments.

A five-axis Vanguard TH series planer-type horizontal mill machines the thick manifold plate. This represents one of 20 individual machining setups totaling 300 hours in which 800 out of 5,000 pounds of metal will be removed.

Based in Houston, Texas, Longhorn specializes in machining small quantities of large, complex parts for offshore drillers and oil service tool companies. The company's current project—machining expensive stainless steel blanks into large manifold plates for offshore petroleum production and distribution systems—epitomizes many of the difficulties inherent in such demanding applications. Thanks in part to CAD/CAM and machine tool upgrades, the company has managed to meet the tolerances dictated by its customers while reducing machining time and labor.

Expected to extend into 2009, the manifold plate project involves 30 pieces with a total of about 6,000 hours of work, most of which is metalcutting. Operating at depths of about 5,000 feet, the plates are subject to significant undersea corrosion and pressures reaching as high as 10,000 psi. To meet these demands, Longhorn cuts the plates from Nitronic 50, a corrosion-resistant, stainless steel alloy that is similar to AISI 316 stainless but tougher.

Measuring 65 by 45 by 4.5 inches, the manifold plates are both large and heavy. The blanks from which they are machined weigh 5,000 pounds each. The plates have dozens of drilled and bored holes—some are through, some are blind, some are intersecting, and many are threaded. The manifold plates' mating surfaces require a finish of 32 RMS or better, and each plate requires 20 separate setups on half a dozen CNC machine tools. During 300 hours of cutting and handling each plate, Longhorn machines away 800 pounds of metal.

Despite all this, the company's biggest challenge is the potentially huge cost of a programming or machining error. Each steel blank carries a hefty price tag before machining even begins. In addition, the company must deal with an inflexible delivery schedule. After machining, the manifolds go to offshore drilling rigs in the Gulf of Mexico. "The

rates for those drilling rigs can total hundreds of thousands of dollars per day," says Jim Weatherly, Longhorn president. "We can't be late."

All of these considerations make error-free machining the first time around imperative for the company to maintain its bottom line. To deal with the size and complexity of this job, Longhorn made some changes. In 2005, the company invested in a CAD/CAM consultant, a new CAD system to replace a previous mix of 3D design packages, and a new machine tool. Tying it all together is EdgeCAM, a CAM software package from Pathtrace Systems (Southfield, Michigan). Two Longhorn programmers—one of whom also manages the shop—use this software to run all the machines, including the five-axis models.

Following these changes, programming time per manifold plummeted from an initial 250 hours per job to about 10 hours. A key part of that effort was the CAM consulting work performed by Steve Duke of Houston-based EdgeCAM reseller Digital Graphic Systems, a unit of ECAD Inc. Mr. Duke was hired to clean up manifold design files and relieve Longhorn's beleaguered programmers, who became bogged down in their efforts to ensure zero errors in machining operations.

"Steve helped us simplify and use a complex model from our customer, which helped us program the manifolds faster," Mr. Weatherly says.

The company achieved other productivity gains by taking advantage of the features of the software itself. The company relies on the CAM software for opening solid models, feature finding, CNC program verification and machining cycle simulation. For internal CAD tasks, the company uses SolidWorks from Dassault Systems, but customers typically send files in Autodesk Inventor, Solid Edge/Parasolids (Unigraphics) and Granite/ProEngineer. EdgeCAM's Solid Machinist packages can open all these solid model formats.

Company: Longhorn Machine Inc.

Problem: Long cycle times and overworked programmers because of demanding part specs

Solution: EdgeCAM software, Vanguard TH-Series Boring Mill

Results: Less time spent programming and machining

"A solid model is preferred over any other form of geometry for programming," Mr. Weatherly says. " Solid models enable us to simplify the programming process so that only the incoming part model and necessary cutting tools are needed to generate a CAM tool path. After that, job programs are post-processed to specific machine tools with the Code Wizard.

The simulation features are used to prove-out programs and review the action of the cutting tools. However, Mr. Weatherly says simulation is not practical for estimating the manifolds' total cycle times or costs because of their lengthy machining time. In addition, while using simulation to estimate machining time can be helpful for bids and quotes, the company's manifold plates were not competitively bid (although the customer did impose budget constraints).

Also important is ease of use. Many CAM packages achieve ease of use by limiting the programmer's options to fixed sequences of steps. As it refined EdgeCAM over the years, developer Pathtrace took a different approach, applying ease-of-use principles to even the most complicated tasks. According to Longhorn, the result is leaps in programming productivity rather than only ease of learning and quick comprehension for new, inexperienced users.

Part of the company's productivity gains result from using the software to standardize its cutting tools, feeds and speeds.

"We have now associated the tools with the job, and this association has allowed us to standardize a large part of our programming," Mr. Weatherly says. Linking tools to jobs saves programming time, eliminates variances in processing on the shop floor and removes a potential source of programmer error, the company says.

"EdgeCAM and the new ways of handling customers' solid models have allowed us to simplify our methods of programming and minimize the inevitable variations," Mr. Weatherly says. "That has given us the proper tools to expand our work load. The solids feature of EdgeCAM makes possible the visualization of complex features. Also, the feature finder is very helpful."

The software allows the company to program "the same way we approach a particular machine," he continues. "We pick a tool, go there and do the programming."

The new machine tool is the five-axis Vanguard TH-Series planer-type horizontal boring mill. Longhorn's 15th CNC machine, the mill features a 63 by 71 inch worktable that can accommodate a 22,000-pound load; a Fanuc 18iM control with digital readouts; and a 40-pocket ATC. The machine's 50-hp motor generates as much as 4,500 foot-pounds of torque for the 5.1-inch spindle. For five-axis machining, the mill has a B axis, W axis and a rotary table. XYZ positioning accuracy is 0.0003 inch, and XYZ repeatability is 0.0002 inch.

The manifold plates are milled with 6-inch-diameter Iscar FF-type indexable cutters. The tungsten carbide cutters are run at 320 sfm and a feed rate of 45 to 50 ipm.

"We take as many as 30 roughing passes before welding, then two more after welding for straightness, flatness and parallelism," says Miguel Lazo, programmer and shop superintendent. The manifold plates are not heat-treated.

For finishing operations, the company uses 8-inch-diameter Ingersoll indexable Micro-Mill cutters at 150 sfm. "We take as many as 10 finishing passes, which gives us surfaces that are many times better than the specification, which is 32 RMS," Mr. Lazo says.

For drilling, the company uses Iscar Chamdrills, Star-SU gundrills and Sumitomo carbide tooling. Threading is done with Emuge spiral flute taps.

These upgrades complement its faster, more accurate programming. The company says this has reinforced its preeminent position among shops that specialize in large, complicated, high-value work. Thanks to the CAM package, Steve Duke's work and shop-supervision efficiencies, machining time and labor has been reduced from 400 man-hours to less than 300 for the second plate and to less than 250 for each subsequent plate, Mr. Weatherly says. Further reductions are expected.

"There is no other way for us to remain the leaders in the Houston market for large, complicated, tight-tolerance jobs in costly materials such as the Nitronic stainless," Mr. Weatherly concludes. "As time goes on, we expect more and more of this business, and we'll be ready for it.
