Cutting Gears on a Machining Center

DEPO PROVIDES ALL-IN-ONE MACHINING CAPABILITIES FOR GEAR INDUSTRY

A large spur gear finished using the Depo concept (courtesy of Depo).

In an age of continuous improvement and lean manufacturing, the gear market seems in favor of flexible technology now more than ever. What if a company could provide the software, the CAM system, the cutting tools and multi-axis machining centers capable of cutting any type of gear? This was the question engineers at Depo, headquartered in Marienfeld, Germany, asked in 2005.

A coarse pitch double helical gear completely machined by Depo, including chamfering and deburring (courtesy of Depo).

High speed machining, a milling process that uses standard, high performance solid carbide and indexable 3-D milling tools, has long been used in the mold and die industry. The technology allows high performance tools, in conjunction with multi-axis machining centers, to run virtually lights out. In addition, it allows a manufacturer to minimize operator involvement, thus reducing labor costs while improving workpiece accuracy and surface finishes.

"Depo transitioned into a complete solution provider in the mid 1990s with its *DepoCAM* software and its own line of optimized, high-end vertical and horizontal multi-axis machining centers," says Brian Nowicki, vice president of Tech Tool & Abrasives and a North American sales agent for Depo. "This made Depo globally capable of providing their customers with a fully integrated turnkey machining solution all from a single supplier, with all aspects manufactured and designed in-house."

In 2005, Depo was asked by a large European gear manufacturer to visit their facility to evaluate the possibility of using their successful multi-axis machining solutions for manufacturing gears. In evaluating this request, the management and engineering staffs came to the realization that a gear tooth form is nothing more than a complex 3-D shape. As they continued their investigation, talking to potential customers, they asked themselves why this technology wasn't already in use in the gear industry.

"The fact was that every gear print—including all of the necessary gear data to manufacture a gear using traditional gear cutting processes—did not translate for high speed machining," Nowicki says.

Depo immediately went to work to develop a solution for this issue, starting with spur and helical gears. By the

end of 2007, the company introduced the first version of its *Gear Engineer* software.

"By taking a step-by-step process defining the gear's or pinion's dimensions, tool geometry, tolerances and tooth profile data, a 3-D model could be generated from the existing, readily available gear data in less than 15 minutes," Nowicki says. "This model could then be used in conjunction with *DepoCAM*, which includes a complete cutting tool library, to generate a cutter path for each of the tools in an additional 15 minutes. With the introduction of *Gear Engineer*, the gear industry is now wide open for high speed machining technology."

The company has sold machines in both the European and Asian markets and is now looking closer at providing its unique system capabilities in North America. Depo has made external and internal spur and helical, straight bevel, spiral bevel, double helical and herringbone gears for both service and production parts.

"Companies in heavy equipment, farm and the mining industry have an interest in this technology specifically for service parts," Nowicki says.

The system is best-suited for short-run gears ranging from 12 inches to 16 meters. "While cycle times are not as quick as conventional methods on smaller gears, the benefits come as you get into the larger sizes," Nowicki says.

"In the traditional gear cutting world, each of the gear families requires a different type of machine. With this new technology, one machine is equally effective for all gear types within its given diameter range."

In addition, the technology can be utilized for both roughing and semi-finishing of pre-heat treated gears, but it also offers the ability to "hard mill" either induction hardened or through hardened gears. From a quality standpoint, all the gears can be machined either pre- or post-heat treatment to an AGMA 12 quality or better.

"A single machine tool cuts all gear and pinion types, it can machine all lifting and mounting holes, machine gearboxes complete and in some cases, even turn the parts prior to machining the gear teeth," Nowicki says. "With Depo *Gear Engineer* and *DepoCAM* software, a new gear can go from gear print to CNC program in less than 60 minutes."

In order to use these high-speed machining principles to manufacture gears, the machine tools must be incredibly accurate and repeatable, according to Nowicki. "These are the same requirements necessary for some

continued

Inspection software from Depo allows for on-the-machine inspection of a large bevel gear (courtesy of Depo).

Advances in Depo's *Gear Engineer* software now allow the following gears to be produced utilizing this integrated technology in the following size ranges:

External Gears
- A maximum outside diameter of 16,000 mm
- Spur gears/helical gears

Internal Gears
- A maximum outside diameter of 16,000 mm, depending on the face width dimension
- Complex workpiece up to a maximum outside diameter of 3,300 mm can be cut on a vertical machining center
- Spur gears/helical gears

Bevel Gears
- Straight, skewed-tooth, spiral
- A maximum outside diameter of 4,000 mm
- Spiral (Klingelnberg Palloid and Cyclo-Palloid, Gleason system)

Pinions
- A maximum shaft diameter of 350 mm (depending on the table options)
- Total workpiece length, including the teeth, can be customized as needed by modifying the foundation layout

Double Helical/Herringbone Gears
- A maximum outside diameter of 16,000 mm
- Continuous-tooth herringbone gears also possible

Worm and Worm Wheels

of the high-end mold and die applications that Depo was already very familiar with."

Depo recently went to work on what is now known as their Depo Expert Line. This new line consists of five- and seven-axis vertical and horizontal machining centers, which are all dual-column machines with a five-axis simultaneous positioning accuracy of five microns or better. They include thermal compensation, broken tool detection and on-the-machine workpiece inspection; all features necessary to produce gears of the highest quality.

"When gear manufacturers first hear of this technology, the first question is commonly, 'What type of tool do you use?' Understandable, as our industry has been built using hobs, shaper cutters, shaving cutters and stick blades, all with the tooth form already existing to a large degree," Nowicki says. "Not anymore. Using high speed machining principles, all types of gear forms can be manufactured using standard, conventional, off-the-shelf solid carbide and indexable carbide cutting tools."

In high-speed machining, the tooth form is generated by way of the CAM software and machine tool control. The result is a fully-integrated gear manufacturing system that includes *Gear Engineer* to generate the surface data, *DepoCAM* to generate cutter path, Depo's Expert Line machine tools for accuracy and Depo's high-end tooling solutions, all integrated and designed to produce the gears.

"The flexibility that this technology brings will help to free the industry from the long lead times traditionally considered acceptable in the gear business," Nowicki says. "Low lot sizes, coarse pitch gears, large gears and much more can now be produced with significantly shorter lead times.

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