Phoenix Rising

Gleason Corp. of Rochester, NY, has redesigned its Phoenix® bevel gear cutting machine to take up less space but have more capacity than the previous model. The Phoenix® II 275HC will be unveiled at EMO in September and Gear Expo in October. According to Gleason, this new dry or wet cutting machine is more than an upgrade of existing technology.

"Our customers are hungry for savings, whether through elimination of coolant costs, reductions in cycle times, savings in precious floor space, lowering inventories, or maximizing the use of manpower," says Gary J. Kimmet, Gleason's vice president of worldwide sales and marketing. "We knew the next Phoenix would have to be designed from the ground up to address all of these areas ... not incrementally, but a complete technological leapfrog over anything currently available."

From the outside, with its guards in place, the Phoenix® II 275HC looks like most small machine tools. But inside, it's unlike any other bevel gear cutting machine.

The Phoenix® II is built around a stiff, monolithic cast-iron column, to which the slides and the spindles are attached.

"This presents a unique and perfectly symmetrical way of positioning the cutting tool and the workpiece, which provides advantages in ergonomics, chip removal, stiffness and accuracy," says Dr. Hermann J. Stadtfeld, Gleason's vice president of research and development.

On previous machines, including the Phoenix® 175HC, a large base sat under the rest of the machine to support the various components.

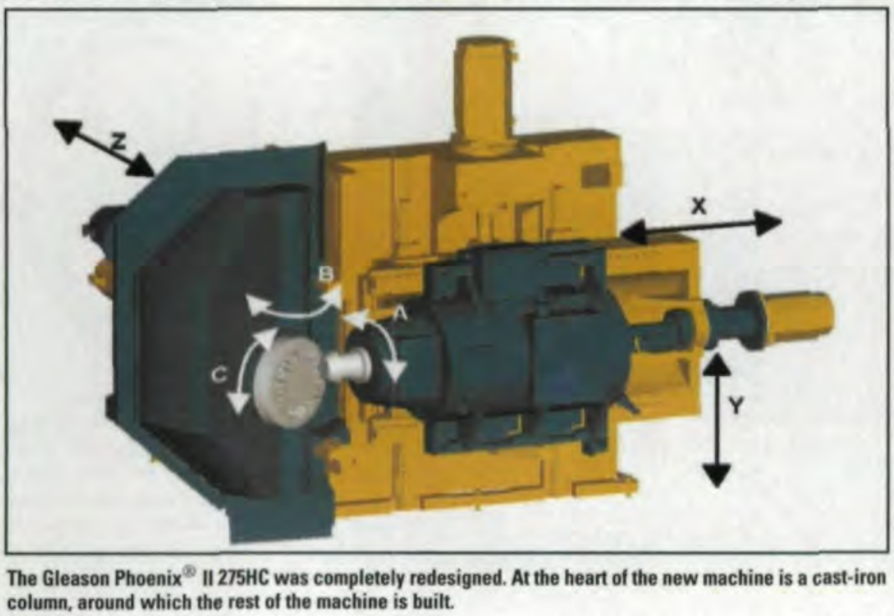
Instead of complicated, bulky mechanisms, like change gears and cams, positioning and indexing of workpiece and cutting tool are accomplished entirely by CNC-controlled direct drives.

The result of those changes is a much smaller machine—90 square feet vs. the 140 square feet of the Phoenix® 175HC. Although smaller, the Phoenix® II can cut much larger bevel gears than its predecessor—up to 275 mm in pitch diameter vs. the 175 mm of the Phoenix® 175HC.

Also, the design and the direct drives lead to several other advantages, according to Craig Ronald, Gleason's chief design engineer.

Chip removal is simplified during dry cutting, Ronald says. "Now, hot dry chips are free to fall completely clear of the machine structure into a simple chip conveyor, without the need for shrouds, vacuum systems, or even hot chip-related temperature compensation, because there's no bed to 'grow' with heat buildup.

"In addition, we're now pivoting the cutter spindle to create the root angle rather than mounting the workspindle on a swinging base. This permits the shortest possible structural overhang of both cutter and work for maximum stiffness and thermal stability."



The Gleason Phoenix® II 275HC was completely redesigned. At the heart of the new machine is a cast-iron column, around which the rest of the machine is built.

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Also, the redesign placed the work and cutter spindles much closer together. Now, both cutter and workpiece face the operator and are only 6" and 11" ***(15 and 28 cm)*** away, respectively. Ronald says the design is meant to reduce operator fatigue.

The use of direct drives also should help reduce setup and machining times, Ronald says. "In addition to the obvious benefits of eliminating mechanical adjustments, change gears or draw rod switch setups, the new spindle motors deliver high torque as well as high cutter and work speeds. This gives us the capability for wet or dry cutting, with room to spare for future process developments."

The direct-drive motors also deliver much higher acceleration and deceleration rates, Ronald says, with the spindles stopping in as little as 200 milliseconds. "Savings in stop/start times of even a few seconds quickly add up," he says. Also, direct-coupled linear-axis drives are used, with possible travel rates of 10 m/min. and a cutter pivot rate of 40 deg./sec. Those higher speeds combine with the new design's inherently shorter linear motions to result in further reductions in non-cutting time.

The Phoenix® II can accommodate all styles and types of Gleason and non-

Gleason cutters and cutter systems for face milling and face hobbing. The new machine is available with either the Fanuc 160i or the Siemens 840D CNC control.

Also, Gleason will build a European version of Phoenix II in its factory in Ludwigsburg, Germany. That version is designed to fit European customer specifications and requirements, like CE codes.

Circle 300

Engineer Is Designing Test Stand To Measure Planetary Gear Vibration

Rob Parker sees a problem with analytical models of planetary gear vibration and dynamics: The models aren't supported by experimental data.

Parker, an engineering professor at Ohio State University, specializes in vibration and dynamics, particularly in high-speed systems and power transmission devices, such as planetary gears.

He explains that in basic research, complex systems—like planetary gears—are boiled down to a couple of mathematical equations, which means lots of approximating for analytical models.

But, complex systems need quality benchmark data to develop accurate analytical models.

Parker uses a pair of spur gears as an example. According to him, analytical single-mesh gear models had been used for about 50 years, but recent experiments showed strong nonlinearity, contact loss and—sometimes—chaotic response in single-mesh gear pairs. The experiments showed the models needed to be improved.

Planetary gears, with multiple bodies and meshes, are a lot more complicated than spur gears.

"There's a cloud hanging over any of those [planetary gear] models," Parker says, "until you get experimental investigation."

Investigation could be done with a test stand that measures planetary gear vibration and dynamics. Parker knows of no such stand. He knows of stands that measure durability and wear, but they aren't suited for measuring dynamics thoroughly because they usually lack access to the sun, planet and ring gears.

So, Parker is designing a stand to measure the gears' vibration and dynamics.

This contour plot shows a planetary gear system's maximum principal stresses, as calculated by the analysis program CALYX. Such analytical models will be verified for accuracy via a test stand that measures planetary gear vibration and dynamics, being built by Ohio State University engineering professor Rob Parker. Image courtesy of Advanced Numerical Systems of Hilliard, OH.

The test stand will have two planetary gear sets, a test set and a slave set, in a "back-to-back" configuration. Power will be circulated between the sets by locking a torque into the stand through the loading plates' relative rotation. A drive motor will control speed and provide power to overcome frictional losses.

Parker estimates the stand would be 12' long, 5'–6' wide and 6' tall.

Measurements will be taken from the planetary gear test set and would be used to support analytical models, identify the most important tolerances for making quieter planetary gears, and show the important behaviors that occur in special combinations of speed, torque and mesh phasing in operating conditions.

Parker expects to complete his design by the end of October. By that time, he expects to have contracted a company to build the stand. He estimates it will be ready for experiments in summer 2002.

But, the experiments may be limited to relatively few types of planetary gears. Parker may not have enough money to build the stand with a full set of fixtures for testing different types of planetary gears.

The stand will include an infrastructure, a torque actuator, a lubrication system, a computerized control system, a variable-speed drive motor with controller, and fixtures to operate in fixed-ring, fixed-carrier and fixed-sun configurations.

Some of those parts, like the motor, are generic. But, the fixtures aren't generic, so they aren't cheap.

Parker has $500,000 for the project, but: "Whether or not I can do what I want to do with that amount of money, I'm not sure—I think I can."

If his costs go over his budget, Parker hopes to get the extra money for a full set of fixtures from companies interested in the stand's uses.

This summer, he focused on attracting helicopter companies. Parker did so because he expects the stand to advance the dynamic models used for helicopters. He expects such advancement because helicopters' planetary gears are his main focus; $250,000 of his $500,000 is from the U.S. Army for investigating planetary gear dynamics in military helicopters.

The Army wants to reduce vibration and noise in its helicopter cabins. The vibration and noise in the cabins come partly from planetary gearboxes. The vibration can create noise greater than 110 dB. Tim Krantz of the Army Research Laboratory compares that noise to the noise near a chainsaw or in the front row at a rock concert.

Such noise hinders crewmembers' communication, fatigues them and can be a health hazard to them. "There's a need to reduce noise and vibration," Krantz says.

A mechanical engineer, Krantz specializes in gear research for the laboratory's Vehicle Technology Directorate, located at NASA's Glenn Research Center in Cleveland, OH. He is an advisor on Parker's project.

Given the Army's goal, Parker is designing his stand to operate at a military helicopter's typical horsepower, like the 350–450 hp of the Army's OH-58 Kiowa Warrior, an armed reconnaissance helicopter. The stand's "back-to-back" configuration lets it test the gears at much higher power than the motor's rating because the motor has to overcome only frictional losses.

Military helicopters often use planetary gears because the assemblies have excellent torque/weight ratios, are compact, and have several load paths for reliability and for continued operation despite a damaged gear or load path.

Those are some of the reasons the gears are used in aircraft; automobiles; other ground vehicles, like farm and construction equipment; heavy machinery and marine applications, like submarines.

Consequently, the stand promises to benefit more than helicopters.

"The real purpose of this machine is for basic research," Parker says, adding the machine isn't really for one application. "The research questions you would ask would be the same for any application."

Ohio State University will own the test stand and its design—Parker's other $250,000 came from the university and the Ohio State Board of Regents. Each organization contributed $125,000.

Parker says the stand won't be sold commercially, but research and resulting mathematical modeling will be published.

Krantz says the Army has no set schedule for receiving data from Parker's stand or for improving its helicopters based on the data. He explains that the Army has "windows of opportunity" to upgrade or retrofit helicopter gearboxes. When the next window opens, the Army would like to have techniques—verified by experiment—for minimizing gearbox vibration and noise.

"More knowledge is good when it comes to a new design," Krantz says.

Circle 301

A New Shaper Cutter Design

A university lecturer in Romania has a model of a new type of gear cutting tool, which he says has theoretical profile errors of zero and can create perfect helical involute gears.

Márton Máté created his model and tested it for his doctoral dissertation, which he worked on from 1992 to 1998. According to Máté, the tests showed the involute profile error using his cutter was less than that obtained using a classic Fellows cutter.

Today, he holds a doctorate in the science of metal cutting and cutting tools and is a faculty member at "Petru Maior" University of Targu-Mures.

Máté created his gear cutting tool from his research on optimizing the Fellows cutter for helical gears.

The Fellows cutter has helical involute tooth flanks and cuts using a helical motion. But, according to Máté, the classic Fellows cutter presents theoretical profile errors.

Máté's cutter has non-helical involute tooth flanks, but it cuts with a helical chipping motion. According to him, that motion allows his cutter's edges to create perfect helical involute gears.

He adds that the edges won't vary with resharpening and the cutting geometry can be adapted to conform to a workpiece material's mechanical properties.

Máté wants to offer his doctoral work to a company interested in gear cutting tools and understands the success of his work depends on it being successfully applied by a company.

But, a company would face a major undertaking to independently verify whether Máté's work is technically sound.

"We'd have to reanalyze all his work," says Walter Pluss, manager of cutter services at Fellows Corp. of Springfield, VT.

As Pluss explains, reanalysis would require understanding all of Máté's theory and spending time verifying it in a laboratory. The verification would mean obtaining and evaluating Máté's laboratory data, modeling the cutter, running it through test trials, and evaluating the trials to see if Máté's cutter shows definite improvement over a conventional cutter.

Pluss doesn't know how long the reanalysis would take or what it would cost.

Also, Pluss sees a problem with Máté's seeming view of the gear cutting process: "The process cannot be that simplistic."

Pluss says the process depends on many factors, including the cutting machine, cutting tool geometry, tool coating, fixturing, coolant, and cutting cycle. He adds that Máté's research focuses on cutting tool geometry, so it isn't clear how changing the cutting tool would affect the resulting gears' cost and quality.

Still, Pluss says he's interested in more information on the Máté cutter's applications, like test results—something that can be duplicated to check the tool's effectiveness. But, for now, Pluss says of Máté's work: "I don't have enough information to say 'Yes, you're right' or not."

Circle 302

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