Closed-Loop Gear Machining

A MAZAK/DONTYNE SYSTEMS/RENISHAW COLLABORATION

Randy Stott, Managing Editor

Mazak and Dontyne Systems, with the help of Renishaw, have developed a flexible gear machining solution that combines the multi-tasking capabilities of Mazak's 5-axis machine tools with Dontyne Systems' gear production software solutions and CMM inspection.

Through this process, shops with full 5-axis multi-tasking capabilities can productively and profitably produce tight-tolerance gears in small and medium volumes. This technique also makes it possible to generate more complex and specialty forms that offer better overall gear performance.

Mazak and Dontyne employees were introduced to each other at Gear Expo 2013 in Indianapolis, IN, and have since developed their joint Closed-Loop Gear Machining solution with the help of Renishaw. They've exhibited the solution at Gear Expo 2015 (Detroit, MI); Mazak's Discover 2015 (Florence, KY); PRI 2015 (Indianapolis, IN); and AeroDef 2016 (Long Beach, CA). The solution will also appear at IMTS 2016, where developers promise additional improvements and advances to make it even more effective and productive.

The closed-loop process includes three major components, says Mike Finn, senior application development engineer for Mazak. The first is gear design software. The second component is CNC machining in a 5-axis or multi-axis machine. The last component is gear inspection.

Dontyne's *Gear Production Suite* software generates design and load analysis models for the engineer, while providing the manufacturer with links to machine tools and inspection equipment and easy evaluation of incoming measurement data.

"Our software is aimed at improving not just the design, but also the manufacturing, the productivity, and ultimately, the gear performance," says Dontyne co-founder Dr. Michael Fish.

Designers can create spur or helical gears, splines, planetary systems or bevel gears (using generic bevel gear types). The software can design the parts for manufacture using either standard tools, such as end mills, or custom tooling, such as hobs.

In the design stage, the software can be used to produce optimized gear profiles based on the required load capacities for the particular application at hand. It can also simulate how that gear system will react in the gearbox and under specific loads — the level at which components will bend and/or deflect. With such a simulation, the software can then compensate by altering the surface of the gear according to those conditions. Once the appropriate profile is determined, the software exports a 3-D model of the part.

The 3-D model can then be used to generate G-code using CAD/CAM software. "Programming the machine is rather simple," Finn says. "It's really no different than programming any other 5-axis part. Once you get the model, you really don't need to think of it as a gear. It's just geometry."

The G-code is loaded into an Integrex machine and the part is cut with no special gear knowledge required on the part of the operator.

"The next step of the process is to take the part out of the machine and put it onto the CMM," says Finn. The closed-loop process can be used with any CMM machine, but it has been developed specifically in conjunction with inspection equipment that uses Renishaw's probes and inspection software.

Dontyne has a long-established interface to Renishaw CMM equipment for gear and spline evaluation. According to Dan Skulan, National Sales Manager for Renishaw, the same solid model that's used to generate the G-code for the Mazak machine is also used by the Renishaw *Modus* software, so that the

part that's manufactured and the part that's inspected are both based off the same theoretical model.

Parts can be inspected on a CMM using scanning technology. Renishaw has the ability to scan in full 5-axis using Revo technology or compared against a master using Renishaw's Equator gauging system, which provides thermally compensated measurement on the shop floor. It's also possible to measure parts directly on the Mazak machine, which is especially advantageous for larger gears. Machines can be equipped with high-precision probing, such as an RMP600 strain gauge system or even scanned using new Sprint technology. Machine positioning accuracy can be established by using tools like the QC20W ballbar that quickly verifies the linear positioning and Axiset/Mazacheck that ensures proper adjustment of the axis centers of rotation. "With the right calibration and setup," Skulan says, "it's very possible to measure gears right on the machine and provide the same output data that's required by the Dontyne software."

Once the part is measured, the CMM data is then fed back into the Dontyne software, which analyzes the inspection data, looking for any differences between the manufactured gear profile and digital master. In instances where errors are identified, the software identifies necessary adjustments that are made to the cutting operation and the cycle repeats. The loop continues until the desired gear tolerance levels are achieved.

Depending on the tolerances required, though, the process might require just one iteration, Fish says. "If it should need correction, we just press a button, it modifies the file, feeds it back into the machine, and the next part should be spot on."

The closed-loop system provides a viable option for manufacturers who need to produce gears in small- to medium-sized batches, who don't have dedicated gear machinery or who wish to produce gears using standard tooling, Finn says. This includes many applications in small-lot manufacturing and prototyping.

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See Mazak's Mike Finn explain the closed-loop gear manufacturing process here: *www.youtube.com/watch?v=eQzLDryzz3Y*

See a live demonstration of a straight bevel gear being cut on a Mazak machine here: *http://downloads.dontynesystems.com/BevelInMazak.MOV*

Forest City Gear

INSTALLS KEYENCE IM SERIES INSTANT MEASUREMENT SYSTEM

Quality Inspector Amy Sovina says she's not a big fan of turning the knobs on an optical comparator. Not only is it time consuming and tedious, but measurement results are often subjective as well. So when she learned that her employer, Forest City Gear, was purchasing an IM Series automated inspection machine from Keyence, she looked forward to the time it would save on incoming inspection of gear blanks from outside suppliers. Little did she know the Keyence IM would soon become one of the busiest pieces of metrology equipment on the shop floor.

"Overall, the Instant Measurement has received a very favorable reception," says Sovina. "It's especially popular with the people in the turning department. They're able to get accurate dimensional checks very quickly, and it's reduced a lot of the hands on work with height gages and micrometers. The more they use it, the more confident they are with the results."

Forest City Gear sits a short distance from the Rock River, in the heart of Roscoe, Illinois. The company has been in business more than 60 years, machining high-quality gears for the aerospace, medical, transportation and other industries that require hobbed, skived and precision-ground geared components. This includes helical, spur, spline and worm gears, some with tolerances to ten-millionths of an inch and diameters larger than a bicycle wheel.

"With those accuracy requirements, the company had to invest millions in gear form measurement and analysis equipment, but was looking for a quick and easy way to measure other part features," explains Dennis Atchley, quality manager at FCG. That need arose with the recent contract from a robotics manufacturer that supplies pick and place machines for use in the warehouses of a major online consumer products reseller. "Forest City Gear has traditionally focused on very high-tech, low-volume work — gears for unmanned drones, satellites, aircraft components, etc. A big order to us was 100 pieces. Suddenly, we were faced with inspecting 100,000 parts per year."

Atchley turned to Keyence for help. The IM-6700 Series Image Dimension Measurement System measures multiple part features simultaneously, without the need for positioning fixtures — simply place the workpiece on the measurement stage and press the measure button. Within three seconds, up to 99 part features and hundreds of points are identified and measured, and the results automatically recorded.

Lines, circles and arcs are automatically recognized, and a special algorithm applied to fit such features within a user-definable number of points. Chips, burrs, and debris are likewise filtered, improving accuracy and ease of use for the operator. Most importantly, the IM is accurate to within ±2 µm.

This was all good news for Atchley, who is especially pleased with the IM's ability to calculate 6sigam, CPK and other statistical analyses. "We had a job running just last week where the customer was asking for a process capability study on a ground taper," he says. "We set it up so the operator could take in-process measurements of the gage line as the parts came off the machine. It's been very useful for things like that, especially with our higher part volumes."

Another area where the IM has come in handy is statistical process control (SPC) of subcontracted operations. Atchley said one of the new part families is comprised of 16 different components and requires thousands of measurements per month. Having the ability to simultaneously check all the lengths on a gear shaft, for example, or multiple bearing journal diameters, has greatly increased throughput on receiving inspection, and at the same time makes data capture and report generation much simpler. "It gives us greater confidence in the subcontractor's process control."

As the one responsible for taking all those measurements, Sovina is quite happy with the IM's speed and easy setup. "Programming was quite easy to learn," she says, and it took no more than half a day with the Keyence representative for her and her team to become familiar with the system. As a result, she's expanded the IM's role beyond inspection of the parts coming in the receiving door.

"Quite often I can use the same program for the subcontracted gear blank and final inspection of the workpiece," she says. "Some of the dimensions will have changed during our in-house machining and gear cutting operations, but the IM is still able to pick up the part features. Because I only have to program it once, it saves us a lot of time. Long term, the Instant Measurement will be a big benefit to the company."

For more information:

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Keyence Corporation of America
Phone: (888) 539-3623
www.keyence.com

Gleason Threaded Wheel Grinding Machines

COMBINE MAXIMUM PRODUCTIVITY WITH MINIMUM IDLE AND SETUP TIMES

Gleason Corporation recently introduced the 200GX and 260GX Threaded Wheel Grinding Machines, its latest addition to the highly successful Genesis series. The twin spindle concept combines maximum productivity with minimum idle and setup times. The machine allows users to setup the GX Series from one workpiece to another in just 20 minutes using a single tool.

"First Part Cycle" features a fully automatic workflow from setup to grinding the first workpiece. In addition, the machine is equipped with latest innovative technology features such as: Twist controlled grinding, automated process data proposal, variable rate method (VRM) for a favorable surface structure and polish grinding for an excellent surface finish. The ability to directly interface with Gleason GMS Analytical Gear Inspection machines via simple scanning of QR codes further enhances the productivity of the GX Series. In addition, the GX series productivity is further enhanced when paired with automation solutions from Gleason Automation Systems.

Easily accessible machine components make maintenance simple and efficient while standard dimension grinding wheels allow you to use your existing tools along with precision dressing tools from Gleason. All of this in an energy efficient, small footprint machine designed to meet the needs of customers in high-productivity, high-quality environments.

The 200GX and 260GX are supported by the Gleason Global Service network with strategically located spare parts centers and over 250 service professionals in all major markets worldwide.

For more information:
Gleason Corporation
Phone: (585) 473-1000
www.gleason.com/260GX

EMCO

OFFERS PORTAL-STYLE 5-AXIS MILLING CENTER

The Umill 1800 from Mecof, part of EMCO Group, offers milling and turning solutions designed to meet the needs of mold makers, aerospace, automotive and precision engineering users. Umill 1800 is a 5-axis milling center in a bridge design with moving table and crossbeam permitting loading from the top or the front of the machine.

Umill 1800 has a working range of 2,150 mm on the longitudinal axis Y, 1,800 mm on the cross X axis, and 1,250 mm in the vertical Z axis. Fourth and fifth axes are separately on the table and on the head, both with unique characteristics. The 5-axis machine can be equipped to work as a milling machine or as a multitasking solution for milling and turning operations. The table can be dedicated to milling (and therefore with a rotation speed of 10 rpm, transmission by means of torque motor, by 1.700 × 1.400 mm plate and a load capacity of 10 tons) or turning (up to 250 rpm, transmission by means of torque motor, plate with 1,800 mm diameter and a load capacity of 5 tons. Rapid traverse is 60 m/min. The movement of the table is carried out on two guideways size 65 with three trucks per guideway.

With these dimensions, the maximum workable piece has a diameter equal to 2,500 mm. In case of turning operations, the spindle is locked by using a Hirth coupling/ face gears, thus disengaging the spindle and bearings from their stresses.

Umill 1800 is equipped with two specific types of numerical controls, the Siemens 840D Solution Line or the Heidenhain TNC 640 HSCI able to manage both milling operations and turning operations. The head is available in two versions, which differ in the type of motor: a high-speed motor spindle (45 kW and 300 Nm in S1, HSK 100 and 12,000 rpm and beyond) and as an alternative, a 38 kW solution with mechanical transmission, tool taper ISO 50 or HSK 100, 600 Nm of torque in S1 and a rotation speed of up to 6,000 rpm.

The head has another unique feature connected to the rotary axis: its shape allows positioning the tool for working in undercut up to -15 degrees. In the horizontal position the tool axis is exactly aligned with the direction of the table movement. Other machines cannot orient it in the same way; and then to perform an operation along the Y-axis they must interpolate the axes X and Y. Being

able to engage a single axis, however, has accuracy advantages, thrust force benefits, and a reduction of complexity in programming.

The structure of the Umill 1800 is composed of three main parts rigidly attached to each other; so installation time is minimized. The machine can be located on the workshop floor without having to build expensive foundation and without interfering with current production.

The machine configuration supports optimum machining dynamics at any point within the working volume: the head overhang is the same regardless of the position of the axes. Without components such as rams that modify the geometric conditions, it ensures maximum repeatability and precision.

For more information:
EMCO Maier
Phone: (248) 313-2700
www.emco-world.com

Sandvik CoroMill 745

OFFERS MULTI-EDGE MILLING CONCEPT

Offering high productivity and a low cost per edge, the CoroMill 745 has a double-sided, multi-edge design that is ideal for large batch productions. With its tilted insert positioning system and sharp cutting edges, this milling cutter offers a light cutting action at low power consumption.

With a total of 14 cutting edges per insert, the CoroMill 745 is a cost-efficient choice for face milling. The assortment includes three pitch versions. The differential pitch design of the MD pitch is best when vibration is a factor and is radially compensated to ensure equal chip thickness for every insert. The M pitch is best for general applications and the H pitch has a higher number of teeth making it the best choice for higher productivity. The M and MD pitch both have the same number of teeth.

Designed to make insert indexing quick and easy, the unique insert positioning system in the tip seat and heptagonal insert design keep the inserts securely in the pocket when mounting. The inserts are tilted in the tip seat to create a positive cutting action. Inserts geometries and grades are available for steel and cast iron materials. For roughing to semi-finishing applications, the strong and light cutting inserts provide reliable face milling in all types of milling machines.

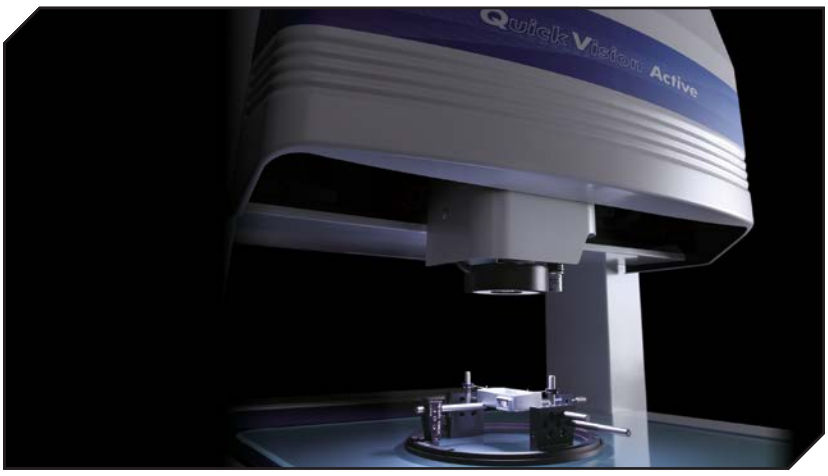
According to Matts Westin, global product manager for milling, "You might see other multi-edge concept milling cutters on the market but none have the performance of the CoroMill 745. The science behind it is impressive. The unique double-sided, multi-edge insert

design has 14 positively tilted cutting edges which are spaced out at different positions resulting in a milling cutter that is quiet and soft. For our customers, that means that they get a highly-productive milling cutter, increased tool life at a lower cost per component."

For more information:
Sandvik Coromant
Phone: (800) 726-3845
www.sandvik.coromant.com

Mitutoyo America

ADDS QUICK VISION ACTIVE SERIES TO MEASUREMENT SYSTEMS



Mitutoyo America Corporation recently announced the addition of the Quick Vision Active series to the line-up of vision measurement systems. This CNC vision measuring system is an easy-to-operate, space-saving model with advanced functionality to meet many contact and noncontact measuring needs.

The Quick Vision Active is highly efficient and flexible, offering a wide field of view with interchangeable objective zoom lenses to meet the challenges of measuring small to large features. The eight-step zoom lens can achieve a magnification range of 0.5× to 7× while maintaining crisp image quality. The 1× optional objective achieves a magnification range of 0.5× to 3.5× with a working distance of 74 mm. The 2× option can achieve a magnification range of 1× to 7×.

Quick Vision Active is available with measuring ranges of 10 × 8 × 6 inches (250 × 200 × 150 mm) or 16 × 16 × 8 inches (400 × 400 × 200 mm), with or without the touch-probe measuring option. *QVPAK* software uses edge detection and pattern recognition to locate and orientate the coordinate system with minimal operator input, ensuring accuracy and repeatability of the measurement results.

For more information:
Mitutoyo America Corporation
Phone: (630) 820-9666
www.mitutoyo.com

Bell-Everman Inc.

INTRODUCES ROTARY STAGE COLLET CLOSER

Bell-Everman Inc. has developed a compact, air-driven collet closer that can precisely secure cylindrical goods in the company's rotary stages. The collet closer solves a common workholding problem in inspection, metrology and laser engraving applications. This new collet closer squeezes into through-hole openings as small as 15 mm and extends just 42 mm from the face of the stage. The initial offering, "ER-16," collet closer handles cylinders with diameters from 1 to 10 mm. The collet closer has the ability to close without changing the workpiece's axial position. It also offers the ability to customize the opening and clamping behavior: The same air cylinder that closes the collet can be set to open it, making it easy to set it up as a spring-close, air-open device. The collet closer can optionally be integrated with a single-axis controller to handle indexing tasks and process fourth-axis motion commands for contouring. Bell-Everman has designed larger sizes that can accommodate cylindrical parts up to 30 mm in diameter and withstand higher side loads—opening up the possibility of some light CNC machining applications.

For more information:
Bell-Everman
Phone: (805) 685-1029
www.bell-everman.com

Oelheld

EXPANDS GRINDING OIL PORTFOLIO

Oelheld U.S. Inc. has added SintoGrind TC-X 630 to its portfolio. The oil is designed for flute grinding, profile grinding and outside and inside diameter grinding. It works on a wide variety of materials including tungsten carbide, HSS, PCD, CBN, cermet and ceramics. SintoGrind TC-X 630 was especially formulated for demanding grinding tasks and delivers exceptional feed and speed rates with superior surface finish. SintoGrind IG 540 is designed for flute grinding, profile grinding, and outside and inside diameter grinding. It works on a wide variety of materials including tungsten carbide, HSS, PCD, CBN, cermet and ceramics. Its lubricity lends to extended wheel life and minimal heat build-up, which in turn eliminates surface cracks and burns.

ToolGrind TC-X 620 is based on additive technology borrowed from Oelheld's flagship SintoGrind series. ToolGrind TC-X 620 is formulated with highly refined base oils that have very good viscosity and temperature characteristics combined with low misting and aromatic content. ToolGrind TC-X 620 promotes clean grinding wheels, low grinding temperature and less wheel wear. It prohibits workpiece corrosion and is suitable for most filtration systems.

For more information:
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