Improved Inspection Software Helps Provide Optimum Gear Cutting Results

KLINGELNBERG MEASURING CENTERS ELIMINATE TRIAL-AND-ERROR WITH MODERN ANALYSIS TOOLS

Figure 1—The P26 Gear Measuring Center from Klingelnberg now offers advanced analysis software.

Improved software for assessing gear deviations is creating a new generation of more efficient gear cutting systems. Gear metrology and subsequent evaluation of test data play a crucial role in the gear manufacturing process. This is especially true if gear quality specifications are not met, or if a component fails to achieve the desired running behavior despite being within tolerances. Whereas modern gear measuring centers (Fig. 1) now achieve very high performances and possess a wide range of measurement and evaluation functions, analysis of gear variations and definition of suitable countermeasures still rely mainly on empirical know-how.

Relying on Empirical Data

Although a broad spectrum of remedial aids is stored in the machine control, gear know-how and the experience of qualified operators are often essential. This is particularly the case if the selected quality criteria or parameters (e.g. according to DIN 3962) do not sufficiently reflect the required component design. This frequently leads to systematic trial-and-error procedures, which may involve a whole series of iteration steps that often fail to obtain an optimum solution (Fig. 2). Klingelnberg has developed an analytical tool that supports detailed analysis of the diagrams (e.g. profile line and tooth trace, pitch and radial runout) to assist even the experienced specialist.

The aim of the new software is to support systematic solution-finding and to identify and quantify non-apparent influences. It provides four basic functions, which are described in more detail below.

Improvement through Comparison

When a gear is tested, the shape of the teeth is identified by means of profile and tooth trace measurements, usually on four teeth, and the position of all teeth is determined by pitch and radial runout measurements. With the aid of machine support and in some cases empirical know-how, the numerical quality values calculated from the variations are then converted into remedial steps. This procedure is usually reliable and simple. If it fails to produce the desired result, consideration of the variation curves themselves will be required.

In particular, the new software optimally supports the comparison of different test results. Figure 3 shows an example of profile measurements on two workpieces that have been profile ground on different machines. The profiles exhibit similar curves, and the calculated parameters are also the same. Only when they are shown together does it become apparent that the upper machine generates a much greater scatter of the profile form. Such a scatter could be due to a worn grinding spindle, for example. By contrast, the reproducibility of the profile on the lower grinding machine is very high. Its remaining waviness could be improved by optimizing the dressing process.

The potential offered by comparative curve displays is clear from this example. There are other application potentials in many other areas, such as the investigation of hardening distortions, tool wear, noise problems and production fluctuations, including capability testing of processes, machines and measuring devices.

Focusing on Tooth Thickness

Functionally, the tooth thickness of a gear describes the clearance in the installed state or the allowance for post processing. Geometrically, it represents a measurement that varies over the diameter. It can be measured directly by a gear inspection system or coordinate measuring machine, or indirectly in shop operation on the basis of the base tangent length or the two-ball dimension.

On gear measuring machines, the profile and tooth trace variations for various teeth are measured and presented as form variations in relation to the desired form, without the curves being related to one another in terms of their position. The pitch variations are also unrelated to the tooth thickness of the individual tooth.

With the aid of Klingelnberg's new analysis software, it is now possible to display all variation curves in the correct positions in relation to one another. The profile and tooth trace curves (Fig. 4) are now displaced horizontally in line with the existing pitch variations and are offset to the desired line by the amount of the base tangent length variations.

The pitch variations are likewise shifted vertically from the desired line by the amount of the base tangent length variations. The relationship of the form variations to the nominal

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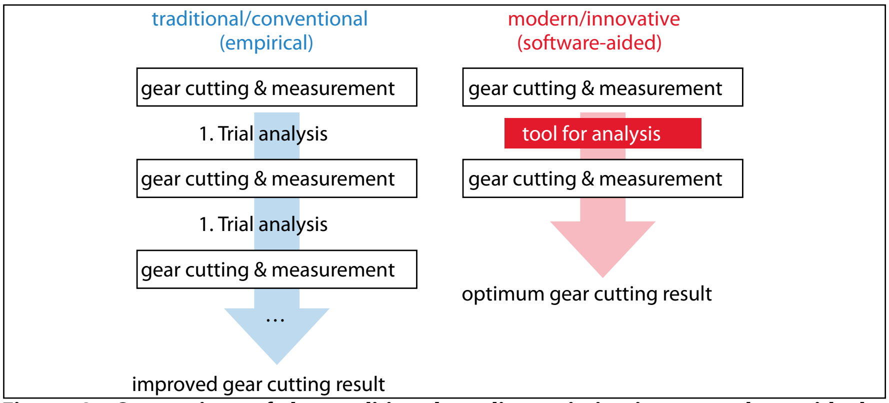

Figure 2—Comparison of the traditional quality optimization procedure with the procedure available using modern software.

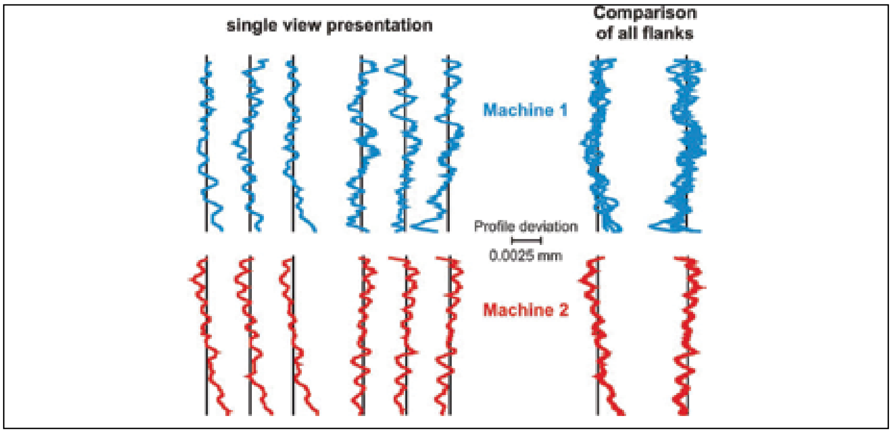

Figure 3—Klingelnberg analysis software allows side-by-side comparison of profile inspection traces.

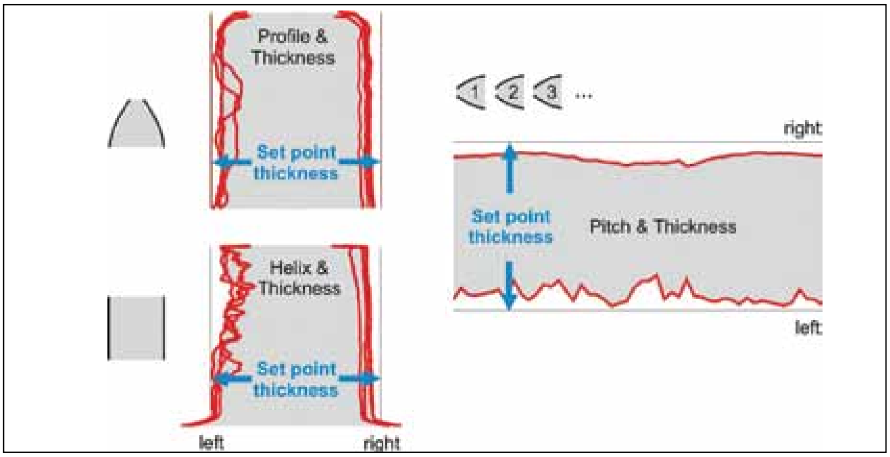

Figure 4—All variation curves are displayed in the correct positions relative to one another.

dimension can therefore be seen at a glance.

The material side is shown in grey for easier visualization. It is evident from the example that the gear is undersized in almost all areas.

Determining the Cause of Variations

Gears have a highly complex geometry, which must be manufactured with great accuracy. Disturbances that occur in the production process frequently affect several quality attributes at the same time, though in very different forms and sizes. Deducing the causes of a quality problem from the measured variations requires a great deal of experience, especially if the influences are superimposed. Here, the new analysis software acts in a supporting role, simulating the causes of variations very simply through their influence on the measured curves and qualitatively assigning existing variations in the measured results to their causes. The cause may usually be ascribed to clamping errors during the production process or during measurement.

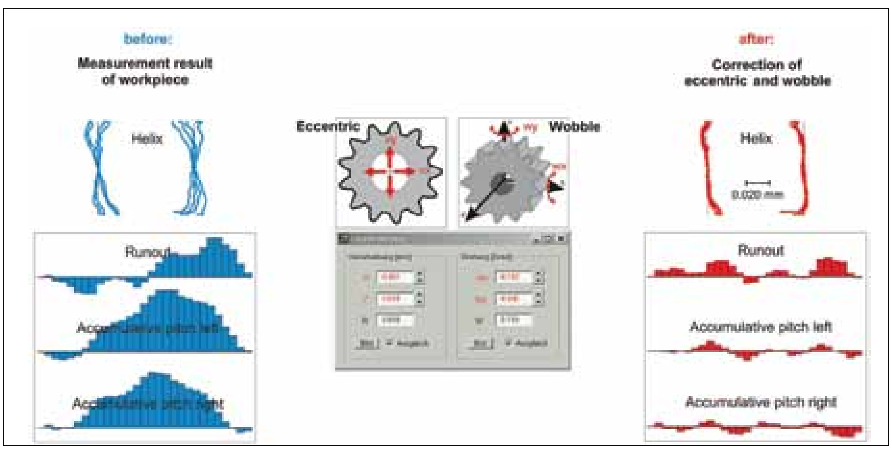

Figure 5—Software provides visualization of errors.

Positional deviations occur when the center of the gear does not coincide with the desired axis of rotation in the installed state. Geometrically, variations in position are described as gear eccentricity or wobble, as shown in Figure 5. In the measured results, this leads to a variation in the profile and tooth trace direction and to sinusoidal variations in radial runout and pitch (Fig. 5, left).

On the one hand, the analysis software enables the user to visualize the effects of positional variations on gear quality. On the other hand, the clamping errors resulting from positional variations can be quantified and the measured values ironed out to rectify the respective defect rates (Fig. 5, right). In this optimum position, the remaining gear errors are clearly evident and can be analyzed and interpreted much more effectively.

Waviness Analysis for Low-Noise Gears

Another feature of the analysis software is waviness analysis. A frequency spectrum is calculated and displayed for each profile and tooth trace on the basis of measured variations (Fig. 6). The dominant frequency is plotted in the variation curve and expressed as a parameter in terms of amplitude and wave number. For purposes of further analysis, the variation curve is then rectified and the procedure repeated as necessary for further frequencies. The calculated frequencies can be plotted individually or as a mass curve, allowing comparison of compensating curves with real variation curves.

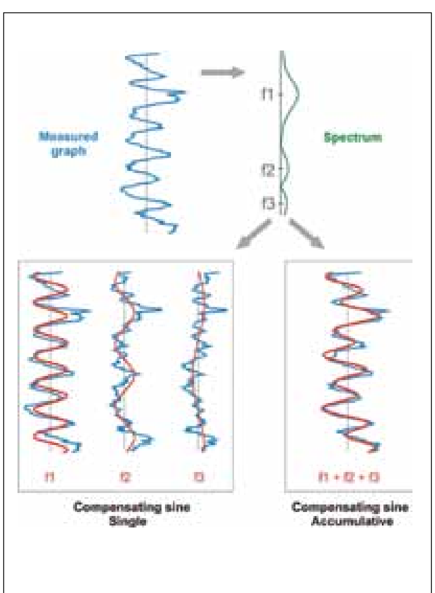

Figure 6—Waviness analysis allows a frequency spectrum to be calculated and displayed for each profile and tooth trace on the basis of measured variations.

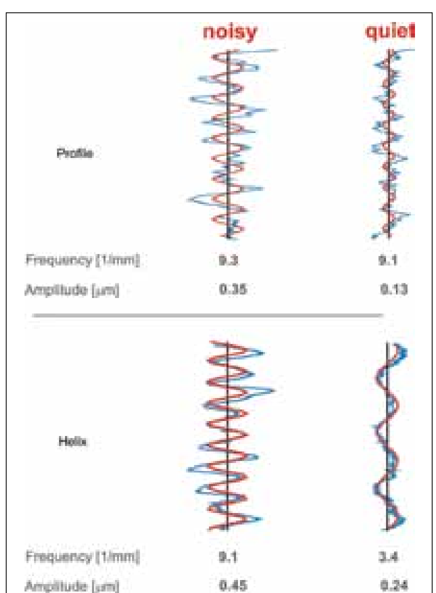

Figure 7—Example waviness analysis comparison between a noisy and quiet gear.

Figure 7 illustrates a first application of this new analysis option. Following installation of a new batch of ground gears, unacceptable noise behavior was noted in the gearbox. A comparison of measured values between the new batch and reference parts indicated the same frequencies in the profile, but higher amplitudes (approx. 0.2 μm), which could be attributed to altered dressing conditions for the grinding wheel. The tooth trace exhibits a change in frequency and amplitude caused by an increase in the feed rate during grinding.

Valuable Support

Modern gear metrology not only has to test gears as fast and reliably as possible, but must also support production in identifying the cause of errors. Klingelnberg's new variation analysis software is intended to bring users a step closer to this goal for a wide variety of problems and causes. Although the software cannot replace the necessary basic understanding of gear geometry and production experience, it can substantially support and simplify the process of troubleshooting.

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Lube-Seal Solution

OPTIMIZES WIND APPLICATIONS

The Freudenberg Group embraces a natural synergy with the Lube&Seal package, jointly from Simrit and Klüber Lubrication, which combines the features of lubrication and sealing to benefit the greater system in wind turbine applications. The product integrates sealing lip systems and lubricants to create a more reliable tribological system.

"This is the first time we look at the lubrication and seals as an entire system instead of as individual components," says Tim Lomax, Simrit marketing communications director. "If, as in the past, each is regarded as completely independent of the other, one may be maximized at the expense of the other. For example, additives may be blended with a grease to give it certain lubrication properties with no regard as to how those additives affect the seal material. Certain additives

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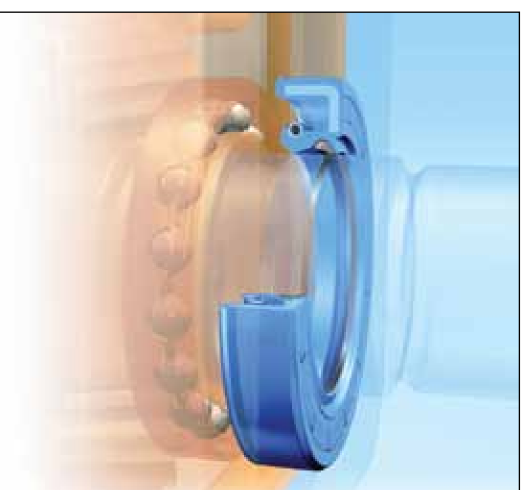
are more aggressive toward rubber compounds, and by looking at the system as a whole, we can match the seal material and lubrication to maximize the life of each, reduce maintenance costs and eliminate costly downtime."

The Lube&Seal system helps minimize breakdowns in wind turbines due to leaks while preventing wear and reducing damage that can result from thermal instability or other environmental elements of concern to wind turbine manufacturers, such as ozone, salty air and mineral oils. This is well-suited for wind applications because manufacturers and operators look to extend maintenance cycles.

"Repairs on wind turbines can be costly, difficult and dangerous," says Jesse Dilk, industry group manager–wind, Klüber Lubrication North America L.P. "Therefore, it is vital to use high-quality components at every opportunity. Bearings, seals and lubricants are essential design elements when analyzing mechanical systems. Optimization of these elements leads to a more efficient, reliable machine design."



By looking at the lubrication in an application, the Lube&Seal system matches sealing materials to operate with that specific lubricant. Klüber's lubrication is designed to minimize the number of different lubes needed in wind turbines, which results in a simpler system. Simrit's low-friction seals provide reliable sealing with minimal energy loss. As an example of this, according to Lomax, "We've introduced [an] extremely low-friction labyrinth seal for turbine gearboxes, which combines PTFE and rubber elements for long-life and low-drag sealing."

The Lube&Seal package undergoes extensive testing and certification procedures to ensure chemical compatibility, low friction, temperature resistance, corrosion protection, contamination reduction and extended service life. The technology reduces wear and deterioration of

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key mechanical components.

Simrit and Klüber were a natural fit for this product collaboration. "Since Simrit and Klüber are both part of the Freudenberg and NOK Group of companies, we are uniquely positioned to look at both sealing and lubrication within the same group," Lomax says.

"The collaboration began in Europe when we began to study the effects of lubrication on sealing. It has since expanded to collaboration at the customer level to bring this knowledge out into the field where it can be used on a daily basis."

The Lube&Seal system debuted at Windpower 2010 in Dallas. "We are excited about our partnership with Klüber as it allows us to design, develop and manufacture a complete sealing system using the best possible materials and lubricants," says Dave Monaco, president of Simrit. "As a result, we can provide our customers with an all-in-one solution of the highest quality and durability, which is critically important in the wind power industry."

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KISSsoft

RELEASES NEWEST VERSION OF ISO/CD TR 15144

In the hitherto existing draft ISO/CD TR 6336-7, the information for the definition of the permissible specific lubricant film thickness λGFP was missing. Therefore, reference values considering λGFP had to be derived from literature. But the information in this context was often contradictory. The newest draft of the ISO/CD TR 15144, replacing the planned part of the ISO 6336, allows now the determination of the permissible specific lubricant film thickness λGFP, if the load level for micropitting of the oil is known. With the implementation of this standard addition in *KISSsoft*, the safety against micropitting is calculated.

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Vertical Grinder

RE-ENGINEERED FOR WELTER GEAR

The Welter Gear Division of Germany recently took delivery of a PFG re-engineered Doerries vertical grinder that offers some unique features that enhance the machine's use to Welter.

The grinder is equipped with two cross rail saddles; the left one supports a light, finish turning ram and a separate, straight vertical grinding head; and the right saddle provides a grinding spindle mounting support that will allow the grinding spindle to be mounted on two separate surfaces, 90 degrees opposed. Also, the entire right-side saddle can swivel ± 45, allowing surface grinding operations of ID and OD tapers, as well as angled surfaces on the top of a bearing ring, for example.

Welter has capabilities for spiral and straight bevel gears conforming to the Klingelnberg, Gleason and Kurvex cutting systems, as well as cylindrical gears up to 3,000 mm diameter. The re-engineered machine allows Welter Gear to machine finish and grind larger gear and

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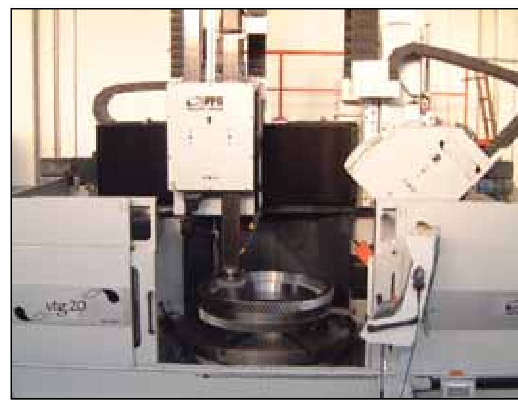
bearing workpieces without re-fixturing or moving to another machine. This increases finished accuracies, reduces tolerances and improves fits. The PFG vertical grinder eliminates wasted set-up times while improving accuracy.

PFG is a privately owned builder of vertical machining centers and gantry mills located in Northern Italy, near Vicenza. PFG also re-engineers precision specialty machines that include grinders and turning machines. PFG is represented in the United States by Nanier Machine Tools of Ohio.



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60-Inch Diameter Gear Vacuum Carburized

Solar Atmospheres successfully vacuum carburized a large gear required for a defense application that had previously not been successfully processed using atmospheric-type equipment.

The achievement is directly related to modifications made to Solar's large 10 Bar Quenching Furnaces, so they can handle larger and more extensive loads. By adding new instrumentation, carburizing nozzles and improving the backfill system, this furnace—with a work zone measuring 48 inches wide by 72 inches long by 38 inches high and load capacity of 10,000 pounds—is capable of performing carburizing cycles on large parts and loads not previously thought possible in vacuum.

This successful application was a large gear of 9310 steel material with dimensions of 60 inches diameter by 13 inches high and weighed 1,900 pounds. The part was low pressure vacuum carburized to achieve an effective case depth of 0.070 inches, followed by a temper, a minus 225 degrees Fahrenheit freeze and a second temper operation. Quenching was accomplished using a mixture of nitrogen and helium gases. Flatness was within 0.100 inches and roundness within 0.050 inches.

Solar anticipates these types of results further expanding the applications for low pressure vacuum carburizing.

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High-Speed Inserts

INCORPORATE THROUGH-COOLANT

Several products released by Ingersoll Cutting Tools expand machine tool cutting capabilities.

The Power-Feed+Mini high feed cutter features high-speed geometry with a double-sided, four-edge insert engineered specifically for high-

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speed machining to deliver economy, strength and performance.

The inserts infuse Power-Feed+ technology into a smaller insert to provide high-feed capabilities with higher insert densities in smaller diameter end mills. The cutter bodies incorporate through-coolant and are constructed of premium alloy steel materials. They are appropriate for high-speed roughing at lighter depths of cut.

The CVD coated series T-Tinox grades increase productivity, for stainless steel turning. The copper-colored T-Tinox coating resists material build-up on the cutting edge, and a smooth, stable cutting edge results from Ingersoll's T-Turn+ technology.

The T-Tinox series consists of three grades. The TT9215 provides high wear and chipping resistance appropriate for high speed and continuous cutting in stainless. TT9225 provides a balance of wear and fracture resistance for general purpose stainless steel applications. The TT9235 provides fracture resistance and toughness for interrupted stainless steel cutting at low speeds.

The 3n1-Rounds series 45D...RP solid carbide roughing endmills feature high-feed geometry with variable pitch and chip slitters. This series covers a range of applications including slotting, pocketing, helical interpolation and contouring.

Four- and five-flute versions are available with a 38-degree helix and large corner radii to enable high-feed application. The serrated cutting edge features flat peaks for improved surface finish. Diameters range from 0.250 inches to 0.750 inches and are supplied in IN2005 grade.

Ingersoll also introduced integral collet tooling to connect to the Hi-PosMicro indexable end mills and Chip-Surfer solid carbide tipped tooling lines. Worn tooling can be replaced in seconds with 0.0005 inches axial and radial repeatability. Economy and higher feed rates of the indexable Hi-PosMicro end mill tips allow for high throughput at less cost. The Chip-Surfer tips can be applied to a wide range of materials. Cutter diameters range from 0.250 inches to 2.00 inches. Medium- and high-density versions expand application options.

For more information:
Ingersoll Cutting Tools
(815) 387-6600
www.ingersoll-imc.com

Zeiss Machines

MEASURE AUTO, ROUND PARTS

The Carmet II from Carl Zeiss was developed specifically for suppliers and manufacturers in the automotive industry. The horizontal-arm measuring machine is available in four sizes up to a measuring range of 7 meters by 1.6 meters by 2.5 meters (x, y and z axes respectively). It comes standard with the RDS stepping articulating probe holder featuring computer aided accuracy (CAA). It uses the foam insulation technology that was introduced recently with the Accura machine.

Setting new standards regard-

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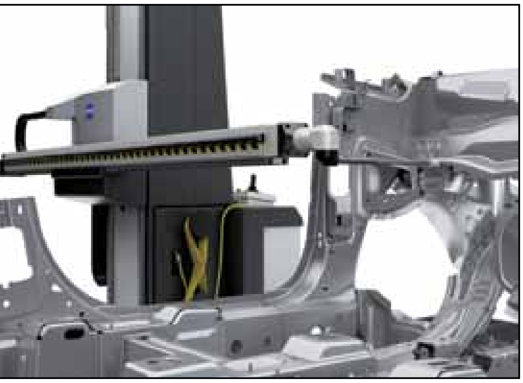

ing robustness, ergonomic design and performance, Carmet II features an attractive price/performance ratio and low lifecycle costs. Carmet II has a smaller footprint than similar measuring machines, which is the result of the onboard controller on the machine. Sensitive machine components are enclosed in a special, high-tech material providing the machine with high temperature stability. A shortened maintenance time increases the machine availability with maintenance-relevant parts easily accessible.

The robust guideway system features pre-stressed friction drives that unite a high level of safety and quietness. The machine's design facilitates access to the measuring location and simply loads the complex components commonly found in car body measuring. Touch-trigger sensors achieve shorter calibration times, increasing productivity. Difficult-to-reach areas, like the wheel arch of the car body, can be assessed with different touch-trigger sensors and extensions up to 350 mm.

Carl Zeiss also introduced the O-Inspect multi-sensor measuring machine available with a rotary table that inspects small and complex parts used in the electronics and plastics industries, medical and automotive technology, as well as precision engineering applications.

The rotary table developed specifically for this machine can be mounted and removed by the measuring machine operator. It can be positioned both horizontally and vertically for added benefit. The rotary table enhances the effectiveness of the measurement of round parts that no longer have to be re-clamped for the optical measurement. Mechanical influences are minimized as the measuring axes of the CMM are only subject to minimal movement with the rotary table.

The O-Inspect essentially combines the functions of a profile projector, measuring machine, microscope and contour measuring machine. Multiple sensors on the O-Inspect allow alternation between optical and contact measurements in one run. The optical measurements are performed with the 2-D camera sensor with the image processing function contained in the Discovery zoom lens. Contact measurements are the domain of the Vast XXT scanning probe. The CAD-based *Calypso* measuring software comes standard.

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Induction Hardening and Tempering System

FOR DRIVELINE COMPONENTS

Inductoheat, Inc., an induction heating equipment manufacturer, recently delivered an induction hardening and tempering system to a leading supplier of driveline components. This machine was designed specifically for hardening and tempering hub spindles and ball races.

The equipment is comprised of a STATISCAN IV unit for induction hardening and a STATISCAN II unit for induction tempering. The part goes through an eight-station cycle using the following material handling features; four pneumatic linear transfer 180 degree grippers, two pneumatic accept/reject arms and a continuous feed conveyor.

Each of the eight stations adheres to

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the following responsibilities: Station 1, parts are automatically loaded; Station 2, pneumatic part locator and check; Station 3, induction hardening O.D. of hub shaft; Station 4, I.D. auxiliary quench cooling; Station 5, pneumatic exist and acceptable parts are transferred onto the tempering system conveyor; Station 6, parts travel through a channel coil for tempering; Station 7, conveyor quench cooling; and Station 8, automatic part unload for accepted parts or exit conveyor for rejected parts.

There are two induction power supplies for this compact system. The hardening inverter is a UNIPOWER UP12 power supply, which provides 200 kW at 10 kHz, and a STATIPOWER SP16 power supply offering 50 kW at 10 kHz for the tempering portion. Allen-Bradley PLC controls with touch-screen HMI interface, and process monitoring offers superior process control and monitoring capabilities assuring the highest quality and repeatability, according to the company. For system cooling and part quenching, an integrated closed-loop water recirculation system is included.

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Robotic Blast Machine

INCORPORATES TRANSFER CART

Guyson Corporation has introduced a robotic blasting system that incorporates a component-manipulating six-axis robot and a shuttle transfer cart to fully automate processing of tray-loads of components. The new Model RB-TRR-900 is designed for precise surface preparation, shot peening and cosmetic finishing operations.

The robotic blast machine is provided with a single suction-blast gun or pressure-blast nozzle that is rigidly bracketed in a fixed position inside the 42 x 42 x 42-inch blast chamber. Guide rails form a track extension into an antechamber on one side of the blast cabinet. Rolling on the track, the transfer cart bearing a tray full of components is moved in and out of the blast enclosure by a precision linear actuator, and a pneumatically actuated vertical sliding door closes to isolate the load/unload station from the blasting zone. A FANUC M-10iA robot with a custom-engineered pneumatic gripper serves as a component handler in the automated blasting system, grasping and removing a part from the tray, presenting the component to the blast, then replacing the finished work piece. A tailored skirt seals the cabinet wall and protects the robot from the potentially abrasive environment of the blast chamber.

FANUC Robotics offers larger and smaller 6-axis robots that can be integrated in the RB-TRR-900, should a different payload or reach be required. To blast a production lot of parts, a tray of oriented components, typically 6 to 24 in number, is placed on the transfer cart, the sliding load door is closed and a part identification number is entered or selected at the touch-screen control panel. Alternatively, component recognition features are available, including a bar code reader, to positively identify the work and prompt the recall of the correct motion program and blasting process recipe, with automatically controlled parameters such as blast pressure, media flow rate and the duration of the blast and blow-off cycles. While the robotic blast system methodically and identically repeats the surface treatment on each of the components in the batch, the human operator is freed for an extended period to perform other work.

According to the blast equipment manufacturer and authorized FANUC integrator, the robotic component manipulator constantly and accurately maintains the specified blast angle, nozzle offset and surface speed, even

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when following the contours of complex-shaped aerospace or medical parts, which makes it possible to produce extremely consistent surface conditions and eliminate non-conformities in finish quality.

Prospective users of automated and robotic blasting systems are invited to submit sample components for free laboratory testing and application engineering evaluation at the machine builder's factory in northeastern New York.

For more information:

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Coolant Delivery

OPTIMIZED BY JET COLLETS

The Perfect Jet Collet from Big Kaiser Precision Tooling Inc. is designed to optimize coolant supply in high-speed operations for better coolant delivery and the option to seal the collet for coolant-through tools.

The Perfect Jet Collet is designed for use with Big Kaiser's Hi-Power Milling Chucks and Mega Double Power Chucks. The collet seals the chuck face and directs the coolant down the tool shank to the cutting edge instead of centrifugal force disrupting the coolant supplied through the tool holder, resulting in coolant spraying wide.

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