The Multisensor

Issue 2016

Multisensor Systems – Perfectly Integrated

WinWerth® 8.40 | ScopeCheck® FB DZ | Multi-Spectra-Tomography

ScopeCheck® FB DZ – collision-free measurements also on the shop floor: dual ram approach for optimal measuring with each sensor, for example image processing sensor or touch probe (cover picture)

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Multisensor Systems – Perfectly Integrated

This year, once again, "The Multisensor" contains information on the latest developments from Werth Messtechnik GmbH, corporate news, and reports on interesting applications. A series of product innovations have concentrated on perfecting Werth multisensor technology. They address both tactile and non-contact optical sensors. Many details of the machines that use X-ray tomography have been improved and expanded with new functions, some of which are patented. The latest edition of the WinWerth® software is substantially more user friendly and in addition contains many new capabilities valuable to the user.

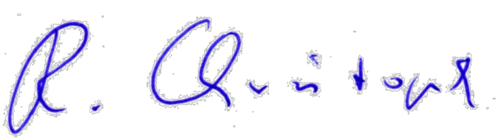
The new ScopeCheck® FB DZ shop floor measuring machine has been designed to allow Werth multisensor technology to be applied perfectly. With two separate rams, measurements can be taken optimally with each sensor and in every direction. The Werth multisensor interface ensures that a wide variety of sensors can be used with no loss of measurement range. Contour and fiber probes, conventional probe systems, and various optical sensors can be changed out fully automatically and used in any desired combination, depending on the measurement task at hand.

A new feature has been added to the image processing sensor. Raster scanning along a predefined path enables even large workpieces to be measured entirely at a high measurement speed. The analysis of the features is then simply performed "in the image." Functions such as "AutoElement" or "AutoCalculate" make it simple to use this approach.

This year in the field of computed tomography we are announcing new solutions for measuring workpieces made from several different materials as well as a specialized process for high-resolution measurement of complex workpieces.

Our latest software version, WinWerth® 8.40, convinces with an interactive operating concept. Initial user reports have praised the ease of taking measurements with tactile sensors in particular. Among other improvements, the automatically generated scan paths or point distributions (with or without CAD data) leave few wishes unfulfilled. Of course, the new and convenient functions for changing and adapting measuring programs as well as the feature-oriented measurement capabilities can also be used with optical sensors and X-ray tomography.

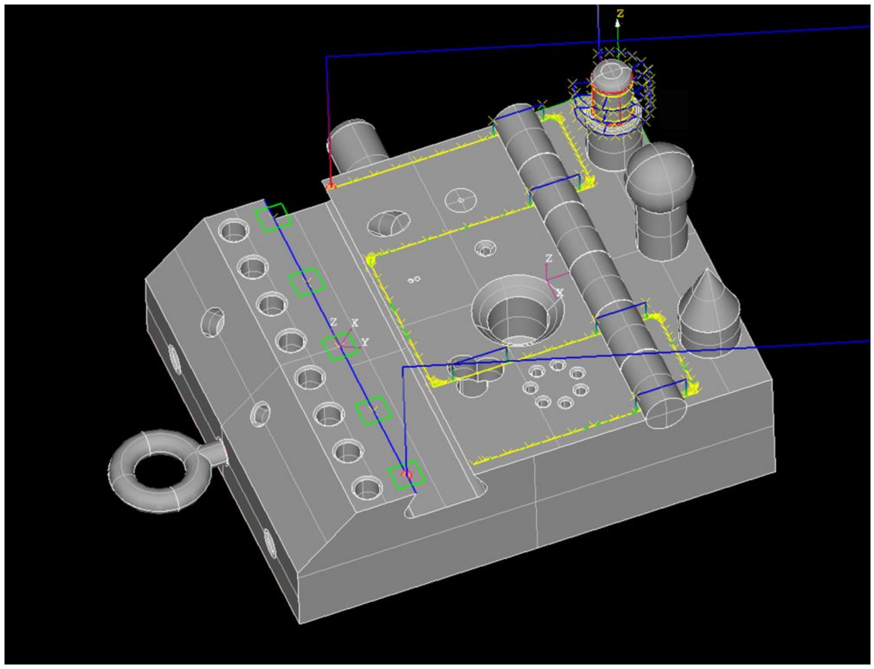
Whether touch probes, optics, or tomography, we provide multisensor systems – perfectly integrated. Find out for yourself!



Dr. Ralf Christoph
President and Owner
Werth Messtechnik GmbH

WinWerth® 8.40 – the Tactile and Optical Interface of Choice

The new version 8.40 of WinWerth® has a number of additional functions. The expansion of scan path and point distribution modes to cover all standard geometric elements eliminates the need for time-consuming manual positioning of the sensor. The risk of collision is minimal, as WinWerth® detects obstacles on the workpiece and generates travel paths to avoid them. Using feature-oriented measurement, individual dimensions can be selected out of an extensive measurement program. The user selects the desired features and WinWerth® automatically identifies the alignment of the workpiece and all of the relevant elements with their associated settings.



Scan path and point distribution on a CAD model

Several new functions are available for TomoScope® and TomoCheck machines as well. For example, the volumetric capacity of a container or the volume of a workpiece can be calculated. Using the void filter, computed tomography measurements (CT) can be analyzed without the detrimental influence of voids – or the voids can be sorted by size and displayed and analyzed separately. Multi-Spectra-Tomography provides a unique solution for multi-component workpieces such as assembled plug connectors (see page 12).

The new AutoAlign function automatically recognizes the workpiece in a rastered image and aligns it to a reference element using a best-fit algorithm. The new HD raster scanning can be used to capture large areas at high structural resolution automatically (see page 12). Displaying sensor travel paths in the 3D graphics window makes it easier to quickly check the measurement sequence and reduces measurement time by optimizing the travel paths (see page 18).

Reliable Measurements Despite Unreliable Temperatures

Temperature sensor in the measurement range

Every measurement result is associated with a measurement uncertainty that is influenced by numerous factors. In addition to the measuring machine, the operator, the measuring object, and the features to be measured, the environmental conditions are a factor that is often underestimated. The temperature, in particular, has a substantial influence on measurement uncertainty. In order to take a correct measurement, both the measuring machine and the workpiece must typically maintain a temperature within a few Kelvin of the reference temperature of 20 °C. The temperature must also remain constant over time and throughout the space.

Such optimal measurement conditions are often not available. Therefore, correcting temperature-induced measurement deviations is critical for many users. When measuring a distance dimension of 100 mm on a workpiece made of aluminum at an ambient temperature of 25°C, for example, the temperature-induced measurement deviations are about 7 µm. For plastics, the deviation under similar conditions can be as much as 50 µm. In extreme cases, the measurement deviations are the same order of magnitude as the tolerance on such workpiece dimensions.

Automatic correction of measurement deviations resulting from differences between the ambient temperature and the reference temperature of 20 °C is standard for all Werth coordinate measuring machines. In the simplest case, the effects on the behavior of the measuring machine itself (e.g., expansion of the scale) are determined and corrected. The thermal expansion coefficient of the measuring object is treated as 11 µm / K m (a typical value for steel). This means that measuring objects and standards made of steel and materials with similar thermal expansion coefficients can be measured at a very low measurement uncertainty despite the temperature deviation. This is also helpful when performing maintenance work.

When measuring workpieces in a poorly controlled environment, a correction of the workpiece temperature should also be made to compensate for the expansion coefficient of the workpiece. To do so, a temperature sensor can be placed in the measurement volume, or a workpiece temperature probe can be mounted directly on the measuring object. Using the thermal expansion coefficient of the workpiece material, as entered by the operator, all measured lengths are corrected accordingly.

When using coordinate measuring machines in a non-climate-controlled environment, temperature correction is highly recommended, as this is the only way to effectively minimize measurement deviations.

Sensor Parking Without Limits for ScopeCheck® S Machines

Changing racks for parking probes and multisensor systems support great flexibility and a high level of automation with rapid, simple sensor changeovers. Setup times are also minimized substantially. Traditional changing racks need to be located within the measurement volume in order for the corresponding sensor axes (interfaces) to reach them. This always meant giving up part of the measurement range, and in some cases even forced the purchase of a machine with a larger measurement range to accommodate the changing racks.

Multisensor changing rack is now outside of the measurement range

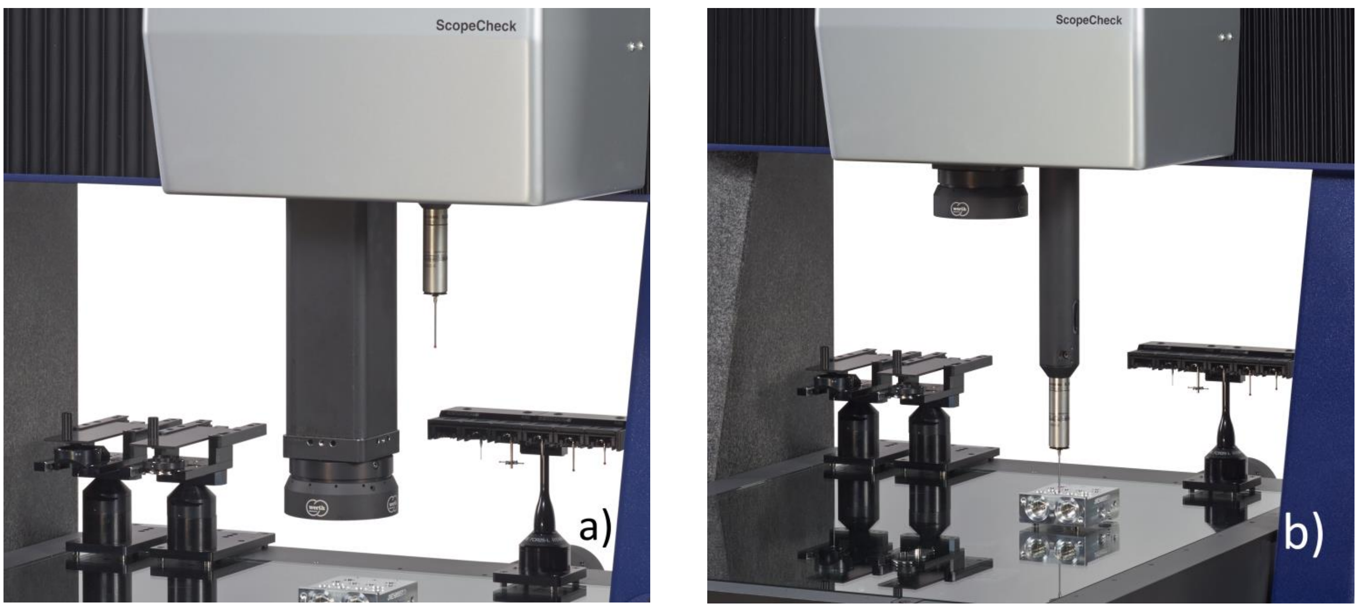
With the new, optional retracting axis for changing racks, the entire measurement range is available for measuring workpieces. The changing rack is only positioned by the machine axes within the measurement volume for a sensor change, then it is pushed back into its park position.

Two Independent Sensor Axes Now Also Available for ScopeCheck® FB Machines

The ScopeCheck® series of measuring machines permits optimal measuring with each sensor. Using the dual ram approach and the Werth multisensor interface, collision-free measurements with multiple sensors can now be used on the shop floor. In essence, two coordinate measuring machines in one are available to users, one with image processing and another with a scanning probe. The combination of these sensors within a single measurement application is also possible.

The ScopeCheck® series of devices has been developed from the ground up based on the proven technology. One important advantage of the new ScopeCheck® FB DZ in comparison to the previous model can be found in the combined measuring range in multisensor mode of at least 400 mm x 500 mm x 350 mm. Of course, machines with larger measuring ranges are available on request. In addition, the ScopeCheck® FB DZ has been equipped with thinner sensor rams and optimized guides. The design uses two independent sensor axes, preventing sensors that are not involved in the measurement from colliding with the workpiece. Only the ram with the active sensor is used to measure the workpiece; the other ram is positioned outside of the measuring range. This, as well as the thinner rams, makes it possible for a sensor to reach all necessary positions even on a large workpiece. Furthermore, sensors that are attached to a rotary/tilt joint, such as scanning probes and the IP 40 T image processing sensor, can be used in all directions without restrictions. The same applies to the Werth 90° mirror attachment, whose viewing direction is not limited by the second ram. While the basic configuration contains just one ram, the second ram can also be retrofitted any time later on. For measurements with only one sensor, the ScopeCheck® provides a measuring range of 530 mm x 500 mm x 350 mm.

In the basic configuration, the ScopeCheck® FB DZ contains the proven optical system. Additional sensors, such as the Werth Laser Probe or the Werth fiber probes, can be used with the multisensor interface. In case a conventional scanning probe is needed, a second ram can be installed. This ram can also be equipped with additional optical sensors. The new version 8.40 of WinWerth®, with optimized operation for tactile and optical sensors, rounds out the design.

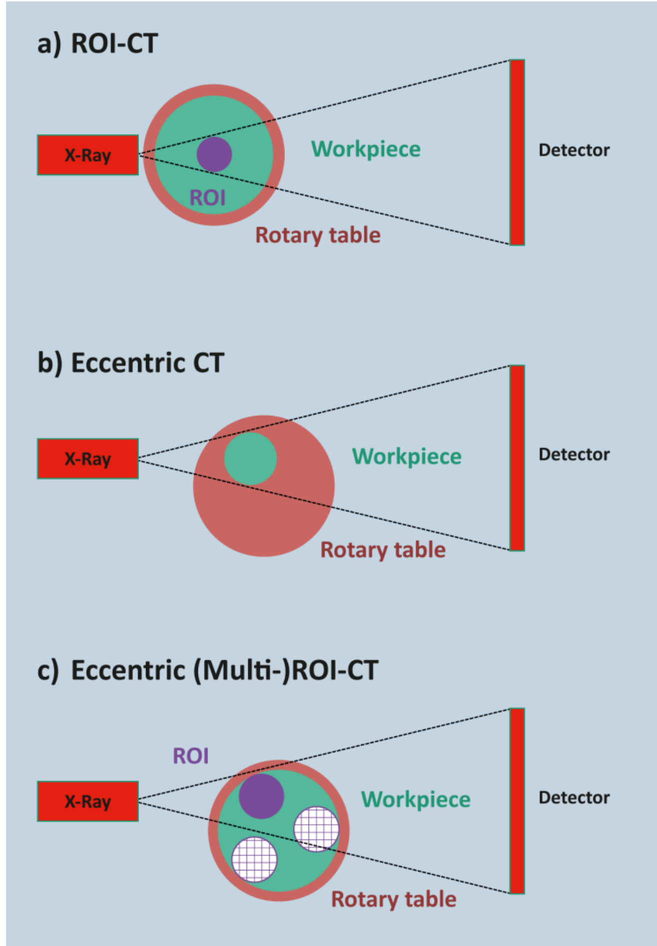


ScopeCheck® FB DZ with two independent sensor axes for collision-free measurement in the production environment: a) image processing sensor in use; b) scanning probe in use – the changing racks for the multisensor systems and the probe styli are in the background

Increased Efficiency for High-Resolution Measurements

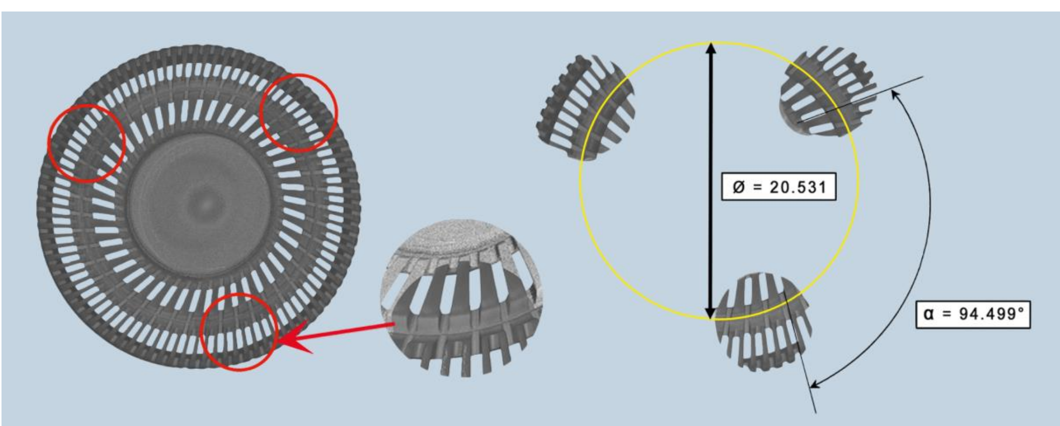
"Region of Interest" (ROI) tomography was developed to create high-resolution images of some regions of larger workpieces. In the past, the entire workpieces always had to be fully scanned at high resolution. ROI-CT only measures the relevant area at high magnification. To accomplish this, the entire workpiece is first captured at low resolution and the desired partial region (ROI) is captured at an appropriately high resolution. This can improve measurement time and reduce the resulting file size.

With conventional ROI tomography, ROI zones needed to be in the exact center of the rotary axis, greatly limiting both the flexibility and number of possible regions of interest. The new, patented function of Eccentric Computed Tomography (CT) now makes it possible to place the workpiece arbitrarily on the rotary table. This eliminates the laborious and time-consuming alignment of the workpiece, making measurements more convenient and efficient. The WinWerth® software automatically calculates a virtual axis of rotation at the center point defined by the operator within the measured volume. During the measurement, rotation about the virtual axis of rotation is ensured by moving the precise machine axes.

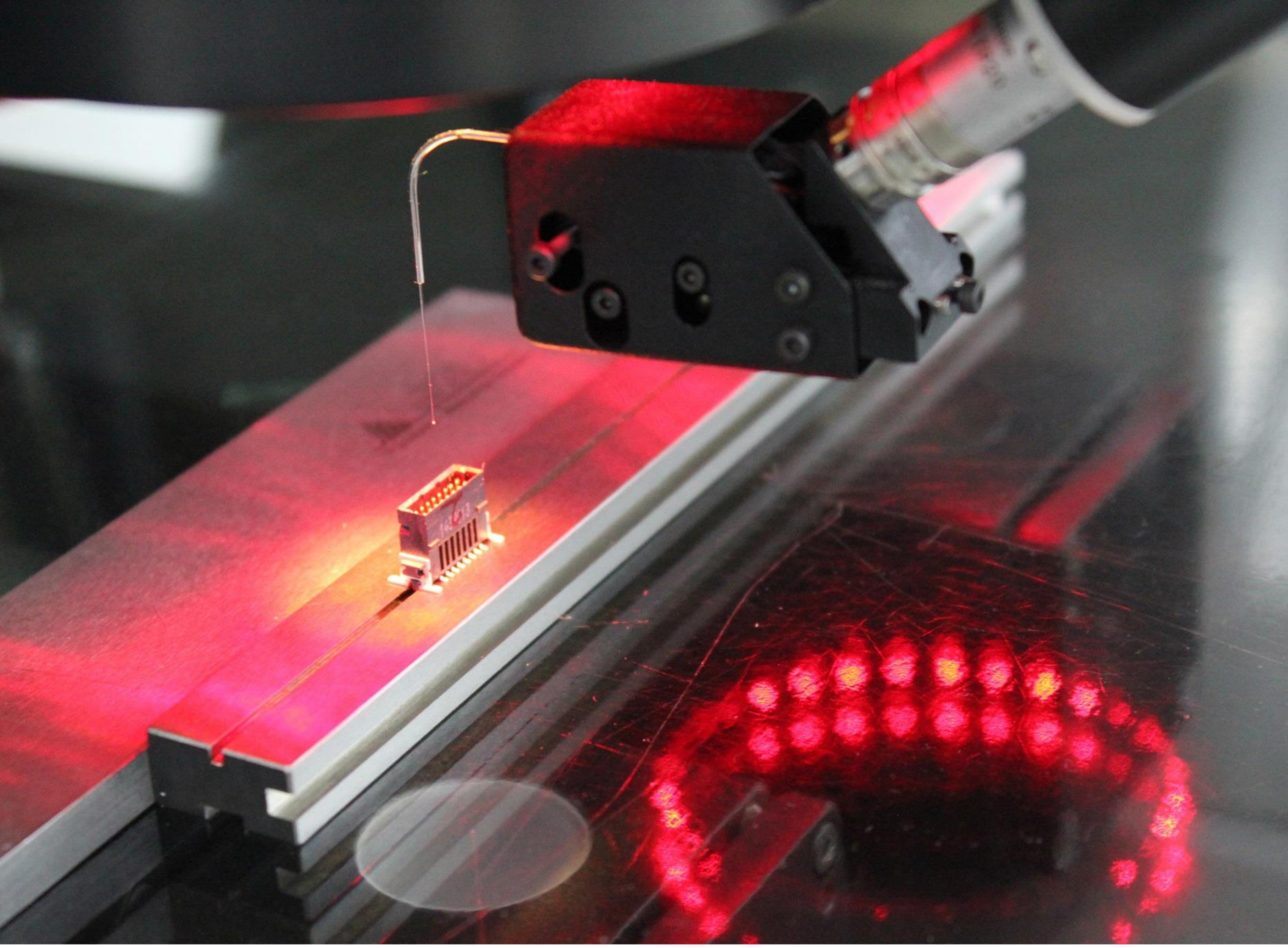


Principles of ROI-CT: a) conventional ROI-CT, b) Eccentric CT, and c) combination for eccentric (Multi)-ROI-CT

The Multi-ROI-CT option combines the advantages of Eccentric and ROI tomography. The high-resolution regions of the workpiece can be located at any arbitrary position within the measured object. Several ROI zones can even be captured and linked together. The overall volume and the ROI volume are located within the same coordinate system. This means that an overall point cloud for the workpiece can be computed automatically with different structural resolutions. During analysis, features from the overview volume and the various ROI measurements can be linked to each other. This unique combination of patented Eccentric CT and ROI CT makes computed tomography an economically feasible solution for an even greater range of applications.



Multi-ROI-CT regions on an electric razor head



Metrology for the Future

Multisensor Systems Are the Basis for Zero-Defect Production

Electronic components such as plug connectors are getting smaller, presenting ever greater challenges for manufacturing. ERNI Electronics uses 3D CNC multisensor measuring machines to secure its manufacturing processes, one of which has mastered X-ray computed tomography. Modern metrology allows rapid process validation.

ERNI Electronics has embraced "zero-defect production." The company produces a wide range of circuit boards and I/O plug connectors, backplanes, cables with plug connectors, housings, systems, and tools in Adelberg, near Stuttgart. Many of the products end up in the automotive industry via supplier companies, where the installed components are subject to particularly high quality requirements.

Accordingly, the quality assurance department is professionally equipped. In the measurement lab, in addition to various 3D CNC multisensor measuring machines, there is also a coordinate measuring machine (CMM) with an X-ray computed tomography sensor. One multisensor coordinate measuring machine is even used in production in order to allow workers to rapidly check the results of their work.

Oliver Jehlitschke, Head of Quality Management, explains: "The automotive industry in particular always wants to increase the packing density of circuit boards. This means that the plug connectors that we develop are continuously getting smaller. We therefore have to adapt our production and measurement prerequisites on a continuous basis."

His department's long-term guide and partner is Werth Messtechnik GmbH. The company from Giessen is one of the leading providers of modern coordinate metrology and specializes in coordinate measuring machines with optical sensors, X-ray tomography, and multisensor coordinate measuring machines. Back in 1996 a VideoCheck IP 250 was installed at ERNI, a compact machine that is used for optical measurement of plug connectors, housings, and punching strips. It has since been replaced by a newer, more precise version of the same type of measuring machine. For larger components, ERNI uses the VideoCheck FB fixed bridge measuring machine, which covers a measurement volume of (400 x 400 x 200) mm and was put into service in 1999. It is equipped with telecentric optics, as well as the patented Werth Fiber Probe and a conventional 3D trigger probe.

Computed Tomography Supplements CMMs

One highlight in the ERNI measurement lab is the Werth TomoScope® HV Compact, which has been in use there since 2008. This coordinate measuring machine utilizes computed tomography to analyze or measure components without contact, at micron precision.

The principle is as follows: Radiographic images of the test object are taken at various rotational positions. Then a 3D reconstruction of the individual images is performed to create a complete 3D volume that describes the entire internal and external part geometry. Measurement Technician Rüdiger Teufel explains: "We use the TomoScope® to measure all of our empty housings and some assembled plugs, including male and female multi-point connectors. Our delicate punching strips can also be measured with the TomoScope®."

The time saved in the creation of a reliable production process was the deciding factor for the investment in this sustainable technology. Nominal-to-actual comparisons between 3D CAD data and tomographically measured 3D data can be used to generate color-coded deviation plots from the nominal model. This can be used, for example, to rapidly determine whether the plastic in an injection mold has been properly distributed or not. Depending on the results, the mold or injection parameters are optimized until the process is reliable. Quality Manager Jehlitschke states more precisely: "We need to achieve a process capability index C_p of 1.67. This applies to the housing as well as to the contact strips that we punch."

The fixed portal measuring machine is equipped with telecentric optics as well as a fiber probe and a conventional trigger probe.

Rüdiger Teufel and his colleagues use the TomoScope® to take micron-precision measurements: "For example, we do all of the first article inspections of our housings on the TomoScope®. I can scan the components and have the entire 3D geometry available for analysis as a point cloud within a few minutes. It even measures the internal geometry of the component, such as chambers. Previously we had to cut, machine and polish the cross sections, now we can get virtual cross section images in the point cloud practically at the push of a

button. This saves a tremendous amount of time. The cross section plane can also be moved to any position in the point cloud."

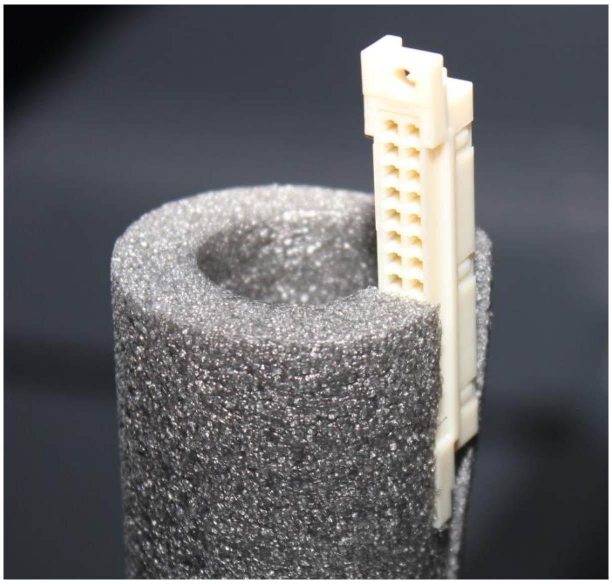
The measurement technicians also use the volume section method, for which Werth has applied for a patent, on SKV punched strips. They do so in order to capture a dimension that is important for its function later. This procedure takes place alongside production, as Rüdiger Teufel points out: "We get one section from each batch. The strip is sent on for galvanic coating only if the inspected dimension is within tolerance."

Reliable Coplanarity Measurement

In the first half of 2015, the ERNI measurement lab obtained another Werth VideoCheck® S 400 model 3D CNC multisensor measuring machine. It is equipped with the latest sensor technology, such as the Chromatic Focus Probe (CFP) and the focus variation sensor, Werth 3D-Patch. Oliver Jehlitschke gives the reason for this investment: "The solder pads that make contact between the plug connector and circuit board must be in a constant plane within a tight tolerance in order to prevent defects in the downstream soldering process. We determine whether this has been met by taking a coplanarity measurement of all the solder points."

One particular challenge is that the pins that protrude from the plug connector are bent to a 90° angle after assembly. This means that the bend angle and thus the position of the solder pads can vary slightly. The longer the plug connector, the more difficult this becomes, due to shrinkage and distortion of the plastic housing. Currently this measurement task is primarily the job of quality assurance within the manufacturing process. A measurement system integrated in the production automation systems for this purpose uses a triangulation laser to measure the height. This method is – as required in production – very fast, but not as precise as the Werth VideoCheck® machine that provides reference measurements and greater process reliability in the measurement lab.

Rüdiger Teufel explains: "We are completely confident in the potential that our new VideoCheck® S 400 with Werth 3D-Patch and CFP will provide us. The machine has the latest digital camera technology, the Werth HiCam, which provides optimal conditions for the contrast focus variation method. We can use a standard to establish reference dimensions that production uses for comparison with inline measurement results in order to make any needed corrections."



The coordinate measuring machine with computed tomography measures various components without special fixturing.

Measuring the Surface Topography

And this is how the Werth 3D-Patch works: While moving only the axis of the camera, similar to autofocus, images are taken continuously. From these images the maximum contrast for each image is evaluated. The contrast maxima within the image stack provide the measurement points, which describe the three-dimensional component surface. A new patent-pending focus variation method makes it possible to measure surface topographies over an extremely wide dynamic range. Dark and light areas of the same segment of the object can be captured simultaneously with optimal lighting; from this a measurement point cloud can be calculated. The highest points of the individual pins can then be captured and used to define a contact plane. This allows simulation of how the component will be positioned prior to the soldering process, and measurement of the solder pad spacing.

The chromatic focus sensor provides an alternative measurement method. This is a one-dimensional distance sensor that captures scan lines as the machine axes move it over the component. Point clouds are then calculated from these scan lines and evaluated. Due to its physical properties, this method is excellent for measuring shiny and mirror-finish materials.

Oliver Jehlitschke justifies ERNI's repeated selection of measurement technology from Werth as follows: "First, Werth measuring machines provide continuous high precision. I can confirm this from many years of experience. Second, the technology that Werth brings to the market is always fully developed and reliable. And third, our working relationship is excellent, whether in service or application support, especially for new technologies."

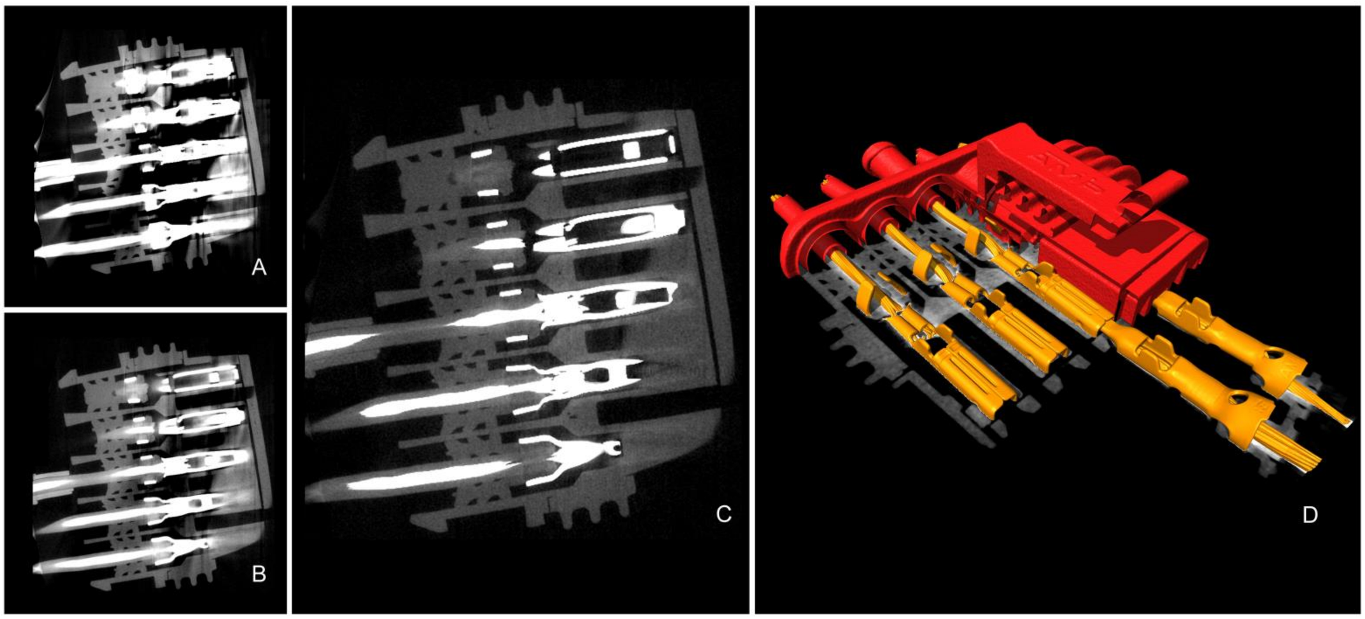
The Head of Quality Management at ERNI, Oliver Jehlitschke (left), discusses important inspection features with his experienced Measurement Technician, Rüdiger Teufel.

Werth Gives Insight to Multi-Material Workpieces

In coordinate measuring technology with computed tomography (CT), the dimensional analysis of workpieces made of multiple materials is particularly challenging. Werth Messtechnik in Giessen has developed a unique solution.

Multi-material workpieces are often metal and plastic components, such as assembled plug connectors. The measurement task is typically to determine the position and bend angle of the internal metal pins. In a CT measurement, however, the metal pins often cause artifacts due to beam hardening and scattered radiation. Historically these effects made the measurement of the plastic enclosure much more difficult.

With Multi-Spectra-CT, Werth Messtechnik offers an innovative solution for workpieces made of multiple materials. The WinWerth® measurement software takes two CT measurements with spectra tuned to a specific material and computationally combines them into a single volume. This volume can be used to check dimensions in any desired cross section using 2D contour image processing. A patented method for local edge detection can also be used to derive a 3D point cloud for the entire workpiece. By reducing the artifacts in the volume, dimensions measured between the different materials have lower measurement uncertainty.



Werth Multi-Spectra-Tomography: by combining several CT measurements (A and B) tuned to each specific material, artifacts are minimized (C and D)

Non-Contact Measurement of Complete Workpieces with Intelligent Raster Technology

Raster scanning can be used to capture large areas with high structural resolution automatically. The image processing sensor is continuously in motion as many overlapping images are recorded at a high frequency. A patented reconstruction process integrates these images into one overall image within the WinWerth® measurement software. The final analysis takes place in this image, which greatly reduces measurement time, particularly when measuring many dimensions, since it is not necessary to position the sensor for each feature. By overlapping many images, measurement uncertainty is also reduced, as several images are evaluated simultaneously for each measurement.

The image processing sensor can also follow any predefined 2D or 3D path (for example when measuring cutting inserts or complex stamped parts). The predefined path can be generated from a CAD model or a previously measured contour. To further reduce measurement time, unnecessary regions are not recorded with this technique, making the process significantly faster than the "rectangular raster" method. When measuring an O-Ring for example, the predefined path would just be a circle, and the corners and center of the overall image are "filled in" automatically or as defined by the user.

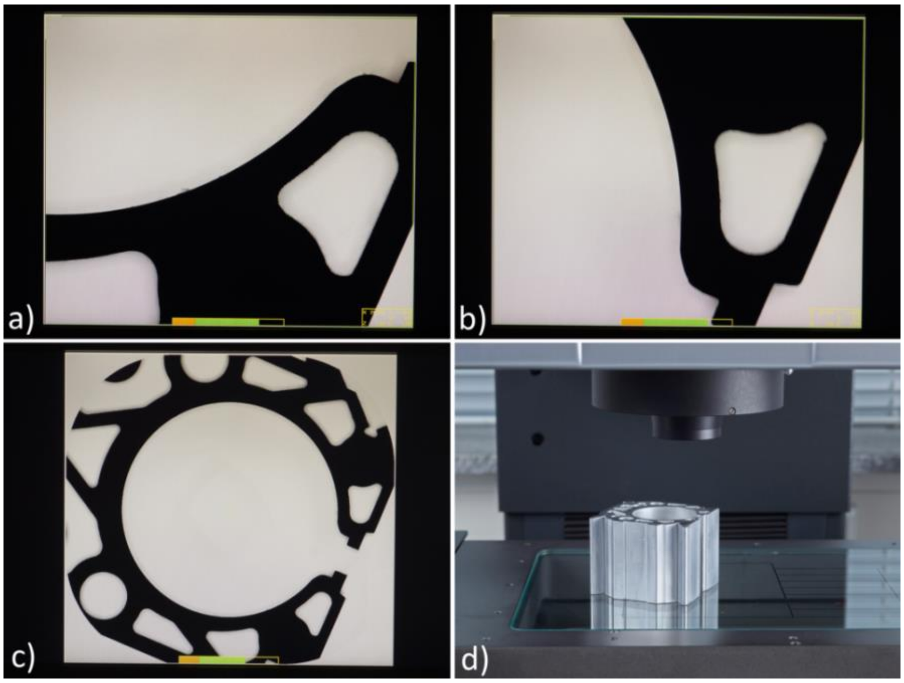


Image detail at the start a) and end b) of the predefined circular path, overall image c) and workpiece d)

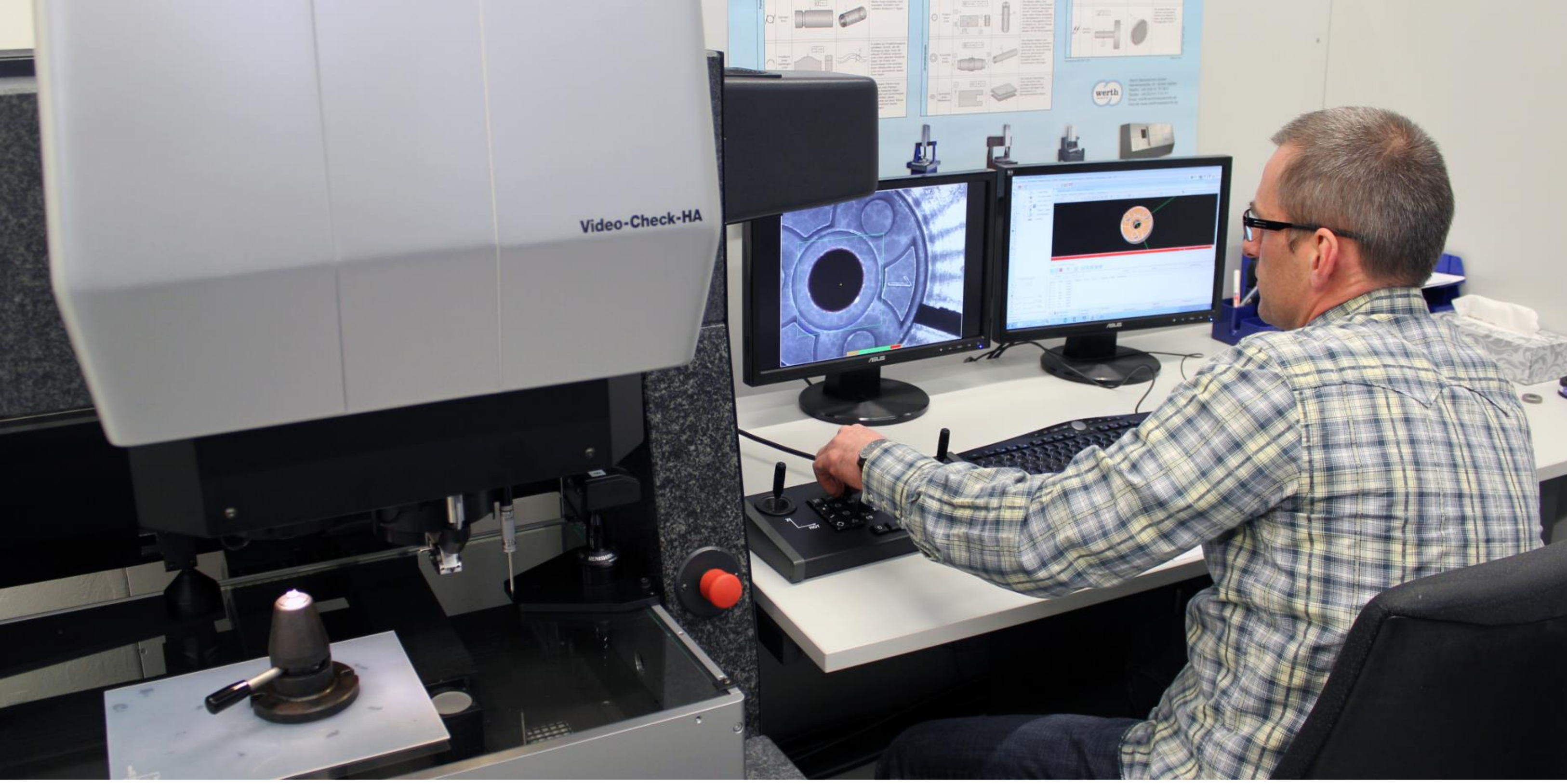
Measuring High-Precision Master Workpieces

VideoCheck® V HA – higher precision with a larger measurement range

Precision requirements for workpieces are becoming more demanding and are often in the micrometer range. This means that requirements for master workpieces for gaging benches and machines as used in the automotive industry are also increasing. The VideoCheck® V HA, like all Werth machines, is traceable and can be used to calibrate the calibration masters at the factory. If the quality management system requires a DAkkS certificate, the machine can be calibrated by Werth's own DAkkS lab in accordance with DIN EN ISO/IEC 17025. Werth is the first and only manufacturer to provide DAkkS calibration certificates for optical, and tactile, and computed tomography coordinate measuring machines. DAkkS (Deutsche Akkreditierungsstelle) is the national accreditation body of the Federal Republic of Germany. It is legally mandated to carry out accreditations of conformity assessment bodies.

With its solid granite construction, special air-bearing technology, and thermally stable scale system, the VideoCheck® V HA achieves measurement uncertainty in the range of tenths of microns. The high-precision machine has an integrated vertical rotary axis to prevent heavy workpieces such as shafts and tools from sagging under their own weight.

In addition to external dimensions, the flexible 3D machine can also measure a number of other features, such as teeth, transverse holes, etc. The VideoCheck® V HA is also available for workpieces up to 1000 mm in length and 320 mm in diameter. The combination of image processing and the SP80 tactile sensor allow for the very highest measurement precision.



Measuring Gear Profiles with Micro-Probes

Sensors and Software for Micro-Gears

How to ensure the quality of tiny planetary gears in micro-drive systems? The combination of a multi-sensor coordinate measuring machine, a fiber probe, and specialized software makes it possible – using scanning operation, even tooth flanks can be measured quickly, accurately and in accordance with the strictest standards.

Extreme temperatures from -100 to +200 degrees, vibrations, and impacts – drives from maxon motor, based in Sachseln, Switzerland, get the job done with absolute reliability under the toughest conditions. This makes them the first choice for unusual and especially challenging industries and applications. In space exploration, for example: The NASA Mars Rovers, Spirit and Opportunity, are each equipped with 39 maxon drives. For over ten years they have been steadily doing their job under difficult conditions on the red planet.

Drive Elements Are Getting Smaller and More Precise

Back on Earth, maxon DC motors function with up to 90 percent mechanical efficiency. They are used in antennas, radio masts, ships, and aircraft to provide smooth communications. They enhance driving safety in shock absorbers, advance automation in industrial production, help to correct vision problems in eye surgery, and even provide exact dosages of insulin for diabetes patients.

The trend toward miniaturization can be seen across every industry. This means that drive element have to get smaller and smaller. Maxon motor offers a modular series of motors, gearboxes, sensors, and control electronics under the name micro drives that can be combined into tiny drive units just 6 mm in diameter.

Even these miniature units and their micro-components still need to meet the highest quality requirements – a tradition at maxon. In 1988 the company obtained ISO 9001 certification. Today the drives manufacturer also meets various other quality standards, including EN 9100, conceived for companies that develop and produce components for the aerospace industry. The maxon medical business unit is certified to the ISO 13485 medical standard, which confirms that all processes and procedures are documented and that traceability is guaranteed.

The Challenge: Gears with Module 0.12

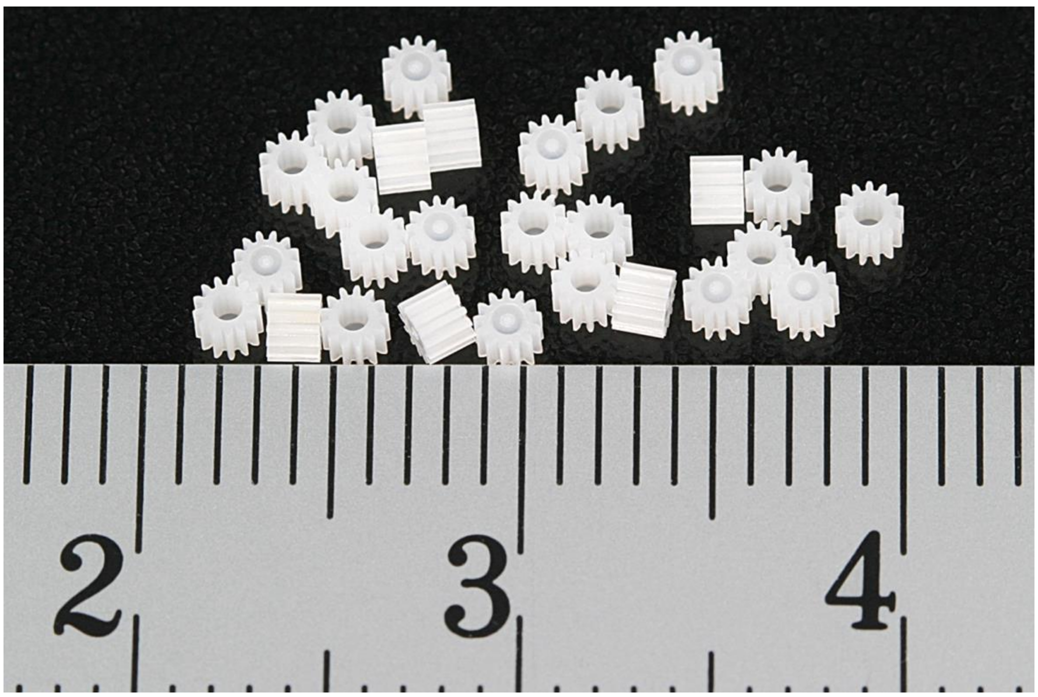
Roland Rossacher, Head of Technical Development, was responsible for quality assurance at maxon motor for over 20 years. He explains: "Our certifications mean that we are obligated to test even the smallest drive components. Measuring the injection-molded plastic gears used in our 6 mm diameter GP6 planetary micro-gearbox, which have a module of 0.12, presents a particular challenge."

A few years ago, the Head of Quality and his team had to find suitable measurement equipment and methods in order to be able to check the design requirements for these tiny toothed components in detail. Adrian Burch, Manager of Quality Assurance for Assembly Testing, dedicated himself to this task. The skilled precision mechanic outlines the requirements: "We need measurement results that our mold shop can use to make effective corrections and produce a series-capable injection mold with the fewest possible modification cycles. The measurement must also be suitable for first article inspections of micro-gears and for sample testing of production lots."

The molding, production, and measuring of these micro-gears are core competencies of maxon motor, which means they are located at the main plant in Sachseln, near Lucerne, Switzerland. A micro-EDM machine in the production area uses wires with diameters from 0.02 to 0.2 mm to shape the mold inserts to the desired tooth contour. Molds with as many as eight cavities are used to produce the plastic gear in their micro-injection molding process.

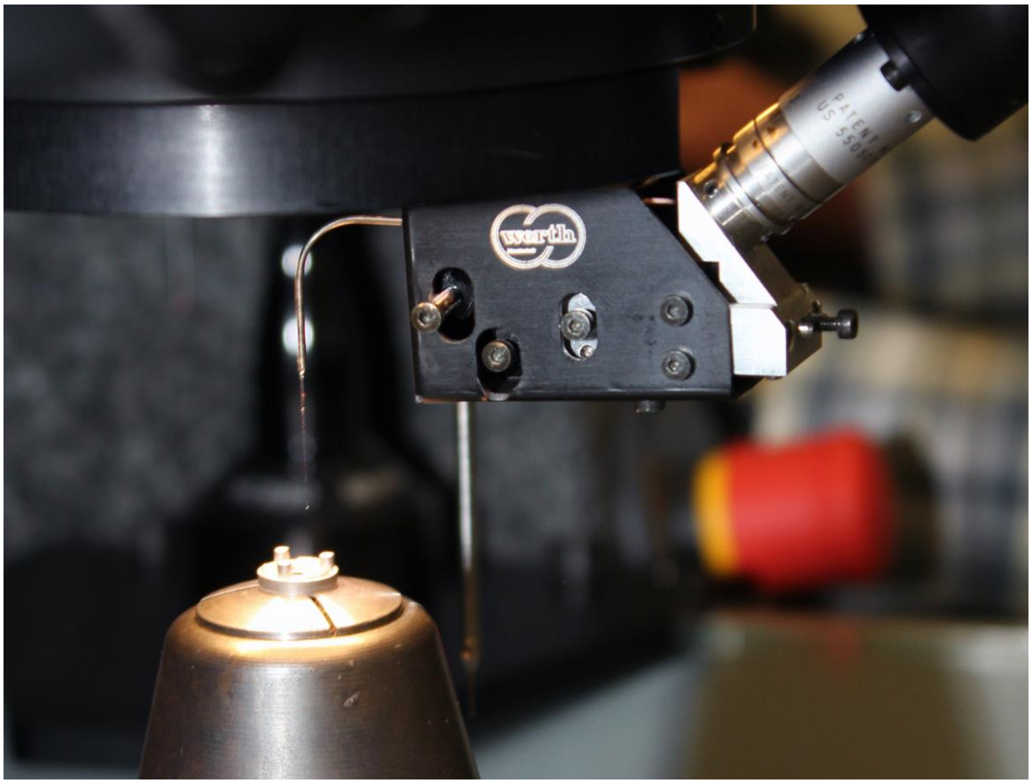
Typical Methods Fail for Small Plastic Gears

Previously, tooth measurements at maxon motor mostly used standard double flank gear rolling inspections. This is a conventional inspection method for spur and planetary gears, described in the VDI/VDE 2608 guideline. A special master gear is required for every tooth pattern. The master engages with the test gear with low force, and then they are meshed and rotated together. The two gears then roll through their entire circumference with no clearance. Changes in the distance between the centers and the uniformity of the motion are then measured and analyzed by software. For the small plastic gears with module 0.12, however, the double flank rolling inspection was problematic because even the slightest pressure caused the teeth of the tiny gears to deform, yielding false results.



Tiny planetary gears like this are found in the GP6 planetary gearbox. Measuring them is a challenge: gears with module 0.12 (tip diameter 1.908 mm, root diameter 1.347 mm, number of teeth 13, material Delrin 100; image: maxon motor).

For Adrian Burch, it was clear that conventional tactile measurement using a touch trigger or scanning probe also had no chance. "Here again we would need contact pressure for the measurement, in order to generate the probe signal. The diameters of such probe spheres are also too big to measure the tooth flanks down to the root circle." Optical methods would be fundamentally suitable for the measurements, but the flanks of micro-gears are not accessible with optical sensors.



The WFP fiber probe is a micro-probe for high-precision applications. It makes it possible to perform contacting measurements of extremely small geometries, with very small contact forces, at high precision.

The Solution: Tactile-Optical Measurement with a Fiber Probe

The quality team ultimately found a suitable solution for reliably measuring micro-gears at Werth Messtechnik. The company from Giessen is the leader in coordinate measuring technology, with optical sensors, multi-sensor systems, and X-ray tomography, as well as in the measurement of micro-features.

The quality team at maxon motor decided on the Werth VideoCheck® HA high-precision 3D multisensor measuring machine. The choice was clear since this machine has a bidirectional maximum permissible error specified of just (0.5 + L/900) µm when using the image processing sensor under quality laboratory conditions. They selected a telecentric 10X lens, TP200 touch trigger probe, Werth Zoom Optics, patented WFP (Werth Fiber Probe), and the WinWerth® Gear-Measure software package. "The primary driver for our decision was the Werth Fiber Probe," explains Roland Rossacher. "We have been able to use it to perform standardized measurements even on the flanks of micro-gears, including in scanning mode."

The WFP consists of a glass fiber with a probe sphere on the end with a diameter as small as 20 µm. In contrast to tactile measurement with a conventional probe, the fiber probe operates on a tactile-optical basis. Instead of serving to transmit a mechanical signal to the probe head, the probe shaft of the WFP only serves to position the tiny probing sphere. The sphere position is captured optically by the image processor through the telecentric lens. This makes it possible to use tiny probe geometries with correspondingly high precision (contact deviation ≤ 0.3 µm). As with a conventional probe, the software uses the probe sphere radius to calculate the corresponding measurement point. Because of the thin probe shaft, the contact forces are negligible, even for the smallest probe sphere. Thus, even the most sensitive plastic gear will not be deformed.

Contour Comparison for Mold Correction

Another advantage is that no complex fixturing is required, since the force exerted on the workpiece is virtually zero. Ralf Nutto, Measurement Technician, has been responsible for measuring with the Werth VideoCheck® HA for two years. He explains: "We just fix the little gear to a pedestal with a piece of tape and set it up on the measurement plate. Then we use the optical sensor to capture the tooth profile contour." The WinWerth® measurement software package uses the 2D data to calculate the path that the fiber probe will travel during scanning. While a nominal path is not strictly necessary, because the fiber probe can also scan unknown contours, scanning along a predefined path is faster. Because the height of the gear is about 1 mm, the measurement technician sets the depth of the fiber probe to 0.5 mm, where the contact area of the gears is greatest, for the scan of the tooth profile contour. This area cannot be reached by any other method. Finally, the runout of these gears can also be measured, simply by measuring the shaft seat diameter using the same approach.

Scanning provides a high point density for the contour, with precisions better than 1 µm. This actual contour can then be visualized in a 3D-CAD comparison, as a color-coded deviation plot based on the CAD data set. This analysis is of primary interest to the mold shop, in order to be able to correct the mold, in case of deviations, precisely on the problem locations.

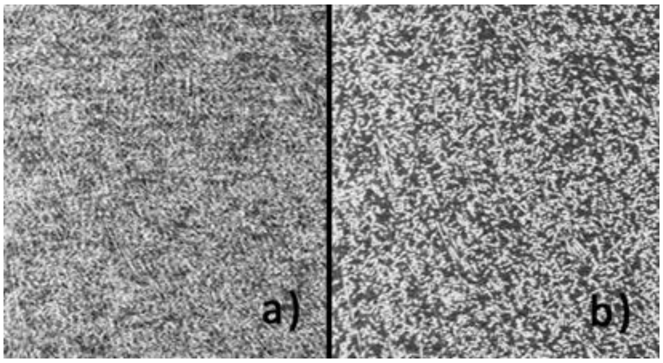
Simple Procedures, Precise Data

The GearMeasure measurement program for gears is completely integrated in the WinWerth® software package. After entering nominal and measurement data, the measurement sequence, including travel paths, is generated and executed fully automatically. The software calculates the typical tooth profile deviations, such as involute and flank deviations, single and cumulative pitch, surface tomography, tooth thickness deviations, and runout.

The Manager of QA for Assembly Inspection, Adrian Burch, is also very satisfied with the time required for the measurement. "The measurement time per sample is about ten minutes, while one-time programming for each type of gear takes a little more time. We can then analyze the data offline." For him and for the Head of Technical Development, Roland Rossacher, there is no doubt that expanding the measurement expertise at maxon motor to include gear measurements using a fiber probe has been worthwhile. Ultimately, the correction cycles in the mold shop have been reduced, and the inspection efforts during series production have been cut back greatly due to both improved first article inspections and process assessment. Roland Rossacher is very satisfied: "We have several thousand of these gears in use, and the measurements work perfectly."

Roland Rossacher (L), Head of Technical Development at maxon motor, and Adrian Burch, Manager of QA Assembly Inspection, evaluate the measurement results using a printout with a color-coded deviation plot.

Drift Correction Improves Resolution and Repeatability



The orientation of the glass fibers – which are just a few micrometers thin – in the fiber reinforced plastic workpiece become clearly visible only during measurement using drift correction (b)

To meet the growing demands of modern X-ray tomography measuring machines must provide high absolute precision and repeatability of measurements as well as the ability to resolve very small features. Temperature changes in the instrument can have an impact on the position of individual components and can cause drift effects, resulting in scattering of the measured values or an imprecise voxel volume. In coordinate measuring machines with computed tomography (CT), primarily the drift of the focal spot and of the workpiece influence the measured results. Starting with WinWerth® 8.40, two different methods for the drift correction of measurements can be used with Werth TomoScope® and TomoCheck machines.

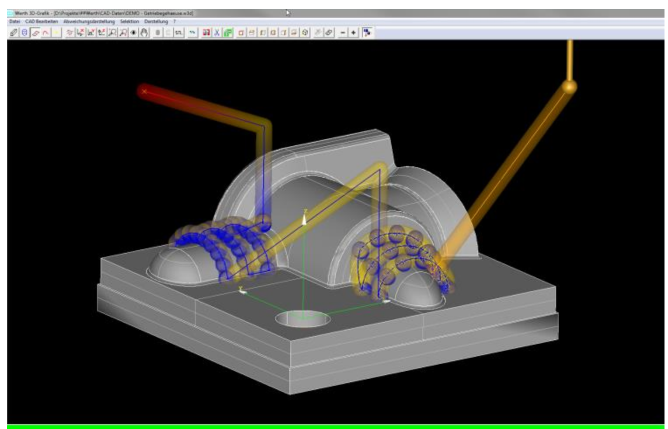
One method consists of measuring the position of a marker in the workpiece fixture. If done before carrying out tomography this method can correct the drift in comparison to the calibration status of the machine. The drift that occurs during the measurement can also be corrected using continuous position determinations during tomography; this is especially advantageous for longer term or high magnification measurements. During the reconstruction of the voxel volume, the drift is then taken into account, thus improving the absolute precision and repeatability of the measuring results.

Alternatively, a quick tomography can also be performed before or after a CT measurement with just a few rotary steps. Since almost no drift effects occur during a short measurement time, the radiographic images from the quick tomography can be used to correct the drift of the actual measurement.

In practice, drift correction improves, for example, measurement capability during measurements on workpieces with tight tolerances as well as the resolution for inspection tasks, such as during the analysis of fiber structures.

New Visualization of Sensor Paths in the 3D Graphics Window

The depiction of sensor paths can be within the WinWerth® 3D graphics window to verify and optimize the measurement sequence. The number of features between which the travel path is shown can be selected for better overview. This is defined by an insertion mark placed at any point in the feature tree for the measurement sequence. Depending on the sensor and the measurement task, the type of view can also be selected: For example, "minimal" shows only the travel paths for the image processing sensor, while for tactile sensors, "maximal" also shows the probe sphere diameter.



Depiction of travel paths with probe sphere diameter in "maximum" view

The graphic simulation of the sensor paths makes it easy to quickly check the measurement sequence at a glance. By optimizing these paths, the measurement time can be reduced and the measurement sequence can be improved.

Sponsorship of Scientific Work

In 2015, the Dr.-Ing. Siegfried Werth foundation awarded three dissertations and one bachelor thesis in the field of non-contact dimensional metrology. Two bachelor theses prepared in-house at Werth were also recognized with the Friedrich-Dessauer foundation prize and the Optence development prize.

Award ceremony of the Werth foundation

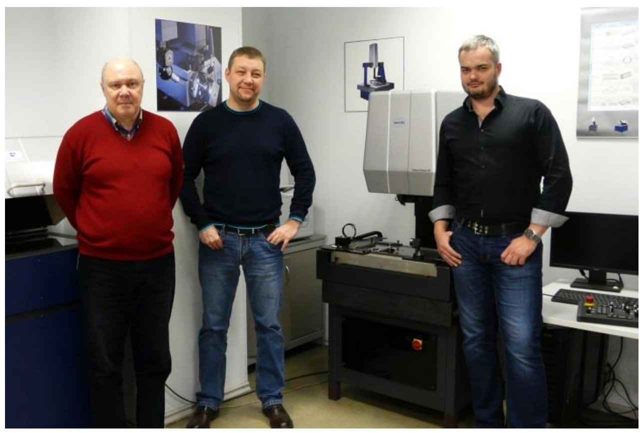
A Decade of Cooperation with Our Russian Partner Uran Joint Company

In January 2016, Uran Joint Company and Werth Messtechnik celebrated the tenth anniversary of their successful collaboration. The twentieth anniversary of the founding of the Uran Joint Company was also in 2016. The 3D measurement technology specialist sells Werth multisensor coordinate measuring machines in Russia from its headquarters in St. Petersburg. The company has a fully furnished demonstration showroom with VideoCheck®, ScopeCheck®, and FlatScope machines. Uran also provides training sessions for its customers and technical services for all Werth products.

Traditional opening celebration at Werth Metrology China

Werth Expands in China

The new headquarters of Werth Metrology China has been located in the Nanopolis high-tech park in Suzhou since the end of last year. At the same time, in cooperation with the Dantsin company in Suzhou, a demonstration center with about 200 m² was also opened. It is equipped with Werth VideoCheck® S, ScopeCheck® S, and Inspector® FQ multisensor coordinate measuring machines, as well as a FlatScope and a TomoScope® M.



Company founder Sergey Luchko and Dr. Andrey Loskutov with Sales Manager Anton Orlov (from left) in front of the VideoCheck® S in the company's showroom.

Expansion of Company Headquarters

The expansion of the company headquarters in Giessen, Germany has been completed recently. With approximately 1,000 m^2 of additional office space it is both a reflection of the positive growth of the company and a clear sign of our commitment to products “Made in Germany”.

Company headquarters in Giessen with new addition

"Multisensor Coordinate Metrology"

In 2003 a book titled "Multisensor Coordinate Metrology" was published. It was the first work to provide a concentrated report on this technology. After several amendments, a comprehensive revision was released under the same title. In this new work sensor technology, operation and potential applications are discussed in greater detail. Other topics of importance to coordinate metrology, such as contact forces, the effects of temperature, and the subject of measurement uncertainty are also presented in detail, making the field of multisensor coordinate metrology accessible even to a much broader audience.

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