The Multisensor Advantage

Using Different Sensors in Practice

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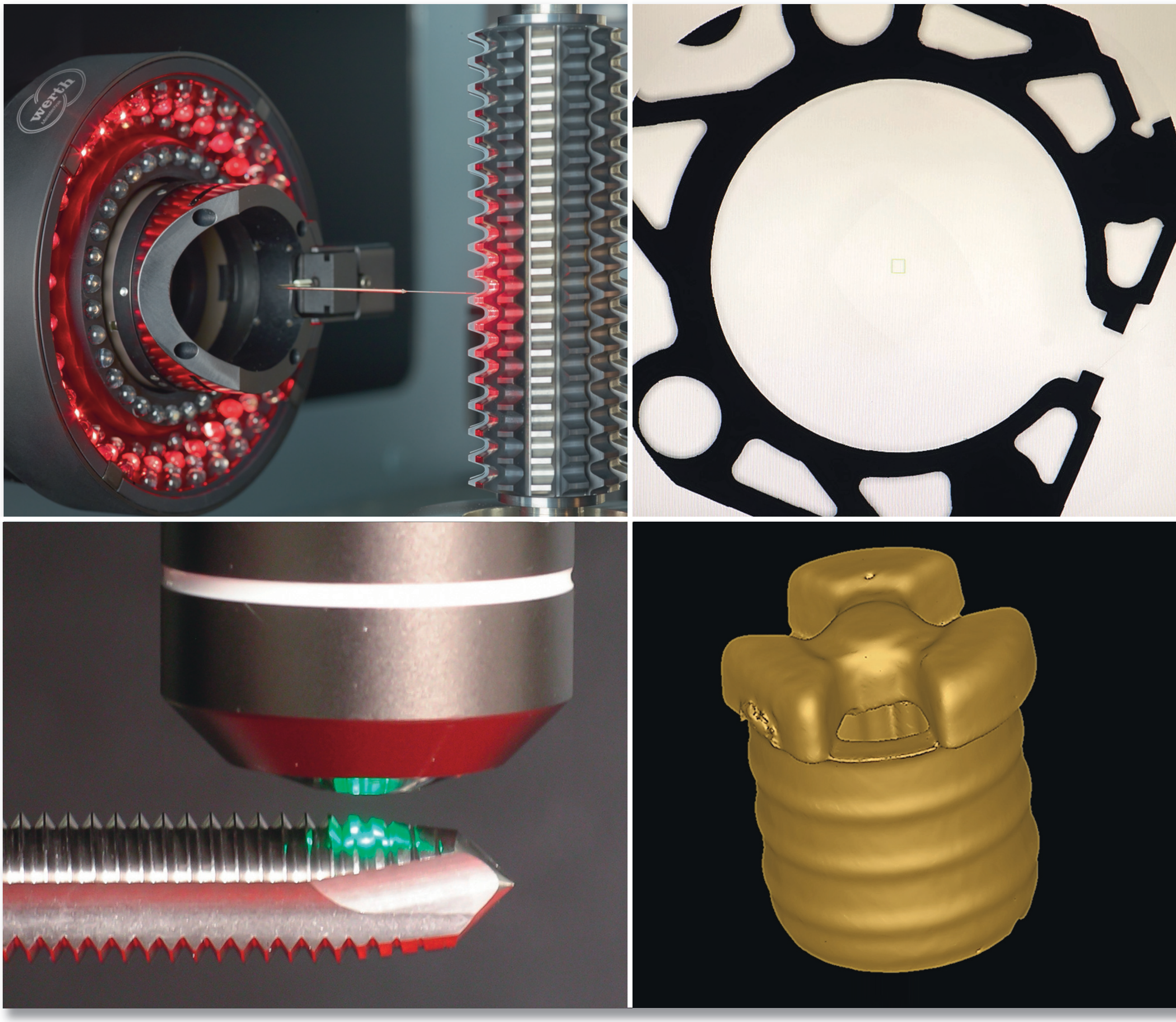

Special Edition

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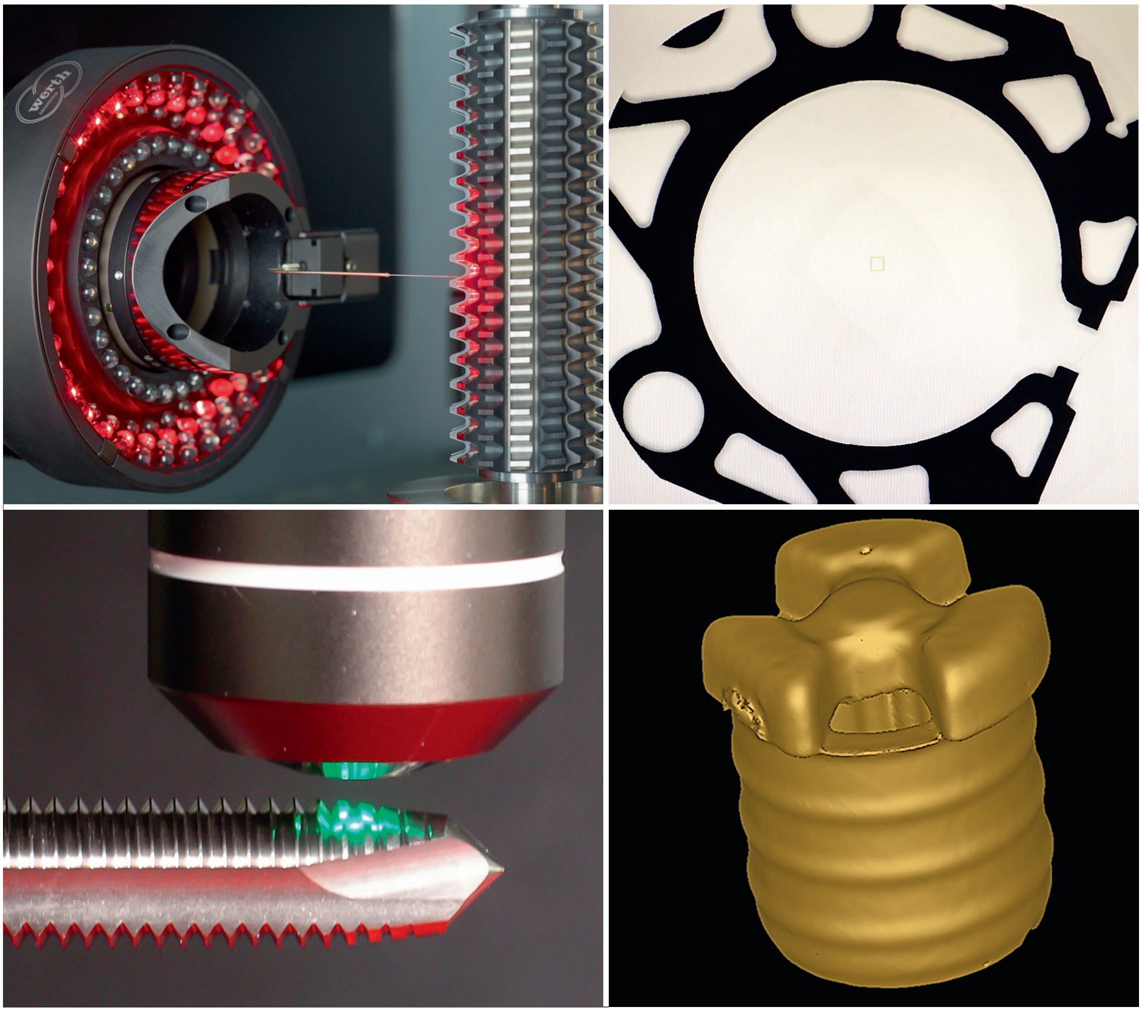


The range of multisensor systems: measuring points and scanning contours or surfaces with the Werth Fiber Probe (top left), edge measurement with the image processing sensor and Raster Scanning (top right), surface measurement with confocal Nano Focus Probe (bottom left), and volume measurement with the computed tomography sensor (bottom right)

Using Different Sensors in Practice

The Multisensor Advantage

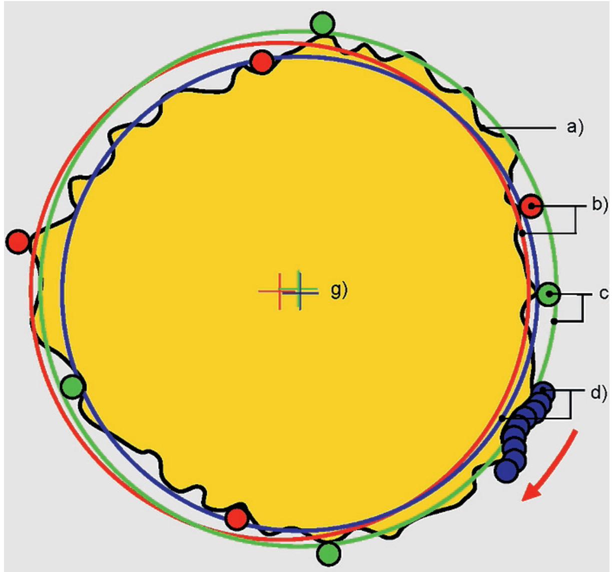
Modern coordinate measuring technology has an optimal sensor for virtually any measurement task. Different measurement tasks on the same workpiece can usually be handled most efficiently with a multisensor coordinate measuring machine.

The central question in any measurement task is that of suitable sensor systems. Sensor selection is determined by the type of dimensional or geometrical deviation to be tested, their tolerances, and the features to be measured along with their properties such as size and surface finish. The desired measuring speed must also be taken into consideration.

The type of dimensional or geometrical deviations and the features to be measured must be considered in context. Even simple characteristics such as distance and diameter first require determining which features should be used for the distance, i. e. edge (line) or surface (plane)? Or for a hole diameter, the exit of the hole (circle) or the inside surface (cylinder)? These features are ideally measured with specific sensors—such as an image processing sensor for edges or a touch probe for surfaces.

When geometrical deviations need to be checked, such as the straightness of a hole axis or its inclination to a plane, this often requires several features to be measured in different spatial directions and their characteristics linked to each other. This increases the requirements for point density. For roughness measurements, the sensor needs to capture very small differences in height at a very high point count. Another consideration is whether the workpiece is easily damaged or deformed, so that only sensors with very low contact forces (optical sensors or Werth Fiber Probe) can be used.

The reference defined for each characteristic is also of great significance, as this affects the dimensionality of the measurement. Different sensors measure points, edges, surfaces, or volumes in one, two, or three dimensions. Where a laser distance sensor can measure the Z coordinate of a point in one dimension, a measuring probe system determines the position of the point in three dimensions. Information on all three dimensions is not always necessary; the distance, for example, is often relevant in only one spatial direction. However, workpieces must be measured and computationally aligned in all spatial directions to avoid projection errors, so care is needed when selecting sensors. Purely 2D measurements are correct only for flat workpieces.
For small features, appropriately high-resolution measurements are needed; for measuring larger features at a high point density, on the other hand, many points need to be captured in as short a time as possible. For very tight tolerances, a sensor with very low measurement deviation is needed. For roughly toleranced features, sensors with high measuring speed are preferred. The measuring speed is an important factor for the efficiency of a measurement, and the quantity of points has a substantial influence on repeatability.



Point density greatly influences the measurement deviation: Contour (a) and two sets of four contact points (b, c) resulting in different best-fit circles (center point g) and more precise capture via scanning (d), shown in part

Higher Measuring Speed

Image processing sensors with focus variation methods are often a standard feature of a multisensor coordinate measuring machine. Non-contact edge measurements allow for high measuring speeds, for example for shop floor measurements during production, because no clearance positions are needed. In addition to the On The Fly and Raster Scanning modes, which can increase measuring speeds even further, various other methods and sensors have been patented by Werth.

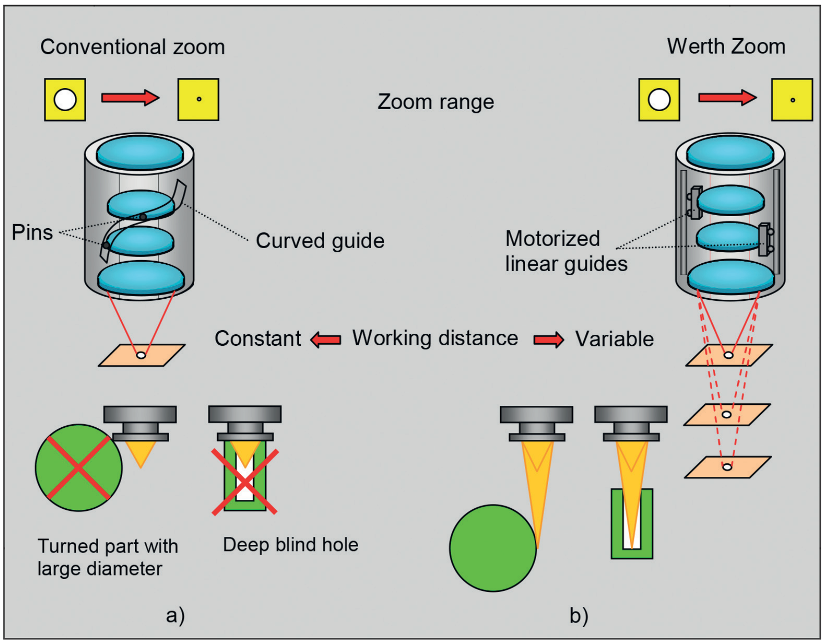
Measurements On The Fly are made while the machine axes are in continuous motion, and Raster Scanning automatically combines many small images into an overall image, so that the overall evaluation can be performed in the image without moving the machine axes again. Due to the high resolution and low measurement uncertainty of high-magnification lenses, even the smallest features can be measured. The adjustable working distance of the Werth Zoom and adjustable incident light angle can also make it possible to measure otherwise inaccessible features. The measured contour can be fit to the tolerance range of the CAD model using ToleranceFit software, allowing functionally appropriate inspection of workpieces such as plastic or aluminum profiles.

With focus variation methods, the focal spot of the image processing sensor is varied in the region above and below the surface of the workpiece. The surface is located at the position where the image is in focus and contrast is maximum. Sensors such as the Werth 3D-Patch allow rapid three-dimensional surface measurements at high point density, for example for analyzing surface defects. The sensor can be positioned freely within the measuring volume of the coordinate measuring machine, and several measurement point clouds can be lined up and combined into an overall surface.

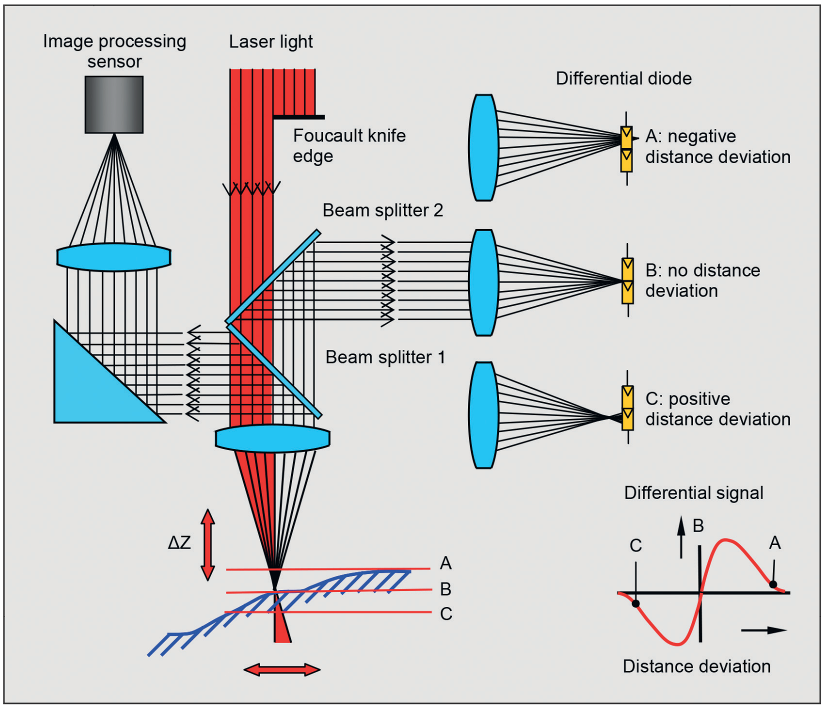
For point sensors using the Foucault principle, the laser beam is split on one side. The split beam is projected onto the surface of the workpiece at the aperture angle of the lens. This varies the signal on a differential photodiode depending on the position of the surface. The WLP Werth Laser Probe is integrated in the beam path of the Werth Zoom image processing sensor with zero offset.

Chromatic focus point sensors make use of the chromatic aberration of a specialized imaging optic. This effect results in each color being in focus at a slightly different height. The most intensive color can then be used to determine the position of the workpiece surface. This sensor is nearly independent of the surface properties and can even measure highly reflective and transparent surfaces.

In scanning mode, the sensor captures measurement points continuously as it follows the workpiece surface. This means that features can be captured with high point density for good repeatability and applications in measurement of geometrical deviations. The various sensors also result in shorter measurement times. Optical distance sensors such as the WLP and CFP Chromatic Focus Point provide the surface measurements in scanning mode to measure flatness, distortion, or twisting of surfaces in a fraction of the time that the image processing sensor requires. The CFP can also perform optical roughness measurements that can be reproduced at the same location.



The variable working distance of the Werth Zoom lets it reach otherwise inaccessible features



Laser distance sensors using the Foucault principle vary the signal on the differential photodiode depending on the position of the surface

Measuring in Any Direction

Conventional touch probe systems and micro-styli like the WFP fiber probe excel for measurements in various spatial directions. This flexibility can be increased further with rotary/tilt joints and star- or L-shaped styli. The strengths of conventional stylus systems are in 3D measurements on rigid, robust workpieces, such as large metal parts. For the Werth Fiber Probe, the deflection of the small probe sphere (diameter as small as 20 µm) is captured optically with a high resolution (tactile-optical principle). The thin, flexible stylus shaft is used only for positioning the probe sphere. This means that the probing force is negligibly low. The fiber probe is used wherever conventional measuring technology fails due to small feature size, for example for measuring nozzle holes on fuel injectors with diameters as small as 90 µm. The small stylus tip also makes the WFP suitable for roughness measurements.

With the computed tomography sensor, the workpiece is penetrated with X-rays from different directions by rotating it between the X-ray source and detector, and a volume model is reconstructed from the 2D radiographic images. This is a continuous point cloud of the entire workpiece, including internal geometries. The point cloud can be evaluated dimensionally for first article inspections, or used for tool correction with a nominal vs. actual comparison to the CAD model.

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