Coordinate Measuring Machines with Computer Tomography
Computer Tomography in Coordinate Measuring Machines

Computer Tomography (CT), based on X-rays, was originally developed for medical applications. For several years now, systems using the CT principle have been used for non-destructive materials testing in industrial applications. With the world’s first presentation of a coordinate measuring machine with integrated computer tomography, the TomoSco-ope®, Werth has created entirely new possibilities for rapid measurement of workpieces with many dimensions.

The workpiece is placed on a rotary table and scanned with X-rays. An X-ray detector converts the X-ray projection into a 2D digital image for further processing. The object is rotated 360° and X-ray images are captured at hundreds of positions. The software reconstructs these X-ray images into a point cloud, which describes the entire workpiece geometry. This generated volume model includes even the internal geometries and undercuts of complex components. The integration of additional sensors expands the possibilities of applications of Werth tomography measuring machines.

Complete Measurement with Computer Tomography

The requirements for complete and precise capture of workpiece geometry are only partially met by traditional coordinate measuring machines. However, modern Werth multisensor coordinate measuring machines with tomography have significant advantages. These systems, which are optimized for measurement technology, ensure high precision and reliability. This has previously been unachievable with computer tomography. The machines are based on proven mechanical and control components that have been used by Werth in many other coordinate measuring machines. The ability to capture a complete part geometry with tomography is thus possible for many applications.

Raster tomography, which expands the measuring range and increases the resolution of the computer tomography sensor, provides additional flexibility. Partial images of the workpiece are taken and merged together to form larger scanned high resolution images. Using these images, the entire volume is then reconstructed with the same high resolution. Even small details on large components can be measured this way.

A specification of the maximum permissible error for this special type of CMM is comparable to classical CMMs. Complete software integration of all functions needed for automated measurement makes it easy to use.

The principle of computer tomography: the measured object is placed on a rotary table between the X-ray source and the detector. A short distance between the object and the detector provides low magnification and large field of view to rapidly capture larger parts (left picture); a larger distance between the detector and the object provides higher magnification for higher precision measurement (right picture).
Multisensors and Computer Tomography

When computer tomography is combined with classical sensors, such as contact probe systems, image processing, laser sensors or tactile-optical fiber probes, it opens up a range of additional possibilities.

Workpieces made from combinations of materials with very different densities (metal/plastic) can be measured for the first time, using combinations of sensors. In addition to the rapid and complete capture of the workpiece using tomography, highly precise measurements of tightly tolerated dimensions can be made using classical sensors of the Werth multisensor system.

The Werth »Autocorrection« process captures and corrects systematic measurement deviations in tomography. Measurement deviations of a few micrometers can therefore be guaranteed for the first time for tomographic measurement. The traceability of the measurements to the standard of length of the German National Metrology Institute, the Physikalisch-Technische Bundesanstalt (PTB), is provided by considering the real workpiece properties in the reconstruction process.

Suitable Configuration for the Application, Based on Proven Components

The modular design of the machines allows optimal adaption of the application:

- Basic coordinate measuring machine with tomography sensor, based on proven software and machine components, traceable to the standard of length of the German National Metrology Institute, the Physikalisch-Technische Bundesanstalt (PTB)
- Optionally, raster tomography can be used to measure small features, even on large components, with high resolution
- Expansion of possibilities of applications with multisensors by the addition of tactile or optical sensors, such as the Werth Fiber Probe or Werth Laser Sensors, provides:
  - Measurements of workpieces made from a combination of materials (e.g., steel interior, plastic exterior)
  - Reduction of measurement deviation in tomography to a few micrometers, using Werth Autocorrection by considering the real workpiece properties in the reconstruction process.
  - Complete measurement with tomography, and additional measurement of functional dimensions with high-precision sensors in one setup and in one coordinate system.

Analysing Measured Data with WinWerth®

The principle of raster tomography — high-resolution measurement:

Measuring a two material part with multisensors

Measuring planes in the point cloud

CAD model of workpiece in Werth 3D module

CAD model and point cloud obtained with tomography

Color coded actual to nominal comparison between measured points and CAD model after BestFit alignment
One Measurement Software, even for Computer Tomography

The multisensor software »WinWerth®«, used successfully in thousands of machines worldwide, has been expanded with functionality for tomography measurements. In addition to the user-friendly interface for setting tomography parameters, WinWerth® also offers powerful functions for the reconstruction of 3D data. Additionally, functions are integrated for automatically locally finding and measuring the material boundaries to accurately define the point cloud. The complete measurement, with computer tomography and other sensors, is controlled entirely by WinWerth®.

To perform a tomography scan, the user must first select appropriate settings for the X-ray source. This is done similarly to the light settings for optical sensors, using slider controls on the user interface. In order to expand the dynamic range for poorly contrasting objects, additional tools are available. These allow the detector exposure duration to be increased, or noise to be filtered from the image.

The relevant section of the image is selected for tomography in exactly the same way as for optical measurement, by setting a measuring window in the X-ray 2D image. When the tomography process is started, the necessary calibration process for the system sensors are automatically initiated and carried out, if required. The tomography process then runs automatically, without any user interaction, even for raster tomography. The measurement can be automatically repeated (teach in/automatic) for additional parts, including palette mode.

The point Cloud is Bestfit with the 3D CAD Model

Following the completion of tomography process and the 3D reconstruction that runs in parallel with it, the workpiece geometry is captured and automatically imported into the WinWerth® 3D CAD software module in the form of a point cloud. The data can now be BestFit with a CAD model for dimensional analysis, and compared to the model. In addition to the numerical output, the results can be displayed as a color coded image of the deviations between the actual points and the nominal model.

Regular geometric elements can also be calculated from the measured points. So dimensions can be measured with a simple click on the CAD elements. Other measurement evaluations, such as determining form and positional tolerances, can also be carried out in that similar manner. If a measurement is saved as a program for a part type, additional measurements can be made without additional actions.

Due to the universal software concept, the user does not need to switch between various program packages. The WinWerth® DMIS code of the tomography machines is compatible with purely tactile or other multisensor coordinate measuring machines from Werth Messtechnik.

Award-winning technology

Innovation Award in Hessen, Germany, and Gold Euromold Award

Gold in Brno, Czech Republic

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