Industrial computed tomography (CT) for geometry measurement

Dimensional measurements with CT

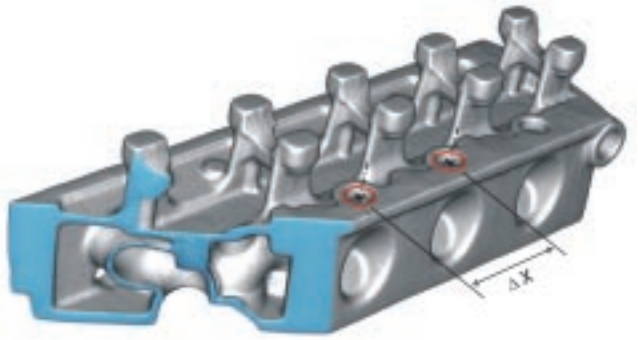
Today, safety-relevant or high-quality industrial components routinely undergo non-destructive inspection for defects by means of special, non-medical CT systems. Beyond this, CT has also been used for a few years as coordinate measuring technique to determine the geometry of industrial components. PTB develops procedures to improve “CT coordinate metrology”, particularly for the

- correction of measurement deviations
- interim checks of CT facilities
- traceability of the measurement values (determination of the task-specific measurement uncertainty).

Correction of measurement deviations

By joint measurement of the component to be investigated and suitable calibrated reference bodies the measurement deviations can be determined and corrected in further steps of data evaluation (analogous to numerical geometry correction in the case of classical coordinate measuring machines). The total measurement process comprises the following characteristic steps:

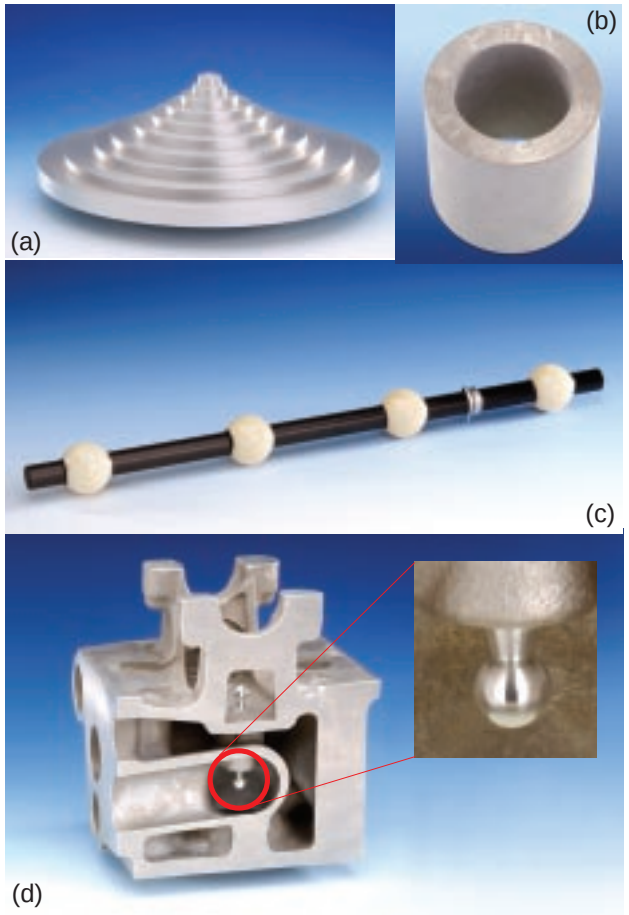
1. Joint CT measurement of component to be measured, threshold reference body (hollow cylinder) and scale reference body (ball bar)
2. Determination of the correct threshold for the calculation of the component’s internal and external geometries on the basis of the CT dimensional deviations of the hollow cylinder
3. Determination of the dimensional deviations of the ball distances of the ball bar
4. Geometric correction of the component’s CT data with the aid of the ball distance deviation determined before
5. Generation of the component’s polygon surface from the measurement data of the CT.



CT-measured automobile cylinder head
right: distance measurement of two channels,
front left: virtual cut of the CT-measured data

Interim checks of CT facilities

Interim checks of CT facilities for dimensional measurements are to be performed analogous to standards and guidelines for classical coordinate measuring machines (DIN EN ISO 10360, VDI/VDE 2617) with the aid of reference bodies suited for industrial use. Concepts have been developed for CT facilities measuring large parts. Calibrated reference bodies (ball bar, step cylinder and hollow cylinder) and uncalibrated reference bodies (typical components) are used here. Concepts for CT facilities for the measurement of micro-components are under development.



Reference bodies for interim checks of CT
(a) aluminium step cylinder (Ø 300 mm),
(b) hollow cylinder (Ø 30 mm, outside),
(c) ball bar (length 300 mm),
(d) cylinder head (165 mm × 140 mm × 170 mm) with reference structures.
(a) and (b) developed together with Rautenbach Aluminium Technologie GmbH, Wernigerode, Germany.

Traceability of the measurement values – determination of the measurement uncertainty

Due to the great number of influence quantities, the measurement uncertainty has to be determined task- and component-specific. PTB here investigates the applicability of the concept from coordinate metrology "Uncertainty determination with calibrated specimens" (ISO/TS 15530-3).

For the expanded uncertainty U, the following holds:

$$U = k \cdot \sqrt{u_{cal}^2 + u_p^2 + u_w^2} + |b|$$

- k coverage factor (normally k = 2 for 95 % confidence range)
- u_{cal} standard calibration uncertainty of the calibrated specimen (measurement with coordinate measuring machine)
- u_p standard uncertainty of repeated CT measurements
- u_w standard uncertainty contribution of CT resulting from material and manufacturing variations
- b systematic deviation between mean value of the CT measurements and calibration value.

Investigations show that the measurement uncertainty can be successfully determined for well-conditioned measurement tasks by this approach. Quantitative parameters for task classification have been determined for different CT facilities and measurement tasks.

With the procedures developed, task-specific measurement uncertainties (single-point uncertainty of the component surface measured) smaller than the volume element (voxel-) edge length of the CT measurement have been achieved.

Information

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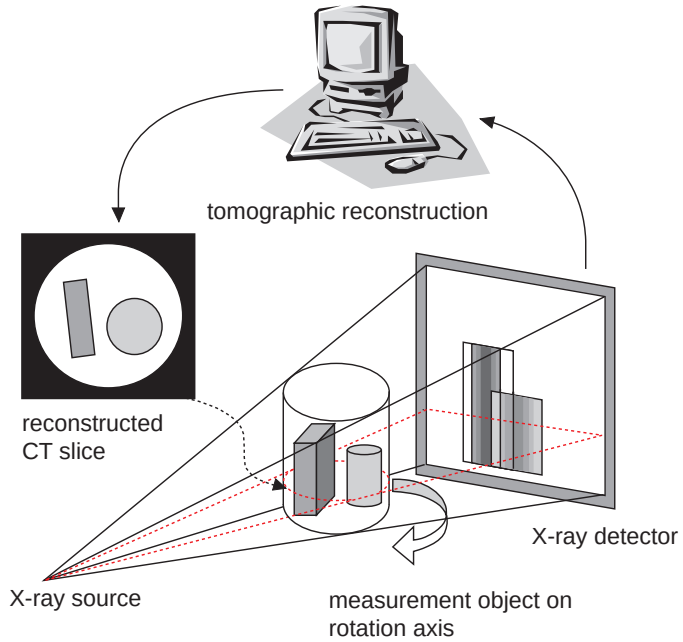

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