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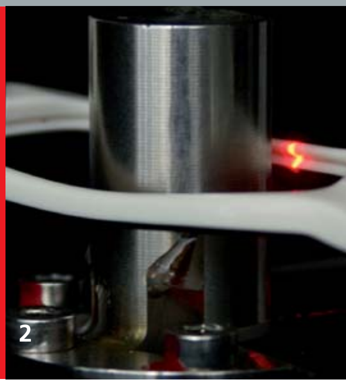
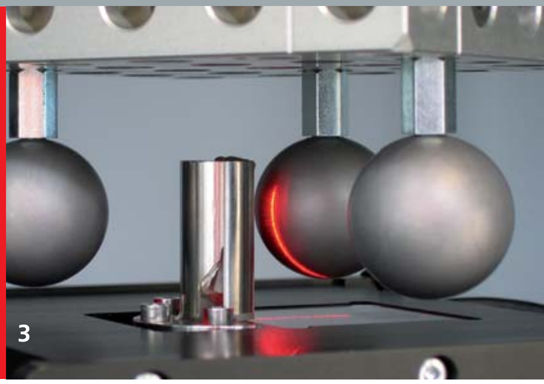

1 *Measurement of a cast part's inner contour.*
2 *Measurement of a V-groove's free-form inner contour.*
3 *Spatial orientation with precision spheres. Photos: Fraunhofer IFF*

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OPTOINSPECT 3D Measuring Device

TECHNOLOGY FOR INTEGRATED 3-D INNER CONTOUR MEASUREMENT

Initial Situation and Motivation

Inspecting geometric features inside components with limited accessibility is frequently a challenge. Examples are grooves and channels in bores, inside threads and inner contours of extruded profiles. Tactile measurement equipment, measuring microscopes or profile projectors are commonly used to inspect the quality of such inner contours.

Drawbacks for in-line use ensue from the difficulty of automating such systems. Modified optical contactless 3-D inner contour measurement systems furnish a solution.

The Measurement Technology

Laser light-sectioning is a measurement technology that has proven itself for industrial inner contour measurement systems many times over. A light-sectioning sensor facilitates quick scanning of object surfaces with a high density of measuring points and accuracy. The acquisition of measured data and the determination of geometric features is automatable and thus may be integrated directly in machinery or manufacturing. The accessibility determines whether the beam path from the laser and camera captures a feature obliquely from outside or by beam deflection into the cavity. Both cases necessitate selecting a measuring field size and resolutions adjusted to the task. Developed design modules used to size and configure such sensors can be employed to efficiently develop and implement application-specific solutions for in-line quality assurance.

Development of Application-specific Solutions

Sensor Design

In a first step of sensor design, proper triangulation angles and measuring fields are

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identified. The smallest width of the component opening in which a measurement will be taken limits the size of the measuring field in the cavity. The triangulation angle influences measurement uncertainty. Larger triangulation angles lessen measurement uncertainty but require more space for accessibility. In a second step, suitable image sensors (image rate, pixel count, sensitivity), lens systems (magnification, actuation distance) and laser line projectors are selected and a configuration is computed for the resolution required in the depth of the measuring field. Mirrors can be positioned to design suitable beam deflection. This allows arranging the components as a function of the installation space available. The outcome of this design step is parameters that specify the geometric arrangements of the components (camera with lens, laser projector and beam deflection). Thus, a CAD model is created and the components are manufactured and assembled into a light sectioning-sensor array.

Measuring Motions and Multiple Sensors

A single measurement along the profile section is normally not enough to determine most inspection characteristics. Surfaces may be scanned by moving systems consisting of rotary and translatory axes. Depending on the application, either the target or the sensor array moves. Multi-sensor arrays take measurements quickly without relative motion between sensors and the target.

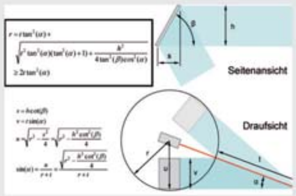
Calibration and Spatial Orientation

The mapping between a camera's image sensor and the measuring field's points in sensor coordinates may be calibrated on a coordinate inspection machine with an appropriate probe sphere. Once the sensors have been installed in the measurement system, they are oriented in space relative to the axes' coordinate systems or other sensors with normals composed of precision spheres.

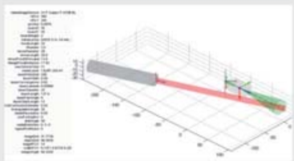
Benefits

Development tools have been created for the stages of design. They automate the design process and thus make it possible to efficiently design and implement light-sectioning arrays for specific tasks and inner contour measurement systems based on them.

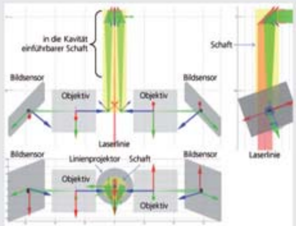
Measuring field sizing



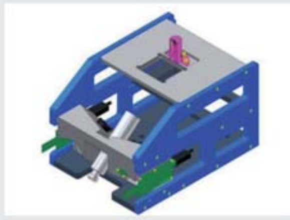
Sensor configuration



Beam deflection



Engineering and manufacturing



Calibration and spatial orientation

Model applicationl