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Precision on a Thread of Glass

How Micro-Geometries Can Be Captured

PRACTICAL TIP In coordinate measuring technology, size is no longer so important. In fact, the opposite is true, as the future of industry lies in miniaturization. This has driven a rise in demand for intelligent micro-probe concepts. They can be used to master even complex measurement tasks.

CONVENTIONAL PROBE systems share a common principle, the transmission of a signal from the contact element via a rigid shaft to the actual sensor – typically a switch, piezo element, or laser sensor. Measurement points can be captured by contacting individual points, and, for scanning probe systems, by means of continuous contact in scanning mode. Because the bending of the stylus affects the measurement result, the manufacturer strives to use styli that are as rigid as possible. Together with the typical spring-loaded stylus pivot and the corresponding sensors, this typically results in a relatively large package.

Such probe systems are therefore of limited use for measuring very small geometric features and sensitive elements, such as micro-gear teeth, orifices in fuel injectors, or aspherical plastic lenses. The smaller the components, the more prone to breakage the stylus in particular will be. An elastic design is not possible, because this would hinder the transmission of the signal to the sensor via the stylus. Furthermore, high contact forces result in high surface pressures, particularly for small sphere radii, which are unacceptable for sensitive micro-components. Such conventional probes with sphere diameters less than 0.3 mm are therefore of limited practical use.

Optical Sensors Provide Alternatives

Optical sensors can be used for a large number of measurement tasks. With image processing and various optical distance sensors, measurements can be made without any contact force. Geometries down to almost any size can be captured, due to the high resolution. The limits are reached when, for example, edge finding with image processing sensors is hindered by burrs. Most optical sensors also cannot measure side surfaces and undercuts, such as the cylindrical surfaces of small holes.

Tactile-Optical Micro-Probe

The functional principle of the Werth Fiber Probe (WFP) is based on using imaging optics and an image processing sensor to determine the location of the probe sphere. The probe consists of an optical fiber stylus with a spherical tip at the end. Light from an LED enters the optical fiber and illuminates the tip. The tip is positioned in the center of the field of view of the image processing beam path, so the measurement range is the same size in all directions.

An image of the illuminated tip is produced in the CCD camera, but the stylus remains invisible, as it is outside of the focal plane. As soon as the tip makes contact with the surface of the workpiece, it shifts position relative to the camera. This change in position can be detected and analyzed with sub-pixel accuracy (Figure 1). The probing error can be as low as 0.3 µm.

With the fiber probe, the image processing sensor measures the deflection of the stylus directly. No signal needs to be transmitted through the stylus between the tip and the sensor in order to capture the measurement points. As a result, any influence due to elastic deformation of the stylus is eliminated. The glass fiber can be extremely thin. Standard probes are available with a stylus diameter of about 10 µm and tip diameter of 20 µm. They are small enough to measure complex micro-features with high precision. The elastic stylus reduces the probing force to less than 1 µN, so even sensitive workpieces will never be damaged (Figure 2). The elastic behavior also practically eliminates breakage of the stylus in normal operation.

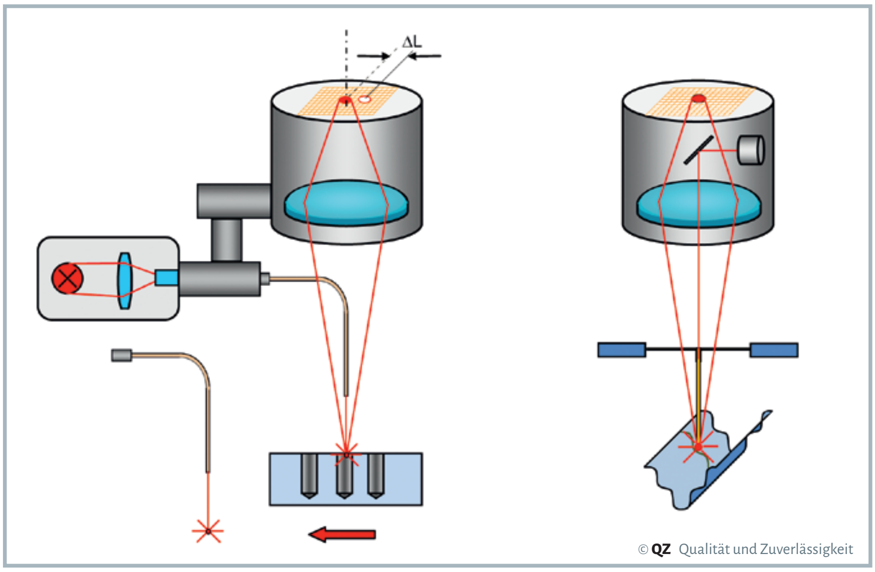

Figure 1. Functional principle of 2D (left) and 3D fiber probe (Source: Werth Messtechnik)

Tactile-Optical in Three Dimensions

In order to be able to use the advantages of the tactile-optical probe with any three-dimensional measurement object, this measurement principle has been expanded to three dimensions. To do so, the deflection of the stylus perpendicular to the plane of the image is measured with a laser distance sensor integrated in the image processing sensor. The stylus is attached by means of a spiral spring element in front of the optical sensor. The spring is designed so that the probe has nearly identical probing force in all directions (isotropic, Figure 1).

The 3D fiber probe is integrated like a conventional probe into the coordinate measuring machine's control system. This micro-probe can therefore be used to measure nearly any free-form surface or three-dimensional geometric element, either point by point or by scanning. It can even be used with such complex processes as "helical scanning" in combination with a rotary axis, or scanning along any prescribed contour in space.

The great challenges of quality assurance for micro-features and sensitive workpieces, such as gears for medical devices, injection orifices in fuel injectors, workpieces for micro-optics, or small plastic components, can be best mastered using state-of-the-art tactile-optical micro-probes. ■

Translated by Werth Messtechnik GmbH

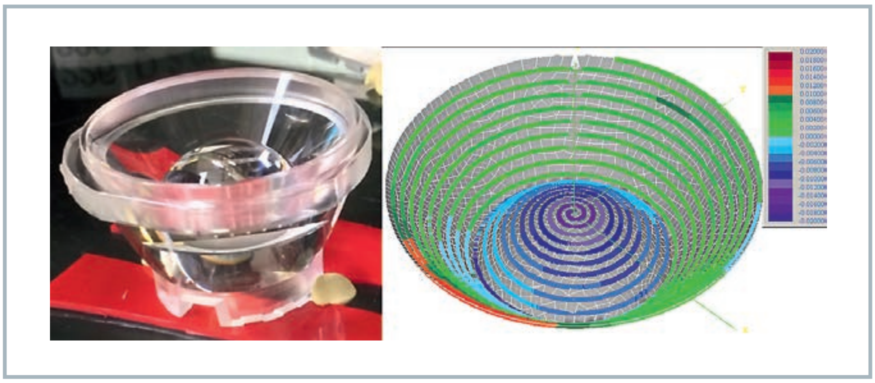

Figure 2. Scanning sensitive surfaces (© Werth Messtechnik)

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