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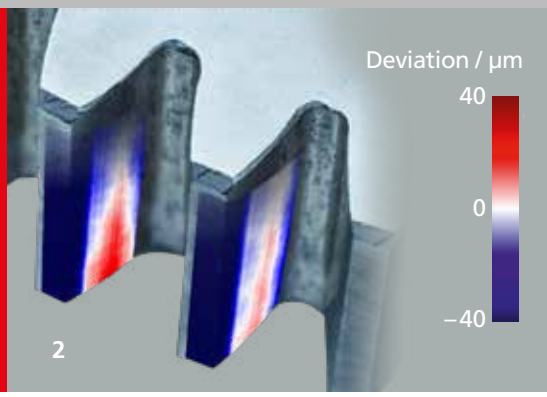
FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM



1 *The digital holographic measurement system HoloGear captures the entire surface of gear geometries – faster and with greater precision than any other measurement system in the world.*

2 *HoloGear measures each tooth flank of a gear individually and supplies exact values for all dimensions of the entire gear. This way, the system provides 100 percent quality control and documentation of the gears.*

HOLOGEAR

OPTICAL GEAR MEASUREMENT: FAST, PRECISE, COMPREHENSIVE

Gears, worms, racks and pinions with high-quality gear geometries are used in many industrial applications. Dimensional accuracy of gears is essential, especially in automobile production, mechanical engineering, aerospace technology, and medical technology, to ensure optimal function, maximum efficiency, and minimum noise emissions. The optical gear measurement system HoloGear from Fraunhofer IPM revolutionizes quality inspection for gears.

Today's standard: measuring individual points

Gear geometries are usually inspected using coordinate measuring machines and gear measuring machines. These methods are highly precise, but are also complicated and correspondingly tedious: A measurement probe is brought into contact with each individual point to be measured. In practice, these time-consuming tactile measuring methods merely allow to take measurements at a small number of selected points. To date, full measurements of all functional surfaces on a gear are only performed in individual cases.

100 percent inspection of gears

The optical gear measurement system HoloGear is the first system to inspect gear geometries quickly, completely, and with high precision. The contact-free measurement system captures over 100 million 3D points in just a few seconds. Where tactile methods require hours, HoloGear provides a comprehensive dataset covering every gear flank with millions of measurement points within minutes. The reproducibility of the deviation data is less than one micrometer – which is precise enough for even the highest quality requirements.

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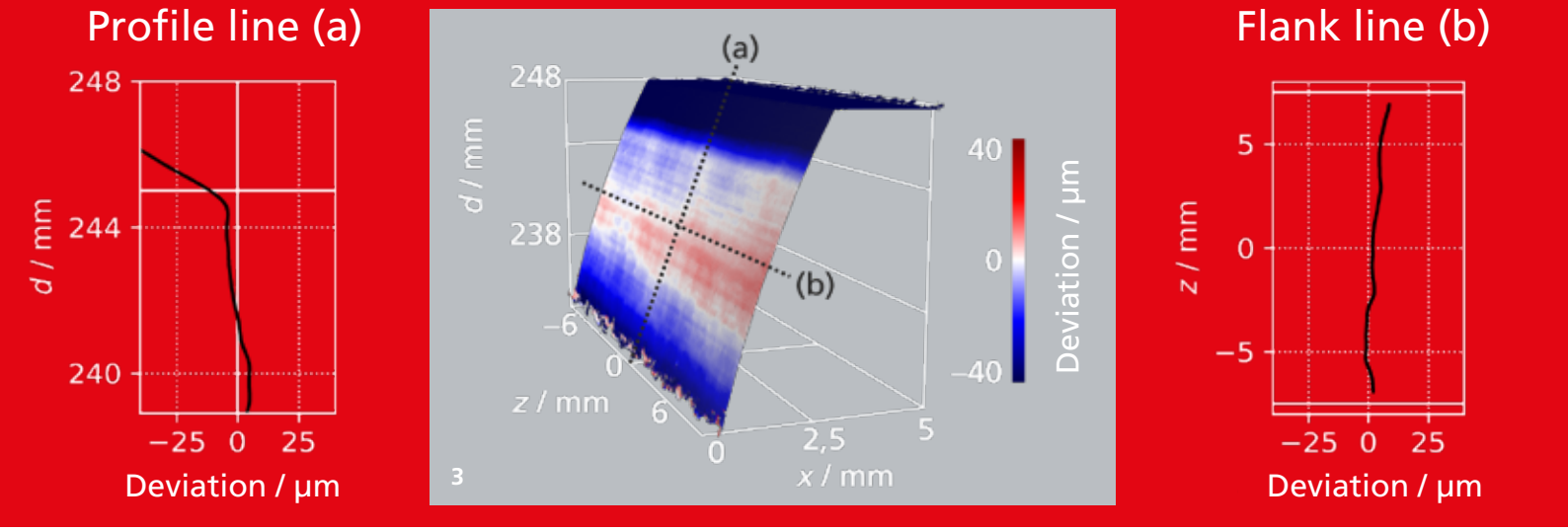

3 *HoloGear captures the entire tooth flank of an involute gear (incl. the addendum circle) in a single shot.*

HoloGear: optical instead of tactile

In measurement technology, optical methods have some advantages over tactile methods: They are faster, often yield more precise results, and are usually easier to handle. In the area of gear measurement, though, fast optical measurements have failed up to now due to steep flanks, very little reflected light, deep structures, and multiple reflections. Fraunhofer IPM was able to combine the precision of tactile technology with the speed of optical measurements using digital multiwavelength holography: In terms of measurement accuracy and measurement times, HoloGear fulfills the highest requirements. With this measurement system, highly precise quality control of gears with 100 percent coverage has become possible for the first time. This is especially important for large gears with high power transfer because these gears need to meet exact geometric specifications with tolerances in the micrometer range.

Precise measurement of gears

HoloGear can measure the absolute geometry of gears directly in production: When measured, the entire tooth flank (incl. addendum circle and root circle) is captured in a single shot – without scanning. HoloGear measures tooth flanks 15 × 15 mm² in size with about 10 million 3D points. By rotating the gear, each tooth is measured individually, after which the datasets are numerically combined to form a single digital representation of the gear, visualized, and then evaluated: depending on the customer's needs, it is possible to extract hundreds of profile and flank lines. It is even possible to detect periodic structural errors that are normally very hard to detect. Furthermore, it is possible to perform noise analyses and simulations of outstanding quality based on this data.

Multiwavelength digital holography

Fraunhofer IPM has established multiwavelength digital holography over the past years in industry for other measurement tasks. Recent developments have made it possible to utilize the advantages of this laser-based method for gear measurements. Through the use of multiple narrow-band lasers, various synthetic wavelengths are generated. Thanks to these different wavelengths, measurements can be taken across a wide spectrum ranging from the (sub-) micrometer scale to the millimeter scale, depending on the surface roughness. It is possible to take measurements even when little light is scattered back. In addition, the use of two sensors (as shown in Fig. 1) enables the right and the left tooth flank to be measured simultaneously. Another advantage: With holographic measurement data, it is possible to measure objects lying outside of the depth of field of the imaging optics using numerical refocusing. In this manner, it is possible to take a sharp image of a tooth from the root circle to the addendum circle in a single shot.

Advantages of HoloGear

- **Fast:** An entire gear flank is captured in just one measurement.
- **100 percent inspection:** Every single gear and every single tooth is completely mapped.
- **Highly precise:** The reproducibility of the gear dimensions is in the micrometer range.
- **Contact-free:** Measurements are taken optically using a laser.

Measurement example
Gear with outer diameter 248 mm, 60 teeth, module 4, tooth width 15 mm

Measuring time for entire gear	~ 4 min
Number of 3D measurement points	~ 3,6 Mio. on one tooth flank ~ 430 Mio. on the entire gear wheel
Reproducibility of height data at a single measurement point	< 1 µm (1 σ)