Fraunhofer IOSB

Brilliant insights

Deflectometry for the inspection of (partially) specular surfaces

Inspection of a car's paintwork using deflectometry: Bumps and dents are revealed by the distortion of the reflected pattern.

For surfaces used in the manufacturing industry, or surfaces that just need to look »nice«, such as car body parts, specular (directional) reflection often plays a critical role. In practice, however, the inspection of specular surfaces presents particular challenges. On the one hand, most established surface inspection methods, such as fringe projection, are based on diffuse reflection. On the other hand, the results of such methods cannot easily be used for the assessment of specular surfaces without additional effort, because the customer assesses the quality on the basis of specular reflections of the environment from the inspected surface. Deflectometry fills this gap in inspection and measurement technology, providing a simple means of defining and monitoring objective quality criteria.

Complementary to fringe projection

Deflectometry is the term used to describe all methods used to obtain topographical information on reflective surfaces by automatically analyzing the reflections of known scenes and their deformations. Deflectometry is fundamentally different from fringe projection, where a projector illuminates the test object with a pattern and a camera observes it from an angle away from the direct reflection so that the displacements and/or distortions of the pattern encode the height of the surface. In deflectometry, the surface to be inspected is used as a mirror for a selfluminous or illuminated reference pattern, and the distortions observed at the angle of direct reflection are a consequence of irregularities of the reflecting surface. However, they encode the inclination of the surface, not its height.

Fast Facts

1. Defects on glossy surfaces significantly reduce perceived quality
2. Glossy surfaces can only be characterized by evaluating reflections
3. Deflectometry accurately measures the distortion of mirror images

Deflectometric inspection principle: The camera observes how a pattern displayed on the screen is reflected by the specular inspection surface. From the mirror image, the geometry of the inspection surface and any defects can be deduced.

Deflectometry portal for the inspection of moving objects: Fraunhofer IOSB's AutoInspect demonstrator combines deflectometry and other inspection methods into a complete system.

Better than the human eye

To obtain a complete picture of the surface structure, it is necessary to measure the slopes in both the horizontal and vertical directions; mathematically speaking, these are the partial directional derivatives. Therefore, a deflectometric measurement is usually performed with two pattern sequences, one with vertical and the other with horizontal fringes. The combined tilt information allows the surface curvature to be calculated. This quantity is equivalent to the rate of slope change. It is a very good indicator for detecting surface features such as bumps or dents, which the human eye perceives as imperfections.

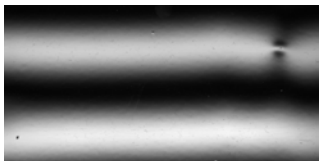
By displaying, recording and processing user-defined pattern sequences, angle changes of a few millidegrees can be reliably measured. This means that even a simple and compact deflectometry setup can significantly outperform the human eye, making it an excellent system for automatic and objective surface inspection.

Gold standard for coating quality

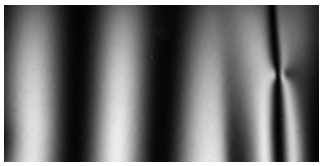
For example, by quantitatively measuring the so-called ‚orange peel' (surface waviness), deflectometric data, which is highly reproducible, can be decisive in defining and maintaining tolerances. As the deflectometric technique always produces twodimensional data, such structures can also be analyzed for direction and wavelength. However, the specular reflectance data contains even more information about variables such as gloss level and surface brightness. These are taken into account in the evaluation and help to detect additional defects not associated with surface deformation.

The procedures for deflectometric inspection of specular and partially specular surfaces offered by Fraunhofer IOSB are suitable for a wide variety of tasks in industrial quality control. Thus, an optical inline measurement method is available for such surfaces. It complements conventional approaches of qualitative inspection with a quantitative measurement approach and enables robust defect recognition and assessment.

In the AutoInspect demonstrator (see photo above right), two deflectometric measurement principles are implemented in addi-tion to other inspection modalities: Moving object deflectometry under an »arch« of monitors for pattern display, and deflec-tometry using a mobile monitor/sensor unit mounted on a robotic arm for deflectometric inspection of hard-to-reach locations. All inspection results are recorded at their exact location on a 3D model of the specimen.



Reflection of a horizontal fringe pattern by a sheet metal sample.



The same sheet metal sample reflecting a vertical fringe pattern.

Contact

Dr. Jan Burke
Tel. +49 721 6091 316
jan.burke@
iosb.fraunhofer.de

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

Fraunhoferstr. 1
76131 Karlsruhe
www.iosb.fraunhofer.de/en