Corrosion in Focus

Focus-Variation for the Understanding of Corrosion Mechanics

The ability to measure polished and strongly reflective surfaces with steep flanks in true color information has been mandatory for the Christian Doppler Laboratory for Localized Corrosion when it came to purchasing a new measurement device to perform meaningful corrosive investigations. Today, the institute uses high resolution 3D measurement device for the evaluation of individual corrosive mechanics, leading to the development of new measures to avoid corrosive attacks.

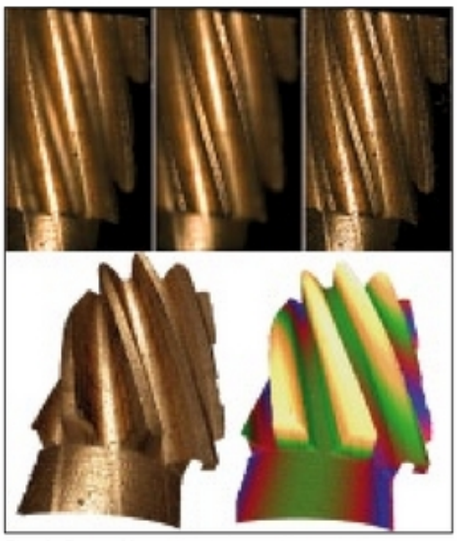

Fig. 1: Focus-Variation is based on vertical scanning of the specimen. For each position the sharpness is calculated. This variation of focus is utilized to extract depth information.

The Christian Doppler Laboratory for Localized Corrosion particularly focuses on the evaluation and measurement of pit and degradation depths via surface and roughness measurement. Results obtained with InfiniteFocus (Alicona Imaging Austria) are used for further R&D activities, targeting the development of new measures to strengthen corrosive resistance of metallic components.

Irrespective of the type of corrosion, attacked surfaces usually show steep flanks and strongly varying reflection properties. Targeting the aim of strengthening corrosion resistance, the laboratory was looking for an instrument that meets clearly specified requirements. Joachim Haberl from the scientific staff about the demands: "We were looking for an instrument that is able to measure polished and literally glassy surfaces and flanks of more than 80°. We wanted a system that offers true color visualization to make sure that surfaces are measured effectively. Also, we expected a system providing high resolution measurements on mechanically polished surfaces with a roughness Ra > 50nm. Also, the measurement of large measurement fields had to be provided."

Corrosion yearly causes a remarkable loss of the gross domestic product. Besides various rather predictable forms of corrosion that cause general corrosive attack, industry also faces several hardly predictable corrosive forms that affect components locally. As corrosive attacks can lead to sudden damage and breakdowns of buildings, industrial facilities, plants, transport systems etc., high emphasize has to be placed on risk avoidance which is based on the understanding of corrosive mechanics.

Measuring of Corrodes Surfaces with a Vertical Resolution of up to 10 nm

Today, the laboratory works with high resolution optical 3D measurement device. Based on the principle of Focus-Variation, the instrument meets all requirements of the scientific staff. Measurements reach a vertical resolution of up to 10nm even at steep flanks and strongly varying reflection properties. Additionally, the entire surface topographic information is captured in combination with its true color information. Both, the topographic and color information are registered to the 3D data file.

The 3D system is mainly used to analyse mechanically influenced corrosion, e.g. stress corrosion cracking, corrosion fatigue cracking or erosion corrosion. Pitting corrosion, crevice corrosion and selective corrosion are further fields of in-

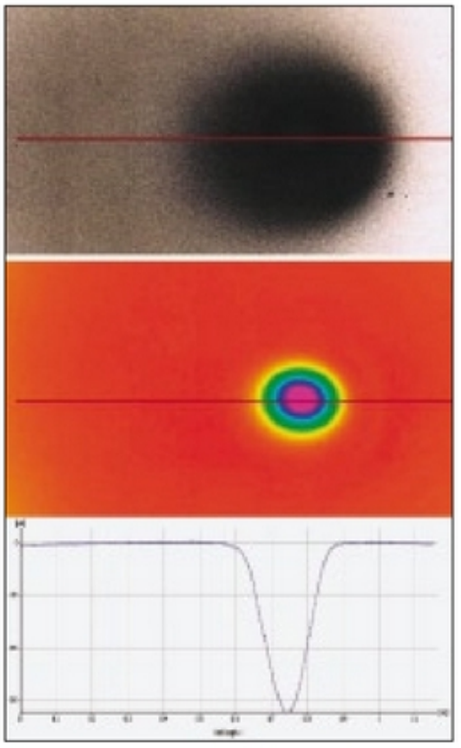

Fig. 2: The Christian Doppler Laboratory for Localized Corrosion measures erosion corrosion in true color information.

terest. "We mainly use the system to measure metallic components such as stainless steels, nickel-base alloys, titanium or aluminium alloys", Joachim Haberl about the use of the instrument. "Due to meaningful surface analysis we better understand corrosive mechanics and attacks." In terms of measuring degradation coming along with e.g. erosion corrosion, profile analysis to measure depth and area analysis to show the deepest void are the most distinctive characteristics. Conventional computations such as the calculation of the average depth are not as meaningful as the numerical verification of a voids´ depth. Values as average data are less representative since they do not comprise any information about the deepest degradation depth. The Christian Doppler Laboratory for Localized Corrosion uses measurement results for further computations of degradation rates.

Focus Variation. A New Technology Delivers Depth Measurement and True Color Information of Corroded Surfaces

The operating principle of Focus-Variation, developed by Alicona, combines the small depth of field of an optical system with vertical scanning to provide topographical and colour information from the variation of focus. Depending on the topography of a surface the information from the variation of focus is analyzed in relation to the distance to the optics. Using conventional optical measurement techniques a high vertical resolution can only be reached with a small vertical scanning range whereas the use of InfiniteFocus yields a high vertical resolution over the entire scanning range, allowing a dynamic of 1:430000. Additionally, a quality measure is determined for each measurement point.

The precision optics consists of various lens systems and can be equipped with different objectives, allowing measurements with different resolution. With a beam splitting mirror, light emerging from a white light source is inserted into the optical path of the system and focused onto the specimen via the objective. Depending on the topography of the specimen, the light is reflected into several directions as soon as it hits the specimen. If the topography includes diffuse reflective properties, the light is reflected equally strong into each direction. In case of specular reflections, the light is reflected mainly into one direction. All rays emerging from the specimen and hitting the objective are bundled in the optics and gathered by a light sensitive sensor behind the beam splitting mirror. Due to the small depth of field of the optics only small regions of the object are sharply imaged. To allow a complete detection of the surface with full depth of field, the precision optic is moved vertically along the optical axis. This means that each region of the object is sharply focused. A sensor captures a series of 2D datasets during this scanning process. Thereby, all sensor parameters are optimized at each vertical position according to the reflective properties of the surface. After the scanning process, the 2D datasets are evaluated to generate 3D information as well as an image with full depth of field. This is achieved by analyzing the variation of focus along the vertical axis. Due to the large amount of data mechanical restrictions can be eliminated, allowing measurement results with a high resolution. Once all height measurements are determined, an image with full depth of field is computed.

The technique of Focus-Variation has been accepted in the draft of the new ISO standard 25178, which is a recently developed standard for the classification of topographical measurement techniques.

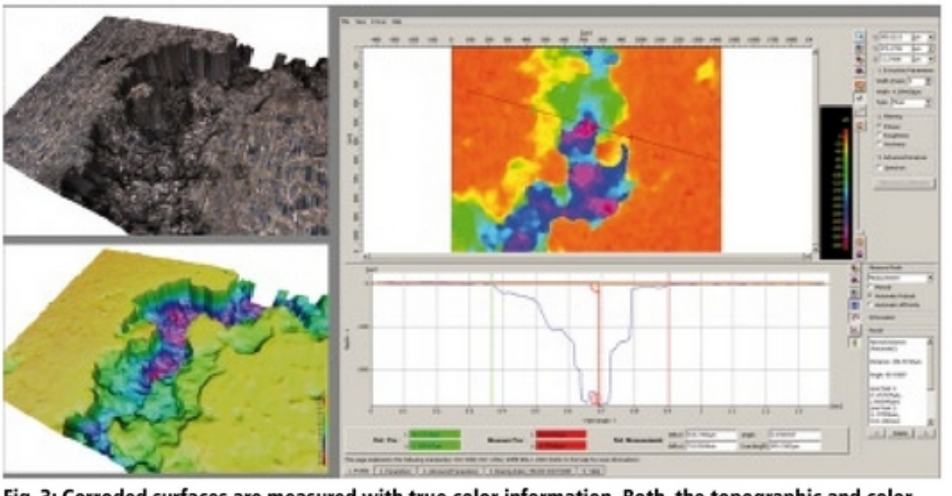

Fig. 3: Corroded surfaces are measured with true color information. Both, the topographic and color information are registered to the 3D data file.

Summary: Corrosion Becomes Measurable and Visible in 3D

Focus-Variation is used for the analysis of different forms of corrosion, corrosive data and clarification of individual corrosive mechanics. The knowledge about circumstances causing erosive and corrosive attack of material surfaces and protective layers of components leads to the establishment of new guidelines to develop more resistant material. In particular, profile and area measurements are used for further mathematical computations of degradation rates. Also, measurement data and 3D visualizations of fractured surfaces are used for further research and development activities.

The technology is a well established technique to characterize surfaces with complex geometries. Typical surface features coming along with corrosive specimen are steep flanks and highly reflective properties. The vertical resolution up to 10nm can also be achieved at very inhomogeneous and rough geometries.

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