CORROSION EVALUATION
USING 3D PROFILOMETRY

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INTRO:

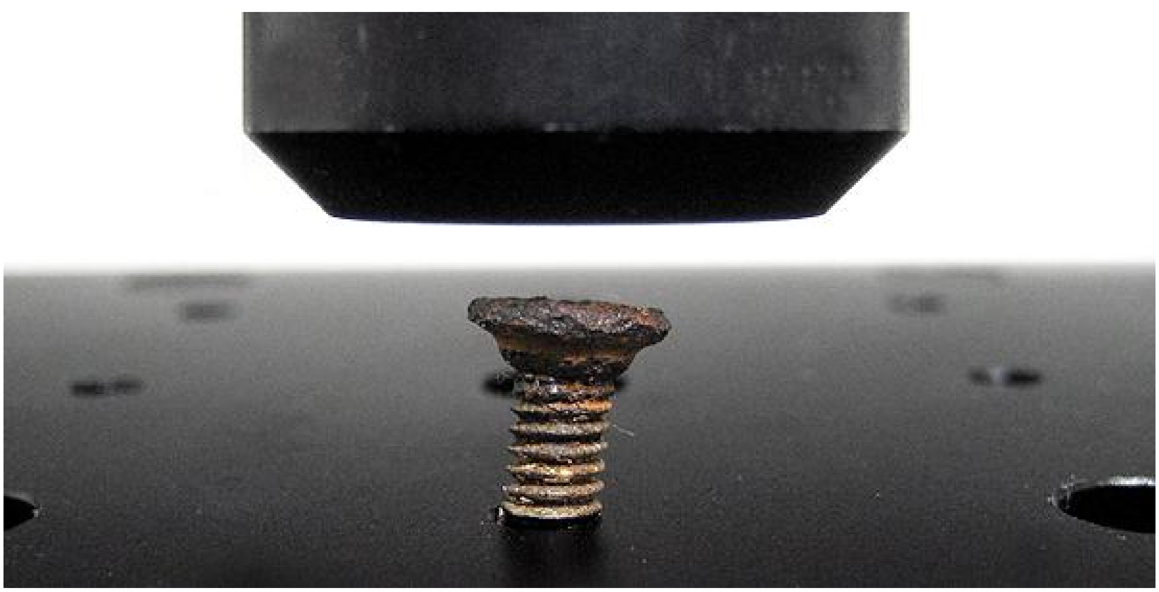
Corrosion is responsible for millions of dollars in material loss every year. Iron, steel and many other metals corrode during oxidation slowly causing the breakdown of the material surface. Corrosion measurement is a quantitative method by which the rate of corrosion can be evaluated to provide control and prevention understanding. Interest in corrosion measurement covers a broad spectrum of technical approaches including acoustic, electrical & mechanical. Non-contact Profilometry is an alternative approach used to measure the corrosive rate and material loss by obtaining surface topography measurement at nanometer levels.

IMPORTANCE OF SURFACE METROLOGY INSPECTION FOR R&D AND QUALITY CONTROL

Surface measurement is vital to understanding and responding to corrosion and ultimately material failure. To control future integrity of a given material will depend upon quantifiable, reproducible and reliable measurement of corrosive rates and topography evaluation. Precise measurement and evaluation of corrosion characteristics, on a given material or existing structure, can lead to the best selection of material, protective coatings and or corrosion control measures. Nanovea 3D Non-Contact Profilometers utilize chromatic confocal technology with unmatched capability to measure rough corrosive surfaces. Where other techniques fail to provide reliable data, due to probe contact, surface variation, angle and reflectivity, Nanovea Profilometers succeed and now with portable capability.

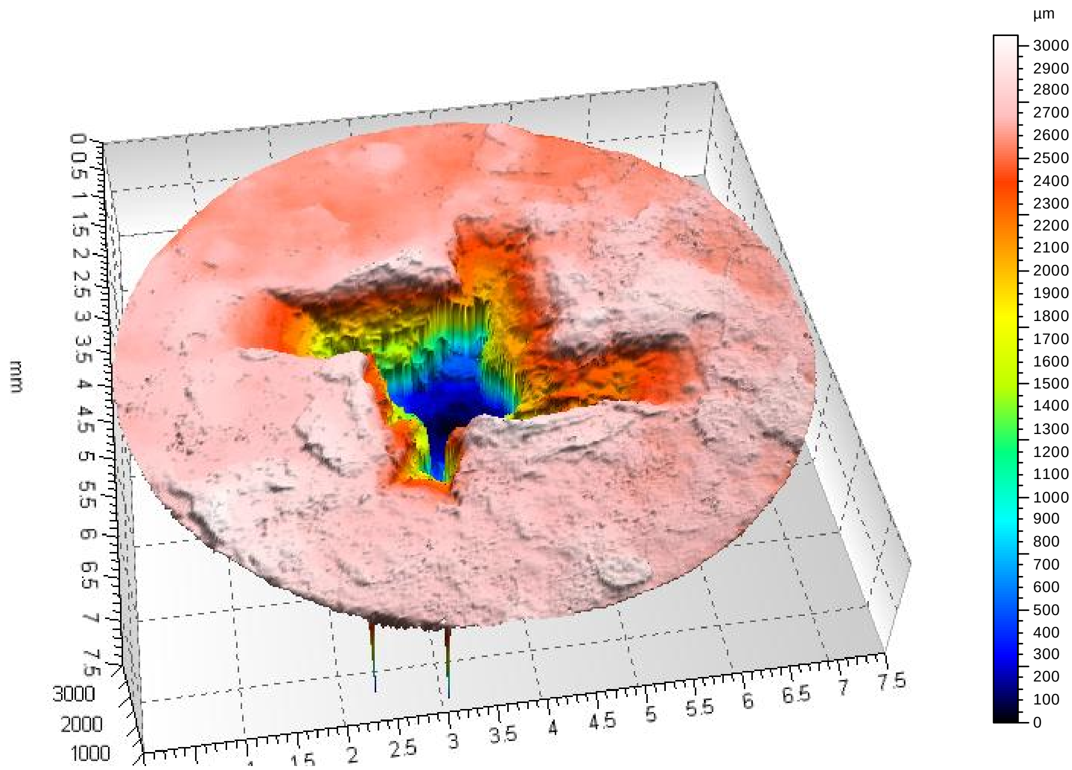
MEASUREMENT OBJECTIVE

In this application, the Nanovea JR25 (Portable Profilometer) is used to measure the surface of a metal sample before and after corrosion. Several surface parameters will automatically be calculated including the most common, Sa (average surface roughness).

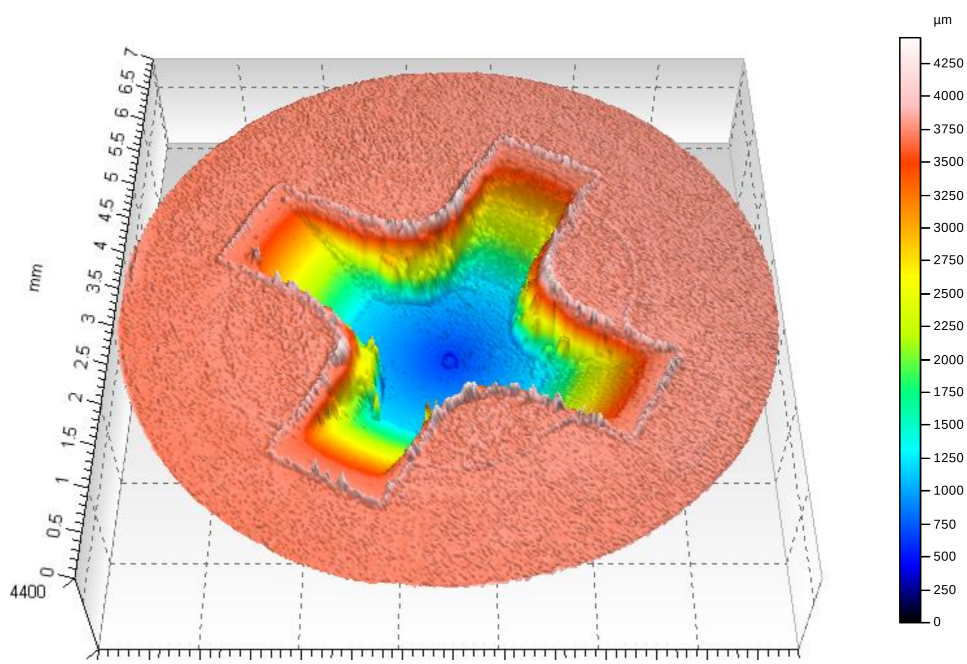


RESULTS:

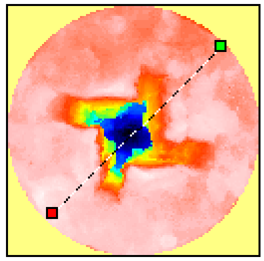
3D Corroded Surface

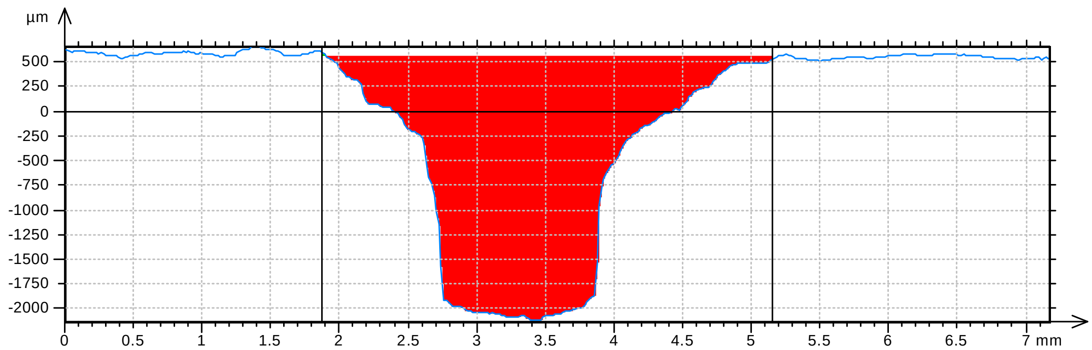


3D Non- Corroded Surface



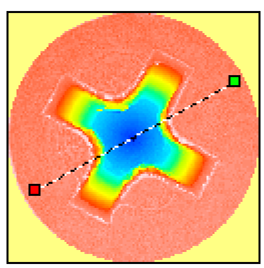
Profile Extraction of Corroded Surface

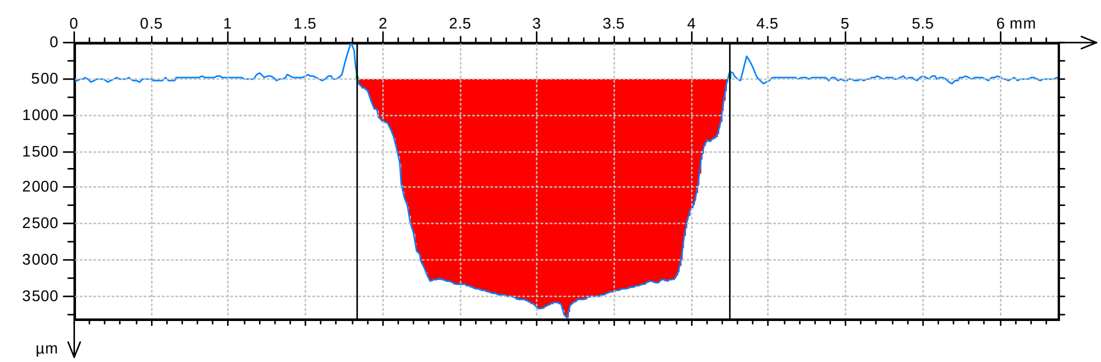




Maximum depth 2.700 mm Area of the hole 4.083 mm2

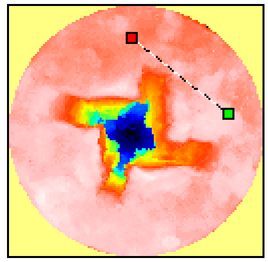
Profile Extraction of Non- Corroded Surface

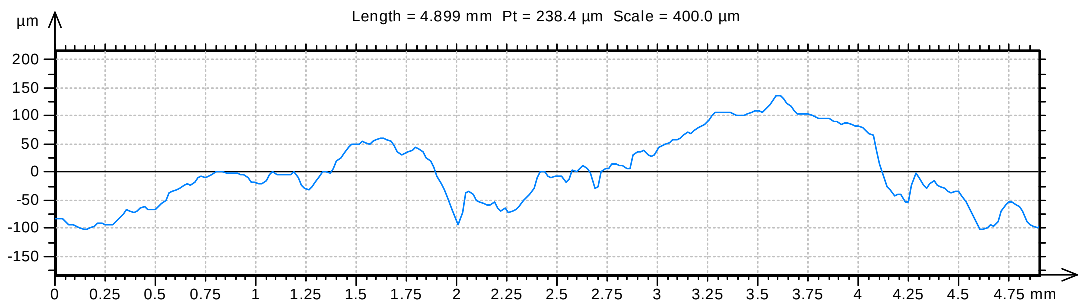




Maximum depth 3.332 mm Area of the hole 5.721 mm2

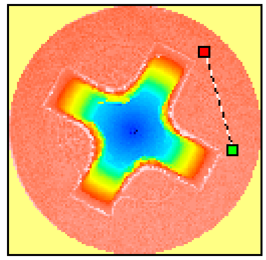
Roughness Extraction of Corroded Surface

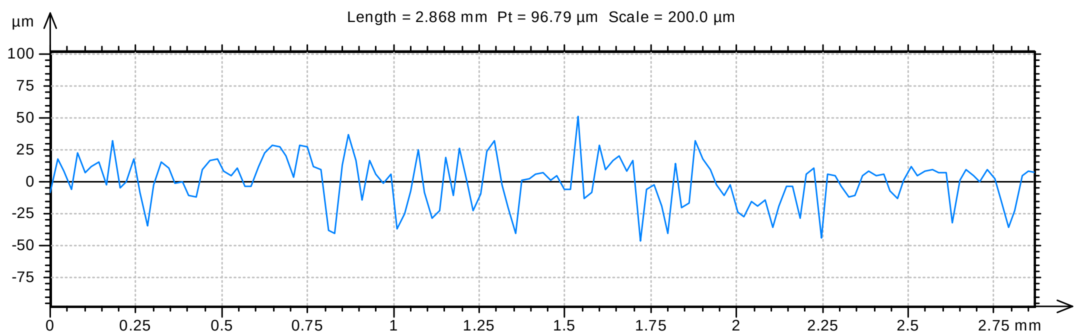




ISO 4287		
Amplitude parameters - Roug		
Rp	21.02	µm
Rv	31.94	µm
Rz	52.97	µm
Rc	37.00	µm
Rt	79.80	µm
Ra	10.80	µm
Rq	13.55	µm
Rsk	-0.4432	
Rku	2.877	
Material Ratio parameters - R		
Rmr	1.086	%
Rdc	20.85	µm

Roughness Extraction of Non-Corroded Surface





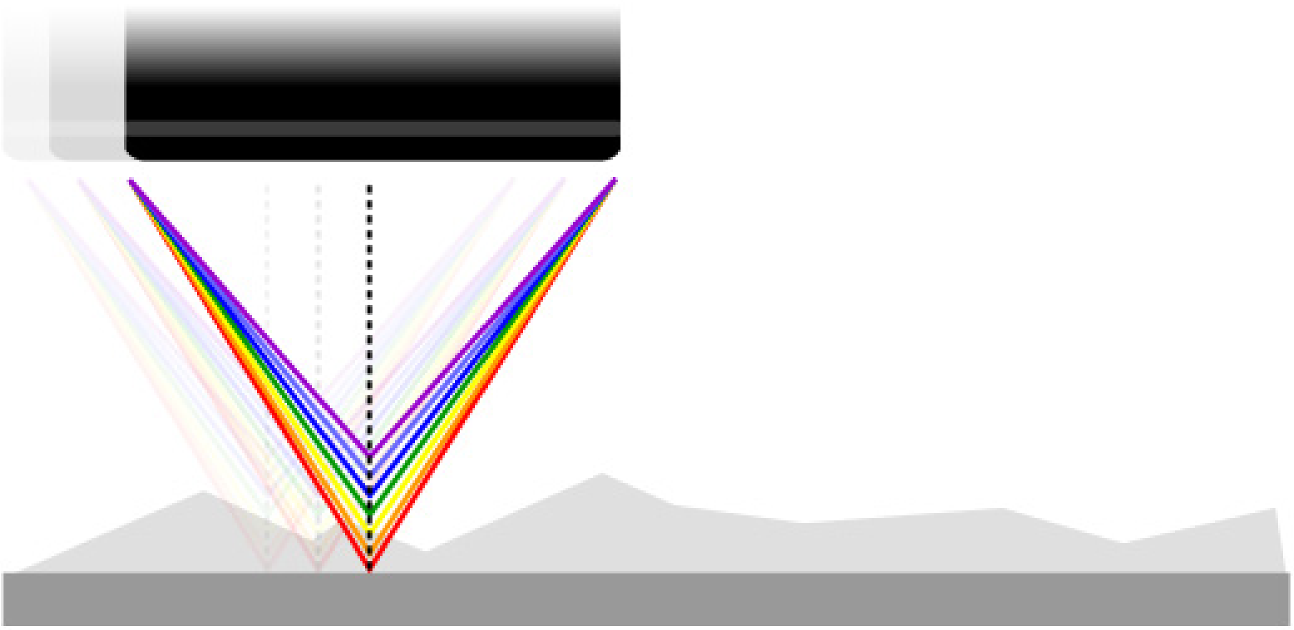
ISO 4287		
Amplitude parameters - Roug		
Rp	32.80	µm
Rv	38.66	µm
Rz	71.46	µm
Rc	32.54	µm
Rt	87.17	µm
Ra	11.04	µm
Rq	14.83	µm
Rsk	-0.2575	
Rku	3.509	
Material Ratio parameters - R		
Rmr	0.9709	%
Rdc	19.77	µm

CONCLUSION:

The areas measured on the corroded and non-corroded sample display how a portable non-contact profilometer could be an ideal tool for corrosion evaluation and comparison. Volume and roughness results shown were given as examples of capability to be applied with systematic evaluation procedures. The results shown are rare to acquire during field studies and open the door to many opportunities with portable non-contact profilometry. With no weight restrictions and a maximum measurement area of $25mm^2$, the JR25 makes an ideal choice for portable surface measurements of large immovable surfaces. Vital field study surface measurement will now have the option of Nanovea 3D non-contact technology with a compact potable profilometer.

MEASUREMENT PRINCIPLE:

The Chromatic Confocal technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.

DEFINITION OF HEIGHT PARAMETERS

	Height Parameter	Definition
Sa	Arithmetical Mean Height	Mean surface roughness. $$Sa = \frac{1}{A} \iint_A \lvert z(x,y) \rvert dxdy$$
Sq	Root Mean Square Height	Standard deviation of the height distribution, or RMS surface roughness. $$Sq = \sqrt{\frac{1}{A} \iint_A z^2(x,y)dxdy}$$ Computes the standard deviation for the amplitudes of the surface (RMS).
Sp	Maximum Peak Height	Height between the highest peak and the mean plane.
Sv	Maximum Pit Height	Depth between the mean plane and the deepest valley.
Sz	Maximum Height	Height between the highest peak and the deepest valley.
Ssk	Skewness	Skewness of the height distribution. $$Ssk = \frac{1}{Sq^3}\left[\frac{1}{A} \iint_A z^3(x,y)dxdy\right]$$ Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Sku	Kurtosis	Kurtosis of the height distribution. $$Sku = \frac{1}{Sq^4}\left[\frac{1}{A} \iint_A z^4(x,y)dxdy\right]$$ Kurtosis qualifies the flatness of the height distribution. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Spar	Projected Area	Projected surface area.
Sdar	Developed Area	Developed surface area.