SHOT PEENED SURFACE AREA USING 3D PROFILOMETRY

Prepared by

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INTRO:

Shot peening is a process by which a substrate is impacted with round metal, glass or ceramic beads, also known as shot, at a force intended to create plasticity on the surface. The characteristics present prior to and after the peening process provides vital information to better the understanding and control of the process. Among many others, surface roughness and dimple coverage area left by the shot, are of particular interest.

IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR PEENED SURFACES

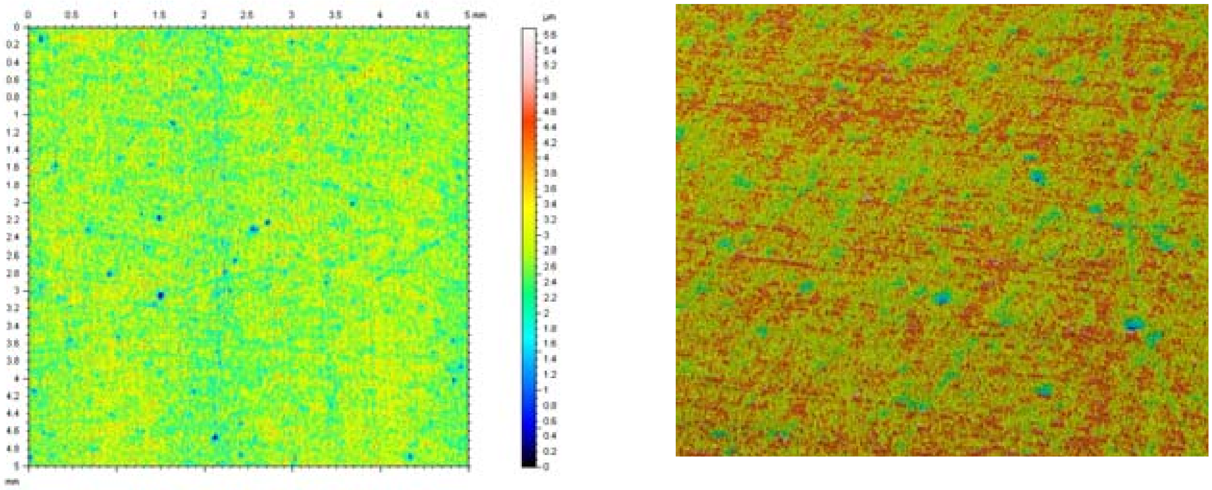
Unlike traditional contact Profilometers which traditionally have been used to measure peened surfaces, 3D non contact measurement provides a full 3D image to give a more complete understanding of coverage area and surface topography. Without 3D capabilities, an inspection will be solely relying on 2D information, which provides insufficient information for characterizing a surface. Understanding the topography, coverage area and roughness in 3D is the best option to control or improve the peening process. The Nanovea 3D Non-Contact Profilometers utilize chromatic confocal technology with unique capability to measure the steep angles found with machined and peened surfaces. Additionally, where other techniques fail to provide reliable data, due to probe contact, surface variation, angle, or reflectivity, Nanovea Profilometers succeed.

MEASUREMENT OBJECTIVE

In this application, the Nanovea ST400 is used to measure raw material and two differently peened surfaces for a comparative review. There is an endless list of surface parameters that can be automatically calculated after the 3D surface scan. Here we will review the 3D surface and select areas of interest to further analyze, including quantifying and investigating the roughness, dimples and surface area.

RESULTS:

Steel Surface

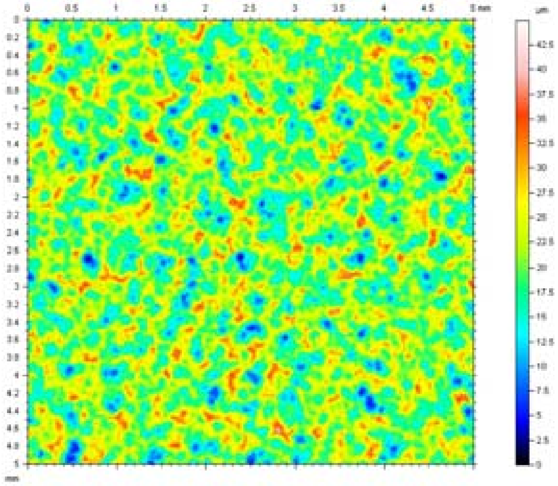


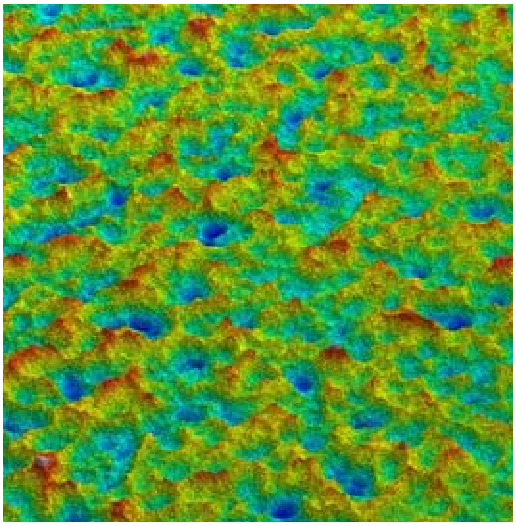
3D Measurement of Steel Surface

3D Roughness Parameters
ISO 25178

Sa	0.399µm	Average Roughness
Sq	0.516µm	RMS Roughness
Sz	5.686µm	Maximum Peak-to-Valley
Sp	2.976µm	Maximum Peak Height
Sv	2.711µm	Maximum Pit Depth
Sku	3.9344	Kurtosis
Ssk	-0.0113	Skewness
Sal	0.0028mm	Auto-Correlation Length
Str	0.0613	Texture Aspect Ratio
Sdar	26.539mm^2	Surface Area
Svk	0.589µm	Reduced Valley Depth

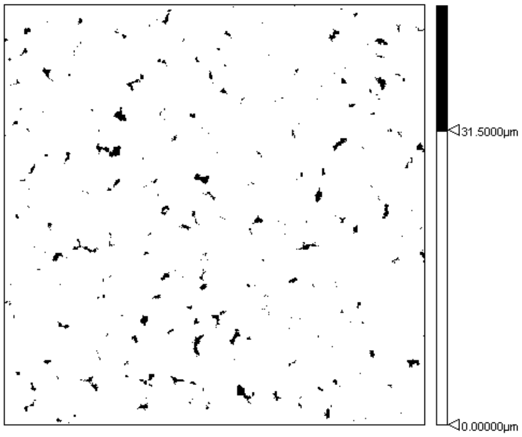
Peened Surface 1





3D Measurement of Shot Peen Surface 1

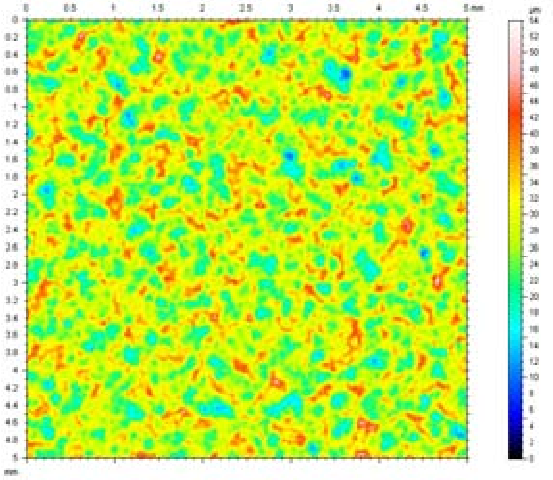
Surface Coverage
98.105%

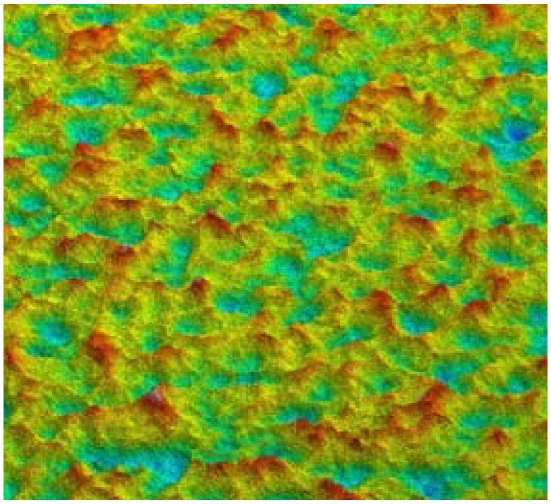


3D Roughness Parameters
ISO 25178

Sa	4.102µm	Average Roughness
Sq	5.153µm	RMS Roughness
Sz	44.975µm	Maximum Peak-to-Valley
Sp	24.332µm	Maximum Peak Height
Sv	20.644µm	Maximum Pit Depth
Sku	3.0187	Kurtosis
Ssk	0.0625	Skewness
Sal	0.0976mm	Auto-Correlation Length
Str	0.9278	Texture Aspect Ratio
Sdar	29.451mm^2	Surface Area
Svk	5.008µm	Reduced Valley Depth

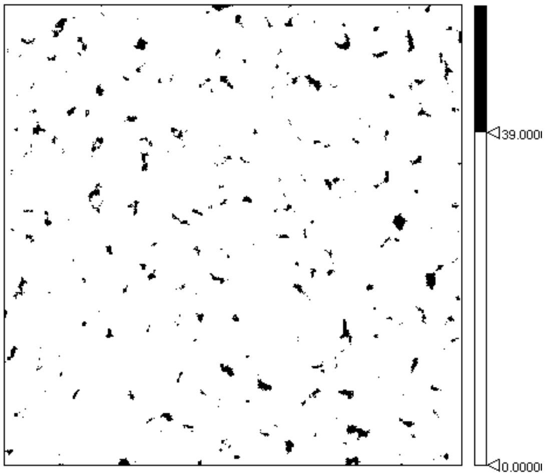
Peened Surface 2





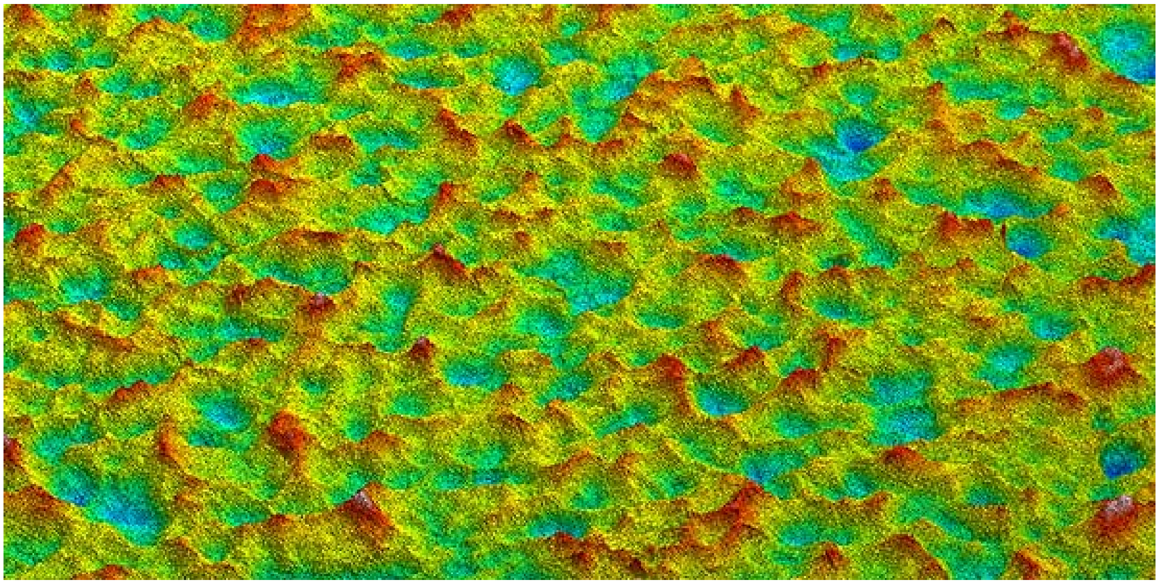
3D Measurement of Shot Peen Surface 2

Surface Coverage
97.366%



3D Roughness Parameters
ISO 25178

Sa	4.330µm	Average Roughness
Sq	5.455µm	RMS Roughness
Sz	54.013µm	Maximum Peak-to-Valley
Sp	25.908µm	Maximum Peak Height
Sv	28.105µm	Maximum Pit Depth
Sku	3.0642	Kurtosis
Ssk	0.1108	Skewness
Sal	0.1034mm	Auto-Correlation Length
Str	0.9733	Texture Aspect Ratio
Sdar	29.623mm^2	Surface Area
Svk	5.167µm	Reduced Valley Depth



CONCLUSION:

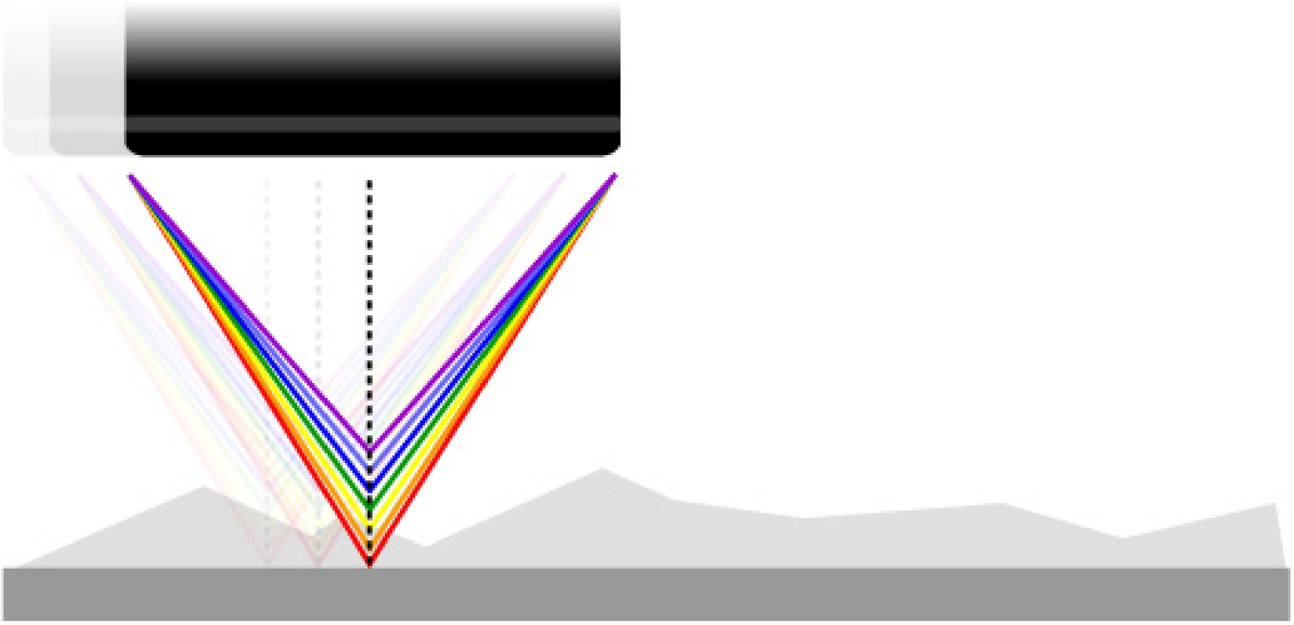
In this application, we have shown how the Nanovea ST400 3D Non Contact Profilometer can precisely characterize both the topography and the nanometer details of a peened surface. We can clearly see that both Surface 1 and Surface 2 have a significant effect on all parameters reported here when compared to the raw material. Simply by looking at the image you can see that Surface 1 and 2 are different. This is verified by looking at the coverage area and the parameters listed. Compared to Surface 2, Surface 1 shows a lower average roughness (Sa), dents that were not as deep (Sv), less surface area (Sdar), but a slightly higher coverage area.

From these 3D surface measurements, areas of interest can quickly be identified and then analyzed with a list of endless measurements (Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height and others). A 2D cross section can quickly be chosen to analyze further details. With this information peened surfaces can be broadly investigated with a complete set of surface measurement resources. Special areas of interest could have been further analyzed with integrated AFM module. Nanovea 3D Profilometers speeds range from 20mm/s to 1m/s for laboratory or research to the needs of hi-speed inspection; can be built with custom size, speeds, scanning capabilities, Class 1 Clean Room compliance, with Indexing Conveyor and for Inline or online Integration.

*A special thanks to Mr. Hayden at IMF for supplying the sample shown in this note. Industrial Metal Finishing Inc. | www.indmetfin.com

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.