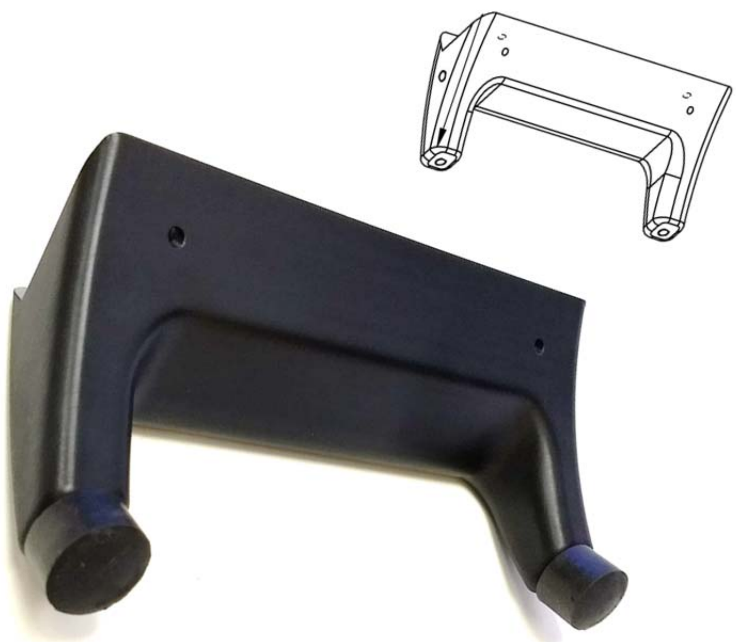
INSPECTION OF MACHINED PARTS FROM CAD MODEL USING 3D PROFILOMETRY



Prepared by
Duanjie Li, PhD, Erik Steinholt and Jeronimo Silva

6 Morgan, Ste156, Irvine CA 92618 · P: 949.461.9292 · F: 949.461.9232 · nanovea.com

INTRO

Precision machining fabricates parts of complex geometries and high precision in a wide variety of industries, such as aerospace, automobile, tech gears, machinery and music instruments. The increasing precision expectation requires the development of advanced and reliable surface inspection technique.

IMPORTANCE OF 3D NON-CONTACT PROFILOMETER FOR PART INSPECTION

Manufacturing of high precision parts calls for stringent inspection to ensure product quality and repeatable production standards. The 3D surface inspection of the part compared to CAD model is essential to verify part tolerance and machine quality. Moreover, during the service time, wear and tear of the parts may create surface defects such as scratches, dents and cracks. The part needs to be replaced when the deviation from the required specification is over the tolerance limit. Unlike a touch probe technique, the Nanovea Profilometer performs 3D surface measurement without touching, making it possible to precisely scan parts with a complex shape at a high speed.

MEASUREMENT OBJECTIVE

In this application, we showcase that the Nanovea HS2000 3D Non-Contact Profilometer equipped with a line sensor performs a comprehensive surface inspection including dimension, radius, and roughness in 40 seconds.

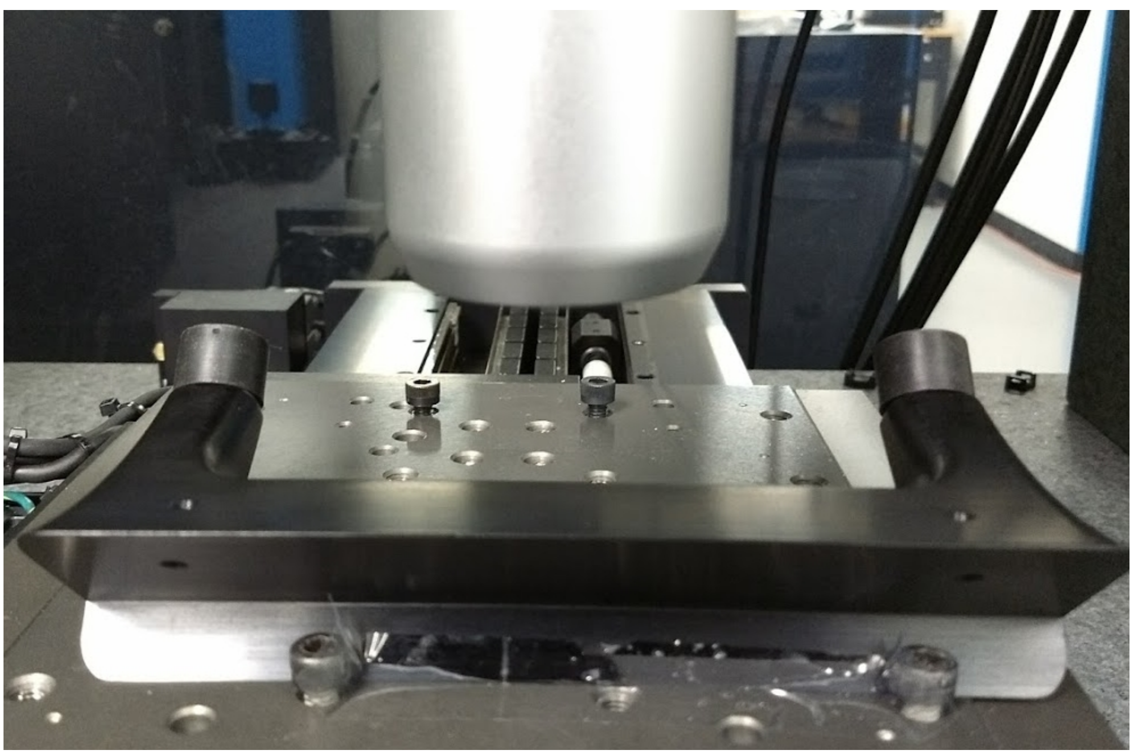


Fig. 1: Optical sensor scanning on the surface of a machined part.

RESULTS AND DISCUSSION

A precision measurement of the dimension and surface roughness of the machined part is critical to make sure it meets the desired specifications, tolerances, and surface finishes. The 3D model and the engineering drawing of the part to be inspected is shown in Fig. 2 and Fig. 3, respectively. The false color view of the CAD model and the scanned machined part surface are compared Fig. 4. The height variation on the sample surface can be observed by the change of color.

Three 2D profiles are extracted from the 3D surface scan as indicated in Fig. 4b to further verify the dimensional tolerance of the machined part. The three profiles (Profiles 1 to 3) are shown in Fig. 5 to Fig. 7. Quantitative tolerance inspection is carried out by comparing the measured profile with the CAD model to uphold rigorous manufacturing standards. Profile 1 and Profile 2 measures the radius of different areas on the curved machined part. The height variation of Profile 3 is 30 µm over a length of 156 mm, which meets the desired tolerances of ± 125 µm. By setting up a tolerance limit value, the analysis software can automatically determine pass or fail of the machined part.

The roughness and uniformity of the machined part surface play an important role in ensuring its quality and functionality. Fig. 8 extracts a surface area on the machined part for roughness analysis to evaluate the machining quality of the part. The average roughness Sa of the extracted surface is 2.31 µm.

Fig. 2: 3D model of the part.

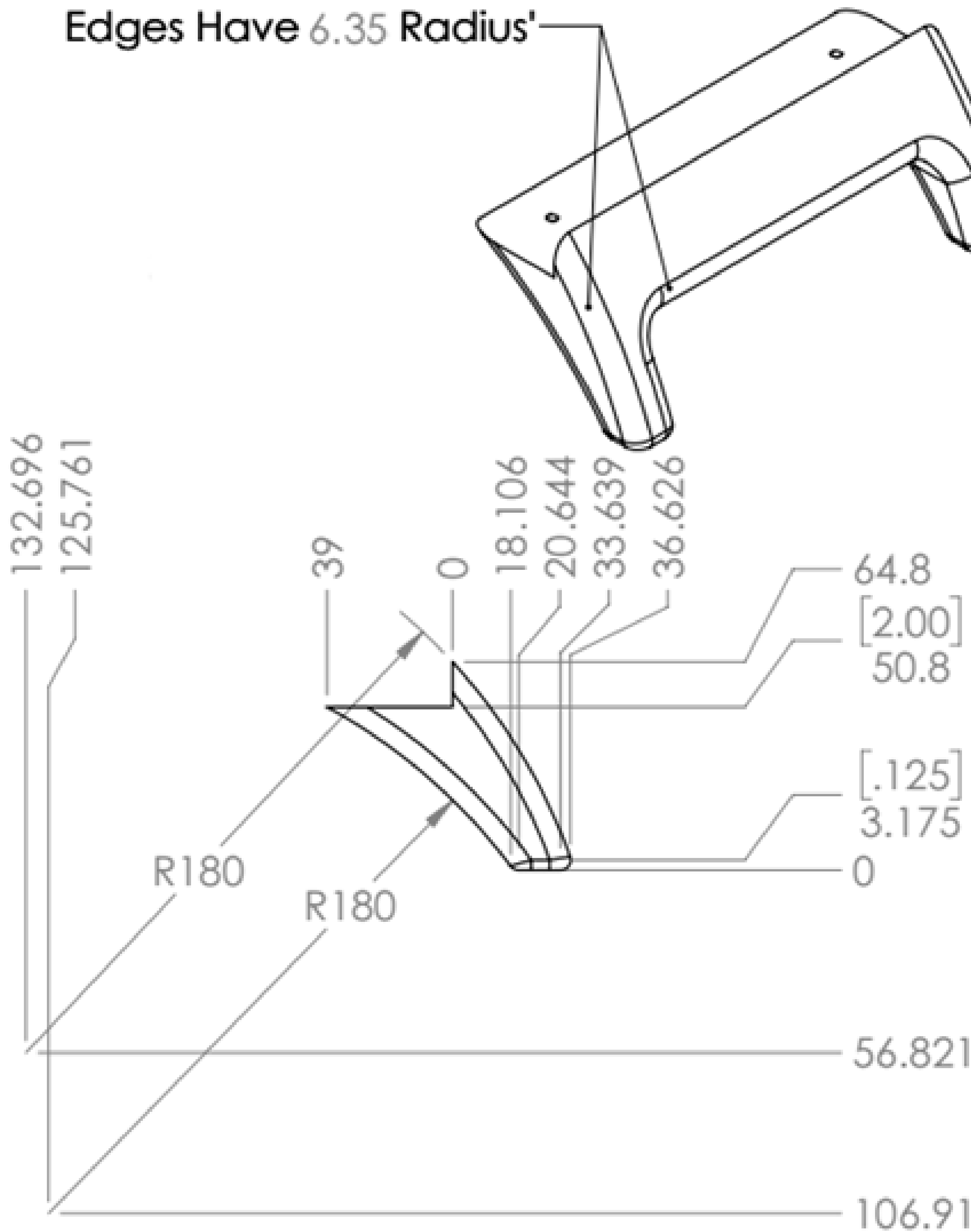
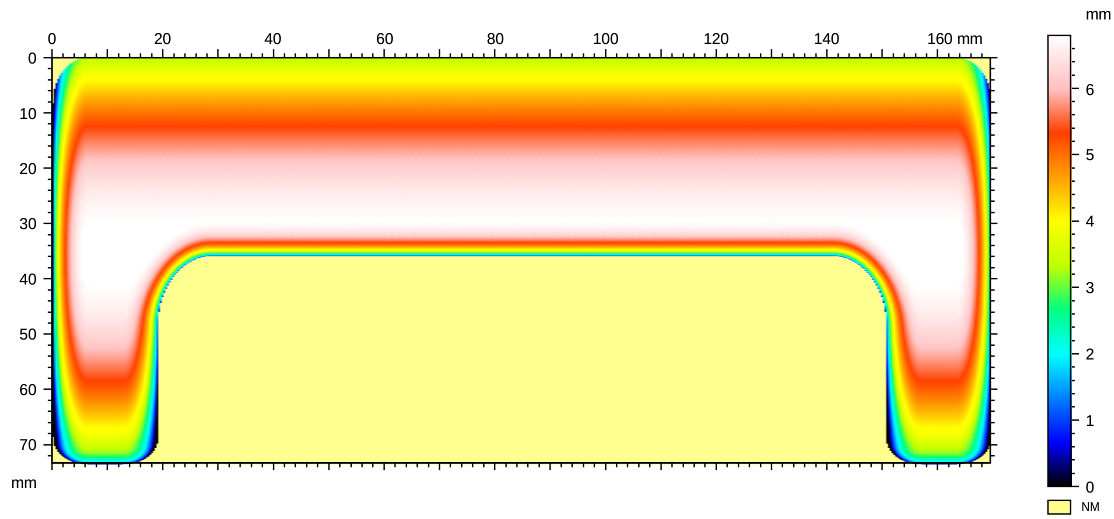


Fig. 3: Engineering drawing of the part (unit mm).

(a) 3D surface of the CAD model:



(b) 3D surface morphology of the machined part:

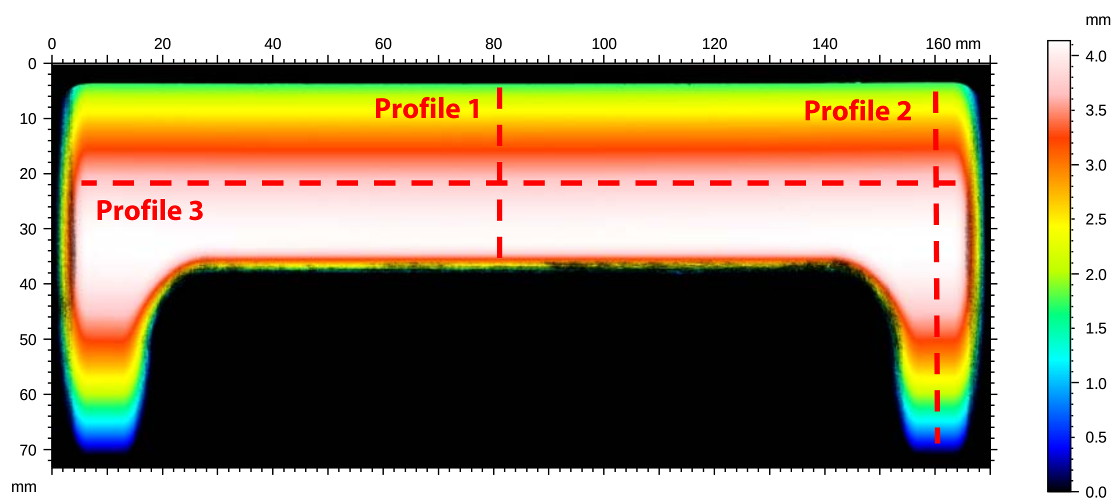
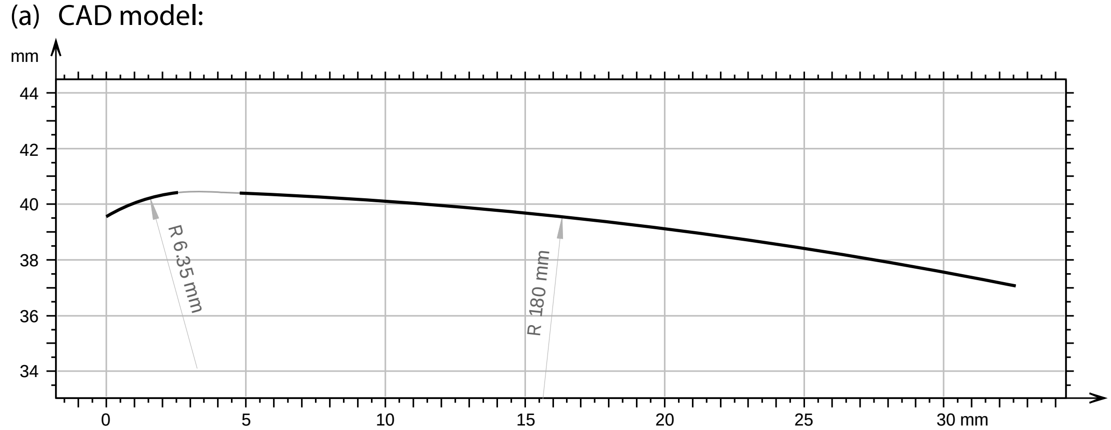


Fig. 4: Comparison of false color views of the CAD model and the machined part.

(a) CAD model:



(b) Machined part:

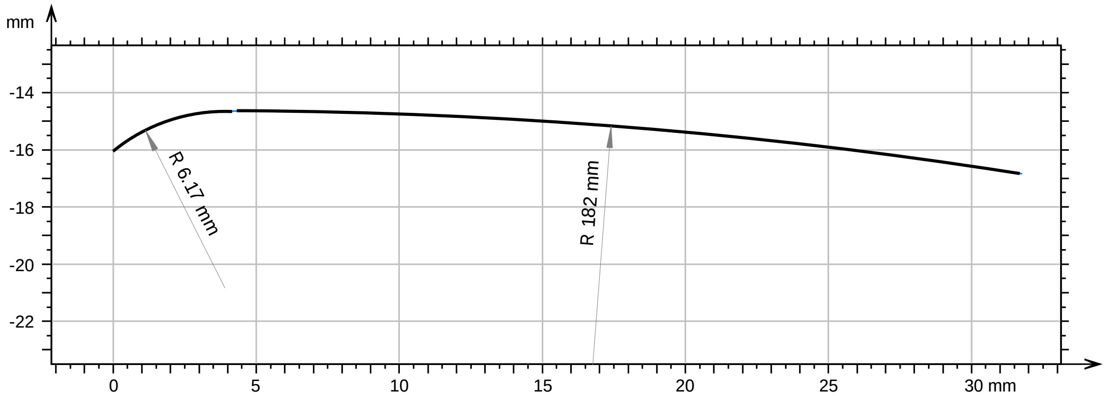
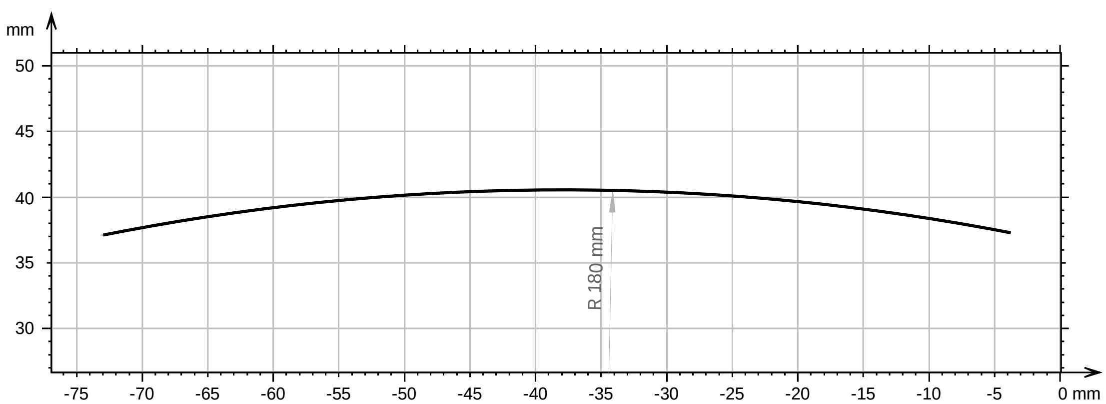


Fig. 5: Comparison of Profile 1 on the CAD model and Machined part.

(a) CAD model:



(b) Machined part:

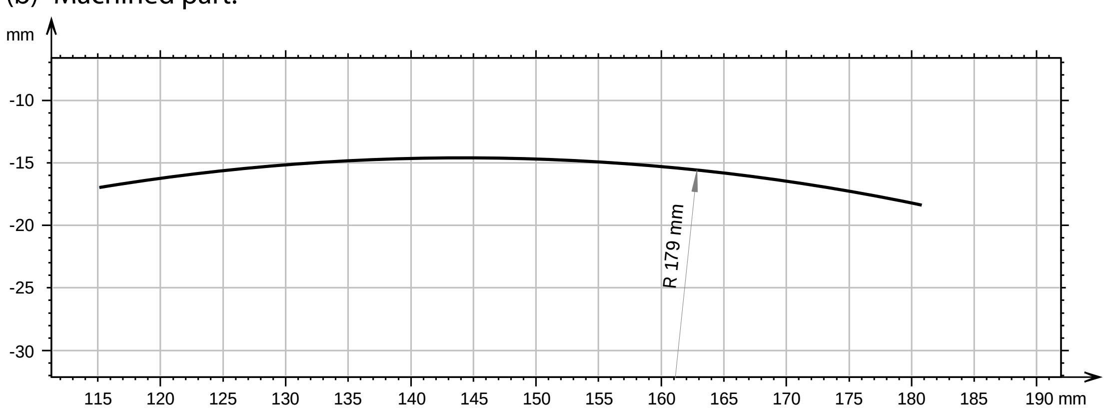


Fig. 6: Comparison of Profile 2 on the CAD model and Machined part.

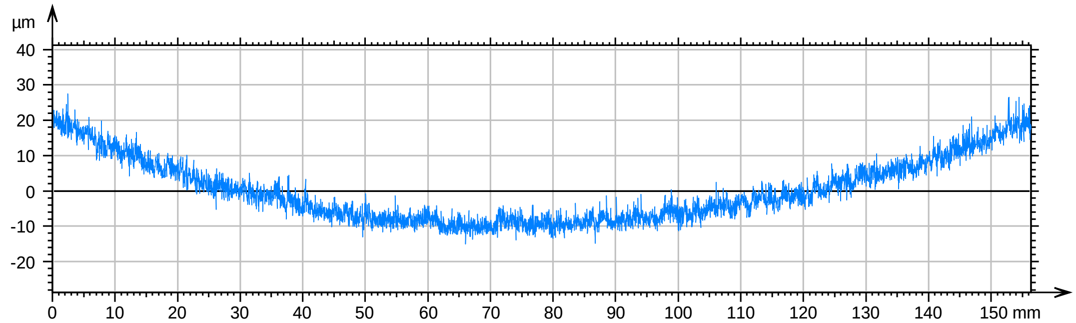
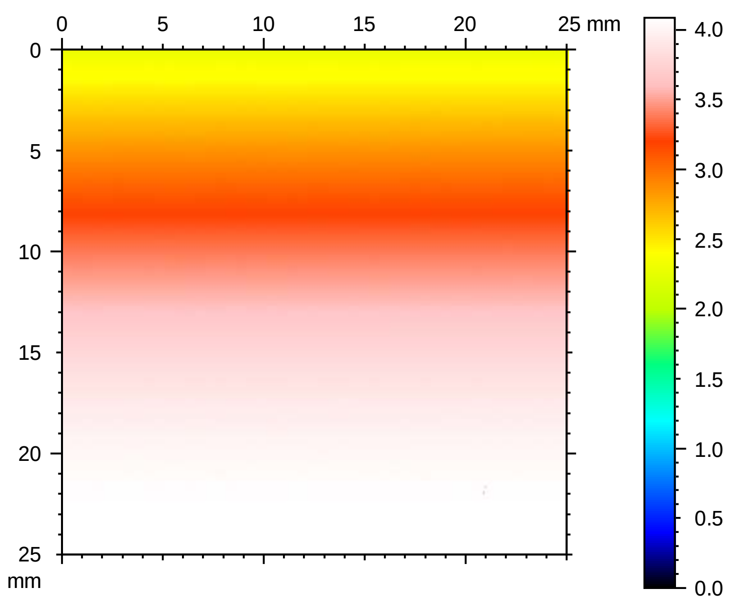


Fig. 7: Profile 3 on the Machined part.

ISO 4287			
Amplitude parameters - Roughness profile			
Rp	2.92	µm	*Maximum peak height of the roughness profile.*
Rv	2.61	µm	*Maximum valley depth of the roughness profile.*
Rz	5.53	µm	*Maximum Height of roughness profile.*
Rc	3.76	µm	*Mean height of the roughness profile elements.*
Rt	13.1	µm	*Total height of roughness profile.*
Ra	1.04	µm	*Arithmetic mean deviation of the roughness profile.*
Rq	1.30	µm	*Root-mean-square (RMS) deviation of the roughness profile.*
Rsk	0.149		*Skewness of the roughness profile.*
Rku	3.00		*Kurtosis of the roughness profile.*

Table 1: Roughness values of Profile 3.



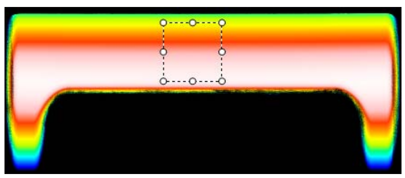


Fig. 8: Extracted area for roughness analysis.

ISO 25178			
Height Parameters			
Sq	3.04	µm	*Root-mean-square height*
Ssk	-0.445		*Skewness*
Sku	30.1		*Kurtosis*
Sp	23.3	µm	*Maximum peak height*
Sv	146	µm	*Maximum pit height*
Sz	169	µm	*Maximum height*
Sa	2.31	µm	*Arithmetic mean height*

Table 2: Summary of the roughness values from the extracted area.

CONCLUSION

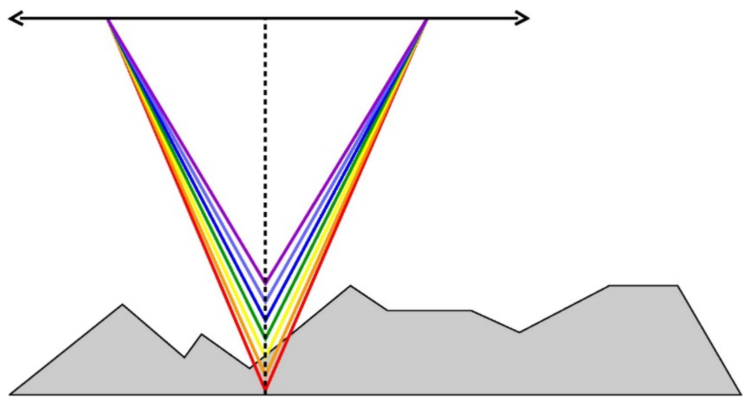
In this application, we have showcased that the Nanovea HS2000 3D Non-Contact Profilometer equipped with a line sensor performs comprehensive surface inspection including dimension, radius, and roughness. The capacity of high resolution scan enables users to measure the detailed morphology and surface features of the machined part and to compare it with the CAD model. Moreover, it can pick up any undesired defects including scratches or cracks on the part. The detailed contour analysis provides a useful tool to determine whether the machined parts fall in line with manufacture specifications, and to evaluate the failure mechanism of the worn components.

The data shown here represents only a portion of the calculations available in the analysis software. Nanovea Profilometers measure virtually any surface in fields including Semiconductor, Microelectronics, Solar, Fiber Optics, Automotive, Aerospace, Metallurgy, Machining, Coatings, Pharmaceutical, Biomedical, Environmental and many others.

Learn more about the Nanovea Profilometer or Lab Services

MEASUREMENT PRINCIPLE

The axial chromatism 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.



Nanovea optical pens have zero influence from sample reflectivity. Variations require no sample preparation and have advanced ability to measure high surface angles. Measure any material: transparent/opaque, specular/diffusive, and polished/rough.