DIMENSIONAL MEASUREMENT OF CUTTING TOOL EDGE USING 3D PROFILOMETRY

Prepared by
Craig Leising

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

INTRO:

Measuring the sharp edges of cutting tools is a challenging measurement because it involves a small radius which requires high lateral resolution and high angles. To fully understand, it is also important to be able to measure a diverse range of heights. The study becomes more difficult when the surface is worn such as chipping and other deformation. Precision Cutting tools generally require a sharp tool edge with radii from several tens nm or even smaller. There is an endless range of cutting tools and each has a uniquely shaped edge for its cutting purpose. Tools with round cutting edges could be used for machining surface forms and structures while straight cutting edges are typically used for machining of grooves.

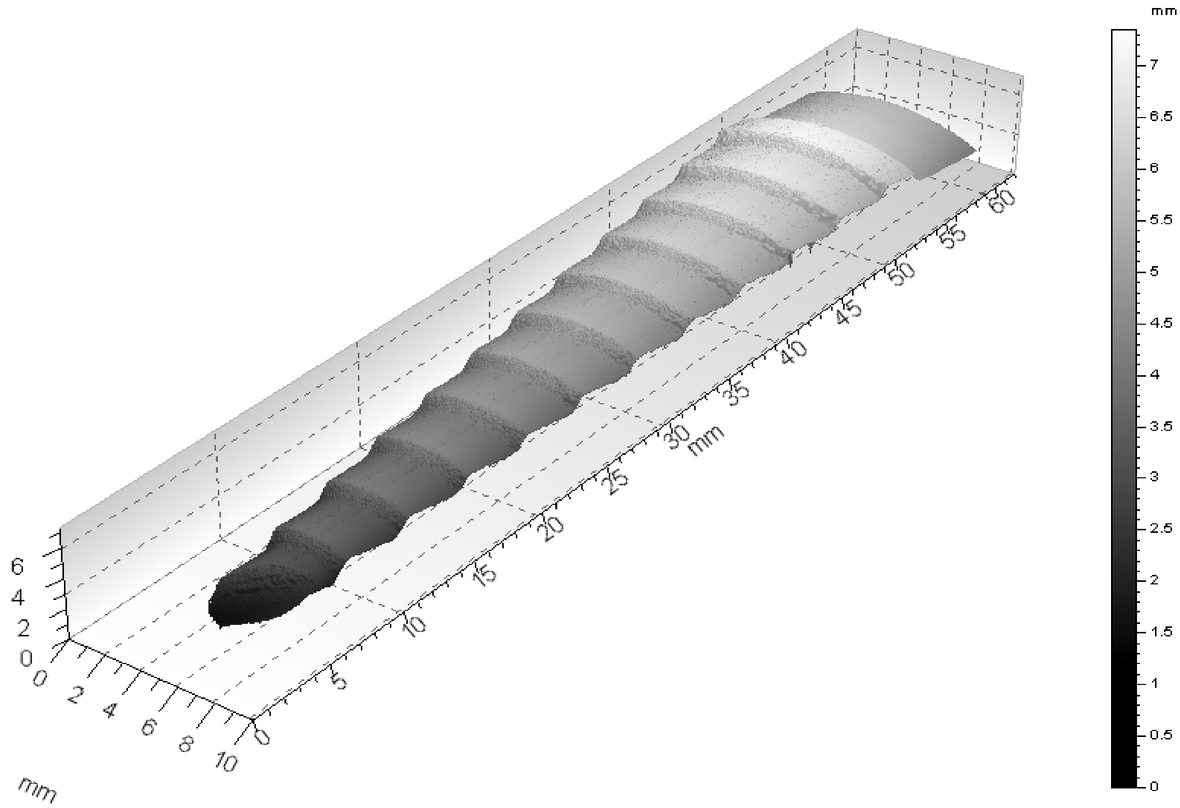
IMPORTANCE OF SURFACE METROLOGY INSPECTION FOR QUALITY CONTROL

For a particular tool, the edges precision is expected to meet intended results during use in machining. Because the depth of cut is controlled to the nanometer level, the tool cutting edge profile is an important factor to influence the final quality of a machined surface. By analysis of a 3D-Profilometer the edge correctness can be determined to insure quality control before production and or during the life of the tool.

MEASUREMENT OBJECTIVE

In this application, the Nanovea ST400 is used to measure the cutting edge of a cutting tool shown below. We also used the ST400 to verify the full diameter of the bit and resulting hole that it would create during utilization.

By scanning the full length of the cutting tool we are able to calculate the full diameter of each of cutting diameter ring measured and compare them with ideal values.



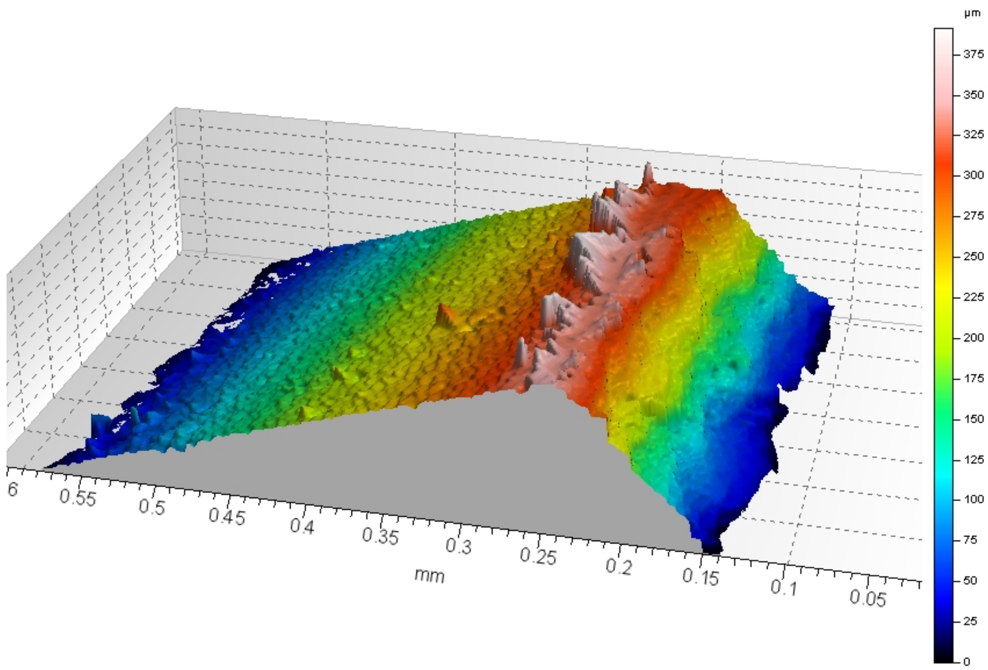
3D Image of Cutting Blade

In this case, we have measured this radius at three different locations and compared them to what it is supposed to be.

Large Diameter = 10.951mm 0.43114" Ideal = 0.5"
Small Diameter = 3.1412mm 0.12367" Ideal = 0.125"
Middle Diameter = 7.0264mm 0.27663" Ideal = 0.28125

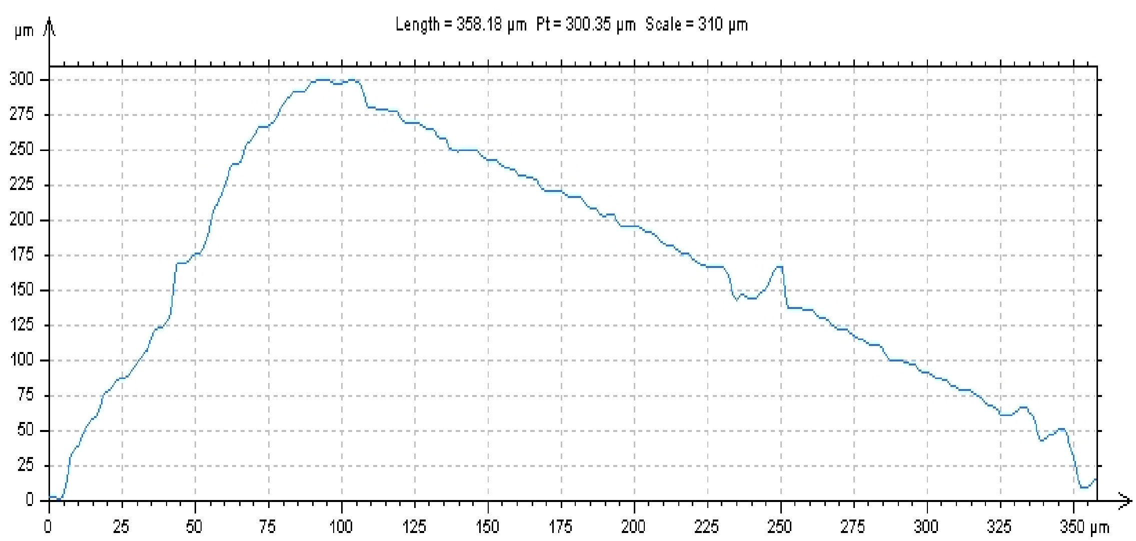
We have found that the variation compare to the ideal diameter is more pronounced for the larger diameter.

Using the powerful analysis software we can measure the edge diameter



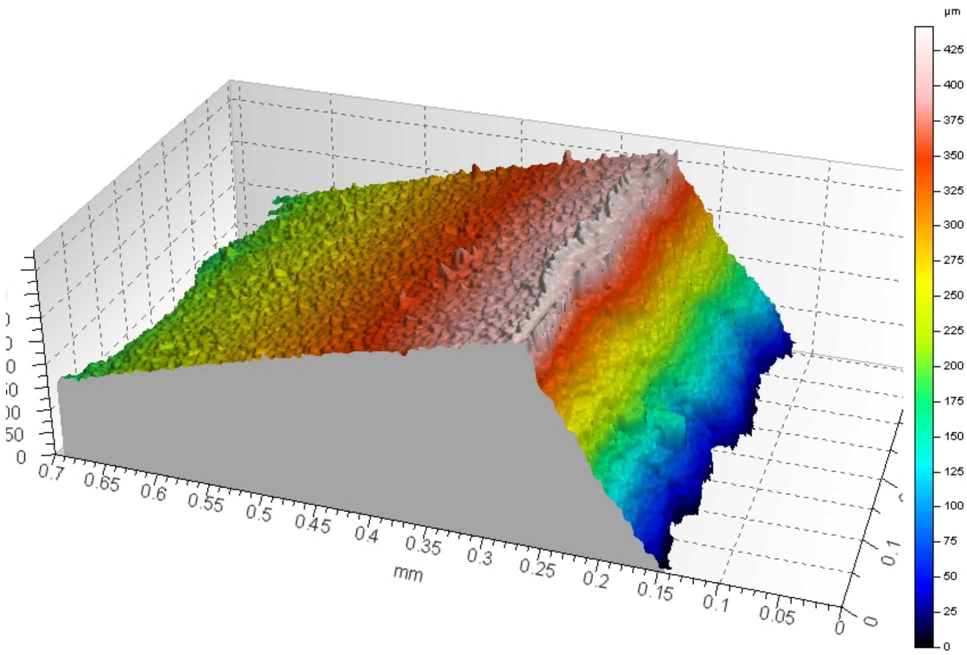
15-32

Cutting Edge

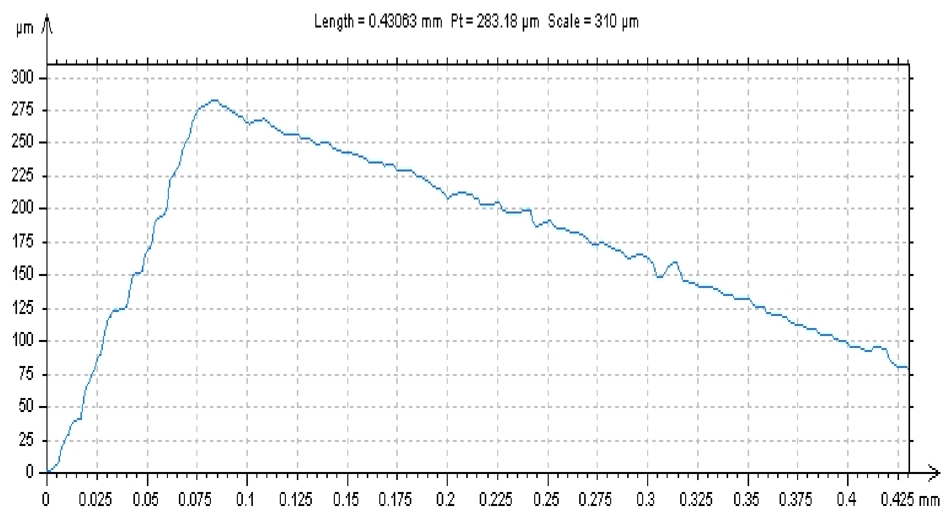


15-32 Cutting Edge

For the 15/32, the diameter of the cutting edge is 15.771um. We can also see that there is some defect close at the edge.



1/2inch Cutting Edge



1/2inch Cutting Edge

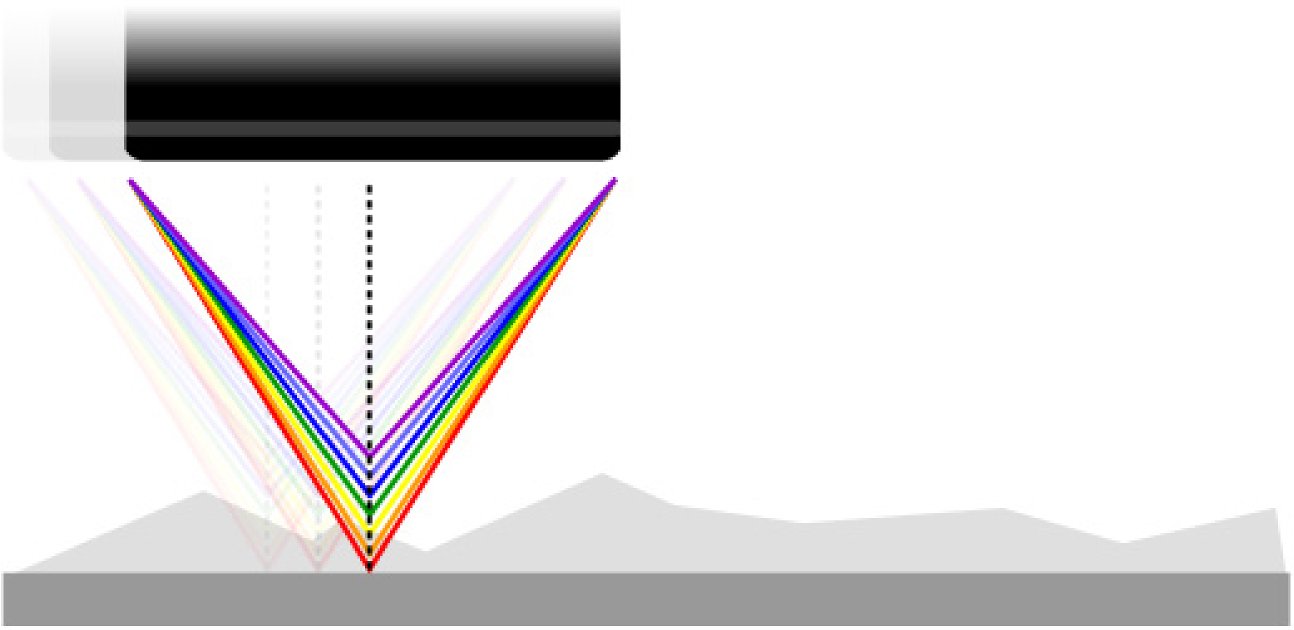
For the 1/2", the diameter of the cutting edge is 6.1825um. This surface is much better. We can also calculate the angle between the two surfaces to be 60.477deg.

CONCLUSION:

In this application, we have shown how the Nanovea ST400 3D Profilometer with 12mm and 400 micron optical pen can precisely characterize both the macro surface/shape and the nanometer details of critical cutting edge. Although a cutting tool was used in this application, Nanovea's 3D Profilometer would be an ideal measurement tool for both research and quality control environments. Nanovea 3D Profilometer provides the diverse measurements of larger surface/shape measurements to the precise nanometer measurement of critical edge inspection.

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.