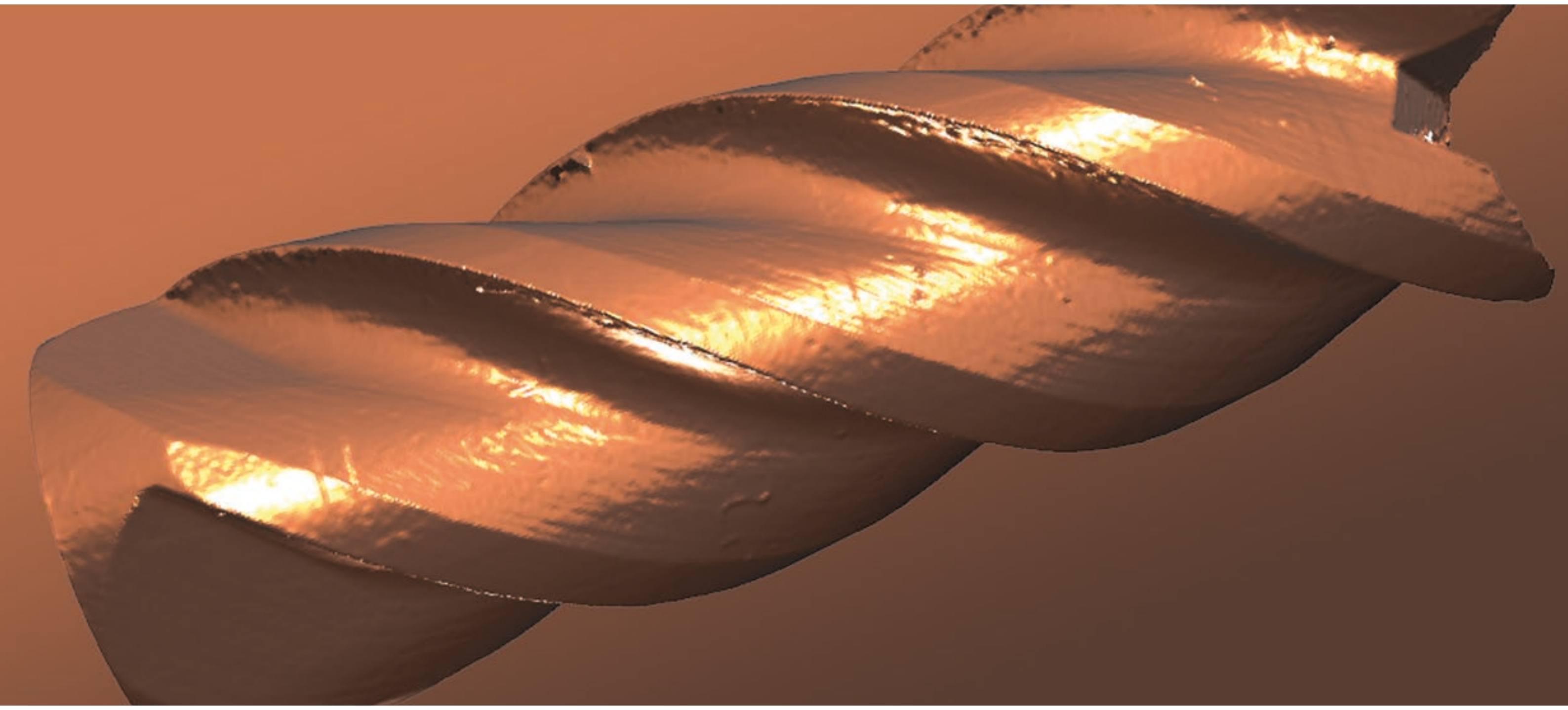


Multi-perspective characterization of an end mill

"In the tooling industry, optical metrology is crucial in achieving success from both design and tool use perspectives. Optical profilometers provide valuable information to help manufacturers optimize their tools and processes."

One of the critical applications of optical metrology in tooling is the dimensional characterization of cutting tools to ensure that tools perform optimally and have a long service life. In addition to dimensional characterization, roughness measurements can be interesting for predicting how well the removed material will exit the tool. This information is critical in preventing clot formation or overheating of the tool during use.

Optical metrology systems can also provide local measurements to help identify potential cutting tool issues. For example, these systems can detect chipping or coating peeling, indicating that a tool needs to be replaced or repaired.

This work was carried out by Digital Surf and Natalia Bermejo from Sensofar.

Digital Surf is a software company that specializes in surface imaging and metrology. The company offers a range of solutions for analyzing and characterizing surfaces at the micro- and nano-scale. Digital Surf's software platforms enable users to process and visualize surface data from various sources. With a global network of partners and distributors, Digital Surf serves customers in automotive, electronics, and more industries.

Digital Surf

SENSOFAR

It is important to note that these characterizations can come in very different orders of magnitude. Dimensional measurements of common end mills, for example, are typically within the millimeter range, while chipping or roughness assessments generally are on the micron scale. Yet, it is nowadays possible only with one set-up: a Sensofar system, the S neox Five Axis, with Digital Surf software, SensoMAP.

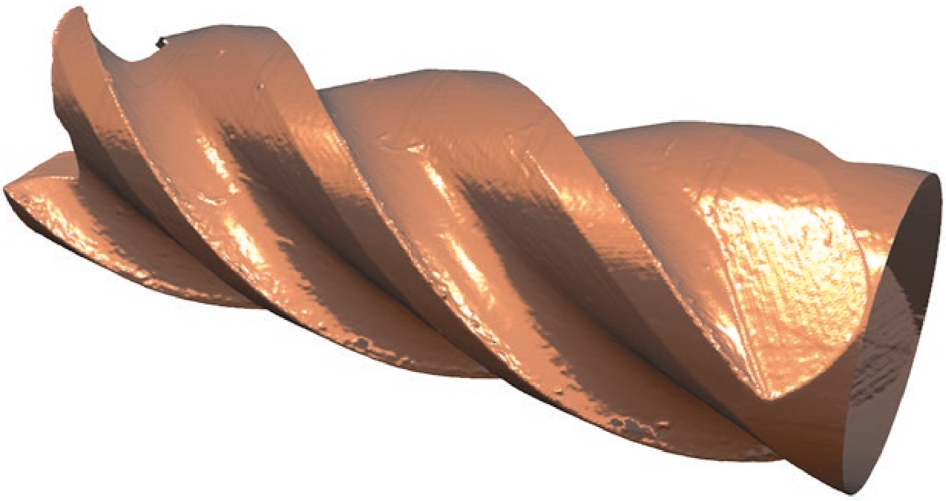


Figure 1 *shows the total 3D measurement of an endmill taken with the S neox Five Axis. This measurement provides a complete view of the endmill's surface, allowing for accurate analysis and assessment.*

This case study aims to share a multi-perspective characterization of a hard steel cobalt squared end mill 4 flute square (Figure 1).

3D SHAPE ACQUISITION

Optical metrology systems like Sensofar's S neox Five Axis are critical in characterizing various parts and optimizing manufacturing processes in the tooling industry. The S neox Five Axis system can acquire the entire 3D shape of objects, including end mills, and offers high precision and accuracy.

One of the key features of the S neox Five Axis system is its rotational module, which allows for the complete measurement of a sample's shape. This feature is particularly useful in the tooling industry, where precise measurements of cutting tool geometries are critical to achieving optimal performance.

The S neox Five Axis system offers three technologies: Confocal, Interferometry, and Active Illumination Focus Variation (Ai FV). That set of measuring technologies has made us capable of measuring multiple things in tooling like roughness, cutting edge, the entire shape of tools, and micro-tools. Although in this case, Ai FV is the preferred choice y due to its fast measurement speeds and superior ability to measure slopes.

Measurements

After acquiring the necessary data, we analyzed the mesh data comprehensively. This is where the Mountains software proves extremely useful, particularly its Shell Module, which allows for extracting information from mesh data at various levels.

The Shell Module of SensoMAP software is a powerful tool that enables users to extract dimensional and roughness information by navigating from mesh to topographical data and then to profile data. This module provides an effective means of obtaining valuable insights from the acquired data.

DIMENSIONAL ANALYSIS

In our analysis, we performed several measurements using parametric profiles generated from shell data to understand the endmill's geometry comprehensively.

The first measurement involved extracting cross-section measurements perpendicular to the cutting axis of the endmill at multiple locations along the flute length (as shown in Figure 2). By doing so, we could determine whether the tool maintained a consistent external diameter across its entire length. Additionally, we calculated the concentricity between the inner and outer circles to check for any tool run-out.

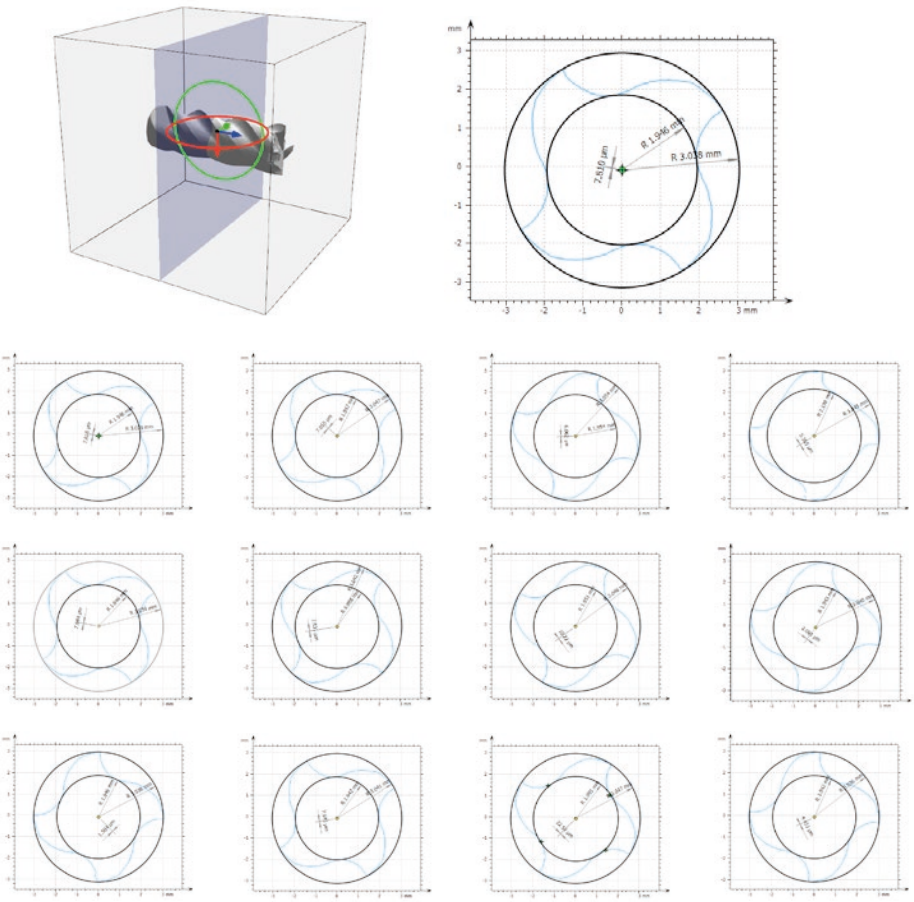


Figure 2 , *cross-sections perpendicular to the tool axis are taken with a separation of 1 mm to check the flute's diameter uniformity.*

The second measurement aimed to examine the pitch of the helix. To achieve this, we fitted the tool into a cylinder and unrolled it. Next, we extracted a profile perpendicular to the helix angle and measured the pitch distance (Figure 3). This measurement provided valuable insights into the endmill's geometry and was crucial in ensuring it functions optimally.

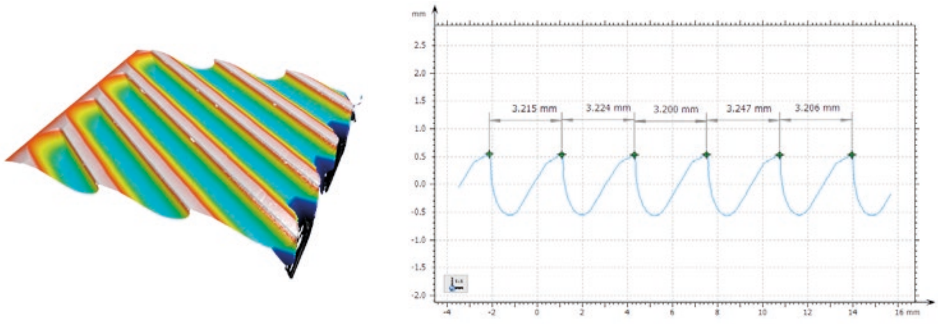
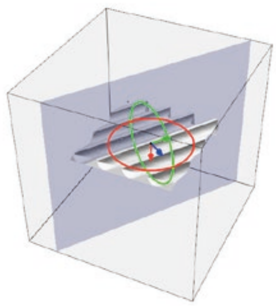


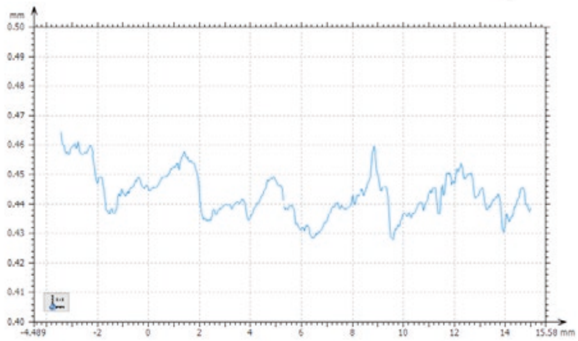
Figure 3 *displays an unrolled tool image on the right and a pitch distance measurement on the left.*

ROUGHNESS ANALYSIS

The surface finish of the edges plays a crucial role in determining the outcome. Therefore, we utilized the previously unrolled data to take a profile on top of the flute and calculated the roughness parameters according to ISO 4278.

By doing so, we ensured that the end part would have clean edges rather than rough ones, which can negatively impact the quality and performance of the final product.





ISO 4287 - Roughness (S-L)		
F: None		
S-filter (λs): Gaussian, 2.5 µm		
L-filter (λc): Gaussian, 0.8 mm		
Evaluation length: All λc (23)		
Amplitude parameters		
Rz	11.30	µm
Rt	16.95	µm
Ra	2.297	µm
Rq	2.831	µm
Rsk	-0.09558	
Rku	2.461	

Figure 4 *displays the roughness measurement from one of the tool's cutting edges. This measurement provides information on the surface texture and can help determine the tool's wear and tear.*

In conclusion, measuring the surface roughness of the edges using advanced techniques and software, such as those employed in this analysis, is crucial in achieving optimal surface finish and ensuring that the end product meets the desired specifications.

PEELING ASSESSMENT ON A CUTTING TOOL

One of the most promising features of cutting tools is their coating, which significantly impacts their durability and ability to withstand high-stress processes. Coated cutting tools have been shown to last longer and perform better than their uncoated counterparts. However, coating peeling is a significant concern and can significantly impact the performance and durability of the tool.

Fortunately, the Shell Module from SensoMAP offers an excellent solution to this issue by enabling the extraction of topographies from the mesh (Figure 4).

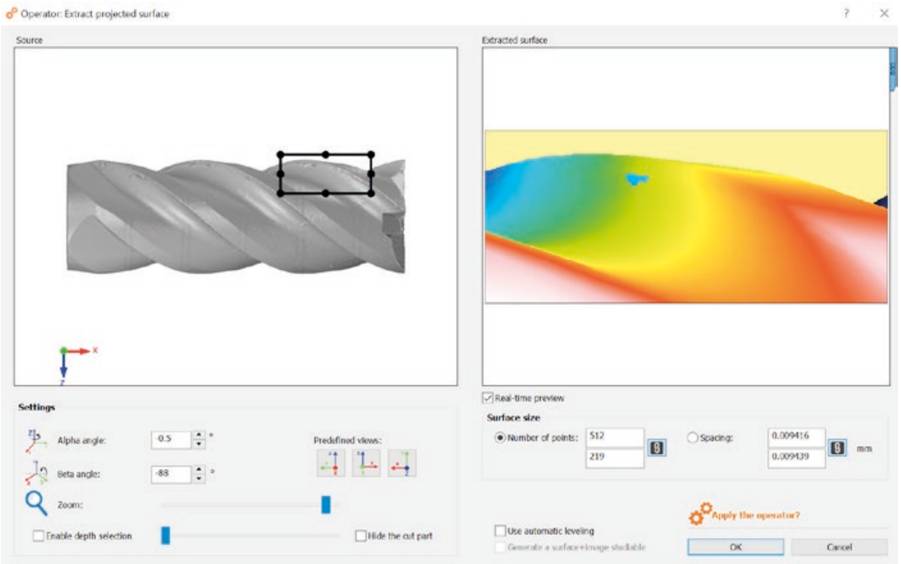


Figure 5 , *the topographical data is extracted from a complete 3D measurement to further study the peeling for a detailed examination.*

By utilizing particle analysis, we can focus solely on the areas where peeling has occurred and determine the extent of the damage. This allows us to understand the peeling area's dimensions and decide whether it is limited to the coating or if some material is missing due to chipping.

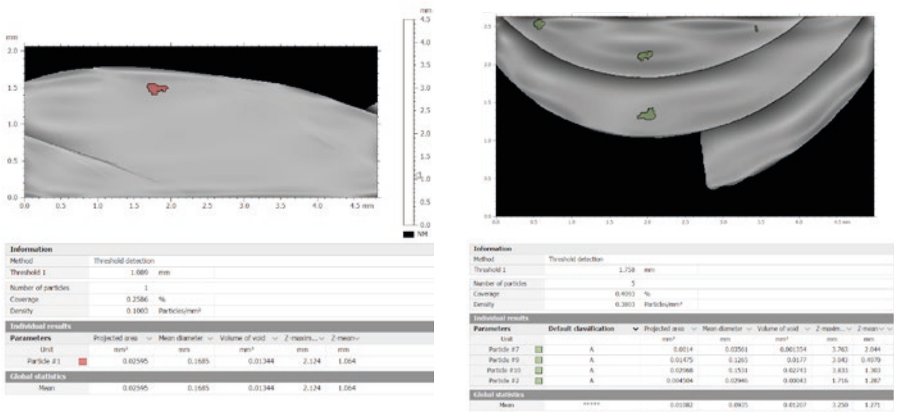


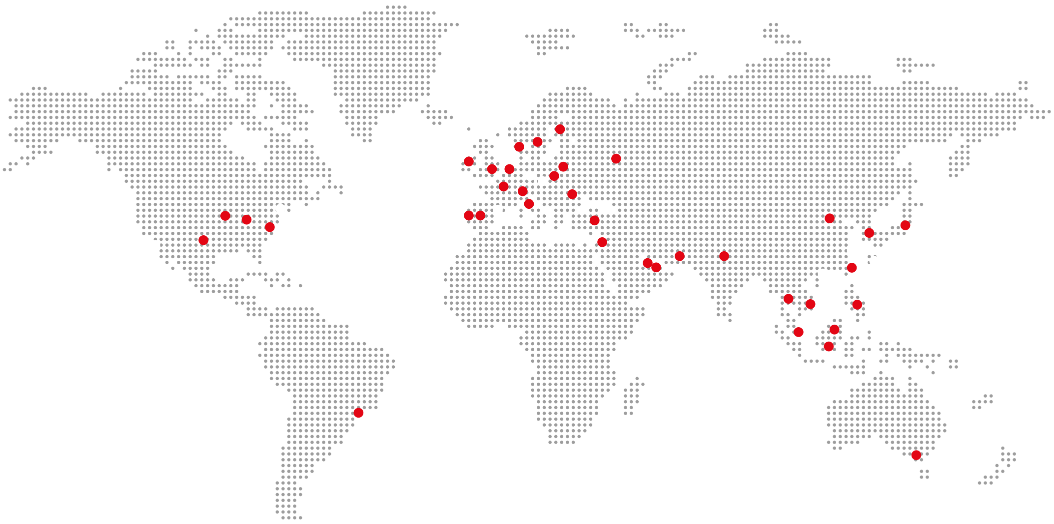
Figure 6 , *showcases the use of automatic detection from SensoMAP's Particle Detection module for peeling assessment. This technology allows for quick and accurate detection of any particles or debris on the endmill's surface, which can affect its performance.*

By identifying the extent of coating peeling and chipping, we can take appropriate action to ensure that the tool remains in optimal condition and performs to its fullest potential.

Conclusions

Integrating the S neox Five Axis and SensoMAP has proven to be an exceptional solution for tooling applications. The S neox Five Axis's innovative combination of three different measuring technologies and a rotational module has made it an indispensable tool in the tooling characterization process. Additionally, SensoMAP provides a comprehensive suite of analysis tools for shells.

This combination of SensoMAP and S neox Five Axis made it possible to characterize an end mill's dimensions, roughness, and peeling defects. With this innovative technology, manufacturers can achieve unprecedented levels of precision and accuracy, making it possible to produce high-quality products that meet the demands of today's market.



SENSOFAR is a leading-edge technology company that has the highest quality standards within the field of surface metrology

Sensofar Metrology provides high-accuracy optical profilers based on confocal, interferometry, focus variation and fringe projection techniques, from standard setups for R&D and quality inspection laboratories to complete non-contact metrology solutions for in-line production processes. The Sensofar Group has its headquarters in Barcelona, also known as a technology and innovation hub in Europe. The Group is represented in over 30 countries through a global network of partners and has its own offices in Asia, Germany and the United States.

HEADQUARTERS
SENSOFAR METROLOGY | BARCELONA - Spain | T. +34 93 700 14 92 | info@sensofar.com

SALES OFFICES
SENSOFAR ASIA | SHANGHAI - China | T. +86 21 61400058 | info.asia@sensofar.com
| TAIPEI - Taiwan | T. +886 988106002 | info.asia@sensofar.com
SENSOFAR DACH | LANGEN - Germany | T. +49 151 14304168 | info.germany@sensofar.com
SENSOFAR USA | CONNECTICUT - United States | T. +1 617 678 4185 | info.usa@sensofar.com

sensofar.com

CS29-05A-EN-DIGITAL SURF