CASE Study

Drill Bit Characterization with the NPFLEX 3D Optical Microscope

Comprehensive and Rapid Non-Contact Tool Metrology

An industry-leading hand and electric tool company is utilizing Bruker's NPFLEX™ 3D Optical Microscope for R&D and product quality control in their drill bit manufacturing. It is known within the industry that there is a correlation between the surface roughness of critical tool surfaces and a tool's ultimate function. The difficulty for this company was finding a solution that could easily, quantitatively, and repeatably measure the surface roughness.

Previously they had used 3D stereo microscopes to take pictures of the drill bits from differing angles. They would then use simple image analysis to identify metal burrs and damage to the drill bits. This methodology was very user dependent and was subject to varied part positioning and subjective user analysis. Surface roughness and its impact on the quality of the production grade product remained an enigma. Additionally, it was very difficult to compare new data to prior measurements due to these variables and resulting lack of gauge capability.

Figure 1. NPFLEX 3D Optical Microscope.

Smaller optical microscopes provided a challenge for positioning larger samples or imaging drill bits from an end-on perspective. Bruker's NPFLEX resolves this issue with a large gantry capable of holding a 1 foot cubed part that weighs up to 150 pounds (see figure 1).

Part loading and manipulation on this system is very easy. Secondly, the NPFLEX has optimized long working distance objectives that allow the part being imaged to be in focus at a distance of 33 millimeters from the objective (see figure 2). This makes capturing images from difficult to reach geometries much easier. The long working distance combined with a crash mitigation device also gives everyday users a large margin of error and serves to ensure crashing of the objective does not occur, providing operators peace of mind.

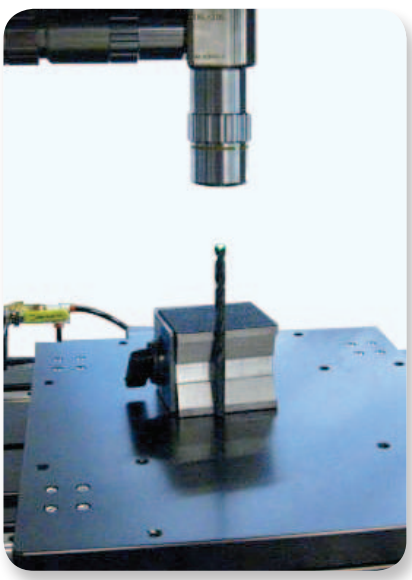

Figure 2. Drill bit.

The result of this combination of features enabled the NPFLEX to perform repeatable multiple measurements on multiple drill bits from even end-on angles. Metric surface dimensional data was rendered easily into standard reports (see figures 3 and 4). This gave the manufacturer a metric measurement capability that was objective and comparable through time. The issue of user dependence is minimized, allowing the company to focus on their metrology problem rather than the metrology process.

In this case, the surface roughness on the drill bit for the simple changes in critical surface finish that could impact the tool's longevity. They set up a testing regime to identify parameters to ensure production was within specified parameters (see tables 1 and 2).

In addition to the QC applications of NPFLEX, the tooling manufacturer's R&D group was able to utilize the tool for more extensive material and tribology analysis. Studies were conducted on high-speed steel drill bits used to drill into anodized aluminum plates. Data was collected from three distinct regions of the drill bits (see figure 5).

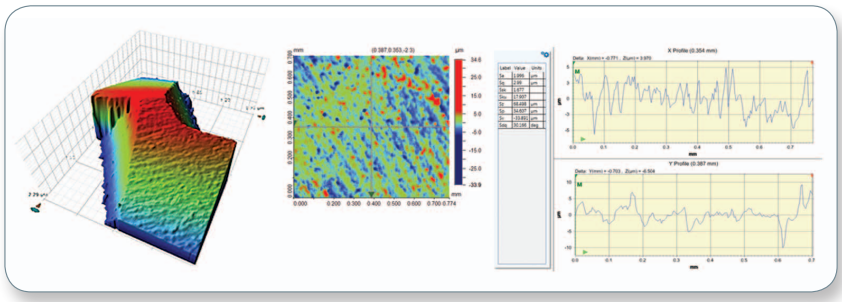

Figure 3. New drill bit off production line.

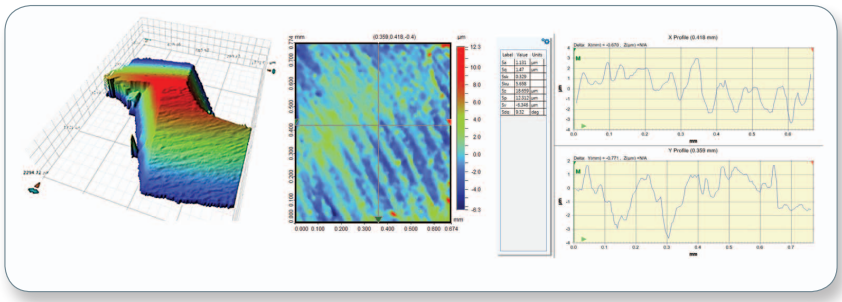

Figure 4. Same drill bit post drilling sequence tribology test.

Label	Value	Units
Sa	1.989	µm
Sp	34.437	µm
Sq	2.962	µm
St	68.344	µm
Sv	-33.907	µm

Table 1. New drill bit roughness parameters.

Label	Value	Units
Sa	1.114	µm
Sp	7.408	µm
Sq	1.418	µm
St	12.896	µm
Sv	-5.488	µm

Table 2. Used drill bit roughness parameters.

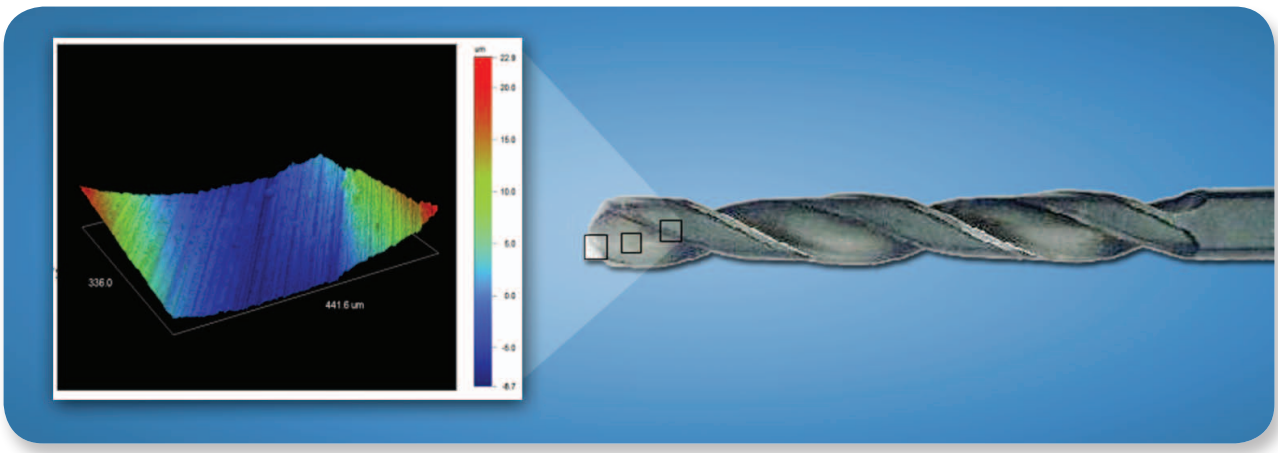

Figure 5. Image showing points of data collection (head, forward surface, and inside surface) from various drill bits.

It was found that the radii of curvature and edge quality remained unaffected but the Str parameter (which helps determine lay or recurring pattern) and bearing ratios changed after certain usage amounts (see figure 6).
This indicated that although initial drill bit usage smoothed the surface (as indicated by results in figures 3 and 4) further prolonged usage caused decreased smoothing. The images obtained actually showed significant material re-deposition occurring upon prolonged test periods (see figure 6). Initially, the drill bits would smooth out but with prolonged usage the drill bit material was displaced causing a roughening of the surface.

Additionally, a cross-material analysis was performed where several drill bits that differed, either in materials or coatings, were used and measured pre- and post-testing. The drill bits used were Titanium CarboNitride (TiCN), High Speed Steel (HSS), a drill bit with Titanium Nitrite (TiN) coating, and one containing a Silicon Carbide nano-composite. The post usage results obtained with these bits are shown in figure 7.

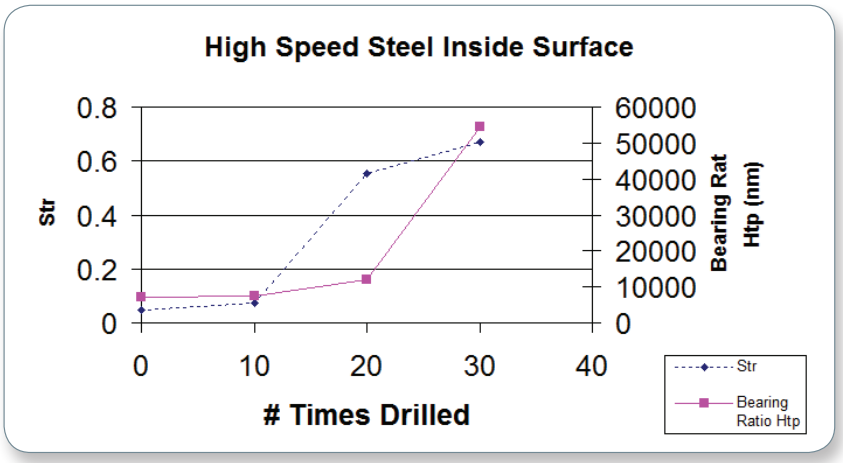

Figure 6. Surface texture analysis of drill bits with increasing usage.

The results clearly indicated that the Silicone Carbide composite drill bit experienced the least amount of material re-deposition after usage.

The simplicity and ease of use of the NPFLEX 3D Optical Microscope, combined with critical measurement capabilities, allowed this large tool manufacturer to test drill bit performance, develop improved tool quality at lower cost, while increasing their speed to market.

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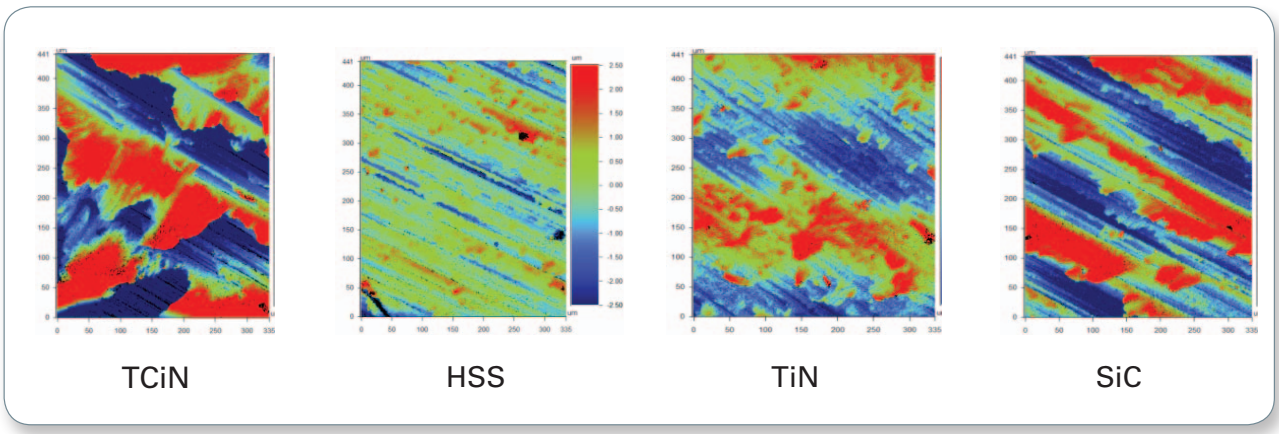

Figure 7. Cross-material characterization of drill bits post-tribology testing.

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