PROGRESSIVE WEAR MAPPING OF FLOO

USING TRIBOMETER WITH INTEGRATED PROFILOME

Prepared by

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INTRODUCTION

Flooring materials are designed to be durable, but they often suffer wear and tear from everyday activities such as movement and furniture use. To ensure their longevity, most types of flooring have a protective wear layer that resists damage. However, the thickness and durability of the wear layer vary depending on the flooring type and level of foot traffic. In addition, different layers within the flooring structure, such as UV coatings, decorative layers, and glaze, have varying wear rates. That's where progressive wear mapping comes in. Using the **NANOVEA** T2000 Tribometer with an integrated 3D Non-Contact Profilometer, precise monitoring, and analysis of the performance and longevity of flooring materials can be done. By providing detailed insight into the wear behavior of various flooring materials, scientists and technical professionals can make more informed decisions when selecting and designing new flooring systems.

IMPORTANCE OF PROGRESSIVE WEAR MAPPING FOR FLOOR PANELS

Flooring testing has traditionally centered on the wear rate of a sample to determine its durability against wear. However, progressive wear mapping allows analyzing the sample's wear rate throughout the test, providing valuable insights into its wear behavior. This in-depth analysis allows for correlations between friction data and wear rate, which can identify the root causes of wear. It should be noted that wear rates are not constant throughout wear tests. Thus, observing the progression of wear gives a more accurate assessment of the sample's wear. Progressing beyond traditional testing methods, the adoption of progressive wear mapping has contributed to significant advancements in the field of flooring testing.

The **NANOVEA** T2000 Tribometer with an integrated 3D Non-Contact Profilometer is a groundbreaking solution for wear testing and volume loss measurements. Its ability to move with precision between the pin and the profilometer guarantees the reliability of results by eliminating any deviation in wear track radius or location. But that's not all - the 3D Non-Contact Profilometer's advanced capabilities allow for high-speed surface measurements, reducing scanning time to mere seconds. With the capability of applying loads of up to 2,000 N and achieving spinning speeds of up to 5,000 rpm, the **NANOVEA** T2000 Tribometer offers versatility and precision in the evaluation process. It's clear that this equipment holds a vital role in progressive wear mapping.
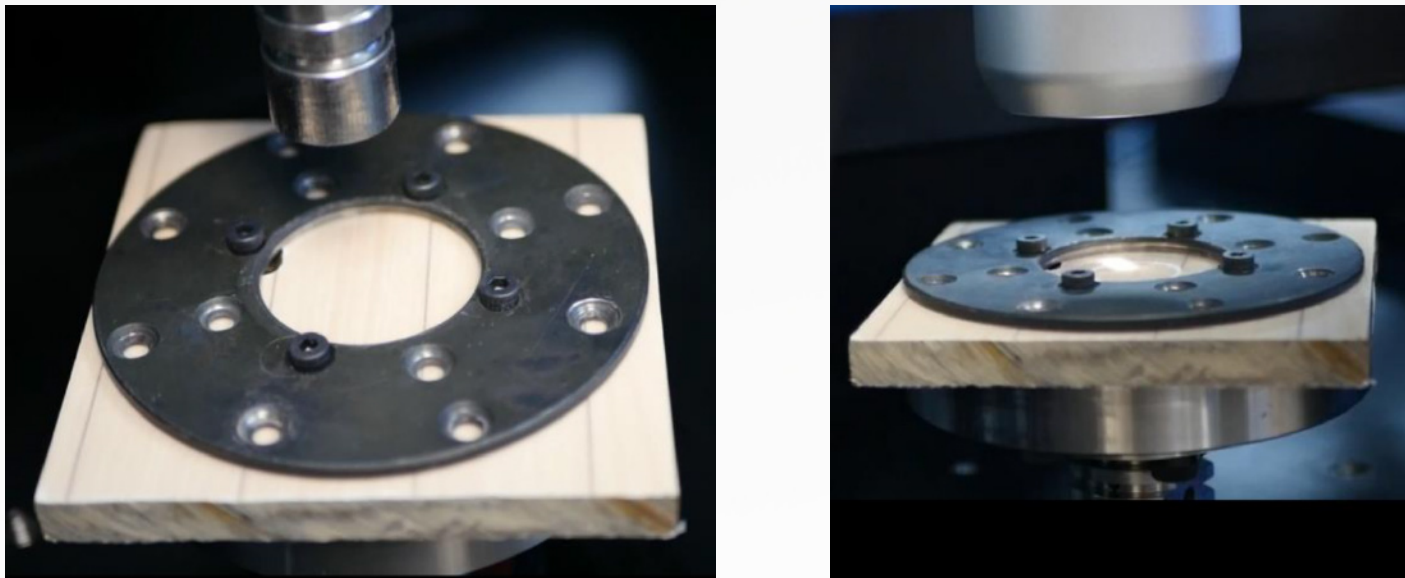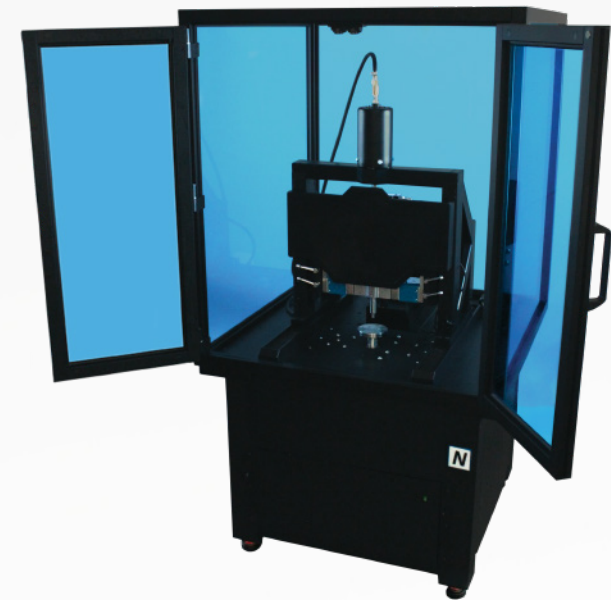

FIGURE 1: *Sample set-up prior to wear testing*
(left) and post wear test profilometry of the wear track (right).

MEASUREMENT OBJECTIVE

NANOVEA T2000
High-Load Pneumatic Tribometer

Progressive wear mapping testing was performed on two types of flooring materials: stone and wood. Each sample underwent a total of 7 test cycles, with increasing test durations of 2, 4, 8, 20, 40, 60, and 120 s, allowing for a comparison of wear over time. After each test cycle, the wear track was profiled using the **NANOVEA** 3D Non-Contact Profilometer. From the data collected by the profiler, the volume of the hole and wear rate can be analyzed using the integrated features in the **NANOVEA** Tribometer software or our surface analysis software, Mountains.

THE SAMPLES

TEST PARAMETERS

LOAD .... 40 N

TEST DURATION .... varies

SPEED 200rpm

RADIUS .... 10 mm

DISTANCE .... varies

BALL MATERIAL .... Tungsten Carbide

BALL DIAMETER .... 10 mm

Test duration used over the 7 cycles were 2, 4, 8, 20, 40, 60, and 120 seconds, respectively.

The distances traveled were 0.40, 0.81, 1.66, 4.16, 8.36, 12.55, and 25.11 meters.

TEST RESULTS

WOOD FLOORING

Test Cycle	Max COF	Min COF	Avg COF
1	0.335	0.124	0.275
2	0.337	0.207	0.295
3	0.380	0.229	0.329
4	0.393	0.265	0.354
5	0.352	0.205	0.314
6	0.345	0.199	0.312
7	0.315	0.211	0.293

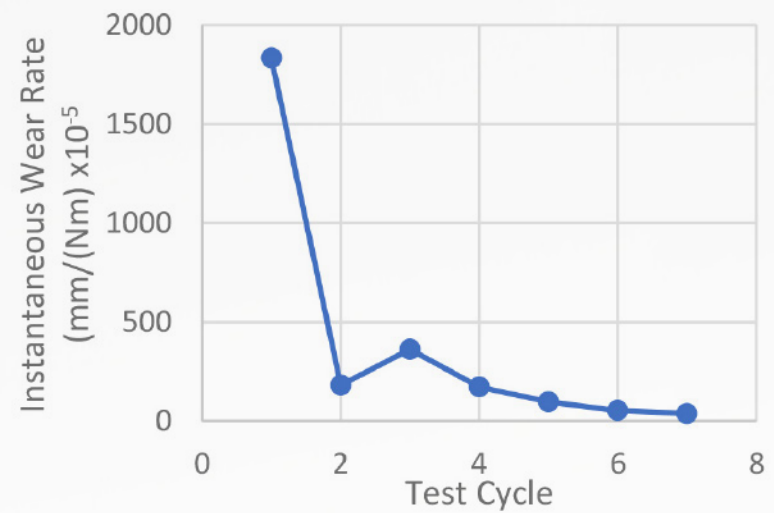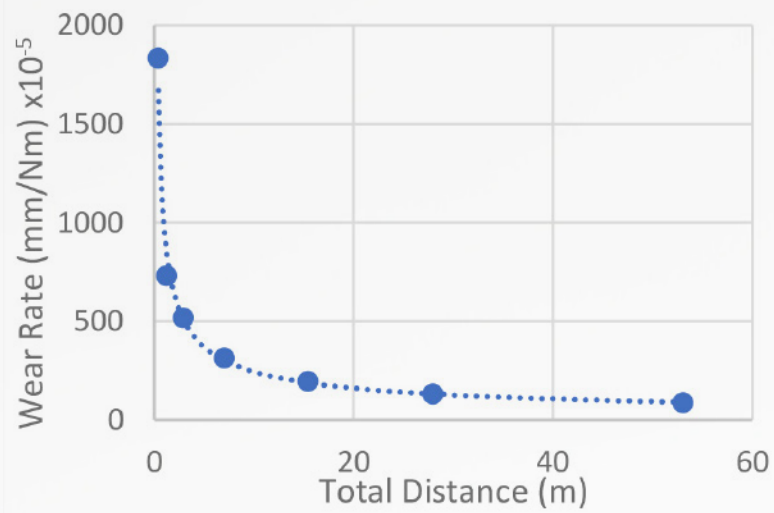| Test Cycle	Total Volume Loss (μm^3)	Total Distance Traveled (m)	Wear Rate (mm/Nm) $x10^{-5}$	Instantaneous Wear Rate (mm/Nm) $x10^{-5}$
1	296247687	0.40	1833.746	1833.746
2	355245227	1.22	1093.260	181.5637
3	596371326	2.88	898.242	363.1791
4	883747767	7.04	530.629	172.5496
5	1207179951	15.40	360.889	96.69074
6	1472745318	27.95	293.329	52.89311
7	1851319210	53.06	184.343	37.69599

FIGURE 2: *Wear rate vs total distance traveled (left)
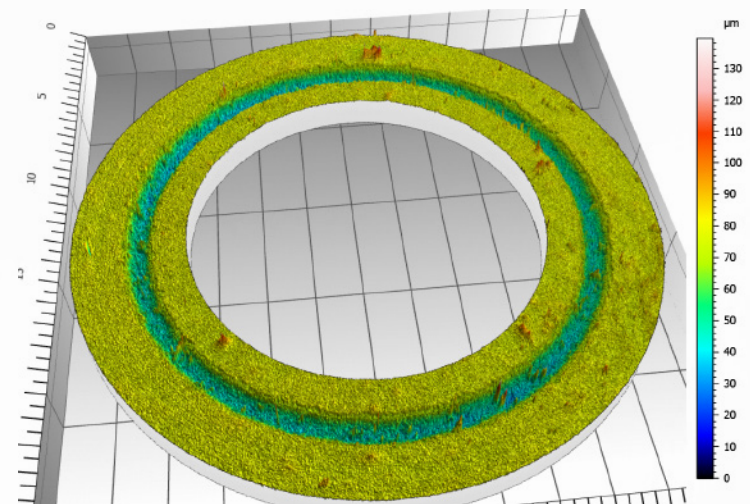and instantaneous wear rate vs test cycle (right) for wood flooring.*

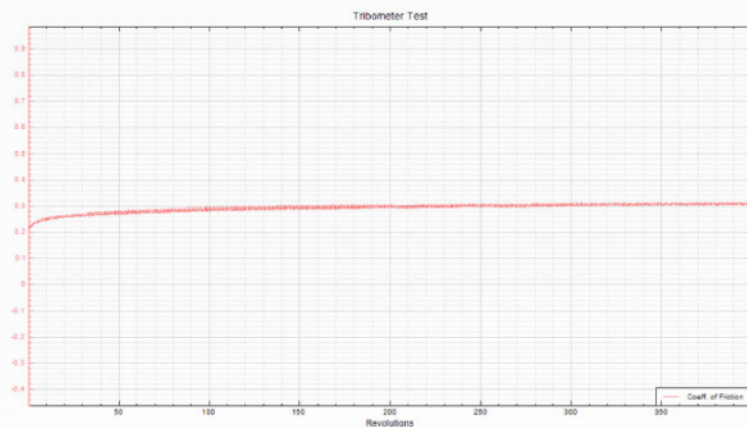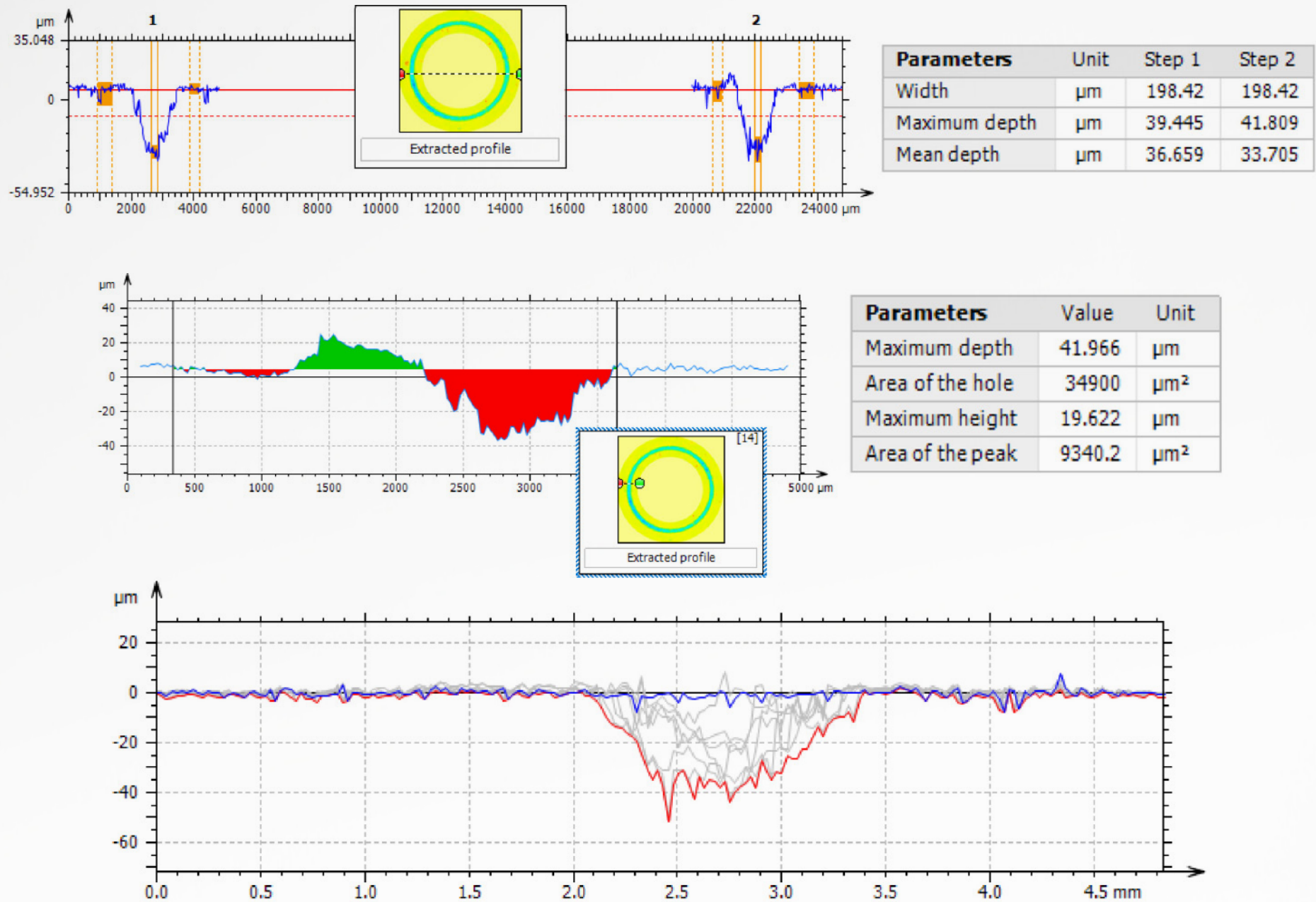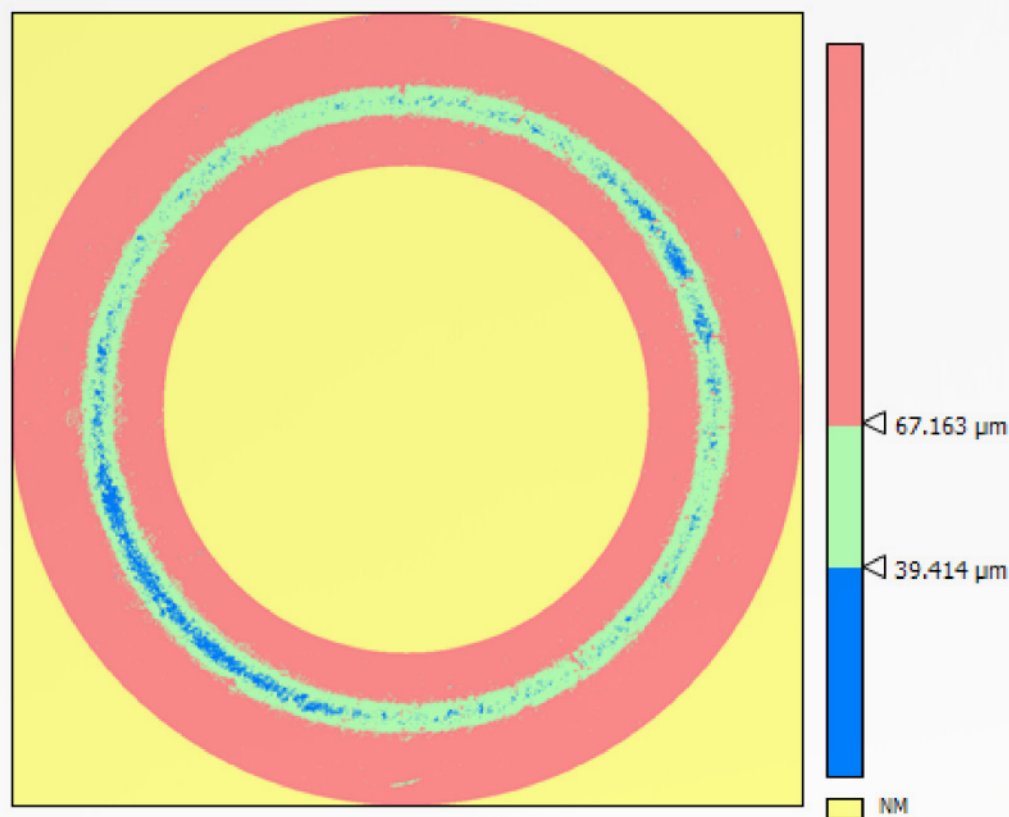**FIGURE 3:** *COF graph and 3D view of wear track from test #7 on wood flooring.*

Parameters	Unit	Step 1	Step 2
Width	μm	198.42	198.42
Maximum depth	μm	39.445	41.809
Mean depth	μm	36.659	33.705

Extracted profile

Parameters	Value	Unit
Maximum depth	41.966	μm
Area of the hole	34900	μm²
Maximum height	19.622	μm
Area of the peak	9340.2	μm²

[14]

Extracted profile

FIGURE 4: *Cross-Sectional Analysis of Wood Wear Track from Test #7.*

Parameters	Unit	■ (blue)	□ (green)	■ (red)
Projected area	%	2.1486	17.685	80.167
Volume of void	%	0.21185	11.485	87.522
Volume of material	%	99.788	88.515	12.478
Volume of void	µm³/µm²	0.083501	3.1870	63.326
Volume of material	µm³/µm²	39.331	24.562	9.0286
Mean thickness of void	µm	0.083501	3.1870	63.326
Mean thickness of material	µm	39.331	24.562	9.0286

FIGURE 5: *Volume and Area Analysis of Wear Track on Wood Sample Test #7.*

For full result details, click here.

TEST RESULTS

STONE FLOORING

Test Cycle	Max COF	Min COF	Avg COF
1	0.249	0.035	0.186
2	0.349	0.197	0.275
3	0.294	0.154	0.221
4	0.503	0.124	0.273
5	0.548	0.106	0.390
6	0.510	0.129	0.434
7	0.527	0.181	0.472

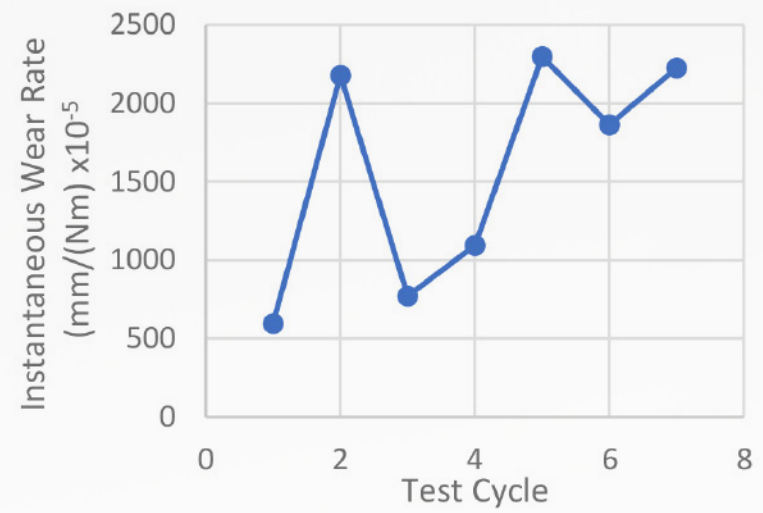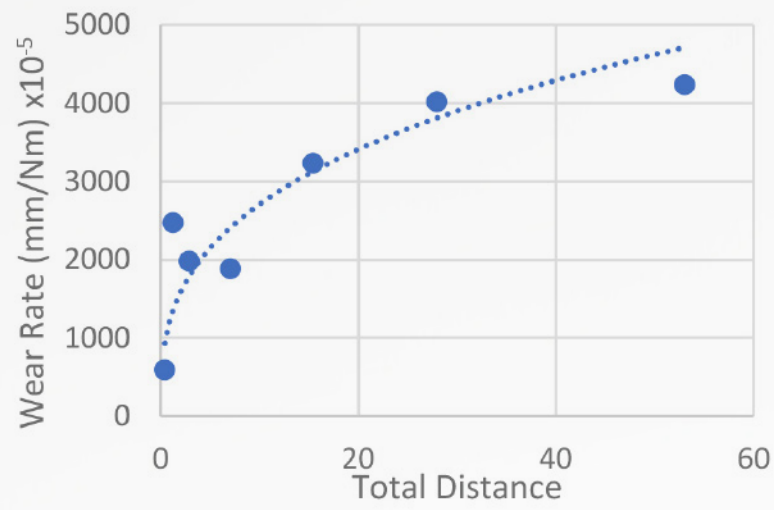| Test Cycle	Total Volume Loss (μm^3)	Total Distance Traveled (m)	Wear Rate (mm/Nm) $x10^{-5}$	Instantaneous Wear Rate (mm/Nm) $x10^{-5}$
1	96278846	0.40	595.957	595.9573
2	804289731	1.22	2475.185	2178.889
3	1316147855	2.88	1982.355	770.9501
4	3136530215	7.04	1883.269	1093.013
5	10821732180	15.40	3235.180	2297.508
6	20174960343	27.95	4018.282	1862.899
7	42512063420	53.06	4233.081	2224.187

FIGURE 6: *Wear rate vs total distance travelled (left) and instantaneous wear rate vs test cycle (right) for stone flooring.*
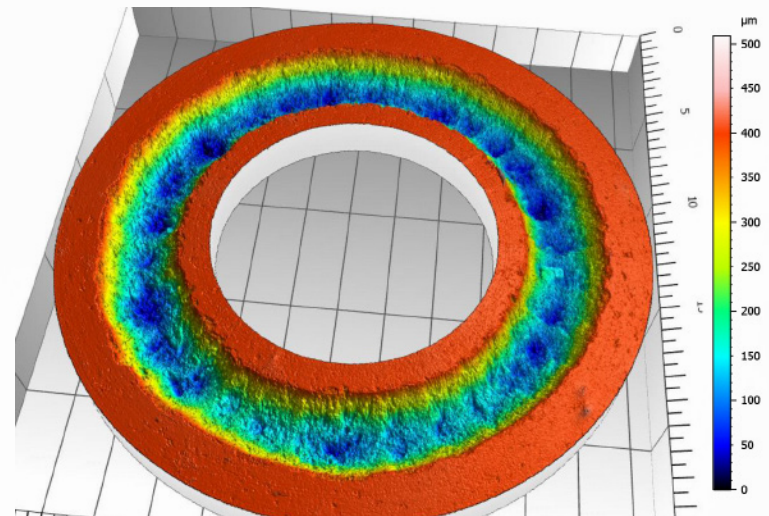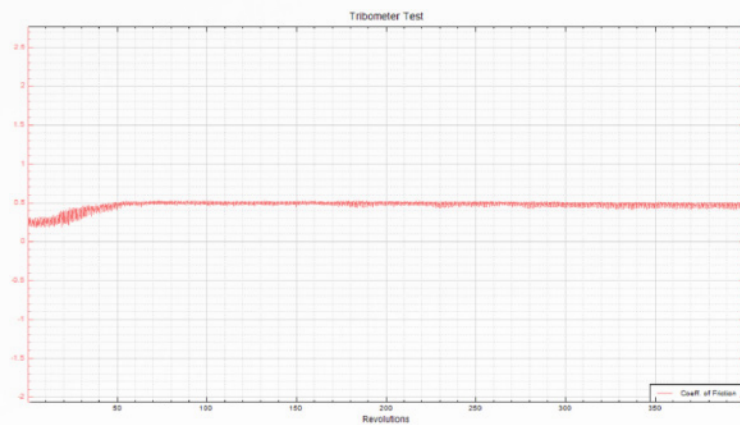

FIGURE 7: *COF graph and 3D view of wear track from test #7 on stone flooring.*
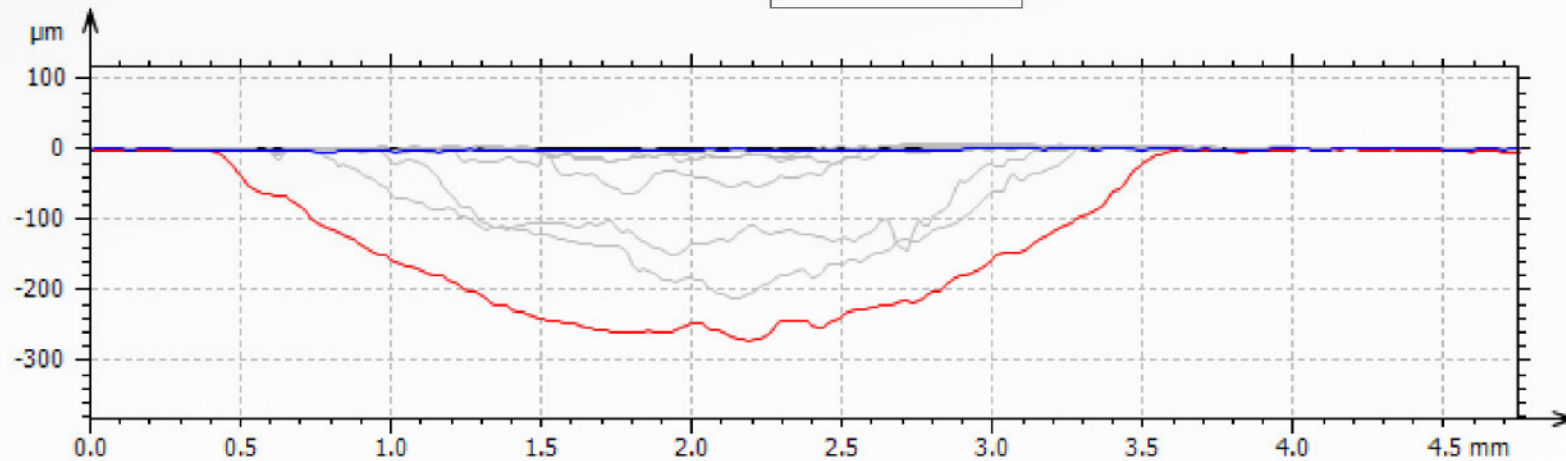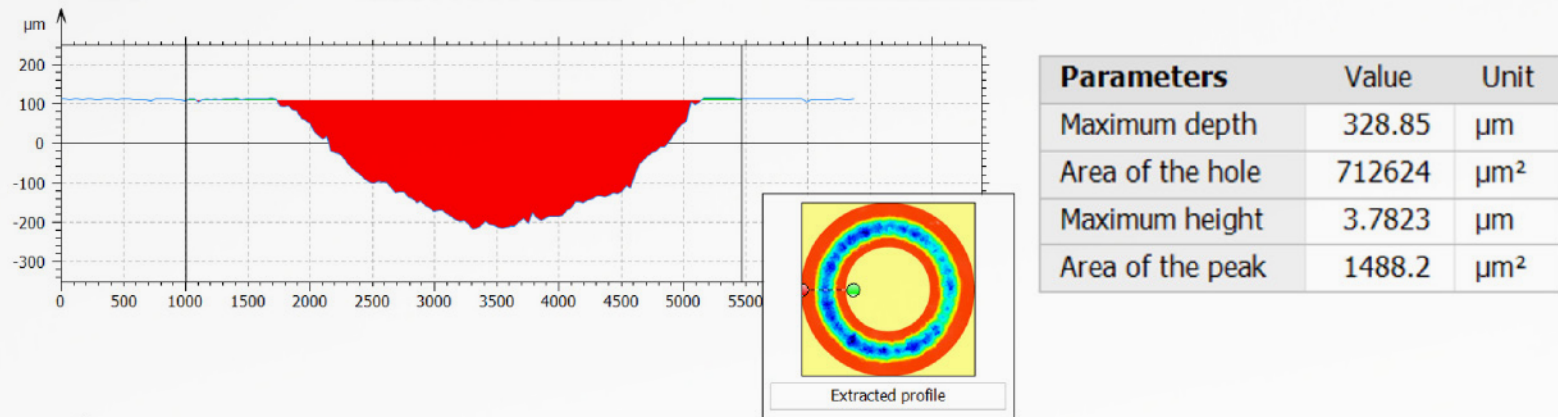
Parameters	Unit	Step 1	Step 2
Width	µm	550.69	447.43
Maximum depth	µm	327.79	308.56
Mean depth	µm	319.39	301.89

Parameters	Value	Unit
Maximum depth	328.85	µm
Area of the hole	712624	µm²
Maximum height	3.7823	µm
Area of the peak	1488.2	µm²
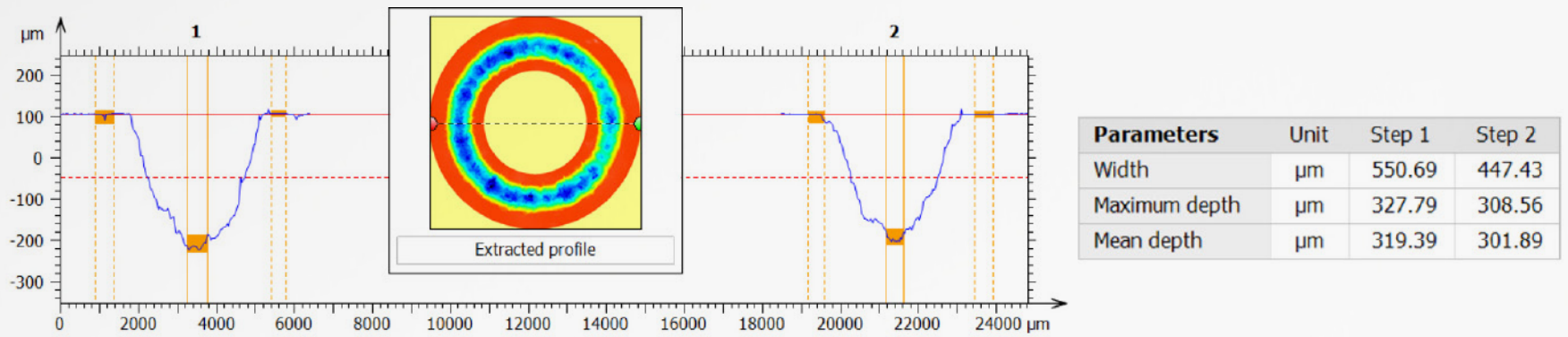
FIGURE 8: *Cross-Sectional Analysis of Stone Wear Track from Test #7.*

Color scale markers: 364.01 µm, 139.24 µm, NM

Parameters	Unit	■	■	■
Projected area	%	17.517	30.037	52.445
Volume of void	%	4.7471	35.328	87.177
Volume of material	%	95.253	64.672	12.823
Volume of void	µm³/µm²	6.6096	79.410	126.71
Volume of material	µm³/µm²	132.63	145.37	18.639
Mean thickness of void	µm	6.6096	79.410	126.71
Mean thickness of material	µm	132.63	145.37	18.639

FIGURE 9: Volume and Area Analysis of Wear Track on Stone Sample Test #7.

For full result details, click here.

DISCUSSION

The instantaneous wear rate is calculated with the following equation:

$$\frac{\Delta V}{N \Delta X} = \frac{V_n - V_{n-1}}{N(X_n - X_{n-1})}$$

where V is the volume of a hole, N is the load and X is the total distance.[1] This equation describes the wear rate between test cycles. The instantaneous wear rate can be used to better identify changes in wear rate throughout the test.

Both samples have very different wear behaviors. Over time, the wood flooring starts with a high wear rate, but quickly drops to a smaller, steady value. For the stone flooring, the wear rate appears to start at a low value and trends to a higher value over cycles. The instantaneous wear rate also appears to show little consistency. The specific reason for the difference is not certain, but may be due to the structure of the samples. The stone flooring seems to consist of loose grain-like particles which would wear differently compared to the wood's compact structure. Additional testing and research would be needed to ascertain the cause for this wear behavior.

The data from the COF seems to agree with the wear behavior observed. The COF graph for the wood flooring appear consistent throughout the cycles, complementing its steady wear rate. For the stone flooring, the average COF increases throughout the cycles, similar to how the wear rate also increases with cycles. There are also apparent changes in the shape of the friction graphs, suggesting changes in how the ball is interacting with the stone sample. This is most apparent in cycle 2 and cycle 4.

[1] Erck, R. A., and O. O. Ajayi. "Analysis of sliding wear rate variation with nominal contact pressure." Proceedings of international joint tribology conference. 2001.

CONCLUSION

The **NANOVEA** T2000 Tribometer showcases its ability to perform progressive wear mapping by analyzing the wear rate between two different flooring samples. Pausing the continuous wear test and scanning the surface with the **NANOVEA** 3D Non-Contact Profilometer provides valuable insights into the material's wear behavior over time.

The **NANOVEA** T2000 Tribometer with the integrated 3D Non-Contact Profilometer provides a wide variety of data, including COF (Coefficient of Friction) data, surface measurements, depth readings, surface visualization, volume loss, wear rate, and more. This comprehensive set of information allows users to gain a deeper understanding of the interactions between the system and the sample. With its controlled loading, high precision, ease of use, high loading, wide speed range, and additional environmental modules, the **NANOVEA** T2000 Tribometer takes tribology to the next level.

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