WOOD WEAR TESTING
USING TRIBOMETER

Prepared by

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INTRO

Wood has been used for thousands of years for building houses, furniture and flooring as a construction material. The combination of environmental profile, natural beauty, durability and restorability make it a common choice as a flooring material. Unlike carpet, the hardwood floor keeps its color for a long time and it can be easily cleaned and maintained, particularly in the living room, hallways, and kitchens. However, as natural materials, the hardwood floors are expensive and time-consuming to install. This makes it important to compare and select the most affordable and durable wood as flooring material.

IMPORTANCE OF RELIABLE WEAR EVALUATION FOR WOOD

The service behavior of the species of wood used for flooring is often related to its wear resistance. The change in the individual cellular and fiber structure of different species of wood contributes to their different mechanical and tribological behaviors. Actual service-tests of wood as flooring materials are expensive, difficult to duplicate, and require long periods of testing time. As a result, it becomes valuable to develop a simple wear test for simulating and indicating the wear resistance of wood.

MEASUREMENT OBJECTIVE

In this study, we simulated and compared the wear behaviors of three types of wood to showcase the capacity of Nanovea Tribometer in evaluating the tribological properties of wood in a controlled and monitored manner.

Fig. 1: Pin-on-disk wear test on the cherry wood sample.

TEST PROCEDURE

The coefficient of friction, COF, and the wear resistance of three wood samples were evaluated by Nanovea Tribometer using Pin-on-Disc Wear Module. An SS440 ball (6 mm diameter) was used as the counter material. The test parameters are summarized in Table 1. The wear rate, K, was evaluated using the formula $K=V/(F\times s)$, where V is the worn volume, F is the normal load, and s is the sliding distance. Wear track 3D profiles were measured by the Nanovea Optical Profilometer, and the wear track morphology was examined using optical microscope.

Please note that the SS440 ball as a counter material was used as an example in this study, any solid material with different shapes can be applied using custom fixture to simulate the actual application situation.

Wood samples	Cherry, Maple, Walnut
Normal force	30 N
Wear ring radius	5 mm
Speed	100 RPM
Duration of test	60 min

Table 1: Test parameters of the wear measurements.

RESULTS AND DISCUSSION

The evolution of COF during the wear tests of three wood samples are plotted in Fig. 2. The Maple and Walnut samples show relatively constant low COFs of ~0.14 and ~0.12, respectively, throughout the wear test. Smooth shallow wear tracks were created with no visible presence of debris. In comparison, the Cherry sample exhibits a low COF of ~0.13 in the first 150 revolutions, followed by a significant increase to high COF values above 0.45. Such a drastic change of COF is due to the severe wear of the Cherry sample against the SS440 ball taking place at the contact face, which generates abrasive debris in the wear track and in turn accelerates the wear process.

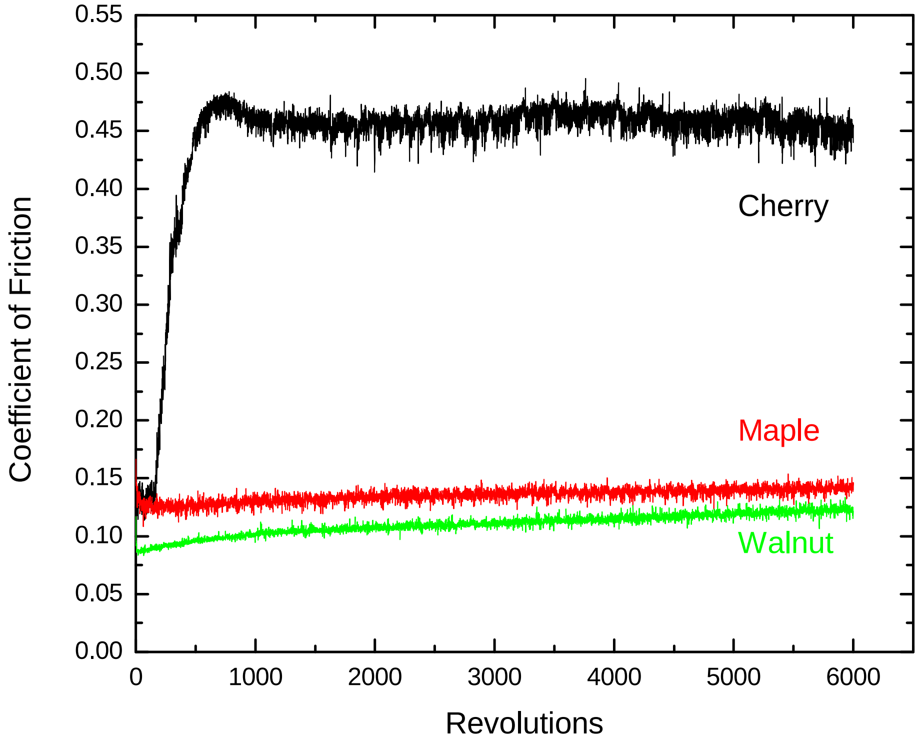


Fig. 2: Evolution of COF of the three wood samples.

Fig. 3 shows the wear tracks of the samples under the optical microscope and Fig. 4 compares the 3D wear tracks of the wood samples after the wear tests. Table 2 summarized the results of the wear track analysis. The wear track evaluation is in agreement with the observation of COF evolution: The Cherry sample, which shows increased COF after the first 150 revolutions, exhibits the highest wear rate of 14.5×10^4 mm^3/N m, compared to 5.1×10^4 and 1.2×10^4 mm^3/N m for Maple and Walnut, respectively. It is interesting to note that the Cherry sample possesses a high hardness of 0.095 GPa, compared to 0.031 and 0.078 GPa, respectively, for Maple and Walnut. This makes it seemingly counterintuitive to the fact that the harder material usually shows better wear resistance.

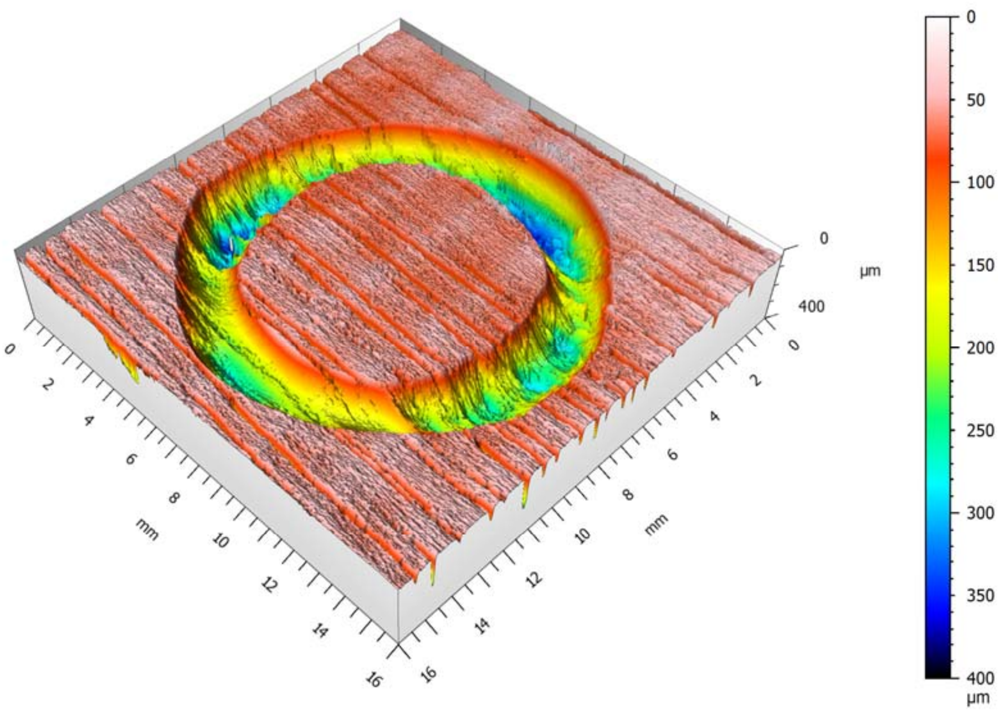
Closer observation on the 3D profiles of the wear track shows that the cherry sample surface possesses a coarse texture full of gaps or cracks along the wood cellular and fiber direction. Such surface defects could probably act as weak spots where the wear initiates and propagates. The debris generated in this process plays a role as an abrasive media and in turn accelerates the wear process. In comparison, Maple and Walnut show relatively dense and smooth surface texture, which is critical in reducing their risk of getting worn.

This study not only compares the wear resistance of three types of wood, but also demonstrates the importance of surface finish and treatment on the hardwood flooring, e.g. oil-modified urethane and water-based polyurethane coatings. Proper surface treatment can fill and cover the defects in the wood and provide a more durable and long lasting surface. In addition, it protects the wood floor from stains, damage, and moisture penetration, which is the key of the longevity of wood flooring.

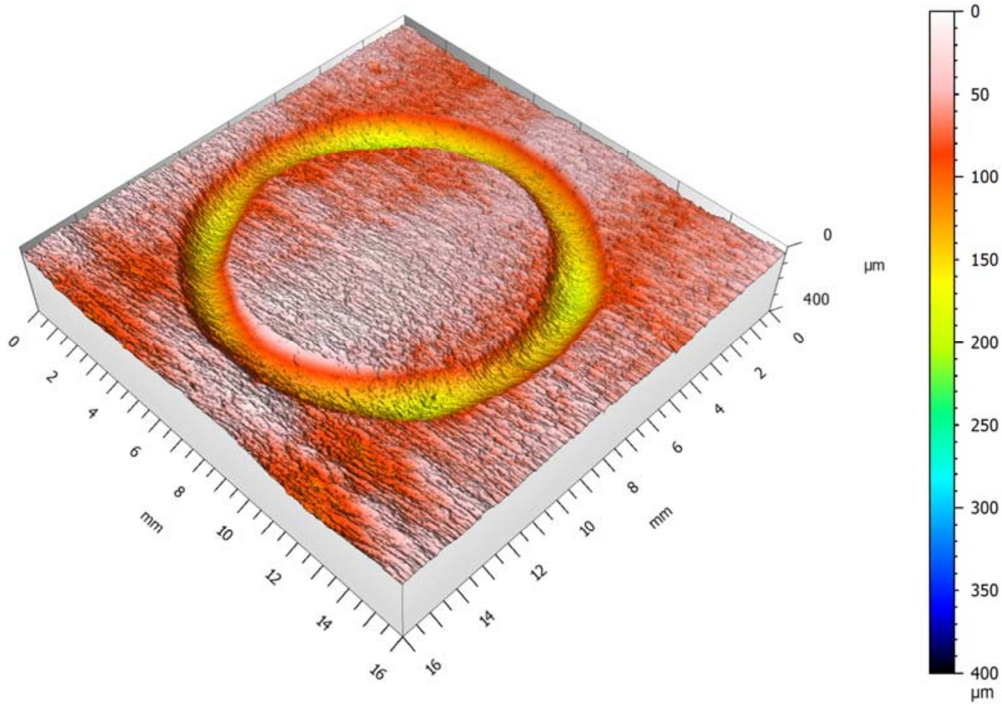
(a) Cherry: (b) Maple: (c) Walnut:

Fig. 3: Wear tracks under optical microscope.

(a) Cherry:



(b) Maple:



(3) Walnut:

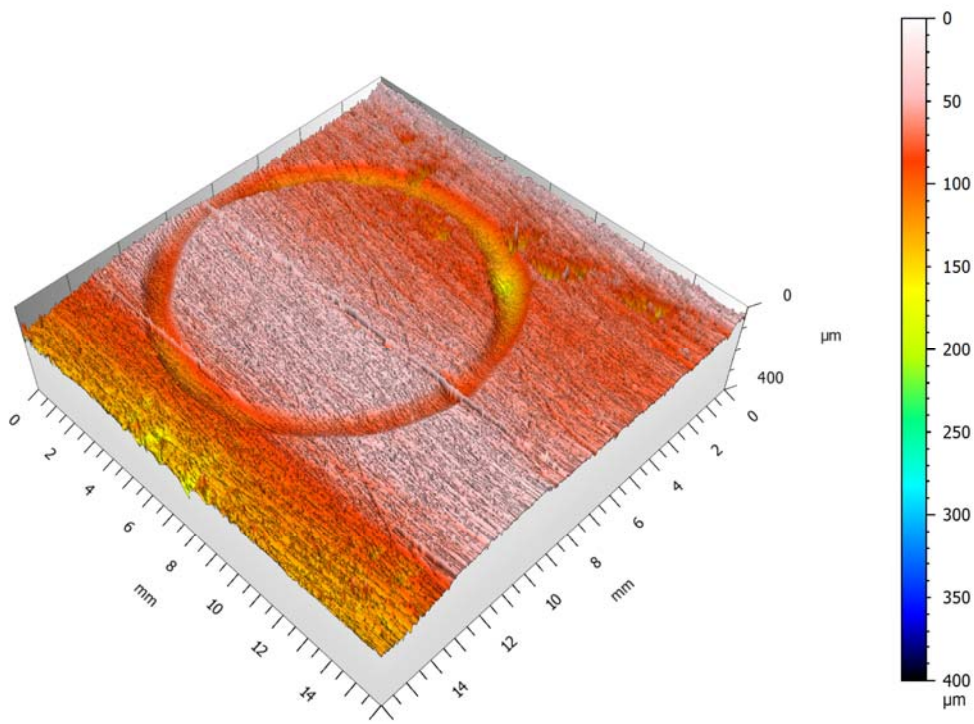


Fig. 4: 3D views of the wear tracks.

	Wear track volume mm^3	Wear rate mm^3/N m
Cherry	8.24	14.5×10^4
Maple	2.94	5.1×10^4
Walnut	0.67	1.2×10^4

Table 2: Result summary of wear track analysis.

CONCLUSION

In this study, we showcased the capacity of Nanovea Tribometer in evaluating the coefficient of friction and wear resistance of three types of wood, i.e. Cherry, Maple and Walnut in a controlled and monitored manner. The superior mechanical property of the Walnut leads to its better wear resistance. The texture and homogeneity of the wood surface plays an important role in the wear behavior. The surface defects such as gaps or cracks between the wood cell fibers may become the weak spots where the wear initiates and propagates.

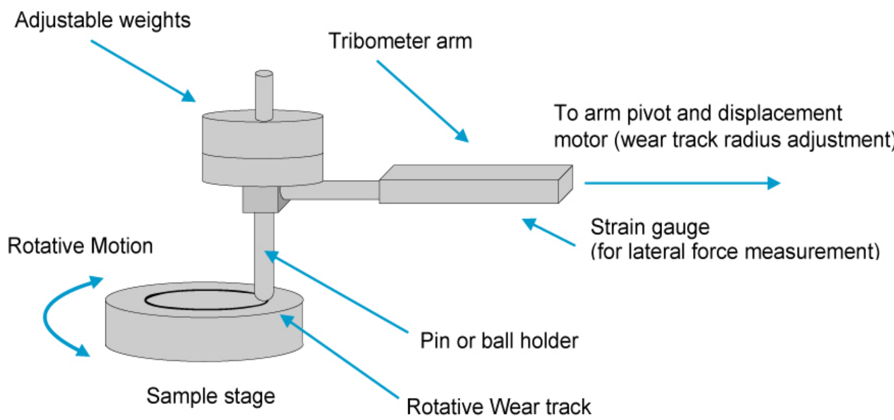
Nanovea Tribometer offers precise and repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes, with optional high temperature wear, lubrication and tribo-corrosion modules available in one pre-integrated system. Nanovea's unmatched range is an ideal solution for determining the full range of tribological properties of thin or thick, soft or hard coatings, films and substrates.

Learn More about the Nanovea Tribometer, Nanovea Profilometer and Lab Service

APPENDIX: MEASUREMENT PRINCIPLE

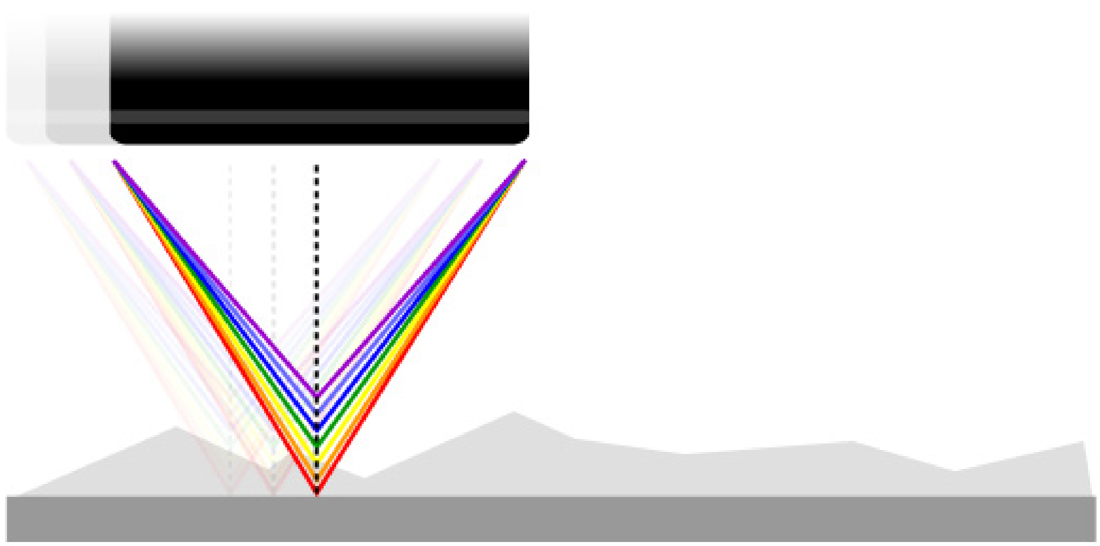
PIN-ON-DISC WEAR PRINCIPLE

A flat or a sphere shaped indenter is loaded on the test sample with a precisely known force. The indenter (a pin or a ball) is mounted on a stiff lever, designed as a frictionless force transducer. As the plate slides in a rotational motion, the resulting frictional forces between the pin and the plate are measured using a strain gage sensor on the arm. Wear rate values for both the pin and sample may also be calculated from the volume of material lost during a specific friction run. This simple method facilitates the determination and study of friction and wear behavior of almost every solid state material combination, with varying time, contact prescsure, velocity, temperature, humidity, lubrication, etc.



3D NON-CONTACT PROFILOMETER 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.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, White light Axial Chromatism 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/opaque, specular/diffusive or polished/rough.