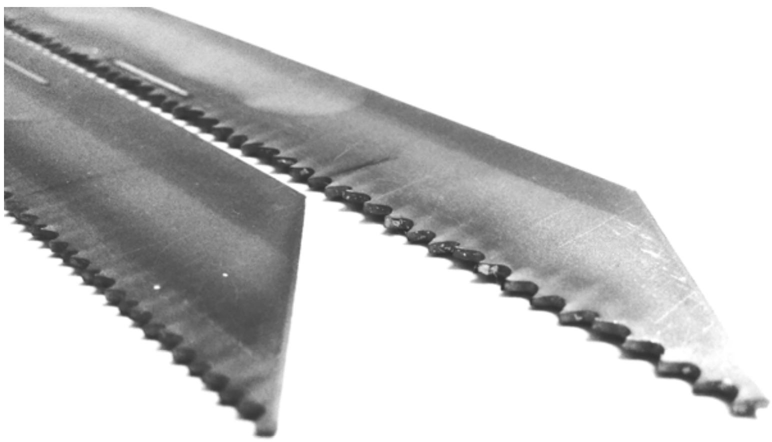
WEAR EVALUATION OF HARD METAL
USING TRIBOMETER



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INTRO

Wear is related to the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. Different types of wear, e.g. abrasion, friction and erosion, take place in virtually every industrial sector and create huge direct and consequential annual loss to the U.S. economy. A study carried out by ASM International (American Society for Metals) showed that wear imposes costs of ~0.75% of the GDP[1]. As a result, tribology research is critical in improving production efficiency, application performance, as well as conservation of material, energy and the environment.

IMPORTANCE OF WEAR EVALUATION FOR HARD METAL

In order to extend the lifetime of the mechanical components and to cut the cost and time on part repairing and replacement, Surface Engineering is carried out to harden the metal surface for wear protection while maintaining the toughness of the core metal. In particular in this study, surface treatment on the test saw blades has formed a hard surface layer to enhance the wear resistance. Additionally, a low surface friction is favorable to reduce the interaction of the blade and the object to be cut, so as to reduce tool wear and improve cutting efficiency. Therefore, reliable evaluation of the wear performance of surface treated metals is desirable for R&D and quality control in the metal industry.

MEASUREMENT OBJECTIVE

In this study, we simulated and compared the reciprocating wear behaviors of saw blades to showcase the capacity of Nanovea Tribometer in measuring the coefficient of friction and wear rate of surface hardened metals in a controlled and monitored manner.

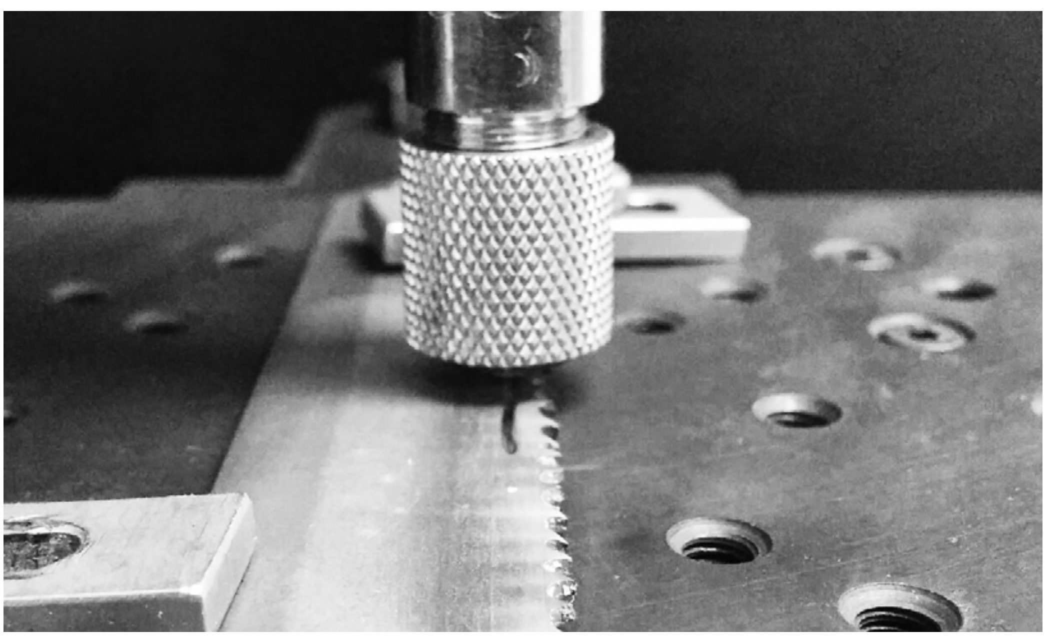


Fig. 1: Setup of the wear test.

TEST PROCEDURE

The coefficient of friction, COF, and the wear resistance of three saw blades were evaluated by Nanovea Tribometer using Linear Reciprocating Wear Module. An Al_2O_3 ball (6mm diameter) was used as the counter material. The wear track was examined using Nanovea 3D non-contact profilometer after the tests. The test parameters are summarized in Table 1.

Please note that the Al_2O_3 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.

	Three saw blades
Normal force	20 N
Amplitude	15 mm
Speed	200 cycles/min
Duration of test	15 min

Table 1: Test parameters of the wear measurements.

RESULTS AND DISCUSSION

The COF and wear rate of three surface hardened saw blades were measured using Linear Reciprocating Wear Module. Fig. 2 shows that the three saw blades exhibit significantly different wear behaviors as indicated by the evolution of COF during the tests. Sample A shows a low COF of ~0.1 at the beginning of the wear test, which slowly increases to a value of ~0.25 until 1600 revolutions. The COF drastically climbs to ~0.7 in the following 100 revolutions, and maintains above this value in the rest of the test. Such a drastic change of COF is attributed to the penetration of the Al_2O_3 ball through the hardened surface and the exposure of the fresh metal underneath. In comparison, Sample B and Sample C exhibit such significant change to high COF values after 900 and 80 revolutions, respectively, indicating their relatively poorer wear performance compared to Sample A.

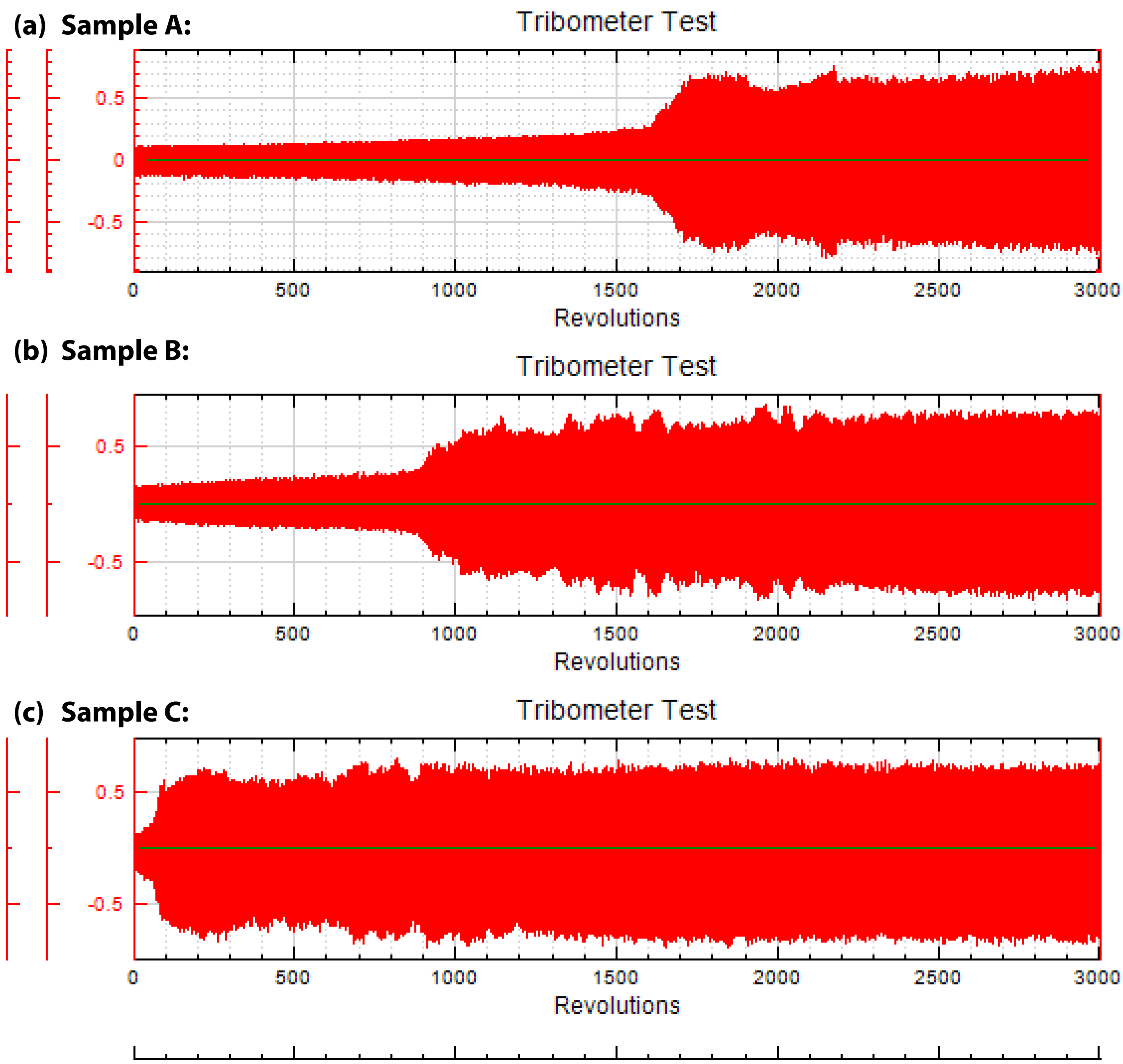
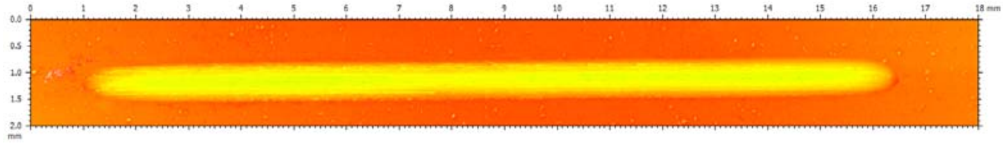


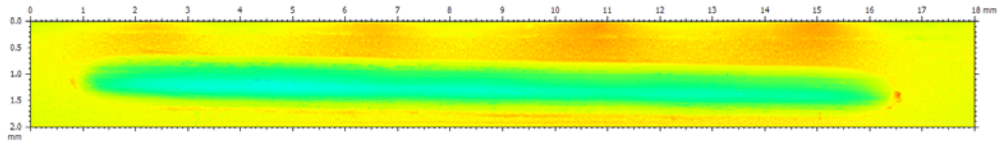
Fig. 2: Evolution of COF of saw blades.

Fig. 3 compares the 3D wear track images after the tests measured by Nanovea non-contact profilometer. The 3D wear track profile allows direct and accurate determination of the wear track volume calculated by Nanovea analysis software, and Table 2 summarized the results of the wear track analysis. Fig. 4 shows the wear tracks of the three saw blades under the optical microscope. The wear track evaluation is in agreement with the observation of COF evolution: Sample A, which maintains the low COF for the longest period, exhibits the lowest wear volume of 0.13 mm^3, compared to 0.23 and 0.32 mm^3 for Samples B and C, respectively. The data shown here represents only a small portion of the calculations available in the analysis software.

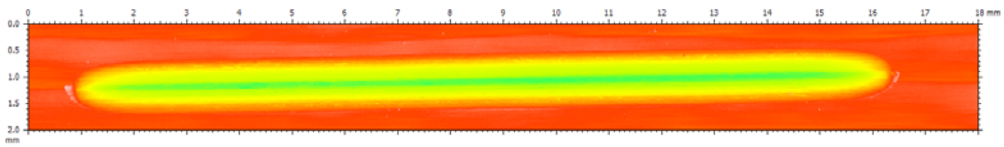
(a) Sample A:



(b) Sample B:



(c) Sample C:



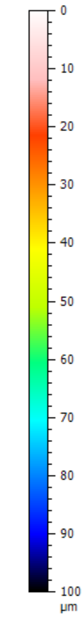
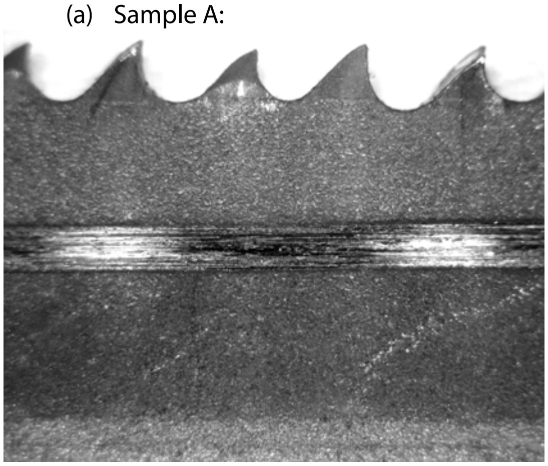


Fig. 3: 3D false color view of the wear tracks after the tests.

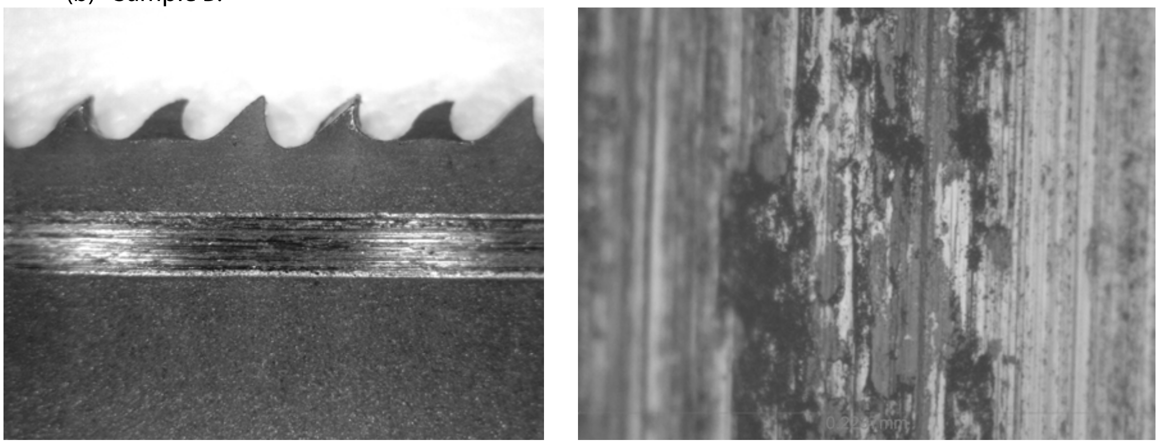
	Valley area mm^2	Valley depth µm	Perimeter mm	Volume mm^3
Sample A	11.7	34.8	31.5	0.13
Sample B	15.8	46.5	32.3	0.23
Sample C	16.4	47.9	32.2	0.32

Table 2: Result summary of wear track analysis.

(a) Sample A:



(b) Sample B:



(c) Sample C:

Fig. 4: Wear tracks under optical microscope.

CONCLUSION

The wear resistance of the cutting tools, e.g. saw blades in this study is critical in their service performance. A hardened surface layer can significantly extend the lifetime of the cutting tools, and reduce the time and cost on tool repairing or replacement. In this study, we showcased the capacity of Nanovea Tribometer in evaluating the coefficient of friction and wear rate of surface hardened metals in a controlled and monitored manner.

This measurement allows users to quantitatively assess the tribological behaviors of the materials and select the best candidate for the targeted applications. COF serves as an important indicator of the failure of the protective surface layer or coating. Nanovea 3D non-contact profilometer enables precise wear volume measurement and offers a tool to analyze the detailed morphology of the wear tracks, providing more insight in fundamental understanding of wear mechanism.

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

RECIPROCATING 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 linear reciprocating 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 pressure, velocity, temperature, humidity, lubrication, etc.

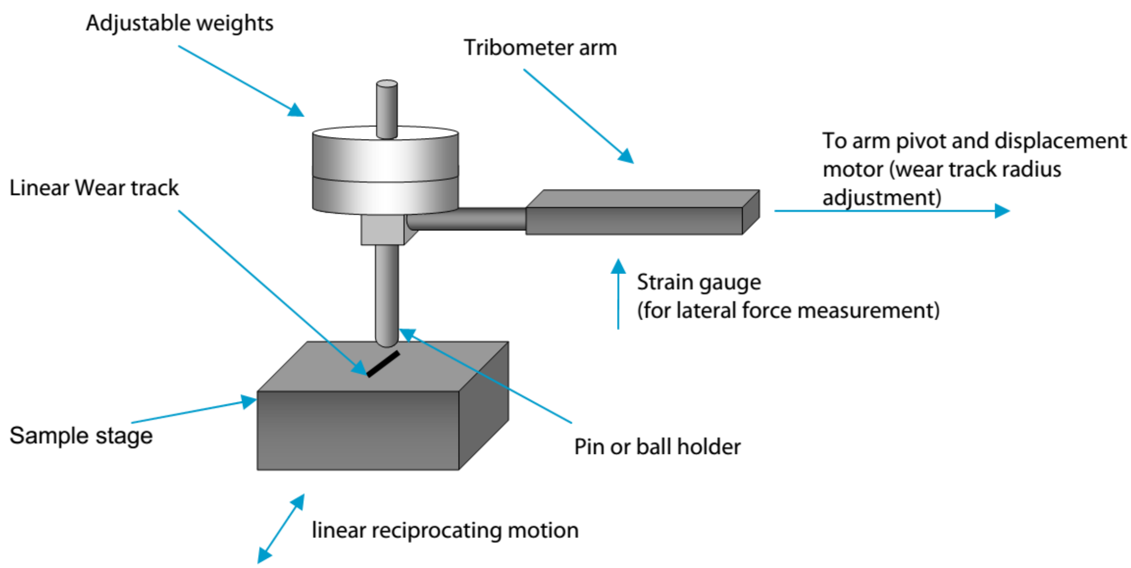
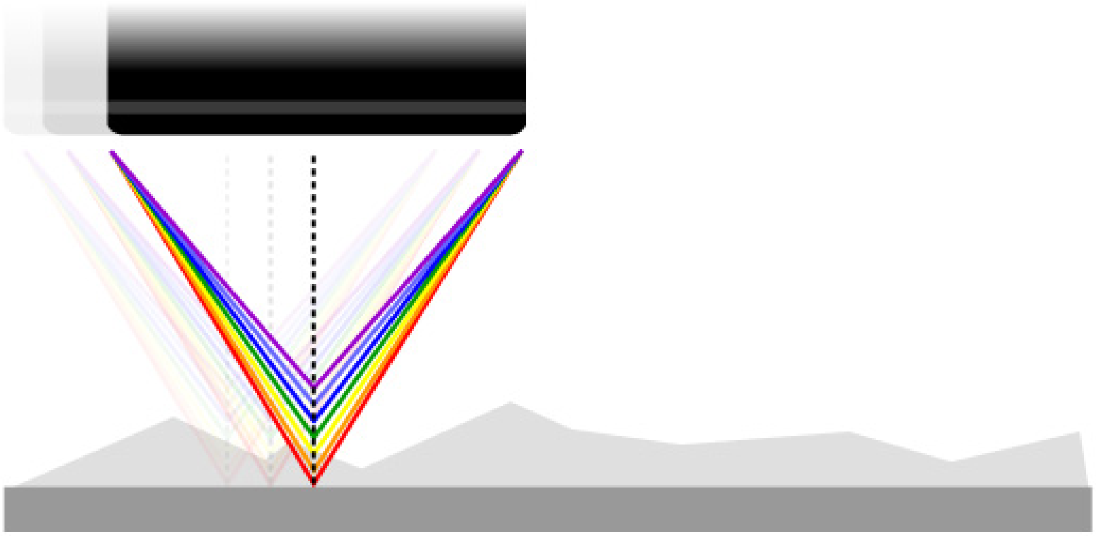


Fig. 5: Schematic of the linear wear test.

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.

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[1] J R Davis, Surface Engineering for Corrosion and Wear Resistance, ASM International, 2001.