HONEYCOMB PANEL WEAR RESISTANCE USING TRIBOMETER

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INTRO

Sandwich structure is commonly used in aircraft panels**,** boat hulls, automobile hoods and satellites, etc., where the combination of high strength and minimal weight is required. Honeycomb structures feature an array of hollow cells between thin vertical walls forming hexagonal shape. The honeycomb sandwich panel is composition of a honeycomb-structured core layered between two faceplates that provide strength in tension. Several key properties can be achieved by the honeycomb sandwich structure, such as high stiffness and load bearing capacity to weight ratio, excellent thermal insulation, and good vapor barrier and soundproofing[1].

IMPORTANCE OF WEAR EVALUATION FOR HONEYCOMB PANELS

In the honeycomb sandwich structure, the honeycomb core mainly carries the shear stresses whereas the faceplates carry the bending stresses. The faceplates also act as a protective layer against aggressive environments and as a thermal, water vapor and sound barrier. Therefore, mechanical and tribological properties of the faceplates are critical for the service life and quality of the honeycomb panel. The faceplates can be manufactured using different materials, such as glass or carbon fiber-reinforced thermoplastics, thermoset polymers and sheet metals[2]. Their distinct mechanical characteristics contribute to their varied wear behaviors. It is valuable to develop a simple wear test for evaluating the wear resistance of the honeycomb panel.

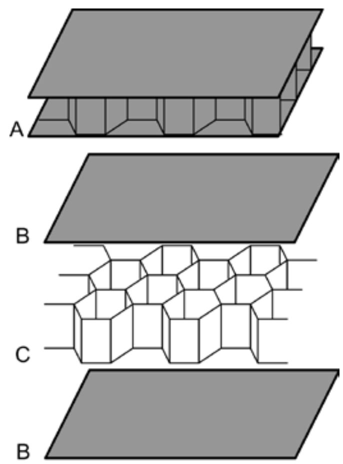


Fig. 1: Honeycomb sandwich structure.

MEASUREMENT OBJECTIVE

In this study, we simulated and compared the wear behaviors of two honeycomb sandwich panels to showcase the capacity of Nanovea Tribometer in measuring the coefficient of friction and wear rate of honeycomb sandwich panel in a controlled and monitored manner.

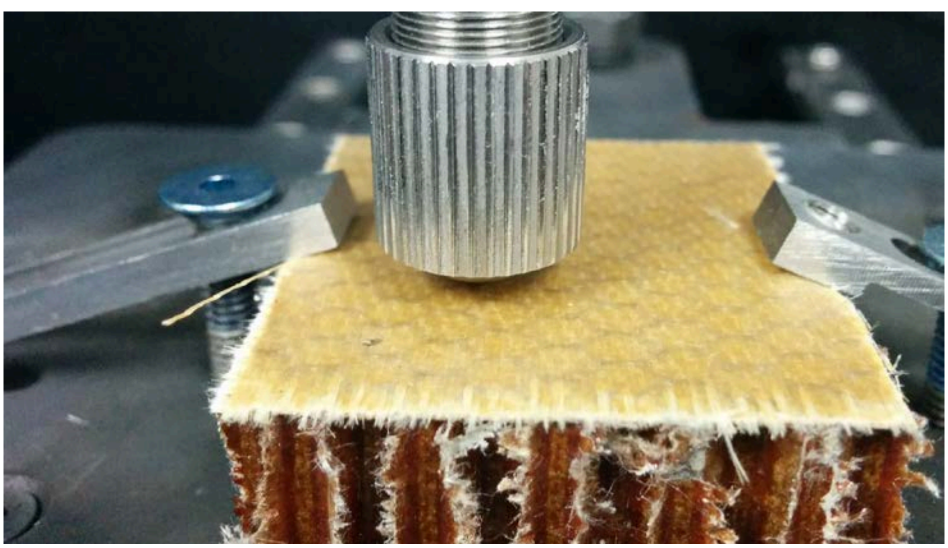


Fig. 2: Wear test on a honeycomb sandwich panel.

TEST PROCEDURE

The coefficient of friction, COF, and the wear resistance of two honeycomb panel samples were evaluated by Nanovea Tribometer using linear reciprocating wear mode. An SS440 ball (6 mm diameter) was used as the counter material. The test parameters are summarized in Table 1. Wear track profiles were evaluated by the Nanovea Non-contact Optical Profilometer, and the wear track morphology was examined using optical microscope.

Sample	Two honeycomb panels
Normal force	20 N
Reciprocating amplitude	5 mm
Speed	300 RPM
Duration of test	20 min

Table 1: Test parameters of the wear measurements.

RESULTS AND DISCUSSION

The evolution of COF during the wear tests of the two honeycomb panel samples are plotted in Fig. 3. Both samples show progressively increased COF during the run-in period at the beginning of the wear test. Sample 1 exhibits a relatively constant COF of ~0.5 after 1600 revolutions of reciprocating wear. Sample 2 shows a constant COF of ~0.4 from 1500 to 2700 revolutions, which progressively increases to ~0.56 in the following test.

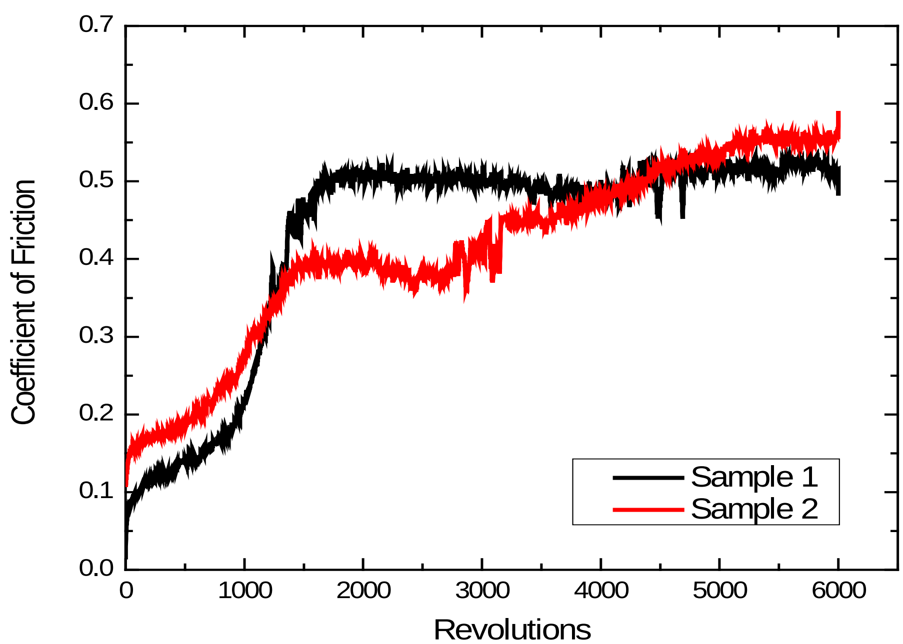


Fig. 3: Evolution of COF of the honeycomb panel samples.

Fig. 4 compares the wear track of the two honeycomb panel samples after the wear tests, and Table 2 summarizes the results of the wear track analysis. Fig. 5 shows the 3D view of the wear tracks measured using Nanovea optical non-contact profilometer, which provides more insight in fundamental understanding of the wear mechanism. The 3D wear track profile allows direct and accurate determination of the wear track volume calculated by Nanovea analysis software. After the 6000-revolution reciprocating wear test, Sample 1 possesses a shallow wear track with a volume of 0.13 mm^3 and maximum depth of 116 µm. In comparison, Sample 2 exhibits a much larger wear track with a volume of 4.86 mm^3 and maximum depth of 568 µm.

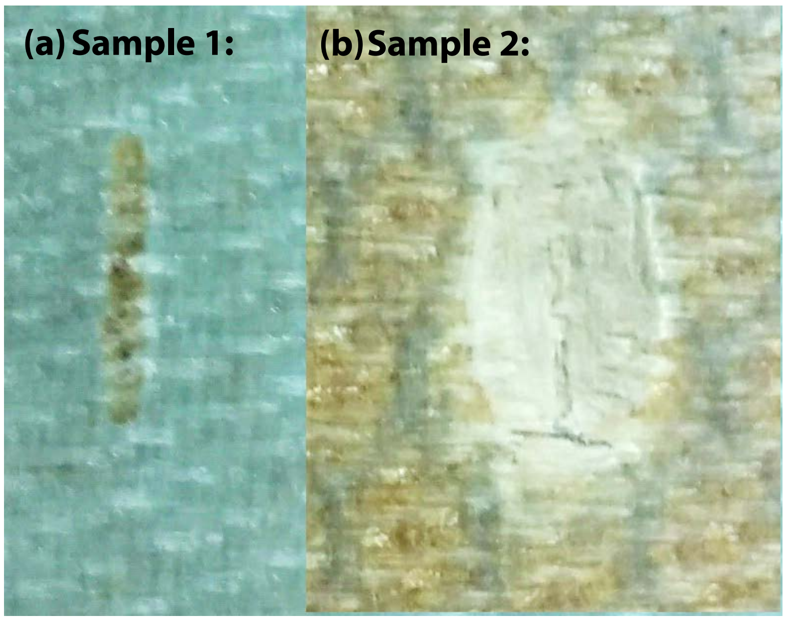


Fig. 4: The wear tracks after the test.

	Wear track area mm^2	Track depth µm	Track volume mm^3
Sample 1	5.4	116	0.13
Sample 2	23.6	568	4.86

Table 2: Result summary of wear track analysis.

(a) Sample 1: (b) Sample 2:

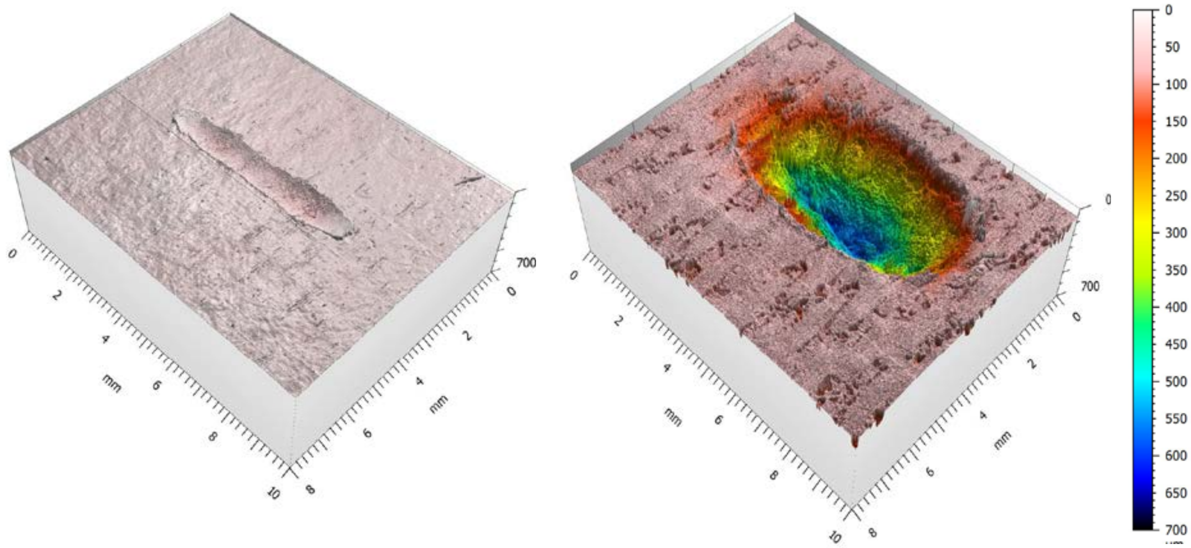


Fig. 5: 3D view of the wear tracks after the tests.

CONCLUSION

In this study, we showcased the capacity of Nanovea Tribometer in evaluating the coefficient of friction and wear resistance of two honeycomb panel samples in a controlled and monitored manner. Sample 1 possesses superior wear resistance compared to Sample 2. It can significantly extend its lifetime serving as a quality airplane interior wall.

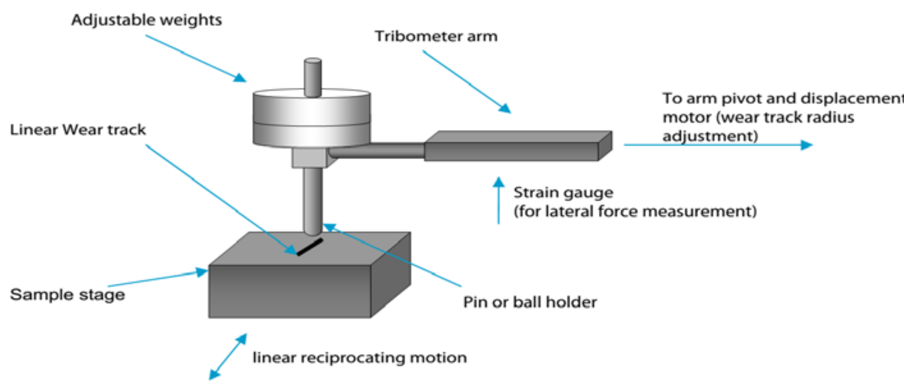
Nanovea Tribometer offers precise and repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes, with optional high temperature wear, lubrication and tribo-corrosion modules available in one pre-integrated system. Nanovea's unmatched range is an ideal solution for determining 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

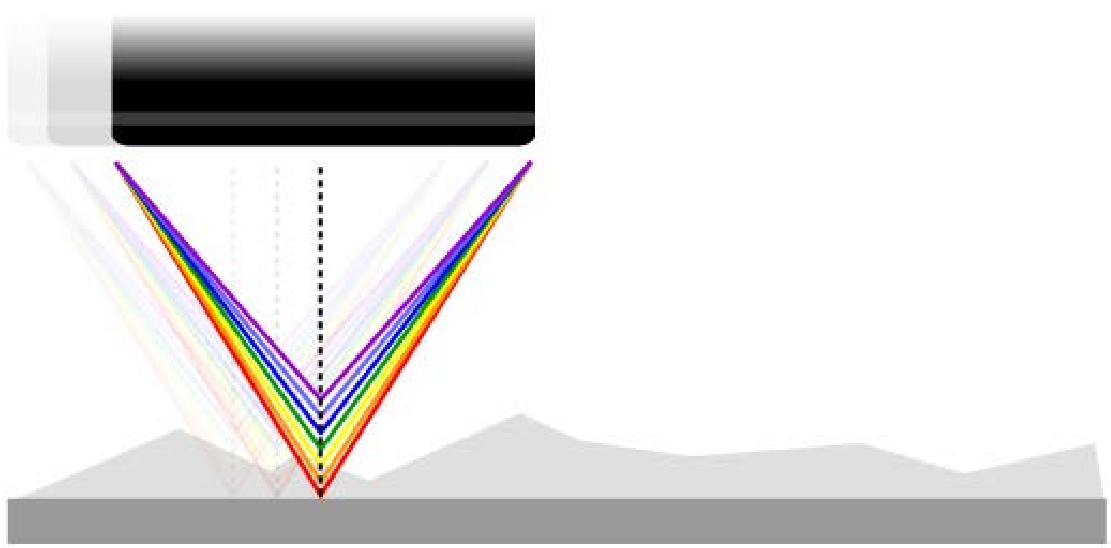
RECIPROCATING WEAR PRINCIPLE

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.



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] www.suparco.gov.pk/downloadables/properties-honeycomb.pdf
[2] https://en.wikipedia.org/wiki/Sandwich-structured_composite