WEAR RESISTANCE OF MAGNETIC STRIPES USING TRIBOMETER

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INTRO

Magnetic stripes are widely used in a variety of products, including credit cards, identity cards, transportation tickets and many others. The magnetic stripes on the cards encode information that can be read by swiping past a magnetic reading head. Such repeated swiping on a daily basis may gradually create wear scratches to the magnetic stripes, and eventually leads to failure of the cards. Due to the importance of the information stored in the cards, good wear resistance of the magnetic stripes becomes a critical factor.

A reliable and repeatable technique is in need to simulate the wear process and evaluate the wear resistance. Due to the complex nature of wear process which involves a variety of factors, such as unidirectional sliding, reciprocating, rolling, as well as impact loads, speed, temperature and others, it is important to simplify the wear test setup by using the linear reciprocating sliding motion to simulate the real-life wear process of magnetic card stripes. The well controlled and monitored wear measurement allows users to follow the evolution of coefficient of friction and correlate it with different stages of the wear process, which provides more insight in the wear mechanism and failure modes.

MEASUREMENT OBJECTIVE

In this application, the Nanovea Tribometer is used to simulate the wear process of the magnetic stripes on cards and measure the wear resistance and coefficient of friction in a controlled and repeatable manner. We would like to showcase the capacity of Nanovea Tribometer in performing fast wear evaluation with simplicity and reproducibility.

![Fig. 1: Setup of the wear test on magnetic card stripes.](image-url)
TRIBOLOGY MEASUREMENT PRINCIPLE

The sample is mounted on a moving stage, while a known force is applied on a pin, or ball, in contact with the sample surface to create the wear. As the sample moves in a linear reciprocating motion, the resulting frictional forces between the pin and the sample are measured using a strain gage sensor on the arm.

The wear test is generally used as a comparative test to study the tribological properties of the materials. The, coefficient of friction, COF, is recorded in situ. The volume loss allows calculating the wear rate of the material. Since the action performed on all samples is identical, the wear rate can be used as a quantitative comparative value for wear resistance. 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. 2: Schematic of linear reciprocating wear test.](image)

TEST PROCEDURE

The tribological behavior, e.g. coefficient of friction, COF, and wear resistance of the magnetic stripes of two different cards was evaluated by Nanovea Tribometer using a linear reciprocating setup. A flat tip was applied against the tested samples. The COF was monitored in situ. The test parameters are summarized in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Force applied</td>
<td>7.0 N</td>
</tr>
<tr>
<td>Sliding speed</td>
<td>80 rpm</td>
</tr>
<tr>
<td>Length of wear track</td>
<td>50 mm</td>
</tr>
<tr>
<td>Duration of test</td>
<td>Sample dependent</td>
</tr>
<tr>
<td>Total disk rotations</td>
<td>Sample dependent</td>
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</tbody>
</table>

**Table 1: Wear test parameters.**
RESULTS AND DISCUSSION

Airline Fidelity Program card

Fig. 3 shows the raw COF between the pin and the Fidelity card sample over the course of the test. The COF goes back and forth from positive to negative because of the back and forth motion of the stage during this test. The pin slid on the sample for ~1200 revolutions without causing visible damage, after which the pin started creating debris and the full wear occurred over a couple strokes as shown in Fig. 4. For the remainder of the test, no significant further wear was observed; however, an increase in the amplitude of the COF can be observed, due to the failure of the surface layer and exposure of the substrate which possesses higher COF.

![Graph showing coefficient of friction over time during test.](image)

**Fig. 3: Coefficient of friction over time during test.**

![Image of Airline Fidelity Program card after the wear test of 3,000 revolutions.](image)

**Fig. 4: Airline Fidelity Program card after the wear test of 3,000 revolutions.**

Automobile Club card

In comparison, the automobile club card exhibits surface layer failure after a much higher number of cycles of ~14,000 revolutions. Fig. 5 compares the COF (squared) against the number of cycles during the tests for both samples. It clearly shows that the Automobile Club card has
much superior wear resistance. The sliding motions in this test simulates the actions of swiping these cards in readers or sliding them in and out of a wallet. The result indicates that the Airline Fidelity card could exhibit damages to its magnetic stripe earlier than the Automobile Club card. The wear test of different cards using identical experimental setup and test conditions allows us to compare and improve the material and manufacturing process in order to obtain the best performance in real-life application.

![Graph showing COF evolution](image)

**Fig. 5:** COF (squared) evolution of Airline Fidelity and Automobile Club cards.

![Image of a worn automobile club card](image)

**Fig. 6:** Automobile Club card after the wear test of 15 000 revolutions.
**CONCLUSION:**

Although the tribometer is often used in conjunction with the profilometer to measure wear rate of coated or uncoated samples, the standard tribometer can provide reliable evaluation of wear resistance on its own in some applications where coatings or specific properties of materials have a certain lifetime. In this study, the magnetic stripes would not show evident wear until the point of failure, allowing user to compare the wear resistance of the magnetic stripes on different cards using the same test conditions. The wear test can also be applied to samples where a top material layer wears gradually over time, uncovering a second material with a different COF, or where a surface texture is worn through. The change in COF also serves as a useful indicator of the coating lifetime.

Nanovea Tribometer offers precise and repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes. It provides optional high temperature wear, lubrication and tribocorrosion modules available in one pre-integrated system. Such versatility allows users to better simulate the real application environment and improve fundamental understanding of the wear mechanism and tribological characteristics of various materials.

Optional 3D non-contact profiler is available for high resolution 3D imaging of wear track in addition to other surface measurements such as roughness.

Learn More about the Nanovea Tribometer and Lab Service