> Brake Material Screening

Introduction:

Brake shoe friction materials are critical elements of every vehicle. The advent of hybrid and electric cars, regenerative braking and modern safety regulations are key motivations to develop brake friction materials. Brake materials are typically evaluated by standard protocols such as SAE J2522 on a full-blown dynamometer. The test involves evaluating behavior of a friction material at varying pressures, speeds, temperatures and deceleration conditions. Designing and manufacturing real components for such tests is often a tedious and expensive process.

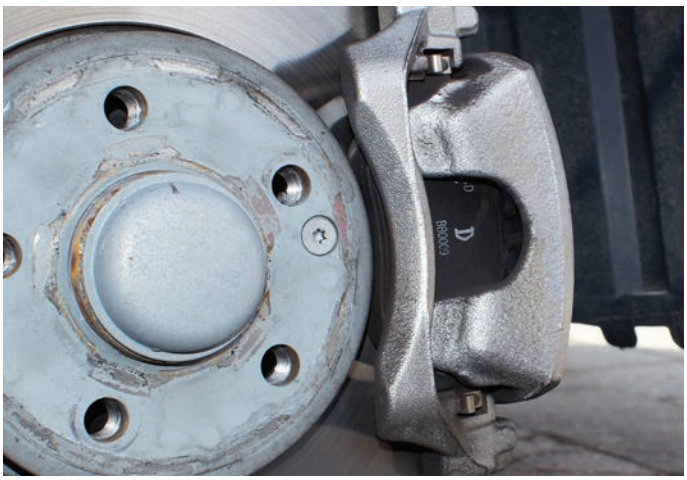

Figure 1. car brake

Rtec-Instruments MFT-5000 is a modular tribometer that offers several ASTM/ISO/DIN standard and customized test on the same platform. Specifically, for the brake industry, MFT-5000 offers a cost-effective method for rapid brake materials testing. The versatile platform can test functionality and wear resistance of the brake pad material in conditions simulating dynamometer testing. It can measure inline torque, friction, pressure, temperature and speed. In addition, the patented in-line imaging options allows characterize wear w.r.t number of cycles.

This application note describes the use of MFT-5000 to perform standard tests (SAE J2522) and a custom test to measure wear rate of the brake pad friction materials.

Other tests such as pin on disc, linear reciprocating wear, fretting wear etc. can also be performed on the same platform.

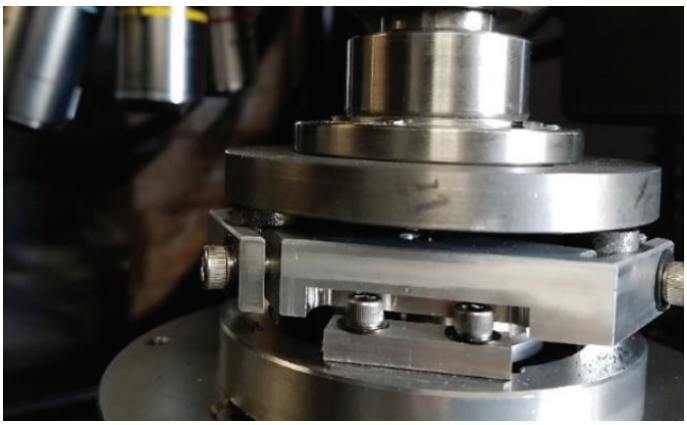

Figure 2. Brake Material Screening Setup on MFT 5000

Simulating Brake Testing on MFT-5000 Platform:

The surface of the brake materials is very non-uniform It is critical to use test coupons that reflect the non-homogeneity of the brake materials.

Rtec-Instruments MFT-5000 offers unique advantages over typical benchtop testing systems and full-blown dynamometers. The heavy duty, floor standing design allows researchers to apply up to 5'000N downforce on the samples. This along with high torque motors (up to 50 Nm), allows flexibility in sample size while maintaining the required contact pressures.

In a typical dynamometer test, the design of calipers also plays an important role. This makes it difficult to specifically study material interaction. Samples of consistent geometry on MFT platform allow a test procedure that assesses brake pad material composition independent of design.

The same set up can be used to evaluate materials for motor vehicles fitted with disc brakes or drum brakes. The technique assesses the effectiveness behavior and tribological properties of candidate materials before proceeding to component level testing.

To perform meaningful tests, it is important to simulate the physical parameters in the brake system:

- Contact pressure between the slide pad and brake rotor
- Initial temperature
- Sliding Speed
- Deceleration

Key parameters recorded during the test include friction, coefficient of friction, torque, contact pressure, sliding speeds and temperature of interacting surfaces.

The standard tests involve simulating conditions of vehicle deceleration e.g. a complete halt or reduction in speed. Other tests e.g. constant sliding speeds (drag mode) tests can also be performed on the Rtec-Instruments MFT-5000 platform.

Test Setup and Results:

Here, we demonstrate use of Rtec-Instruments MFT- 5000 to simulate a subsection of SAE J2522.

Different material combinations can be quickly evaluated by testing on coupons. Three cylindrical samples are mounted as representative of brake materials.

A cast iron disc is used as the counter surface.

A minimum sample size of 12.7 mm X 6.35 mm [0.5”X0.25”] for brake materials and a disc of 50.8 mm radius [2”] for rotor is recommended.

Other sample sizes can also be accommodated easily on the platform.

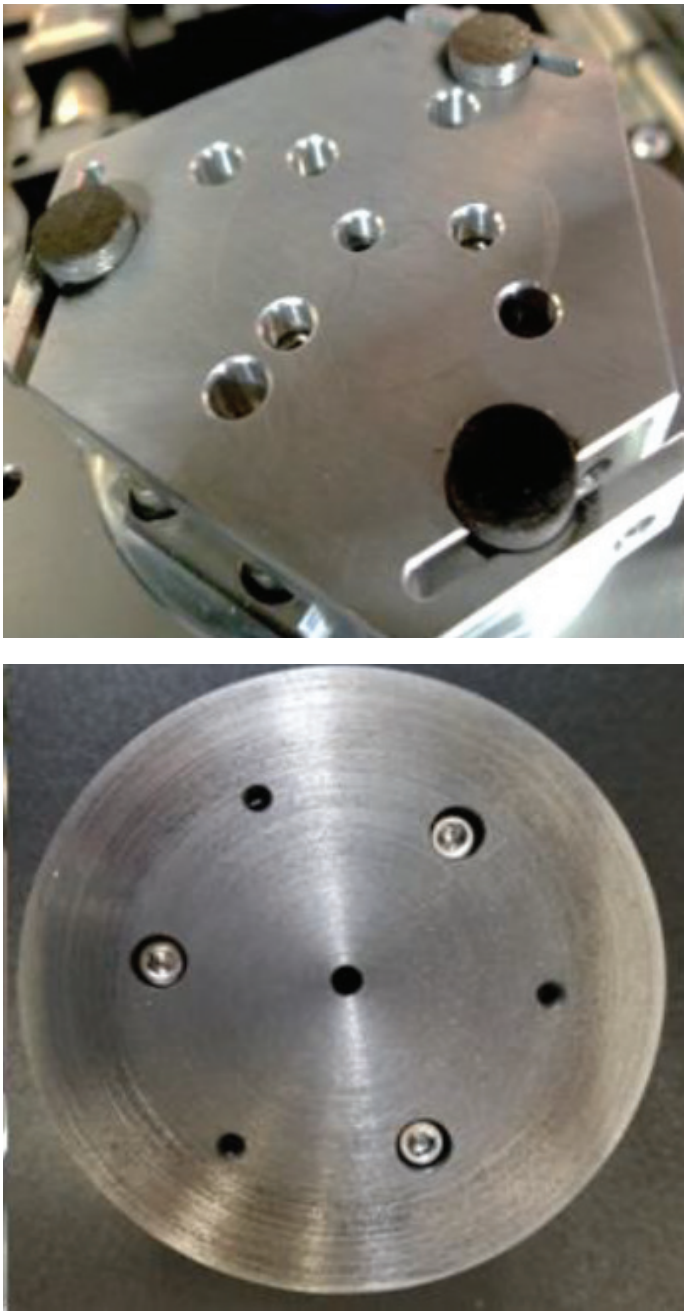

Figure 3: Samples that simulate brake pad and rotor for testing. Other sizes can also be easily accommodated

This note describes results obtained from a test setup using 12.7 mm X 6.35 mm cylinders obtained from commercial brake pads.

The samples were mounted as the lower surface. A cast iron disc 50.8 mm radius was used to represent the rotor. It was mounted as the upper sample.

The setup is mounted on a self-leveling platform for uniform contact.

To simulate a snub from SAE J2522, the samples were loaded to 300 N (0.75 MPa contact pressure) at 2089 rpm.

The speed was then reduced to 787 rpm under load in 5.5s.

These conditions were selected to represent change in speed for motor vehicles from 80 to 30 Km/h.

The load was chosen to represent 3'000 kPa in fluid line.

The speed and load are controlled while measuring torque, friction and temperature of the interacting surfaces.

Test data is collected with precision and reliability using advanced sensors and high-speed data acquisition system.

The data collected during one cycle is shown in Figure 3.

The test can be repeated for any number of cycles.

The MFT-5000 platform can work across a range of loads (up to 5'000N) and speeds (up to 10'000 rpm).

Various other speeds and pressure combinations can be easily tested on the platform. Several steps of SAE J2522 protocol such as Green μ characteristics, Speed/ Pressure sensitivity, cold application, fade, recovery etc. can be simulated.

It is also possible to control the environmental conditions such as temperature and humidity.

The debris produced can be collected for further analysis.

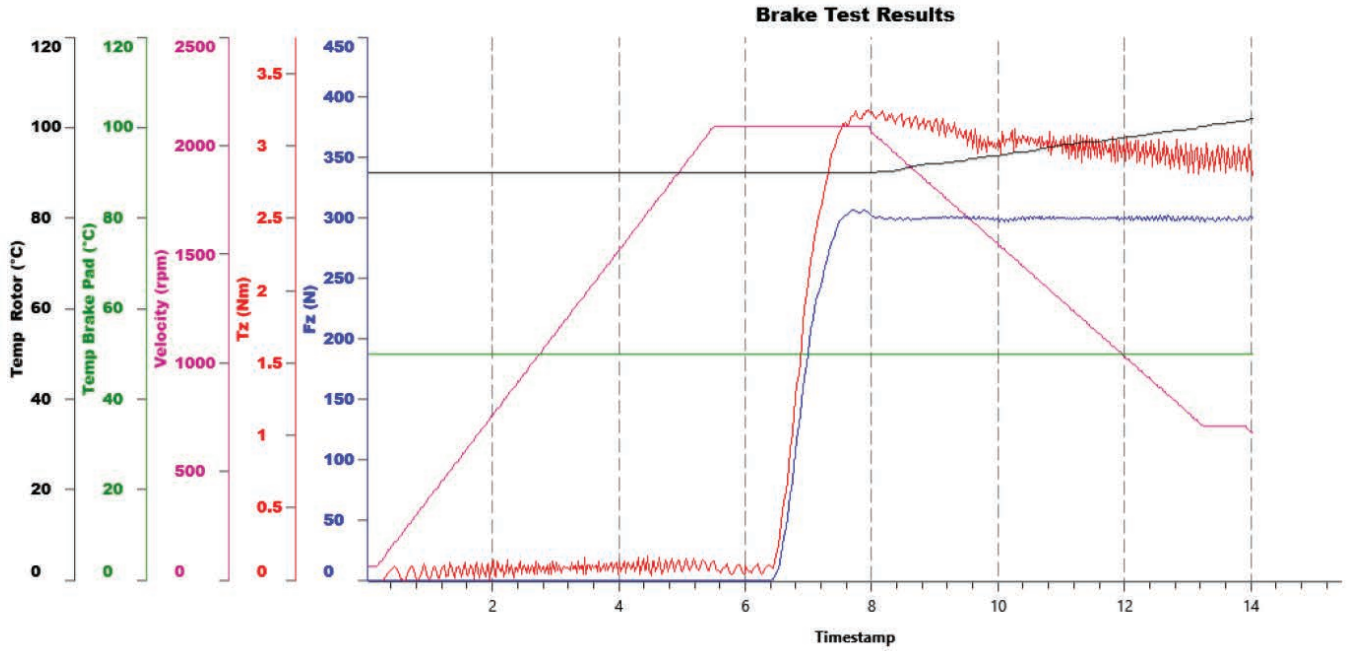

Figure 4: Results from a typical test in which the conditions are simulated to represent a change in speed from 80 km/h to 30Km/h at a contact pressure of 0.75 MPa.

Wear Studies on MFT 5000 platform

MFT-5000 with patented inline imaging technology offers the unique advantages to characterize wear vs. number of cycles on brake materials.

The setup includes a 3D Profilometer designed specifically for tribology that combines spinning disc confocal and white light interferometry.

Advanced encoders on the automatic stage allow the sample to alternate between mechanical test area and profilometer.

High resolution 3D profiles with sub nm resolution are captured using the profilometer.

These images can be captured at user defined conditions such as number of cycles, time or change in torque, temperature etc.

This information can be extremely useful to compare wear rate, material transfer, roughness change. It also allows the researcher to capture information about initiation of failure.

An example data set where test was paused every 15s of testing at 1500 RPM is presented. The test was continued for 60s at constant load and velocity.

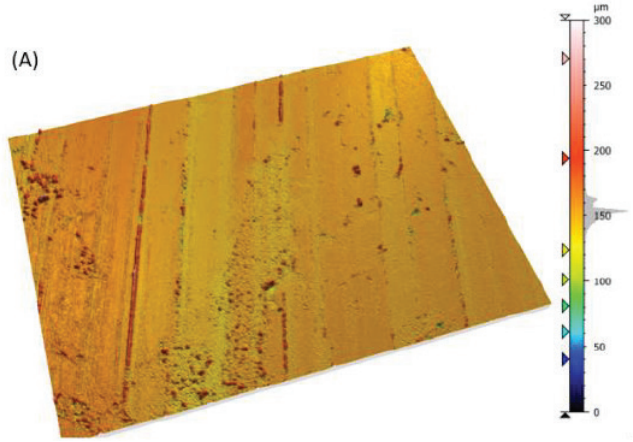

Figure 5a: before test

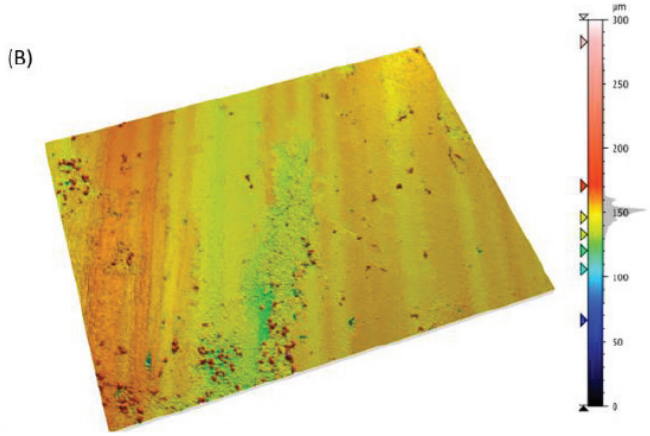

Figure 5b: after 15 sec of test at 1'500 rpm with 300 N

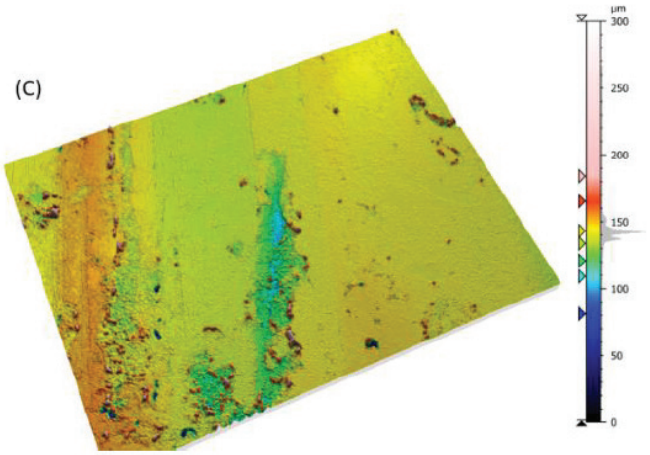

Figure 5c: after 60 sec of test at 1'500 rpm with 300 N

ISO 25178		
Height Parameters		
Sq	8.96	µm
Ssk	2.61	
Sku	22.9	
Sp	115	µm
Sv	79.0	µm
Sz	194	µm
Sa	5.53	µm

(a)

ISO 25178		
Height Parameters		
Sq	7.36	µm
Ssk	1.18	
Sku	17.4	
Sp	115	µm
Sv	71.1	µm
Sz	187	µm
Sa	4.90	µm

(b)

ISO 25178		
Height Parameters		
Sq	8.36	µm
Ssk	1.57	
Sku	30.0	
Sp	125	µm
Sv	117	µm
Sz	241	µm
Sa	4.63	µm

(c)

Figure 6: Roughness results A) before test B) after 15 sec C) after 60 sec

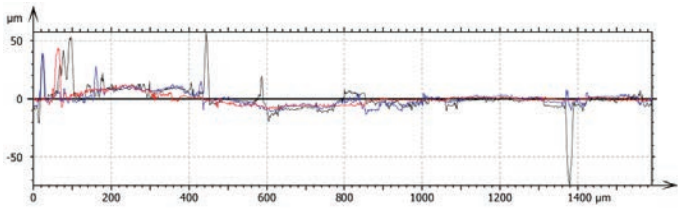

Figure 6: profile distribution
(red initial, blue after 15 sec, black anfter 60 sec)

Conclusions:

Rtec-Instruments MFT-5000 is a fast, reliable and cost-effective tool for screening of brake materials.

The high-resolution sensors can characterize even small changes in the composition of material.

Using the inline profilometer it is possible to study the change in sample surface with sub nm resolution.

The advantages in size and flexibility makes MFT-5000 an ideal tool to compliment full scale dynamometer testing.

Multi Function Tribometer MFT-5000

The state of the art Rtec-Instruments Multi Function tribometer MFT-5000 is globally regarded as the most versatile and technologically advanced tribometer.

The tribometer offers next generation patented force sensors with ultra low resolution, highest speeds and wide environmental control range than any other commercially existing tribometer.

The patented integrated 3D profilometer allows to analyse surface change vs time. The universal tribometer MFT-5000 allows to create a comprehensive report on friction, wear, tribology and surface analysis.

Should you require further information, please contact

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