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A Better Measure.

Friction & Roughness Measurement of Elastomer

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INTRO

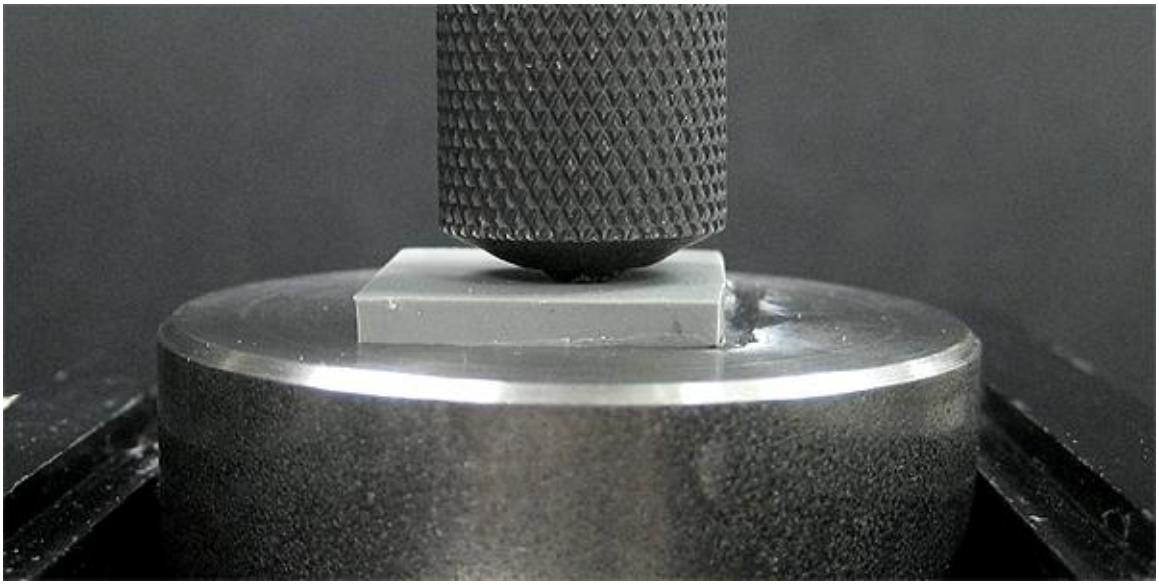
Many rubber, also called elastomer, applications require varying levels of intended surface friction properties (COF). A basic characteristic of rubber is its relatively high coefficient of friction. High friction is used in applications where rubber grip is required such as with tires, feed rollers, engine belts or medical tools. However, applications could also require a low level of friction where parts are sliding and ease of glide is needed. Rubber can behave in many different ways, under many different conditions, and requires modification through specialized compounding to insure these intended results. It is for this very reason that surface friction (COF) and surface topography should be closely controlled and monitored during development.

IMPORTANCE OF COFFICIENT OF FRICTION FOR QUALITY CONTROL

As reviewed above rubber has many uses, with intended purpose and intended friction properties to insure a given performance. In particular, rubber used for printer feed rollers or commercial size feed rollers are dependent upon a known frictional grip to provide processing control. It is systems such as these that can highly benefit from a quality control process to reduce cost in malfunction. The rubber in these systems should have a controlled and known surface friction level to insure intended performance. Additionally, wear studies could also be used to identify and target when a rubber surface should be replaced.

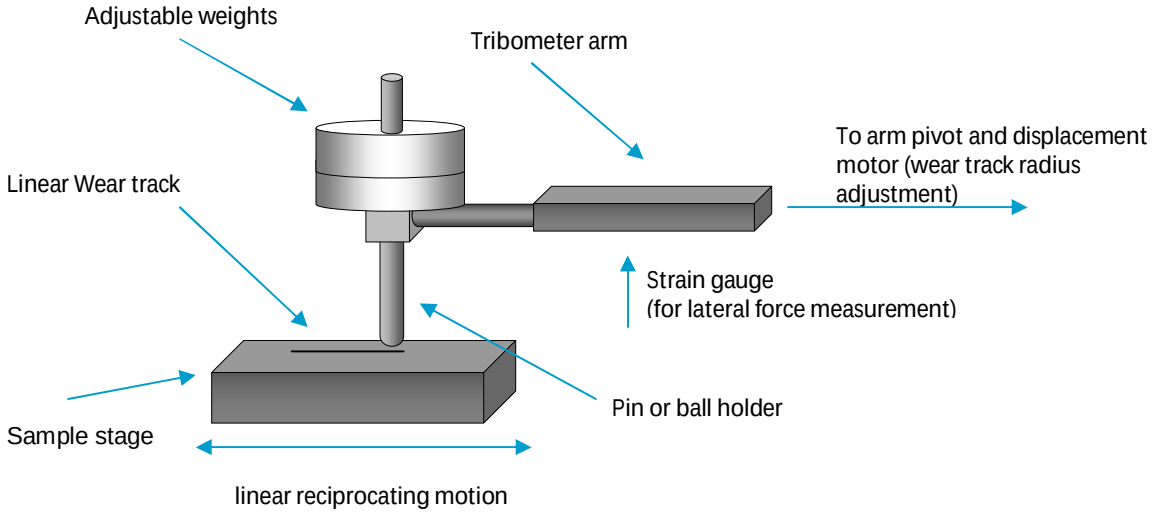
MEASUREMENT OBJECTIVE

In this application, the Nanovea Tribometer (seen below) is used to measure the coefficient of friction between a 6mm stainless steel ball (typically of low COF value) and the rubber from a feed roller. This technique uses the Linear Tribometer method to determine coefficient of friction. The surface topography was also studied using the Tribometers integrated 3D non contact optical profiler.



MEASUREMENT PRINCIPLE:

A flat or a sphere shaped indenter is loaded on to 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 acting between the pin and the plate are measured by very small deflections of the arm using a strain gage sensor. 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.



TEST PROCEDURE

The instrument base is first leveled in the horizontal position by screwing or unscrewing the adjustable rubber pads at each corner. A ball-holder containing a 3 or 6 mm diameter ball is held in the load arm and placed at a height that allow the tribometer arm to be leveled horizontally when resting on the sample to ensure that normal load will be applied vertically. The arm is then balanced with counter weights to ensure that the arm and ball holder initially apply no force on the sample surface. Finally, weights corresponding to the load required for the test are finely placed on the arm over the ball holder. Through software, the test is then launched and the test is performed at a specified speed for a specified duration, and the frictional force is recorded over time.

TEST CONDITIONS

Test parameters

Load	1 N
Duration of test	10 min
Sliding rate	80 rpm
Amplitude of track	6.28 mm
Révolutions	762
Ball Diameter	6 mm
Ball Material	Stainless Steel 440

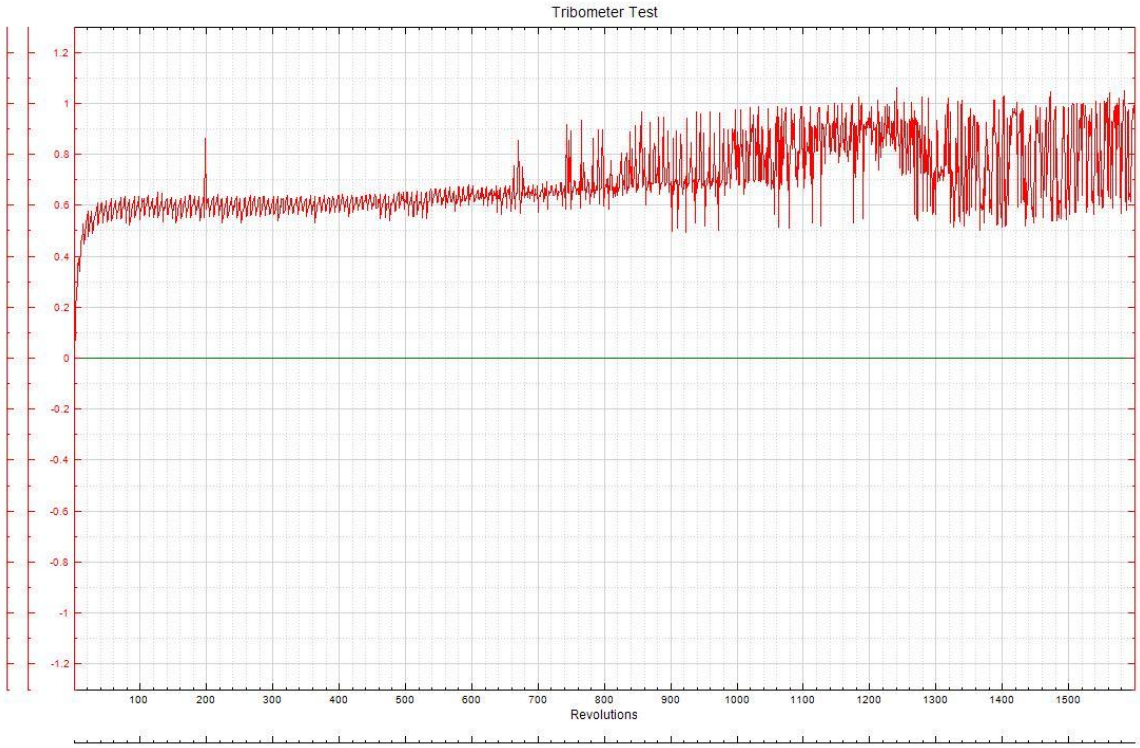
Environmental conditions

Lubricant	None
Atmosphere	Air
Temperature	23°C (room)
Humidity	35%

Results

Coefficient of friction summary table for: Rubber

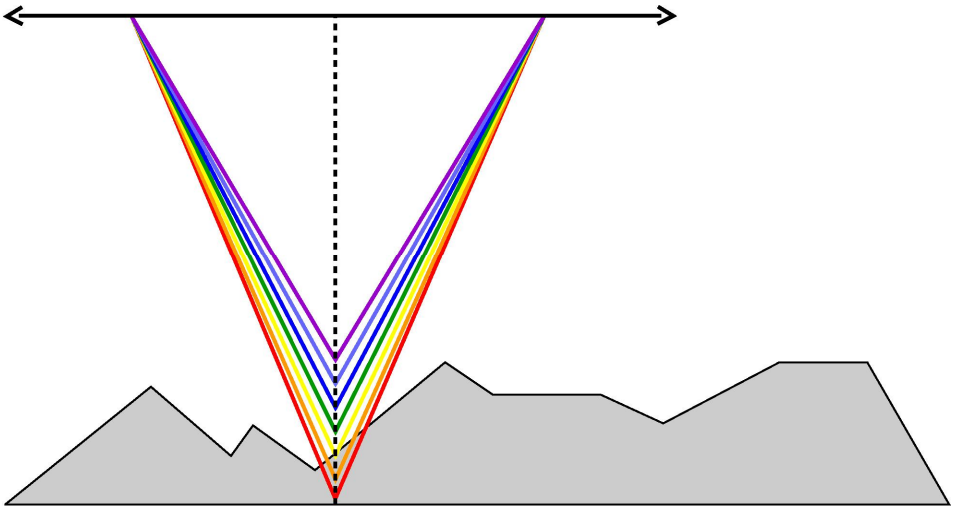
Rubber	
Max COF	1.062
Min COF	0.018
Average COF	0.700



Graph of coefficient of friction (ZOOMED) – Rubber

OPTICAL PROFILER MEASUREMENT PRINCIPLE:

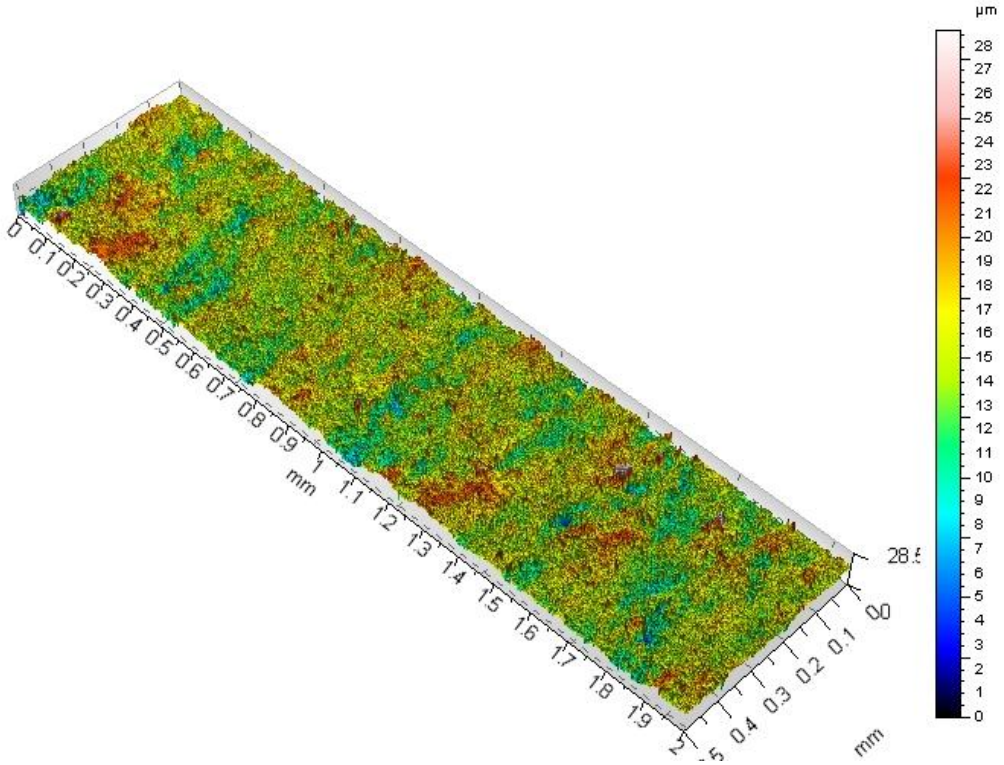
The axial chromatism technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white 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.

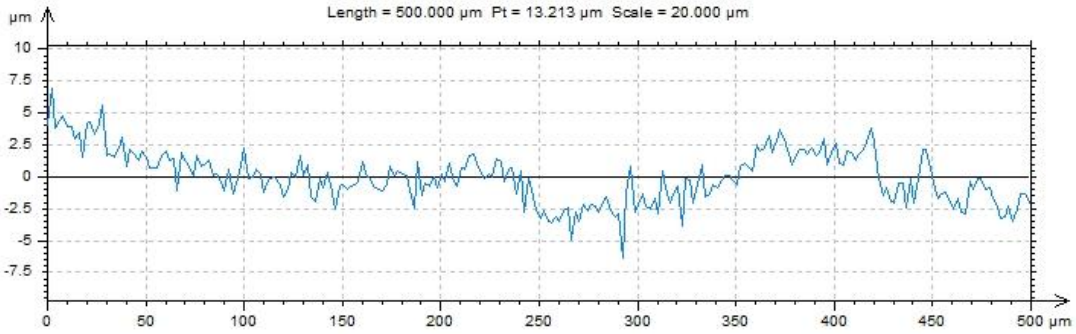


Nanovea optical pens have zero influence from sample reflectivity. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Unlike other optical techniques, Nanovea optical pens provide ability to measure any material, whether transparent, opaque, specular, diffusive, polished or rough.

Results

Surface Topography (Before Test)

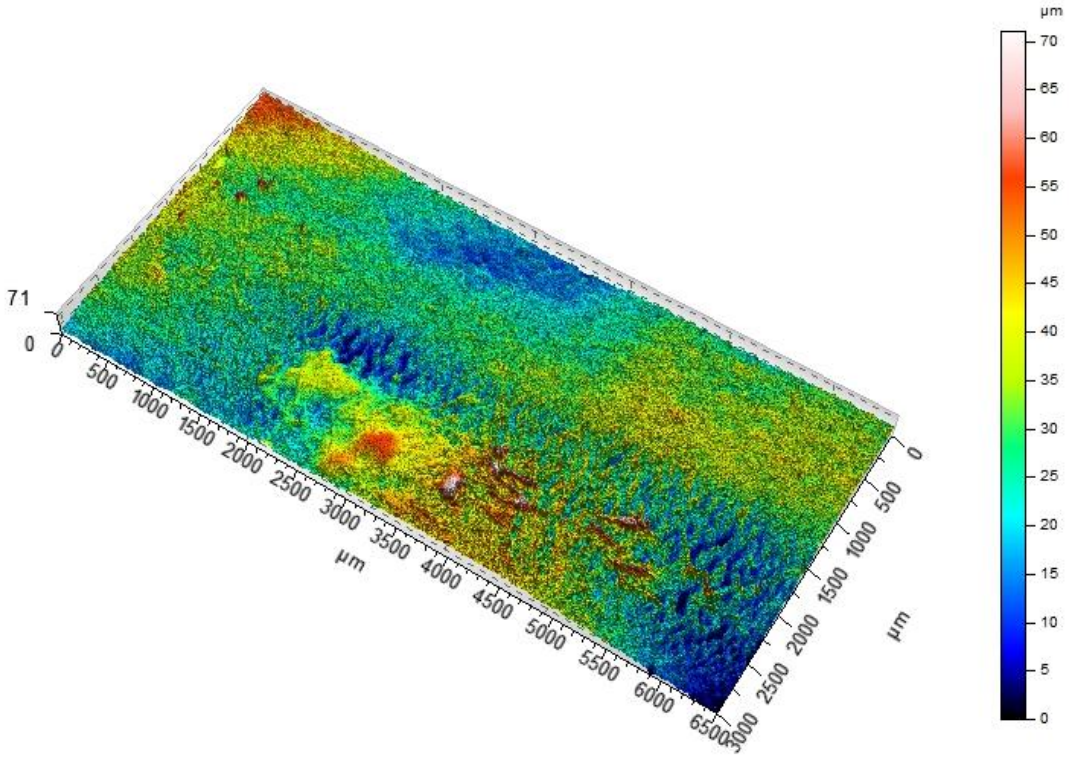


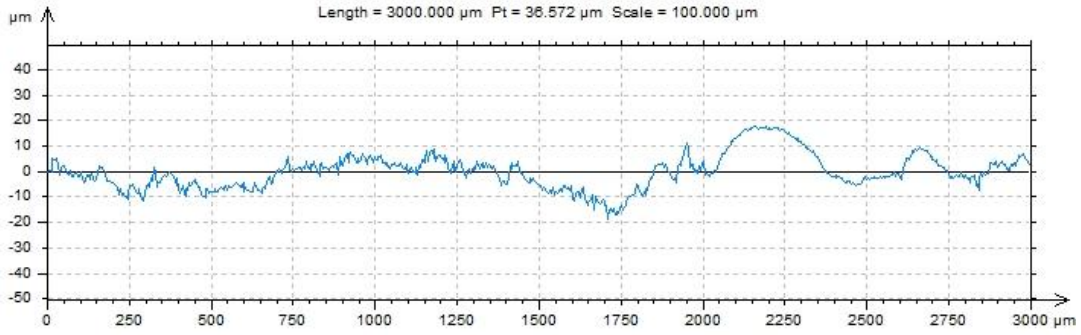


ISO 25178		
Height Parameters		
Sq	2.7023	µm
Ssk	0.016762	
Sku	4.0152	
Sp	13.753	µm
Sv	14.927	µm
Sz	28.680	µm
Sa	2.0893	µm

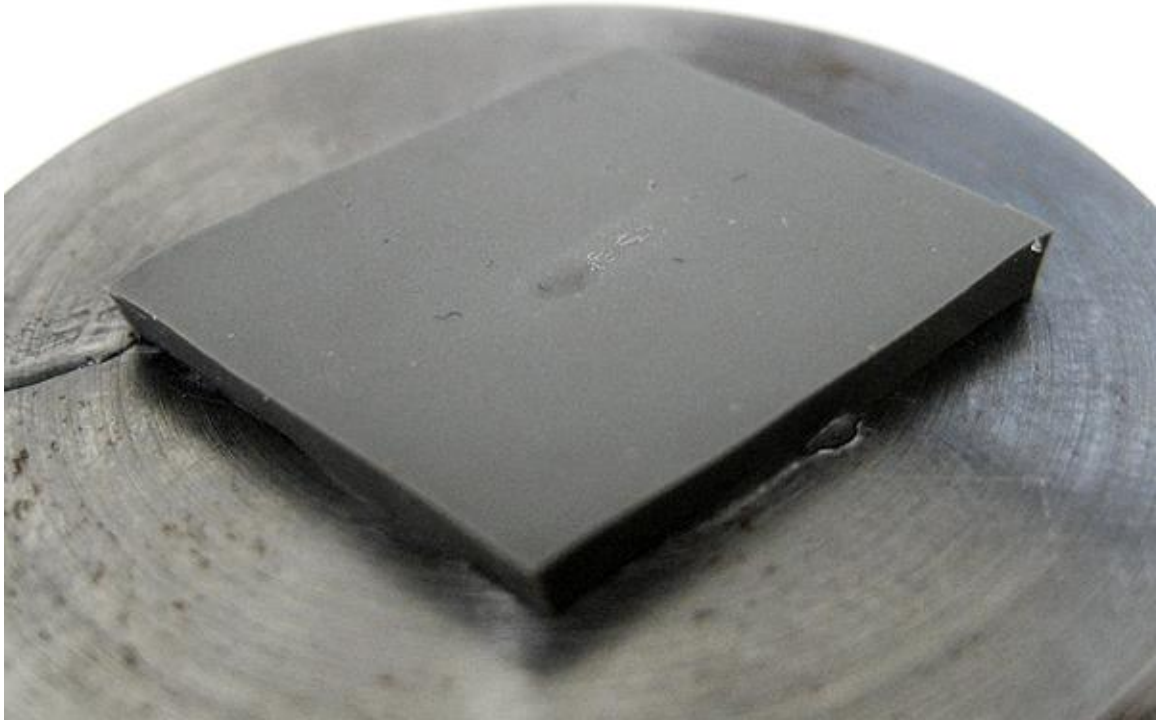
Results

Surface Topography (After Test)





ISO 25178		
Height Parameters		
Sq	9.424	µm
Ssk	0.171	
Sku	3.653	
Sp	42.018	µm
Sv	29.040	µm
Sz	71.058	µm
Sa	7.324	µm



CONCLUSION

The Nanovea Tribometer provided reliable coefficient of friction results between a steel ball and a rubber sample. The test was performed through a Linear method, although, the Nanovea Tribometer could also provide Pin 0n Disk method. The coefficient of friction was constant up to the point where the back and forth motion started to create damages on the surface. This wear was observable with the mobile video (see picture above). The attached 3D Non Contact profiler can show the 3D wear from which the volume of materials removed or the average roughness can be measured. Many of the test parameters can be varied to meet specific applications requirements. For example, using higher loads will create a more aggressive wear rate. However, if the purpose is to study the surface coefficient while minimizing wear, lower loads can be used. The limit on the Tribometer is 0.25N. For test to much lower loads which might be useful in application such as for medical devices, the nano mechanical tester can be used to load down to 0.0001N with balls up to 6mm in diameter. To simulate real-life applications, it might be necessary to test at high temperature or under liquid. In conclusion, the Nanovea Linear Tribometer is a very effective way to study COF under different conditions to compare the gripping and useful life of various types of rubbers.