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FRICTION EVALUATION

AT

EXTREME LOW SPEEDS

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Importance of Friction Evaluation at Low Speeds

Friction is the force that resists the relative motion of solid surfaces sliding against each other. When the relative motion of these two contact surfaces takes place, the friction at the interface converts the kinetic energy into heat. Such a process can also lead to wear of the material and thus performance degradation of the parts in use.

With a large stretch ratio, high resilience, as well as great waterproof properties and wear resistance, rubber is extensively applied in a variety of applications and products in which friction plays an important role, such as automobile tires, windshield wiper blades. shoe soles and many others. Depending on the nature and requirement of these applications, either high or low friction against different material is desired. As a consequence, a controlled and reliable measurement of friction of rubber against various surfaces becomes critical.

MEASUREMENT OBJECTIVE

The coefficient of friction (COF) of rubber against different materials is measured in a controlled and monitored manner using the Nanovea Tribometer. In this study, we would like to showcase the capacity of Nanovea Tribometer for measuring the COF of different materials at extremely low speeds.

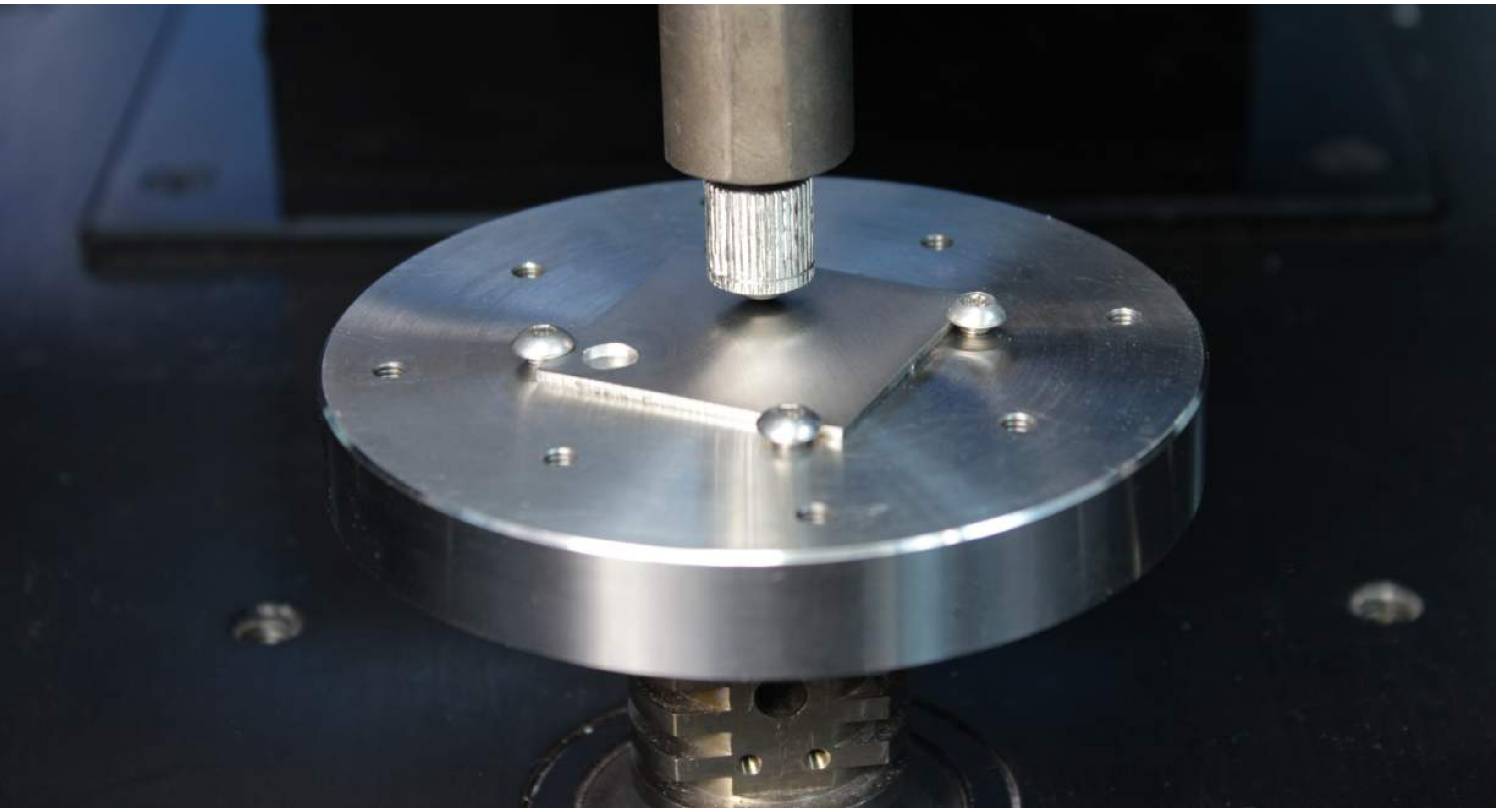


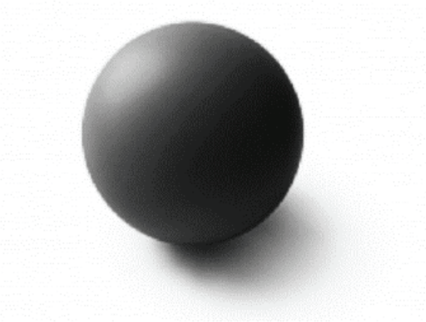
Figure 1: Pin-on-disc test setup for COF evaluation.

TEST PROCEDURE

The coefficient of friction (COF) of rubber balls (6 mm dia., RubberMill) on three materials (Stainless steel SS 316, Cu 110 and optional Acrylic) were evaluated by the Nanovea Tribometer. The tested metal samples were mechanically polished to a mirror-like surface finish before the measurement. The slight deformation of the rubber ball under the applied normal load created an area contact, which also helps to reduce the impact of asperities or inhomogeneity of sample surface finish to the COF measurements. The test parameters are summarized in Table 1.

Test Parameters	Value
Normal Force	1 N
Speed	0.01, 0.05, 0.5 and rpm
Duration of test	0.25 Revolution

Table 1: Test parameters of the COF measurement



Sample of rubber ball

RESULTS AND DISCUSSION

The COF of a rubber ball against different materials at four different speeds is shown in Figure. 2, and the average COFs calculated automatically by the software are summarized and compared in Figure 3. It is interesting that the metal samples (SS 316 and Cu 110) exhibit significantly Increased COFs as the rotational speed increases from a very low value of 0.01 rpm to 5 rpm -the COF value of the rubber/SS 316 couple increases from 0.29 to 0.8, and from 0.65 to 1.1 for the rubber/Cu 110 couple. This finding is in agreement with the results reported from several laboratories. As proposed by Grosch[4] the friction of rubber is mainly determined by two mechanisms: (1) the adhesion between rubber and the other material, and (2) the energy losses due to the deformation of the rubber caused by surface asperities. Schallamach[5] observed waves of detachment of rubber from the counter material across the interface between soft rubber spheres and a hard surface. The force for rubber to peel from the substrate surface and rate of waves of detachment can explain the different friction at different speeds during the test.

In comparison, the rubber/acrylic material couple exhibits high COF at different rotational speeds. The COF value slightly increases from ~ 1.02 to ~ 1.09 as the rotational speed increases from 0.01 rpm to 5 rpm. Such high COF is possibly attributed to stronger local chemical bonding at the contact face formed during the tests.

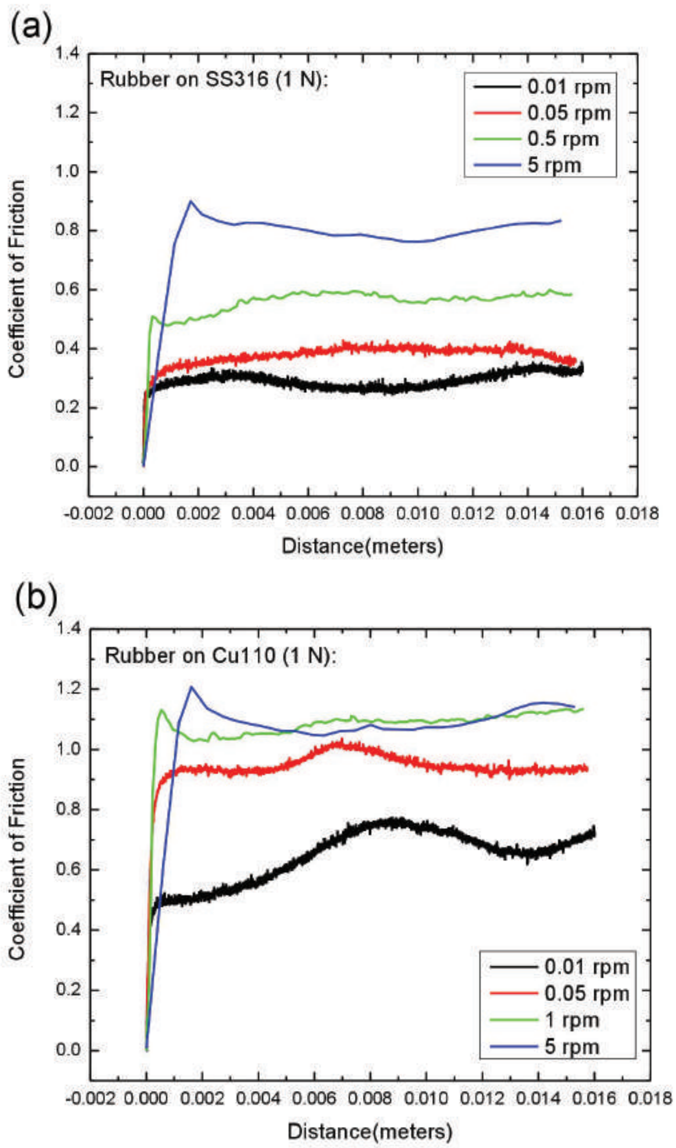
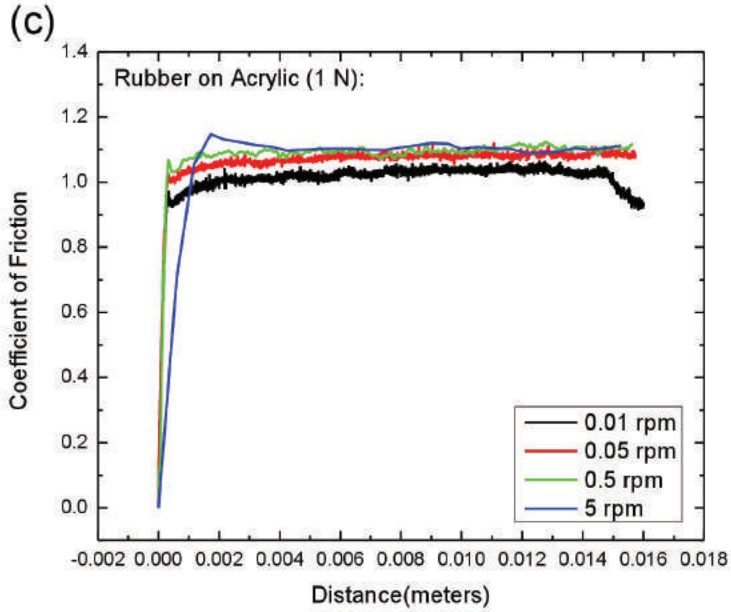


Figure 2: Coefficient of friction rubber ball against (a) SS 316, (b) Cu 110, (c) Acrylic.



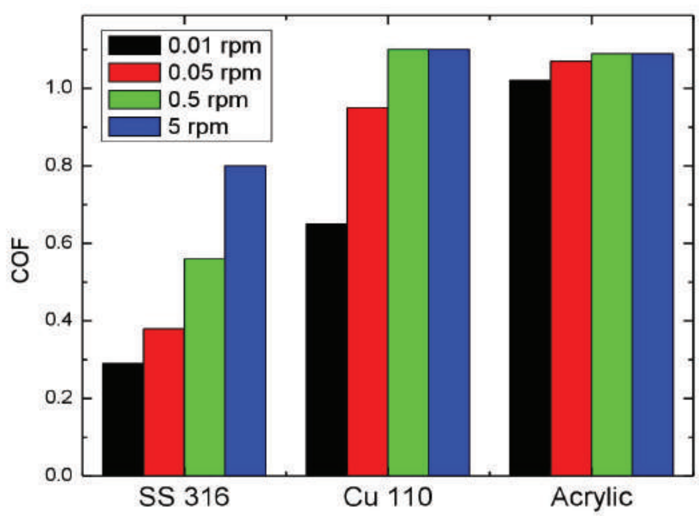


Figure 3: Comparison of COF of rubber against different material couples at different speed.

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Conclusion

In this study, we show that at extremely low speeds, the rubber exhibits a peculiar frictional behavior - its friction against a hard surface increases with the increased speed of the relative movement. Rubber shows different friction when it slides on different materials. The Nanovea Tribometer can evaluate the frictional properties of materials in a controlled and monitored manner at different speeds, allowing users to improve fundamental understanding of the friction mechanism of the materials and select the best material couple for targeted tribological engineering applications.

The 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. It is capable of controlling the rotational stage at extremely low speeds down to 0.01 rpm and monitor the evolution of friction in situ. 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.