# Evaluation of Elastic Properties of Elastomer Micro-Springs with CETR Micro-Tribometer

***Summary:*** The mechanical behavior of elastomer conical samples has been studied with the CETR UMT Series Micro-Tribometer. Accurate data for the spring characteristics and elastic modulus were obtained, which demonstrated consistent results and coincided with the theoretical curve.

***Instrumentation:*** The elastic properties of the elastomer cone springs were accurately measured utilizing the CETR UMT Series Micro-Tribometer. This tribometer provides precision measurements of the spring characteristics and elastic modulus of elastomers, as well as of the tribological properties of ferrous and non-ferrous metals, plastics, paper, composites, thin and thick coatings, lubricants.

The following parameters can be measured:

1 - Friction force and coefficient of friction,
2 - Adhesion force,
3 - Wear and wear rate (including fatigue, abrasive and adhesive wear),
4 - Contact resistance or capacitance,
5 - Temperature in the friction zone,
6 - Acoustic emission.

The UMT can accommodate both upper and lower specimens of a wide variety of shapes and dimensions. The upper specimen is connected to the vertical linear motion system that has a travel more than 100 mm with resolution of 1 µm (optional 50 nm). The lower specimen is fixed on a rotating table that has a velocity range from 0.01 rpm up to 5,000 rpm (the rotation is used for positioning and/or tribological measurements). The ultra-accurate strain-gauge sensor performs simultaneous measurements of the normal load and friction force up to 250 mN (25 g) with resolution of 0.2 mN and very high repeatability. The normal load sensor provides feedback to the vertical motion controller, actively adjusting the upper specimen position to control the load during testing.

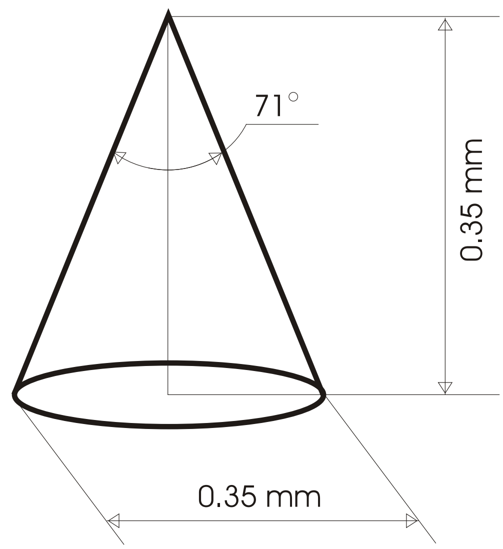


**Fig. 1. Schematic of a micro-spring**

The tester has a fully automated PC-based motor control and data acquisition, with a user-friendly software interface in a Windows 95/98 multitasking environment. The test data can be acquired, calculated and displayed in real time, as well as stored for future retrieval.

***Sample description:*** The conical elastomer samples had the following geometry (see Fig. 1):

- height 0.35 mm,
- cone angle 71º.

***Experimental procedure:*** The upper specimen (flat or divot) and the conical spring fixed on the lower disc were mutually aligned before starting the test. The upper specimen was moved down by steps of 1 µm, compressing the spring, with 5-10 second rest after each step. Measurements of both the vertical compression force from the load sensor and the vertical displacement of the upper specimen from the vertical position encoder were recorded continuously to the test file.

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After the spring deformation of 25 µm, the upper specimen was moved up by steps of 1 µm, decreasing the spring compression, so that the hysteresis of elastic characteristics of the spring was also obtained. Similar cycles were performed 5 times for every spring.
The recorded data was transformed into ASCII format for evaluation.

***Results and discussion:***

The results of the five independent experiments are presented as spring characteristics in Fig. 2.

These data represented both the compression and release processes. The hysteresis was found to be very small. The compressed force F that provided displacement of 25 µm was equal 1.6 mN. The linear portion of the spring characteristic curve has the spring constant of about 90 N/m (Fig. 3). The elastic module $E$ was calculated using the following equation

$$E = F^* / p(\tan \quad )^2 * (l-d)/(l*d^2)$$

where
$d$ is the total displacement,
is one half of the cone angle,
$l$ is the cone height.

The calculated elastic modulus E was 1.5 MPa.

***Conclusions:***

1. The Micro-Tribometer provides accurate measurements of the spring characteristics.

2. The experimental data are consistent and coincide with the theoretical curve.

**Fig. 2. Experimental and theoretical spring characteristics**

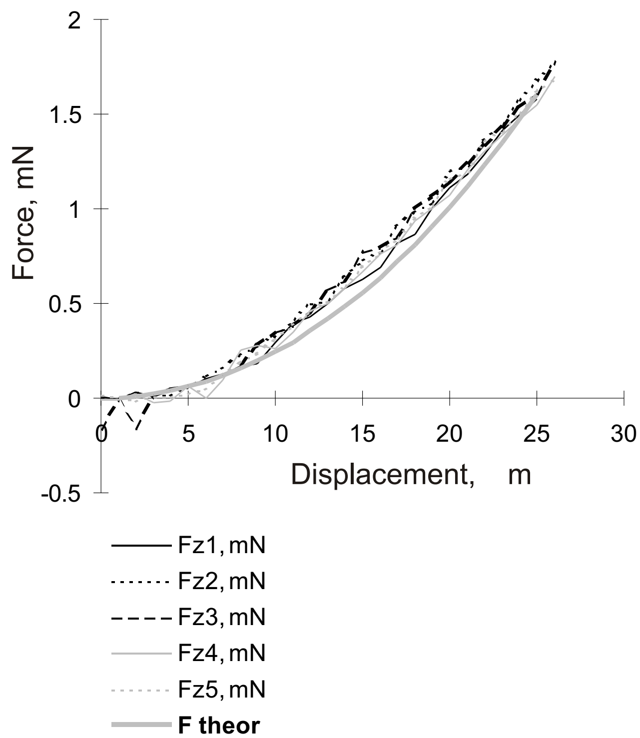
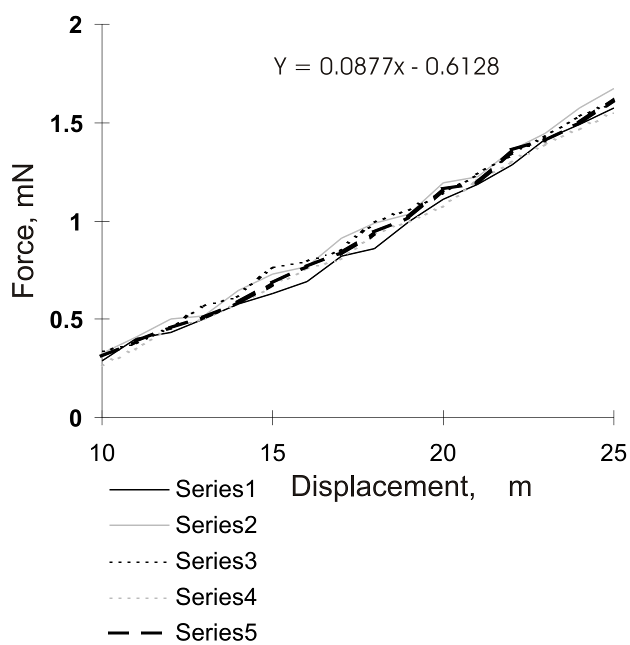



**Fig. 3. Partial spring characteristic**





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