Using a micrometer screw

Objects of the experiment

- Measuring the diameters of two thin wires and examining the accuracy of measurement.
- Demonstrating the deformation of a wire occurring when the friction clutch is not used in the measurement.

Principles

Small thicknesses are often measured by means of a micrometer screw. A micrometer screw consists of a massive bow carrying a rigid measuring jaw on the left and a travelling measuring jaw on the right (see Fig. 1). The measuring jaws are opened or closed, respectively, by turning a thimble around a cylinder, which is rigidly connected with the bow.

A scale on the cylinder corresponds to the distance between the measuring jaws in steps of 0.5 mm. The zero of the scale is reached when the measuring jaws are completely closed. When the thimble is turned by a full revolution, the right measuring jaw is moved by half a millimetre. The accuracy of measurement is enhanced by an additional scale engraved around the thimble having 50 graduation marks that correspond to a change of the distance between the measuring jaws of 10 μm. Thus the accuracy of reading is approx. 2 μm (see Fig. 2).

The object to be measured is clamped between the measuring jaws. In order to prevent the object from being deformed, a screw is turned which is connected to the thimble via a friction clutch.

In the experiment, the thicknesses d of different wires are each measured several times. Apart from the mean value of the sample

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i \qquad \text{(I)},$$

n: number of individual measurements,

also the standard deviation of the sample

$$s = \sqrt{\frac{1}{n-1}\cdot\sum_{i=1}^{n-1}\left(d_i - \bar{d}\right)^2} \qquad \text{(II)}$$

is calculated. The latter is a measure of the straggling of the individual measurements around the mean value [1]. It is compared with the accuracy of reading of the micrometer screw.

Next the meaning of the friction clutch is investigated by measuring a soft wire with and without using the friction clutch.

Fig. 1 Micrometer screw
a: rigid measuring jaw, b: travelling measuring jaw,
c: cylinder with rough scale, d: thimble with fine scale,
e: screw with friction clutch, f: bow

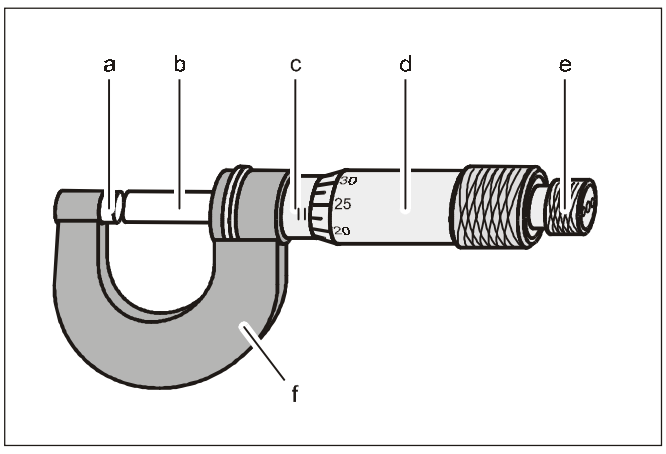
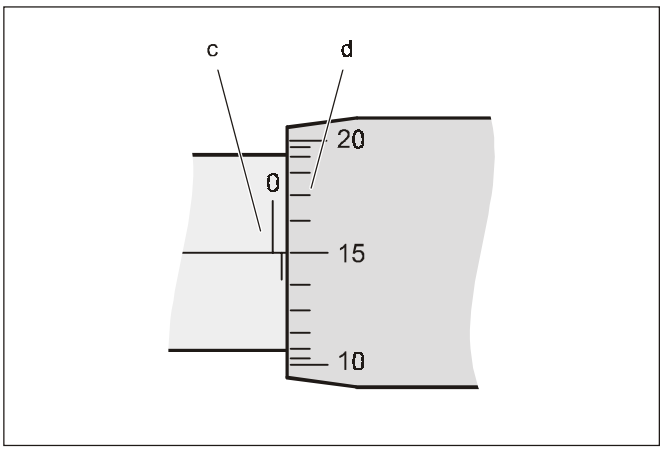


Fig. 2 Representation of a distance d on the rough scale (c) and on the fine scale (d):
d = 0.5 mm + 0.150 mm = 0.650 mm



Apparatus

1 precision micrometer screw gauge	311 83
1 copper wire, 100 m, 0.2 mm dia.	550 35
1 brass wire, 50 m, 0.5 mm dia.	550 39

Setup and carrying out the experiment

a) Measuring the thickness of a wire at several positions:

– Take the brass wire between the measuring jaws.

– Bring the measuring jaws together by turning the screw until the wire is clamped and the thickness to be read no longer changes.

– Read the thickness *d*.

– Clamp the brass wire at another four positions each time reading the thickness *d*.

– Repeat the measurements with the copper wire.

b) Demonstrating the deformation when the friction clutch is not used:

– Take the brass wire between the measuring jaws and bring the measuring jaws together by turning the screw until the wire is clamped.

– Continue turning the screw and read the thickness of the wire several times.

– Then turn the thimble, and read the thickness of the wire several times.

Measuring example and evaluation

a) Measuring the thickness of a wire at several positions:

Table 1: thickness of the brass wire

i	Rough scale	Fine scale	$\frac{d_i}{\mu m}$
1	0.0	48.0	480
2	0.0	47.9	479
3	0.0	48.0	480
4	0.0	48.5	485
5	0.0	48.1	481

Mean value: 481 μm
Standard deviation: 2 μm
Graduation of the scale: 10 μm

Table 2: thickness of the copper wire

i	Rough scale	Fine scale	$\frac{d_i}{\mu m}$
1	0.0	21.2	212
2	0.0	20.9	209
3	0.0	20.8	208
4	0.0	21.2	212
5	0.0	20.6	206

Mean value: 209 μm
Standard deviation: 3 μm
Graduation of the scale: 10 μm

b) Demonstrating the deformation when the friction clutch is not used:

after the wire has been clamped gently: $d = 0.48$ mm

after turning the screw repeatedly: $d = 0.48$ mm

after turning the thimble repeatedly: $d = 0.30$ mm

Results

With the aid of a micrometer screw, the thickness of a wire can be measured to an accuracy of about 2 μm.

The result is distorted if the wire is squeezed together too strongly. Therefore the friction clutch between the screw and the thimble should be used.

Literature

[1] P.R. Bevington and D.K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw Hill College Div.

LD Didactic GmbH Leyboldstrasse 1 D-50354 Huerth / Germany Phone: (02233) 604-0 Fax: (02233) 604-222 e-mail: info@ld-didactic.de