Evaluation of Leather Softness

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Received 17 November 2007; accepted 15 April 2008

Up to now leather softness is evaluated using different methods and expressed using different units. Thus, obtained results it is difficult to compare. The aim of the research was to develop a reliable and commonly acceptable leather softness evaluation method. Due to that the analysis of traditional and most recent leather softness evaluation methods was performed. It is shown that the most appropriate method for defining leather softness can be the values of conditional elasticity in percentage under certain load.

Keywords: leather, measurement, mechanical softening, sharing, deformation, elasticity of leather.

INTRODUCTION

One of the most important characteristics during exploitation of leather products is leather softness. But up to now standard means for evaluation of this parameter do not exist and measurements are performed in different ways. As a rule, they are subjective or so called hand evaluation method, evaluation of different mechanical properties (elongation, stress, etc.) during uni-axial or biaxial tension [1, 2]. As a result the same leather physical characteristics can be evaluated using different methods [3 – 7]. Normative documents, which regulate the values of the parameters evaluating leather softness and their grouping into separate categories in dependence on the kind of leather, do not exist. So it is expedient to analyse different means applied for the evaluation of leather softness and to develop common methodology and means, according to which leather softness would be evaluated at different deformation stages and re-evaluated in dependence of sample geometrical parameters into standard values of the physical properties of materials.

Peng Wenli, e*t al* [8 – 11] have analyzed possibilities of leather softness evaluation according to the work processed during sample punch using the coin of constant mass at punch height *h*. Unfortunatelly, the authors provide only positive conclusions for application of this method, but no recommendations. Moreover, it is not clear why the leather properties was not evaluated although it will undoubtedly affect the deformation work.

Suitable parameter for leather softness evaluation can be elasticity, because it defines deformability of leather within the limits of elastic deformations. But no methods or recommendations exist which can be used for comparision softness values obtained using different evaluation methods. The aim of this investigation was to find out methodology according to which relative elasticity determined during bi-axial tension as parameter for leather softness evaluation can be used.

EXPERIMENTAL

Two types of chromium tanned leather, i. e. leather for footwear and furniture production in thickness of 1.4 mm ±0.2 mm and 1.0 mm ±0.2 mm respectively were used. All samples were prepared from the counter part of the softened or unsoftened catle leather.

Three methods were used for the leather softness evaluation.

I method. The uni-axial tension at 100 mm/min of lower head speed rate was used to evaluate mechanical and physical properties and produce control tests. 125 dogbone shaped samples were prepared and tested according to the LST EN ISO 3376:2004.

II method. Fig. 1 is presents a scheme of the pneumatic device ST 300 recommended by the Society of Leather Technologists and Chemists, EU and Lithuanian standards [1, 2]. This device enables to measure the depth of punch in millimetres of a fixed sample when it is under clamp of the pin of a certain size and mass.

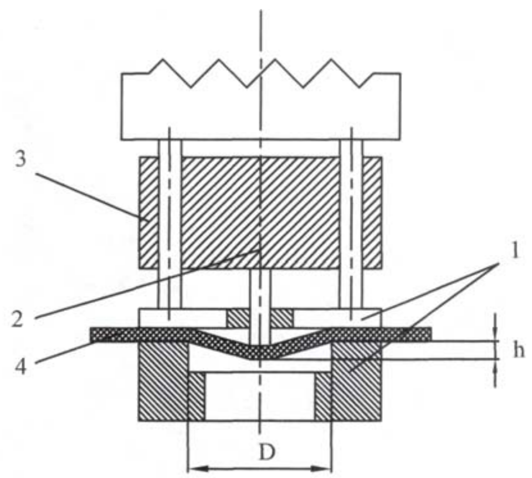

Fig. 1. Scheme of a device ST 300: 1 – clamp; 2 – pin; 3 – weight; 4 – leather sample

III method. A patented pneumatic device for bi-axial tension, was used for the sample deformation [12]. Using this method leather softness is expressed by its conditional elasticity in percentage. The samples of 120 mm × 150 mm in the measure were tested. Relative leather elasticity was calculated in dependence of the pressure *P* (Fig. 2). *P* value used in the calculations was determined at the moment when the upper surface of the sample contacts a sensor 4 at the height *h*. At this moment relative elasticity of 2.6 % is reached (constant of the device). Geometrical

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parameters (D and h) of the pneumatic device are calculated according to the experimental results. It was found that for leather samples of 1.4 mm ±0.2 mm in thickness 1 MPa stress is reached at the deformation of 2.6 %. Besides, it was determined that the relation between the stresses and relative elasticity in the interval from 0 MPa to 1.5 MPa is close to the linear.

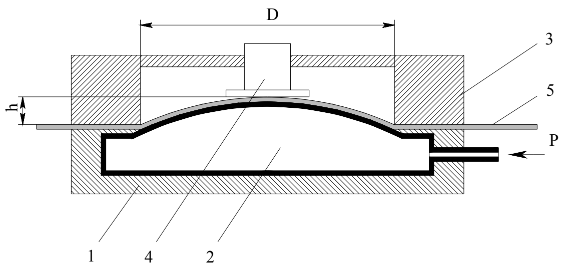


Fig. 2. Pneumatic device for bi-axial deformation: 1 – frame; 2 – pneumatic chamber; 3 – mandrel; 4 – sensor; 5 – leather sample

For the scheme presented in Fig. 2 the following equation holds true:

$$\frac{\sigma}{2.6} = \frac{1}{S}, \tag{1}$$

where σ is the average stress of the sample during tension; 1 is the value of reached relative stress (MPa); 2.6 is the constant of the device; S is the relative elasticity of the sample.

Using Eq. (1) the relative elasticity S of the sample can be calculated using the real stress values and proportional to 1 MPa stresses, which cause relative elasticity of 2.6 % (Fig. 3).

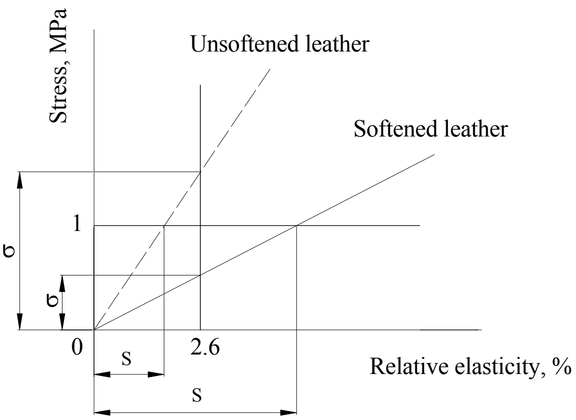


Fig. 3. Scheme for the stress evaluation

Average stress σ of the leather sample is calculated according to:

$$\sigma = \frac{FP}{L\delta}, \quad \text{MPa}, \tag{2}$$

where F is the surface area under pressure, m^2; P is the pressure fixed in the pneumatic unit, MPa; L is the length of a circle of a convex dome, m; δ is the thickness of the leather sample, m.

To eliminate calculation errors during evaluation of value of relative elasticity, stress values σ and constant 1 in the Eq. (1) can be replaced with the pressure values, which were applied to achieve the stress. It follows that:

$$S = \frac{2.6 P_1}{P}, \tag{3}$$

where P is the pressure in the unit of the device, MPa; P_1 is the calculated pressure constant, at which stress of 1 MPa is reached.

The device is equipped with a sensor indicator, which fixes pressure value in the pneumatic unit. Therefore constant P_1 is recalculated.

After rearrangement of Eq. (3), the relative elasticity can be calculated as:

$$S = \frac{752}{P}, \tag{4}$$

where P is pressure in the unit of the device, mm Hg.

Leather elasticity evaluation method based on bi-axial tension and the pneumatic device developed by the authors have been sufficiently tested: sensibility potential of the device was identified. The sensibility of the device was evaluated using leather samples softned by shearing [13]. Fixed stress values at selected deformation indicates suitability of device for measurements (Fig. 4). The device is able to fix 0.089 MPa stress at 1 % of elongation. After that it was assumed that the device is suitable to investigate relative elasticity of leather samples.

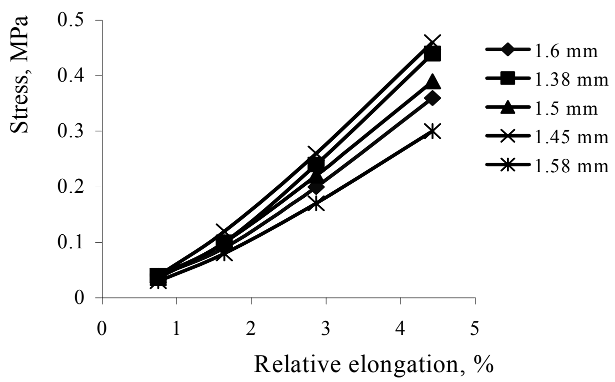
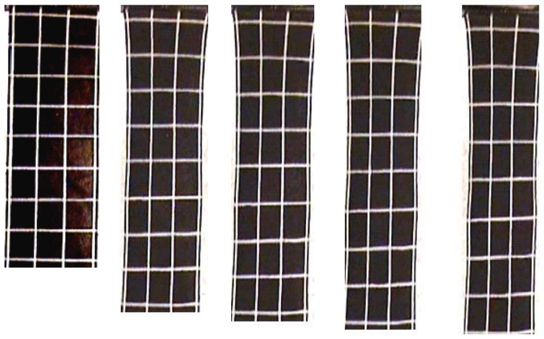


Fig. 4. Stress-strain dependencies used for evaluation of the device sensibility

RESULTS AND DISCUSSION

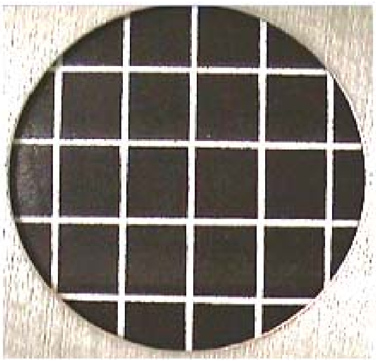
The leather softness obtained using the methods of uni-axial and two types of bi-axial tension (pneumatic and with a flat coin) can be re-evaluated to conditional elasticity at equivalent load but different deformation conditions. In order to evaluate the effect of deformation conditions the quadratic network (10 mm × 10 mm) on the samples surface was formed and the samples were deformed during uni-axial and bi-axial tension. The process was recorded using a digital video camera. During the uni-axial tension the sample was deformed unevenly trough the whole length (Fig. 5). While during the bi-axial tension network boarders changes symetrically on the whole surface of the sample (Fig. 6).

The next stage of investigation was to find out the correlation between the softness calculated using results of the uni-axial and bi-axial spherical tension. The results of 125 measurements were analysed. They demonstrated, that the values obtained for uniaxial tension is lower than those determined during bi-axial tension.

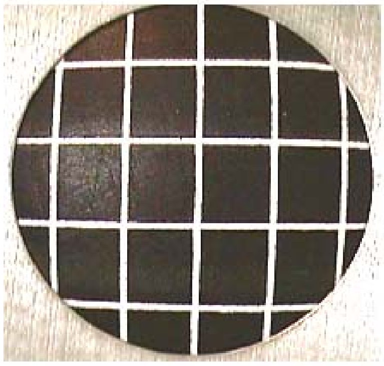


1 2 3 4 5

Fig. 5. Stages of uni-axial deformation: 1 – undeformed; 2–4 – intermediate positions; 5 – deformed up to selected load value (measures of mesh was 10 mm × 10 mm)



a



b

Fig. 6. Sample for the bi-axial deformation by pneumatic punch with the device: a – undeformed; b – after deformation (measures of mesh was 10 mm × 10 mm)

To compare the obtained results correlation coefficient was calculated. Correlation coefficient of 0.1 between the uni- and bi-axial tests was obtained. That indicates that functional correlation between the leather softness using different tension methods does not exist. It may be explained by the fact that the surface of the samples during uni-axial tension was relatively small on the scattering of the the thickness of the investigated samples.

The supplementary measurements showed a significant scattering in thickness δ (Fig. 7) within deviation limits and in softness S (relative elasticity) of softened and unsoftened leather samples.

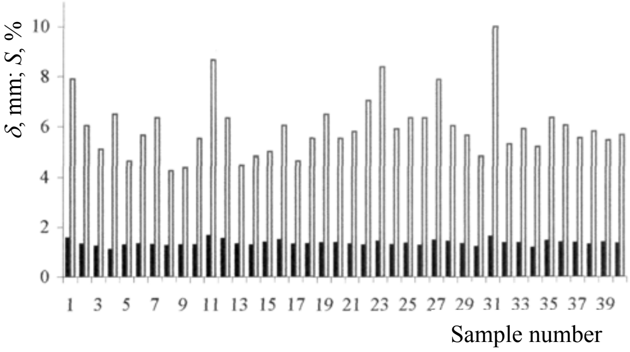


Fig. 7. Scatter of relative elasticity and thickness of soft leather: ■ – thickness; □ – relative elasticity

It is known that physical and mechanical properties of leather also depend on the direction of deformation in respect of back line of leather [14] (Fig. 8). However, comparition of the results obtained during the uni- and bi-axial tension showed that influence of the sample direction for bi-axial tension does not influence on properties changes, like those obtained during the uni-axial tests (Figs. 6 and 8).

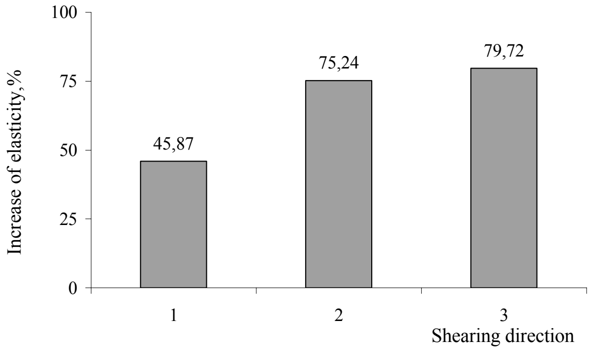


Fig. 8. The influence of shearing direction on the value of relative elasticity: 1 – perpendicular to back line ; 2 – along back line; 3 – perpendicular and along back line

During punch the sample for several times bigger surface is stressed into two directions, the effect of all the mentioned factors is evident and therefore generalised characteristics of softness are obtained [15]. Moreover, in cases of the both tension methods different conditions of deformation are produced.

In this way, two exploring methods of bi-axial tension: spherical pneumatic and spherical with a flat coin are more suitable for the evaluation of leather deformation parameters. However, one should keepi in mind that these two methods are not equivalent. The deformation using the pneumatic device results on the even load distribution over all surface area. eanwhile deformation with a flat coin results on the additional deformation of the sample in the centre zone. Besides, the device must not leave damages on the sample surface.

In order to define correlation between the values of softness obtained using different softness evaluation methods it is necessary to carry out additional investigations. This task becomes more complicated because the same sample cannot be loaded twice on the same place as the changes in softness from the previous trial exist (Fig. 9) [16].

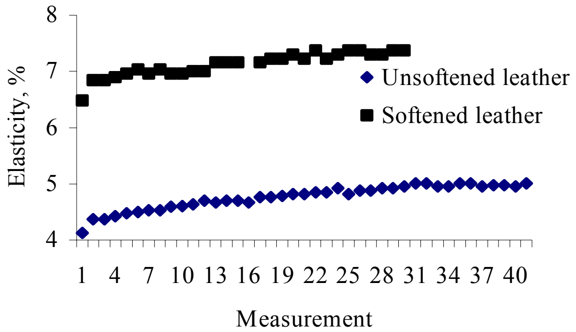


Fig. 9. The effect of measurement times in the same place on the leather elasticity value

CONCLUSIONS

Leather softness can be expressed by its conditional elasticity in percentage at certain load values during bi-axial tension. The original device presented by the authors for this purposes can be used.

Due to percularities of the leather structure no clear correlation between the uni-axial and bi-axial tension results exists.

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