PECULIARITIES OF EVALUATING OF LEATHER SOFTNESS

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Introduction

At the present stage of development of science and technology attempts are made to evaluate the characteristics of researched objects by their most corresponding standard values. Because of a certain specificity of leather industry where very many kinds of raw leather with different characteristics are treated under different conditions by using different means and different technologies, leather softness is measured differently. In opinion of the authors of the paper, under such conditions it is expedient to analyse different means applied for the evaluation of leather softness and to develop common methodology and means, by which leather softness would be evaluated referring to the agreed means of deformation and re-evaluation of the geometrical parameters of the samples under certain load values into standard values of the evaluation of physical characteristics of materials.

Experimental methods

In order to select a research method the authors chose 4 main methods used in leather softness evaluation. Traditionally the most common method used to evaluate the quality of final mechanical treatment of leather is the subjective or hand evaluation method. The method of one-axis stretching is used in scientific works and for control tests. Using this method it is possible to set numerical values for the selected physical characteristics. In their works the authors used a patented [1] pneumatic device, which works by the principle of two-axis spherical stretching, and leather softness evaluation method (Figure 1).

Using this method leather softness is expressed by its conditional elasticity in percentage. Relative elasticity of leather is calculated by pressure *P* which is fixed in the unit of the device at the moment when the upper surface of the convex sample contacts a process sensor 5 at the depth *h*:

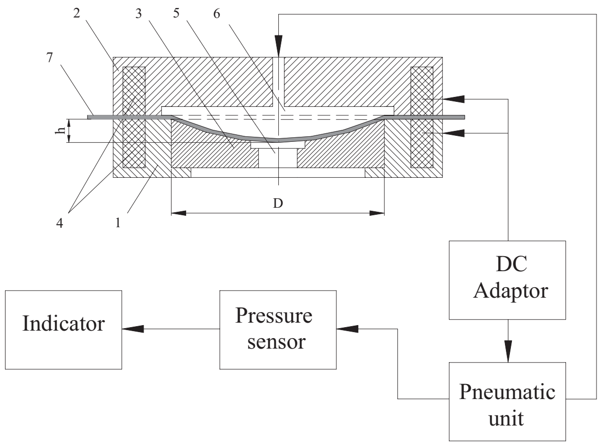

Figure 1. Diagram of pneumatic device for determination of leather mechanical properties: 1 - housing, 2 - mandrel, 3 - die, 4 - circular solenoid windings, 5 - contact sensor, 6 - pneumatic chamber, 7 - leather sample

$$S = \frac{2.6 \times P_1}{P}, \tag{1}$$

where P – pressure in the unit of the device, MPa; P_1 – calculated pressure constant, at which 1MPa stretches are reached.

Recently the device ST 300 (Figure 2) has been recommended by the Society of Leather Technologists and Chemists, EU and Lithuanian standards [2, 3]; it measures the depth *h* of press pins in millimetres in a fixed sample when it is under clamp of the pin of a certain size and mass.

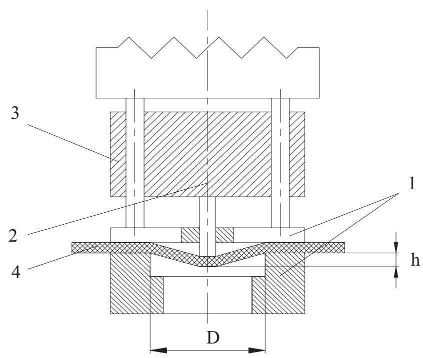

Figure 2. Device ST 300. 1 - clamp; 2 - pin; 3 - weight; 4 - leather sample

No methodology by which the obtained results are evaluated and no values of softness as well as indications to other standards regulating the parameters of leather quality are provided in the above mentioned standards.

The same leather physical characteristics are evaluated differently by each of the above mentioned methods. No normative acts, which regulate the values of the parameters evaluating leather softness and their grouping into separate categories by the purpose of leather, exist. Thus the task is to develop an indicator common to all leather softness evaluation methods and linked to the results obtained by using each of the above mentioned methods. Therefore it is expedient to carry out researches on the link among the leather softness evaluation results obtained by using different methods.

Leather elasticity, an indicator of leather basic softness, was selected for this research; leather elasticity defines its possibilities for deformation within the limits of elastic deformations under influence of deformation agents.

Results and discussion

Scientists Peng Wenli, Zhang Xiaolei and Chen Shuru have researched possibilities of leather softness evaluation by the work of the coin of fixed mass on the weight, which makes a dent of the depth *h* into the leather sample in their work [4]. The authors provide only positive conclusions but no recommendations. Moreover, it is not clear why the leather resistance law is not taken into consideration although it will undoubtedly affect the work.

For example, as the leather deformation characteristics are different and the samples are under unequal initial strain which cannot be controlled, the work of fixed weight intensity $F_{\max} = const.$ will also be of different values (Figure 3).

If the samples are under strong and slight strain (Figure 3; 1-2), leather distension work may be defined by the equation:

$$W = \int_{F_0}^{F_{\max}} F\, h_{(F)} dF\ , \tag{2}$$

in case of normal strain (Figure 1; 3)

$$W = \tfrac{1}{2} F_{\max} h_1\ . \tag{3}$$

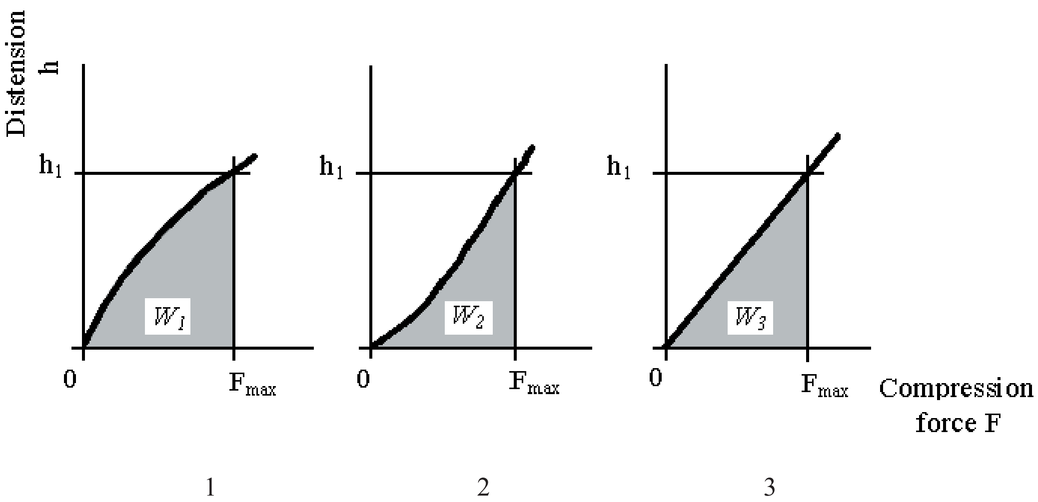

Figure 3. Dependence of leather distension work on the initial strain of the:
1 - slight strain, 2 - strong strain, 3 - normal strain

As the force of leather resistance to deformation is not measured in any of the above mentioned cases, the work of the force cannot be fairly precisely calculated. We are of opinion that because of this reason it is inexpedient to evaluate leather softness by the work.

The values of leather softness, which were obtained by using the methods of one-axis and two-axis (pneumatic and with a flat coin) stretching may be re-evaluated into conditional elasticity when load is equivalent and deformation conditions are different. In order to test the effect of deformation conditions the samples marked by checks were deformed using the methods of one-axis and two-axis stretching. The process was recorded using a digital video camera. During one-axis stretching the sample was deformed unevenly on the whole length, during two-axis stretching – proportionally on the whole surface of the sample.

At the following stage a correlative relation between softness values calculated from test results obtained during one-axis and two-axis spherical stretching was studied. For that purpose 125 soft leather samples used in upholstery were studied.

Correlation coefficient of 0.1 was calculated (Table 1). Thus no functional correlation between leather softness set using the methods of one-axis and two-axis spherical stretching was found. It may be explained by the fact that the surface of the samples stretched by the method of one-axis stretching was small.

Table 1. ***Empirical coefficients of correlation***

	Thickness	**One-axis stretching**	**Two-axis stretching**
Thickness	1.000	-0.088	0.134
One-axis stretching	-0.088	1.000	0.105
Two-axis stretching	0.134	0.105	1.000

The experiment showed that leather physical characteristics in adjacent surfaces were different; they also depended on the direction of deformation. Measurements showed a significant difference in thickness within permissible deviation limits and in softness (relative elasticity) of softened and non-softened leathers.

However, analysing results it is observed that the deformations when stretching leather by two-axis stretching occur gradually [5].

In case of spherical stretching the sample of a several times bigger surface is stretched into two directions, the effect of all the mentioned factors is evident and therefore generalised characteristics of softness are obtained [6].

Two methods of two-axis stretching – spherical pneumatic and spherical with a flat coin – are best for the evaluation of leather deformation characteristics. However, these two methods are not equivalent because when the sample is deformed by a pneumatic device load distributes equally on the whole surface meanwhile in case of a flat coin the centre of the sample is additionally affected. Moreover, in cases of both stretching methods different conditions of deformation are created.

The devices which are used for these methods should be evaluated with regard to their possibilities to be used for leather softness evaluation when no damage to its integrity is made, their possibility to leave signs of evaluation on the final product as well as their convenience to be used for leather quality control in laboratories and production processes. In order to define correlation between the values of softness obtained by using these methods it is necessary to carry out supplementary researches. This task becomes more difficult because the same sample cannot be loaded in the same place as changes in softness from the previous trial are unavoidable [7].

Leather elasticity evaluation method based on two-axis spherical stretching and the pneumatic device developed by the authors have been sufficiently tested: sensibility potential of the device was identified, it was used for evaluation of leather softness reached by shearing [8] and in the research on forecasting shearing parameters [9].

Fixed average sensibility of 0.089 MPa on 1% of relative elongation is sufficient to research relative elasticity of leather.

Furthermore, using the results [9] of the research, measurement uncertainty of this device was identified: error field of the measurement result, which is the real value of softness expressed by elasticity S. The increase of softness E_m under the influence of different deformation parameters by shearing was researched.

$$E_m = \frac{S_1 - S_0}{S_0} \times 100,\% \qquad (4)$$

here S_0 and S_1 are measured values of elasticity before and after softening.

In this way an experimental validation of the prediction allows its application for the calculation of the uncertainty of evaluation. As the upper and bottom limits of this prediction in principle are symmetric to the dotted prediction in its whole interval of changes (Figure 4) it may be assumed that the values of the dotted prediction correspond to the theoretical value of the measured increased elasticity, and the interval of elasticity values from the selected point to the upper limit of the predictions is a total uncertainty of an increased elasticity.

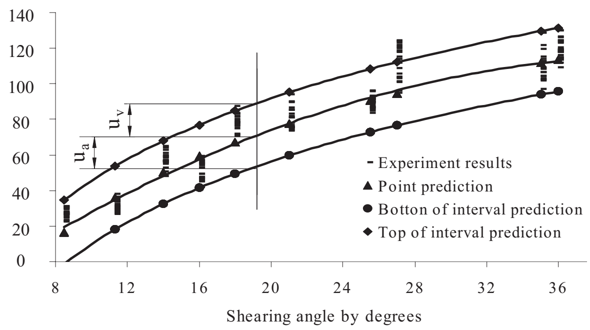

Figure 4. Point and interval predictions of change in relative elasticity, where u_v is the upper limit of the total uncertainty, u_a is the bottom limit of the total uncertainty

The uncertainty of the measured value, i.e. elasticity, as directly related to the total uncertainty of an increased elasticity, may be expressed in the following way:

$$u_v = \frac{E_{mt} - E_{mp}}{100}, \% \quad \text{and} \tag{5}$$

$$u_a = \frac{E_{mp} - E_{mb}}{100}, \% \ , \tag{6}$$

where E_{mt}, E_{mp} and E_{mb} are the volumes of the increase of elasticity on top of interval prediction, point prediction and bottom of interval prediction, 100 is constant, evaluating return from E_m to S.

Taking the data of the middle point of the predictions interval its values is calculated:

$$u_v = \frac{84.8 - 67.1}{100} = 0.18\% \ \text{and} \ u_a = \frac{67.1 - 49.4}{100} = 0.18\%$$

As the marginal intervals of predictions and adequate total uncertainty are symmetric with regard to the dotted prediction in the entire interval of changes the value of the evaluated elasticity will be $S \pm 0.18\%$. Such measurement uncertainty is sufficient when measuring leather softness.

Conclusions

1. When no alternative leather softness physical characteristics, using which the results obtained by the latest research methods could be calculated, exist, it is expedient to express leather softness by its conditional elasticity in percentage having reached certain load values.
2. The development of methodology to be applied both in calculations of conditional elasticity and evaluation of leather softness reached by pneumatic and spherical with a flat coin method is necessary. As its basis the leather elasticity evaluation method developed by the authors may be used.
3. The measurement devices, which function on the basis of spherical pneumatic and spherical with a flat coin methods, and are used to evaluate thickness of the sample and load values, calculate and produce leather softness values in visual and electronic forms which may be processed using software packages, should be developed. Researches should be carried out and recommendations for the development of leather softness standards should be worked out.

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Summary

In order to evaluate leather softness several different and difficult to compare methods are used. Thus the problem how to guarantee equivalent results of evaluation arises. The aim of the research is to develop a reliable and commonly acceptable leather softness evaluation method. The analysis of traditional and most recent leather softness evaluation methods has been done. The results of the trials are presented in the paper. It is summarised in the conclusions that in case no alternative physical characteristics showing leather softness exist, the most appropriate mean of defining leather softness may be the values of conditional elasticity in percentage under certain load values. It is also necessary to develop a general methodology to define conditional elasticity which could also be used for the evaluation of leather softness reached by the method of spherical deformation. Leather elasticity evaluation method developed by the authors is proposed to be used.

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

ODOS MINKŠTUMO ĮVERTINIMO YPATUMAI

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Santrauka

Odų minkštumas nustatomas keliais būdais naudojant skirtingus prietaisus. Dėl matavimų rezultatai kartais būna skirtingi tam pačiam gaminiui. Tyrimo tikslas yra eksperimentiniu – analitiniu būdu rasti patikimą ir visuotinai priimtiną būdą odų minkštumui įvertinti. Vienaaše ir dviaše tokio paties dydžio apkrovomis paveiktų odos bandinių deformacijos yra skirtingos ir nėra susietos aiškia funkcine priklausomybe. Darbe aprašytas autorių sukurtas odų minkštumo nustatymo būdas, pateikiamos prietaisų schemos bei bandymų duomenų diagramos.

Išvadose teigiama, kad odų minkštumą tikslinga išreikšti jos santykiniu slankumu procentais, pasiekus tam tikrą dviašės apkrovos dydį. Pagrindu tam galėtų būti autorių sukurtas odų slankumo nustatymo būdas.

Prasminiai žodžiai: oda, matavimas, mechaninis minkštinimas, šlytis, deformavimas, odos minkštumas.

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