# METHOD AND DEVICE FOR LEATHER SOFTENING

**Kazys Kazanavičius, Vaclovas Tričys**
*Šiauliai University*

## Introduction

Despite the advances in leather treatment methods and equipment, increased productivity and decreased pollution, some technology processes are still imperfect. One of such processes is mechanical softening. During this process, half of hides or even whole hides are treated. The uniform softness within the entire area is virtually impossible to achieve, as there is no way of bypassing or re-treating an area of different softness when flow machines are used for softening. Moreover, the detection of areas with insignificant differences in softness is difficult when softness is hand-evaluated and there is no industrial-scale equipment for softness measurement [1-5]. The aim of this investigation is to create equipment for the solution of the problem.

## Experimental methods

The tests were performed on chrome tanned cattle hides for manufacturing footwear vamp. Eight 1.4±0.2 mm thick half-hides from a single production batch were tested. All of them were divided into 200x150 mm topographic areas. The leather elasticity in these areas was determined with a pneumatic device [6]. The relative elasticity range was 2.5-3.7%. Relative elasticity is relative deformation of a material exposed to a definite load within the limits of resilience deformation. Calculated mean relative elasticity is 2.7%.

Four half-hides were conditioned and softened with a vibration softening machine, employing technologies used in leather production process. Their compliance with the softness quality requirements was determined by five experts (leather manufacture professionals) using a hand evaluation method. Then the relative elasticity of these half-hides was measured in the same areas marked prior to the softening. The data obtained was used for the calculations of the reference value of relative elasticity of softened leather.

It was found that the approximate value of mean relative elasticity of separate softened reference half-hides is 5.8%. The elasticity differences among adjacent topographic areas amounted to 3-5% of mean elasticity. The maximum difference in relative elasticity values within the entire half-hide area was 38% of mean elasticity.

It was assumed, according to the outcome of the above test and in the absence of reference documents for the evaluation of leather softness quality and changes in physical properties, that the softened leather elasticity value of 5.8±0.3% was to be considered as a sufficient, or a reference, value for leathers of this type.

The softening effect is defined as the increase in the lowest relative elasticity of non-softened leather to the reference value (Fig. 1).

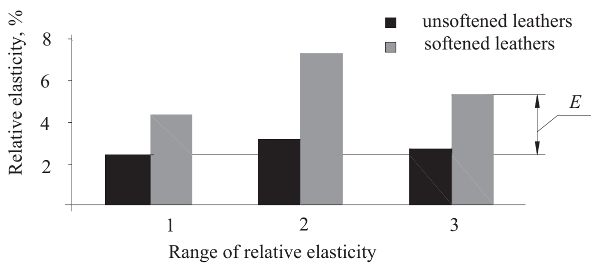



**Figure 1.** Diagram of desired softening effect determination
1 - minimum values; 2 - maximum values; 3 - mean values; E – desired softening (relative elasticity) effect

The softening effect is best expressed in its percentage form:

$$E_m = \frac{5{,}8 - S_0}{S_0} \times 100\,, \quad (1)$$

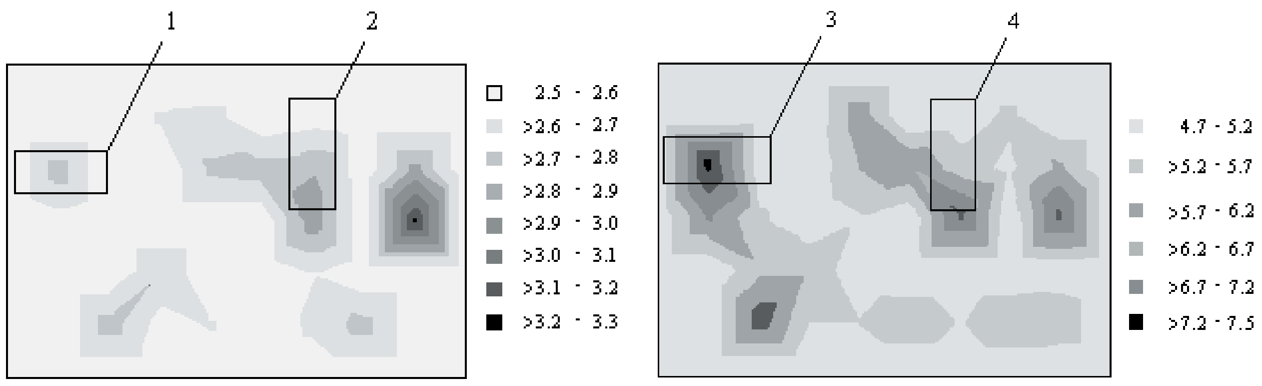
where $S_0$ is initial elasticity of the sample (non-softened leather).

## Results and discussion

To establish the general patterns of changes in relative elasticity during mechanical leather softening, the elasticity values before and after the softening of the same half-hide were compared.

According to the half-hide elasticity measurements, graphical diagrams of relative elasticity before and after the softening were created (Fig. 2) [5].

The analysis of the results showed that the determined relative elasticity in each topographic area was not proportional to its corresponding values before the softening.




a) b)

**Figure 2.** Topography of leather relative elasticity in % before (a) and after softening (b)

For instance, the ratio of maximum elasticity before and after the softening within a specific topographic area (Fig. 2 a, area 1 ($E_1$=2.8%) and Fig. 2 b, area 3 ($E_3$=7.45%) respectively) was lower than the same ratio within another topographic area (Fig. 2 a, area 2 ($E_2$=2.9%) and Fig. 2 b, area 4 ($E_4$=6.95%) respectively):

$$\frac{E_1}{E_3} < \frac{E_2}{E_4} = \frac{2{,}8}{7{,}45} < \frac{2{,}9}{6{,}95}.$$

Besides, higher increase in elasticity in areas with lower initial elasticity was observed. These data were compared with the outcome of a previous pilot experiment [7] leading to a conclusion that higher increase in leather relative elasticity was obtained in samples with lower initial elasticity (Fig. 3).

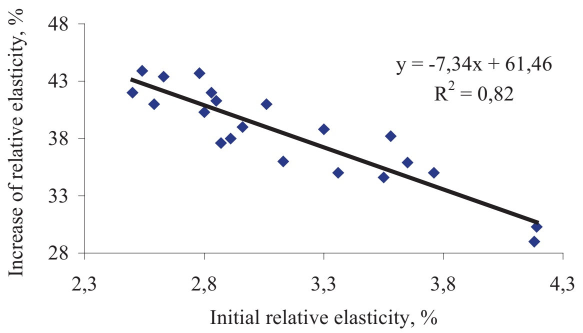



**Figure 3.** Increase in relative elasticity as function of initial leather elasticity

As the elasticity differences between adjacent topographic areas of non-softened leather were not significant, we could assume that more uniform elasticity pattern could be achieved if separate cuttings encompassing one or multiple adjacent areas were softened in different modes. The present situation is that cuttings from softened leather are not softened repeatedly thus resulting in quite different elasticity values in the entire marked area (Fig. 2, areas 3 and 4). Softening of separate leather pieces in cyclic modes is not feasible with the equipment used during production. As an alternative we have developed a method and a programmable controlled device for softening by shearing. Its application range includes relatively small leather pieces encompassing one or multiple adjacent topographic areas. In its application, a shearing angle and a number of shearing cycles are selected. According to the relation between softening and initial elasticity, an appropriate device operating mode is set to achieve a uniform relative elasticity pattern across different topographic areas of the piece (Fig. 4).

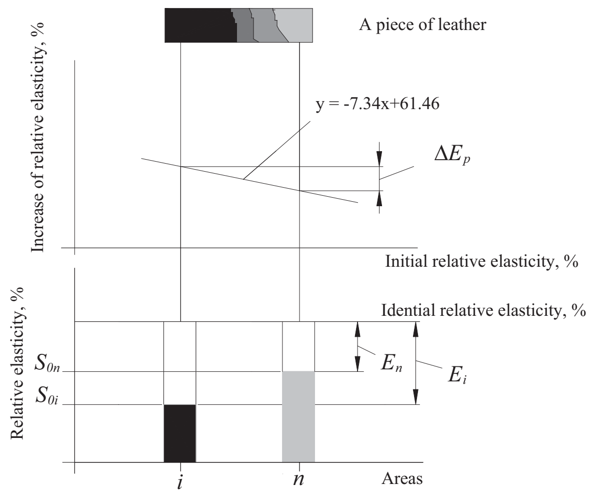



**Figure 4.** Diagram illustrating the selection of a common softening mode across the entire piece

To achieve the same estimated relative elasticity value across different topographic areas of the leather piece, the following condition must be met: $\Delta E_I \leq \Delta E_p$,Where $\Delta E_I$ is the difference between the required increases in relative elasticity in the n$^{th}$ ($E_n$) and i$^{th}$ ($E_i$) areas; $\Delta E_p$ is the difference between the possible increases in elasticity in the n$^{th}$ and i$^{th}$ areas due to the influence of the initial elasticity.

Thus:

$$E_n - E_i \leq 7.34\ (S_{0n} - S_{0i}), \quad (2)$$

where: $S_{0i}, S_{0n}$ are initial elasticity in the i^th and n^th areas.

This condition is met if

$$S_{0n} - S_{0i} \leq 0.7 \quad (3)$$

The required increase in relative elasticity values across the leather piece is achieved with the impact of the following factors: shearing angle *α*, number of shearing cycles *n*, factor of shearing direction relative to the longitudinal axis *c*, and speed *v*:

$$E = f(\alpha, n, c, v). \quad (4)$$

A nomogram was created on the basis of experimental data to evaluate the influence of shearing angle and number of cycles (Fig. 5).

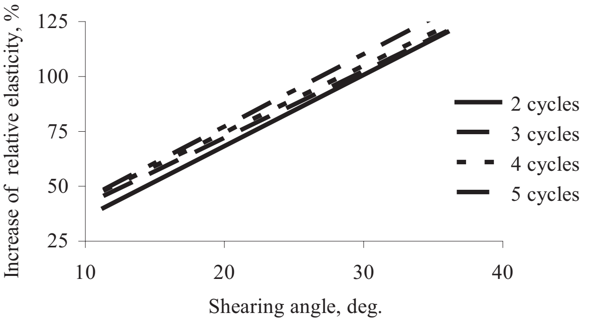



**Figure 5.** Nomogram. Number of shearing cycles – shearing angle – relative elasticity

The factor *c* takes into account the impact of shearing direction:

*c* = 1.0 : lateral shearing,
*c* = 0.39 : longitudinal shearing,
*c* = 0.42 : lateral and longitudinal shearing.

The shearing direction factor is only applied if the position of the piece is relative to the longitudinal axis of leather.

The shearing speed factor is not considered in the current stage as its influence has not been sufficiently studied. The velocities required from the economic perspective and permissible from the technical perspective have not been determined as this would require additional studies of physical characteristics of leather and determination of design characteristics of the softening device. All tests in the shearing experiment were carried out at the same speed [3].

Considering the above, the required softening effect with the selected shearing angle and number of cycles is:

$$E_{(\alpha,n)} = cE_n. \quad (5)$$

It is determined that patterns of leather respond to a softening process differently because of structural properties. To compensate for this, the work piece must be appropriately selected before softening. This sizing factor must be experimentally determined for different types of leather. The measurements are performed before the softening and when the estimated (reference) softening level has been achieved.

To increase the technological capabilities of softening by shearing, a new method and a technology device have been developed [8] (Fig. 6). With this device the entire piece of leather is softened at once, without shifting and in compressed state. The device operates as follows: a piece of leather (3) (Fig. 6) is compressed between the top (1) and bottom (2) multiplate mandrels.

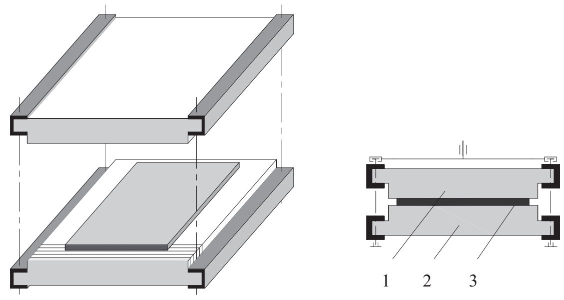



**Figure 6.** Device for leather softening by shearing: 1 – top mandrel; 2 – bottom mandrel; 3 – leather piece

Both mandrels synchronically move along a symmetric lateral path (Fig. 7) according to the selected shearing angle *α* and the number of cycles *n*.

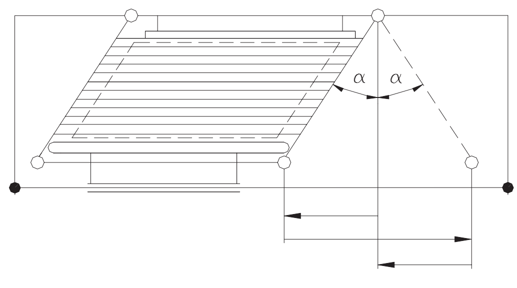



**Figure 7.** Kinematic diagram of multiplate mandrel

A controllable compression force is applied on the piece being softened between the mandrels. The compression force must prevent the piece from slipping during softening. The mandrel plates are made of a material with good frictional properties.

*Softening Procedure:* Initial relative elasticity is measured in at least five points of the leather piece. The compliance of separate topographic locations of the piece with the condition $S_{0n} - S_{0i} \leq 0.7$ is checked. The required softening effect is calculated with the shearing direction factor taken into account (Equation 5). The softening mode (shearing angle and number of shearing periods) is selected from the nomogram (Fig. 5) depending on the calculated required softening effect. The softening mode settings are entered into the control program of the softening device. The piece is inserted into the softening device and softened in the set mode. Finally, the elasticity is measured.

Should the obtained elasticity not match the estimated value, the softening procedure is performed again.

Following the softening procedure presented above, the prediction method for determination of softening mode settings has been successfully tested [9-11]. The test showed that 94.8% of relative increases in the relative elasticity of the sample fell within the predicated interval (Fig. 8) [9].

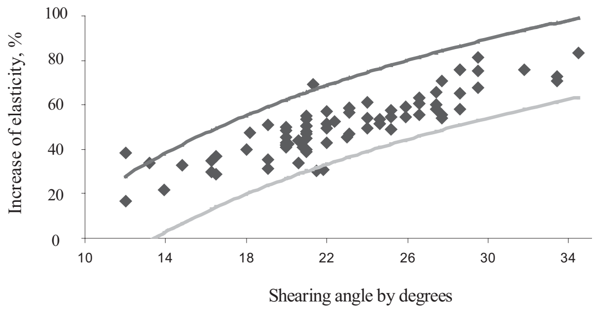



**Figure 8.** Dispersion of test result with respect to prediction interval

The cornerstone of this method is a constant number of shearing periods assumed (*n*=2) while the shearing angle is predicted according to the initial leather elasticity.

The mean $S_{0a}$ of measured elasticity values of the leather piece and the mean softening effect required $E_a$ are calculated. The recommended shearing angle necessary to achieve the calculated $E_a$ is then selected from the calculated array [12-16] of predicted settings.

## Conclusions

The evaluation of softness of leather treated in vibration softening machines by numerical values of relative elasticity obtained during full-area, non-destructive measurements shows that a uniform softness is difficult to obtain in the entire area of hides and half-hides by softening them in a conventional way due to the lack of required capabilities in softening equipment and softness evaluation methods.

The practical application of our new leather softening method and softening device should result in a more uniform pattern of leather softness.

The application of a prediction method to determine shearing settings enables creation of a softening device with automatically programmable operating modes.

## References


1. Aivazian S., Mhiturian V., 1998, Applications of the Statistics and Basics of the Econometrics. Moscow.
2. Čekanavičius V., Murauskas G., 2002, Statistics and Its Applications, T. 2. Vilnius.
3. Drucker H., Burges C. J. C., Kaufman L., Smola A., Vapnik V., 1997, Support vector regression machines. *Advances in Neural Information Processing Systems*, Cambridge, MA, MIT Press. P. 155-161.
4. Kazanavičius K., Tričys V., 2008, Evaluation of Leather Softness. *Materials Science (Medžiagotyra)*. Kaunas: Technologija. Vol. 14, No. 2, p. 179-182.
5. Kazanavičius K., Tričys V., 2004, Leather Softening by Shearing. *Materials Science (Medžiagotyra)*. ISSN 1392-1320. Kaunas: Technologija. No. 10 (1). P. 40-44.
6. Kazanavičius K., Tričys V., 2005, Peculiarities of the Uncertainty of Measurement in the Evaluation of Leather Elasticity. *Technology of Products and Design. (Gaminių technologijos ir dizainas)*. Kaunas: Technologija. P. 233-237.
7. Kubilius J., 1980, *Probability Theory and Mathematical Statistics*. Vilnius.
8. Loginovas A., Gudelevičius E., 1997, *Calibration, uncertainty and trust in the metrology*. Kaunas: Technologija.
9. LST EN ISO 17235:2003 Leather – Physical and Mechanical Tests – Determination of Softness (ISO 17235:2002).
10. Matsukawa M. et al., 1992, Application of regression analysis to deriving measurement formulas for feedback control of plasma shape in JT-60 *Plasma Phys. Control. Fusion*. No. 34. P. 907-921.
11. Patentas Nr. EP10865077. Device and Method for Softening Skins by Shearing. C14B 1/40. 2007.
12. Pat. LT 5199. Method of Determination of Leather Softness. C14B 1/00. 2005.
13. Wenli P., Xiaolei Z., Shuru Ch., 2006, The Principle and Method of Testing Leather Fullness and Softness. *Journal of the Society of Leather Technologists and Chemists*. May-June. Vol. 90. No. 3. P. 117-122.
14. Tričys V., Kazanavičius K., 2006, New Possibilities for Mechanical Softening of Leather. *Journal of the Society of Leather Technologists and Chemists*. May-June. Vol. 90. No. 3. P. 112-116.
15. Vaičiulis M., Kazanavičius K., Tričys V., 2005, Linear Regression of Relative Elasticity. Materials Science *(Medžiagotyra)*. Kaunas: Technologija. Vol. 11. No. 3. P. 301-305.
16. Vekteris V., Kasparaitis A., Kausinis S., Kanapenas R., 2000, *Theory and practice of the measurement*. Vilnius. P. 111–126.

## METHOD AND DEVICE FOR LEATHER SOFTENING

*Kazys Kazanavičius, Vaclovas Tričys*

### Summary

The present paper discusses the results of a study on quality of mechanical leather softening. Relative elasticity was used as the parameter for evaluation of leather softness after the softening process. The data was obtained during a full-area, non-destructive measurement process. The results show that a uniform softness is difficult to obtain in the entire area due to the lack of required capabilities in softening equipment and softness evaluation methods. A softening method and a softening device developed by the authors as well as a corresponding softening procedure are described here. A conclusion is drawn that the application of this new leather softening method and softening device could result in a more uniform pattern of leather softness.

**Keywords**: leather, measurement, mechanical softening, shearing, deformation, elasticity of leather.

## ODOS MINKŠTINIMO BŪDAS IR ĮRENGINYS

*Kazys Kazanavičius, Vaclovas Tričys*

### Santrauka

Straipsnyje pateikiami odų mechaninio minkštinimo kokybės tyrimo rezultatai, gauti nauju patentuotu odų minkštinimo įrenginiu. Odų minkštumas vertintas santykinio slankumo skaitinėmis reikšmėmis, gautomis matuojant daugelyje odos ploto vietų, nepažeidžiant odų vientisumo. Nustatyta, kad tradiciniu metodu minkštinant odas pasiekti vienodą minkštumą visame jų plote labai sudėtinga dėl ribotų minkštinimo įrengimų ir minkštumo įvertinimo metodų galimybių.

Aprašomas autorių sukurtas būdas ir programiškai valdomas įrenginys taikomas sąlyginai nedidelėmis odų detalėms minkštinti šlytimi. Būdo esmė: atsižvelgiant į minkštėjimo priklausomybę nuo pradinio odos slankumo, parenkamas šlyties kampas bei šlyties periodų skaičius, kuriais pasiekiama vienoda numatyta odos detalės santykinio slankumo vertė.

Mechaninio minkštinimo esmė: odos detalė suspaudžiama tarp plokštelinių matricų ir deformuojama šlytimi, t. y. minkštinama šliejant parinktu režimu.

Išvadose teigiama, kad pritaikius autorių sukurtą naują mažų odų bei odos detalių minkštinimo būdą ir įrenginį, būtų galima pasiekti tolygesnį jų minkštumą, gerinti darbo sąlygas ir aplinkos būklę, sumažinti energijos sąnaudas.

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

Įteikta 2011-11-16