The effect of roller pressure and feed rate on hides squeezing

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Abstract. The article presents the results of experimental studies of the process of extracting excess liquid from a water-saturated hide. The experiments were conducted in two options: using a rigid base plate and a cermet base plate for the feed mechanism of the roller machine. In the study, samples of a wet hide on rigid and cermet base plates were pulled between rotating squeezing rollers using conveyor chains. Mathematical dependences of the amount of liquid removed from a wet hide on its feed rate and the pressure of the squeezing rollers were obtained for two special options. The experimental results showed a significant increase in the efficiency of the squeezing process of a wet hide due to the use of a cermet base plate in comparison with a rigid base plate.

1 Introduction

All technological processes affect the quality of the finished leather; therefore, after the implementation of each of them, it is necessary to analyze the condition of the skin. Experimental research in the leather industry is aimed at solving complex multifactorial problems, the result of which is determined by rational modes of conducting technological processes for treating raw hides. The quality and performance properties of raw hides vary depending on the moisture content in them.

It is known that the structure of raw hides differs by type, breed, sex, age of the animal, as well as by the main sections and other factors. The technology of mechanical processing of raw hides is influenced by various factors related to its properties.

Studies of the properties of various hides and skins were performed in [1–5]. Great difficulties in studying the patterns of skin deformations are due to their fibrous- reticulate structure, which has a different shape in different types of leather, in different directions, and in different main sections.

The authors have experimentally determined the properties and characteristics of chrome hides of bovine of medium weight in the main sections and the properties of coatings of processing working rollers [6–16].

The rough surface and thickness of the skins in all the main sections create significant difficulty in choosing the optimal elastic characteristics of the coating of the working rollers.

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rollers and do not provide a uniform residual moisture content of 45 to 65% in the main sections of the skins. To eliminate this shortcoming in the technology of squeezing the liquid from hides, an aging operation after squeezing is provided, which takes a certain time, after which, as a rule, the next technological operation is continued. In order to eliminate the aging of raw hides, it is necessary to study the deformations in the main sections of the hides in order to ensure the uniformity of the residual moisture content in it, thereby shortening the time for aging.

Therefore, it is necessary to take into account changes in the deformation properties of raw hides in its main sections when calculating and designing technological devices and equipment [17–22].

To expand the functional and technological capabilities of roller machines, the authors have developed a method and a number of new designs of roller machines and devices protected by patents.

The method of squeezing the liquid from wet hides. The method developed by the authors uses a horizontal conveyor, on the supporting bars of which the raw hides and absorbent material are alternately placed; the layers make up the package. With the movement of the horizontal conveyor, this package is fed into the zone of capture by the base plate. The base plate, expanding the support bars from below, transports the package of hides with absorbent materials vertically upwards to two pairs of squeezing rollers located one above the other.

2 Material and method of research

For two similar options of experiments considered, the following research method was used: for the 1st option, a rigid base plate was used for processing hides; for the 2nd option, a cermet base plate was used for processing hides (Fig. 1).

The package consists of one layer of hide and three layers of liquid-wicking material - LASCH cloth [23–28].

Fig. 1. Schematic of a roller experimental stand.
In the leather industry, the analytical characteristics of a batch of raw materials and hides are usually determined. The selection of samples and the processing of the results are carried out by the method of the average sample. A batch can consist of several hundred hides, and only a few of them are selected for analysis.

To determine the physical and mechanical parameters of hides, from a batch of 100 hides 3 pieces are selected, from a batch of 100–625 skin products 5 pieces are selected, and from a batch of 625 and more 10 pieces are selected, and then the number of hides samples selected is determined.

For comparability of the research results of various factors or technological parameters, it is necessary to exclude the influence of the topography of the hides. In this case, the asymmetric fringe method is used to take the average sample, which is as follows. The required number of research options is marked and the number of samples (strips) included in the group intended for each option is specified (usually at least 5). The larger the number of samples, the more reliable the average value characterizing the option. The sample size is predetermined by a set of physical-mechanical or physical tests to be conducted, and all samples must fit into a rectangle inscribed in the butt morphological section.

Therefore, we need to select five groups of five samples each, 5×5=25. In the middle part of unhaired hide, excluding the backbone and peripheral areas, two rectangles are outlined and divided into 30 strips (15 on each side).

The stripes are numbered on the left side from bottom to top, and on the right side, on the contrary, from top to bottom (that is why the method is called asymmetric).

The first group contains any of the first five strips; all subsequent ones are taken after another 5 strips. The method of asymmetric fringe, depending on the number of options studied and the desired degree of reliability can be slightly modified in relation to several hides[29–36].

In total, we made 45 packages of hides for the experiment. The study took into account two factors: \(x_1\) – the pressure of the rollers \(P\), kN/m; \(x_2\) – the sample feed rate \(V\), m/s.

The diameter of the squeezing rollers was 0.3 m coated with a layer of 0.01 m thick, made from a liquid-wicking material of BM brand cloth. Before conducting the experiment, the required number of measurements (the number of replicates) was selected by the methods of mathematical statistics to provide the required accuracy [37–42].

\[ G_{cal} = \frac{83.79}{266.68} = 0.314 < G_T = 0.358 \]

2nd option.

\[ G_{cal} = \frac{17.29}{101.81} = 0.1698 < G_T = 0.358 \]

For a hide product in coded form the values are \(b_0=23.77; b_{11}=-0.62; b_{22}=0.23; b_1=3.06; b_2=-2.09; b_{12}=0.5\).

We obtain the following coded regression equations: for skin product

1st option.

\[ y = 23.77 - 0.62x_1^2 + 0.23x_2^2 + 3.06x_1 - 2.09x_2 + 0.5x_1x_2 \]

2nd option.

\[ y = 22.8423 - 0.1722x_1^2 - 0.0722x_2^2 + 4.1921x_1 - 2.2961x_2 - 0.85x_1x_2 \]
The results of measurements before and after squeezing out liquid from skin product at various values of the pressing force $x_1 (P)$ and velocity $x_2 (V)$. After the implementation of the working matrix, the arithmetic mean values were obtained.

### 3 Results

So, the regression equation can be considered suitable with a 95% confidence level, which in the named form after decoding has the form:

**for hides:**

1st option.

$$
\Delta W = 26.5096 - 0.0006055 \ P^2 + 31.8339 \ V^2 + 0.1263 \ P - 273.8809 \ V + 0.1838 \ PV
$$

2nd option.

$$
\Delta W = 14.9072 - 0.0001 \ P^2 - 9.9929 \ V^2 + 0.2106 \ P - 1.9166 \ V + 0.3125 \ PV
$$

The graphs of the dependence of the amount of removed liquid $\Delta W$ (%) from wet hides on various feed rates $V$ and pressures of the rollers $P$ were plotted for the 1st option – using a rigid base plate (Fig. 2, (a)) and for the 2nd option – using a cermet base plate (Fig. 2, (b)).

![Fig. 2. Change in the amount of liquid $\Delta W$ removed from hides, depending on the feed rate $V$ and the pressure of the rollers $P$: (a) – when using a rigid base plate (1st option); (b) – when using a cermet base plate (2nd option)](image)

1st option. The research results show that the minimum amount of liquid extracted from the hides is 17.5%, and the maximum amount is 28.3% of the initial liquid content in the wet hides from the topographic section of the belly – 73%, and from the butt section – 65.5% after the chrome tanning operation. Therefore, we can additionally extract from 4.5 to 15.3% of excess liquid from the wet hides.

2nd option. The results of the experiment showed that the minimum amount of liquid removed from the hide product under squeezing was 16.5%, and the maximum amount was 30.4%. Therefore, it is possible to additionally remove excess liquid from wet hides from 3.5 to 17.4%.

### 4 Conclusion

1st option. An analysis of the experimental results shows (Fig. 2, a) that it is possible to increase the productivity of liquid extraction from hides by increasing the extraction speed by using a metal base plate with two layers of liquid-wicking material from LASCH fibrous
cloth with a roll diameter of 0.3 m.

The results show that the highest liquid extraction at a down pressure of the rolls $P=9600$ N/m and a feeding rate $V=0.255$ m/s, is on average, 28.3%, and the lowest liquid extraction at a rate $V=0.425$ m/s is 24.4% of the initial weight of the hide sample.

The highest amount of liquid extraction at a down pressure $P=3200$ N/m and a feeding rate of 0.255 m/s is 23.2%, and at a feeding rate of hides $V=0.425$ m/s, it is 17.5% of the initial weight of the samples.

In our case of an experimental study, the residual liquid should be in the order of 65%. Therefore, we need to extract a maximum of 13% liquid when squeezing out the sample on a roller bench. The experiment showed that the liquid in excess of the required 13% is in the order of another 4.5–15.3% of the initial weight of the hides. Consequently, it is sufficient to squeeze out liquid from wet hides at a rate of more than 0.425 m/s under a pressing force of the rollers from 32 to 9600 N/m.

2nd option. Thus, the maximum liquid removal under pressure $P=9600$ N/m of the rollers and feed rate $V=0.255$ m/s is on average 26.5%, and the lowest one at feed rate $V=0.34$ m/s is 23.4% of the initial moisture content of the skin samples (Fig. 2, b). At the same time, there is a reserve of removed liquid of 10.4%, which makes it possible to increase the pulling-in rate. At a roller pressure $P=3200$ N/m and pulling-in rate of 0.255 m/s, it is 18.9%, and at feed rate $V=0.34$ m/s, the liquid removal is 16.5% of the initial liquid content of the samples. At the same time, there is a reserve of removed liquid of 3.5% to accelerate the process of pressing the capillary-porous material.

Thus, it was determined that with an increase in the pressing force of the rollers $P$, the amount of removed liquid $\Delta W$ from the processed hides sharply increases.

Experiments have shown that the efficiency of the process of squeezing out wet hides using a liquid-wicking material LASCH on a rigid base plate (1st option) at low pressure of the rollers $P=3200$ N/m is higher than when using a cermet base plate (2nd option). At high pressure of the rollers $P=6400$ N/m and more, on the contrary, the efficiency of liquid extraction from wet hides increases due to the use of a cermet base plate. To reduce energy consumption in the process of squeezing the liquid out of hides, a metal base plate coated with LASCH cloth is recommended.

The efficiency of the process of pressing a piece of wet hides using porous cermet plate (1st option) at low feed rates $V=0.17$ m/s is higher than when using a rigid base plate with liquid-wicking LASCH material (2nd option). Here, at high feed rates $V=0.34$ m/s and more, the efficiency of liquid extraction from wet hides increases likewise, due to the use of a cermet base plate, compared to the use of a rigid base plate with a liquid-wicking LASCH material.

Therefore, to increase productivity, it is advisable to carry out the pressing process of wet hides between the rotating rollers at a feed rate higher than average ($V=0.255$ m/s).

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