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Efficiency issues of the roller squeezing process

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Abstract. The paper presents the results of an experimental study of the influence of the main parameters of skin squeezing on the intensity of the process. A mathematical model of the residual moisture of the skin from the main parameters of the process is obtained. It is established that a decrease in the radius and speed of the roll, as well as an increase in the linear load lead to an improvement in the effect of squeezing on the selected two-roll module.

1 Introduction

Roll machines are used in light, chemical, mining and metallurgical and other industries for the implementation of various technological operations. One of these operations is spinning, which creates the moisture necessary for subsequent operations and determines the environmental situation in production.

All previously performed studies devoted to the study of the spinning process can be grouped according to two principles: studies related to the phenomenon of contact interaction and water filtration and, obtaining mathematical dependencies to describe them, followed by the development of recommendations for changing the parameters of existing squeezing machines [1-12]; and studies conducted in technological direction, which set the task of experimental study of the influence of the roller machine parameters on the efficiency of the process and finding optimal solutions and operating modes for existing roller machines [13-20].

Numerous experimental studies of the pressing process of various materials give basically identical dependencies of the process efficiency (residual moisture content of the material) on its parameters, such as load intensity, roll velocities, roll radii, and others. Only fluid, which under the influence of mechanical impact receives movement relative to the fibers, can be removed mechanically. Moisture from macrocapillaries, non-capillary pores, and wetting fluid could be considered as water removed by squeezing [21].

Pressed materials are very heterogeneous in terms of the distribution of pores and voids in which fluid can move.

The paper considers the effectiveness of the process of roller pressing of leather (semi-finished leather product after chrome tanning), that is, a description of the dependence of the

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residual moisture content of the skin on the main factors obtained on the basis of an experimental study.

To conduct an experimental study, first, it is necessary to justify and select a design scheme for a machine for squeezing leather.

Based on the study of the design of squeezing machines for the leather and textile industries, as well as paper machines and the features of the roll pressing of wet materials, we select the design scheme of the roll machine for squeezing leather (Figure 1), in which the upper roll is mixed relative to the lower roll towards the movement of the leather semi-finished product. The leather product has a uniform thickness and is fed in such a way that the line, which is a continuation of its front end, passes through the axis of rotation of the upper roll since no additional external pushing forces are required to realize the gripping.

The leather product before squeezing presents a viscous material with a moisture content of approximately 70%. Therefore, in some cases, a pushing force may be required; it may be realized by inertia forces, accelerating the feed of the semi-finished leather product when it enters the working rolls.

The smooth feed of the semi-finished leather product to the processing zone and the force of inertia are carried out by a conveying device. An example of a device for transporting, straightening, and feeding a semi-finished leather product, developed in [22], is shown in Figure 1.

The papers [23-25] consider the issues of experimental research and description of the residual moisture of the skin in machines with vertical material supply, and in work [26] with horizontal supply.

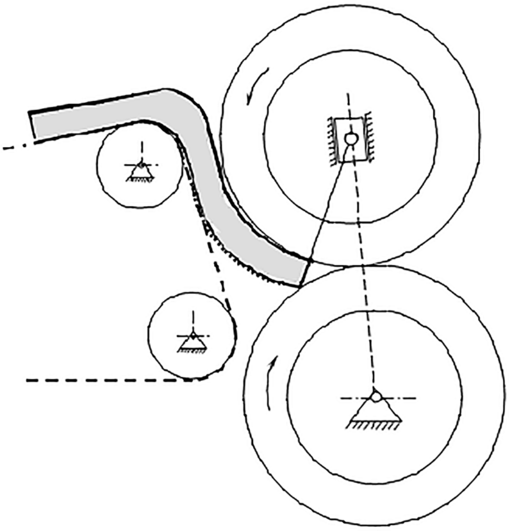


Fig. 1. Scheme of the design of the machine under study.

2 Materials and methods

Based on a priori information, the residual moisture content of the leather semi-finished product was studied depending on the intensity of the load, the roll radius and the roll velocity.

To conduct experimental studies, a pilot installation was made (Figure 2), corresponding to the selected design of the machine for squeezing the leather, shown in Figure 1.

Fig. 2. Experimental setup.

The design of the installation allows you to change the pressing force of the rolls, their speed and radius.

At that, the variation of radii is realized by changing the rolls of one diameter with the rolls of other dimaters after a series of experiments with one pair of rolls according to the planning matrix.

Distance L varies after a series of experiments depending on the radius of the rolls according to the following formula:

$$L = 2R \sin 10^{o} = 0{,}35R\ . \tag{1}$$

The intensity of the load varies by a spring-screw system.

The velocity of the rolls varies by means of a gearbox and a DC motor.

On the basis of a priori information, the range of factors change is taken for load intensity - $15-65kN/m;$ roll radius $-0.058-0.170m;$ and thickness of the material being processed $-0.003-0.007m.$

Experimental studies were carried out using the second-order D-optimal planning method [27].

The homogeneity of the dispersions and the hypothesis of the adequacy of the found equations were tested using the Fisher criteria [27]:

$$F_{\text{est}} = \frac{S_{\max}^2}{S_{\min}^2} = \frac{19.788}{3.409} = 5.8 < 6.26 = F_{tab}\ , \quad F_{\text{est}} = \frac{S_{ad}^2}{S_{\{y\}}^2} = \frac{16.342}{10.234} = 1.6 < 11.85 = F_{tab}.$$

Thus, all variances can be considered homogeneous and all coefficients can be considered statically significant.

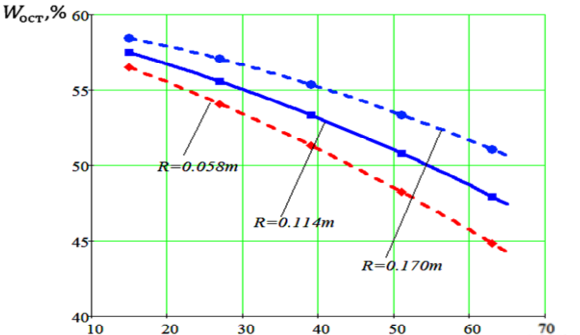
After determining and eliminating insignificant coefficients, we obtain:

$$\begin{aligned}\hat{W}_{\text{res}} &= 56.02 - 0.692x_1^2 - 1.395x_3^2 + 1.107x_1x_2 + \\ &+ 1.664x_1x_3 - 3.351x_1 + 2.088x_2 + 2.422x_3\ .\end{aligned} \tag{2}$$

or after decoding

$$\begin{aligned}W_{\text{res}} &= 54.71 - 0.0011Q^2 - 100V^2 + 0.786QR + \\ &+ 0.554QV - 0.258Q + 5.658R + 40.63V\ .\end{aligned} \tag{3}$$

Figures 3-5 show graphical interpretations of (3).



a)

Fig. 3. Dependence of residual moisture content of leather on load intensity for $V = 0.10 m/s$.

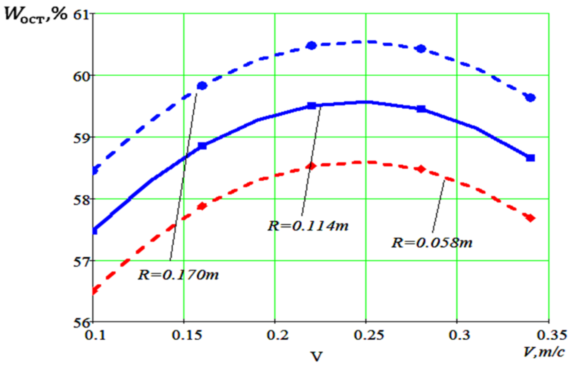


Fig. 4. Dependence of residual moisture content of leather on the roll velocity for $Q = 0{,}15 kN/m$.

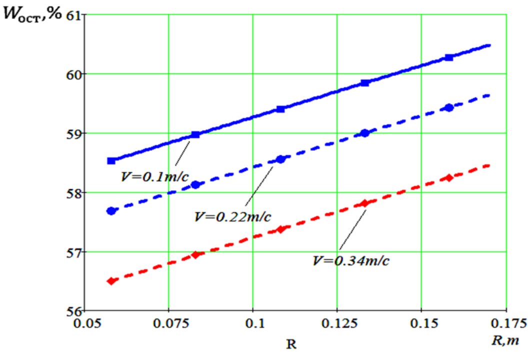


Fig. 5. Dependence of residual moisture content of leather on the roll radius for $Q = 0.15 kN/m$.

3 Results

Regression model of residual skin moisture from linear pressure, radius and speed of the roll is obtained.

The results of the experiment show that a decrease in the radius and speed of the roll, as well as an increase in the linear load, lead to an improvement in the effect of squeezing the skin on the selected two-roll module.

4 Conclusions

From the analysis of the graphs, the resulting equation revealed that

- with an increase in the linear pressure, the residual moisture of the skin decreases, which leads to an increase in the efficiency of the extraction, since the residual moisture of the skin decreases;
- with an increase in the windrow speed, the residual moisture increases and asymptotically approaches a certain value.
- with one roll radius, the pattern of change in residual moisture from the roll speed is characterized by a parabolic law.

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