Construction of experimental inter-operational conveying device

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Abstract. The results of the construction of inter-operational conveying devices for the creation of an automatic line for the mechanical processing of a leather semi-finished product between several technological machines for leather processing are considered in the article. At the same time, on this line, all processing machines must be feed-through ones. The dimensions and principles of operation of the mechanism of conveying devices are shown. The main mechanisms of this conveyor are string conveyors, cutting and pressure rollers. The results of the experiments are presented. The task of this proposed conveying device is to increase labor productivity by automating the process of transportation and partial straightening of the sheet material during transportation, as well as communicating the desired speed to the sheet material after partial straightening. It is shown that with the wrong choice of the diameter of the work rolls, the design of the machine, changes in the angular speed of the spreader shaft affect the quality of the extraction and straightening of the folds of the leather semi-finished product.

1 Introduction

The aim of the study is to develop an inter-operational transport device and create on its basis automatic lines connecting several technological machines for processing leather, reducing the manual labor of operators, increasing economic efficiency and ensuring the continuity of the technological process.

The most urgent tasks of leather production in the conditions of market relations are improving quality and reducing production costs, increasing the competitiveness of goods and the efficiency of their production, and compliance with environmental standards. All this should be achieved through a significant improvement in technological equipment (in particular, equipment for the mechanical processing of leather) and the use of multifunctional machines, i.e. creation of automatic lines connecting several mechanical operations for processing semi-finished leather products instead of equipment that performs one operation at a time. Since production processes are an integrated set of various machine operations implemented by a specific set of technological equipment, it is obvious that the

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most efficient equipment, in terms of economic performance and product quality, should be based on the most optimal machine processes and implementation of advanced technology.

The process of leather production has not changed for many years and its main part is realized by manual labor [1, 2]. To create automatic lines that connect several operations for processing a semi-finished leather product, ensuring an increase in the quality of products and the efficiency of its production, it is necessary to study the sequence of the main processes and operations of leather production. Among the mechanical operations of processing a leather product, the following are distinguished: fleshing, planing, squeezing, setting, softening, and grinding, which determine the quality of leather. The mechanical treatment of the surface of a semi-finished leather product in light industry enterprises is conducted as the main operation of the technological process, performed in order to change the geometric dimensions of the semi-finished leather product [3-6]. In [7], the rheological parameter of the inert resistance of the skin is studied. An improved rheological model of the skin was obtained. The rheological model makes it possible to obtain numerical values of the rheological parameter of the resistance of an inert material during its deformation. In [8], the design of the mechanism for exercising pressure on the working rolls of a technological machine was developed. The working rolls, in addition to forced rotation around their axes, during the operating mode, in contact with the material being processed, perform a symmetrical arcuate movement. This allows high-quality processing of leather of variable thickness. In [9], the conditions for gripping material laid in a kink on a conveyor were studied. The initial contact zone, the gripping zone in a steady process, and the contact condition at the exit from the gripping zone are considered. In [10-12], the processes of removing excess fluid from multilayer moisture-saturated materials were experimentally studied. The parameters of the process, the conveyer velocity, the pressing force of the working rolls on the processed materials are set. In [13], the vertical motion of flat material, put in a kink on a base plate between rotating pairs of rolls, was studied. Pairs of rolls are located one above the other, and the distance between them is equal to the height of the base plate. The technological process is considered analytically to determine the energy consumption for the steady operation of the roller machine. Four cases of the state of the base plate under its movement between pairs of rolls were considered. According to the conditions of the technological process, the position of the base plate was studied at the entrance between the lower pair of rolls, the position between two pairs of rolls, at the exit between the lower pair of rolls and the upper pair of rolls. In [14,15], a universal belt conveyor with a concave carrying surface was proposed for performing various conveying operations in the leather industry, in particular, for reloading raw hides from transporting line to delivery chambers, storing raw hides in them, and loading raw hides into vehicles. The velocity of the skin on a conveyor with a concave carrying surface was determined.

2 Materials and methods

The proposed conveying device is built on the basis of the kinematic diagram shown in Fig.1, located between two technological machines for the mechanical processing of semi-finished leather products (for example, squeezing and setting machines). From the squeezing machine, the semi-finished leather product is transported through a roller conveyor to the first group of conveyor strings and moves at a velocity of $\vec{\vartheta}_1$ Then, the skin is transferred through the second group of conveyor strings, moving at a velocity of $\vec{\vartheta}_2$, to the setting-out machine. The technical result is expressed by the fact that the proposed conveyor, without stopping the technological processing of skin products, ensures stable operation of the automatic line for processing raw hides. On this line, the squeezing and setting machines must be feed-through ones (i.e., on such a machine, the leather is processed once: it enters from the front and exits from the back).

The frame is mounted on scissor lifts (elements 14 and 15 of the device, Fig.1), which provide the ability to adjust the height of receiving and transporting sheet material. The endless strings of the conveyor consist of two groups that alternately go around the support shaft of the straightening block and provide the ability to control the difference in velocities when the sheet material enters and exits the processing zone. The device contains a transport conveyor, a straightening unit and a control system.

The inter-operational transporting device contains a string transporting conveyor, consisting of two groups of strings (1 and 2), straightening block I, and control system II (elements 1-18 of the device, described in the text) . The strings of the first group 1 envelope the grooves of transporting roll 3 and support roll 4 of straightening block I. The strings of the second group 2 envelope the grooves of transporting roll 5. Rings 6, freely installed in the grooves of support roll 4 of straightening block I. In the section of the strings of the second group 2, above support roll 5, pressure roll 10 is installed (Fig. 1), [16, 17].

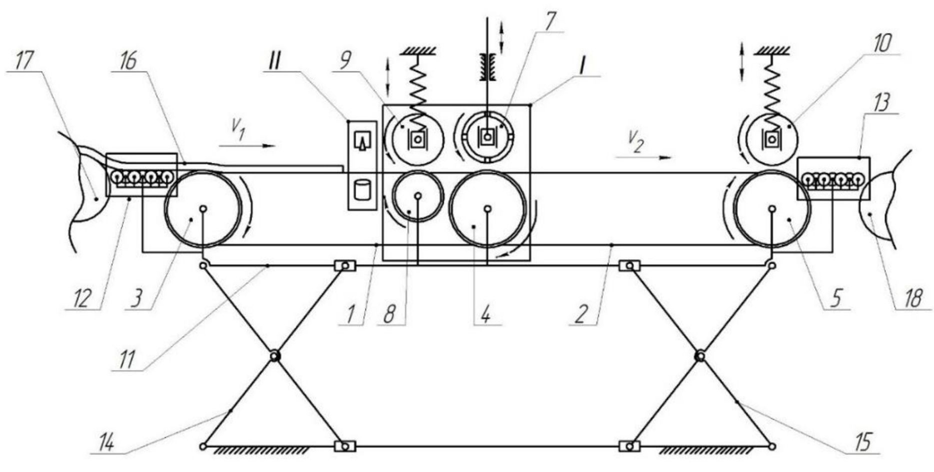

Fig. 1. Scheme of the inter-operational conveying device (side view)

Moreover, the infinite strings of the first 1 and second 2 groups alternately envelope support roll 4 of straightening block I. Support rolls 3, 4, 5 and 8 are mounted on frame 11. On the section of the strings of the first group 1 in front of the support roll, roller conveyor 12 is attached to frame 11. In the section of strings of the second group 2, behind support roll 5, roller conveyor 13 is attached to frame 11 (Fig. 1).

As seen in Fig. 1, an experimental inter-operational conveying device was built to remove fluid and bring the semi-finished leather product in the straightened form to the second technological machine.

The task of the conveying device proposed (a conveyor) is to increase labor productivity by automating the process of transportation and partial straightening of the sheet material during transportation and adjusting the desired feed rate to the sheet material after partial straightening.

3 Discussion and results

To perform an experimental determination of the quality and expansion of the surface area of the skin, and the supply of a semi-finished leather product to the next stage of processing in a straightened form, we use the new conveying device. First, we determine the straightening factor, which is the increase in the area of the semi-finished leather product, i.e. the difference between its areas in the straightened/un-straightened positions, referred to the area of the semi-finished leather product in the un-straightened position [18], i.e.

$$\mathrm{K} = \frac{H_1 - H_2}{H_2}$$

where K - is the coefficient of straightening of the folds of the leather semi-finished product; H_1, H_2 -are the areas of the leather semi-finished product in the straightened and un-straightened positions, respectively. As is known, in order to perform various mechanical operations for processing a semi-finished leather product (fleshing, squeezing, straightening, splitting, planing, etc.), a certain moisture content of the processed leather semi-finished product is required.

To conduct experimental studies to determine the moisture content and straightening of the leather semi-finished product, we use a new inter-operational conveying device for transporting and feeding the semi-finished leather product to the processing zone, prepared with the following technical characteristics based on Fig. 1:

Diameters in cm:	
of straightening pressure roll	20
of upper squeezing roll without moisture-wicking material (monshon)	16.6
Diameters of 1, 2 conveying rolls, sm	16
Distance between axles of 1 and 2 conveyor rolls, m	1.150
Groove pitch:	
of the 1st conveying roll, sm	2.5
of the 2nd conveying roll, sm	2.5
Number of grooves:	
in the 1st conveying roll, pcs	26
in the 2nd conveying roll, pcs	26
Working width:	
of the1st conveying roll, sm	65
of the 2nd conveying roll, sm	65
Groove depth of the 1st and 2nd conveying rolls	2x3
Spring stiffness, *N*/*m*	29400
Electric motor power, kW:	
straightening roll	1.5
pressure rolls	1.5
Number of strings in the conveyor	5

Note: *Support roll 4 was replaced with a plate 65x8 fixed to the support.*

The use of squeezing rolls with a free upper working roll and a straightening roll provides an increase in the area of finished skins by 7-8%. The straightening roll not only flattens the pressed skin, but also contributes to a uniform extraction of fluid from it over the entire area since the leather semi-finished product, processed in the mode of operation of the squeezing machine with a free upper working roll and straightening roll, in addition to compression, experiences a slight stretch. Apparently, as in other mechanical operations (for example, planing, straightening, staking, etc.), the fibers are displaced and oriented in the force field due to the friction force transmitted through the driving roll. The coefficient of mutual friction of the fibers of a wet leather semi-finished product is negligible.

When squeezing without forced rotation of one of the working rolls, the fibers of the leather semi-finished product are shifted. As fluid is removed from the wet leather semi-finished product with squeezing and straightening rolls (Fig. 2), the coefficient of mutual friction of the fibers of the leather semi-finished product increases, and hence the tension between the fibers.

This leads to an increase in the area of the skins, breaking load and a decrease in tensile elongation, which makes it possible to reduce the pressing force between the working rolls, providing the necessary residual moisture content of the processed leather semi-finished product.

To assess the significance of individual factors in fold forming, in relation to the design and requirements of the leather industry, a straightening roll was added. To ensure the required pressure of the pressing and straightening rolls on the leather material and to reduce vibration during straightening, springs are installed [19-22].

The percentage of straightening and expansion of the semi-finished leather product was determined as follows: first, the coefficient of straightening of the semi-finished leather product was determined. After squeezing and straightening the wet leather semi-finished product, on the specified conveyors, without changing the conditions of the leather semi-finished products, their masses and areas were measured at the exit from the conveyor zone, and all the results were recorded in the table.

a) *b)* *c)*

Fig. 2. Laboratory installation of inter-operational conveying device: a) an inter-operational conveying device with a straightening roll; c) straightening the leather semi-finished product at the exit; d) pressing and straightening rolls (side view).

The results of experimental studies have shown that the percentage of straightening of the semi-finished leather product and the change in the percentage of moisture content depend on its area and the design of the technological machine. The test object was chrome-tanned ox hide.

In the process of removing fluid from a wet semi-finished leather product, its moisture content and physical and mechanical properties, and hence the quality, change significantly. At the same time, the quality of the finished product is formed, which, in particular, determines its grade. This occurs after liquid operations in the process of removing fluid from a wet semi-finished leather product .

Table 1. Results of experimental studies

Number of tests	Before the test		After the test		Results of the tests		Straightening factor	Straightening of he skin at the exit %
	Hide weight, kg	Hide surface area, cm^2	Hide weight, kg	Hide surface area, cm^2	Decrease in hide weight, %	Increase in hide surface area, %		
№1								
1	2.150	50x100	1.900	50.4 x 101.6	11.63	2.41	0.0241	70
2	2.150	50x100	1.800	50.6 x 102.3	16.3	3.52	0.035	80
3	2.150	50x100	1.785	50.7 x 102.7	16.98	4.14	0.041	90
№2								
1	2.152	49x102	1.899	49.5 x 103.4	12.1	2.24	0.024	90
2	2.152	49x102	1.800	50.0 x 103.5	16.36	3.52	0.0354	90
3	2.152	49x102	1.690	51.0 x 104.6	21.469	6.7	0.0673	100
№3								
1	2.135	49.5x101	1.900	50.4 x 101.6	11.01	3.13	0.031	90
2	2.135	49.5x101	1.750	50.6 x 102.3	18.03	5.38	0.0537	90
3	2.135	49.5x101	1.750	50.7 x 102.7	19.906	8.89	0.0889	100

4 Conclusions

Based on the results of monitoring the conveying process, the following conclusions can be drawn:

- the effect of velocity on fold forming is obvious because, at higher velocities, the leather semi-finished product moves to the right or left side, due to the non-uniform pressure; as the velocity decreases, the productivity of the machine decreases in direct proportion, so, this problem must be solved in a different way;
- the state and physical and mechanical properties of the semi-finished leather product, i.e. the homogeneity of its properties and the uniformity of moisture content also affect the quality of fold forming of the processed leather semi-finished product. In case of incorrect connection of the strings, that is, a change in thickness during connection and improper installation of the pressure and straightening rolls, a long soak after tanning, in general, after any liquid operations, the open areas of the semi-finished leather product, especially the edges, dry out, sometimes the moisture content of these areas is less than required for performing the subsequent mechanical operation. These areas cannot be straightened out.
- if the diameter of the working rolls is incorrectly selected, the design of the machine (with a wicking cloth in the form of an endless belt or with working rolls) also affects the formation of folds during squeezing;
- changes in the angular velocity of the straightening roll also affect the quality of squeezing and straightening the folds of the leather semi-finished product.

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