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IMPROVEMENT OF PHYSICAL-MECHANICAL AND OPERATIONAL PROPERTIES OF MATERIALS OBTAINED BY USING A NEW LEATHER PRODUCTION TECHNOLOGY

УЛУЧШЕНИЕ ФИЗИКО-МЕХАНИЧЕСКИХ И ЭКСПЛУАТАЦИОННЫХ СВОЙСТВ МАТЕРИАЛОВ, ПОЛУЧЕННЫХ С ИСПОЛЬЗОВАНИЕМ НОВОЙ ТЕХНОЛОГИИ ПРОИЗВОДСТВА КОЖИ

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The operational properties of the leather are defined as a set of indicators of chemical, physical and specific properties, and given the increased demand for the quality of the material of work shoes, a comprehensive research of the properties of the leather was carried out. In the following sequence: chemical analysis of leathers, research of physical-mechanical and operational properties of leathers.

The tests of the properties of the new material showed the advantages of using the new methodology for the production of leather for special purposes.

Эксплуатационные свойства кожи определены как совокупность показателей химических, физических и специфических свойств, а с учетом возросшей потребности в качестве материала рабочей обуви было проведено комплексное исследование свойств кожи. В следующей последовательности: химический анализ кож, исследование физико-механических и эксплуатационных свойств кож.

Испытания свойств нового материала показали преимущества использования новой методики производства кожи специального назначения.

Keywords: chemical analysis, physical and mechanical tests, resistance to repeated bending of the leather, operational properties of the leather.

Ключевые слова: химический анализ, физико-механические испытания, стойкость к повторному изгибу кожи, эксплуатационные свойства кожи.

It is known that the operational properties of the leather are defined as a set of indicators of chemical, physical and specific properties [1]. In this regard, a comprehensive research of the properties of yuftleathers (Russia leather) was undertaken.

The necessity of such a research is due to the fact that, in contrast to other types of leathers, the operational properties of shoe shoes are determined not only by the degree of additional structure of the dermis during tanning, but also by the peculiarities of the formation of the dermis volume, the degree of reversibility, filling and fatliquoring effects. The research of the technological and operational properties of complex mineral tanning leathers based on tanning salts of aluminum, titanium and chromium for shoe upper [2], intended for the manufacture of protective shoes for chemical workers, was carried out in the following sequence:

- chemical analysis of leathers;
- research of the physical and mechanical properties of leathers;
- research of the operational properties of leathers.

The results of chemical analysis of experimental and control yuftleather (Russian learther) are shown in the following table 1.

Table 1

Indicators of the chemical analysis of the leather	Units	Experienced leather	Control leather
Moisture	%	12,4	11,2
The content based on the dry substance:			
- total ash	%	6,8	3,4
- fatliquoring substances	%	26,5	24,6
- residual fat after dust treatment	%	22,9	16,8
- substances washed out by common water	%	2,0	2,9
- golovy substance	%	38,9	40,8
- chromium oxide	%	0,7	0,9
- aluminum oxide	%	0,85	-
- titanium dioxide	%	0,92	-
- tanning bound	%	16,2	15,3
Through-tanning number	%	41,9	37,6
pHpotassium chlorideexhaust	-	5,2	5,0

From the data of table 1 it can be seen that the main indicator associated with water resistance and wear resistance is the residual amount of fatliquoring substances after processing by "dust". The content of fatliquoring substances after treatment with "dust", which in experimental samples decreased slightly, while in control leathers it decreased by one third. Fat is removed during operation, mainly as a result of exposure to moisture, dust and dirt.

It is known that aqueous solutions of chemical industries acting in a displacing manner affect the removal of fatty substances. Aqueous solutions together with dust form dirt, the action of which is to remove fat by capillary suction in a drying layer. Similar to this, but more intensively, the dust of chemical industries acts, since the leather is in contact with its constantly updated layers.

The ability of fats to stay in the leather mainly depends on nature, but the nature of tanning substances also has a significant effect on the degree of fat migration. During the fatliquoring of leathers of the chromalumotitansintane tanning method, additional bonds between heteropolynuclear complexes and fatty acids may occur, resulting in an increase in the amount of fixed fat in the leather structure.

The through-tanning number in experimental leathers is higher than in control leathers, which indicates an increase in the tanning effect during complex mineral tanning due to the multifunctional interaction of chromium, aluminum, and titanium compounds, including heteropolynuclear complexes with active collagen groups.

The chromalumotitansintane tanning method leads to improved fixation of syntans used for subsequent retanning. This is evidenced by a decrease in the content of the chromium-alumotitansintane tanning method common in experimental leather, washed out by water, in comparison with control leather. The absence of a specific defect in yuft leathers as a cage for the front surface of the leather in experimental leather, in contrast to the control ones where local cage took place, shows that a decrease in the water washed in the experimental leather has a positive effect on improving performance. Minerals in experimental leather contain more than in control ones. The acidity of the leather is characterized by a pH indicator of potassium chloride extract and depends on the content of free and associated protein functional groups in it.

A research of the chemical analysis of experimental and control leathers showed that the performance of experimental leathers is superior in some parameters to the control leathers. In general, the indicators of chemical analysis correspond to those of the standard for yuft leathers of the combined tanning method.

Physical and mechanical tests constitute one of the many diverse forms of laboratory research. They allow to define and measure quality indicators that characterize the purpose, reliability and durability of the leather. The results of physical and mechanical tests are shown in table 2.

Table 2

Indicators	Finished leather	
	Control	Experienced
Tensile Strength, MPa	26,8	29,3
Tension in the appearance of crack front layer, MPa	25,2	28,8
The elongation at a tension of 10 MPa, %	28,5	23,5
Inflexibility, %	164	162

As can be seen from the data in table 2, there is a difference between the physical and mechanical tests of experimental leathers of the chromalumotitansintane tanning method and control leathers of the chromostraintynthane tanning method. Experienced leather has a greater value of the tensile strength and durability of the front layer compared with the control leather.

The high tensile strength and great strength of the front layer of leathers hollowed out by complex mineral tanning agents can be explained by the fact that, due to the heteropolynuclear nature of the complexes, their sorption deposition in the interfibrillar space and mono functional attachment are of great importance, as evidenced by an increase in the number of through-tanning. The performance properties of leathers to a certain extent depend on the composition of tanning compounds and the nature of their association with collagen functional groups [3].

Table 3 shows the data on the finished experimental leathers developed by complex mineral tanning agents based on tanning salts of aluminum, titanium and chromium, where operational defects are revealed, as well as test results of parts with technological defects.

Table 3

Indicators	Technological defects			Operational defects				Without defects
	front layer cage	Leather break	punching	creasing and cracking of the front layer	deformation of the upper of the shoe and cracks	inflexibility of the upper of the shoe	big deformation	164 leather
Number of defective parts	8	4	6	7	5	2	4	-
Thickness, mm	1,30	1,20	1,30	1,70	1,30	1,40	1,60	1,31
Capacity, 9,8 N:								
on a standard strip:								
in crack in the front layer	11,4	16,1	17,2	19,2	19,3	25,0	16,0	21,5

Continuation of table 3

in leather break	33,9	21,8	24,7	27,8	25,7	28,0	24,1	29,9
in breaking through a ball:								
at the time of the appearance of a crack in the front layer	36,7	41,1	43,1	35,0	52,3	51,0	41,5	60,7
in leather breakthrough	77,2	65,2	72,2	84,3	77,6	88,9	76,8	117,4
Elongation, %:								
incapacity 98 N	28	26	26	20	27	22	30	29
in tension $9{,}8*10^6$ Pa	41	33	28	36	28	40	54	35
in breaking	72	54	58	55	57	62	76	66
Resistance to repeated bend-ing, thousand bends	61,6	-	75,6	35,6	89,6	More than 100	More than 100	More than 100
Resistance to difficult bend-ing 9,8 N	8,0	5,4	-	15,7	9,0	13,4	7,7	8,1

From table 3 it follows that for assessing the technological properties of the leather, the most important are the tensile strengths of a standard strip and a ball forcing. It is important to clarify the permissible lower tensile strength. When assessing the operational properties of the leather, ductility indicators, reflecting deformation properties, and strength are of great importance. Obviously, should also set the upper tensile strength, since often excessive strength is associated with an increase in leather hardness and a decrease in resistance to repeated bending. It has been established that cracks in the front layer (the most common defect during operation) are characteristic of leathers with high resistance to complex bending and low resistance to repeated bending.

The difference in the tensile strength of the leatherin the upper of the shoe before wearing, depending on the method and production, as well as the unequal rate of decrease of this indicator during operation, make it difficult to use the tensile strength of the leather to characterize the performance properties of the upper of the shoe.

Due to the duration and high material consumption of the experimental wear and given that there are currently a large number of instrumental methods for testing leather under dynamic conditions that simulate the operating conditions of products made from these materials, providing for a shorter period of objective indicators of leather properties that correlate with the data of the experimental wear.

Great opportunities to replace testing in experimental wear are opened by laboratory methods for assessing the resistance of leathers for upper shoes to repeated mechanical capacity.

The necessity to obtain a quick and objective assessment of the operational properties of leathers for upper shoes (in particular, wear resistance) served as the basis for testing multiple leather bends of leather samples. To assess the resistance of the leather to repeated bending, a German-made DP-5/3 VEB device was used. The design of the device allows to simultaneously test three samples with a width of 15 mm and a length of 150 mm. Each sample is fixed in a clamp, which is driven into a swing around the axis of rotation. Swing angle -180°. The number of bends per minute is -100. The tension of the sample occurs under the influence of a cargo weighing 100 g per 1 mm^2 of the cross section of the sample. Inspection of 200 details of the upper of the shoe with technological defects that arose during the tight-drawn-out shoe manufacturing operations showed that most of them belong to the unions. The defect “cage of the front surface” was in 10% of all defective parts, “tear of the leather” - in 15%, “notch” - in 11%.

The results of comparing the indicators of the experimental leathers of the chromium-lumititansintane tanning method and control leathers of the chromo-vegetable-synthane tanning method with repeated bending are shown in table 4.

Table 4

Indicators	Inrepeated bending	
	Experienced	Control
The number of cycles to failure	21324	9125
The number of cycles before cracks	5274	2101

From the data presented in table 4 it is seen that the samples of experimental leathers withstand a significantly larger number of bends of the leather before fracture, and before the appearance of cracks than the samples of the control leather.

A repeated bend test showed that the difference between the experimental and control leathers is due to the fact that with complex mineral tanning, the leather fibers may have a different degree of structure orientation and due to the intense interaction between the active collagen groups and tanning agent. Thus, the most common defects are cage of the front surface (cracks in the face layer) and tearing of the leather; in operation, cracks in the front layer and loss of shape stability. The appearance of cracks is characteristic of leathers with high resistance to complex bending and low resistance to repeated bending. The nature of changes in the properties of the leather during repeated bending depends on the uniformity of the ductility of the leather and the direction of the greatest (or smallest) ductility.

CONCLUSIONS

A comprehensive research of the properties of leathers obtained by the new technology showed that the results of chemical analysis of leathers are closely related to the results of physical and mechanical tests.

It has been established that in evaluating the performance properties of leathers, ductility indicators reflecting the deformation properties and strength of the leather are of great importance.

It was revealed that the operational properties of leathers to a certain extent depend on the composition of materials used in the new technology and influence on the properties of finished leathers.

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