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Der Chemica Sinica, 2018, 9(1):560-569

ISSN : 0976-8505
CODEN (USA): CSHIA5

Optimization of the Filling-Greasing Process of the Leather Semi-Finished Products with the use of Nano-Silica

Danylkovych AH*, Bilinskii SA, Lishchuk VI

Department of Biotechnology, leather and fur Kyiv, National University of Technologies and Design, Kyiv, Ukraine

ABSTRACT

The optimization of the ingredients` expenses of the filling-greasing composition with the use of nano-silica in the manufacture of light-colored leather from the chrome tanning semi-finished product was carried out. A second-order mathematical model was developed using a central composite rotatable plan for the three input variable components of the filling-greasing composition, namely, the expenses of aerosil A-300, acrylic dispersion 2037 and the trupol RA greasing material and three physico-chemical indexes of the obtained leather quality. The multicriteria optimization of the filling-greasing process of leather semi-finished product with the use of the desirability function and the limitations of the values of the indicators taking into account their desirable values was carried out. The optimal values of the expenses of the ingredients of the filling-greasing composition for the production of light-colored leather in the processing of leather semi-finished products of chrome tanning using aerosil A-300 and acrylic dispersion were established.

To investigate the effectiveness of the factors` influence on the physico-chemical properties of leather, the semi-finished product of chrome tanning of the plant was used after its planing to a thickness of 1.5-1.6 mm. 20 parts of the samples were stacked from the sheltered area using the asymmetric fringe method. For approbation of the optimized process of the filling-greasing technology of the leather semi-finished product in the semi-manufactured conditions the alternating halves of the plant were used.

The developed technology of the filling-greasing process with the use of nano-silica in the formation of light-colored leather was tested in the semi-productive conditions of PJSC "Chinbar". This technology provides the production of material of the high elasticity and durability with an increase of the exit area on 2.6% compared with the production technology, which involves the formation of leather materials using a colored tannin filler.

The obtained light-colored leather meets the requirements for elastic leather for sewing products according to DSTU 3115-95 and the requirements of the international standard of quality management systems "ISO 9001: 2008". The availability of the developed filling-greasing process is stipulated due to the possibility of its use in the technologies of chrome tanning of semi-finished products in the manufacture of light-colored leather of wide use.

Keywords: Leather semi-finished product of chrome tanning, Filling-greasing process, Multicriteria optimization, Mathematical model, Components of the filling composition

INTRODUCTION

Improvement of the existing and development of innovative technologies for production of leather elastic materials of a wide range and, especially light-colored ones, can be considered an objective necessity in the modern conditions of technological progress. Due to the fact that in the technologies of leather production of tanning with chromium compounds provides high elastic-plastic material properties, the actual problem is the implementation of processes of add-duplication-filling of leather semi-finished products with the exclusion of natural painted reagents while producing light-colored leather. In this case, the search for effective chemical reagents for filling the leather semi-finished products of chrome tanning in the post-tanning processes can be effective. At the same time, such reagents, due to their colloid-chemical properties, should be characterized by high diffusion ability regarding the micro fibrillar structure of the dermis collagen, evenly distribute in the structure of the semi-finished product and, thus, provide a complex of high physico-chemical properties of light-colored leather.

In the processes of add-duplication-filling of leather semi-finished products, a wide range of chemical reagents of natural and synthetic origin is used. It is known the usage of aqueous emulsions of copolymers synthesized on the basis of acrylic acid [1], butyl acrylate and styrene [2] for the formation of leather semi-finished products with the necessary thermal stability. The recommended techniques provide the reduction of contamination of waste water solutions.

In the after-tanning processing of leather semi-finished products of chrome tanning, dispersions of water-soluble polyacrylates, including amino resins [3,4], are also used. In this case, amino resins effectively diffuse into the structure of leather semi-finished product. The resulting leather is characterized by the increased density and durability of the facial layer. Dicyandiamide polymers [5] combined with inorganic, vegetable or synthetic reagents are used to fill the semi-finished product. The usage of a sulfated melamine-formaldehyde oligomer for add-duplicating chrome semi-finished product gives an opportunity to increase the degree of filling of its structure, but the resulting leather material can contain up to 10 mg/kg of free formaldehyde.

The article [2] presents the results of the research of the influence of polymaleinate and polyacrylate on the porosity and vapor permeability of leather semi-finished product. At the same time a certain increase of these indicators with the use of polymers dispersion at the final stage of liquid maintenance is observed.

In the technology of leather production for add-duplication-filling the combined vege. and synthetic tannins are the most commonly used. In order to obtain the necessary technological effect, the processes of add-duplicating and filling are carried out differentiated, taking into account the range of leather. The article describes the technology of combined processing of leather semi-finished product of chrome tanning with the use of tinides of mimosa with oxazolidine [6], which gives the opportunity to get leather with the necessary complex of physico-mechanical properties that meet the standard requirements.

The influence of the particles` size of a composition on the basis of nano-SiO_2 and oxazolidine [7] in the range of 60-150 nm on the uniformity of their distribution in the structure of semi-finished products with a wide range of concentrations was investigated. At concentration of SiO_2 more than 7% the agglomeration of the majority of particles up to 400 nm is observed. At the same time, leather with the increased resistance up to mold formation is obtained.

Consequently, the analysis of scientific papers shows that the usage of a wide range of natural and synthetic reagents at the stage of add-duplicating-filling practically does not allow producing light-colored leather with the necessary complex of operational properties. In this case, very promising filler can be highly dispersed hydrophilic aluminosilicate - aerosil when making light-colored leather is combined with polymer dispersion. In order to form leather with a complex of high physico-chemical properties with the use of nano-silica, it is necessary to optimize the technological process of add-duplication-filling of leather semi-finished product of chrome tanning.

Problem definition

The goal of the work is to optimize the process of filling-greasing of leather semi-finished product of chrome tanning by using nano-silica while manufacturing light-colored leather. In order to reach this goal the following tasks were set in the work:

1. Obtaining a mathematical model of the filling-greasing process of semi-finished products of chrome tanning by using the central composite rotatable plan (CCRP) of the second order;
2. Multicriteria optimization of the filling-greasing process by using nano-silica;
3. Semi-production tests of the developed technology of filling-greasing of leather semi-finished products.

MATERIALS AND METHODS

To explore the effectiveness of factors` influence on the physico-chemical properties of leather material, a semi-finished product of chrome tanning of the plant was used after its planing to a thickness of 1.5-1.6 mm. 20 consignments of samples **(Figure 1)** were stacked from the sheltered area of the plant by using the asymmetric fringe method [8]. In this case, the numbered strips 10 × 30 mm in size from the right side of each sample were used to determine the indicator of volume formation.

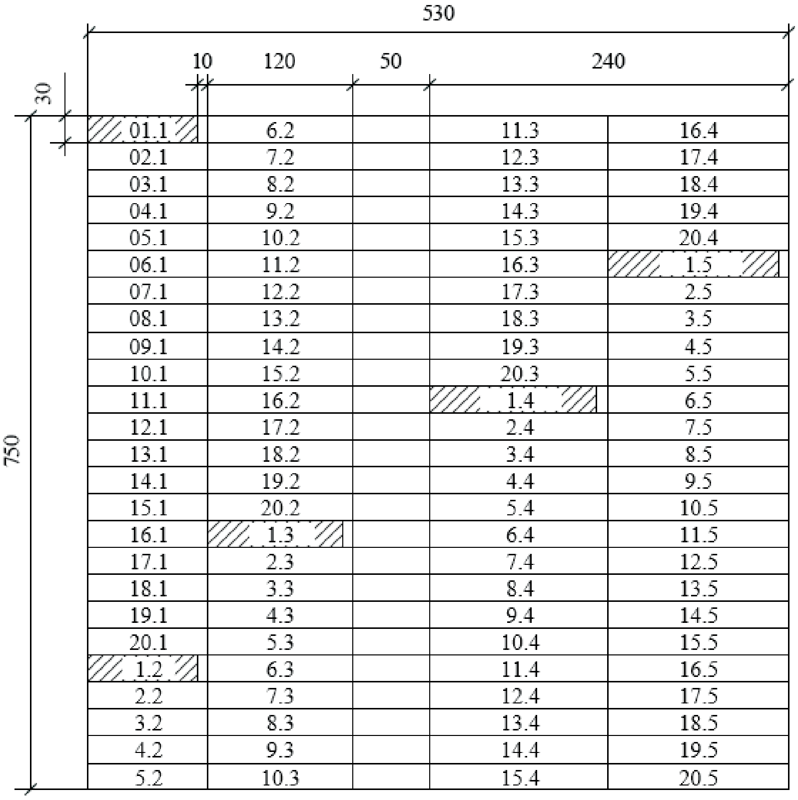

Figure 1: 20 consignments of samples were stacked from the sheltered area of the plant by using the asymmetric fringe method.

According to the set goal, in order to obtain a mathematical model, the experiments were carried out in the laboratory of the Department of Biotechnology, Leather and Fur for the CCRP [9], as the advantage of the chosen plan is the approach of the information surface to the spherical one. In this case, accuracy at all points that are at the same distance from the center of the plan is practically the same. For providing the approbation of the optimized process of the filling-greasing method of leather semi-finished products of chrome tanning in the conditions of semi-manufacturing, alternating branch halves were used.

A number of chemical reagents have been used for add-duplicating-greasing:

1. Nano-silica aerosil A-300 with a particle's size of 4-50 nm, a specific surface of 300 g/m^2 and a mass fraction of silicon oxide (II) not less than 99.9% produced by Kalush Chemical and Metallurgical Plant (Ukraine);
2. Acrylic polymer of the anionic nature of Retanal RCN-40 chemical company Cromogenia-Units, S.A. (Spain) with pH of 6.8, dry residue of 39.8% and a viscosity of 12×10^3 sPs;
3. Greasing material Trupol RA as a mixture of sulphated and sulphided synthetic and natural fats of anionic type with an active substance content of 70%, a pH of 10% emulsion of 7.5 produced by Trumpler (Germany);
4. Quebracho natural extracts containing tannides of 80.5% of dry substance weight, benign of 89.3% (China).

The filling of the leather semi-finished product was performed after its complete neutralization at the ratio of the working solution: semi-finished product 1:1 and rinsing for 10 minute, and the expense of the composition ingredients of the corresponding content of the experimental point, at the temperature of 28-30°C and a constant rotation at a rate of 18-20 min^{-1}. Aerosil A-300 was used in a mixture with the Trupol RA greasing emulsion in the amount of 50% of A-300 mass, in 15 minutes of the semi-finished product processing the acrylic dispersion 2037 was added into the working solution, and in another 30 minutes the rest of the greasing material. The process of filling the leather semi-finished product was completed at pH 4.4. The following technological processes and operations of add-duplication-filling of leather semi-finished products were performed according to the technology of PJSC "Chinbar" (Ukraine).

Physico-chemical properties of the filled leather material were determined according to the methods [8]. In particular, the volumetric output of the material was estimated by the ratio of the material volume in the finished form, filled with the composition, to the volume of semi-finished product of chrome tanning with the use of cut-off samples **(Figure 1)**. The physico-mechanical properties of the filled leather material were determined on a tear-off RT-250 machine while deformating of samples at a rate of 90 mm·min^{-1}. Rigidity-on the device PZU-12M.

The basis of the second-order CCRP is a full factorial experiment supplemented by the experiments at the star points in the number η_α and in the centre of the plan-η_0, which allow us to estimate the error of the experiment [10]. The mathematical model of the process looks like this:

$$\hat{y} = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} b_j\, x_i x_j + \sum_{i=1}^{n} b_i\, x_i^2 \quad (1)$$

Where, $\hat{y}$-predictive value of the dependent variable, $\sum_i$-factors, n-number of factors, b_0, b_i, b_{ij}, b_{ii}-coefficients of the model, i, j-factor counters.

While optimizing the filling-greasing process of a semi-finished product of chrome tanning, the effect on the leather properties of three factors in % of the semi-finished product`s weight was investigated:

χ_1 -aerosil A-300;

χ_2 -acrylic polymer Retanal RCN-40

χ_3 -greasing material.

In order to obtain a mathematical model of the process, a zero level of the selected factors and their variation interval **(Table 1)** was established. The experiment plan in the encoded and natural values is given in the **Table 2.**

Table 1: Options of the experiment plan.

Name	Value of the factor		
	X_1	X_2	X_3
Zero level	2.0	6.0	7.0
Variation interval	1.0	1.5	1.5

Table 2: Experiment plan.

Number*	Factors influencing the process in values					
	Coded			Natural, % mass of semi-finished product		
	x_1	x_2	x_3	X_1	X_2	X_3
1	-1	-1	-1	1.0	4.5	5.5
2	-1	-1	1	1.0	4.5	8.5
3	-1	1	-1	1.0	7.5	5.5
4	-1	1	1	1.0	7.5	8.5
5	1	-1	-1	3.0	4.5	5.5
6	1	-1	1	3.0	4.5	8.5
7	1	1	-1	3.0	7.5	5.5
8	1	1	1	3.0	7.5	8.5
9	0	0	-1.682	2.0	6.0	4.477
10	0	0	1.682	2.0	6.0	9.523
11	0	-1.682	0	2.0	3.477	7.0
12	0	1.682	0	2.0	8.523	7.0
13	-1.682	0	0	0.318	6.0	7.0
14	1.682	0	0	3.682	6.0	7.0
15	0	0	0	2.0	6.0	7.0
16	0	0	0	2.0	6.0	7.0
17	0	0	0	2.0	6.0	7.0
18	0	0	0	2.0	6.0	7.0
19	0	0	0	2.0	6.0	7.0
20	0	0	0	2.0	6.0	7.0

*-experimental point

The transition from coded $\sum_i$ to the technological values X_i is carried out according to the formula:

$$x_i = \frac{X_i - X_{i0}}{\Delta X_i}, \tag{2}$$

Where, X_{i0}=zero factor level, ΔX_i=variation interval.

Obtaining of the mathematical model of the filling-greasing process of leather semi-finished products

According to the CCRP, variants of the filling-greasing process of the semi-finished product of chrome tanning with the corresponding expense of the compositions ingredients at 20 experimental points were realized **(Table 1)**. The obtained values of physico-chemical properties of the leather materials samples are given in **Table 3**. At the same time, the effectiveness of the influence of the ingredients of the filling composition on the leather physico-chemical properties was assessed by the following indicators:

y_1=Relative elongation of leather at a stress of 10 MPa,%;

y_2=material hardness on PZU-12M, sN;

y_3=volumetric output of leather material, %.

Table 3: Results of filling-greasing of semi-finished product of chrome tanning.

i	Experimental point									
	1	2	3	4	5	6	7	8	9	10
y_1	21	25	22	28	24	30	26	32	25	36
y_2	38	35	36	34	31	29	28	29	34	28
y_3	52	54	55	57	56	63	58	65	55	68
	11	12	13	14	15	16	17	18	19	20
y_1	30	27	25	29	32	33	30	31	32	30
y_2	27	30	37	30	26	26	28	27	27	29
y_3	57	59	57	67	64	66	62	63	64	63

RESULTS AND DISCUSSION

Filling-greasing of semi-finished product of chrome tanning

To find the coefficients of the model (1), the least squares method in the matrix form was used:

$$B=(F^TF)^{-1}F^TY=DF^TY \tag{3}$$

Where, B=vector of the desired coefficients of the model, F=matrix of experimental data of plan X, generalized by model type $\tilde{f}^T(\bar{x})$ at $\bar{x} = \|x_1, x_2, x_3\|$ [10]; T-matrix transferring operation; «-1» - operation of finding the inverse matrix; D-dispersive matrix; Y-vector-column of the dependent variable.

The experimental error s^2_{eken} is calculated using the experimental points of the center of the plan by the formula:

$$s^2_{ekcn} = \frac{1}{n_0 - 1}\sum_{i=1}^{n_0}\left(y_{i0} - \bar{y}_0\right)^2 \text{ if } \bar{y}_0 = \frac{1}{n_0}\sum_{i=1}^{n_0} y_i \tag{4}$$

The significance of the coefficients of the mathematical model is verified according to Student's criterion according to the formula:

$$t\left\{b_j\right\} = \frac{|b_j|}{s\left\{b_j\right\}} > tm\partial\pi[q; f_{ekcn}] \text{ if } s\left\{b_j\right\} = \sqrt{d_{jj}s^2_{ekcn}}, \tag{5}$$

Where, q=level of the criterion significance; $f_{eken} = n_0 - 1$ = number of freedom degrees; d_{jj} - corresponding diagonal element of the dispersive matrix D.

The coefficient of a model is considered significant when the calculated value of the Student`s criterion is bigger than the table`s one. After excluding the insignificant coefficient, the adequacy of the model according to Fisher's criterion is determined. For this, the dispersion of adequacy is calculated according to the formula:

$$s_{a\partial}^2 = \frac{s_{3\alpha\pi} - s_{ekcn}}{f_{a\partial}} \quad \text{at} \quad s_{3a\pi}^2 = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n-l}. \tag{6}$$

Where, $f_{a\partial} = f_{3a\pi} - f_{ekcn}$, $f_{3a\pi} = n - l$ = number of freedom of dispersion in accordance with adequacy and residuality.

Verification of the model adequacy is carried out by the formula:

$$F_p = \frac{s_{a\partial}^2}{s_{ekcn}^2} \geq F_{ma\partial\pi}\left[q; f_{a\partial}; f_{ekcn}\right], \tag{7}$$

Where, $F_p, F_{ma\delta\pi}$ =calculation and tabular value of Fisher's criterion.

After the computer calculation of the CCRP, the coefficients of the models bj and the corresponding estimated values of the Student`s coefficients are given in **Table 4**, and the parameters of the medellars adequacy in **Table 5.**

Table 4: The coefficients of the models and the calculated values of the Student's criterion.

Coefficient	Model $\hat{y}_1$		Model $\hat{y}_2$		Model $\hat{y}_3$	
	b_j	$t\{b_j\}$	b_j	$t\{b_j\}$	b_j	$t\{b_j\}$
b_0	31.4168015	-	27.1246128	-	63.7602158	-
b_1	1.6651034	5.0787764	-2.7673550	8.7441406	2.9901500	8.0843134
b_2	*0.2169325*	*0.6616715*	*-0.0703569*	*0.2223099*	0.9791284	2.6472187
b_3	2.9666979	9.0488043	-1.1784708	3.7236695	2.9197938	7.8940949
b_{12}	*0.0*	*0.0*	*0.0*	*0.0*	*-0.25*	*0.3030457*
b_{13}	*0.25*	*0.3418818*	*0.5*	*0.7083376*	*1.25*	*1.5152286*
b_{23}	*0.25*	*0.3418818*	*0.5*	*0.7083376*	*0.0*	*0.0*
b_{11}	-2.0644879	1.3310804	2.5105045	14.2742853	-1.1835907	5.7582803
b_{22}	-1.5330223	8.4140959	0.7389672	4.2016373	-2.6008203	12.6532364
b_{33}	-0.8244048	4.5248008	1.6247383	9.2379751	-1.3607414	6.6201353

Table 5: Estimation of the models adequacy by experimental data

Indicator	Model		
	$\hat{y}_1$	$\hat{y}_2$	$\hat{y}_3$
Experiment error - s_{ekcn}^2	1.466667	1.366667	1.866667
Table Student`s criterion - t_T (5, 5%)	2.571	2.571	2.571
Adequacy dispersion - $s_{a\partial}^2$	5.736937	4.474275	8.3434
Fisher's Criterion calculated -F_p table - $F_{ma\delta\pi}\left[5\ \%; f_{a\partial}; f_{ekcn}\right]$	3.911548 4.78 (9 ; 5)	3.27386 4.78 (9 ; 5)	4.469678 4.82 (8 ; 5)

Note. In the foreground, the insignificant coefficients of models are highlighted.

In such way, the obtained mathematical model (8)

$$\begin{cases} \hat{y}_1 = 31.4168 + 1.665103 x_1 + 2.966698 x_3 - 2.064488 x_1^2 - 1.533022 x_2^2 - .8244048 x_3^2 \\ \hat{y}_2 = 27.12461 - 2.767355 x_1 - 1.178471 x_3 + 2.510504 x_1^2 + .7389672 x_2^2 + 1.624738 x_3^2 \\ \hat{y}_3 = 63.76022 + 2.99015 x_1 + .9791284 x_2 + 2.919794 x_3 - 1.183591 x_1^2 - 2.60082 x_2^2 - \\ \quad - 1.360741 x_3^2. \end{cases} \tag{8}$$

Adequately describes the process of filling-greasing the leather semi-finished product of chrome tanning to produce white leather. The given mathematical model was used for optimization of the investigated process.

Optimization of the filling-greasing process of leather semi-finished product of chrome tanning

The use of the mathematical model (8) as a target function involves solving the problem of multi-criteria conditional optimization. As the resulting model includes three optimization parameters and each of them has three factors influencing the process, then the desirability function [11] was used to solve this issue:

$$\Phi = \sqrt[m]{d_1 d_2 \ldots d_m} \; , \tag{9}$$

Where, m=the number of dependent variables influencing the filling-greasing process;

d_i (i=1, 2, …, m)=partial desirability function of the i-th parameter y_i, which takes values in the interval [0; 1], is determined by the formula:

$$d_i = \exp[-\exp(-y_i'] \; , \tag{10}$$

Where, y'_I = dimensionless value of quality index y_i, determined by linear dependence:

$$y_i' = b_0^{(i)} + b_1^{(i)} y_i \tag{11}$$

Coefficients $b_0^{(i)}$, $b_1^{(i)}$ of dependencies (11) are determined from systems of equations:

$$\begin{cases} y_i'^{\,гірше} = b_0^{(i)} + b_1^{(i)} y_i^{гірше} \\ y_i'^{\,краще} = b_0^{(i)} + b_1^{(i)} y_i^{краще} \end{cases} , \qquad (i = 1, 2, \ldots, m), \tag{12}$$

Where, $y_i^{гірше}, y_i^{краще}$=therefore, worse and better value of criterion of the leather semi-finished product quality yi, which is set by the researcher; $y_i'^{\,гірше}, y_i'^{\,краще}$ - worse and better values of the dimensionless criterion, determined on the basis of the formula (10) according to the dependencies:

$$y_i'^{\,гірше} = -\ln(-\ln d_{гірше}), \quad y_i'^{\,краще} = -\ln(-\ln d_{краще}) , \tag{13}$$

Where, $d_{гірше}$ і $d_{краще}$ – worse and better value of partial desirability functions (10), which, as a rule, take in practice the values of 0,2 and 0,8 respectively.

The maximum of the desirability function F constructed according to (9), corresponds to the optimal mode of the filling-greasing process, which has the best compromise values of the output variables yi (i = 1, 2, ..., m).

By using the obtained mathematical model (8) and the formulas of the desirability function (9)-(12) by the scan method within [-1,68; +1,68] the optimal values for the implementation of the process are found **(Table 6)**.

Table 6: The result of the process optimization by scanning method.

i	Coordinates of the optimum point		Input optimization parameters		The optimal value of the output variable y_i
	x_i	X_i	$y_i^{гірше}$	$y_i^{краще}$	
1	0.6399984	2.6399984	24	33	33.53185
2	9.999872.10^{-2}	6.14999808	33	27	26.54569
3	0.8399982	8.2599973	57	67	66.7535
Desirability function* 0.8119443					

Note: * The number of calculations of the values of the desirability function 37933056

To determine the intervals of the ingredients expenses of the filling-greasing composition, it is necessary to find an optimal part of the implementation of the technological process. To do this, a compromised part of the process is first defined, namely, all possible values of the ingredients of the composition, at which simultaneously the physical and chemical parameters will acquire the values at given intervals of the **Table 6**. The compromise area in which the isolines of the function of desirability correspond to its maximum value is optimal for the implementation of the process, shown in **Figure 2 and 3**. At the same time, moving towards the increasement in the desirability function, the values of factors and physico-chemical indicators of the quality of leather material are improved. It should be not ed that the construction of the optimal area is performed in the program STAT-SENS [12]. As can be seen from **Figure 2 and 3** intervals of the optimal values of the factors are within the coded values: x_1=0.5-0.7, x_2=0-0.2, x_3=0.8-0.9.

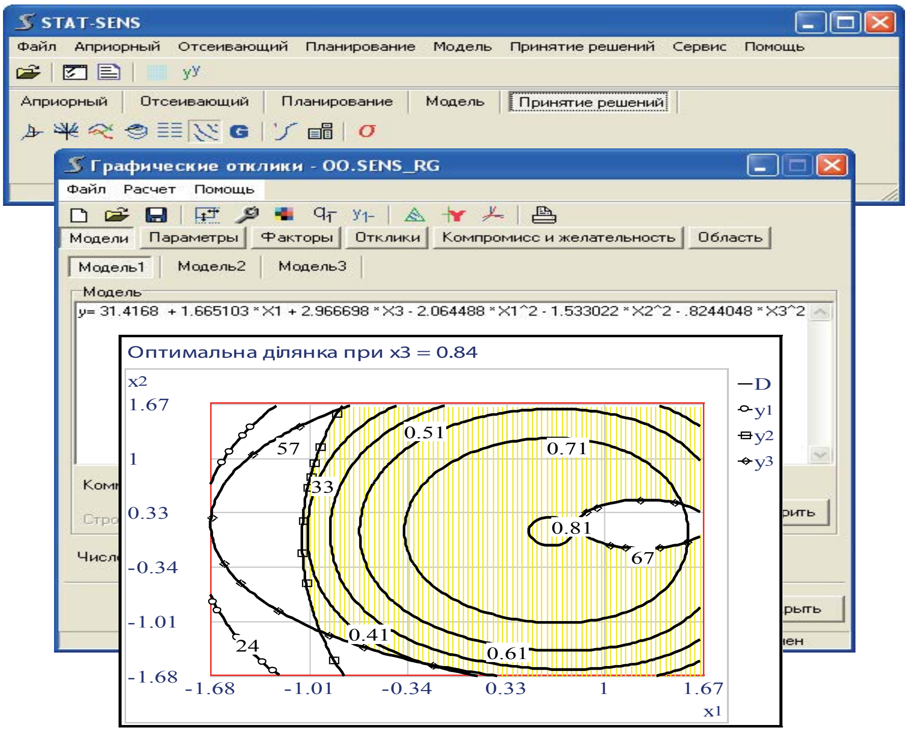

Figure 2: Construction of the optimal area in the coordinate's $x_1 0 x_2$ at x_3=0.84.

Consequently, the optimum values of the ingredients` expenses of the filling-greasing composition while processing of the leather semi-finished product of chrome tanning will be, % of mass of the semi-finished product: aerosil A-300 2.5-2.7, acrylic polymer Retanal RCN-40 6.0-6.3, greasing material 8.2-8.35. At the same time, the physico-chemical parameters of the obtained semi-finished product acquire the following values: relative elongation at a stress of 10 MPa-33.3-33.7%, leather hardness-26.3-26.7 sN, formation of the volumetric output,%- 66.5-66.8.

Semi-productive testing of the filling-greasing technology of leather semi-finished products

The technology of filling-greasing of leather semi-finished product of chrome tanning by using the certain optimal expenses of ingredients is tested in the conditions of the research department of PJSC "Chinbar" (Ukraine). In order to compare the developed technology, a production technology which involves the use of quebracho plant extract and acrylic dispersion with consumption at the stage of filling-greasing, is used, % of the semi-finished product mass: **(Table 7)**

According to the obtained results, leather obtained by using aerosil A-300 at the filling-greasing stage according to the experimental technology is characterized by white color, has a higher strength of the front layer, which corresponds to the strength of leather, and the increased elasticity compared with leather obtained by using the technology of PJSC Chinbar. At the same time, thanks to the higher elasticity, the resulting leather has a bigger 2.6 % exit area, which can be explained by the more effective diffusion of highly dispersed nano-silica into the interdisciplinary space of the dermis and the equable distribution of the ingredients of the filling-greasing composition in the structure of the formed leather.

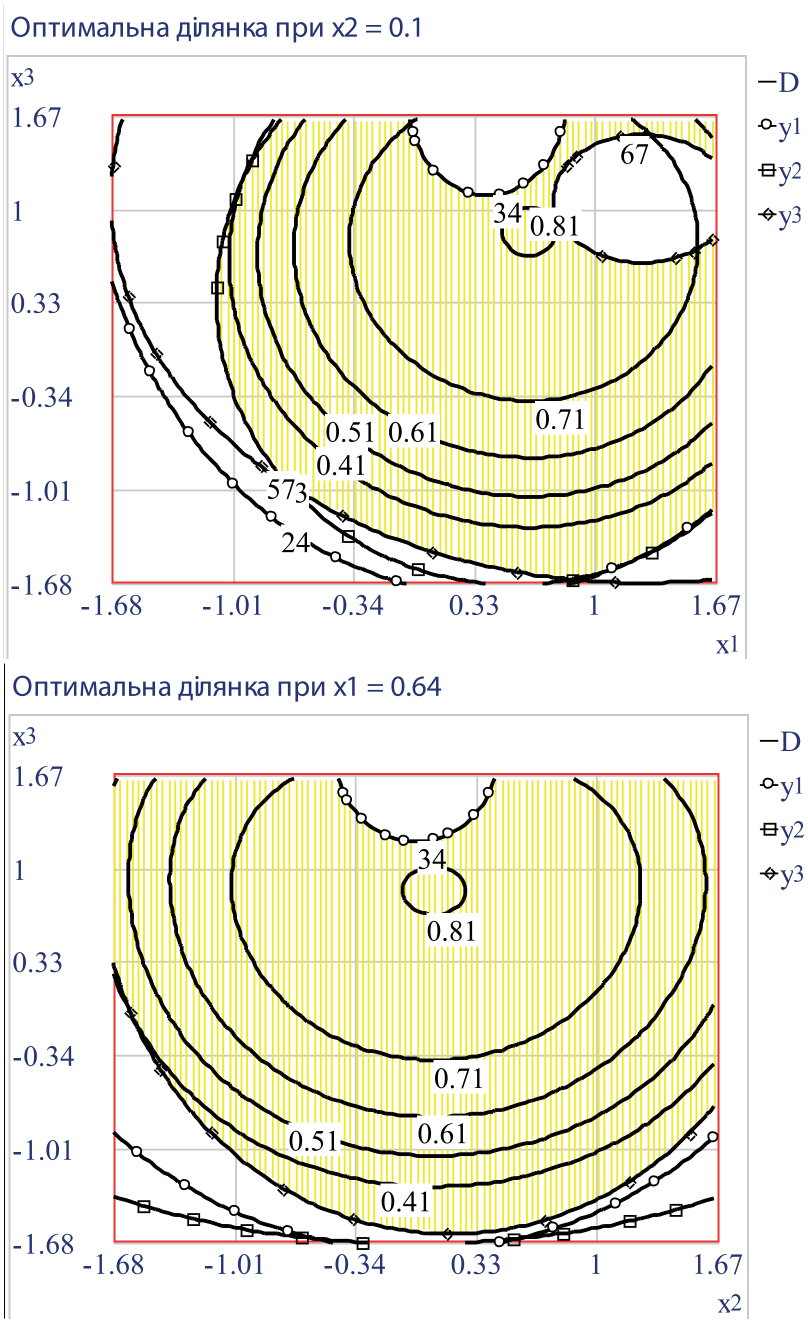

Figure 3: Optimal area of the filling-greasing process in the coordinates: a-$x_1 0 x_3$; b-$x_2 0 x_3$.

Table 7: Physico-chemical properties of the filled leather semi-finished product of chrome tanning.

Index	Technology	
	optimized	working
Color	white	Light-brown
Measure of strength at stretching, MPa	23.0	21.0
Measure of strength of the facial layer, MPa	23.0	19.0
Extension at 10 MPa,%	31.0	29.0
Elongation at break,%	59.0	55.0
Hardness, sN	28.0	31.5
Volume formation,%	65.0	66.0
Exit of leather area,%	102.6	100.0

CONCLUSION

The mathematical model of the second order of the technological process of filling-greasing of leather semi-finished product of chrome tanning on the basis of the central composite rotatable plan with three input variable components of the filling composition and three physico-chemical indexes of the obtained leather material was developed.

The multicriteria optimization of the filling-greasing process of leather semi-finished products with the use of the desirability function and limitations of the indicators values taking into account their desirable values was carried out. The optimal values of the ingredients` expenses of the filling-greasing composition for the light-colored leather production while processing leather semi-finished product of chrome tanning using aerosil A-300 and acrylic dispersion were established.

The developed technology of the filling-greasing process with the use of nano-silica for the formation of light-colored leather provides the production of the material of increased elasticity and durability with an increase of the exit area on 2.6% compared with the production technology, which involves the formation of leather materials using colored tannin filler.

The obtained light-colored leather meets the requirements for elastic leather for sewing products according to DSTU 3115-95 and the requirements of the international standard of quality management systems "ISO 9001: 2008". The availability of the developed filling-greasing process is stipulated due to the possibility of its use in the technologies of chrome tanning of semi-finished products in the manufacture of light-colored leather of wide use.

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