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CONSTRUCTION OF A REGRESSION MODEL FOR THE TECHNOLOGICAL PROCESS OF LINT SEPARATION FROM COTTON SEEDS

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Abstract: This article presents a regression model for the lint separation process with an enlarged working chamber.

Keywords: cotton cleaning, lint separation, linter, unit, seeds, lint, seed comb, grate, seed chamber, working chamber, seed moisture, matrix, regression

At cotton-cleaning enterprises, lint separation from seeds is carried out on linters multiple times and at different speeds. For this purpose, linter units of types **PMP-160M, 5LP, and 6LP** are currently used [1].

The performance of lint separation machines, as well as the efficiency of extracting short fibers (lint) remaining in the seeds after ginning, mainly depends on the probability of their contact with saw teeth and the operation of the device that forms the seed flow in the working chamber. The main drawback of existing machines is the small size of the working chamber. Because of this, the probability of partially uncleaned seeds striking the saw teeth is low, leading to residual lint. Therefore, an enlarged working chamber has been proposed, and scientific studies have been conducted [2,3].

As an example, let us consider building a mathematical model to study the influence of factors on the quantity and quality of lint extracted in the linting process with an enlarged working chamber [4,5].

When statistically processing the experimental results to optimize the factors and output parameters, methods of mathematical experiment planning were used. In this work, a full factorial experiment was applied.

For this purpose, we consider the influence of the perimeter of the proposed enlarged seed chamber, the moisture of seeds entering the chamber after ginning, and the productivity of the linter machine per seed on the quantity of high-quality lint obtained.

The output parameter is the amount of high-quality lint scraped in the enlarged working chamber. The influencing parameters (input factors) are: the perimeter of the enlarged seed chamber, the moisture of seeds entering the chamber, and the productivity of the linter machine per seed. Their effect on the amount of lint obtained was determined experimentally under production conditions.

For this purpose, based on the planning matrix, experiments are conducted under each condition with triple repetitions. In this case, if we take into account the number of experiments $N = 2^3 = 8$ and the number of repetitions $m = 3$, the total number of experiments will be $N \quad m = 24$.

Table 1.

Condition of the experiment planning

№	Factor name, designation	Encoded designation	Real values of the factor			Variation interval
			-1	0	1	
1	Perimeter of working chamber, P_k , мм.	x_1	1120	1230	1340	110
2	Seed moisture, W_c, (%).	x_2	8,8	10,9	13	2,1
3	Productivity, P_r, (kg/h).	x_3	628	650	672	22

The experimental results of the output parameter and the homogeneity of variances were checked using the tabular value of **Cochran's criterion**. The free term, coefficients of nonlinear terms were determined, and a multifactor regression model was constructed. To obtain the final form of the model, the significance of the coefficients was tested using **Student's t-test**.

For this, the formulas of Student's t-test were used.

Thus: the tabular value of Student's criterion.

$$t_T[P_D, f(S_u^2) = N\ \ (m-1)] = t_T[P_D = 0.95;\ \ f = 8\ \ (3-1) = 16] = 2.12$$

Therefore,

Since the calculated values of the coefficients b_1 , b_2 , b_3 , b_{13} , b_{23} , b_{123} are greater than the tabular value, these coefficients are significant, while the remaining coefficients are insignificant. As a result, we obtain the following model:

$$y_R = 3.45 + 0.90 \cdot x_1 - 0.43 \cdot x_2 + 0.34 \cdot x_3 - 0.11 \cdot x_1 x_3 - 0.175 \cdot x_2 x_3$$

By transitioning from the real values of the factors to the coded ones according to the following relations, the calculated values of the output parameter are determined using the model.

$$x_1 = \frac{P_k - 1230}{110}; \qquad x_2 = \frac{Wch - 10{,}9}{2{,}1}; \qquad x_3 = \frac{P_r - 650}{22}.$$

To verify the adequacy of the obtained model, formulas of Fisher's criterion were applied. For this, the experimental and calculated values of the output parameter were compared, taking into account the number of significant coefficients of the model. $N_k = 5$.

$$S_{nad}^2(y) = \frac{\sum_{n=1}^{n} (\bar{y}_u - Y_{Ru})^2}{N - N_k} = \frac{0{,}1170}{8-5} = 0.039$$

Since this number $S^2(\bar{y}) = 0.0118$ is greater than the specified value, the calculated value of the criterion is determined by the formula:

$$F_R = \frac{S^2_{nad}(y)}{S^2(\bar{y})} = \frac{0,039}{0.0118} = 3,31.$$

The tabular value of Fisher's criterion is found from a special table: $F_T[P_D = 0.95; f(S_y^2) = 16, f(S^2_{\text{хад}}) = 4] = 5.85.$. Consequently, $F_R < F_T$, that is 3.31 < 5.85, is smaller, therefore the model is adequate, i.e., it correctly reflects the changes in the indicators of the lint removal process in the linter machine with an enlarged working chamber.

In this machine, such factors as the perimeter of the working chamber, seed moisture, and productivity of the linter machine per fluffy seeds were studied as complex factors affecting the amount of lint obtained in the separation process.

From the conducted experiments and analysis, it can be concluded that the perimeter of the working chamber of the enlarged linter has a significantly higher influence compared to other indicators. In lint production, a sharp increase in the amount of lint is observed when the perimeter of the working chamber exceeds 1225 mm**.**

Thus, the introduction of an improved linter machine with a working chamber perimeter greater than 1225 mm creates the possibility of obtaining a higher amount of lint that meets standard quality requirements.

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