DEVELOPMENT OF LINEAR MATHEMATICAL MODELS OF THE TECHNOLOGICAL PROCESS OF CRUSHING SEEDS CRUSHING

F. Yusupov
Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi

T. Y. Kim
Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi, tatyana_kim92@mail.ru

B. B. Nurmetova
Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi

J. M. Xojibayev
Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi

Follow this and additional works at: https://uzjournals.edu.uz/capmse

Recommended Citation

This Article is brought to you for free and open access by 2030 Uzbekistan Research Online. It has been accepted for inclusion in Central Asian Problems of Modern Science and Education by an authorized editor of 2030 Uzbekistan Research Online. For more information, please contact brownman91@mail.ru.
DEVELOPMENT OF LINEAR MATHEMATICAL MODELS OF THE TECHNOLOGICAL PROCESS OF CRUSHING SEEDS CRUSHING

Yusupov Firnafas senior lecturer
Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi.

Kim Tatyana Yurevna assistant
Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi
E-mail: tatyana_kim92@mail.ru

Nurimetova Bonuraxon Bakhromovna assistant, Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi

Xojibayev Jonibek Maxmudjonovich assistant, Urgench branch of Tashkent university of information technologies named after Muhammad Al-Khwarizmi

Annotatsiya – Yog' ekstraksiyasi zavodidagi paxta chigitini yanchish texnologik jarayonini tajriba-statistik izlanishlar asosida mazkur jarayonning soddalashgan chiziqli statistik modeli tajribani rejalshtirish metodidan foydalanib qurildi. Tajriba-statistik ma’lumotlar dispersiyasini bir jinsligi, chiziqli modeling koeffitsientlarini ishouchligi va modeling jarayonga adekvatligi tahlil qilindi.

Abstract - The simplified statistical linear model of the object under study is developed on the basis of experimental and statistical studies of the technological process of crushing the cottonseed of an oil extraction plant using the experimental
design method. The analysis of the homogeneity of the dispersion, the significance of the coefficients of the linear model and the adequacy of the resulting model.

**Annotación** - На основе экспериментально-статистических исследований технологического процесса дробления семени хлопчатника маслоэкстракционного производства разрабатывается упрощенная статистическая линейной модель исследуемого объекта с помощью метода планирования эксперимента. Проведен анализ однородности дисперсии, значимости коэффициентов линейной модели и адекватность полученной модели.

**Kalitso’zlar** – jarayoninitahlilqilish, korrelyatsiyavaregressiya, paxtachigitinimaydalash, chiziqliregressiya, dispersiyflarningbirjinsilig, modelningadekvatligi.

**Keywords** - technician process analysis, correlation and regression, cottonseed crushing, linear regression, dispersion homogeneity, model adequacy.

**Ключевые слова** - анализ процесса, корреляция и регрессия, дробление семени хлопка, линейная регрессия, равномерность дисперсии, адекватность модели.

**INTRODUCTION**: The statistical models of the technological process of grain crushing built in this paper can be the basis for the development of many models of deterministic, dynamic and stochastic models for planning and controlling the production process using fuzzy logic. To create a multi-level hierarchy of optimization algorithms for an oil extraction plant with a discrete-continuous nature of production, it is necessary to study the structural organization of the production and technological process and build a mathematical model of the control object.
LITERATURE REVIEW

Firstly, we give a qualitative description of the object, which then allows you to go to the analytical representation of the object model.

The object under study will be considered as a complex consisting of some set of technological installations (equipment) for processing cottonseed, warehouses of various types of raw materials and final products, intermediate storage of semi-finished products [1]. The input of the control object is a set of modifications of the initial raw material - cottonseed of various types of harvest and varieties. The output of the control object is a variety of end products - cottonseed oil, husks, meal, soap, etc., various types of waste. The main material flows in the studied enterprise with discrete-continuous technological processes are the flows of raw materials, intermediate and final products of processing cottonseeds.

The manufactured products of the preparatory workshop of the oil extraction plant, consisting of a seed warehouse, seed cleaning, peeling and separating workshops and roller section, are cotton mint.

The final product of the preparatory workshop is mainly cotton mint - it is a product obtained by grinding cottonseed kernels on roller machines. The grinding of the kernel of cottonseeds is carried out in order to achieve the maximum possible opening of the cells of the kernel of cottonseeds. It is allowed to add husk to the crushed kernel - the mint, bringing the total content of the husk in the mint obtained from a mixture of seeds of various varieties to 15-17%. The thickness of the petal of the mint determines the quality of grinding, it can be from 0.1 to 1.0 mm. The thinner the petal, the more opened cells.

When shelling (peeling) of cottonseeds, a whisker is obtained, consisting of a mixture of kernels, husks and whole seeds. The process of rushanka separation has
the goal of obtaining a kernel with a minimum content of husk with the lowest oil content.

**Research methodology** The number of whole seeds in a small hook after the first breaking (peeling) should be no more than 30%, after the second - no more than 0.8%. During the separation (separation) of the rushanka, two fractions are formed - the husk and the core.

The husk is a product whose content in seeds is 39-43%. Oil dust is finely crushed particles of the core contained in a whisker or husk. Usually, these particles are no larger than 1 mm.

The cottonseed kernel is a product that is subject to further processing to extract oil from it, so long-term storage is not recommended because it is devoid of a shell and the acid number of the oil quickly increases, destructive processes are observed, leading to loss of oil and reducing its output.

For the purpose of operational management of the production process, a simplified mathematical model of the technological process of crushing cottonseeds is being developed. The technological process of crushing cottonseeds consists of a number of technological installations (equipment), control and regulation devices, warehouses of various types of raw materials (modification of cottonseeds: a selection of cottonseeds, industrial variety, type of harvest, cottonseeds grade, contamination, humidity and etc) and intermediate products, semi-finished products (the core of cottonseeds, husks, unbroken seeds, etc.).

The developed mathematical model for creating algorithms for controlling the technological process of crushing cottonseeds is a formalized description of the structure of the technological process and characterizing its parameters.
The technological process of crushing cottonseeds consists of the following main technological operations: seed loosening, conveyor, drying, cleaning, crushing, seed peeling, the sieve of various sizes [1].

The purpose of this work is an experimental statistical study of the technological process of crushing cottonseed, as well as the construction of a simplified statistical linear model of the process under study. The technological process of crushing cottonseeds, as a control object, has dynamic properties, which imposes a number of difficulties in mathematical formalization. The effect of the object dynamics on the accuracy of the statistical model will be minimal in the case when the moments of data recording at the object input and output are separated by a time interval equal to the maximum shift of the mutual correlation function between the process parameters considered.

Statistical examination of the process of crushing cottonseeds also requires a preliminary assessment of the required number of observations. The amount of necessary statistical data can be determined by the method described in [2,3].

According to the considered methodology for collecting experimental data under conditions of the normal functioning of the technological process of crushing cottonseeds, the parameters of the crushing processes were recorded, considering the time shifts and the data collection interval calculated from the results of the preliminary experiment.

In this case, the readings of the recording and indicating instruments and the data of express analyzes specially organized in the laboratories (nuclei yield, husk, non-shredded seeds) were used.

All collected statistical material is presented in the form of tables of initial data (Table 1 and 2). The obtained experimental data were an approximate equivalent of
the object and were used in mathematical modelling of the technological process of crushing cottonseeds using the experiment planning method.

Based on the analysis of existing methods for constructing models of complex dynamic objects, for the technological process, experimental statistical methods of identification based on the methods of correlation and regression analysis are most acceptable [4,5].

A preliminary study of the crushing of cottonseeds, as well as an analysis of a priori information about the processes contained in the practical experience of technologists and specialists, made it possible to identify technological parameters telling the greatest influence on the process of crushing cottonseeds.

The entire set of parameters determining the current state of the technological process of crushing cottonseeds can be divided into two groups of parameters [6].

I. The set of primary (input) process parameters characterizing the quality and quantity of the initial processes:

a) input parameters of raw materials of cottonseeds for the crushing process $X = \{x_1, x_2, x_3\}$;

where $x_1$ - cottonseed contamination, in%;

$x_2$ - cottonseed damage, in%;

$x_3$ - cottonseed moisture, %.

b) The set of secondary (output) process parameters, characterizing those generalized technical and economic indicators that assess the quality and economic efficiency of the process of crushing cottonseeds $Y = \{y_1, y_2\}$,

где $y_1$ – yield kernel of cottonseeds (crushed seeds), in%.
$y_2$ – the output of the husk, seed seeds and cottonseeds not chopped, in%.

The levels of the factors $X = \{x_1, x_2, x_3\}$ were chosen in such a way that they covered the assumed range of optimal values of the factors, which follows from the table. 1.

Table 1.

<table>
<thead>
<tr>
<th>Factor’s levels</th>
<th>designation</th>
<th>$B%$</th>
<th>$B%$</th>
<th>$B%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_1$</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>$x_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$x_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>The range of</td>
<td>$\Delta x$</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>variation in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>+1</td>
<td>9</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Lower</td>
<td>-1</td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

Analysis and results

It was chosen that $X = \{x_1, x_2, x_3\}$ were the levels of the factors. one.

The coded value of the factors $z_1, z_2, z_3$ was determined by the known formulas [7].

As a mathematical model of the object of study, choose a first-order polynomial that is linear in all variables:

$$\hat{y}_2 = b_0 + b_1 z_1 + b_2 z_2 + b_3 z_3 + b_{12} z_1 z_2 + b_{13} z_1 z_3 + b_{23} z_2 z_3 + b_{123} z_1 z_2 z_3 \quad (8)$$

where $z_1, z_2, z_3$ – coded values of factors; $b_0$ - free member; $b_1, b_2, b_3$ - coefficients showing the degree of influence of each factor on the optimization
parameter; $b_{12}, b_{13}, b_{23}, b_{123}$ are coefficients showing the degree of influence of the interaction of the relevant factors on the optimization parameter.

Table 2

<table>
<thead>
<tr>
<th>The real importance of the factors</th>
<th>The coordinates of the factors without a unit</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of experiments</td>
<td>$x_1$</td>
<td>$x_2$</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

We calculate the average values of $y_2$ in each row of the planning matrix, for this, we carried out additional experiments.
m (m = 3) times: \[ y_i = \frac{\sum_{j=1}^{m} y_{ji}}{m}. \]

\[ y_1 = 30.9, \quad y_2 = 30.9, \quad y_3 = 30.2, \quad y_4 = 30, \]
\[ y_5 = 30.06, \quad y_6 = 29.7, \quad y_7 = 29.4, \quad y_8 = 29.1. \]

Then the line dispersions were calculated by the formula
\[ s_i^2 = \frac{\sum_{j=1}^{m} (y_{ji} - y_j)^2}{m - 1}. \]

\[ s_1^2 = 0.24, \quad s_2^2 = 0.04, \quad s_3^2 = 0.08, \quad s_4^2 = 0.02, \]
\[ s_5^2 = 0.05, \quad s_6^2 = 0.005, \quad s_7^2 = 0.045, \quad s_8^2 = 0.125. \]

Next, the experimental value of the Cochren criterion is calculated by the formula
\[ \sigma_{pacu} = \frac{s_{i,max}^2}{\sum_{i=1}^{n} s_i^2}. \]

\[ \sigma_{pacu} = 0.206. \]

At \( f_1 = m - 1 \) and \( f_1 = n \) from the reference tables [9], the value was taken to be 0.516. Since the line-by-line dispersions should be considered homogeneous, and the reproducibility of the experiment — satisfactory.

The variance of the optimization parameter in accordance with the formula is equal to:
\[ s_y^2 = \frac{\sum_{i=1}^{n} s_i^2}{n}. \]

\[ s_y^2 = 0.075, \quad s_y = 0.273 \]

According to the corresponding formulas [3,4], the coefficients of the regression equation were calculated:
\[ b_0 = 8.34, b_1 = -3.86, b_2 = -3.86, b_3 = -3.775, b_12 = 0.35, b_13 = 0.15, \]
\[ b_{23} = 0.35, \quad b_{123} = 0. \]

The regression equations took the form

\[
\hat{y}_2 = 8.34 - 3.86 z_1 - 3.86 z_2 - 3.775 z_3 + 0.35 z_1 z_3 + 0.15 z_2 z_3 + 0.35 z_1 z_2 z_3 \quad (5)
\]

The dispersion of the coefficients of the regression equation in accordance with the formula was:

\[
s_{b_j} = \frac{s_y}{\sqrt{NM}}, \quad s_{b_j} = 0.055 .
\]

The experimental value of student's criterion is equal to:

\[
t_j = \frac{|b_j|}{s_{b_j}} . \quad t_{p_0} = 151.27, \quad t_{p_1} = 70.18, \quad t_{p_2} = 70.18, \quad t_{p_3} = 68.63, \quad t_{p_{12}} = 6.36, \quad t_{p_{13}} = 2.45, \quad t_{p_{23}} = 6.36, \quad t_{p_{123}} = 0 .
\]

When \( f_1 = n (m-1) = 16 \) and \( \alpha = 0.05 \), the table value is \( t_{tabl} = 3.24 \) with the number of degrees of freedom equal to 16 [10, 11]. Comparing \( t_{ras} \) with \( t_{tabl} \) showed that \( (t_{ras}>t_{tabl}) \) only coefficients are statistically significant

\[ b_1, \quad b_3, \quad b_{12}, \quad b_{23} . \]

Therefore, the final regression equation is:

\[
\hat{y}_2 = 8.34 - 3.86 z_1 - 3.86 z_2 - 3.775 z_3 + 0.35 z_1 z_3 + 0.35 z_1 z_2 z_3 \quad (3)
\]

Check the adequacy of the model. The variance of adequacy calculated by the formula

\[
s_{a0}^2 = \frac{m}{n-q} \sum_{j=1}^{m} \left( \hat{y}_j - y_j \right)^2 ,
\]

where \( q \) is the number of members of the regression equation (\( q = 6 \)) remaining after checking the significance of the coefficients \( b_j \); line-by-line values of the optimization parameter, calculated by the final type of the mathematical model [12, 13].
To test the adequacy of the finally adopted mathematical model (3), the Fisher criterion was calculated using the formula

\[ F = \frac{S_{\alpha}^2}{S_y^2}, \quad F_{pave} = 3.75 \]

When \( f_1 = n - q - 2, \quad f_2 = n (m-1) - 16 \) and \( \alpha = 0.05 \), the table value \( F_{tabl} = 4.49 \) [2]. Since \( F_{ras} < F_{tabl} \), we can assume that equation (6) adequately describes the technological process of crushing cottonseed. From this equation, it follows that, only the coefficients have a significant effect on the parameter \( y_1 \). The coefficients \( b_{12}, b_{13}, b_{23}, b_{123} \) on the technological process in the studied intervals on the indicator \( y_2 \) have no significant effect.

The results obtained can be applied:

a) to select the optimal technological mode;

b) in case of machine simulation for the purpose of checking and evaluating the process control algorithms for crushing cottonseeds, as well as for creating a process control system;

c) to select an effective plan for the main production process of cottonseed processing based on simplified linear mathematical models.

**CONCLUSION**

Based on theoretical and experimental studies, the developed models and algorithms of the technological process of crushing cottonseeds (grains of various materials) by the production processes of cotton oil production will help to increase the efficiency of functioning under conditions of integrated systems of automated control of oil extraction enterprises.
As a result, the following results were obtained:

1. The analysis of the state of scientific and practical developments on the materials of the open press in the field of automation and construction of mathematical models of the technological process of crushing cottonseeds (grain of various materials), industrial control systems of oil extraction enterprises;

2. A linear and non-linear statistical model was developed by the least squares method and the model was analyzed for adequacy.

REFERENCES

1. Production process regulations. For the production of cotton mint according to the scheme of double peeling, separation and grinding of the kernel with a capacity of 800 tons/day of cottonseeds. TP 1602-28-12-08. Tashkent, 2008. – 93 p.


