Substantiation of the optimal parameters by processing with electric contact methods to decrease the moisture content of technical seeds

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Abstract. To reduce moisture content of technical seeds in compliance with standard requirements, electric contact heating method is applied. The technical seed moisture content reduction process has been studied experimentally through electric contact processing. The mathematic model of the process has been defined. The optimal parameters of the process have been identified based on the mathematic model. To identify the optimal parameters of the technical seed moisture content reduction process the computer program, calculation algorithm has been developed by using computer program PascalABC.

1. Introduction

During the experimental research, the method of mathematical planning of researched is utilized with the view of getting important information about the established process by spending less time and effort to conduct experiment. The experimental research was set a task to develop a mathematical model of the process of relating external effect and object parameters with the quality. Special experimental researches have to be carried out to assess the process of optimizing the main parameters of moisture technic seed content and linting time reduction by applying the electrical contact processing method [1-5].

By considering the requirements set for development of the mathematical model of the process, the relevant factors and their variation intervals needed to be determined. According to the analysis of literature and results of preliminary studies, several factors have effect on the moisture discharge process, the followings of which are basic: screw rotation speed (X1), air speed (X2), and temperature of sheet (X3) [6-10].

The time of holding the product in heating equipment and the quantity of lint output are considered as criteria for optimizing the parameters of the technical seed moisture content reduction process [11-14]. To decrease the moisture content of the technic seed, the relative weight of the technical seed and the electrical contact heating parameters were accepted as the key indicators for assessing the electric contact heating system. In their condition, effect of different electrical and technological factors takes place. To learn and understand the effect of factors equally, it is important to identify their functional relationship with the relative weight and electrical contact heating parameters [15-17].
2. Research Methodology

In order to reduce the quantity and increase the accuracy of the experiments, to get the equations of the mathematical descriptions of the process, and to establish the mode parameters in the optimal field of research, we worked using the mathematical theory of experimental planning [18-21].

The experimental researches were conducted in moisture decreasing equipment by meaning of electrical contact which processing to fall the moisture content of technical seeds (Figure 1).

![Equipment for reducing seed moisture](image)

**Figure 1.** Equipment for reducing seed moisture: 1 - hopper for wet seed, 2 - screw shaft, 3 - step-down transformer, 4 - electricity measuring instruments, 5 - autotransformer, 6 - fan, 7 - processed seeds output, 8 - dust air output, 9 - moisture reducing camera

To construct the experimental planning matrix, transition from the actual values of the factors to the coded (non-dimensional) values was performed using the following expression:

\[
x_i = \frac{X_i - X_{io}}{\varepsilon}
\]

Where:
- \( X_i \) - coded value of the factor;
- \( X_i \) - control value of the factor;
- \( X_{io} \) - zero level of value of the factor;
- \( \varepsilon \) - factor of variation interval

For each factor, initially zero degree and changing range shall be encoded.

We select the following mathematical model:

\[
y = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i<j}^{n} b_{ij} x_i x_j + \sum_{i=1}^{n} b_{ij} x_i^2
\]

We use the current method of planning \( B_n \) type secondary experiment.

3. Research Results

From the previous experiments, the basic parameters influencing the relative weight (\( \Delta \)) of the technical seed were obtained as follows:
- \( X_1 \) - screw rotation speed, 1/sec;
- \( X_2 \) - air speed, m/s;
- \( X_3 \) - sheet temperature, °C.

During the experiments, three experiments were conducted at every point of \( V_4 \) plan spectrum. The order of the experiments was carried out in accordance with the table of numbers [18, 19].
The specified factors, their variation intervals and levels are described in Table 1.

| Identification of the factors | Factor | Interval | Levels |
|-------------------------------|--------|----------|--------|
| Coded | Natural | Factor Description | 1 | 1 | 2 | 3 |
| X₁ | n | Screw rotation speed, 1/sec | | | | |
| X₂ | Vₓ | Air speed, m/s | 0.5 | 2.5 | 3 | 3.5 |
| X₃ | t | Sheet temperature, °C | 15 | 120 | 135 | 150 |

Figure 2. Block diagram of algorithm for calculation of technic seed moisture content reduction
We examine the expression of the experiment according to the Cochrane criteria. \( q = 0.05 \) for 
\[
G = 0.8563 < G_{\alpha=q} \{v_1 = 2, \ v_2 = 14 \} = 0.2354 ,
\]
This value does not contradict the hypothesis of experimental expression of the observational results. 
The dispersion expression level (reproducibility) is calculated by using the following formula:
\[
S^2 \{y\} = \frac{1}{N} \sum_{x=1}^{N} S^2 \{\varepsilon\} = \frac{1}{N_1 + 2n + N_0} \sum_{x=1}^{N} S^2 \{\varepsilon\} = \frac{89.53}{14} = 6.395 \quad (4)
\]
The average variance is calculated as the following:
\[
S^2 \{\bar{y}\} = \frac{S^2 \{y\}}{m} = \frac{6.395}{3} = 2.13167 \quad (5)
\]
When subtracting the non-significant coefficients and according to data calculation results, the mathematical model is coded as followings:
\[
y(x, b) = 87.1 + 0.76x_1 - 0.79x_2 - 0.92x_3 + \\
+0.8x_1x_2 + 1.18x_1x_3 - 1.45x_2x_3 - 0.61x_1^2 - 0.26x_2^2 + 0.09x_3^2 \quad (6)
\]
Convert the coded values to natural values and amount natural and after appropriate changes the wet of technic seeds by electric contact reducing method is used by the following mathematical model:
\[
\Delta = -0.61n^2 - 1.04V_x^2 + 0.04t^2 12.22n + 27.56V_x^2 + 0.2534t + \\
+1.6nV_x + 0.0786nt - 0.193V_x t + 46.63 \quad (7)
\]
The mathematical model value shall be determined by using the computer program PascalABC. Figure 2 shows the technic seed moisture reduction calculation algorithm block diagram.
As a result of the researches, the following optimal parameters of the process of technic seed moisture content reduction by applying electrical contact method have been identified as follows: screw rotation speed is 1.5 sec\(^{-1}\), air speed is 2.9 m/s, sheet temperature is 128 °C. The relative weight of technical seeds processed by using these parameters is 66.7%.

4. Conclusion
1. The following optimal parameters of the factors obtained for reducing the technical seed moisture content by electrical-contact processing can be recommended:
   - screw rotation speed of 1.5 sec\(^{-1}\), air speed of 2.9 m/s, sheet temperature of 128 °C. The relative weight of technical seeds processed by using these parameters is 66.7%.
2. In the proposed electrical technology, decrease in the technical seed moisture content reduction process temperature and linting time will lead to energy saving, product quality improvement and extension of technical seed storage life, maintaining the nutritional value of the of secondary product, i.e. oil cake, and can prevent loss of proteins in it.

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