HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

UDC: 631.356.4.02

OPTIMIZATION OF PARAMETERS OF A DIGGER EQUIPPED WITH A CENTRIFUGAL BAR ELEVATOR

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Doi: https://doi.org/10.5281/zenodo.21312087

Abstract: The article presents the results of optimization of the operating parameters of a centrifugal elevator with a screw conveyor using the mathematical planning method. Experiments were conducted based on the Hartley-4 design, and the main factors affecting the degree of soil erosion and damage to the nodules were identified. Based on the obtained regression models, optimal values were determined that ensure high efficiency of the machine.

Keywords: elevator, excavator, mathematical planning, regression equation, soil erosion, root damage.

Introduction

Mechanization of technological processes in the cultivation of agricultural products, especially in the cultivation of root crops, is one of the urgent tasks. One of the main factors determining the productivity of diggers is the efficiency of soil separation from nodules. It is observed that many separator devices currently used cannot completely separate the soil or, conversely, cause serious mechanical damage to the nodules during the process [1-3].

a centrifugal elevator is an innovative solution aimed at eliminating these problems. The principle of operation of this device is a complex dynamic process , the efficiency of which depends on a number of interrelated design and technological parameters. In particular, the number of revolutions of the drum, the speed of the elevator and the size of the gaps between the working bodies directly affect the degree of crushing and the integrity of the product [4].

The purpose of this study is to study the interaction of centrifugal elevator parameters through mathematical modeling and to determine the optimal operating modes that meet agrotechnical requirements. Although previous single-factor experiments have shown the separate effect of each parameter , it was necessary to use a multi-factor mathematical planning method to analyze their combined effect. This, in turn, allows to reduce the energy consumption of the machine and maximize the quality of work [5-8].

Methods

was to test the centrifugal lifting sifting elevator (MQKEChE) (KP-2) in farm conditions. The tests were conducted in accordance with field conditions, in 2024-2025, at the farms "Baratov Sherkhon Nuriddinovich" in Yangikurgan district of Namangan region and "Jurayev Akhathon Azamhon ugli" in Chartok district . These tests made it possible to practically assess the machine's soil

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separation ability, the degree of damage to the nodules, energy consumption and work efficiency. The test results were compared with the existing KKS-1.4 combine, and the technical and economic efficiency of the new development was calculated [9].

theoretical and experimental studies, the effective operating parameters of a new lifting-separating working body (MQKEChE) based on centrifugal forces were determined and confirmed.

The optimal values of the parameters of an excavator equipped with a centrifugal lifting rod elevator, studied in theoretical and single-factor experiments, were determined using the method of mathematical design of multifactor experiments [10].

Four different input factors were selected in the study : the number of drum revolutions (X_1), the elastic drum width (X_2), the elevator speed (X_3), and the working gap (X_4). The ranges of variation of the factors are given in Table 1 below.

Table 1
Factors, their conditional designation, variation range and level

No.	Name and designation of factors	Change levels			Replacement intervals
		-1	0	+1	
1	X_1 – Number of revolutions of the drum, rpm	80	100	120	20
2	X_2 – Elastic drum width, m	1.2	1.3	1.4	0.1
3	X_3 – Elevator speed , m/s	0.4	0.8	1.2	0.4
4	X_4 – Working gap , m	0.06	0.07	0.08	0.01

according to the Hartley-4 design , and the results were processed in the “PLANEX” program based on the Cochrane, Student, and Fisher criteria [11].

Results

multifactorial experiments, the soil permeability (Y_1, %) and nodule damage (Y_2, %) were taken as evaluation criteria. The experimental results were mathematically processed using the "PLANEX" program, and the following second-order regression equations were obtained, which adequately represent the evaluation criteria:

Soil permeability (Y_1, %):

$$Y_1=81.6209+1.580X_1-1.317X_2-2.333X_3-1.333X_4+4.819X_1X_1-1.512X_1X_2+ +2.919X_2X_2-2.296X_2X_3+3.454X_2X_4+3.013X_3X_4-3.031X_4X_4; \quad (1)$$

Node damage (Y_2, %):

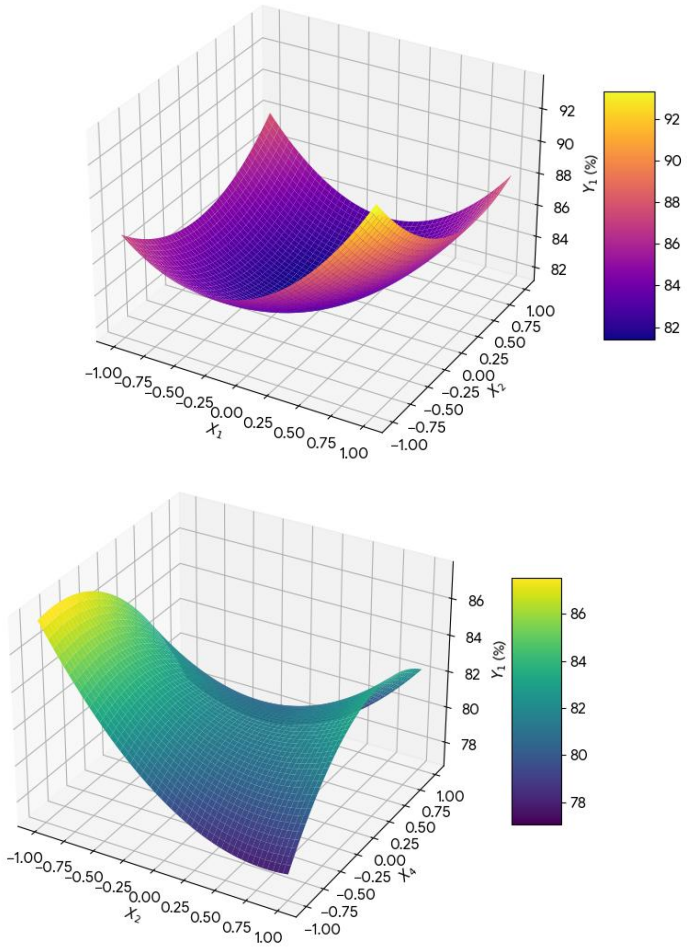
$$Y_2= 5 , 7459 -0.214X_1-0.413X_2+0.117X_3+0.737X_4-1.423X_1X_1+0.194X_1X_2+ + 0.318X_1X_3-0.376X_1X_4-0.688X_2X_2-0.383X_2X_3-0.429X_2X_4+ +0.695X_3X_3+0.177X_3X_4+0.138X_4X_4. \quad (2)$$

Analysis of graphical relationships based on the obtained regression equations showed that the quality of soil sifting increased with an increase in the number of drum rotations (X_1). On the contrary, it was observed that the damage to the nodules decreased with an increase in the number of drum rotations, but increased with an increase in the elevator speed (X_3).

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By solving the regression equations together using the "solution search" function of Excel, the optimal parameters of the machine were determined. The optimal values obtained from these calculations are summarized in Table 2.

from the obtained regression equation (1) and the graphical relationships in Figure 1 constructed on its basis , the quality of soil sifting increased with an increase in the number of drum rotations.



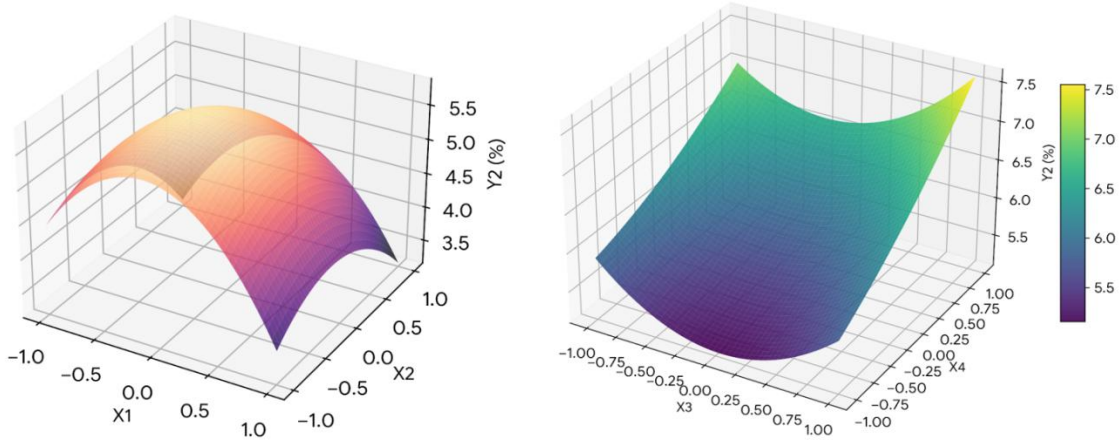
X1 and X2 X2 and X4

1-V $_a$=3 km/h, 2-V $_a$=5 km/h

Figure 1. Graphs of the change **in soil permeability (Y $_1$) depending on the factors X_1, X_2, X_3 and X_4**

Also, the regression equation (2) and the analysis of Figure 2 based on it show that the damage to the nodes decreased with increasing drum rotations and increased with increasing elevator speed.

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X1 and X2 X3 and X4

1-V $_a$=3 km/h, 2-V $_a$=5 km/h

Figure 2. Graphs of changes in the damage of nodes in a centrifugal elevator depending on the factors X_1, X_2, X_3 and X_4

As a result of theoretical and experimental studies, the effective operating parameters of the new MQKEChE working body based on centrifugal forces were confirmed. Studies have shown that, unlike traditional grate elevators, MQKEChE significantly improves the process of soil separation and at the same time reduces crop damage.

As a result of field tests, the KP-2 potato digger-loader equipped with the new MQKEChE demonstrated high technical and economic efficiency compared to the existing KKS-1.4 combine harvester. This indicates the suitability of the new development for use in farm conditions and its full compliance with agrotechnical requirements for soil separation ability.

Conclusions

1. Mathematical Models: Second-order regression equations developed via the "PLANEX" program accurately express the centrifugal elevator's performance factors, with adequacy confirmed by Fisher and Student tests.
2. Optimal Parameters: Multifactorial experiments established the optimal operating values for the MQKEChE: a drum rotation speed of 120 rpm, an elevator linear speed of 0.94 m/s, and a working slot size of 0.010 m.
3. Agrotechnical & Practical Efficiency: At these optimal parameters, the machine achieved an 81.62% soil loosening rate and limited mechanical damage to nodules to just 5.74%. Production tests of the KP-2 machine in Yangikurgan and Chartok districts proved its reliability, improving soil separation quality by 10-12% compared to the KKS-1.4 combine without clogging in heavy or wet soils.
4. Economic Value: The integration of the new working body enhances machine productivity, significantly reduces crop waste, and lowers overall potato production costs while extending the shelf life of the harvest.

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ISSN: 2058-5519|Impact factor-15.9
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