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Optimization of the parameters of a continuously operating feed mixer with mathematical planning of experiments

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ABSTRACT: The article used a method of mathematical planning of multi-factor experiments with the aim of determining the parameters of the feed mixer, which ensures that the feed mixture is at the level of zootechnical requirements. From the results of the theoretical studies carried out and one-factor experiments, the following parameters were taken as the factors most affected by the quality of work of the mixer: the frequency of rotation of the Shnek, the amount of transmission per second, the radius of the one that forms the semi-cylindrical part of the lid, the angle at which the

KEY WORDS: feed, mixer, multi-factor experiment, mathematical planning, regression coefficient, specific energy consumption, mix quality.

I. INTRODUCTION

In the sustainable development of the country's economy, the introduction of the world's best practices and achievements of modern technologies and science in the preparation of feed in the livestock industry, which is one of the most important areas of agriculture, plays an important role in increasing the cost efficiency and competitiveness of the livestock industry. Special attention is paid to the creation of energy- and resource-saving devices that make it possible to mix coarse and succulent feed, nutrient with industrial waste products at the zootechnical level. In this regard, for the flow method preparation of feed mixtures, the development of a feed mixer, the parameter and technological modes of work of their working parts, providing continuous maintenance, energy and resource-efficiency, high working yield and quality, is relevant.

II. SIGNIFICANCE OF THE SYSTEM

1.Improves Animal Health
• Since the feed is mixed evenly and correctly, all the necessary nutrients for the animals are delivered uniformly.
• This, in turn, improves the animals' digestive system, prevents diseases, and strengthens overall health.
2. Increases Productivity
• Properly mixed and continuously supplied feed enhances the animals' ability to produce milk, gain meat, or lay eggs.
• This leads to an increase in farm income.
3. Saves Labor and Time
• Operating automatically or semi-automatically reduces human labor in feeding the animals.
• The feed preparation process speeds up and becomes more intensive.
4. Economic Efficiency
• When feed is mixed incorrectly or some components are over- or under-supplied, feed wastage occurs.
• Continuous mixers help use resources efficiently, thus reducing costs.
5. Ensures Stable Feed Quality
• Consistent feed mixing provides animals with constant high-quality nutrition.
• Variable feed supply is minimized, reducing stress and ensuring animals stay in good condition.
6. Effective in Large-Scale Farms

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• In large farms, manually mixing and distributing feed is very difficult and time-consuming.
• Continuous mixers enable fast and efficient preparation of large volumes of feed.

III. METHODOLOGY

To determine the optimal values of the mixer parameters, a method of mathematical planning of multi-factor experiments was used in order to determine the parameters of the improved mixer that ensure that the feed mixture is at the level of zootechnical requirements [2; 98-112-p., 3; 124-162-p., 4; 76-89-p., 6; 63-78-p.]. In doing so, the evaluation criteria were seen as fully illuminating the influence of factors by a second-order polynomial, and the experiments were conducted under the Hartley-4(X_{a4}) plan.

Based on the results of the theoretical studies carried out and one-factor experiments, the following parameters were taken as the factors most affected by the quality of work of the mixer: the frequency of rotation of the Shnek, the amount of transmission per second, the radius of the cap forming the semi-cylindrical part, the angle of the mixer cap forming the arc forming (Table 1).The factors were conventionally defined as follows: X_1 – the rotation frequency of the auger, X_2– second transmission quantity, X_3– radius of the cover forming the semi-cylindrical part and X_4– The angle of the mixer cover forming the arc of the semi-cylindrical part. Table 1 lists the factors, their designations, ranges of variation, and levels.

Feed mixing quality Y_1, % and specific energy consumption Y_2, (q, kVt·s/t) were adopted as evaluation criteria in multi-factor experiments.

In order to reduce the impact of uncontrollable factors on evaluation criteria, the sequence of conducting experiments was determined using a table of random numbers [2; 98-112-p., 3; 124-162-p., 4; 76-89-p., 5; 63-78-p.].

Table 1
Factors, their designation, ranges of change and levels

Factors and their units of measurement	Conditional designation	Change intervals	Surface		
			lower (–1)	main (0)	high (+1)
Screw rotation frequency, min^{-1}	X_1	50	300	350	400
Second transmission quantity, kg/s	X_2	2	2,8	4,8	6,8
Radius of the cover semi-cylindrical part, mm	X_3	25	75	100	125
The angle of the arc forming the semi-cylindrical part of the mixer cover, °	X_4	20	130	150	170

IV. EXPERIMENTAL RESULTS

The data obtained in the experiments were processed according to the “PLANEXP” program developed in the experimental testing Department of the Research Institute of agricultural mechanization [1; 3-26-p.]. In this, the Coxrain criterion was used to assess the uniformity of dispersion, the Styudent criterion to assess the value of regression coefficients, and the Fisher criterion to assess the adequacy of regression models.

The data obtained in the experiments were processed in the above order, obtaining the following regression equations that adequately represent the evaluation criteria:

- the degree of uniformity of the feed mixture, %:

$$Y_1=+93,055+1,216X_1-1,002X_2+0,798X_3+0,702X_4-1,753X_1^2- -1,083X_1X_2-1,137X_1X_3+1,135X_1X_4-0,850X_2^2-1,384X_2X_3+ +1,138X_2X_4-2,210X_3^2+1,139X_3X_4-1,160X_4^2 \quad (1)$$

- comparative energy consumption (q, kVt·s/t):

$$Y_2=+2,042+0,148X_1+0,305X_2-0,268X_3-0,075X_4-0,037X_1^2- -0,014X_1X_2-0,020X_1X_3+0,006X_1X_4-0,037X_2^2+0,032X_2X_3+ +0,030X_2X_4+0,829X_3^2-0,031X_3X_4+0,173X_4^2 \quad (2)$$

The analysis of the derived (1) and (2) regression equations and the built-up graphical links on them (figures 1 and 2) shows that all factors had a significant impact on the evaluation criteria.

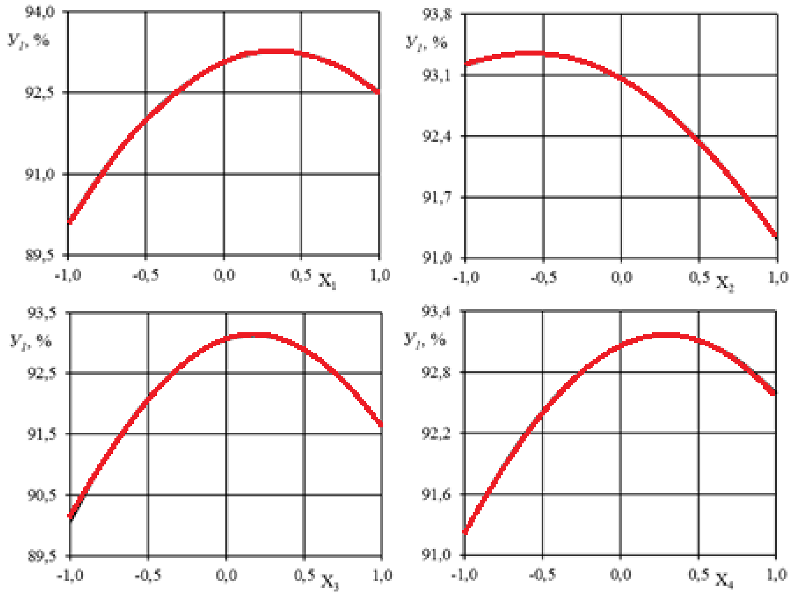

Figure 1. Change in feed mixing quality depending on factors X_1, X_2, X_3 and X_4

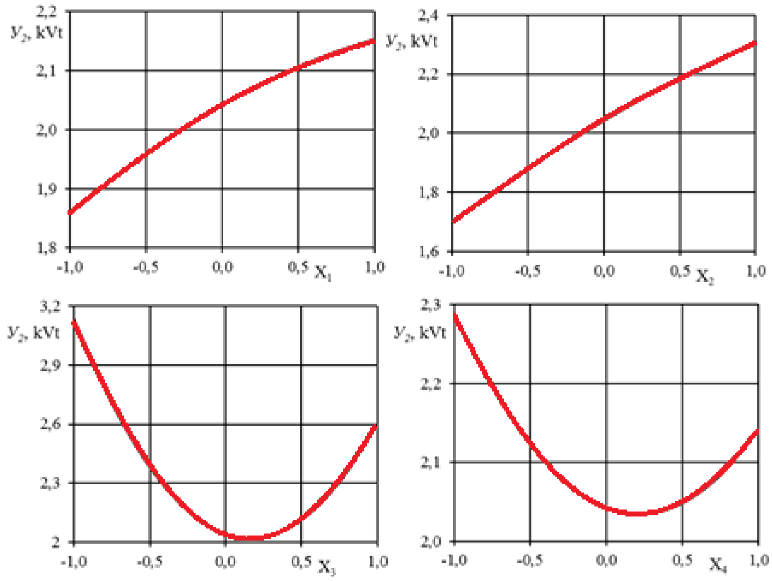

Figure 2. Specific energy consumption changes depending on factors X_1, X_2, X_3 and X_4

The regression equations (1) and (2) found that the following values of factors ensuring that these conditions are met are solved from the conditions that the" Y1 "criterion, the mixing quality of the feed is not 90% less, the" Y2 " criterion, and the specific energy consumption has a minimum value (table 2).

Table 2
Optimal values of factors

X_1		X_2		X_3		X_4	
Coded	Real	Coded	Real	Coded	Real	Coded	Real
-0,55741	322,1296	-0,6942	3,4116	0,23424	102,856	0,169507	153,3901

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V. CONCLUSION

In order to ensure the quality of work at the required level with low energy consumption: the rotational frequency of the Shnek should be 322 ayl/min, The amount of transmission per second should be 3.41 kg/s, the radius of the one that forms the semi-cylindrical part of the cover should be 102.8 mm, the angle of then order to ensure the quality of work at the required level with low energy consumption: the rotational frequency of the Shn.

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