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OPTIMIZATION OF THE SAW CYLINDER PARAMETERS OF THE 1LB COTTONSEED DELINTER USING THE MATHEMATICAL DESIGN OF EXPERIMENTS

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Abstract
This study investigates the effects of the main operating parameters of a saw-cylinder cottonseed delinter on the degree of fluff removal and mechanical seed damage. A full factorial experimental design was conducted using Namangan-77 cotton seeds. Regression models were developed to describe the influence of the inclination angle of the wavy intermediate seal, the pitch of the wavy surface, and the rotational speed of the saw cylinder on the delintering process. The adequacy of the models was confirmed using Student's, Cochran's, and Fisher's criteria. The results showed that excessive values of the investigated parameters reduce the efficiency of fluff removal and increase mechanical seed damage. The obtained mathematical models can be used to optimize the operating parameters of cottonseed delintering machines and improve seed processing quality.

Keywords: Cotton seed, delintering, saw cylinder, fluff removal, mechanical damage, regression model, optimization, factorial experiment, seed quality, operating parameters.

Introduction

According to the results of the preliminary experiment, the main factors affecting the quality delintering of cotton seed were determined and full factorial experiments were conducted. Experimental work was carried out on seeds of Namangan-77 selection variety, seed hairiness of 9.5%, initial contamination - 0.5%, moisture - 8.8%, mechanical damage of seed - 3.2%.

In the technology, the degree of fluff removal from the seed U_1 and the increase in the mechanical damage of the seed U_2 were taken as the criterion limit for evaluating the quality of seed delintering. The main factors affecting the specified criteria are: the angle of inclination of the wavy surface of the intermediate seal of the saw cylinder X_1, the step of the wavy surface of the seal X_2, the number of revolutions of the saw cylinder X_3[1].

According to the calculation of the degree of fluff removal from the seed Y_1, the table indicator of Student's criterion is T(28)=2.048, the table indicator of Cochran's criterion is G(2, 14)=0.3539, the mathematical indicator of Cochran's criterion is equal to 0.2261905 , the repeatability variance is 2.000001E-02.

A regression equation was obtained for the degree of fluff removal from seed U_1:

$$Y_1=5.163-0.097X_1-0.150X_2-0.177X_3-0.692X_1^2+0.088X_1X_3-0.426X_2^2-0.188X_2X_3 \quad (1)$$

Checking the adequacy of the mathematical model (1) showed that: the adequacy variance is equal to 0.0144836, the calculated indicator of Fisher's criterion is equal to 2.172539, the tabular indicator of Fisher's criterion is equal to FT(6, 28) = 2.44, indicating the adequacy of the model showed.

According to the calculation of the increase of mechanical damage of the seed by Y_2, the table index of Student's criterion is T(28)=2.048, the table index of Cochren's criterion is G(2, 14)=0.3539, the calculation index of Cochren's criterion is equal to 0.318182 , the repeatability variance is 5.238096E-03.

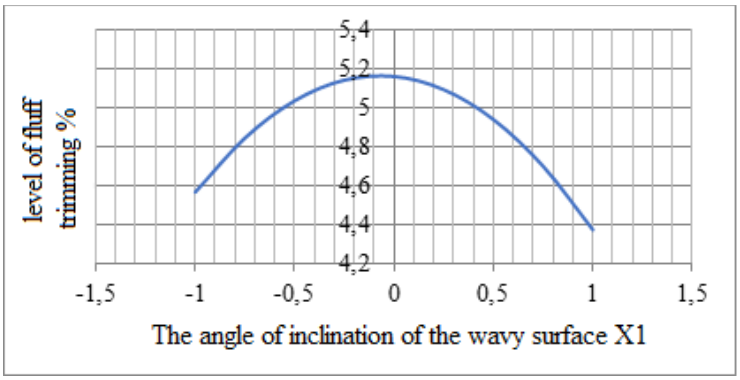
A regression equation was obtained for the increase in mechanical damage to the seed Y_2:

$$Y_2=0.296-0.0137X_3+0.154X_1^2+0.067X_1X_3+0.171X_2^2+0.187X_3^2 \quad (2)$$

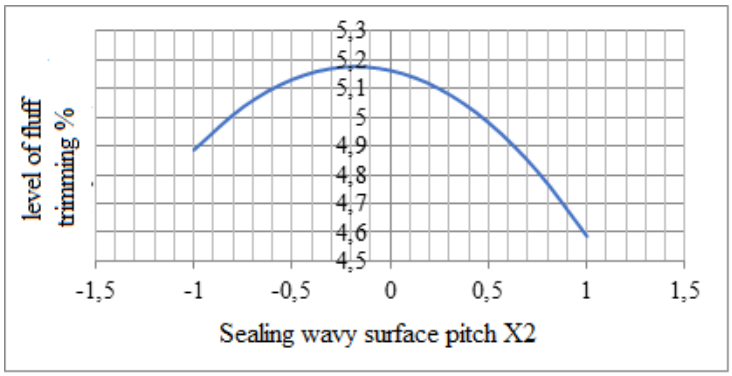
Checking the adequacy of the mathematical model (2) showed that: the adequacy variance is equal to 2.555556E-03, the calculated indicator of Fisher's criterion is equal to 1.463636, the tabular indicator of Fisher's criterion is equal to FT(8, 28) =2.29 demonstrated model adequacy.

The results of the processed calculations were presented in graphic form (Figures 1-2).

(A)



(B)



(C)

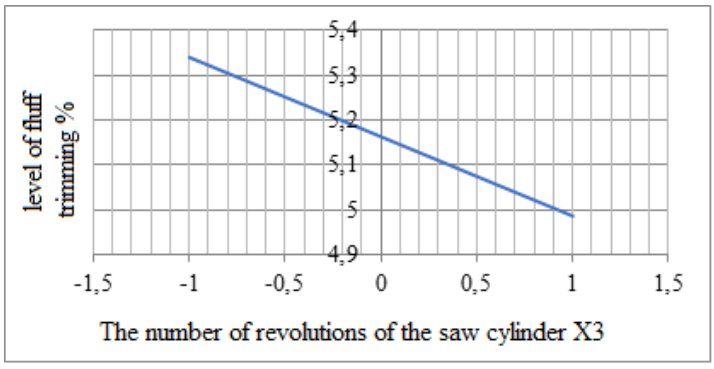


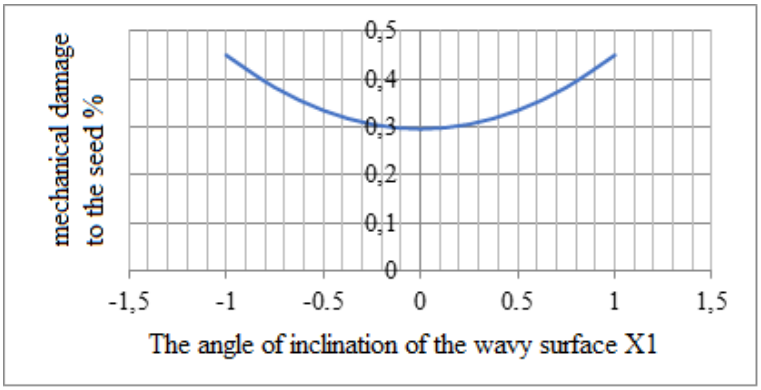
Figure 1. Dependence of the change in the level of fluff from the seed on the incoming parameters.

From the graph in Fig. 1 (A), the wavy surface of the saw spacer affects the values of the degree of fluff removal from the seed surface in the studied variants of the angle of inclination as follows. The undulating surface has a positive effect on the degree of fluffing from the minimum amount of tilt angle to the base amount. As the amount of seed goes up in the base, it has a negative effect on the fluff. Therefore, the excessive angle of inclination has a negative effect on the movement of seeds, and therefore the removal of fluff from the surface of the seed slows down.

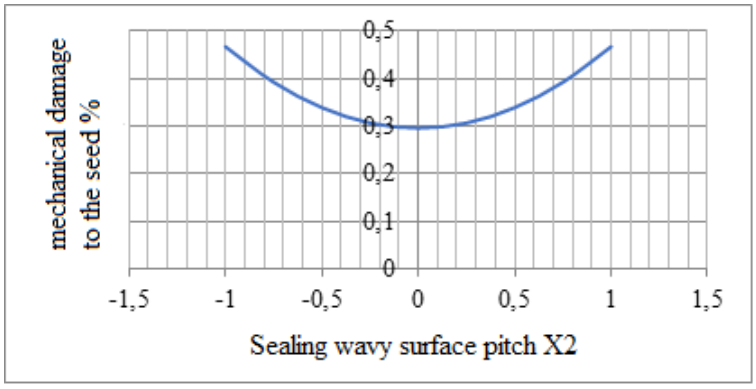
The change in pitch of the serration of the saw blade affected the degree of lint removal from the seed, leading to a decrease in the degree of lint removal as the experimental variants passed the baseline amount (B).

From the graph of the influence of the number of revolutions of the saw cylinder on the degree of fluff shaving (C), it can be seen that the degree of shaving decreases.

(A)



(B)



(C)

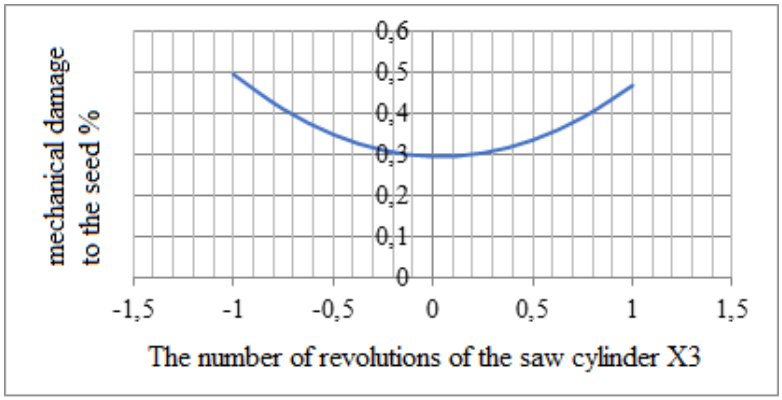


Figure 2. Dependence of the increase of the mechanical damage of the seed on incoming parameters.

From the graphs in Fig. 2, it can be seen that mechanical damage to the seed decreases up to the base index in the experimental variants of the angle of inclination of the saw intermediate gasket to the base index, and it was found that the damage increases from the base index to the maximum index (A). Even with the increase in the step of the wavy surface, the mechanical damage from the compression of the seeds to the step interval is increasing with the passage of the base (B). A negative effect on the degree of mechanical damage of the seed is also seen when the number of revolutions of the saw cylinder exceeds the basic one (C).

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