

COMBINE HEADER ACTIVE SIDE DIVIDER

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Abstract

The headers of modern combine harvesters are mainly equipped with passive side dividers. When harvesting lodged and tangled crops (for example, peas), plant mass accumulates on passive side dividers, the harvested strip is poorly separated from the rest of the field, which leads to a decrease in combine productivity and an increase in losses of the grown crop. To eliminate these shortcomings, the design of an active field divider is proposed, the main working body of which is a disk cutter. The article describes the design of the active side divider, provides a laboratory setup and describes the methodology for laboratory research to justify the optimal design and operating parameters of the proposed divider. The studies were carried out using the theory of multifactorial experiment. The optimization criteria are the completeness of separation of tangled stems and the amount of losses of the grown crop. The completeness of the separation of tangled stems is determined visually and by photographing, and the losses are determined by the method of collecting and weighing crumbled grains. As the results of laboratory studies show, the smallest losses are provided with the number of teeth of the disk cutter $z=8$ pieces, the frequency of rotation of the disk cutter $n=125 \text{ min}^{-1}$ and the operating speed of the feed conveyor $v_p=2.0 \text{ m/s}$. At the same time, the active side divider works stably, the completeness of separation of tangled stems is 100%. The smallest losses are provided with the number of teeth of the disk cutter $z=8$ pieces, the frequency of rotation of the disk cutter $n=125 \text{ min}^{-1}$ and the operating speed of the feed conveyor $v_p=2.0 \text{ m/s}$. At the same time, the active side divider works stably, the completeness of separation of tangled stems is 100%. The smallest losses are provided with the number of teeth of the disk cutter $z=8$ pieces, the frequency of rotation of the disk cutter $n=125 \text{ min}^{-1}$ and the operating speed of the feed conveyor $v_p=2.0 \text{ m/s}$. At the same time, the active side divider works stably, the completeness of separation of tangled stems is 100%.

Key words: legumes, peas, harvesting, combine harvester header, active side divider, disk cutter, laboratory tests, significant factors.

INTRODUCTION

When harvesting lodged and tangled leguminous crops, in particular peas, plant mass accumulates on the passive side dividers of the header of the combine harvester, the harvested strip is poorly separated from the main field mass, which leads to a decrease in the productivity of the combine and an increase in losses of the grown crop (Kuhmazov et al., 2019; Meloyan et al., 2021; Meloyan et al., 2019; Shumaev et al., 2020; Shumaev et al., 2021; Yadin, 2009; Patent, 1983).

MATERIALS AND METHODS

To solve this problem, it is proposed to install on the sidewall 1 (Figure 1) with the toe 2 of the combine harvester an active side divider, consisting of a disk cutter 3 mounted on the shaft of the hydraulic motor 4 and an anti-

cutting plate 5. The hydraulic motor 4 is fixed with screws 6 to the bracket 7, welded to sidewall of 1 combine harvester.

To substantiate the optimal values of the design and operating parameters of the active side divider, laboratory studies were carried out on an experimental setup consisting of a frame 1 (Figure 2), on which a feed belt conveyor 2, a side frame 3 of a combine harvester with a bar divider 4 and an active side divider are installed, consisting of a disk cutter 5 and a counter-cutting plate 6.

The infeed belt conveyor 2 is driven by a gear motor (ZG1 KMR 71G4) 7 by a chain drive 8. The speed of the infeed belt conveyor 2 is controlled by a frequency converter 9 (DELTA VED-B7).

The drive of the disk cutter 5 of the active side divider is carried out from the motor-reducer (SEV-EVRODRIVE) 10 and V-belt transmission 11. The rotational speed of the

disk cutter 5 is controlled by the frequency converter 12 (FCV 103). Switching on and off of the drive mechanisms is carried out from the control panel 13. To the belt of the supply belt conveyor 2 are attached lodged and tangled stems of leguminous crops (peas) 14 with a given lodging. The height of the sidewall 1 of

the combine harvester relative to the supply belt conveyor 2 is set in accordance with the requirements for harvesting lodged and tangled grain. To collect lodged and tangled stems and losses, a collection box 15 is located behind the supply conveyor 2.

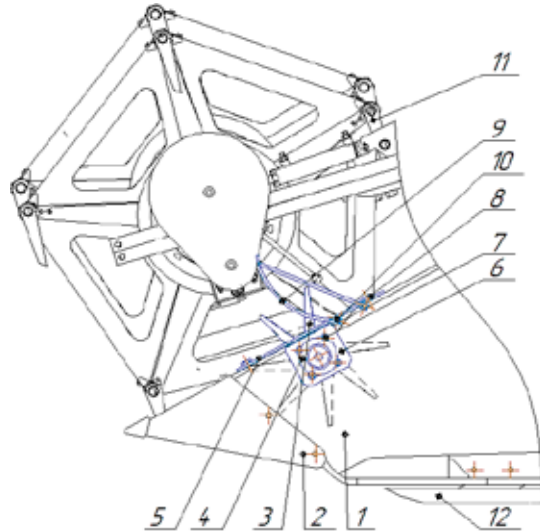


Figure 1. General view of the active header side divider

The counter-cutting plate 5 is fixed to the inclined surface of the sidewall 1 with bolted connections 8. To feed long stems into the cutting zone of the active side divider, a bar divider 9 is provided, fixed to the sidewall 1 of the header with bolted connections 10. Based on the geometric parameters of the sidewall 1 of the combine harvester, the outer diameter of the disc cutter 3 taken equal to 300 mm.

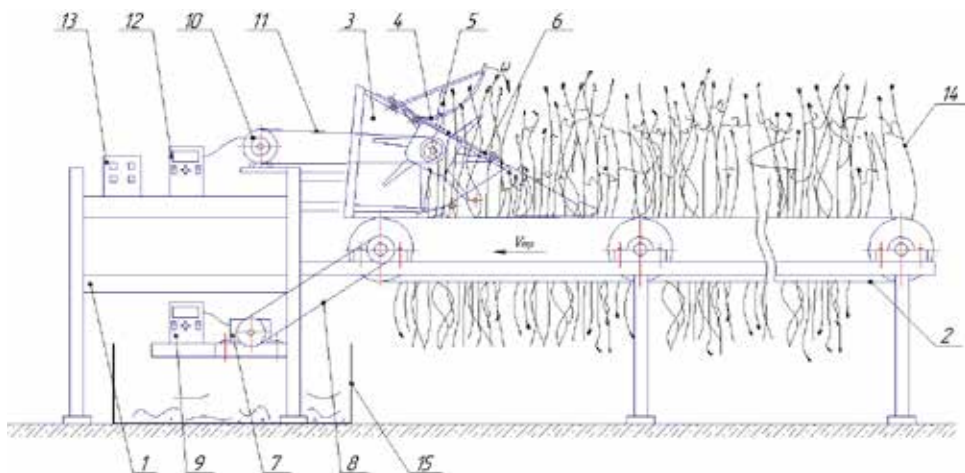


Figure 2. General view of the laboratory setup

The experimental procedure is as follows. On the feed conveyor belt 2, we fix the lodged and tangled stalks of leguminous crops 14 with a given lodging, and on the active side divider we install the tested disk cutter 5. We select the required rotational speed of the disk cutter 5 and the supply belt conveyor 2 with frequency converters. Sequentially, from the control panel 13, we turn on the drive of the disk cutter 5 and the supply belt conveyor 2. When the conveyor belt 2 moves, the lodged and tangled stems with the front part of the sidewall 3 rise and are fed into the cutting zone of the disk cutter 5 of the active side divider. Thus, the harvested mass is clearly separated from the rest of the array. The lost grains are sent by the belt conveyor 2 to the collection box 15.

RESULTS AND DISCUSSIONS

The studies were carried out using the theory of multivariate experiment. As an optimization

criterion, the completeness of separation of tangled stems (N, %) and grain loss (G, %) were taken. The completeness of the separation of tangled stems was determined visually and by photographing, and the grains that fell into the collection box 15 are considered losses.

$$G = \frac{m_n}{m_o + m_n} \cdot 100, \% \quad (1)$$

where:

- m_n is the mass of lost grains, g;
- m_o is the mass of grains remaining in the pods, g.

Based on a priori information and previous studies, three most significant factors were identified that affect the quality indicators of the active field divider: the number of teeth of the disk cutter z , pcs., the rotational speed of the disk cutter n , min^{-1} and the speed of the feed belt conveyor V_t , m / from .

Intervals and levels of variation of significant factors are shown in Table 1.

Table 1. Regulated factors, intervals and levels of their variation

Factors	Designation	Levels of variation			Variation intervals
		+1	0	-1	
Number of cutter teeth, pcs	x_1	12	8	4	4
Disc cutter speed n , min^{-1}	x_2	175	125	75	50
Feeding conveyor speed, m/s	x_3	2.2	1.7	1.2	0.5

After processing the results of the experiments in the Statistica 6.0 program, an adequate mathematical dependence of grain losses behind the header on the design and kinematic parameters of the active side divider of the combine harvester was obtained in coded form:

$$y = 1,528 - 0,073x_2 + 0,142x_3 + 0,043x_1x_2 - 0,047x_1x_3 + 0,397x_1^2 + 0,307x_2^2 + 0,292x_3^2 \quad (2)$$

In this case, the multiple correlation coefficient is $R = 0.99$, which is more than the confidence probability $P = 0.95$, and $F\text{-test} = 0.99$, showing the degree of density (scatter) of experimental and calculated values, then the adequacy of the obtained mathematical dependence is 99% .

To determine the optimal design and kinematic parameters of the active side divider of a combine header in terms of grain loss, it is necessary to investigate the mathematical dependence (2) for an extremum, that is, to determine the possible maximum or minimum of this dependence as a function of three variables x_1, x_2, x_3 .

The MathCAD program was used to determine the extremum and construct the response surface. The mathematical model (2) was differentiated separately for each variable x_1, x_2, x_3 .

As a result of further calculations, the grain loss response surfaces behind the header were built when using the active side divider of the combine harvester and their two-dimensional sections (Figures 3, 4 and 5).

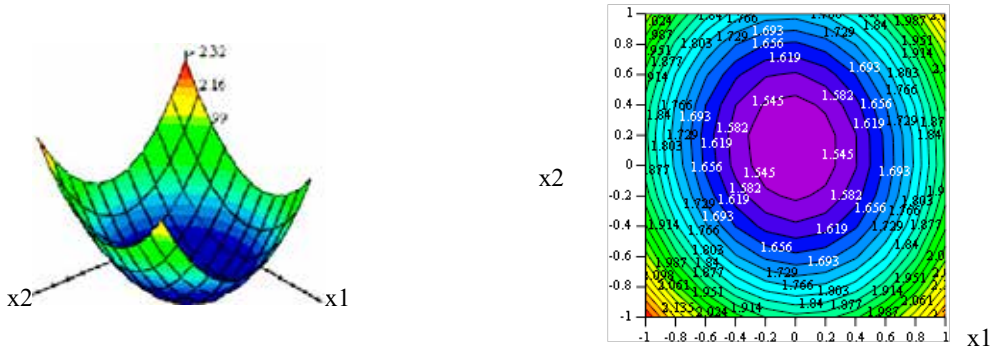


Figure 3. The surface of the grain loss response behind the header and its two-dimensional cross section on the rotational speed of the disc cutter x_1 and the number of teeth of the disc cutter x_2 at the optimal value of the feed conveyor speed x_3

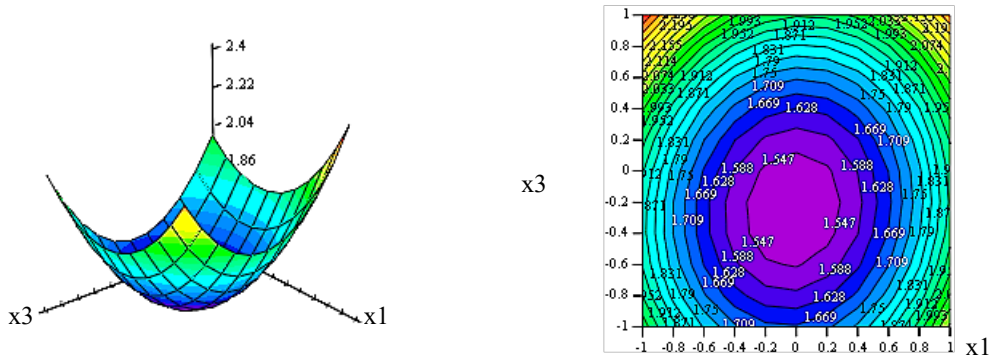


Figure 4. Response surface of grain loss behind the header and its two-dimensional cross-section on the speed of the disc cutter x_1 and the speed of the feed conveyor x_3 at the optimal value of the number of teeth of the disc cutter x_2

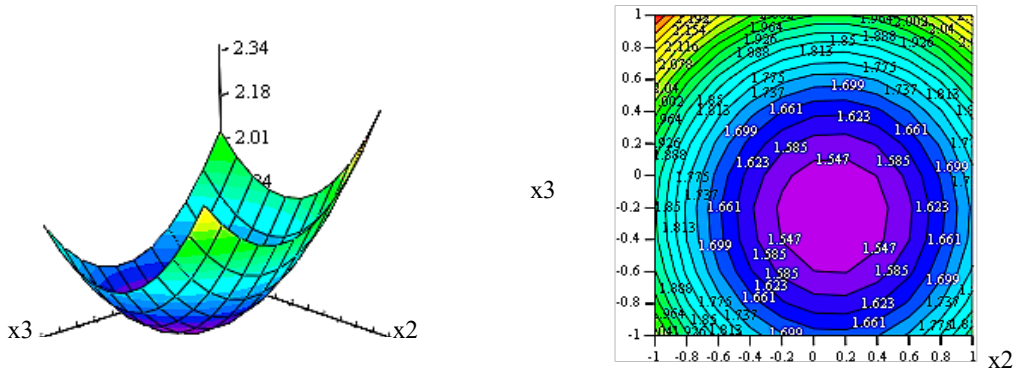


Figure 5. The surface of the grain loss response behind the header and its two-dimensional cross section on the number of teeth of the disc cutter x_2 and the speed of the feed conveyor x_3 at the optimal value of the speed of the disc cutter x_1

CONCLUSIONS

Analyzing the graphical representation of two-dimensional sections, we can conclude that the optimal values of the studied factors are: the rotational speed of the disk cutter $n=125.6 \text{ min}^{-1}$; number of teeth of the disc cutter $z=8$ pcs.; feed conveyor speed (combine working speed) $V_{tr}=2 \text{ m/s}$. At the same time, the side divider works stably, the completeness of separation of tangled stems is 100%.

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