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Research Paper

Perspectives of grain pile separation before it enters the thresh-ER

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Abstract

The results of laboratory studies confirming the possibility of preliminary separation of free grain from the stripped grain heap before it enters the threshing chamber of a combine harvester are presented. For example, it has been established that the maximum free grain passage through the holes of the lath bottom is 68, 7% with a width of its holes of 8 mm and a length of 160 mm. The length increase of the lath bottom of the inclined chamber of the combine harvester up to 1182 mm ensures a complete separation of grain from the heap and exclude the possibility of its falling into the threshing chamber.

Keywords: *Combine Harvester; Stripping; Inclined Chamber; Lath Bottom; Preliminary Separation of Stripped Grain Heap.*

1. Introduction

One of the promising directions for improving the technological process of harvesting grain and leguminous crops is stripping standing plants [1], [2]. The spread of this harvesting method is restrained by the fact that, with an orientation toward the existing combine harvester technological scheme, theoretically possible potential for increasing efficiency is not realized. Part of this is due to the fact that a hackled heap entering the thresher contains about 80% of free grain. From the point of view of technological process optimization, it would be expedient to separate this heap into fractions before it enters the thresher, minimizing the supply of free grain and small impurities to the threshing apparatus. As a consequence, the thresher throughput and consequently, the productivity of the combine harvester should increase.

For this purpose, several variants of mechanisms were synthesized that made it possible to carry out a preliminary separation of the hackled grain heap feeding only unmilled ears and straw of different lengths to the threshing device. At the same time, the most radical option involves the use of cyclones and the air flow energy generated by the stripping cylinder as separating working bodies, which requires a complete combine harvester re-assembly. In this connection the combine harvester has not yet been fully implemented in practice [3].

The second option involves a step-by-step stripped heap separation, starting with the separation of light impurities directly in the stripping adapter body and completing the process by separating the remaining heap of free grain on the lath bottom of the inclined chamber of the combine harvester [4]. At the same time, its radical rearrangement is not expected, so there is a higher degree of universality of the machine, which should positively affect its price and the cost of harvesting.

Thus, an actual task is to evaluate the possibility of separating the stripped heap in an inclined chamber and determining the optimum parameters of the separating device.

2. Scientific research hypothesis

When the grain heap 3 is moved by the cross slats (scrapers) of the floating conveyor 2 upward along the inclined chamber lath bottom 1, free grain 5 must, under the action of gravity, pass through the holes of the separating grid 4, directly into the combine harvester cleaning system 7 (Fig. In this case only unmilled ears 8 which have not passed through the holes of the grid 4 enter the thresher 6.

To improve the separation, the holes in the grid 4 of the bottom 1 are suitably made with the slope of their side edges 9 relative to the direction of movement 14 of the scraper 11 of the floating conveyor 2 by an angle α (Figure 2) [4].

Under these conditions, two variants of grain passage through the hole are possible. Either it begins to fall like a free body thrown at an angle to the horizon, that is, along a trajectory in the form of a parabola, or (position 12 in Figure 2) tilts through the lateral edge 9 of the hole. For these variants, differential equations of motion were obtained, as a result a minimum length of the hole was established, guaranteeing the free grain passage through it with the speed of the movement of the scraper 11 of the floating conveyor 2 adopted in combine harvesters [5], [6].

However, it should be borne in mind that the heap 3 moved by the scraper 11 of the floating conveyor 2 consists of elongated particles (grains, straw and chaff particles) which, interacting with each other, form vaults above the holes of the separation grid 4 of the inclined chamber bottom 1, that complicates the migration of grains down. In this connection, the grains that appeared in the upper layer of the heap can't be considered as fully free bodies having six (as a free body in space) or at least four degrees of freedom (as an extended body on the surface). Moreover, due to the presence of pressure from the top layers of the heap on the lower ones, there is no guarantee that the latter will tilt into the hole through its side edge, even in positions 12 or 16 when their center of gravity (for example, point C_2) is directly above the hole (Figure 2).

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Thus, the separation process is expediently considered as a probabilistic, the optimal parameters of which can't be predicted theoretically. In this connection, it is inapproppriate to refine them experimentally.

3. Experimental procedure

The experiment was planned as a two-factor (type 3^2), in which the length of the hole L and its width B were varied. The holes were placed on the surface of the separation grid in the form of consecutive rows. At the same time, their total clear opening remained unchanged in all variants of the experiment (with a maximum deviation of ± 0,5%). As a result, it was possible to exclude the influence of the third factor (the clear area) on the result, which could introduce uncertainty into the understanding of the essence of the process of interaction of the heap with the sieve holes.

First, a setup experiment was conducted, which allowed us to estimate the output parameters of the process within the variation zone formed on the basis of theoretical modeling results (Table 1). In this case, as a "zero" point of the plan for the length L, the value obtained in solving the differential equation of grain motion with its tilting through the lateral edge of the hole was adopted [7]. A zero point for width B was assigned based on the size of the separated grains and ears. It does not make any sense to go beyond the limits of B_{max} = 10 mm, since in this case the pass of individual unmilled ears through the holes is possible.

Since the extremum of the response surface constructed on the basis of the setup experiment results turned out to be on the boundary of the factor variation zone (Fig. 3a), the response surface parameters were appropriately adjusted, resulting in a plan for the second series of experiments (Table 2).

Since the experiment was planned as a full-factor experiment, in each series, nine variants of the experiment were realized with a tenfold repetition of each of them. Thus, in each series of the experiments, the results of 90 measurements were taken into account and processed.

The experimental machine simulating an inclined chamber with a lath bottom was made on the basis of the grain elevator of the grain harvester KZS-1218 "Polesie". The bottom wall of the elevator casing was removed, and replaceable sieves with a size of 950×150 mm were installed, the dimensions of the holes in which corresponded to the planned parameters. At the same time, the length of each replaceable sieve corresponded to the length of the free part of the bottom of the inclined chamber of the KZS-1218 "Polesie" combine harvester, through which the heap separation process can be organized. The experiment was carried out when the elevator was tilted at an angle of 45°, which corresponds to the parameters of most serial combine harvesters.

Calculation for the heap passage and the removal from the sieves was carried out in five zones. To do this, four containers were placed under the sieve (along its entire length), and a fifth container was installed at the heap outlet from the elevator casing. Thus, the total heap mass in the first four tanks is the volume of the passage through the sieve holes, and in the fifth container, the descent from the sieve was accumulated. As a result of this, it becomes possible to determine the regularity of heap passage distribution through the sieve holes along its length.

In the experiment, a heap of a controlled composition was used, the parameters of which were determined earlier when testing the stripping device in the process "Moskovskaya 56" winter wheat harvesting [8]. For about one second, a heap weighing about one kilogram was delivered to the receiving part of the elevator (based on "Moskovskaya 56" wheat). With a width of the experimental sieve of 150 mm, the feed (in terms of the full inclined chamber width and the combine harvester grinder) corresponded to 10 kg/s. The experiment was carried out at a conveyor speed of 3 m/s, which corresponds to the kinematic parameters of the floating conveyors of most combine harvesters.

4. Experiment results

The results obtained during the measurements were processed in Excel and STATISTICA-10 programs. They constructed response surfaces that characterize the dependence of the fraction of free grain that passed through the openings of the separating lath on the dimensions of the latter (Fig. 3).

The set of experiments allowed to conclude that the response surface does not have a clearly pronounced extremum, but the maximum value of the output parameter corresponds to the dimensions of the holes 8×160 mm (Fig. 3a). Therefore, when planning the second series of experiments, these dimensions were taken as the "zero" point of the plan.

The response surface, constructed from the results of the second series of experiments (Fig. 3b), has a pronounced extremum at which 68,7% of the free grain passes through the openings of the separating grid. At the same time, the closest to the extremum point are the holes with a width of 8 mm and a length of 160 mm.

The regression equation, which most adequately reflects the nature of the dependencies (with a determination coefficient of R^2=0,958), is a second-order polynomial

$$Y = -140{,}8612 + 0{,}5929 \cdot L + 37{,}1868 \cdot B - 0{,}0012 \cdot L^2 - 0{,}0229 \cdot L \cdot B - 1{,}9261 \cdot B^2 \quad (1)$$

Where Y – fraction of free grain that has passed through the openings of the separating grid, %;

L – Hole length, mm.

B – Hole width, mm.

5. Discussion of the experiment results

The nature of the response surface and the regression equation indicates that the separating ability of the sieves is much less dependent on the length of their holes than on the width. At the same time, as it was predicted in the theoretical hypothesis, an excessive hole width increase worsens its separating ability. It is most likely that this is due to the jamming in the holes of unmilled ears, which drastically reduces their clear area.

With regard to the availability of 31,3% of free grain coming off the separation grid, then, firstly, separation with a 100% result is impossible in principle. Especially when it comes to a mixture consisting of components which dimensional fields intersect.

Secondly, there is a reserve for increasing separation degree. This is evidenced by the nature of the trend line built on the grain remainder in the heap as each of the four tanks placed under the separating grid passes through. With a high degree of probability (R^2=0,982), the trend line is rectilinear and is characterized by the following equation

$$y = -80{,}424 \cdot x + 95{,}045 \quad (2)$$

Where y – the current grain remainder in the heap, as a percentage of its initial mass available at the beginning of the separation process;

x – The distance from the beginning of the separating grid, m.

Therefore, to achieve a result approaching 100%, the length of the separation grid should be increased. Extrapolation of the trend line shows that for this it is sufficient to lengthen the lath by approximately 175 mm.

If, as an analogy, to use the theory of the keyboard straw shaker performing grain separation from the straw heap, then in this case the trend line should be an exponential function of the type $y=ke^{-ax}$. When constructing an exponential function from the experimental data obtained, it has the following form

$$y = 100{,}07 \cdot e^{-1{,}364 \cdot x} \quad (3)$$

At the same time, the coefficient of determination increases only to R^2=0, 9865, which indicates that there are no significant differences compared to the straight line we adopted.

6. Conclusion

The results of the experiment allow us to draw the following conclusions.

1. It is possible to allocate most of the free grain from a combed heap on the lath bottom of the combine harvester inclined chamber.
2. To ensure the highest degree of grain separation, the length of the grid surface must be at least 1125 mm, and the holes must be 8×160 mm in size.

Table 1: Conditions for Setup Experiment Planning

Factors		Variation levels			Variation nterval
Natural view	coded view	-1	0	+1	
Hole length, mm	L	80	120	160	40
Hole width, mm	B	8	10	12	2

Table 2: Conditions for Planning the Experiment (Second Series)

Factors		Variation levels			Varition interval
natural view	coded view	-1	0	+1	
Hole length, mm	L	120	160	200	40
Hole width, mm	B	6	8	10	2

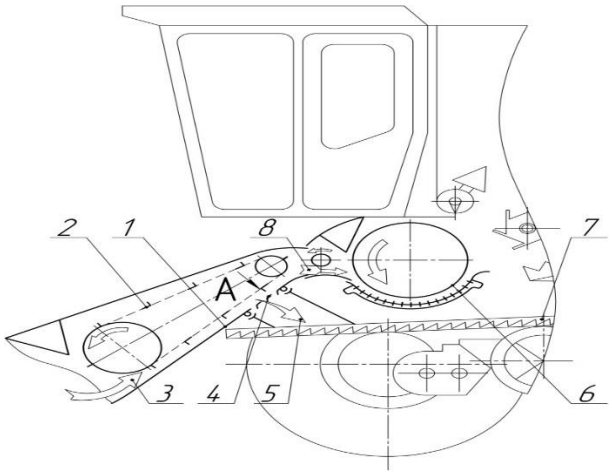


Fig. 1: Schematic Diagram of an Inclined Chamber with A Lath Bottom: 1 – Bottom; 2 – Floating Conveyor; 3 – Receipt of A Heap from the Stripping Adapter; 4 – Separating Grid; 5 – Free Grain; 6 – Thresher; 7 – Cleaning System; 8 – Unmilled Ears.

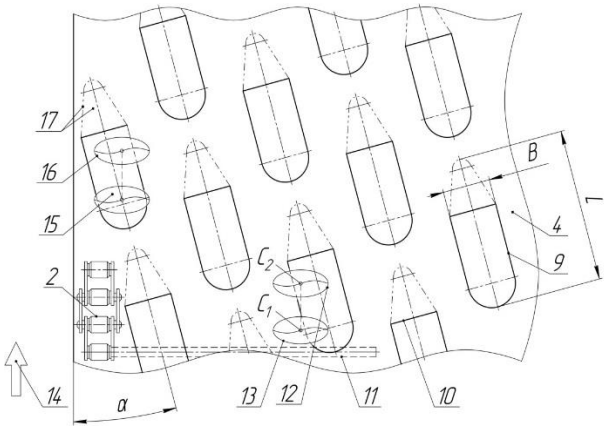


Fig. 2: Separation of Grain through the Inclined Chamber Lath Bottom (View A in Figure 1): 2 – Floating Conveyor; 4 – Separating Grating; 9, 10 and 17 – are the Elements of the Holes; 11 – Floating Conveyor Scraper; 12, 13, 15 and 16 – are Grains; 14 – Conveyor Movement Direction.

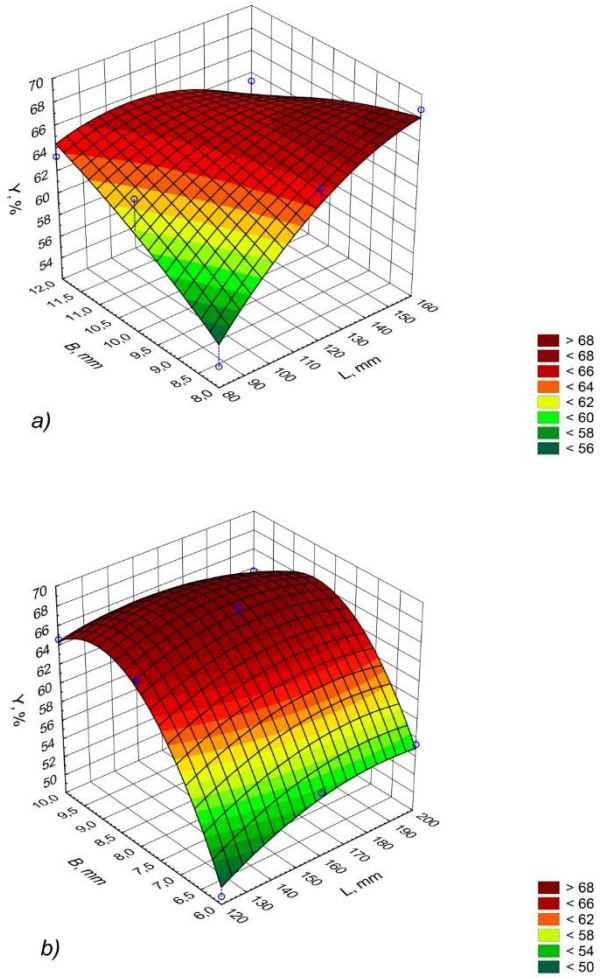


Fig. 3: Free Grain Fraction Passing through the Openings of the Separating Grid, Depending on the Dimensions of the Latter: A – Setup Series; B – Second Series of Experiments.

References

[1] Aldoshin N., Lylin N., Mosyakov M. (2017): Harvesting of leguminous crops by the method of stripping. Far Eastern agrarian bulletin, 1: 67-73.

[2] Ozherelyev V., Nikitin V. (2015): Preliminary separation of combed grain heap in an inclined chamber. Agro-industrial complex at the turn of the century, 1: 165-170.

[3] Ozhirelyev V., Nikitin V. (2014): Device for threshing standing plants. Patent Russian Federation No. 2566017.

[4] Khodayari Bavil, A., Razavi, S.E., on the thermo-flow behavior in a rectangular channel with skewed circular ribs, Mechanics & Industry, 18 2 (2017) 225, https://doi.org/10.1051/meca/2016057.

[5] Ozhirelyev V., Nikitin V., Alakin V., Syanovov S. (2013): Investigation of stripped grain heap parameters. Engineering in agriculture, 1: 7-9.

[6] Khosravi M., Mosaddeghi F., Oveisi, M., khodayari-b, A., Aerodynamic drag reduction of heavy vehicles using append devices by CFD analysis, Journal of Central South University, Volume 22, 2015, pp 4645–4652.

[7] Ozherelyev V., Nikitin V., Komogortsev V. (2016): An inclined chamber of a combine harvester. Bulletin of the Bryansk State Agricultural Academy, 3: 65-69.

[8] Savin V. (2011): Substantiation of rational parameters and operating modes of the towed combing device for harvesting grain crops: the author's abstract. Dis. ... cand. Tech. sciences. Voronezh.