Experimental studies of grain material separation by a sieve track

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Abstract. In the process of postharvest handling the greatest load on cleaning and sorting the heap coming from the combines falls on grain-cleaners with sieve working bodies. The limitation of the increase in the separation efficiency of the passage fraction from the grain heap by the sieve working bodies is the principle itself in which the material being processed moves along the grating surface during the separation process. It is shown that an increase in the separation efficiency of the passage fraction is possible through the use of grain-cleaners as a working body of a conveyor sieve boot. A functional diagram of a conveyor sieve boot is proposed. The influence of the main kinematic parameters of the conveyor sieve boot on the qualitative and quantitative indicators of the separation process is presented.

1. Introduction

One of the technological operations of grain post-harvesting is cleaning of heap coming from the combines from gross impurity (straw, ears, stones, etc.). Numerous studies [1, 2] have established that it is possible to ensure the safety of the harvested crop and increase the efficiency of grain-cleaning aggregates use due to the preliminary normalization of a grain pile.

Operational coarse separation of the heap of chaff and grain due to the removal of impurities reduces or eliminates hotbeds of heat, humidity, workload and material and labor costs. First-operation work provides improved performance when performing subsequent operations such as drying, primary, secondary, final processing, of aggregates and complexes in general [3,4].

Processing of large volumes of wet and clogged grain coming from the combines requires high performance and technological reliability of the equipment for coarse separation ensuring the required quality of processing.

Increasing productivity of sieve separators due to the increase in specific loads leads to the increase in grain losses at the same time as large impurities. Increasing the size of the holes sieve reduces the quality of cleaning. To ensure the effectiveness of the selection of grain from the pile, it is necessary that, the time the layer stays on the sieve surface is greater or equal to the time it is sifted, at a certain size of the holes:

\[ T \geq t_1 + t_2 \tag{1} \]

where \( T \) – detention time of the layer on the sieve surface; \( t_1 \) – period of grain screening through the pile layer; \( t_2 \) – period of particulate dressing through the sieve hole.

One of the main factors determining the continuity of grain material separation process on the sieve is the relative movement of the separating material along the sieve [5,6]. As a result of self-sorting, the particles of the passage component should fall onto the surface of the sieve from the whole layer of the heap. Pre-cleaning a freshly harvested grain pile, due to the low concentration of gross impurities (straw, ears, stones, etc.), self-sorting does not have a large effect on the results of the process as a whole. Dressing becomes crucial [7]. Detention time of the layer on the sieve surface depends on sieve lengths and average heap speed:
where $L$ – is the length of the sieve; $W_{av}$ – the average speed of the movement of the sieve.

The increase in the average speed of the heap of chaff and grain on the working surface reduces the layer thickness and the time of separation at a constant sieve length. Insufficient spending time of grain heap leads to a decrease in the efficiency of separation. The efficiency of separation increases with decreasing the thickness of the bulk material on the sieve but up to a certain limit below which the efficiency decreases. When the critical value is reached, the separation efficiency assumes a zero value, since the grain does not have time to fall into the sieve holes.

Analysis of the separation process gives grounds to believe that the very principle of separating particles from the loose material moving in a sieve limits the possibility of increasing the efficiency of the sieve separating devices [8,9].

2. Experimental studies

Based on the analysis of the advantages and disadvantages of existing sieve boot for high-quality and productive work, a technical solution has been proposed in the form of a sieve track (Figure 1).

![Figure 1. Scheme of track sieve boot: 1 – creeper, 2 – sieve surface, 3 – side frame, 4 – hold frame, 5 – hold frame bearings, 6 – receiving apparatus of passage fraction, 7 – receiving apparatus of overtail fraction, 8 – crank rod, 9 – eccentric workpiece.](image)

The main kinematic parameters of the sieve track, which determine the quality of the separation process (amplitude and oscillation frequency of the sieve surface), are aimed at ensuring that the particles are sifted into the holes. The forward movement of the track provides the movement of the grain pile. The speed of the track movement determines the separation time and the layer thickness of the material being processed.

The working surface of the track type sieve boot is formed by a set of grating aprons. The length of the aprons is greater than the distance between the articulating links of their attachment to the chain, as a result of which, on the upper branch of the track, the sieve aprons are placed in the same horizontal plane and form a working grating surface 2. Under the action of gravity, the sieve aprons are angled to
the lower branch of the chain and do not prevent the passage fraction from falling in the receiver 6. The separation process is as follows. The processed material is given to the beginning of the upper branch of the sieve track and is transported by it.

Oscillations in the transverse plane provide the orientation of the particles relative to the holes and their sieving. Particles that have passed through the openings of the sieve apron enter the receiver of the passage fraction 6, and particles whose size is larger than the working size of the openings of the sieve aprons are transported by the track to the receiver 7.

The laboratory installation was made. The experimental studies were carried out that allowed to determine the effect of the main kinematic parameters of the operation of a conveyor sieve boot on the qualitative and quantitative indicators of the separation process.

3. Determination

Studies of grain screening ability changes depending upon the load (according to the different meanings of kinematic parameters) are presented in Figure 2.

![Figure 2](image)

Figure 2. The dependence of the screening on the sieve surface frequency and amplitude of oscillations at the speed of the track 0.26 m/s, complete selection of wheat seeds $\varepsilon = 1$.

Studies were carried out at the initial loads, ensuring the completeness of the wheat seed selection $\varepsilon = 1$. A further increase in the load in this kinematic mode leads to the departure of full-value grain from the sieve surface. With all the indicated amplitudes, the oscillations of the sieve surface, the dependence is extreme. Optimal conditions for the passage of the particles through the sieve with the round holes are achieved by the certain combination of amplitude and frequency of oscillations.

The maximum screening ability was obtained with the frequency of oscillations of the sieve surface $n = 1000 \text{ min}^{-1}$ and the amplitude of oscillations $A = 2 \text{ mm}$.

Figure 3 shows the dependences of the content of full-value grain during the overtail on the speed of sieve surface movement and the load.
When the speed of the track is less than \( V = 0.25 \text{ m/s} \), the grain arriving at the working surface does not have time to pass into the holes and the increase in the thickness of the layer of the material being processed is observed on the sieve surface, which leads to the loss of full grain to the scratch fraction. An increase in the speed of track movement is more than \( V = 0.25 \text{ m/s} \), it leads to the sifting of the grain material over a shorter sieve surface. Increasing the speed of more than \( V = 0.31 \text{ m/s} \) leads to a gradual increase in the loss of full-value grain into the overtail.

4. Conclusion
It has been established that the quantitative indicators of the sieve track operating in the pile mode are determined by the choice of the optimal combination of the amplitude and frequency of oscillations of the sieve surface and the speed of the track. The maximum grain throughput on the sieve track operating in the heap mode is achieved when the working surface oscillations \( n = 1000 \text{ min}^{-1} \), the amplitude of oscillations \( A = 2 \text{ mm} \) and the working surface speed \( V = 0.28 \text{ m/s} \).

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