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Study of a pneumatic separator for grain cleaning

M.A. Begunov[1*], *V.S.* Koval[1], and *A.V.* Chernyakov[1]

[1]Tara branch of Omsk State Agrarian University named after P.A. Stolypin, Tara, Russia

Abstract. This article deals with experimental studies of a pneumatic separator with a passive deck. Post-harvest handling of grain is one of the important operations in grain production. Quality cleaning and drying contribute to grain storage without significant losses. The grain litter after the harvest of the combine harvester, which takes place in the shortest possible time, is the most clogged. This causes a problem in terms of cleaning. An important problem is also the physical and obsolescence of the cleaning machines, even though the annual workload is relatively small. This has a significant impact on productivity. Of all those in the agricultural industry, the most commonly used separation of grain from impurities is by aerodynamic properties and separation by size on the sieve. The design of an experimental pneumatic separator with a passive deck was developed. Experimental studies of the pneumatic separator with a passive deck were carried out, based on which plots of the dependences of the completeness of the separation were plotted on the angle of inclination of the flap and the feed of the grain material. The optimal parameters and modes of the grain cleaning machine were determined: the lowest losses of the main crop and the cleaning efficiency are achieved at the flap inclination angle α=0˚.

1 Introduction

Grain cleaning equipment, together with the entire culture of agriculture, has come a long way from the primitive cleaning of grain by means of wind, until modern grain cleaning machines appeared. This was preceded by many years of research on physical, mechanical and biological properties of grain, seeds, kinematics, dynamics of working bodies, their arrangement in grain-cleaning machines and in flow lines [1-15].

One of the complex and critical tasks of post-harvest processing is cleaning the grain from impurities and sorting. The cleaning of seed grain is of particular importance. In this regard, it is recommended to create new, more efficient machines and improve existing grain and seed cleaning machines.

The timely post-harvest treatment of grain contributes to high harvesting rates, prevents grain spoilage, and reduces its quality. One of the important stages, its most responsible part, is cleaning the grain material from impurities. The share of impurities in grain is 15...20% of the harvested crop.

* Corresponding author: maksim-begunov@mail.ru

In agriculture of our country the majority of operated machines of air-shed (wind-shed) type, the main body of which is the grid part, and additional - pneumatic system.

Studying the features of existing types of machines for grain separation in the air flow [1-4], we received the following classification in the direction of air flow:

1. Vertically-directed;
2. Inclined;
3. With swirling air flow.

The use of a pneumatic separator with a passive deck contributes to the cleaning efficiency.

2 Materials and Methods

A pneumatic separator with a passive deck has been developed, the design of which is shown in Figure 1.

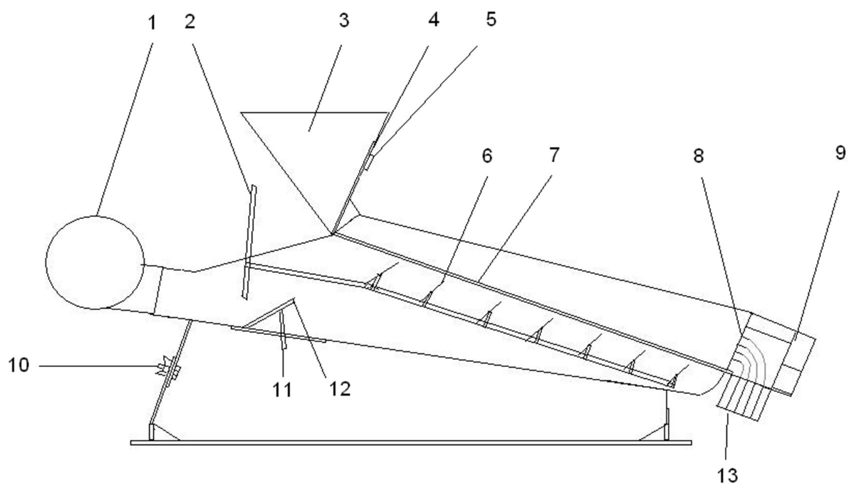

Fig. 1. Pneumatic separator with passive deck: 1 - fan; 2 - louver adjustment lever; 3 - hopper; 4 - grain feed flap; 5 - grain feed flap adjustment lever; 6 - louver; 7 - sieve; 8 - bar; 9 - chamber for dust and light impurities; 10 - grate angle adjustment screw; 11 - air flow direction adjustment lever; 12 - flap; 13 - outlet channel of cleaned grain, feed and light impurities

Fan 1 takes the air flow directly from the atmosphere and feeds it to the discharge pipe that directs the flow to the zone of interaction with the object of treatment (heap, grain, fruit, fibre). The damper 12 and louver 6 have a significant impact on the operation process of air networks. We apply the piping of rectangular cross-section. Install the fan of discharge system in the separator so that the flow would blow the crop over the whole area of the sieve. High-quality separation of the heap occurs when the flow is directed at an angle ą = 20...30º to the plane of the grid. During installation, we take into account that the flow, leaving the channel, expands and part of the sieve is blown by the reflected air. For easy passage of the grain through the grid 7, regulate the inclination angle with the screw 10. The grain feed is regulated by the slide 4. Light impurities and dust are removed by the air flow and they go into the chamber 9. Cleaned grain and fodder go into chambers 13 [5, 6].

Experimental sample of pneumatic separator with passive deck for grain cleaning is shown in Figure 2.

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Fig. 2. Prototype pneumatic separator with passive deck

Pour the unfinished grain into hopper 3 (Fig. 1). Set shutter 12 at an angle ą=0^0. Switch on fan 1. Open shutter 4 for a certain time t=10 seconds, set grain flow G=min. The air flow will separate the grain into chambers 13. Weigh the grains separated in chamber 1 on the scales, determining the mass of the main crop$m_{m.c.}$Determine the completeness of the separation of E, the separation of forage Ef and light impurities El. Record the results in the table. In each of the five channels and chamber 9 determine the separation efficiency E. In this way we carry out three tests, changing the feed rate G=average and G=max. The next step is to set the damper 12angleą=25^0. Carry out three experiments, changing the parameters G. Conduct the next three experiments according to the same scheme, setting the damper 12 to an angle of ą=50^0 [7].

3 Results

The main objective of developing a pneumatic separator with a passive deck is to achieve maximum separation completeness and minimum losses of the main crop $m_{m.c.}$by changing the feed and the angle of the flap, increasing the frequency class of the grain at the outlet of the grain cleaning complex.

Wheat was used as the test grain material. The moisture content was constant in all experiments and was 14%. The characteristics of the initial grain crop are shown in Table 1.

Table 1. Characteristics of the initial grain chaff

Cropname	Content, %
Wheat 'Rosinka'	89
Including: friable broken	 3 4
Wild oat	0.2
Long strawimpurities	9.5
Amaranth	1.1
Chaffandotherimpurities	0.2

According to the given initial values of parameters of the slope angle of slide 12 and feed grain material, plots of completeness of separation of forage and light impurities were plotted (Fig. 1.3). Here are plots of the function of quality indicators from the angle of inclination of the flap 12, since the performance of the separator is directly proportional to it. Graphs Ef=f(G, ą) El= f(G, ą) - the completeness of the separation of forage, light impurities andL=f(G, ą).The main crop losses are taken to mean that the completeness of the separation of the grain mixture is directly related to these values. The graphs are plotted as a function of the value of ą – the angle of the damper 12 ą =0, ą =25 ą =50 at a constant value of G(t) supply T/h [8-9].

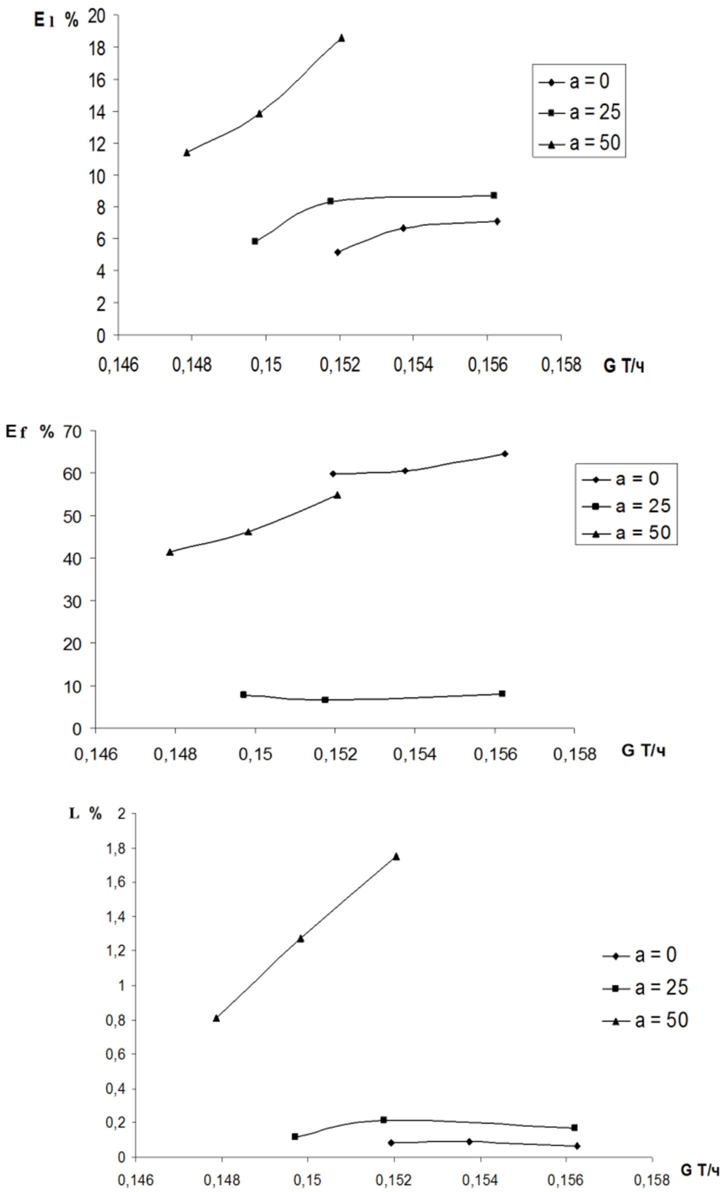

Fig. 3. Graphs Ef=f(G, ą) El= f(G, ą), and I=f(G, ą)

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The mass of all outputs and fractions per unit time is determined by the formula (1):

$$m = m_{m.c.}^{1} + m_{f}^{1} + m_{l}^{1} + \dots + m_{m.c.}^{n} + m_{f}^{n} + m_{l}^{n} \ , \tag{1}$$

heremdetermines all outputs and fractions per unit time;
$m_{m.c.}$ – main crop weight;
m_f – for age weight;
m_l – mass of light impurities.
The grain feed is determined by the formula (1):

$$G = \frac{\sum_{i=1}^{n} m_{m.c.} + \sum_{i=1}^{n} m_{f.} + \sum_{i=1}^{n} m_{l}}{t} \ , \tag{2}$$

hereGisflow rate, t/h.
The total excretion of forage and light impurities is determined by formulae (3) and (4):

$$E_f = \frac{m_f}{m \cdot \Delta f} \ , \tag{3}$$

$$E_l = \frac{ml}{m \cdot \Delta l} \ , \tag{4}$$

hereEf – completeness of forage separation;
El –completeness of the light impurity emission.
The main crop loss is determined according to the formula (5):

$$\Pi = \frac{m_{m.c.}^{L}}{\sum m_{m.c.}} \cdot 100\% \ , \tag{5}$$

here Π is losses of a major crop, %;
$m_{m.c}^{L}$ - weight of the lost staple crop;
$\sum m_{m.c}$ - wholecropweight.

Table 2. Permissible values for quality indicators

Cleaning, grading of grain and seeds	Pararmeter		
	E, %	Impurity content of processed grain material, %	Loss of the main crop, %
Preliminary	50	-	0.05
Primary	60	3.0	1.5
Secondaryandspecial	80	0.5	1.0

From the data in the table, select the type of cleaning of the grain material from the charts Ef=f(G, ą) El= f(G, ą) (Fig. 3). Through practical calculations, a graph of the value of the main crop loss has been plotted L=f(G, ą) (Fig. 3). It shows that the losses are highest at slope angles ą=50^0.At damper angles of inclinationą =0^{0}there is minimal loss of the main crop, which improves the separation process[10].

4 Conclusions

Thus, based on the results of experimental studies of the pneumatic separator with a passive deck, it can be concluded that all the set tasks have been solved:
1. The design of experimental pneumatic separator with a passive deck is developed, and the principle of its operation is described;
2. Experimental studies of a pneumatic separator with a passive deck were conducted, on the basis of which the dependences of complete separation on the angle of inclination of the flap and the feed of the grain material were plotted;
3. Based on the analysis of the experimental data, the optimal parameters and modes of the grain cleaning machine were determined: the lowest losses of the main crop and the cleaning efficiency are achieved at the angle of inclination of the flap α=0˚.

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