Two-aspiration air-sieve grain cleaning machines of new generation

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Abstract. The paper provides a review of fractional technologies developed by the authors, allowing to divide the grain heap coming from combines into 3 fractions: seed, fodder and unused waste. They are based on the use of two-aspiration air-sieve grain cleaning machines. The authors have developed a line of grain cleaners OZF-50/25/10 and OZF-80/40/20. Their productivity in terms of preliminary cleaning is 50 and 80 t/h, primary cleaning productivity is 25 and 40 t/h and secondary cleaning productivity is 10 and 20 t/h, respectively. The machines use an improved two-aspiration system with the ability to independently adjust the speed of air flows in the channels (patent No. 2298441), a new design of a sieve mill with a two-tier arrangement of sieves and setting in each tier sequentially two (at OZF-50/25/10) and three (on OZF-80/40/20) sieves. The mills implement a new sieve arrangement scheme (RF patent No. 43798), as well as original devices for a ball sieve cleaner and a pneumatic separation channel for the second aspiration. These devices make it possible to obtain the required quality of sieve cleaning and to isolate biologically defective grain in the pneumatic separation channel of the second aspiration. The separator for secondary cleaning of seeds SVS-30 is designed for the preparation of seeds of grain, spike, leguminous, industrial and oil crops when implementing fractional technology during post-harvest processing. Like all machines for secondary cleaning of seeds, the pneumatic system of the separator has two pneumatic separation channels for pre-screening and post-screen cleaning. A distinctive feature of the pneumatic system of the SV-30 separator is the consistent use of the same air flow in both aspirations. Fractional technology for processing grain heaps, implemented on an air-sieve separator, will increase the cleaning performance by 1.5...1.8 times with a minimum amount of mechanical stress on the seeds.

1. Introduction

The key to obtaining high-quality seeds for commercial grain, along with modern varieties and applied technologies for growing agricultural crops, is the immediate, without intermediate storage, post-harvest processing of the grain heap coming from the combines with its division into fractions: seed, fodder and unused waste. Such separation of the grain heap at the earliest stage of processing is possible with the use of two-aspiration air-sieve grain cleaning machines implementing fractional cleaning technology [1-5].

The grain heap arriving for post-harvest processing contains high-grade, biologically defective and injured grain, as well as weeds of organic and mineral origin. Biologically defective grain and weeds, as a rule, have high humidity and tend to self-heating. These components, as well as damaged grains, are a favorable environment for the habitation and reproduction of microorganisms that impair the...
sowing quality of seeds even with a short storage of an unclean heap. Efficient isolation of these components is possible only when using the technology of post-harvest processing of a grain heap with its fractionation immediately as it comes from the combines. With the right choice of fractionation modes, as a rule, it is possible to obtain the required seed quality. If in the grain heap there were hard-to-separate weeds and it was not possible to isolate them, then the cleaned grain can be put for temporary storage. During storage, it is necessary to diagnose the grain, i.e. to determine in what way and with the use of what technical means with a minimum amount of mechanical interaction on the grain it is possible to bring it to the requirements of seed conditions [6-8].

2. Materials and methods

A technology for fractionation of a grain heap is proposed, protected by the RF patent No. 2264068.

Processing the entire grain heap immediately as it comes from the combines is possible with high-performance machines. Along with this, machines must be universal, i.e. used for preliminary, primary and secondary grain cleaning.

With the support of the Fund for the Development of Small Forms of Enterprises in the Scientific and Technical Sphere, the staff of the Department of Agricultural Machines, Tractors and Cars has developed a family of grain cleaners OZF-50/25/10 and OZF-80/40/20 that meet all of the listed requirements.

Their productivity during cleaning was 50 and 80 t/h for preliminary cleaning, 25 and 40 t/h for primary cleaning and 10 and 20 t/h for secondary cleaning.

The machines use an improved two-aspiration system with the ability to independently adjust the speed of air flows in the channels (patent No. 2298441), a new design of a sieve mill with a two-tier arrangement of sieves and setting in each tier sequentially two (at OZF-50/25/10) and three (on OZF-80/40/20) sieves. The mills use a new sieve arrangement scheme (RF patent No. 43798), as well as original devices for a ball sieve cleaner and a pneumatic separation channel for the second aspiration. These devices enabled the required quality of sieve cleaning and to isolate biologically defective grain in the pneumatic separation channel of the second aspiration.

The carried out state acceptance tests of the machines showed that after the secondary cleaning of winter wheat Moskovskaya 39, the content of crushed grain was 0.06...0.0%, and that of Gonor barley was 0.04...0.07%, and the number of weeds did not exceed 5 and 4...17 pcs/kg, respectively. The purity of seeds in all experiments was not less than 99.2%.

According to the results of the tests of the TsCHMIS, the machines can be installed in the technological lines of the ZAV-20, ZAV-25, ZAV-40 and ZAV-50 grain cleaning units.

The production of machines is organized at the Oskolselmash LLC (Novy Oskol, Belgorod Region). A new innovative development for the agro-industrial complex of the Russian Federation, created by the creative team of the Voronezh State Agrarian University named after Emperor Peter I, is the SVS-30 secondary seed cleaning separator.

The separator for secondary cleaning of seeds SVS-30 (Fig. 1) is designed for the preparation of seeds of cereals, spikes, legumes, industrial and oilseeds in the implementation of fractional technology in post-harvest processing. Like all machines for secondary cleaning of seeds, the pneumatic system of the separator has two pneumatic separation channels for pre-screening and post-screen cleaning.

A distinctive feature of the pneumatic system of the SV-30 separator is the consistent use of the same air flow in both aspirations. Outside air intake is carried out by a vertical post-sieve cleaning channel with its sequential passage through the sediment chamber of the channel, where the fodder fraction is separated, which is carried out by the air flow, taking into account the differences in the aerodynamic properties of the components of the grain heap. After that, the air is directed into a horizontal pre-sieve cleaning channel with a sectional sedimentation chamber. In the horizontal channel, the heap is divided by aerodynamic properties into three fractions: light impurities, fodder and main fractions. Light impurities are carried out by the air flow outside the machine. The fodder fraction is separated in a sectional sedimentary chamber and subsequently withdrawn into fodder. The
main fraction is sent to sieve cleaning to separate large impurities and feed fraction by size, and further final separation of biologically defective grain in the vertical channel of post-sieve cleaning (Fig. 2)

Figure 1. Separator for secondary cleaning of seeds. 1 – separator frame; 2 – separator pneumatic system; 3 – lower sieve mill; 4 – upper sieve mill; 5 – feeder-distributor; 6 – horizontal pre-sieve cleaning channel; 7 – channel for feeding the main fraction to sieve cleaning; 8 – air duct for connecting an external fan; 9 – sediment chamber of the post-sieve cleaning channel; 10 – post-sieve aspiration channel; 11, 12 – devices for withdrawing fractions from sedimentary chambers

Figure 2. Aspiration system of the SVS-30 secondary seed cleaning separator.

This design of the pneumatic system makes it possible to increase the completeness of separation into fractions by aerodynamic properties and to reduce the total air consumption of the pneumatic system by 25...40% in comparison with analogs. The pneumatic system is serviced by a radial-type fan with a medium pressure installed outside the pneumatic system.

3. Results

The cleaning sieve of the machine includes 2 sieve mills with a series-parallel scheme of passing the grain heap. Separation of the grain heap by sieve cleaning of the machine by size is carried out into
three fractions: large impurities, main and fodder fractions, which made it possible to install two types of sieves (tailing and sorting) in it, excluding under-sowing sieves. The tailing sieves are installed in the upper separate tier of the upper mill, which makes it possible to apply for them an individual angle of inclination to the horizon. The lower tier of the upper mill is occupied by sorting sieves. In the lower mill, which has a counter slope relative to the upper mill, two tiers of sorted sieves operating in parallel are installed. The opposite angle of inclination of the sorting sieves of the lower mill increases the path of air passage through the sieves due to the installation of a grain flow divider in front of them. The used arrangement of sieve cleaning will increase the share of main (sorting) sieves up to 75%, reduce the thickness of the heap layer on the sorting sieves and increase the completeness of separation into fractions.

The grain heap is fed into the post-sieve cleaning channel by means of a tray fixed to the lower mill at a level below the lower tier of the sorting sieves and having a supporting air-permeable mesh.

The vertical post-sieve cleaning channel has a depth of 0.24 m and is divided by a partition into two zones. The depth of the preliminary zone of the channel in the upper part is 15...20%, and the front wall of the channel to increase the length of the preliminary zone is set at an angle of 10-12° to the vertical. The height of the dividing wall is 0.6 m.

The gravitational vibration distributor is installed to distribute air across the width of the machine, and a feeder roller with an elastic working surface is installed to feed the heap into the horizontal channel of pre-sampling aspiration (Fig. 3).

The scheme of operation of the SVS-30 separator for secondary cleaning of seeds is shown in Figure 4.

Figure 3. Gravitational vibration distributor
Figure 4. Scheme of work of the separator for secondary cleaning of seeds SVS-30. 1 – pneumatic separation channel of post-sieve cleaning; 2 – sedimentary chamber of the pneumatic channel; 3 – guiding visor; 4 – horizontal pre-sieve cleaning channel; 5 – section of the main fraction of the sedimentary chamber of the pre-sieve cleaning channel; 6 – dividing wall with a valve; 7 – section for collecting forage; 8 – power supply; 9 – channel to the cyclone and fan; 10 – upper sieve mill; 11 – lower sieve mill; 12 – feeding device; 13 – aspiration fodder output; 14 – trays for output of large impurities; 15 – trays for forage output of sieves; 16 – the output of the refined grain of the main fraction; 17 – tailings sieves; 18 – sorting sieves of the lower mill; 19 – sorting sieves of the upper mill.

4. Conclusion
Cleaning grain for seed purposes with a separation completeness of 80% is possible with the installation in a sieve mill in a separate tier of three sorting sieves with a specific load of up to 47 kg/(h dm²); when installing two, it should be no more than 36 kg/(h Dm2), respectively. The planned technical characteristics of the SVS-30 separator are presented in Table 1.

Table 1. Planned technical characteristics of the SVS-30 separator.

| Indicators                                                      | Value   |
|----------------------------------------------------------------|---------|
| Specific productivity of the machine when cleaning wheat for seed purposes, t/(h·dm) | 3.0     |
| Separation completeness, %                                     | 85.0    |
| Total resistance of the pneumatic system, Pa                   | 475     |
| Air consumption, thousand m³/(h·dm)                            | 0.8     |
| Specific power consumption for the fan drive, kW/dm             | less than 0.5 |
| Permissible specific load on sorting sieves, [q], kg/(h·dm²)   | 37      |

New technical solutions embodied in the design of new generation machines are protected by patents for inventions. Some are listed below: no. 1676503; no. 43798; no. 2298440; no. 32298441; no. 63715; no. 68373 and a number of others.

The design and technological scheme of the air-sieve separator, which implements the fractional technology of seed preparation, makes it possible to divide the initial heap into the main feed and
waste fractions on a double-aspiration pneumatic system and into a fraction of large impurities, the main and feed on sieve cleaning.

Fractional technology for processing grain heaps, implemented on an air-sieve separator, will increase the cleaning performance by 1.5...1.8 times with a minimum amount of mechanical stress on the seeds.

Such indicators of the work of seed cleaning machines will improve the quality of the prepared seed material, which will increase the yield and, as a consequence, the gross harvest of agricultural crops.

Based on many years of research with the support of the Ministry of Agriculture of the Russian Federation, the creative team of the Department of Agricultural Machines, Tractors and Cars has developed scientific and technical documentation for the manufacture of a prototype separator for a pile of seeds.

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