Analysis and features of operation of fractional grain cleaners and secondary seed cleaning separators

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Abstract. To obtain high-quality grain and seeds, it is necessary to clean the combine heap of weeds. Modern air-screen grain cleaners equipped with a screen cleaning systems, flat screens and a double-aspiration pneumatic system with pre-screen and post-screen cleaning channels are used. The fractional principle of post-harvest grain processing is promising. To create a universal grain cleaning machine to isolate the main fraction from the grain heap at the first stage of post-harvest processing, Voronezh State Agar University named after Emperor Peter I carried out theoretical and experimental studies, which made it possible to develop OZF-50, OZF-80 and SVS-30 separators. The machines have higher productivity, the original sieve design with an increased share of sorting sieves and an exclusive aspiration system. A number of new technical solutions have been used in the design of the separators, protected by patents of the Russian Federation. Theoretical prerequisites established the possibility of increasing the productivity 1.6-1.8 times according to GOST R 52325-2005. The total air consumption of the pneumatic system of grain cleaning machines can be reduced by 25-40%. Further improvement of separators requires a deeper study of the grain fractionation process, aerodynamic characteristics of aspiration systems, receiving and distribution devices, and establishment of close mutually beneficial relations between scientific institutions and agricultural engineering enterprises. This can contribute to the development of both domestic agricultural science and grain cleaning equipment production.

1. Introduction

Along with modern varieties of agricultural crops grown by Russian farms and technologies used for their cultivation, to produce high-quality seeds, high-performance fractional cleaners for post-harvest processing of grain heaps are required [1-5]. Separators must ensure the uninterrupted processing of grain. The separation of seed, fodder and unused waste at the earliest stage of cleaning is not possible without the use of two-aspiration air-sieve grain cleaning machines based on the fractional cleaning technology [4-5]. To manufacture grain cleaning machines, mathematical modeling [6-9] and scientific research of the technological process [10-13] are required.

2. Materials and methods

For post-harvest processing of grain, a huge number of grain and seed cleaning machines are produced. The Department of Agricultural Machines, Tractors and Cars of Voronezh State Agrarian University named after Emperor Peter I with the support of the Fund for the Development of Small Science and Technology Enterprises developed highly efficient separators OZF-50/25/10 and OZF-
80/40/20 (Figure 1). The technological scheme of operation of fractional grain cleaners OZF is shown in Figure 2.

**Figure 1.** Fractional grain cleaners OZF designed by Voronezh State Agricultural University: a - OZF-50; b - OZF-80

**Figure 2.** The technological diagram of the fractional grain cleaner OZF-80:
1 - frame; 2 - power supply device; 3 - channel of the first aspiration; 4 - channel of the second aspiration; 5 - sediment chamber of the first aspiration; 6 - sediment chamber of the second aspiration; 7 - screws; 8 - cross-flow fan; 9 - air outlet pipe; 10 - divider of the grain heap; 11 - air intake window; 12 - valve; 13 - sieve camps; 14 - tray for the output of the ear heap; 15 - tray for output of fodder fraction; 16 - tray for output of small impurities; 17 - unloading channel of cleaned grain; 18 - visor; B
- spike sieve ø 8-10 mm; C - undersowing sieve □ 1.7 mm; D - sorting sieve □ 2.2-2.4 mm;

- direction of air movement; — direction of grain heap movement;

- direction of movement of light impurities; — sorting sieve passage;

- direction of movement of light impurities; — direction of movement of light impurities;

- sorting sieve passage; — forage fraction; — cleaned grain; — sorting sieve descent; — second aspiration forage fraction

Figure 3. The technological diagram of the fractional grain cleaner OZF-80:
1 - frame; 2 - power supply device; 3 - channel of the first aspiration; 4 - channel of the second aspiration; 5 - sediment chamber of the first aspiration; 6 - sediment chamber of the second aspiration; 7 - screws; 8 - cross-flow fan; 9 - air outlet pipe; 10 - divider of the grain heap; 11 - air intake window; 12 - valve; 13 - sieve camps; 14 - tray for the output of the ear heap; 15 - tray for output of fodder fraction; 16 - tray for outputting small impurities; 17 - unloading channel of cleaned grain; 18 - visor; 19 - air intake windows; B - spike sieve ø 6-9 mm; C - undersowing sieve □ 1.7 mm; D - sorting sieve □ 2.2-2.6 mm;

- direction of air movement; — direction of grain heap movement;

- direction of movement of light impurities; — sorting sieve passage;

- direction of movement of light impurities; — direction of movement of light impurities;

- sorting sieve passage; — forage fraction; — cleaned grain; — sorting sieve descent; — second aspiration forage fraction
Highly efficient OZF grain cleaning machines are designed for preliminary, primary and secondary cleaning of grain heap, cereals, legumes and other crops. In the pre-cleaning mode, light and large impurities are released with an air flow and sieves in order to safely store grain and seeds, as well as to increase the efficiency of post-harvest processing. During the primary cleaning of grain, it is divided into fractions with bringing the content of impurities to basic conditions in accordance with GOST R 52325-2005. With the secondary cleaning of grain and leguminous crops, it is necessary to bring them to the requirements for sowing material and marketable grain.

3. Results and their discussion

For the OZF machines, several new technical solutions have been applied. They are protected by patents of the Russian Federation:

- two-aspiration air cleaning, which ensures the removal of light impurities into the waste fraction to the sieve mill, as well as the isolation of feeble and biologically defective kernels into the forage fraction after sieve cleaning, and the system is served by one diametrical fan with independent stepless air flow rate control in each of the aspiration systems using a frequency converter and changing the opening value of the adjusting air intake windows;
- sieve mills with a two-tier arrangement of sieves according to a new scheme, which makes it possible to double the area of the sorting sieves with the same dimensions of the machine, which ensures the allocation of up to 25% of defective grain to the fodder part;
- the original device of the ball cleaner, which allows for cleaning the sieves from "dead" zones.

The main technical characteristics of OZF separators are presented in Table 1.

### Table 1. Main technical data of OZF grain cleaners

| No. | Indicator | Machine brand |
|-----|-----------|---------------|
|     |           | OFF-50        | OFF-80        |
| 1   | Wheat processing capacity, t/h: |
|     | - for preliminary cleaning; |
|     | - for primary cleaning; |
|     | - on secondary cleaning |
|     | fifty     | 80            |
|     | 25        | 40            |
|     | 10        | twenty        |
| 2   | Electric motor power, kW: |
|     | - drive of the fan of the aspiration system and augers; |
|     | - drive of sieve mills |
|     | eleven    | eleven        |
|     | three     | three         |
| 3   | Rotation frequency of the electric motor, min⁻¹: |
|     | - drive of the fan of the aspiration system and augers; |
|     | - drive of sieve mills |
|     | 970       | 970           |
|     | 945       | 945           |
| 4   | Overall dimensions, mm: |
|     | - length; |
|     | - width; |
|     | - height |
|     | 2995      | 4000          |
|     | 2260      | 2260          |
|     | 2760      | 2760          |
| 5   | Weight, kg |
|     | 2300      | 2600          |

The acceptance tests of the machines showed that after the secondary cleaning of winter wheat Moskovskaya 39, the content of crushed grain was 0.06-0.1%, and the number of weeds did not exceed 5 pcs/kg. At the same time, the purity of seeds was 99.2%. During the secondary cleaning of spring barley Honor, the content of crushed grain was 0.04-0.07%, and the number of weeds varied from 4 to 17 pcs / kg.

The OZF separators are mass-produced by the Oskolselmash enterprise in Novy Oskol, Belgorod region. Voronezh State Agrarian University with the support of the Ministry of Agriculture of the Russian Federation has developed a new grain cleaning machine SVS-30 (Figure 4).

The process flow diagram of the SVS-30 secondary seed cleaning separator is shown in Figure 5.
Figure 4. The separator for secondary cleaning of seeds SVS-30 developed by Voronezh State Agrarian University.

Figure 5. The diagram of operation of the secondary cleaning separator 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 reshetny camp; 11 - lower reshetny camp; 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 - spike sieves; 18 - sorting sieves of the lower mill; 19 - sorting sieves of the upper mill.

The SVS-30 separator for secondary cleaning of seeds is designed for the preparation of seeds of cereal crops, legumes, industrial and oil crops using the fractional technology of post-harvest processing of grain heaps. The planned technical characteristics are presented in Table 2.
Table 2. Planned technical characteristics of the SVS-30 separator

| Indicators                                          | Value       |
|-----------------------------------------------------|-------------|
| Specific productivity of the machine when wheat seed cleaning, t / (h · dm) | 3.0         |
| Separation completeness,%                           | 85.0        |
| Total resistance of the pneumatic system, no more, Pa | 800         |
| 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          |

The innovative development is characterized by the consistent use of air flow in aspiration systems for pre-sieve cleaning with a horizontal channel and post-sieve cleaning with a vertical channel, as well as multi-tiered placement of the main sieves with a heap feeding. This design ensures the separation of the heap from combine harvesters into fractions at the pre-sieve cleaning stage. The advantages of the SVS-30 separator are improved quality of works, increased completeness of separation into fractions. This will increase the productivity of the grain cleaning machine by 1.5 ... 1.8 times and reduce the total air consumption of the pneumatic system by 25 ... 40%. The design of the SVS-30 separator has a lot of new technical solutions protected by patents of the Russian Federation. The employees of the University have developed scientific and technical documents, which was transferred to agricultural engineering enterprises.

4. Conclusion
Voronezh State Agricultural University has developed grain cleaning machines for various purposes. Their originality is confirmed by a number of patents of the Russian Federation, and their efficiency is due to high technical and economic indicators. Without further scientific research of the grain fractionation process, aerodynamic characteristics of aspiration systems, receiving and distributing devices, it is not possible to increase the productivity and quality of separators. It is necessary to establish close mutually beneficial relations between the scientific organizations and agricultural engineering enterprises of the Russian Federation, which will speed up the production of developed machines. This will increase the performance of domestic agricultural science and grain cleaning equipment production.

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