Analysis of design features and test results of fractional grain cleaners

A V Chernyshov, V I Orobinsky, I V Baskakov, A M Gievsky and V A Gulevsky

Voronezh State Agrarian University named after Emperor Peter the Great, 1 Michurin Str., Voronezh, 394087, Russia

E-mail: smachin@agroeng.vsau.ru

Abstract. Stable preservation of sown areas for agricultural production in the Russian Federation is crucial for increasing the gross grain yield. Only high-quality seeds with a low level of injury during harvesting and post-harvest processing will provide a significant increase in the yield of crops. Weediness of the grain heap decreases the yield up to 40 ... 60%. According to long-term data, weediness of the grain heap in the natural and climatic regions of the CIS is 6.0 ... 15.0%. Moisture during threshing is 16.0 ... 20.0%, and in unfavorable years it can reach 22.0 ... 25.0%. A safe storage period for such a heap is fairly limited and can attain several hours. Impurities of organic origin with the moisture content of 50.0 ... 80.0% have a negative effect on the grain heap safe storage and the quality indicators of seeds. The study carried out during secondary cleaning show that the OZF-50 and OZF-80 machines provide the required productivity of 10.27 t/h and 20.40 t/h, respectively. With this productivity, the main crop content is 99.22 and 99.61%. The content of weed seeds is 3 and 5 pcs/kg, while the grinding of grain meets the technical specifications and attains 0.12 and 0.15% for the above machines. The results of regular periodic tests of the new generation OZF machines show that all operational and technological indicators and performance indicators of the machines meet the requirements of technical specifications. The developed new fractional grain cleaners ensure the production of original seeds in accordance with GOST R52325-2005.

1. Introduction

The requirements for the varietal, food and sowing qualities of grain and seeds are regulated by the relevant standards. In particular, the national standard of the Russian Federation Varietal and Sowing Qualities (GOST R 2325-2005) applies to seeds of agricultural plants. Table 1 summarizes the standard requirements for the quality of wheat seeds as a reference crop. The seeds are not allowed for sowing if they exhibit:

- weeds (seeds, fruits), pests and pathogens of quarantine significance for the Russian Federation according to the list approved in a prescribed manner;
- live pests and their larvae that damage seeds of the corresponding crop, except for ticks allowed by the standards in the amount not more than 20 pcs/kg;
- seeds of poisonous plants – pubescent heliotrope and the gray-haired trichodesma.

The purchase and consumption of safe, high-quality and natural food products are of main interest to consumers. At the same time, the main goal of producers is to obtain maximum income in the competitive production of products. Food, especially wheat, plays a leading role in the world politics of any state. Grain export requires new requirements for its quality. Stable preservation of sown areas...
for agricultural production in the Russian Federation is the main way to increase the gross yield of grain. Only high-quality seeds with a low level of injury during harvesting and post-harvest processing will provide a significant increase in the yield of crops. Weediness of the grain heap leads to a decrease in the yield up to 40 ... 60%. According to long-term data, weediness of the grain heap in the natural and climatic regions of the CIS is 6.0 ... 15.0%. Moisture during threshing can be 16.0 ... 20.0%, and in unfavorable years it can attain 22.0 ... 25.0%. The safe storage period for such a heap is some hours. Impurities of organic origin with the moisture content of 50.0 ... 80.0% have a negative effect on the preservation of the grain heap and the quality indicators of seeds [1–5].

Table 1. Varietal and sowing qualities of wheat seeds (GOST R52325-2005)

| Seed category | Varietal purity, % not less | Defeat of sowing with smut, %, not more | Seed purity, %, not less | Content of seeds of other plants, pcs/kg, not more | Impurity, % not more | Germination, %, not less |
|---------------|-----------------------------|---------------------------------------|------------------------|-----------------------------------------------|-------------------|------------------------|
| OC            | 99.7                        | 0/0                                   | 99.0                   | 8                                             | 3                 | 0                      | 0                      |
| ЭС            | 99.7                        | 0.1/0                                 | 99.0                   | 10                                            | 5                 | 0                      | 0.01                  |
| PC            | 98.0                        | 0.3/0.1                               | 98.0                   | 40                                            | 20                | 0.002                  | 0.03                  |
| PCт           | 95.0                        | 0.5/0.3                               | 97.0                   | 200                                           | 70                | 0.002                  | 0.05                  |

2. Materials and methods
Untimely preliminary processing of the grain heap coming from the combine harvesters decreases the sowing and commercial qualities of seeds and grain. A high level of injury and insufficient isolation of weeds and biologically defective grain contributes to the rapid development of pathogens [6–10].

Figure 1. OZF grain fractional cleaners developed at Voronezh SAU: a) OZF-50; b) OZF-80
The low level of technology for growing crops and the technical level of mechanization of production cannot provide seeds that meet the requirements of GOST R 52325-2005. In mechanization of post-harvest processing of grain and seeds in the Russian Federation, it is necessary to develop energy-saving technologies with minimal use of chemicals and create environmentally friendly equipment competitive at the world level. With the support of the Foundation for Assistance to Small Enterprises in the Scientific and Technical Sphere and the Ministry of Agriculture of the Russian Federation, scientists from the Department of Agricultural Machines, Tractors and Cars, Voronezh State Agrarian University, have developed OZF grain cleaners and a SVS-30 separator for secondary grain cleaning. A general view of these machines is shown in Figures 1 and 2.

3. Results and their discussion

To implement the proposed ideas, the scientists from VASU for the first time proposed a method for fractionating a grain heap at the earliest stage of its post-harvest processing, which was embodied in the design of these machines and protected by the RF patent No. 2264068.

A new arrangement of sieves has been proposed for a 1.5 ... 2.0 fold increase in the area of sorting sieves with established total area, separation of feeble, crushed and biologically defective grain, as well as machine productivity, energy and metal consumption. The proposed technical solutions are protected by RF patents No. 43798, 63715, 135543, 189918, 189555, 2708970, 185732 and implemented in OZF-80 and SVS-30 grain cleaning machines.

The improved identification of lightweight impurities through a two-stage cleaning of the grain heap, in both the unloading and the pneumatic separation channels, at an air flow rate not exceeding the rate of grain hovering to reduce energy costs by preventing air leaks during secondary cleaning of grain with separation of biologically defective and crushed grain and difficult-to-separate impurities, at a doubled air flow rate and similar air flow rate in the separation zones in the discharge and pneumatic separation channels, is proposed in the utility model patent Device for post-sieve cleaning of grain heaps (patent No. 68373) and implemented in the OZF separators design.

The method for pneumatic separation of grain materials and a device for its implementation (patent No. 2457047) improve the quality of separation of the grain heap.

A dual-aspiration system of the universal grain cleaning machine (patent No. 2366518) reduces the energy consumption for the drive of the diametrical fan rotor of the OZF grain cleaning machine and quickly sets the required air flow rates in the pneumatic separation channels of the first and second aspiration during preliminary, primary and secondary cleaning of the grain heap.

The aspiration system of the grain cleaning machine (patent No. 2298441) provides technologically independent air flow rates in the pneumatic separation channels due to a diametrical fan with
adjustable rotation frequency and special air intake windows with a regulation mechanism.

The use of a stamped perforated reflective surface and a flat sieve cleaner manufactured according to patent No. 2298440 dated 10.05.2007 improve the quality of sieve cleaning and provides a sieve cross-section ratio of at least 0.95, which increases the completeness of separation.

The use of the original device of a ball cleaner manufactured according to patent No. 2326745 in the design of grain cleaning machines for post-harvest processing of grain heaps will reduces ‘dead zones’. This technical solution will improve the quality of cleaning sieves in sieve mills of grain cleaning machines, ease the maintenance and increase the productivity of new machines.

The use of a device for gravitational distribution of bulk materials in the design of grain separators (patent No. 2404864) will increase the efficiency of uniform introduction of the grain heap into the pneumatic separation channel along the width of the grain cleaning machine and reduce the level of grain injury.

A new design of the sieve for the sieve mill of the grain cleaning machine manufactured according to patent No. 139851 will increase the efficiency of separating the grain mixture into fractions and identification of impurities.

In accordance with the state assignment for compliance with the technical specifications, periodic tests were carried out for grain cleaning machines developed by the scientists from the Department of Agricultural Machines, Tractors and Cars, Voronezh State Agrarian University. The machines were manufactured by Oskolselmash LLC. Data on the main indicators of state periodic tests of OZF machines provided by the CCh MTS are presented in Tables 2 and 3.

The operational and technological assessment of the OZF-80 machine was carried out as part of the ZAV-40 grain cleaning unit on a pile of Augustina winter wheat in the Glinnoye department of Krasnoyaruga grain company, and the OZF-50 machine was tested on a pile of Almera winter wheat at O. V. Kormakov IE in Novooskolsky district, Belgorod region [11, 12].

The moisture content of the initial heap for all types of cleaning corresponded to the requirements of technical specifications. The weed content in the initial material corresponded to the regulatory requirements – 1.99% and 0.82% (according to the requirements of technical specifications, it is up to 5.0% for preliminary and up to 3.0% for primary cleaning). The content of weeds in pieces per 1 kg is 73 (according to technical specifications – up to 100 pcs/kg). No other crops were found in the initial pile of seeds. All other indicators of the tested grain heap meet the corresponding specifications. Data presented in Table 2 show that the OZF-50 and OZF-80 machines for preliminary cleaning of winter wheat at productivity of 50.66 and 80.50 t/h, respectively, provide a good quality of the grain heap separation. At the same time, the amount of grain from the main crop in the unused waste, in the fodder fraction was 0.38 and 1.91% for OZF-50 and 0.38 and 1.92% for OZF-80, which meets the requirements of technical specifications. The grinding of grain, 0.16 and 0.18%, respectively, is also below the existing requirements of 2.0%.

The study carried out during primary cleaning of the grain pile of winter wheat confirm the passport productivity of the OZF-50 separator and were equal to 25.31 and 40.23 t/h. At this productivity, the grain purity is 97.88 and 98.0%, respectively, the grinding of grain at the given productivity is 0.15 and 0.17%, and the amount of the main crop in the fodder fraction is 2.99 and 3.61%. In technical specifications, these indicators are higher than those obtained during periodic tests.
### Table 2. Data on agrotechnical indicators of the state periodic tests of the OZF-50/25/10 grain cleaning machine proposed by CCh MTS (processed crop – winter wheat)

| Indicator | Indicator values by technical specifications | Indicator values by test data |
|-----------|---------------------------------------------|------------------------------|
|           | Pre-cleaning | Primary cleaning | Secondary cleaning | Pre-cleaning | Primary cleaning | Secondary cleaning |
| Productivity, t/h | 50 | 25 | 10 | 50.66 | 25.31 | 10.27 |
| Grain content of the main crop, % | no data | no data | not more 5 – ES, 20 – RS | 96.71 | 97.88 | 99.22 |
| Weed seeds content, pcs/kg | - | - | 3 |
| Seed content of other crops, pcs/kg | not more 0.5 | not more 2 | not more 5 | 0.38 | 1.45 | 2.25 |
| Amount of the main crop in the unused waste, % | not more 2 | not more 5 | not more 10 | 1.91 | 3.61 | 4.33 |
| Grinding of grain, % | not more 0.2 | 0.16 | 0.15 | 0.12 |
| Contamination of grain and waste | not allowed | absent | - |
| Seed category according to GOST R 52325-2005 | OS, ES, RS | - | OS |
| Basic norms according to GOST 52554-2006 | must meet the requirements | - | absent |

### Table 3. Data on agrotechnical indicators of the state periodic tests of the OZF-80/40/20 grain cleaning machine proposed by CCh MTS (processed crop – winter wheat)

| Indicator | Indicator values by technical specifications | Indicator values by test data |
|-----------|---------------------------------------------|------------------------------|
|           | Secondary cleaning | Pre-cleaning | Secondary cleaning | Pre-cleaning | Primary cleaning | Secondary cleaning |
| Productivity, t/h | 80 | 40 | 20 | 80.50 | 40.23 | 20.40 |
| Grain content of the main crop, % | no data | not less 5 – ES, 20 – RS | 97.08 | 98.00 | 99.61 |
| Weed seeds content, pcs/kg | - | - | 5 |
| Seed content of other crops, pcs/kg | not more 0.5 | not more 2 | not more 5 – ES, 20 – RS | 0.38 | 1.52 | 2.69 |
| Amount of the main crop in the unused waste, % | not more 2 | not more 5 | not more 10 | 1.92 | 2.99 | 4.82 |
| Grinding of grain, % | not more 0.2 | 0.18 | 0.17 | 0.15 |
| Contamination of grain and waste | not allowed | absent | - |
| Seed category according to GOST R 52325-2005 | ES, RS | - | ES |
| Basic norms according to GOST 52554-2006 | must meet the requirements | - | meet the requirements | - | - |
4. Conclusion
The study carried out during secondary cleaning show that both machines provide the required performance equal to 10.27 t/h for the OZF-50 machine and 20.40 t/h for the OZF-80 machine. With this productivity, the grain content of the main crop is 99.22 and 99.61%, respectively. The content of weed seeds is 3 and 5 pcs/kg, respectively, while grain grinding meets the requirements of technical specifications and attains 0.12 and 0.15% for the aforementioned machines. The results of regular periodic tests of the new generation OZF machines show that all operational and technological indicators and performance indicators of the machines meet the requirements of technical specifications. The new fractional grain cleaners developed by scientists from Voronezh State Agrarian University of Higher Education meet the existing requirements and ensure the production of original seeds in accordance with GOST R52325-2005.

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