STUDY OF THE GRAIN MIXTURES TRIER CLEANING PROCESS FROM SHORT IMPURITIES

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Abstract: As a result of experimental studies of the operating and tuning parameters of the trier operation, it was found that the quality of the process for separating short impurities is significantly affected by the rotation speed of the mesh cylinder, the angular position of the receiving tray and the radial clearance between the upper edge of the front wall of the receiving tray and the mesh surface. Moreover, lower angles correspond to a higher degree of separation of the impurity component. With an increase in the cylinder rotation speed, there is a tendency to increase in the rate of separation of the impurity, which is reflected in an increase in the degree of separation.

It was established that, together with impurity particles, particles of the main culture, oriented by the longitudinal axis in the direction of rotation and captured by the meshes of the cylinder, enter the receiving tray. Their number increases with an increase in the cylinder rotation speed, a decrease in the installation angle of the upper edge of the tray, and an increase in the radial clearance between the upper edge of the tray and the cellular surface.

Key words: Mesh surface, Grain mixture, Allocation dynamics, Parameters, Tray installation angle, Process quality.

1. Introduction

In post-harvest cleaning of grain and seeds, it is quite a challenge to separate impurity components that have comparable characteristics with the grain of the main culture in terms of particle size and aerodynamic properties. Russian standards for food grains impose high requirements for weediness. The content of cockle should not exceed 0.5%, and oats and Tatar buckwheat - 2% for the 1st and 2nd classes of wheat. Even more stringent weed control requirements for cereal seeds [Tishaninov and Anashkin (2015)]. In wheat reproductive seeds, no more than 20 seeds allowed of weed seeds per 1 kg of seeds, in elite seeds - no more than 5 pcs/ kg, in original ones - no more than 3 pcs/ kg.

Existing trier blocks, when used according to a sequential scheme, do not provide the identical quality of the technological process when separating long and short impurity components [Tishaninov and Anashkin (2015), Tishaninov and Anashkin (2018)]. This is due to the different optimal load of oat and bell-shaped cylinders. If the trier block is used in modes close to optimal for the operation of oat cylinders, the degree of separation of short impurities will be insufficient. If the load is oriented to the high-quality operation of cockle cylinders, then the free surface of the oat cylinders due to their underloading will cause long impurities to be thrown into the output tray, reducing the quality of the trier cleaning to grain mixture [Tishaninov and Anashkin (2015)]. Thus, there have always been new
ideas and various methods that have been applied to trier.

Research of trier cleaning of grain mixtures are the work of many authors [Urkhanov et al. (2012)]. The search for reserves for upgrading the trier blocks is associated with the need to further study the dynamics of the separation of impurity particles and grains of the main culture from grain mixtures by mesh surfaces, to establish the relationship of the quality of the process with high-speed operation modes and tuning parameters. However, in the literature there are no results of studies on the dynamics of the separation of impurity components and grains of the main culture from grain mixtures by cellular surfaces, on the basis of which it would be possible to establish directions for the modernization of trier blocks. To eliminate the noted problem, it is necessary to develop special research equipment and experimentally establish, with its help, the interconnections of the quality of the process of separating components of grain mixtures with cellular surfaces with high-speed operating modes and tuning parameters of the trier.

2. Materials and methods

Experimental studies were carried out using a device for separating impurities from grain mixtures developed at the Federal State Budgetary Institution “All-Russian Research Institute for the Use of Engineering and Petroleum Products in Agriculture” (FSBI ARRIUEPPinA) (Fig.1).

It works in the following way. In the mesh cylinder (with a diameter of 300 mm and a length of 300 mm) 1 through a funnel unloads the grain mixture 7 of mass \( m_n \) and level along with it. Turn on the drive disk 3. Impurity particles from the contact layer are captured by the meshes and fed into the tray 2, attached by the end wall 10 to the bracket 6 of the frame 9. Possessing the initial kinetic energy, impurity particles quickly roll along the inclined bottom 5 of tray 2 into capacity 8.

At the end of the process, which is controlled by the set regulatory time for the set values of residual clogging (or visually), the drive disk is turned off. Then the blocking ring 4 is removed and the capsules of the main culture are unloaded by tipping over the mesh cylinder into an additional container. According to the results of measurements of the extracted masses, the following indicators were determined for assessing the process of separation of impurities: the degree of separation; the duration of the process; the mass of grains of the main culture in the selected impurities; residual contamination of refined grain.

3. Results and Discussion

At a speed of rotation of the mesh cylinder \( n = 35 \) rpm and an angle of elevation of the upper edge of the tray \( \gamma_p = 35^\circ \), a rather high degree of separation of the impurity component was observed - 95.5%, but the duration of separation was 14-time intervals of 5 seconds. An increase in \( \gamma_p \) successively to 40° and 45° was accompanied by a decrease in the degree of separation of the impurity component to 68.1 and 34.3%, respectively. Moreover, the duration of the selection did not end in 15-time intervals (Fig. 2).

Fig. 2 shows that the main fraction of the selected impurity particles occurs in four-time intervals after the first (acceleration) one. The most intensive selection process takes place in the second interval, by which you can assess the impact of the \( \gamma_p \) on the intensity of the process. With an increase in \( \gamma_p \) from 35° to 40°, the mass of the impurity released in the second interval decreases by 2.7 times, while by 9.2 times. The achieved degree of separation of the impurity at \( \gamma_p \) is quite high, but the duration of the separation of 75 s is unacceptable. An increase in the rotational speed of the mesh cylinder to 40 rpm ensured the degree of emission of the impurity at the level of 97.1%. However, it reduced the degree of isolation to 66%. In this part of the experiments, a relationship was found which consists of the following. An excessive increase in the value of the angle \( \gamma_p \) relative to the operating mode of the device (n) leads to a decrease in the degree of separation of the impurity component but reduces the amount of the number of grains of the main crop in the selected impurity is 2 times. From the obtained experimental results, it was found that the number of grains of the main culture in the selected impurity decreases with increasing \( n \), but with equal \( n \) the degree of impurity release decreases and the duration of the process increases.

The subsequent increase in \( n \) to 50 ... 55 rpm provided an acceptable level of the degree of separation of impurity particles even with an increase in \( \gamma_p \) to 55 ... 65°. In this case, the mass of grains of the main culture, isolated together with the impurity component, remained at a sufficiently low level. A tendency was observed to reduce the duration of the separation of
impurity particles to 5 ... 9-time intervals of 5 seconds, (Fig. 3)

From Fig. 3 it is seen that the time for the separation of the impurity was reduced to 25 ... 45 s, the degree of separation of the impurity was 97.5 ... 99.1%. An increase in the degree of impurity release to $C = 99.1\%$ due to an increase in the duration of the process leads to an increase in the content of grains of the main crop in divided impurities by 3.7 ... 4.8 times.

The probabilistic orientation of the grains of the main crop (wheat) with the longitudinal axis in the direction of rotation of the mesh cylinder leads to their capture by cells and inertial retention. An additional increase in the speed regime and angle $\alpha_p$ did not give a significant effect on the degree of isolation, duration, and loss of grains of the main crop.

In this series of experiments, the average radial clearance between the front edge of the tray and the
mesh surface was $Z_i = 23$ mm. An analysis of a series of experiments allowed us to decide on the need to reduce the gap between the front edge of the tray and the mesh surface by 10 mm due to the extension of the front wall.

A further search for optimal parameters for the implementation of the process consisted of maintaining a high-speed mode - at the level of 50 ... 55 rpm and gradually decreasing (from $\gamma_p = 65^\circ$) the angle. This confirmed the effectiveness of the decision. The duration of the separation of the impurity component was gradually reduced to 5-time intervals of 5 seconds, and the degree of separation reached 99.3 ... 100%.

However, the mass of the grains of the main crops captured by the meshes and sent to the tray together with the impurity component remained unstable (21 ... 52 grains per 1 kg of grain mixture). The time of impurity release at $\gamma_p = 55^\circ$ increased to 7 ... 8 intervals of 5 s. Therefore, we decided to further reduce the gap between the front edge of the tray and the mesh surface due to the rubber insert - by 5 mm and - to 40°.

As a result, optimal parameters were established. $\gamma_p = 40^\circ$; $n = 50$ rpm the duration of the separation of the impurity component was 4 intervals of 5 seconds, the degree of separation of the impurity reached 100%, and the selected number of grains of the main crop did not exceed 20 pieces per 1 kg of grain mixture (Fig. 4).

Reducing the radial clearance ($Z_r$) to 8 mm prevented the entry of main crops into the tray with the unstable placement of the in the meshes that make up the lower part of the emission plume of emitted particles.

The stages of searching for the optimal values of $Z_r$, $\gamma_p$, and $n$ are fully illustrated by the indicators of the degree of separation (C) and the residual content of the impurity component ($Z_{out}$) in the grain mixture, (Fig. 5).

From Fig. 5 it is seen that the path has been passed
1 - the degree of isolation (C) and residual clogging (Z_{c}) at: n = 35 rpm; \( \gamma = 35^\circ \), \( Z_i = 23 \text{ mm} \); 2 - the degree of isolation (C) and residual clogging (Z_{c}) at: n = 35 rpm; \( \gamma = 40^\circ \), \( Z_i = 23 \text{ mm} \); 3 - the degree of separation (C) and residual clogging (Z_{c}) at: n = 50 rpm; \( \gamma = 40^\circ \), \( Z_i = 8 \text{ mm} \)

**Fig. 5:** The degree of separation and residual contamination of grain at the stages of research

**Table 1:** Dependence of residual debris (Z\(_o\)) on the initial (Z\(_i\)) and the degree of excretion (C) for a 1 kg sample.

<table>
<thead>
<tr>
<th>No.</th>
<th>The degree of allocation of impurities (C),%</th>
<th>Residual clogging (Z(_o)), %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( Z_i = 0.5 )</td>
</tr>
<tr>
<td>1</td>
<td>90</td>
<td>0.0375</td>
</tr>
<tr>
<td>2</td>
<td>91</td>
<td>0.0336</td>
</tr>
<tr>
<td>3</td>
<td>92</td>
<td>0.03</td>
</tr>
<tr>
<td>4</td>
<td>93</td>
<td>0.0263</td>
</tr>
<tr>
<td>5</td>
<td>94</td>
<td>0.0225</td>
</tr>
<tr>
<td>6</td>
<td>95</td>
<td>0.0188</td>
</tr>
<tr>
<td>7</td>
<td>96</td>
<td>0.015</td>
</tr>
<tr>
<td>8</td>
<td>97</td>
<td>0.0113</td>
</tr>
<tr>
<td>9</td>
<td>98</td>
<td>0.0075</td>
</tr>
<tr>
<td>10</td>
<td>99</td>
<td>0.0038</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

by the degree of separation from 68.1 to 100\%, and the residual impurity content - from 31.9 to 0\%. However, the most important characteristic of the process of separating grain mixtures with mesh surface is residual clogging (Table 1).

Table 1 presents the calculated data on the residual clogging (Z\(_o\)) of the grain mixture controlled by the device for wide ranges C and Z\(_i\), which can be typical for various impurity components.

The value of Z\(_o\) was calculated by the formula (1)
\[ Z_i = \frac{m_p i (1 - C)}{m p_i} \times 100\% = m p_i (1 - C) / 10 \]  
(1)

where,

\( m_{pi} \): The initial mass of impurity particles in the sample before the experiment, gr;

\( m_n \): The mass of the sample before the experiment, gr.

Table 1 shows that the maximum residual contamination of the controlled grain, mix to be accounted for \( Z_i = 0.225\% \) at the lowest degree of separation of impurities \( C = 90\% \) and the highest initial weedingness \( Z_i = 3\% \).

4. Conclusion

As a result of the studies, optimal conditions and parameters for the implementation of the process of separation of grain mixtures along the length were established. The rotation speed of the mesh cylinder is 50 rpm, the installation angle of the upper edge of the front wall of the output tray is 40°, radial clearance between the upper edge of the front wall of the tray and the mesh surface is 8 mm. Moreover, the duration of impurity release is 20 sec., the degree of impurity release is 100%.

The research results can be transferred to other trier cylinders by the coefficient of the kinematic regime \( K = \pi^2 n^2 R / 900 g = \text{const.} \)

References


