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Research and Defining Parameters and Indicators of the Longitudinal-Transverse Oscillation Sieve Grain Cleaning Mashine

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Abstract: Work quality of the grain cleaning machines depends on work indicators of the sieve. Based on this, longitudinal-transverse oscillation sieve developed for grain cleaning machine. The developed sieve researched theoretically and experimentally. According to the researches, it was defined that the longitudinal oscillation of the grain-cleaning sieve nfr = 140 – 175 rpm, the amplitude of the longitudinal oscillations Al =30 mm, the amplitude of the transverse oscillations At = 3 – 5 mm, and the slope angle αs=14o. In these operating parameters work indicators of the sieve consisted of the grain losses is not more than 0.5 % and cleaning efficiency is 99.6 %.

Keywords: grain, cleaning process, grain-cleaning machine, sieves, grain losses, cleaning efficiency.

Introduction

During the cereal and mung bean producing one of the main operations is harvesting, cleaning as well storage or recycling before usage it as food stuff. According to the limited norms of grain preparation, the content of other impurities in the grain must be no more than 5.0%, and by the baseline values not more than 1.0%. According to these requirements, the amount of other impurities in the grain that harvested by combine is allowed up to 5.0%.

However, experimental observations have shown that in some cases, the amount of non-grain impurities in the grain harvested due to uneven ripening in the fields, excessive drying or moisture of the grain, high weeds, improper adjustment of combine work units and breakdown of milling machines [1, 2]. It has also been reported to increase up to 7–9 %. Therefore, post-grain harvesting measures indicate that other impurities need to be removed before storing or using the grain for consumption. Otherwise, in component of the grain to become stalk pieces and other types impurities causes to increase the rate of fusarium and mycotoxins and other harmful microorganisms [3, 4]. For this, grain is sent through the initial cleaning, primary cleaning, secondary cleaning and pre-milling stages.

However, the most used devices a flat sieves. A grain cleaning machine is designed and tested for small farms in Uzbekistan. This machine is simple and resource-saver and it has the parameters to clean the grain from the unthreshed ears. In addition, unlike the well-known machines, a rolling rubbing device for placing the grain from unthreshed ears is considered in design in order to segregate the grain from unthreshed ears of wheat separated out during grains volume cleaning in the course of cleaning by masticating them with rollers that rotating against each other. On the basis of implemented research it is determined that the best mastication of unthreshed ears by least damage of grain is achieved at a rotation frequency of the first roller at

600 rpm, and the second roller within 800-1200 rpm and at clearance between rollers of 2-3 mm. For achievement of qualitative clearing of grain lots at minimum loss of grain it is necessary to choose the following intervals of parameters and the operation modes: frequency of sieve fluctuations is 100 - 150 rpm; amplitude of oscillations sieve is 30 - 50 mm; an angle of slope sieve is 8 - 11 [5].

However, this machine has not been investigated and its parameters used for cleaning grain from other impurities after being harvested in a combine. Moreover, these and other grain-cleaning machines that have flat sieve have only a longitudinal oscillation due to the fact that the grain size does not sufficiently separate the grain. This requires the improvement of the grain cleaning machines' sieve unit.

According to above mentioned views, the sieve of cleaning machine was chosen as an object of the research. As an aim and tasks of the research, development longitudinal-transverse oscillation sieve as well defining its parameters and indicators by theoretical and experimental researches were appointed.

Research Methods

Prior to experiments, the moisture and size-mass classifications of grain and its other impurities were determined on the basis of the State Standard 20915-2011 - Testing of agricultural tractors and machines. Procedure for determination of test conditions. An experimental sample of the grain cleaning machine with longitudinal-transverse oscillation sieve was prepared for experiments (Fig. 1).

For defining indicators State Standard 33735-2016 - Agricultural machinery. Grain-cleaning machines. Test methods and Uzbek State Standard 880: 2004 - Wheat requirements for state purchases and deliveries were used as standard methodological guidelines. Laboratorial means used for analyzing and measure were shown in Fig.2.

Grain cleaning and loss are largely dependent on the type and size of the holes. For this reason, different types of sieves were compared in the machine's upper and lower sieves to select the appropriate type of grain cleaning unit. In the experiments, long rectangular shapes and with rounded holes 4 mm, 5 mm and 6 mm, 5x20 mm were used to remove large impurities in the grain mixture, also with a long rectangular 2x18 mm round holes with a diameter of 2 mm and 3 mm holes were studied for separation of small other impurities in the grain mixture.

Fig. 1. Experimental grain cleaning machine

Fig. 2. Laboratorial means for analyzing and measure

Grain cleanliness and losses were considered as criteria for assessing the performance of the sieve of experimental machine. The grain that went from the machine's sieve gathered and the grain losses were determined by their proportion to the total sample.

Results and Discussion

The slope angle of the sieve is determined by unmoving condition of the grain mixture that is on its surface when it stays at without moving. For this, slope angle of the sieve α_s should be less than minimal friction angle φ_{min} of the grain

$\alpha_s < \varphi_{\min}$. (1)

As the image progresses smoothly along the longitudinal plane, the rollers that are placed next to it are moved horizontally as a result of movement along the direction. This movement is accelerated by the passage of grains and separation from other forces due to the direction of the forces affecting the grain on the surface of the vortex (For long-term and transverse oscillatory movements.) Determine the forces acting on the grain mixture acting on the gravity surface. The gravity $G=mg$, the inertia $J = m\omega^2 r\cos\omega t$, the normal reaction $N=mgcos\alpha_s$ and the frictional $F_{fr}=fN=f(mgcos\alpha_s - Jsin\alpha_s)$ forces influence along X axis to grain mixture that moving on surface of the sieve (Fig. 3).

In this case the condition of a longitudinal movement of a grain will be as in the following:

$$g\sin\alpha_s + \omega^2 r\cos\omega t\cos\alpha_s > f_g(g\cos\alpha_s - \omega^2 r\cos\omega t\sin\alpha_s), \quad (2)$$

where ω – angular velocity of the sieve crank, c^{-1}; r – radius of the crank, m; t – moving time, s. f_g – friction coefficient of the grain.

Friction coefficient depends on grain moisture [25]. During the researches, we receive friction coefficient f_g = 0.5 – 0.55 at 15 – 18 % grain moisture.

The equation has solution in case if $t=(0;t_r)$ then it will be $2r>A_d$.

Then longitudinal movement of grain A_l will be as in the following:

$$A_l = \frac{2g(f_g\cos\alpha_s - \sin\alpha_s)}{\omega^2(\cos\alpha_s + f_g\sin\alpha_s)}. \quad (3)$$

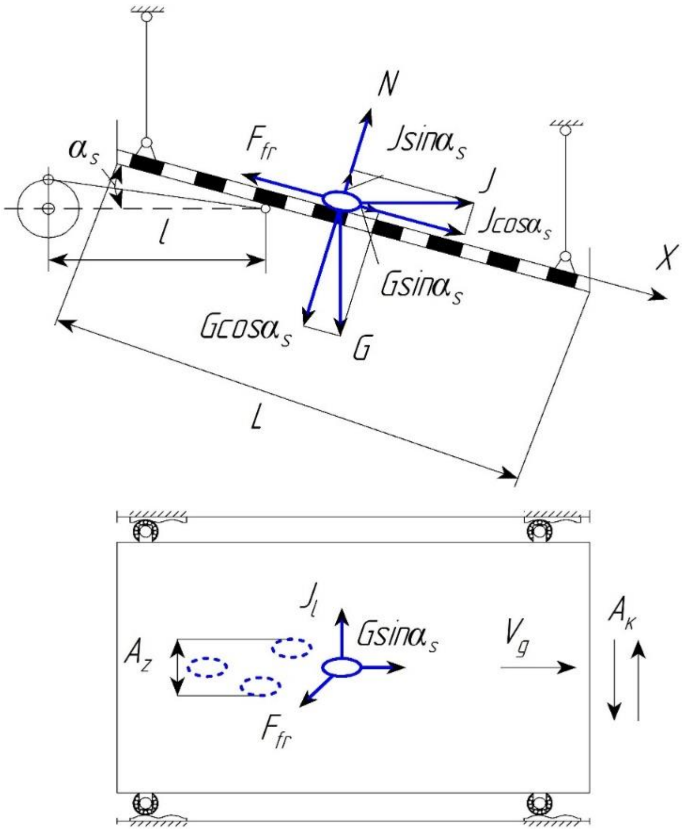


Fig. 3. Scheme of forces influencing on a grain at a sieve

Transverse movement of grain:

$$A_t = \chi A_l \sin\omega t, \quad (4)$$

where A_l – longitudinal amplitude of the sieve oscillations, m; χ – coefficient, considering difference between amplitude of the grain and sieve oscillations, χ=0.8–0.9.

Based on the theoretical research, the grain cleaning machine was theoretically grounded in the longitudinal oscillation of the grain through the holes and separating it from the alien forces. Experimental studies also performed to study the separation of grains from other forces in the longitudinal oscillations. In experiments investigating the effects of different holed sieves on grain cleaning and loss, the slope angle of the sieve is set to 10^o, the frequency of oscillations is 150 rpm, and the amplitude of the oscillations is 20 mm.

In order to study the performance characteristics of the sieve of grain cleaning machine, the experiments were compared with the oscillation frequency of the sieve n_{fr}=140 rpm, sieve longitudinal oscillation amplitude A_l=30 мм, slope angle α_s=14^0 the grain cleaning efficiency was 99.3 % during the experiments and the losses was 0.7 % (Table 1). In the same parameters and operating modes, but with a transverse oscillation of A_t=5 mm, the grain's cleanliness increased partially to 99.5 %, and its losses decreased to more than twice to 0.3 %.

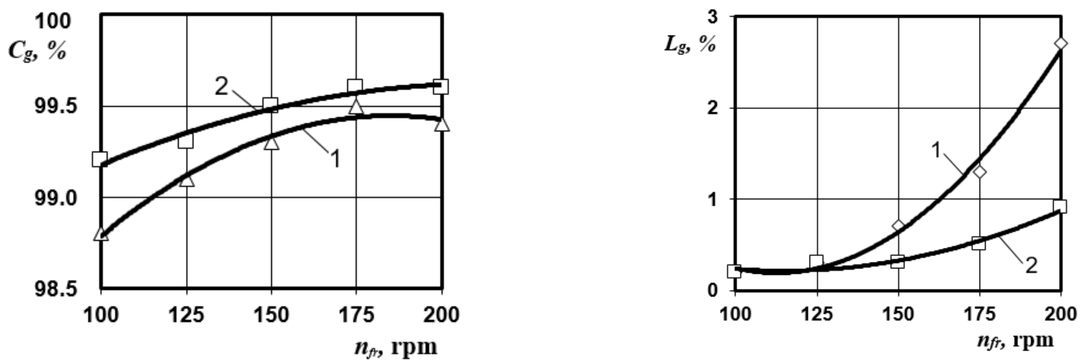
The two types of sieves tested at different oscillation frequencies in order to better study the performance.

Table 2. Work quality indicators of the sieve of grain cleaning machine

Names of indicators	Amount of indicators	
	longitudinal oscillation sieve	longitudinal-transverse oscillation sieve
Grain cleanliness C_g (%)	99.3	99.5
Grain losses L_g (%)	0.7	0.3

In experiments, the frequency of oscillations increased from 100 rpm to 175 rpm, while the grain cleanliness in the longitudinal oscillations increased from 98.8 % to 99.5 %, while the frequency of oscillations increased from 175 rpm to 200 rpm and decreased to 99.4 % (Fig. 4).

When the frequency of the oscillation increased from 175 rpm to 200 rpm, grain cleanliness decreased because of passing the major impurities with together grain through hole of the sieve.



a) grain cleanliness b) grain losses

1- longitudinal oscillation sieve; 2-longitudinal-transverse oscillation sieve.

Fig. 4. Changing of grain cleanliness and losses as depending on oscillation frequency of the sieve

In the longitudinal-transverse oscillation sieve, when the frequency of oscillations increased from 100 rpm to 175 rpm, grain cleanliness increased from 99.2 % to 99.6 %, and the frequency of oscillations increased from 175 rpm to 200 rpm this indicator did not change. In general, grain cleanliness was higher in longitudinal-transverse oscillation sieve than in longitudinal oscillation sieve at all frequencies.

The grain losses was defined too at these oscillations frequency of the sieve. It was the same for the two types of sieve at the frequencies of 100 rpm and 125 rpm it consisted of 0.2 and 0.3 % respectively. When the oscillations frequency increased from 150 rpm to 200 rpm it was observed the significant difference between this indicator of two types of the sieves (Fig. 4).

In particular, at 150 rpm, the grain loss was 0.7 % in the longitudinal oscillations and 0.3% in the longitudinal-transverse oscillations.

This indicator increased at sieve with longitudinal oscillations at frequency 175 rpm and 200 rpm reaching 1.3 and 2.7 %, however the grain losses in the sieve with longitudinal-transverse oscillations was slightly lower, at 0.5 and 0.9 % in these frequencies.

According to the previous experiments, the quality indicators of longitudinal-transverse oscillation sieve on the same loads are 1.2 – 2.3 times higher than the longitudinal oscillation sieve. This is the basis for the development of grain cleaning machines with high work efficiency.

Conclusions

According to the researches, it was defined that the work quality indicators of the longitudinal-transverse oscillation sieve on the same loads are 1.2-2.3 times higher than those of longitudinal oscillation sieve. It is recommended that the oscillations frequency of the longitudinal-transverse sieve to become n_{fr}=140-175, longitudinal oscillations amplitude A_l=30 mm, transverse oscillations amplitude A_t 3-5 mm and slope angle $\alpha_s=14^o$. In these operating parameters of the sieve, it was achieved that the grain losses is not more than 0.5 % and the cleaning efficiency is 99.6 %.

References

1. Craessaerts, G., Saeys, W., Missotten, B., De Baerdemaeker, J. Identification of the cleaning process on combine harvesters. Part I: A fuzzy model for prediction of the material other than grain (MOG) content in the grain bin. Biosystems Engineering. 2008, 101 (1). p. 42-49.
2. Wang, L. Separation and initial cleaning chamber in grain-wheat combine harvester. Transactions of the Chinese Society of Agricultural Engineering. 2011, 42. P. 62-64.
3. Cheli, F., Pinotti, L. Rossi, L., Dell'Orto, V. Effect of milling procedures on mycotoxin distribution in wheat fractions: A review LWT. Food Science and Technology. 2013, 54. p.307-314.
4. Tibola, C.S., Fernandes, J.M., Guarienti,E.M., Nicolau, M. Distribution of Fusarium mycotoxins in wheat milling process. Food Control. 2015, 53. p. 91-95.
5. Astanakulov, K.D., Karimov, Y.Z., Fozilov, G.G. Design of a Grain Cleaning Machine for Small Farms. AMA. Agricultural mechanization in Asia, Africa and Latin America. 2011, 42 (4). p.37-40.