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Results of theoretical and experimental researches about determination the corn seed separator sieve parameters of the corn-thresher machine

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Abstract. For use in Uzbek fields, a novel sort of corn-thresher machine was created and tested. To separate the cornhusks from the pods, the peeler bars were positioned symmetrically on the cornthresher machine's rotor surface. However, around 4-5 percent grain was going out from machine's outlet for pith and husk when the corn thresher was tested experimentally. It was decided to create the sieve in order to save losing grain from outlet. We observed the sieve theoretically to determine the optimal parameters for the corn thresher. The corn thresher machine was equipped with specific grain separator sieve in front of outlet. Some experimental researches were carried out to define optimal parameters of the sieve for developed corn-thresher machine. Minimal amount of grain and impurities in the grain that coming from outlet is ensured during the technological process of the machine. The corn-thresher machine uses the least amount of metal and energy while functioning qualitatively. The corn-thresher machine weighs 400 kg, uses 5 KW of power, and can process 4600 kg of grain per hour in pure time.

1 Introduction

Nowadays, maize, or corn, is one of the valuable plants farmed in many nations. The reason is that corn is a major forage plant used to develop livestock and poultry ranches worldwide [1–5]. In addition, corn is used in a variety of productions for the food industry, medicine, and technical purposes. These include pop corn, canned foods, starch, crystallized sugar, alcohol, and other products [6].

North America is the primary corn-growing region. Archaeologists and botanists have provided clear proof that corn was first cultivated as a cultural plant in the southwest of the United States of America 3024 years ago. First, it was discovered that wild corn existed in

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the Tehuacon Valley in southern Mexico 7024 years ago, and that corn was first cultivated there for cultural purposes 4624 years ago [7]. Nowadays, more than 500 million tons of maize are planted worldwide, with the United States being the world's top producer, accounting for more than 40% of the crop. The Corn Belt, an area in the Midwest that includes Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska, is where the majority of the crop is cultivated. China, Brazil, Mexico, India, Russia, Italy, and other countries with the introduction of new technologies and technical equipment are the other main corn-growing nations [8-14].

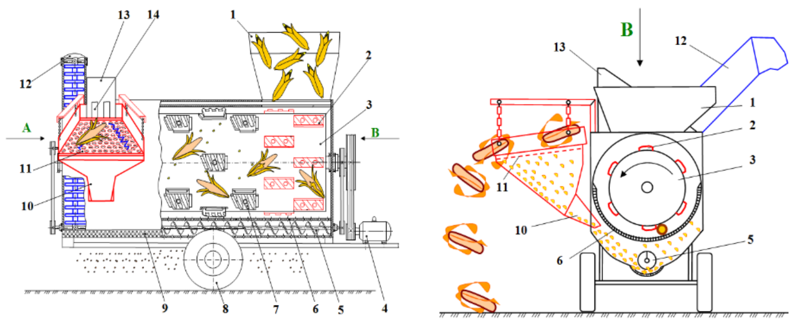
According to Massino A.I. et al. (2010) [15], corn is planted annually in around 31308 hectares in Uzbekistan, along with the other mentioned countries. If we factor in the fact that wheat is planted in vacant land instead of corn, this indication rises to 300 000 hectares. The cultivation of maize for grain is one of the most significant duties. Gathering ripped crops without sacrificing quality is necessary. In particular, labor and material costs will be much reduced if this procedure is carried out with the aid of technical equipment and the automation approach [16–19].

In Uzbekistan, for harvesting the ripped crop of the corn at first the pod-corn is picked, then the husks are peeled by special cornhusk peeler machine or hand-labor, the grains of corn are threshed and separated by the help of corn-thresher machines MKP-3 or BP-6M. For separating corn's grains this using method is being reason to increase labor and material expenses [20].

We paid attention above written problems and we developed the new type of corn-thresher machine for peasant farms and large farms. We planned to substantiate the parameters and modes operations of the sieve, and then we researched theoretically and experimentally.

2 Materials and methods

The corn-thresher machine was developed based on initial requests and technical tasks, as shown by the technological scheme (Figure 1) and experimental sample (Figure 3). The machine's dimensions are as follows: length: 2500 mm; width: 1630 mm; height: 1650 mm.



1-receiving hopper; 2-peeler bar; 3-thresher drum; 4-electric motor; 5-grain auger; 6-concave; 7-rasp bar; 8-wheel; 9-auger tray; 10-gutter; 11-sieve; 12-grain uploader; 13-outlet for pith and husk;14-thrower bar

Fig. 1. The technological scheme of the corn-thresher machine.

The following is how the corn-thresher machine's technological process is carried out: Through receiving bunker 1, the pod-corns are fed to the rotary thresher drum 3, which pulls the pod-corn between concave 6 and drum 3.

Next, using peeler-bar 2, the husk is removed from the pod-corn. Subsequently, the ear-corn is processed by the use of Rasp-Bar Thresher 7. These threshers were mounted onto the drum's outside. 3. The pod-corn is mechanically influenced by the rasp-bar, which threshes it along its axis. Subsequently, the grains undergo threshing and are separated by concave apertures 6, with the separated grains landing on the auger 5.

The auger then advances the grain in the direction of uploader 12. Grain is unloaded onto a transport vehicle or placed in sacks. Through thrower bar 14, the separated cob and husks that were coupled with a little amount of unseparated grains emerge collectively from outlet 13. They reach the sieve 11's surface.

On the auger, the separated grains pass through a sieve-gutter ten times more. 5. When grain is delivered to grain uploader 12, it is either unloaded into sacks or placed on a transport truck. Through the auger tray's opening, smaller combinations than grain fall to the ground. 9. The corn-thresher machine is driven by either the tractor's cardan shaft or electric motor 4.

The laws of mathematics, physics, and theoretical mechanics were followed when doing theoretical study. Experiments were put to the test numerous times; the impact on grain damage, cleanliness, and thoroughness of threshing as well as the modes of operation of the corn-thresher machine were all learned. Every experiment involved feeding 10 kg of pod corn into a corn-thresher machine.

3 Results and discussions

3.1 Theoretical research

3.1.1 Parameters of the sieve device that separates the grains from the core and the husk

According to existing studies, following has to be fulfilled in order for the movement of the grain mixture on the surface of the sieve [21-23]

$$g\, sin\, \alpha_s + \omega_c^2 r\, cos\, \omega_c\, t\, cos\, \alpha_s > f(g\, cos\, \alpha_s - \omega_c^2 r\, cos\, \omega_c\, t\, sin\, \alpha_s), \quad (1)$$

where ω_c – angular speed of the sieve's crank, rad/s; r – radius of crank, м; α_s – sieve slope angle, degree; f – the coefficient of friction of the grains to the sieve material; t – time, s.

This inequality is satisfied in the time interval $t = (0;\ t_r)$ an $2r = A_V$, amplitude of swingions in flat-surfaced beams A_V, frequency of swingings ω_c and slope angle α_s the following inequality is obtained, which represents the relationship between

$$A_V \geq \frac{2g(f\, cos\, \alpha_s - \sin\alpha_s)}{\omega_c^2(cos\, \alpha_s + \mathrm{f}\sin\alpha_s)}\,. \quad (2)$$

Mathematical analysis of this expression shows that this condition is fulfilled in the expression $\mathrm{f}\cos\alpha_s - \sin\alpha_s > 0$ the condition must be met. And for that $f - tg\alpha_s > 0$ or $\mathrm{tg}\,\alpha_s < \mathrm{f} = \mathrm{tg}\,\alpha_{\mathrm{fric.}}$ and finally, it follows that the grain's slope angle ought to be less than the friction angle of the grain mixture, namely.

$$\alpha_s < \alpha_{fric.}, \quad (3)$$

where $\alpha_{fric.}$ – grain friction angle, degrees.

Considering that the maize grain's angle of friction is 14-21^0, the angle of inclination of the halyard should be less than 14 degrees.

The number of swingings of sieve will be equal to the following

$$n = \frac{30}{\pi}\sqrt{\frac{2g(f\cos\alpha_S - \sin\alpha_S)}{A_V(\cos\alpha_S + f\sin\alpha_S)}}. \quad (4)$$

According to the expressions (2), (3) and (4) above, in order to ensure good separation of the grains during the movement of the mixture in the sieve device, the amplitude of the sieve swingion is 20-50 mm, the number of swingions is in the range of 150-300 min^{-1}, and the angle of inclination should be less than 14°.

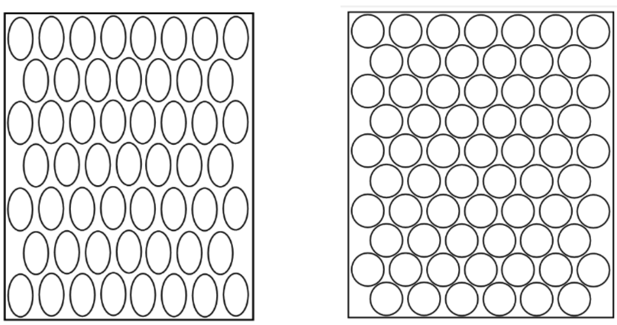


Fig. 2. Two types schematic views of researched sieve of the corn-thresher machine.

The coefficient of the useful working surface in the elliptical (5) and round (6) shaped eyes of the sieve (Figure 2) is as follows:

$$\mu = 0{,}25\frac{N_{\text{N.E}}\cdot\pi\cdot l_g\cdot e_g}{B_S\cdot L_S} \quad (5)$$

$$\mu = \frac{N_{N.E}\cdot\left(\frac{\pi\cdot D_E^2}{4}\right)}{B_S\cdot L_S} \quad (6)$$

where $N_{N.E}$ – the number of all eyes in the sieve, pcs; l_g – grain length, m; e_g – grain width, m;
B_s – the width of the sieve, m; L_s – the length of the sieve, m; D_E – the diameter of the eye of the sieve, m.

Calculations based on these expressions showed that the coefficient of the useful area of the sieve depends on the number of its eyes, the diameter of the holes, and the width and height of the sieve, at $N_{N.E}$ = 273 pcs; l_g = 15 mm, e_g = 8,7 mm, B_s = 350 mm, L_s = 460 mm; D_E = 15 mm; B_s = 350 mm; L_s = 460 mm values coefficient of useful working surface of the sieve was found to be equal when its eyes are ellipsoidal in shape μ = 0,17, and when it is circular μ = 0,3. Accordingly, it was considered acceptable that the eyes of the sieve device should be circular in shape.

3.2 Experimental research

3.2.1 The impact of sieve swinging number on work quality metrics

After preparing and installing a sieve swinging device in front of the core and husk outlet of the corn thresher, the effect of the number of swinging on the amount of grain coming out of the core and husk was studied (Figure 3).

Fig. 3. Experimental sample and testing process of sieve of the corn-thresher machine.

3.2.2 Choosing the shape and size of the sieve eyes for the corn thresher

In the trials carried out to investigate how various mesh sieves affect the quantity of grain coming out of the core and husk, the angle of inclination of the sieve was 10^0, the number of swingings was 200 min^{-1}, and the amplitude of swingings was 20 mm.

At the beginning of the experiment, in order to separate the grain coming out of the core and the husk, a circular sieve with a diameter of 9 mm, 12 mm and 15 mm and an elliptical sieve with a size of 9x15 mm were installed and compared (Table 1).

Table 1. The influence of the type of sieve's eyes on work quality indicators.

The type and size of sieve eyes	Completeness of separation of grains from core and husk, %	Grain loss, %
Ø 9 mm	98.9	1.1
Ø 12 mm	99.4	0.6
Ø 15 mm	99.5	0.5
⬭ 9x15 mm	98.8	1.2

The results showed that the completeness of separation of grains from the core and husk was 98.9, 99.4 and 99.5 percent respectively, and 98.8 percent in ellipse-eyed grain, the separation of grain from the core and husk was the highest when the diameter of the grain was 15 mm, that is, the amount of grains combined with the core and husk was 0.5 percent.

4 Conclusion

According to theoretical and experimental researches, it was found that calculations based on these expressions showed that, the coefficient of the useful area of the sieve depends on the number of its eyes. Also, the diameter of the holes and the width and height of the sieve were equal at $N_{N.E}$ = 273 pcs; l_g = 15 mm, e_g = 8,7 mm, B_s = 350 mm, L_s = 460 mm; D_E = 15 mm; B_s = 350 mm; L_s = 460 mm. Values coefficient of useful working surface of the sieve was found to be equal when its eyes are ellipsoidal in shape μ = 0,17, and when it is circular μ = 0,3. Accordingly, it was considered acceptable that the eyes of the sieve device should be circular in shape. In addition, the specified optimal parameters and operating modes of the developed corn thresher device, the output grain is 0.46 percent, and the amount of impurities in the grain is around 0.5 percent. In the developed corn thresher device sieve, the number of swinging of the sieve is 230 min^{-1}, the amplitude of swingions is 20 mm, the angle of inclination is 50, and the diameter of the sieve eyes is 11 mm.

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