Experimental registrations of plain sieve operation, making transverse fluctuations

U K Sabiev, E V Demchuk, A Yu Golovin and I V Skysanov

Omsk State Agrarian University named after P.A. Stolypin, Omsk, Russia

Abstract. Possible methods of attachments improvement of grain cleaning machines by means of mobilization factors, influencing direct on qualitative and quantitative separation are represented. Graphical dependences of grain separation completeness from the parameters of sieve vibration for different values of specific loads are also given. Basic relationships intensified the separation process of grain on the sieve, making transverse fluctuations has been detected according to the classical experiment results, as well as the influence of more important factors by the results of sieving experiment on separation completeness as on optimization criteria. The range vibrations of significant factors is also proved.

1. Introduction

Grain production is the basis of stable development of agricultural sector. The most resource-intensive process in all technological production chain is post harvest treatment. The aim of post harvest treatment is to obtain seed, productive and feed grains, corresponding to the requirements provided for standards.

Feed grain can be processed into compound feed, developing own feed production, which enables to reduce costs for purchase of raw material and its transportation. It provides profitable conducting of livestock breeding [1]. In order to provide the population with food it is necessary to get seed and productive grain.

Qualitative and quantitative conservation of grain depends upon providing enterprises of agroindustrial complex with modern equipment for post harvest treatment, its technical level and efficient usage. Foreign grain cleaning machines of different makes are recommended good enough itself at farm commodity producers but not every farm can buy these machines because of the cost level for foreign technique and others connected with its maintenance and at present days it is impossible to buy foreign machines.

Post harvest treatment of grain is carried out by current grain cleaning lines where all grain passes through after combine harvesting. Characteristics of harvested grain lots are greatly influenced on the quality of grain cleaning machines operation. That is why agricultural enterprises of our country need innovative grain cleaning machines for post harvest treatment of grain. It is the main problem in the conditions of the Western Siberia with high moisture of grain during post harvest treatment.

Carried-out review and analyses of literature show that at present in creation of new grain cleaning methods, there are not any cardinal changes to the best in developments of progressive attachment of grain cleaning machines.

The most widespread separate elements for grain cleaning are penetrative sieves with rectangular openings separating the seeds on thickness. These sieves have greater values of specific productiveness than the sieves with round openings.

R. Aguirre [2] studied the problems of increasing efficient separation of grain on plain sieves in the result of the whole complex variation of kinematic parameters for the sieves making harmonious fluctuations. However they have essential disadvantages. Existing sieves and kinematics of motions don't promote the orientation of grain mixture particles with regard to openings. The sieve in the machine operates as vibroconveyor. But the fluctuations of cleaning shoes are accompanied by
considerable dynamic loads caused the increasing frame vibration and as a result the reduction of reliability grain cleaning aggregate.

2. Problem definition
Scientific researches on post harvest treatment of grain are carried out in the agroengineering department of the Omsky SAU. It is suggested to intensify the grain separation without increasing outline dimension of attachments by means of mobilization factors direct influencing on qualitative and quantitative operations of separative attachments of the grain cleaning machines. Constructive solutions on sieve separators improvement and researches of rational kinematic regimes of cleaning shoes operations are related to these factors. Especially perspective suggestions permitted to obtain essential effect not only under conditions of new machines creation, but can be used for intensification of cleaning process and grain separation on serial grain cleaning machines. One variant of increasing fractional, plain sieve grain cleaning machine productiveness by usage the sieves with rectangular openings located under an optimal angle towards its motion is suggested in this work [3]. It is established that it allows to increase the possibility of particle pass in opening in 1.7 times under angle of opening edge arrangement 20°. Productive check of sieves operation suggested by construction showed the increasing of productiveness on 23% in comparison with serial analog.

There are another methods influencing on separation intensification process, for example, complication of fluctuations law of plain sieves according to different trajectory [4,5].

Sieves of grain cleaning machines located in such a way that the direction of sieve long cross points match with fluctuations direction and perpendicular to the direction of grain movement are of great interest. Search experiences are carried out according to the classical plan with the aim to define the arrangement range of the main factors, influencing on technological process. Experimental researches of the plain sieve operation results making transverse fluctuations are carried out on modernized laboratory arrangement in two stages.

Classical experiment is done during the first stage. Its aim is to detect the area regimes of the sieve transverse fluctuations intensified the grain separation process and to define the frontier lines and the content of the planned experiment. Usage of classical experiment for these purposes are distinguished from planned search methods (steepest ascent method, gradient method and others) are justified because every value of specific load on the sieve corresponds the definite optimal value of the sieve acceleration. Using transverse fluctuations of the sieve we change in a great range of acceleration and for wide range of specific load values, extremums of the response function it is very difficult to seek for every fixed values of delivery.

According to the results of sieving experiments of plain sieve operation making transverse fluctuations, statistic significants on Student’s criteria on the 5% level are the following factors: specific load on the sieve, angle of sieve forward pitch to the level and fluctuations parameters of the sieve (amplitude and frequency).

Variable arranged parameters (factors) according to the sieving experiment are as follows:
- specific load on unit area of the sieve (G) has been changed in limits 0,335...1,34 kg/(m² • c), that corresponds to the regimes of the grain cleaning machines operation;
- angle of sieve forward pitch α has been changed from 8° to 16°. Essential increasing of this parameter in comparison with serial machines is explained by necessity to increase (compensations) of medium rate of material movement on sieve surface because under forward travels of cleaning shoe, fluctuations help this process, taking into account that there movement corresponds to material movement;
- frequency of fluctuations n has been changed in limits from 300 to 500 min⁻¹;
- amplitude equals 7,5 • 10⁻³ m, that corresponds to fluctuations regime of plain sieves of home machines of initial and secondary cleaning CM-4 and MC-4,5.

Completeness of separation has been calculated according to the standard method. Obtained meanings were statistically treated and systematized.
The dependences of qualitative indicator of sieve operation from variable parameters of experience are built-up according to the experiments results.

3. The results of experiments
The dependences of completeness separation from regimes parameters of sieve transverse fluctuations, particularly from the angle of sieve forward pitch for different value meanings of specific load are obtained in the result of the first stage of classical experiment (figures 1…3).

**Figure 1.** The dependence of completeness separation from the angle of sieve forward pitch for value of specific load (◊ – 0,335; □ – 0,838; Δ – 1,34) kg/(m² • c) if n = 300 min⁻¹.

**Figure 2.** The dependence of completeness separation from the angle of sieve forward pitch for value of specific load (◊ – 0,335; □ – 0,838; Δ – 1,34) kg/(m² • c) if n = 400 min⁻¹.

**Figure 3.** The dependence of completeness separation from the angle of sieve forward pitch for value of specific load (◊ – 0,335; □ – 0,838; Δ – 1,34) kg/(m² • c) if n = 500 min⁻¹.

From analyses of figures 1-3 we can see:
1. Under increasing of the angle of sieve forward pitch α, value of completeness separation ε is increased for all regimes of specific load on the sieve. And with subsequent increasing α, completeness separation begins to reduce, it can be caused by influence of this angle on the movement rate of grain material on the sieve and by excess of maximum rate, after that cleaning is not so
effective. Under increasing rate characteristics of grain material the cleaning regimes changes into the stage of movement with separation from sieve surface. At the same time the particles are orientated transverse with regard to the direction of descent of grain flow from the sieve.

2. Increasing frequency $n$ completeness separation is increased and explained that any value of specific load on the sieve corresponds its own rate value. It is clear from told; the more the specific load value on the sieve, the more acceleration value must be. That just achieved by increasing $n$.

3. The influence of angle sieve forward pitch is reduced with the growth of specific load. According to the figures 1.1…1.3 we can see that completeness separation under specific load $G = 1,34 \text{ kg/(m}^2 \cdot \text{c})$ with the change of angle sieve forward pitch is changed less than under specific loads $G = 0,335...0,838 \text{ kg/(m}^2 \cdot \text{c})$. It is explained by considerable grain layer on the sieve under heavy load, that increase two-three thickness of wheat grain. Only lower grain layer which is located directly on the sieve surface connects with the sieve and its openings. Thus we draw conclusion that this sieve is used more effectively for leading grain material to the basic conditions.

We conducted experiments with variation of radius eccentric value, generating the reciprocating motion of cleaning shoe for investigation of fluctuations amplitudes influence of the sieve fluctuations on completeness separation. At the same time for shortage the number of experiences it was taken into consideration to eliminate following established regimes, more perspective completeness separation value.

As value of specific load $G = 1,34 \text{ kg/(m}^2 \cdot \text{c})$ in series of experiments increase completeness separation it was decided not to use it. Frequency of the sieve fluctuations during next series of experiments has been fixed on the level of 500 min$^{-1}$. The fluctuations amplitude varies on the following levels $(7,5; 8,1; 8,7; 9,3; 9,9) \cdot 10^{-3} \text{ m}$. The dependences $\varepsilon = f(R)$, shown in the figures 4…6 are obtained in the results of experiments.

**Figure 4.** The dependence of completeness separation from the fluctuations amplitude for angle of forward pitch $\alpha = 10^\circ$, value of specific loads: (◊ – 0,335; □– 0,838) kg/(m$^2$ · c).

**Figure 5.** The dependence of completeness separation from the fluctuations amplitude for angle of forward pitch $\alpha = 12^\circ$, value of specific loads: (◊ – 0,335; □– 0,838) kg/(m$^2$ · c).
Figure 6. The dependence of completeness separation from the fluctuations amplitude for angle of forward pitch $\alpha = 14^\circ$, value of specific loads: (◊– 0,335; □– 0,838) kg/(m² • c).

From the analysis of figures 4...6 it is possible to reveal the following

1. At increase of amplitude fluctuations of sieve the completeness of separation increases too, and for the size of specific load $G = 0,838$ kg/(m² • c) its influence is more expressed. Also as well as in case with change of frequency fluctuations it is possible to explain with the fact that to any value of specific load on the sieve corresponds the value of acceleration. And acceleration of the sieve is in direct ratio to amplitude of its fluctuations. In addition it is possible to note that at the value of specific load $G=0,838$ kg/(m² • c) the completeness of separation changes in big limits, then at $G=0,335$ kg/(m² • c). The conditions under which mixing processes in grain mass proceed quicker are created at increase of fluctuations amplitude on this mode, larger impurities rise upward and small impurities fall to a lower layer. It leads to their faster allocation from the grain lots. In a case when specific load on the sieve is 0,335 kg/(m² • c), the thickness of grain layer on it is rather small and increase of fluctuations amplitude leads to slight increase of completeness of separation.

2. Increase of forward pitch angle of the sieve increases completeness of separation and it reaches the maximum value at the modes which are shown in the figure 4.6. Increase $\alpha$ in our case increases the resultant rate of grain flow on the sieve, from this we can draw the conclusion that with increase of grain flow rate the completeness of separation increases too. And we compensate by increase of rate that increased way of grain material on the sieve which takes place at transverse vibrations. Respectively, the motion rate of grain material on the sieve remains former at increase of separation completeness.

3. At value of fluctuations amplitude $(8,75...9,5) \cdot 10^{-3}$ some stagnation of separation completeness at the certain level is observed. It is obvious that in this case, grain motion rate on the sieve comes nearer to limit at which process of separation stops. Further increase of fluctuations amplitude will negatively affect the value of separation completeness and increase in cleaning shoe imbalance and all grain cleaning machine.

4. Conclusions

1. On the results of classical experiment the main patterns intensifying process of separation of grain on the sieve making transverse vibrations and also influence of the most significant factors by results of the sieving experiment on completeness of separation as on criteria of optimization are revealed.

2. The variation range of following factors: for the value of specific load ($G$) – 0,335...0,838 kg/(m² • c); angle of forward pitch of the sieve ($\alpha$) – 10...16°; amplitude of sieve fluctuations ($R$) - $(7,25...9,25) \cdot 10^{-3}$ m; frequency of sieve fluctuations ($n$) – 450...550 min$^{-1}$ has been proved.
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