Researching the parameters sieve of the safflower seed cleaner machine

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Abstract: Sowing areas of oilseeds (sunflower, safflower, soybean, etc.) are expanding in Uzbekistan. Crops of these plants are harvested by existing grain harvesters. Grain material collected in bunker of the combine is grain mixture of the main culture, other plants and impurities of heterogeneous litter of mineral and organic origin. A small-sized machine has been developed for cleaning oilseeds from weed impurities at Research Institute of Agricultural Mechanization. Differential equations are obtained that describe the oscillatory motion of the sieve of its speed and acceleration. Based on results of decision obtained  equations, influence graphs number of vibrations, angle of inclination and amplitude of sieve vibrations on length movement of the seed material on its surface over period of time crank rotations are constructed. The rational parameters of sieve are substantiated, an angle of inclination-10°, number of oscillations-300 rpm, amplitude of oscillations-7.5 mm.

1. Introduction

Safflower is one of the important types of oil seed crops with sunflower, soybean and that usually grown in rain fed lands [1]. Valuable oil is extracted from safflower seeds, and the straw after grinding is used as roughage for animals [2]. Currently, harvesting of oil crops such as sunflower, safflower, soybeans and wheat that are grown in agricultural clusters and farms is carried out by combine harvesters “Case-2166”, “Dominator-130”, “New Holland TS-5060” and “Vector” in condition of Uzbekistan [3-6]. In bunker of the combine along with clean seeds falls impurities consisting of small brushwood, dry leaves and small particles of soil. In composition of such a mixture, the proportion of impurities is more than 2 per cent, seed moisture is more than 13 per cent, and i.e., they exceed permissible norms.

Due to rainfed areas, except oil crops, weed plants such as small-fruited cousin, saltbush, camel thorn and others grow and ripen. The part of such plants is 8–13%, of which 2–3% are light impurities. When processing weed mixtures in creameries, the percentage of oil yield from seeds decreases, its taste deteriorates, and other quality indicators deteriorate.

Therefore, it is required cleaning and drying seed mixture before processing [7-10]. In practice, there are various methods and machines for cleaning wheat and other grain crops [11-18]. Unfortunately, due to lack of seed cleaning machines for safflower at farms and household plots, such work is done manually.

In order to eliminate these shortcomings, Scientific-Research Institute of Agricultural Mechanization has created a small-sized mobile machine for cleaning oilseeds from impurities in conditions of farms [1]. Flat sieves of this machine oscillating movement under action of a crank mechanism. Theoretical and innovative research is underway to optimize parameters and increase the efficiency of this machine.
2. Materials and Methods
Primary materials are oilseeds and impurities, consisting of small particles of weeds and soil. The development was carried out on the basis of methods of higher mathematics and theoretical mechanics. In method of mathematical theory, numerical method Runge-Kutta-Feldberg was used, and a program was developed in accordance with algorithm for finding the solution \( n_{\text{sw}}, A_{\text{sw}}, \alpha_{\text{sw}}, s_{\text{sw}}, v_0 \), slip \( s \) and slip velocity of seed mixture at different values of input parameters were counted.

The results of the calculations showed that although movement of the seed mixture on sieve is unstable at initial times, but in a short time the process stabilizes and particle (seed or its mixture) moves less backwards and more forward, and this is periodically repeated.

We introduced two criteria to evaluate the process:
1. \( v_{\text{ave}} \) – average velocity of the particle, m/s;
2. \( v_{\text{eff}} \) – at velocities below the limit velocity of the particle rate of absolute displacement at moving times or effective velocity of the particle, m/s.

According to the first criterion, if average velocity of the particle is \( v_{\text{ave}} \) low, due to the fact that the mixture stays on the surface of the sieve for a long time, large compounds along with the seed pass through the sieve in large quantities and the efficiency of the sieve is low.

If the average velocity \( v_{\text{ave}} \) of the particle is high, the mixture will move rapidly on the surface of the sieve and the seeds will be released into the waste.

According to the second criterion, if the effective velocity of the particle, ie the velocity of the sieve \( v_{\text{eff}} \) is low, it becomes difficult for it to pass through sieve, and the seeds are observed in the waste.

3. Results and discussion
We accept the following assumptions:
1) movement of grain layer element is considered as the motion of material particle;
2) resistance force to displacement of layer element along sieve surface is taken equal to the friction force;
3) resistance of air to layer movement is neglected;
4) It is believed that sieve, and with material point, perform harmonic vibrations. The equation of oscillatory motion of any point of sieve, installed at an angle \( \alpha \) to the horizon (figure 1):

\[
X = A - A \cos\left(\frac{2\pi}{T} t + \varphi\right)
\]  

(1)

where \( A \) – is oscillation amplitude of sieve, m; \( T \) – oscillation period, s; \( T=60/w \); \( w \) – is number of oscillations, rpm; \( \varphi \) – is the phase of oscillations (It varies between 0-2\( \pi \)).

Figure 1. Scheme of oscillatory motion of sieve

The values of sieve point displacements according to (1):
Movement diagram corresponding to these values is shown in (figure 2)

![Movement Diagram](image)

**Figure 2.** Oscillatory motion schedule of sieve

Differentiating (1), we obtain the expression for sieve velocity:

\[
\dot{X} = -A[-\sin(\frac{2\pi}{T} t + \varphi)] \frac{2\pi}{T} \cos(\frac{2\pi}{T} t + \varphi)
\]

Differentiating this expression, we determine the sieve acceleration:

\[
\ddot{X} = \frac{2\pi A}{T} \cos(\frac{2\pi}{T} t + \varphi) \frac{2\pi}{T} \cos(\frac{2\pi}{T} t + \varphi) = \frac{4\pi^2 A}{T^2} \cos(\frac{2\pi}{T} t + \varphi)
\]

Following forces act on a material particle lying on surface of a sieve, performing harmonic vibrations: \(mg\) – grain weight; \(F_i\) – portable inertia force; \(N\) – normal reaction of sieve; \(F\) – friction force (Figure 3)
Formulas for determining the inertia forces and resistance:

\[ F_i = -m\ddot{x} = -m\frac{4\pi^2 A}{T^2}\cos\left(\frac{2\pi}{T}t + \phi\right), \]

\[ F = \pm fN = \pm fm g \cos \alpha, \]

where \( m \) – the particle mass, kg; \( f \) – particle friction coefficient over the surface of sieve; \( g \) – acceleration of gravity, m/s^2.

The differential equation of a particle relative motion on surface of sieve with acceleration \( S \):

\[ m\ddot{S} = F_i + mg \sin \alpha - F = -m\frac{4\pi^2 A}{T^2}\cos\left(\frac{2\pi}{T}t + \phi\right) + mg \sin \alpha \pm fm g \cos \alpha \]

or

\[ \ddot{S} = -\frac{4\pi^2 A}{T^2}\cos\left(\frac{2\pi}{T}t + \phi\right) + g \sin \alpha \pm f \cos \alpha. \]  \tag{2}

Integrating expression (2), one can determine the particle displacement over distance \( S \) and corresponding velocity \( \dot{S} \). At \( \dot{S} < 0 \) in expression (2) take the sign “+”, and at \( \dot{S} > 0 \) the sign “-”.

Initial conditions of differential equation (2): \( S(0) = S_0, \dot{S}(0) = \dot{S}_0 \), Where \( S_0 \) - the initial coordinate of the particle on sieve surface, m; \( \dot{S}_0 \) - initial particle velocity, m/s.

The solution of equation (2) was sought using the numerical Runge-Kutta method. Calculated values of displacements \( S \) particles in the time range were determined \( t = \phi/w = 0 - 2 \) sec of the sieve crank turn in various input parameters \( w, A, \phi, \alpha, S_0, \dot{S}_0 \) (figure 4).

From the graphs shown in Figures 4, 5, 6 it can be seen that with increasing movement time \( t \), the number of oscillations \( w \), the angle of inclination \( \alpha \), and the amplitude of oscillations \( A \), the displacements \( S \) of the grain mixture along sieve surface will increase.
Figure 4. Graphs influence number of oscillations \( (w) \) of the sieve \((1, 2, 3)\) on length \((S)\) of the seeds movement on surface of sieve in time \(t\): 1 - \( w = 250 \text{ rpm} \), 2 - \( w = 300 \text{ min}^{-1} \), 3 - \( w = 350 \text{ min}^{-1} \)

The calculations showed the increase in degree of grain purification from impurities with number of sieve vibrations \( w = 300 \text{ rpm} \), oscillations amplitude \( A = 7.5 \text{ mm} \), sieve angle \( \alpha = 10^\circ \), at the starting point \( S_0 = 0.05 \text{ m} \) and speed \( \dot{S} = 0.5 \text{ m/s} \) hit of the mixture on sieve surface. At \( w = 250 \text{ rpm} \), \( \alpha = 5^\circ \) and \( A = 5 \text{ mm} \) the quality of seed cleaning decreases, and at values \( w = 350 \text{ rpm} \), \( \alpha = 15^\circ \) and \( A = 10 \text{ mm} \) the probability of some particles escaping from sieve surface increases.

4. Conclusions

Rational parameters that ensure high-quality cleaning of seeds from weedy impurities moving along the surface of an oscillating sieve: an inclination angle of \( 10^\circ \), the number of oscillations of 300 rpm and oscillations amplitude of 7.5 mm.

Delivery of seed mixture corresponding to designated yield of the first cleaning machine for oilseeds is achieved when the width of the seed drill is 600 mm and the number of revolutions is 230 min\(^{-1}\) and the width is 1000 mm and the number of revolutions is 140 rpm.

Qualitative separation of seeds in the sieve is ensured when number of oscillations is 300 rpm, amplitude of vibrations is 7.5 mm, angle of inclination is 12, starting point of the mixture in sieve is 0.5 m/s.

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