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Enhancing the Operation of The Ginning Machine Chamber to Improve Efficiency

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Abstract: In this work, a mathematical model of the pulsating forces acting on the working chamber of a cotton-cleaning machine was developed and analyzed. It was demonstrated that maximum productivity is achieved by installing triangular accelerators at a 60° angle, which eliminates sequential impulses and prevents unnecessary collisions.

Keywords: Ginning machine, accelerator, efficiency, mathematical model.

Introduction: "In order to prevent the raw material from accumulating in the middle of the working chamber of the saw gin, triangular, rectangular and pentagonal separators are installed inside the working chamber, which serve to reduce the density of the cotton gin in the working chamber. In addition, separators of various shapes are installed, which allow the separated seeds to come out as a result of the impact of the cotton gin on the surface of these separators. This serves to evenly separate the seeds from the cotton gin in the working chamber. As a result of theoretical analysis of this process, the issue of ensuring the uniformity of the density of the cotton gin was considered.

The directions of external forces acting on the cotton ball in the working chamber are given - the weight of the cotton ball, $P = m \cdot g$ $\quad F_{el} = \mu \cdot (\vartheta \cdot t - \breve{S})$- the elastic force of the accelerator acting on the cotton ball, where: - the coefficient of elasticity between the cotton ball.μ

$F_{ishq} = f\left(\frac{m \cdot \vartheta_1{}^2}{R} + m \cdot g\right)$-the friction force generated by the cotton ball on the surface of the working chamber

here: $\frac{m\cdot\vartheta_1{}^2}{R}$ centrifugal force; – coefficient of friction.f

We analyze the state of a piece of cotton moving along an arc in a working chamber under the influence of external forces. The differential equation of motion resulting from the action of a straightener-accelerator on the piece of cotton is expressed as follows$A\breve{B} = \breve{S}\breve{S} = R \cdot \phi_1$

$$m \cdot R \cdot \ddot{\phi}_1 = \bar{F}_{эл} + P - \bar{F}_{иш} \quad (1)$$

(1) We form the equation using the external forces acting on the cotton ball in the working chamber above

$$m \cdot R \cdot \ddot{\phi}_1 = \mu\left(\vartheta \cdot t - \breve{S}\right) + m \cdot g - \frac{f\cdot m\cdot\vartheta_1{}^2}{R} \quad (2)$$

Since in equation (2) and$\breve{S} = R \cdot \phi_1 \vartheta = \omega \cdot R = \dot{\phi}_1 \cdot R$

$$m \cdot R \cdot \ddot{\phi}_1 = \mu \cdot m \cdot R \cdot \dot{\phi}_1{}^2{}_2 + m \cdot g - \frac{f\cdot m\cdot\vartheta_1{}^2}{R} \quad (3)$$

Equation (3) is integrated under the following initial conditions. If the working chamber is a circular segment on the surface, equation (3) is integrated up to the moment, where is determined from the condition

$$\phi_1(0) = 0\dot{\phi}_1(0) = 0\dot{\phi}_1 \cdot Rt = t_0\phi_1(t_0) = \phi$$

$$\ddot{\phi}_1 - \frac{\mu\cdot t}{m} \cdot \dot{\phi}_1 + \frac{\mu}{m} \cdot \phi_1 = \frac{g}{R} - \frac{f\cdot\vartheta_1{}^2}{R^2} \quad (4)$$

By introducing definitions into equation (4), we obtain a differential equation, $n = -\frac{\mu\cdot t}{2\cdot m} k = \sqrt{\frac{\mu}{m}}$

$$\ddot{\phi}_1 + n \cdot \dot{\phi}_1 + k^2 \cdot \phi_1 = 0 \quad (5)$$

We define the solution of the homogeneous equation (5) as follows$\phi_1 = e^{\lambda\cdot t}$

$$\lambda^2 + n \cdot \lambda + k^2 = 0 \quad (6)$$

This means that from the definition and when the solution to equation (5) is as follows$\lambda_{1/2} = -n \pm \sqrt{n^2 - k^2} k_1 = \sqrt{n^2 - k^2} n < k$

$$\phi_1 = e^{-n\cdot t} \cdot (C_1 \cdot sin(k_1 \cdot t) + C_2 \cdot cos(k_1 \cdot t)) \quad (7)$$

We define the initial and boundary values of the constant values S1 and S2 in expression

$$\phi(0) = \phi_0; \dot{\phi}(0) = 0 \quad (8).$$

$$\dot{\phi}_1 = -n \cdot e^{-n\cdot t} \cdot (C_1 \cdot sin(k_1 \cdot t) + C_2 \cdot cos(k_1 \cdot t)) + e^{-n\cdot t} \cdot (C_1 \cdot k_1 \cdot cos(k_1 \cdot t) - C_2 \cdot k_1 \cdot sin(k_1 \cdot t)) \quad (9)$$

Using the initial conditions above, we substitute these values into equation

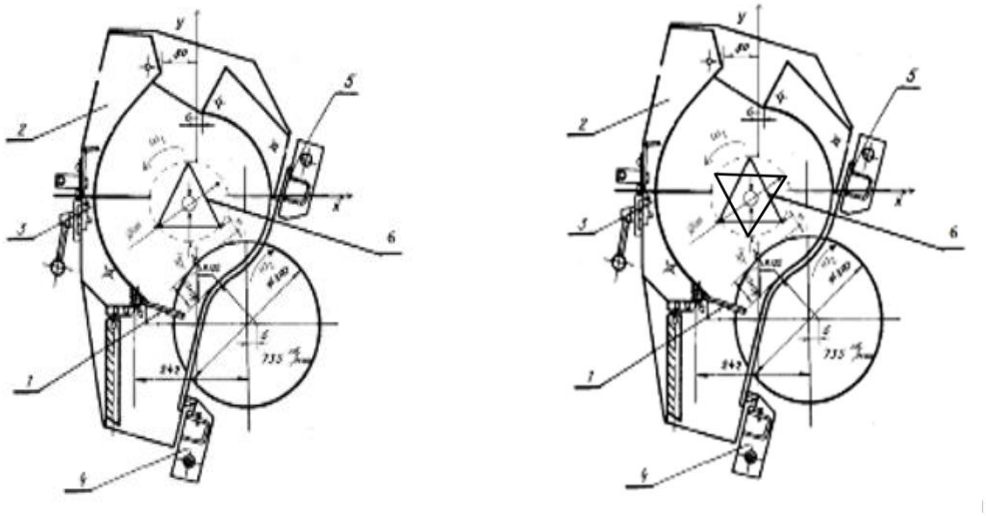
$$C_1 = -\frac{\phi_0}{k_1},\ C_2 = \phi_0 \quad (10).$$

$$\phi_1 = e^{-n\cdot t} \cdot (-\frac{\phi_0}{k_1} \cdot sin(k_1 \cdot t) + \phi_0 \cdot cos(k_1 \cdot t))$$

$$L_1 = R \cdot \phi_1 \quad (11)$$

The results of the calculation of the motion of the accelerator along the AB arc during the transfer of the cotton piece, the analysis of the effect of the various geometric shapes of the accelerators installed in the working chamber on the cotton piece, are presented in graphs in terms of rotation angles - coverage angles in terms of eliminating jams of cotton pieces in the working chamber [1-4].$\phi_1 \phi$

The cotton pieces are separated by the time of changing the angle, preventing clogging in the working chamber. If the laws of motion of cotton pieces are known, the efficiency of separating seeds from them can be determined.



a) evenly **b) 60ohWith C**

1-seed comb; 2-front apron; 3-lower apron; 4-lower beam;
5-upper beam; 6-straightener-accelerators

Figure 1. Scheme of the movement of various accelerators installed in the working chamber of a sawmill.

The graphs above show the trajectories of the effects of various geometric shapes of accelerators installed in the working chamber on a piece of cotton. The graphs also analyze the dependence of the spread of a piece of cotton on the angle of coverage without changing its density along the arc AB during uniform transfer.

Formalization: impulsive field

If the worker is in the cell*N*If two accelerators are placed and their angles with respect to the center are

ϑi= iθ, *I*= 0,1,...,N − 1,

The total impulsive force is divided by the method

$$F(t) = \sum_{i=0}^{N-1} F_0\,\delta(\omega t - \theta_i)$$,

hereF_0— elastic impulse amplitude of each accelerator,ω— rotor bur speed.

Insertion into a differential equation

From the basic equation (1)–(3):

$m\ddot{x}$ + kx + µmg − mō2r = F(t).

For analysis, separating the constant additions, leaving only the impulsive part:

$$m\,\ddot{x} + k\,x = \sum_{i=0}^{N-1} F_0\,\delta(\omega t - i\,\theta)$$.

$$\omega_0 = \sqrt{\frac{k}{m}},$$

$$H(\Omega) = \frac{1}{-m\,\Omega^2 + k}, \quad \Omega = \omega.$$

System response: Green's function

Free resonant frequency, transfer function, Stationary impulse response:

N−1 xss(t) = X F0 H(ω)e−j(ωt−ith). i=0

Amplitude coefficient:

$$A(\theta) = F_0 \left|H(\omega)\right| \left|\sum_{i=0}^{N-1} e^{-j\,i\,\theta}\right| = F_0 \left|H(\omega)\right| \frac{\left|\sin\left(\frac{N\theta}{2}\right)\right|}{\left|\sin\left(\frac{\theta}{2}\right)\right|}.$$

Optimal turn:ϑ=60◦theta=60°. IfN= 6if,ϑ= 2π/6 = 60◦Then: Equal distribution of impulses: the recovery terms are equal to zero[5-9].

$$\sum_{i=0}^{5} e^{-j\,i\,2\pi/6} = 0,$$

Reduction of amplitude dispersion: i.e. avoidance of resonance.

$$\frac{\sin(N\theta/2)}{\sin(\theta/2)} = \frac{\sin(\pi)}{\sin(\pi/6)} = 0$$

In this case, congestion and damage will be minimal.

Performance indicators

Dispersion: ϑ= 60◦at$D$= 0, in other corners D >0.

$$D(\theta) \propto \left|\frac{\sin(N\theta/2)}{\sin(\theta/2)}\right|.$$

Congestion index*TI* and density retention index*DS*: $TI_{60°} \approx 0$, $DS_{60°} \approx 1$.

Real momentum distribution (in Maple graphs): *TI* <0.05, *RE* >95% [1].

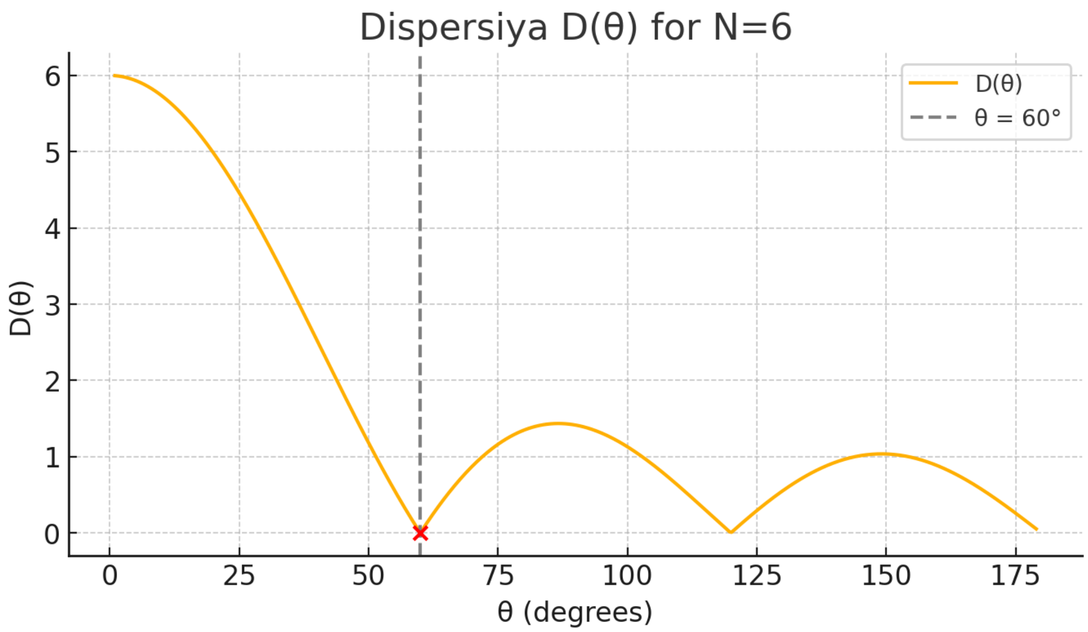


Figure 2. Dispersion*D* (θ)graph

Dispersion $D(\theta) = \left|\frac{\sin(N\theta/2)}{\sin(\theta/2)}\right|$ function$N$= 6for. The first zero point (ϑ= 60◦): D(60◦) = 0- momentum dispersion disappears, oscillations are minimized. The second zero point (ϑ= 120◦): the second periodic zero of the function, but in this case the side lobes are larger. Side lobes and maximum peaks: ϑ→ 0◦at D≈ 6is, all the pulses are added together and a maximum oscillation occurs. Then it decreases linearly, reaches zero, and at 120° zero occurs again. Conclusion: The 60° configuration distributes the pulses at once, eliminating the oscillation. There is also a zero at 120°, but the synchronicity weakens.

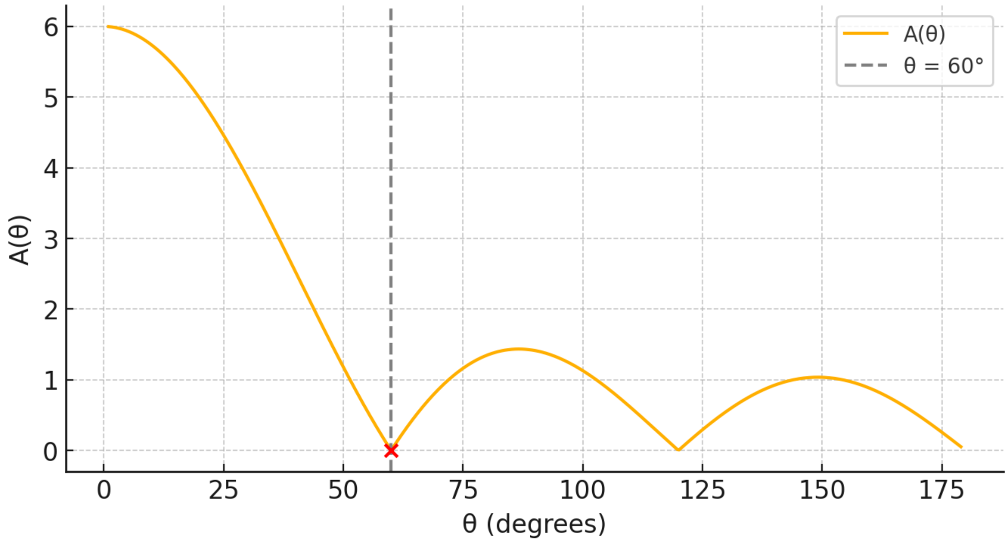


Figure 3. Normalized amplitude *A*(θ) graph

Normalized amplitude *A*(θ) function *N*= 6for. The minimum amplitude (ϑ= 60◦): *A*(60◦) ≈ 0-pulses destructively cancel each other, the system "relaxes" to oscillation. Side lobe amplitudes: The amplitude increases in the range 90°–100°, the synchronism is not sufficient. There is another minimum at 120°, but the pulse interval here is long. Resonance avoidance: Side lobe maxima occur at unfavorable angles, increasing the risk of damage. Combined analysis: ϑ= 60◦also *D*(θ) = 0, both *A*(θ) ≈ 0: - the zero-dispersion and zero-amplitude points coincide. 6 accelerators act with a synchronous rhythm, at equal intervals:

1. Jamming does not occur.
2. Mechanical damage will be minimal.
3. Seed separation efficiency is maximized.

CONCLUSION

The working chamber clearly shows triangular diffuser-accelerators**60**°should be installed with a twist. The rotor speed should be maintained at values that are far from the side lobes (about 70 rpm). To reduce the coefficient of friction, the surface should be improved by polishing or coating.

The triangular separators distribute the impulse symmetrically at a 60° angle. This ensures that the cotton pieces are conveyed in a stable and dense manner. As a result, blockages and damage are minimized, and the efficiency of the separation of the seeds is maximized.

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