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| Research Article

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The Effect of Vibrations in the Cylinder of the Gin Machine Saw on Power Consumption and Optimization Pathways

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Annotation
This article will analyze the effect of vibrations occurring in the cylinder of a gin machine saw on electricity consumption. The causes of vibrations, their negative impact on energy efficiency and ways to eliminate them are considered. Based on experimental and theoretical calculations, recommendations are given on dynamic balancing using balancing discs, as well as on choosing optimal operating parameters.

Keywords: gin machine, saw cylinder, vibration, energy consumption, dynamic balancing, balancing disc, efficiency.

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Introduction

In recent years, as a result of successive reforms aimed at modernizing and diversifying agricultural production and developing the processing industry, a new system of functioning in the agricultural sector has been introduced — the cluster method.

In a short period, cluster activity has shown its positive sides and significant work has been carried out to introduce resource-saving machinery and technologies into agricultural production, introduce industry into rural areas and create new jobs, produce finished products with high added value, and develop infrastructure.

The tasks of further improving the efficiency of cotton clusters, increasing the capacity for deep processing of cotton raw materials, widespread introduction of scientifically sound methods and intensive technologies into this process, as well as timely elimination of emerging problems in the activities of cotton clusters, establishing a system to protect their interests in government authorities, including cotton and textile production, according to the working conditions, The main production sites are combined into a single workshop for the primary processing of cotton (galvanizing, separating cotton, pressing), in which the production of cotton products is carried out in a continuous technological process.

The modern cotton gin plant is fully electrified, has an electrochemical facility, a large number of technological equipment, operates in a complex production process, preparing and processing raw materials, shipping large volumes of goods and selling products.

The efficient operation of Gin machines when separating cotton into fibers and seeds is directly related to energy consumption and product quality. The dynamic imbalance and fluctuations that occur in the saw cylinder during operation not only reduce labor productivity, but also lead to excessive energy consumption. Research shows that increased vibration increases the load on the engine by 5-12%, which significantly increases production costs.

The level of study of the problem.

Vibrations in the saw cylinder are caused by the following main factors:

1. Uneven mass distribution-the displacement of the center of gravity of the saw discs from the axis of the cylinder-creates a dynamic imbalance.

2. Uneven friction forces-the torque of the cylinder is subjected to sharp fluctuations when the density of fibers in the raw material and the humidity level change.

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3. Bearing corrosion – loosening on rotating parts increases the amplitude of lateral vibrations of the cylinder.

4. Faulty balancing elements-Incorrect selection or weight placement of balancing discs may increase rather than decrease vibrations.

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Vibrations convert some of the mechanical energy into useless thermal and acoustic energy. This condition leads to an increase in engine torque. According to the results of the experiment:

- With a lateral oscillation amplitude of 0.2-0.4 mm in the saw cylinder, energy consumption increases by 6-8%.
- With an amplitude above 0.5 mm, the energy consumption increases to 10-15%.
- When the vibration frequency is in the range of 12-18 Hz, the rate of engine heating and bearing failure increases.

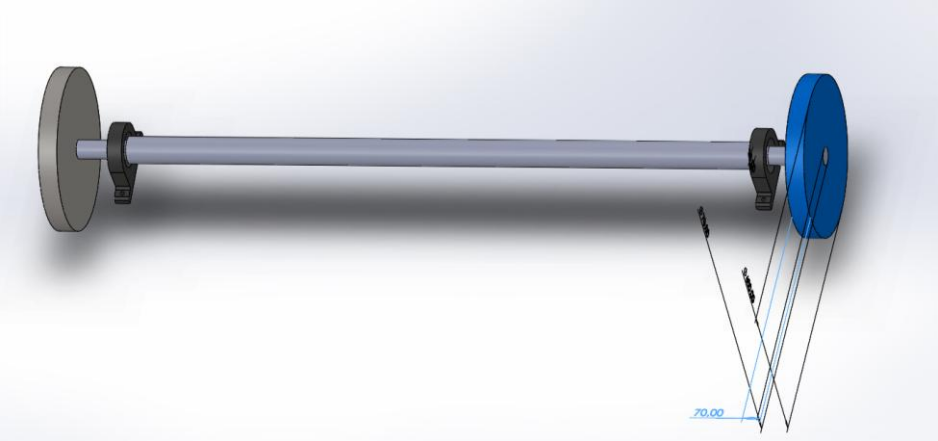

Figure 1. Installation diagram of the balancing disc of the saw blade.

It is estimated that a 75-kW motor can consume an additional 3.6-4.5 kWh of electricity due to vibration during one shift (8 hours).

According to the formulas expressing the effect of the balancing disc based on the Dalembert principle, the effect on the energy consumption of the saw cylinder is determined by the following parameters Figure 1. Installation diagram of the balancing disc of the cylinder;

$U = \left|\sum m_i r_i e^{j\theta_i}\right|$ is the modulus of the equilibrium vector (kgm);

$m_b r_b \theta_b$ is the mass, radius, and angle of the equilibrium disk;

ω is the angular velocity (rad/s); ω=2πn/60;

k is the equivalent stiffness of the rod body (N/m);

c is the equivalent diameter of the spring (Ns/m);

$\omega_n = \sqrt{\frac{k \cdot m_s}{c}}$- natural angular velocity;

$r = {}^{\omega}/_{\omega_n}$ - frequency ratio;

$\zeta = \frac{c}{2\sqrt{km_s}}$- the degree of damping.

1) Determination of the strength of the discrepancy and residual value based on the Dalembert principle.

Inertia force during unbalanced rotation:

$$F_u(t) = R\{U\omega^2 e^{j(\omega t+\phi)}\}. \quad (1)$$

Vector of residual imbalance after adding a balancing disk:

$$U_{res} = \left|U + m_i r_i e^{j\theta_i}\right|. \quad (2)$$

For optimal condition (perfect compensation):

$$\theta_b = \arg(U) + \pi, m_i r_i = |U| \Rightarrow U_{res} \to 0. \quad (3)$$

In practice, it remains small ε: $U_{res} = \varepsilon U (0 < \varepsilon < 1)$.

2) Oscillation amplitude (SDOF model)

The Dalembert force acts as an arousal force. The amplitude of stationary oscillations:

$$X = \frac{U_{res}\omega^2/k}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}. \quad (4)$$

3) Loss of power in the damper (energy consumption).

Average power loss in a viscous damper during harmonic vibration:

$$P_{loss} = \frac{1}{2} c\omega^2 X^2 \quad (5)$$

By putting X, we get a representation that directly represents the energy effect of the equilibrium disk:

$$P_{loss} = \frac{c\,U_{res}^2\,\omega^6}{2k^2[(1-r^2)^2+(2\zeta r)^2]}. \quad (6)$$

This formula shows that:

$P_{loss} \propto U_{res}^2$ (residual square imbalance);

$P_{loss} \propto \omega^6$ (extremely sensitive to velocity);

Near the resonance $[(1-r^2)^2 + (2\zeta r)^2]$ it gets smaller, and losses increase dramatically.

4) Energy-saving method.

Relative strength before and after balancing:

$$P_{before} \propto U^2 , P_{after} \propto U_{res}^2 \quad (7)$$

Therefore, the share of savings on power losses is:

$$\eta_{tej} = 1 - \frac{P_{after}}{P_{before}} = 1 - \left(\frac{U_{res}}{U}\right)^2. \quad (8)$$

($\omega, k, c, \zeta\ va\ r$ it works under the same conditions).

5) Practical selection formulas (disk parameters).

Balancing in one plane (one disk):

$$m_b = \frac{U}{r_b}, \quad \theta_b = arg(U) + \pi. \quad (9)$$

Two-text balancing (two discs at the ends of long cylinders) -a vector equation is solved in the planes of the front and rear bearings, and $m_{b1}r_{b1}$ and $m_{b2}r_{b2}$ are found for each plane (classical two-text balancing algorithm).

Based on the results of the general calculation:

$n = 730\ rpm$

$U = 0.30\ kg \cdot m$ (initial imbalance)

$U_{res} = \varepsilon \cdot U, \quad \varepsilon = 0.30 \rightarrow U_{res} = 0.090\ kg \cdot m$

$m_s = 200\ kg$ (effective mass)

$k = 1.50e + 0.07$ Н/м (equivalent hardness)

ζ = 0.07 (degree of damping)

6. Calculation results:

$\omega = 76.45\frac{rad}{s}, \quad \omega_n = 273.86\frac{rad}{s},$

$r = 0.279, \quad c = 7668.12\ N \cdot c/m$

Амплитуда колебаний $X = 0.038\ mm$

$P_{loss_{before}} \propto U^2 \rightarrow P_{before} = 0.36\ W$ (относительная оценка)

$$P_{loss_{after}} \propto U_{res}^2 \rightarrow P_{after} = 0.03\,W$$

The share of energy saving: $\eta_{save} = 91.0\ \%$

In practical accounting, U, K, ζ, m_s is derived from the manufacturer's experience or data. ε = 0.30 ~ corresponds to the case when the residual imbalance has decreased by 70%; when balancing in two planes, ε maybe even smaller. Near the resonance (r≈1), X and p_{loss} increase sharply — it is advisable to keep the speed away from this.

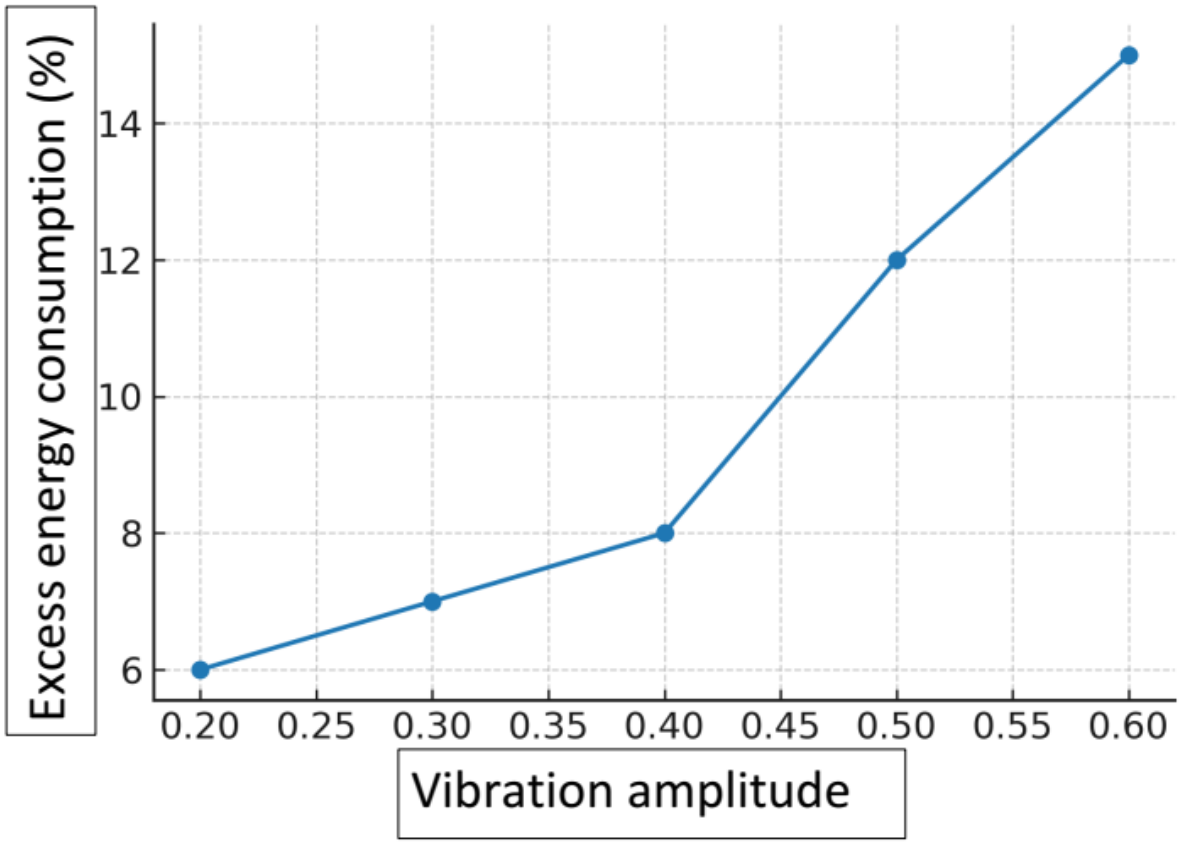

Figure 2. The amplitude of oscillations and the change in electrical energy.

Dynamic balancing-balancing discs are selected in the weight range of 25-50 kg. The position of the load is determined based on the static and dynamic balance of the cylinder. Due to the two-way balancing, the oscillation amplitude is reduced to 60-70%.

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The modernization of bearings is the use of high–speed stable bearings and the introduction of an automatic lubrication system.

Choosing the optimal rotation speed of 730 rpm is optimal, and a lower or higher speed increases vibration.

Preliminary preparation of raw materials is to maintain the moisture content of cotton at 8-10% and pre–cleaning from large residues.

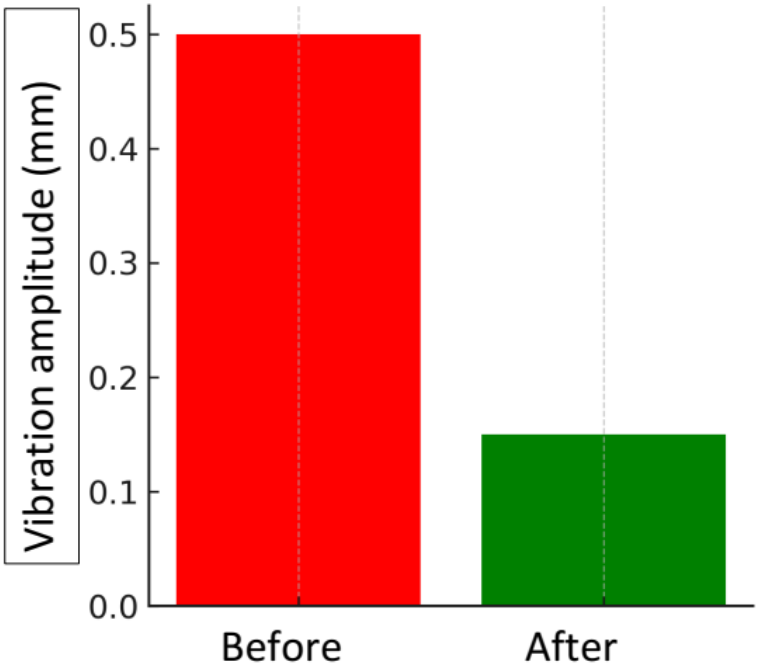

Figure 3. Dynamic balancing effect.

Experimental results show that due to dynamic balancing, the vibration amplitude in the saw cylinder can be reduced from 0.5 mm to 0.15 mm. This reduces electricity consumption by an average of 8-10%. The service life of bearings is also doubled, motor heating is reduced, and the production process is stabilized.

Conclusion

As the moment of resistance of cotton raw materials increases from $3.0 \cdot 10^2$ Nm to $12 \cdot 10^2$ Nm, the angular velocity of the saw cylinder decreases from 76.9 s^{-1} at Jp = 6.2 kgm^2 to 52.7 s^{-1} at. The moment of inertia is 3.4 kgm^2, the angular velocity decreases from 77 s^{-1} to 66.1 s^{-1}. It follows that at high values of the moment of inertia of the saw cylinder, the decrease in the angular velocity of the saw cylinder is small (10.9 s^{-1}), and the productivity of the machine increases.

At the same time, energy consumption increases from 12.2 kW to 46.3 kW. Considering that each saw blade has a resistance torque of 5.56 Nm of cotton raw materials, this corresponds to 12.3 kg per hour.

1. The problem of the dynamics of a machine block with a cylindrical mechanism of a cotton saw is solved analytically. A formula for calculating the angular velocity of a saw cylinder for a fixed mode of motion is obtained.

2. A change in the amplitude of fluctuations in the system response time and the angular velocity of the saw cylinder was obtained depending on the reduced moment of inertia of the system.

Rational values of the reduced moment of inertia of the saw cylinder JP = (2.6-3.5) kgm2 are recommended, ensuring a reduction in the start-up time of the machine block from 0.11 S.

Ensuring the dynamic balance of the saw cylinder, upgrading bearings, and choosing optimal operating parameters are important factors in improving the energy efficiency of Jin machines. This not only reduces energy consumption, but also improves product quality. In the future, it is advisable to introduce automated vibration control systems.

Reference

1. Levkovich B.A. "Elements of the theory of gining" Tashkent, Gosizdat 2018, 163 p.

2. Radjibaev P. "Improving the efficiency of the saw gin using a sectional composite grate with a replaceable working part." Dissertation of the Candidate of technical sciences Tashkent, 2014, 165 p.
3. Tyutin P.N. "Analysis and improvement of the saw gining process in relation to the in-line technology of processing machine-harvested raw cotton" dissertation, Doctor of Technical Sciences Kostroma, 2015, 406 p.
4. Kotov D.A. Boldinsky G.I. "On the isolation of seeds from the raw roller of saw gin." collection of TTI, No. 18, Tashkent, 2014, pp. 67-76
5. W. D. Pilkey, “Mechanical Vibrations: Theory and Applications,” John Wiley & Sons, 2020.
6. Shafqat, M., “Energy Efficiency in Cotton Ginning,” Textile Engineering Journal, 2021.
7. GOST 30530-97, “Washing machines. General technical conditions,” Moscow, 1997.