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STUDYING INTERACTION OF COTTON-RAW MATERIAL WITH WORKING BODIES OF COTTON-CLEANING MACHINES

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Annotation

The article presents the elastic-plastic interaction of raw cotton with the working organs of cotton ginning machines. The maximum deforming force and the maximum collision rate of the fly with the grate are experimentally determined.

Key words

physical bodies, raw cotton, cotton cleaner from large litter, grate, seed damage.

All real physical bodies have both elastic and plastic properties. Raw cotton also acts as an elastic as well as a plastic body during impact. It should be noted that there are a number of studies on the improvement of designs and methods for calculating the graters of cotton cleaners from large litter [1].

Let us consider the process of blowing a fly about the grate taking into account the elastoplastic properties of cotton.

We assume that the deformation of the volatility has an elastic-plastic character. According to Gerstner's empirical law, the local deformation α consists of an elastic and plastic component that develops under loading independently of one another. We assume that the elastic strain obeys the Hertz law, while the plastic deformation depends linearly on the contact force.

When loaded, the deformation equation has the form

$$\alpha = \alpha_1 + \alpha_2 = b_1 P^{n_1} + xP, \qquad (1)$$

when unloading

$\alpha = \alpha_1 + \alpha_{2\,\max} = b_1 P^{n_1} + x\,P\max$ (2)

where b1 and n1, are the coefficients characterizing the elastic deformation;

P - the current shock load;

P is the maximum shock load.

We consider the solution of this problem without taking into account the wave oscillations, since we are mainly interested in the changes occurring in the volume, and the dimensions of the volatility are small. It is usually assumed that the wave nature of the processes is neglected if the total duration of the impact is several (5-8) times greater than the time of travel of the elastic wave along the body. In our case, the total duration of the impact is hundreds of times greater than the travel time of the elastic wave along the volcano.

Equations of motion of colliding bodies will have the form

$$\left.\begin{aligned} m_1 \frac{d^2 X_1}{dt^2} = m\frac{dV_1}{dt} = -P(\alpha) \\ m_2 \frac{d^2 X_2}{dt^2} = m\frac{dV_2}{dt} = -P(\alpha) \end{aligned}\right\} \qquad (3)$$

where X1, and X2 - the motion of the centers of the fly and the grate;

V1, and V2-velocities from colliding bodies.

$$X_1 + X_2 = \alpha \qquad (4)$$

Differentiating equation (4), we obtain

$$\frac{dX_1}{dt} + \frac{dX_2}{dt} = V_1 + V_2 = V, \qquad (5)$$

where V is the speed of flying relative to the grate.

From the above equations, we can formulate the following deformation equation

$$\frac{dV}{dt} = \frac{d^2\alpha}{dt^2} = -\frac{1}{M} P(\alpha) \qquad (6)$$

where is the reduced mass of the colliding bodies; $M = \dfrac{m_1 m_2}{m_1 + m_2}$

m_1 - mass of flying;

m_2 - mass of the body.

The displacement of the centers of the volatility and the grate during the impact is equal to the deformation of the fly (the stiffness of the grate is much higher than the rigidity of the fly, so the deformation of the fly will be much greater than the deformation of the working member, ie, X1 << X2).

The impact process is divided into two stages. During the first (active) stage of impact, the contact force increases, and deformations in the contact zone of colliding bodies are of an elasto-plastic character, i.e. During the active stage of impact, the bodies are loaded. In this case, the centers of the colliding bodies approach each other.

During the second (passive) stage, the bodies are unloaded, i.e. the restoration of elastic deformations, and the distance between the centers of inertia of colliding bodies increases, the contact force decreases, and as soon as it becomes zero the contact of colliding bodies will fail. Let's consider each stage separately:

a) active stage of impact.

Substituting in (6) the expression for elastic deformation

$$\alpha = bP^n, \qquad (7)$$

we get

$$V\frac{dV}{d\alpha} = -\frac{\alpha^{1/n}}{M\,\beta^{1/n}} \qquad (8)$$

Initial conditions: when

$t = 0,\ \alpha = 0,\ V = V_0$. Integrating equation (8), we obtain

$$V = V_0\sqrt{1-\frac{2}{MV_0^2}\frac{1}{b^{1/n}}\frac{n}{1+n}\alpha^{\frac{1+n}{n}}} \qquad (9)$$

From here we can find the maximum value of elastic-elastic deformation, which is achieved at V = 0

$$\alpha_{\max} = \left[\frac{MV_0^2}{2}b^{1/n}\frac{1+n}{n}\right]^{\frac{n}{1+n}} = \left[E_0 b^{1/n}\frac{1+n}{n}\right]^{\frac{n}{1+n}} \qquad (10)$$

Where $E_0 = \frac{mV_0^2}{2}$ – reduced kinetic energy of colliding bodies

Substituting (9) into (10), we obtain $$V = \frac{d\alpha}{dt} = V_0\sqrt{1-\left[\frac{\alpha}{\alpha_{\max}}\right]^{\frac{1+n}{n}}} \qquad (11)$$

Location

$$\frac{V_0 t}{\alpha_{\max}} = \int_0^{\frac{\alpha}{\alpha_{\max}}}\frac{dX}{\sqrt{1-X^{\frac{1+n}{n}}}} \qquad (12)$$

We introduce the dimensionless parameter

$$\psi = \left(\frac{\alpha}{\alpha_{\max}}\right)^{\frac{1+n}{n}} \quad (13)$$

which varies within. $0 \le \psi \le 1$.

Then expression (13) has the form

$$\frac{V_0 t}{\alpha_{\max}} = \frac{n}{1+n}\int_0^{\psi}\frac{X^{-\frac{1}{1+n}}\,dX}{\sqrt{1-X}} = \frac{n}{1+n} I(\psi,\, n) 14)$$

Integral $I(\psi, n)$ can not be expressed in terms of elementary functions because the parameter n is arbitrary. But with ψ =1 you can find the exact solution

$$I(1,n) = \int^1 (1-X)^{-\frac{1}{2}} X^{-\frac{1}{1+n}} dx \quad (15)$$

those. we obtain a beta function whose solution has the form

$$I(1,n) = \frac{\Gamma\left(\frac{n}{1+n}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left[\frac{1+3n}{2(1+n)}\right]} \quad (16)$$

Taking into account the well-known property of the gamma functions

$$\tilde{A}(X+I) = X\tilde{A}(X), \quad (17)$$

we obtain (for $t = \tau$)

$$\frac{V_0 \tau}{\alpha_{\max}} = \frac{n}{1+n} I(1,\, n) = F_1\,(n) \quad (18)$$

Substituting here the well-known expression of maximum strength

$$P_{\max} = \left(\frac{\alpha_{\max}}{b}\right)^n \quad (19)$$

we get

$$\frac{2P_{\max}\cdot\tau}{M\cdot V_0} = \frac{1+n}{n} F_1(n) = F_2(n). \quad (20)$$

The values of the functions F1 (n) and F2 (n) are given in the literature [2].

Since m2 »m1, we obtain

$$M = \frac{m_1 \cdot m_2}{m_1 + m_2} = m_1. \quad (21)$$

Let us determine the maximum velocity of the collision of the fly with the grate

$$V_0 = \frac{2\cdot P_{\max}\cdot\tau}{m_1\cdot F_2(n)} \quad (22)$$

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Expression (22) allows us to determine the maximum velocity if the remaining terms of the expression are known.

he collision time and mass of the volatility m1 were determined by us earlier [3]. The values of the function F2 (n) depend on n. The value of n was determined in [4].

If = 0,001 seconds; m1 = 0.0002 kg; n is 1.3; then F2 (n) = 2.88.

It remains only to determine the maximum deforming force Pmax.

Experimental determination of the maximum deforming force.

The maximum deforming force Pmax is the force that, when applied to flying, the deformation of the seed of volatility will be maximum. A further increase in strength leads to the destruction of the seed.

Since the force Pmax depends on many physicomechanical properties of cotton raw cotton, it can not be determined theoretically. Therefore, the value of the force Pmax is determined experimentally.

The experiment was carried out on a special bench consisting of a screw rod, an elastic element, two indicators according to the following procedure:

The cotton raw cotton loaf was installed on the elastic element and loaded with a screw rod. One indicator showed the value of the load, and the second - the deformation of the volatility. Letuchka loaded until the destruction of the seed. The force at which the seed is destroyed is fixed. During the experiment 500 seeds were destroyed, the frequency was determined by the amount of destroyed seeds.

Assuming that the dependence of seed damage on the loading force obeys the law of normal distribution, calculate the theoretical frequency of seed damage in each load force interval and the total number of damaged seeds.

Substituting the magnitude of the destructive force in equation (22), the speed of the volatility at which the seed is damaged is determined.

The results of the experiment, processed by methods of mathematical statistics, are given in Table.

Table

Probability of seed damage depending on the speed of the fly.

Intervals of the seed strength, N	The frequency of damage to seeds (expert)	The frequency of damage to seeds (theoretical)	The theoretical number of damaged seeds	Speed, corresponding to the force of the load m / s	Probability of seed damage,%
0-10	0	1	1	3,5	0,2
11-20	2	4	5	6,9	1,0
21-30	3	9	14	10,4	2,8

31-40	22	18	32	13,9	6,4
41-50	38	33	65	17,4	13,0
51-60	68	50	115	20,8	23,0
61-70	37	66	181	24,3	36,2
71-80	59	75	256	27,8	52,0
81-90	63	74	320	31,3	66,0
91-100	69	63	393	34,7	78,6
101-110	60	47	440	38,2	88,0
111-120	37	30	470	41,7	94,0
121-130	21	17	487	45,1	97,4
131-140	3	9	496	48,6	99,2
141-150	4	3	499	52,1	99,8
151-160	2	1	500	55,6	100,0

As can be seen from the table, even at a velocity V0 = 3.5 m / s, the damage to the seeds will be about 0.2%, at a velocity V0 = 6.9 m / s about -1.0%, and at a speed of 10 m / 2.8%. With further increase in speed, the damage quickly increases. Nevertheless, to obtain a 100% damage to the seeds, a speed of more than 55 m / s is required.

In conclusion, it should be noted that the quantities m, n given above are averaged. For a more accurate determination of the permissible speed of the working organs of cotton ginning machines when limiting the damaged seeds, it is necessary to clarify the above parameters for each variety and raw cotton grade, taking into account its moisture content

CONCLUSIONS:

1. Damage to raw cotton seeds occurs at any speed of the working organs of cotton ginning machines, but its intensity at low speeds is insignificant, and increases with speed.

2. To determine the permissible speed of the working bodies of cotton ginning machines, it is necessary to determine the values m, n, for each variety and raw cotton grade, taking into account its moisture content.

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