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PHYSICAL AND MECHANICAL PROPERTIES OF NON-GENINED SEEDS AND THEIR FIBROUS COVER

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Abstract
The purpose of this work is to find and develop the optimal shape of the working chamber of the catcher and its working elements, as well as their influence on the fiber yield and the catching effect. For this purpose, an experimental setup was developed and the processes of trapping under-ginned seeds were studied.

Keywords. cotton, seed, fiber, sorter, mesh surface, fine dirt, lint, fraction, damage, productivity, hairiness.

Introduction

The physical and mechanical properties and aerodynamic characteristics of cotton seeds and their fibrous cover affect the operation of machines and mechanisms during their processing and transportation. These include: density, volumetric weight, shape, size, specific gravity, flowability, windage.

The seeds have an irregular convex shape and their structure is not uniform. They can be classified as poorly flowing materials capable of arching .

Seeds of various breeding varieties have a maximum length of up to 14 mm and a width of 6 mm. The absolute weight of 1000 seeds ranges from 70–120 to 150 g.

A seed is a complex, insufficiently studied living system in which the future plant is programmed . It is covered with a thick shell that is in loose contact with the core. The shell has a long grain on the surface and a rough short lint and delint .

Theoretical Research

Important parameters that characterize not only the physical properties, but also the state of the material during free filling and transportation include volumetric weight .

M. B. Rybalskaya determined changes in the volumetric mass of seeds from normal pressure, the elastic properties of seeds, the adhesion forces between them, the coefficients of friction of seeds on steel depending on their pubescence and the frequency of surface treatment.

A mathematical expression has been found for the dependence of the volumetric mass of seeds on normal pressure:

$$g = a_0 + a_1 \lg\left(H + \frac{P}{2F}\right) kg * m^{-3} \quad (1)$$

Where a_0, a_1 are constant coefficients depending on the hairiness of the seeds;

H - specific pressure on seeds, N/cm^2.

P is the area affected by the compaction load, cm^2.

The formula is valid for pressures H=14.7 10^3, N/cm^2. At the same time, an empirical relationship was established between the volumetric mass of seeds and total pubescence .

$$g = b_0 + \frac{b_1}{lgC} \quad (2)$$

C - complete pubescence of seeds in %;
b_0, b_1 are constant coefficients depending on the specific pressure.

With increasing full pubescence, the volumetric mass of seeds decreases. Pubescence has a greater effect on the volumetric mass in free filling and less in a compacted state. As the variety decreases, the bulk density of seeds at the same moisture content and hairiness decreases. With increasing specific pressure on the seeds, the bulk mass increases according to a parabolic dependence.
Sown pubescent seeds have a bulk weight of about 350-400 kg/m^3, while 1 m^3 completely bare seeds weigh 560-600 kg.
According to G. Miroshnichenko /7/ the density of pubescent seeds of grade II is 11000, grade III is 10850 N/m^3, bare seeds of grade I are 10800 and grade IV is 9600 N/m^3.
The elastic properties of cotton seeds are characterized by a compaction coefficient and volume recovery after removal of the load. The first characterizes the degree of change in the initial volume occupied by the seeds (V_1) after applying a compacting load to them (V_2):

$$K_\gamma = \frac{V_1}{V_2} \quad (3)$$

The compaction coefficient of seeds depends on their complete pubescence; it ranges from 1.4 to 1.7. A higher value of the compaction coefficient refers to seeds with greater pubescence .
The volume recovery coefficient characterizes the degree of change in seed volume after removal of the compaction load;

$$K_v = \frac{V_K}{V_2} \quad (4)$$

where V_K is the volume of seeds after removing the load.
According to I.B. Rybalskaya, it is insignificant and ranges from 1.02 to 1.05. The elastic properties of seeds when they collide with other bodies are determined by the coefficient of elasticity or recovery, and characterize their physical properties (the magnitude and direction of the reflection velocity).
If we assume that there is no friction during impact, then the coefficient of recovery will be equal to:

$$K_B = \frac{V_2}{V_1} \quad (5)$$

where V_1 and V_2 are the speeds of falling and reflection of seeds, which, without taking into account air resistance, can be determined by the formulas:

$$V_1 = \sqrt{2gh_1} \quad (6)$$

$$V_2 = \sqrt{2gh_2} \quad (7)$$

where h_1 and h_2 are the height of the fall and reflection of the seeds.

After substituting the obtained values into formula (5), we obtain:

$$K_V = \sqrt{\frac{h_2}{h_1}} \quad (8)$$

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Seed recovery coefficient, depending on their pubescence and maturity, was determined as follows: K_v = 0.37: 0.40; 0.41, with complete pubescence - 13.9; 9, 9; 6, 8, and for unripe seeds - K_v = 0, 29.

An important characteristic of seeds is flowability, determined by pubescence . Cotton seeds are a caking material, so during processing, transportation and compaction, the seeds bind to each other and require some effort to separate. The strength of adhesion depends on their pubescence . According to S.P. According to Ivanov, the adhesion force increases in proportion to the pubescence until it is about 10%, and then increases proportionally, and the adhesion force tends to a constant value, independent of the pubescence . Seeds that are more pubescent have greater adhesive forces than those that are less pubescent . At the same time, a change in the hairiness of grade I seeds within 10+14% has little effect on the adhesion force, but a further decrease in hairiness sharply reduces the amount of adhesion. For grade I, the hairiness is in the range of 0.2-0.55 cN /cm^2.

C.P. Kagalovsky, when processing machine methods for sorting seeds of the 108-F variety, studied a number of their physical and mechanical properties - linear dimensions (thickness, width, length), weight, specific gravity, coefficient of internal friction and coefficient of friction on the surface. He believes that for pubescent seeds, i.e. bound granular medium, the angle of repose is not identical to the tangent of the friction angle and that there is no good correlation of the natural repose. He measured the coefficient of internal friction from equilibrium on a tribometer and from the angle of repose. Since the values of the coefficients for bare seeds in both methods are the same, Kagalovsky considers them separately free-flowing. Friction coefficient for iron. Kagalovsky determined it at 0.37, and Tsulatov at 0.36-0.42. Wet seeds have a higher coefficient of friction. The dependence of the coefficient of friction of seeds on a cast iron surface on the value of normal pressure was determined by S.P. Ivanov. As pressure increases, the coefficient of friction decreases, which can be explained by an increase in the area of contact of the seeds with the friction surface, deformation of the seeds and fibrous cover, as well as the presence of adhesion forces between the cotton fibers and the surface of the seeds.

The coefficient of friction under significant loads does not depend on the pubescence . The relationship between seed pubescence and the coefficient of static and sliding friction was established by I.I. Novitsky. The first decreases with increasing pressure and increases sharply with increasing roughness of the contacting surface. At a normal pressure of 0.009 N/cm^{2,} the coefficient of static friction of seeds on steel, depending on the pubescence , ranges from 0.59 to 0.66 at a normal pressure of 4.5 N/cm^2 , in the range from 0.18 to 0.33 , With an increase in the speed of relative sliding to 0.4+0.8 m/s, the value of the coefficient increases, acquiring the greatest value at the least pubescence and minimum pressure. With a further increase in speed, the friction coefficient decreases, stabilizing at a certain constant value.

Its value on the sliding speed is well described by the Kragelsky formula .

$$\mu = (A + Bv)e^{-cv} + D \quad (9)$$

where v is the speed of relative sliding of seeds, m/s;

e is the base of natural logarithms;

A, B, C, D - constants determined experimentally.

Experiments have shown that with an increase in seed pubescence from zero to 14.0%, the angle of repose lies in the range from 24 to 45^0 . In the same work, a simplified dependence is recommended for calculating the lateral pressure of seeds of standard moisture with hairiness from 1.0 to 9.0%:

$$q = (0.31 - 0.34)P_N \text{N/cm}^2 \qquad (10)$$

where P_N is the normal pressure on the seeds, N/cm^2.

When creating mechanization means, the strength of the seeds is important, i.e. their ability to withstand external loads without destroying the shell. Mature seeds have a stronger shell and a fuller kernel. They withstand external loads better than unripe ones. Statically, a seed can withstand pressures significantly greater than its weight. When moving on a smooth surface, it is able to withstand both significant pressure forces and movement speeds. When seeds collide with a smooth steel surface, crushing is detected at a speed of 30-40 m/s. The literature contains material on the resistance to external influences of only single seeds, and when justifying the choice of optimal parameters of mechanization means, the damage of seeds in the flow at different speeds of their collision with a stationary wall is important.
With an increase in the speed of movement of raw cotton in a pneumatic transport system, its throughput increases, but at the same time the damage to the seeds increases, which affects the quality of the fiber and seeds, i.e. their germination energy and germination rate decreases.
Justification of the parameters for transporting seeds by air flow involves studying the mechanics of the air stream, its interaction with the transporting material and its aerodynamic properties. The amount of pressure of the air flow on the body created by a jet of air is determined by the well-known Newton formula. The speed of the air flow, at which there is no forward movement of the body washed by air and the body is only supported in the air flow, is called the soaring speed and is defined as follows:

$$V_0 = \sqrt{\frac{gq}{K\gamma F}} \qquad (11)$$

where q is the particle mass, kg;
K - resistance coefficient;
γ- air density, kg/ m^3; g - gravity acceleration, m/s^2;
F is the area of projection of the body onto a plane perpendicular to the direction of the air flow, midsection, m^2.

The behavior of seeds in the air flow is characterized by the windage coefficient and its values are necessary when designing installations for cleaning and transportation. The windage coefficient is determined by the formula :

$$K_n = K\frac{\gamma F}{q} \qquad (12)$$

The K_n coefficient is directly proportional to the midsection area per unit body mass.

Outcome Analysis

In pubescent seeds, V_n, and along with it the flight range of seeds in the air flow, will have different values depending on the weight of ginned seeds in the range of 3.7-6.1 m/s, linted 4.6-6.7 m/s, bare 5.0-11.8 m/s. A decrease in the hairiness of seeds leads to an increase in the energy intensity of the pneumatic conveyor, and with an increase in the turbulence of the air flow, the energy intensity decreases.

The behavior of seeds in an air flow depends on many factors: air speed, seed weight, condition and shape of the surface (hairiness) and other factors, but no mutual connection has been established between them.

The results of scientific research in the study of the physical and mechanical properties of cotton seeds, as a low-flowing material, are not yet sufficient for a thorough knowledge of the behavior of seeds in an air flow.

Conclusions

The formulation of the question and the study of the process of separating under-ginned seeds are relevant, since existing separators do not fully meet the requirements.

In order to increase the catching effect and reduce losses of fibrous mass, a study was carried out of the operating modes of various designs of catchers and the optimal parameters of their individual elements.

the study of the process of separating under-ginned seeds, but they do not resolve issues that are important in theoretical and practical terms, namely:

a) the dynamics of the yield of under-ginned seeds after gin has not been fully studied;

b) the regeneration process has not been studied and the dependence of productivity on the residual fiber of the seeds has not been studied;

c) the reasons for clogging the net and the issues of eliminating these shortcomings are not fully clarified;

d) the issues of determining fiber losses and ways to reduce them have not been studied.

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