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Study of Cotton Seeds as a Processing Material

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Abstract

The purpose of this research is to improve the qualitative and quantitative indicators of fiber, lint and seeds by improving the technology of preparing cotton seeds for processing. The state of the seeds after the gin was studied and their division into fractions according to the degree of pubescence was recommended, the probabilities of the seeds emerging from the gin with varying degrees of pubescence were investigated, the geometric sizes and shapes of cotton seeds were studied. It has been established that when seeds come out of gin, they have different pubescence. The conditional movement of seeds without separation from the surface has been determined; found a formula describing the movement of seeds without detaching from the surface; the movement of seeds in a micro-flight is determined; the sizes of the cells of the mesh surface were determined as a function of d_c, α and on the speed of seed movement. The aim of the research work is to increase the yield of cotton fiber by improving the processing technology of germinated seeds, to improve the quality indicators of seeds and lint. In order to achieve this goal, a mesh surface device was created to sort the seeds into fractions. Sorting technology was developed on this device and operating modes were determined. In addition, the law of surface distribution of the fractions separated from the cotton stream moving along the surface of the net was determined, and based on the results of practical and theoretical research, a mode of sorting of cotton seeds was developed.

Keywords

Fiber, Lint, Raw Cotton, Ginning, Saw Gin, Working Chamber, Raw Grate, Linting, Cotton Seeds

1. Introduction

Comprehensive measures are being taken in our Republic to develop the cotton

industry, improve equipment and technology, re-equip cotton ginning enterprises, increase the profitability of production and processing of raw cotton, and ensure the competitiveness of manufactured products.

The development action strategy of the Republic of Uzbekistan for 2017-2021 defines tasks, in particular, to...increase the competitiveness of the national economy, reduce energy and resource costs, and widely introduce energy-saving technologies [1] [2].

The solution of this problem can be achieved mainly through the widespread use of innovative development factors, the introduction of the latest achievements of science and technology, advanced technology, and the efficient use of production potential.

With the transition of enterprises of the republic to market principles of relations with their partners, with the advent of competition among manufacturers, consumer requirements for the quality of products have increased, which sets the workers of the cotton ginning industry, scientists and designers to identify and eliminate the most "narrow" sections of the technological process, where there is a deterioration in the quality of raw cotton, loss of manufactured products.

It has been established that one of such sections in the technological process of processing raw cotton is the section from gin to linter, where the quality and quantity of products are mainly formed. The linter, along with normally ginned seeds, receives underpinned seeds, raw cotton bats, as well as free fiber. The results of the studies on the residual fibrous content of ginned seeds showed that almost complete elimination of the fallout of under-ginned raw cotton volatiles from the gin working chamber is possible with the introduction of new processes.

In recent years, the world market has been in demand by consumers for a certain range of cotton products and quality indicators. In this regard, the tasks for scientists and researchers in the field of primary processing of cotton are set for creation "smart" technologies which can control the quality and quantity of cotton products. In addition, current issues of the present period, there are several issues about separation of cotton fiber from seeds and increase of efficiency of processing of ginned seeds [3] [4] [5] [6] [7].

Scientists in the ginning industry face important tasks such as quality production without destroying cotton fiber, which is a valuable raw material for the textile and light industry. Loss of cotton fiber occurs mainly in the gin-linter section of the gin. In this area, fiber loss occurs due to the addition of fiber-containing seeds to other fibrous wastes.

The newly developed device is used when it is necessary to sort the seeds of raw cotton from the ginning process according to their fiber content. The use of this device prevents the addition of fiber, which is the main raw material of the textile industry, to the waste, lint. The amount of fiber output in the enterprise is increased due to the re-ginning of fibrous seeds or letuchka separated in the device and the separation of free fibers [8] [9] [10] [11].

For the correct compilation of the technological process of primary processing,

a comprehensive study of the geometric parameters and physical and mechanical properties of cotton seeds is required, which include geometric dimensions, strength, weight, specific gravity, bulk density, elastic properties, friction coefficient, windage, electrical properties.

On the shape and size of seeds.

For sorting seeds, the size and shape of seeds are of great importance, in many studies the shape of the seeds is considered as a ball [12] [13] [14], in the work the shape of the seeds is considered as an ellipsoid, however, in practice it is somewhat different. and rounded on the side of the chalaza and narrowed towards the micropyle, their widest part at a distance of 1/4 of the length of the seed from the blunt end.

This article investigates the processes of interaction of the detergent properties of the paste with the working surfaces of technological equipment, depending on the angle of their inclination, the size of the cells and the vibration of the working surface. A new sorter is proposed, which provides sorting of processed cotton fractions according to their degree of ripeness.

The production of cotton products and the cotton industry occupies an important place in the economy of Uzbekistan, as a result of which a number of decrees and higher-level decisions on the cardinal transformation of this sphere of the economy have been adopted lately, and the output of cotton for the last 5 years has been declining its consumption within the country is gradually increasing. The country is striving to rebuild its economy with the production of deep processing of cotton, bringing raw cotton to finished products. Therefore, scientific research aimed at improving the quantitative and qualitative indicators of cotton products for the country is of great importance. Currently mechanical method of catching not-well-ginned seeds and free fiber is being used, and in this process fiber and seeds can get harmed as well. One of the main advantages of vibro-catchers for not-ginned fractions of cotton seeds and free fiber is the absence of punching effect to material [9]

2. Research Methods

For the correct compilation of the technological process of primary processing, a comprehensive study of the geometric parameters and physical and mechanical properties of cotton seeds is required, which include geometric dimensions, strength, weight, specific gravity, bulk density, elastic properties, friction coefficient, windage, electrical properties.

Studying the geometry of cotton seeds, we came to the following conclusion: the closest geometric figure for cotton seeds is the combination of a hemisphere with a cone (**Figure 1**). In this case, the volume of one seed can be determined by the following formula:

$$V_c = \frac{3}{2}\Pi r^3 + h/3\,\Pi r^2 = \left(\frac{3}{2}r + \frac{h}{3}\right)\Pi^2 \tag{1}$$

Surface area

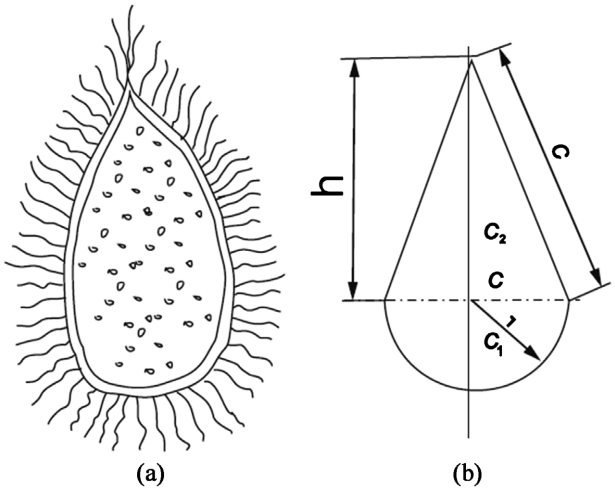

Figure 1. Cross section of cotton seeds. (a) Drawing; (b) Diagram.

$$F_c = 2\Pi r^2 + \Pi rc = \Pi r^2\left(2r + \sqrt{r^2 + h^2}\right) \tag{2}$$

The center of gravity along the length of the seeds is determined taking into account its two components

$$C = \left[\frac{\Pi r^2}{2}(0.4244r) + 0.5hr\right] \Big/ 0.5r(\Pi r + h) \tag{3}$$

According to formula (1), the specific gravity of an individual seed can be determined, and according to formula (2), the surface area of seeds can be determined by determining the number of fibers on a certain surface.

Seeds that have the form of a combination of a hemisphere with a cone enable them to fly and fall only with a blunt end, while the aerodynamic air resistance is minimal.

The location of the center of gravity according to formula (3) confirms this process.

The geometric dimensions of the seeds of each plant vary quite widely, so for a clear idea of their true sizes, it is necessary to know the variability of seeds in length, width and thickness.

Despite numerous studies on the study of the size of cotton seeds, the task of studying the sizes of the most promising varieties of cotton, such as C-6524, etc., is urgent. In the studies, the size of the seeds is determined after the seeds are completely exposed from the fibrous cover. These works were dedicated to the accurate sowing of seeds. The work [15] [16] [17] considers the influence of the cotton germination zone on the quality of seeds.

Geographically, the Republic of Uzbekistan is divided into three zones: northern, central, southern. Cotton seeds grown in the southern zone are characterized by high maturity and size compared to those grown in the northern and central zones. **Table 1** below shows the size of the bare seeds:

It is impossible to determine the size of pubescent seeds with a fibrous shell by the above method. Therefore, we have developed a methodology and bench in-

stallation for determining the size of seeds. The L-4 enlarger was taken as the installation. The film cassette of the photographic enlarger was replaced by organic glass, in which a line was drawn with a step of 0.25 mm. Seeds put on this glass stirred into an enlarger. And from the board, the increase was observed in the length and width of the seeds according to their projections and simultaneously recorded in a table. Size measurements were carried out in triplicate, 100 seeds each. Based on the measurement results, we built a histogram of the variational distribution (Figures 2-4). Research confirms the above assumptions about seed sizes, since the length of the seeds varies from 8 to 12 mm. More mature and larger seeds are more pubescent. Seeds are distributed along the length in the following order.

Seeds with a length of 8 to 9 mm make up 20% - 25%, from 9 to 10 mm - 35% - 40%, from 10 to 11 mm - 30% - 35%, from 11 to 12 mm make up 10% - 15%. Below in Table 2 when conducting research on the results of research on selection parameters.

The size of the seeds varies not so much depending on the variety, on the zone of germination and the variety of seeds, but on the location of the seeds in one box. To study the above, we studied the size of the seeds in one piece of cotton. The length of the seeds from the lower to the middle gradually increases, from

Table 1. The size of the bare seeds is given.

Growth Zone	Seed Sizes			Thickness Shells	Weight of 1000 Seeds
	Length	Width	Thickness		
Northern	7.27 - 9.72	4.33 - 5.32	3.93 - 4.48	0.22 - 0.28	107.0
Central	7.34 - 9.29	4.44 - 5.53	4.09 - 4.75	0.24 - 0.35	109.0
South	8.02 - 10.2	4.73 - 5.65	4.49 - 4.94	0.27 - 034	112.0

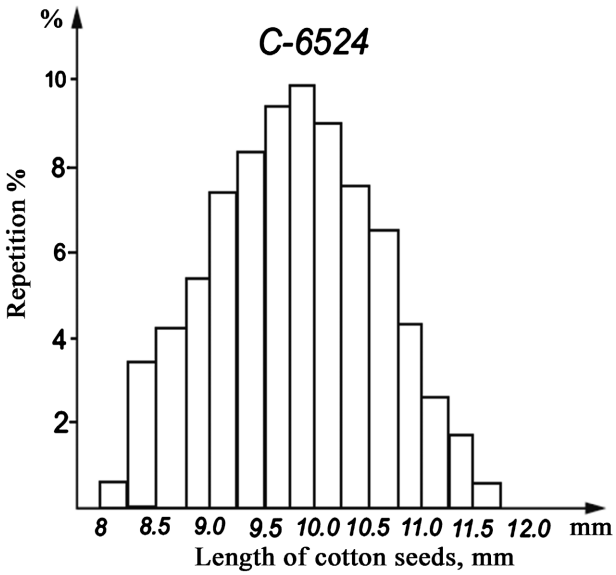

Figure 2. Histogram of distribution of cotton seeds along the length of variety C 6524.

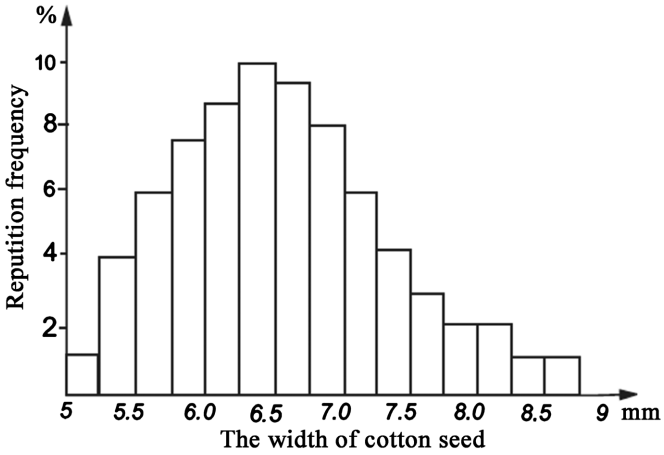

Figure 3. Histogram of distribution of seeds by width of variety C-6524.

Table 2. Cotton selection and seed sizes are given.

Cotton Selection	Seed Sizes		
	Length	Width	Thickness
C 6524	8.00 - 12.25	5.5 - 8.75	5.1 - 8.2
Namangan 1	7.75 - 12.300	5.60 - 9.00	5.4 - 8.2
AN 60	6.50 - 9.60	4.30 - 5.35	4.0 - 5.2
Namangan 77	7.6 - 9.5	5.4 - 8.6	5.1 - 8.1
Porloq	7.6 - 11.8	5.4 - 8.6	5.4 - 8.1

the middle to the top it gradually decreases.

The width of cotton seeds with different degrees of pubescence is distributed as follows.

Seeds that have more hairiness have a greater width than seeds that have a lower degree of hairiness. Seeds with a width of 5 to 6 mm make up 20% - 25%, from 6 to 7 mm—35% - 40%, from 7 to 8—20% - 25%, from 8 to 9—10% - 15%.

The conducted studies on the study of the size of the seeds allow you to correctly select the size of the sieve openings.

According to Kagalovsky [18], the specific gravity of bare seeds fluctuates around unity (1.0 - 0.06), which makes it possible to use water for sorting sowing seeds. When immersed in water, light, defective seeds float, and mature ones sink.

The specific gravity of raw cotton at normal humidity is approximately 1.3 g/cm^3. As the fibers are removed from the seeds, their specific gravity increases, since the specific gravity of the seeds is much greater than the fibers. Bulk weight, due to the fact that the fiber is removed along with a large layer of air, grows. Thus, sowing pubescent seeds have a bulk weight of about 350 - 400 kg/m^3, ginned seeds 300 - 320 kg/m^3, while 1 m^3 completely bare seeds weigh 560 - 600 kg/m^3.

With an increase in full pubescence, the volumetric mass of seeds decreases.

The pubescence of seeds has a greater effect on the bulk mass when they are freely dumped and less so when they are compacted. Rybalskaya M.B. [18] determined the change in the volumetric weight of seeds from normal pressure, the elastic properties of seeds, and the cohesive force between them. A mathematical expression is proposed for the dependence of the volumetric weight of seeds on normal pressure:

$$g = a_0 + a_1 \lg\left(H + \frac{P}{2F}\right) \tag{4}$$

where: a_0 a_1—constant coefficients depending on the pubescence of seeds;

H—is the specific pressure on seeds in N/sm^2;

F—is the area on which the compacting load acts in sm^2;

P—weight of seeds under compacting load, kg.

The formula is valid for pressures:

$$H = 14.7 \times 10^{-3} \text{ mH/sm}^2$$

At the same time, an empirical relationship was established between the volumetric mass of the mixture and the complete pubescence of seeds:

$$q = B_0 + \frac{B_1}{\lg C}$$

where C—is the total pubescence of seeds,%

B_0, B_1—constant coefficients depending on the specific pressure.

B.L. Begelman [19] studied the dependence of the bulk density of the cotton mixture on the specific pressure at its pubescence from 0 to 8.0%. So, with a pubescence of 0.49%, the volumetric mass with an increase in specific pressure from 0 to 33,500 Pa increases from 612 to 635 kg/m^3 (by 4.0%), with a pubescence of 2.5%—from 523 to 594 kg/m^3 (by 13.0%), and with pubescence of 7.7%—from 248 to 480 kg/m^3 (by 30.0%).

The complex of physical-mechanical and biological properties of seeds can be assessed by density, which indicates their maturity. Studies have shown that seed sorting by density is an important agricultural technique that significantly increases the yield of cotton. To determine the amount of cotton seeds, it is necessary to establish their volume, which is complicated by the irregularity of the shape, the heterogeneity of its rare parts and the presence of an air layer in the seed. Therefore, along with the density indicator, researchers use such an indicator as the specific gravity of seeds [20].

According to G.I. Miroshnichenko [21], the specific gravity of pubescent cotton seeds of grade II is 1100 kg/m^3, III—1085 kg/m^3, for bare seeds of grade I this figure is 1080 kg/m^3, and IV grade—960 kg/m^3.

The mass of individual seeds varies widely and depends on the variety of cotton and the conditions of its growth. For a correct assessment of the mass of seeds of individual varieties of cotton, a mass of 1000 pieces is taken, and it ranges from 70 to 150 g. We have determined the mass of 1000 pieces of seeds for promising varieties of cotton. In **Table 3**, the results of these studies are given,

Table 3. Seed weight depending on breeding and industrial varieties.

Cotton variety	industrial grade	
	I	IV
C-6524	128.6	118.5
Namangan-1	114	107.5
AN-60	96.2	89.7
Namangan-77	11.50	10.26
Porloq	11.38	11.22

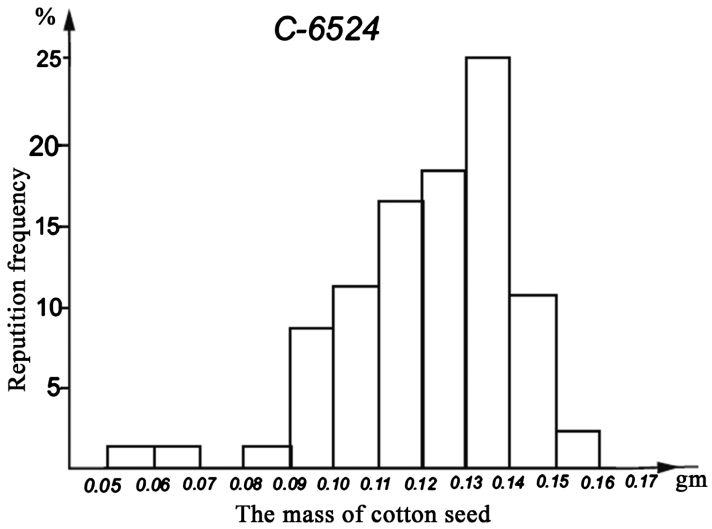

Figure 4. Histogram of seed distribution by weight of variety C-6524.

on the basis of which it can be concluded that with a decrease in the industrial grade of cotton, the mass of seeds decreases, respectively. These data may be different for different growing zones. Figure 4 shows a histogram of seed distribution by weight. From the histogram it can be seen that out of 100 seeds, about 2 - 3 seeds. Empty seeds weigh 0.025 - 0.05 g. From the histogram it can be seen that out of 100 seeds, about 2 - 3 seeds. Empty seeds weigh 0.025 - 0.05 g. Of the total mass of seeds, about 5% - 6% of the seeds have an increased pubescence and they weigh from 0.15 to 0.18 g. Seeds with reduced pubescence weigh from 0.08 to 0.11 g and they make up 40% - 45%. Seeds of normal pubescence weigh from 0.11 to 0.14 g and make up 45% - 50%.

3. Conclusions

Study of the physical and mechanical properties of cotton seeds, especially promising breeding varieties of medium fiber cotton:

- analysis of the fractional composition of ginned seeds and determination of their percentage depending on various factors;
- theoretical studies on the issues of vibration sorting of seeds;
- development of a device for sorting cotton seeds according to the degree of

pubescence and preparing them for further processing.

It has been established that the closest geometric figure for cotton seeds is the combination of a hemisphere with a cone.

Formulas were found for calculating the volume, surface area and center of gravity of the seed.

The sizes and weight characteristics of seeds were studied.

The probabilistic distribution of ginned seeds according to the degree of pubescence was determined;

It has been established that when seeds come out of gin, they have different pubescence: the number of under-ginned seeds and voles is 4.3% - 7.7%, the number of seeds subject to double and single lintering is 54% - 59% and 33% - 39%, respectively, the number of bare seeds is 0.25% - 1.47%;

The conditional movement of seeds without separation from the surface was determined;

A formula has been found that describes the movement of seeds without leaving the surface.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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