**Studying the Impact Interaction of Cotton Particle with Working Organs**

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**Abstract.** This article discusses the dynamic models of the interaction between raw cotton particles and foreign impurities, as well as the interaction of the cleaning machine's working elements with raw cotton particles. It is known that the contamination level of raw cotton entering the ginning process significantly affects the quality of the fiber obtained after ginning. Therefore, the task arises to maximize the cleaning of raw cotton from coarse and fine foreign impurities before the ginning process. The section for cleaning raw cotton from fine impurities in cleaners or other technological machines includes a drum with hooks, a hook-plate, or a knife drum equipped with a screen or grating placed beneath it. This limited selection of impurity separation devices leads to uniformity in the impact of the working bodies on the cotton, which, in turn, causes a diminishing cleaning effect on subsequent drums in a geometric progression. Increasing the overall cleaning efficiency is achieved by sequentially installing a large number of cleaning drums. Analyzing the interaction between the cleaning machine's working bodies and raw cotton particles, as well as the transfer of this impact to foreign impurities, can suggest ways to improve the cleaning section to enhance its overall efficiency. As a result of the research, a motion equation for a raw cotton particle during impact interaction was derived. An expression for determining the impact duration was obtained, which shows that the impact time does not depend on the velocity of the interacting particles.

**Keywords:** cotton, fine impurities, coarse impurities, cotton cleaner, hook drum, impact interaction, working body.

**INTRODUCTION**

Raw cotton received for processing contains large and small weed impurities. By origin, weed impurities are organic and mineral. Organic weed impurities consist of parts of leaves, fruit stems, flower buds, stems, cotton boll leaves, and other foreign impurities of gummy and pastel. Mineral impurities are sand, dust, and clods of earth. Impurities larger than 10 mm are classified as large impurities [1].

Raw cotton contamination is characterized by two assessments: quantitative, which determines the total soreness content in raw cotton, and qualitative, which determines the size characteristics of soreness and its relationship with the fiber particles of raw cotton [2].

Weed impurities are located both on the surface of raw cotton particles and inside its particles and flakes with varying degrees of adhesion [3]. Fine weed impurities penetrate deeply into the fibers and require significant shock-absorbing effects on the raw cotton to separate them [4]. Large weed impurities are mainly located on the surfaces of raw cotton, have weak adhesion to the fiber, and are more easily separated from it [5].

The presence of small and large weed impurities in raw cotton determined two main directions in the development of the designs of the working bodies of cleaning machines:

1) in cleaners used to separate fine weed impurities from raw cotton, the joint operation of loosening drums, mesh surfaces, and air flows is combined;

2) in cleaners intended for removing large weed impurities, the joint operation of saw drums, brushes for applying and fixing raw cotton particles on saw drums, removal ribs, and removal drums is combined.

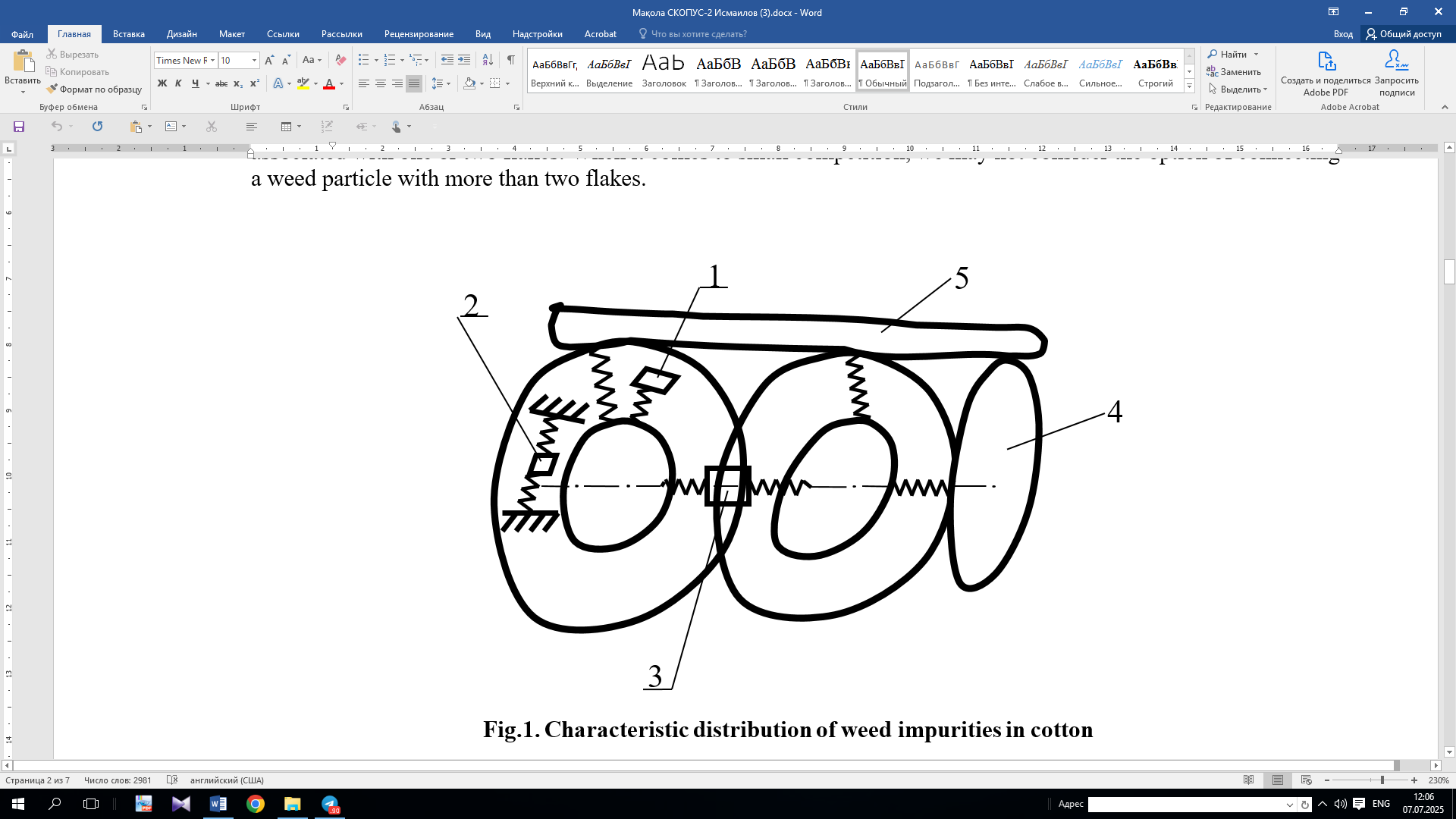
The section for cleaning raw cotton from fine particles in cleaners or other technological machines includes a spiked, spiked-plank or knife drum with a mesh or rib installed underneath it (in recent times, variants of installation above the drum have appeared) [6]. Such a poor selection of soron extraction means leads to a uniform effect of working organs on cotton, which, in turn, causes the cooling of the cleaning effect on subsequent drums in geometric progression [7]. Increases in the total cleaning effect are achieved by sequentially installing a large number (up to 32) spiked drums [8]. In the UXK type cotton cleaning line, the cleaning sections from fine sorghum alternate with the cleaning sections from coarse sorghum, which allows for a somewhat different effect on the cotton [9]. However, the overall increase in the number of spiked drums in the cleaning line increases the number of soft defects in the fiber [10]. An increase in the number of knife drums leads to increased seed damage and the appearance of defects in the fiber, such as seed damage and leather with fiber [11].

The section for cleaning raw cotton from large weed impurities consists of a saw drum, a lapping brush, and a rib. Moreover, the negative impact of the number of sawtooth drums on the fiber quality indicators is even greater.

The interaction of the working bodies of cleaners with raw cotton or fiber particles has been considered in many studies [12]. Analysis of the interaction of the working bodies of cleaners with raw cotton particles and the transmission of this effect to weed impurities can suggest ways to improve the cleaning section in order to increase its efficiency [13].

**MATERIALS AND METHODS**

Let's consider the distribution of weed impurities in the cotton particle. Only in harvested cotton, sor is located on the surface of particles, and these cotton particles are quite large (compact rollers in manual and stretched rollers in machine harvesting). During the transfer, storage, drying, and cleaning processes, these large particles of raw cotton break down into smaller particles containing from one to 3-4 flakes [6]. Part of the sorghum is separated in this process, but part of the weed impurities penetrates deeper into the cotton particle, transitioning to a more bound state. Let's consider the position of three small and two large weed particles (Fig.1.), associated with one or two flakes. When it comes to small competition, we may not consider the option of connecting a weed particle with more than two flakes.

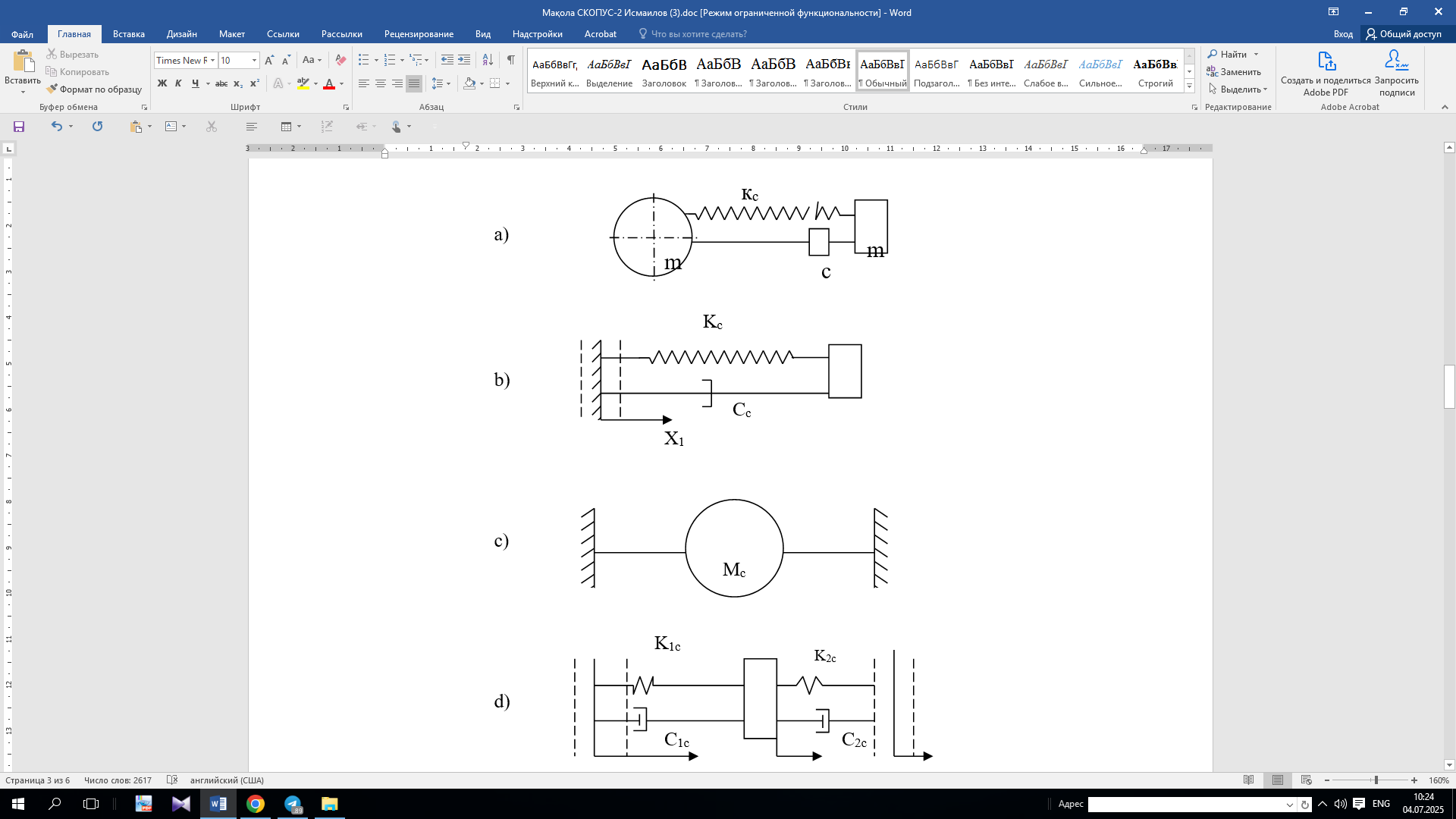


**FIGURE 1.** Characteristic distribution of weed impurities in cotton

Sorrow 1 can be located on the surface or inside the flower head in such a way that the largest radial connection from the seedling to the flower head surface is for it. For Sorghum 2, the strongest are the lateral connections with the fibers. And, finally, the 3rd weed is connected simultaneously with two flower buds.

Large weed particles are usually located on the surface of flakes or lobes, and their bonds with fibers are less strong. The weed 4 shown in Fig.1 is associated with one flower, while the weed 5 is associated with two (or more) flower heads.

Let us consider the process of separating fine weed impurities from raw cotton particles. In the process of cleaning from small weed impurities, a small mass of weeds practically does not affect the movement of cotton particles. Figure 2.a shows a dynamic model of the relationship between sorghum 1 and the cotyledon. Here m is the mass of the fly brought to the center of mass, ms is the mass of the sorghum.



**FIGURE 2.** Dynamic models of the relationship of fine sorghum with cotton particles

Since m»mс- from model 2-а one can move to model 2-b, assuming that the displacement of the mass center of the batch causes disturbing vibrations of the support, causing forced vibrations of the weed.

Here: k - is the stiffness coefficient, с - attenuation coefficient of the fibrous bond of the weed with the seed.

Figure 2-c shows a dynamic model of a weed 2 held by lateral fibrous bonds, which is conveniently interpreted as a mass m1 fixed to a string.

If we repeat the reasoning that allowed us to move from model 2.a to model 2.b, then the position of the weed 3 will be described by the dynamic model 2.d, where x1 and x2 are the displacements of the center of mass of the particles; k1c and k2c - stiffness coefficients of the fibrous bonds of the weed with adjacent seeds; с1c and с2c - are the damping coefficients of the corresponding fibrous bonds.

Of all the options considered, the 2.b consolidation option is most common. Therefore, we will examine it in more detail in the following works.

**RESULTS AND DISCUSSION**

During the interaction process with the working parts of the waste cleaning section, the cotton particle experiences quite diverse effects. Analysis of film and photographic materials showing the behavior of cotton in the cleaning section of the fine waste cleaner allows us to identify the following stages of cotton interaction with the working organs, during which the separation of waste occurs:

1. The impact of a knock on a stationary or moving cotton particle.

2. Impact of raw cotton particles on stationary or rotating (vibrating) ribs.

3. Impact of the cotton particle on the sifting surface.

4. Separation of particles when dragged along the sieving surface and others.

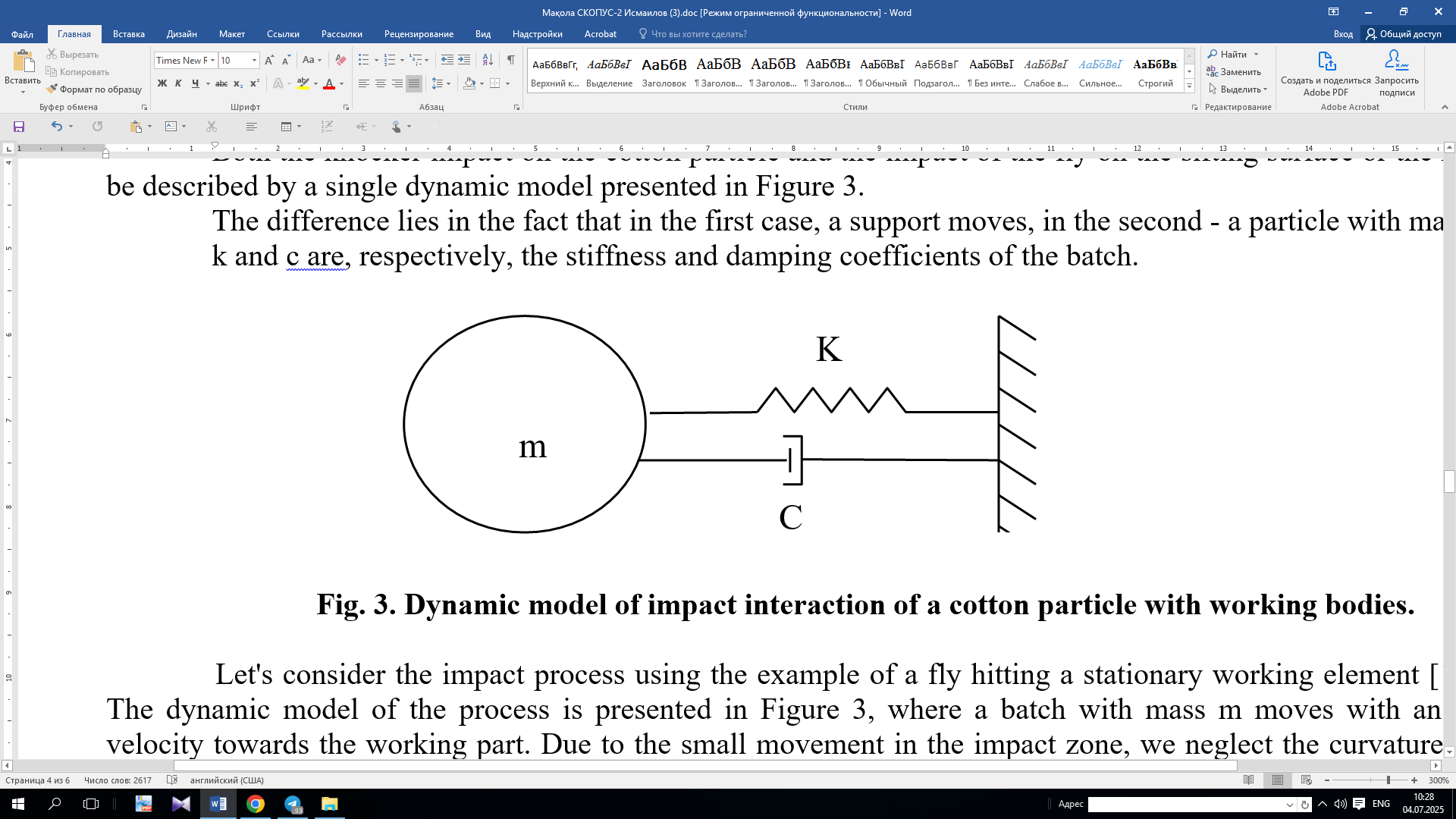
Let's consider the impact interaction of the cotton particle with the moving and stationary working parts of the cleaner.

During the cleaning process, raw cotton experiences repeated impacts on the machine's working parts. The displacement of the pulp's center of mass during impact causes the vibrations of weed particles bound to the seeds by fibers. These fluctuations lead to the separation of some weeds from the flakes. Therefore, it is necessary to study the behavior of the cotton particle when it hits the working part.

A stationary, lying on the mesh surface, or a moving cotton particle is subjected to impacts from the hooks or knives of the drum. After receiving the impact impulse, the cotton particle flies freely until it hits the sieving surface. Since the impact time is many times less than the time of all other processes during the cleaning process, it is possible to disregard the friction forces of the sliver against the sieving surface, the centrifugal force, and other forces, and consider only the elastic-viscous interaction of the sliver with the working part.

Both the knocker impact on the cotton particle and the impact of the fly on the sifting surface or the rib can be described by a single dynamic model presented in Figure 3.

The difference lies in the fact that in the first case, a support moves, in the second - a particle with mass m. k and c are, respectively, the stiffness and damping coefficients of the batch.



**FIGURE 3.** Dynamic model of impact interaction of a cotton particle with working bodies

Let's consider the impact process using the example of a fly hitting a stationary working element [13, 14]. The dynamic model of the process is presented in Figure 3, where a batch with mass m moves with an initial velocity towards the working part. Due to the small movement in the impact zone, we neglect the curvature of the particle's trajectory.

Let's compose the differential equation of particle motion:

 (1)

Dividing equation (1) by m and introducing the notations

(2)

we get:

 (3)

The solutions of equation (3) have the form:

(4)

where- is the circular frequency of damped oscillations; С1- and С2 - are constants determined from the initial conditions.

By differentiating equation (4), we obtain:

(5)

Substituting the initial conditions at t=0, Х=Хо=0 Х’=Х’о=Vо into equations (4) and (5), we find the values of C1 and C2

C1=0 (6)

Substituting (6) into (4), we obtain

(7)

The system shown in Fig. 3 exists for only half a period of oscillation, after which the sliver moves away from the colostrum surface. At the moment when the sliver breaks off, the condition X = 0 is satisfied again.

Then from (7)

sin(p1t) =0 (8)

The solution of equation (8) has the form p1t= nπ, where n=0,1,2, 3,.... are integers.

The solution p1t=0 corresponds to the beginning of the impact process, pt=π to the end. The remaining solutions have no physical meaning for this model, since after the impact ends, the model shown in Figure 1 ceases to exist. From this it follows that the impact time is:

(9)

As can be seen from equation (9), the impact time depends only on the physical and mechanical properties of the raw cotton.

Similarly, the problem of hammering a particle of raw cotton is solved. In this case, V0 is the pin's velocity.

It should be noted that the stiffness and damping coefficients in equations 1-9 are coefficients determined when the batch is compressed. The elastic-viscous properties of cotton for compression and stretching must be different, as compression deforms the fiber and seed, while stretching deforms only the fiber.

The obtained data are well consistent with the results of experiments conducted by A.E. Lugachev to determine the impact time, where it was experimentally shown that the impact time does not depend on the speed [6].

**CONCLUSIONS**

Raw cotton contamination is characterized by two assessments: quantitative, which determines the total content of impurities in the raw cotton, and qualitative, which determines the dimensional characteristics of the impurities and their relationship to the fiber of the raw cotton segments.

Waste impurities are located both on the surface of raw cotton particles and inside its particles and flakes with varying degrees of adhesion. Fine impurities penetrate deeply into the fibers and require significant impact-shaking effects on raw cotton to separate them. Large impurities are mainly located on the surface of raw cotton, have weak adhesion to the fiber, and are more easily separated from it. The disclosure of the process of interaction of trash impurities with cotton made it possible to find a new approach to the issue of separating trash impurities from cotton.

Based on the analysis of cotton cleaning operations, it has been established that in modern cotton cleaners, it is impossible to increase the cleaning effect without increasing the damage to cotton and the loss of fibrous material to waste. Intensification of the cotton ginning process must be carried out along the path of finding fundamentally new technical solutions.

The equation of motion of the raw cotton particle under impact interaction was derived. An expression for determining the impact time was obtained, which shows that the impact time does not depend on the velocity of the interacting particles.

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