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STUDY OF THE DEFORMED STATE OF THE ROTATING COTTON OF COTTON SEEDS IN THE WORKING CHAMBER OF THE LINTER MACHINE

Sulaymonov Rustam Shennikovich[1], Mardonov Botir Mardonovich[2] and Rakhmatov Rabbim Rakhmatovich*[3]

[1]Docent, Joint Stock Company, Paxtasanoat ilmiy markazi.

[2]Professor, Tashkent Institute of Textile and Light Industry.

[3]Docent, Tashkent University Information and Technologies.

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***Corresponding Author**
Rakhmatov Rabbim Rakhmatovich
Docent, Joint Stock Company, Paxtasanoat ilmiy markazi.

ANNOTATION

The deformed state of the seed in the working chamber of the 5LP linter using the models of a continuous medium with elastic characteristics is considered. The mechanical properties of this semiconductor are characterized by the Young's modulus and the Poisson's ratio, which are average in the volume of the working chamber. In this case, the raw roller, formed by a mass of cotton seeds, is adopted by an elastic body with Lame coefficients filling the cylindrical vessel with a certain radius and length. A theoretical study was made of the state of the seed mass in the area of rotation of the tedder and closer to the inner surface of the working chamber affecting the efficiency of the seeding process.

ABSTRACT

The deformed state of the seed in the working chamber of the 5LP linter is considered. A theoretical study was made of the state of the seed mass in the area of rotation of the tedder and closer to the inner surface of the working chamber affecting the efficiency of the seeding process.

KEYWORDS: Linter, working chamber, saw cylinder, agitator rall, cotton seeds, seed roller, deformation, tension, rotation.

INTRODUCTION

At cotton growers in the process of seed lintering, 5LP linterers are used. In the working chamber of the 5LP linter, a seed roller is formed when the saw cylinder and the agitator interact.[1] The process of lintering on this machine is carried out by scraping the saws from the surface of the seeds of the fibrous surface and removing it outside the grate.

The products of the technological process of cotton seed lining are unprofitable for a cotton processing enterprise, and the cost of lint production is attributed to the cost of the fiber. The results of the conducted studies and their analysis show that low procurement prices for lint are incommensurable with the costs of obtaining it.

According to the technological procedure of the PID 70-2017, after the process of jinning of raw cotton, a lint remains on the seeds, amounting to about 10-15% of its initial fiber content in the total volume.[2] In this connection, cotton processing plants are provided with a technological operation-the lintering of cotton seeds on liner machines in order to obtain lint widely used in the textile, chemical and pulp and paper industries.[3,4]

The degree of removal of lint is determined by the size of the gap between the edge of the vertical part of the worm blade and the surface of the saw cylinder headset. Due to the low percentage of lint removal, it is difficult to remove the seeds from the working chamber, which leads to their long stay in the zone of lintering, and at the same time to increase the mechanical damage to the seeds, and to reduce the quality of the linters.

Low productivity of the 5LP linter by seeds is characterized by inefficient scraping of the fibrous cover from the seed surface. The most probable cause of this phenomenon is the imperfection of one of the main working organs - the seed worm. Because of the drawbacks of the structure of the tedder, its slatted organs limit the scraping of lint from the seeds with the teeth of the saws. This leads to a decrease in the efficiency of the removal of lint, and, accordingly, the productivity of the linter in the seeds and lint, the deterioration in the quality of the products produced, the unjustifiably high consumption of electricity for rotating the seed roller, and the increased pubescence and damage to the seeds leaving the working chamber. In addition, the agitator 1 in the working chamber 2 does not provide the required speed of the seed roller 3.[5,6] In this case, several layers are formed in the seed roller, which rotate at different speeds around the wagon (Figure 1).

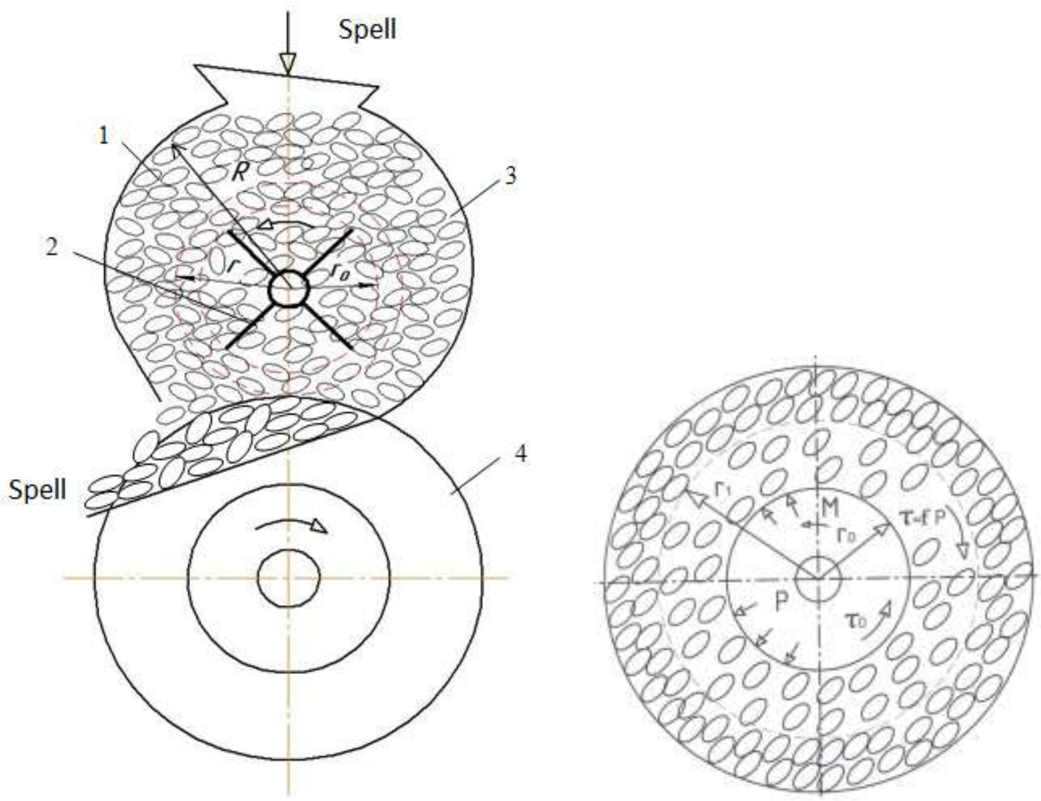
MATERIALS AND METHODS

For a theoretical study of the process of deformation of the mass of cotton seeds in the working chamber, various models of a continuous medium can be used. In particular, as such a model it is possible to choose an elastic medium whose mechanical properties are characterized by the Young's modulus values and the Poisson's ratio that are average in the volume of the working chamber. Such a model can be used to analyze the state of the lint-seed mixture at small fractions in its composition of fibrous ($\nu = 5 - 10\%$ A by volume) mass. In this case, it is possible to determine the mechanical properties of the mixture under the known law of deformation of seeds and fibers separately, and thus, according to known averaging laws, a model of a continuous medium with known elastic characteristics can be considered.[7,8] Roller formed mass of cotton seeds accept elastic body with Lamé coefficients λ, G, which fills the cylindrical vessel radius R_2 and a length l (Figure 1).

Moreover, the coefficients λ, G, Young's mo dulus E and Poisson's ratio ν are related by the formulas[9]

$$\lambda = \frac{E\nu}{(1+\nu)(1-2\nu)}, \; G = \frac{E}{2(1+\nu)} \qquad (1)$$

Part of the cylindrical layer with internal and external radii R_0 and R_1 of the body, concentric with the original cylinder R_2 ($R_0 < R_1 < R_2$), rotates about the axis with a constant angular velocity ω, the problem is assumed to be axisymmetric, and we introduce cylindrical coordinates (r, z), where the Oz axis is directed along the axis of the cylinder, and the axis is perpendicular to it.



a) b)

1- working chamber, 2 mowers, 3 seeds, 4-saw cylinder Figure 1 (a and b). Scheme of movement of the seed roller in the working chamber linter 5LP.

We denote by $u_i(r,z)$ and $w_i(r,z)$ the radial and axial displacements of the cross sections for the inner $R_0 < r < R_1 \quad (i=1)$ and outer $R_1 < r < R_2 \quad (i=2)$ of the cylindrical layers (Fig. 1), respectively, which satisfy to the Lame equations.[10]

$$(\lambda+2G)\frac{\partial}{\partial r}\left(\frac{\partial u_1}{\partial r}+\frac{u_1}{r}+\frac{\partial w_1}{\partial z}\right)+G\frac{\partial}{\partial z}\left(\frac{\partial u_1}{\partial z}-\frac{\partial w_1}{\partial r}\right)=-\omega^2\rho r \qquad (2)$$

$$(\lambda+2G)\frac{\partial}{\partial z}\left(\frac{\partial u_1}{\partial r}+\frac{u_1}{r}+\frac{\partial w_1}{\partial z}\right)-G\frac{\partial}{\partial r}\left(\frac{\partial u_1}{\partial z}-\frac{\partial w_1}{\partial r}\right)-\frac{G}{r}\left(\frac{\partial u_1}{\partial z}-\frac{\partial w_1}{\partial r}\right)=0,\ 0<r<R_1, \qquad (3)$$

$$(\lambda+2G)\frac{\partial}{\partial r}\left(\frac{\partial u_2}{\partial r}+\frac{u_2}{r}+\frac{\partial w_2}{\partial z}\right)+G\frac{\partial}{\partial z}\left(\frac{\partial u_2}{\partial z}-\frac{\partial w_2}{\partial r}\right)=0 \quad (4)$$

$$(\lambda+2G)\frac{\partial}{\partial z}\left(\frac{\partial u_2}{\partial r}+\frac{u_2}{r}+\frac{\partial w_2}{\partial z}\right)-G\frac{\partial}{\partial r}\left(\frac{\partial u_2}{\partial z}-\frac{\partial w_2}{\partial r}\right)-\frac{G}{r}\left(\frac{\partial u_2}{\partial z}-\frac{\partial w_2}{\partial r}\right)=0,\ R_1<r<R_2,\ (5)$$

$0<z<l$,

To integrate equations (2) - (5), we accept the conditions for the absence of tangential stresses σ_{irz} and radial displacements u_i on the outer surface of the inner cylinder $r = R_0$ and on the inner surface of the cylinder $r = R_2$. In the sections $z = 0$, $z = l$, tangential stresses $\sigma_{ir\theta}$ and axial displacements w_i will vanish. Thus, we have

$$u_1 = 0,\ \sigma_{1rz} = 0 \ \text{at}\ r = R_0,\ 0 < z < l \tag{6}$$

$$u_2 = 0, \sigma_{2rz} = 0 \ \text{at}\ r = R_2,\ 0 < z < l \tag{7}$$

$$w_1 = 0, \sigma_{1r\theta} = 0 \ \text{at}\ z = 0,\ z = l,\ R_0 < r < R_1 \tag{8}$$

$$w_2 = 0, \sigma_{2r\theta} = 0 \ \text{at}\ z = 0, z = l,\ R_1 < r < R_2 \tag{9}$$

In addition, on the boundaries of two cylindrical layers $r = R_1$, the conjugation conditions are fulfilled, according to which the radial and axial displacements, as well as the normal and tangential stresses, will be continuous:

$$u_1 = u_2,\ \sigma_{1r} = \sigma_{2r},\ w_1 = w_2,\ \sigma_{1rz} = \sigma_{2rz} \ \text{at}\ r = R_1,\ 0 < z < l \tag{10}$$

where σ_{ir}, σ_{irz}, $\sigma_{ir\theta}$ − are the radial and tangential stresses in the cylindrical

Equations (2) - (5) represent partial differential equations and require numerical methods to solve them with the boundary conditions (6) - (9) and the conjugation conditions (10). Proceeding from the boundary conditions (8) and (9), a). The length of the cylindrical layers in the chamber is constant, i.e. we assume that $\frac{\partial w_i}{\partial z} = 0$, b). The tangential stress $\sigma_{irz} = 0$ is everywhere equal to zero. Proceeding from the boundary conditions (8) and (9), we can assume $w_i(r, z) = 0$. Then under the conjugation conditions the last two conditions are fulfilled identically. From the equality $\sigma_{irz} = G\left(\frac{\partial u_i}{\partial z} + \frac{\partial w_i}{\partial r}\right)$ follows $\frac{\partial u_i}{\partial z} = 0$, i.e. radial displacements of u_i do not depend on the variable z. Under these conditions, equations (3) and (5) are satisfied identically, and equations (2) and (4) are reduced to the following types:

$$(\lambda + 2G)\frac{d}{dr}\left(\frac{du_1}{dr} + \frac{u_1}{r}\right) = -\omega^2 \rho r \quad 0 < r < R_1 \tag{11}$$

$$(\lambda + 2G)\frac{d}{dr}\left(\frac{du_2}{d} + \frac{u_2}{r}\right) = 0,\ R_1 < r < R_2 \tag{12}$$

From the boundary conditions (6) and (7) and the conjugation conditions (10) with allowance for expressions for radial stresses σ_{ir} follow

$$u_1 = 0 \text{ at } r = 0,\ u_2 = 0 \text{ at } r = R_2 \quad (13)$$

$$u_1 = u_2,\ \frac{du_1}{dr} = \frac{du_2}{dr} \text{ at } r = R_1 \quad (14)$$

Equations (11) and (12) are ordinary and their general solutions can be represented in the form

$$u_1 = A_1 r + \frac{B_1 R_0^2}{r} - \frac{\omega^2 \rho r^3}{8(\lambda + 2G)},\ u_2 = A_2 r + \frac{B_2 R_2^2}{r}$$

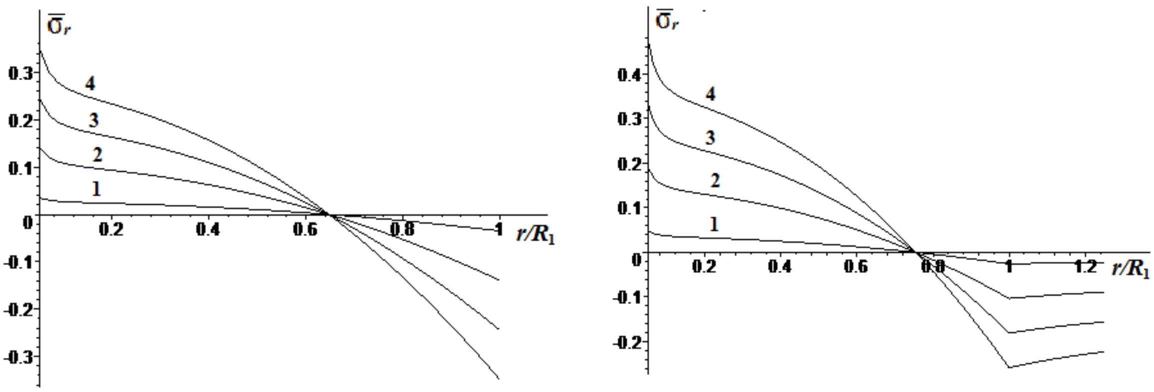
where the arbitrary constants A_i and B_i – are determined from the conditions (13) and (14)

$$A_1 = \frac{a_{11}c_2 - a_{21}c_1}{\Delta},\ A_2 = \frac{a_{22}c_1 - a_{12}c_2}{\Delta},\ B_1 = \beta k_1^2/8 - A_1,\ B_2 = -A_2,$$

Where $a_{11} = 1 + 1/k_2^2$, $a_{12} = -(1 + k_1^2)$, $a_{21} = 1 - 1/k_2^2$, $a_{22} = -(1 - k_1^2)$, $c_1 = \beta(k_1^4 + 3)/8$, $c_2 = \beta(k_1^4 - 1)/8$, $\Delta = a_{11}a_{22} - a_{12}a_{21}$, $k_1 = R_0/R_1$, $k_2 = R_1/R_2$, $\beta = \omega^2 \rho R_1^2/(\lambda + 2G)$

In Fig. 2 are presented in the form of graphs of changes in radial stresses (related to $\lambda + G$) along the reduced radius $\bar{r} = r/R_1$ of the cylindrical layers for different values of the parameters k_2 and β, where $k_1 = 0.05$. is accepted. If all the stresses are related to the value of $\lambda + G$, the dimensionless quantities $\bar{\sigma}_{ir} = \sigma_{ir}/(\lambda + G)$, $\bar{\sigma}_{i\theta} = \sigma_{i\theta}/(\lambda + G)$, $\bar{\sigma}_{iz} = \sigma_{iz}/(\lambda + G)$ depend on the Poisson's ratio ν, which is adopted by $\nu = 0.3$.

$k_2 = 1$ $k_2 = 0.8$



$k_2 = 0.6$ $k_2 = 0.2$

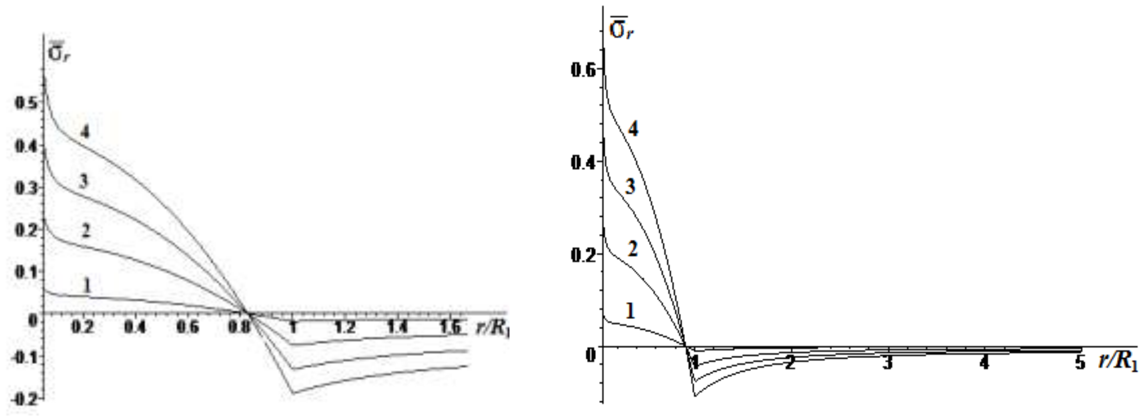


Fig. 2: Dependences of the reduced radial stress $\bar{\sigma}_r$ on the radius of the cylindrical medium for different values of the parameters: $k_2 = R_1 / R_2$ $\beta = \omega^2 \rho R_1^2 / (\lambda + 2G)$: $1 - \beta = 0.1$, $2 - \beta = 0.4$, $3 - \beta = 0.7$, $4 - \beta = 1$.

Analysis of the graphs shows that the radial stresses in the inner layer $R_0 < r < R_1$ have a positive sign up to a certain distance $\bar{r} = k_* = r_* / R_1$, which increases with decreasing k_2, which corresponds to an increase in the length of the zone of rotation of the medium layer, or to a decrease in the radius of the working chamber of the machine. So, for example, this distance is equal to $k_* = 0.65$ for $k_2 = 1$ and to $k_* = 0.8$, for $k_2 = 0.6$. In zone $k_* < r / R_1 < k_2$, the voltage has a negative sign. Thus, in the zone $k_1 < r / R_1 < k_*$, the layer material is stretched, and in the zone closer to the inner surface of the working chamber the layer is in a compressed state.

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