Determination of the Reaction During the Interaction of Cotton Flyers with the Multifaceted Network Surface of the Small Lot Cleaner

Murodov Orif Jumayevich[1]	[1,2,3]Tashkent Institute of Textile and Light Industry, Shokhdzhakhan 5, 100000, Tashkent, Republic of Uzbekistan baxrinjom@mail.ru
Pardayev Bahrom Choriyevich[2]	[1,2,3]Tashkent Institute of Textile and Light Industry, Shokhdzhakhan 5, 100000, Tashkent, Republic of Uzbekistan baxrinjom@mail.ru
Qulqorayev Abdumumin Xolmurot ugli[3]	[1,2,3]Tashkent Institute of Textile and Light Industry, Shokhdzhakhan 5, 100000, Tashkent, Republic of Uzbekistan baxrinjom@mail.ru

ABSTRACT

In the article, the new constructions of the piled drum and the polygon mesh surface for cleaning cotton from the initial small debris are presented, and the dynamics of interrelationships between the cotton fabric and the polygon surface are theoretically and practically studied.

Keywords: Cotton, cotton, integriruya, tensile strength, small waste, net mesh, multi-angle, friction force, cotton dynamics.

Cotton fiber is the main raw material used in the global textile industry. According to world statistics and the International Cotton Advisory Committee (ICAC), "the top five exporters of cotton fiber include: the United States, India, Australia, Brazil and Uzbekistan, as well as importers - Bangladesh, Vietnam, China, Turkey and Indonesia." In these countries, special attention is paid to the dynamic and sustainable development of the cotton ginning industry, the introduction of modern equipment at the enterprises of the industry, increasing the efficiency and rational use of production capacities, which are the basis for competitiveness in the global cotton market. In this regard, further improving the consumer properties of cotton products on a global scale, along with improving their quality indicators, reducing their cost, ensuring the efficiency of the cotton ginning process, improving cotton ginning machines and creating resource-saving technologies remains one of the important tasks [1].

When pulling cotton with a peg drum along the mesh surface, the force of interaction of cotton with the mesh surface is random [2]. In this case, the vertical component of the disturbing force is determined from the expression:

$$F(t) = F_b(t)\cdot \sin\beta \qquad (1)$$

here, $F_b(t)$ - total resultant perturbing force, β - angle of inclination of the perturbing force with the horizontal axis.

In the course of work, after interaction with the mass of cotton "m" with a mesh surface, angular vibrations of the latter occur, due to the elastic support of the grate. Accordingly, the mass "m" fluctuates. These fluctuations mainly depend on the strength of the interaction reaction.

Those who used the d'Alembert principle [3], it is possible to obtain differential equations of motion of the dragged cotton and the mesh surface of the fine litter cleaner:

$$m\ddot{y} + N - F(t) = 0$$

$$I_{c.n.}\ddot{\varphi} + bL^2\dot{\varphi} + cL^2\varphi = -NL$$

(2)

here, N- reaction force, L – distance between mesh surface supports;

y – vertical movement of mass «m» cotton; φ – angular displacement

At the same time, excluding the reaction force from the system of equations (2) and taking into account small displacements of the mass "m" along the vertical:

$$y = l\varphi \qquad (3)$$

can be written:

$$(I_0 + ml^2)\ddot{\varphi} + bL^2\dot{\varphi} + cL^2\varphi = fF(t)$$

(4)

here, I_0 is the moment of inertia of the mesh surface relative to the left support.

Reducing (4) to the standard form:

$$\ddot{\varphi} + 2n\dot{\varphi} + p_0^2\varphi = \frac{lF(t)}{I_0 + ml^2}$$

(5)

here, $2n = \frac{\alpha L^2}{I_0 + ml^2}$; $p_0^2 = \frac{cL^2}{I_0 + ml^2}$

In Fig.1. the mass of cotton "m" and the mesh surface are shown at an arbitrary point in time.

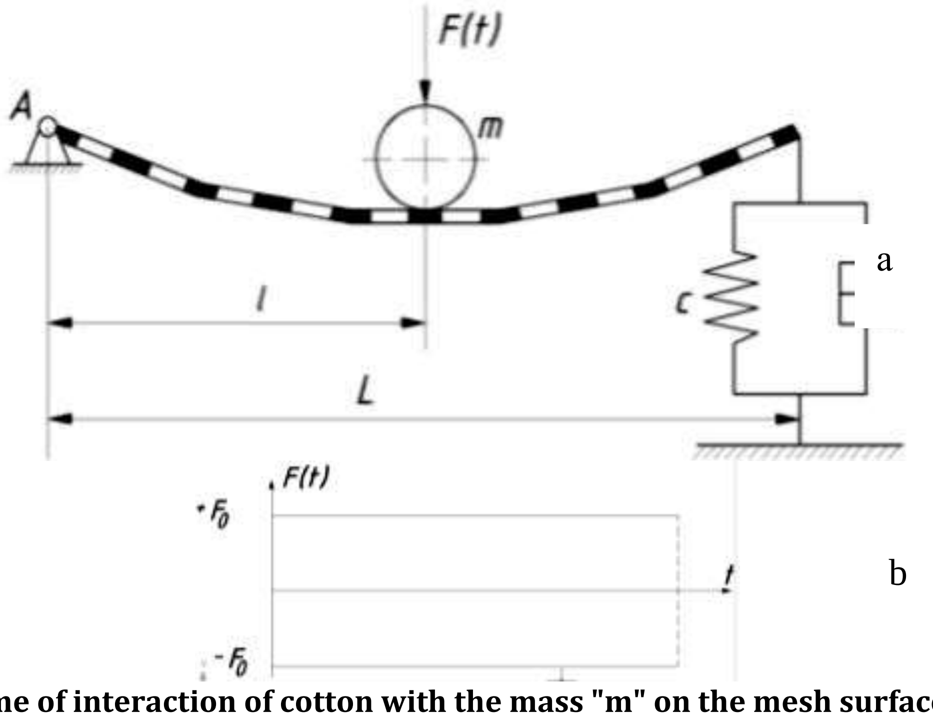
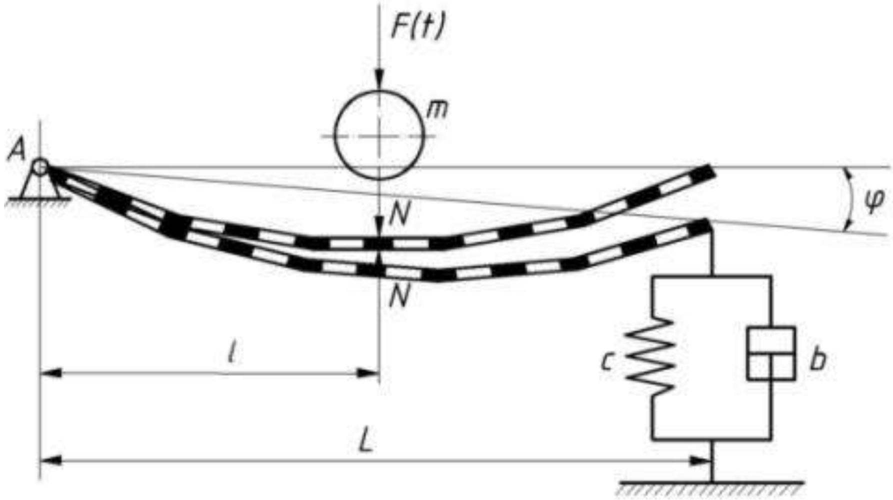


Fig.1. a - scheme of interaction of cotton with the mass "m" on the mesh surface of the cotton cleaner; b - graph of the perturbing force from cotton



here, c, b are the stiffness and viscous friction coefficients of the elastic support.

Fig.2. Scheme of the working position of the mesh surface

The solution of the differential equation (5) according to the well-known [4] methods can be represented as:

$$\varphi = \frac{1}{(I_0 + ml^2)p_1}\int_0^t l^{-n(t-\tau)} \sin p_1(t-\tau)F(t)dt \qquad (6)$$

here, $p_1 = \sqrt{p_0^2 - n^2}$

Taking into account the relationship between y and φ, from the first differential equation of system (2) we determine the dynamic response:

$$N = F_b(t)\sin\beta - ml\frac{d^2\varphi}{dt^2} \qquad (7)$$

Taking time derivatives (6) and substituting them into (3) we have:

$$N = F_b(t)\sin\beta - \frac{F_b(t)ml^2}{I_0 + ml^2} + \frac{ml^2\sqrt{p_0^4 + 4n^2p_1^2}}{(I_0 + ml^2)p_1}\cdot\int_0^t l^{-n(t-\tau)}\sin\left[p_1(t-\tau) - \gamma\right]F_b(t)d\tau \qquad (8)$$

here, $\gamma = arctg\frac{2np_1}{p_0^2}$

Dynamic response reaches its maximum value when the raw cotton fly breaks with the mesh surface of the fine litter cleaner. Dynamic response reaches its maximum value when the raw cotton fly breaks with the mesh surface of the fine litter cleaner. In this case, the perturbing force $F_b(t)\sin\beta$ takes the values $\pm F_0$, and the integrand remains positive all the time. The break point of the function $F(\tau)$ is determined from the condition [5]:

$$\sin(p_1\varepsilon_k + \gamma) = 0,\ p_1\varepsilon_k + \gamma = k\pi$$

wherein $\varepsilon_k = \frac{k\pi - \gamma}{p_1}$

Then, integrating (8), it is possible to determine the maximum value of the dynamic response during the interaction of cotton with the mesh surface of the cleaner:

$$N = \frac{I_0F_0}{I_0 + ml^2} - A\left[l^{-n\varepsilon}\sin(p_1\varepsilon + \gamma + \gamma_1)\Big|_0^{\varepsilon_1} - l^{-n\varepsilon}\sin(p_1\varepsilon + \gamma + \gamma_1)\Big|_{\varepsilon_1}^{\varepsilon_2} + \ldots\right] \qquad (9)$$

где, $A = \dfrac{ml^2 F_0 \sqrt{p_0^2 + 4n^2 p_1^2}}{p_0 p_1 (I_0 + ml^2)}$; $\gamma_1 = arctg \dfrac{p_1}{n}$

In order to obtain the values of the dynamic response $N_{\max}$, the upper limit is assumed to be infinity. In doing so, we get:

$$N_{\max} = \frac{I_0 F_0}{I_0 + ml^2} - A\left[\sin(\gamma + \gamma_1) + 2\sin\gamma_1 \sum_{k=1}^{k=\infty} l^{\frac{-n(k\pi - \gamma)}{p_1}}\right] \qquad (10)$$

taking into account $\sum_{k=1}^{k=\infty} l^{-\frac{n(k\pi-\gamma)}{p_1}} = \dfrac{l^{\frac{-n(k\pi-\gamma)}{p_1}}}{1 - l^{-\frac{n\pi}{p_1}}}$

Finally, we obtain an expression for calculating the maximum dynamic response in the form:

$$N_{\max} = \frac{I_0 F_0}{I_0 + ml^2} - A\left[\sin\gamma\cos\gamma_1 + \cos\gamma\sin\gamma_1 + 2\sin\gamma_1 \frac{l^{-\frac{n(\pi-\gamma)}{p_1}}}{1 - l^{-\frac{n\pi}{p_1}}}\right] \qquad (11)$$

here, $\gamma_1 = \arcsin \dfrac{p_1}{\sqrt{p_0^2 + n^2}}$

It is known [5] that when cleaning raw cotton with high pubescence (fibrillation), the tear of cotton from the mesh surface occurs to a sufficient extent.

At low values of the coefficient of viscous friction of the elastic support of the mesh surface of the cleaner, we can write:

$\sin\gamma \approx \dfrac{2n}{p_0}$; $\cos\gamma \approx 1$; $\sin\gamma_1 \approx 1$; $\cos\gamma_1 \approx \dfrac{n}{p_0}$

Then, expanding $l^{-\frac{n\pi}{p_1}}$ and $l^{-\frac{n\lambda}{p_0}}$ into a series and keeping only the linear terms of the expansion, from (11) we have:

$$N_{\max} \approx \frac{2F_0 p_0 ml^2}{\pi n(I_0 + ml^2)} \qquad (12)$$

The dynamic reaction during the interaction of cotton with the surface of the mesh of the fine litter cleaner will be:

$$N = \frac{ml^2 F_0 p_0^2}{(I_0 + ml^2)^2 2np_0} \sin\left(\frac{\pi}{2} + p_0 t\right) + F_0 \sin p_0 t \qquad (13)$$

During the operation of the cotton cleaner from small litter, about 40÷60 voles are concentrated in one row of pegs. At the same time, F_0 changes within $(12,8 \div 20)\cdot 10^{-3}$kg. The maximum value of the dynamic response in the discontinuous behavior of the perturbation from cotton up to 30% and more than at $F(t) = F_0 \sin\omega t$.

Summary: A mathematical model of the movement of a cotton particle along the flat surface of the face of the drum peg during its cleaning from small litter has been obtained. An analytical problem of the nature of the movement of the cotton fly along the x and y axes of the flat face of the drum peg is obtained, taking into account the angle of inclination of the peg face

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