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Improvement in Design and Methods of Calculation of the Characteristics of Vibrant Diamond Bars of Cotton Cleaners

A.Djurayev, R.X.Maksudov, Sh.Shukhratov, D.S.Tashpulatov

Tashkent Institute of Textile and Light Industry

ABSTRACT: The article gives information about the operating concept of the recommended diamond bar on the elastic bearing support, analyzes the excursion of the bar, justifies the characteristics and gives the results of the comparison production tests.

KEYWORDS: Cotton cleaner, bar, diamond, rubber bushing, oscillation, stiffness, movement law, effect.

I.ACTUALITY

Maximum preservation of the natural qualities of cotton should be based on the improvement of the machine design and the equipment of the preliminary treatment of cotton and creation of the movable operating elements of the machine affecting the cotton. The main indicator of the cotton cleaning machines operation is their ability to isolate rubbish, motes and various impurities from the seed-cotton by maximum preserving the natural qualities of the fiber and seeds [1].

Where in one of the drawback so f the existing machines and devices, intended for cleaning of the seed-cotton is the low efficiency of the impact of the movable operating elements to the treated material. This leads to the increase of the cleaning frequency. Multiple exposure of the seed-cotton to the existing devices and machines damages the fibers and seeds, decreasing their natural quality[2].That’s why, creation of the new highly-effective vibrant diamond bars on the elastic bearing supports of the cotton cleaners from the large litter, development of the methods of calculation of their main characteristics is the actual scientific-technological task of the industry.

II. Design of the diamond bar on the elastic bearing support.

For the reduction of the frequency of cotton cleaning from the small litter by intensification of the influence to the cotton of the cleaning zone elements has been developed the bar structure [3,4].

Thestructureconsistsofdiamondbars1, which are installed in aciform straps 4, by means of the elastic bushing and rotating saw cylinder 2 (see Pic. 1). In the offered design the purification process of the fibrous material is done in the following way. In the operation process the seed-cotton (fibrous material) enters the serrate drum 2, jags of which clenches the seed-cotton and pull it through the fire grate. In the operative range of the serrate drum 2 the cotton strike against the diamond bar1.Here in the force and the direction of the strikes along the rotation motion of the drum 2 will be different due to the different amount of the faces of the bar 1. In this case with the increase of the mount of the bar faces the impulsive strike force f the cotton against the bar faces 1, and with the decrease of the bar face amount 1, vice versa, the strike force increases. Such contact of the cotton with diamond(of different amount) bars1 favors the prominence of admixtures of various weight from the seed-cotton and with various depth of location in the seed.

For the control of the seed-cotton cleaning process, the installation of the bars 1 along the drum rotation motion 2 is performed according to the sinusoidal law. Here in smoothness of the process is eliminated, the scope of the direction of the impulsive strike against the various bar faces will change periodically 2, which conducts the significant prominence of drossy admixtures from the seed-cotton.

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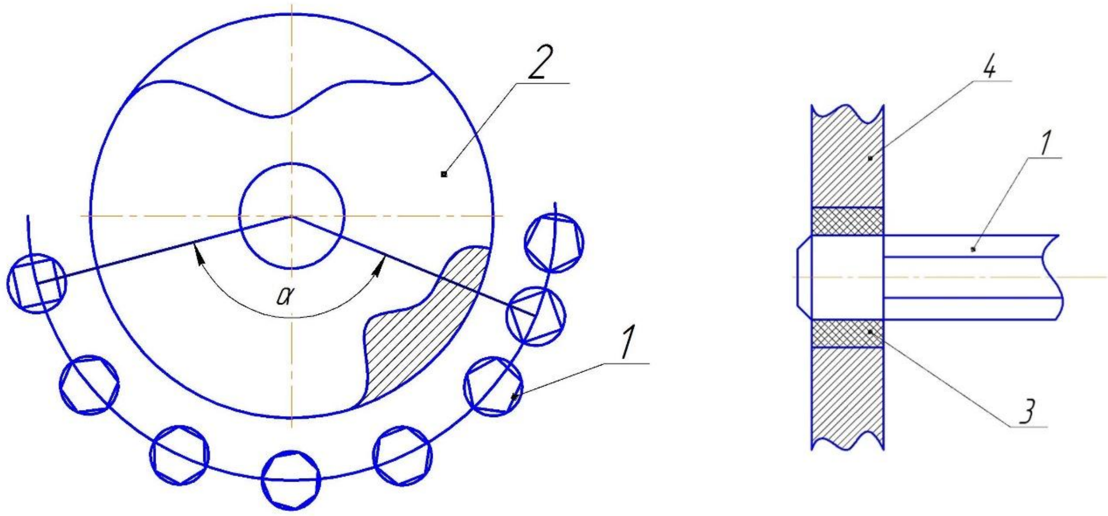

Pic. 1. The fire grate of the fibrous material cleaner

Generalized expressions, by which it is possible to determine the bar faces are f the following form:
$n_{i+1}= n_i+1$; $n_{i+2}= n_i+2$; $n_{i+3}= n_i+3$; $n_{i+4}= n_{i+2}$; $n_{i+5}= n_{i+1}$; $n_{i+6}= n_i$; $n_{i+7}= n_i+1$; $n_{i+8}= n_i+2$; $n_{i+9}= n_i+3$; $n_{i+10}= n_i+8$ ит.д.,

where n_i, n_{i+1},… n_{i+10}–the number of faces i, i+1,…, i+10-th bars.

The period of changes of the bar faces is chosen depending on the size of the bars 1, interwar gap, drum size 2 and the gap between the bars 1 and the drum 2.

Theinstallationofthebarsinthe1 arciformstraps4 by means of elastic (rubber bushing) 3allows increase the process of litter elimination from cotton due to additional vibration of the bars 1.

III. Calculation of the bar characteristics.

Taking into account of the random function of the perturbing force from the seed-cotton, nonlinearity of the restoring force of the elastic bearing support, its dissipative characteristics with the account of the operation [5,6,7] is possible to write down the equation of the oscillatory movement of the diamond bar as:

$$m\frac{d^2x}{dt^2}+в\frac{dx}{dt}+c_1x+\frac{c_2}{\mu}x^3=M(F_в)\pm\delta(F_в) \qquad (1)$$

where, в – coefficient of the internal resistance of the bar elastic bearing support.

Here in the following estimated values of the parameters were taken into consideration:

$$m=4{,}0Нс^2/м;\; c_1=2{,}5\cdot10^4\,Н/м;\; c_2=0{,}12\cdot10^4\,Н/м;\; в=60\ Нс/м;$$

$$\mu=1{,}0м^2;\quad \begin{aligned}M(F_k)&=19{,}67+0{,}98\sin(x+55^012')+7{,}83\sin(2x+112^014')+\\&+1{,}8\sin(3x+103^023')+3{,}37\sin(4x+4^039')+\\&+6{,}96\sin(5x+93^024')+2{,}7\cos6x\end{aligned}$$

From the analysis of the observed data and treatment of the m by the method of mathematical statistics was determined the expectation value of the perturbation force from the cotton on the bars and its possible variations not only by frequency, but also according to the amplitude.

The fragment of movement, speed and acceleration of the diamond bar on the elastic bearing support is given on the Pic.2 with the nonlinear restoring force at $m=3{,}0\,Нс^2/м$ и $c_1=2{,}5\cdot10^4\,Н/м$,

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$c_2 = 1{,}2 \cdot 10^4 H/м, \; M(F_в) = 12{,}5H, \quad \delta F_в = (0{,}8 \div 1{,}1)H$ .It should be noted that, the oscillation frequency of the bar is (40…55) Hertz. In this case the high-frequency component of the oscillation of the bars is (147…178) Hertz.

Low-frequencycomponentoftheforcedoscillationscomplieswiththerotational frequency of the saw cylinder of the UCM unit, and the high-frequency component conforms to the consideration of the amount of the bars in the section. From the Pic. 2 it is visible, that at the forced oscillations of the diamond bar, the bar inclines in average to the degree $X_{ср} = (1{,}4 \div 1{,}6) \cdot 10^{-3} м,$ and the peak-to-peak amplitude at the calculated values of the characteristics makes $\Delta X = (1{,}8 \div 2{,}1) 10^{-3} м.$

For the cylindrical bars on the elastic bearings according to the operation[8] peak-to-peak amplitude makes $\Delta X = (2{,}2 \div 2{,}5) \cdot 10^{-3} м.$ Comparison of the results shows, that in the offered structure of the diamond bar the amplitude of oscillation decreased to (20÷25)% due to the nonlinear hardening characteristics of the elastic bearing support. Similarly change the meanings $\dot{X}$ and $\ddot{X}$. Peak-to-peak amplitude of the speed reach from 0,6m/sto1,25 m/s, and the amplitude of oscillation of acceleration at the design values of the system within the range пределах (6,5÷10)m/s^2. Speed and acceleration oscillation frequencies comply with high-frequency component of the technological load from cotton.

The characteristic curves of the amplitude are given in the Pic. 3, speed and acceleration due to the increase in weight of the fire grate. It is known, that with the increase in weigh to fthe oscillating system, a great force is necessary for its perturbation that is with the increase in weight the oscillation amplitude of the diamond bar decreases. With the increase in weigh to fthebar from1,0ns^2/mupto5,0 nc^2/m the peak-to-peak amplitude of the diamond bar drops from $1{,}85 \cdot 10^{-3} м$ to $0{,}65 \cdot 10^{-3}$ m along the non linear pattern. Regarding the considered oscillating system it should be noted that with the increase in weight of the bar the decrease of speed and acceleration is also nonlinear. What is special, is that the intensity of the increase of the pea-to-peak amplitude ΔX, $\Delta \dot{X}$ and $\Delta \ddot{X}$ decreases with the increase in weight. It is due to the nonlinear hardening characteristic of the elastic bearing. In this case, with the increase in load to the bar, the intensity of deformation of the elastic bearing decreases which leads to the reduction of the oscillation amplitude of the bar. The recommended weight values of the diamond bars are (3,5÷4,0)ns^2/m.

In the process of cleaning of the seed-cotton from the large litter the important this is the bars' oscillating amplitude limitation. As these oscillations directly influence the gap width between the bars and saw cylinder. The value of the oscillation amplitude of diamond bars in our case is controlled by the nonlinear hardening characteristics of the elastic bearing support.

It is found by the studies that the increase of the coefficient of stiffness C_1 of the elastic bearing leads to the proportional decrease of the oscillation amplitude of diamond bars. For the provision of oscillation of diamond bars with the amplitude (0,5÷1,0) $\cdot 10^{-3} м$ the nonlinear component of the of the stiffness coefficient of the elastic bearing should the values (1,4÷2,0) $\cdot 10^4 н/м$, and stiffness coefficient $c_1 = (2{,}5 \div 3{,}5) \cdot 10^4 н/м$. Change of the width of the rubber bushing makes up to $3{,}0 \cdot 10^{-3} м$ (for the rubber band HO-68).

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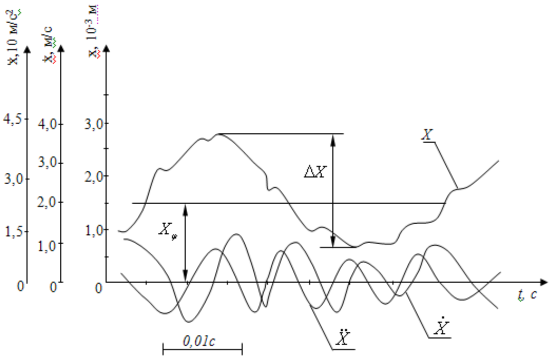
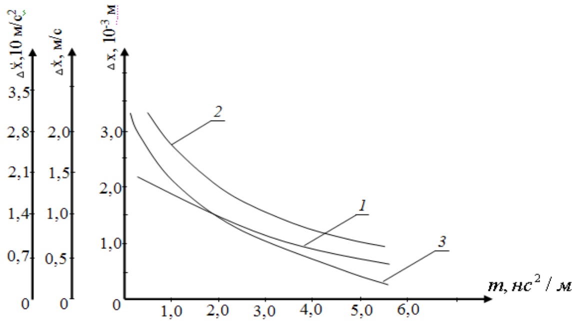


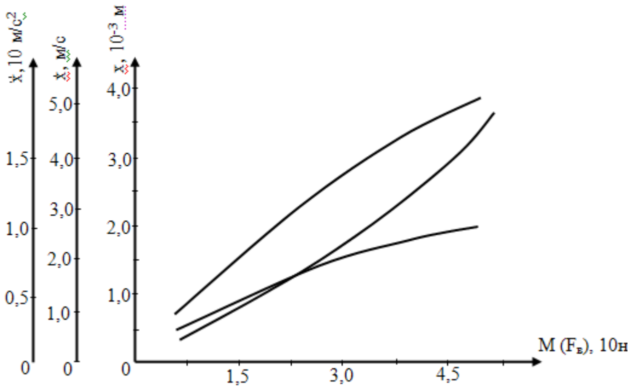
at $m = 3{,}0 нс^2/м$; $c_1 = 2{,}5 \cdot 10^4 н/м$
$c_2 = 1{,}2 \cdot 10^4 н/м$ $M(F_в) = 12{,}5$ H, $\delta F_в =$ (0,8÷1,1) H

Pic. 2 Change of the movement, speed, acceleration of the diamond bar on the elastic bearing at the random perturbation.



where,
$1 - \Delta X = f(m); 2 - \Delta\dot{X} = f(m); 3 - \Delta\ddot{X} = f(m);$
at $c_1 = 2{,}5 \cdot 10^4 H/м$; $c_2 = 1{,}2 \cdot 10^4 H/м$;
frictions $\delta\Delta X, \delta\Delta\dot{X}, \delta\Delta\ddot{X} = (10 \div 12)\%$

Pic. 3 Characteristic curves of the change of peak-to-peak amplitude of movement, speed and acceleration of the diamond bar due to the change in weight of the bar



Herein, frictions $\delta x, \delta\dot{x}, \delta\ddot{x} = (8{,}0 \div 10)\%$ $c_1 = 2{,}5 \cdot 10^4 н/м$ $c_2 = 1{,}5 \cdot 10^4 н/м$

Pic. 4. Dependence of the movement change, speed and acceleration of the diamond bars as a function of resistance from cotton

Dependencies of the movement change speed and acceleration of the diamond bars on the elastic bearing supports with the nonlinear hardness at the load variation of the seed-cotton is given in the Pic. 4. With the increase of resistance from cotton from 19,7Hup to 60H (average value) the movement of the bar increases from $0{,}65 \cdot 10^{-3} м$ up to $3{,}2 \cdot 10^{-3} м$. In this case, the hunting speed increases according to the nonlinear regularity up to 2,45m/s, and the acceleration raises up to 21m/s^2. Here in the frictions δx, $\delta\ddot{x}$ and $\delta\ddot{x}$ which depend on the random component of the load is within the range (8,0÷10)%. For prevention of dilation of briefings between the bars due to big oscillating amplitudes of the bar and decrease of the technological gap between the saw cylinder and bars the amplitude of the diamond bars according to the results of the experiments should not exceed $(0{,}8 \div 1{,}2) \cdot 10^{-3} м$.

That is why, for the provision of necessary oscillation amplitudes of the diamond bars, it is advisable to choose the seed-cotton resistance within the range (25÷35)H, which comply with the (5,0÷7,0) T/hin the machine UCM.

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IV. Results of application of diamond bars on the elastic bearing supports.

According to the results of the conducted full factorial experiment were recommended the following optimum value of characteristics of the large-scale cleaning cone: rotary velocity of the serrated drum– 300 min^{-1}; taper on the elastic bearing -0,015; stiffness of the elastic bearing support (rubber brand) – НО – 68 ($c_1 = 3{,}0 \cdot 10^4 H/м$; $c_2 = 1{,}6 \cdot 10^4 H/м$.)

In the separameter values of the large cleaning zone of UCM machine get the high effect of cleaning, decreased the mechanical defect of the seeds and the free fibers in the seed-cotton. Firegrate of the large cleaning section was made with these parameters of the cleaner UCM.

The results of the conducted comparative tests in the in-line systems of with the commercial and offered conical bars on the elastic bearings are shown in the table.

At the conduction of experiments the recommended structure of the firegrate with the conical bars on the elastic bearings showed high reliability and consistency of operation. Experiment results showed, that the cleaning purificatory effect increased in average upto 8,11% in comparison with the existing option of the fire grate, mechanical damage of seeds decreases to 1,09%, free fiber in the seed-cotton decreases two times, to 0,113%. This is due to the fact that in the interaction of raw cotton with vibroisolating conical grates, cotton-yarn is additionally shaken, increases their direction of movement due to the taper rate of

Table

Results of the comparison production tests

Indicators in %	After the cleanser with the pilot bars on the elastic bearing supports in 1-line UCM	After the cleaner with commercial bars in the 2nd Line of UCM
Initial seed cotton		
Humidity	8,7	8,7
Content of impurity	4,2	4,2
After cleaning purify effect		
Impurity content of the seed-cotton	67,95	59,84
Mechanical defect of the seeds		
Free fibers	1,41	1,83
	2,07	3,16
	0,107	0,22

the bars, which leads to the increase of the cleaning effect. Besides, the contact of the seed-cotton briefings with the bars will be elastic [9,10]. This brings to the decrease of the mechanical damage of the seeds, as well as the decrease of the formation of the additional free fiber.

V. Summary.

The new effective structure of the fire grate with conical bars on the elastic bearing supports with tapered thickness has been developed. On the basis of the numerical solution of the task, the characteristics and form of oscillations of the diamond bar of the cotton cleaner from the large litter were obtained. By the results of comparison production tests it is determined that at the recommended, чтоприрекомендуемых parameters of the cleaner with application of the diamond bars on the elastic bearings the cleaning effect increases up to 8,11%, mechanical damage decreases to 1,09% and reduces the number of free fibers to 0,113% in the seed-cotton.

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