The American Journal of Applied sciences
(ISSN – 2689-0992)
Published: February 28, 2021 | **Pages:** 126-137
Doi: https://doi.org/10.37547/tajas/Volume03Issue02-15

IMPACT FACTOR
2021: 5. 634

OCLC - 1121105553

The Theoretical And Experimental Basis For Calculating And Justifying The Parameters And Regimes Of The Working Areas Of The Cleaning Zone Of Fibrous Materials

Anvar Djurayevich Djurayev
(D.Sc) Doctor Of Science Tashkent Textile And Light Industry Institute, Tashkent, Uzbekistan

Shukhrat Latibjonovich Daliyev
(PhD) Doctor Of Philosophy In Technical Sciences Andijan Machine Building Institute, Andijan City, Uzbekistan

ABSTRACT

In the article, there is the scheme and principle of the work of the cotton cleaner from small litter includes a composite pin drum with elastic elements and a vibrating mesh surface on elastic hinges. Theoretically, the torsional-vibrational motion of a two-mass system of a composite shoe drum has been studied, and the regularities of the dependence of changes in the parameters of the pin drum have been obtained. Based on the approximate analytical solution of the integro-differential equation, the law of angular vibrations of the net surface on the elastic supports of the cotton cleaner is studied. Experimental studies revealed regularities of loading and a change in the speed of rotation of the drum. The results of the full-factor experimental studies of the sample of the composite fluke drum are given. Based on the study of each of the three factors on the changes in the cleansing effect of cotton, the graphical dependencies of the parameters are postrene. The best values of the factors at which a high purifying effect of cotton from small weeds are achieved are recommended. Production tests revealed that the cleaning effect in comparison with the existing version of the drum spindle in the recommended increases by an average of 2.7%.

KEYWORDS

Cleaner, fibrous material, splines, headset, elastic bushing, mesh, oscillation, equations of motion, analytical solution, law, dependence, optimization, testing, loading, cleaning effect.

INTRODUCTION

Topicality. In the world market, it is important to obtain textile fibers, especially cotton fibers of high quality [1]. At the same time, up to now, the existing technique and technology for cleaning fibrous materials from small litter does not meet modern requirements [2].

Development of an effective scheme for the zone of fine cleaning of fibrous materials. To ensure efficient cleaning of fibrous materials from small sludge, a new purifier scheme has been developed [3,4]. The main elements of the cleaning zone (Fig. 1) are the pin drum 1 equipped with an elastic sleeve 4 between the ring headset 2 and the shaft 3 of the drum 1 and also the mesh surface 5 installed in the machine casing 6 by means of elastic elements (bushings) 7 in the hinges. In the process of work, due to the elastic elements 4 and 7, torsional vibrations of the ring headset 2 and the mesh surface 5 with the required amplitudes and frequencies are performed to provide the necessary cleaning effect.

Analysis of the vibrations of the headset. When determining the amplitude of the angular vibrations of the drum headset, the system was considered as two mass rotational system [5].

The resulting system of differential equations describing the dynamics of the motion of the drum wheel in the steady state has the form

$$\frac{J_1 d^2\varphi_1}{dt^2} + c(\varphi_1 - \varphi_2) + b\left(\frac{d\varphi_1}{dt} - \frac{d\varphi_2}{dt}\right) = M_y \sin\omega t$$

$$\frac{J_2 d^2\varphi_2}{dt^2} - b\left(\frac{d\varphi_1}{dt} - \frac{d\varphi_2}{dt}\right) - c(\varphi_1 - \varphi_2) = M_c \qquad (1)$$

where, J_1, J_2 - moments of inertia of the internal cylinder with flanges (shaft) and a loaded cylinder with a headset of drum pins; φ_1, φ_2 - angular movements of the inner cylinder and the headset; c, b - coefficients of rigidity and dissipation of the elastic element; M_y - amplitude of the disturbance in steady state; M_c - resistance from dragged raw cotton (fibrous material).

The solution of problem (1) is carried out with the following values of the parameters: $M_y = 1{,}5 \div 2{,}0 N/m$; $\omega = 45 \div 50c^{-1}$; $c = 400 \div 600 Nm/rad$; $b = 7{,}2 \div 10 Nms/rad$. On the basis of a numerical solution of the problem, graphical dependences of the variation $\Delta\varphi_2$ on the variation of M_c, J_2 and c, which are presented in Fig. 2 and Fig. 3.

Analysis of the results shows that with increasing values of the rigidity of the elastic element, the amplitude of the oscillations φ_1 and φ_2 decreases.

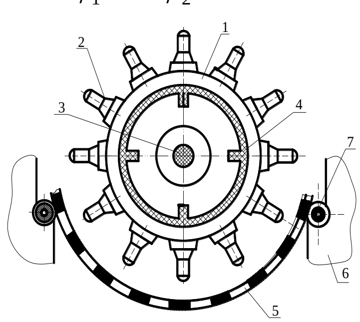


Fig. 1. Drum with elastic elements.

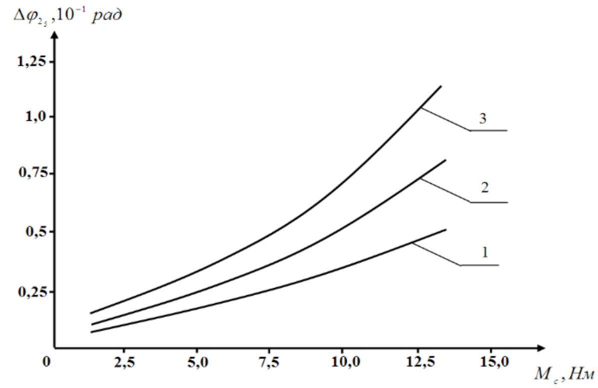


Fig. 2. Dependences of the swing of the oscillations of the angular movements of the ring headset on the technological loadwhere; 1- $c = 800\ Nm/rad$; 2- $c = 600\ Nm/rad$; 3- $c = 400\ Nm/rad$.

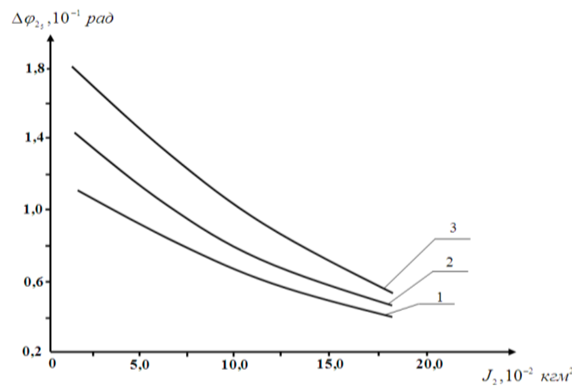


Fig. 3. Regularities in the variation of the swing of the oscillation of the headset from changes in its moment of inertia and the stiffness coefficient of the elastic element;
where, 1- $c = 800\ Nm/rad$; 2- $c = 600\ Nm/rad$; 3- $c = 400\ Nm/rad$.

It can be seen from the graphs obtained that with increasing technological resistance from raw cotton pulped by cotton barrel, the range of angular vibrations of the drum headset is increased by a nonlinear regularity. Thus, at $c = 400\ Nm/rad$ and the increase in M_c from $2{,}5\ Nm$ to $12{,}5\ Nm$, the swing $\Delta\varphi_2$ increases from $0{,}01\ rad$ to $0{,}054\ rad$, and at $c = 800\ Nm/rad$ the angular displacement $\Delta\varphi_2$ is within $(0{,}24-1{,}03)\cdot 10^{-1}\ rad$. To select the necessary amplitudes of angular vibrations of the headset, it is advisable to select the values of the moment of inertia J_2. According to the analysis of the graphs in Fig. 3 it can be noted that the increase in J_2 from $0{,}042\ kgm^2$ to $0{,}17\ kgm^2$ range $\Delta\varphi_2$ decreases from $0{,}16\ rad$ to $0{,}059\ rad$ at $c = 400\ Nm/rad$, and at a stiffness value of an elastic rubber sleeve $600\ Nm/rad$ $\Delta\varphi_2$ decreases from $0{,}127\ rad$ to $0{,}052\ rad$.

To ensure the swing of the angular vibrations of the drum headset within $(0{,}08-0{,}11)\ rad$, the recommended values are $J_2 = (0{,}068-0{,}12)\ kgm^2$, $c = (550-650)\ Nm/rad$.

The American Journal of Applied sciences
(ISSN – 2689-0992)
Published: February 28, 2021 | **Pages:** 126-137
Doi: https://doi.org/10.37547/tajas/Volume03Issue02-15

IMPACT FACTOR
2021: 5. 634
OCLC - 1121105553

Calculation of small angular vibrations of the mesh surface of the cleaner.

In the working area for cleaning raw cotton from small litter, one of the main technological parameters is the distance between the ends of the drum pins and the mesh surface. Angular vibrations of the mesh surface vary from the technological parameter. In principle, this gap should not exceed the size of the cotton fly. With a significant increase in the clearance between the pins and the mesh surface, braking can lead to further stopping the pulling of cotton flys over the mesh surface, and in some cases also slaughtering the system. Therefore, it is important to determine the maximum angular displacement and the speed of the mesh surface of the cleaner fibrous material from small litter.

The differential equation of small forced angular vibrations of the mesh surface under the condition that there is no dissipation of the elastic support according to (1) has the form:

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

Taking into account the following initial conditions, $\dot{\varphi}(0) = \varphi_0$, $\varphi(0) = 0$ we represent the solution of equation (2) according to [6] in the form:

$$\dot{\varphi}_k = \dot{\varphi}_0 \cos p_0 t_k + \frac{l}{I_0 + ml^2}\int_0^{t_k} \cos p_0(t_k - \tau)\cdot F(\tau)d\tau$$

To determine the law of variation of the disturbing force at $t_k = 2\pi / p_0$, an extreme value of the angular velocity $\dot{\varphi}(t_k)$ of the mesh surface

$$\dot{\varphi}_k = -\dot{\varphi}_0 + \frac{l}{I_0 + ml^2}\int_0^{t_k} \cos(3\pi - p_0\tau)F(\tau)d\tau \qquad (3)$$

Consequently, $\dot{\varphi}_k = \dot{\varphi}_{k\max}$ with the following law of variation of the disturbing force from raw-cotton:

$$F(\tau)=\begin{cases}+F_o npu 0\le\tau\le\dfrac{\pi}{2p_o};\\ -F_o npu\dfrac{\pi}{2p_o}\le\tau\le\dfrac{3\pi}{2p_o};\\ +F_o npu\dfrac{3\pi}{2p_o}\le\tau\le\dfrac{5\pi}{2p_o};\\ -F_o npu\dfrac{5\pi}{2p_o}\le\tau\le3\dfrac{\pi}{p_o}=t_k\end{cases}\qquad(4)$$

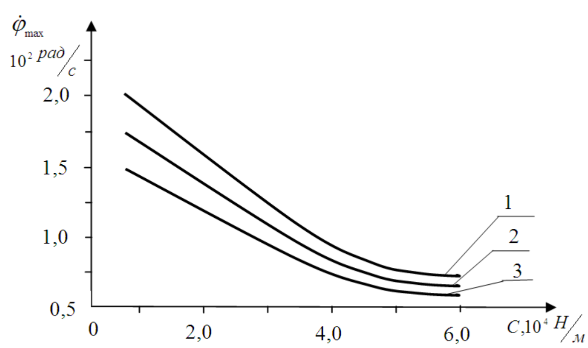
These regularities correspond to the number of tine rows, the rotation frequency and the phase of their arrangement.

Integrating Eq. (3) with allowance for the found law of variation of the perturbing force, we have:

$$\left|\dot{\varphi}_{\max}\right|=\dot{\varphi}_0+\frac{6lF_0}{L(I_0+ml^2)\sqrt{\dfrac{c}{I_0+ml^2}}}\qquad(5)$$

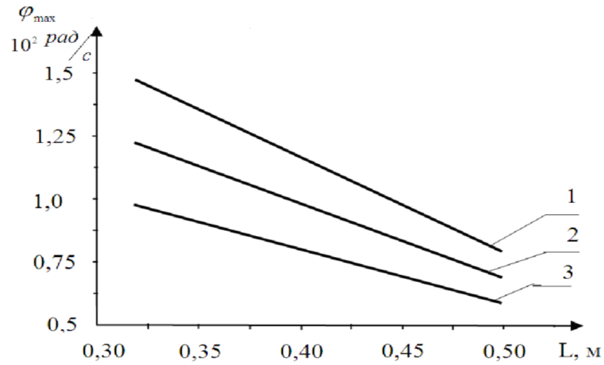
The numerical solution (5) is carried out at the following values of the main parameters of the cotton fine cleaning section: $I_0=(0.012\div0.02)\ kgm^2$; $c=(2.5\div6.5)\cdot10^4\ N/m$; $m=(0.025\div0.045)\ kg$, $L=(0,35-0,55)\ m$.

In Fig. 4 shows the graphical dependences of the change in the maximum value of the angular velocity of the oscillations of the mesh surface with the variation of the stiffness coefficient of the elastic support for different values of the moment of inertia of the mesh surface with respect to the hinged support.



where, $1-I_0=0,012\ kgm^2$; $2-I_0=0,016\ kgm^2$; $3-I_0=0,02\ kgm^2$.

Fig. 4. Graphical dependences of the change in the maximum angular velocity of vibrations of the mesh surface from the change in the rigidity of the elastic support



where, $1-m=25g;\ 2-m=35g;\ 3-m=45g;$

Fig. 5. Dependences of the change in the maximum angular velocity of vibrations of the mesh surface from the change in the distance between its supports.

Analysis of the graphs shows that with increasing rigidity of the elastic support, the maximum angular velocity of the mesh surface of the cotton cleaner is reduced by a nonlinear regularity. Thus, with an increase in the stiffness coefficient from $1{,}7\cdot10^4\ N/m$ to $6{,}2\cdot10^4\ N/m$ at $I_0=0.012\ kgm^2$, the angular velocity $\dot{\varphi}_{max}$ decreases from $1{,}6\cdot10^2\ rad/s$ to $0{,}76\cdot10^2\ rad/s$, and at the moment of inertia of the mesh surface $I_0=0{,}02\ kgm^2$, $\dot{\varphi}_{max}$ decreases from $1{,}36\cdot10^2\ rad/s$ to $0{,}73\cdot10^2\ rad/s$.

It should be noted that for large values of $\dot{\varphi}_{max}$, not only the maximum dynamic reaction is provided, but also the effect of cleaning raw cotton from small litter is significantly increased. Therefore, the following parameter values are recommended: $c=(2{,}5\div4{,}2)\cdot10^4 N/m$; $I_0=(0{,}012\div0{,}015)\ kgm^2$.

In Fig. 5 shows the obtained graphical dependences $\dot{\varphi}_{max}=f(L)$. The analysis of the constructed graphs shows that an increase in the distance between the supports of the mesh surface leads to a decrease in the maximum value of the angular velocity of the mesh vibrations according to a linear regularity. Thus, with an increase in the distance L from 0.33 m to 0.51 m, the angular velocity decreases from $1{,}43\cdot10^2\ rad/s$ to $0{,}877\cdot10^2\ rad/s$ with the weight of cotton acting on the mesh of $0{,}025\ kg$, and at a cotton weight of $0{,}035kg$, $\dot{\varphi}_{max}$ decreases from $1{,}134\cdot10^2\ rad/s$ to $0{,}74\cdot10^2\ rad/s$. It should be noted that the difference between the reference distance decreases with the increase between the reference distance 1,2,3 (see Figure 5). This is explained by the fact that for large values of L, the influence of the mass of cotton becomes insignificant on the angular velocity of the grid. Recommended values are: $L=(0{,}35\div0{,}45)\ m$; $m\le(25\div35)\ gr$.

Experiments to determine the loading of the spear drum.

Drum drive is carried out from the DC motor. The latter is connected to an autotransformer of the type AOMN-40-220-75. This allows you to change the drum speed in a wide range. The force dynamic loading of various structures was determined by strain gauging in bench conditions. The experimental study was carried out in three regimes with a triple repetition. The drum rotational speed was $350, 400, 450\ \min^{-1}$. Serve raw cotton $4\ kg/s$.

In Fig. 6 shows a typical oscillogram where the following are recorded: M_{kr} - is the torque at the shaft of the spinner, ω_b - is the angular velocity and n - is the number of revolutions per minute of the drum, and ε - is the angular acceleration, and τ - is the time.

In the steady state of the system, when the technological load is not included from the raw cotton, the amplitude of the moment oscillations on the drum shaft does not exceed 10-15% of the nominal value. When the technological load is switched on from raw cotton, the amplitude of the moment oscillations on the drum shaft sharply increases, but the nature of low-frequency and high-frequency oscillations is clearly expressed. Random fluctuations are caused by the load of raw cotton.

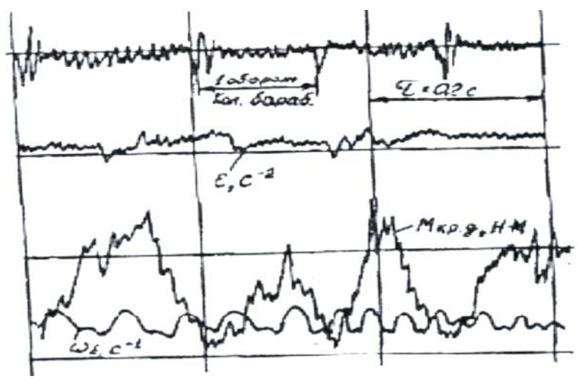


Fig. 6. Sample of the oscillogram when the technological load from the cotton to the pin drum.

Changes in the angular velocity of the drum correspond to the change in the transmission ratio of the belt drive. In this case, the unevenness of the rotation of the drum varies within 0,015 ... .0,2. On the basis of the results obtained, the shape and nature of the technological loads on the pin cylinder from raw cotton are revealed. The determination of these loads was carried out by the difference in the amplitude of the values of the torque on the shaft of the drum of the load and idle operating modes of the system. The obtained results were used for dynamic theoretical studies of the machine unit with the mechanism of the pin drum.

The results of full-flow experiments on the effect of the parameters of the cotton cleaning zone on fine sludge on the cleaning effect. To determine the effect of the main parameters of the fine-cleaning section on the cleansing effect of fine rubbish, a prototype

The American Journal of Applied sciences
(ISSN – 2689-0992)
Published: February 28, 2021 | Pages: 126-137
Doi: https://doi.org/10.37547/tajas/Volume03Issue02-15

IMPACT FACTOR
2021: 5. 634
OCLC - 1121105553

composite drum spinner with an elastic bushing was made and full factor experiments were carried out. Table 1 shows the limits of change in input factors.

For the output factor, the purifying effect of raw cotton is selected for small sors. On the basis of the technique given in [10, 11], the corresponding calculations and experiments were given, according to which the following regression equation was obtained:

$$Y = 38{,}81 + 1{,}81x_1 - 1{,}71x_2 + 1{,}08x_3 - 0{,}63x_1x_2 - 0{,}2x_1^2 - 0{,}2x_2^2 - 0{,}21x_3^2; \qquad (6)$$

Table 1.

Name factors	Coding	Factor Values					Limits of Change
		-1,682	-1	0	+1	+1,682	
Rotary drum rotation frequency, *n- min*$^{-1}$	X_1	364	380	430	480	514	50
The gap between the pint drum and the mesh , *t-mm*	X_2	16	17	20	23	25	3
The circular stiffness of the elastic bushing of the pin drum, *v - Nm/rad*	X_3	0,1318	0,2	0,3	0,4	0,4682	0,1

The adequacy of the regression equation was determined by the Fisher criterion [10, 11]. To optimize the parameters, equation (6) was given in the following form:

$$M_z = -4{,}04 + 1{,}84n + 2{,}03t + 0{,}225v - 4\cdot10^{-3}n\cdot t - 8\cdot10^{-5}\cdot n^2 - 0{,}022t^2 - 10^{-3}v^2; \qquad (7)$$

Numerical solution (7) was produced by Excel program in PC. Figure 7 shows the graphical dependences of the change in the purifying effect on the change in factor X_1. In this case, in Fig. 7, the new one is obtained for low values of X_2 and X_3, the second curve for intermediate values, the third curve for high values of factors X_2 and X_3.

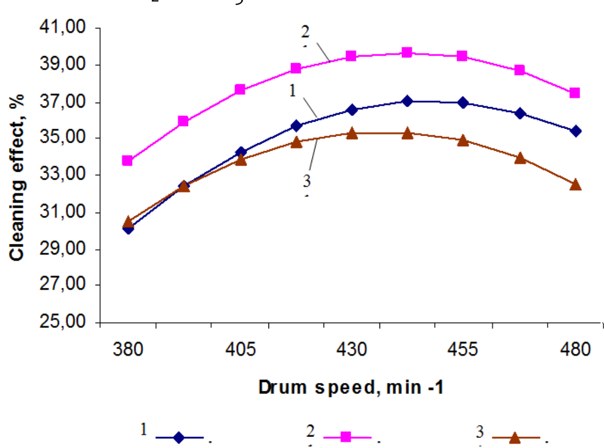


Fig.7. The graphs change the cleaning effect of changing the rotational speed of the composite spear drum with a rubber bush.

With a drum rotational speed of $380\,\text{min}^{-1}$, the cleaning effect is 30% (see Fig.7, graph 1), $n = 450\ \text{min}^{-1}$ the cleaning effect is up to 36.8%, and further increase to $n = 480\ \text{min}^{-1}$, the cleaning effect is reduced to 38%. In the second graph in the Fig.7 at $X_2 = 20\,mm$, $X_3 = 0{,}30 \cdot 10^4\ Nm/rad$, the cleaning effect reaches 33,8%, at $n = 380\ \text{min}^{-1}$, and at $n = 447\ \text{min}^{-1}$, the cleaning effect is 39,6%, and at $n = 480\ \text{min}^{-1}$, $M_z = 37{,}2\%$. In the third graph in Fig. 7 with $X_2 = 23mm$, $X_3 = 0{,}40 \cdot 10^4\ Nm/rad$ and $n = 438\ \text{min}^{-1}$, the cleaning effect will be 29,7%, and at $n = 480\ \text{min}^{-1}$ $M_z = 35{,}2\%$, with $n = 480\ \text{min}^{-1}$, it drops to 32.1%.

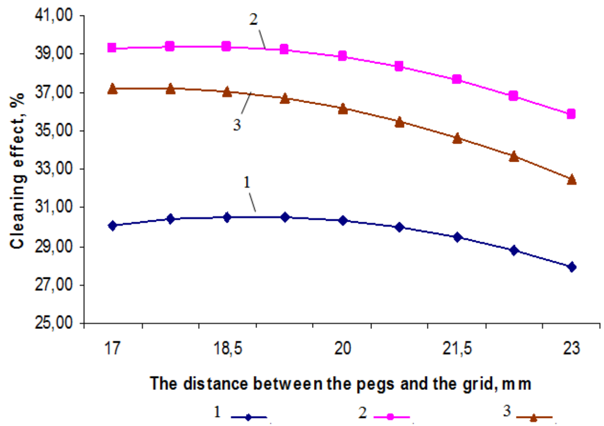


Fig.8. Charts change the cleaning effect of changing the distance from the end of the picks to the grid.

At the values of $X_1 = 380\ \text{min}^{-1}$ and $X_3 = 0{,}20 \cdot 10^4\ Nm/rad$, the cleaning effect was 30,1%, and at $X_2 = 17mm$, $M_z = 30{,}8\%$, at $X_2 = 23mm$ cleaning effect is reduced to 28% (the first graph in Fig. 8). In the second graph in Fig. 8 with $X_1 = 430\ \text{min}^{-1}$, $X_3 = 0{,}30 \cdot 10^4\ Nm/rad$, the purifying effect was 39,2%. At $X_2 = 17mm$, and $X_2 = 18mm$, $M_z = 39{,}8\%$, and at 23 mm the cleaning effect is reduced to 36%. In the third graph in Fig. 8, the greatest purifying effect of cotton from small litter comes to 37.4% at $X_1 = 480\ \text{min}^{-1}$, $X_3 = 0{,}40 \cdot 10^4\ Nm/rad$ and $X_2 = 18mm$.

In Fig. 9, (graph 3) at $X_1 = 380\ \text{min}^{-1}$, $X_2 = 17mm$ and at $X_3 = 0{,}20 \cdot 10^4\ Nm/rad$, the cleaning efficiency was 30,1%, and at $X_3 = 0{,}30 \cdot 10^4\ Nm/rad$ received the greatest cleaning effect of 33,2%. Analysis of graphs 2 and 3 in Fig. 9 showed that the maximum value of $M_z = 38{,}3\%$ was obtained for $X_3 = 0{,}35 \cdot 10^4\ Nm/rad$.

The American Journal of Applied sciences
(ISSN – 2689-0992)
Published: February 28, 2021 | Pages: 126-137
Doi: https://doi.org/10.37547/tajas/Volume03Issue02-15

IMPACT FACTOR
2021: 5. 634
OCLC - 1121105553

According to the analysis of the conducted studies, the recommended values are $n = 444\ \min^{-1}$, $t = 19\ mm$, $v = 0{,}35 \cdot 10^4\ Nm/rad$, at which the maximum effect of cleaning cotton from small litter is 39,9%.

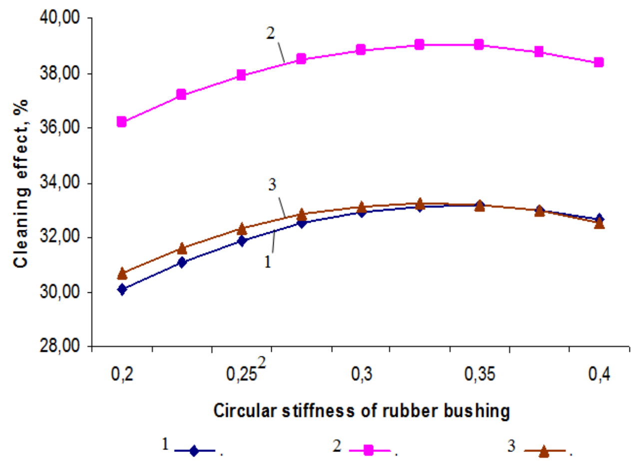


Fig.9. Charts change the cleaning effect of changing the coefficient of circular rigidity of the rubber bushing.

Analysis of the test results of the developed design of the fibrous material cleaner. The prototype purifier was installed in the cotton production line in the cotton plant. The initial weakening of raw cotton has a significant effect on the cleaning effect. During the tests, the moisture content and initial weakening of the compared cleaning sections of the production lines were maintained in the same range. Analyzes were carried out at the factory laboratory

Table 2

The results of a comparative technological production test for 1st and 2nd cleaning lines mod. 1XK.

Indicator in%	**After the upgraded section of the unit in the 1st line (mod. 1XK)**	**After the serial unit in the 2nd line (mod. 1XK)**
Humidity (%)	10,1/8,1	10,1/8,1
	9,4/8,4	9,4/8,4
	9,6/8,2	9,6/8,2
Weediness (%)	4,8/2,85	4,8/3,2
	4,5/2,75	4,5/3,05
	4,2/2,45	4,2/2,9
After cleaning, the cleaning effect	40,6	33,3
	38,9	32,2
	40,3	30,9

When carrying out the tests, the recommended design of the drum spinner in the raw cotton cleaner from small (Mod. 1 XK) litter showed high reliability, stability of operation. The results of the tests showed that the cleaning effect increased by an average of 2.7% compared to the existing version of the drum spinner. Due to additional torsional vibrations of the spinner drum, effective isolation of weed impurities is ensured and the process of braking of cotton is eliminated. The results of comparative technological tests on the cleaning line with the serial and experimental designs of the cleaning sections of the (Mod. 1 XK) aggregates are given in Table 2 [7,8].

CONCLUSIONS

An effective scheme for the construction of a cleaner for fibrous material from small litter has been developed. The oscillations of the headset and the net surface are theoretically studied, their parameters are justified. Experiments studied the loading of the pin drum. Based on the analysis of the existing designs of cotton cleaners from small litter, a new effective scheme of the cleaner was recommended. The full-factor experiments proved the optimal values of the parameters of the cleaning zone.

REFERENCES

1. Holt, GA; Baker, RV; Brashears, AD. Lint quality and turnout of stripper cotton when bypassing the second stage extractor. APPLIED ENGINEERING IN AGRICULTURE Volume: 18, Issue: 4 P/: 411-415.
2. Baker, RV; Lalor, WF. Multistage trash extractor for cotton gins. TRANSACTIONS OF THE ASAE. Volume: 33. Issue: 5. P.: 1457-1463.
3. A.D.Djuraev, J.Mirakhmedov, A.H.Bobamatov, J.M.Mukhamedov, T.Bobomurodov. The mesh surface of the fibrous material cleaner. The patent of the Republic of Uzbekistan FAP 00696 Byulleten №. 2/2012.
4. A.P.Mavlyanov, A.Djuraev, Sh.L.Daliyev. Working out of designs and methods of calculation of parametres are caustic drums. LAP LAMBERT Academic Publishing, Deutschland, 2016, 134p. Saarbruken 2016.
5. A.Djurayev, Kuliev T.M. Modeling of grid vibrations on elastic supports of raw cotton cleaner // Improvement of the Construction and Justification of Parameters of the Fibrous Material Regenerator, International Journal of Advanced Science and Technology Vol. 29, No. 8s, (2020), pp. 453-460
6. A.Djurayev, Kuliev T.M.. Creation of a design and justification of parameters of a single-stage fiber cleaner // International Journal of Advanced Science and Technology Vol. 29, No. 5, (2020), pp. 4522 – 4529
7. A.D.Djuraev, Sh.L.Daliyev. Development of the design and justification of the parameters of the composite flail drum of a cotton cleaner. European science review Scientific journal, – Vienna, Austria. № 7–8 2017 July–August, 96-99 p.
8. M. Augambaev, A.Z.Ivanov, Y.I.Gerekhov. Basics of planning a research experiment. Moscow 1986. 53-56 p.
9. A.Djuraev , K.Yuldashev Dynamics of the Screw Conveyor for Transportation and Cleaning of Fiber Material International Journal of

Published: February 28, 2021 | **Pages:** 126-137
Doi: https://doi.org/10.37547/tajas/Volume03Issue02-15
IMPACT FACTOR
2021: 5. 634
OCLC - 1121105553

Advanced Science and Technology. Vol. 29, No. 5, (2020), P. 8557-8566.

10. A.Djuraev Kuliev T.M. Designing and methods of calculating parameters of a fibrous material cleaner from large litter International Journal of Advanced Science and Technology Vol. 29, No. 8s, (2020), pp. 444-452

11. A. Djuraev Sh. S. Khudaykulov, A. S. Jumaev Development of the Design and Calculation of Parameters of the Saw Cylinder with an Elastic Bearing Support Jin International Journal of Recent Technology and Engineering (IJRTE) Volume-8 Issue-5, January 2020

12. D.D.Alijanov, U.A.Axmadaliyev. (2020). The Pecularities Of Automatic Headlights. The American Journal of Engineering and Technology, 13-16.