A novel cotton cleaning section design with innovative branched gears

Dilrabo Mamatova[1], *Muhammad Ali* Turgunov[2], *Igor* Tyurin[3,4*], and *Abdumutal* Nabiyev[5]

[1]Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan
[2]Turin Polytechnic University in Tashkent, Tashkent, Uzbekistan
[3]Jizzakh polytechnic institute, Izzah, Uzbekistan
[4]Kosygin University, Moscow, Russia
[5]Tashkent Institute of Chemical Technology, Tashkent, Uzbekistan

Abstract. The purpose is to create an effective design diagram for a small trash cotton cleaning machine and an improved diagram of the drive mechanism of a large and small trash cotton cleaning machine. The results of comprehensive experiments on the design of a cleaning machine with a new drive mechanism arrangement are presented. This article presents the results of production testing of the proposed design of a cotton filter with a new drive mechanism arrangement, including a variable gear ratio (VGR) belt drive. Comparative indicators are presented regarding batch cotton cleaning machines. Production testing shows that the working parts of the modernized unit are connected to each other when changing the angular velocity at appropriate intervals compared to the existing cleaning unit, power consumption is reduced by 3 .7 kW; cleaning efficiency increased by 7.7%; The quantity of clean cotton decreased by 0.08%; Cotton slaughter was abolished.

1 Introduction

Currently, when improving cotton processing technology and techniques, the most important thing is to obtain high quality yarn, meeting high productivity requirements [1]. The demand for high quality cotton yarn is increasing in the global market [2]. In the country, it is important to obtain more finished products from cotton fibers [3]. However, research on the influence of the modes of movement of working bodies during technological processing turned out to be out of bounds. In addition, the identification and analysis of the kinematic and kinematic characteristics of the transmission mechanisms of technological machines as well as the development of optimal options for their kinematic diagrams have not been carried out in practice. presently. Up to now, most theoretical and even experimental studies have assumed that the working part of the cotton processing machine rotates evenly. Therefore, it is important to study the irregular rotation of working objects, the effects of speed and acceleration in the technological process, and on that basis to select appropriate modes and develop transmission mechanisms. Ensuring these motion modes, thereby proposing the best kinematic diagram options for the industry, is a problem. Our research

* Corresponding author: tyurin-in@rguk.ru

aims to address these issues. Therefore, a project with a new cotton seed line is recommended [3; 4].

It is known that the current facility of the cotton ginning complex (ICGC) has a cotton cleaning area with 3 stages for large and small waste, the total number of working units is 32. At the same time, there are 15 unique actuators. create. . Therefore, 15 electric motors were used in the ICGC unit and their movements were not interconnected [5-8]. It should be noted that the analysis of the given kinematic chains shows differences in the loading of each working part, i.e. diversity in the nature of the change in angular velocity regardless of the sequence of the process technology. In this case, each working body is kinematically separated from the others, that is, the speed of linear movement in the working bodies is multiplied and expansion occurs sequentially. In turn, this leads to damage to fibers and grains, their accumulation and jamming during cotton movement. To eliminate these undesirable phenomena, it is important to reduce the kinematic chains and ensure the alignment of the laws of motion of each working body. In the proposed kinematic scheme of the new drive, the number of main kinematic chains is reduced to three. In this case, the movement of the brush shaft is considered independently. Therefore, in the new kinematic scheme of the ICGC unit, only 3 electric motors transmit motion. At the same time, the movement rules of the working agencies in each large and small trash cleaning area are chosen to correspond to Figure 2. 1, a) to the movement of cotton.

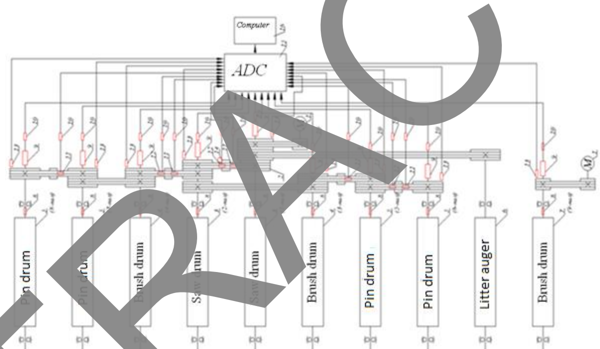

Fig. 1, (a). Recommended cleaning section layout

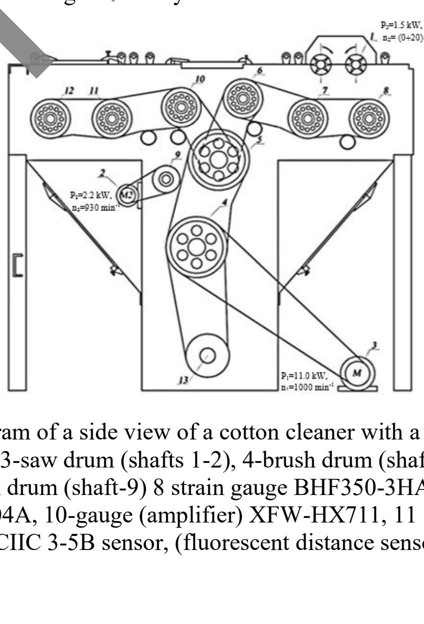

Fig. 1, (b). Kinematic diagram of a side view of a cotton cleaner with a new drive layout: 1-electric motor, 2-belt transmission, 3-saw drum (shafts 1-2), 4-brush drum (shafts 3-4), 5-pin drum (shafts 5-6-7-8) 6 litter auger 7 brush drum (shaft-9) 8 strain gauge BHF350-3HA attached to the shaft, 9 current collector MSC-22-04A, 10-gauge (amplifier) XFW-HX711, 11 strain gauge BF1000 glued tension roller, 12- brand I2CIIC 3-5B sensor, (fluorescent distance sensor module) 13- Hall sensor brand LM393 roller, 14 damper brand VAG 03C145299Q tension roller, 15-Arduino microcontroller (ADC) UNO R3, 16-computer.

In the ICGC type large and small cotton washing machines, 3 electric motors are installed with capacities of 1.5 kW, 2.2 kW and 11 kW respectively. The task of the 1.5 kW electric motor is to transmit motion to the feed rollers. In this case, the inventory device connects the electric motor to the source. An electric motor with a capacity of 2.2 kW should only drive the separator brush 9. The task of an electric motor with a capacity of 11 kW is to transmit motion to the rest of the working parts of the device. In this case, the movement is transmitted to the lower tooth drum 4, then to the upper tooth drum 5 and worm 13 (Fig. 1, b). At the same time, the upper saw drum 5 separately drives the guide brush drums 6 and 10. The left brush drum 10 is driven by the pin drum 11 and the movement of the guide brush drum 12. The motion is transmitted by sequentially to the right brush drum 6 which in turn is transmitted to the latch drums 7 and 8. In figure 1.7. (a) shows the kinematic diagram of the ICGC cotton gin with the recommended drive mechanism and Figure 2. 1.7. (b) shows the front view of this kinematic diagram. It should be noted that almost all working organs are kinematically interconnected. At the same time, eccentric tension rollers are used in the belt drive. At the same time, they affect the law of changing the angular velocity of the corresponding working organs and accelerate the cleaning process. The corresponding drive pulleys are made of composite. They meet the characteristics of elastic and g couplings and allow to reduce torque fluctuations in the respective parts of the drive system. This, in turn, leads to reduced vehicle load and reduced power consumption [3; 4].

2 Materials and Methods

2.1 Analysis of the results of full-factorial experimental studies

During the research process, methods of analyzing the transmission mechanism of a machine that cleans cotton from weeds, solving differential equations using the Runge-Kutta numerical method, based on the full equations of Newtonian regression, and formulating Experimental planning and mathematical statistics, and the processing of experimental results were used.

Operating modes and acceptable parameter values are determined using the mathematical programming method of multi-element experiments [9; ten]. To carry out the study, the eccentricity of the inlet and outlet belt driving tension rollers as well as the efficiency were selected as factors affecting the cleaning efficiency and uneven rotation coefficient. Based on the above single-factor theoretical and experimental studies, the levels of the factors recorded and the values of the intermediate changes are shown in Table 1.

Table 1. Levels of factors and interval of their change.

Factors and their designations	**Unit of measurement**	**Factors**				
		Coded designation	**Change interval**	**Levels**		
				Lower (-1)	**Basic (0)**	**Upper (+1)**
Performance	t/h	X_1	2	5	7	9
The eccentricity of the tension roller of the input peg drum	Mm	X_2	1	1,5	2,5	3,5
The eccentricity of the tension roller of the output peg drum	Mm	X_3	0,5	0,5	1,0	1,5

Considering the influence of factors in the evaluation criterion of the illuminating polynomial of the second degree, the experiments were carried out according to the Hart-3 plan [10; 11]. When carrying out full-factorial experiments, the efficiency of cleaning cotton (Y1,%) and the coefficient of uneven rotation (Y2,) were taken as evaluation criteria. The plan for conducting multivariate experiments and their results are shown in Table 2.

Table 2. Plan for conducting multivariate experiments and their results.

X_1	X_2	X_3	U_1			U_2		
			1	**2**	**3**	**1**	**2**	**3**
-1	-1	-1	+87.910	+87.930	+87.360	+0,0192	+0,0190	+0,0192
+1	-1	-1	+87.880	+88.480	+87.930	+0,0074	+0,0073	+0,0074
-1	+1	-1	+89.800	+89.940	+89.390	+0,0263	+0,0262	+0,0264
+1	+1	-1	+88.330	+88.260	+87.710	+0,0165	+0,0166	+0,0166
-1	-1	+1	+89.800	+89.920	+89.330	+0,0204	+0,0202	+0,0204
+1	-1	+1	+88.480	+88.370	+87.830	+0,0106	+0,0105	+0,0106
-1	+1	+1	+91.800	+91.230	+90.660	+0,0295	+0,0294	+0,0296
+1	+1	+1	+87.430	+87.460	+86.900	+0,0217	+0,0217	+0,0218
-1	+0	+0	+90.200	+90.600	+90.030	+0,0204	+0,0202	+0,0204
+1	+0	+0	+89.350	+88.990	+88.430	+0,0106	+0,0105	+0,0106
+0	-1	+0	+90.530	+90.010	+89.450	+0,0094	+0,0093	+0,0094
+0	+1	+0	+90.010	+90.560	+90.000	+0,0185	+0,0185	+0,0186
+0	+0	-1	+90.600	+89.990	+89.450	+0,0114	+0,0113	+0,0114
+0	+0	+1	+89.950	+90.580	+90.030	+0,0146	+0,0145	+0,0146

3 Results

The results of experimental studies of the loading of the working bodies and the modes of movement of the drive mechanisms of the new layout of the raw cotton cleaning unit, the methodology for conducting experimental studies, the analysis of the modes of movement of the shafts of the working bodies of the drive with the new layout of the UCC unit, the analysis of the law of changes in the loading of the working bodies and rotational speeds, analysis of the results experimental studies.

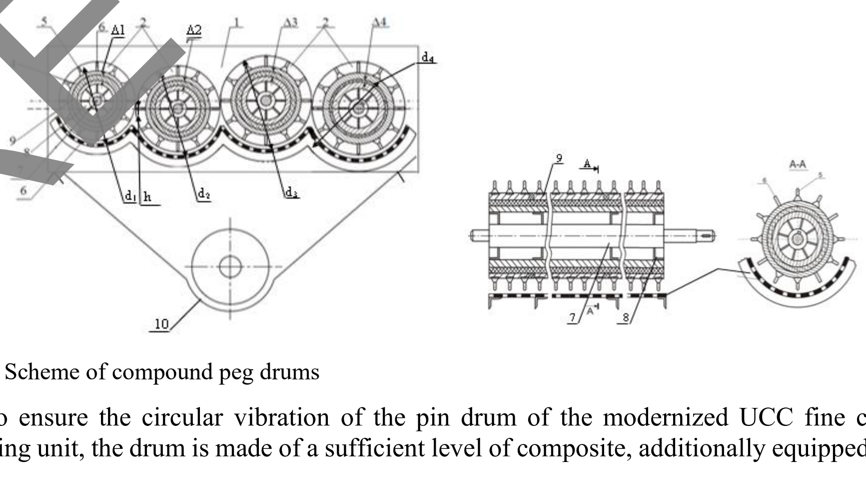

Fig.2. Scheme of compound peg drums

To ensure the circular vibration of the pin drum of the modernized UCC fine cotton cleaning unit, the drum is made of a sufficient level of composite, additionally equipped with bushings. The cleaning unit with the proposed drive configuration mainly provides the following features:

- the modes of operation of the working bodies are interconnected and this process is carried out continuously;
- to ensure the full movement of the cotton particles and avoid jamming, it is necessary to increase the angular velocity of each sequentially installed working body;
- rotational oscillation of the working bodies is ensured with their successive decrease. It is the cotton cleaning system that causes the increase in the degree of looseness (Fig. 3);
- due to the reduction of the electric drive, the energy consumption decreases, the resource increases;
- To ensure sufficient rotational vibration of the pin drum, they are additionally equipped with elastic parts.

The main angular vibrations are generated by the eccentric tension rollers of the belt drive (Figure 4).

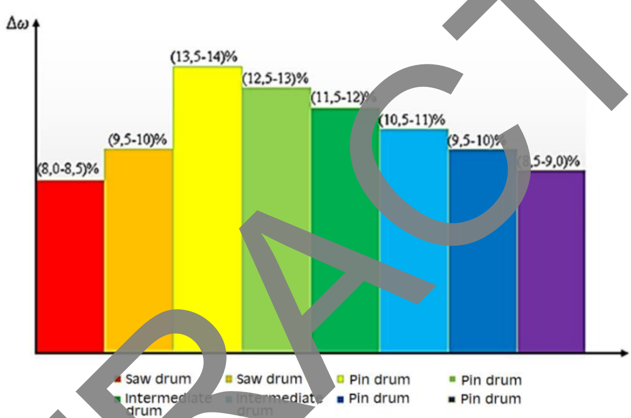

Fig.3. Average values of the modes of movement of the working bodies

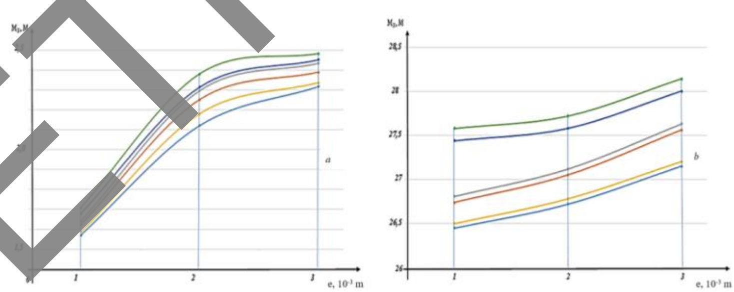

Fig.4. Graphs of the connection between the loading of the shafts of the input and output peg drums

The information obtained in the experiments was processed using the PLANEX program. At the same time, to assess the uniformity of the variance, the Cochran test, the values of the regression coefficients, the Student's test, and the adequacy of the regression models, the Fisher test, were used. The information obtained in the experiments was processed using the PLANEX program developed for the special computer software (SCS) of the Research Institute of Agricultural Mechanization (Tashkent, Uzbekistan), and the following regression equations (1; 2) were obtained expressing the adequacy of the evaluation criterion.

- cleaning efficiency of cotton (%):

$$Y1=+90{,}519-0{,}802X_1+0{,}276X_2+0{,}294X_3-0{,}9197X_1^2-0{,}560X_1X_2-$$
$$-0{,}522X_1X_3-0{,}426X_2^2-0{,}175X_2X_3-0{,}419X_3^2 \quad (1)$$

- coefficient of the unevenness of the angular speed of rotation of the input peg drum:

$$Y2=+0{,}0117-0{,}049X_1+0{,}0046X_2+0{,}0016X_3+0{,}0037X_1^2+0{,}0005X_1X_2+$$
$$+0{,}0005X_1X_3+0{,}0022X_2^2+0{,}0005X_2X_3+0{,}0013X_3^2 \quad (2)$$

Based on statistical analyzes of the 95% probabilistic reliability and verification of the resulting equations for adequacy, the following results were obtained [10-12]:

(1) for the equation F_p=0,18<F_m=2,49; (2) for the equation F_p=1,63<F_m=2,65;

where F_p and F_m–are the values of the Fisher criterion given in the calculations and the table [13]. From these data, it can be seen that for two equations, the calculated value of the Fisher criterion is less than the value given in the table. Therefore, they express the adequacy of the considered process. From the graph constructed based on regression equations (1) and (2) it can be seen that with an increase in productivity (X1), the purity of cotton (U1) (eccentricity of the tension roller of the output belt drive is 1 mm) with an eccentricity of 1.5 mm of the tension roller of the input belt transmission decreases from 90.35 to 88.50 percent, with an eccentricity of 2.5 mm from 91.20 percent to 89.04 percent, with an eccentricity of 3.5 mm from 91.21 to 88.74 percent. The coefficient of uneven rotation (U2) with the eccentricity of the tension roller of the input belt drive decreases with an eccentricity of 1.5 mm from 0.01469 to 0.00469, with an eccentricity of 2.5 mm from 0.01797 to 0.00817, with an eccentricity of 3.5 mm from 0.02369 to 0.01409. With an eccentricity of the output belt idler roller of 0.1 mm, the purity of cotton (U1) (with an eccentricity of 2.5 mm of the input belt idler roller) with an eccentricity of 0.5 mm of the output belt idler roller decreases from 90.45 to 88.26 percent, at 1.0 mm from 91.20 to 89.04 percent, at 1.5 mm from 91.48 percent to 89.30 percent. The coefficient of uneven rotation (U2) with an eccentricity of 0.5 mm of the tension roller of the output belt drive decreases from 0.01531 to 0.00698 in Fig.5 with an eccentricity of 1.0 mm from 0.01797 to 0.00817, with an eccentricity of 1.5 mm from 0 .01998 to 0.01058.

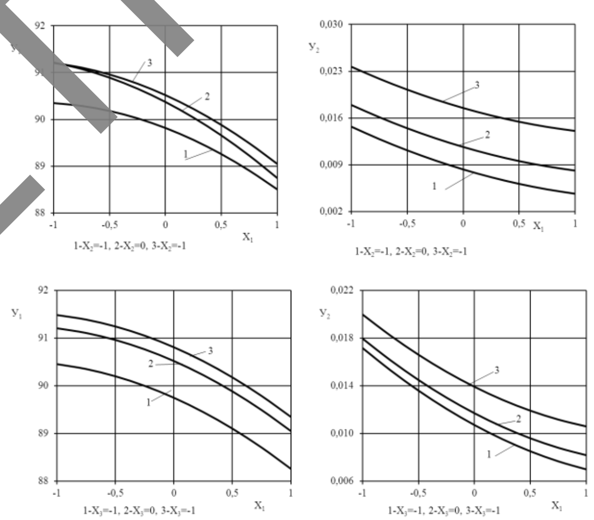

Fig.5. Graphs of changes in cotton cleaning (Y1) and the coefficient of uneven rotation (Y2) depending on productivity (X1)

Building on the basis of regression equations (1) and (2), it can be seen that with the increase of eccentricity (X2) of the belt drive tension roller in Figure 6, the purity of cotton (U1) (with 1.5 mm eccentricity (X3) of the belt drive tension roller) at 5 t/h increased from 90.36 to 91.53%, at 7 t/h increased 89, 83 to 90 .68%, at 9 t/h 88.52 to 89.60%. Uneven turnover coefficient (U2) at 5 t/h productivity increased from 0.01469 to 0.02369%, at 7 t/h from 0.00832 to 0.01752% and at 9 t/h from 0.00469 to 0.01409%. With an eccentricity of 0.1 mm (X3) of the output belt drive tension roller, the purity of cotton (U1) (with a labor productivity (X1) of 7 t/h) when the eccentricity is 0, 5 mm increased from 89.22 to 90.23%, 1.0 mm eccentricity from 89.83 to 90.68%, 1.5 mm eccentricity from 89.96 to 90.66%. The coefficient of uneven rotation (U2) increases with an eccentricity of 0.5 mm from 0.00738 to 0.01648, with an eccentricity of 1.0 mm from 0.00832 to 0.01752, with an eccentricity of 1.5 mm from 0.01048 to 0.01978.

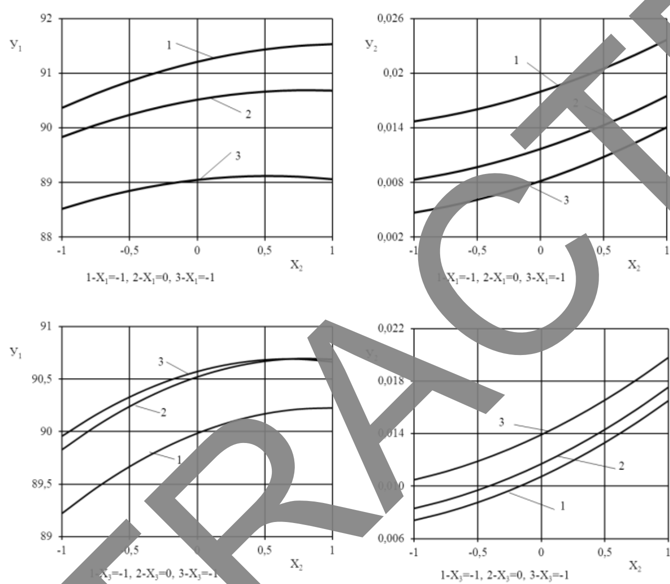

Fig.6. Graphs of changes in cotton cleaning (U1) and the coefficient of uneven rotation (U2) depending on the eccentricity of the tension roller (X2) of the input belt drive.

Graph of the cotton cleaning process (U1) and uneven rotation coefficient (U2) according to the eccentricity of the tension roller (X2) of the input belt drive. From the graphs (Figure 7), built on the basis of regression equations (1) and (2), it can be seen that with an increase in eccentricity (X3) of the tension roller of the belt drive , cotton purity (U1) (with 1.5 mm eccentricity (X2) of the tension roller input belt drive) at 5 t/h productivity increased from 90.74 to 91.47% , at 7 t/h from 90.17 to 91.57%, at 9 t/h from 88.08 to 88.95%. The coefficient of uneven rotation (U2) at a capacity of 5 t/h with an eccentricity of the tension roller of 1.5 mm of the input belt drive increased from 0.01718 to 0.01998, at 7 t/h from 0 .01071 to .01391, at 9 t/h from .00716 to .01058. With an eccentricity of 1.5 mm, the input belt tensioner (capacity 5 t/h) increases from 89.11 to 90.04%, with an eccentricity of 2.5 mm from 89.98 to 90.57% , with 3.5 mm eccentricity from 90.01 to 90.57%.

The uneven rotation coefficient (U2) of the tension roller input belt drive increases from 0.00738 to 0.01048 with an eccentricity of 1.5 mm, from 0.01071 to 0.01391 with an eccentricity of 3.5 mm, from 0.01648 to 0.01978.

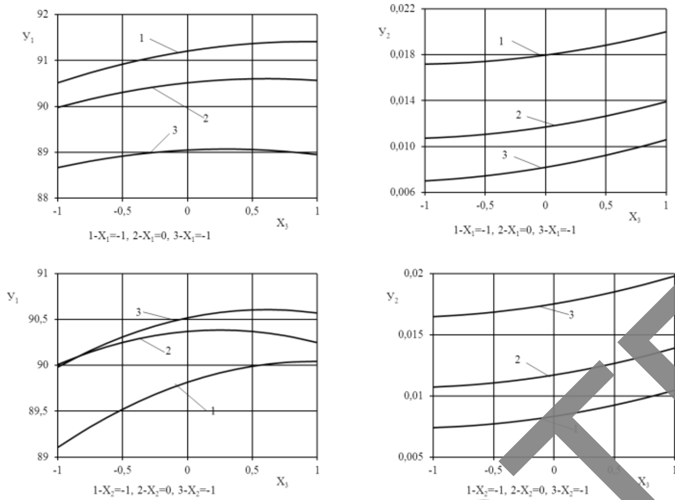

Fig.7. Graphs of changes in cotton cleaning (Y1) and unevenness coefficient (Y2) depending on the eccentricity of the tension roller (X3) of the output belt drive.

When determining the values of the parameters that ensure the quality of work to the required degree, equations (1) and (2) were solved together by the action of "search for a solution" of the Excel program on a Pentium PC. When solving the regression equations, together take the criterion Y1, i.e., the efficiency of cotton cleaning is the maximum criterion Y2, i.e., the coefficient of uneven rotation in the range of 0.01-0.02 [14]. The results obtained are shown in Table 3.

Table.3. Accepted values of the parameters of the working bodies of the combined unit

encoded	original	encoded	original	encoded	Original
-0,32185	6,356294	0,106513	2,606513	0,4145	1,207238

So, with high purity cotton, so that the coefficient of uneven rotation does not exceed the required level, the productivity should be 6.35 t / h and the eccentricity of the tension roller of the input pin drum equal to 2, 6 mm and the eccentricity of the tension roller of the output latch drum is 1.2 mm. Among these coefficient values, the cleaning efficiency of cotton is 90.83%, and the irregular rotation coefficient of the input pin drum is 0.015. Production comparison test results of modern cotton filtering machines. The transmission scheme of the recommended cotton cleaning equipment has been improved by ensuring the connection between the working parts. A prototype of the cotton cleaning device was installed in the first process of the REAL AGRO COTTON universal cotton cleaning system and comparative tests were carried out based on the existing design of the second process. 2. At the same time, the power consumption of the proposed version is 3.7 kW lower than that of the serial player version.

The results of comparative technological tests between serial design and testing of the cleaning unit of the ICGC device are presented in the table 4.

Table. 4. Results of experimental tests

Indicators, %	After one 1-cleaning line of the modernized ICGC unit	After the 2-cleaning line of the existing ICGC unit
Cleaning efficiency after cleaning	91,1	83,7
Humidity	7,8÷11,5	7,8 ÷11,5
Infestation	2,52	2,60

Fig.8 shows a general view of the area of the drive mechanisms of the recommended cotton gin.

Fig. 8. View of the modernized cotton gin

Note: Experiments were performed in triplicate. Table 4 shows the average values of the indicators. According to the results of experiments on the modernization design of belt drives with changing parameters of the ICGC cleaning machine, it is recommended to use detergents in the drives of the working parts during production at the cotton gin factory. Comparative technological tests between the gray structure and the experimental structure in the cleaning sections of the ICGC unit are presented in Table 5. The tests were performed on lines 1 and 2 of the ICGC cleaning machine. The experiments were performed in triplicate. Table 5 shows the average values of the indicators

Table 5. Average values of indicators

Indicators, %	After one 1-cleaning line of the modernized ICGC unit	After the 2-cleaning line of the existing ICGC unit
Cleaning efficiency after cleaning	92,6	85,6
Humidity	8,8÷11,7	8,8 ÷11,7
Infestation	3,12	3,60
Number of cotton jams	0	2

The results of production tests showed that the dynamic relationship of the working parts with a sufficient increase in speed and the movement of the pin and the saw drum at a variable angular speed improved the cleaning system without observing clogging. The testing of the recommended design of the pin-belt drive for cleaning cotton from small batches 1XK showed high reliability and continuous operation. The test results showed that the cleaning efficiency of the proposed design compared to the current version increased by an average of 7.05%. When using the recommended design, torsional vibrations also appeared in the pin drum, which ensured effective separation of impurities from weeds and eliminated the phenomenon of cotton inhibition, the number of defects decreased by 1.12%, mechanical damage by 1.23% and free fibers by 0.41%. The results of the comparative testing of the technology in the serial design refining line and the test unit of the 1-CGC unit are presented in Table 6.

Table 6. The results of comparative production technological tests in the first and second purification lines of the 1-CGC purifier.

Indicators, %	After the modernization of the unit section of the first line 1-CGC	After the serial unit of the second line 1-CGC
Humidity	10,2/8,2	10,2/8,2
	9,4/8,6	9,4/8,6
	9,7/8,5	9,7/8,5
Infestation	4,6/2,65	4,6/3,35
	4,6/2,68	4,6/3,079
	4,3/2,59	4,3/3,4
Cleaning efficiency after cleaning	40,76	34,34
	39,1	33,4
	40,2	35,9

4 Conclusions

According to the results of comprehensive factorial experimental research, so that the irregularity coefficient of the rotational angular speed of the input pin drum does not exceed the requirements for high purity cotton, it should be: yield 6.35 t/ h, eccentricity of tension roller of input latch drum 2.6 mm, eccentricity of tension roller of output belt drive latch drum 1.2 mm. Production testing shows that the working parts of the modernized unit are connected to each other when changing the angular velocity at appropriate intervals compared to the existing cleaning unit, power consumption is reduced by 3 .7 kW; cleaning efficiency increased by 7.7%; The quantity of clean cotton decreased by 0.08%; Cotton slaughter was abolished.

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