DEVELOPMENT OF METHODS TO REDUCE THE BENDING OF SHAFTS AND STUDY THE TECHNOLOGY OF THEIR PROCESSING

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Annotation*:*
In the article, the task of reducing the mass of the main working body of the gin, i.e. the cylinder shaft by means of the opening of the groove and the design features of the shaft is determined.Its essence is that the inner groove part of the gin saw cylinder shaft performs the circular side with symmetrical gearsand the entry of external slits into the grooves in the corresponding inner slits of the shaftleads to a specific equilibrium of the mass relative to the axis of rotation and increases its strength and reliability in operation. This will increase resource efficiency and reliability by significantly reducing the mass of the shaft and saw cylinders without significantly reducing the bending stiffness, as well as obtaining cotton fiber with the required quality characteristics. The issues of creating and defining methods for calculating high-efficiency machine drives and shafts are especially important in the creation of machines for the ginning industry
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Keywords*: gin, cylinder gourds, saw cylinder, shaft, raw roller, deflection, weight reduction, grooves, design features, bending stiffness.*

Introduction

Extensive research aimed at developing and improving new techniques and technologies in the ginning of cotton for the ginning industry has led the world's leading research centers and higher education institution. Research is being conducted in a number of priority areas around the world to improve the technology of ginning of medium-fiber varieties of seed cotton. Examples include: improving sawdust to separate fiber from seed cotton in high humidity and pollution; creation of a scientific basis for the process of ginning and aeromechanical separation of fiber from saw teeth; calculation methods to substantiate ginning modes and working parameters, to create a scientific basis for calculating the accelerator and parameters of the raw material roller to ensure maximum output of the seed from the working chamber, to develop and substantiate the parameters of lightweight saw cylinder design with high efficiency; etc.
The main problems in the operation of sawdust gin working bodies include low fiber yield, high fiber and seed damage, difficulty in separating cleaned seeds from the chamber, high consumption power, low efficiency, inability to gin cotton in high humidity.
Materials and methods
Today, the role of shafts and shaft-type shafts in modern technology, especially in the field of agricultural machinery and production, is invaluable. At the same time, machining the shafts and reducing the bending in them is one of the current problems, because bending in them causes various problems. For example, it can cause the bearings on the bearings to wear out quickly, and other spare parts that work with it during operation can quickly lose their ability to work. Before we cover the subject, let's find out what the shaft is.
Shafts and axles are the parts that hold the details of a machine or mechanism and transmit motion from one detail to another. [1] Because the rotating parts and the shafts that support the joint are usually tightly connected to each other by means of dowels, slits, etc., the shafts have only a rotating characteristic and always transmit the rotational torque. , in which case they are affected by torsional voltages. , i.e., the shafts used to transmit and distribute the motion and to lift the details of the transmission (gears, sprockets, pulleys, etc.). A number of machines (agricultural, road, hoisting) use transmission shafts to transmit torque to the actuators [2]. Heat-treated carbon and alloy steel 45, 45X steel materials are selected for the manufacture of shafts and

shafts. In this case, the shafts of heavy-duty machines are made of steel materials 40XN, 40XN2MA, 30XGSA, which are treated with high-frequency current to improve their properties [1].

As we know, a saw gin cylinder consists of a toothed saw disk that enters the shaft groove, seals between the saws, washers, and a compression nut.
Disadvantages of this design: The large bending of the shaft, which leads to a change in the technological distance and gap between the saws, is the high power required due to the large mass of the saw cylinder, which leads to fiber and seed damage, as well as reduced productivity. The disadvantage of this design is the formation of high reaction forces on the bearing supports due to the cyclical variation of the mass of the saw cylinder, as well as the disproportion of the mass. The saw cylinderis shown in Fig. 1.

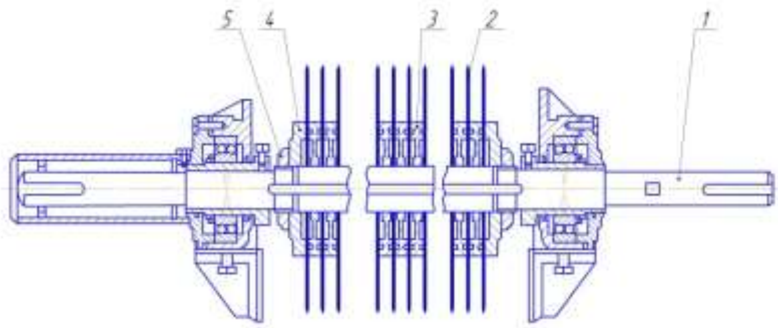


Fig. 1. Saw cylinder
It consists of saw shaft 1, saw discs 2, saw seals 4, washers 4, right and left clamping nuts 5. One end of the saw shaft is covered with a protective bushing, and the other is attached to the shaft of the armature by means of a half-bracket coupling. A functional washer is installed in the middle of the saw shaft
In the middle of the saw shaft, a functional washer is mounted on both sides of the saw blade.
A functional washer is mounted in the middle of the saw blade and saw blades are placed on both sides.
The diameter of the saw discs is 320 mm, the diameter between them is 162 mm, and calibrated seals are placed, which increase the rigidity of the saws and ensure their precise spacing.
The bending of the shaft should not exceed 0.3-0.4 mm and the side impact in rotation should not exceed 0.15 mm, otherwise the position of the saws in the space between the columns will change, which will lead to damage to the fibers attached to the disc teeth between the columns.
In the current design, the rotational speed of the saw shaft is 730 rpm.

Results and discussion
In view of the above, a new lightweight design of the saw gin cylinder has been developed to reduce the mass of the saw cylinder in the bending strength required by the proposed new design. It leads to further reduction of mass at the expense of the groove opened from the shaft, maintains the integrity of the shaft, saves resources, increases reliability and allows obtaining cotton fiber in the required quality. The inner part of the saw gin cylinder shaft ensures that the shaft bends within the allowable limit due to the execution of the groove, provides the required process of separating the fiber from the cotton, reduces the required power of the gin. (Fig. 2)

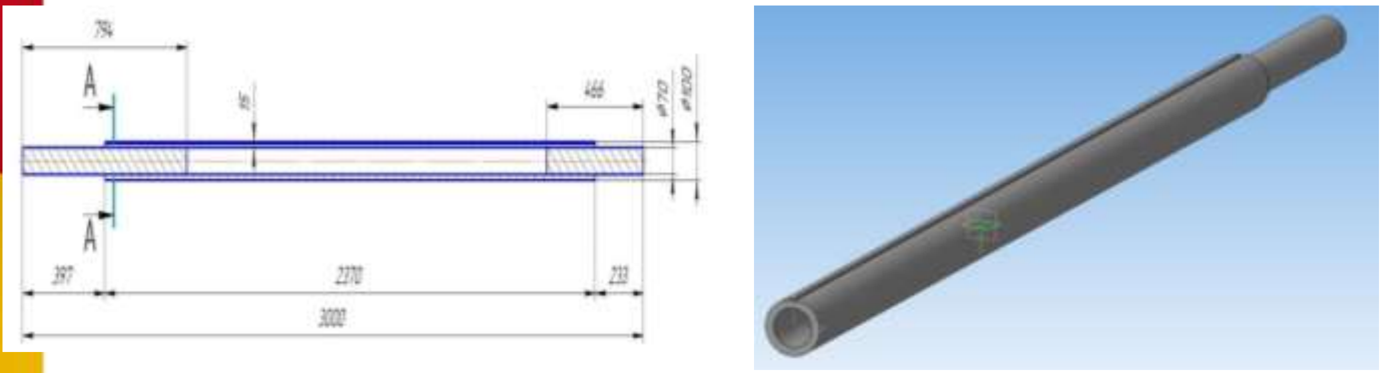


Fig. 2. New design of saw cylinder shaft.

Saw groove cylinder performs the inner groove part of the shaft symmetrically threaded on the circular side and the input mass of the outer grooves entering the grooves in the corresponding inner grooves of the shaft leads to a specific equilibrium (no disproportion) with respect to the axis of rotationand leads to increased robustness and reliability in operation

In theoretical studies, the saw blade was considered as a two-mass machine aggregate (Fig. 3). In solving the problem of the dynamics of the machine unit, the motion of the saw cylinder, the electric drive rotor was studied.

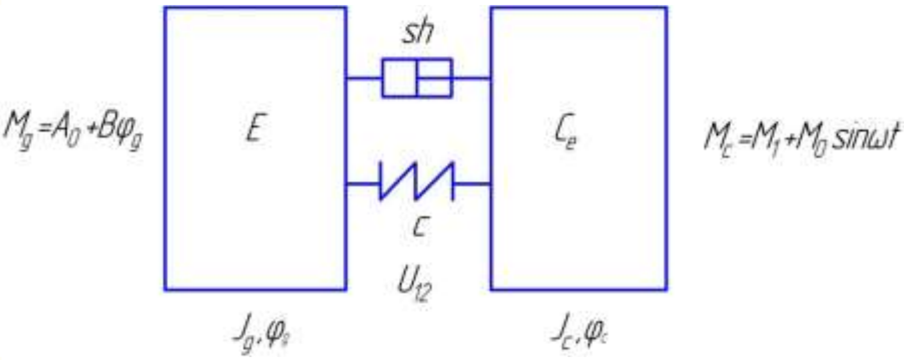


Fig. 3. Calculation scheme of a two-mass machine unit

It is known from the calculation scheme shown in Fig. 3 that the rotor of the electric drive and the saw cylinder rotate, so that two generalized coordinates can be determined. [4,5]

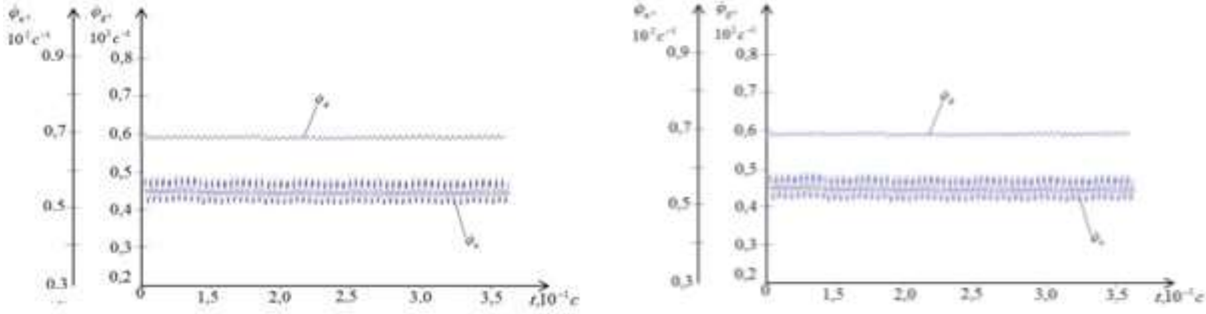
Because of the research, a system of differential equations representing the motion of a machine unit was formed as follows.

$$J_g \ddot{\varphi}_g = A_0 + B\dot{\varphi}_g - c(\varphi_g - U_{12}\varphi_c) - b(\dot{\varphi}_g - U_{12}\dot{\varphi}_c);$$

$$J_c \ddot{\varphi}_c = U_{12} c(\varphi_g - U_{12}\varphi_c) + U_{12} b(\dot{\varphi}_g - U_{12}\dot{\varphi}_c) - M_c \pm \delta M_c, \qquad (1)$$

whereJ_g, $J_ц$, φ_g, $\dot{\varphi}_ц$ are engine and saw cylinder inertia moments and angular displacements; b, $c$are rigidity and dissipative coefficients of the coupling; A_0,B are parameters of the engine; $U_{12}$is transmission function.

MathCAD software was used to obtain a numerical solution of the differential equations (1) obtained in a result of theoretical research [6,7]. Based on the numerical solution of the obtained differential equations (1), the laws of change of angular speeds of the engine and the light-weighted saw cylinder were obtained (Fig. 4).



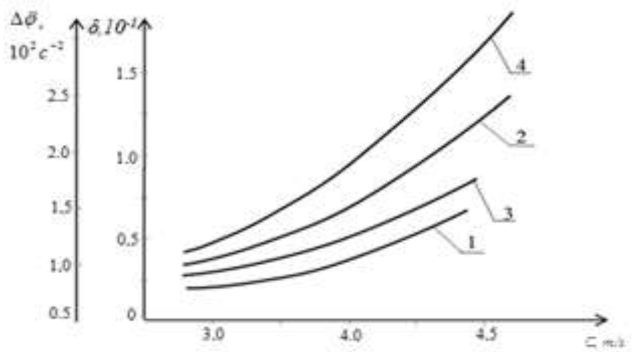
a б

a-work efficiency is 3.5 t/h; *b*-work efficiency is 3.5 t/h

Fig. 4. Laws of variation of angular speeds of the engine and the light-weighted saw cylinder

The studies analyzed the movements of the saw cylinder. The analyzes showed that as the work efficiency increases, the amplitude of oscillation of the angular speed of the saw cylinder also increases. This creates an angular acceleration. It is known that angular acceleration leads to the appearance of additional impulsive forces. Therefore, due to the formation of impulsive forces, the ability of the saw teeth to separate the fiber from the seed increases. However, if the acceleration is too great, fiber damage is also possible. [8,9].

The studies also explored ways to ensure that the working processes of the saw cylinder were uniform [10,11.] (Fig. 5 and 6). Theoretical studies have taken into account the resistance forces generated during the separation of fiber from seed cotton in the form of resistance moments to the performance of the saw cylinder.



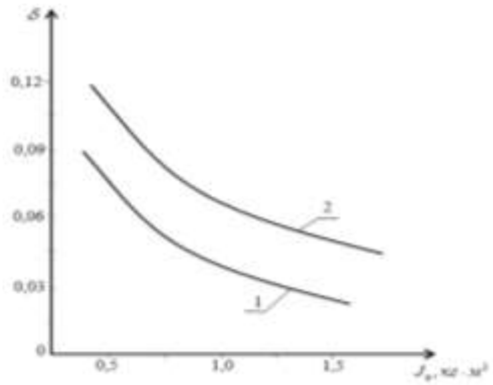


Fig. 5. Graphs of the coverage of the change in the angular speed of the saw cylinder and the coefficients of unevenness of the angular speed in relation to the work efficiency

Fig. 6. Graphs of the dependence of the coefficient of inequality of the angular speed of the saw cylinder on the moment of inertia

From the graphs in Fig. 5 it can be seen that the angular speed oscillation also increases with increasing work efficiency, i.e. load, but as the inertia moment increases, the coefficient of unevenness of the saw cylinder angular speed decreases (Fig. 6).

Technological machines are designed for a simplified shaft design, including a saw gin cylinder, to reduce the bending of the shafts of long, heavy and fast rotating bodies, based on which increased fiber output, pollution and power consumption due to adequate maintenance of the technological gap between the saw cylinder and fiber separation beam.

A special experimental stand was prepared to measure the parameters to be studied in the experimental studies. The electrotenometric scheme of the experimental stand is shown in Figure 11 and consists of: 1-asynchronous electric drive, 2-coupling, 3, 6-supports, 4-sensor, 5-cylinder cylinder shaft, 7-tokosyomnik, 8-Arduino ATSP microcontroller, 9-computers, 10-power supplies, 11-electronic calipers.

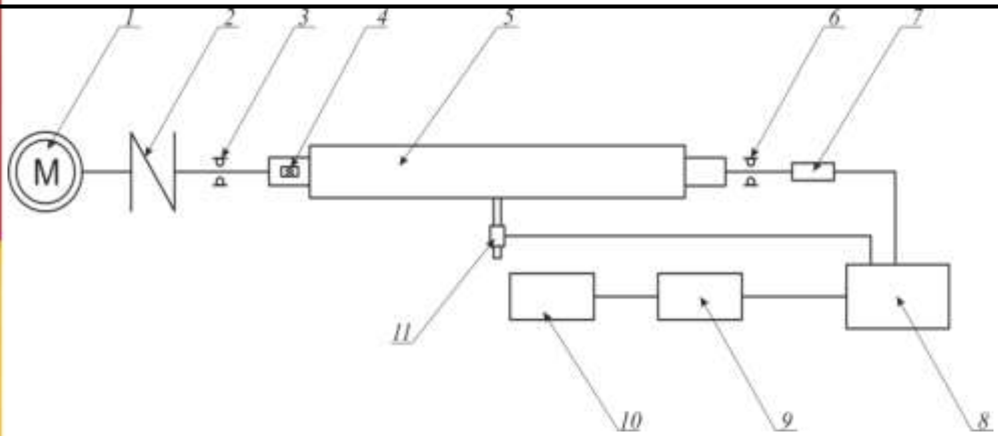
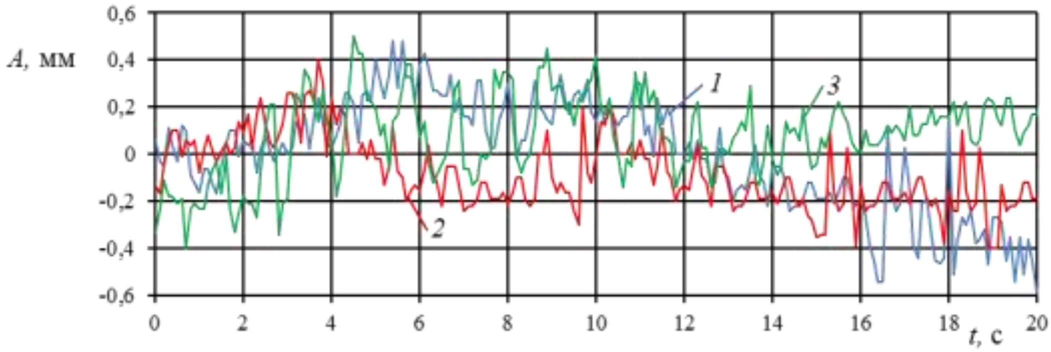
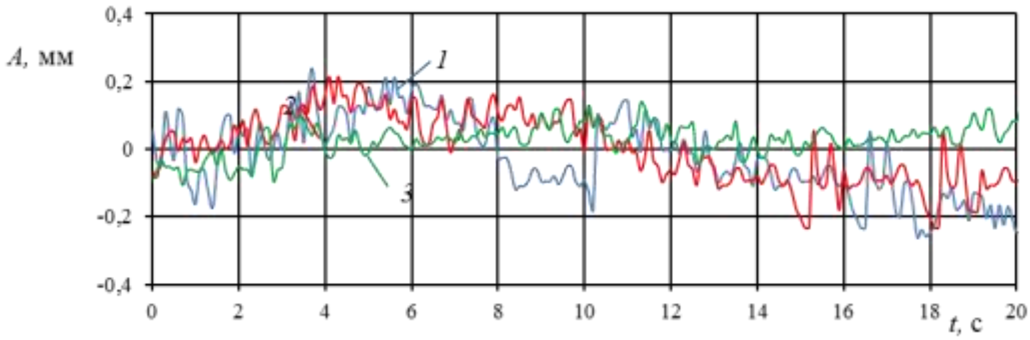


Figure 7. Electrotensometric scheme of the experimental stand

In order to determine the number of revolutions and torque on the shaft in the experiments, the strain gauges were attached to the shafts by thebridge method, and the data were transmitted to the Arduino ATSP microcontroller through a tokosyomnik. In determining the deflection of the shaft, an electronic caliper was specially installed and the data were transmitted to a computer using an Arduino ATsP microcontroller. As a result of experimental studies, a series of oscillograms were obtained (Figure 8).



a



b

1 working capacity 3.5 t / s; 2-work yield 4.0 t / s; 3-work yield 4.5 t / s
a-existing shaft; b-shaft in the open position

Figure 8. Oscillograms showing the oscillations of the shaft

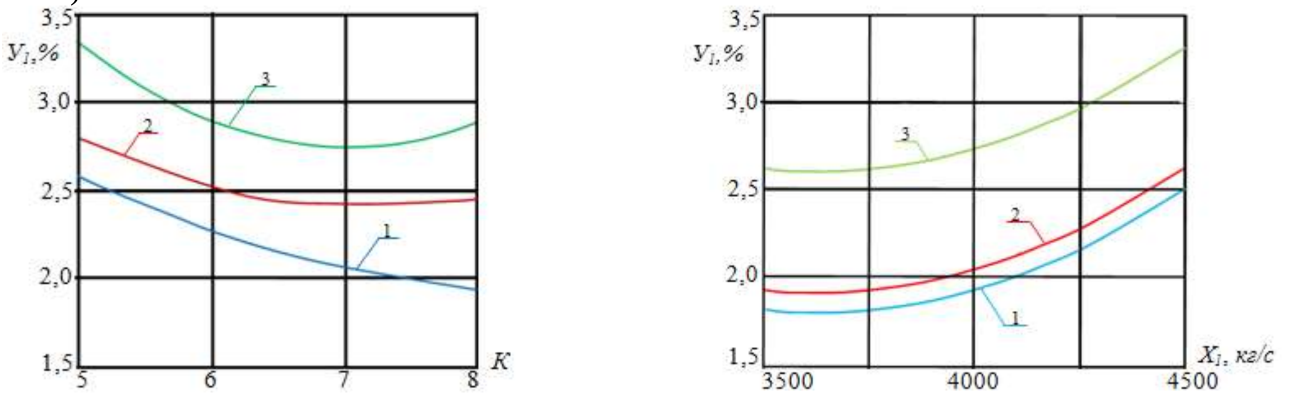
Based on the analysis of oscillograms, it can be said that the oscillation coverage at the bending of the existing saw cylinder shaft exceeds 0.9 mm, while in the proposed saw cylinder this coverage decreases to (1.5-2.0) times.

The data obtained in the experiments were processed using the program "regression analysis". The Cochrane criterion was used to assess the homogeneity of the variance, the Student's criterion was used to assess the value of the regression coefficients, and the Fisher criterion was used to assess the adequacy of the regression models. The output factors were the sum of impurities in the fiber (Y1) and the fiber output (Y2). The effect of incoming factors on outgoing factors was studied on the basis of repeated experiments. To do this, a planning matrix is created. In each case, the experiments were repeated 3 times. If the number of incoming factors was 3, the total number of experiments was n = 8, the number of repetitions was m = 3, the total number of experiments was 24. The experimental results and variances of the output factor were recorded in tabular form. obtained regression equations

$$Y_1 = 3{,}14 + 0{,}421X_1 - 0{,}671X_2 + 0{,}543X_3 + 0{,}362X_1^2 + 0{,}293X_1X_2 + \\ + 0{,}31X_2^2 - 0{,}291X_2X_3 + 0{,}531X_3^2 \qquad (2)$$

$$Y_2 = 34{,}323 + 0{,}419X_1 + 0{,}92X_2 - 0{,}512X_3 - 0{,}291X_1^2 + 0{,}334X_1X_2 - \\ - 0{,}446X_1X_3 - 0{,}229X_2^2 \qquad (3)$$

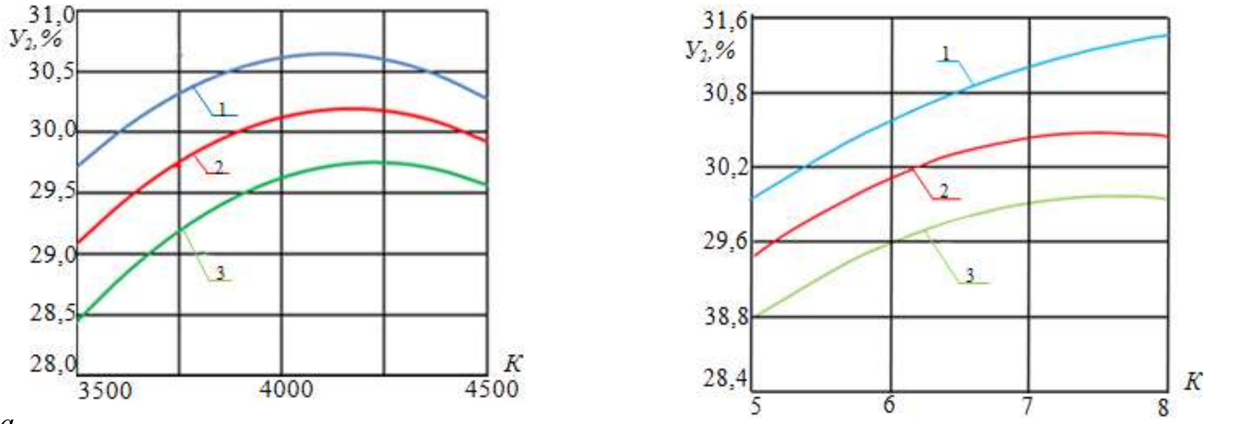
and (3) dependence graphs were obtained based on numerical solutions of the regression equations (Figures 9 and 10).



a *b*

1-cotton moisture content 8.5%; 2-cotton moisture 9.5%; 3-cotton moisture 10.5%

Figure 9. Graphs of the dependence of the sum of the waste on the internal diameter of the saw cylinder (a) and the yield (b)



a *b*

1 cotton moisture content 8.5%; 2 cotton moisture 9.5%; 3 cotton moisture 10.5%

Figure 10.Graphs of fiber output saw cylinder inner diameter (a) and work efficiency (b)

Conclusion

Technological machines are designed for lightweight shaft design, including saw gin cylinder, to reduce the bending of shafts of long, heavy and fast rotating bodies, on the basis of which increased fiber output, pollution and power consumption due to sufficient maintenance of the technological gap between the saw cylinder and fiber separation beam. According to the test results of the production of gin construction with a lightweight saw cylinder, the fiber output increased by 0.25-0.30% due to the reduction of the saw cylinder bending, the amount of impurities in the fiber decreased by 0.45% compared to the existing structure, power consumption decreased by 15-18%. a 1.5-fold increase in resource was found.

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