 https://doi.org/10.1051/e3sconf/202339006011

Investigation of seeds mechanical extraction through the seed-removing device from saw gin

Davlat Mukhammadiev*, and *Ilhom* Ergashev

Institute of Mechanics and Seismic Stability of Structures of the Academy of Sciences of the Republic of Uzbekistan, 100125, Tashkent, Uzbekistan

Abstract. The article provides research materials on the extraction of seeds through the seed-removing device from the working chamber of a saw gin with a husking chamber. The maximum values of the angular velocity of the raw cotton roller to the saw blades were determined ω_{max} =16.09 rad/s (153.71 rpm) for a pipe diameter of 125 mm, then the angular velocity of the seed-removing pipe should be within ω=34.35 rad/s (328.05 rpm), since k=2.45. It was determined that the ratio of seed flow through pipe perforations for pipes of various radii is 21÷38.2% of the total amount of seeds. An account for the productivity of cotton is 7000 kg/h (for seeds, it is 4667 kg/h) and a perforated pipe with a useful area of 20% and a radius of R_1=0.0625 m allows the seed extraction at a productivity of 1382.19 kg/h (0.3839 kg/s).

1 Introduction

When creating gins with a husking (cleaning) chamber that meet the requirements for the arrangement of machine units in terms of productivity, it is necessary to determine the design and operating parameters of the developed gin and, first of all, such parameters as the optimal value of the saw clearance, the dimensional characteristics of the working chamber and their mutual coordination, the speed modes of the movable working units, productive and qualitative characteristics of the gin performance.

Using the formula proposed by G.I. Boldinsky [1], we determine the changes in the productivity of a saw gin depending on the utilization factor of the saw teeth (Figure 1).

The maximum performance value of a gin according to formula [1] is 21.7 kg of fiber per saw per hour. The performance of a gin depends on the speed of the saw blades, the geometry of the tooth. The change in these values within certain limits makes it possible to determine ways to increase the performance of a gin. It was determined that the main influencing factor on the performance of a gin is the utilization factor of saw tooth, which depends on the speed of raw cotton roller [1]. Consequently, the greater the speed of rotation of the raw cotton roller, the more the teeth of the saw blades are used [2].

In the studies by A. Maksudov [3], the theoretical values of the productivity of a saw gin are determined through the speeds of the saw cylinder and raw cotton roller, and its mass:

$$Q_t=Q_o+1.35\cdot(\upsilon-\upsilon_o)+7.1\cdot(\upsilon_b-\upsilon_{bo})+0.5\cdot(G-G_o)\ . \qquad (1)$$

* Corresponding author: davlat_mm@mail.ru

To increase the productivity of a saw gin, it is necessary (1) to increase the circumferential speed of the saw cylinder and raw cotton roller, as well as the mass of the raw cotton roller, and from the point of view of upgrading the serial saw gin 5DP-130, to increase the rotation speed and mass of the raw cotton roller. This is feasible when installing a seed-removing pipe inside the working chamber.

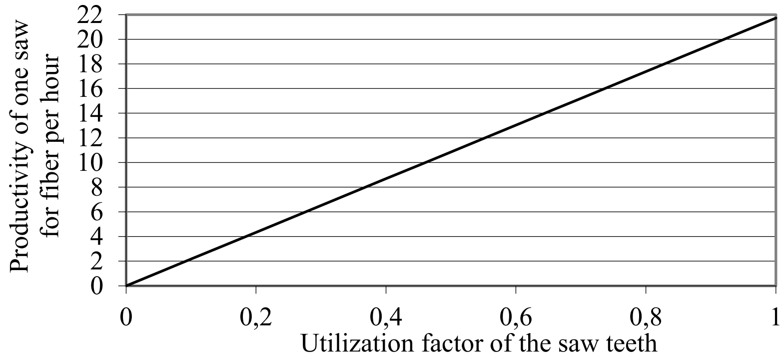

Fig. 1. Change in the productivity of one saw for fiber in kg/h.

Research conducted by P.N.Tyutin, M.Tillaev, N.K.Safarov, A.S.Ibragimov, D.M.Mukhammadiev proved the fundamental possibility of installing an additional seed-removing device from the central part of the raw cotton roller by means of a drive tubular seed-removal device, inside which a seed auger is installed; this will allow increasing the performance of a gin [4-6].

In particular, N.K. Safarov proposed a saw gin with a seed-removing device with the following design parameters of the pipe [6]:

- pipe diameter $\varnothing$165mm, with useful area - 9.5%;
- rotation frequency - 290 min^{-1};
- orientation of the holes (oval 10x20) on the pipe surface 44.5x43.1 mm.

This design made it possible to bring the optimal performance of the gin up to 12 kg per saw per hour and the seed auger up to 380 kg/hour. The influence of the gin productivity, the rotation frequency of the seed-removing device and the extraction of ginned seeds by the seed-removing device on the ginning process was established [6].

However, in [6], there is no method for calculating the dynamic parameters of a saw gin with a seed-removing device, and the effect of the machine unit drive of the saw gin with shorter distances of saw blades on the ginning process was not studied.

2 Materials and methods

Installation of a seed-removing pipe with a radius R provides a reduction in the volume of the working chamber $(V_{ob} - \pi \cdot R^2 \cdot l)$, while the mass of the raw cotton roller is G. The distance along the radius of the working chamber from the pipe wall to the front beam is $r–R$ and it decreases with an increase in R, then equation (1) takes the following form [7]:

$$Q_t=Q_o+1.35\cdot(\upsilon-\upsilon_o)+7.1\cdot[k\cdot w_b\cdot(r-R)-\upsilon_{bo}]+0.5\cdot[\rho\cdot(V_{ob}-\pi\cdot R^2\cdot l)-G_o], \quad (2)$$

where k is the coefficient that accounts for the increase in the speed of the raw cotton roller.

For a saw gin with a husking chamber [8, 9]:

Q_o= 14.9 kg of fiber per saw per hour - the productivity of a saw gin with a husking chamber;

υ_o =12.31 m/s - the peripheral speed of the saw cylinder;

υ_{bo}=1.58 m/s – the circumferential speed of raw cotton roller;

$w_b = \upsilon_b / r$ =9.42 rad/s - the angular velocity of raw cotton roller;

$r=0.168$ m - the radius of the wall of the front beam from the center of the working chamber;

G_o =13.8 kg - the mass of the raw cotton roller at its density $\rho=300\ kg/m^3$, $V_{ob}=0.046\ m^3$ – the volume and $l=0.54m$ - the length of the working chamber.

For the developed gin [8, 9]:

υ=12.31 m/s – proposed circumferential speed of the saw cylinder;

$\upsilon_b = w_b \cdot r$= 1.58 m/s – proposed circumferential speed of the raw cotton roller;

$w_b = \upsilon_b / r$ =9.42 rad/s - the angular velocity of the raw cotton roller;

$r=0.168$ m - the radius of the wall of the front beam from the center of the working chamber;

$G=\rho \cdot (V_{ob} - \pi \cdot R^2 \cdot l)$ kg – the mass of the raw cotton roller;

R - the radius of the seed-removing pipe.

Using equation (2), we plot a graph of the change in the calculated productivity of a saw gin with a husking chamber and a seed-removal system on the pipe diameter $2 \cdot R$ and the coefficient k that accounts for the increase in the angular velocity of the raw cotton roller (Figure 2).

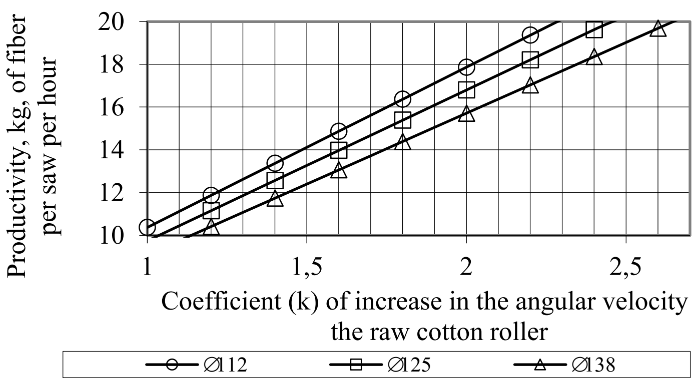

Fig. 2. Change in the calculated productivity of a saw gin with a husking chamber and a seed-removing system, depending on the coefficient of increase in the angular velocity of the raw cotton roller for different diameters of the pipe.

To increase the productivity of the saw gin up to 20 kg of fiber per saw per hour with a seed-removing pipe, when changing its diameter from 112 to 138 mm, it is necessary to increase the speed of the raw cotton roller from 2.3 to 2.7 times (Figure 2). In this case, the clearance between the saw blade and the pipe is reduced from 50 to 41 mm, and the volume of the working chamber is reduced from 11.4 to 15.4%. In addition, the clearance between the pipe and the legs of the ribs, necessary for the replacement or elimination of clogging of the ribs, is reduced from 105.8 to 96.8 mm.

From dependence (2) it is seen that a decrease in the volume of the working chamber by installing the seed-removing pipe leads to an increase in the density of the raw cotton roller. To increase productivity and reduce the mass of the raw cotton roller by 15%, it is necessary to increase the number of saws on the saw shaft and the useful area of the pipe to 15%; this means reducing the spacing of the saw blades from 18 to 15 mm. An increase in the number of saws and the useful area of the perforated pipe by 15% in the saw shaft will lead to a decrease in the density of the raw cotton roller, removing the seeds through the perforation holes, and removing the fiber with saw blades.

We determine the required angular velocity of the raw cotton roller and the coefficient of its increase k, using equations (2), Figure 2 for different diameters of the pipe, given in table

1. This allows us to bring the productivity of the saw gin up to 20 kg of fiber per saw per hour.

Table 1. Determination of the required rotational speed of the seed-removing pipe of various diameters, ensuring the productivity of the gin up to 20 kg of fiber per saw per hour.

Outer diameter of pipe (R_1), mm	Maximum angular velocity of the raw cotton roller in the area of circular saws (without pipe)		Coefficient *k* of increase in angular velocity of the raw cotton roller from equation (2) and Figure 2	Required speeds of the seed-removing pipes	
	rad/s	rpm		rad/s	rpm
112	16.53	157.87	2.30	30.38	290.08
125	16.09	153.71	2.45	34.35	328.05
138	15.63	149.29	2.65	36.36	347.24

T. Saidkhodzhaev [10] has found that the length of the fiber with a decrease in the saw-to-saw distance from 20.64 to 14.59 mm during ginning of raw cotton of the 108F variety decreases by 0.1-0.2 mm.

Based on the above, to make a saw gin with a husking chamber, it is necessary to increase the number of saws by 20% and install a seed-removing pipe with holes.

3 Results and discussion

Analyzing table 1, it was found that, for example, for a pipe diameter of 125 mm, the maximum value of the angular velocity of the raw cotton roller to the saw blades is ω_{max}=16.09 rad/s (153.71 rpm), then the angular velocity of the seed-removing pipe should be approximately ω=34.35 rad/s (328.05 rpm), since k=2.45.

Seeds that move slower than the perforated pipe enter the inside of the pipe and are then carried outside by an installed screw auger. The amount of seeds taken out of the slots from the inner cylinder (seed-removing pipe) is determined by the equation

$$Q_{ts}=\rho_c \cdot K_1 \cdot b_1 \cdot \omega_1 \cdot R_1^2=68 \cdot b_1 \cdot \omega_1 \cdot R_1^2 \qquad (3)$$

where ρ_c=340 kg/m^3 is the density of seeds [1]; $K_1 \approx 0.2$ is the coefficient of the useful area of the seed-removing pipe; b_1 is the width of the outlet zone of the chamber, m; $\cdot\omega_1$ and R_1 are the rotation frequency (rad/s) and outer radius (m) of the seed-removing pipe.

Let us determine the ratio of the rate of seeds carried away by the auger to its total amount

$$\frac{Q_{ts}}{Q_{seed}}=\frac{Q_{ts}}{Q}\cdot\frac{Q}{Q_{seed}}\ , \qquad (4)$$

where $Q=Q_{seed}+Q_f$ is the rate of cotton mass entering the working chamber; Q_f is the amount of fiber. Then

$$\frac{Q}{Q_{seed}}=1+\frac{Q_f}{Q_{seed}}\ , \quad \text{so} \quad \frac{Q_{ts}}{Q_{seed}}=\left(1+\frac{Q_f}{Q_{seed}}\right)\cdot\frac{Q_{ts}}{Q} \qquad (5)$$

Now let us determine the amount of raw cotton entering the working chamber:

$$Q=\rho_{ct} \cdot l \cdot b_o \cdot U_\theta(R_2,\pi/2)=138.63 \cdot b_o\ , \qquad (6)$$

where l=2.358 m is the width of the working chamber; ρ_{ct} =50 kg/m^3 is the density of cotton in the gin feeder; $U_\theta(R_2,210^\circ)$=1.1757 m/s is the tangential speed of the raw cotton roller in the inlet zone of the working chamber (6). For Q=7000 kg/h (1.94 kg/s or 0.0388 m^3/s) $b_o=h$=1.94/(1.1758·2.358)=0.014 m.

Thus, from equations (4), (5) and (6) we have the following expression to determine the ratio of the amount of seeds:

$$\frac{Q_{ts}}{Q_{seed}}=\left(1+\frac{Q_f}{Q_{seed}}\right)\cdot\frac{68\cdot b_1\cdot\omega_1\cdot R_1^2}{138.63\cdot b_o}\ . \quad (7)$$

Depending on the type of cotton fiber and the amount of work of the saw that removes the fiber from the cotton seeds, the fiber yield can be about 33% of the total amount of raw cotton. Therefore, the ratio is $Q_f/Q_{seed}\approx0.5$.

Hence, we determine the ratio of the amount of seeds removed by the inner cylinder to their total amount

$$\frac{Q_{ts}}{Q_{seed}}=0.7358\cdot\frac{b_1\cdot\omega_1\cdot R_1^2}{b_o}\ . \quad (8)$$

Then, for the case when the widths of the inlet zone b_o=0.014 m and the outlet zone b_1=0.042 m are the same ($b_1/b_o=3$) and for Q_{seed}=4667kg/h, we will have the following indices (table 2):

Table 2. Productivity of inner cylinder

Name of parameters	**Parameter value**		
R_1, m	0.056	0.0625	0.069
ω_1, s^{-1}	30.38	34.35	36.36
Q_{ts}/Q_{seed}	0.2103	0.2962	0.3821
Q_{ts}, kg/h (kg/s)	981.40 (0.2726)	1382.19 (0.3839)	1783.21 (0.49534)

The result of calculating the ratio of seed flow through the perforations of pipes of various radii is 21÷38.2% of the total amount of seeds. Considering the productivity of cotton 7000 kg/h, after ginning we get the total amount of seeds 4667 kg/h. Then, for example, a perforated pipe with a useful area of 20% and a radius R_1=0.0625 m allows us to remove seeds with productivity of 1382.19 kg/h (0.3839 kg/s).

The amount of seeds taken out of the slots by an auger is determined by the following equation [1]:

$$Q_{sc}=60\cdot S\cdot n\cdot\psi\cdot\rho\cdot\pi\cdot D^2/4,\ kg/h \quad (9)$$

where D is the diameter of a screw, m; S=(D/1.15) is the screw pitch, m; n is the rotational speed of the screw or the seed-removing pipe, rpm; ψ=0.40 is the volume factor for cotton seeds; ρ= 340 kg/m^3 is the bulk volume density for seeds of medium-staple varieties of raw cotton [1].

It was stated that an installation of the auger relative to the working chamber and rotating the pipe relative to the auger makes it possible to facilitate the design of the seed-removing pipe [11]. However, the risk of clogging and breakage of the screw auger increases. Therefore, a gearbox is provided for the drive of the seed-removing device to increase the rotational speed of the screw relative to the seed-removing pipe.

The power required to drive the horizontal conveyor screw is determined by the following formula [1]:

$$N=Q_{sc}\cdot l\cdot W/(367\cdot\eta) \quad (10)$$

where l=2.358m is the length of a conveyor; η=0.8 is the drive efficiency factor; W=4 is the coefficient of the total resistance in the conveyor.

Using equations (9), (10) and the data from table 1, it is possible to determine the performance and power consumption of the seed-removing device for various pipe diameters, given in table 3.

Table 3. Changes in the productivity of the seed-removing auger depending on the diameters of the auger blades.

Outer diameter of a pipe, m	Diameter of a screw, m	Screw pitch, m	Rotational speed of seed-removing auger, rpm	Productivity of seed-removing auger, kg/h	Power consumption by seed-removing device, kW
0.112	0.082	0.071	435.16	1337.13	0.043
0.125	0.095	0.083	492.03	2350.94	0.076
0.138	0.108	0.094	520.82	3656.28	0.117

4 Conclusions

An analysis of table 2 shows that, for example, the productivity of a screw conveyor with a seed–removing device is 2350.94 (however, for a pipe with a 20% perforation, it is 1382.19) kg/h for pipes with a diameter of 125 mm. Therefore, this seed-removing pipe has a performance margin of more than 1.7 times. The output of fiber and seeds from cotton mass in percentage is 34 and 66%, respectively. The productivity of seeds is 4667 kg/h. We assume that up to 50% of the amount of seeds are extracted from the gin through the seed-removing pipe; thus, this device ensures the productivity of the gin up to 10500 kg/h for cotton. The power consumption for conveying seeds inside the seed-removing pipe is 0.076 kW.

References

1. G. D. Dzhabarov, S. D. Baltabaev, D. A. Kotov, N. D. Soloviev, *Primary processing of cotton* (Light Industry, Moscow, 1978)
2. M. Agzamov, M. Rakhmatov, M. Agzamov, O. Olimov, K. Nosirov, *Search for ways to increase yield and improve product quality in the process of saw ginning*, IOP Conf. Ser.: Earth Environ. Sci. **939(1)**, 012073 (2021)
3. A. Maksudov, *Influence of the optimal ratio between the speeds of the saw cylinder and the raw cotton roller on the quality indices of ginning* (Tashkent, 1976)
4. A. Khamidov, P. N. Tyutin, Sh. U. Rakhmatkariev, D. M. Mukhammadiev, *On the movement of cotton and seeds inside the working chamber of a fiber separator with an additional seed-removing device*, Int. Conf. on Actual problems of flax processing in modern conditions (Kostroma, 2002)
5. M. T. Tillayev, *Technology of primary processing of cotton* (Tashkent, 2015)
6. N. K. Safarov, *Influence of raw cotton roller density on technological parameters of saw ginning* (Tashkent, 1998)
7. D. M. Mukhammadiev, *Dynamics of machine units of saw gin with seed retractor device and condenser with pulse air stream* (Tashkent, 2014)
8. Kh. A. Akhmedov, *Development resourcesaving parts of saw gin with throwing drum* (Tashkent, 2018)
9. B. Kh. Primov, *Substantiation of the parametres of the working chamber and transmission system of the saw gin with a peeling chamber* (Tashkent, 2021)
10. T. Saidkhodzhaev, *Research on the influence of saw spacing on the ginning process* (Tashkent, 1966)
11. O. S. Mallaev, *Substantiation of the design of a seed removal device for a saw gin with a peeling chamber* (Tashkent, 2022)