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Cutting length the fodders of green stalks by drum chopper

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Abstract. In Uzbekistan, special attention is paid to the development of livestock, poultry, and fish farming. In the ration of animals, green fodder obtained by cutting green stalks corn, alfalfa and other feed crops have a special place. For high-quality chopping of stalks with the required cutting length for each type of animal, a chopper has been developed with a simple design for chopping green feed. Testing of the chopper work, carried out at an engine speed of 2800 rpm, a cutting drum rotation speed of 950 rpm and in two rotations of the feed rollers 10 rpm and 20 rpm with an average length of alfalfa stalks 71.6 cm and an average length of corn stalks 216.4 cm, showed that at a feed roller rotation speed of 10 rpm the average cutting length of the stalks was 10.6 mm, and at a feed roller rotation speed of 20 rpm - 17.6 mm. It can be seen from the data that with a twice increase in the feed roll speed, the cutting length increases 1.66 times, which confirms the theoretical assumptions obtained.

1. Introduction

Uzbekistan pays special attention to the development of livestock, poultry, and fish farming. The emphasis is on the introduction of modern technology and innovative developments in industries. In the face of energy and resource shortages, it is important to create a universal design of feed chopping machines that are resource-intensive, low-power, and reliably carry out technological processes and allow for the proper chopping of staple feeds. Therefore, research has been carried out on the development of choppers used in chopping of green stalk feeds in livestock, poultry and fisheries farms and cutting the feeds for each category of animal. As you know, feeding efficiency of livestock, poultry, and fish farming depends on sorts of fodder and chopping them as well depending on the type and size of the creatures, it is necessary to trim the stalks from 5 to 100 mm [1, 2]. This is achieved by selecting the optimal type of chopping equipment, which is the main working part of the chopper. The results of the study of existing devices have shown that choppers with more blade drums meet this requirement [3-10].

2. Methods

For defining the work-quality indexes of the cutting used methods in State Standard 11448-2002 «Powered shredders and chippers. Safety requirements and test procedures» and testing the fodder choppers and their work efficiencies were determined according to State Standard 20915-2011 «Testing of agricultural tractors and machines. Procedure for determination of test conditions».

The technological scheme of the green stalk chopper was developed based on the analysis of existing equipment used for chopping and preparing feeds and the structure of their cutting apparatus.

The experiments were performed on the device's experimental sample.The experiments were carried out on chopping alfalfa and corn at a drum rotation frequency of 950 rpm and at a feed roller speed of 10 rpm and 20 rpm.

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3. Results and Discussion

Devices for chopping and preparation of beetroot and other types of feeds, types of cutting machines used for chopping stalks, and their cutting knives were studied [11-15]. Based on the research, a technological scheme of a compact lightweight device for chopping green staples for livestock, poultry, and fish was developed (Fig. 1).

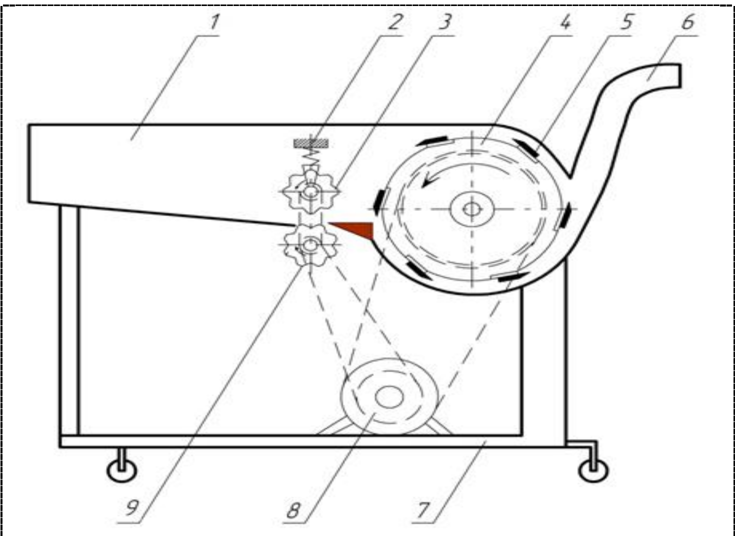

Figure 1. Green stalk chopper machine
1 is hopper; 2 is spring pressing mechanism; 3 is top roller; 4 is cutting drum; 5 is cutting knife; 6 is deflector; 7 is frame; 8 is electric motor; 9 is bottom roller.

Chopping and feed cutting device consist of hopper 1, spring pressing mechanism 2, top and bottom roller 3 and 9, cutting drum 4, cutting knife 5, deflector 6, frame 7, and motor 8. The operation of the equipment for coarse chopping unit is as follows (Fig.1). The coarse chopping unit is capable of chopping green stalk feeds, and the stalk feeder passes hopper 1 to the roller 3 and 9. Then, rollers deliver to the cutting drum 4 using a counter-cutting plate and after completion of the chopping process, put in a special container. The movement is transmitted by the transmission of the motor 8. It is possible to trim the stalks to the required length by varying the number of rotating shafts and cutting drum rotations. The operation of this device has no negative impact on the environment and nature.

The theoretical studies were conducted to determine the cutting length of the stalk on the developed device. One of the most important indicators of stalks chopping is the cutting length [16-19]. When designing the chopper, several expressions are used to determine the cutting length depending on the type of chopping machine. The following expression is proposed by S.V.Melynikov to determine the computational cost of cutting length of stalk feeds

$$l_c = \frac{Q}{0.16az\rho\omega} \quad (1)$$

where Q is the working capacity of the chopper, m;
a is the height of the transmission line, m;
b is the width of the transmission line, m;
ρ is the density of chopped feed, kg/m^3;
z is the number of blades in the drum, m;
ω is the angular velocity of the drum, s-1.

This expression determines the length of the feed depending on the milling performance, the feed density, the height and the width of the feed, and when the stalk density changes, there is some uncertainty in determining the length of the trimming.

Based on the foregoing, the theoretical study of the cutting length of the stalk on the chopping equipment being fitted with the drum cutter was carried out. We use the following technological scheme for the chopping machine drum cutter to determine the cutting length (Fig. 2).

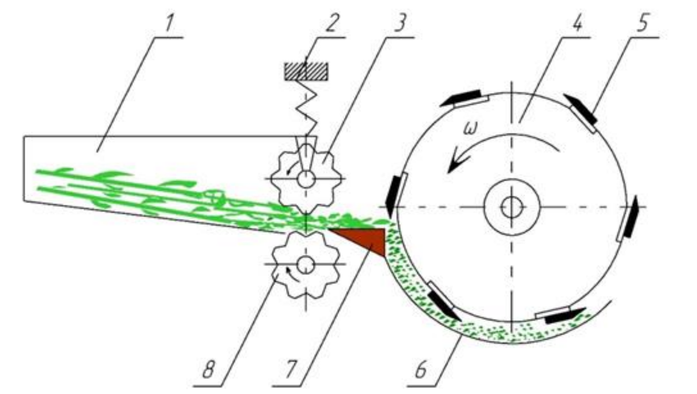

Figure 2. Cutting apparatus with a drum
1 is the hopper; 2 is the spring pressing mechanism; 3 is the top roller; 4 is the cutting drum; 5 is the cutting knife; 6 is the housing; 7 is the counter-cutting plate; 8 is the bottom roller.

For some degree of compression of the chopping stalks to the cutting drum corrugated coriander is applied. The stalks are directed to pairs of rollers, consisting of the top 3 and the bottom 8 rollers. The transmission rods extend to the drum with a knife slower or faster, while pressing the stalk layer. The drum cuts the stalks at the desired speed and chops them to the required size.

The cutting length of the trunks transmitted to the chopper is usually the following:

$$l_c = V_{tr} t_c \qquad (2)$$

where V_{tr} is the speed of the stalks transfer, m/s;

tc is the time the knives are placed in the cutting drum to cut the stalks, s.

The time it takes to cut the stalk from the side blades can be calculated as follows

$$t_c = \frac{\pi D_d}{Z_k V_d} = \frac{2\pi}{Z_k \omega_d} \qquad (3)$$

where D_d is the cutter drum diameter, m;

V_d is the drum rotation speed, m/s;

Z_k is the number of knives in the drum, m;

ω_d is the angular velocity of the drum, s-1.

Taking into account the time it takes to cut the stalk knives in parallel, the expression (1) appears as follows

$$l_c = V_{tr} \frac{2\pi}{Z_k \omega_d} \qquad (4)$$

The unknown value in this expression is the rate at which the stalks are transmitted to the truncation, as determined by the transmitter parameters. In the projected chopper, we choose the most commonly used corrugated surface pair of transporter-coupling transmission mechanisms. In such a transmission mechanism, the movement of the stalks between the transmitting joints is variable and the time is taken to pass them

$$t = \frac{2\alpha_0}{\omega_r} \qquad (5)$$

where αo is the angle of inclination of the stalk, degrees;

ω_r is the angular velocity of rollers, s-1.

The passing distance of stalks through rollers is as follows

$$S_d = 2(R_r + r_s)\sin\alpha_0 \qquad (6)$$

where R_r is the radius of roller, m;

r_s is the radius of the stalk, m.

According to (5) and (6), the speed of passing or transmitting the stalk between the rollers is as follows.

$$V_{tr} = \frac{2(R_r + r_s)\sin\alpha_0}{\frac{2\alpha_0}{\omega_r}} = (R_r + r_s)\omega_r \frac{\sin\alpha_0}{\alpha_0} \qquad (7)$$

In terms of the value of (7) and (4), the length of the stalk cutting in the cutter drum is:

$$l_c = \frac{2\pi}{Z_k\omega_d}(R_r + r_s)\omega_r \frac{\sin\alpha_0}{\alpha_0} \qquad (8)$$

In this expression, the value of all of the constituents in determining the length of the rods in the chopping process is unchanged, and only by adjusting the number of rotation cores and the transporter rotation can ensure the required cutting of the straps in the chopper. According to S.V.Melynikov's research, the speed of the feeder mounts should be higher than the transporter's velocity $V_r \succ V_{tr}$ and in this range, to better transfer the stalk to the cutting drum $V_r = (1.25 \div 1.35)V_{tr}$. According to N.E.Reznik there is a slip in the transmission of the stalk, and the rate of transmission of the stalks is always lower than the speed of the stalk $V_{tr} = (0.88 - 0.93)V_r$ and this is the ratio.

Taking this into account, the expression for determining the length of the straps on the drum chopper appears as follows.

$$l_c = \frac{2\pi}{Z_k\omega_d}(R_r + r_s)0.9\omega_r \frac{\sin\alpha_0}{\alpha_0} \qquad (9)$$

In this regard, the aim of the study is to develop an innovative small chopping machine that breaks down the green feed at the minimum requirements and justifies its parameters and operating modes.

From equation (9) it can be seen that the length of cutting of the stalks decreases with increasing frequency of rotation of the drum and the number of knives on the drum, and with increasing frequency of a rotation and the diameter of the feed rolls, the length of cutting of stalks increases.

To determine the correctness of the obtained formula, experimental studies were conducted.

Studies to determine the cutting length were carried out on the stalks of alfalfa and corn. When chopping stalks, it is important to know the physical-mechanical properties of the stalks [20-25]. Therefore, before the experiment, the length and diameter of the stalks were determined. During chopping, the average length of alfalfa stalks was 71.6 cm with a standard deviation of 16.3 cm and a coefficient of variation of 22.7 %, and the length of corn stalks was 216.4 cm with a standard deviation of 26.7 cm and a coefficient of variation of 12.3 % (table 1).

Table 1. The length of the stalks of green feed of roughage

Type of fodder culture	Length of stalk		
	Average value	Standard deviation	Coefficient

	M_{av} (cm)	±σ (cm)	variation V (%)
Alfalfa	71.6	16.3	22.7
Corn	216.4	26.7	12.3

The study of the thickness of the stalks was carried out on single stalks in the laboratory. For this, samples of 100 pieces were taken from a pile of stalks in a circle in ten places each. Then they were taken samples of 15 ... 30 cm from the butt, in the middle of the stalk and at a distance of 10 ... 40 cm from the apex, depending on the type of culture. The last place is conditionally called the top. As can be seen from Table 2, all cultures have the largest thickness of stalks in the butt part, slightly less in the middle. It significantly decreases in the apical part.

The longest and thickest stalks are corn, their average length is 211.6 cm with a deviation from the average value of 23.3 cm, the lengths of stalks of alfalfa and wheat straw are close to each other and on average are 70.9 cm and 86.1 cm with RMS deviations, respectively 18.7 cm and 11.9 cm.

Table 2. Thickness of stalk along zone at the top part of the stalk

Zone sample	Average value M_{av} (cm)	Standard deviation ±σ (cm)	Coefficient variation V (%)
	Alfalfa		
At butt	4.8	0.5	12.1
In the middle	3.7	0.6	16.7
At the top	2.2	0.4	18.7
	Corn		
At butt	18.8	2.6	14.3
In the middle	14.7	3.5	24.0
At the top	10.6	1.9	18.4

Stem chopping by the developed chopper was carried out at a rotational speed of the engine of 2800 rpm, a rotational speed of the cutting drum of 950 rpm, and in two frequency of the feed rollers 10 rpm and 20 rpm. With a feed roller speed of 10 rpm, the average cutting length of the stalks is 10.6 mm with a standard deviation of 0.85 mm and a variation coefficient of 8%, and at a rotation speed of the feed rolls of 20 rpm, the average cutting length of the stalks is 17.6 mm with a standard deviation of 2.79 mm and a coefficient of variation of 15.8%. From these data, it is seen that with a twice increase in the feed roller speed, the cutting length increases 1.66 times, which confirms the theoretical assumptions obtained.

4. Conclusions

Testing of the chopper work, carried out at a motor speed of 2800 rpm, a cutting drum rotation speed of 950 rpm and in two frequency of the feed rollers 10 rpm and 20 rpm with an average length of alfalfa stalks 71.6 cm and an average length of corn stalks 216.4 cm, showed that at a feed roller rotation speed of 10 rpm the average cutting length of the stalks was 10.6 mm, and at a feed roller rotation speed of 20 rpm - 17.6 mm. It can be seen from the data that with a twice increase in the feed roll speed, the cutting length increases 1.66 times, which confirms the theoretical assumptions obtained.

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