Theoretical research of the parameters of the biters that distribute feed to the grinding rotor

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Abstract. Justifying the diameter of the distribution biters and the number of rotations of the device that grinds the pressed feed to the level required by zootechnical standards is the primary goal of the study. The press feed distribution biters' plan and its working principle are presented. It is necessary to scientifically justify the number of shovels of the proposed distribution biters and the width of the slits between them. During crushing the feed collected by the press, it should ensure the transfer of specified amounts without being stuck in the rotor of the device. The output of the pressed feed grinding device should be 500-600 kg/h in the main time, 400 kg/h during its use, and the length of the crushed feed should be for cattle. 30-50 mm, for sheep it should be 30-40 mm. Based on this, we accept the productivity of 600 kg/hour, the cutting length of 30 mm. In this instance, it was found that in order to maintain the device's stated productivity of 500–600 kg/h, the biter revolutions should be between 250 and 300 r/min.

1 Introduction

Currently, various studies are being carried out to develop technologies and technical means and methods of their application in order to improve the efficiency of agriculture [1-10].

The following technical scheme of the grain food grinder was established based on an analysis of the design and technological work processes of several types of grinders used in food grinding. This grinder is distinguished by the fact that a pair of counter-rotating biters is placed at the bottom of the inlet, the blades are plate-shaped and have the ability to change the diameter and angle by installing them in the corresponding holes in the rotor disc. Based on the created device's technological scheme, the transmission shaft, the standard transmission biters, the grinding rotor and its blades, and counter-cutting knives are directly involved in the grinding of saturated food, and theoretical studies have investigated the

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interaction of these working parts with the saturated food. Justification of their parameters and operating modes is required [11-16].

The function of the device distribution biter is to separate the saturated food coming from the transmission line into parts and transfer it to the grinding device in accordance with the device's performance.

According to the developed initial requirements, the productivity of the device should be 500-600 kg/hour in the main time, 400 kg/hour during the use, and the length of the ground food for cattle.

It is determined that it should be 3-5 cm, for sheep it should be 3-4 cm. Based on this, work productivity 600 kg/h, we accept 3 cm cutting length. To ensure the length of this accepted size, the distance between the bits is one of the most important indicators. It is necessary to apply it theoretically and empirically justify the found indicator.

2 Research techniques in the device's operational domain

According to the results of previous studies we determine the parameters of the supply bits based on the scheme in [17-21] Figure 1.

Condition of equilibrium of a piece of saturated food on biters in the general state

$$m_p g - N_1 sin\alpha_q - N_2 sin\alpha_q + F_1 cos\alpha_q + F_2 cos\alpha_q = 0 \quad (1)$$

where m_p - the mass of the pressed piece of feed, *kg;*

N_1 *and* F_1 – normal pressure and friction force of the first biter, *N;*

N_2 *and* F_2 – normal pressure and friction force of the second biter, *N;*

α_{k1}, α_{k2} – coverage angle of biters, grad.

Biters should have the same diameter for smooth feeding. But when the biter plates are moved relative to each other as shown in Figure 1, the condition for food to pass through the biter gap

$$G + F_2 + F_1 \, cos\alpha_q - N_1 sin\alpha_q \geq 0 \quad (2)$$

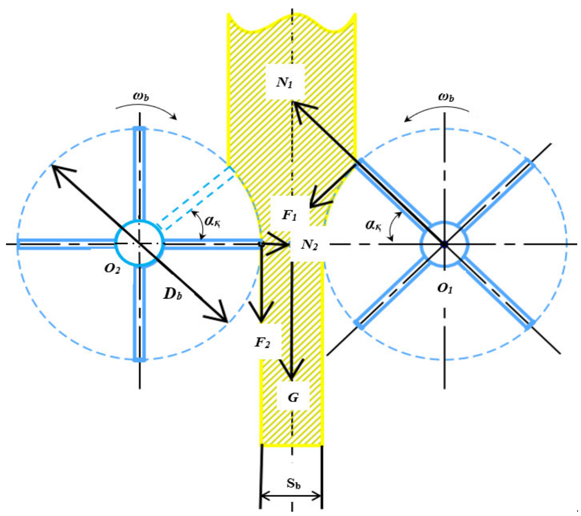


Fig. 1. Scheme of coverage of feed by biters.

If $F_1 = f_{d.o} N_1$; $F_2 = f_{d.o} N_2$ and $N_2 = 0$, considering that, then

$$G + f_{d.o} N_1 sin(90-\alpha_q) - N_1 sin\alpha_q \geq 0, \quad (3)$$

$sin(90-\alpha_q) = cos\alpha_q$ because it was

$$G + f_{d.o} N_1 \, cos\alpha_q - N_1 sin\alpha_q \geq 0, \quad (4)$$

or

$$G + N_1(f_{d.o}\cos\alpha_q - \sin\alpha_q) \geq 0, \quad (5)$$

according to the expression, the following condition must be met for a piece of food to pass between the biters

$$G \geq N_1(\sin\alpha_q - f_{d.o}\cos\alpha_q), \quad (6)$$

Performing some operations on the (6) expression, we get the following expression previously obtained by other researchers [17-21]

$$N_1 \geq \frac{G}{\sin\alpha_q - f\cos\alpha_q}, \quad (7)$$

where $G=m_pg$ from being

$$N_1 \geq \frac{m_pg}{\sin\alpha_q - f\cos\alpha_q} \quad (8)$$

where m_p – the mass of a piece of feed, kg;

f_d – friction coefficient of feed.

for an expression to have a correct solution, it must have (8) a positive result. For this, the following condition is required, namely

$$\sin\alpha_q - f_{d.o}\cos\alpha_q < 0 \quad (9)$$

or

$$\sin\alpha_q < f_{d.o}\cos\alpha_q \quad (10)$$

in the expression (10) $\frac{\sin\alpha_q}{\cos\alpha_q} = tg\alpha_q$ and $f_{d.o} = tg\varphi_{d.o}$ taking into account that, we have the following condition for biters to cover the saturated feed

$$tg\alpha_q < tg\varphi_{d.o} \quad (11)$$

$$\alpha_q < \varphi_{d.o} \quad (12)$$

where $\varphi_{d.o}$ – friction angle of feed, grad.

Angle of friction of agar-based feeds $\varphi_{d.o} = 30^o$ taking into account the fact that, then the angle of coverage of biters $\alpha_q < 30^o$ must be.

We determine the diameter of the biters as follows. According to the above scheme

$$\cos\alpha_q = \frac{D_b + \frac{S_b}{2}}{O_1A} \quad (13)$$

If $O_1A = \frac{D_b}{2} + \frac{S_b}{2\cos\alpha_q}$ considering that, then the diameter of biters

$$D_b = \frac{\frac{2S_b}{\cos\alpha_q} - S_b}{1 - \cos\alpha_q} \quad (14)$$

3 The tools and resources used in research

The piece separated from the food is 3-5 cm wide, and the slot between the bits is enough to cover them and take them inside. $S_b \leq 3cm$ must be.

Based on the above, the diameter of the supply biters according to the calculations according to the expression (14). D_b=157,8 mm it was determined that it should be. For ease of construction D_b=160 *mm*.

We determine the number of feeder biter plates and the number of revolutions by separating pieces of 3-5 cm from the saturated feed in the amount suitable for the work of the grinder and transferring them to the grinding machine.

Length ℓ_n from the inclined rod to the feed biters V_{toy} let it come down quickly. Using the expression (14), we determine the speed of the food coming down the inclined rod as follows

$$V_{toy} = g(\sin\alpha_q - f_p\cos\alpha_q)t_n \quad (15)$$

Here are the fast-growing bales that provide biter planks φ_b turning the corner, S_b separates a piece equal in size.

Where

$$\varphi_b = \frac{l_{yoy}}{r_b}, \tag{16}$$

Where ℓ_{yoy} – the length of the arc between the plates of the biter, m;

The length of the arc between them depends on the number of planks in the biter

$$l_{yoy} = \frac{2\pi R_b}{Z_p}, \tag{17}$$

where Z_p – the number of plates in the biter, pcs.

In turn

$$\varphi_b = \omega_b t, \tag{18}$$

where t – the time taken for the biter plank to turn to an angle equal to the length of the arc between the planks.

In that case (16) and (18) equating the expressions and (18) taking into account we determine the time *t*.

$$t = \frac{2\pi}{Z_p \omega_b} \tag{19}$$

Both sides of the expression (19) V_{toy} if we multiply by

$$V_{toy} t_n = \frac{2\pi V_{toy}}{Z_p \omega_b} \tag{20}$$

in the expression (20) $V_{toy} t_n$ is equal to the size of the piece separated from the fattened food coming down from the inclined rod by the forming biters, namely.

$$V_{toy}\, t_n = S_b\,. \tag{21}$$

In that case (20) based on

$$S_b = \frac{2\pi V_{toy}}{Z_p \omega_b} \tag{22}$$

To this expression (15) in the expression V_{toy} putting the expression of , we finally get the following expression

$$S_b = \frac{2\pi g(\sin\alpha_q - f_p \cos\alpha_q) t_n}{Z_p \omega_b} \tag{23}$$

The expression (21) depends on the speed of the feed coming down from the inclined bar and the number of plates in the biter S_b is an expression that allows you to determine the number of biter revolutions to extract a piece of thickness.

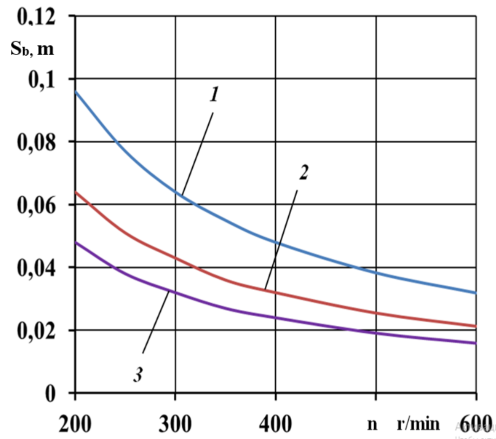
4 The results and discussion

Based on the expression (23), we build a graph of interdependence between its constituents (Figure 2).

Table 1. S_b dependence of the thickness of the slice (m) on the number of rotations of the biter and the number of planks in it

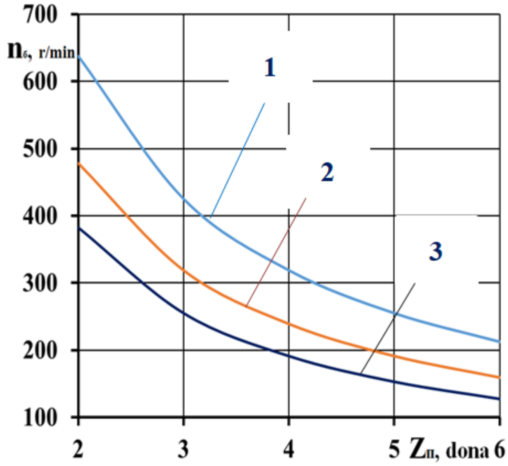
No.	The biter's number of planks	The biter's number of rotations, r/min						
		200	250	300	350	400	500	600
1	2 pieces	0.096	0.077	0.064	0.055	0.048	0.0383	0.0319
2	3 pieces	0.064	0.051	0.043	0.036	0.032	0.0255	0.0213
3	4 pieces	0.048	0.038	0.032	0.027	0.024	0.0191	0.0159

As Figures 2, 3 and Table 1 demonstrate, the width of the fed feed S_b=*3-5 sm,* to separate the pieces n_b=300 r/min, Z_p=4 should be one.



1-biter plates 2 pieces; 2-biter plates 3 pieces; 3-biter plates 4 pieces

Fig. 2. Variation in the piece's width when it separates from the saturated feed based on the biter's plate count and number of rotations.



1) when M_b=0,44 kg ; 2) when M_b=0,59 kg; 3) when M_b=0,74 kg;

Fig. 3. Depending on the piece's bulk, the number of biter plates and biter revolutions Sb vary.

This lump mass is separated from the digested food with the help of biter plates

$$M_b=\rho_p b_p h_p S_b \tag{24}$$

where ρ_p – the density of saturated feed, kg/m^3;

bp – the width of the feed line, m;

hp – the height of the feed, m.

From this

$$S_b = \frac{M_b}{\rho_p b_p h_p} \tag{25}$$

by taking (22) if we put it in (20)

$$\frac{M_b}{\rho_p b_p h_p} = \frac{2\pi g(\sin\alpha_q - f_p \cos\alpha_q)t_n}{Z_p \omega_b} \tag{26}$$

Now from (23) the expression biter's angular velocity ω_b we define

$$\omega_b = \frac{2\pi \rho_p b_p h_p g(\sin\alpha_q - f_p \cos\alpha_q) t_n}{z_p M_b} \tag{27}$$

We use the equation to calculate the (27) biter's number of rotations

$$n_b = \frac{60 \rho_p b_p h_p g(\sin\alpha_q - f_p \cos\alpha_q) t_n}{z_p M_b} \tag{28}$$

the mass of the saturated food piece that is sent to the grinding machine based on the expression M_b we plot the change of the number of biter cycles depending on (28).

5 Conclusion

In order to have the product of the fraction of the specified sizes at the same rate and without clogging to the rotor of crushing the pressed feed, it is necessary to ensure the specified rotation of the distribution biter.

If the device 600 kg/hour to its grinding apparatus during operation at t=1 $M_b=0,167$ *kg* if we take into account the amount of food to be given, then the number of rotations of these biters is achieved when is achieved when the number of revolutions is *320* r/min.

The number of device allocation bit cycles in experiments it should be taken into account to ensure that it is within 300-350 r/min.

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