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Theoretical Research of the Process of Work of the Crusher-Grinder for Feeds

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ABSTRACT: The article presents the results of theoretical studies of the operation of the crusher-grinder of roughage. Based on the conducted studies, the pattern of cutting stems with the least effort when they enter the crusher-grinder and the intensity of splitting stems of roughage in the working chamber, as well as the main parameters and operating modes of the crusher-grinder, are determined.

KEYWORDS: Crusher-grinder, stem, cutting, splitting, knife.

I.INTRODUCTION

Livestock in Uzbekistan is one of the important sectors of agriculture. Therefore, the Government of the Republic pays great attention to the development of the industry and implemented specific reforms, as well as a state program for the development of livestock production, the basis of which is the creation of small livestock farms and dehkan farms with a small number of animals. Now in the Republic there are many such farms and they mainly use roughage as feed.

The development of small livestock farms and dekhkan farms is closely associated with the preparation of high-quality feed at lower operating costs. However, practice has shown that unsatisfactory processing of stalks of roughage by feed preparation machines leads to a decrease in the quality of the resulting feed and, accordingly, to an increase in its losses (up to 30%). A significant reduction in operating costs and an increase in the quality of preparation of feed from coarse stalks of forage crops is possible when combining grinding and crushing operations in feed preparation machines, since grinding and splitting of plants leads to an improvement in their feed quality, reduction of losses and saving of material resources.

In connection with the foregoing, studies aimed at finding a technological scheme and substantiating the parameters of the working body of the crusher-grinder, combining the process of grinding and crushing are important.

II. MATERIALS AND METHODS.

Theoretical studies of the operation of the crusher-grinder of roughage were carried out using the basic principles of theoretical mechanics and mathematical analysis. The purpose of theoretical research was to determine the patterns of cutting stems with the least effort, the intensity of the splitting of the stems of roughage and theoretically determine the main parameters and operating modes of the crusher-crushed. When studying the process of the crusher-grinder, the works of N.E. Reznik, V.A. Zhenikhovsky, E.S.Bosogo, S.V. Melnikov, V.I. Fomin and other researchers [1-6].

III.RESULTS AND DISCUSSIONS.

According to previous studies, the most acceptable method of cutting stems is an inclined slice with a slide, which allows you to cut the material with the least effort.

According to the scheme (Fig. 1), the angle of inclination of the stems is equal to the feed angle

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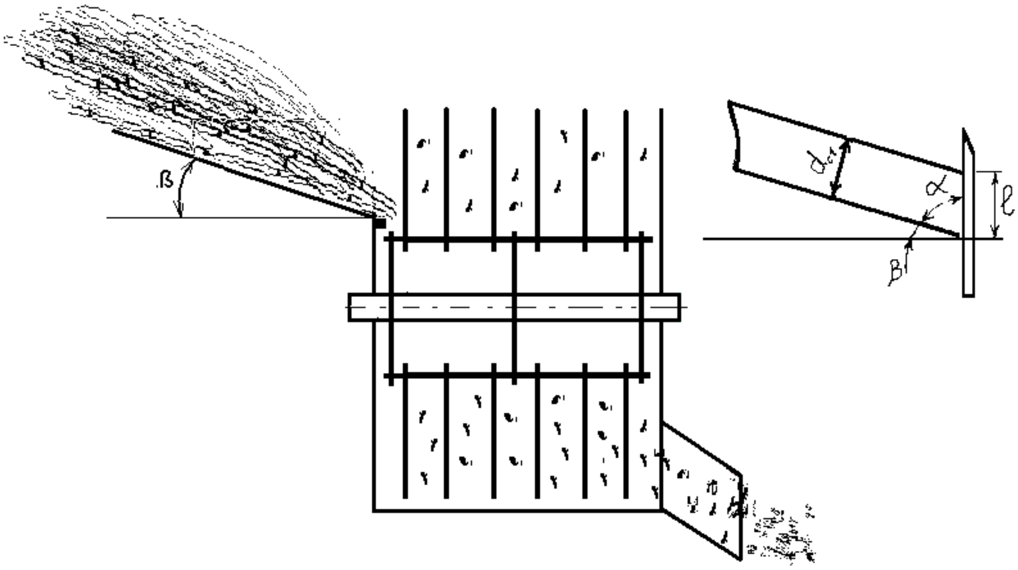
$$\beta_n = \frac{\pi}{2} - \alpha_p, \quad (1)$$

where α_p - is the angle of the stem relative to the knife, deg.



1 - stem; 2 – feed tray; 3 – knife; 4 – hammers.

Pic.1. Scheme for determining the feed angle

With inclined cutting, the cross section of the sections of the stems will be in the form of an ellipse with a small and large axis. (pic.2). In this case, the major and minor axes of the ellipse are connected by relations.

$$2r_б = \frac{d_{cm}}{\cos\beta_n} \quad и \quad 2r_м = d_{cm} \quad (2)$$

The scheme of oblique cutting of the stems when the knife moves in the direction of the small axis of the ellipse in the coordinates combined with its axes has the form (pic. 2)

$$4x^2\cos^2\beta_n + 4y^2 = d_{cm}^2 \quad (3)$$

and the equation of straightness of the edge of the blade in the same coordinates

$$y = (x - x_0)ctg\psi_c, \quad (4)$$

where ψ_c - glide angle.

X_0 - the length of the uncut part of the stem relative to x, m.

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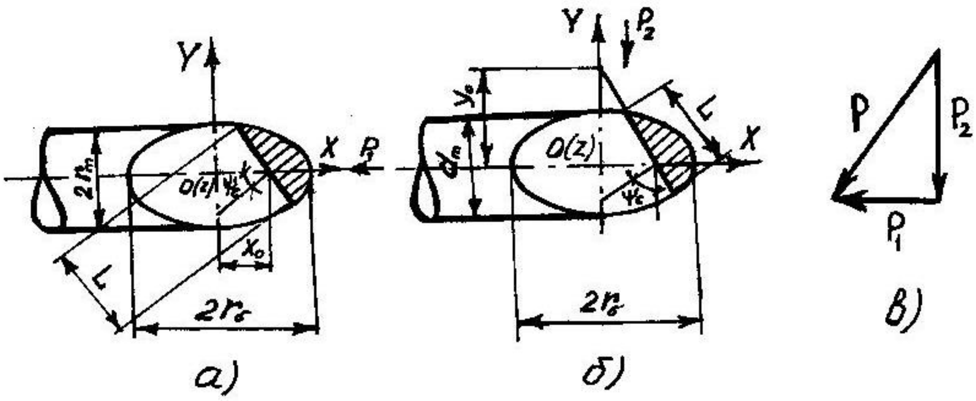

a and b - in the direction of the major and minor axes of the ellipse, c - the sum of the forces.
Pic.2. Scheme oblique oblique cut of the stem when the knife moves

Having solved equations (3) and (4) together, we determine the coordinates of the points of intersection of the ellipse with the edge of the blade

$$x^2(\cos^2\beta_n + ctg^2\psi_c) - x_0 ctg^2\psi_c(2x - x_0) = r_{cm}^2 \qquad (5)$$

After some transformation of equation (5), we can determine the angle of supply of stems to the crusher

$$\cos\beta_n = \sqrt{\frac{r_{cm}^2 + (2xx_0 - x_0^{\,2})ctg^2\psi_c}{x^2} - ctg^2\psi_c} \qquad (6)$$

The cutting force of the cut stalk by the chamfers of the knife blade can be determined by the formula /1,5/:

$$P = L\mu\sigma\cos\beta_n \quad \text{или} \quad P = \sqrt{P_1^2 + P_2^2} = \mu\sigma\, d_{cm}\sqrt{1+\cos^2\beta_n}\,, \qquad (7)$$

where L – the length of the cut part of the stem, m;

σ - contact voltage, н/m^2;

μ - knife blade thickness, m.

P_1 - the cutting force of the knife with an inclined cut of the stem and when matching directions of movement of it with a large axis of the ellipse, H;

P_2 - the cutting force of the knife with an inclined cut of the stem and when matching directions of movement of it with the small axis of the ellipse

Substituting various possible values of factors into expression (7) ($d_{ст}$=10...18 mm; β_n =30...70^0), build a graphical dependence of the cutting force P from the angle of the stem (pic.3) The graph shows that the cutting force P_c c increase in angle β_n filing from 30 before 70^0 decreases by 15… 20% at various diameters d_{st} the stalk.

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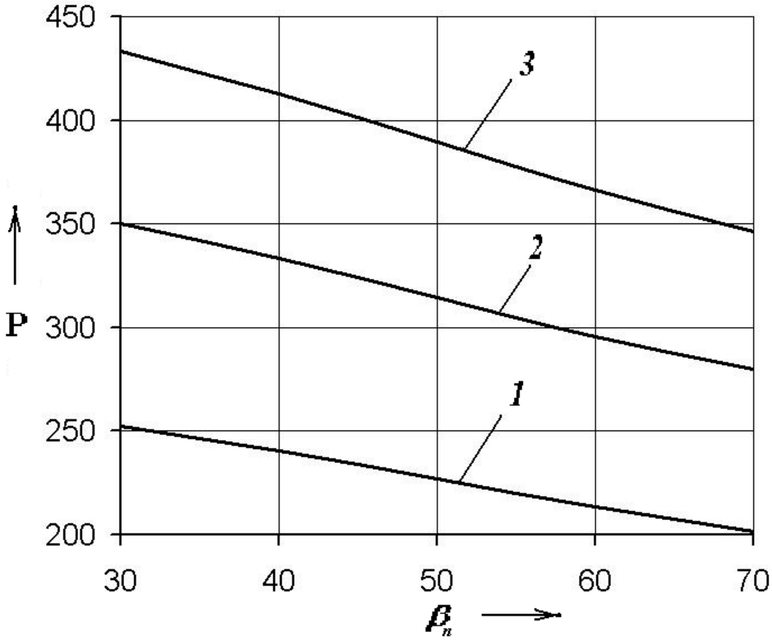

1 - d_{st}= 10 mm; 2 – d_{st}= 14 mm; 3- d_{st}= 18 mm.

Pic.3. Change in cutting force P depending on the angle β_n stalk feed.

Based on the foregoing, we can conclude that the cutting force will be the smallest at the angle of supply of the stem $50^0…70^0$, than at corners $30…40^0$. However, the practice of using crushers and grinders shows that an increase in the feed angle over 50^0 complicates the manual feed of the stem, which leads to a decrease in the number of feed and, in turn, the productivity of the machine. Therefore the angle β_n less desirable 50^0.

The process of splitting stems in the chamber of the crusher-grinder.

The splitting of crushed stems occurs if the magnitude of the stress resulting from the impact of hammers exceeds the strength of the stems. This is achieved provided that:

$$V_1 \geq \sqrt{\frac{(m_1+m_2)P_{раз}^2 L_x \Delta L_c r_{cm}}{(1-k^2)m_1 m_2 E S_c^2}} + V_2, \tag{8}$$

Where m_1, m_2 – accordingly, the mass of the hammer and stem, kg;
$P_{раз}$ - stem breaking force, H;
S_c - stem cross-sectional area, m^2;
к – recovery ratio;
ΔL_c - deformation of the surface of the stem upon impact, m.
E – elastic modulus, H/m^2;
L_x – contact circumference, m.
V_1, V_2 – respectively the speed of the hammer and stem, m/s.

For intensive cleavage of stems at the highest possible values $P_{раз}$=1400-1800 H [7], rotor peripheral speed V_1 should be within 30…35 m/s.

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IV. FINDINGS

Based on the data obtained, it can be concluded that the cutting force will be the smallest at the angle of supply of the stem $50^0…70^0$, than at corners $30…40^0$, however, in order to improve the feed and machine performance, it is desirable to select a feed angle of less than 500. In addition, for intensive cleavage of the stems at the highest possible values $P_{раз}$=1400-1800 H, hammer peripheral speed V_1 should be within 30…35 m/s.

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