THE WORK OF CONE-SHAPED WORKING BODY OF MINI-GRINDER FOR ROUGH FODDER

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Abstract: Technological process of crushing and crushing stalks weights of rough forages this rotors working body stationary pass - a crusher-grinder. Development pass a crusher-grinder and a substation of parameters and operating modes of its working body, processing of stalks of rough forages. Theoretical researches by definition of parameters rotors the device were carried out with use of substantive provisions of theoretical mechanics and the mathematical analysis. Experimental researches on check of the basic theoretical positions and a substantiation of the form and design data of a crusher-grinder are lead on specially developed and made laboratory installation. The basic statistical characteristics of stalks of rough forages including corn, Lucerne and straw wheat, cultivated in irrigation agriculture, and their making parts are determined.

The model of interaction rotor the device with stalks in weight is developed in view of shock influence of elements of a rotor and moving of weight on knife at ist movement. Analytical dependences for definition of key parameters of work of working body, a crusher-grinder are established depending on parameters of its work.

Key words: crusher-grinder, a rotor, a knives, submitting a tray, splitting, rough forages, corn, stew, Lucerne, qualities of crushing, frequency of rotation of a rotor, submission of stem weight.


Animal husbandry in Uzbekistan is one of the most important branches of agriculture. Therefore, by the Government of the Republic much attention is paid to animal husbandry development on State Programme for developing animal husbandry, basis of which is the creation of small cattle-breeding, farming and peasantry with a small amount of animals. At the moment, there are many farms in the Republic with a small number of large horned cattle. They mostly use rough fodder.
The development of small farms and livestock and peasantry farms are closely connected with preparation of high quality fodder at few material expenses. Practice of such kind of farms showed, that unsatisfactory processing of rough fodder stalks by fodder preparation machinery bring to quality decline of got fodder and accordingly to the increase of its loss (to 30 %).

Essential decrease of exploitation expenses and the quality increase of fodder from rough stalks of fodder culture possibly at combining operations of grinding and cutting in fodder preparation machines, as the grinding and cutting of plants bring to the improvement of their fodder quality, decline of loss and economy of material remedies [1].

That’s, why the investigations, directed to develop the scheme and defining angle bent of blade of the cone shaped working body of mini-grinder for rough fodder (fig.1), and also studied the speed, exertion, work and capacity of cutting the stalks.

The grinder consists of a submitting tray 1, a casing 2, a rotor 3 with disks for fixing of knifes 4. The loads 5 are set to knives for providing rotor balancing. The grinder has a support 6. Diagrams of cutting process of a stalk is given below.

With the aim of providing qualified work of the grinder without vibration is necessary of defining some parameters of its working bodies.

At this the calculations on defining parameters of cone shaped working organ of mini-grinder is given with using main conditions of theoretical analyses [2,3].

Fig. 1. Diagram of a mini-grinder for roughage:
1-tray; 2-casing; 3-shaft with a disk rotor; 4-knife; 5-lead; 6-support; 7-rotor; 8-stalk.

As the working body of a grinder is cone-shaped, its diameter will be defined proceeding from the following correlation.

\[ D_1 < D_2 < D_3 < ... < D_i \]  \hspace{1cm} (1)

where \( D_1, D_2, D_3, ..., D_i \) - diameters of working body is measured by a final part of the knife rotating with balanced loads, mm.

For prevention of an imbalance of working body should observe a condition

\[ m_1 > m_2 > m_3 \ldots > m_i \]  \hspace{1cm} (2)

where \( m_1, m_2, m_3 \ldots m_i \) - masses of the load of balancing knife, kg.

![Diagram of a mini-grinder for roughage:](image)

1-tray; 2-casing; 3-shaft with a disk rotor; 4-knife; 5-lead; 6-support; 7-rotor; 8-stalk.

As it is known, the speed of knife rotation, and consequently its capacity, can reduce considerably, having provided sliding cutting in the chopping moment of stalks for rough fodder [4].

As the stalk sliding on an edge at the moment of recutting is substantially caused by a corner (\( \alpha_s \)) a stalk inclination concerning a knife blade, which is provided with the help of submitting tray of a grinder when handling the stalks to a knife.

Centrifugal power influences a stalk

\[ P = \frac{mV^2}{R} \]  \hspace{1cm} (3)

where \( m \) - mass of a cut-off part of the stalk, given to the plane of a cut, gr.;

\( V \) - encircled speed of a stalk in the plane of a cut, m/s;

\( R \) - distance from a stalk axis to an axis of rotation of working body, m.

Using the theorem of cosines, and we find

\[ R = \sqrt{R_r^2 + \frac{d_{st}^2}{4}} \cos^2 \alpha_n - R_p d_{st} \cos \alpha_n \cos \beta_s, \]  \hspace{1cm} (4)

where \( R_r \) - radius of a rotor, mm;

\( d_{st} \) - diameter of a stalk, mm;

\( \beta_s \) - corner of a stalk submission, degree.

So we find radius of the rotor

\[ R_r = 0.5D_i - lH, \]  \hspace{1cm} (5)

where \( lH \) - i-of that length of the knife, mm.
After substitution (4) to a formula (3) we will receive

\[ P = \frac{mV^2}{\sqrt{R_r^2 + \frac{d_y^2}{4}\cos^2\alpha_n - R_r d_y \cos\alpha_n \cos\beta_s}} \]  \hspace{1cm} (6)

so, force of inertia

\[ T = ma , \]  \hspace{1cm} (7)

where, \( a \) - circle component of stalk acceleration in the plane of a cut, \( \text{m/s}^2 \).

On the accepted assumption

\[ a = \frac{V}{\Delta t} \]  \hspace{1cm} (8)

where, \( \Delta t \)-time, for which the stalk gets speed of \( V \) during a cut, \( \text{c.} \)

At this stalk sliding on a knife blade interfere force of a friction

\[ F = fN, \]  \hspace{1cm} (9)

where \( f \) - factor of a friction of a stalk on an edge;

\( N \)-normal pressure of a stalk upon an edge, \( \text{n.} \)

As at big encircled speeds of a knife bending of a stalk is insignificant, its elastic resistance is also insignificant, and we will not consider it.

Then, according to above given assumption, we will determine a condition of stalk sliding along a knife blade. In this case, the sum of projections of all powers, effecting the stalks cutting, should be more than the power of a friction.

For an edge with an inclination to the back, this condition is described by an inequality

\[ \frac{mV}{\Delta t} \sin\beta_s + \frac{2mV^2}{\sqrt{4R_r^2 + d_y^2\cos^2\alpha_n - 4R_r d_y \cos\alpha_n \cos\beta_s}} > f \left( \frac{mV}{\Delta t} \cos\beta_s - \frac{2mV^2}{\sqrt{4R_r^2 + d_y^2\cos^2\alpha_n - 4R_r d_y \cos\alpha_n \cos\beta_s}} \right) \]  \hspace{1cm} (10)

After transformations we’ll get

\[ \frac{1}{4}d_y^2 \cos^2\alpha_n - R_r d_y \cos\beta_s \cos\alpha_n + R_r^2 - \Delta t^2 V^2 \sec(\beta_s - \phi) < 0 \]  \hspace{1cm} (11)

We designate \( \Delta x_1 = tV \) as stalk moving in the course of cutting.

Then, solving the inequality (11) consequently \( \beta_s \), we will achieve:

\[ \beta_s < \phi - \arccos \left( \frac{d_y^2 \cos^2\alpha_n - 4R_r d_y \cos\beta_s \cos\alpha_n + 4R_r^2}{2x_i} \right) \]  \hspace{1cm} (12)
On the basis of above given experimental studies (figure 2), that with the increase of cutting speed from 15 m/s to 19 m/s and diameter of stalks from 4mm to 16mm at regular submission speed of stalks, exertion of cutting decreases by hyperbolic types from 89,4 N to 85,5 N, as well as the cutting job increases to a straight line forms in the cutting speed from 4,79 N.m to 5,93 N.m on diameter of stalks from 5,14 N.m to 6,10 N.m.

This is explained with that, at crossing of the curves determine the optimal value of parameters of that cutting speed of 16,6 m/s , diameter of stalks 7…10mm, cutting exertion 85,2 n, and the work 5,25 n.m.

![Figure 2](image)

The change of exertion $P_{cut}$ and the work $A_{cut}$ cutting depending on the circle speed $V_o$ and diameter $d_{stalk}$ stalks.

As well as the cutting work of the knife depends on the geometry of cutting edge, which depends on the thickness, sharpening angle and sharpness of the blade. Research results are indentified by tenzonometric method (table)

<table>
<thead>
<tr>
<th>Parameters of the knife, mm</th>
<th>Of work cutting, n.m</th>
</tr>
</thead>
<tbody>
<tr>
<td>The thickness, mm</td>
<td>2,69 / 2* 3,03 / 3</td>
</tr>
<tr>
<td>The captivity angle of the knife, degree</td>
<td>5,54 / 11</td>
</tr>
<tr>
<td>The blade sharpness, mkm</td>
<td>6,75 / 25</td>
</tr>
</tbody>
</table>

*)Note: in numerator – the cutting work;
In denominator – geometry of the knife.
It is seen from the table 2, that with the increase of the knife thickness from 2mm to 6 mm, the sharpening angle of the knife from 11 degrees to 19 degrees and the sharpness of the knife from 25 mkm to 225 mkm the cutting work increases accordingly to 63%, 81% and 75.3%.

So, with the increase of value of the parameters of the knife the cutting work also increases in average 73.1%.

The results of studies on defining consuming the capacity of mini grinder to the cut of stalks depending from the length of the knife is cited in the fig.3, that with the increase of the knife length from 80 mm to 120 mm decrease the consuming capacity to 11.3%, i.e., their curved depending has hyperbolic view.

Also, with the increase of angle bent of the knife edge from 22 degree to 54 degree the consuming capacity is increased to 3.9 %, i.e., their depending will have line character.

![Figure 3. Depending the consuming N capacity of mini-grinder on lh length and βh angle bent of the blade.](image)

So, on the basis of expression (5) and (12) theoretical data are compared with experimental, and difference between them don’t exceed 5%.

Based on conducted researches it is possible to make the following summaries:
- there defined dependence of angle bent of the knife blade (βh) from different factors of stalk cutting process, i.e., at the following calculations: R₁ = 130...190mm, x₁ = 0.5...2mm, α₁ = 0...20°, φ = 24...30°, dh = 4...16 mm and β₁ = 0...48°.
- at circle speed till 18 m/s is observed the noticeable decrease of cutting exertion, but its further increase bring it to smooth over the difference of exertion;
- with the increase of circle speed of cutting at regular speed of handling stalks the activity of cutting edge of the knife, and smoothing action of cutting edge is increased, i.e. the general work, spent to the cut, is decreased in the account of increasing the cutting time about 1,7...4,7·10⁻³ s, but the optimal speed of knife cutting is equal to 17...19 m/s.

References:

2. Каримов Р.Р., Иманов Б.Б., Каримов Ё.З., Абдулов М.Р. К исследованию конусообразного рабочего органа мини-измельчителя грубых кормов. // "Вестник ТашГТУ" журнал, №3, 2013, - P.123-126.
5. Каримов Р.Р., Тураев Б.Б., Тулганов А.А., Авазов Д.Ж. Определение усилия резания стебельчатых кормов. //"Проблемы механики" журнал, Ташкент, № 4, 2010, -P.42-44.