THEORETICAL STUDY OF THE INTERACTION AND DISTRIBUTION OF SHORTED STEM PIECES WITH THE KNIFE IN A FOOD GRINDING DEVICE

[1] Borotov Atkham
[2] Baimakhanov Kenzhemirza
[1] National research university "Tashkent institute of irrigation and agricultural mechanization engineers" (Uzbekistan).
[2] Associate Professor of the Department of Water Resources, Land using and Agrotechnology, M.Auezov South Kazakhstan State University (Kazakhstan).
*E-mail: atxamborotov@mail.ru
https://doi.org/10.5281/zenodo.8194795

Abstract. The article presents data and a conclusion on the study of blade interaction and flaking of cut stem pieces of a blue stem forage chopper. The time change of the speed of movement of the cut stem piece along the blade under its influence when the radius of the drum is 75, 100, 125 and 150 mm shows that the speed of the stem pieces constantly increases during its movement along the blade towards its upper part and 4.5-6 from the upper part of the blade It shoots out with a speed of m/s.

Introduction. Achieving good results in livestock, fisheries and poultry feeding depends on the type and quality of feed provided to them. Animal feed, concentrated feed and additional feed are used in livestock, fishery and poultry feeding. In Uzbekistan, maize, wheat, sorghum and legumes are grown, and sorghum and maize grains are widely used as bran and bran concentrate feed [1; 2; 3; 4].

Excessive consumption of concentrated feed for livestock, fisheries and poultry leads to increased body fat. Among the above-mentioned feeds, the use of blue feed helps to prevent the accumulation of fat in the body of fish and poultry and promotes rapid growth and development. Blue stalk feeds come from a variety of plants, including corn stalks, cane, alfalfa, legumes, and more. In order to provide livestock, fisheries and poultry feed with blue stems, it is necessary to grind them. Taking into account the above, the analysis of today's existing devices [5; 6; 7] research and development work was carried out to create a small and compact blue stem feed grinder. As a result of research and experiments, a feed grinding device for livestock, fisheries and poultry was developed. Using the knives installed in the developed device, the ejection of crushed feed was studied by means of a theoretical experiment.

After the stalks are trimmed with the chopper drum blade, the stalk pieces are thrown out with the blade. In this case, the cut stem pieces interact with the blade and move in two stages, i.e. (Fig. 1):

1) the movement of stem pieces after cutting from the end of the blade to the end (Fig. 1, a);
2) the movement and shaking of stem pieces from the end of the blade to the tip (Fig. 1, b).

The following forces act on the blade end-to-end movement of stem pieces after cutting, and its equation of motion is as follows

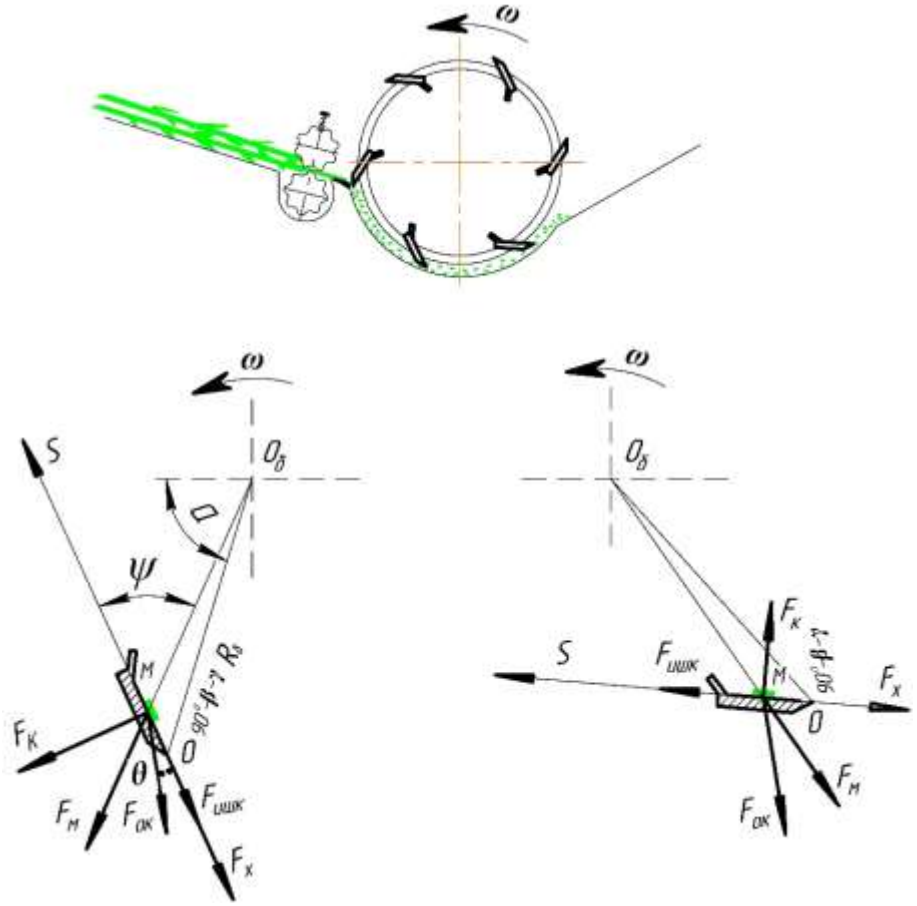
$$m\ddot{s} = -F_x - F_м \cos\psi - F_{о.к.} \cos\theta - F_{ишк}, \qquad (1)$$

where F_x is aerodynamic resistance force, N;

F_m - centrifugal force, N;

F_{ishq} - force of friction, N;

$f_{o.k.}$ – force of gravity, N.



a) b)

Figure 1. The grinder interacted with the drum blade diagram of the forces acting on the stem piece

we take into account the friction force $F_{ишк} = f(F_к + F_{о.к}\sin\theta + F_м\sin\psi)$, coriolis force $F_к = 2m\omega\dot{s}$, aerodynamic force $F_x = mk_n(\dot{s}+V_x)^2$, centrifugal force $F_м = m\omega^2 O_б M$, gravity force , $F_{о.к.} = mg$ then the equation of movement of the stem pieces from the end of the blade to the end after shearing is as follows

$$\ddot{s} = -k_n(\dot{s}+V_x)^2 - \omega^2 O_б M\cos\psi - g\cos\theta - f(2\omega\dot{s} + g\sin\theta + \omega^2 O_б M\sin\psi), \quad (2)$$

in this $\ddot{S}$ - acceleration of the stem, m/s ^{2};

k_n – smoothness coefficient, m $^{-1}$;

ψ – the angle between the current radius direction and the S axis, degrees;

θ – deviation of the S axis relative to the vertical, degrees;

The movement of the stem pieces from the blade end to its tip is seen in two different cases, and their equation is:

- the speed of the stem piece is less than or equal to the speed of the air, i.e. $|\dot{s}| \le V_в$ when

$$m\ddot{s} = F_{иик} - F_x - F_м \cos\psi - F_{о.к.} \cos\theta\,, \qquad (3)$$

For expression (3), the last state of expression (2) is the initial condition.

- the speed of the stem piece is greater than the speed of the air, i.e. $|\dot{s}| > V_в$ when

$$m\ddot{s} = F_{иик} + F_x - F_м \cos\psi - F_{о.к.} \cos\theta\,, \qquad (4)$$

where it is considered as frictional force $F_{иик} = f(F_{о.к} \sin\theta + F_м \sin\psi - F_к)$.

Then the equation of movement of the stem pieces from the end of the blade to its tip after cutting will have the following form:

- the speed of the stem piece is less than or equal to the speed of the air, i.e. when

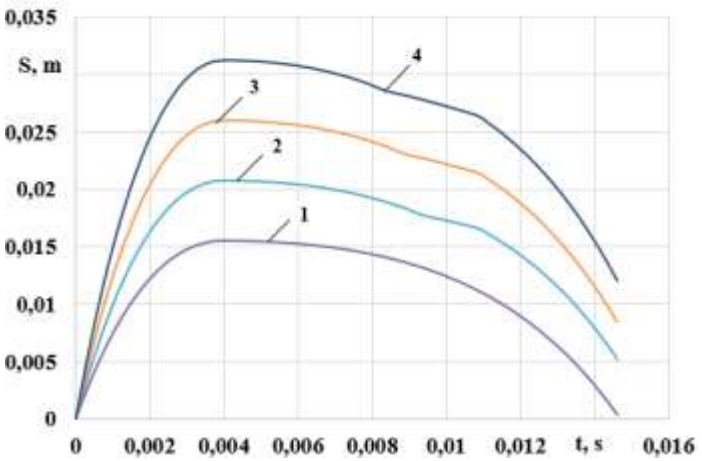
$$|\dot{s}| \le V_в \quad \ddot{s} = f\left(2\omega\dot{s} + g\sin\theta + \omega^2 O_б M \sin\psi\right) - k_n\left(\dot{s} + V_x\right)^2 - \omega^2 O_б M\cos\psi - g\cos\theta\,. \qquad (5)$$

- the speed of the stem piece is greater than the speed of the air, i.e. $|\dot{s}| > V_в$ when

$$\ddot{s} = f\left(2\omega\dot{s} + g\sin\theta + \omega^2 O_б M \sin\psi\right) + k_n\left(\dot{s} + V_x\right)^2 - \omega^2 O_б M\cos\psi - g\cos\theta\,. \qquad (6)$$

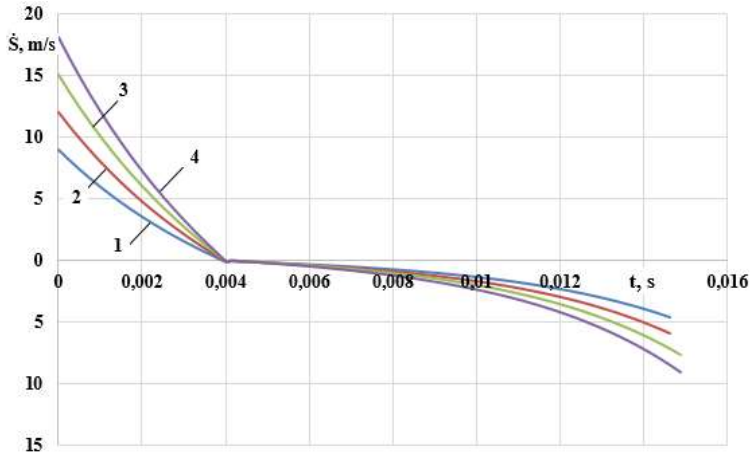
Expressions (2), (5) and (6) express the relationship between the quantities affecting the movement of the stem piece along the blade and the shaking from the blade as a result of the interaction of the chopped stem pieces with the chopper drum blades.

The analysis of the expressions (2), (5) and (6) shows that the movement of the pieces of the product to be crushed inside the grinder mainly depends on the radius and speed of the drum.



The radius of the 1st drum is 75 mm; The radius of the 2nd drum is 100 mm;
The radius of the 3rd drum is 125 mm; The radius of the 4th drum is 150 mm

Figure 2. The movement of the stem piece along the blade change over time



The radius of the 1st drum is 75 mm; The radius of the 2nd drum is 100 mm;
The radius of the 3rd drum is 125 mm; The radius of the 4th drum is 150 mm

Figure 3. Variation of the speed of the stem piece moving along the blade over time

Using the above expressions, the displacement and velocity changes of the sheared stem pieces during their movement along the blade were calculated, and the results were graphically depicted in Figures 2 and 3.

Conclusions. The time change of the speed of movement of the cut stem piece along the blade under its influence when the radius of the drum is 75, 100, 125 and 150 mm shows that the speed of the stem pieces constantly increases during its movement along the blade towards its upper part and 4.5-6 from the upper part of the blade It shoots out with a speed of m/s.

References:

[1]Borotov A 2020 IOP Conference Series: Materials Science and Engineering 883 012160
[2]Borotov A Research the parameters of cutter bar of the rotor of a green stalk forage chopper. IOP Conference Series: Earth and Environmental Science this link is disabled , 2022, 1076 (1), 012027
[3]Sadri H, Ghorbani GR, Alikhani M, Babaei M, Nikkhah A Ground, dry-rolled and steam-processed barley grain for midlactation Holstein cows. 2007 Animal Feed Science and Technology 195-204
[4] Zhang M, Sword ML, Buckmaster DR 2003 Transactions of the ASAE 46 (6) 1503-1511
[5]Borotov, A. , Choriev, R. , Boykulov, U. , Khatamov, A. A theoretical method of the reception of blue stem feed by the feeders and transfer to the grinding drum. E3S Web of Conferences , 2023, 390, 04038
[6]Ball MA, Shaver RD, Jirovec AG, Shinners KJ and Coors JG 2000 Article in Journal of Dairy Science 6(83) 1264-1273
[7] Yascheritsyn PI, Feldshtein EE and Kornievich MA Minsk: New knowledge
2006 5-20