DOI: 10.63550/ICEIP.2025.36.70.004

Assessment and Analysis of the Stress State of a Cantilified Curved Stem to Reduce Cutting Work

D. Alijanov[1][a], B. Shaymardanov[1][b], Sh. Abdurokhmonov[1][c], N. Umirov[1][d], F. Karshiyev[2][e] and A. Tulayev[3][f]

[1]National Research University Tashkent Institute of Irrigation and Agriculture Mechanization Engineers. Republic of Uzbekistan

[2]Termez State University. Termez. Republic of Uzbekistan.

[3]Samarkand State University of Veterinary Medicine. Livestock and Biotechnology. Samarkand. Republic of Uzbekistan

abduroxmonov.shavkatjon@bk.ru

Keywords: bending, cutting, knife, stem, tension, deformation force, stretching.

Abstract: The article is devoted to the issues of equalizing the state of a cantilevered rod of rectangular cross-section, which makes it possible to determine the amount of bend to ensure the cutting process with a knife without disturbing the elastic properties of the material, comparison of the numerical values of these quantities with the critical values of tensile and crushing stresses for a specific material will make it possible to determine the conditions for the implementation of the cutting process within the limits of elastic deformations, as well as by estimating the energy intensity of the process of cutting a rod of a rectangular cross-section with a knife and obtaining the dependences of the change in cutting force, effort on the knife when cutting a pre-bent stem into different sizes. Based on the obtained dependences of the change in cutting force, the forces on the knife when cutting a pre-bent stem into different sizes, a computational program was compiled that can be used to search for optimal control of the bend $f=\varphi(t)$, ensuring cutting of the stem within the limits of elastic properties, that is. without ruptures and crushing of the fiber during the movement of the knife. The results of experimental studies carried out in laboratory conditions are also presented. Results of experimental studies, prove the correctness of the results of theoretical research, i.e. cutting with a bend of the stem significantly reduces the cutting work in comparison with cutting. The use of preliminary bending when cutting curved material reduces the cutting work compared to the cutting work of 201.12 N cm. compared to cutting 290 N cm. and reduces the cutting performance by 35.05%.

[a] https://orcid.org/0009-0007-6362-6376
[b] https://orcid.org/0000-0001-7733-9721
[c] https://orcid.org/0000-0003-4069-074X
[d] https://orcid.org/0009-0006-0568-6576
[e] https://orcid.org/0009-0003-3067-7418
[f] https://orcid.org/0009-0003-0849-3858

DOI: 10.63550/ICEIP.2025.36.70.004

1 INTRODUCTION

Features of the architectonics of plant raw materials. pronounced anisotropic properties, the presence of intercellular moisture, nonlinearity of strength characteristics and their dependence on high-speed loading conditions determine the complexity of describing deformation processes.

A large number of works with basic experimental plans are devoted to the study of the physical and mechanical properties of agricultural materials. Fundamental works include Goryachkina V.P., Zheligovsky V.A., Rebinder P.A., Gutyar E.M., Reznik N.E., Bosogo E.S., Melnikova S.V., Kukty G.M., Leontyeva P.I., Rumpf G., Sablikova M.V., Bremera. G.I., McRandal. D., Bakhareva G.F., Demidova A.R. Eliseeva V.A., Sakharova V.V., Aleshkina V.R., Alizhanova D. et al.

There are a large number of works devoted to particular issues of deformation and strength characteristics of agricultural materials, various methods and processes of cutting, crushing. pressing. etc. Their distinctive feature is that they were performed in relation to a pre-selected working body and method of processing the material. The direction of modeling the processes of deformation and destruction of materials is very promising.

When cutting with a blade. the material is destroyed mainly under the influence of pressure directly from the very top of the dihedral angle of the working part of the knife. called the blade. The working process of cutting a bunch or layer of stems with a knife consists of two stages: preliminary compaction and the actual cutting of the material.

The disadvantages of the known cutting method are the large magnitude of working forces and the energy intensity of the cutting process due to the significant magnitude of the destructive stress on the knife blade and the forces of compression of the knife edges by the material.

The proposed cutting method is carried out as follows. A bending force is applied to the free end of the stem using a bending plate moving with the knife at the same speed. As a result, the stem bends and the upper fibers on the knife side become stretched. The knife is inserted into the body of the stem and it is cut.

The effect of reducing the force P_{cr} and cutting work is achieved by reducing the forces on the blade and knife edges. This position is confirmed by analyzing the well-known formula of N.E. Reznik [5]:

$$P_{cr} = dG_r + \frac{Eh_{pr}^2}{2h}[tg\beta + f sin^2\beta + \mu(f + cos^2\beta)].$$

where P_{cr} is the critical cutting force;

d - blade sharpness;

h - thickness of the material being cut;

h_{pr} – thickness of the layer compressed by the blade before the start of cutting;

β – blade sharpening angle;

E – elastic modulus;

f – coefficient of friction of the material on the blades;

μ – Poisson's ratio.

From the formula it is clear that G_r for our case will consist of two parts:

$$G_r = G_r^1 + \Delta G$$

where G_r^1 is the stress of the stretched fiber during bending;

ΔG – residual stress for fracture on the sharp edge of the knife.

The second part of the formula represents the forces arising on the edges of the knife as a result of deformation of the material and the resulting friction forces. In our case. deformation of the material leads to a decrease in h_{pr}.

2 PUTTING THE ISSUE

2.1 Assessing the condition of a cantilevered stem for lighting work

It is known [24] that the work of cutting stem forage crops is reduced if the stem is pre-bent and the knife is inserted from the side of the stretched fiber. However, the difference in the elastic properties of the stem under tension and compression leads to a displacement of the neutral 2-2 axis relative to the central one by the amount Z_0 (Fig. 1). which in turn leads to a difference in the moments of inertia and maximum stresses of the stretched and compressed fiber.

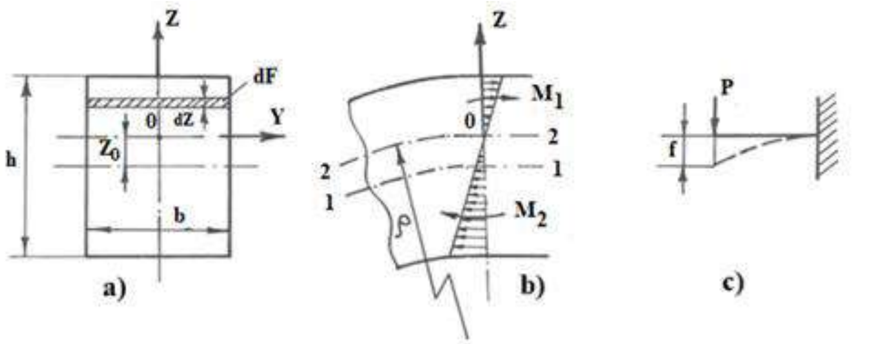


Figure 1: To determine the characteristics of the stressed state of a cantilevered rod at different elastic moduli in tension (*E1*) and compression (*E2*).

The displacement of the neutral axis Z_0 can be found from the condition of equality of the total forces of tension and compression. Since the strength $P = \sigma \cdot F$, and $\sigma = \frac{E \cdot z}{\rho}$ where σ- is tension, *F*-cross-sectional area, *E* – elastic modulus, *ρ* – radii of curvature along the neutral axis. then the elementary force $dp = \frac{E \cdot z}{\rho}$

From Fig. 1 for a rectangular section, we have $dF=b \cdot dz$. As a result, we obtain for the upper section:

$$P_1 = b\frac{E_1}{\rho}\int_0^{\left(\frac{h}{2}-z_0\right)} z dz = \frac{b \cdot E_1}{2\rho}\left(\frac{h}{2} - z_0\right)^2; \quad (1)$$

for lower section

$$P_2 = b\frac{E_2}{\rho}\int_0^{-\left(\frac{h}{2}+z_0\right)} z dz = \frac{b \cdot E_2}{2\rho}\left(\frac{h}{2} + z_0\right)^2. \quad (2)$$

From the condition P1=P2 it turns out:

$$z_0 = \frac{h\left(\sqrt{E_1}-\sqrt{E_2}\right)}{2\left(\sqrt{E_1}+\sqrt{E_2}\right)}. \quad (3)$$

From this equation it is clear that the displacement of the neutral axis Z_0 during bending depends on the height of the rod *h* (linearly and tensile elastic moduli E_1 and compression E_2 and does not depend on the bending moment. At $E_1<E_2$ Z_0 has a positive value, and the neutral axis shifts upward.

Moments of inertia of sections:

$$J_1 = b\int_0^{\left(\frac{h}{2}-z_0\right)} z^2 dz = \frac{b}{3}\left(\frac{h}{2} - z_0\right)^3; \quad (4)$$

$$J_2 = b\int_0^{-\left(\frac{h}{2}+z_0\right)} z^2 dz = \frac{b}{3}\left(\frac{h}{2} + z_0\right)^3. \quad (5)$$

Bending moment in the shear plane:

$$M = P \cdot l = M_1 + M_2. \quad (6)$$

where *P*- is the bending force under a cantilever load;

l-console length (cutting length);

M_1 and M_2 – bending moments in the upper and lower parts of the sections:

$$M_1 = \frac{P \cdot l}{h}\left(\frac{h}{2} - z_0\right); \quad (7)$$

$$M_2 = \frac{P \cdot l}{h}\left(\frac{h}{2} + z_0\right). \quad (8)$$

Since during the cutting process bend the character with the bend arrow *f*, which can be constant or variable, then the bending force will be variable even at *f*-const:

$$P = \frac{3f(E_1 J_1 + E_2 J_2)}{l^3}. \quad (9)$$

Tensile and compressive stress can be determined by the formulas:

$$\sigma = \frac{E \cdot z}{\rho} \text{ where } \rho = \frac{E_1 \cdot J_1 + E_2 J_2}{M} \quad (10)$$

or by formula

$$\sigma = \frac{M \cdot z}{J}. \quad (11)$$

Using the last expression, we obtain the maximum voltage values:
for upper section

$$max\, \sigma_1 = \frac{M_1\left(\frac{h}{2}-z_0\right)}{J_1}; \quad (12)$$

for lower section

$$max\, \sigma_2 = \frac{M_2\left(\frac{h}{2}+z_0\right)}{J_2}. \quad (13)$$

Comparison of the numerical values of these quantities with the critical values of tensile and crushing stresses for a specific material will make it possible to determine the condition for the implementation of the cutting process within the limits of elastic deformations.

2.2 Assessment of the energy intensity of the cutting process

This work is a continuation of work 2.1 and is aimed at assessing the energy intensity of the cutting process.

First of all. let us estimate the maximum work of cutting a rod of rectangular cross-section with a knife moving at a low speed. which allows us to consider the process as static.

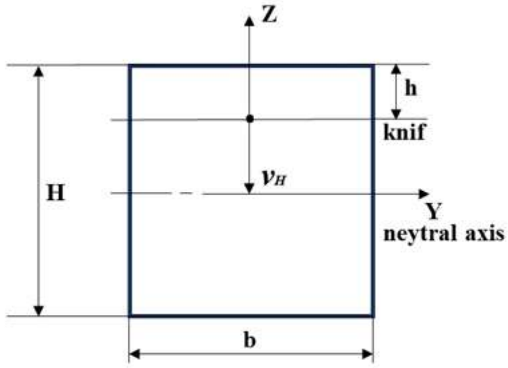


Figure 2: To determine the maximum cutting work.

In accordance with [5], we accept the elastic modulus E = 3300 N/cm^2 and the breaking stress during fiber tensile σ_{max} = 1450 N/cm^2, which corresponds to corn stalks. Taking H=5 cm. b=4 cm. blade thickness σ=100 mk. we obtain the maximum possible cutting work

$$A_{max} = b \cdot H \cdot \delta \cdot \sigma_{max} = 2.9\ J. \tag{14}$$

If you perform a cantilever bend of the rod relative to the cut plane, then a tensile stress σ_p arises in the upper fiber, which reduces the stress on the knife blade required for destruction (Fig. 3).

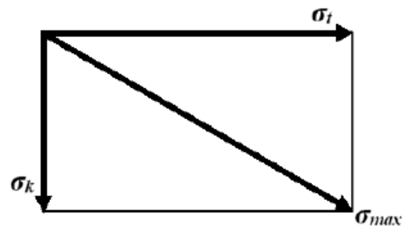


Figure 3: To determine the voltage on the knife blade σH necessary to destroy the fiber.

$$\sigma_k = \sqrt{\sigma_{max}^2 - \sigma_r^2}. \tag{15}$$

If at the beginning of cutting we apply the maximum deflection of the rod

$$f_{max} = \frac{P_{pun} \cdot l^3}{3EJ}. \tag{16}$$

where P_{pun} is the bending force applied at the end of the console with its length l, which provides stress σ_{max} in the outer fiber;
E – elastic modulus.

$$P_{pun} = \frac{\sigma_{max} \cdot J}{l \cdot z}. \tag{17}$$

here $z = \frac{H}{2}$ is the distance from the neutral axis OY to the outer fiber;

$J = \frac{bH^3}{12}$ - moment of inertia of the section.

If you do not change the bend value during the cutting process, i.e. take f_{max}=*const*. then from (16) and (17) we get

$$\sigma_P = \frac{3 \cdot f_{max} \cdot E \cdot z'}{l^2} \tag{18}$$

here $z' = \frac{H-h}{2}$, h is the depth of the knife blade into the body of the rod. E is the elastic modulus that is the same for stretched and compressed fiber. From (5.5) it is clear that in the case of cutting at f_{max}=*const*, the tension of the upper stretched fiber changes linearly as a function of the knife depth h, and changes from σ_t=σ_{max} to σ_t=*0*. However, from (5.2) it is clear that σ the stress on the knife blade σ_H is nonlinear with respect to h and varies from 0 - at the beginning of the cutting process to σ_{max} - at the end of the process.

Knife blade force

$$P_k = b \cdot \delta \cdot \sigma_k$$

and the cutting work accordingly

$$A_k = \int_0^H P_p dh. \tag{19}$$

3 RESULTS AND DISCUSSION

3.1 Implementation and discussions outlined above in paragraph 2.1. Assessment of the stress state of a cantilevered stem to reduce cutting work

Based on the above, we have compiled a computational program, the numerical implementation of which was obtained on a desktop computer in the MatLAB environment [25]:

$b = 4; e1 = 3500; e2 = 500; l = 10; p0 = 50;$

$h = (1{:}\,0.1{:}\,10);$

$a = \left(e1.^{\left(\frac{1}{2}\right)} - e2.\,^\wedge{\left(\frac{1}{2}\right)}\right);$

$c = \left(e1.^{\left(\frac{1}{2}\right)} + e2.\,^\wedge{\left(\frac{1}{2}\right)}\right);$

$z0 = (0.5 * h.* a)/c;$

$j1 = \left(\frac{b}{3}\right) * (0.5 * h - z0).^3;$

$j2 = \left(\frac{b}{3}\right) * (0.5 * h + z0).^3;$

$f0 = 0.3798;$

$P = \big(3 * 0.398 * (e1 * j1 + e2 * j2)\big)/(1.\hat{}3);$

$S1 = (3 * \rho * 1.)/\big(b * h.* (0.5 * h - z0)\big);$

$S2 = (3 * \rho * 1.)./\big(b * h.* (0.5 * h + z0)\big);$

$plot(S1.h.S2.h).grad$

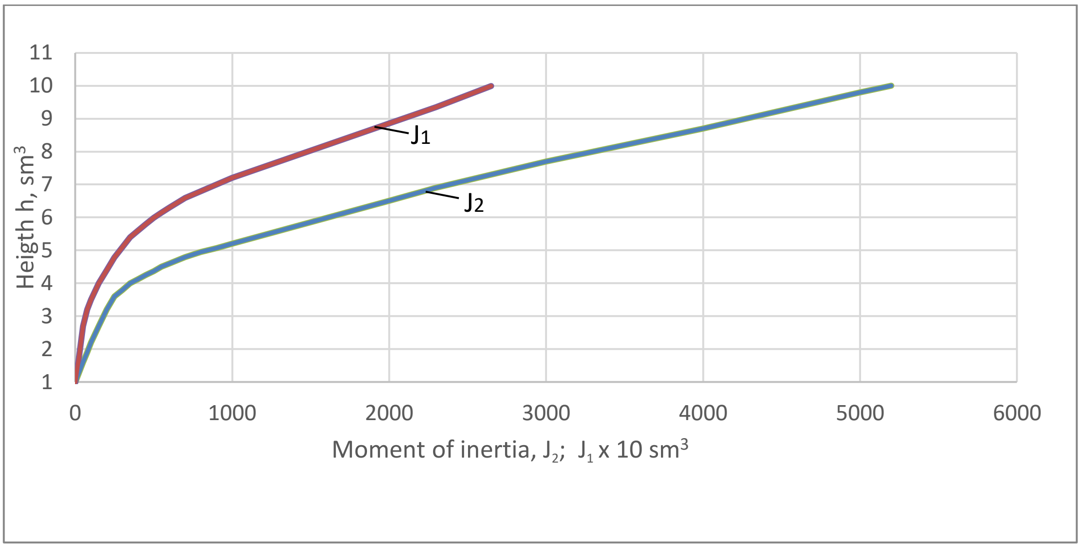


Figure 4: Change in the moments of inertia of sections at different heights and widths b=4 elastic moduli E_1=3500 N/cm^2. E_2=500 N/cm^2.

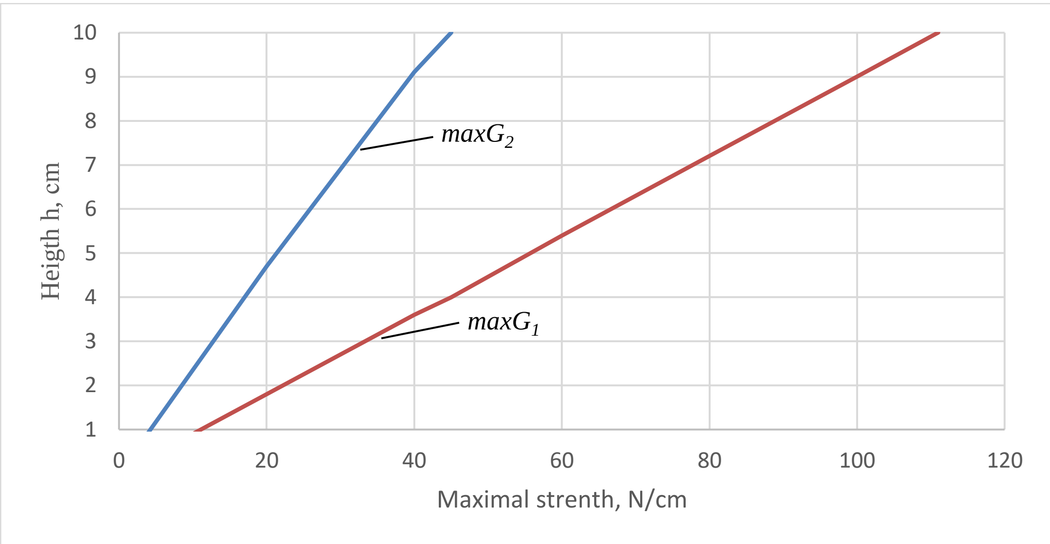


Figure 5: Maximum tensile $\boldsymbol{max\,\sigma_1}$ and compressive stresses $\boldsymbol{max\,\sigma_2}$ at different heights h.

Figures 4 and 5 show the calculation results for a cantilever beam with and at width $E_1=3500$ *N/cm*^{2} and $E_2=500$ *N/cm*^{2} constant deflection.

When the knife is at a height of 5 cm $M=500$ *N cm*, $M_1=137.5$ *N cm*, $M_1=360.285$ *N cm*, $J_1=3.4285$ *cm*^{4}, $J_1=63.6572$ *cm*^{4} and $max\sigma_1=54.737$ *N/cm*^{2}, $max\sigma_2=20.688$ *N/cm*^{2}. At breaking stress $\sigma_1=1450$ *N/cm*^{2} *for a corn stalk [5], fiber rupture in the upper section will not occur.*

The linear nature of the stresses (Fig. 3) is explained by the linear nature of the relative deformation we accepted (Fig. 1. b). The computer program can be used to search for optimal control of the bend $f= \varphi(t)$ which ensures cutting of the stem within the limits of elastic properties, that is, without tearing or crushing the fiber during the movement of the knife.

3.2 Implementation and discussions outlined above in paragraph 2.2. Assessment of the energy intensity of the cutting process

Below we present a computational rule implemented on the FDA in the MATLAB system [25] to study the influence of the stem bend on the cutting work:

$\gg b = 4; H = 5; S_m = 1450; d = 0.01; E = 3300; h = (0{:}0.5{:}5); L = 10;$

$\gg I = b * (H.\hat{}3)/12; \gg P_{om} = S_m * 2 * I/(L * H);$

$\gg F_m = P_{om} * (L.\hat{}3)/(3 * E * I);$

$\gg Z1 = (H - h)/2;$

$\gg S_P = 3 * F_m * E * z1/(L.\hat{}2);$

$\gg S_n = \left((S_{m.}\hat{}2) - (S_{P.}\hat{}2)\right).\hat{}0.5;$

$\gg P_P = b * d * S_n;$

$\gg A1 = 0.5 * P_P;$

$\gg sum(A1)$

ans = 239.5776

In Fig.6. shows the change in cutting force on the knife blade as it moves from the moment of contact with the stem until the end of the cut. At the beginning of cutting at maximum bending and $\sigma_c=\sigma_{max}$ in the upper fiber of the stem, the force on the knife is $P_k=0$, and at the end of the cutting, the stress in the stretched fiber is $\sigma_p=0$ and $P_H=58\ N$. The nonlinear nature of the change in curve (2) is explained by a decrease in voltage σ_{max}. Straight line (1) characterizes the constancy of the cutting force $P_H=58\ N$, because to destroy the fiber on the knife blade, it is necessary to create a tension $\sigma_{max}=1450\ N/cm^2$.

Figure 7 shows the nature of the change in force on the knife of a pre-bent stem by different amounts. It can be seen that as the bend decreases, the cutting force on the knife increases, which inevitably leads to an increase in the cutting work accordingly.

Table 1. shows the results of calculations of the cutting work A, tensile stress σ_p of the upper fiber, and stress on the knife blade $\sigma_{H.}$ which is necessary to destroy the fiber. The calculation was carried out for two cases:

1-when cutting a stem with an initial bend $f_{max}=const$, providing an initial stress σ_{max}, i.e. the beginning of cutting with a force on the knife $P_H=0$;

2-when cutting with a bend $f=f_{max}+h$, i.e. the bend is first made by f_{max}, and then increases in accordance with the movement of the knife. In the first case, cutting work $A_1=239.5776\ N\ cm$, in the second $A_2=201.1229\ N\ cm$, which reduces cutting work compared to cutting $A_{max}=290\ N\ cm$ (2.9 J) by 22.39% and 35.65%, respectively.

Theoretically, it is possible to achieve cutting work A_H tending to zero if at each position of the knife h the tension of the stretched fiber is $\sigma_{max}=\sigma_P$. In this case

$$f = \frac{\sigma_{max} \cdot l^2}{3 \cdot E \cdot z'}.$$

where $z' = \frac{H-h}{2}$ is the distance from the neutral axis to the maximum stretched fiber.

In table 1. the last line shows the results of f for each step of moving the knife. If we subtract the value of the previous f_{i-1} from each subsequent f_i. we obtain the increment vector Δf, which determines the theoretical control law for the example under consideration:

$$\Delta f = [0; 0.640; 0.814; 1.066; 1.390; 1.950; 2.93; 4.850; 9.760; 29.230;\ \infty]$$

Full implementation of such control of the bend arm f is, of course, impossible. The technical implementation of controlling even part of Δf is difficult. Therefore, the result obtained in a specific example has rather theoretical significance.

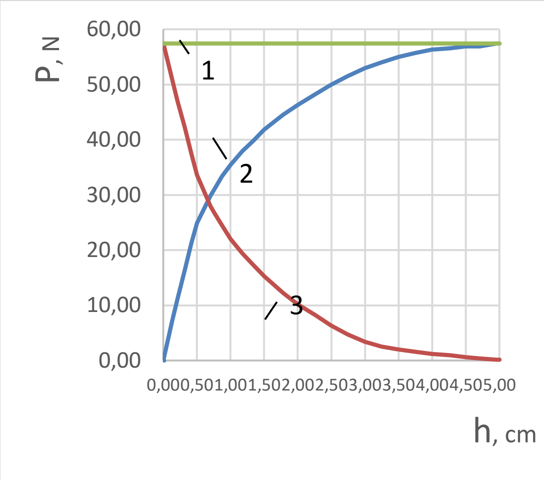
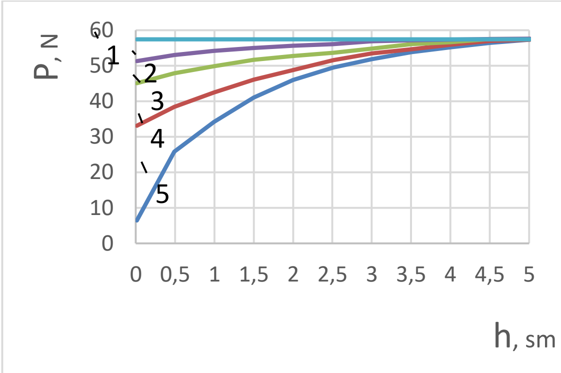


Figure 6: Forces on the knife without bending (1), with maximum bending f_{max}=5.85 cm at the beginning of cutting (2), 3- the nature of the difference between efforts (1) and (2).

Therefore, for the practical implementation of the process of cutting stems with preliminary bending, it is preferable to use the second method, which gives the greatest reduction in cutting work. Structurally, the device of the chopper is simplified with a bending device adjustable relative to the knife, which will make it possible to make maximum use of the preliminary bending effect for various types of stem material.



$1 - f = 5\ cm; 2 - f = 4\ cm; 3 - f = 3\ cm; 4 - f = 2\ cm; 5 - f = 0\ cm.$

Figure 7: Force on the knife blade at various values of preliminary bends less than the limit fmax=5.85 cm.

This work does not provide a calculation of the energy loss due to fiber crushing by the chamfer of a knife blade on the assumption that the destroyed fiber instantly restores its shape and practical compression of the fiber does not occur.

Table 1: Calculation results: fiber tensile stress σ_P, required tension on the knife blade for fiber destruction σ_H, corresponding force on the knife blade P_H and cutting work A when dividing the total displacement H at intervals of 0.5 cm.

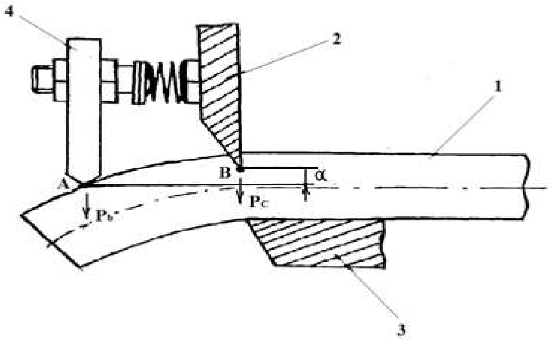
Knife position during cutting process, cm	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0		
Fiber tensile stress $\sigma_{P_1} \cdot 10^3$, N/cm²	1.45	1.305	1.160	1.015	0.830	0.725	0.58	0.435	0.290	0.145	0		
Fiber tensile stress $\sigma_{P_2} \cdot 10^3$, N/cm²	1.45	1.416	1.358	1.275	1.092	1.034	0.877	0.695	0.488	0.256	0		
Necessary tension on the knife to destroy the fiber $\sigma_{H_1} \cdot 10^3$, N/cm²	0	0.630	0.870	1.030	1.160	1.25	1.370	1.380	1.480	1.440	1.450		
Necessary tension on the knife to destroy the fiber $\sigma_{H_2} \cdot$ 10·, N/cm²	0	0.310	0.510	0.690	0.860	1.01	1.150	1.270	1.360	1.42	1.450		
Knife force P_{H_1}, N	0	25.78	34.80	41.40	46.40	50.23	53.20	55.20	56.20	57.60	58.00		

Knife force P_{H_2}, N	0	12.40	20.40	27.64	34.40	40.64	46.18	50.88	54.60	57.08	58.00		
Cutting work on site 0.5 cm. $A_1, N \cdot cm$	0	12.64	17.40	20.71	23.20	25.11	26.57	27.66	28.41	28.85	29.00	$\sum A_1$=239.5776	
Cutting work on site 0.5 cm. $A_2, N \cdot cm$	0	6.210	10.16	13.81	17.21	20.32	23.09	25.45	27.30	28.54	29.00	$\sum A_2$=201.1239	
The amount of bend f_1 at each step of moving the knife is necessary to obtain $\sigma_P = \sigma_{max}$	5.86	6.509	7.323	8.369	9.764	11.72	14.65	19.53	29.29	58.59	∞		

Note: the top line corresponds to the cutting process with a constant bend value f_{max}; the bottom line corresponds to the cutting process with a variable bend value $f=f_{max}+h$.

3.3 Experimental study of cutting corn stalks with a bend and in comparison. without a bend

The proposed method is implemented as follows. A bending force is applied to the free end of the stem using a bending plate moving along with the blade at the same speed, as a result, the stem bends, and the upper fibers on the side of the blade are stretched. The blade freely penetrates the body of the stem and cuts it.



1-stem material; 2-knife; 3-anti-cutting plate; 4-bending plate.

Figure 8: Cutting scheme with preliminary bending.

To carry out experimental studies, the device S.V. Melnikov designed for cutting stems of various crops [7]. In which the knife is equipped with a plate for preliminary bending of feed, which is made with the possibility of adjustment in the horizontal and vertical planes relative to the knife by means of a screw with a spring at the end.

To do this, two bolts for fastening the knife of the device S.V. Melnikov are replaced by two M8 studs 100 mm long and are used for fastening the bending plate with the blade. The bending plate was made of steel material with a thickness of 3 mm, a length of 100 mm and a width of 45 mm. To install the plate relative to the knife vertically up and down to the desired dimensions, grooves 70 mm long are made.

The method is carried out as follows, that is, the bending plate is attached to the knife using two pins. The installation distance of the bending plate from the knife is determined based on the physical and mechanical properties of the stem material and its degree of grinding.

Let's develop a diagram of the cutting method (Fig. 8). The bending force P_b is applied to the free end of the stem material (1) at point A by means of a bending plate (4). The bending plate (4) moves together with the knife at a speed ϑ_k. As a result, the material of the stem 1 bends and the knife is inserted from the side of the stretched fiber of the stem and cuts. The effect of reducing the cutting work P_c is obtained by reducing the force on the knife blades and reducing the compressive forces on both sides of the blade.

Table 2: Results of experimental studies of stems with preliminary bending.

Characteristics of the cutting process	Kitting stems with	Cutting stems with a bend							
		Condition of the bending dress relative to the book a, mm							
		-1	0	1	2	3	4	5	6

	bending								
Average effort	293.9	263.9	234.5	200.1	199.2	188.4	209.9	258.0	303.1
Maximum force	412.02	380.6	372.8	336.5	326.7	317.8	358.61	384.6	422.8
Cutting work A, G	6.867	6.18	5.49	4.71	4.51	4.42	5.00	5.98	7.13

Note: the value a = -1 mm corresponds to the location of point A 1 mm above point B; a = 1 mm means that point A is 1 mm below point B.

Cutting the stem with a bend was carried out in laboratory conditions. Experiments were conducted on cutting corn stalks with a diameter of 23-27 mm.

The distance between the knife and the bending plate was 50 mm, the relative humidity of the stems was 20-25%. The results of the experiment are shown in Table 2. From Table 2 it can be seen that at a = 3 mm the magnitude of the force and cutting work were minimal.

All calculations were carried out using the arithmetic mean value of 5 replicates. Cutting the stems between nodes has not yet been done. The experiments were carried out in the lower part of the stem in order to conduct experiments under identical conditions. If you take for the experiment from different parts of the stem (in front between the nodes, in the middle between the nodes and close to between the nodes), then this will be wrong, because the strength of the stem changes significantly from between the nodes to the top.

It was shown that the average force decreased by 1.3 times and the cutting work decreased by more than 1.5 times when cutting stems with a bending plate compared to cutting without bending.

4 CONCLUSIONS

1. In the work, the obtained equations for the stress state of a cantilever bent rod of rectangular cross-section allow us to determine the amount of bending to ensure the cutting process with a knife without disturbing the elastic properties of the material. The compiled program allows you to make appropriate calculations for stems with different physical and mechanical properties.

2. From the results of calculations of cutting work A, tensile stress σt of the upper fiber, tension on the knife blade σk, which is necessary to destroy the fiber, it is preferable to use the method when cutting with a bend f=fmax+h, i.e. the bend is made first at fmax, and then increases in accordance with the movement of the knife, which gives the greatest reduction in cutting work.

3. The results of experimental studies carried out in laboratory conditions prove the correctness of the results of theoretical studies, i.e. cutting with a bend of the stem significantly reduces the cutting work in comparison with cutting.

REFERENCES

Goryachkin, V.P., 1969. Collected works.-in 3 volumes, second ed.-M.: Kolos T-3.-384.

Zheligovsky, V.P., 1950. Experimental theory of cutting with a blade. Proc. MIMESHA. issue 9. 27-29 p.

Rebinder, P.A., 1979. Selected works. Surface phenomena in dispersed systems of physical and chemical mechanics. 341 p.

Gutyar, E.M., 1931. On the theory of cutting stems. *Agricultural Machinery*, No. 7-p.13-13.

Reznik, N.E., 1975. Theory of cutting with a blade and the basics of calculation of cutting devices. 312 p.

Bosoy, E.S., Sizy, V.V., 1977. Resistance of stems to cutting. *Scientific principles of design of agricultural machines. Rostov n/d,* P.3-11.

Melnikov, S.B., 1978. Mechanization and automation of livestock farms. 560 p.

Kukta, G.M., 1987. Machines and equipment for preparing feed. 304 p.

Leontyev, P.I., 1984. On the issue of grain grinding. *Flour-elevator and feed milling industry.* No. 7. -With. 50.

Rumpf, G., 1966. On the main physical problems during grinding.114 p.

Sablikov, M.V., 1963. On the critical value of the pinch angle. *Mechanical and electrical. social rural economy.* No. 2 P.6-8.

Sablikov, N.V., 1962. Cutting resistance of cotton stems (guza-pai). Tr. TIIIMSH. issue 19. - Tashkent, P.61-65.

Bremer, G.I., 1963. Basic theory of cutting with a blade and calculation of cutting machines for livestock farms. 75 p.

McRandal, D., 1980. Mechanical and physical properties of grasses. *Trans. am. soc. agric. eng.* No. 4. –p. 816-821.

Bakharev, G.F., 1992. Improving equipment for preparing and distributing feed on cattle farms: Dissertation in the form of a scientific report...Ph.D. tech. Sciences.35 p.

Demidov, A.R., 1991. Determination of the strength characteristics of grain of various crops. *Flour-grinding industry.* No. 8-p. 29-30.

Eliseev, V.A., 1970. Theoretical and experimental substantiation of methods for increasing the efficiency of the process of grinding grain feed on livestock

farms: Abstract of thesis. Diss...doc. tech. Sciences. Voronezh, 43 p.
Sakharov, V.V., 1971. Study of technological indicators of the cutting apparatus of mowers, algorithmization and determination of ways to improve them.-Dis. Candidate of Technical Sciences 167 p.
Aleshkin, V.R., 1995. Increasing the efficiency of the process and technical means of mechanization of feed grinding: abstract of thesis. diss. ... Doctor of Technical Sciences. 38 p.
Alizhanov, D., Aldabergenov, M.K., 2008. Estimation of model parameters from experimental data. *Bulletin of Agricultural Science of Kazakhstan. Almaty.* No. 10.
Alijanov, D., Abdurokhmonov, Sh., Jumatov, Ya., 2020. A. Bozorboev. “Reducing the energy capacity of the cutting of stem fodder”. International Scientific Conference "Construction Mechanics, Hydraulics and Water Resources Engineering".
Alizhanov, D., Zhumatov, Y.K., 2020. Resistance of forage plant stems to bending. *Agro Ilm. (makhsus dream 70)* B. 75.
Alijanov, D., Jumatov, Y. K., 2024. Evaluation of the influence of inhomogeneous inclusions of the stems bend of agricultural plants. EAS Web conferences 486, 04001 AGRITECH-IX 2023.
Alijanov, K.N. D., Namazov, J.M., Achilov, K.N., 2008. Energy-saving technology for cutting coarse feed with a knife. Proceedings of the International Scientific and Technical Conference “Modern Problems of Mechanization and Water Management Development of the Republic of Uzbekistan”. pp. 285-286.
Dyakonov, V.P., 1993. Handbook of MatLAB PC, Moscow, “Nauka”, 213 p.
Alijanov, D.. Abdurokhmonov, Sh.. Umirov, N., 2020. IOP Conference Series: Materials Science and Engineering.. **883** 012117
Abdurokhmonov. Sh., Umirov. N., Ismaylov, K., 2024. E3S Web of Conferences **486**. 05003.