



ських виробників преміксів потребує комплексного підходу, який включає модернізацію виробництва, впровадження систем управління якістю (НАССР, GMP+), розвиток науково-дослідної бази та тісну інтеграцію з підприємствами тваринництва. Отримані результати можуть бути використані для вдосконалення технологій виробництва преміксів та формування ефективної стратегії розвитку галузі в Україні.

**Ключові слова:** премікс, комбікорм, технологія, підприємства-виробники, ринок.

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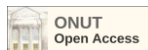
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## RESEARCH ON THE FLAKING ROLLS

### Annotation

The article discusses the problems associated with the processing of oats on flaking rolls. The diameter of the rollers of flaking rolls is much larger than that of the rollers of rolling machines and is 400 - 800 mm. The length of the rollers of flaking rolls is mainly from 500 mm to 1000 mm. Despite the increased size, the rollers of flaking rolls bend, as they are made double-layered and hollow. The uneven feeding of oat grain into the working zone (more is fed in the central part) leads to additional bending of the rollers, which can lead to an extremely undesirable mode when the cylindrical surfaces of the rollers roll over in the extreme zones without grain. The operation of the flaking rolls in this mode leads to a significant difference in the thickness of the flakes along the length of the rollers and, as a consequence, contributes to a decrease in the quality of the products produced. During the operation of flaking rolls, their bearings and housings wear out, which also leads to an increase in the compliance of the flattening rollers. Kinematic schemes of modern flaking rolls are presented and their shortcomings are identified. The design of a flattening roller with increased rigidity parameters has been developed, especially in its central part. A simplified scheme has been drawn up, and the stresses and deformations of the flaking rolls shaft have been calculated. The process occurring in the working area of the flaking rolls has been considered, the compression zones and product shape recovery zones have been calculated. Analysis of the flake formation process allowed us to link the feeder productivity with the filling coefficient of the working area with oat grain. The obtained intermediate results allowed us to draw up a realistic scheme of the flattening roller loading by zones and calculate it. The operating conditions of the flattening roller with increased rigidity have been simulated in Inventor CAD and the distributions of stresses and deformations have been obtained. The results of the calculations formed the basis of recommendations for the design and adjustment of the flaking rolls.

**Key words:** flaking rolls, oats, flakes, Ansys.

### Introduction

Flaking rolls are designed to produce flakes from oat, rice, buckwheat, wheat, corn, barley and other grain crops. Structurally, the flaking rolls resemble roller mills for grinding grain, but have a number of differences. The rollers of the flaking rolls have an increased diameter, which is necessary to increase the time of grain deformation and prevent cracking of the flakes at the edges. The flaking rolls itself consists of one pair of smooth rollers with a small working gap between them. According to the rules [1], the flakes should have a thickness of no more than 0.5 mm, but the exact thickness depends on many factors. A number of publications [2-6] have indicated that maintaining a certain flake density for feeding to animals is essential. This ultimately leads to improved starch digestibility.

This requires increasing the rolling force applied to the grain in the processing area.

There is a need to produce flakes from amaranth grain (grain diameter 0.6-0.8 mm), which poses certain challenges [7]. One of the most important aspects of flattening is ensuring a uniform feed of raw materials along the entire length of the rollers of the flaking rolls. The unevenness of the oat grain supply to the working zone leads to additional bending of the rollers, which can lead to an extremely undesirable mode when the cylindrical surfaces of the rollers roll over in the extreme zones without grain. As a result, microcracks appear in the zones of direct contact, which grow over time. The surface crack usually spreads in the direction of the load. As a result of this mode of operation, the cantilever elements of the barrel of the flaking roller are destroyed.



The feeder is used for uniform and precise distribution of raw material into the working area, which ensures the operation of the flaking rolls at optimal productivity, and also provides uniform wear of the rollers. To ensure uniform thickness of the flakes, the rollers are installed using hydraulic or screw mechanisms. Unfortunately, the design of the machine and rollers does not provide increased rigidity, which leads to thicker flakes in the central part of the rollers. To ensure proper uniformity of thickness, flake samples should be regularly taken along the length of the rollers.

It is also necessary to control the condition of the surface of the rollers and after the recommended time they should be re-ground. Practical recommendations for flattening rollers, operating time no more than 3-4 months.

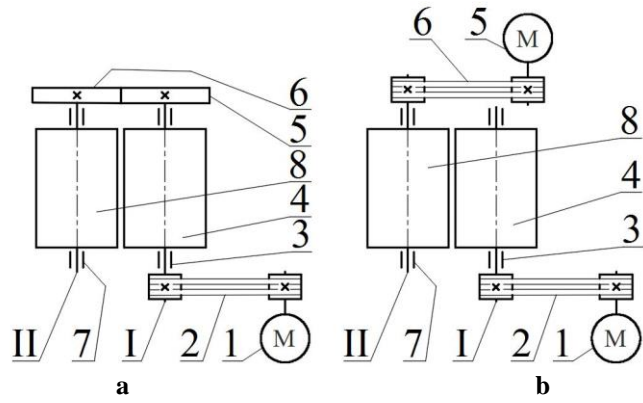
Flaking rolls are mainly performed according to two schemes presented in Fig. 1. In the scheme of Fig. 1a, rotation is transmitted from the electric motor 1 through the belt drive 2 to the shaft I, which is located in the bearings 3. On the shaft I is located the barrel of the roller 4 and the gear wheel 5, which transmits rotation to the gear wheel 6, which is located on the shaft II. The barrel of the roller 8 is fixed on this shaft, and the shaft itself is located in bearings 7. The considered scheme has fixed bearing housings 3, in which the shaft I rotates, and movable bearing housings 7, which allows you to adjust the working gap between the barrels of the rollers 4 and 8. Considering that the gear (5, 6) fails when adjusting the working gap between the rollers, most machine-building companies switch to the production of flaking rolls according to the scheme shown in Fig. 1b. In this scheme, the drive of the second shaft II with the barrel 8 is carried out from the electric motor 5 through the belt transmission 6, which allows you to abandon the gear transmission with its disadvantages. Other structural elements of the scheme remain unchanged.

**Purpose and tasks of the work.** Development of a calculation methodology for flattening machine rollers.

**Materials and methods**

When developing new, highly efficient process equipment, it became necessary to increase the rigidity of the rollers. Several design options for the crushing roller were proposed. A model of the designed roller needed to be loaded with the loads that arise during operation. This required knowing the zones of application of the forces that deform the oat grain, as well as the flake shape recovery zone. The process occurring in the grain deformation zone was examined, and the geometric dimensions of this zone were determined. A similar approach was applied to the flake shape recovery zone.

The geometric data obtained for these zones then allowed the application of operating pressure in the roller's working zone. The model of the proposed roller was loaded not with a linear load, but with a more realistic loading pat-



**Fig. 1. Schemes of flaking rolls**

tern. A similar model of the process occurring between two rollers is considered in [8]. Given that in our case we have a roller feeder, considering the product acceleration zone (or deaeration zone) is pointless. By determining the angle at which the grain is compressed, it is possible to determine other parameters: the time it takes to pass through this zone and the pressure on the roller walls. This allowed the INVENTOR CAD environment to determine the most rigid version of the crushing roller. Modeling was performed using the finite element method, which allowed for the generation of deformation and stress distribution maps. The calculations and modeling carried out made it possible to develop a design methodology for this type of equipment.

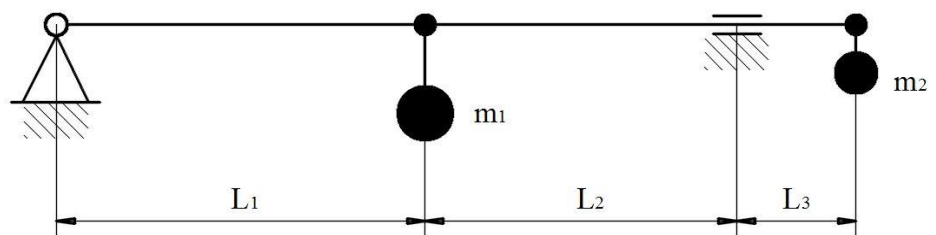
**Results of the study and their discussion**

The loads on the roller from the compressed product have a complex form, it is not a point or linear load, which is accepted by most researchers to simplify calculations (Fig. 2). For example, for static calculation it is possible to consider the shaft of a flaking roll on two supports, fixed on the left and movable on the right, with two masses, from the roller barrel  $m_1$ , and on the console from the pulley  $m_2$ .

In initial design work, this approach makes it possible to determine the nature of deformations along the length of the shaft and their magnitudes (Fig. 3), which improves the decision on the layout of the flaking rolls.

It is also possible to determine the stresses that arise in the shaft (Fig. 4).

In order to apply working forces to the roller, it is necessary to determine their zone of action and magnitude. Experimentally, it is possible to find the working forces in the core flattening zone using strain gauges or determining the working pressure in the hydraulic cylinders of the flaking rolls. The length of the working zone in which the pressure forces act remains



**Fig. 2. Simplified loading diagram of the shaft**

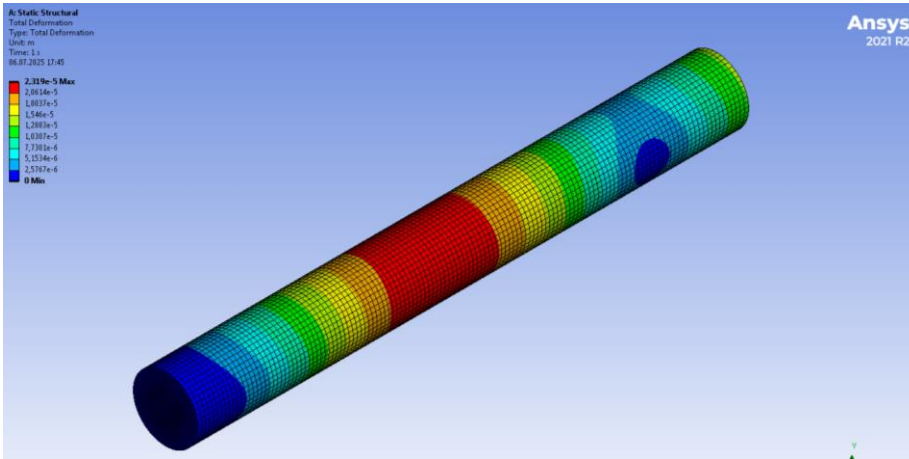


Fig. 3. Shaft deformations in static state

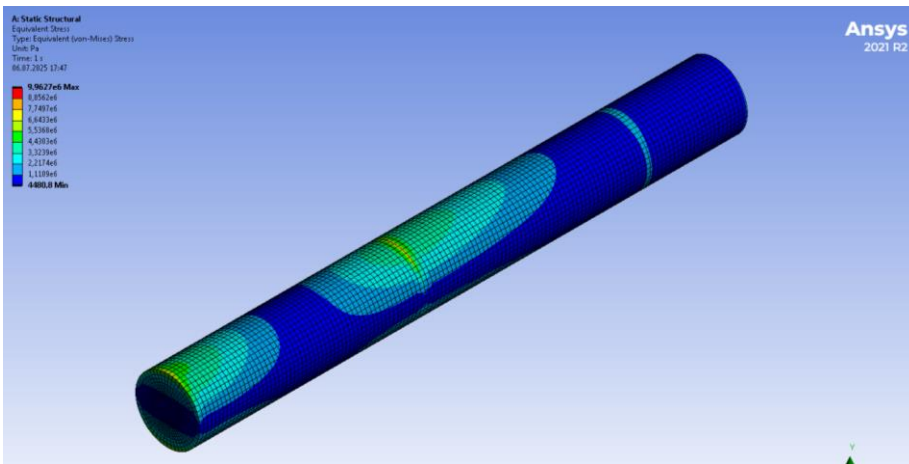


Fig. 4. Shaft stress in static condition

undetermined. First, the width of the working zone is usually the length of the roller minus two thicknesses of the edge cheek. But the length of the working zone, the length of the arc where the product contacts the roller, is not determined.

Therefore, let us consider the process that occurs in the working zone between the flattening rollers. Fig. 5 shows a simplified diagram of the working zone of the flaking rolls. Between the barrels of rollers 1 and 2 there is a working zone 3 in which grain destruction and the formation of flakes occur. Taking as a basis the aver-

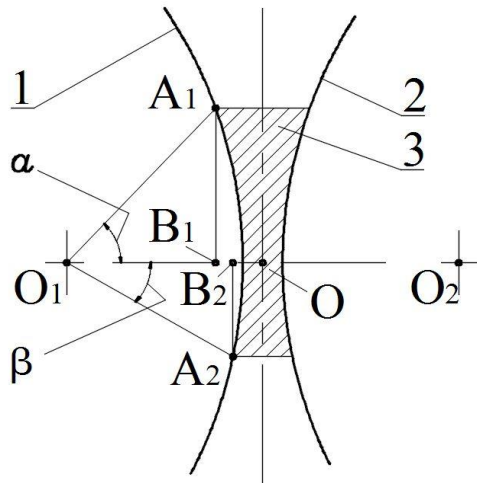


Fig. 5. Diagram of the working area of the flaking rolls

age radius of the grains, which is equal to the distance  $OB_1$ , we will construct a triangle  $O_1B_1A_1$  ( $O_1A_1 = R$  – the radius of the roller). At point  $A_1$ , the grain will begin to contact the barrel of roller 1 (the same will happen on the other side of the grain).

The angle  $\alpha$  will determine the grain compression zone:  
 $\alpha = \arccos(O_1B_1/O_1A_1)$

Reasoning in a similar way, i.e. taking the distance  $OB_2$  as half the thickness of the flake, it is possible to construct a triangle  $O_1A_2B_2$  and find the angle of recovery  $\beta$ .

Arc length of the working zone

$$A_1A_2 = \pi \cdot R \cdot (\alpha + \beta) / 180$$

Determine the total contact area of the roller in the working area

$$S_p = B \cdot A_1A_2,$$

where  $B$  is the width of the working area,  $B = L - 2c$ ;

where  $L$  - is the length of the cylinder,

$c$  - is the thickness of the edge cheek.

Let's find the productivity of the grain feeder in pcs/s:

$$N = Q \cdot 1000 \cdot 1000 / (3600 \cdot M),$$

where  $Q$  – productivity kg/hour;

$M$  – mass of 1000 grains, g.

Grain area in projection (for oat grain – shape approximately elongated ellipsoid of rotation) ellipse:

$$S = a \cdot b \cdot \pi,$$

where  $a$  is the length of the first semi-axis of the ellipse,

$b$  is the length of the second semi-axis of the ellipse.

The volume of an oat grain

$$V = 4 \cdot a \cdot b^2 \cdot \pi / 3.$$

Determine the area filling factor before entering the working area

$$k_3 = N \cdot S / (1000 \cdot v \cdot B), \%$$

where  $v$  is the linear velocity of the roller surface, m/s.

As calculations show, it is 5 – 9 %.

The number of grains in the working area

$$N_1 = S_p \cdot k_3 / (100 \cdot S).$$

Assuming the transverse rolling coefficient  $k_{pop} = 4.5$  based on experimental data, we find the length of the second semi-axis of the flake  $b_1 = k_{pop} \cdot b$ . Considering that the density of the flakes varies slightly in relation to the grain density, it is possible to find the other semi-axis of the ellipse

$$a_1 = 3 \cdot V / (4 \cdot b^2 \cdot \pi).$$

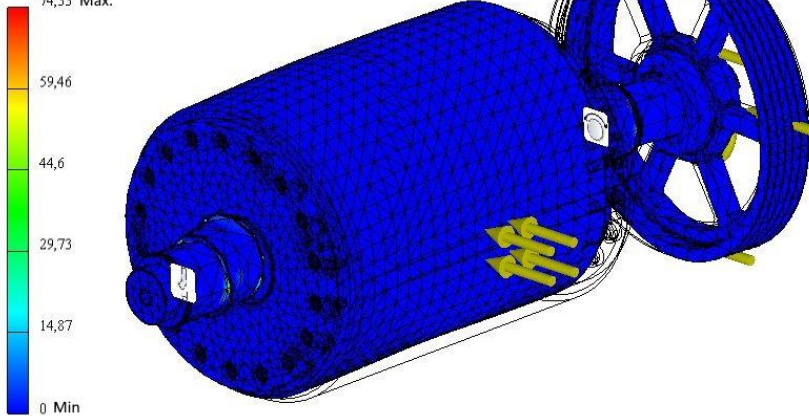
Longitudinal roll coefficient

$$k_{под} = a_1 / a.$$

Area of the flake  $S_{fl} = V / H,$

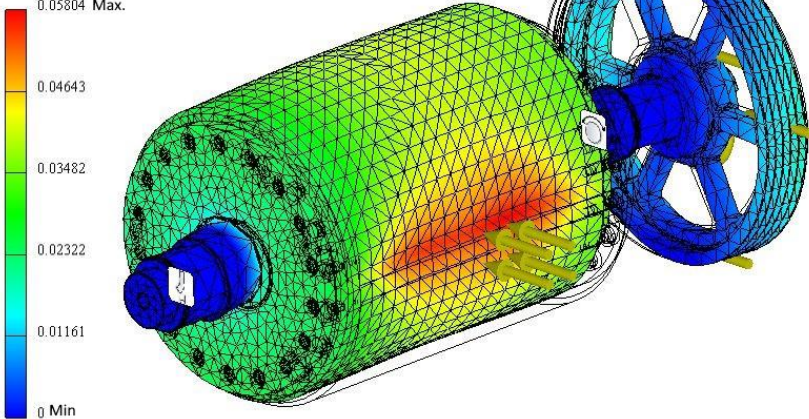


Nodes: 486278  
 Elements: 310915  
 Type: Von Mises Stress  
 Unit: MPa  
 24.07.2025, 18:32:48  
 74,33 Max.



**Fig. 6. Mises stress distribution map along the roller**

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 Elements: 310915  
 Type: Displacement  
 Unit: mm  
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 0.05804 Max.



**Fig. 7. Map of deformation distribution along the roller**

where  $H$  is the thickness of the flakes.  
 The area of the flakes rolling in the working area

$$S_{3ar} = S_n \cdot N_1.$$

Let's find the work area fill factor

$$k_{31} = S_{3ar} \cdot 100 / S_p.$$

Typically, this coefficient is 65-75%. As the coefficient of filling the working zone increases, the probability of obtaining stuck flakes increases, which affects the quality of the produced product.

Time of grain in the working zone

$$t_n = A_1 A_2 / v.$$

Having determined the total contact area of the roller and knowing the expansion forces in the working zone, it is possible to find the specific load on the roller barrel in the working zone

$$\Delta P = P / S_p,$$

where  $P$  is the expansion force in the working zone.

To prevent the flattening roller from bending in the working area along a parabola, we will introduce several design solutions to increase the rigidity of the standard roller.

After that, in Inventor CAD, you can go to the "Environments" section and specify the supports, the gravity force of the roller, the specific loads in the working area, the belt tension force, and the torque on the drive pulley on the model of the roller of the flaking rolls.

The next step is to divide the cylinder into tetrahedra and obtain a finite element mesh (Fig. 6).

After the calculation, we obtain a map of the Mises stress distribution over the volume of the roller. As follows from the results obtained at maximum working loads, the stresses and the safety factor are in the safe zone. The maximum stresses are at the stress concentrators, these transitions during the operation of the machine accumulate microcracks during cyclic operation, which after some time leads to the appearance of a crack and breakage of the roller pin. And this occurs at a time when the working stresses are less than ten times the permissible ones for the main design.

Let us turn to the deformations obtained at maximum working loads (Fig. 7). As follows from the data obtained, the vertex of the roller deflection parabola in the working zone has significantly aligned with its two branches. The maximum deflection is 0.06 mm. In practice, this makes it possible to increase the thickness of the flakes by 0.12 mm, compared to the flakes that we obtain at the edges of the rollers. In order for the flakes to meet the requirements of the Rules [1], it is necessary to maintain a working gap between the rollers at the edges of 0.13 mm.

Taking into account the low angular speed of rotation of flaking rolls, studies and Campbell's diagram were not constructed. The first critical speed is twice the operating speed of the roller.

### Conclusions

1. Kinematic schemes of flaking rolls are considered. Disadvantages of some kinematic schemes are identified.
2. Static calculations of the flaking rolls shaft are performed.
3. A more realistic scheme of the roller loading is presented and the distributions of stresses and deformations of the roller are obtained.
4. The simulation carried out at the design stage of the process equipment allowed us to improve the rigidity characteristics of the flattening machine and improve reliability indicators.
5. The calculations and modeling carried out made it possible to develop a design methodology for this type of technological equipment.



## REFERENS

1. Pravyla orhanizatsii i vedennia tekhnolohichnoho protsesu na krupianykh zavodakh. - K.: VIPOL, 1998.
2. Ronald J. Trotta, Kelly K. Kreikemeier, Randy F. Royle, Todd Milton, and David L. Harmon. Flake density and starch retrogradation influence in situ ruminal degradability characteristics of steam-flaked corn and predicted starch digestibility and energetic efficiency. *Journal of Animal Science*, 2021, Vol. 99, No. 11, 1–9. <https://doi.org/10.1093/jas/skab298>
3. Ronald J. Trotta, Kelly K. Kreikemeier, Randy F. Royle, Todd Milton, and David L. Harmon. Corn processing, flake density, and starch retrogradation influence ruminal solubility of starch, fiber, protein, and minerals. *Journal of Animal Science*, 2022, 100, 1–8. <https://doi.org/10.1093/jas/skac149>
4. Samsami, R., Naserian, A. Ali, Tahmasebi, A., Ebrahimi, S. H. Flaking method affects the rate and extent of ruminal starch degradation in maize grains. *Journal of Livestock Science and Technologies*, 2024; 12(1): 49-60. [doi:10.22103/jlst.2024.22904.1524](https://doi.org/10.22103/jlst.2024.22904.1524)
5. Nixdorff C., McKinnon J.J., Shreck A.L., Juárez M., Penner G.B. Comparison of the effects of dry rolling, temper rolling, and steam flaking barley grain on dry matter intake, growth, and carcass characteristics of finishing beef steers. *Applied Animal Science*, 36, 6, 820–829. <https://doi.org/10.15232/aas.2020-02020>
6. Gutierrez, BH, Alvarez, EG, Montano, MF, Salinas-Chavira, J., Torrentera, NG, & Zinn, RA (2018). Вплив щільності пластівців та темперування на кормову цінність кукурудзи, приготовленої паровими пластівцями, для великої рогатої худоби на відгодівельних фермах. *Journal of Applied Animal Research*, 46 (1), 155–158. <https://doi.org/10.1080/09712119.2017.1278699>
7. Martínez-Damián E., Arambula-Villa G., Argumedo-Macías A., Palacios Pola G.. Are Food Meanings Crucial for Novel Product Acceptance and Purchase Intent? A Case Study With Amaranth Flakes. *Journal of Sensory Studies*, 2025, 40 (5). <https://doi.org/10.1111/joss.70082>
8. Rashidi S., Rajamani R.K., Fuerstenau D.W.. A Review of the Modeling of High-Pressure Grinding Rolls. *KONA Powder and Particle Journal*. 2017, 34, 125-140. <https://doi.org/10.14356/kona.2017017>

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У статті розглянуто проблеми, пов'язані з переробкою вівса на плющильних верстатах. Діаметр вальців плющильних верстатів значно більший ніж у вальців вальцьових верстатів і складає 400 – 800 мм. Довжина вальців плющильних верстатів в основному від 500 мм до 1000 мм. Незважаючи на збільшені розміри вальці плющильних верстатів прогинаються, так як виконуються двошаровими та пустотілими. Нерівномірність подачі зерна вівса в робочу зону (в центральній частині подається більше) приводить до додаткового вигину вальців, що може привести до вкрай небажаного режиму, коли циліндричні поверхні вальців перекочуються в крайніх зонах без зерна. Робота плющильного верстата в такому режимі приводить до значної різниці в товщині пластівців по довжині вальців і як слідство сприяє зниженню якості випускаємої продукції. В процесі експлуатації плющильних верстатів їх підшипники та корпуси зношуються, що теж приводить до збільшення піддатливості плющильних вальців. Представлені кінематичні схеми сучасних плющильних верстатів та виявлені їх недоліки. Розроблена конструкція плющильного вальця з підвищеними параметрами жорсткості, особливо в його центральній частині. Складена спрощена схема, та розраховані напруження та деформації вала плющильного верстата. Розглянуто процес, що відбувається в робочій зоні плющильного верстата, розраховані зони стиску та відновлення форми продукту. Аналіз процесу формування пластівців дозволив зв'язати продуктивність живильника з коефіцієнтом заповнення робочої зони зерном вівса. Отримані проміжні результати дозволили скласти реалістичну схему навантаження плющильного вальця по зонам та обчислити її. В САПР Inventor змодельовані умови роботи плющильного вальця з підвищеною жорсткістю та отримані розподіли напруг та деформацій. Результати розрахунків лягли в основу рекомендацій до проектування та налаштування плющильного верстата.

**Ключові слова: плющильний верстат, овес, пластівці, Ansys.**Received 12.12.2025  
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