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UNRAVELING MECHANISM DRIVE POWER FOR EFFICIENT SEPARATION OF STEM FEED FROM MONOLITHIC RESERVES

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Abstract

The rapid advancement of agricultural technology has driven a notable surge in the utilization of hydrophysical mechanisms within working bodies. An ongoing trend in hydraulic drive development is the miniaturization of its components, which consequently elevates the operational pressure of hydraulic systems to levels exceeding 500 bar. This evolving landscape necessitates research endeavors aimed at enhancing the design of hydraulic machines and allied components [1]. As agricultural production technologies evolve, novel machine categories emerge, spurring the wider adoption of hydraulic drives and the innovation of hydraulic systems boasting enhanced technical attributes [2].

In the realm of stalk feed handling from trench storage facilities, optimizing the physical and mechanical properties of feed monoliths stands as a key pathway to creating new and refining existing loading mechanisms. Within this context, the triad of material, tool (working components of the machine), and energy, as defined by Academician V. A. Zheligovsky, governs technological processes [3]. Consequently, familiarity with material properties and the confluence of structural dynamics of working bodies is indispensable for the development of machines, including stalk loaders. Furthermore, delving into the interplay between these parameters and their impact on the quality of automatically controlled drives defines the contemporary significance of this study [4].

This research is dedicated to probing the influence of the physical and mechanical attributes of stem feed, alongside the structural performance of working bodies, on the work quality and power efficiency of isolation mechanisms. The challenge of mechanizing the discharge of stalk feed from trench storage has long persisted, leading to an array of designs and continuous research into continuous and intermittent loaders. While studies have unveiled insights into the interaction between working bodies and materials, the pursuit of enhanced reliability, extended service life, and energy-efficient drives remains pivotal [5].

Various structural configurations of working bodies are deployed for unloading stalk feed from trench storage, often integrated into the front

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hitches of tractors (Fig. 1). Cutting-type working bodies hold prominence due to their straightforward operation and maintenance requisites. A rich body of research by scholars such as V.V. Krasnikov, V.F. Dubinin, V.G. Popov, A.A. Tolkalov, A.R. Makarov, and external contributions like those from Pirkelmann H. and Maier L. [6] have informed the development and substantiation of working body parameters for block loading of stalk forage (silage and haylage) using cutting implements. Moreover, the pioneering contributions of Academician V.P. Goryachkin underpin the scientific theory of cutting devices [7], while the standard for cutting devices is built upon the groundwork laid by L.P. Kramarenko and the experimental studies conducted by Karpenko O.M. [8]. Notably, technological frameworks for sliding cutting were pioneered by V.A. Zheligovskiy [9].
Proposing an alternative analytical approach, V.P. Goryachkin, I.F. Vasilenko, A.I. Ishlinskiy [7], N.V. Sablik, and V.N. Gyacheva introduce a methodology for determining cutting speeds of agricultural plant stalks, diverging from existing approaches [8]. Further contributions by Bosoy E.S. involve the investigation of cutting knife balance, which manifests as a wedge with varying chamfer configurations. Complementary research by N. Reznik encompasses the comprehensive theoretical and empirical underpinnings of blade-based cutting processes [3].

1. Introduction

The current state of the development of agricultural technology provides for a further increase in the level of hydrophysical reasons for working bodies. One of the directions of development of hydraulic drives is to reduce the size of its elements. As a result of these changes, the pressure level of the working fluid in the hydraulic systems rises to 500 bar and more. This, in turn, requires research to improve the design of hydraulic machines and other devices that are part of hydraulic systems [1].

The development of agricultural production technologies has led to the emergence of new types of machines. In turn, this process stimulated the expansion of the use of hydraulic drives and the creation of new hydraulic systems with an increased level of technical characteristics [2].

Creation of new and improvement of existing loaders for stalk feed from trench storage facilities is possible through the rational use of the physical and mechanical properties of feed monoliths. According to the definition of academician V. A. Zheligovsky, three elements take part in any technological process: material, which is the object of research; tool, or working parts of the machine that act on this material; the energy with which the working bodies are activated [3].

Therefore, knowledge of the physical and mechanical properties of the material and taking into account the structural performance of the working body is a prerequisite for the research and development of any machine, including a stalk loader. And the study of the influence of these parameters on the quality of the drive with automatic control makes this study modern and relevant
[4].

The purpose of the work is to study the influence of the physical and mechanical properties of the stem feed and the structural performance of the working body on the quality of work and the drive power of the mechanism for isolation.

The problem of mechanizing the unloading of stalk feed from trench storage has been around for a long time. Therefore, there is a fairly large number of designs and developments of loaders of continuous and periodic action, research on the study of the peculiarities of the interaction of working bodies with material, substantiation of their geometric and kinematic parameters. But nevertheless, the issues of reliability, an increase in the service life and the creation of an energy-saving drive for these machines [5] are relevant.
For unloading stalk feed from trench storages, different types of structures of working bodies are used, which are located on the front hitch of the tractor (fig. 1). The most widespread are the working bodies of the cutting type, due to the simpler operating conditions and maintenance.
The development and substantiation of the parameters of working bodies for block loading of stalk forage (silage and haylage) with cutting bodies are devoted to the works of V.V. Krasnikov, V.F. Dubinin, V.G. Popov, A.A. Tolkalov, A.R. Makarov., Pirkelmann H., Maier L. and others [6].
Academician V.P. Goryachkin developed the foundations of the scientific theory of cutting devices [7]. The works of L.P. Kramarenko and experimental research Karpenko O.M. formed the basis of the standard for cutting devices [8]. Technological foundations for sliding cutting were developed by V. A. Zheligovskiy [9].
V.P. Garyachkin, I.F. Vasilenko, A.I. Ishlinskiy [7], N.V. Sablik and V. N. Gyacheva proposed a different approach and method for the analytical determination of the cutting speed of the stalks of agricultural plants. Their work is devoted to the study of the possibility of using grooved segments for cutting devices of mowers [8]. Bosoy E.S. conducted a study of a cutting knife, the edge of which lost balance in the form of a wedge with a straight, convex and concave chamfer. Research by N. Reznik are aimed at generalizing the scientific, theoretical and experimental foundations of the process of cutting with a blade [3].

Fig. 1. Loaders of stalk feed from a silage trench: b – cutting grip V-LOAD Shear (Germany), c – forage cutter V-Load Cutter BVL (Germany), d – feed mixer Trioliet Triotrac M (Netherlands)

It should be noted that the cutting process is the most common type of destruction of agricultural materials [3, 7, 9]. It is from him that the features and design parameters of the cutting elements determine the energy consumption for the technological process of unloading the stalk feed and the performance of the loader. Cutting stem feed is a complex mechanical process in which material properties such as elasticity and viscosity are of paramount importance. The presence of such phenomena as relaxation and creep in silage and haylage makes it possible to classify these materials as elastic-binder materials. They are tissues formed by a spatial fibrous system, the voids of which are filled with liquid and gas. During deformation, the fibers of the material are pressed against the rare and gaseous medium that surrounds them, forcing it to move into less stressed zones. For elastic - binding materials, the characteristic dependence of deformation not only on its size, but also on the rate at which it develops [7].

2. Materials and Methods

The diagram that characterize the properties of the material, elasticity is depicted in the form of a spring, the deformation of which obeys Hooke's law, and viscosity - in the form of a cylinder with a viscous fluid [3, 7, 9]. Here the movement of the piston is described by Newton's law. Sequential and parallel connection of the given elements allow simulating the deformation of materials with complex properties. Elastic - binding properties of the considered forage massifs can be most fully characterized by a physical model, which contains three series-connected elements (fig. 2). The proposed model quite fully reflects the picture of the circulation of fibrous plant materials under stress. It includes the element E_1 of instant elasticity, the element E_2 of retarded elasticity, connected in parallel with the viscosity element 2, the flow element 1, connected in series with the first two.

This model makes it possible to explain the essence of the deformation process of elastic - binding materials under load. With a fast loading of the model, its complete deformation occurs mainly due to the compression of the spring - element E_1. When fixed in a compressed state, the spring E_1 moves the piston of the element η_1. As the piston progresses, the spring E_1 expands and the stress decreases. This is a typical stress relaxation pattern at constant strain.

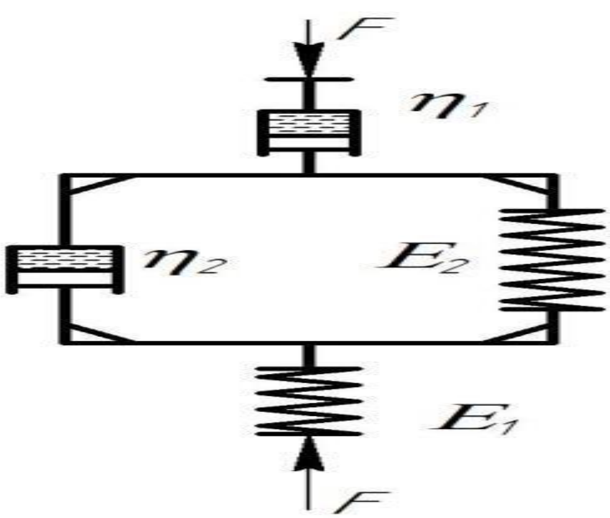


Fig. 2. Rheological model of plant material

The additional load at the initial moment of time causes rapid deformation due to the compression of the spring of the element E_1, and then - gradual deformation due to the compression of the spring of the element E_2 together with the movement of the piston of the element η_2. When the load is removed, the spring of element E_1 will be released instantly, and E_2 can only be released gradually, acting on the piston of element η_2. The position of the piston of element η_1 will fix the permanent deformation.

The rheological model makes it possible to explain the nature of the behavior of elastic-binding materials in the process of their loading [10] and to represent the process of interaction of the edge and bevels of the blade with the material, especially taking into account the cutting speed.

When cutting with a blade, a new surface is formed directly in the area of contact of the cutting edge with the material. The separation of the material into parts under the action of the blade transfers the process of the previous compression of the material by it to the occurrence of a breaking stress G_p. The moment of its occurrence is determined by the value of the critical cutting force F_{cr} applied to the knife. When cutting elastic - binding materials, the force F_{cr}, at which the process of compression of the material is completed and its cutting begins, is the maximum of all the forces that arise during the cutting process. The conditions under which the cutting force takes on the value of F_{cr} are critical. When the blade interacts with the material, the force F_{cr} becomes the most important.

Consider the interaction of the blade with the material when it enters the material in the direction normal to the edge.

When a single-chamfered blade deepens into a layer of material with a thickness h (fig. 3) by the value h_{st}, when a destructive stress G_p arises at the edge of the blade, the cutting process begins. The following forces act on it: F_{cr} – resistance to destruction of the material under the edge of the blade; F_{obt} – the forces of compression by the material, which have a horizontal direction and act on the edge of the blade; F_{st} – resistance of the formation to compression by the edge of the blade, directed upwards.

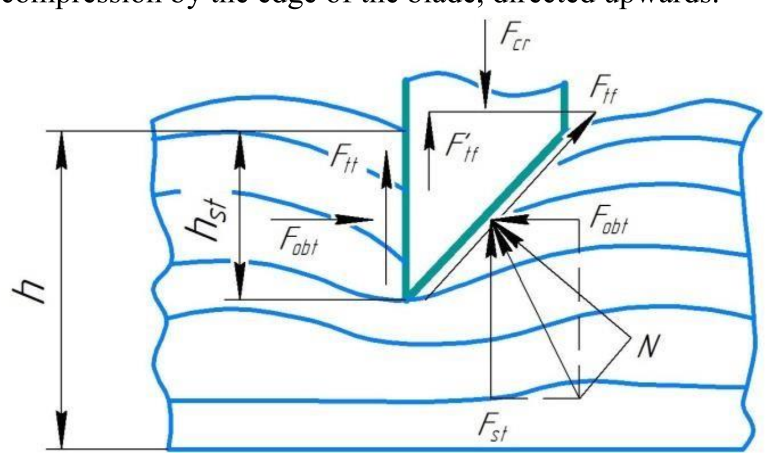


Fig. 3. Forceful interaction of the blade with the material

The force N acts on the edge of the blade, which is the sum of the projections of the forces F_{st} and F_{obt} on the direction of the normal:

$$N= F_{stsin\beta}+ F_{obt}\cdot cos\beta. \qquad (1)$$

The friction force F_{tf} arises from the force on the chamfer:

$$F_{tf} =N_f; \qquad (2)$$

where $f = tg\varphi$ – coefficient of friction of the material against the edge of the blade, φ – is the angle of friction.

Similarly, the friction force F_{tt} arises on the back side of the blade from the force F_{obt}:

$$F_{tt}= F_{obt}f. \qquad (3)$$

Force F_{tt} is directed vertically upwards, and F_{tf} – at an angle β of inclination of the edge of the blade. The vertical projection of the force F_{tf} is equal to:

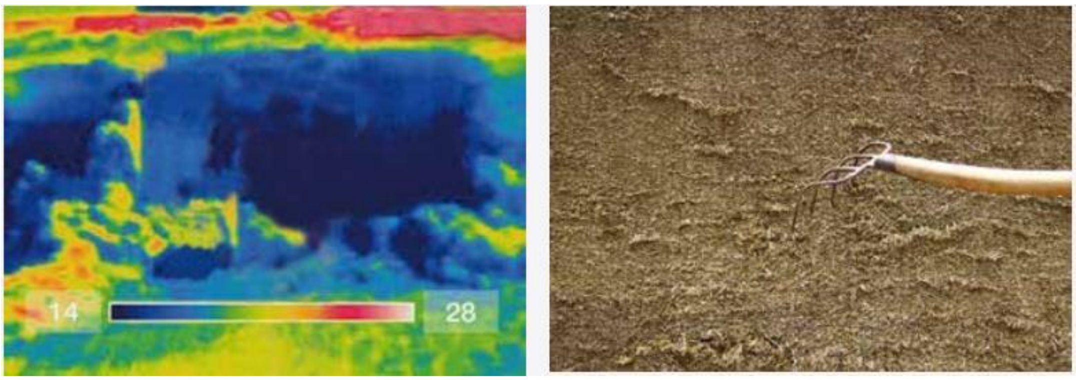
$F'_{tf} = F_{tf} \cos \cdot \beta$. (4)

Substitute the value N from expression (1) into expression (2), we get:

$$F_{tf} = f\left(F_{st}\frac{1}{2}\sin 2\beta + F_{obt}\cos^2\beta\right). \qquad (5)$$

At the moment of the beginning of cutting, a critical force is applied to the knife, must overcome the sum of all forces that act in the vertical direction:

$F_{kr} = F_{st} + F_{obt} + F_{tt} + F'_{tf}$. (6)



a b

Fig. 4. Quality indicators of the cutting apparatus of the stalk feed loader: a – decrease in feed heating, b – preservation of feed density

The quality and nutritional value of the feed left in the trench also depends on the work of the cutting body of the stalk loader. Therefore, the cutting body, after acting on the feed monolith, must leave an equal and not ripped surface, which will exclude the appearance of secondary fermentation of the feed. In the presence of this process in the forage mass, it is intensely heated, which leads to the loss of energy in the form of heat and the forage becomes less tasty for farm animals. Smoothly cut stalk feed during unloading retains its firm, stable shape and quality longer [5, 6].

The work of the cutting bodies of stalk feed loaders, made in the form of knives, takes place in difficult conditions of squeezing them by the forage mass, different mechanical-physical-mechanical properties of the feed, which vary both in depth and in width, and research of such cutting bodies is not enough. This restrains the level of developments in the mechanization of loading and unloading operations in the extraction of stalk feed.

In the context of the urgent need to increase the energy efficiency and economic efficiency of agricultural machines, the directions of creating means of mechanization of operations, the separation and unloading of stem feed, in which the principle of adaptation of the work of executive hydraulic drives to the conditions of their load is implemented [1, 8].

The use of this principle of regulating the operating modes of the hydraulic drive system will significantly reduce the power of the executive hydraulic motors, as well as reduce the loss of time during stops caused by overloads of the cutting mechanisms.

The energy efficiency of most industrial hydraulic systems depends, first of all, on two factors - the circuit design and the type of pumping unit and the operating modes of the actuators [1, 6].

The study of the physical and mechanical properties of the stem feed and the design and technological parameters of the working body was carried out at the branch named after V.I. Michurina ZAO Zernoprodukt MHP, Vinnytsia region, Khmel-growing region during 2018-2020 in ground silos. The shelf life of the stem feed was 3 to 9 months.

Stem feeds stored in trench storage are characterized by botanical and fractional composition, density and moisture content, which vary in width and depth, and in turn affect the operation of the separation mechanism [11]. Therefore, the program for the study of the physical and mechanical properties of stem feed is provided to investigate:

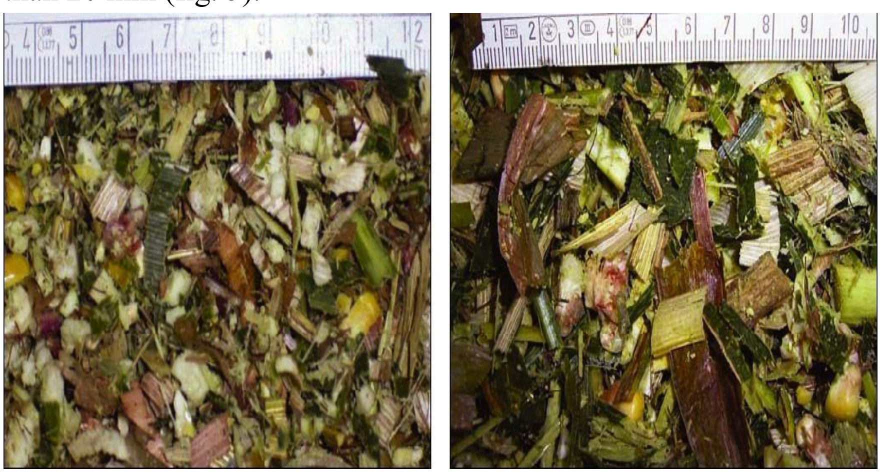
- moisture content of stem feed in the trench storage; - the density of the feed in the trench; - fractional composition of the mass.

The study of these properties was carried out directly in trench storages, since, as the experience of working with piles of stem feed shows, it is practically impossible to cut out a block of feed for laboratory studies of its physical and mechanical properties without changing its internal connections, and carrying out this research leads to distortion results.

To determine the moisture content and fractional composition of the fodder monolith, an average fodder sample was taken. Stem feed (silage, haylage) was taken from the trench in small portions from different sections of the cut of the forage massif. After that, it was mixed and an average sample weighing 1000 g was taken for research [11].

The study of physical and mechanical properties was carried out according to DSTU 4782-2007.

When conducting studies of physical and mechanical properties, the culture from which the feed was prepared, the phase of its development, moisture and bulk density, the fractional composition with the distribution of particles into classes - less than 3 were noted; 3,1–5; 5,1–7; 7,1–10; 10,1–12; 12,1–15; 15,1–20 mm and more than 20 mm (fig. 5).



a b

Fig. 5. Shredded mass with a theoretical rod length of 5 mm (a), with a theoretical rod length of 20 mm (b)

3. Results and discussion

The distribution of the fractional composition of the crushed mass into the classes given in table 1.

It should be noted that today's forage harvesters allow you to regulate the degree of crushing of green mass within wide limits, which excludes additional crushing of the stalk feed before feeding [12].

Table 1. Distribution of fractional composition into particles

Particleclass (length, mm)	1 – sample		2 – sample		3 – sample		Average value	
	Weight, g	%	Weight, g	%	Weight, g	%	Weight, g	%
Less than 3	57	4,07	30	3,0	52	5,2	46,33	4,09
3,1–5	72	5,14	37	3,7	49	4,9	52,67	4,58
5,1–7	154	11,00	90	9,0	125	12,5	123,00	10,83
7,1–10	356	25,43	232	23,2	210	21,0	266,0	23,21
10,1–12	314	22,43	217	21,7	233	23,3	254,67	23,55
12,1–15	136	9,72	151	15,1	132	13,2	139,66	12,67
15,1–20	149	10,64	143	14,3	98	9,8	130,0	11,58
More than 20	162	11,57	100	10,0	101	10,1	121,0	9,49
Sampleweight, g	1400	100	1000	100	1000	100	1133,3	100

According to GOST 4782-2007, the moisture content of the silage mass was determined by this method. The weighing bottle was hung up to 5 g of chopped feed and dried in an oven at 130°C for 40 minutes. After drying and cooling in an exsicator, the weighing bottles were weighed again and the moisture content of the mass was determined according to the difference in weight before and after drying according to GOST 27548-87 according to the formula [11]:

$W_B = \frac{m - m_n}{m} \cdot 100$; (7) where m – is the mass of the sample before drying, g; m_n – is the mass of the sample after drying, g.

Figure 6 shows the change in the moisture content of the stem feed from the height H of bedding in the storage, from which it can be seen that the moisture content of the forage at the base is higher than in the upper layers of the forage monolith. An increase in the moisture content of the stalk feed in the lower layers has a positive effect on the operation of the loader cutter bar, since excess moisture in the feed reduces the friction of the moving elements.

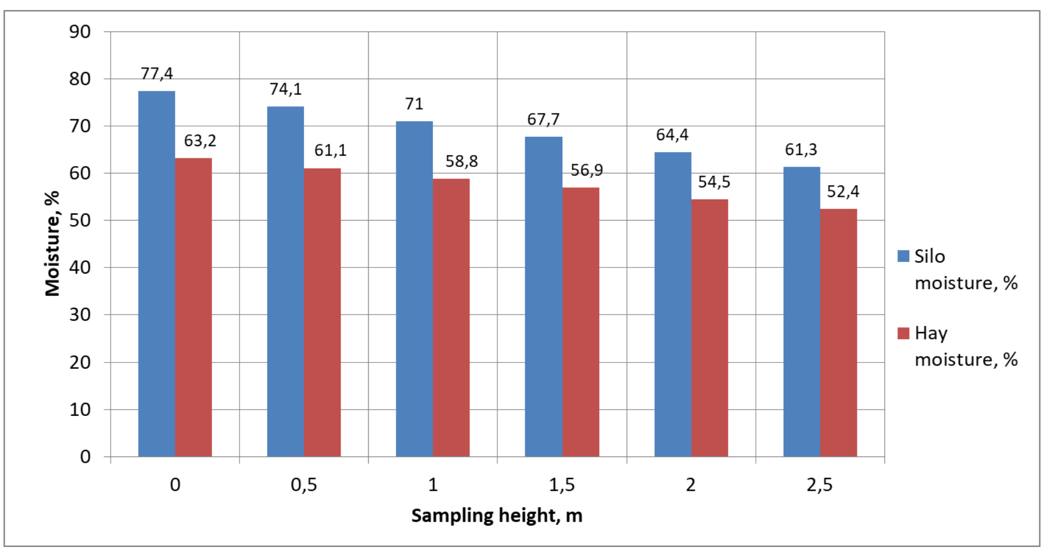


Fig. 6. Changes in feed moisture at bedding height

The density of the forage monolith was determined as follows: a 100 × 50 × 20 cm metal box without a bottom (volume 0.1 m^3) was placed on the compacted mass. Then the mass was chosen from its inner side until the box settled to the upper edge and weighed on a balance and the density was determined according to the well-known formula [11].

$\rho = \frac{m}{V}$, (8) where ρ – is the density of the silo, kg/m^3, m – is the mass of the cube, kg, V – is the volume of the cube, m^3.

The density of the stem feed, as well as the moisture, varies from the base to the upper layers of the feed, which can be seen from fig. 7.

When using a double knife [13], the change in the drive power of the cutting mechanism occurs according to the response surface shown in fig. 8. According to the dependences shown, the power of the double knife drive increases with increased feed rates, and with an increase in feed from 0.018 m/s to 0.028 m/s, the double knife drive power required to create an effective cutting force increases by more than 2.5 times.

At the same time, the research results of I.G. Pavlova testify that with an increase in the cutting speed (frequency of rotation of the drive motor) from 3 to 8 r/s, the level of the knife drive power can be reduced from 5,5 kW to 4,75 kW (at a feed rate of 0,028 m/s) [14].

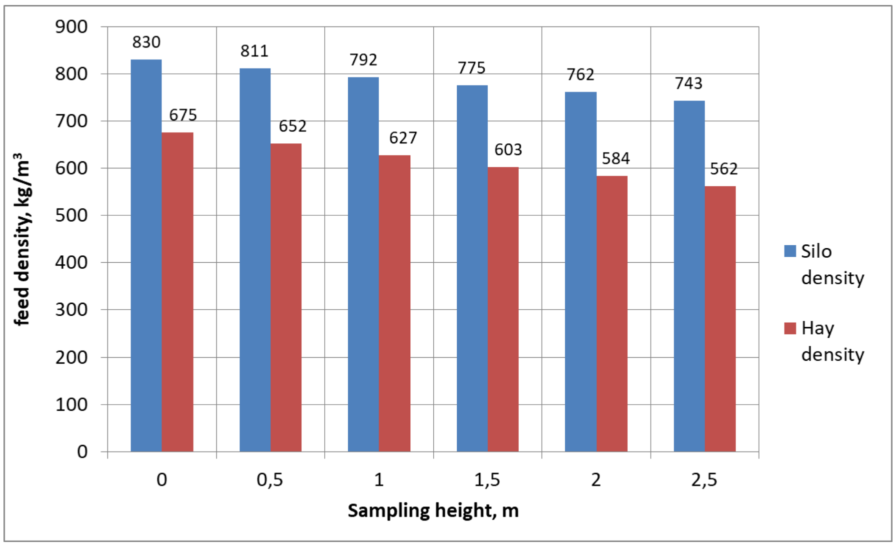


Fig. 7. Change in density of feed depending on the height of the storage

At the same time, the power of the double knife feed drive, while ensuring the rational performance of the stalk loader (feed rate 0,02 – 0,028 m/s), varies within 0,1 – 0,8 kW.

It should be noted that the required power according to the one shown in fig. 8 of the graph can be reduced to 2 kW depending on the feed rate and the rotation frequency.

The recommended operating modes of the mechanism for the separation of stalk feed provide for fixed values of the cutting speed and feed rate, in fact, without providing for a possible significant increase in cutting forces when corn rosettes and other inclusions of increased hardness fall under the knife (or changes in the physical and mechanical properties of feed along the height of occurrence). Obviously, it is these circumstances that are the reason for the increase by foreign manufacturers of the drive power of the cutting mechanism and the feed drive of the U – like frame. Their total capacity in machines manufactured by European leading firms is 20 to 25 kW.

The indicated fact of a significant excess of the power of the movers of the mechanisms for isolating the stalk feed over the theoretically and experimentally substantiated values of the required power of the movers indicates the need to improve the system of hydraulic drives of loaders. The direction of improvement should provide for the coordination of the regulation of the cutting speed and feed rate in order to stabilize the total power of these reasons, which will provide a significant energy-saving effect.

To reduce the energy consumption of the hydraulic drive system of the mechanism for separating stalk feed, the structure and construction principle of the hydraulic drive system was developed, which allow realizing the effect of a significant reduction in the power of the drive hydraulic motors by adapting their operating modes to the state of the technological system [15].

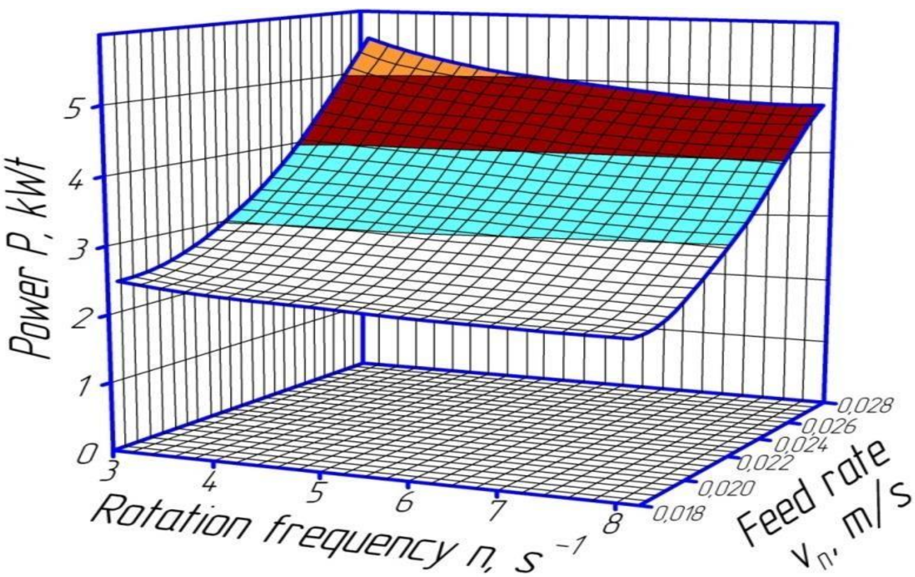


Fig. 8. Double knife drive power

A schematic diagram of the hydraulic drive system of the mechanism for separating stalk feed, developed according to the above, is shown in fig. 9.

The principle of operation of this system provides for the regulation of the U – like frame feed according to the change in the cutting force that acts on the cutting device, as a result of which the energy consumption for the separation of the block portion of the stalk feed is stabilized with fluctuations in the parameters that determine the characteristics of the cutting process.

The drive system of the mechanism for separating stalk feed contains a hydraulic tank 1, a safety valve 2, a hydraulic pump 3, a spool flow divider 4 with a control line 13, a controlled spool 12, a hydraulic motor 7, a high pressure hydraulic line 5,6, a three-line three-position valve with electrohydraulic control 8 , hydraulic cylinder 9, hydraulic drain lines 10, filter 11, check valve 17, throttle 16,18 and spring 14 (fig. 9).

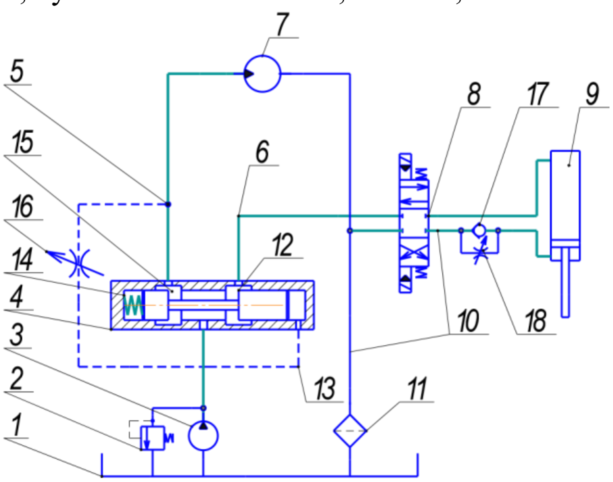


Fig. 9. Hydraulic diagram of the hydraulic drive system of the mechanism for separating stalk feed

The proposed use of a flow divider 4 between the cutting mechanism 7 and the feed hydraulic cylinder 9 makes it possible to coordinate a decrease in its feed with an increase in the load on the cutter, which in turn leads to a decrease in the cutting force (fig. 10). At the same time, this increases the supply of working fluid to the cutter bar drive hydraulic motor, which also helps to reduce the cutting force and the required power of the cutter bar hydraulic drive.

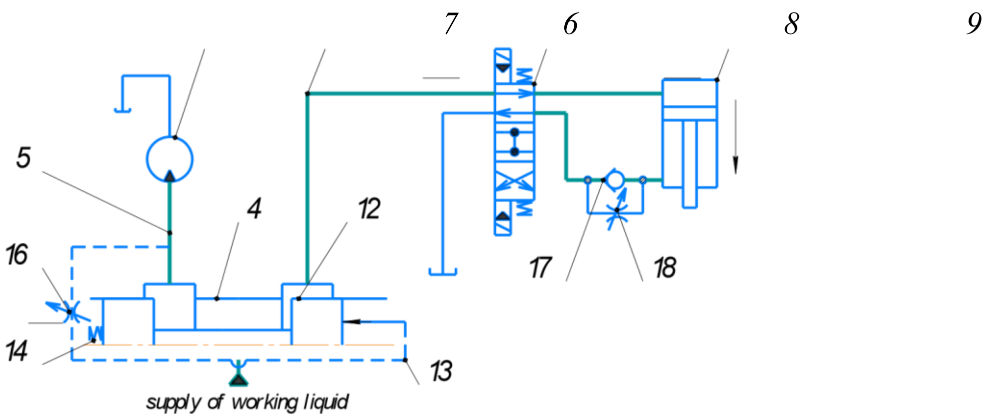


Fig. 10. Adjustment of giving at increase of the mechanism for separation on the cutting device of the loader of stalk forages

At the same time, as the cutting force decreases, the distributor reduces the supply of working fluid to the hydraulic motor of the cutting device and accordingly increases its supply to the hydraulic cylinder of the cutting drive, which allows to reduce the cutting force of the stalk feed monolith.

One of the effective tools for the implementation of this task is the reasonable application of modern calculation methods, optimal and automated design with further modeling of the main processes, as well as a multifactor experiment [16].

Figure 11 shows the obtained as a result of mathematical modeling of the adaptive system of the hydraulic drive of the mechanism for separation of stem forages using the software product MathCad.

Transients are calculated at the following initial values of parameters of system of hydraulic drives of the mechanism for separation of stalk forages: Q_n=2,38·10-4 m^3/s, a=0,5 mm; l_1=6 mm, l_2=2 mm; μ=0,62; p_0=10,0 MPa; ρ=850 kg/m^3; K=0,6·10^{-9} m^2/N, d_{zol}=27 mm; I=100 kg·m^2; m_{pr}=45 kg; β=2,5·10^3N·s; D_{ts}=63 mm; W_1= W_2= W_4=100 cm^3; W_3=25 cm^3; b_1=1 mm; b_2=2 mm; C_{pr}=0,5 N/mm.

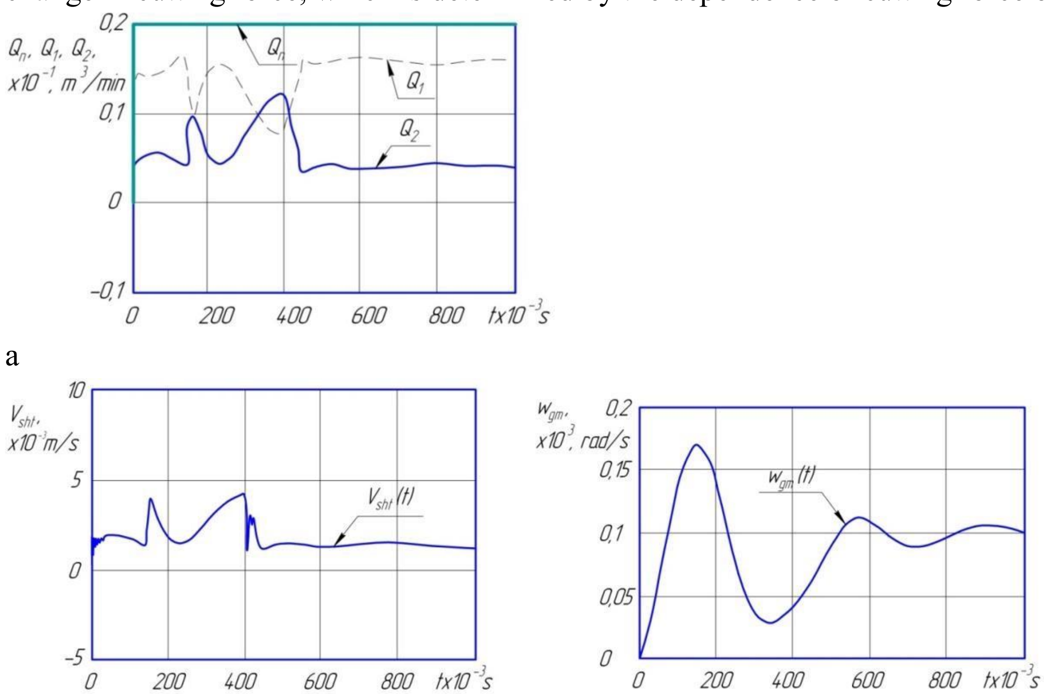
As a result of mathematical modeling of work of adaptive system of hydraulic drives of the mechanism for separation of stalk forages the possibility of adaptation of working bodies to conditions of their work is proved.

The transient process (fig. 11), which occurs when starting the adaptive hydraulic system of the block-batch separator, is completed fairly quickly. By four hundred milliseconds with access to stable values - the system works steadily. Moreover, in this case, the system of hydraulic actuators in the start-up process reaches the level of the value of the supply of working fluid to the hydraulic motor and the hydraulic cylinder of the supply U – like frame $Q_1 = Q_2 = 0.10 \times 10^{-1}$ m^3/min (fig. 11, a).

After loading the initial parts of the hydraulic motors with the cutting moment and the feed force for 400 ms, the transient process also has the character of damping, which indicates that the hydraulic drive system does not lose stability under load, but there is a change in fluid supply to the hydraulic motor $Q_1 = 0.16 \times 10^{-1}$ m^3/min. (increases by 50 %), and the supply of working fluid to the hydraulic cylinder of the feed drive U – like frame decreases to the value of $Q_2 = 0.05 \times 10^{-1}$ m^3/min, which corresponds to a decrease in the feed rate by 50 %. In this case, the angular velocity of the hydraulic motor shaft increases to the value of $\omega_{gm} = 0.1 \times 10^3$ rad/s (fig. 11, c), and the feed rate of the U – like frame decreases to $V_{sht} = 2.8 \cdot 10^{-3}$ m/s.

Thus, it is shown that in this case the possibility of implementing the principle of interconnected control of the parameters of the cutting mode – speed and feed of the cutting tool when changing the cutting force, which determines the load on the hydraulic motor shaft of the cutting tool. Reducing the supply of U – like frame while increasing the speed of the motor according to the laws that determine the cutting force on the cutting tool, should reduce the load on the drive motors and thus stabilize the value of power required to separate the block portion of the stem feed.

Proportional changes in the speeds of the working bodies – the hydraulic motor of the cutting device and the hydraulic cylinder of the drive U – such a frame, under certain conditions may not always provide a proportional change in cutting force, which is determined by the dependence of cutting force on cutting and feed speeds.



b c

Fig.11. Transient operation of the hydraulic drive system the mechanism for separation of stalk forages at change of loading on the cutting device: a – expenses of liquid which are consumed by the pump (Q_n), the hydraulic motor (Q_1) and the hydraulic cylinder (Q_2); b – changing the feed rate of the U-shaped frame by the hydraulic cylinder; c – change in the angular velocity of the hydraulic motor

Here we denote: Q_n – pump flow, a – width of the working edge of the controlled spool 12, l_1 – spool stroke to the right, l_2 – spool stroke to the left, μ – flow rate, p_0 – initial value of pump pressure, ρ – density of the working fluid, K is the coefficient of compressibility of the working fluid, d_{zol} is the diameter of the controlled spool, I is the moment of inertia on the hydraulic motor shaft, m_{pr} is the reduced mass, β is the coefficient of binding friction, D_{ts} is the diameter of the hydraulic cylinder, W_1, W_2, W_3, W_4 are the volumes of the system, b_1, b_2 – the distance to the stops that limit the movement of the spool, C_{pr} – the stiffness of the spring of the controlled spool.

Working bodies of agricultural machines requires further research, which should show directions for solving the problem of reducing the impact of load instability of the working bodies on the energysaving properties of agricultural machine drives.

4. Conclusions

Effective operation of the loader of stalk forages is possible only at the conditions of the maximum adaptation to technological process and physical and mechanical properties of the unloaded forage. Experimental studies of physico-mechanical and technological properties of feed monoliths allow to establish:

- with increasing height of the massif, the density of stem forages decreases (silage from 830 kg/m^3 in the base to 743 kg/m^3 at a height of 2,5 m and haylage from 675 kg/m^3 in the base to 562 kg/m^3 at a height of 2,5 m).
- humidity also varies from the height of the silage from 77 to 61 %, haylage from 63 to 53 %.

The power of the double knife drive increases with increased feed speeds, and when the feed increases from 0.018 m/s to 0.028 m/s, the power of the double knife drive required to create an effective cutting force increases more than 2,5 times.

Therefore at design of loaders of stalk forages it is necessary to consider physical and mechanical properties of forage as their change leads to disturbance and temporary overloads of hydraulic system of the loader; constructive executions of working bodies which directly influence power of a drive of the loader of stalk forages.

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