

CONSTRUCTION AND TECHNOLOGICAL PARAMETERS OF THE PROCESS OF REDUCING GREEN MASS OF ENERGY- AND RESOURCE-SAVING PRODUCTION OF LIVESTOCK PRODUCTS

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Legumes and leguminous crops, especially alfalfa, clover, amaranth, etc., should be considered the most promising from the point of view of providing animals with feed with a high protein content. One of the possible promising ways to solve this problem is the technology of fractional processing of alfalfa and other legumes. One of the important operations in this technology is the grinding of green mass. After all, the amount of green juice obtained - the raw material for the production of PVC (protein-vitamin concentrate) - depends on the length of the cut and the degree of splitting of the plant stems. A significant role is also played by the energy consumption of the process of grinding green mass. Among serial stationary machines for grinding fodder, only a few of them can perform the task with acceptable quality, productivity and energy consumption. When designing the technological line, the IKV-5A shredder was planned for the grinding operation. Conducting the first production tests on the functioning of the equipment for grinding green mass of alfalfa on the IKV-5A feed grinder confirmed the assumption that the degree of grinding has a significant effect on the yield of green juice. Thus, when the cutting length was reduced from 50 mm to 10 mm, the juice yield during further squeezing increased from 15% to almost 22%. But during the first tests, shortcomings in the operation of the IKV-5A shredder were also discovered. This shredder turned out to be too energy-intensive and unreliable in operation. The analysis of literary sources, our own experience proves that currently in Ukraine there are practically no technical means for successfully carrying out the grinding operation for the needs of the technology of fractional harvesting of leguminous herbs. A promising way to solve the problem of the implementation of the grinding operation within the framework of the technology of fractional harvesting of legumes is the development of our own machines that meet the set requirements, in particular, disintegrators with a vibration effect on the material during the grinding operation.

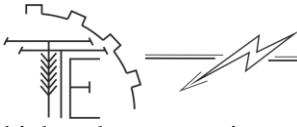
Key words: shredder, green mass, technology, process parameters, degree of grinding, productivity, energy consumption of the process.

Eq. 1. Fig. 4. Ref. 13.

1. Problem formulation

Sustainable development of animal husbandry and poultry farming in Ukraine is impossible without an adequate fodder base. Unfortunately, this problem remains unsolved for many years [1]. This especially applies to high-quality feed with a significant protein content and a high level of digestibility. Legumes and legumes, especially alfalfa, clover, amaranth, etc., should be considered the most promising from this point of view. The protein quality of these crops (higher fodder value, digestibility), especially alfalfa and amaranth, is much higher than similar indicators of forage crops [2]. The yield of digestible protein in legumes is much





higher than, even, in corn. In terms of 1 ha, soybeans have 2 times more digestible protein than corn, and amaranth and alfalfa have almost 3-3.5 times more.

It should be noted that not all "alfalfa proteins" reach animals [3]. Quite significant losses of feed nutrients on the way from the field to the cow's feeder become an obstacle. It should be noted that losses in the field exist not only during forage harvesting. Similar problems exist in almost all technologies of harvesting and post-harvest processing of agricultural plant products. For example, the same problem exists when collecting grass seeds, including alfalfa [4].

New approaches to the procurement of high-quality feed can solve this problem. In particular, one of the possible promising ways is the technology of fractional alfalfa processing [5]. This approach to the preparation of fodder allows you to reduce the loss of nutrients to a minimum and obtain several types of highly nutritious fodder.

To obtain the main type of fodder (protein-vitamin concentrate), it is necessary to carry out a number of technological operations, one of the main ones of which is the operation of grinding green plants. The yield of green alfalfa juice depends on the quality of the crushed mass, which is the basis for the production of protein and vitamin concentrate. Most of the machines for grinding green mass operating in Ukraine cannot provide the necessary parameters of the material for further processing. The main reason for this phenomenon is that these machines are made for grinding coarse fodder and cannot provide the required size of alfalfa parts. The purpose of this work is to consider possible options for implementing solutions to ensure the required quality of equipment for grinding the green mass of alfalfa and other leguminous herbs for the purpose of extracting green juice.

2. Analysis of recent research and publications

In the technology of fractional processing of alfalfa, the operation of grinding the green mass plays a special role. The amount of green juice obtained - raw material for the production of PVC (protein-vitamin concentrate) - depends on the length of the cut and the degree of splitting of the plant stems. A significant role is also played by the energy consumption of the process of grinding green mass. After all, the energy consumption of the grinding process is second only to the cost of heat treatment of pulp and green juice.

A number of works are devoted to the issue of energy consumption of the process of grinding green plants. So, for example, in [6], the issue of the influence of the parameters of the cutting elements on the value of the destructive force is considered. It was established that the greatest influence on the energy efficiency of the process has the sharpening angle of the disc knife blade and the sliding angle. The work [7] presents an analytical study on determining the required power for the drive of a drum shredder. It was concluded that the power to drive the drum depends on many factors, including the operating parameters of the equipment, the condition of the working organs, and the physical and mechanical properties of the plants. The works [8, 9] present studies of different orientations, but they are united by the study of one process - the grinding of green plants. If [8] is dedicated to the research of the narrow issue of grinding a separate crop, then in [9] the grinding process is considered quite broadly, the main regularities of the cutting process are defined there.

Works [10, 11, 12] are devoted to the issue of reducing energy costs for the implementation of the cutting process. Although they are devoted to different aspects of the study of the cutting process, they are united by one general idea - an effective reduction of the energy consumption of the process is possible under the condition of applying a vibrational effect on the material that is subject to the action of the working organs of the machine.

Analysis of recent research and publications shows that researchers have a certain interest in the process of grinding green plants. But a significant majority of them are dedicated to the narrow issue of chopping vegetables, fodder crops, corn stalks, etc. Issues of grinding the green mass of leguminous herbs are practically not found in recent publications. This once again shows that the technology of fractional processing of leguminous herbs is given much less attention than it deserves. Perhaps this is due to the fact that the implementation of this technology requires the involvement of a significant number of machines, rather complex equipment, the operation of which requires greater energy costs than "traditional" technologies for harvesting fodder. But it should be remembered that along with higher production costs, we will receive several types of feed with high energy potential and with almost complete absence of product losses.

This also applies to the technological process of grinding green plants. It is necessary to study in more detail the regularities of the grinding process with machines available in Ukraine, to develop a general methodology for selecting machines and their operational parameters.

3. The purpose of the article

The purpose of the work is to increase the efficiency of feed production of fractional harvesting of legumes by improving the process of grinding green plants at the stationary plant.



4. Results of the researches

In the technology of fractional processing of green mass of alfalfa with obtaining PVC, the grinding operation is performed at a stationary station with subsequent squeezing of the crushed mass. As a result of squeezing, green juice and pulp are obtained. These fractions are further processed in order to obtain high-quality fodder.

The successful performance of the next technological operation to remove green juice - the main raw material for the production of PVC - depends on the quality of the grinding operation. The grinding operation must provide the required degree of grinding without excessive grinding of the fibrous mass, as the yield of green juice depends on this. The working bodies of machines for grinding green mass perform their function by cutting, breaking, tearing, splitting, splitting, and abrasion.

The degree of grinding of the material is a function of many parameters and in general it can be represented by the following dependence:

$$S_p = f(Q, K, D, V), \quad (1)$$

where S_p – is the degree of grinding of the material; Q – material supply; K – physical and mechanical properties of the material; D – design parameters of the machine; V – mode parameters of the machine.

Each member of the right-hand side of dependence (1) is in turn a function of several parameters. For example, the physical and mechanical properties of the material include the moisture content of the material, its dimensional characteristics, fractional composition, strength characteristics, etc. Design and operational parameters of the machine depend on its type, design features, for example, the diameter and speed of rotation of the drum, or the number and size of hammers, etc.

To build mathematical models that describe the operation of a machine for grinding green plants, a certain number of experimental studies must be conducted. On their basis, relationships between the main factors that regulate process parameters can be established.

Among serial stationary machines for grinding fodder, only a few of them can perform the task with acceptable quality, productivity and energy consumption.

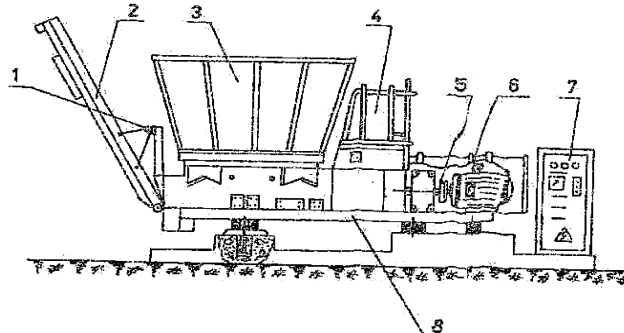


Fig. 1. Shredder IRT-F-80:

1 – lifter conveyor; 2 – inclined protractor; 3 – loading hopper; 4 – bridge for maintenance; 5 – drive shaft of the shredder; 6 – electric motor; 7 – electrical cabinet; 8 – frame.

A similar picture using the IHK-30 B roughage chopper (Fig. 2).

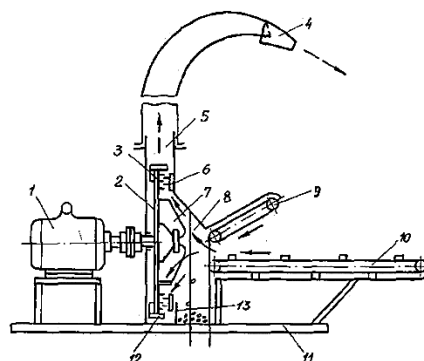
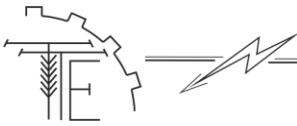


Fig. 2. IHK-30B roughage grinder:

1 – electric motor, 2 – disk rotor; 3 – rotor pins; 4 – flow guide; 5 – rotary reflector; 6 – fixed disk; 7 – rotor blades; 8 – reception chamber; 9 – sealing conveyor; 10 – feeding conveyor; 11 – frame; 12 – blades; 13 – reflector.



In work [5], the IKV-5A "Volgar-5" fodder grinder was recommended as a green mass shredder for fractional alfalfa harvesting technology (Fig. 3).

Conducting the first production tests on the functioning of the equipment for grinding green mass of alfalfa on the IKV-5A feed grinder confirmed the assumption that the degree of grinding has a significant effect on the yield of green juice. Thus, when the cutting length was reduced from 50 mm to 10 mm, the juice yield during further squeezing increased from 15% to almost 22%. This can be explained by the fact that when grinding on the IKV-5A, the plant stem is cut not only in the transverse, but also in the longitudinal direction.

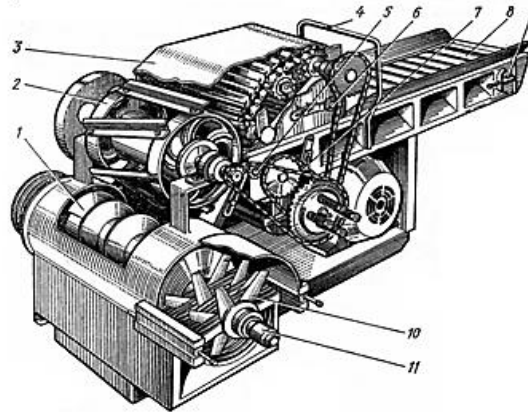


Fig. 3 Feed grinder IKV-5A "Volgar-5":

1 – screw; 2 – cutting drum; 3 – pressure conveyor; 4 – feed conveyor control mechanism; 5,6,7 – tension sprockets of chain gears; 8 – supply conveyor; 9 – secondary cutting apparatus; 10 – knives of the secondary cutting apparatus; 11 – automatic disconnection; 12 – electric motor.

Crushing the mass twice on the same unit does not significantly increase the yield of green juice compared to a one-time crushing, despite the greater number of destroyed cells. This can be explained by the fact that when squeezing the crushed mass, there is practically no structural skeleton that ensures the normal exit of juice through the capillaries.

This can be explained by the fact that when squeezing the crushed mass, there is practically no structural skeleton that ensures the normal exit of juice through the capillaries. This shredder turned out to be too energy-intensive and unreliable in operation. This shredder used a little more than 8 kWh of electricity to process 1 ton of green mass. In addition, almost 72% of the total downtime of the alfalfa fractional processing line falls on the shredder due to the imperfection of the secondary shredding device. The presence of only one IKV-5A shredder in the technological line cannot ensure uninterrupted operation of further equipment due to its insufficient performance.

Analysis of the operation of shredders in the technological line of fractional processing of alfalfa shows that it is necessary to continue the work on the development of new energy-efficient disintegrators that are able to ensure sufficient productivity and a high degree of destruction of plant cells. From this point of view, first of all, it is necessary to pay attention to the machines presented in works [10, 11, 12]. They declare a high degree of crushing of plants, in addition, the use of vibration will make it possible to significantly reduce energy costs for the implementation of the process.

It is also necessary to pay attention to a new series of machines manufactured in Ukraine for grinding various plant materials, for example, the VPZ-1000 grinder (Fig. 4).

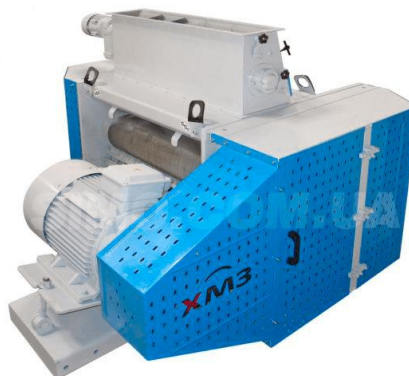
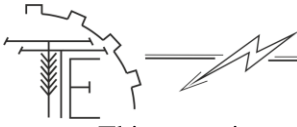


Fig.4 Shredder VPZ-1000



This operation can also be performed by imported machines, for example, the hammer mill presented in [13]. Unfortunately, along with obvious advantages, such as high reliability, productivity, quality of the obtained material, etc., this shredder, like almost all imported machines, has a significant drawback - a high price. It is this shortcoming that prevents us from currently recommending the use of such machines in the technology of fractional harvesting of legumes.

Therefore, for the practical implementation of this promising technology, it is necessary to carry out hard work on the creation of a domestic line of machines for the implementation of technological operations, first of all, the operation of grinding green mass.

5. Conclusions

1. One of the possible ways to reduce losses during forage harvesting is the implementation of fractional legume harvesting technology. All operations of this technology are performed at the hospital, which avoids field losses of nutrients.

2. The output of the main product of the technology - green juice - depends on the quality of the operation of grinding the green mass, in particular the length of the cut and the number of destroyed plant cells.

3. Analysis of literary sources, own experience proves that currently in Ukraine there are practically no technical means for successfully carrying out the grinding operation for the needs of the technology of fractional harvesting of leguminous herbs.

4. A promising way to solve the problem of implementing the grinding operation within the framework of the technology of fractional harvesting of legumes is the development of our own machines that meet the set requirements, in particular, disintegrators with a vibration effect on the material during the grinding operation.

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КОНСТРУКЦІЙНО-ТЕХНОЛОГІЧНІ ПАРАМЕТРИ ТА РЕЖИМИ РОБОТИ ПРОЦЕСУ ПОДРІБНЕННЯ ЗЕЛЕНОЇ МАСИ ЕНЕРГО- ТА РЕСУРСООЩАДНОГО ВИРОБНИЦТВА ПРОДУКЦІЇ ТВАРИННИЦТВА

Найперспективнішими з точки зору забезпечення тварин кормами з високим вмістом протеїну слід вважати зернобобові та бобові культури, особливо люцерну, конюшину, амарант та ін. Одним із можливих перспективних шляхів вирішення цієї проблеми є технологія фракційної переробки люцерни та інших бобових культур. Однією з важливих операцій у цій технології є подрібнення зеленої маси. Адже від довжини зрізу та ступеня розщеплення стебел рослини залежить кількість отриманого зеленого соку – сировини для виробництва ПВХ (білково-вітамінного концентрату). Значну роль відіграє також енергоємність процесу подрібнення зеленої маси. Серед серійних стаціонарних машин для подрібнення кормів лише деякі з них можуть виконати поставлене завдання з прийнятною якістю, продуктивністю та енергоємністю. При проектуванні технологічної лінії для операції подрібнення передбачався подрібнювач ИКВ-5А. Проведення перших виробничих випробувань функціонування обладнання для подрібнення зеленої маси люцерни на кормоподрібнювачі ИКВ-5А підтвердило припущення про істотний вплив ступеня подрібнення на вихід зеленого соку. Так, при зменшенні довжини різку з 50 мм до 10 мм вихід соку при подальшому віджиманні збільшився з 15% до майже 22%. Але під час перших випробувань були виявлені і недоліки в роботі подрібнювача ИКВ-5А. Цей шредер виявився занадто енергоємним і ненадійним в роботі. Аналіз літературних джерел, власний досвід свідчить, що на сьогодні в Україні практично відсутні технічні засоби для успішного проведення операції подрібнення для потреб технології дробового збирання бобових трав. Перспективним напрямком вирішення проблеми реалізації операції подрібнення в рамках технології фракційного збирання зернобобових культур є розробка власних машин, що відповідають встановленим вимогам, зокрема дезінтеграторів з вібраційним впливом на матеріал під час операції шліфування.

Ключові слова: подрібнювач, зелена маса, технологія, параметри процесу, ступінь подрібнення, продуктивність, енергоємність процесу.

Рис. 4. Літ. 13.

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