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B. Iegorov[1]**,** Dr. of Technical Sciences, Professor, E-mail: bogdanegoroff58@gmail.com,
https://orcid.org/0000-0001-7526-0315, ResearcherID: Q-1365-2015, Scopus Author ID: 56578802600
N. Khorenzhy[2]**, PhD., Associate professor, Candidate of technical science,** E-mail: natalka.onaft@gmail.com,
http://orcid.org/0000-0001-7912-4791 ResearcherID: B-3897-2016
[1]*Department of Feed and Biofuel Technologies*
[2] *Department of Grain Processing*
Odessa National Academy of Food Technologies, 112, Kanatna Str., Odessa, Ukraine, 65039

DETERMINATION OF THE INTERNAL POTENTIAL OF ENERGY EFFICIENCY IN COMPOUND FEED PRODUCTION

Annotation.

Grass flour is a unique protein-vitamin feed product, the role of which in animal feeding can hardly be overestimated. In 2010, the industry for the production of grass meal from alfalfa, for example, in Europe included 300 factories and 50 farms, which produced 4200 million tons of products. In Russia, the development of poultry and livestock farming has also increased the demand for this fodder and gradually restored its production. But in Ukraine, due to its high energy intensity, the production of herbal flour has almost ceased. It is shown that the fuel and energy balance of this technology that diesel fuel provides about 92.3% of all equipment needs for energy, and its cost is 90.8% of the total cost of all fuel and energy resources (FER). On the other hand, electricity accounts for only 7.7% of the total needs, and the costs of paying for it also serve 9.2% of the total costs of purchasing fuel and energy resources.

The purpose of the work is to study the energy feasibility of using extrusion for dehydration of wet feed products during their complex processing in feed products. To achieve this goal, the following tasks were solved: the selection and calculation of the necessary technological equipment for the principle technological scheme of the production of feed products with the inclusion of wet forage grasses was carried out; an energy audit of the basic (traditional) and new technologies for the production of compound feed products with the inclusion of forage grasses was carried out. Since the new technology is recommended to be implemented at feed mills of small capacity due to the proximity of raw materials, it must be able to process forage grasses in an amount no less than the basic technology for the production of grass meal. The minimum capacity of the ABM-type drying unit for cooking is 0.65 t/h for grass meal (2.7 t/h for raw materials). Thus, an energy audit of the basic (traditional) and new technology for the production of mixed feed products with the inclusion of forage grasses was carried out and proved that as a result of the use of the extrusion process for the purpose of dehydration, the new technology becomes more energy efficient in comparison with the traditional technology of drying forage grasses and further production of products with the inclusion of grass flour, which means it is economically feasible, since there is a total saving of fuel and energy resources of 875 MJ/t or - in the amount of 514.18 UAH (44%).

Key words: energy efficiency, electricity, fuel, fuel and energy resources, extrusion, compound feed, herbal meal.

Introduction

Despite the status of an energy-deficient country, Ukraine is one of the world leaders in terms of energy intensity of production. High energy costs for the production lead to a decrease in the competitiveness of the products obtained both in the domestic and foreign markets, a decrease in the level of economic and energy security of the country [1-3].

The constant rise in prices for electricity, fuel, gas forces the population and producers to resort to energy-saving measures. After all, it is known that the cost of implementing energy-saving measures is 2 - 3 times less than the cost of extracting energy resources or purchasing them [4, 5]. But the development and implementation of energy efficient technologies that would reduce their total energy intensity without reducing production volumes seems to be more urgent.

Analysis of literature data and problem statement

Grass flour is a unique protein-vitamin feed product, the role of which in animal feeding can hardly be overestimated. Grass flour production in the world began in the early 50s of the last century with the aim of producing a nutritious fodder alternative to hay or haylage, with minimal losses of nutrients and biologically active substances [6]. Now it has a permanent technology, the main stages and modes of which are almost the same throughout the world. The traditional method of obtaining granulated grass meal involves mowing leguminous grasses with a moisture content of more than 70% at the budding stage (cereals - at the stage of entering the tube) with simultaneous grinding, loading this mass into vehicles that supply it to the drying unit, high-temperature drying to the final moisture 9 - 12%, grinding, granulating and cooling [7-11]. Further use of this fodder agent in compound feed production is accompanied by its purification from impurities, grinding, dosing and mixing with other components, as well as, if necessary, granulation of loose compound feed.

In 2010, the industry for the production of grass meal from alfalfa, for example, in Europe included 300 factories and 50 farms, which produced 4200 million tons of products [12]. In Russia, the development of poultry and livestock farming has also increased the demand for this fodder and gradually restored its production [6]. But in Ukraine, due to its high energy intensity, the production of herbal flour has almost ceased.

In the industrial production of granulated grass flour, equipment is used, for example, of the following configuration: the Volgar-5A grinder, an AVM-1.5 R drying unit and a set of equipment for granulating OGM-

Table 1 - Fuel and energy balance of technology per unit of product

Fuel and energy resources (FER)	Conver-sion factor in kWh	Energy equivalent		% energy	Cost, UAH	% of the cost	Actual FER costs for evapo-ration of 1 kg of water, MJ	Specific cost UAH / MJ
		kWh	MJ					
Electricity	1	177	636	7,7	517*	9,2	-	0,812
Diesel fuel	11,7	2106	7582	92,3	5085*	90,8	3,79	0,671
Total		2751	8218	100	5602	100		

* The tariff for electricity for enterprises is 292 kopecks / kWh, for 1 liter of liquid fuel - 28.25 UAH

1.5 [13]. In this case, the specific consumption of electricity for its production is about 177 kWh/t or 636 MJ/t (with an initial moisture content of forage grasses of 70%). Moreover, the analysis of the structure of electrici ty costs shows that most of it, 66%, falls on the drying process [14]. But when drying, not only electricity is used as a source of energy, but also fuel. The fuel and energy balance of this technology (Table 1) shows that diesel fuel provides about 92.3% of all equipment needs for energy, and its cost is 90.8% of the total cost of all fuel and energy resources (FER). On the other hand, electricity accounts for only 7.7% of the total needs, and the costs of paying for it also serve 9.2% of the total costs of purchasing fuel and energy resources.

That is, the conducted fuel and energy balance of the technology for the production of granular herbal flour implies that the most expensive source of energy used in the drying process is fuel. The high market cost of fuel, combined with its growing share in the formation of the cost of finished products, leads to the economic inexpediency of restoring plants for the production of grass meal. Therefore, at one time, a scientific hypothesis was put forward that the technology of processing grass cutting in compound feed production will be energy efficient in terms of replacing the energy obtained from fuel with electric energy or avoiding the drying process altogether.

At the Odessa National Academy of Food Technologies, at the Department of Feed and Biofuel Technology, a new technological method for the production of feed products using wet feed products without their preliminary or subsequent drying has been proposed and scientifically substantiated, which reveals the resource reserves of the raw material base of feed production, including through forage grasses and green mass of cultivated plants, etc. [15]. In the new technology, the leading place belongs to the extrusion process, the task of which, in addition to increasing the feed value and disinfection, is also the dehydration.

The purpose of the work is to study the energy feasibility of using extrusion for dehydration of wet feed products during their complex processing in feed products.

To achieve this goal, the following tasks were solved:

-the selection and calculation of the necessary technological equipment for the principle technological scheme of the production of feed products with the inclusion of wet forage grasses was carried out;

-an energy audit of the basic (traditional) and new technologies for the production of compound feed products with the inclusion of forage grasses was carried out.

Research materials and methods

The determination of the energy efficiency potential is carried out through a comparative energy audit of innovative and basic technologies. It is based on calculating the amount of consumed energy, energy balance and comparing the values obtained in the study of the existing traditional technology for the production of grass flour, basic and new technologies for the production of feed products.

For this, proceeding from the principle flow diagram of the production of feed products, from the beginning we carry out the selection and calculation of the necessary technological equipment according to the methods given in [16].

At feed mills, energy consumption is recorded by fixing the amount of received energy carriers. Therefore, when carrying out an energy audit of the basic and unchanged section of the improved technology, we use the passport data of the equipment, and in the case of a new technology in the areas subject to changes - the data of experimental studies [17, 18].

Experimental production of samples and a pilot batch of loose and extruded feed concentrate of the developed composition [14] with the inclusion of cutting blue hybrid alfalfa in an amount of 20 %, dried to a moisture content of 70%, was carried out in accordance with the recommendations of the "Rules for organizing and maintaining the technological process of production of mixed feed industry "[19].

The technological process of extrusion of experimental feed samples was carried out in ONAFT at the Department of Feed and Biofuel Technology in an EZ-150 extruder (Bronto). The productivity of the extruder was determined by weighing the mass released from the outlet of the screw part of the extruder for 20 minutes. The result obtained, multiplied by 3, characterizes the hourly productivity of the installation. To bring the productivity to the nominal density of 750 kg/m^3, the obtained value of the productivity is multiplied by the coefficient determined by dividing the conditional density by the actual one. The capacity of the installation is determined under the condition that the current load of the main electric motor is 100%, the quality of the extruded product is satisfactory, and the temperature is correct. Before starting work, an ammeter and a wattmeter are connected to the extruder to determine the power characteristics. After starting, the press is brought to a mode in which its performance, process temperature and current load of the electric motor must correspond to the nominal value.

The power of the electric motor of the extruder was determined at intervals of 2 - 5 minutes by measuring the mains voltage, current consumption and power factor. The measurement of these quantities is carried out using a voltmeter, ammeter and phase meter, respectively [20]. Power is calculated by the formula:

$$N = U \cdot I \cdot \cos\varphi \quad (1)$$

де U – mains voltage, V;

I – consumed network current, A;

$cos\ \varphi$ – power factor.

The total installed power is calculated as the product of the power of the technological equipment electric motor by its quantity. A similar calculation is carried out for each of the technological lines and its results are used to calculate the specific consumption of electricity in energy and estimated terms for each of the technological lines. Specific electricity consumption in energy terms is determined by the formula:

$$N_{num} = \frac{\sum N}{Q} \quad (2)$$

where ΣN – total power consumption of electric motors of the equipment performing this operation, stage, etc., kW;

Q – productivity of the equipment (lines), kg / h.

Specific electricity consumption in estimated terms is calculated by multiplying the specific electricity consumption in energy terms by the current industrial electricity tariff. Next, the total electricity costs are calculated for the entire technology (basic and new) at actual humidity. For correct comparison and analysis of the obtained values, we list them on dry matter.

Research results

Since the new technology is recommended to be implemented at feed mills of small capacity due to the proximity of raw materials, it must be able to process forage grasses in an amount no less than the basic technology for the production of grass meal. The minimum capacity of the ABM-type drying unit for cooking is 0.65 t/h for grass meal (2.7 t/h for raw materials). For the design of the technological process, the selection and calculation of the necessary technological equipment for the basic and new technologies for the production of feed products, we take the capacity of 18 t/h. For the implementation of these technologies, according to the developed recipe, the lines given in table 2 are provided. [21-23].

To calculate the technological equipment for each of the technological lines, we take the following raw material costs: grain 60%, oil meals 15%, meals - 20%, forage grasses 15%, mineral raw materials 4%, premix - 1%, granulated grass flour - 5%. The final results of the selection and calculation of the required technological equipment are shown in Table 2.

Based on the data obtained, we determine the specific consumption of electricity in energy and estimated terms (Table 3).

Thus, the savings in electricity during the implementation of the new technology with the selected variant of the technological scheme in comparison with the base one are 84.6 kW•h/t or ~247.03 UAH/t of dry matter. However, in the basic technology, the production of grass meal is carried out by high-temperature drying, which uses diesel fuel. Therefore, in order to correctly compare the specific energy consumption of the basic and new technologies, a comprehensive technical and economic analysis of all fuel and energy resources was carried out (Table 4).

The technical and economic analysis of the fuel and energy resources costs showed that the elimination of the energy-intensive drying process even when using non-energy-intensive extrusion can significantly reduce the cost of fuel and energy resources. Fuel economy is 9 l/t (379 MJ/t), and electricity savings - 32 MJ/t (in terms of dry matter of compound feed) or in estimated terms - 252.25 UAH/t and 25.85 UAH/t, respectively.

Table 2 - Calculation of technological equipment

Technological line name	Line capacity, t/hour	Total installed capacity by technology			
		basic		new	
		kW	MJ	kW	MJ
Grain preparing line	10.0	151.4	545	151.4	545
Grain extrusion line	10.0	1603	5760.5	-	-
Oil meal preparing line	2.7	57.2	205.9	57.2	205.9
Preparing line of meal ingredients	3.6	2.2	7.9	2.2	7.9
Preparing line of mineral ingredients	0.72	23.5	84.6	23.5	84.6
Line of pelleted grass meal	0.9	24.2	87.1	-	-
Line of cut grass	2.7	-	-	26.1	94
Line mixtures of free-flowing components	15.3	-	-	23.5	84.6
Main dosing and mixing line	18.0	23.5	84.6	10	36
Compound feed pelletizing line	18.0	437.3	1574.3	-	-
Compound feed extrusion line	18.0	-	-	2193.7	7897.3

Table 3 - Comparative energy audit

Name of technological line	Specific electricity consumption for technology in terms of					
	energetic				estimated, UAH/t	
	basic		new		basic	new
	kW•h/t	MJ/t	kW•h/t	MJ/t		
Grain preparing line	15.1	54.5	15.1	54.5	44.09	44.09
Grain extrusion line	160.2	576.0	-	-	467.78	-
Oil meal preparing line	21.2	76.3	21.2	76.3	61.90	61.90
Preparing line of meal ingredients	0.6	2.2	0.6	2.2	1.75	1.75
Preparing line of mineral ingredients	32.6	117.5	32.6	117.5	95.19	95.19
Line of pelleted grass meal	26.9	96.8	-	-	78.55	-
Line of cut grass	-	-	9.7	34.8	-	28.32
Line mixtures of free-flowing components	-	-	1.5	5.5	-	4.38
Main dosing and mixing line	1.3	4.7	0.6	2	3.80	1.75
Compound feed pelletizing line	29.3	87.5	-	-	85.56	-
Compound feed extrusion line	-	-	121.9	438.7	-	355.95
Total for technology: At actual moisture content Based on dry matter	 282.4 320.9	 1015.4 1153.9	 203.2 236.3	 731.5 850.6	 838.62 952.98	 593.33 689.92

Table 4 - Feasibility study of fuel and energy resources, per 1 ton of dry matter

Production technology	Costs for fuel and energy resources in expression				
	energy, MJ		estimated, UAH		
	electricity	diesel fuel	electricity	diesel fuel	total
Grass flour	636	7582	517	5085	5602
Compound feed concentrates	1154	-	953	-	953
Total (compound feed with 5% grass flour)	1186	379	978,85	252.25	1231.1
Extruded feed concentrates (new)	689.92	-	689,92	-	689.92

Conclusions

Thus, an energy audit of the basic (traditional) and new technology for the production of mixed feed products with the inclusion of forage grasses was carried out and proved that as a result of the use of the extrusion process for the purpose of dehydration, the new technology becomes more energy efficient in comparison with the traditional technology of drying forage grasses and further production of products with the inclusion of grass flour, which means it is economically feasible, since there is a total saving of fuel and energy resources of 875 MJ/t or - in the amount of 514.18 UAH (44%).

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Б.В. Єгоров[1], д-р техн. наук, академік УНААН, професор, E-mail: bogdanegoroff58@gmail.com, https://orcid.org/0000-0001-7526-0315, ResearcherID: Q-1365-2015, Scopus Author ID: 56578802600
Н.В. Хоренжий[2], канд. техн. наук, доцент, E-mail: natalka.onaft@gmail.com, http://orcid.org/0000-0001-7912-4791, ResearcherID: B-3897-2016
[1]Кафедра технології комбікормів і біопалива
[2]Кафедра технології переробки зерна
Одеська національна академія харових технологій, 112, Канатна, Одеса, Україна, 65039

ВИЗНАЧЕННІ ВНУТРІШНЬОГО ПОТЕНЦІАЛУ ЕНЕРГОЕФЕКТИВНОСТІ У КОМБІКОРМОВОМУ ВИРОБНИЦТВІ

Анотація.

*Трав'яне борошно – унікальний білково-вітамінний кормовий засіб, роль якого в годівлі тварин важко переоцінити. У 2010 році індустрія виробництва трав'яного борошна з люцерни, наприклад, в Європі включала 300 заводів та 50 фермерських господарств, які виготовляли 4200 млн.т продукції. В Росії також розвиток птахівництва та тваринництва підвищив попит на цей кормовий засіб та поступово відновив його виробництво. Але в Україні внаслідок своєї високої енергоємності виробництво трав'яного борошна майже припинилось. Паливо-енергетичний баланс цієї технології показує, що дизельне паливо забезпечує біля 92,3 % всіх потреб обладнання в енергії, а його вартість складає 90,8 % від загальних витрат на всі паливно-енергетичні ресурси. На електрику ж припадає лише 7,7 % від загальних потреб, а витрати на її оплату становлять також 9,2 % від загальних витрат на придбання паливно-енергетичних ресурсів. В Одеській національній академії харчових технологій на кафедрі технології комбікормів і біопалива запропоновано та науково обґрунтовано новий технологічний спосіб виробництва комбікормової продукції з використанням вологих кормових засобів без їх попереднього або наступного сушіння, який розкриває резерви ресурсів сировинної бази комбікормового виробництва, у тому числі за рахунок кормових трав та зеленої маси культурних рослин, тощо. Мета роботи полягає у вивченні енергетичної доцільності застосування екструдування для зневоднення вологих кормових засобів при комплексній їх переробці в комбікормову продукцію. Для досягнення поставленої мети вирішені наступні **задачі**: проведено підбор та розрахунок необхідного технологічного обладнання для принципової технологічної схеми виробництва комбікормової продукції з включенням вологих кормових трав; проведено енергетичний аудит базової (традиційної) та нової технології виробництва комбікормової продукції з включенням кормових трав. Оскільки нову технологію рекомендовано реалізовувати на комбікормових підприємствах невеликої потужності через близькість сировини, вона повинна бути спроможною переробляти кормові трави в обсязі, не меншому ніж базова технологія виробництва трав'яної муки. Мінімальна продуктивність сушарного агрегату типу АВМ для приготування складає 0,65 т/год по трав'яній муці (2,7 т/год по сировині). Таким чином проведений енергетичний аудит базової (традиційної) та нової технології виробництва комбікормової продукції з включенням кормових трав доказав, що в результаті застосування процесу екструдування з метою зневоднення нова технологія стає більш енергоефективною у порівнянні з традиційною технологією сушіння кормових трав та подальшого виробництва продукції з включенням трав'яної муки, а*

значить і економічно доцільною, оскільки відбувається загальна економія ПЕР 875 МДж/т або - на суму 514,18 грн (44 %).

Ключові слова: енергоефективність, електроенергія, паливо, паливно-енергетичні ресурси, екструдування, комбікорм, трав'яна мука

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