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IMPROVEMENT OF THE DESIGN AND INVESTIGATION OF OPERATING MODES OF A ROTARY-DISC WOOD SHREDDER TO ENHANCE THE ENERGY EFFICIENCY OF BIOMASS COMMINUTION

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Today, about 3.5–4.0 million m³ of woody biomass is used for energy purposes, such as heating individual residential buildings and social facilities in rural areas with fuelwood, heat generation based on wood waste for technological processes and space heating at wood-processing enterprises, production of thermal and electrical energy at combined heat and power plants and municipal boiler houses, as well as the production of wood briquettes, pellets, charcoal, and synthesis gas.

An effective state policy in the field of woody biomass utilization will make it possible to additionally involve about 4.0 million m³ of energy woody biomass in the energy balance of Ukraine, which will contribute to reducing the country's energy dependence.

In recent years, there has been an intensification of private business activity in the field of energy use of wood, which indicates the economic attractiveness of this area, but at the same time creates risks of excessive competition due to the limited wood resources in Ukraine.

Thus, stimulating the rational processing of wood waste and the development of innovative technologies is a strategic task of the state and society aimed at increasing the efficiency of woody biomass utilization.

To improve the energy efficiency of the wood biomass comminution process, it is necessary to study the influence of design parameters, in particular the cutting angle and rotor rotational speed, on specific energy consumption and comminution quality.

The results of experimental studies showed that the optimal specific energy consumption at the level of 1.3 Wh/kg is achieved at a cutting angle of 32°44' and a rotor rotational speed of 1409 min⁻¹. Under these parameters, when using screens with a hole diameter of 0.019 m in the design of a rotary-disc wood biomass grinder, the formation of a particle size distribution of the comminuted material with particle sizes from 3.15 to 45.00 mm in the amount of 89.5% is ensured at a wood moisture content of 34.5%.

The obtained data make it possible to improve the design of the rotary-disc grinder and to substantiate optimal operating modes for reducing energy consumption in the process of wood biomass comminution.

Key words: *shredder, operating modes, rotary-disc, energy efficiency, quality indicators, shredding, woody biomass.*

Eq. 7. Fig. 7. Table. 1. Ref. 12.

1. Problem formulation

Today, the price of natural gas for some consumers in Ukraine has already been brought in line with market conditions, and in the near future it will become market-based for all gas consumers. This creates favorable economic prerequisites not only for the production but also for the consumption of woody biomass in the Ukrainian market, especially given the substantially lower quality requirements for this product in Ukraine compared with Europe. This situation will persist for several years at least, until Ukrainian standards regulating the quality of fuel wood biomass are adopted.

Therefore, the authors predict that, initially, chipped fuel wood biomass that does not meet European standards and cannot be sold in EU countries will be supplied to the domestic market at low prices. This will contribute to the formation of an alternative fuel market in Ukraine, which will later absorb a large share of the chipped woody biomass produced in the country. The above can be substantiated as follows. Forest resources in

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Ukraine are relatively limited, and under normal economic development all these resources–including energy wood in the form of sawmilling residues and logging residues–will be absorbed by the domestic market.

An important direction for increasing the volumes of woody biomass is the establishment of energy plantations of woody species, in particular willow. According to the materials of the 5th International Conference "Energy from Biomass," some willow varieties can yield an increment of up to 15 tonnes of air-dried woody biomass per hectare per year. However, this issue requires certain forestry and environmental groundwork. Therefore, the prerequisites for plantation cultivation, processing, and utilization of energy willow should be considered separately; the prospects in Ukraine are enormous.

The most important aspect determining the prospects and efficiency of using wood residues is the technical and technological support of both their processing and their generation.

Until recently, Ukraine relied mainly on imported equipment for the production and consumption of wood biofuels. Therefore, a major positive development is that several domestic enterprises already manufacture inexpensive and high-quality equipment both for sawmilling and for processing sawmill residues into wood chips, briquettes, and pellets, as well as boilers for burning these types of biofuels.

Despite the growing need to use woody biomass efficiently as an alternative energy source, scientific research aimed at improving the designs of rotor–disc shredders and optimizing their operating modes remains insufficiently developed. Of particular relevance is improving the energy efficiency of the comminution process by reducing power consumption and enhancing the design and technological characteristics of the shredder's working units.

An analysis of existing technical solutions indicates the absence of a systematic approach to substantiating and regulating key parameters such as knife geometry and positioning, the feed angle of woody raw material, rotor rotational speed, material capture depth, and others. These parameters significantly affect energy consumption, comminution quality, wear of cutting-mechanism components, and the reliability and durability of the equipment. Special attention should be given to small household shredders used in private households, where energy efficiency, ease of operation, affordability, and environmental safety are paramount.

At the same time, most studies focus on general aspects of woody biomass processing or on analyses of industrial installations, whereas a scientific substantiation of the parameters of rotor–disc cutting systems specifically in the context of shredding woody branches is virtually absent. As a result, there is a need for comprehensive studies aimed at developing and improving shredder designs, determining rational operating regimes, and forming scientifically grounded recommendations for parameter adjustment to achieve an optimal balance of energy saving, productivity, and comminution quality.

In addition, our research can be integrated into the overall strategy for the harmonious development of agriculture in Ukraine, which is aimed at increasing the environmental sustainability of agricultural products [1, 2].

2. Analysis of recent research and publications

In the study by Karwandy Y. [3], the technological process and technical means used for the production of fuel material under industrial conditions in the province of Saskatchewan (Canada) are described. At the same time, it should be noted that technological solutions applied in industry differ significantly from the conditions of wood-fuel production in the private sector, in particular in individual household farms. In this context, Campbell C. [4] provides a technical and economic justification of the needs of farms and small enterprises that are interested in producing and marketing agropellets from biomass. Despite the relevance of this technology, the authors note that under the conditions of an individual household farm, for example in Poltava region, there is a shortage of agricultural woody biomass required for the sustainable production of fuel pellets.

The innovative technical solution proposed by Vargula L. [5] involves developing a wood shredder design capable of continuous operation. The author considers the possibility of using wood chips as a biomass source for biogas, composting, and waste-incineration plants, as well as using large wood fragments as a solid fuel for central heating systems in individual residential buildings. This technology of integrated wood processing (chips + firewood) can be adapted to the conditions of private households in Ukraine. At the same time, the design characteristics of wood shredders require further improvement to ensure efficiency under conditions of small-scale mechanization.

In order to identify optimal combinations of design and technological parameters for processing various types of woody raw materials (hard and soft roundwood, branches), Krajnc M. [6] conducted a series of experimental studies using a drum-type shredder. The topic of these studies is highly relevant, as it предусматриє the possibility of further adapting the results to designs with a disc comminution system [7]. In turn, the results obtained by Wegener Y. [8] indicate that the wood cutting angle significantly affects energy consumption during the comminution process, which highlights the importance of considering this parameter when designing shredding mechanisms.

Despite the above-mentioned studies, it should be stated that the issues of scientifically substantiating the main parameters of rotor–disc cutting systems in woody biomass shredders remain insufficiently investigated. In particular, there is a lack of comprehensive research aimed at determining optimal, adjustable design and technological parameters and assessing their impact on the energy efficiency of shredder operation. This is especially relevant for small household models, whose performance largely depends on their settings.

3. The purpose of the article

The aim of this study is to improve the energy efficiency of the woody biomass comminution process by enhancing the design of a rotor–disc shredder and optimizing its operating modes, taking into account the influence of design and technological parameters on energy consumption and comminution quality.

Research objectives:

– To analyze modern designs of rotor–disc shredders and assess their energy efficiency when processing woody biomass under private household conditions.

– To substantiate the feasibility of improving the shredder design with regard to the specific features of woody biomass processing.

– To develop a structural model of a rotor–disc shredder with the ability to adjust key technological parameters (feed angle, rotational speed, etc.).

– To conduct experimental studies to identify the influence of design and operating parameters on the energy consumption of the woody biomass comminution process.

– To determine rational operating modes of the shredder that ensure minimum energy consumption while maintaining the required quality of the comminuted material.

– To develop recommendations for implementing the improved rotor–disc shredder in private households in order to ensure energy-efficient processing of wood residues.

4. Results and discussion

Experimental studies aimed at identifying the patterns of changes in the energy and quality performance indicators of a small-sized mobile woody biomass shredder, developed in the laboratory of the Faculty of Engineering and Technology of Poltava State Agrarian University, were conducted (Fig. 1) [9].

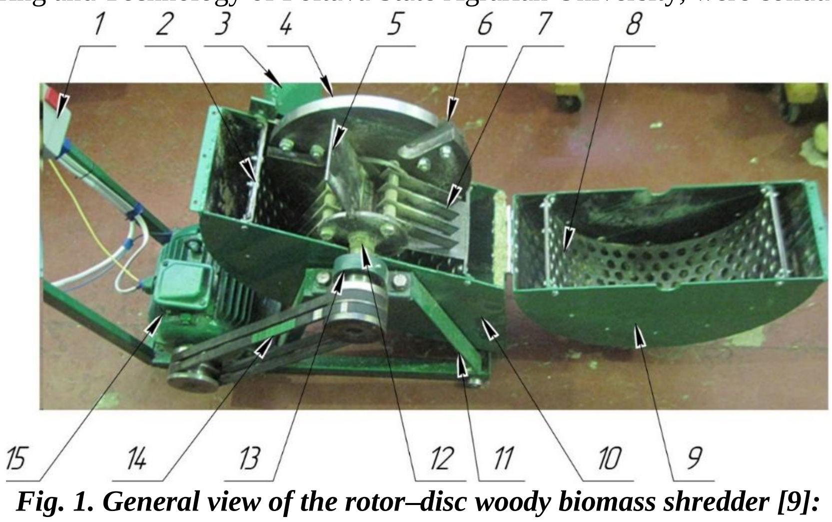


Fig. 1. General view of the rotor–disc woody biomass shredder [9]:
1 – control panel; 2 – screen mounting bar; 3 – feed hopper; 4 – knife mounting disc; 5 – fan blades; 6 – cutting knife; 7 – shredding hammers; 8 – screen; 9 – upper casing; 10 – lower casing; 11 – frame; 12 – working shaft; 13 – support bearing; 14 – V-belt drive; 15 – electric motor.

Preparation of the rotor–disc woody biomass shredder for conducting experimental studies includes the following operations:

1. First, prepare the material for shredding: sort it by diameter (it must not exceed 80 mm), remove any metal inclusions, and arrange the material pieces by length (they must not exceed 1.5 m).
2. Next, prepare the shredder for operation:

- check the fastening of the machine units, verify completeness, and inspect its technical condition;

- pay special attention to the correct fastening of the knives (6) on the working disc (4) (they must be installed according to the disc rotation direction);
- check the correct installation of the screen and the fixation of the screen (8) in the upper (9) and lower (10) casings;
- lubricate the bearings (13);
- check the insulation of the power cable and the reliability of the grounding wire connection;
- check the tension of the V-belts of the V-belt drive;
- check the reliability of the bolted connection between the upper and lower casings;
- place the machine on a flat horizontal surface.

3. The third stage includes:

- be sure to use personal protective equipment (safety glasses, hard hat, hearing-protection earmuffs, and rubber footwear).
- check the presence and serviceability of the protective guards on the V-belt drive..

The rotor–disc woody biomass shredder operates as follows (Fig. 1). The shredder is connected to the power supply and allowed to run for a period of time to accelerate the working disc to the заданої rotational speed. The material to be shredded is then fed into the загрузочный chute 3. The knife 6 cuts part of the material and throws it into the screen compartment, where the particles are further comminuted by the hammers 7. The blades 5 provide a circular motion in the direction of rotor rotation. Sliding over the screens 8, the comminuted particles are sieved by the airflow to the required fraction size. Due to the airflow, the material is discharged through the machine chute.

During the experiments, the influence of the working disc rotational speed and the cutting angle on electric power consumption was determined. At the second stage, the quality of the shredded material was assessed.

Let us present all stages of the multifactor experiment used to study the optimal parameters of the rotor–disc woody biomass shredder.

1. Choose the objective, optimization parameters, and independent factors. When conducting a multifactor experiment, an interpolation problem is formulated–i.e., it is necessary to establish only the existing relationship between the optimization parameter and the factors.

The technological process of woody biomass comminution in a rotor–disc shredder is influenced by the following controllable parameters (factors): *a* – cutting angle, degrees; *n* – rotational speed of the machine's working disc, s^{-1}.

The technological process of woody biomass comminution is also influenced by the following non-controllable parameters: *W* – moisture content of woody biomass; *T* – density of woody biomass; *t* – temperature of woody biomass.

The output (response) variables in woody biomass comminution are:

1) *W* – specific energy consumption during woody biomass comminution;
2) *R* – percentage of comminution uniformity of woody biomass.

Thus, many factors influence the processes in a rotor–disc woody biomass shredder. In experiment planning, only controllable factors are taken into account. To eliminate the influence of uncontrollable factors, the experiments are randomized. The number of optimization parameters is reduced to one (specific energy consumption during comminution, *W*), while parameter *R* is treated as a constraint.

2. Collection and analysis of a priori information about the technological process of woody biomass comminution. It was established that specific energy consumption during comminution is most strongly affected by two factors: *a* – cutting angle and *n* – rotational speed of the machine's working disc.

3. Selection of a mathematical model. When the course of the process inside a "black box" is unknown, the analytical expression of the response function is also unknown. Therefore, the response function is described by a regression equation of the form [9]:

$$y = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i=j}^{n} b_{ij} x_i x_j + \sum_{i=1}^{n} b_{ii} x_i^2 \quad (1)$$

where x_i and x_j are the coded values of the factors; b_0 is the intercept term, equal to the response at $x_i = 0$; b_i is the regression coefficient of the corresponding factors for the object under study; b_{ij} is the regression coefficient of the pairwise interaction of the corresponding factors.

With two factors $x_1 = d$ and $x_2 = n$, the regression equation takes the form:

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_{1.2} x_1 x_2 + b_1 x_i^2 \quad (2)$$

The coefficients of the regression equation are calculated from the experimental results. The magnitude of the regression coefficients and the sign ± characterize the given factor and its influence on the optimization parameter.

4. Develop a scheme for conducting the research. When planning, the method of a full factorial experiment (FFE) is used [10]. Construction of the FFE design: two levels of factor variation are adopted and denoted as "+1" and "−1" (see Table 1).

Table. 1

Investigated factors in actual values.

Levels	Investigated factors	
	Cutting angle *a*, degrees	Rotational speed of the working disc, *n*
Coded designation	X_1	X_2
Upper x=+1	50	1820
Lower x=-1	20	1410
Variation interval	30	1410

The combinations of experimental conditions are determined using an exponential function $N = 3^n$, where n is the number of factors [10]. Conducting the experiment.

In accordance with the compiled working matrix (taking into account randomization of the trials), the experiments are carried out in triplicate. The value of the optimization parameter obtained in each trial is recorded in the working matrix.

5. The processing of the research results is performed using statistical methods and regression analysis.

a) The regression coefficients of the mathematical model are calculated using the:

$$b_0 = \frac{\sum_{u-1}^{n} \overline{y_u}}{n}, \quad (3)$$

$$b_0 = \frac{\sum_{u-1}^{n} \overline{x_{iu}} \cdot \overline{y_u}}{n}. \quad (4)$$

For the mathematical model, the coefficients are determined: $b_0, b_1, b_2 mab_{1.2}$.

b) Substitute the obtained values of the regression coefficients into the equation:

$$y = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + b_{1.2} \cdot x_1 \cdot x_2 + b_1 \cdot x_1^2 \quad (5)$$

We verify the reproducibility of the experiments, assess the significance of the regression coefficients, and also check the adequacy of the linear model using established methods [10].

Research results. Laboratory studies were carried out using a rotor–disc woody biomass shredder (Fig. 2).

a ***b*** ***c***

Fig. 2. Photographs of material shredding using the developed machine: a – tree branches; b – rotor–disc shredder; c – shredded products

The dependence of the specific energy consumption of the rotor–disc woody biomass shredder on the cutting angle and the rotational speed of the working disc was investigated. The moisture content values of the materialnduring the laboratory studies are shown in Fig. 3.

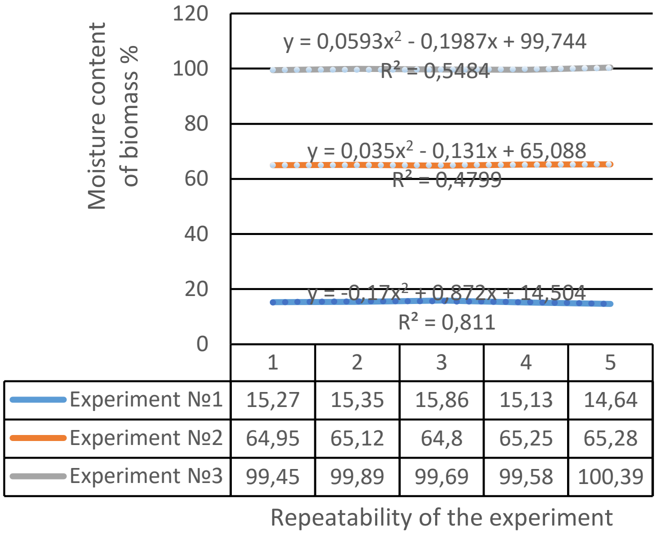


Fig. 3. Results of determining the moisture content of the material under laboratory conditions

After processing the statistical data on the specific energy consumption of the rotor–disc woody biomass shredder obtained during the laboratory studies, it became possible to describe the technological process by an equation for determining the specific energy consumption of the rotor–disc woody biomass shredder. After converting the parameters from coded values to actual (natural) values, the regression equation took the following form:

$$W = 0{,}3333 + 9{,}4202 \cdot d - 0{,}0006 \cdot n + 496{,}8833 \cdot d^2 - 0{,}0172 \cdot d \cdot n + 2{,}9145 \cdot E \cdot n^2 \quad (6)$$

where W is the specific energy consumption of woody biomass comminution, Wh/kg; a is the cutting angle, degrees; n is the rotational speed of the shredder working disc.

The obtained equations were analyzed using the Statistica software package. A graphical interpretation of the dependence of the specific energy consumption of the rotor–disc woody biomass shredder on the rotational speed of the working shaft is presented in Fig. 4.

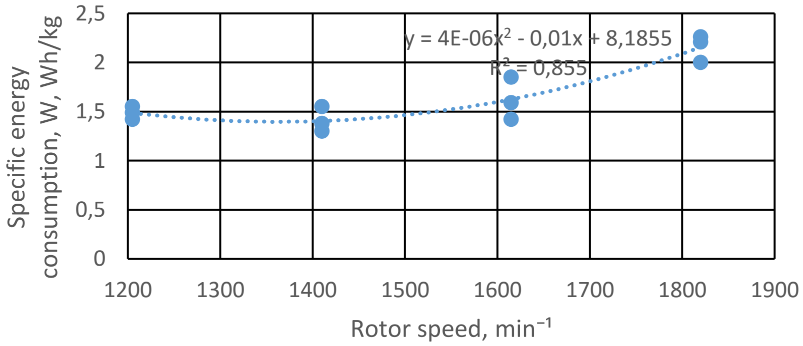


Fig. 4. Dependence of the specific energy consumption of the rotor–disc woody biomass shredder on the rotational speed of the working shaft.

A graphical interpretation of the dependence of the specific energy consumption of the rotor–disc woody biomass shredder on the cutting angle is presented in Fig. 5.

According to the analysis of variance of the regression equation, the model adequately describes the operation of the rotor–disc woody biomass shredder and makes it possible to determine the value of the optimization criterion for different values of the factors.

The optimal values of the specific energy consumption of the woody biomass comminution process varied within the range of 1.0 to 1.6 Wh/kg (Figs. 4, 5), provided that the rotational speed of the working shaft was set within 1350 to 1450 min^{-1} and the cutting angle (defined as the inclination angle of the hopper feed opening) within 27° to 33°.

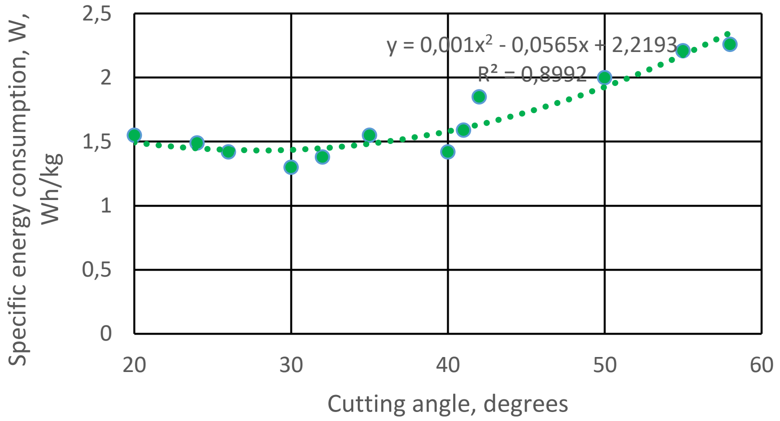
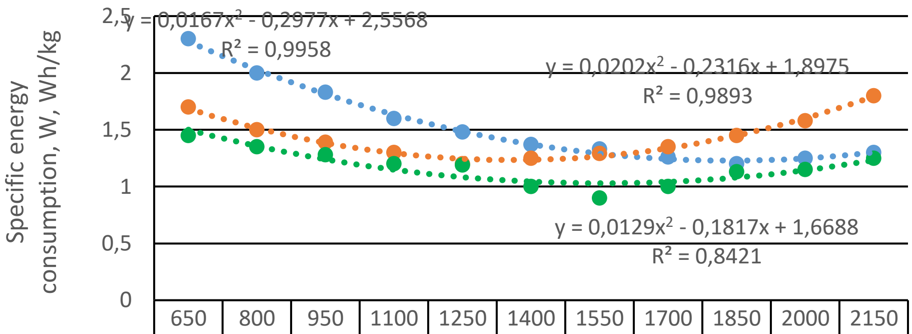


Fig. 5. Dependence of the specific energy consumption of the rotor–disc woody biomass shredder on the cutting angle

The analysis of the experimental data indicates that the influence of the cutting angle on changes in specific energy consumption is insignificant. This is explained by the fact that when the inclination angle of the hopper opening increases, the feeding intensity of the branches into the working chamber decreases; as a result, the amount of material being processed simultaneously is reduced, which in turn lowers energy consumption per unit mass.

The results of the study of the quality indicators of woody biomass comminution show that when a screen with smaller-diameter holes is used, a longer circulation time of the material in the working chamber is required. Changing the rotor rotational speed leads to changes in the kinematics of particle motion in the working chamber: the velocity and ejection angle of particles from the rotor blade change, as do the trajectory from the point of leaving the rotor blade to the point of impact on the surface of the deck impactor, and the angle at which the particle collides with the impactor surface. All these changes affect the nature of the comminution process, influencing the number of collisions of particles with the rotor blades and deck impactors and, accordingly, the number of material circulation cycles within the working chamber.

An analysis of the dependence $W = a(n)$ (Fig. 6) at заданих values of d and n showed that for screens with hole diameters of $d = 0.01$ m and $d = 0.02\ m$, the optimization criterion has a minimum that lies within the factor variation range.



	650	800	950	1100	1250	1400	1550	1700	1850	2000	2150
The value of W at D = 0.01 m, α = 32°44'	2,3	2	1,83	1,6	1,48	1,37	1,33	1,26	1,2	1,25	1,3
The value of W The value of W at D = 0.02 m, α = 32°44'	1,7	1,5	1,39	1,3	1,2	1,25	1,29	1,35	1,45	1,58	1,8
The value of W at D = 0.03 m, α = 32°44'	1,45	1,35	1,28	1,2	1,19	1	0,9	1	1,13	1,15	1,25

Rotor speed, min^{-1}

Fig. 6. Graphs of the dependence of specific energy consumption for woody biomass comminution on the rotational speed nnn of the working disc of the rotor–disc shredder:
blue line – W values at $D = 0.01\ m$, $\alpha = 32°44'$;
yellow line – W values at $D = 0.02\ m$, $\alpha = 32°44'$;
green line – W values at $D = 0.03\ m$, $\alpha = 32°44'$.

For the screen with d = 0,03 m, the value of the optimization criterion within the factor variation range decreases as the rotor rotational speed increases; its minimum value corresponds to $n = 1550\ \mathrm{min}^{-1}$. Nevertheless, for the screen with $d = 0.01$ m, there is a minimum at $n = 1850\ \mathrm{min}^{-1}$ outside the investigated range. This minimum was determined under the assumption that the obtained model remains valid at higher rotor rotational speeds. For the screen with $d = 0.02$ m, the value of the optimization criterion within the factor variation range decreases with increasing rotor speed; its minimum value corresponds to $n = 1409\ \mathrm{min}^{-1}$.

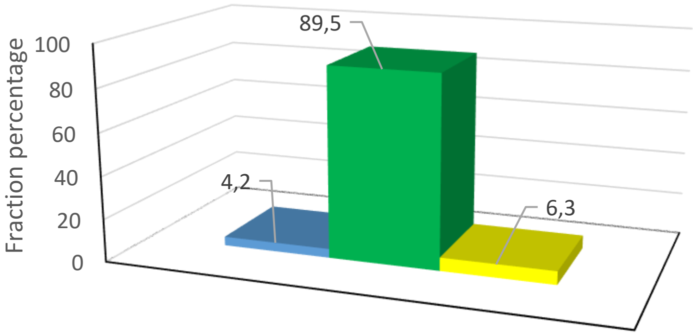
To determine the minimum values of the optimization criterion, the function $W = a(n)$ was analyzed for an extremum. The points at which the specific energy consumption is minimal are determined by the formula:

$$d = \frac{0{,}0061467 - 0{,}000001416 \cdot n}{0{,}21985}, \qquad (7)$$

where d is the diameter of the screen holes, m; n is the rotational speed of the working disc of the woody biomass shredder.

As a result of solving the equation, by substituting the minimum value $n = 1409\ \mathrm{min}^{-1}$ from the graph (Fig. 4) of the dependence of the specific energy consumption of the rotor–disc woody biomass shredder on the rotational speed of the working shaft, we obtain:

Analyzing the processed results of the particle-size distribution of the comminuted woody biomass, it should be noted that the highest percentage of the fraction that meets the requirements of DSTU EN 15234-4:2013 [11] is 89.5%.



	Fraction size
the size of crushed particles is less than 1 mm., %	4,2
the size of crushed particles ranges from 3.15 mm to 45.00 mm., %	89,5
the size of crushed particles is greater than 45.00 mm., %	6,3

Figure 7. Histogram of the particle-size distribution of the comminuted biomass

The quality of fuel wood biomass is determined mainly by its particle-size distribution and moisture content, which affect both the efficiency of material use and the stability of transportation and combustion processes. According to the requirements of DSTU EN ISO 17225-4:2022 [11], the main quality criterion for fuel wood chips is ensuring maximum uniformity of the particle-size distribution, which implies minimizing the content of excessively large and overly fine particles. The uniformity of the size of comminuted woody biomass is essential for ensuring uninterrupted conveying of the material by mechanical transport systems, in particular screw and belt conveyors used in boiler plants. In the case of significant non-uniformity of comminuted woody biomass, the risk of blocking the working parts of machines with large elements increases, which may lead to disruption of the technological process.

Therefore, ensuring a uniform particle-size distribution of the comminuted woody biomass and preventing the entry of large fragments are key conditions for improving the quality of both the fuel material and the shredded feedstock. Taking into account the results of theoretical calculations and experimental data, the lowest specific energy consumption–1.3 Wh/kg–was achieved at a cutting angle of $32°44'$ and a rotor rotational speed of $1409\ \mathrm{min}^{-1}$. Under these parameters, provided that screens with a hole diameter of 0.019 m are used in the design of the rotor–disc woody biomass shredder, the particle-size distribution of the comminuted material with particle sizes from 3.15 mm to 45.00 mm is 89.5% at a wood moisture content (walnut species) of 34.5%.

5. Conclusion

1. An analysis of modern rotor–disc woody biomass shredder designs was carried out; based on the results, the main development trends were identified and energy-efficiency indicators under private household conditions were evaluated.
2. The feasibility of improving the shredder design with regard to the specific features of woody biomass comminution was substantiated. By installing screens with a hole diameter of 0.019 m in the design of the rotor–disc biomass shredder, the particle-size distribution of the comminuted material in the range from 3.15 mm to 45.00 mm will be 89.5% at a wood moisture content (walnut species) of 34.5%. The proposed improvement increases the efficiency of processing woody biomass into a заданої fraction of comminuted material.
3. A structural model of a rotor–disc shredder was developed, providing the ability to adjust key technological parameters, in particular the material feed angle, knife protrusion, and rotor rotational speed.
4. Experimental studies were conducted to evaluate the influence of design and operating parameters on the energy consumption of the woody biomass comminution process. It was found that the optimal specific energy consumption ranged from 1.0 to 1.6 Wh/kg (Figs. 4, 5), provided that the working shaft rotational speed was set within 1350 to 1450 min^{-1} and the cutting angle (defined as the inclination angle of the hopper feed opening) within 27° to 33°.
5. Rational operating modes of the shredder were determined, ensuring minimum energy consumption while maintaining the required particle-size distribution quality of the comminuted material. The lowest specific energy consumption of 1.3 Wh/kg is achieved at a cutting angle of $32°44'$ and a rotor rotational speed of $1409\ min^{-1}$.
6. Practical recommendations were developed for implementing the improved rotor–disc shredder in private households to increase the energy efficiency of woody biomass processing.
7. The results showed that reducing the diameter of the screen holes requires increasing the material circulation time in the working chamber. Changes in rotor speed affect the kinematics of particle motion, including their velocity, ejection angle, and trajectory to the impactor, which determines the nature of comminution and the number of collisions in the working zone. The established relationships indicate the need for further research to optimize the woody biomass comminution process.

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УДОСКОНАЛЕННЯ КОНСТРУКЦІЇ ТА ДОСЛІДЖЕННЯ РЕЖИМІВ ЕКСПЛУАТАЦІЇ РОТОРНО-ДИСКОВОГО ПОДРІБНЮВАЧА ДЛЯ ПІДВИЩЕННЯ ЕНЕРГОЕФЕКТИВНОСТІ ПОДРІБНЕННЯ ДЕРЕВНОЇ БІОМАСИ

Сьогодні близько 3,5–4,0 млн куб. м деревної біомаси використовується для енергетичних потреб, таких як опалення індивідуальних житлових будинків і соціальних об'єктів у сільській місцевості паливними дровами, тепло генерації на основі відходів деревини для технологічних процесів та опалення на деревопереробних підприємствах, виробництво теплової та електричної енергії на ТЕЦ і комунальних котельнях, а також виробництво деревних брикетів, пелет, деревного вугілля і синтез-газу.

Ефективна державна політика у сфері використання деревної біомаси дозволить додатково залучити до енергетичного балансу України близько 4,0 млн куб. м енергетичної деревної біомаси, що сприятиме зниженню енергетичної залежності країни. В останні роки спостерігається активізація приватного бізнесу у галузі енергетичного використання деревини, що свідчить про економічну привабливість цього напряму, але водночас породжує ризики надмірної конкуренції через обмеженість ресурсів деревини в Україні. Таким чином, стимулювання раціональної переробки деревних відходів та розвиток інноваційних технологій є стратегічним завданням держави і суспільства, спрямованим на підвищення ефективності використання деревної біомаси.

Для підвищення енергоефективності процесу подрібнення деревної біомаси необхідно вивчити вплив конструктивних параметрів, зокрема кута різання та частоти обертання ротора, на питомі енергозатрати та якість подрібнення.

Результати експериментальних досліджень показали, що оптимальне питоме енергоспоживання на рівні 1,3 Вт·год/кг, досягається за кута різання 32°44' та частоти обертання ротора 1409 хв⁻¹. За таких параметрів, при використанні у конструкції роторно-дискового подрібнювача деревної біомаси решіт із діаметром отворів 0,019 м, забезпечується формування гранулометричного складу подрібненого матеріалу з частками розміром від 3,15 до 45,00 мм у кількості 89,5% за вологості деревини 34,5%..

Отримані дані дозволяють удосконалити конструкцію роторно-дискового подрібнювача та обґрунтувати оптимальні режими його експлуатації для зниження енергоспоживання у процесі подрібнення деревної біомаси.

Ключові слова: *подрібнювач, режими експлуатації, роторно-дисковий, енергоефективність, якісні показники, подрібнення, деревна біомаса.*

Ф. 7. Рис. 7. Табл. 1. Літ. 12.

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