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INVESTIGATION OF THE BEET PULP FILTRATION DRYING KINETICS

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Abstract. The article describes the results of experimental studies of the kinetic regularities of beet pulp drying by the filtration method. The influence of the main process parameters on the rate of moisture removal, including the height of the wet layer of material H (0.04 m, 0.08 m, 0.12 m, 0.16 m), temperature T (60 °C, 70 °C, 80 °C, 90 °C) and the velocity of the thermal agent v_0 (1.24 m/sec, 1.76 m/sec, 2.29 m/sec, 2.82 m/sec), was investigated. The kinetic dependencies for the periods of complete and partial saturation of the thermal flow with moisture were derived. This allows us to describe the change in the material moisture content and duration of the filtration drying process. Verifying of the accuracy of the obtained dependencies presents a maximum relative error of 36.54 % and an average deviation of 8.46 %, which is acceptable for practical calculations of drying equipment.

Keywords: biomass, secondary raw materials, beet pulp, filtration drying, kinetics.

1. Introduction

The reuse and recycling of secondary raw materials are essential for ensuring sustainable development and the rational use of natural resources. These processes help to reduce the burden on the environment by reducing the amount of waste that goes to landfills and reducing greenhouse gas emissions. The use of recycled materials also reduces the need for primary resources, which reduces pressure on ecosystems and contributes to the preservation of biodiversity. In addition to environmental benefits, recycling also has economic benefits, as it creates new jobs and promotes the development of innovative technologies in the field of waste processing and utilization.

One of the most important types of secondary raw materials is food production waste, such as beet pulp, which is a valuable resource for further use. Its recycling and reuse can significantly reduce waste and provide additional economic benefits, which emphasizes the importance of integrating such waste into the sustainable development system (Muir, Anderson, 2021).

Beet pulp is a feed stock waste from sugar beet production that is formed after the juice is removed from beet shavings, and makes up the bulk of sugar production waste. One ton of beets may produce approximately 130 kg of sugar and 50 kg of dried pulp on a dry weight basis (Misra, Shrivastava, 2022). In 2023, the volume of sugar beet harvest in Ukraine was ≈10 million tons, which indicates a significant amount of secondary raw materials that will be generated during the processing of the material (Ministerstvo ahrarnoyi polityky ta prodovolstva Ukrainy, 2023).

Beet pulp is an important type of secondary raw material due to its high organic content (Zheng et al., 2013). This makes it a valuable resource for various industries, contributing to the rational use of waste and reducing the burden on the environment. In

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particular, beet pulp can be used in the feed industry to feed animals (Semenova et al., 2013; Joanna et al., 2018), and can be used for bioethanol production (Mojovic et al., 2009; Gumienna et al., 2014). Another promising area of beet pulp use is the production of alternative solid fuels (Zarringhalam-Moghaddam et al., 2011; Zanjani et al., 2013).

One of the main problems with the use of beet pulp is its high moisture content, which is approximately 80 % (Dygas et al, 2023). This moisture content makes it difficult to transport and store the pulp, as well as limits its effectiveness in various areas of application. High moisture content leads to additional handling and processing costs, so dehydration of beet pulp is critical to ensure its efficient use.

It is proposed to dry beet pulp by the filtration drying method, which has shown high efficiency compared to the rotary drum dryer widely used in the industry (Mujumdar, 2014; Thibault et al., 2010) on the example of similar secondary organic raw materials of plant origin (Ivashchuk et al., 2024, a).

The hydrodynamics of the thermal agent movement through a stationary layer of the material was previously studied (Ivashchuk et al., 2024, b). The results obtained will allow us to predict the hydraulic resistance of a material layer of different heights and the necessary pressure drop to ensure the course of the drying process. In addition, it is also important to study the kinetic regularities of filtration drying, which will make it possible to determine the intensity and duration of the material dehydration process. The total experimental data obtained allows us to evaluate the overall efficiency of filtration drying for drying beet pulp and increases the economic feasibility of processing, which would lead to a reduction in the negative impact on the environment.

2. Experimental part

The object of the study was the beet pulp obtained on the production line of a local sugar plant in Lviv region, Ukraine (Fig. 1).

In accordance with the methodology given in (Ivashchuk et al., 2021), the initial parameters of the research object were experimentally determined, including the initial moisture content of the beet pulp 88.12 % wt. and its bulk density 432.36 kg/m^3.

Fig. 1. The beet pulp obtained in the result of drying

The beet pulp was dried to the equilibrium moisture content by the filtration method in an experimental installation, the principle of operation and schematic diagram of which are described in detail in (Ivashchuk et al., 2024, c). The analysis of the kinetics of filtration drying of plant material, as well as the development of generalizing equations for estimating the intensity and duration of this process, was carried out in accordance with the theoretical foundations and methods described in (Ivashchuk et al., 2024, c).

3. Results and Discussion

To evaluate the efficiency of the filtration drying process of the beet pulp, experimental studies were conducted to determine the effect of the main process parameters on the rate of moisture removal from the material. These parameters include the height of the stationary layer of material H, the temperature of the thermal agent T, and the velocity of the thermal agent filtration flow v_0. At the same time, two of the three parameters remained unchanged for each series of experiments, which made it possible to assess the impact of individual factors on drying efficiency.

As a result of the study, it was obtained the kinetics curves that show the nature of the change in the moisture content of the beet pulp layer over time at different values of the material layer height (Fig. 2), thermal agent flow temperatures (Fig. 3), and different flow velocities across the wet material layer (Fig. 4).

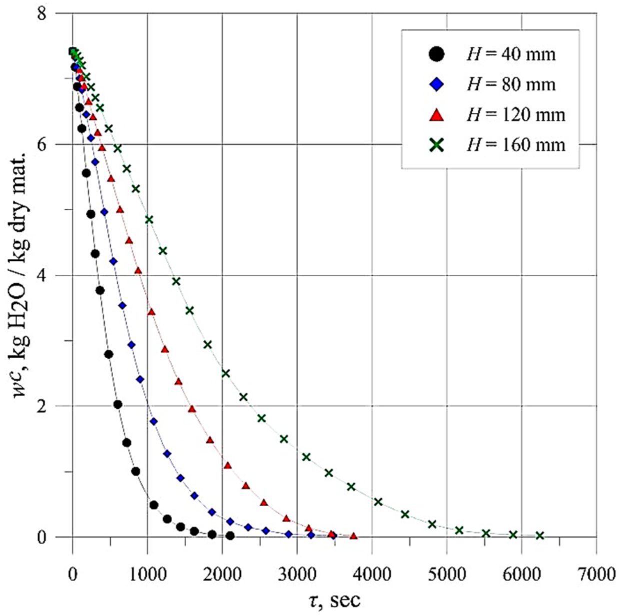

Fig. 2. Filtration drying kinetic curves of changes in the moisture content of the beet pulp at different heights of the stationary layer over time

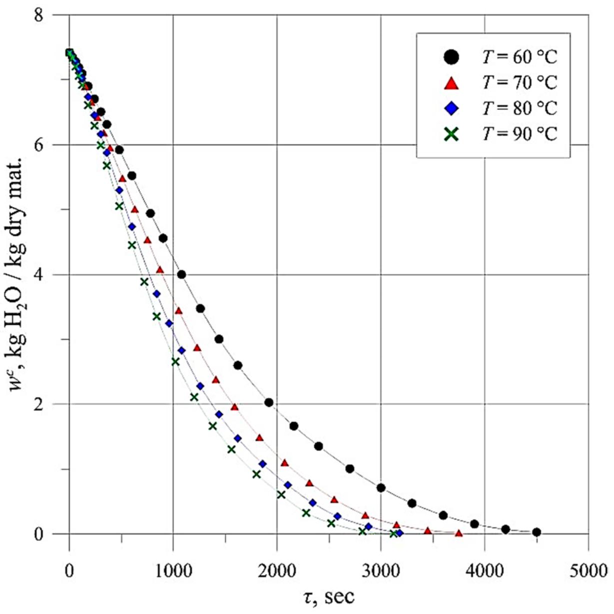

Fig. 3. Filtration drying kinetic curves of changes in the moisture content of the beet pulp at different temperatures of the thermal agent flow over time

Analyzing the obtained kinetic curves, it may be seen that the drying time of beet pulp increases with a decrease in the height of the wet layer, an increase in the temperature and velocity of the thermal agent. It is also worth noting that for the thermal agent filtration flow velocities of 1.76 m/sec, 2.29 m/sec, and 2.82 m/sec, there is virtually no difference in the intensity of the beet pulp drying by the filtration method, indicating that the process takes place in the internal diffusion region (Fig. 4). In view of this, for further calculations, a flow velocity of 1.76 m/sec was taken into account as a common point for other series of experiments.

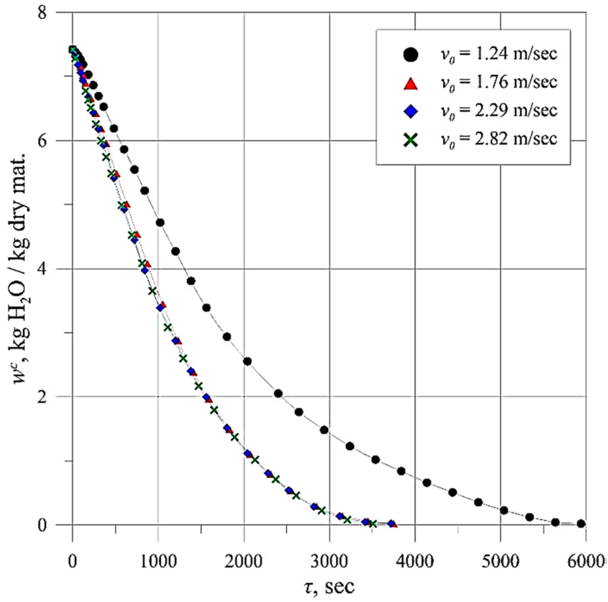

Fig. 4. Filtration drying kinetic curves of changes in the moisture content of the beet pulp at different flow velocities of the thermal agent over time

In addition, the equilibrium moisture content w^c_e of the beet pulp was determined, which varies depending on the temperature of the thermal agent and is 0.031, 0.023, 0.015, and 0.009 kg H□O/kg dry material for the studied temperatures of 60 °C, 70 °C, 80 °C, and 90 °C, respectively.

To determine the value of the critical moisture content w^c_{cr} and the time of its establishment τ_{cr}, a graph-analytical method (Ivashchuk et al., 2024, c) was used for each of the series of experiments (Figs. 5–7). The obtained numerical values of the desired parameters of the beet pulp drying process are given in Table 1.

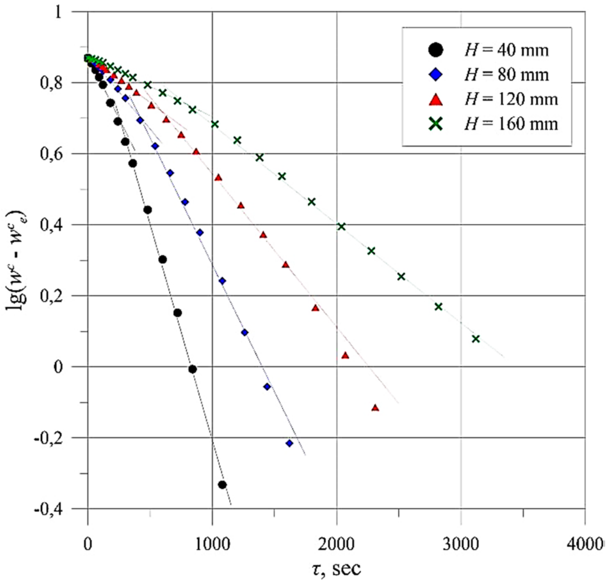

Fig. 5. Graphical determination of the beet pulp critical moisture content and time of its achievement at different heights of wet material for the filtration drying process

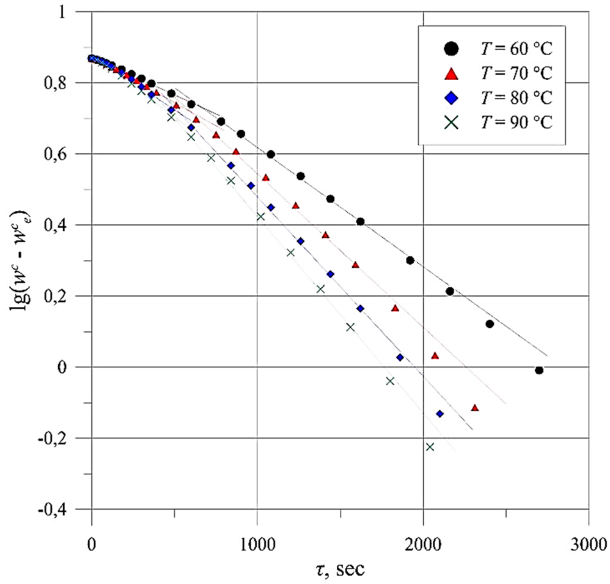

Fig. 6. Graphical determination of the beet pulp critical moisture content and time of its achievement at different temperatures of the thermal agent for the filtration drying process

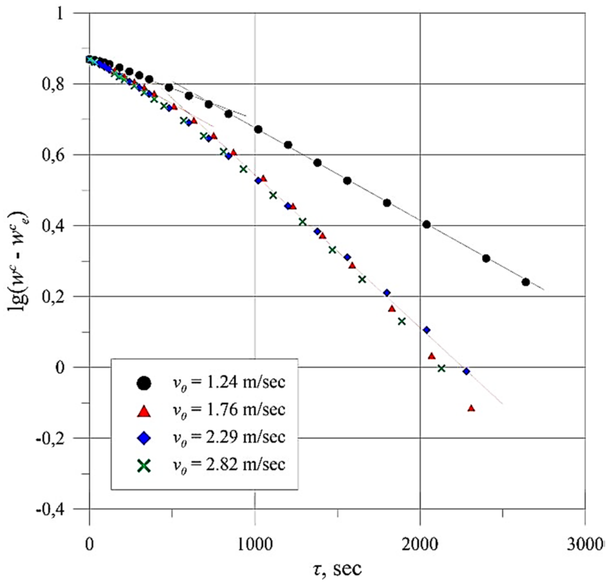

Fig. 7. Graphical determination of the critical moisture content and the time of its achievement at different thermal agent velocities for the filtration drying process

Table 1

The results of the graph-analytical determination of the beet pulp critical moisture content w^c_{cr} and its establishment time τ_{cr} for the filtration drying process

H, mm	T, ˚C	v_0, m/sec	lg $(w^c – w^c_e)$	w^c_{cr}, kg H_2O / kg dry material	τ_{cr}, sec
40	70	1.76	0.689	4.910	250
80			0.704	5.081	410
120			0.72	5.271	580
160			0.739	5.506	790
120	60		0.731	5.414	660
	80		0.709	5.132	520
	90		0.706	5.091	470
	70	1.24	0.748	5.621	730

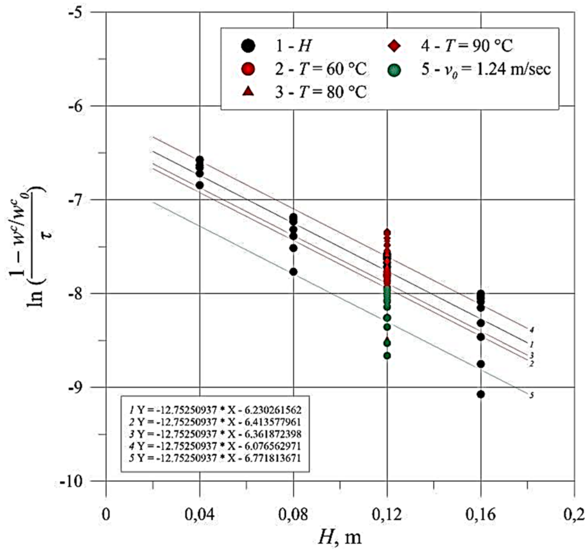

Fig. 8. Graphical determination of the coefficients a and η of the kinetic equation for the period of complete saturation of the thermal agent with moisture for the beet pulp filtration drying

Evaluation of the kinetic characteristics of the filtration drying process of the beet pulp under the conditions of the period of complete saturation of the thermal agent with moisture can be performed by determining the kinetic coefficients a and η. This is achieved by constructing a graph of the dependence ln $((1 – w^c/w^c_0)/\tau)$ = f (H) shown in Fig. 8 (Ivashchuk et al., 2024, c).

The numerical values of the graphically determined kinetic coefficients a and η are given in Table 2.

Based on the data from Table 2, the coefficients $A = 6.159\cdot10^{-5}$, m = 0.61, n = 1.547 were calculated according to the methodology given in (Ivashchuk et al., 2024, c). The values of the kinetic coefficients allow us to obtain a dependence to describe the intensity of the process of filtration drying of beet pulp for the first conditional period of drying:

$$w^c = w^c_0 \cdot (1 - 6.159 \cdot 10^{-5} \cdot T^{0.61} \times$$
$$\times v_0^{1.547} \cdot \tau \cdot e^{-12.753 \cdot H}). \qquad (1)$$

In order to summarize the intensity of the beet pulp drying in the second conditional period of drying, graphical dependencies were built that allow us to determine the drying coefficient K (Fig. 9–11).

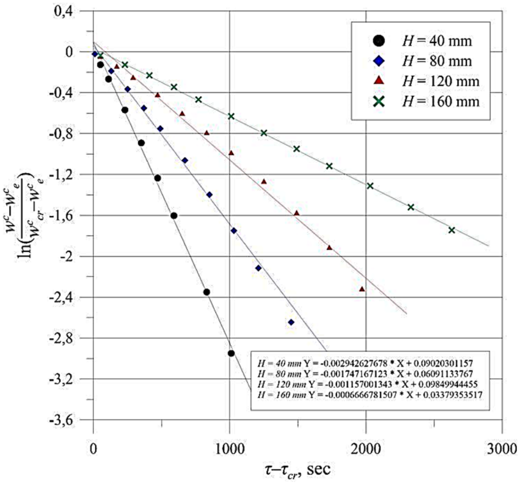

Fig. 9. Graphical determination of the drying coefficient K at different material layer heights of the beet pulp filtration drying

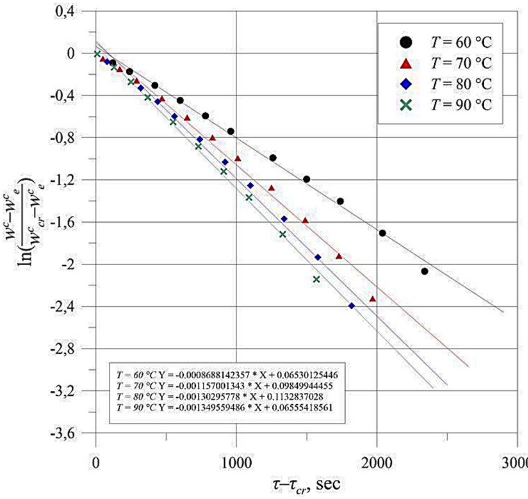

Fig. 10. Graphical determination of the drying coefficient K at different temperatures of the thermal agent filtration flow of the beet pulp filtration drying

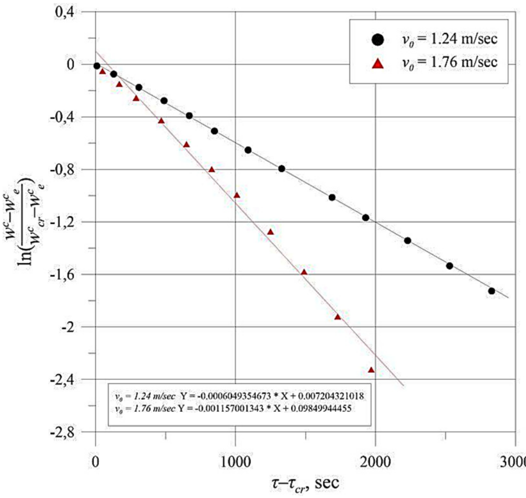

Fig. 11. Graphical determination of the drying coefficient K at different flow velocities of the thermal agent filtration of the beet pulp filtration drying

Table 2

The influence of the process parameters of filtration drying of beet pulp on the kinetic coefficients a and η

No. of the line	H, mm	T, ˚C	v_0, m/sec	a, 1/m	ln(η)	η, 1/sec
1	40	70	1.76	12.753	- 6.230261562	0.001968937
	80					
	120					
	160					
2	120	60			- 6.413577961	0.001639149
3		80			- 6.361872398	0.001726132
4		90			- 6.076562971	0.002296055
5		70	1.24		- 6.771813671	0.001145615

To determine the influence of the drying rate N on the drying coefficient K during the filtration drying of the beet pulp in the period of partial saturation of the thermal agent with moisture, a graphical dependence (Fig. 12) was constructed based on the previously obtained values given in Table 3.

Table 3

Influence of filtration drying parameters of the beet pulp on K and N coefficients

H, mm	T, ˚C	v_0, m/sec	K, 1/sec	N, kg H_2O / kg dry matter
40	70	1.76	0.002942627678	0.010026422
80			0.001747167123	0.005694835
120			0.001157001343	0.003698370
160			0.0006666781507	0.002418176
120	60		0.0008688142357	0.003033987
	80		0.00130295778	0.004392905
	90		0.001349559486	0.004947946
	70	1.24	0.0006049354673	0.002528948

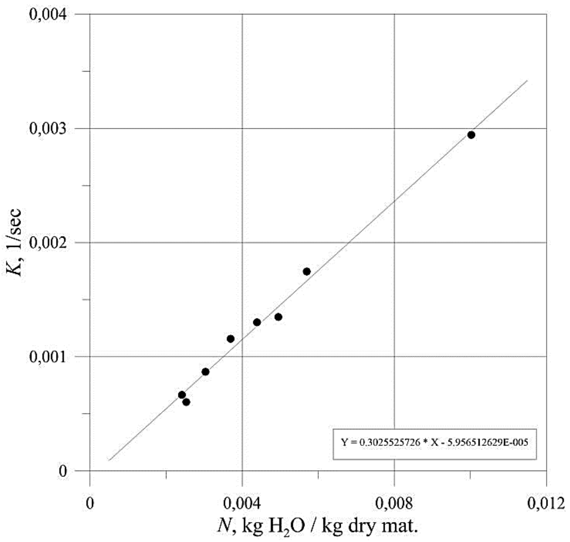

Fig. 12. Determination of the drying rate N influence on the drying coefficient K during filtration drying of the beet pulp

The relative drying coefficient of the studied material is determined by the tangent of the line slope (Ivashchuk et al., 2024, c) and is χ = 0.303 kg H_2O ⁄ kg dry material.

Thus, based on the determined coefficient, a kinetic dependence was obtained that would be valid for the second conditional period of the filtration drying of the beet pulp:

$$w^c = (w^c_{cr} - w^c_e) \cdot e^{-0.303 \cdot N \cdot (\tau - \tau_{cr})} + w^c_e. \quad (2)$$

To verify the accuracy of the obtained mathematical models (1) and (2), it was analyzed the graphical distribution of errors (Fig. 13) between the experimental and calculated values according to the dependencies. The maximum deviation of the calculated values from the experimental values was 36.54 %, and the average deviation was 8.46 %.

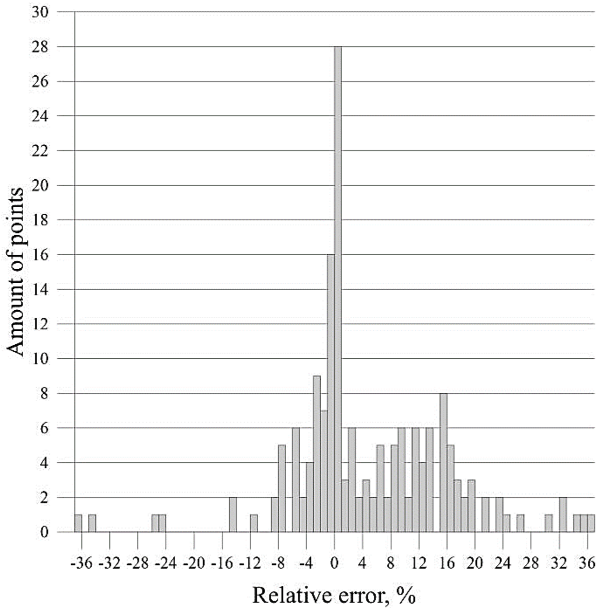

Fig. 13. Graphical distribution of the deviation between the experimental data and theoretically calculated data for the filtration drying of the beet pulp

Based on the experimentally obtained dependencies (1) and (2), the process time can be expressed. This will make it possible to obtain an equation for determining the duration of the filtration drying process of beet pulp in the first conditional period τ_I and in the second conditional period τ_{II}.

$$\tau_I = \frac{1-\frac{w^c}{w_0^c}}{6.159\cdot 10^{-5}\cdot T^{0.61}\cdot v_0^{1.547}\cdot e^{-12.753\cdot H}}; \quad (3)$$

$$\tau_{II} = \frac{0.303\cdot(w_0^c - w_{cr}^c) - ln(\frac{w^c - w_e^c}{w_{cr}^c - w_e^c})}{0.303\cdot N}. \quad (4)$$

4. Conclusions

The paper presents the results of experimental studies of the kinetic regularities of beet pulp drying by the filtration method. The influence of the main process parameters (the height of the stationary layer of the material H, the thermal agent temperature T, and the flow velocity of the thermal agent v_0) on the rate of moisture removal from the material was studied.

The subsequent processing of the experimental data made it possible to derive kinetic dependencies for the periods of full (1) and partial (2) saturation of the thermal flow with moisture. These equations make it possible to describe the intensity of the drying process in each of the drying periods, as well as the duration of the process – Equation (3) and (4).

To verify the accuracy of the obtained kinetic dependencies (1) and (2), it was analyzed the graphical distribution of errors between the experimental and theoretically calculated values. The maximum value of the relative error was 36.54 %, while the average deviation was 8.46 %, that is acceptable from the point of the practical calculations of experimental and industrial drying plants.

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GREEN BUILDING STANDARDS AND THEIR IMPLEMENTATION IN UKRAINE

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Abstract. Today, one of the most discussed topics among builders is the post-war reconstruction of the country using the principles of green construction. Ever since the conclusion of the Association Agreement with the EU, Ukraine has been actively implementing EU environmental standards into national legislation. The threat posed by the war to the environment resembles an iceberg, because most of the negative consequences are hidden and will manifest themselves decades after the end of the war. That is why right now, we have to make maximum efforts to reduce the negative impact of man and his activities on the surrounding natural environment. Application of environmental standards in construction will make it possible to minimize the impact of the industry. For this purpose, we conduct an analysis of advanced BREEAM, LEED, DGNB systems. Each of the standards has its own characteristics and their application in the conditions of Ukraine has its pros and cons. Standards are one of the tools for the implementation of state policy, belong to the category of "normative document" (ND) and establish uniform rules, requirements, methods of control and testing, marking. Despite the intensive implementation of EU environmental standards in the legislation of Ukraine, there is still no legally established requirement for the certification of buildings according to a specific "green construction" standard. The development of own national standards is a significant step towards the introduction of green building standards in Ukraine.

Keywords: green construction, BREEAM, LEED, DGNB, building certification, implementation of environmental standards.

1. Introduction

The construction industry plays an important role and has a close connection with other branches of the national economy of the state. Realizing the important tasks of providing housing for the population, creating a developed infrastructure of settlements, providing all sectors of the economy with buildings and structures, the construction industry at the same time has a great impact on the natural environment. In today's conditions, we must take into account the damage caused by construction at all stages and try to reduce the negative impact on nature in the interests of current and future generations. The implementation of "green construction" norms is the basis of sustainable development for the construction industry. Certification of buildings and structures according to standards occupies a special place in "green construction".

The World Green Building Council points out that city must first strive to reduce global carbon emissions. This is because half of the world's population lives in cities, accounting for more than 70 % of CO_2 emissions. Buildings are the biggest contributors to urban emissions, accounting for 50–70 % of urban emissions and 38 % of global emissions. About 75 % of building emissions are operational emissions generated by building systems (e.g. heating, ventilation and air conditioning, lighting and others). The remaining 25 % are embodied emissions, i.e. carbon dioxide generated during the production of building materials, construction and interior design of buildings (World Economic Forum, 2022).

2. Materials and Methods

The purpose of this study is to review some environmental standards for the certification of

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buildings, to establish the positive consequences and features of their application in Ukraine.

Among the wide variety of "green building" standards:

- LEED (USA);
- BREEAM (Great Britain);
- DGNB (Germany);
- Green Globes (USA, Canada);
- Living Building Challenge (Australia);
- Beam (Hong Kong);
- CASBEE (Japan);
- Green Mark Scheme (Singapore);
- Green Star SA (South Africa);
- Pearl Rating System for Estidama (United Arab Emirates).

The British BREEAM system (Building Research Establishment Environmental Assessment Method), the American LEED (The Leadership in Energy & Environmental Design) and the German DGNB (Deutsche Gesellschaft fuer nachhaltiges Bauen) have gained the most popularity. In Ukraine, there are already buildings certified according to these standards. The BREEAM standard is most popular among developers. According to the Educational and Scientific Institute of Energy Saving and Energy Management, six certificates for new construction projects and eight for existing buildings have been received under the BREEAM certification system. For new construction projects, out of six certificates, four have the status of intermediate (after the design stage), and two – final (after the end of construction). Most often, projects in Ukraine receive the Good certification level (10 certificates), and two certificates each have the Pass and Very Good levels, respectively (Educational and Scientific Institute of Energy Saving and Energy Management, 2022).

Despite the intensive implementation of EU environmental standards in the legislation of Ukraine, there is still no legally established requirement for the certification of buildings according to a specific "green construction" standard. So, the developer himself chooses the standard according to which he certifies the building, and he does it voluntarily. Each of the standards has its own characteristics and their application in the conditions of Ukraine has its pros and cons. BREEAM "Method for assessing the environmental efficiency and level of energy consumption of building structures" is a method of voluntary assessment of the energy efficiency of a building according to the principle of "green certification". The BREEAM method is based on the principle of assessment, establishment of nominal value and certification of the main factors of construction, which ensure its long-term environmental and socio-economic stability (MCL Group, 2022). This method considers and evaluates the construction process and the building or structure itself at such stages of the operational cycle as construction, overhaul and commissioning. Also, the BREEAM method evaluates and emphasizes the cost of construction and the rational distribution of eco-resources and eco-materials, makes certification more attractive for investment, and creates an environmentally sustainable and safe natural environment and office space for building workers (MCL Group, 2024). The biggest advantage of BREEAM is that the building assessment takes place step by step at each stage of the construction process, and therefore an expert can be involved in the assessment of the building both at the design stage and at the stage of construction completion. No less important is the flexibility of this evaluation system, taking into account national characteristics. In 2017, the Optima Plaza shopping center in Lviv received BREEAM In-Use, Very Good (Fig. 1). In 2018, BC Astarta Organic Business Center received BREEAM International NC v.2013, Good (Fig. 2).

The LEED system was developed by the USGBC to certify high-performance buildings and sustainable environments. According to this standard, "green" construction must meet the so-called concept of the triple criterion, which combines economic development (income), social responsibility (people), environmental protection (planet) (MCL Group, 2020). LEED, like BREEAM, is aimed at evaluating the energy efficiency of buildings, but the following criteria are taken into account for the evaluation: land plot, building materials or resources for production, the level of technical support for the operation of the building, as well as the transport accessibility of the building (MCL Group, 2024).

This method has less stringent requirements for building evaluation, but requires starting the evaluation from the design stage, which, accordingly, does not allow for evaluation of already completed buildings. Shell company office in the capital BFK "Toronto-Kyiv" became the first object in our country, which received such a rating, namely LEED Gold in 2013. The second was the building of the US Embassy located in Kyiv – in 2014 it won LEED Silver (Fig. 3).

Fig. 1. BC "Optima Plaza" (Lviv)

Fig. 2. Astarta Business Center (Kyiv)

Fig. 3. Embassy USA in Ukraine

At the end of 2020, the B9B10 business campus of the Kyiv innovation park UNIT.City received the “green” LEED Silver certificate from the American Counci of Green Building (USGBC). This object was implemented development company UDP in 2019. In general, she certified two of its buildings with a total area of more than 31,500 m^2 (Comercial Property, 2021).

The DGNB environmental certification system is used as a tool for designing and assessing the quality of buildings, based on the concept of integrated planning and taking into account all important aspects of construction. The basis for evaluating the building is the criteria that take into account functional and socio-cultural, technical, economic, ecological characteristics and the location and management of the process. At the same time, the system has a high degree of flexibility (“Novatorstroy” company, 2024).

According to statistics, the majority of the population lives in cities, which leads to the fact that a person spends most of his life in buildings. Of course, it is equally important to understand that the building must be ecologically and economically balanced. Therefore, the DGNB certification method pays great attention to the study of the building’s environmental friendliness. Determining how comfortable a person’s stay in a building is determined by eight criteria, including air quality and air temperature in the room, sound insulation, and visual comfort. To ensure compliance with the mandatory DGNB certification criteria, it is important that all involved parties (architects, engineers, builders, designers and other professionals) work closely together. After all, obtaining a DGNB certificate requires detailed supporting documents of all implemented activities and their results.

Table “Comparison of certification systems” shows the criteria by which the building is assessed and the assessments used by the British, American and German certification systems. All evaluation systems have their own features and advantages, but what puts them in the same row are the benefits that each of the participants in the construction and operation process receives. For the tenant, this is an opportunity to create a more comfortable environment for employees, in each evaluation system sufficient attention is paid to comfort in the middle of the building.

The developer gets a marketing advantage in the market, the opportunity to fill the vacancy faster, increase the capitalization rate, it is easier to get credit financing, and provide the building with a stable and solvent flow of tenants. A certificate of compliance with “green” requirements is a modern trend. The investor, first of all, reduces the risks of moral aging of the asset, increases in energy prices and improves the corporate image. For architects, designers, engineers and contractors, participation in a project certified according to international standards is an independent international confirmation of their competence, the quality of design solutions and an additional competitive advantage (Advansys Group, 2016).

Comparison of certification systems

	BREEAM	LEED	DGNB
Evaluation criteria	Management Healthy microclimate Energy efficiency. Transport interchanges nearby Use of water resources Materials for construction Waste management Use of land resources Harmful emissions Innovations	Location and transport interchanges A place in the local ecosystem Use of water resources Energy efficiency Materials for construction A healthy indoor environment Innovations Local priorities	Environmental friendliness Economy Functionality and comfort Technical criteria Process organization Site evaluation and location area
Assessments	have passed fine very good ideally excellent	certified silver gold platinum	certified silver gold platinum

3. Results and Discussion

Since 2017, the Law "On the Energy Efficiency of Buildings" has been in force in Ukraine, which defines the term energy certificate – an electronic document of the prescribed form, which indicates the indicators and class of the energy efficiency of the building, provides recommendations for its improvement formed in accordance with the procedure established by legislation, as well as other information defined by law. The energy efficiency of buildings is determined in accordance with the Procedure for conducting energy efficiency certification and energy audit of buildings, which is developed taking into account the requirements of the legislation of the European Union, the Energy Community, harmonized European standards in the field of energy efficiency of buildings and is approved by the central executive body, which ensures the formation of state policy in in the field of energy efficiency of buildings.

In the process of determining the energy efficiency of buildings, information on:

1) local climatic conditions;

2) functional purpose, architectural planning and constructive solution of the building;

3) geometric (taking into account the location and orientation of the enclosing structures), thermal and energy characteristics of the building, as well as the energy balance of the building;

4) regulatory sanitary and hygienic and microclimatic conditions of the premises of the building;

5) technical characteristics of engineering systems;

6) use of renewable energy sources, passive solar systems and sun protection systems, as well as energy produced by cogeneration (On Energy Efficiency of Buildings, 2017).

Undoubtedly, such certification has a positive impact, but in order to achieve a more sustainable and effective result, it is necessary to implement certification of all buildings and structures according to green construction standards at the legislative level. Taking into account the best elements of the above standards and national features, Ukraine is in the process of developing its own standards. Standards are one of the tools for the implementation of state policy, belong to the category of "normative document" (ND) and establish uniform rules, requirements, methods of control and testing, marking. In accordance with international practice, European law and Article 8 of the Law of Ukraine "On Standardization", the objects of standardization are technical standardization committees (On Standardization, 2014). The National Technical Standardization Committee TK 82 "Environmental Protection" was established in 1993. As of today, TC has undergone a number of reorganizations and operates in accordance with the Regulation on TC 82, which corresponds to the legislation and the system of standards in the field of national standardization. 51 collective and individual members make up TC 82. In particular, collective members of TC 82 are 19 state authorities, institutions, establishments and enterprises (Tkachenko, 2023). The draft of the first edition of the energy-efficient green building standard for public buildings has already been approved, which can be considered an important step, but there is still a lot of work ahead.

4. Conclusions

In the cities of Ukraine, the negative consequences of climate change are becoming increasingly apparent: a decrease in the area of green spaces, as well as a decrease in the types of vegetation, an increase in the number of allergic manifestations and infectious diseases, the deterioration of the quality of drinking water, and heat stress. If the necessary measures are not taken, after some time, new ones will be added to the listed ecological problems of cities: disruption of the functioning of energy systems of cities, flooding, landslides, a decrease in the amount of drinking water, natural hydrometeorological phenomena. It is known that environmental problems cause the deterioration of the health of the population, which in turn will affect all sectors of the national economy, and the state of the economy in the state will deteriorate (Kryvomaz; Savchenko, 2021).

Modern trends in the implementation of "green construction" norms are promising for overcoming the ecological crisis of cities and make it possible to reduce the impact of the construction industry on the state of the environment. In order to speed up the pace of implementation of aspects of "green construction", it is necessary to implement European environmental standards into the legislation of Ukraine. The introduction at the legislative level of mandatory environmental certification of buildings (starting with new buildings) is one of the most important steps in this direction (Savchenko, Tkachenko, 2022).

As Green building certification schemes typically take into account partial assessments such as energy efficiency, water savings, acoustic comfort, indoor lighting and air quality, and the use of vegetation. Certification schemes often have different rules and requirements, so it is difficult to compare them with each other (Ujma et al., 2024)

The development of own national standards is a significant step towards the introduction of green building standards in Ukraine.

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