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A. N. Aleksandrova, master's degree student (BSTU); **N. I. Timoshik**, student (BSTU);
I. A. Khmyzov, PhD (Engineering), assistant professor (BSTU);
T. V. Solovyeva, D. Sc. (Engineering), professor (BSTU)

INFLUENCE OF THE PEAT BRIQUETTES COMPOSITION ON THEIR QUALITY INDICATORS

The paper dwells upon investigations of establishing the influence of peat briquette composition containing deciduous tree (alder and birch) wood on its ash content, density and strength. The obtained experimental data allowed to construct the Scheffe diagram, graphically illustrating the effect of the composition on each parameter of peat briquette quality. The compromise task of establishing an optimal ratio of components (peat, alder and birch 64/26/10% respectively) in peat briquettes was solved.

Introduction. The modern period of civilization is characterized by a clear depletion of non-renewable resources of energy and environmental damage during their processing. In this regard, becomes particularly relevant use of biofuels that could replace traditional fuel sources and environmental friendliness of new energy heat carriers plays a big role. Peat is a real resource for the production of high energy and environmentally friendly fuel. Peat briquettes make up a credible alternative to traditional fuels, such as oil and coal. Peat briquettes have fairly stable organic composition and content of harmful impurities in it is minimal. The flue gases from the combustion of briquettes contain virtually no environmentally harmful substances and peat ash is similar to woody, which allows using it as an effective potash fertilizer. Peat briquettes are used for combustion in urban boilers, water heating boilers, as well as for all sorts of domestic purposes [1].

In connection with the depletion of reserves of peat technologies of obtaining energy from peat in recent years are developing and increasing. Particular interest in the technology of peat briquettes is involvement in their composition of wood that can replace part of peat by less liquid woody biomass. It is known that the fuel materials obtained from and with the addition of coniferous wood have relatively high transport strength and calorific value due to the presence in it of resinous substances. Hardwood is not widely used as a component of fuel pellets and briquettes.

The process of obtaining peat bricks traditionally consists of the following main stages: grinding, sorting, drying of peat, pressing the dried peat and cooling of briquettes. Technological line is shown in Fig. 1.

Production of fuel briquettes from peat and wood particles (sawdust) includes a similar stages (from the receiver bin to finished products bin), passing which, peat and sawdust mixed thoroughly, thereby obtaining an isotropic product, which is characterized by a uniform distribution of the wood particles in the volume of peat briquettes. Also averager (rotating shaft with blades) mounted at the receiving bin contributes thorough mixing of the feedstock. Such variant is applicable when the peat and wood have approximately the same moisture content and size distribution. Another variant of the technological scheme of wood-containing peat briquettes production may be the passage of components of two separate lines of raw material preparation, and then mixing them immediately before pressing.

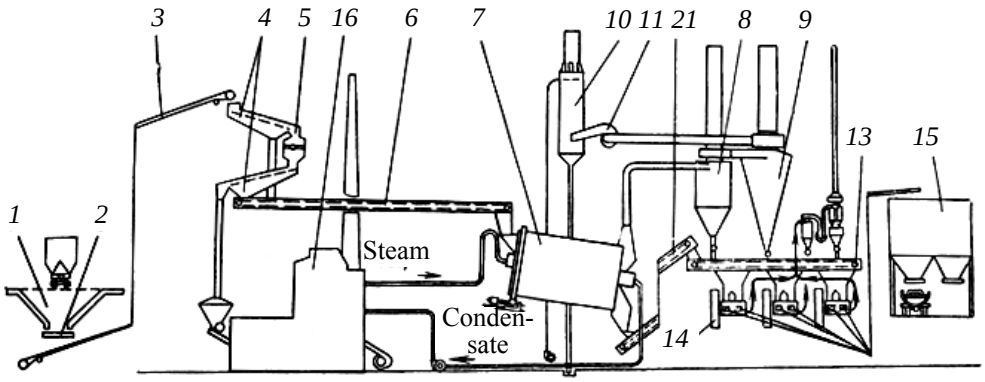

Fig. 1. Technological scheme of peat briquettes production:
1 – receiving bin; *2* – feeder; *3*, *6*, *12*, *13* – conveyors; *4* – screens; *5* – crusher;
7 – dryer; *8* and *9* – cyclones; *10* – scrubber; *11* – fan; *14* – press,
15 – finished products warehouse; *16* – boiler house

As the analysis of patent and scientific literature showed there are exist methods for preparing peat briquettes, containing in their composition various additives, that is coal, shale oil, lignin, sawdust, fuel oil and other refined products, tall pitch, sapropel, agricultural wastes and annual plants (flax campfire, straw, grass, leaves, manure), organic leather wastes, sludge from wastewater treatment [2]. In any case, the feedstock for the production of briquettes goes through the same stages as the peat. According the requirements of STB 1919-2008 "Fuel Briquettes based on peat. Specifications" share of wood in the composition of peat briquettes should not exceed 30%, and the share of agricultural waste 10% because over these dosage strength and calorific value of peat briquettes will decrease due to the low density of the wood.

Proceeding from the above, the purpose of studies was to determine the optimal ratio of peat and wood in the composition, and to check the possibility of increasing the content of the wood in the composition of peat briquettes for more than 30% with preservation of consistently high values of quality indicators.

Main part. The paper presents the results of a study on obtaining peat briquettes containing in their composition wood waste hardwood (alder (Latin *Álnus glutinósa*) and birch (Latin *Bétula péndula*)) in the form of sawdust. These wood species are chosen as the least liquid, low-cost and widely regionalized in Belarus. At the same time, as we know, birch wood has a high calorific value, and alder wood is characterized by high strength properties, which predetermined their inclusion in the composition of peat briquettes. These studies are aimed at increasing the share of such additives to give high-calorie products. Moreover problem of complex processing of plant biomass is solved what is appropriate for the power base of the Republic of Belarus. Wood waste can be crop of alleys, sanitary trim gardens, waste from the shearing bush plants, branches and twigs from preventive care and forest roads glade, and waste plywood (veneer-flaw, pencils) and other waste of woodworking industries.

To establish the content of peat and wood in the initial composition we varied their relations in accordance with the simplex-lattice plans (Scheffe), which allows to get comfortable for the analysis diagrams "structure – property" and the corresponding regression equation. The mass fraction of peat in the composition of peat briquettes we have designated as x1, alder as x2, birch as x3. Location of the experimental points in the factor space is shown in Fig. 2.

Implementation of chosen plan of the experiment carried out in accordance with the coordinates of the experimental points presented in Table 1.

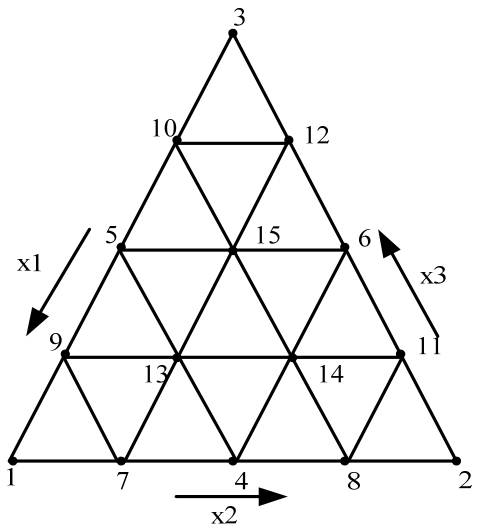

Fig. 2. Location of the experimental points in the factor space of fourth order plan

Table 1

Matrix of the experiment

No. of test	x1	x2	x3
1	1	0	0
2	0	1	0
3	0	0	1
4	0.5	0.5	0
5	0.5	0	0.5
6	0	0.5	0.5
7	0.75	0.25	0
8	0.25	0.75	0
9	0.75	0	0.25
10	0.25	0	0.75
11	0	0.75	0.25
12	0	0.25	0.75
13	0.5	0.25	0.25
14	0.25	0.5	0.25
15	0.25	0.25	0.5

The resulting samples of briquettes were examined for basic quality, which are ash content, density and strength that characterize their physical and mechanical properties. Ash content, %, was designated as y1, density, g/cm^3, as y2, flexural strength, MPa, as y3. Results of laboratory samples test are shown in Table 2.

Based on results of the experiment using the package STATISTICA analytic dependence of the studied quality parameters of peat briquettes on the component ratio in the initial composition was obtained.

Estimated value of each quality indicator was carried out by approximating polynomial for a fourth order equation, which has the form [4]:

$$y = \sum_{i=1}^{3} b_i x_i + \sum_{1 \le i < j}^{3} c_{ij} x_i x_j (x_i - x_j) + \\ + \sum_{1 \le i < j}^{3} h_{ij} x_i x_j (x_i - x_j)^2 + \\ + b_{1123} x_1^2 x_2 x_3 + b_{1223} x_1 x_2^2 x_3 + b_{1233} x_1 x_2 x_3^2. \quad (1)$$

Calculation of the coefficients of the regression equation (b_i, c_i, h_i) was performed using spreadsheets MS Excel. To establish the optimal values of quality indicators of peat briquettes we have received appropriate regression equation, which helped to build response surface of composite compound influence on the ash content, density, strength, which are shown in Fig. 2–4 respectively. For each quality indicator we solved optimization problem on determining the optimal ratio of the components in the composition of peat briquettes.

Table 2

Quality parameters of laboratory samples, depending on their composite compound

No. of test	y1	y2	y3
1	3.09	1.6875	3.03
2	0.76	1.3906	9.18
3	0.21	1.5417	4.12
4	1.36	1.5000	14.36
5	1.14	1.5347	7.58
6	0.36	1.3720	3.40
7	2.2	1.8154	11.74
8	2.2	1.3478	9.14
9	2.84	1.8198	5.72
10	2.01	1.8241	6.05
11	0.09	1.3852	11.91
12	0.8	1.3788	4.90
13	2.28	1.1468	1.35
14	2.33	1.1855	3.01
15	2.16	1.1756	1.56

From the solving the optimization problem the best value of peat briquettes ash content is 1.94% at a ratio of peat, alder and birch 60/35/5% respectively. Adding of wood in peat briquettes composition in an amount up to 40% reduces the ash content of the finished product of about 10%.

The optimum density of peat briquettes should be 1,350 (±50) kg/m^3, because the increase in density will lead to overconsumption of raw materials and to weight gain of finished products, and a decrease in density will not help to increase the strength.

From the solving the optimization problem the best ratio of peat, alder and birch is 65/14/21%, respectively, which contributes to obtaining a finished peat briquettes with optimum density. This ratio is not strict, and the proportion of each component may vary within ±5%.

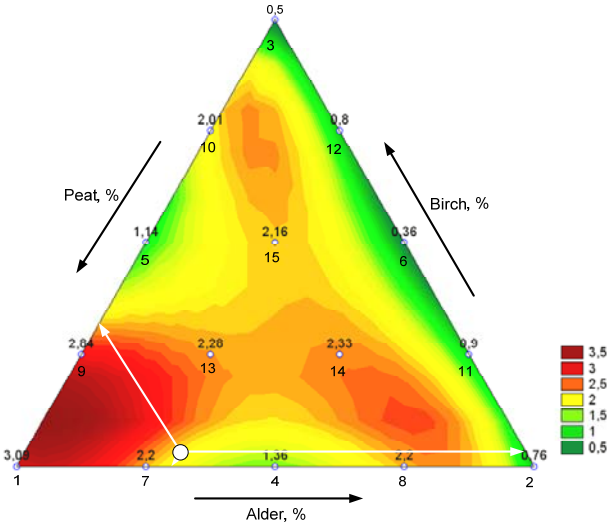

Fig. 3. Dependence of ash content of briquettes from their composite compound

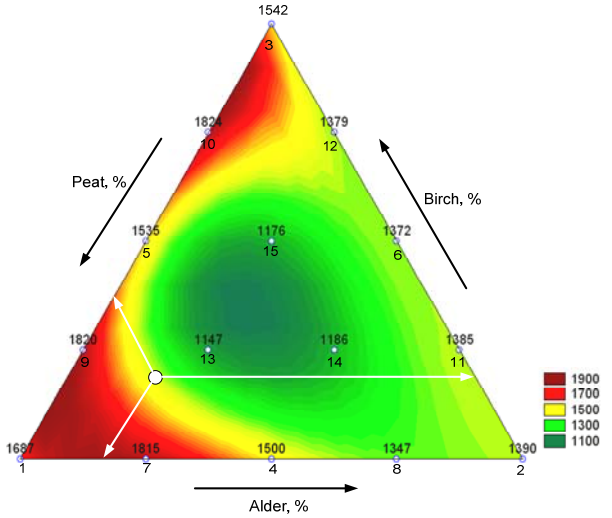

Fig. 4. Dependence of the density of briquettes from their composite compound

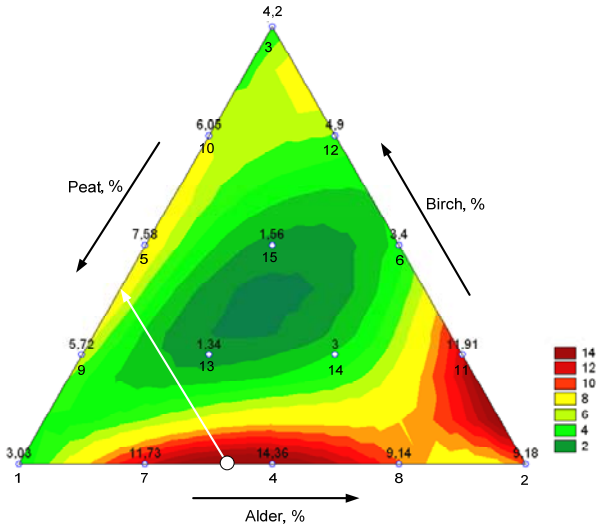

Fig. 5. Dependence of the strength of briquettes from their composite compound

The best achieved value of strength is about 14 MPa. From the solving the optimization problem to ensure of such strength optimal ratio of peat, alder and birch is 65/30/5% respectively.

Solving of the compromise optimization problem shows that peat briquettes containing in its composition 64% of peat, 26% of alder and 10% of birch have the best quality indicators (ash content 2%, density 1,350 kg/m^3, strength 14 MPa.

Presence of hardwood in peat briquette composition up to 36% positively affects the values of the ash content while the strength characteristics of the briquette are within the requirements of STB 1919-2008 [3].

Conclusion. Proceeding from analysis of patent and scientific literature the direction of research production of peat briquettes containing hardwood (birch and alder) in their composition was chosen. The obtained data of solving the compromise optimization problem to determine the best component composition shows that the content of hardwood in the composition of peat briquettes can be increased to 36%. At the same time the decrease in ash content of peat briquettes to 10% is observed, and strength and density are high, which meet the requirements of STB 1919-2008 [3].

References

1. Справочник по торфу / под ред. канд. техн. наук А. В. Лазарева и д-ра техн. наук С. С. Корчунова. – М.: Недра, 1982. – 760 с.

2. Томсон, А. Э. Торф и продукты его переработки / А. Э. Томсон, Г. В. Наумова; Нац. акад. наук Беларуси, Ин-т природопользования. – Минск: Беларус. навука, 2009. – 328 с.

3. Брикеты топливные на основе торфа. Технические условия: СТБ 1919–2008. – Введ. 01.07.09. – Минск: Государственный комитет по стандартизации Республики Беларусь. – 12 с.

4. Пен, Р. З. Статистические методы моделирования и оптимизации процессов целлюлозно-бумажного производства / Р. З. Пен. – Красноярск: Красноярский гос. ун-т, 1982. – 192 с.

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