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The Development of Peat and Wood-Based Thermal Insulation Material Production Technology

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Abstract **– The article presents research results on a thermal insulation material made of low-moor peat. A model based on three components, including peat binder, frame component (wooden aggregate) and additives, was developed in the framework of this study. The conducted research showed that by grinding low-moor peat in water until the particle size is 2–5 mkm increased peat cohesion strength with wooden aggregate 2.5 to 2.7 times as well as increased the compressive strength of peat binder 5.0 to 5.5 times. Optimal parameters of strength and density in the wood peat composition with discontinuous granulometry wooden aggregate were achieved by using two fraction wood filler with fractions 2.5 mm ... 1.25 mm and 0.63 mm ... 0.315 mm in the proportion 50:50 and 60:40. Introducing anionic surfactants and foam forming non-ionic surfactants with neutral reaction against the surface of the peat and wood filler allows to reduce the average density up to 210–220 kg/m^3, thus maintaining the required strength, and to reduce the coefficient of thermal conduction to 0.046 W/mK.**

Keywords **– Foaming additives, peat, thermal insulation, wood peat composite.**

I. Introduction

The scientific and technical development contributes to new paths leading to a more rational use of natural resources. Consequently, it is necessary to take into account certain requirements with regard to the use of raw peat in the national economy for construction purposes. Peat is used as a construction material in water constructions and road building (dams related to canals, antifilters, road embankments). In addition, peat plates and peat insulation panels are widely used in special-purpose buildings; consequently, production of these materials is subject to special requirements [1].

To date, in the construction material production sector leading scientists from around the world make continuous effort focusing their research on technologies that allow producing improved materials with advanced technical performance characteristics. In particular, it refers to thermal insulation materials, which are largely made of polymers. But this raw material has several disadvantages including short exploitation period, low adhesion, increased toxicity and deformation. At the same time, modern standards and norms impose high demands on the construction materials to be environmentally friendly. In particular this applies to construction of residential buildings, where safety and environmental performance are the key indicators. For that reason, such raw materials as peat are used in the development of new construction materials.

Peat, owing to its properties, has a long history of being used in the construction works. For example, refined and processed peat is used as an aggregate for some types of lightweight concrete. It is used in wall coating materials as well - all cavities are filled with peat, which is very efficient for saving energy. Much progress has been achieved in the research focused on the use of peat. This refers to the development of wood peat insulation materials, which are made with additional reinforcing components, resulting in quite good durability and safety of the materials. For example, peat plates and segments that are capable of withstanding critical temperatures from −60 to +100 degrees have been introduced in Russia. Extensive analysis of the materials showed positive dynamics for the potential use of these products. It is possible to assess the usefulness of further research involving peat building materials by performing regular checks on the utilization rates of these materials [2].

The raw material resource base in Latvia is characterised by significant amount of natural raw material resources, as well as significant amount of industrial waste, which can be used in the production of insulation materials with their subsequent use in construction of individual houses and low-rise buildings. These raw materials may include peat and wood processing residues. Structural characteristics and composition of peat allow its wide potential use in building construction. Peat has low thermal conductivity, high porosity and antiseptic properties. It is environmentally friendly and provides wide opportunities for raw material modification due to its complex composition and diversity of organic and mineral functional groups. Low-moor peat types are of particular interest for the production of thermal insulation materials as they are characterised by high mineral content, uniformity of material composition, high content of peat humin and lower acidity compared to the high-moor peat types [3].

Cellulose fiber is present in the composition of peat (as well as of wood); therefore, it has the same positive qualities as wood – it is clean and environmentally friendly, good for human health, breathable material. Unlike glass wool and mineral wool, peat and wood-based thermal insulation materials are characterised by natural moisture regulation, which captures and releases air humidity in the environment, therefore it is not necessary to use vapour barrier film. Due to their air-permeable (breathable) fiber structure, these environmentally friendly thermal insulation materials control moisture levels and ensure ambient indoor climate meeting the standards of environmentally friendly construction. In addition, these materials have high thermal resistance, preventing not only the heat loss in winter but also restricting the heat from entering the building in summer. It leads to a pleasantly cool indoor climate during the hottest summer days and cosy warmth during cold winter days.

The most important characteristic features of peat as both colloidal and dispersed system is its dispersity. Peat consists of particles of different shapes and sizes ranging from a micrometre up to a few centimetres. Dispersity of peat defines its specific

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surface area and its surface free energy as well as the strength of peat.

Directed impact on the low-moor peat colloids allows influencing its structure and modifying its strength and other properties in the necessary direction [4]. High degree of collapse (40 % and higher) and high ash content is also characteristic of the low-moor peat.

Preliminary analysis of the peat quality indicators, which was carried out according to modern scientific research results and various types of peat production technologies, allows drawing conclusions on the possible use of peat in the compositions with organic and mineral components.

II. Models and Selection of Research Object

Two-component composite model is used more frequently for the development of effective materials with the use of peat: organic durable and lightweight aggregate, which forms the structure of the material (peat, sawdust, wood chips, crumbs, flax shives, etc.) and a binder (organic, organic-mineral, mineral).

This study offers a model based on three components, including peat binder, frame component (wooden aggregate) and modifying additives with various effect. Dispersible aggregate provides a rigid dimensional frame, and peat obtains adhesive properties in the catalisation process, filling the cavities in the frame. As a result, monolithic composite material is obtained. However, the given system does not provide complete hydrophobic, thermal and other operating characteristics. The modifying additives allow ensuring optimal composite pore structure and directed control in order to regulate the required operating characteristics.

The offered three-component model of peat thermal insulation material includes:

- peat binder (70 %);
- frame forming component (wooden aggregate) (5–30 %);
- modifying additives with different impact (5–7 %).

Composite materials are promising with regard to their possible use in production of thermal insulation materials. Low-moor peat and transitional peat can be used as a binder and wood processing residues, whose composition, structure and physical-mechanical properties (density, thermal conductivity) are similar to peat, can be used as an aggregate.

Peat belongs to composite multi-component systems. A certain part of peat functional group (bitumen, paraffin, wax) has hydrophobic properties, while another another part (lignin, cellulose, humin) has hydrophilic properties. On the other hand, peat belongs to the group of poly fraction, semi-colloidal macromolecular compounds, having characteristics of polyelectrolyte and micromosaic heterogeneity with the presence of functional group rows. R–OH⁻R–COO⁻ type negative load functional groups predominate in the composition of peat; therefore, to ensure foam stability (foam is introduced into wood peat mixture) it is necessary for the foaming agents to have a positive charge or substance to be neutral.

III. Materials

Peat from the peat deposits in Latvia was used in the experiments. Peat deposit characteristics and main technical characteristics of peat used for the research purposes are given in Table I.

TABLE I

Main Physical and Technical Characteristics of PEAT

Deposit	Peat type	Ash content, %	The degree of decomposition, %	Average density, kg/m^3	Moisture, %	pH
No 11020	Low-moor	18–25	20–25	455	36.8	6.0–6.7
No 11624	Other	8–10	30–35	487	36.5	6.2–7.1
No 11766 Mežružas	Low-moor	36–48	37–44	518	85.1	6.1–6.9
No 11911 Sēreņu	Low-moor	16–17	27–35	451	20.3	7.1–7.7
No 12023 Truļu	Low-moor	26–28	25–30	333	18.5	7.1–7.5
No 12119 Kalnasalas	Other	8–10	15–20	601	62.8	6.2–6.8

All types of peat belong to the transition and low-moor groups with average decomposition level. Peat acidity is close to neutral environment.

The wooden aggregate used in this research consisted of: needle and sawdust mixture. This mixture is a wood processing residue. Main physical and technical characteristics of the wooden aggregate are given in Tables II and III.

TABLE II

Technical Characteristics of Mixed Wood Aggregate

Sawdust grain composition						Moisture, %	Bulk density, kg/m^3 with W = 15 %
Residues in sieves %, with size, mm							
2.5	1.25	0.63	0.315	0.16	Remaining amount		
60.1	2.20	18.50	10.200	4.80	4.2	15–20	100–140

TABLE III

Physical Properties of Wood

Type of wood	Hygroscopic moisture limit, %	Natural moisture, %	Average density, kg/m^3		Bulk density, kg / m^3	Porosity, %	Volume shrinkage coefficient, %
			With natural moisture	With standard moisture			
Pine	35	3.5	490	508	128	53.7	0.44

Sieving schedule of the wood aggregate mixture used is shown in Fig. 1.

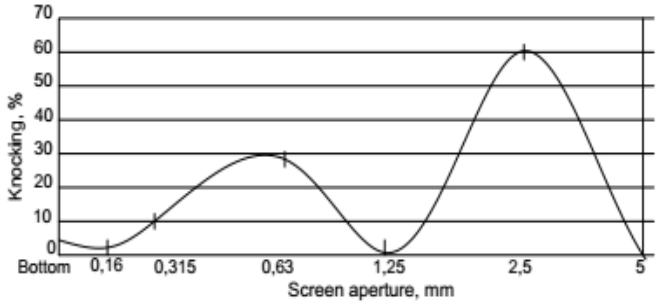

Fig. 1. Wood aggregate mixture sowing schedule.

The used sawdust mainly has two-fraction composition. The used sawdust mainly consists of fractions 0.315 mm to 0.630 mm and 1.25 mm to 2.50 mm. The content of the given fractions comprises more than 75 % of the total wooden aggregate.

Peat binder and graded wooden aggregate mix were used to prepare the test samples.

Mechanisms of action of foaming substances with different composition were considered to draw conclusions about the utility of synthetic active substances of foam belonging to the anion active group or anion active and non-ionic active substance of foam additive mixtures using them in peat systems as foam forming additives. It was based on the selection of modern foam forming agents, whose characteristics are given in Table IV.

TABLE IV

CHARACTERISTICS OF FOAMING ADDITIVE

Group of the active substance of foam	Type of the foaming additive	Country of production	Foam ratio	Surface tension
Alkyl sulfonates	NEOPORS	Germany	10 ... 15	40 ... 48
Oligopeptides hydrolysates of salts	ПБ-2000	Russia	8 ... 12	40 ... 48
	TEAC	Russia	10 ... 14	40 ... 48

Selection of foam-forming additive, as well as selection of optimal consumption should be determined according to the strength criteria and foam-forming mode criteria.

Different natural fibers were used as reinforcing additives. Polypropylene and polyethylene fibers were selected for wood peat composite reinforcement due to their low density, which will not cause increase of the average density in combination with wood peat composition.

IV. METHODS

Raw material research methodology:

– determination of the relative humidity of peat;
– determination of the peat ash content;
– assessment of the physical and mechanical properties of wooden aggregates;
– assessment of the modifying additive characteristics aimed at wood peat composite performance adjustment (assessment of foam-forming additive characteristics; assessment of reinforcing additive characteristics).

Wood peat mixture and sample preparation methods:

Peat binder and graded wooden aggregate mix were used to prepare the test samples. Peat binder was prepared by grinding natural moisture peat in bullet-mill using 5–10 mm grinding bodies with the speed of 75 rpm for 2 hours and adding the necessary amount of water, which corresponds to 280 % of the peat dry substance weight.

The forming mixtures were obtained by adding the prepared aggregate to the peat paste, namely, fractional sawdust (with particle size 1.25 mm to 2.50 mm and 0.630 mm to 0.315 mm) in various proportions and water according to the defined water/solid compound ratio. The mixture was mixed for 10 minutes in a mixer in the forced mode and then molded in layers in the forms sized 40 mm × 40 mm × 160 mm (Fig. 2). The specimens were compacted with the additional weight shield having pressure of 0.02 MPa. Hardening of the specimens proceeded under the following circumstances:

– drying at a temperature of 75–85 °C for 24 hours;
– demolding and additional drying under natural conditions for 2–4 days in order to reach balanced humidity.

Laboratory compositions are given in Table V.

TABLE V

LABORATORY COMPOSITIONS OF WOOD PEAT MIXES

Compo-sition No.	Mix composition, %		Material consumption per 1 m^3, kg	
	Peat paste with W = 280 %	Wood aggregate	Peat paste with W = 280 %	Sawdust with W = 12 %
1	70	30	430	185
2	70	25	450	160
3	70	20	520	150
4	70	15	560	120
5	70	10	590	85
6	70	5	660	50

The following wood peat sample testing methodology was used and discussed:

– wood peat sample pore structure determination methodology;
– peat binder adhesion rate assessment methodology.

Physical and chemical analysis of the wood peat samples were conducted with the following equipment:

TGA / DSC / DTA analyzer SDP Q600, which allows simultaneous registration of the changes in sample mass and processes that take place due to heat release or absorption.

The following wood peat material research methodology was used and discussed:

– methodology of wood peat material thermal conduc-tivity assessment;
– methodology of wood peat material durability assessment.

Durability of the wood peat samples intended for thermal insulation according to the average density indicator was assessed after completion of each test cycle. In case the average density changes exceeded 10 % compared to the control sample, the strength was determined. If it corresponded to the regulatory

indicators, the testing was continued. The testing was not continued, if the average density changes exceeded 15 %, or the strength decreased by more than 20 %. The number of cycles is an indicative quantity corresponding to the number of exploitation years using the material in a structure.

Chemical and mechanical impact is one of the most efficient ways to improve structural characteristics of low-moor peat and transition peat. Using this approach, the weak bonds in the structure are ruptured and macromolecular aggregates are dispersed leading to acceleration of the physical and chemical processes related to the forming of curable structures in the peat binder. Taking into account the increased risk of working conditions and environmental sensitivity related to working with modifying chemical reagents, mechanical dispersion of the low-moor peat in water is a safer choice which might allow obtaining a suspension of peat with the hardening ability.

Previous research was performed to assess the efficiency of mechanical impact on the binding properties of low-moor peat using different mechanical devices [5].

Within this approach, presence of finely ground peat (in Attritor mill) leads to a significant increase of the humin substances (HS). Extraction of HS increased by 35 % to 70 % depending on the duration of impact and extraction of humin acids (HA) – by 75 % to 130 %. Peat treatment with Attritor significantly changes decomposition by molecular weight, which largely depend on the moisture content of the processed peat.

Increase of low-moor peat adhesive strength that defines its chemical activity is related to its degree of dispersion. Previous research shows that mechanical dispersion of the low-moor peat leads to the changes in its structure and composition of the groups. The degree of dispersion was determined according to the obtained particle size. Peat particle size depends on the duration of grinding. Preparation of peat adhesive was carried out using low-moor peat and transition peat with natural moisture levels. Wet grinding method in the ball mill with metal grinding bodies was applied. The diameter of grinding bodies was 20 mm, drum speed was 300 rpm/min, the content of water was increased by 280 % in comparison with the weight of dry substance after the time period of 0.125; 0.25; 0.54; 0.625 and 1 hour. Peat particle size changes according to dispersion duration are given in Table VI.

TABLE VI

PEAT PARTICLE SIZE CHANGES DEPENDING ON THE DURATION OF GRINDING

Type of peat	Size	Grinding duration, hours					
		0.0	0.125	0.25	0.5	0.625	1.0
Low-moor peat	Grain size, mkm	37.6	22.500	16.30	10.1	4.900	16.3
Other	Grain size, mkm	37.6	21.000	15.20	9.1	3.900	14.3

According to the data given in Table VI, in 0.125 to 0.625 hours peat particle size decreased significantly to 1–5 mkm, then in the interval 0.625 to 1 hour the particle size increased to 14–18 mkm. This dependency shows that peat particle aggregation begins after 0.5 hours of dispersion. Aggregation process is related to the changes of particle surface.

Mechanical and chemical activation of peat in water in the time period of 0.125 to 0.375 hours does not lead to full homogenization of the mixture. Structure fragments with dimensions ranging from few units to tens of mkm can be distinguished in the images. After 0.375 hours of grinding separate structure fragments with the size of few micrometers form in the peat, while after 0.625 hours of grinding the composition is a body of agglomerates. After 0.5 to 0.625 hours of grinding particle size is smaller than 4.9 mkm. The forming ultra-fine particles have surplus surface energy which leads to their aggregation during further grinding. Associate formation takes more time. The thermogravimetric rates show that associate formation process is not finished even after the structure formation in the peat binder for 28 days. This was confirmed by the increase of ekzoeffect maximum temperature of the samples (Table VIII). The obtained data show that the bond strength between individual chemical components of peat and their structures resulting from the mechanical and chemical activation (in water) increased.

Mechanical dispersion of the low-moor peat in water to the particle size of 2–5 mkm leads to the activation of their mineral part [6], [7].

Fig. 2. Test samples.

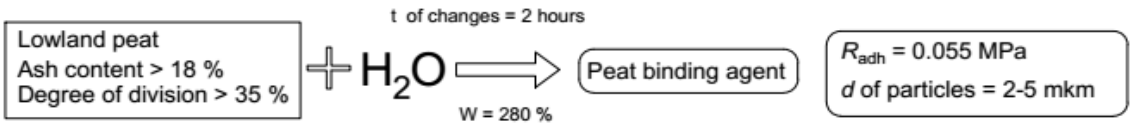

Fig. 3. Peat binder extraction scheme for composite materials.

Hydration and digestion processes release mineral compounds that participate in complex formation and have binding properties.

Increased activity of the mineral part of peat after mechanical impact was confirmed with the data of X-ray analysis. The X-ray analysis was performed with the samples of dispersed raw peat ground in the bullet mill that were dried to constant weight.

The dispersed peat was mainly used as an adhesive component in the studied composite material. From that starting point, it is necessary to aim at increasing the cohesion and adhesion capacity of peat, when raw mixes of peat are prepared.

Possible options for low-moor peat binding characteristic adjustment were considered. In addition, peat binder is in the focus of research.

The complex of physical-mechanical and physical-chemical research revealed that in order to obtain peat binder with higher adhesive strength it is necessary to grind raw peat in the bullet mill for 2 hours adding to the mixture water content of 280 % (Fig. 3) [8], [9].

The impact that low-moor peat dispersion in water has on the activity of the obtained peat binder was assessed considering the tensile strength limit in bending of the samples and changes in its compressive strength.

The results of derivatography analysis of the activated peat (Table VII) show substantial changes in the bond strength of water with peat components. It is attested by the fact that basic loss of mass for the activated samples is observed at higher temperatures compared to the freshly ground peat. It can be expected that due to weak bonds of adsorbed water taking part in the structure formation process, stronger bonds are formed in the crystalline structure of peat.

TABLE VII

DATA OF DERIVATOGRAPHY ANALYSIS

Peat type	Sample	Sample	*DG* (loss of weight), mg	*TAD, C* (ekzoeffect temperature)		
				1	2	3
Low-moor peat	Peat binder. Chemical and mechanical activation	Freshly ground	58.30	111.6	316.8	411.5
		curing for 7 days	2.50	111.9	308.6	407.9
		curing for 14 days	2.57	113.8	310.4	437.4
		curing for 28 days	2.58	116.1	312.3	443.8

Analysing the thermogravimetric curves it can be concluded that the associate formation process in peat binder does not finish after 28 days of structure formation. This was confirmed by the fact that the maximal ekzoeffect temperature increased after the activation process in the samples taken at different times. The obtained data show that the bond strength between individual chemical components of peat and activation of their chemical-mechanical elements (in water) increased.

The impact of temperature is an important factor contributing to the formation of peat binder structure.

Depending on the processing temperature range, peat plasticity increase during the heating can be explained with different processes: development of condensation reactions for flavourings (with subsequent agglomeration), resin melting and softening, bitumen, some water-soluble compounds and lignin [10]. Each peat type has its own temperature range, where it achieves the maximum plasticity. By heating the peat in difficult conditions [11] thermal splitting of plant residues, release of organic acids, transformation of pentoses into furfural, polycondensation of the chemical compounds and their interaction with lignin occur. This leads to more durable products [12].

Temperature increase during the peat drying increases its plasticity during the compacting period as well as reduces the internal friction coefficient of the material against the walls of the mold [13], [14].

By heating the wood peat samples to a temperature of 105 °C significant bitumen sublimation and irreversible coagulation of colloids occur with formation of hydrophobic compounds. This effect can be used for "hardening" of peat insulating slabs.

In order to determine the optimum temperature and duration of heat treatment, the wood peat materials, which were made according to standard methodology (slabs), were left for drying for 3 days at different temperatures (70 °C, 80 °C and 90 °C). At a drying temperature of 70 °C the strength increases gradually and it reaches its maximum on the 3rd day of thermal treatment. At a drying temperature of 80 °C wood peat composite reaches sufficient strength after shorter period of thermal treatment (in 1 day). The strength characteristics does not change significantly in a longer period of drying. It is supposed that the strength increase at a temperature of 70–80 °C is conditioned by the structure of the building process, acceleration associated with solidification of mineral components.

Analysing the results, it can be seen that wood peat material strength indicators are mainly influenced by the drying temperature. In this way, the optimal temperature range for the wood peat composite heat treatment is 70–80 °C.

Directed adjustment of exploitation properties of the peat-based thermal insulation composite materials is possible via the use of modifying additives and rational selection of the granulometric composition of aggregates.

It is known that the macrostructure of composites is formed according to the cementitious properties of the binder, namely ability of the aggregate particles of different shapes, such as grains, fibres, plates, etc., to adhere to each other forming common structure [15]. In a similar way, discrete particles of the binder with compact packing of coarse aggregate mixture seeks to fill intercrystalline cavities with smaller volume allowing reducing the average binder layer of the conglomerate. Granular aggregates were divided in fractions by size for that purpose and then the optimal proportion of each fraction in dense mixture of composite material aggregate was found with continuous experiments or calculations or by obtaining discontinuous granulometric composition. It is demonstrated by the facts that the quality parameters of composite construction material, such as strength, density, deformation capacity, etc., dependent on the physico-mechanical characteristics of the frame-forming components and aggregate packing degree.

Wooden aggregate was added to the composite material as different fractions of sawdust, therefore the effect of grain size on the hydro-physical characteristics of the wooden aggregate was studied.

Sawdust moisture absorption ability depends on the grain size. Sawdust with the fractions from 0.315 mm to 0.160 mm has the highest water absorption ability: whereas the lowest water absorption ability is demonstrated by sawdust with fractions from 5.0 mm to 2.5 mm. These data have to be taken into account in the selection of wooden aggregate grain composition for the wood peat composite.

Full assessment of the impact that the sawdust grain composition has on wood peat composites is given in Table VIII.

TABLE VIII

IMPACT OF WOODEN AGGREGATE GRAINS ON THE PHYSICAL AND CHEMICAL PROPERTIES OF WOOD PEAT COMPOSITE COMPOSITION

Composition of sawdust grains		Physical and chemical compounds		
2.50–1.25	0.630–0.315	$\rho^n m$, kg/m^3	R_{sp}, MPa	R_{liec}, MPa
100		270	0.34	0.19
	100	270	0.40	0.18
50	50	314	0.67	27.00
60	40	324	0.65	0.26
70	30	323	0.60	0.26
40	60	332	0.62	0.25
30	70	289	0.65	0.23
Unfractionated sawdust, 100 %		316	0.56	0.24

The data from Table VIII suggest the following:

- modification of the monofraction grain size of the wooden aggregate increased the flexural strength of the wood peat material, which can be conditioned by increased content of peat binder. At the same time compressive strength decreased slightly, which probably is related to the emptiness of the intercrystalline regions, which is characteristic of monofraction mixtures with larger grain sizes;
- using mixtures with two fractions the strength indicators significantly increased, besides, it was characteristic of all mixtures with two fractions regardless of their proportion. It is related to the aggregate particle packing density;
- significant increase of the wood peat sample strength R_{compr} = 0.67 MPa, R_{flex} = 0.27 MPa was observed using the mixture with two fractions sized 2.50 ... 1.25 mm and 0.630 ... 0.315 mm (discontinuous granulometry mixtures) in the proportion 50:50. Slightly lower strength values were observed using the same factions in the proportion 60:40. This is related to optimal proportion of the aggregate particle size, which leads to denser particle packing providing rigid skeleton of the material;
- wood peat composite materials obtained using the non-fractionated sawdust has sufficiently high strength indicators (R_{compr} = 0.62 MPa, R_{flex} = 0.25 MPa), which can be explained with high content of unfractionated aggregate mainly consisting of two fractions of sawdust 2.50 ... 1.25 mm and 0.630 ... 0.315 mm.

In this way, the wood peat composite strength is mainly influenced by the granulometric composition of the aggregate and aggregate packing ratio.

Rationale for the selection of foaming additive that is used for regulating the porosity of wood peat compositions is related to the fact that the peat group compositions mainly consist of negatively charged R–OH$^-$R–COO$^-$ and others type of functional groups. Therefore, in order to ensure the foam stability by introducing foam-forming additives in the wood peat mixture, it is necessary for the active substances of foam to have opposite charge or to be neutrally charged. By using cationic active substances of foam, the obtained foam is instable, which is detectable by chemical interaction with negatively charged peat particle surface that leads to their degradation. Anionic active or non-ionic active substances of foam in their turn act as independent kinetic formations, which have the ability to move, diffuse and maintain stability in a longer period of time. The described relationship is also in force with regard to the wooden aggregates, namely, sawdust mainly consisting of negatively charged functional groups. In this way, surface charge for the given type of systems with naturally-active substance surface is the main factor that determines selection of the foam-forming additives.

In order to determine a more efficient method for the introduction of foam-forming additives to achieve low coefficient of thermal conductivity, the following methods of mixture forming porisation were studied:

- introduction of foam forming additive in the mixture during the mixing process;
- adding the prepared foam in the mixture during the mixing process;
- separate preparation of the molding mass, which includes preparation of porous peat binder, which is later mixed with the aggregate.

This method foresees two stages of molding mass preparation, it includes preparation of porous peat binder, which is later mixed with the aggregate.

The prepared foam is mixed with peat binder, and then added to the wooden aggregate. More homogeneous dispersion of the aggregate in the binder can be achieved with the aggregate consumption less than 0.7 m^3 on 1 m^3 of the material.

In this way, the method of separate preparation of porous molding mass is more efficient with regard to the homogenous micropore structure of wood peat composite material and the necessary exploitation properties.

Size, shape and volume of air inclusions influence thermal conductivity of the material. In real materials, the form of pores in several cases is different from the spherical form. Therefore, thermal conductivity of materials with large pores depends on the heat flow direction in relation to the location of pores. In addition, the lowest thermal conductivity of the material is observed, when location of air pores is perpendicular to the heat flow. When the heat flow direction passed along the main axis of air inclusions, thermal resistance of the material decreased, as the useful cross-section of heat transfer decreased in this case. Therefore, it is

necessary to try to reduce the interpore partitions thickness and to increase the quantity of air pores.

If the pores are small, the impact of the heat flow direction on the thermal conductivity coefficient of material is insignificant. Therefore, it is necessary to try to create a thermal insulation material, which is characterized by uniformly dispersed small pore structure that allows avoiding heat transfer by convection in the thickness of material.

The character of porous structure has ambiguous effect on the thermal insulation of materials. This impact is different, depending on the ambient temperature. Materials with small closed porosity are the most suitable for thermal insulation that is intended for exploitation at a negative temperature.

Analysis of the pore structure characteristics data with the method of mercury porometrics showed that the type of foaming agent and its content in the molding mixture also have a significant effect on the total pore volume, as well as formation of small pore structure of the wood peat composite.

Fig. 4 shows a material thermal conductivity on the amount of the additive quantity.

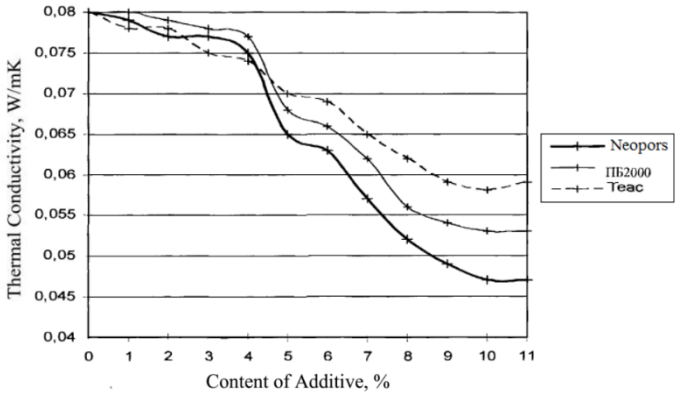

Fig. 4. Influence of the type and content of foam-forming the additives on the thermal conduction of peat-wood insulation material.

V. Analysis of results

The use of reinforcing fiber, regardless of its type and preparation method, reduced the density of material by 8 % in average, compared to the control samples. In addition, the optimal amount of reinforcing additive constitutes 7.5 % from the total mass of the molding mixture. Although the largest amount of fiber leads to reduction of sample density, it is followed by a reduction of strength indicators. The use of polyethylene fibers reduces the density of the material to a lesser extent than the use polypropylene fibers. In addition, maximum strength was observed in the samples with the polypropylene fibers obtained by the fibrillation method.

Molding mixture was prepared in the following order: fractioned ground wooden aggregate was mixed with the necessary amount of the peat binder that was prepared in advance. If the mixture was not modified, it went to molding (production).

If the foam-forming additives were used, the prepared foam was introduced in the peat binder composition to form pores and the mass with pores was added to the wooden aggregate. In addition, the additional mixing time was reduced by 5–8 min. Additional mixing time for the molding mixture depends on the components of the composition.

Peat binder and fractioned wooden aggregate mix was used to prepare test samples. Peat binder was prepared by grinding natural moisture peat in the bullet-mill using 5–10 mm grinding bodies at the speed of 75 rpm for 2 hours adding the necessary amount of water, which corresponds to 280 % of the peat dry substance weight.

Selection of the wood peat product molding mode depends on the type of the raw materials used in the mixture type and modifying additives. The following molding of products is recommended:

A. Vibromolding for a Short Period

It is used for wood peat mixtures with high mobility. Modification is performed only with the foam-forming additives or in combination with flame retardants and reinforcing additives.

A mixture with high mobility is required to preserve the pore structure of a demolded product better. Vibration time is 25 seconds, the product is dried in molds. In the production of some types of materials (multilayer boards, blocks, etc.) two-stage vibromolding can be used. Starting with the lower layer, it results in a denser and stronger structure, and continuing with the upper layer, which helps to maintain the specified parameters.

B. Pressing

It is applied to firm mixtures without modifiers and combinations of modifying reinforcing and hydrophobising additives, as well as without flame retardants.

Pressing pressure of 0.2 MPa should be applied to the products that are demolded in one set, for optimal outcome. A typical feature of the given method is that the firm mixture has high adhesive capacity, therefore the products may be partially demolded (by removing the side walls and leaving only the pad), which in turn reduces the metallic volume in the production cycle resulting in the direct contact of dry hot air and product surface. However, in this case, there is no significant change in the geometric shape of the products caused by the shrinkage deformation.

VI. Conclusion

By grinding low-moor peat in the water until the particle size is 2–5 mkm increased peat cohesion strength with wooden aggregate 2.5 to 2.7 times as well as increased the adhesive strength of peat in compression 5.0 to 5.5 times.

Certain relationship in the composition of wooden aggregate grains affects the physical and chemical properties of the produced composite material. Optimal parameters of strength and density in the wood peat composition with discontinuous granulometry wooden aggregate were achieved by using two fraction wood filler with fractions 2.50 ... 1.25 mm and 0.630 ... 0.315 mm in the proportion 50:50 and 60:40.

Peat dispersion in water occurs together with hydrolysis and hydration processes, allowing to activate mineral compound-based oxides taking part in a complex formation and having binding properties that are proven by physical-chemical research techniques.

It has been demonstrated by the facts that it is possible to use activity-modifying additives in order to improve heat conductivity and strength of the obtained peat and wooden aggregate filler thermal insulation material.

Active foam forming additives of anionic type have significant effect on the wood peat composite material, when they are introduced in the process of molding the mixture as previously prepared foam.

Introduction of anionic surfactants and foam forming non-ionic surfactants with neutral reaction against the surface of the peat and wooden aggregate allows reducing the average density up to 210–220 kg/m^3, thus maintaining the required strength, and reducing the coefficient of thermal conductivity to 0.046 W/mK.

Introduction of synthetic fibers (fiber acting as reinforcement) in the molding mixture increases the strength of the finished products, therefore the greatest effect was observed by introducing polypropylene fibers obtained with defibrillation. The effect of reinforcing additive activity increased with a short exposure of demolded samples to high temperature in the drying stage.

Introduction of reinforcing additives in the form of fibrillated polypropylene fibers in the wood peat mixture, followed by heat treatment at a temperature leading to highly plastic state of fibers, allows increasing the flexural strength of the material up to 1.2 MPa.

The research has shown that the properties of the final material are influenced not only by the composition of raw materials but also by the technological methods used.

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