



RESEARCHES IN THE FIELD OF PRODUCING CERAMIC TILES OF LOWER MATERIAL CAPACITY FOR INTERIOR WALL FACING

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Abstract. The results of researches on the increase of mechanical strength of ceramic tiles for interior wall facing on the stages of pressing and drying with the aim of decreasing their material capacity are given in the article. It is shown that introducing of aluminoborosilikate fiberglass in the raw composition insure increasing of mechanical strength of semifinished tiles on the stages of pressing and drying and optimization of technological parameters of preparation of powder and getting of ceramic tiles cause the maximum density of pressing. It is established that introduction of natural basalt promotes increase of mechanical strength at the bend of tiles after firing that provides possibility of reduction of products thickness at saving of a complexity of demanded physical and chemical properties.

Keywords: ceramic tile, fiber glass, basalt, distribution of sizes, pressing density, mechanical strength, water absorption, shrinkage, klinopyroxene.

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Introduction

The ceramic tile is the most convenient and practical material for internal furnish of premises and buildings due to high physical, chemical and decorative-aesthetic characteristics, durability and hygiene.

In the conditions of market economy a perspective direction of modern development of the industry of building materials and its major scientific and technical problem is working out and introducing resource saving technologies of producing of ceramic tiles for internal facing of walls, which in the given research consist in reduction of products' thickness at saving of a complexity of demanded physical and chemical properties.

Thin ceramic tiles and ceramic granite (slim-formats), which are produced – by leading factories of Italy, Spain and Germany, have strongly taken the positions in the market due to new production tech-

nologies and introduction of innovative decisions according to the 29th International exhibition Cevisama, taken place in February, 2011 in Valencia (Spain) (Katrichenko 2011).

The analysis of the literary facts and patent sources has shown that by production of a ceramic glazed tile of reduced thickness expensive raw materials, the hi-tech equipment (hydraulic and vacuum presses of high vigour) are used and high-temperature modes of firing (more than 1200 °C) are applied (Kumar *et al.* 2001).

In the manufacturing of ceramic tiles by dry pressing method on the flow-conveyor lines by single-firing, the main criterion of obtaining a product of reduced thickness is to increase their mechanical strength in the molded, air-drying and in fired state that connected with the need to provide them with sufficient mechanical strength to be able to make further tech-

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nological operations – transportation of semi-finished products for the roller conveyor in drying unit, its engobing, glazing and firing without deformation and fracture.

At present, the construction industry in the Republic of Belarus, in particular, the production of ceramic tiles, – is in the process of significant updates, primarily due to the adaptation to European norms and standards in this field. Products, manufactured by the enterprise, have a thickness of 6.5 to 7.5 mm, so reducing it will make a significant contribution to solving the problem of resource saving.

In the production of tiles for interior wall facing, in order to improve economic performance of production are used ceramic mass with a high content of local clay materials, which are characterized by multiminerality and variability of chemical composition in the Republic of Belarus.

Thus, the present study focuses on the problem of learning opportunities for producing ceramic tiles of reduced thickness on the existing technological equipment of enterprises with the use of traditional ceramic and recycled materials. The involvement of the available raw materials will also contribute to the expansion of the mineral resource base of ceramic industry.

1. Experimental methods

Preparing the samples of ceramic tiles is carried out by dry pressing. Getting of the press powder was carried out by thermal dehydration of the slurry after the joint wet milling of mass components in a ball mill brand SPEEDY-1 (Italy). Size distribution of the powder was determined by remains on sieves, %¹ sieve number 1 – 0 to 3; number 05 – 10 to 25; number 025 – 50 to 65, less than number 025 – from 20 to 35. The two-step molding tiles made with the maximum specific pressure (20 ± 2) MPa, and then molded semi-finished product fed to the drying and then was fired at the maximum temperature (1110 ± 5) °C in the flow-conveyor line RKK 250/63 in a production environment of enterprise “Berezastroymaterialy”.

Size distribution of the press-powders was determined by laser diffraction particle microanalyzer “Analizette-22” by firm Fritsch (Germany). Mass losses at heating of raw compositions for interior wall facing tiles were determined using a device of combined ther-

mogravimetric analysis and differential scanning calorimetry TGA/DSC1 by company METTLER TOLEDO (Switzerland) in the temperature range 20–1100 °C at a climb rate – 10 °C/min. Phase composition of the product samples was studied in X-ray diffractometer D8 ADVANCE by company “Bruker” (Germany). The study of the microstructure of ceramic tiles was carried out using a scanning electron microscope JSM 5610 LV JEOL (Japan). IR absorption spectra of developed mass were obtained on the spectrometer Specord-IR-75 (Germany) in the frequency range of 250–1500 cm⁻¹.

2. Ceramic tiles on the basis of local raw materials

The first stage of the researches is aimed at studying the possibility of obtaining a ceramic tile of reduced thickness on the basis of a raw composition for producing tiles by single-firing technology at “Berezastroymaterialy” of Republic of Belarus. The object of this study is a ceramic mixture, containing local raw materials: fusible clay “Lukoml-1”, granitoid screenings Mika-shevichith RUPP “Granite”, dolomite deposits “Rube” and quartz sand of Gomel Mining and imported from Ukraine refractory clay “DNPk”.

At the results of studies were obtained samples of ceramic tiles with the following physico-chemical properties: shrinkage – 1.03–2.53%, density – 1599–1778 kg/m³, porosity – 24.3–30.7%, water absorption 13.7–19.2%, the flexural strength after pressing – 0.4–0.6 MPa, after drying – 1.8–2.2 MPa, after firing – 18.5–28.2 MPa. Figure 2a–c shows the dependence of shrinkage, water absorption and mechanical bending strength of fired tiles on the content of the variable components of the mass.

Quartz sand – 7%;
Fusible clay “Lukoml” – 13%;
Waste of tile – 5%.

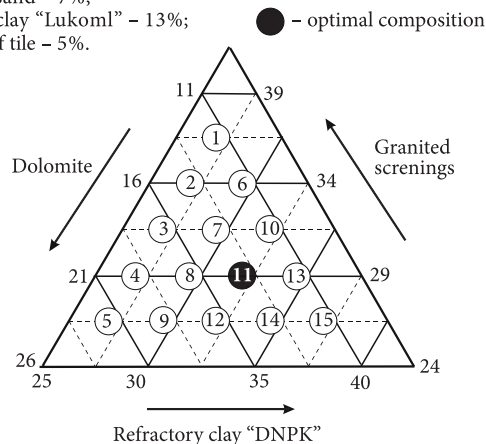


Fig. 1. The area of investigated compositions

¹ here and hereafter given weight content

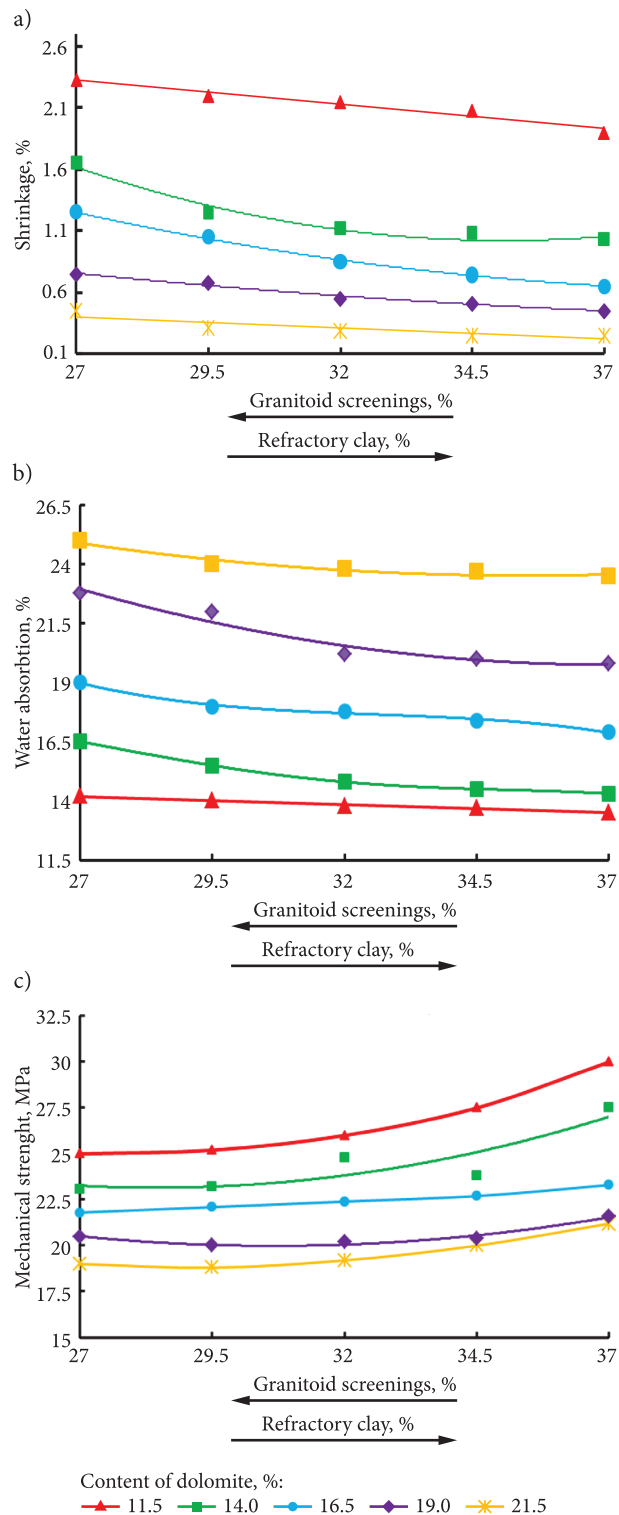


Fig. 2. Dependence of shrinkage (a), water absorption (b), mechanical strength (c) on the composition of ceramic mass

It was found that the determining influence on the mechanical characteristics of the products has a content of dolomite in the composition, which may be connected with the influence of carbonates, namely, the decarbonization process taking place during the

firing of the masses. An approximate reduction of its contents leads to less amount of CO_2 and, therefore, reduced porosity and increased density and mechanical strength of the product.

The phase composition of the samples of ceramic tiles is represented mainly by quartz, anorthite and a small amount of hematite and almost the same for all investigated compositions. It should be noted that with decreasing the content of refractory clay and simultaneously increasing the quantity of granitoid screenings and dolomite, the rise of the diffraction peaks of anorthite is noted, the formation of which is explained by the reaction between CaO , arising during the decomposition of dolomite, with metakaolinite formed during firing of clay and quartz, the introduced with quartz sand. Anorthite crystals take the form of short thick prisms, which are capable of reinforced glass phase and the amorphous component of the structure of the entire product, which is probably one of the reasons for increasing the mechanical strength of the samples.

Thus, on the basis of studies is selected the optimal composition of the ceramic mass, which ensures the obtaining of samples of tiles with high complexity of physical and chemical properties, namely, the shrinkage is 1.08–1.1%, density – 1725–1730 kg/m^3 , porosity – 24.6–25.0%, water absorption – 14.3–14.5%, mechanical strength of fired products 26.7–27.0 MPa.

The preliminary production tests showed that the developed compositions of masses does not provide the stability characteristics of the products of reduced thickness because of the insufficient strength of the semi-finished product after pressing and drying, causing its partial destruction by mechanical stresses that occur during the pipeline transportation of the tiles when you move to a drying unit.

3. Mechanical strength of the ceramic tiles on the pressing and drying stages

The next stage of the research is aimed at a comprehensive study of the issue of increasing the mechanical strength of the ceramic tiles on the pressing and drying stages.

In the technological cycle of production of the tiles by dry pressing molding method refers to the processes that are most decisive semi-sealing properties (density, mechanical strength, etc.) and products produced from them. In practice, the task of increas-

ing the density of semi-finished solving by increasing the pressing pressure, but it is often a significant occurrence of elastic deformations, which can cause reducing its strength in molded, air-dried and fired state along with the further increase in the density compaction. There are ways to control the density of pressed semi-finished by increasing the amount of moisture in the mass, but high moisture content leads to increased fuel and energy resources in the subsequent drying products.

Many studies have established defined effect of size distribution of press powders on the strength characteristics of semi-products produced by dry pressing and forming their dense microstructure, as well as the physical and chemical properties of the final product.

In order to increase the mechanical strength on the stages of pressing and drying was conducted the study of the influence duration of milling ceramic material and size distribution of press-powders as factors, which determines the density and strength of semi-finished products.

To determine the technical characteristics of press-powders were investigated ceramic masses of different size distribution, which ensures by varying the milling time of raw material compositions are from 12.5 to 27.5 min in increments of 2.5 min. Size of particles was evaluated by percentage of press-powder is passed through a sieve reference number 0063. Figure 3 shows the dependence of the remains on the sieve number 0063 and the milling time.

The data in Figure 3 shows that increasing of milling time from 12.5 to 20 min intensively reduces the amount of coarse fraction, and a further increase of duration results in insignificant reduction of the content of the remainder ceramic mass in the sieve because of aggregation of small particles.

However, to assess the degree of dispersion of press-powders the most complete characteristic is the particle size distribution, which allows determining the percentage of particles of each size.

In the ceramic industry is known the use of the triangular diagram of size distribution – the classic diagram, proposed by Winkler, later supplemented by Schmidt – as the criterion of suitability of particulate mass for the production of building ceramics. The three axes of the diagram presented in the following fractions: less than 2 microns, 2–20 microns and more than 20 microns. The area with the optimal balance of small, medium and large fractions provides

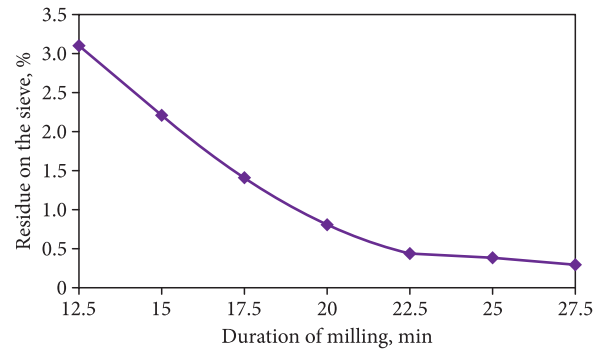


Fig. 3. The dependence of the percentage of residue on sieve of ceramic mass on the duration of milling

obtaining products with high indicators of physico-chemical properties. By analogy, the grain structure of the ceramic press powder was also divided into three fractions: small (less than 2 microns), medium (2–20 microns) and large (greater than 20 microns) (Dondi et al. 1998).

Therefore obtained press-powders were subjected to particle size analysis, which was performed by laser diffraction microanalyzer “Analizette-22” by firm Fritsch, the principle of working is based on dispersion of electromagnetic waves created by a laser beam.

The results of particle size analysis showed that the particle size interval of crushed powders is quite wide, ranging interval from 0.1 to 302 microns. Fractional composition of ceramic press-powder depending on the duration of milling is shown in Table 1.

Table 1. Distribution of press-powder particles by size

Time of milling, min	The contain of particles on fractions, %		
	<20 microns (small)	2–20 microns (medium)	>20 microns (large)
12.5	24.3	64.5	11.2
15.0	25.0	65.8	9.2
17.5	24.2	69.7	6.1
20.0	28.2	64.1	7.7
22.5	33.5	66.5	–
25.0	34.2	65.8	–
27.5	23.5	64.2	12.3

As noted above, the increase in the number of large fraction of grinding duration of 27.5 min connected with the aggregation of small particles, the amount of which is significantly reduced.

In studying the technological characteristics of powders derived from masses of different granulomet-

ric structures, it is determined that the ceramic powder produced by milling mass duration is 20 ± 1 min and corresponding to this is a continuous grain structure (0.1–48 microns), it is necessary to provide the necessary value of the angle of repose (22–24 deg.), which contributes to a more rapid and uniform filling of the mold and getting the most dense and strong compacts.

To optimize the size distribution of powders, and study its effect on the density and strength of semi-finished tiles, physical and chemical properties of tiles are defined.

The masses of various dispersion and with the humidity of $4.5 \pm 0.5\%$ were used to obtain the samples of tiles by pressing. The optimum pressure was determined by constructing compression curves. To do this, an equal number of powder was filled in the form of a cylindrical section and pressed at a pressure of 8, 15, 20, 25, 30, 35 and 40 MPa. We have measured the following characteristics of obtained compacts: charging height molding powder, pressed height, draft, and calculated the ratio and density of the compacts.

According to the experimental data a region of the optimal values of pressure, in the range of 18–24 MPa, was defined. It was found that the maximum compaction is achieved at given values of pressing. At higher pressures there is an increase in density, but its values (more than 2250 kg/m^3) are sufficiently large, which may hinder the removal of gas from the ceramic tile in its heat treatment and cause boiling in single glaze firing. It should be noted that at pressure of 30 MPa a significant amount of cracks on samples is observed.

The optimal values of the pressing pressure is also confirmed by theoretical calculations performed in accordance with the empirical equation A. S. Berejnoi, which approximates the experimental dependence of porosity and density on the compacts of the compacting pressure.

The samples of tiles were made at the selected pressure, strength characteristics of tiles after pressing, drying and firing, as well as physical and chemical properties, depending on the duration of the milling – are given in Table 2.

The optimal duration of milling is established (17.5–22.5 min), this time allows getting of powder of required granulometric structure. Tiles, obtained of mass of given grain composition, are characterized a low shrinkage and low values of water absorption, which may be connected with the action of fluxes of alkali metal oxide, which is manifested in a shorter

Table 2. Physico-chemical properties of semi-finished tiles and finished products

Time of milling, min	Mechanical strength, MPa, on the stages of:			Shrinkage, %	Water absorption, %
	pressing	drying	firing		
12.5	0.45	2.2	32.0	1.1	15.0
15.0	0.43	2.3	32.5	1.1	14.8
17.5	0.56	2.4	33.5	0.95	14.8
20.0	0.62	3.1	34.0	0.9	14.5
22.5	0.56	2.9	33.2	0.9	14.3
25.0	0.53	2.7	33.4	0.98	14.5
27.5	0.43	2.9	32.5	0.95	14.7

time frame, as the diffusion of ions occurs at a relatively short distance. With longer duration of grinding has worsened the above characteristics of samples of tiles due to the aggregation of small particles.

Conducted by X-ray diffraction patterns of fired tiles derived from masses of different grain size, showed that as the dispersion of press powder, an increase of the intensity of the diffraction peaks of anorthite, while reducing the intensity of the diffraction peaks of quartz, which increases the mechanical strength of finished products.

Thus, on a range of conducted studies it was found that the optimal duration of meals is (20 ± 2) minutes. Obtained in this press-powder provides manufacturing of ceramic tiles values of mechanical strength which after pressing is 0.62 MPa, which is 8% higher mechanical strength is the semi-finished products manufactured now.

Note, however, that the values of mechanical strength can reduce the thickness of the product by only 0.5–0.7 mm. To study the possibility of further reduction of material capacity of ceramic tiles intended to explore the influence of introduction in the ceramic mass of fibers that foster reinforcement structure of semi-finished products and, therefore, increase their mechanical strength on the pressing and drying stages.

In the literature, there is information on the use of inorganic and organic fibers to increase the fracture toughness, strength and stabilization of the structure of ceramic and refractory products (Lopez *et al.* 2012).

In this regard, the ceramic mass was introduced to the additive alumino-borosilicate fiberglass of kind E-13-12-4C, the chemical composition of which is rep-

resented oxides, %: SiO_2 54.2; B_2O_3 8.7; Al_2O_3 13.5; $(\text{CaO} + \text{MgO})$ 22.55; $(\text{K}_2\text{O} + \text{Na}_2\text{O})$ 0.35; Fe_2O_3 0.2; F_2 0.5. This glass is electrically insulating and is used for the manufacturing of continuous fiber, which is used for the manufacturing of structural, electrical, electronic materials possessing large heat- and moisture resistance. Glass fibers, used for the experiment have a length of 650 microns and a diameter of 6–10 microns and are characterized by the following indicators of physical and chemical properties: density – 2570–2590 kg/m^3 , softening temperature – 830–860 °C; refraction indicator – 1.548.

Glass fibers are introduced to the mass in an amount of 0.5–4.5% (over 100%) and added together with the clay constituent of the mass during preparing ceramic slurry, and then the resulting suspension was mixed with the other components of the raw composition, made by wet milling. When mixing between finely dispersed clay particles and short fibers act of adhesion, which gives a homogeneous structure of the masses. Clay, overlying fiberglass partially protect it from destruction during mixing with other components of the feedstock composition, which allows to obtain reinforced semi-finished tiles.

Results of the determination of the mechanical characteristics of the samples of tiles after pressing and drying, depending on the content of fiber in composition, are shown in Figure 4.

The data in Figure 4 show that the introduction of a fiberglass increases the indicators of mechanical strength of pressed and dried samples of tiles with glass fiber content up to 1.5%. With further increase of its content increase the mechanical strength practically not observed.

An increase in the integral gallo diffraction patterns of samples of fired tiles shows that the introduction of fiber glass in ceramic mass contributes to the formation of a small additional amount of liq-

uid phase during sintering, which appears due to its melting at 830–860 °C. This is also indicated by the data dependence of the density, shrinkage and water absorption of the composition of ceramic masses. Thus, with increase of content of fiberglass, the decrease of water absorption and improving the overall shrinkage and density of the samples is noted.

It should be noted that the introduction of fiber glass in the mass does not change the temperature coefficient of linear expansion (TCLE), and its values are in the range $(6.73\text{--}7.25) \cdot 10^{-7} \text{ K}^{-1}$, ensuring the required thermostability of the ceramic glazed tiles.

Electron microscopic image of the surface of the chips of pressed samples of tiles with glass fiber content of 0.5, 1.0 and 1.5% is shown in Figure 5 a–c.

Conducted electron microscopy studies showed that after the joint wet milling mass of all the components in a ball mill fibers are saving and have a length of 10–60 mm, fairly even distributed throughout the volume in different directions, which strengthens the structure by reinforcing it.

Thus, on a range of conducted studies it was determined that the optimum glass fiber content is 1.5%, which provides the required mechanical strength of ceramic tiles, the value of which increased after formation by 33%, after drying – by 48.4%, compared with production. This saves the necessary physical and chemical properties of the finished product.

4. Mechanical strength of the ceramic tiles in the fired state

Mechanical strength in fired state can be increased by varying of the composition of ceramic masses, resulting in increased current number of cementing the glassy phase or by creating reinforcing structure ceramics.

To achieve the latter part of the feedstock composition introduce components that are in the process of firing form crystalline phase, mainly acicular and prismatic habitus, as well as minerals of chained structure. It is known that natural rocks of volcanic origin are widely used in industry with a view to obtaining ceramic materials with high strength characteristics (Leonelli *et al.* 2009).

It is now widely used basalt deposits of Rivne (Ukraine), which were used in the manufacture of stone casting and pyroxene glass ceramics because of their high hardness, strength, resistance to abrasion

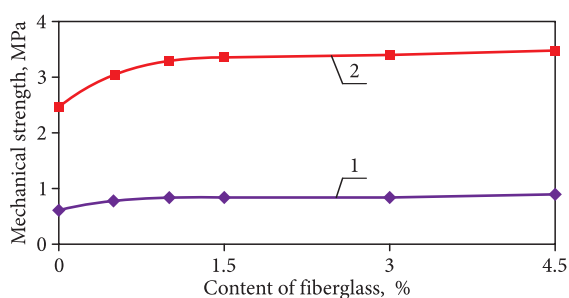
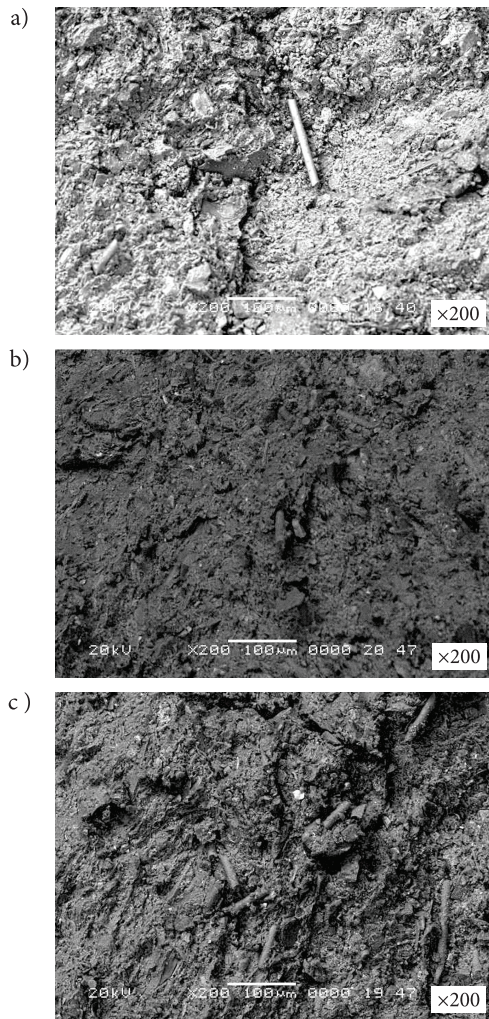


Fig. 4. Dependence of mechanical strength after pressing (1) and drying (2) on the contain of fiberglass



Content of fiberglass over 100%, %:
a – 0.5; b – 1.0; c – 1.5

Fig. 5. Electron microscopic image of the surface of the chips of pressed samples of tiles

and corrosion as well as in the production of mineral fibers due to high technological properties of basaltic glasses.

The information on the application of basalt rock in the composition of ceramic materials for the tiles for interior wall facing is very limited.

In order to increase the mechanical strength of the samples after firing at an optimized composition of ceramic mass injected basalt deposits of Rivne. The choice of this raw material explained its chemical and mineralogical features. First, according to the mineralogical composition of basalt are represented mainly plagioclase and clinopyroxene, which total content is 70–85%. Plagioclase and clinopyroxene have a sufficiently high hardness on the Mohs scale (6 and 5–5.5, respectively), which is likely to contribute to higher strength characteristics of the tiles. Furthermore, the

structure of clinopyroxene, which is present in mainly in the form of augite, is articulated with each other tetrahedra SiO_4 , forming a continuous chain type $[\text{SiO}_3]^{2-}_{\infty}$, which provides a high packing density of the structural elements, and this a way to increase strength. Second, the chemical composition of basalt is characterized by significant total content of iron oxide and calcium (from 18.2 to 21.5%), which provides earlier percolation of the processes of sintering ceramic materials and the formation of an additional amount of liquid phase at about annealing products. The results of a multi-stage heat treatment basalt samples showed that their initial melting point is 1160 °C, which will also contribute to the intensification of sintering basalt containing raw tracks.

Used in the study, Rivne basalt deposit has the following average chemical composition, %: SiO_2 49.53; Al_2O_3 14.23; CaO 9.21; MgO 5.17; Na_2O 2.58; K_2O 2.82; Fe_2O_3 12.27; TiO_2 2.76; MnO 0.19; P_2O_5 0.28.

It was assumed that the basalts in the ceramic mass will play a similar role to granitoids, i.e. emaciated component as well as flux. Therefore, as a part of the composition were held equivalent replacement granitoid screenings on basalt in the range of 2.5 to 22.5% in steps of variation of 2.5%, while the total content of both species remained constant.

Figure 6 shows the dependence of physical and chemical properties of the samples of tiles on the content of the basalt, introduced instead of granitoid screenings.

Analysis of the data shown in Figure 6, indicates that the developed compositions of mass on the content of the basalt from 2.5 to 15% can get ceramic tile, fully satisfying the requirements of GOST 6141-91. With an overall the shrinkage is 0.9–1.2% and is close to shrinkage of manufactured products. Further in-

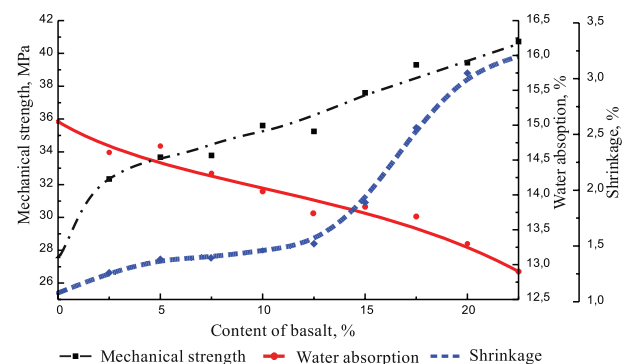


Fig. 6. Dependence of physico-chemical properties of fired samples of tiles on content of basalt

crease of the basalt rocks in the raw tracks instead of granitoid screenings, along with the continuing growth of the mechanical bending strength of the entire product leads to a sharp increase in the total shrinkage and reduced water absorption, which is undesirable because it can lead to a deviation from the required size of the tiles and the distortion of their decor.

Thus, the complex study of the physico-chemical properties as the optimal composition of the ceramic mass is selected, containing 15% basalt.

As is well known, the properties of ceramic products, including tiles for interior wall facing, are determined by the phase composition and structure of the material, which is formed during firing, so the next stage of research is to study these parameters for the samples with different content of basalt.

It was found that in samples of tiles of basalt containing mass are present crystals of augite, quartz, anorthite and a small amount of hematite. The intensity of the diffraction peaks of crystals of augite increases with the rise of amount of basaltic rocks. Augite is introduced with basalt and probably saved as relict formations after firing, which is one of the reasons of increasing the mechanical strength of tiles after firing. The rational combination of the above phases not only provides a dense, homogeneous texture and microstructure of the samples, but is due to the high strength characteristics along with the required water absorption, density, porosity and shrinkage.

It is known that sintering of ceramics during firing is the main and final stage of the process that defines the basic physical and chemical properties of the finished product, with an important role played by the liquid phase and its amount, which is formed during the heat treatment (Sanchez *et al.* 2006).

With the introduction of the raw basalt composition to the additional amount of liquid phase due to the presence in it of glassy components (volcanic glass and analcime), as also evidenced by the increasing profile of diffractometry curve above the background level. The above explains the greater intensity basalt containing sintering ceramic masses, which is associated with a reduced content of Al_2O_3 (14.5–15.5%) in basalts compared with granitoid screenings (17.0–17.4%) and the ability to catalyze P_2O_5 , present in basalt, the rate of formation of the liquid phase.

Infrared absorption spectra of basalt containing ceramic masses are consistent with the data obtained by X-ray diffraction. Absorption band at 1080 cm^{-1} indicates the presence of silicates frame, chain and

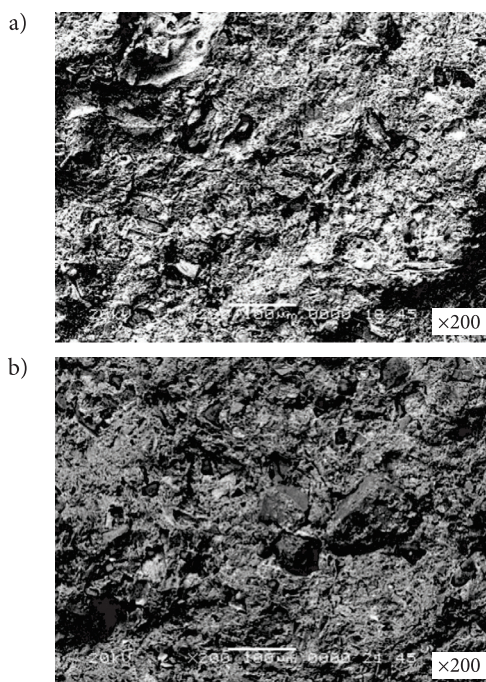
layered structures. Maximum of the band is diffuse, indicating a significant content of amorphous (glassy) component.

The maximum of the absorption bands in the $770\text{--}780\text{ cm}^{-1}$ are related to quartz, which is stored in the form of crystalline component, and in the $500\text{--}600\text{ cm}^{-1}$ and $330\text{--}400\text{ cm}^{-1}$ indicate the presence of different modifiers in the structure of silicates (Ca, Mg, Al, Fe).

The nature of transformations that occurs during firing and their sequence significantly influences the properties of ceramic materials. Thermal analysis of basalt containing ceramic masses showed that with increasing amounts of basalt an increase in mass loss, which, in our opinion, is connected with the content of aqueous minerals in basalt (chlorofeit), which is saturated with water lithification of residual melt.

The results of studies of the structure of samples of ceramic tiles free from basalt and with 15% of basalt rocks are represented in Figure 7 a and b, respectively.

The data in Figure 7 show that the structure of the samples of ceramic tiles both compositions presented isometric crystal form, cemented a small amount of vitreous phase, which is uniformly distributed. However, when we introduce basalt in the composition of masses, it promotes the formation of structure with a



Content of basalt, %: a – without basalt; b – 15.0

Fig. 7. Electron microscopic image of the surface of the fired samples of tiles

high degree of crystallinity, which can clearly be seen in Figure 7 b.

The optimal composition of ceramic mass, which contain basaltic rocks in the amount of 15% imposed, in return granitoid screenings was selected based on a complex of physical and chemical properties, the nature of the structure and phase composition of tiles.

Important role in the production of tiles for internal wall facing, especially for a single firing, plays the temperature coefficient of linear expansion. The values of this index for the samples of ceramic tiles based on the basalt containing masses are $(63.8–71.2) \cdot 10^{-7} \text{ K}^{-1}$, which increases the heat resistance of glazed finished product by improving the consistency of thermal expansion of the ceramic base with a glazed finish.

The preliminary tests in production conditions of “Berezastroymaterialy” showed the possibility of reducing the thickness of the tiles using the developed feedstock composition of 5.5 mm.

The results of the research led to the conclusions of perspectives of the basaltic rocks in the compositions of masses for ceramic tiles for internal wall facing in order to increase their strength characteristics.

Conclusions

The compositions of ceramic masses were developed and parameters of preparing powder were optimized on the basis of a comprehensive study and established regularities of formation of structure and phase composition during the heat treatment processing of developed raw compositions. As the result were obtained the tiles for interior wall facing, providing manufacturing of products of reduced thickness at higher mechanical strength in bending after formation by 33%, after drying – by 48.4%, after firing – by 38.5% compared to the tiles, produced in the enterprises of Republic of Belarus at present.

It was found that the ceramic press-powder, obtained by milling mass of duration (20 ± 2) min and the corresponding continuous grain structure, provides the optimal values of the angle of repose of the powder, which determines the possibility of rapid and uniform filling of the mold, that provides obtaining the most compact and strong compacts.

Introduction of fiberglass to the raw composition of tiles for interior wall facing leads to increase of mechanical bending strength of semi-finished products by creating a reinforced structure. Determined that in order to keep the fibers in the original form and pre-

vent their full milling it is expedient to introduce them when the clay materials are dissolved.

The introduction of basalt to the ceramic masses for obtaining tiles for internal wall facing has a positive effect on their physical and chemical properties. There was a significant increase in the mechanical strength of fired state, which may be explained by changes in the structure of ceramic tiles. The rational combination of components of basalt containing masses ensures the presence in the structure along with anorthite, hematite and quartz crystal phase clinopyroxene – augite, which due to its crystal-chemical features, namely the chain of structural motif, high hardness and density make the structure of the ceramic tiles harder, providing a greater degree of crystallinity. Furthermore, an additional amount of liquid phase formed during firing promotes hardening of the structure of ceramics and contributes to improving the mechanical strength of the samples.

The practical significance of the results is confirmed by production testing of developed ceramic materials by “Berezastroymaterialy” which showed the possibility of reducing the thickness of products (on 1.5–2 mm), which reduces the demand of raw materials and energy resources in their production by providing them with significant savings (8–12%).

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