HIGH-VOLTAGE ACTIVATION TECHNOLOGY IN THE PRODUCTION OF CERAMIC MATERIALS

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For improvement of quality and effective use of building materials there was developed high-voltage electrotechnics of their activation. In abundance of such technologies the technology of high-voltage activation of different objects of treatment in the atmosphere is elaborated. When using high-voltage technology of corona discharge activation as a working tool in the air there can be used two investigation lines:

- elaboration of disturbance technologies by high-voltage corona discharge on arid astringent and other compounds both in moving and in stationary conditions of the activation object;
- elaboration of high-voltage activation technologies by the corona discharge of hardening compounds and moulded articles.

Results of experimental researches of fired materials' properties during high-voltage activation technology of both moulded samples and source ingredients up to the moulding and further high-voltage treatment are viewed in this article.

When conducting the research two conceptual theoretical approaches are taken into consideration. They fill the place in structure formation processes of ceramic articles up to the firing and severely influence on the results of the latter. First when regulating the time of energy-loading of moulded samples in high-voltage activation technology, a superficial and volumetric object changes are tied with the distortion and dipole polarization change in conditions of twofold electric field generation at the interface of phases and deformation of the latter at the simultaneous change of inductive capacity of the whole system.

Secondly the generating of hardening structures, especially at early stages, depends in many respects on the adhesion processes course, which is shown through watering and adhesion of the liquid phase to solid ingredients of ceramic blend. At the same time, thermodynamic conditions of watering are characterized by defined energy balance, which, in conditions of high-voltage activation technology of moulded articles may be extensively regulated when treating arid ingredients by means of increase of their superficial energy and efficient techniques of further use in the general scheme of articles moulding.

High-voltage mounting provides for the voltage change at the corona-forming conductor, whose diameter is 1.7 mm from 30 up to 60 kilovolt, is used in experimental research. The object of activation was placed under the working corona-forming conductor. Objects of activation are moulded pins with the diameter and altitude 15 mm. The moulded mixture compound included 40% of silica sand, 42% of glass powder, 18% of clay, 8% of water (beyond 100% of solid ingredients). High-voltage activation of moulded samples was implemented at the above stated voltage on the corona-forming conductor in perpetual treatment regimes from 5 up to 60 minutes inclusive. Activated samples and control samples (non-activated) were annealed in the laboratory kiln at temperature 750 ^{o}C and then their durability was assessed. Received relations of ceramic samples durability from time of perpetual high-voltage activation in most cases bear undulatory character with the advent of maximum durability in the time range 5-60 minutes. Optimal time of high-voltage treatment is established, when durability of activated samples exceeds durability of control samples. Thus, during high-voltage activation of moulded samples with the voltage on the corona-forming conductor of 60 kilovolt their durability at 10 and 30 minutes exceeds the durability of control samples at 26 and 30% respectively. In view of the consequences of the high-voltage activation of moulded samples and as a corollary the regularity of their durability, the change depending on treatment regimes were determined by sophisticated flow of generation processes and deformation of twofold electrical bed at the interface of phases under the condition of disturbance of high electrical field on moulded samples. In addition it is indispensable to mention the properties change of phases during the perpetual high-voltage treatment of moulded samples. To develop the issue, concerning the role of generation conditions of twofold electrical field in high-voltage activation technology on the properties of ceramic articles the complex of experimental researches on preliminary, up to the generation, high-voltage activation of solid ingredients of raw mix and separately different techniques of their implementation during the preparation of moulded samples was carried out. In fact, energetic balance of thermodynamic watering conditions was regulated both in the process of raw mix preparation and on the moulding samples stage.

The development of the question of influence of formation of double electric layer conditions in the technology of high-voltage activation on the ceramic products qualities was followed by the complex of experimental researches of preliminary, before moulding, high-voltage activation of separate solid ingredients of the raw mix and variety of technological ways of their realization while preparing the moulded samples. The content of raw mix stays unchanged.

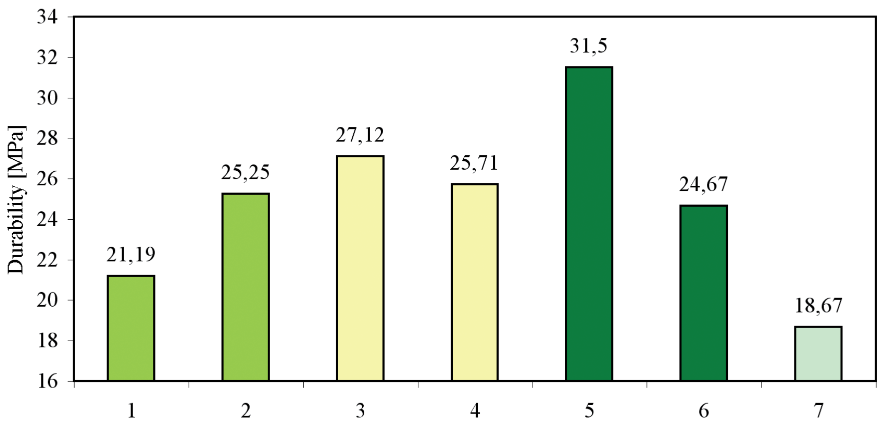
Separately activated solid ingredients were further used during the preparation of raw mix in accordance with two techniques of ceramic samples generation, which in all cases were subject to further high-voltage treatment during 10 minutes:

- activated solid ingredient was gauged with water and blended with residuary arid ingredients and samples were moulded (1st variant);
- activated solid ingredient was gauged with residuary arid solid ingredients and then blended with water and samples were formed (2nd variant).

The time of activation for separate ingredients is 5 minutes.

The autonomous experiments on simultaneous activation of all solid ingredients of blend, on their mixing and further mixing with water and formation of samples have been made. The results of the research are shown on figure 1.

As we see from figure 1 high-voltage treatment of solid ingredients of the blend affects the final durability of the moulded samples during the accepted modes of activation and technological methods of their implementation. Thus, during the separate high-voltage treatment of the solid ingredient with the second variant, the durability of the ceramic samples almost doesn't depend on which of the ingredients of the raw mix was subject to electro-physical activation (variant 2).



1 – separately activated sand (variant 1)
2 – separately activated sand (variant 2)
3 – separately activated glass powder (variant 1
4 - separately activated glass powder (variant 2)
5 – separately activated clay (variant1)
6 - separately activated clay (variant2)
7 – separately activated sand, glass powder, and clay

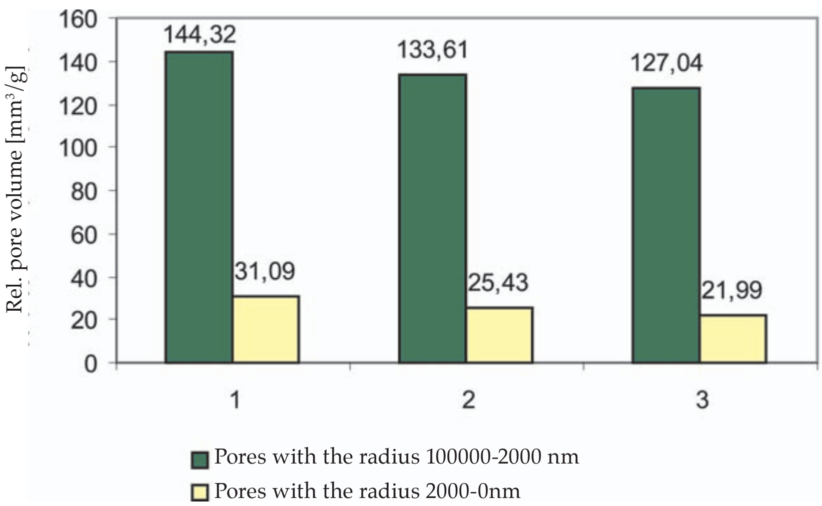
Figure 1. The sample durability depending on the variant of activation

Activation time for several ingredients comprises 5 minutes.

Absolutely different situation can be seen when activated ingredient was mixed with the residuary solid ingredient, and then dry mix was dissolved in water and the samples were formed. In this case the durability of annealed samples increases because of the growth of the most active surface and the value of surface energy density of the activated object (sand, glass powder, clay). The largest increase of durability takes place with the high-voltage clay activation, which comprised 1.7 times in comparison with the control samples.

The mercurial steam diagnosis has shown the changes in the viscosity of ceramic samples. On figure 2 we can see the values of ceramic sample pore volume in accordance with the variants of clay ingredient activation. As a result of clay activation and the following mixing with the rest blend ingredients and after with water (according to the first variant), the major volume of annealed samples pores decreases in comparison with control from 175.41 mm^3/g up to 159.04 mm^3/g. During clay activation according to the second variant the total volume of ceramic sample pores decreases up to 149.03 mm^3/g, because of the stronger bonds between clay particles. The interaction with the rest of ingredients of raw mix is less active which causes the decrease of ceramic samples durability.

The simultaneous but separate activation of solid ingredients, their mixing with each other and the following tempering with water and formation of samples didn't cause the expected increase of durability. Conceivably in the last case during the mixing of the activated ingredients there is a redistribution of charges between them and the flow of recombination processes, which diminishes the total value of surface energy density of the hard mode and as a result worsens the process of moistening on the borders of the modes.



1 - control; 2 - clay (1 variant); 3 - clay (2 variant)

Figure 2. The dependency of relative volume of ceramic sample pores on the variants of activation

Formed samples of mixtures typical for producing decorative majolica were taken to carry out experimental investigations in examination of influence of high-voltage activation on strength properties of ceramic samples with different composition. Raw mixture composition included clay (64%), diopside (23%) and cullet (12%). Samples of 2.5 x 2.5 x 2.5 centimetres in size were formed by method of plastic forming.

High-voltage treatment time of formed samples made up 10 and 20 minutes. After treatment ceramic samples were dried and then fire in laboratory furnace. The investigation data are shown on figure 3.

Figure 3 demonstrates that under high-voltage treatment during 10 and 20 minutes ceramic samples strength increases respectively from 40,9 MPa to 54,4 and 46,4 MPa. Data of conducted investigations confirm the data of the previous ones [1, 2] and show the opportunity of adjusting properties of ceramic materials in high-voltage technology. Determined regularities in changing of strength properties of ceramic materials in high-voltage treatment of formed samples are connected with a series of factors that do take place or can be during the treatment.

It's necessary to remember that when the time of treatment in technology of high-voltage activation is changed then surface and volume changes of object of treatment are connected both with changes in interlayer polarization under conditions of forming double layer in phase interface and with deformation of latter along with permittivity changes of all the system as a whole.

To develop the issue of influence of high-voltage activation on fired materials properties a complex of experimental investigations was carried out using this type of treatment in production of porous materials on the base of rocks containing zeolite. Formed samples were taken as an object of treatment. Mineralogical composition of such rocks is performed by zeolite, quartz, feldspars and clayey minerals (smectite). The chemical composition of the rock containing zeolite is performed in the table below.

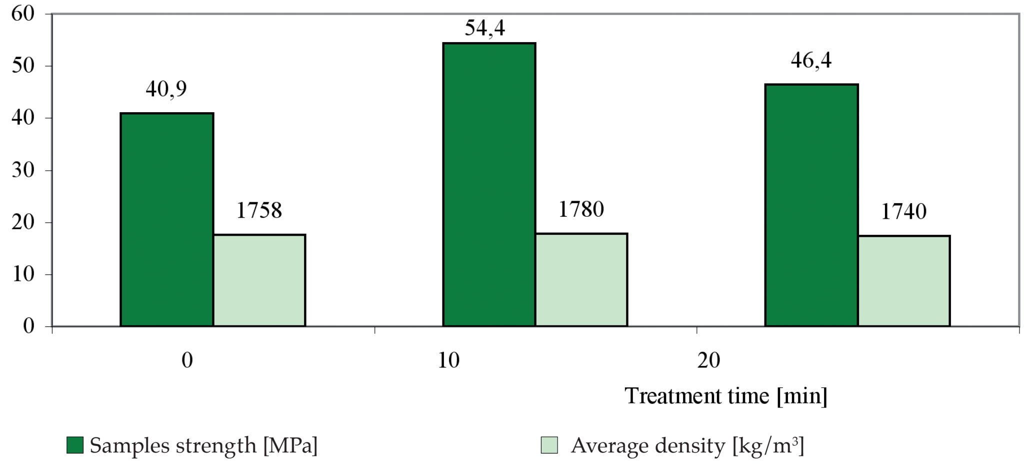


Figure 3. Changes in ceramic samples strength due to time changes of high-voltage treatment

Oxide content, mass %									
SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	ppc	Total
66.1	0.34	12.51	2.36	2.27	1.66	1.04	3.24	10.28	100.0

Table 1.The chemical composition of the zeolitic rock

Formed samples were treated in the field of high-voltage corona discharge during 5, 10, 15 minutes and then were fired at temperature of 850 °C. Investigation data are given in figure 4.

As it is shown on figure 4 material properties depend on the time of prior high-voltage treatment. The data of microscopic investigations of taken samples shown on figure 5 visually demonstrate change of porous structure of the material.

Increase of time of high-voltage treatment results in decrease of pore size and the structure of material becomes small-porous. According to data of microscopic analysis the range of pore sizes of samples produced without high-voltage treatment is 0.47-2.036 mm. Pore sizes of materials being under high-voltage treatment for 5, 10 and 15 minutes range between 0.41-1.6; 0.33-1.66 and 0.21 – 1.68 mm respectively.

The results of investigations confirmed an opportunity of obtaining fired materials with adjusted structure and properties under high-voltage activation by corona discharge before the firing stage. Determined regularities in changes of ceramic materials properties along with energy and time parameters of treatment are connected with a series of factors. The first factor of no small importance is the chosen form of corona discharge (avalanche or stream) in taken conditions of high-voltage treatment. Secondly, at prolonged application of electric field to bodies they accumulate electrical discharges causing irregular spatial and temporal change of intensity in volume. This results in appearance of zones where electric field intensity is higher than calculated value of intensity determined by electrode configuration. To a greater extent this spatial and temporal non-stationarity is peculiar to materials having high structure heterogeneity [2] that resides our treatment objects.

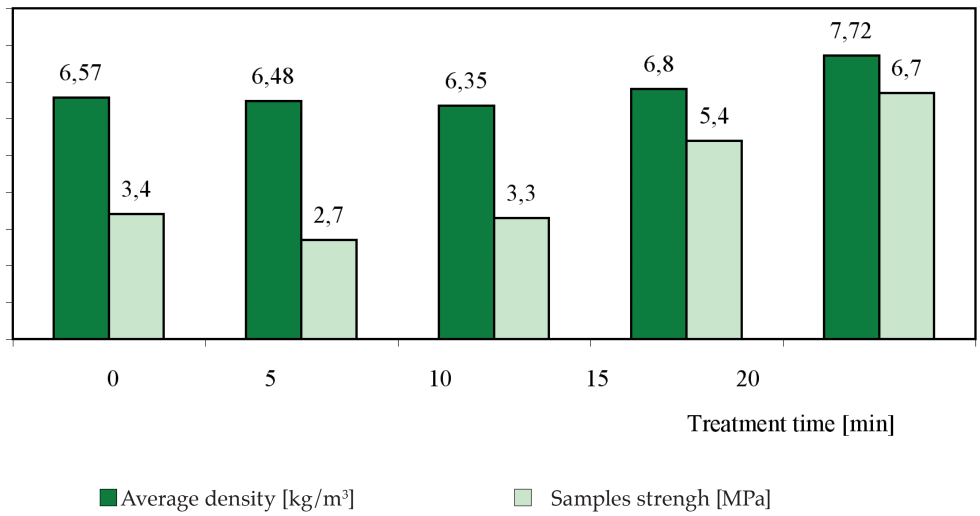


Figure 4. Dependence of samples properties on time of high-voltage treatment

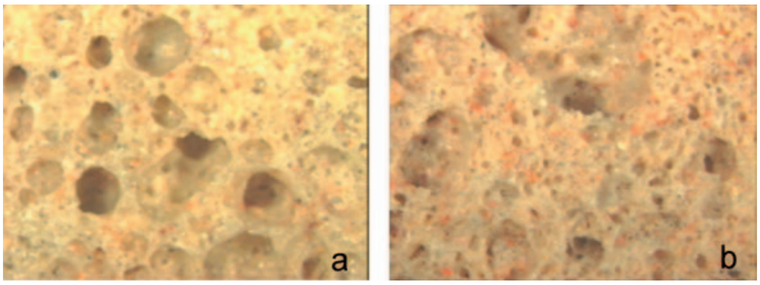


Figure 5. Microscope pictures of foam zeolite samples under high-voltage treatment during: a - 0 min.; b - 15 min

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