The research of different types of clays of the Kazakhstan for the production of wall ceramic products

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Abstract. The manuscript presents the results of analysis and synthesis of researches of scientists of the CIS and Kazakhstan on the use of various clays for the production of wall ceramic products. There was investigated the application of refractory and brown clays, loam to optimize the composition of the furnace charge and the choice of technological parameters of the production of wall ceramic products. The drying and burning properties of the samples burned at 850 °C, 900 °C, 950 °C, 1000 °C and 1050°C, 1100÷1150 °C with determination of strength, shrinkage, water absorption of the material at all specified burning temperatures were studied. The optimal burning temperatures for the study of the burning properties of the above three clays are determined. In many regions of the Republic of Kazakhstan the problem of production of high-quality wall ceramic manufacture is particularly acute. Most seasonal plants turns out low-branded products (the M75-100, B<25), often not conforming to requirements of normative documents, does not have the expanded range, the decorative brick necessary for construction of low houses (country, cottage buildings) as implementation of the similar program requires, first of all, detailed studying of technological and physical and chemical features of clay raw materials is not issued.

1. Introduction
Clays, being the main raw materials of ceramic industry, represent complex structures and demand serious approach to development of technologies taking into account specifics of raw materials. Since the most ancient times (China, the Middle East) paramount attention was paid to processing of raw materials. Different manufacturing techniques of pottery developed on the basis of practical experience which passed from generations to generations throughout centuries. Panel housing construction and excessive hobby for reinforced concrete led in the 50-60th years to decline of the domestic ceramic industry [1-2]. The experience and traditions developing within many decades was lost. As result, at the enterprises of ceramic industry less attention began to be paid to questions of high-quality preparation and processing of raw materials taking into account specifics of production. In this regard the research of a complex of technological and physical and chemical features of clay raw materials based on modern scientific concepts acquires special importance and relevance. In this regard development of structures and technology of receiving more quality front ceramic brick taking into account specifics of local raw materials is relevant [3-6].

The main technological requirements of production of wall ceramics are prevention of formation of cracks because of uneven shrinkage on thickness of a product and difference of humidity on an
internal and outer surface. And a condition of emergence of cracks and ways of fight against them the considerable number of works nevertheless is devoted to studying of the mechanism, the sharpness of a problem remains to this day [7-10].

Results of a research of the last years a directed generally to improvement of drying properties of masses by exhaustion and moistening steam of clays, their warming up, pumping out, additive in clay of plaster, ashes, surfactants, irrigation of a mouthpiece by the moisture detaining structures, introduction of electrolytes, creation of pre-depressed films.

There is theoretically and practically established that drying of stoneware of plastic formation differs in big complexity and it is bound to the considerable expenses of power supplies (gas, coal, fuel oil).

Therefore in the conditions of an energy crisis the special relevance is acquired by synthesis of structures of the ceramic masses, insensitive to drying, and the development of the intensive modes of drying of products allowing reducing duration of drying and will lower costs of energy carriers.

2. Materials and methods

For production of stoneware we in researches used the following raw materials: refractory and brown clay, loam, and as additive chamotte, BaCO₃ and sawdust.

For optimization of compositions of fusion mixture and the choice of process parameters of production of stoneware three types of clay of Kazakhstan, and conditionally designated as are picked up: refractory; brown; loam.

The next technological researches were in laboratory conditions:

Researches on processing were carried out on the laboratory hammer swing mill equipped with a bolter with openings in 3 mm, and the subsequent 100% processing with use of a sieve with openings <1 mm.

Researches of hashing and vacuum formation with determination of the humidity providing consistency of a bar at the exit from a mouthpiece in 1.3÷1.6 kg/cm².

The normal consistency of a bar at extrusion is in limits of 1.4 ÷ 1.8 kg/cm².

Researches of drying properties were studied drying properties of three mixes with determination of the following parameters:

- Durability of dry samples.
- Drying shrinkage.
- Crack resistance limit.
- A sensitivity indicator to drying according to Nosova.
- Curve Bigota.
- Percent of reabsorbed moisture.
- Extent of impact of reabsorbed moisture on durability of dry material.

The burning properties of the samples burned at 850ºC, 900ºC, 950ºC, 1000ºC and 1050 ºC, 1100÷1150 of ºC with determination of durability, shrinkage, water absorption of material at all specified burning temperatures. Depending on a type of clay and type of the final product, burning was begun at a temperature of 850 ºC of 900 ºC, and was complete at a temperature of 1100 ºC of 1150 of ºC.

Burning properties at the optimum temperature determined in the previous researches:

- Burning shrinkage.
- A lose of weight in burning (loss of ignition).
- Forming humidity concerning the burned weight.
- Water absorption of the burned material.
- Density of the burned material.
- Mechanical strength of the burned material.

Thermo-dilatometric researches: for identification of volume changes of material when burning and projections on this basis of an optimum temperature curve of burning.
3. Results and discussions
Drying properties and interaction with humidity of a surrounding medium are given in figures 1, 2, 3, 4.

Consistency of paste on escaping of a mouthpiece: 1.5 kg/cm².
Water for interfusing, necessary for samples with normal consistency, expressed as a percentage weights in the clay which is dried up at 110 °C: 27.76%.
Shrinkage at the drying after elimination of water for interfusing: 7.41 %.
Limit of cracks formation or the maximum length without cracks of sample 200x10x100 mm which is dried up in the following conditions: 20 cm.
Temperature: 75-120 °C.
Time: 90 minutes
Airflow speed: 6 m/s.
Residual humidity at the end of drying: 2.94%.
Sensitivity coefficient on nasal or a ratio between pressed volume during drying and the total pores volume of drying material: 0.67.
The tearing strain on a bend is value between 4 samples (deleting dispersion): 64.85 kg/cm².
The humidity of a surrounding medium absorbed by dry samples after finding of 24 h is in the saturated atmosphere (the relative humidity of 100%): 4.02%.
Flexural strength of samples from the surrounding medium absorbed by moisture: 17.95 kg/cm².
The strength lose of dry samples is due to effect of absorption of moisture of a surrounding medium: 72.32%.
The testing of burned samples:
The recommended temperature for burning: 1050 °C.
The shrinkage of manufactures when burning: 6.08%.
Lose of weight expressed as percentage weights of the clay which is dried up at 110 °C: 6.77%.
Water for interfusing per the mass of the burned products: 29.78%.
Water absorption after 2 h immersion of samples in the boiling water, per the mass of the burned and dry material: 5.58%.
Apparent specific gravity: 2.15 g/cm³.
The tearing strain on a bend, test is carried out on 3 samples (deleting dispersion): 366.79 kg/cm².
Such studies were conducted using brown clay and loam and the following conclusions were made.

![Figure 1. Determination of durability and shrinkage of refractory clays.](image-url)
Figure 2. Dilatometric accumulative curve of % expansion/temperature of refractory clays.

Figure 3. Differential dilatometric curve: % expansion speed on minutes / tº burning of refractory clays.
4. Summary

It is established that percentage of moisture of refractory clay is high: composes 27.76%, also as well as an index of drying shrinkage: 7.41%.

It is revealed that percentage for manufacture of bricks moisture of formation usually fluctuates between 18 and 25%, and percent of drying shrinkage between 4 and 7% in clays.

It is established that indexes of capillary moisture are also high, as well as a ratio of capillary moisture of shrinkable humidity: 1.53 – this indicator favors to drying process. In clays for manufacture of bricks this ratio fluctuates within 1-1.5.

It is established that the mineralogical composition of brown clay has the same components, as refractory clay. The difference consists only in the relative concentration of each component and also the content of quartz (sand) which in refractory clay is very low, in brown clay is high within norm.

It is revealed, despite the high content of sand in brown clay, the volume of the remaining capillaries in a dry product from brown clay: 11.4 in %, is lower, than in refractory clay: 16.80 in %, and the ratio of capillary and shrinkable moisture decreases from 1.53% in refractory clay to 1.50% in brown clay. However, effective diameter of the remained capillaries of brown clay is more, than clays refractory that provides faster process of drying of brown clay.

It is established that loam is less wax, than refractory and brown clays because of higher content of quartz (sand) in it and lime carbonate.

It is established that at loamy clay, besides a sandy quartz component, there is a limy component which isn't in two other clays that reduces its plasticity, compactness and resistance to tension created in material at the beginning of drying process.

It is revealed, the percent of shrinkable humidity which gives plasticity to material gives very low indicators in loam: 5.44 to % while this index is equal in refractory clay to 10.96%, and in brown clay - 7.60%. The percent of drying contraction also gives lower indicators: 4.32 to %.

Figure 4. Variation of water absorption, shrinkage and durability depending on temperature of refractory clays.
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