ABSTRACT

of dissertation for the doctor of philosophy (PhD) on specialty 6D072000 – "Chemical technology of inorganic substances"

Zhanikulov Nurgaly Nodiruly

"Creation of energy and resource saving technologies of Portland cement and wall ceramics using coal production waste and technogenic raw materials"

General description of work. The thesis work is devoted to the development of optimal compositions of low-energy raw mixes for producing Portland cement clinker with utilization of technogenic raw materials, the development of an optimal technology for clinker roasting and the production of wall ceramics using energy and resource saving technology.

Urgency of Research

The first president of the Republic of Kazakhstan, Elbasy N.A. Nazarbayev the production of building materials, the construction of new cement and brick factories, the development of own production of modern materials and products, the reduction of dependence on imports, the creation of import-substituting technologies and industries among the most important areas of development of industries.

Thanks to the constantly developing pace of construction, more and more cement and brick are consumed every year. In this regard, it is necessary to reduce the cost of these materials using various industrial wastes, as well as to improve the ecological situation in the region. Therefore, energy- and resource-saving technology for the production of Portland cement and wall bricks using coal production wastes and technogenic raw materials has been developed. These issues are currently receiving great attention. At the same time, issues of reducing fuel consumption for clinker and brick burning are simultaneously solved, furnace productivity is increased, environmental pollution is reduced due to waste disposal. However, the issues of the integrated use of large-tonnage industrial waste in conjunction with traditional and non-traditional natural raw materials for clinkers and special cements have not been sufficiently studied. As a result, the development of energy and resource saving technologies for the production of Portland cement through the use of various industrial wastes is an urgent problem.

The **research objective** is to develop energy and resource-saving technologies for producing Portland cement and wall ceramics using coal production wastes and industrial products from enterprises in South Kazakhstan.

To achieve this goal, it is necessary to solve the following tasks:

- study of the chemical and mineralogical composition and properties of large-tonnage coal mining waste and technogenicmaterials;

- development of compositions of energy- and resource-saving raw mixtures for clinker production;

- study of the possibility of using coal mining waste and lead slag as an aluminum-containing and iron-containing component in the composition of the raw mixture for producing clinker;

- study of the physical and chemical processes of clinker formation in the developed low-power resource-saving compositions of raw mixtures;

- study of the thermodynamic probability of reactions occurring in the process of clinker formation;

- determination of the effect of modular characteristics of raw materials on the chemical and mineralogical composition of clinkers, sintering processes, absorption of CaO, specific fuel consumption during burning;

- study of the influence of coal mining waste additives on the process of burning wall ceramics, physical and mechanical properties of products and specific fuel consumption during firing of products;

- study of the processes of hydration and hardening of cements obtained from energy resource-saving compositions of raw materials;

- approbation of an energy-saving technology for producing wall ceramics using coal waste in an industrial environment of “Zangar-2003-Z” LLP.

Research methods.

To achieve the goal and objectives in the dissertation, modern research methods were used: chemical, radiographic, differential thermal, scanning electron microscopic analysis. Standard methods for testing raw materials, semi-finished products and finished products are also applied.

The research object is the energy and resource saving technology for obtaining Portland cement and wall ceramics using industrial wastes.

The research subject is compositions of raw mixes for energy and resource-saving technologies for the production of Portland cement clinker and cement, wall ceramics, high-temperature clinker formation processes in low-energy mixtures, ceramic brick sintering processes, hydration and hardening processes of low-energy cements obtained using various technogenic raw materials.

Scientific novelty.

- New compositions of low-energy-intensive resource-saving raw materials have been developed for the production of Portland cement clinker with the integrated use of coal mining waste, tephritobasalt and lead slag.

- For the first time, the regularities of the cumulative effect of technogenic products on the processes of clinker formation, the phase composition of clinkers and the specific heat consumption during burning were established;

- It is shown that in the developed low-energy-consuming raw materials the amount of the liquid phase is 28-32%, the coefficient of adhesion to the lining is 3,11-3,24. This will allow stabilizing the operation of the furnace, increasing its productivity, reducing the specific fuel consumption by 15-18%, and increasing the durability of the lining;

- It has been established that the coal contained in the waste heaps in the amount of 15-24% will improve the energy efficiency of clinker and brick firing. The specific consumption of equivalent fuel per 1 ton of clinker decreases from 218,8 k.f.e. up to 160-170 k.f.e., for 1000 pcs. conv. bricks are reduced from 120,1 k.f.e. to 78.3 k.f.e. (k.f.e. - kg of fuel equivalent)

- The composition of the charge and the conditions for obtaining ceramic bricks from coal mining wastes have been optimized;

- The regularities of the influence of waste heaps on the firing process and the properties of ceramic bricks, on the energy efficiency of brick production technology have been established.

Practical relevance of the research.

The practical relevance of the research is:

- reduction of the clinker burning temperature to 1300-1350 °C, i.e. 100-150 °C lower than in the traditional, lower clinker burning temperature will reduce heat costs to obtain Portland cement clinker;

- reduction of natural fuel consumption for clinker burning by 19%, increase in furnace productivity by 15%.

- improvement of clinker formation due to the introduction of 3.4-5.0% lead slag and 9,1-9,7% tephritobasalt;

- tephritobasalt promotes the appearance of a liquid phase at temperatures of 1280 °C, improves the properties of clinker melt. Zinc contained in lead slag has a destructive effect on the crystal lattices of raw materials, lowers the temperature of calcite dissociation, lowers the temperature of clinker melt by 100-150 °C, improves its viscosity and surface tension;

- increase in the strength of cements obtained from unconventional and technogenic raw materials by 1-4 MPa;

- reduction in specific consumption of coal for brick burning by 34% or 114.2 kg per 1000 pcs of conventional bricks;

- reduction of the average density of bricks to 1743 kg/m^3, improvement of thermal insulation properties, reduction of thermal conductivity to 0,46 W/(m·°C);

- reduction in the cost of cement and brick by reducing fuel costs;

- ecological and economic problems of the region are solved, large-tonnage production wastes are utilized, traditional raw materials are saved, energy intensity is reduced due to the use of non-traditional natural raw materials, and lead slags during production.

Theoretical significance. A new approach is proposed to optimize the technology for producing Portland cement and wall ceramics using low-energy technologies using high-tonnage technogenic raw materials: coal production waste, tephritobasalt and lead slag. Optimum compositions of raw mixes and blends for clinker and brick burning have been developed. The dependences of clinker burning processes on the modular characteristics and type of waste used are established. The possibilities of energy conservation and reduction of environmental pollution during the disposal of various technogenic raw materials are shown. The influence of coal production wastes, tephritobasalts and lead slag on clinker formation processes was studied.

The main provisions to be defended:

- compositions of low-energy resource-saving raw batch blends to produce Portland cement clinker based on large-tonnage technogenicand non-traditional raw materials;

- the possibility and effectiveness of the use of technogenic raw materials and volcanic rock as an aluminosilicate component and a corrective additive in raw mixtures to obtain Portland cement clinker;

- regularities of the combined effect of lead slag, coal production waste and igneous rocks on clinker formation processes, clinker phase composition and specific fuel consumption during clinker burning;

- the possibility of improving such basic indicators of clinker burning processes as the content of the liquid phase, the calcination index, thermal calometric module, sintering coefficient, thermal effect of clinker formation, the coefficient of adhesion to the lining, etc.;

- regularities of the influence of waste heaps on burning processes and the properties of ceramic bricks, on the energy efficiency of wall ceramic production technology.

- the possibility of improving the basic characteristics of bricks such as average density, voidness, thermal insulation properties, thermal conductivity.

Assessment of the completeness of solutions to the tasks.

All the tasks set for solving the purpose of this dissertation are solved in full. X-ray phase analysis investigated the chemical and mineralogical composition and properties of coal wastes and industrial materials. The possibilities of using coal production waste and lead slag as an aluminum-containing and iron-containing component in the composition of the raw material mixture have been studied. Using the PCC3 and ROCS programs, the compositions of raw mixes were calculated to determine the effect of the modular characteristics of raw materials on the chemical and mineralogical composition of clinkers. Sintering processes, CaO assimilation, specific fuel consumption during clinker burning were studied. Physicochemical methods determined the characteristics of the synthesized low-energy clinkers. The processes of hydration and hardening of cements using scanning electron microscopy are investigated. Schematic diagrams and technological regulations for the production of Portland cement based on multi-ton waste have been developed.

The influence of coal wastes on the process of burning wall ceramics, physical and mechanical properties, and specific fuel consumption during brick burning are studied. The energy-saving technology for producing wall ceramics using coal waste in industrial conditions of “Zangar-2003-Z” LLP was tested and implemented.

Thus, the goals of the dissertation research have been achieved - Portland cement and wall brick have been obtained using coal wastes and technogenic raw materials, and their physical and mechanical properties have been studied.

Development of recommendations and initial data on the specific use of the results. The results of this work can be used to obtain Portland cement and

wall ceramics with the aim of increasing the productivity of furnaces and saving fuel consumption when burning clinkers and bricks.

The interrelation of the subject of the thesis and research works and various state programs. The dissertation was carried out at the Department of "Cement, ceramics and glass technologies" and "Chemical technology of inorganic substances" at M. Auezov South Kazakhstan state university in the framework of the project “Study of low-temperature clinker formation processes in raw mixes from unconventional raw materials and industrial wastes with the aim of creating resource-saving technology for special sulfate-resistant and road cements” (state registration number 115 RK01548).

Dissertation contribution. The author analyzed the literature on the topic of the dissertation, carried out research on the initial raw materials and technogenic raw materials, and performed experimental work. In addition, the direct contribution of the dissertation candidate is the development of low-power resource-saving compositions of raw materials for the production of cement clinker and bricks, the performance of physicochemical and physical-mechanical studies, the firing of clinkers and bricks, and production tests of the developed technology in production at LLP «Sastobe Technologies» and LLP «Zangar-2003-Z», processing of the obtained data, generalization of conclusions.

In the process of conducting production tests at LLP «Sastobe Technologies» and LLP «Zangar-2003-Z», the author took samples of raw materials and finished products, chemical analysis of raw materials, clinker and cement was carried out in the factory laboratories, determined the indicators of sludge, clinker, brick (shrinkage, etc.), the parameters of the furnaces, the specific consumption of raw materials, the yield, etc., the conformity of the quality of cement and brick to the requirements of GOSTs.

Testing the results of work.

The main provisions and results of the dissertation were reported at national and foreign international scientific conferences:

- V International scientific practical conference "Industrial Technologies and Engineering", Shymkent, 2018. -P.180-186.

- XII International Scientific Conference "Innovative development and the relevance of science in modern Kazakhstan." Foundation of the First President of the Republic of Kazakhstan - Elbasy, Council of Young Scientists. - Almaty, 2018.-Part 1. -P. 54-57.

- XIII International Scientific Conference of Young Scientists "Innovative development and the relevance of science in modern Kazakhstan". Foundation of the First President of the Republic of Kazakhstan - Elbasy, Council of Young Scientists. - Taraz. 2019. - P.55-57.

- International scientific-practical conference dedicated to the 65th anniversary of V.G. Shukhov BSTU. "High technology and innovation" (XXIII scientific readings) -Belgorod: 2019.-Part 1. -P.153-159.

- International scientific and technical conference of young scientists V.G. Shukhov BSTU. -Belgorod: 2019. -P.2440-2448.

- XXVI International scientific conference of students, graduate students and young scientists "Lomonosov-2019". -Moscow: 2019.-P.943.

- XV International scientific and practical conference "Fundamental and applied science - 2019". Sheffield. -Vol.12. - P.42-46.

- the magazine "Cement and its application", St. Petersburg: 2018. No.1. - P.170-174.

Publications

The main content of the dissertation was published in 13 scientific journals, of which 2 article in journals included in the Scopus database, 4 articles in publications included in the list of Supervisory Committee of the Ministry of Education and Science of the Republic of Kazakhstan and 7 reports and abstracts in proceedings of international, national and foreign scientific conferences. Received 2 patents for a utility model of the Republic of Kazakhstan and 1 Eurasian patent:

1 Taimasov B.T., Saduakasov T.M., Alzhanova A.A., Dauletiyarov M.S., Zhanikulov N.N., Abekov K.O., Khashimov A.N., Seytbekova B.M. Raw mix to produce Portland cement clinker. Patent for utility model of the Republic of Kazakhstan No.2610 by 12.02.2018. bull. No.6.

2 Zhanikulov N.N., Taimasov B.T., Dzhanmuldaeva Zh.K., Aytureev M.Zh., Masatbaev A.T. Raw mix for the manufacture of ceramic bricks. Patent for utility model of the Republic of Kazakhstan No.4121 by 16.01.2019.

3 Taimasov B.T., Khudyakova T.M., Saduakasov T.M., Dauletiyarov M.S., Zhanikulov N.N., Abekov K.O., Serikbaeva A.T., Sabet Zh.K. Raw mix to produce Portland cement clinker. Eurasian patent No.033588 by 11.07.2019.

Thesis work structure and scope.

The thesis work consists of introduction, 6 parts and conclusion. The volume of thesis work is 144 pages, in the course of its implementation 143 sources of literature were used. The work is illustrated by 38 tables and 45 figures.