ANNOTATION

dissertation work on the topic "**Low–energy technology of cement clinker production using zinc and lead production waste",** submitted for the degree of Doctor of Philosophy (PhD) in the specialty 8D07190 - "Chemical technology of refractory non-metallic and silicate materials" KUANDYKOVA AKNUR YERKHANKYZY

The relevance of the topic. Cement clinker production is one of the most energy-intensive and environmentally demanding processes in the construction industry. High firing temperatures (about 1,450 °C) lead to significant fuel costs and CO_2 emissions. In modern conditions, the development of low-energy and resource-saving technologies is of particular importance. The use of zinc and lead production waste, etc. As a raw material, it helps to reduce energy consumption, rational use of resources and environmentally safe disposal of man-made waste.

South Kazakhstan is a region with a developed metallurgical industry and significant potential for the use of such technologies, as there are large enterprises for the extraction and processing of zinc and lead ores, as well as cement plants interested in reducing costs and improving the environmental friendliness of production.

The development of a low-energy technology for the production of cement clinker using clinkers for calcining zinc ores and lead slags allows not only to increase the energy efficiency and environmental safety of cement production, but also contributes to the sustainable development of the region as a whole.

Thus, the relevance of the topic is due to the urgent need to introduce innovative technological solutions aimed at increasing energy and resource conservation, environmental safety and economic efficiency of cement clinker production using industrial waste.

Portland cement is an energy–intensive product, since the cement base, clinker, is fired at a high temperature of 1450 ° C. Clinker firing is a complex multi-stage process. Approximately 5 tons of raw materials, additives, fuel, water, air, refractories, etc. are used to produce 1 ton of cement. Fuel consumption per 1 ton of clinker by the wet method is 220-240 kg, by the dry method – 100-120 kg. In Kazakhstan, 14 plants produce clinker by dry methods and 3 plants by wet methods. Therefore, the issues of clinker firing processes, energy conservation and ecology remain important and relevant.

Today, Kazakhstan and other countries are paying more and more attention to the problems of sustainable development, reducing anthropogenic impact on the environment and the climate system, including reducing greenhouse gas emissions in key industries. Cement production is an extremely material-intensive and energy-intensive process involving the release of significant amounts of carbon dioxide. Cement production is one of the leaders in greenhouse gas emissions into the atmosphere.

The global cement industry produces approximately 6% to 7% of global CO_2 emissions and 5-7% of anthropogenic greenhouse gas emissions each year. At the

same time, during the production of cement clinker, a large amount of CO_2 greenhouse gas is formed, which is released during the decarbonization of carbonate-containing raw materials (technological CO_2) and during the combustion of fuels (energy CO_2). The share of fuel and energy costs in the cement industry is about 40% of the cost of the product produced. In fact, 840-900 kg of CO_2 is released into the environment during the production of 1 ton of clinker. Therefore, it is very important to develop low-energy resource-saving technologies that can reduce both fuel consumption for firing clinker and greenhouse gas emissions of CO_2.

The purpose of the study:

To develop a scientifically sound, low-energy and environmentally friendly technology for the production of cement clinker using waste from zinc and lead production, etc., which reduces energy costs, efficiently disposes of man-made materials and produces clinker with high performance characteristics suitable for the production of Portland cement.

Research objectives:

To achieve this goal, the following tasks are being solved:

1. To carry out a comprehensive analysis of the chemical and mineralogical composition of zinc and lead production waste and other waste in order to assess their suitability as components of a raw charge for the production of cement clinker.

2. To develop optimal compositions of raw material mixtures using waste, ensuring the production of clinker at low firing temperatures without reducing the quality of the final product.

3. Experimentally determine the optimal technological parameters of the firing process in order to minimize energy consumption and ensure the required clinker quality.

4. Evaluate the physico-mechanical and physico-chemical properties of the resulting clinker and cement, heavy metals and other harmful components in the mineral structure of the clinker to ensure the environmental safety of the product.To determine the possibilities of reducing carbon dioxide emissions into the atmosphere when implementing the developed technology.

5. To develop a waste inventory, a technological scheme and technological regulations for the production of clinker and cement based on industrial waste.

The object and methods of research. The object of the study is the production process of cement clinker using waste from non-ferrous metallurgy, in particular clinkers from the smelting of zinc ores from the Achisai Metallurgical Plant, lead slags, etc.

Special attention is paid to the chemical and mineralogical composition of these wastes, their effect on the formation of clinker minerals, as well as the energy intensity of the firing process and the quality of the resulting cement clinker.

The main provisions submitted for defense:

- the developed resource-saving raw materials mixtures based on natural and large-tonnage man-made raw materials for the production of Portland cement

clinker reduce the firing temperature by 100 °C, reduce fuel consumption by 10-15% and reduce heat costs by 150-200 kJ/kg.

- the possibility of a complete or partial replacement of natural raw materials with man-made waste has been established: Achisai clinker and granular lead slags. On this basis, energy–efficient and resource-saving charges have been developed to replace natural raw materials by 30-90% and reduce the consumption of raw materials by 0.1-0.2 tons per 1 ton of clinker. The calculation of charge compositions for various construction and special cements has been performed.

- the calculation of CO_2 emissions into the atmosphere was performed using the developed environmentally friendly low-energy technologies. When using Achisai clinker as a corrective ferrous additive in the raw material mixture for clinker production, CO_2 emissions into the atmosphere are reduced by 64 kg (12.08%) per ton of clinker, and when using lead slag, they are reduced by 42 kg (7.9%) per ton of clinker.

- in the radiological laboratory, dosimetric control of clinker calcination of zinc ores of the Achisai Metallurgical Plant was performed. The measured dose rate of the zinc ore clinker sample was 0.15 mSv/hour, n/sec, which meets the requirements for radiation safety standards. The permissible dose rate is 0.2 + background (mSv/hour, n/sec).

- possibilities for improving the main indicators of clinker firing processes: the amount of liquid phase, the burnability index (op. 2.5–3.5), the thermal calorimetric modulus (op. 0.3–1.8), the sintering coefficient (op. 0.5–0.6), the thermal effect of clinker formation, the coefficient of adhesion to the lining (op. 3.0–5.0) and others.

The main results of the study:

The subject of the study is the influence of the composition and properties of waste from zinc, lead production, etc. on the formation of cement clinker, the peculiarities of reactions during low-temperature firing of raw materials using these wastes, as well as their impact on the energy efficiency of production and the quality of the resulting Portland cement clinker.

Substantiation of the novelty and importance of the results obtained:

1. Low-energy, environmentally friendly technologies for the production of cement clinker using waste from zinc and lead production and other man-made raw materials have been theoretically and experimentally substantiated, allowing to reduce the firing temperature by 100-150 °C compared with traditional technologies.

2. The regularities of the influence of the chemical and mineralogical composition of non-ferrous metallurgy waste and impurity oxides on the formation of the main minerals of cement clinker under reduced temperature conditions of firing have been established.

3. The regularities of the influence of the chemical and mineralogical composition of clinker for calcination of zinc ores of the Achisai Metallurgical Plant, the compositions of raw materials, modular characteristics on the specific fuel consumption during firing and the amount of carbon dioxide emissions into the atmosphere have been established.

4. Optimal compositions of raw material mixtures have been developed with the partial replacement of traditional components with zinc and lead production waste, ensuring the production of clinker with improved performance characteristics.

5. The mechanisms of fixation of heavy metals and toxic components in the clinker structure have been identified, which ensures the environmental safety of products and promotes the disposal of hazardous waste.

The theoretical significance of the work lies in the expansion and deepening of scientific ideas about the processes of cement clinker formation when using waste from the metallurgical industry, in particular waste from zinc and lead industries. For the first time, systematic data on the effect of the composition of lead clinker, lead slags, etc. have been obtained. effects of waste on the kinetics of mineral formation and the phase composition of cement clinkers at low firing temperatures.

New models of interaction of the components of the raw material mixture have been developed, taking into account the complex chemical composition of waste and their activity, which made it possible to justify low-energy firing modes and increase the efficiency of synthesis of the main minerals of Portland cement. The results obtained contribute to the development of the theory of sustainable resource consumption and thermochemistry of high-temperature processes, expanding knowledge in the field of environmentally safe use of man-made materials in construction technologies.

The developed technology confirms its effectiveness and high prospects for industrial implementation at cement plants in South Kazakhstan.

Thus, the work makes a significant contribution to the fundamental foundations of materials science and cement production technology, as well as to the theory of industrial waste disposal and reduction of carbon dioxide emissions into the atmosphere.

Practical significance of the work:

1. The introduction of low-energy technology for the production of cement clinker using waste from zinc and lead industries and other waste at cement plants in South Kazakhstan will reduce the clinker firing temperature by 50-100 ° C, specific fuel consumption for firing by 10-15%, increase furnace productivity by 10-12%, increase output, and improve the economic efficiency of enterprises.

2. The rational use of lead clinker, lead and other slags will contribute to solving global environmental problems: reduce carbon dioxide emissions in cement production, recycle high-tonnage waste, eliminate or reduce the risks to nature and the environment associated with the accumulation of hazardous waste from the metallurgical industry and other industries.

3. When partially replacing natural raw materials with industrial waste emissions of greenhouse gases and other pollutants (NOx, SO3, CO) are reduced by reducing the specific consumption of raw materials for producing 1 ton of clinker, reducing the carbonate component of the raw charge, reducing the clinker firing temperature and the specific fuel consumption for firing clinker.

4. Regulatory documents and technological regulations have been developed for the preparation of energy-saving raw materials and the firing of low-energy, environmentally friendly raw materials mixtures using waste from the metallurgical industry, etc. in the production of cement clinker.

5. The quality and durability of cement materials is improved due to the formation of clinker with improved structural and phase characteristics.

6. The research results are used in the educational process and personnel training in the field of cement technology and resource conservation.

Compliance of the dissertation with the directions of scientific development or state programs.

The dissertation work was carried out within the framework of PCF BR21882292 - "Integrated development of a sustainable construction industry: innovative technologies, production optimization, efficient use of resources and creation of a technology park".

The doctoral student's personal contribution to the preparation of each item consists of:

- an analysis of literary sources of similar studies has been carried out; - the purpose and objectives of the dissertation research are formulated;

- various high-tonnage industrial wastes for low-energy and environmentally friendly clinker production have been selected and justified; - the chemical and mineralogical composition of waste has been studied and the ways of their use in cement production have been substantiated;

- the processes of high-temperature synthesis of clinkers based on high-tonnage industrial waste are investigated;

- the low-temperature completion of the processes of obtaining basic clinker minerals in charges with additives of waste and mineralizers is justified;

- low-energy-intensive raw materials and technological waste disposal schemes for the production of cement clinker have been developed and substantiated;

- the harmlessness of the industrial waste used is shown. - a conclusion has been formulated on the completed dissertation work.

Based on the materials of the dissertation, 8 papers have been published, including 1 work in journals included in the international information resource Scopus, as well as 4 articles in scientific publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan and 2 reports and abstracts in the proceedings of international and foreign scientific conferences. Received 1 patent for the invention of the Republic of Kazakhstan:

1. Kuandykova, A., Taimasov, B., Potapova, E., Sarsenbayev, B., Kolesnikov, A., Begentayev, M., et al. Production of composite cement clinker based on industrial waste. Journal of Composites Science, 2024, vol. 8, July, pp. 257–275. DOI: 10.3390/jcs8070257. Q-2, процентиль -76.

2. Қуандықова А., Жаникулов Н., Таймасов Б., Жакипбаев Б. Ащысай металлургиялық зауытының клинкерін портландцемент клинкерін алуға реттеуші қоспа ретінде қолдануды зерттеу // ҚР ҰҒА баяндамалары. Химия

ғылымдары сериясы. – 2023. – №3. – Алматы. – Б. 146–156. – DOI: 10.32014/2023.2518-1483.232.

3. Қуандықова А., Таймасов Б., Жаникулов Н., Потапова Е. Ащысай металлургиялық зауытының клинкерін белитті клинкер синтездеу үшін қолдану // ҚР ҰҒА хабаршысы. Химия және технология сериясы. – 2024. – №1. – Алматы. – Б. 83–93. – DOI: 10.32014/2024.2518-1491.209.

4. Қуандықова А., Таймасов Б., Потапова Е., Жакипбаев Б., Жаникулов Н. Металлургиялық шлактардан алынатын клинкерлердің микроқұрылымын зерттеу // ҚР ҰҒА баяндамалары. Химия ғылымдары сериясы. – 2025. – №2. – Алматы. – Б. 242–257. – DOI: 10.32014/2025.2518-1483.356.

5. Amiraliyev, B., Kuandykova A, Taimassov, B., Potapova, E., and Ainabekov, N. Modern trends in the development of cement production // Bulletin of the L.N. Gumilyov Eurasian National University. Technical Science and Technology Series. – Astana, 2024. – No. 2 (151). – pp. 38–58.

6. Kuandykova A, Taimasov, B., Potapova, E., Dauletiarov, M., and Amiraliyev, B. Investigation of chemical and mineralogical composition and technological properties of industrial waste for cement production // Proceedings of the X International Annual Conference «Industrial Technologies and Engineering» (ICITE – 2023). – South Kazakhstan Science Herald, vol. 2(30). – Shymkent, Kazakhstan, 2025. – pp. 180–184.

7. Қуандықова А.Е., Таймасов Б.Т., Абдуллин А.А., Амиралиев Б.Б. Клинкер мен портландцемент алу үшін өнеркәсіп қалдықтарын қолдану мүмкіндігін зерттеу // «Заманауи құрылыс материалдары, технологиялары және конструкциялары» атты халықаралық ғылыми-тәжірибелік конференция материалдары. – Оңтүстік Қазақстан ғылым жаршысы. – Шымкент: М. Әуезов атындағы ОҚУ, 2025. – Б. 215–219.

8. Таймасов Б.Т., Даулетияров М.С., Жаникулов Н.Н., Касимбеков Т.А., Қуандықова А.Е., Абдуллин А.А. и др. Сырьевая смесь для получения портландцементного клинкера: Патент на изобретение №36495. – 08.12.2023.

The structure and scope of the dissertation. The thesis is presented on 134 pages of machine-written text, contains 57 tables, 16 figures. The work consists of an introduction, five chapters, a conclusion, a list of 110 references and 4 appendices.