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The methods of improving the technology of Portland cement production with the use of Western Kazakhstan local raw materials and industrial wastes

In this paper, one of the most rapidly developing branches in the construction industry in the Republic of Kazakhstan Portland cement production has been examined. In this connection, the main properties of the constituent components for producing Portland cement based on local raw materials in Western Kazakhstan have been studied. The technological burning process of Portland cement clinker has been made and their X-ray phase analysis has been carried out. The cement obtained main characteristics have been determined in order to assess its quality. The technological process of obtaining Portland cement with the use of local raw materials and the addition of pyritic cinders and carbon black has been organized. It has been established that the introduction of technical carbon and pyrite cinders in Portland cement has a positive effect on the rheological properties, as well as on the increase in the strength characteristics of Portland cement. The economic value has been estimated and the profitability of Portland cement production in the West Kazakhstan region has been calculated. An improved technology for the production of Portland cement including the use of local raw materials with the addition of pyritic cinders of more than 2 % and technical carbon in an amount of up to 3 % has been proposed.

Keywords: clay, flask, limestone, pyritic cinder, technical carbon, clinker, Portland cement.

One of the key directions of the country's industrial and innovative progress is the development of the chemical industry, which has been repeatedly emphasized by the President of the country N.A. Nazarbayev during the annual Addresses to the people of Kazakhstan [1]. Today, the chemical industry in Kazakhstan is becoming an important issue, which is directly related to the construction industry. Technology of production of building silicate materials is of a significant importance in the modern industry, which is one of the areas that cement industry is involved. Nowadays cement production in Kazakhstan is not sufficiently developed, so our country buys cement mainly from the Russian Federation, which is the main supplier of cement to the Republic of Kazakhstan. In turn, West Kazakhstan remains almost with no supplies of domestic products, so the need for cement in the Western region is almost completely satisfied by import. In this regard, the use of available technologies and the full provision of the region with cement produced by means of local raw materials remains relevant. Currently, Portland cement is widely used among many types of cement. It is a well-known fact that, the main components in the production of Portland cement are carbonate raw materials, aluminosilicate clay rocks, and additives [2].

It was of interest to study the physico-chemical properties of the constituent components to obtain Portland cement based on local raw materials and industrial wastes. Clays of the Pogodaevsk and Taskalinsky deposits, flask of the Taskalinsky deposit and the limestone of the Melovye Gorki deposit (West Kazakhstan region) were taken as raw materials in order to implement experimental studies. Chemical and physico-chemical methods have been used to determine physico-chemical characteristics [3].

After the researches and calculations carried out the technological process of production of Portland cement clinker and Portland cement, including extraction of local raw materials, their crushing, drying, grinding, firing clinker in a rotary furnace, cooling clinker, grinding and obtaining cement was fulfilled. One of the promising methods, namely, X-ray phase analysis has been used to control the quality of the clinker obtained, which allows determining the qualitative and quantitative composition of the clinker with high accuracy. Loss on ignition, fineness of grinding, setting time, insoluble residue content, and strength of Portland cement were determined to assess the quality of the Portland cement obtained.

Earlier, we have studied the chemical composition of raw materials and concluded that the limestone of the deposit of the Melovye Gorki, clay and flask of the Taskalinsky field was expedient for use in Portland cement production. We have set the following mineralogical composition of Portland cement: C_3S — 51 %; C_2S — 29 %; C_3A — 9 % and C_4AF — 11 %. At the same time, we accept that the sum of these basic minerals is 100 %. We give the chemical compositions of the raw material after bringing the sum of oxides SiO_2+Al_2O_3+Fe_2O_3+CaO to 100 % (Table).

T a b l e

Chemical composition of the raw material after demonstration of the sum of oxides SiO_2+Al_2O_3+Fe_2O_3+CaO to 100 %

Materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	Total
Limestone	0.3	0.7	0.2	98.8	100.0
Taskalinsky clay deposit	54.7	44.4	0.4	0.5	100.0
Pogadaevsk clay deposit	51.9	45.5	2.0	0.6	100.0
Flask	83.2	10.6	4.4	1.8	100.0
Cinder	15.0	6.3	77.7	1.0	100.0

Based on the mineralogical composition given, the chemical composition of Portland cement clinker in the main oxides was determined:

SiO_2 = 0.3×51+0.3×29 = 24.0 %;

$A1_2O_3$ = 0.4×9+0.2×11 = 5.8 %;

Fe_2O_3 = 0.3×11=3.3 %;

CaO = 0.7×51+0.7×29+0.6×9+0.5×11 = 66.9 %.

A wide range of different additives is widely used in the technology of Portland cement production. One of these additives is carbon black, which is a waste of chemical industries, unutilized reserves of which cause irreparable harm to the environment [4, 5]. Figure 1 shows the technological process for the production of Portland cement. The technological process of obtaining Portland cement with the use of local raw materials and the addition of pyritic cinders (wastes of sulfuric acid production) and carbon black were carried out. The introduction of pyrite cinder reduced the clinker sintering temperature by 50–100 °C, and the addition of carbon black allowed increasing the activity of Portland cement. Cinder and technical carbon in the amount of 3 %, which allows increasing technological efficiency and environmental safety, were added in order to improve the technology. The X-ray phase analysis was performed on a D2 Phaser Bruker powder diffractometer in order to determine the quality of the Portland cement clinker [6]. The phase composition of the clinker using clay of the Taskalinsky deposit is shown in Figure 2.

The X-ray diffraction pattern obtained as a result of the survey is a broken line with sharp peaks-diffraction reflections. The X-ray diffraction was carried out using the software DIFRAC.EVA (Bruker). From the Figures 2 and 3 it can be seen that minerals such as tricalcium silicate $3CaO{\cdot}SiO_2$ (alite), dicalcium silicate $2CaO{\cdot}SiO_2$ (belite), tricalcium aluminate $3CaO{\cdot}Al_2O_3$, and quartet $4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$ alumoferrite are present in the clinker composition. The identification of the phase is considered sufficiently reliable, since there are at least three of the most intense diffraction reflections of the phase on the roentgenogram. Thus, the composition of the clinker obtained is consistent with the literature data [7] and corresponds to the composition of Portland cement clinker, which contains four basic minerals.

The main characteristics of Portland cement obtained were determined, namely, loss on ignition, fineness of grinding, setting time, content of insoluble residue and strength of Portland cement. The results of the research showed that the Portland cement parameters determined with the use of the Taskalinsky clay for all characteristics met the requirements of State Standards [8–10] and had improved properties compared to Portland cement with the use of clay of the Pogodaev deposit. In terms of material composition, cements obtained are of the CEM II / A-K Portland cement type with additives up to 20 %. The results of the research

have shown that the compressive strength of Portland cement with the use of the clay of the Taskalinsky deposit meets the requirements of State Standard [9], corresponds to the M300 grade and has improved properties compared to Portland cement with the use of clay of the Pogodaev deposit.

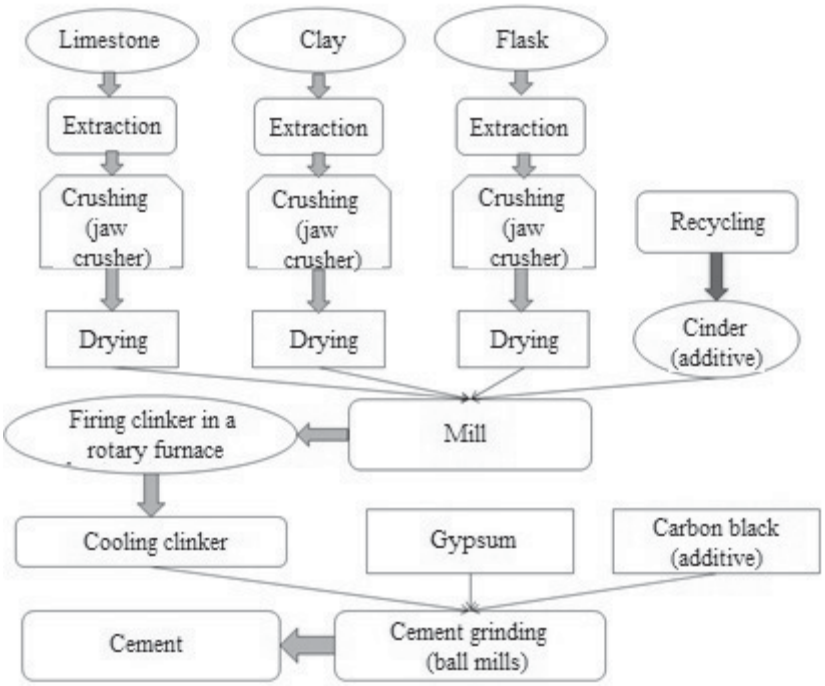

Figure 1. Technological scheme of Portland cement production

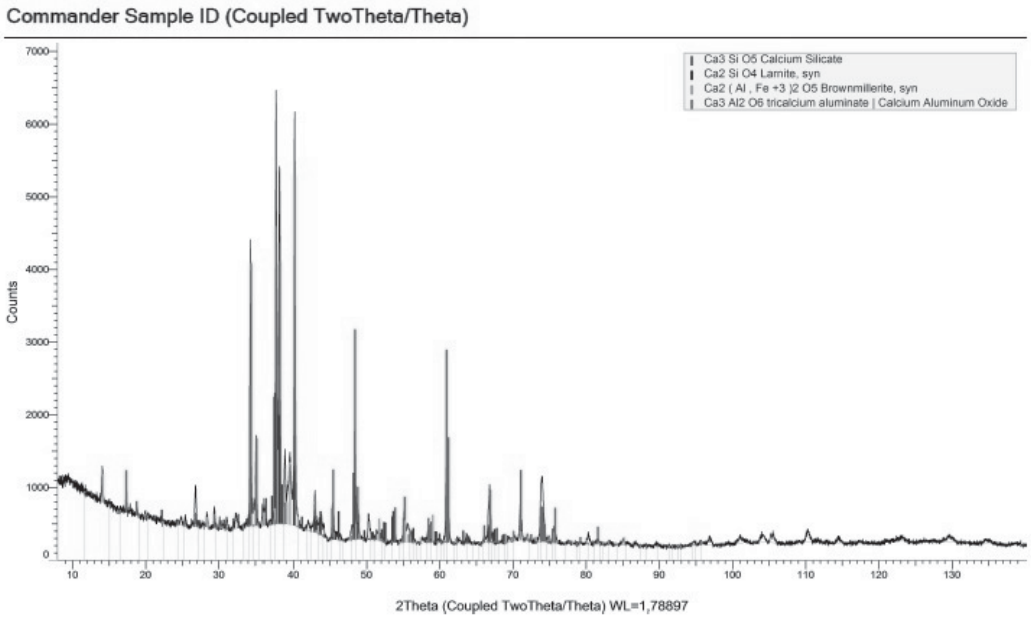

Figure 2. Phase composition of the clinker (using clay of the Taskalinsky deposit)

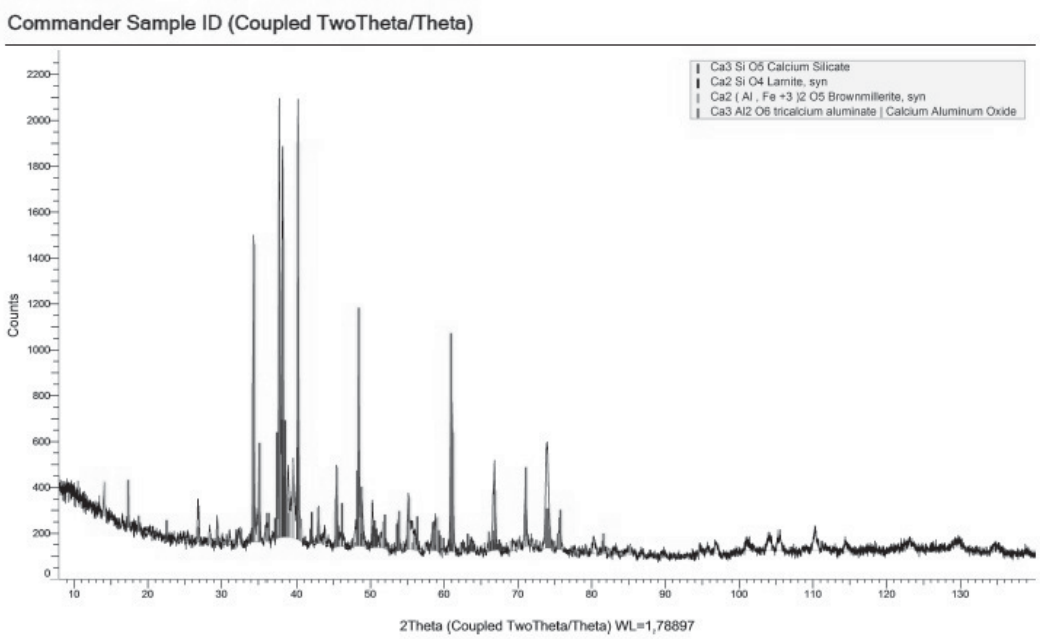

Figure 3. Phase composition of clinker (using clay of the Pogodaev deposit)

Based on the results of the research, we propose an advanced technology for the production of Portland cement, including the use of local raw materials (Limestone of the Melovye Gorki, clay and trough of the Taskalinsky deposit) with the addition of pyritic cinder more than 2 % and carbon black in quantities of up to 3 %. The introduction of pyritic cinders provides reducing the clinker sintering temperature and reducing energy costs. The introduction of carbon black as an additive allowed increasing the activity of cement, as well as to obtain an environmental effect. The economic efficiency of production of Portland cement of local origin in the West Kazakhstan region has been estimated. The profitability of production has been calculated and it has been established that the profit of this technology covers all necessary costs for production and makes up 9891.4 thousand tenge per year. In this way, the expediency of using the clay and the flask of the Taskalinsky deposit, the limestone of the Melovye Gorki deposit as a raw material with the addition of pyrite cinders and carbon black in Portland cement production technology has been established.

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В.А. Бурахта, А.М. Джубаналиева, С.С. Сатаева

Батыс Қазақстанның жергілікті шикізаты мен өндіріс қалдықтарының қолдануымен портландцемент өндірісі технологиясының жетілдіру әдістері

Мақалада Қазақстан Республикасы құрылыс индустриясының қарқынды дамып келе жатқан бағыттарының бірі — портландцемент өндірісі қарастырылған. Осыған байланысты Батыс Қазақстанның жергілікті шикізаты негізінде алынған портландцементтің құрамдас компоненттерінің негізгі қасиеттері зерттелді. Портландцементті клинкердің күйдіру технологиялық процесі жүзеге асырылып, олардың рентгенофазалық талдауы жүргізілді. Алынған портландцементтің сапасын бағалау үшін оның негізгі сипаттамалары анықталды. Жергілікті шикізат пен пирит күлінің қолдануымен портландцемент алу технологиялық процесі іске асырылған. Портландцементке техникалық көміртек және пирит күлін қосу арқылы оның реологиялық қасиеттеріне оң әсер етіп, сондай-ақ портландцементтің беріктік қасиетін арттыратыны анықталды. Батыс Қазақстан облысының жергілікті шыққан портландцемент өндірісінің экономикалық тиімділігі бағаланды және рентабельділігі есептелді. Жергілікті шикізат 2 % астам пирит күлі және 3 % мөлшерінде техникалық көміртекті қосуды қарастыратын портландцемент өндірісінің жетілдірілген технологиясы ұсынылды.

Кілт сөздер: саз, опока, әктас, пирит күлі, техникалық көміртек, клинкер, портландцемент.

В.А. Бурахта, А.М. Джубаналиева, С.С. Сатаева

Методы усовершенствования технологии производства портландцемента с применением местного сырья Западного Казахстана и отходов промышленности

В статье рассмотрена одна из стремительно развивающихся отраслей строительной индустрии в Республике Казахстан — производство портландцемента. В связи с этим исследованы основные свойства составляющих компонентов для получения портландцемента на основе местного сырья Западного Казахстана. Осуществлен технологический процесс обжига портландцементного клинкера и проведен их рентгенофазовый анализ. Для оценки качества полученного портландцемента определены его основные характеристики. Осуществлен технологический процесс получения портландцемента с использованием местного сырья и добавлением пиритных огарков и технического углерода. Установлено, что введение в портландцемент технического углерода и пиритных огарков оказывает положительное влияние на реологические свойства, а также на увеличение прочностных характеристик портландцемента. Оценена экономическая эффективность, и рассчитана рентабельность производства портландцемента местного происхождения Западно-Казахстанской области. Предложена усовершенствованная технология производства портландцемента, включающая использование местного сырья с добавлением пиритных огарков более 2 % и технического углерода в количестве до 3 %.

Ключевые слова: глина, опока, известняк, пиритные огарки, технический углерод, клинкер, портландцемент.

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