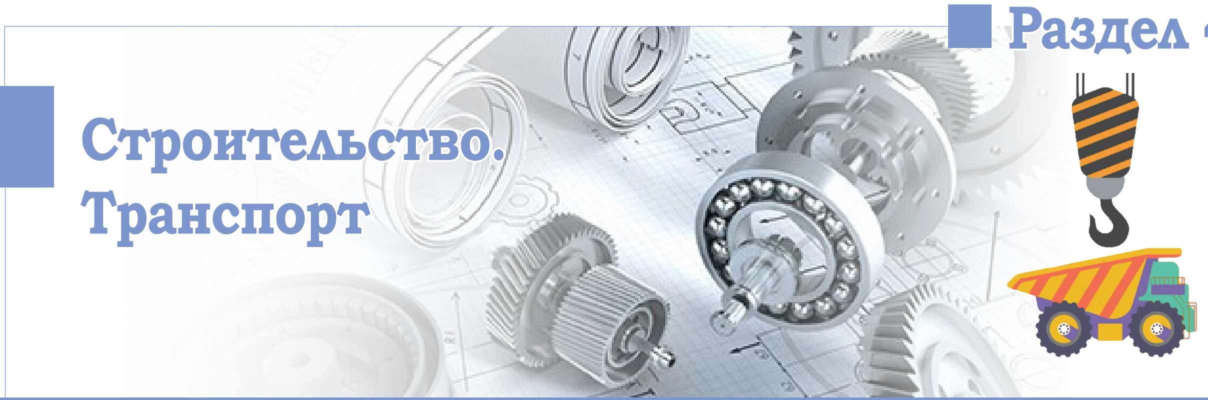

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Expert System Elements in the Technology of Binders of Anthropogenic Raw Materials

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Abstract. *An effective solution to the issue of using slag waste from the production of yellow phosphorus is proposed. The clay component of the Portland cement raw mixture is completely replaced by electrothermophosphoric (ETP) slag. The phenomenon of the formation of Portland cement clinker with a high alite content when using man-made waste has led to a noticeable change in the properties of the processed raw materials, environmental and technological conditions of production including the development of coupled reactions in the apparatus. At the same time, the principle of a single technological raw material with the efficient use of waste must be observed. The aim of the study is to describe adequately the process control and evaluation of the raw material made of ETP slag using an expert system (ES). The ES acts as a powerful tool in solving non-formalized problems in technology, management, etc. This approach makes it possible to find out the possibility of the technology to ensure the conjugation and interaction of the characteristics of the slag of the chemical production and the technical complex.*

Keywords: *electrothermophosphoric slag, cement raw mixture, sludge, control system, expert system, production model.*

Introduction

In the context of a sharp increase in the anthropogenic impact on the natural environment, is more increasing the importance of improving the environmental situation of industrial regions due to the effective disposal of waste from mining and chemical and metallurgical industries. In order to implement the priority area of activity for the processing and disposal of production and consumption waste in the Republic of Kazakhstan by 2030, it is necessary to achieve 40% of the level of waste processing and create an industry for the processing and disposal of waste [1].

Our research studies have shown a relatively high reactivity of wollastonite as a cement raw material. ETP slags are almost 90% composed of lime and silica, and their molar ratio is close to monocalcium silicate. Phosphoric slags contain impurities of phosphoric anhydride and calcium fluoride. The first is a $\beta - C_2S$ stabilizer, and the second is an effective silicate mineralizer. Taking these circumstances into consideration, we studied the possibility of using phosphoric slag to obtain high high alite cement using as a second ingredient the limestone and lime-powder [2]. Similar studies are carried out by scientists from China and other foreign countries [3-5]. At the same time, the results were obtained by traditional research carried out within the framework of one science. Production and application issues are presented only in relation to the subject of research.

The use of non-traditional technogenic raw materials will lead to a noticeable change in the properties of the processed raw materials, environmental and technological conditions of production, including the development of conjugate reactions in the apparatus. At the same time, the principle of a single technological raw material with the efficient use of waste must be observed.

The nature of the tasks to be solved is associated with:

- obtaining more advanced theoretical models based on the principles of artificial intelligence, allowing the use of generalized methods of analysis of cement production technology;

- identification of the possibility of ensuring the conjugation and interaction of the characteristics of the slag of the chemical production and the technical complex, so that joint work would have an effective synthesis of high alite cement.

Research methods

The problem can be solved on the basis of expert knowledge and this knowledge can be identified in a certain way and presented in a formal language.

The production model is more often used in industrial expert systems (ES). It is oriented at providing direct information about the procedures and conditions for their application. ES act as powerful tools in solving non-formalized tasks in technology, management and so on. During the creation an ES, it is implemented: filling the knowledge base with the information obtained, filling in the dictionaries of the communication system with the vocabulary characteristic of the selected problem area, introducing the application software package necessary for calculations into the ES memory, configuring the scheduler to work with the model of the problem area of interest and the explanation subsystem.

As a problem area, we will consider the type of silica-containing waste with which we want to replace the clay component of the cement raw mixture. As a communication system, we will take a dialog in the form of a menu. The knowledge in the system is presented in the form of a products system. The individual products of this system are interconnected by logical transitions generated in the process of interaction with the user. In the knowledge base, a special working field is allocated, where the products coming from the knowledge database and the user's reactions are entered. In the same field, the final decision will gradually be formed.

Research results

At the initial moment, a record with a special HELP signal is stored in the working field, which, after activation, can be products of the following type:

1 IF (TYPE OF SILICON WASTE – "unknown" & (HELP)

THEN Display the text on the display screen:

CHECK WHICH OF THE THREE CASES RELEASES:

1. LOI 0.89, SiO_2 37.99, CaO 43.91, Al_2O_3 11.65, FeO 0.25, MgO 1.9, MnO 0.81.

2. LOI 0.47, SiO_2 41.50, CaO 42.82, Al_2O_3 2.32, Fe_2O_3 0.61, MgO 4.0, MnO 0.58, P_2O_5 1.97 and CaF_2 4.01.

3. LOI 35.89, SiO_2 4.18, CaO 25.92, Al_2O_3 1.47, Fe_2O_3 3.34, MgO 14.42, BaO 7.63, SO_3 5.25.

In the record, 1 means the number of the product, rigidly assigned to it, and the conjunction sign &, showing that both records enclosed in parentheses are simultaneously in the working field. For products (TYPE OF SILICON WASTE) – "unknown" & (HELP) is the condition of the problem, and everything that comes after THAT is a consequence. The network of products of the expert system is shown in Figure 1.

In what follows, instead of the words IF and THEN, we will use the special sign =>. Then, the products in question will take the form:

1 HELP =>

Display text on the display screen:

CHECK WHICH OF THE THREE CASES RELEASES:

1. WASTE CHARACTERIZED: LOI 0.89, SiO_2 37.99, CaO 43.91, Al_2O_3 11.65, FeO 0.25, MgO 1.9, MnO 0.81;

2. WASTE CHARACTERIZED: LOI 0.47, SiO_2 41.50, CaO 42.82, Al_2O_3 2.32, Fe_2O_3 0.61, MgO 4.0, MnO 0.58, P_2O_5 1.97 and CaF_2 4.01;

3. WASTE CHARACTERIZED: LOI 35.89, SiO_2 4.18, CaO 25.92, Al_2O_3 1.47, Fe_2O_3 3.34, MgO 14.42, BaO 7.63, SO_3 5.25.

Checking the sample, we are interested in, we make a conclusion that the second case takes place.

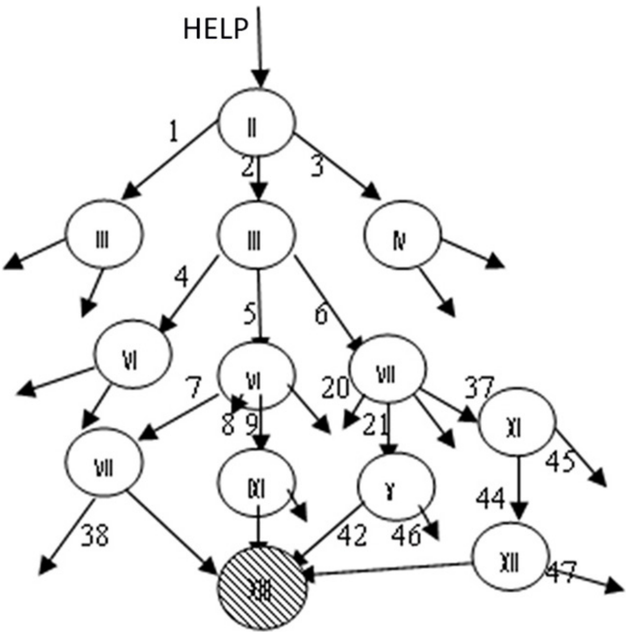

Figure 1 – The network of products of the expert system

We enter the message into the expert system: CASE 2.

The information has the form of a record: CHEMICAL COMPOSITION OF WASTE = "LOI 0.47, SiO_2 41.50, CaO 42.82, Al_2O_3 2.32, Fe_2O_3 0.61, MgO 4.0, MnO 0.58, P_2O_5 1.97 and CaF_2 4.01". This record is entered into the working field and included in the process of searching for the next products. For simpleness, in terms of further productions, we use not the records themselves stored in the working field, but the case numbers that were entered. In Figure 1, the circles represent the products marked with their corresponding numbers. The left parts of the productions mark the arrows entering the corresponding vertices. As can be seen from the figure, after the user's answer CASE 2, the product with number III should "work".

(III) CASE 2 =>

Display text on the display screen:

CHECK WHICH OF THE THREE CASES HAS BEEN RELATED:

4 SLAG CONSISTS OF 90% FRAGMENTS OF COLORLESS GLASS WITH REFRACTIVE INDICATOR 1.652 ± 0.002 AND 10% OF FINE-GRAINED BROWN;

5 THE SLAG IS IN A GLASS STATE WITH A REFRACTIVE INDICATOR 1.622 ± 0.002, 80% HAS WOLLASTONITE COMPOSITION, 10% CaP_2O_6;

6 SLAG CONTAINS 60-65% CRYSTALLINE PHASE AND 35-40% COLORLESS GLASS WITH REFRACTIVE INDICATOR 1.652 ± 0.002.

To the question addressed by the user, he replied that CASE 5 takes place. Then the following production, which uses the system, will have the form:

(VI) CASE 5 =>

Display the text on the display screen: CHECK WHICH OF THE SIX CASES ARE LOCATED:

7 THE SLAG CONTAINS IMPURITIES OF PHOSPHORIC ANHYDRIDE AND CALCIUM FLUORIDE;

8 SLAG STRUCTURE – CRYSTALLINE, UNIFORM GRANULAR, DIFFERENT BY HIGH POROSITY. CLOSED Pores, ROUND FORM. THE MAIN SLAG-FORMING MINERAL IS A MERVINITE-LIKE MINERAL;

9 THE COMPOSITION IS PRESENTED BY METAKAOLIN, ALUMINUM OXIDE AND HYDROXIDE, POTASSIUM HYDROALUMOSILICATES, QUARTZ AND HEMATITE.

10……………………………………………………

For brief introduction, we do not list the remaining cases. We noted that CASE 7 takes place.

Thus, the working field of the expert system has the following record systems:

TYPE OF SILICON WASTE = "unknown"

CHEMICAL COMPOSITION OF WASTE = "LOI 0.47, SiO_2 41.50, CaO 42.82, Al_2O_3 2.32, Fe_2O_3 0.61, MgO 4.0, MnO 0.58, P_2O_5 1.97 and CaF_2 4.01"

PETROGRAPHIC CHARACTERISTIC = "the slag is in a glassy state with a refractive index of 1.622 ± 0.002, 80% has a wollastonite composition, 10% CaP_2O_6"

WASTE TYPE = "the sample contains impurities of phosphoric anhydride and calcium fluoride"

The system receives information about the identification of the slag composition after dissolution of the glass phase of the sample with citric acid.

(VIII) CASE 7 =>

Display the text on the display screen: CHECK THE COMPOSITION OF CRYSTALLINE FORMATION AFTER TREATMENT WITH A SLAG SAMPLE SOLUTION

38) CONSISTS OF GELENITE

39) CONSISTS OF WALLASTONITE, QUARTZ, GELENITE AND FAYALIT;

The user informed the system that CASE 39 takes place, then it uses the final product

(XIII) CASE 39

WASTE TYPE IS DEFINED. THIS IS ELECTROTHERMOPHOSPHORIC SLAG.

DO YOU NEED AN EXPLANATION?

1 NO;

2 YES.

In addition to the noted way, three more options would lead to the same result, but the path of production to XIII is lengthening. The explanatory system based on the diagnostic tree can provide the user with an explanatory text.

Discussion of results

The disclosure of a complex of phenomena in the technology of cement production based on phosphoric slag is associated with control – a special function of complex systems aimed at ordering, maintaining and increasing the integrity of the system and its organization. To describe an object, firstly, the introduction of a hierarchical system of concepts connected by the operations of generalization and concretization is required. Figure 2 shows the structure of the interaction between the environment, the object (phosphoric slag – limestone) and the control system (processes and corresponding methods or technologies).

The control system receives information from the object and the environment using the input converter D. The solutions generated by the control system are delivered to the object via the output converter R. The analysis of real experience must be conceptualized and, together with the generalization, the management function F, which is present as a mechanism for generating decisions, is revealed. The management system is built on the basis of knowledge about the object and about the W management environment. The set of this knowledge will be called the M knowledge model. The observed responses of the object and the control environment to the effects of the control system and processes are interpreted using block I. Based on the analysis of the observed situations; the selection of a certain set of procedures is implemented by the adapter A.

The construction of the knowledge model M is based on the presence of a particular special knowledge representation language (KRL), without which this model will not function. The procedure block F and the adapter A must "understand" the KRL.

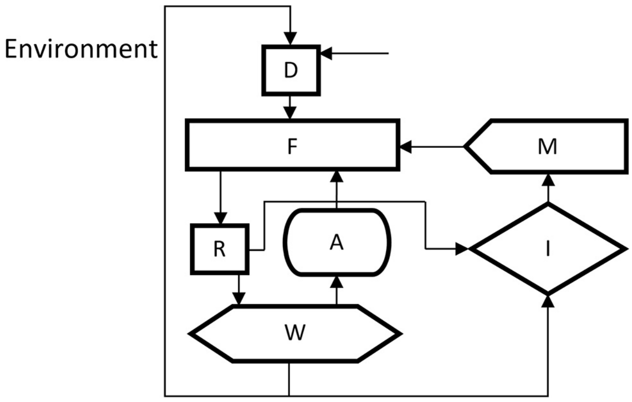

Figure 2 – Block diagram of interaction between the environment, the object and the control system

Conclusions

1. The issue of using slag waste from the production of yellow phosphorus, by completely replacing the clay component of the Portland cement raw material mixture with phosphoric slag, is effectively solved based on the system analysis, using artificial intelligence.

2. An adequate description of the management of processes and evaluation of raw materials with the involvement of an expert system allows for the coupling and interaction of the characteristics of chemical production slags and the technical complex, which will lead to the effective functioning of the new cement production technology.

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Техногенді шикізаттан жасалған байланыстырғыш технологиядағы сараптама жүйесінің элементтері

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Аңдатпа. *Сары фосфор өндірісінің қож қалдықтарын пайдалану мәселесін тиімді шешу ұсынылады. Портландцемент шикізат қоспасының саз компоненті толығымен электртермофосфор (ЭТФ) қожымен ауыстырылады. Техногендік қалдықтарды қолдану кезінде құрамында алит мөлшері жоғары портландцемент* *клинкерінің пайда болу құбылысы қайта өңделетін шикізат қасиеттерінің, өндірістің экологиялық және технологиялық жағдайларының, соның ішінде аппараттағы конъюгативті реакциялардың дамуының айтарлықтай өзгеруіне әкелді. Бұл ретте қалдықтарды тиімді пайдалана отырып, бірыңғай технологиялық шикізат қағидаты сақталуға тиіс. Зерттеудің мақсаты эксперттік жүйенің (ЭС) көмегімен ЭТФ қожынан алынған шикізат материалын бағалау және процестерді басқаруды барабар сипаттау болып табылады. ЭС технологиядағы, басқарудағы және т.б. бейресми мәселелерді шешуде қуатты құрал ретінде әрекет етеді. Бұл тәсіл химиялық өндіріс пен техникалық кешеннің қож сипаттамаларының тоғысуы мен өзара әрекеттесуін қамтамасыз ететін технологияның мүмкіндігін анықтауға мүмкіндік береді.*

Кілт сөздер: *электртермофосфорлы қож, цемент шикізат қоспасы, шлам, басқару жүйесі, сараптама жүйесі, өндіріс моделі.*

Элементы экспертной системы в технологии вяжущих из техногенного сырья

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Аннотация. *Предлагается эффективное решение вопроса использования шлаковых отходов производства желтого фосфора. Глинистый компонент портландцементной сырьевой смеси полностью заменяется электротермофосфорным (ЭТФ) шлаком. Феномен образования портландцементного клинкера с высоким содержанием алита при применении техногенных отходов привел к заметному изменению свойств перерабатываемого сырья, экологических и технологических условий производства, включая развитие сопряженных реакций в аппарате. При этом должен соблюдаться принцип единого технологического сырья с эффективным использованием отходов. Целью исследования является адекватное описание управления процессов и оценки сырьевого материала из ЭТФ шлака с помощью экспертной системы (ЭС). ЭС выступает в качестве мощных средств в решении неформализуемых задач в технологии, управлении и т.п. Такой подход позволяет выяснить возможность технологии по обеспечению сопряжения и взаимодействия характеристик шлака химического производства и технического комплекса.*

Ключевые слова: *электротермофосфорный шлак, цементная сырьевая смесь, шлам, система управления, экспертная система, продукционная модель.*

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