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DEVELOPMENT OF A NEW METHOD FOR OBTAINING CLAYDITE WITH A MINIMAL THERMAL CONDUCTIVITY COEFFICIENT

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Описано створення керамзиту з мінімальною теплопровідністю для використання в якості засипки та в якості складової бетонних сумішей. Для визначення оптимальних технологічних параметрів виробництва керамзиту використано метод планування експерименту та оптимізація отриманого рівняння методом Лагранжу з умовами Куна-Такера. Створено керамзит з покращеними теплофізичними властивостями для використання в якості засипки

Ключові слова: керамзит, глинозем, складова бетонних сумішей, оптимальна теплопровідність, пороутворення, термічна обробка

Описано создание керамзита с минимальной теплопроводностью для использования в качестве засыпки и в качестве составляющей бетонных смесей. Для определения оптимальных технологических параметров производства керамзита был использован метод планирования эксперимента и оптимизация полученного уравнения методом Лагранжа с условиями Куна-Такера. Создано керамзит с улучшенными теплофизическими свойствами для использования в качестве засыпки

Ключевые слова: керамзит, глинозем, составляющая бетонных смесей, оптимальная теплопроводность, порообразование, термическая обработка

1. Introduction

Claydite is a common material used both as a thermal insulation filling and as a separate filler for concrete mixture. Claydite is made either of alumina or from a mixture of alumina and various additives (typically, industrial wastes) [1, 2]. Claydite granules can be fabricated by plastic method (preliminary drying, forming the cylinders on perforated rollers and roasting in a drum furnace) or by the slip method (swelling in a drum furnace or a vortex apparatus). When creating claydite, the choice of parameters of technological treatment of starting mixture will significantly affect coefficient of thermal conductivity and durability of the resulting product. Claydite is typically estimated by the coefficient of swelling rather than paying attention to the thermal-physical characteristics. That is why examining the method of determining such parameters that would enable achieving the best thermal-physical parameters is an important task for the industry.

2. Literature review and problem statement

Article [3] described the production and use of lightweight concrete made of claydite for the elements of structures. Authors investigated the strength of such concrete in chemically aggressive liquid and gaseous environments. Separately, the effect of high concentrations of dioxin, sulphur dioxin, chlorine and oil is examined. However, there is no analysis of the thermal-physical parameters and their change during experiments.

Paper [4] considered a possibility of manufacturing claydite based on industrial waste. Authors conducted research using the samples of different chemical composition. They analyzed physical parameters both of raw materials and of claydite. They also demonstrated a porous metal sample, obtained by the addition of claydite. However, there is no a parameter analysis of porosity and thermal conductivity. Nevertheless, by using the technology reviewed in [5], it is possible to receive a highly porous metal material with low density, high melting point and high strength.

A detailed study of the microstructure of claydite is presented in [6]. In their study, authors used an optical microscope, scanning electron microscope and micro tomography. They demonstrated the shapes, size, arrangement of pores and their contact with one another. Parameters of the porosity of claydite are analyzed. However, the studies have been conducted for only one type of claydite. There is also no analysis of the influence of microstructure on the physical parameters of the material.

Article [7] analyzed the humidity and thermal conductivity of walls made of light blocks. Authors used aerated concrete, claydite concrete and concrete with shale ash as material of the blocks. As a thermal insulation material, they employed mats of polyester and glass wool. The studies conducted demonstrate a change in humidity and thermal conductivity of materials over time. No information is provided about the chemical composition and general porosity of the used materials.

A possibility to use claydite as a filling material to reduce the loads on the supporting walls or slopes near roads is presented in [8, 9]. Authors also proposed to apply the filling made of claydite for «green» buildings and roofs. They outlined the positive and negative factors of using the «green» roofs with the proposed structural layers. However, there is no detailed analysis of the thermal insulation properties of buildings with a «green» roof and a foundation made of a layer of claydite.

Paper [10] investigated claydite made of raw materials, which were extracted in two provinces of Iraq. Authors gave chemical analysis of the used raw materials. Volumetric density of claydite was 448 kg/m^3 for the first sample and 280 kg/m^3 for the second sample. The information is provided about the porosity, bulk density, and water absorbing properties of the resulting material. Authors demonstrated a change in the shape of claydite granules depending on the temperature of their treatment (from 1000–1150 °C). However, there is no analysis of the thermal-physical properties of the resulting material.

The influence of flying ash, ash residue and claydite on the properties of concrete was studied in [11]. Authors conducted a detailed study into characteristics of the strength of the samples. The studies were carried out both at constant and variable load. The maximum amount of time under a load was 56 days. Despite the detailed description of conducted experiments, there is no any information about the chemical composition of the material.

Article [12] proposed to produce the granules of claydite with the use of the following components: clay, lake sapropel, sawdust and glycerin. The article gives a detailed account of the process of preparing the raw materials and thermally treating the material. Authors demonstrated a change in the shape of granules at different temperatures of roasting the non-carbonate clay without additives and the clay with 3 % of sapropel. The work demonstrated that at a certain concentration of additives there occurs an increase in porosity. It was also noted that during roasting the granules, when using organic additives, there occurs a discharge of gases. Based on the experimental data, it was found that the amount of sapropel in the mixture should not exceed 5 %, or sawdust – not larger than 3 %. The work, however, did not pay proper attention to the thermal-physical properties of the developed materials.

3. The aim and tasks of research

The aim of present study is to establish optimal technological parameters for the production of claydite.

To accomplish the set aim, the following tasks were formulated:

– to examine structural changes during thermal treatment of alumina and to define basic stages in the formation of claydite with the required thermal-physical characteristics;

– to select the composition of mixture of the starting material and form claydite out of it with a minimal possible coefficient of thermal conductivity;

– to create claydite with a minimum coefficient of thermal conductivity for usit it as backfill.

4. Materials and methods for studying claydite

Methods of theoretical research are formalization and synthesis.

Methods of empirical research are laboratory and full-scale experiment. Laboratory experiment was employed to study incombustibility, bulk thermal conductivity and strength of the obtained material.

Incombustibility was determined by comparing the behavior of the examined and standard samples when heated. These samples are called pyrometric cones. They are shaped as a truncated pyramid with bases in the form of equilateral triangles with sides of 2 and 8 mm and height of 30 mm. One of the faces of the pyramid was located perpendicular to the bases. When heated, pyrometric cones abandon their shape, they are skewed. The moment when the top of the pyramid touches the substrate determines product incombustibility.

Bulk thermal conductivity was determined by the thermal conductivity meter ITP-MG4 made by SKB Stroypribor, Russia. Strength of the material is determined using the Rockwell method.

5. Study of structural changes in alumina raw materials at its thermal treatment

Based on the results obtained in [13], when creating a mixture from which the material will be made, it is necessary to minimize dimensions of the source components. The time of thermal treatment of the mixture must be defined so that it matches the end of the second stage of pore formation. This time can be derived from formula:

$$\begin{cases} n_{pore} = \tau_s \cdot N_1 \cdot B \cdot e^{-\frac{16 \cdot \pi \cdot \sigma^3}{3 \cdot k_B \cdot T \cdot \left(p_{kr}^{(1)} - p\right)^2}} & \text{if} \quad \tau_s < \tau_1, \\ n_{pore} = \tau_s \cdot \xi_1 \cdot (1 - P) & \text{if} \quad \tau_1 < \tau_s < \tau_2, \\ n_{pore} = \tau_s \cdot \xi_2 \cdot P & \text{if} \quad \tau_s > \tau_2, \end{cases} \tag{1}$$

where τ_s is the time of observation.

At $\tau_s < \tau_2$, the dependence should hold:

$$\tau_s = \frac{n_{pore}}{\xi_1 \cdot (1 - P)}, \tag{2}$$

but the easiest way to determine it is to construct the experimental curves of pore formation for the selected material.

The largest thermal resistance of insulation material will be reached at the following structural characteristics: overall size of a pore along the heat flux is 2–4 mm, the number of pores is 9 pcs. per $6.4\cdot10^{-5}$ m^3 [13].

When creating a highly porous material by swelling with water vapors and gases released during chemical reactions, it is necessary to minimize the content of carbon gas forming agents, as well as isolate iron from the starting mixture. It is necessary to minimize viscosity of the mixture and to maintain the minimum possible temperature gradient. It is also required to isolate the additives with a melting point above the temperature of softening of the base material. However, we cannot use clean clay in order to create elongated pores; clay must contain impurities (for example, small addition of aluminum). In order to create pores following a chemical reaction, it is necessary to consider reactions that proceed at low temperature. The difference between chemical potentials of the material and the gas that creates a pore should be maximal. CO_2 and SO_2 are the most common gases among pore forming agents.

When employing any method of creating refractory materials, it is important to pay special attention to roasting. The main process when roasting clays is the dehydration of clayey material:

$$Al_2O_3\cdot2SiO_2\cdot2H_2O\rightarrow Al_2O_3\cdot2SiO_2+2H_2O. \qquad (3)$$

Formation of mullite proceeds by the following reaction:

$$3(Al_2O_3\cdot2SiO_2)\rightarrow3Al_2O_3\cdot2SiO_2+4SiO_2. \qquad (4)$$

The intensity of formation of mullite from kaolinite is predetermined by the following factors: mineralizing additives, roasting temperature, duration of exposure and dispersion of the starting material.

Thermal-physical properties of material undergo significant changes at roasting. The processes of sintering in the presence of a liquid phase are accompanied by the pore formation due to swelling in the sites of release of gaseous products of reactions. In this case, pores of the closed and semi-closed type mainly form, whose walls are strengthened when wetted with a glass phase.

Given the required structure of the material and recommendations on the formation of this structure, we shall create a new highly porous thermal insulation material.

6. The method for creating claydite from the set composition of the starting mixture with a minimal coefficient of thermal conductivity

As an example of the set composition, we shall consider the creation of claydite granules from raw materials whose quality indicators are given in Table 1. As a raw material base, we selected a material that is a monolithic amorphous mass made by a low-temperature treatment of the starting mixture of rocks. These rocks are characterized by significant content of amorphous silica (tripoli, gaize, etc.), sodium bicarbonate, clay mixed with a water solution of caustic soda [14]. This material is very similar to zeolite. Table 1 shows that iron oxide content does not exceed 5 %. This was achieved by selecting the rocks from different deposits.

Claydite granules with a low coefficient of thermal conductivity can be used as a thermal insulation filling or as a thermal insulation additive to concrete.

Table 1

Indicators of raw materials quality

Indicator	Indicator magnitude
Relative humidity, %, not exceeding	46
Mean density, kg/m^3, not less	1450
Silicon dioxide content, %,	52
Aluminum oxide content, %	8
Iron oxide content, %, not exceeding	5
Calcium oxide content, %, not exceeding	10

The resulting thermal conductivity of granules will be affected by temperature, initial moisture content of the mixture and duration of the thermal treatment. Minimum coefficient of thermal conductivity for the given composition of the mixture will be reached at initial moisture content of 38 % and temperature of 272 °C [1].

Duration of thermal treatment of the material will be determined by building a curve of pore formation (Fig. 1).

By using the constructed curve of pore formation, we determined the optimal duration of thermal treatment of the material – 15 minutes (900 s). The material must cool after the thermal treatment, and then should undergo roasting at a temperature of 1200–1250 °C for 1.5–2 hours.

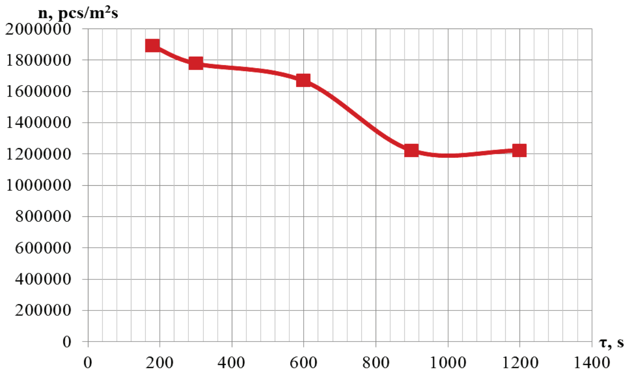

Fig. 1. Curve of pore formation for the material with quality indicators in Table 1

Claydite granules were made in the following way. Clay mixture was dried to humidity of 38 % and discharged onto a metal pallet. The granules were formed by pressing a grid with cell of 6×20 mm. Next, the pallet with granules was placed in a heating furnace for 15 minutes at 270 °C. After the heating furnace, the granules were discharged to a drum furnace and roasted at a temperature of 1250 °C for 1.5 hours. Properties of the resulting claydite are given in Table 2.

Table 2

Properties of the resulting claydite

Indicator	Indicator magnitude
Incombustibility	1750 °C
Porosity (seeming)	23.3 %
Porosity (actual)	24.2 %
Thermal resistance (number of cycles to crack nucleation)	8
Compressive strength	10.6–14.1 MN/m^2
Coefficient of thermal conductivity	0.037–0.043 W/(m·K)

7. Method of making an additive to concrete mixtures of pure clay with a minimal coefficient of thermal conductivity

We also created claydite based on white clay. In order to obtain optimal parameters of thermal treatment, we used the method of experiment planning. We investigated the influence of temperature of thermal treatment X_1, thermal exposure time X_2, and humidity of the starting mixture X_3 on the bulk thermal conductivity Y_1 and compressive strength Y_2 of claydite. Table 3 contains conditions of conducting the experiments. To construct a quadratic model of dependence of initial parameters on the examined factors, we applied orthogonal plan with a core of 2^3. Results of the experiments are given in Table 4.

Table 3

Conditions of conducting the experiment on the formation of claydite

No. of entry	Factor	Code	Factor levels			
			–1	0	1	Δ
1	Temperature, °C	X_1	200	500	800	300
2	Thermal treatment duration, min.	X_2	5	10	15	5
3	Humidity, %	X_3	10	30	50	20

Table 4

Plan and results of the experiment of claydite thermal treatment

No. of entry	X_1	X_2	X_3	Y_1	Y_2
1	+1	+1	+1	0.061	0.09
2	–1	+1	+1	0.035	0.2
3	+1	–1	+1	0.073	0.19
4	–1	–1	+1	0.041	0.25
5	+1	+1	–1	0.067	0.07
6	–1	+1	–1	0.078	0.21
7	+1	–1	–1	0.091	0.11
8	–1	–1	–1	0.095	0.12

After processing the data, determining the significance of coefficients by the Student t-criterion and verification of adequacy of regression equations by the Fisher criterion, we received:

$$\begin{aligned} Y_1 &= 0{,}0676 + 0{,}005375X_1 - 0{,}007375X_2 - \\ &- 0{,}015125X_3 - 0{,}001625X_1X_2 + 0{,}009125X_1X_3 + \\ &+ 0{,}002875X_2X_3 \to \min; \end{aligned} \tag{5}$$

$$\begin{aligned} Y_2 &= 0{,}155 - 0{,}04X_1 - 0{,}0125X_2 + 0{,}0275X_3 - \\ &- 0{,}0225X_1X_2 - 0{,}0025X_1X_3 - 0{,}025X_2X_3. \end{aligned} \tag{6}$$

Since the strength of granules made of white clay is too small, and the granules degrade with prolonged exposure to moisture, then this material can only be used as an additive to a concrete mixture. For such application, the strength of granules is irrelevant. That is why we shall optimize only the equation of thermal conductivity.

The problem on optimization will take the following form:

$$\begin{aligned} Y_1 &= 0{,}0676 + 0{,}005375X_1 - 0{,}007375X_2 - \\ &- 0{,}015125X_3 - 0{,}001625X_1X_2 + 0{,}009125X_1X_3 + \\ &+ 0{,}002875X_2X_3 \to \min, \\ &X1 \geq -1; \;\; X2 \leq 1; \;\; X3 \leq 1. \end{aligned} \tag{7}$$

To determine the optimal regime of thermal treatment, we constructed a Lagrange function:

$$L = Y_1 + \sum \lambda_i \phi_i + \sum \mu_i \phi_i, \tag{8}$$

where ϕ_i is the implicit constraints; λ, μ are the Lagrange multipliers.

We shall rewrite the constraint of the task in the implicit form:

$$\begin{cases} \varphi_1(X) = -1 - (x_1) = 0; \\ \varphi_2(X) = 1 - (x_2) = 0; \\ \varphi_3(X) = 1 - (x_3) = 0. \end{cases} \tag{9}$$

Construct a Lagrange ancillary function:

$$\begin{aligned} L(X,\ \lambda,\ \mu) &= 0{,}0676 + 0{,}005375X_1 - 0{,}007375X_2 - \\ &- 0{,}015125X_3 - 0{,}001625X_1X_2 + 0{,}009125X_1X_3 + \\ &+ 0{,}002875X_2X_3 + \mu_1(-1 - (x_1)) - \mu_2(1 - (x_2)) - \\ &- \mu_3(1 - (x_3)). \end{aligned} \tag{10}$$

The necessary condition of an extremum of the Lagrangian function is the equality to zero of its private derivatives by variables X_i and non-defined multipliers. Construct a system:

$$\begin{cases} \partial L/\partial X_1 = -0{,}001625X_2 + 0{,}009125X_3 - \mu_1 + 0{,}005375 = 0, \\ \partial L/\partial X_2 = -0{,}001625X_1 + 0{,}002875X_3 + \mu_2 - 0{,}007375 = 0, \\ \partial L/\partial X_3 = 0{,}009125X_1 + 0{,}002875X_2 + \mu_3 - 0{,}015125 = 0, \\ \mu_1(-1 - (X_1)) = 0, \;\; \mu_1 \geq 0, \\ \mu_2(1 - (X_2)) = 0, \;\; \mu_2 \geq 0, \\ \mu_3(1 - (X_3)) = 0, \;\; \mu_3 \geq 0. \end{cases} \tag{11}$$

By solving the system with checking the Kuhn-Tucker conditions for constraints (9), we shall receive the following solutions:

$X_1 = -1$, $X_2 = 1$, $X_3 = 1$,

in this case,

$Y_1 = 0.0351$ and $X_1 = 0.012875$, $X_2 = 0.002875$,

$X_3 = 0.021375$,

in this case,

$Y_1 = 0.0673$.

Thus, we select boundary parameters for the thermal treatment of white clay: temperature of the thermal treatment is 200 °C, thermal treatment duration is 15 minutes, and humidity is 50 %.

The resulting granules are rationally used as an additive to the refractory concretes.

8. Discussion of results of examining a new method for obtaining claydite with a minimal coefficient of thermal conductivity

Among the strengths of the present research, it is necessary to highlight the obtained regression equations. By analyzing the obtained regression equations, it can be concluded that a decrease in the temperature of thermal treatment reduces the coefficient of thermal conductivity and increases the strength of the material. Increasing the thermal treatment duration reduces thermal conductivity and strength, while an increase in the initial moisture in the mixture reduces coefficient of thermal conductivity and increases the strength of granules. In this case, the largest impact on the strength of the material is exerted by temperature of the thermal treatment, and on the thermal conductivity – initial moisture.

Not less important are the results obtained by using the Lagrangian and the Kuhn-Tucker conditions, which enable to create claydite with improved thermal-physical properties. Such material will improve the insulation properties of buildings and structures. The results obtained and the technique applied might be used in further research and serve a basis when creating even better claydite.

Under industrial conditions, producing the high-quality material will make it possible to compete in the market; moreover, the re-equipment of existing facilities at enterprises that manufacture claydite is not required.

Among the weaknesses of this study is the lack of experimental samples with improved thermal-physical properties produced under industrial conditions. This in turn requires additional study with fabricated physical samples.

The prospects for further research should include improvement of the received regression equations found through inclusion into governing factors of chemical composition of the starting mixture. It is also promising to conduct similar research using a variety of additives that would allow achieving lower consumption of raw materials.

The difficulties of applying the results include the cost of implementation of the proposed technology of claydite production at industrial enterprises. Such costs will be associated with the necessity of procurement or production of necessary raw materials with the required chemical composition.

9. Conclusions

1. We studied dehydration of material during thermal treatment of alumina and defined two stages of claydite formation with the required thermal-physical characteristics: the stage of pore formation and roasting.
2. We chose a composition of mixture of the starting material and created claydite out of it with the lowest possible coefficient of thermal conductivity. The technology of creation is as follows. Clay mixture is dried to humidity of 38 % and the granules are formed (by pressing a grid with a cell of 6×20 mm). Next, the pallet with granules is put into a heating furnace for 15 minutes at 270 °C. After the heating furnace, the granules are discharged into a drum furnace, where they are roasted at temperature 1250 °C for 1.5 hours.
3. We created claydite with a minimal coefficient of thermal conductivity based on white clay: temperature of the thermal treatment is 200 °C, thermal treatment duration is 15 minutes, and humidity is 50 %. The resulting granules are rationally used as an additive to refractory concretes.

References

1. Lukashevich, O. D. Ekologicheskie problemy obrabotki i utilizacii osadkov stochnyh vod [Text] / O. D. Lukashevich, I. V. Barskaya // Ekologiya promyshlennogo proizvodstva. – 2007. – Issue 3. – P. 68–75.
2. Suhanov, A. M. Ispol'zovanie promyshlennyh othodov v stroitel'stve [Text]: nauch.-prakt. konf. / A. M. Suhanov // Sovremennoe sostoyanie i perspektivy razvitiya agropromyshlennogo kompleksa. – Kurgan: Kurganskaya GSKHA, 2016. – P. 386–388.
3. Hubertova, M. Durability of Lightweight Expanded Clay Aggregate Concrete [Text] / M. Hubertova, R. Hela // Procedia Engineering. – 2013. – Vol. 65. – P. 2–6. doi: 10.1016/j.proeng.2013.09.002
4. Bajare, D. Lightweight Concrete with Aggregates Made by Using Industrial Waste [Text] / D. Bajare, J. Kazjonovs, A. Korjakins // Journal of Sustainable Architecture and Civil Engineering. – 2013. – Vol. 4, Issue 5. – P. 67–73. doi: 10.5755/j01.sace.4.5.4188
5. Sereda, B. The Influence of Deformation Process at Titan Aluminides Retrieving by SHS-compaction technologies [Text] / B. Sereda, I. Kruglyak, A. Zherebtsov, Y. Belokon' // Metallurgical and Mining Industry. – 2011. – Vol. 3, Issue 7. – P. 59–63.
6. Bogas, J. A. Microstructural Analysis of Iberian Expanded Clay Aggregates [Text] / J. A. Bogas, A. Mauricio, M. F. C. Pereira // Microscopy and Microanalysis. – 2012. – Vol. 18, Issue 05. – P. 1190–1208. doi: 10.1017/s1431927612000487
7. Joosep, R. Moisture and Thermal Conductivity of Lightweight Block Walls [Text] / R. Joosep // IOP Conference Series: Materials Science and Engineering. – 2015. – Vol. 96. – P. 012033. doi: 10.1088/1757-899x/96/1/012033
8. Boudaghpour, S. A study on light expended clay aggregate (LECA) in a geotechnical view and its application on greenhouse and greenroof cultivation [Text] / S. Boudaghpour, S. Hashemi // International journal of geology. – 2008. – Vol. 2, Issue 4. – P. 59–63.
9. Pavlenko, A. Analysis of thermal peculiarities of alloying with special properties [Text] / A. Pavlenko, B. Usenko, A. Koshlak // Metallurgical and Mining Industry. – 2014. – Issue 2. – P. 15–19.
10. Turki Khafaji, S. K. Synthesis of light expanded clay aggregates from Iraqi raw materials [Text] / S. K. Turki Khafaji, E. A. Al-Majed // International Journal of Scientific & Engineering Research. – 2016. – Vol. 7, Issue 4. – P. 690–696.
11. Sivakumar, S. Influence of Fly Ash, Bottom Ash, and Light Expanded Clay Aggregate on Concrete [Text] / S. Sivakumar, B. Kameshwari // Advances in Materials Science and Engineering. – 2015. – Vol. 2015. – P. 1–9. doi: 10.1155/2015/849274

12. Vaickelionis, G. Production of Expanded Clay Pellets by Using Non-selfbloating Clay, Lakes Sapropel and Glycerol [Text] / G. Vaickelionis, A. Kantautas, D. Vaiciukyniene // Materials Science. – 2011. – Vol. 17, Issue 3. – P. 314–321. doi: 10.5755/j01.ms.17.3.600
13. Cheilytko, A. A. Experimental studies of thermal properties of porous particulate material according to the different modes of heat treatment [Text] / A. A. Cheilytko // Eastern-European Journal of Enterprise Technologies. – 2009. – Vol. 5, Issue 6 (41). – P. 4–7.
14. Cheilytko, A. A. Vspuchivanie poristogo kremnezemistogo materiala [Text] / A. A. Cheilytko, A. M. Pavlenko. – Saarbrucken, Deutschland: LAP LAMBERT Academic Publishing, 2013. – 130 p.

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DEVELOPMENT OF THE MODEL OF PETROLEUM WELL BOREABILITY WITH PDC BORE BITS FOR UZEN OILFIELD (THE REPUBLIC OF KAZAKHSTAN)

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Для буріння свердловин на великому нафтогазовому родовищі Узень (Казахстан) замість шарошечних доліт з великим ефектом застосовуються долота PDC. Дані про показники роботи інструментів оброблені методами статистики. Створено відповідну модель буримості. Модель містить три параметри: початкову швидкість, темп зниження швидкості і показник ступеня, в яку зводиться час буріння. Модель дозволяє прогнозувати і оптимізувати роботу долота PDC

Ключові слова: свердловина, модель буримості, долото PDC, знос, порівняльна оцінка, шарошечні долота

Для бурения скважин на крупном нефтегазовом месторождении Узень (Казахстан) взамен шарошечных долот с большим эффектом применяются долота PDC. Данные о показателях работы инструментов обработаны методами статистики. Создана соответствующая модель буримости. Модель содержит три параметра: начальную скорость, темп снижения скорости и показатель степени, в которую возводится время бурения. Модель позволяет прогнозировать и оптимизировать работу долота PDC

Ключевые слова: скважина, модель буримости, долото PDC, износ, сравнительная оценка, шарошечные долота

1. Introduction

The boreability model represents an analytical relationship reflecting the process of interaction between the rock-cutting tool and the borehole bottom in time.

A well-established boreability model usually takes into account the main factors influencing well deepening and enables prediction of the bit functioning, well formation at the lowest specific operating costs and optimization of the drilling process.

The numerous boreability models available at present are designed for roller bits. Rotary-percussion method of hole-bottom destruction, design complexity and versatility of use of the mentioned bits should be noted. Comparatively recent PDC bits differ from the roller bits by the rotary method of hole-bottom destruction by a microcutting mode, design simplicity and extremely high durability in soft and partially medium hardness rocks as well as the work of diamond-set hard metal alloy cutting structure by the principle of self-sharpening. Because of the widespread of PDC bit introduction into practice, it is urgent to solve the problem of making the boreability model with an account of the design features of the rock-cutting tool.

2. Literature review and problem statement

There are a number of models of boreability describing the process of bit-to-hole bottom interaction.