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IMPROVING THE EFFICIENCY OF THE PROCESS OF DRILLING WELLS IN COMPLEX CONDITIONS AT GEOLOGICAL PROSPECTING SITES

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Abstract. The state considered the issues of increasing the durability of cutting material of drilling equipment with the help of chemical-physical treatment of the cutting part of the drill bit. A mathematical model is presented for the impregnation of metals by applied accumulations and precipitates, as well as changes in the strength characteristics of the material during the exclusion of materials, due to the formation of defects of various breeds. An experimental study of samples of a rock cutting tool in a pool-type "gamma-installation" with sources of Co^{60} γ-quanta is presented. The effect of radiation irradiation with small doses of gamma rays in the imperfect region of the phases of hard alloy components, which leads to a change in the level of point defects of the Schottky-Frenkel type, is studied. As a result of this process, the density of defects decreases, the perfect area of microcrystals increases, which leads to the removal of superposition stress fields inside and along the grain boundary, and leads to an improvement in the intragranular and intergranular bonds of the emitted material. After processing the bit, an analysis of the performance of the processed bit under operating conditions was carried out, as well as a comparison of the performance of the bit. The use of radiation from the cutting part of the drill bit increases the efficiency and reduces the cost of drilling a well.

Keywords: deformation formation, paddle chisel, gamma radiation, drilling, rock, deformation, hard alloy, density

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ГЕОЛОГИЯЛЫҚ БАРЛАУ ОБЪЕКТІЛЕРІНДЕГІ ҚИЫН ЖАҒДАЙЛАРДА ¦ЊЃЫМАЛАРДЫ БҰРҒЫЛАУ ПРОЦЕСІНІҢ ТИІМДІЛІГІН АРТТЫРУ

Аннотация. Мақалада бұрғылау қашауын кесетін бөлігін химиялық-физикалық өңдеу кимегімен бұрғылау жабдығының кесу материалының беріктігін арттыру мәселелері қарастырылады. Материалдың қоспалары жинақталуымен және таңбаларымен қатаюының математикалық сәулелендіру кезінде материалдың беріктік сипаттамаларының өзгеруі сыналған. Негізгі бағыт-жабдықтың ең аз мөлшерін таңдау және бұрғылау қашауының кесу бөлігінің тиімділігін арттыру. Co60 γ-кванттық көздері бар бассейндік типтегі "гамма қондырғысында" тас кесетін құрал үлгілерін эксперименттік зерттеу келтірілген. "Пул" типті гамма-сәулелік қондырғы әртүрлі материалдар мен өнімдердің қасиеттеріне әсерін және олардың қасиеттерін қзгертуді зерттеуге арналған. Сондай-ақ, қатты қорытпалардың гаммасәулелерімен сәулелену кезіндегі беріктігі мен тозуға төзімділігін бағалау анықталды, иілу, деформация, қаттылық және микроқаттылық бойынша шекті беріктік алынды. Шоттки-Френкель типті нүктелік ақаулар деңгейінің өзгеруіне әкелетін қатты қорытпа компоненттерінің фазаларының жетілмеген аймағындағы гамма-кванттардың шағын дозалымен сәулеленудің әсері зерттелді. Бұл процестің нәтижесінде ақаулардың тығыздығы төмендейді, микрокристалдардың мінсіз ауданы ұлғаяды, бұл астық шекарасындағы және бойында суперпозициялық кернеу өрістерінің жойылуына әкеледі және түйіршік аралық байланыстардың жақсаруына шығарылатын материал. Әр түрлі типтегі қатты қорытпалардың иілу кезіндегі шекті беріктіктің гамма сәулелену дозасына тәуелділігі анықталды. Қашауды өңдегеннен кейін оны жұмыс жағдайында пайдалану кезінде оның жұмыс өнімділігін талдау және салыстыру жұмыстары жүргізілді. Бұрғылау қашауының кескіш бөлігінің сәулеленуін пайдалану тиімділікті арттырады және ұңғыманы бұрғылау құнын төмендетеді

Түйін сөздер: деформация түзелуі, қалақшалар, гамма-сәулелену, бұрғылау, тау жынысы, деформация, қатты қорытпа, тығыздық

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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ПРОЦЕССА БУРЕНИЯ СКВАЖИН В СЛОЖНЫХ УСЛОВИЯХ НА ГЕОЛОГОРАЗВЕДОЧНЫХ ОБЪЕКТАХ

Аннотация. В статье рассмотрены вопросы повышения стойкости режущего материала бурового оборудования с помощью химико-физической обработки режущей части бурового долота. Приведена математическая модель упрочнения металлов примесными скоплениями и выделениями, а также изменение прочностных характеристик материала при облучении материалов обусловлено образованием дефектов различной природы. Основным направлением является выбор минимального количества оборудования и повышение эффективности режущей части бурового долота. Приведено экспериментальное исследование образцов породоразрушающего инструмента в «гамма-установке» бассейнового типа с источниками γ-квантов Co^{60}. Гамма-установка типа «Бассейн» предназначена для изучения влияния на свойства различных материалов и изделий и изменения их свойств. Также определена оценки прочности и износостойкости твердых сплавов при облучении гамма-лучами, принят предел прочности при изгибе, деформации, жесткость и микротвердость. Изучено влияние радиационного облучения малыми дозами гамма-квантов в несовершенной области фаз компонентов твердого сплава, который приводит к изменению на уровне точечных дефектов типа Шоттки-Френкеля. В результате этого процесса уменьшается плотность дефектов, увеличивается совершенная площадь микрокристаллов, что приводит к снятию суперпозиционных полей напряжений внутри и по границе зерен, приводит к улучшению внутризеренных и межзеренных связей излучаемого материала. Определена зависимость предела прочности при изгибе твёрдых сплавов разного типа от дозы облучения гамма-квантами. После обработки долота был проведен анализ работоспособности обработанного долота в условиях эксплуатации. Использование излучения режущей части бурового долота повышает эффективность и снижает затраты на бурение скважины.

Ключевые слова: деформационное образование, лопастные долота, гамма-излучение, бурение, горная порода, деформация, твердый сплав, плотность

Introduction

At present, the provision of geological prospecting enterprises with rational equipment and technologies is important in increasing the efficiency of geological prospecting, reducing the cost of prospecting and exploration of mineral deposits. It is known that at the present time the possibility of easy discovery of low-cost mineral deposits is developing (Muminov et al., 2022a: 5, Khojibergenov et al., 2019: 7). Given the complexity of the location and geological structure of gold deposits, it is important to use geophysical, geochemical and aerospace methods in a rational combination with drilling to increase the efficiency of geological prospecting. This will allow for operational control of geological work and a drastic reduction in drilling work. In recent years, the pace of introduction of modern technical means and advanced world technologies in geological prospecting facilities has intensified. Taking advantage of the potential of progressive methods requires the necessary updating of the drilling rig fleet. The current period of geological prospecting is characterized by the predominance of well drilling over other works (Muminov et al., 2021b: 5, Karsakova et al., 2022: 10). There are many companies which develop about 500 types of drilling rigs and lathes, more than 40 types of pumps, more than 20 types of compressors, more than 200 types of column sets, more than 30 types of drilling columns, more than 2,500 types of drill bits, more than 80 cleaning reagents, more than 30 buffering compounds, etc. but all of them have much more limited rational use conditions. As a result, the excessive diversity of expensive, deficit and non-repairable drilling equipment and well drilling technologies exported abroad leads to the fact that the cost of technical-technological and organizational-economic conclusions and decisions is very high.

Methods

Cut type drilling bits with three cutting point produced by JSC "Uranredmetgeologiya", laboratory indicators carried out jointly with the responsible technical specialists of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan. One of the important factors is not only the contribution to the development of the economy of extractive enterprises, but also the development of such areas as the expansion and extraction of the raw material base of the Republic of Uzbekistan. These rock crushers increase the efficiency of drilling at mining and geological enterprises of the country.

1. Mathematical model of hardening of metals by impurity clusters and precipitates

The change in the strength characteristics of the material during irradiation is due to the formation of defects of various nature, which are effective stoppers for dislocations. Depending on the temperature and characteristics of irradiation, one or another type of defects is formed — impurity clusters, precipitates, accumulations of intrinsic point defects (vacancy pores, stacking faults), etc.

To begin with, let us consider the growth kinetics of clusters of impurity atoms, which proceeds according to the following reversible scheme:

$$A_iC + A \underset{g(i)}{\overset{k(i)}{\rightleftarrows}} A_{i+1}C \tag{1}$$

This model corresponds to the growth of clusters or precipitates from type A impurity atoms on nucleation centers C with a concentration of *NC; k(i)* and *g(i)* are the kinetic coefficients of monomer capture and release by the cluster center. In the first approximation, it will be assuming that this concentration does not change with time and can be determined experimentally. Nucleation centers can either be present in the material before irradiation or be formed at the initial stage of irradiation. If the growth is limited by diffusion, the kinetic coefficient k(i) can be represented as (Khasanov, 2021: 23).

$$k(i) = 4\pi D^* R(i) \tag{2}$$

Where: D* is the effective diffusion coefficient of the impurity monomer in the irradiated material; R(i) is the radius of a cluster of i particles. The dependence of the radius on the number of particles in a cluster can be represented as

$$R(i) = b(i + m)^\alpha \tag{3}$$

where b is on the order of the distance between particles in a cluster; the value m is the initial size of clusters, determined from the condition that the size of the nucleation centers is equal to $R(0) = bm^\alpha$.

The value of the parameter α is determined from simple geometric considerations. Thus, for spherical clusters α =1/3, for disk-like clusters α =1/2, for clusters with fractal dimension DF α =1/ DF. It should be taken into account that irradiation increases the diffusion coefficient of impurity atoms. If the vacancy-accelerated diffusion mechanism is realized, the simplest model gives the following expression (Smoluchowski, 1987: 192):

$$D^* = D\frac{N_V}{N_V^E} \tag{4}$$

where NV is the concentration of vacancies in the material during irradiation; NVE is the equilibrium concentration of vacancies; D is the impurity diffusion coefficient in the absence of irradiation.

If the kinetic coefficients are determined by formula (2), for the average number of particles in clusters i(t) one can obtain the equation (Ivanov et al., 2002: 300):

$$\frac{d\langle i\rangle}{dt} = k_D(N(t) - N_E)(\langle i(t)\rangle + m)^\alpha \tag{5}$$

where kD = 4πD*b, N E is the equilibrium concentration of impurity monomers. In addition, at any time for the system described by scheme (1), the laws of conservation of nucleation centers and the total number of particles in the system are satisfied. Conservation laws allow us to find the average number of particles in the system:

$$\langle i \rangle = \frac{N(0) - N(t)}{N_c} \tag{6}$$

Using formulas (5) and (6), one can obtain a differential equation describing the change in the concentration of monomers during the decomposition of a supersaturated solid solution:

$$\frac{dN(t)}{dt} = -k_D N_C^{1-\alpha}(N(t) - N_E)\{N(0) - N(t) + mN_C\}^{\alpha} \tag{7}$$

and, neglecting the initial size of the clusters (m = 0) and using the approximation N (0) −N (t)≈ N (0) −N E, we will seek the solution of differential equation (7) at the initial stage of solid solution decomposition in the form

$$N(t) = N_E + [N(0) - N_E]\exp(-f(t)) \tag{8}$$

Where

$$f(t) = [(1-\alpha)A(N(0) - N_E)^{\alpha} t]^{\frac{1}{1-\alpha}}, f(0) = 0,$$
$$\exp(-f(t)), \frac{df}{dt} = k_D N_C^{1-\alpha}(N(0) - N_E)^{\alpha} f^{\alpha} \tag{9}$$

After substituting equation (9) into (8), taking into account the approximations indicated above, we obtain an expression describing the kinetics of a decrease in the concentration of monomers at the initial stage of decomposition of solid solutions:

$$\frac{N(t) - N_E}{N(0) - N_E} = exp\left\{-N_C\{(1-\alpha)[N(0) - N_E]^{\alpha} k_D t\}^{\frac{1}{1-\alpha}}\right] \tag{10}$$

At large times, using the approximation N (t) ≈ N_E, the solution of equation (7) can be approximated by the expression:

$$N(t) - N_E = Aexp\{-N_C^{1-\alpha}[N(0) + mN_C - N_E]^{\alpha} k_D t\} \tag{11}$$

where A is some constant. Note that Eq. (10) leads, as a particular result, to the Abrahamia–Ham equation for the decomposition of supersaturated solid solutions (Van Campen, 1990: 376):

$$\frac{N(t) - N_E}{N(0) - N_E} = exp\{-Kt^{\tau}\} \qquad (12)$$

where the constant τ is determined by the geometry of the clusters; K is a constant depending on the concentration of nucleation centers, the degree of supersaturation of the solution, and the diffusion coefficient of monomers. Using the diffusion equation, Ham considered the growth of precipitates of various geometries and found that $\tau = 3/2$ for precipitates with a constant eccentricity, $\tau = 2$ for disk-shaped precipitates, $\tau = 1$ for cylindrical precipitates.

Thus, in the absence of irradiation, as a particular result, we automatically obtain the Abrahamia-Ham equation, which has well confirmed its applicability on a large number of experimental data. From Eq. (5), using Eq. (3), we can find the pattern of change in the average geometric size of clusters at the initial stage of solid solution decomposition:

$$\langle R \rangle = b\big((1-\alpha)k_D(N(0) - N_E)t\big)\frac{\alpha}{1-\alpha} \qquad (13)$$

Under the influence of radiation irradiation with small doses of gamma quanta in the imperfect region of the phases of the components of the hard alloy, changes occur at the level of point defects of the Schottky-Frenkel type (Ruwan, 2016: 102; Williams et al., 1981: 10). As a result of this process, the density of defects decreases, the perfect area of microcrystals increases, leading to the removal of superposition stress fields inside and along the grain boundary, which in turn leads to the improvement of intragranular and intergranular bonds.

Results

As criteria for evaluating the strength and wear resistance of hard alloys under irradiation with gamma rays, the ultimate strength in bending, deformation, rigidity, and microhardness were taken. The regimes of irradiation with gamma quanta varied over a wide range in order to choose their rational values, which were later taken as the basis for the development of the technology of radiation hardening rock cutting tool. The results of studies of the effect of irradiation with gamma rays on the above indicators are presented in Figure 1. From Fig. 1 it can be seen that with an increase in the irradiation dose, the ultimate strength in bending and deformation increase up to the irradiation dose in the range of 8.10^4–5.10^5R, after which they sharply decrease. These results indicate the existence of a limit value for the dose of irradiation by gamma rays for the hard alloy, after which the processes in the hard alloy proceed with the formation of additional, so-called radiation defects. This reduces the ultimate strength in bending and deformation, increases the hardness and brittleness of the alloys.

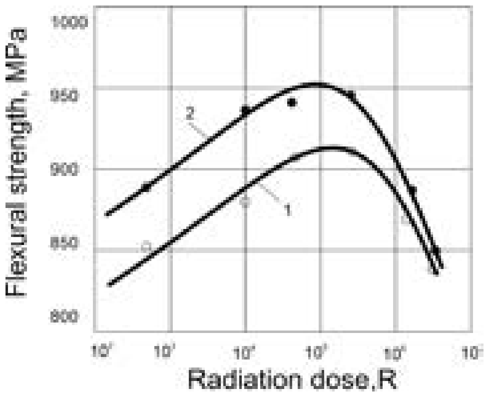

Fig. 1. Dependence of the ultimate strength in bending of hard alloys TC6, TX8 on the dose of irradiation with gamma rays: 1 - hard alloy TC6; 2 - hard alloy TC8

Methods of irradiation with low doses of gamma quanta or bremsstrahlung radiation provide volumetric hardening of the material that does not cause residual radiation, and the mechanism of hardening of various materials during radiation exposure is explained by the effect of low doses of ionizing radiation (Abubakirov, 2003: 494; Goltsev et al., 2021a: 7; Toshov et al., 2020: 12). Gamma rays have a high penetrating power, so the effects caused by them are distributed evenly over the entire volume of PRI, which after irradiation does not acquire residual radioactivity. When irradiated with gamma rays of metals and alloys with a weak absorbed dose of ionizing radiation, not exceeding 105 J/kg, it does not lead to the accumulation of defects, but to their elimination and ordering of the material structure. Structural changes in a solid crystalline body occur due to the release of stored energy as a result of chain reactions between defects initiated by irradiation. Radiation irradiation of hard alloys and composite materials with low doses of gamma quanta produces a deep restructuring of their structure, reduces the density of defects, removes superposition stress fields, which makes it possible to change their physical and mechanical characteristics and performance indicators of rock cutting tool. Irradiation of a solid body with gamma quanta or electrons leads to the ionization of atoms and the birth of point defects (Butkin et al., 2005a: 240). The research results have shown that with an increase in the irradiation dose, the ultimate strength in bending and deformation increase up to the irradiation dose in the range of 8–104–5–105 R, after which their sharp decrease is observed (Butkin et al., 2005a: 240; Goltsev et al., 2020b: 8). An increase in the density of defects, especially dislocations, according to general ideas about the nature of substructural hardening of metals and alloys, leads to a change in their physical and mechanical characteristics. At the same time, the wear resistance of the material and its strength properties increase, and an excessively high density of defects leads to an increase in the fragility and rigidity of products and, as a result, to a decrease in their performance (Butkin et al., 2005: 313; Sherov et al., 2022: 11). When irradiating PRI in the mode of short-term irradiation (20 minutes) with small doses of gamma-quanta of the source of ionizing radiation of cobalt-60, there is a significant decrease in the wear of crowns and an increase in their operational life. Samples of 3-blade bits produced by JSC "Uranredmetgeologia" were subjected to radiation treatment, which are widely used in mining enterprises of the Republic of Uzbekistan and have a relatively low quality compared to foreign counterparts. In this type of rock cutting tool, hard-alloy material TC8 is used as a rock-breaking tooling of a drill bit, the structure of which is characterized by strength and wear resistance (Viktorov et al., 2003: 277; Kesherbaum et al.,2003: 253; Baratov et al., 2021: 4). Nine batches of DZL bit specimens were subjected to field drilling wear resistance testing, and one batch was retained to detect storage tensile strength degradation after combined processing. Irradiation of drill bit samples with γ-quanta with an average energy of gamma-quanta of 1 MeV was carried out at the "Gamma-installation" of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan with sources of ionizing radiation Co^{60} type GIK-7–4 with an exposure dose from $3{,}2\cdot10^4$ to $8{,}9\cdot10^6$ R/s. Simultaneously with gamma irradiation, the samples were subjected to magnetic pulse treatment with a pulsed magnetic field with a magnetic induction from 0.2 to 0.4 Tl and a pulse duration of 3 ms. Samples of stone cutting tools with an average energy of 1 MeV were performed in a pool-type “gamma setup” with g-quantum Co^{60} sources. the physical parameters of the gamma channels are shown in the table 1 below. Figure 2 shows a three-bladed bit.

Fig. 2 - Three-bladed chisel

Table 1 - Physic parameters of the Gamma channels

№ swarm.	isotope	Activity (Ki) on 01.10.13 y.	Dose strength (P/c) on 01.10.13 y.	Number of III things
1	60 GIK-7-4	7 714	7,4	64
2	Co60	2 704	17,5	101
3	Co60	30 449	212,6 center 50,7-138,7 side.	457
General activity on 01.10.19 y.		40867		

The “pool” type gamma unit is designed to study the effects of gamma radiation on the properties and characteristics of various materials, products, and to modify their properties. The process of radiation exposure was carried out in the following order: Cleaning (degreasing) the surface of stone cutting tools; Calculate the required absorbed dose depending on the gamma channel and time effect; Installation of stone cutting tools in the gamma installation channel; Hold the gamma channel to install the stone cutting tools in the approximate time; Irradiation sampling; Dosimetric control of irradiated samples.

Discussion

For the use of the results of scientific research, ie comparative analysis and decision-making on the feasibility, was tested at the Nurato geological expedition belonging to Urankamyobmetgeologiya JSC under the State Committee for Geology and Mineral

Resources of the Republic of Uzbekistan at the drilling site, the test results are shown in the table 2,3 below.

Table 2 - Radiation samples irradiated at different exposure doses

Area	Drilling crew №	Drilling tool №	Amount of holes	Category of rocks by drillability					Amount of DZL-118mm
				II	III	IV	V	total	
Arnasay	27	A (I)	1	14	91	126	34	265	1
	27	A (II)		0	0	75	35	110	1
Total			1	14	91	251	69	375	2
Kukhnur	5	A (II),	1	0	0	195	45	240	2
Total			1	0	0	195	45	240	2
Aulbek	4	A (I),	1	10	100	215	57	382	2
	4	A (II)		0	0	111	35	146	1
Total			1	10	100	326	92	528	3
Arnasay, Aulbek	4; 27	A (I),	2	24	191	341	91	647	3
Arnasay, Aulbek, Kukhnur	27;5;4	A (II),	3	0	0	381	115	496	4
Total			5	24	191	722	206	1143	7

Table 3 - Unprocessed cut type drilling bits with three cutting point DZL Ж

Area	Drilling crew	Amount of holes	Category of rocks by drillability					Amount of DZL-118mm
			II	III	IV	V	total	
Arnasay	27	2	0	48	40	200	288	3
Kukhnur	1	3	0	73	64	247	384	4
Aulbek	2	2		51	66	158	275	3
total		7	0	172	170	605	947	10

Conclusion

At the end of the article I would like to emphasize that today it is important to increase the efficiency of geological prospecting and mining, reduce the cost of prospecting and exploration, to equip geological prospecting and mining companies with rational equipment and technology. gives It is known that at the present time the possibility of easy discovery of low-cost mineral deposits is developing. Given the complexity of the location and geological structure of mineral deposits, it is important to use geophysical, geochemical and aerospace methods in a rational combination with drilling in order to increase the efficiency of geological prospecting and mining. In recent years, the pace of introduction of modern technical means and advanced world technologies in geological prospecting and mining facilities has intensified. Taking advantage of the potential of progressive methods, the level of efficiency of drilling rigs requires the necessary level of renewal of the drilling rig fleet.

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