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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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CREATION OF DAMPING ALLOYS WITH OPTIMUM PHYSICAL-MECHANICAL PROPERTIES FOR GEOLOGICAL EXPLORATION EQUIPMENT PARTS

Abstract. One of the effective methods of reducing noise is to quench it at the source of occurrence. Such methods include replacement of percussion mechanisms with without impact ones, replacement of gears with V-belts, etc. The most acceptable method of reducing noise at the source of occurrence is the use of damping materials. Non-metals (plastics, wood, polyethylene, etc.), non-ferrous metals can be used. However, the most relevant to reduce noise at the source of occurrence in geo-exploration production is the use of iron-based damping metallic materials. In this work, the task was to assess the acoustic and vibration characteristics of standard steels 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25Х2ГНТА, which are used to manufacture parts of geo-exploration equipment, new damping alloys GGR-1, GGR-2, GGR-3. The choice of the chemical compound of the GGR-1 alloy made it possible to obtain an anti-vibration damping alloy having a quenching martensite structure. It is recommended to use it for exploration equipment parts (drilling rigs, drill rod, drilling blade, adapters for drilling head, drill pipe, etc.).

Keywords: noise, vibration, damping, geological exploration, mechanical properties, acoustic and vibration characteristics, chemical compound, equipment, experimental alloys.

Introduction. The noise of impact origin is the most common and harmful industrial factor of industry.

One of the high-performance and efficient production is geological exploration production. The equipment for geological exploration production is characterized by intense vibration and increased radiated noise (drilling rigs, drill rod, drilling blade, adapters to the drill head, drilling pipe, etc.). Industrial noise and sound vibration worsen working conditions, negatively affect the health of workers. Intense vibration is the cause of damage to the structures of machines and mechanisms and reducing their service life. All these problems pose to designers and technologists the task of reducing the parameters of noise and vibration.

Frequently, geological explosive production is dominated by percussion and final noise, characterized as the most harmful to workers health. At short impulses the likelihood of hearing loss increases.

Very often, intense noise is emitted by parts made of 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25 Х2ГНТА steels (standard steels) (gear wheels, gear rims, connecting rods, shaped castings and other parts of geological explosive equipment) [1, 13].

One of the effective methods of reducing noise is to quench it at the source of occurrence. Such methods include replacement of percussion mechanisms with without impact ones, replacement of gears with V-belts, etc. The most acceptable method of reducing noise at the source of occurrence is the use of damping materials. Non-metals (plastics, wood, polyethylene, etc.), non-ferrous metals can be used.

However, the most relevant to reduce noise at the source of occurrence in geo-exploration production is the use of iron-based damping metallic materials.

The aim of the work is the development and research of new grades of damping steels for castings, reducing the noise of impact origin, generated in parts and assemblies during the operation of geological prospecting equipment.

Research objectives:

- to evaluate the vibration and physical-mechanical properties of well-known steels (15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25 Х2ГНТА) used for parts subjected to shock loads;

- to develop new alloys for parts subjected to shock loads, differing in chemical composition, but not inferior in terms of mechanical and technological characteristics to known standard grades of alloyed steels.

As an object, both standard and newly smelted alloys were considered. The purpose of these steels is given in table 1. Table 2 presents the chemical compounds of the investigated steels. The acoustic characteristics (sound level, level of sound pressure) and vibration (vibration acceleration level, overall vibration acceleration level) characteristics of the alloys were investigated.

For the study, standard alloy steels were selected for castings of grades 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25 Х2ГНТА and melted alloyed alloys GGR-1, GGR-2 and GGR-3, whose mechanical characteristics are shown in table 3.

In this work, the task was to assess the acoustic and vibration characteristics of standard steels 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25Х2ГНТА, which are used to manufacture parts of geo-exploration equipment, new damping alloys GGR-1, GGR-2, GGR-3.

Standard alloyed casting steels 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25 Х2ГНТА in the form of a plate were investigated.

The damping ability of metallic materials is characterized by a combination of vibration and physical-mechanical characteristics, such as vibration acceleration level, internal friction, electrical resistivity, density, shear modulus, Young's modulus and a number of metallographic features. In the present study, a series of experiments were aimed at establishing patterns that determine the relationship of structurally sensitive factors and microstructure with the optimization parameter – the level of vibration acceleration of low-alloy structural steels, the composition of which was specified by the experiment planning matrix.

Experimental alloys were smelted in a crucible induction furnace with a capacity of 12 kg with the main lining. The source material was sheet metal of steel 10. Doping was carried out with 97,6% metallic manganese, 77,5% FeSi and 99,98% metallic nickel. Carbonaceous additive served as synthetic cast iron with a carbon content of 3,9%. Steel was cast into a metal mold with dimensions of 210x115x115 mm.

Samples before forging were heated in a laboratory oven to a temperature of 1200 °C with a holding time of 1 hour. Ingots were forged using a forged hammer to stripes with final dimensions of 700x90x10 (12) mm. After each pass, the strips were placed in an oven to achieve a temperature of 1200 °C.

One of the objectives of this work is the development of new damping metallic materials based on iron. In this regard, by adding alloying elements to the chemical compound of standard steel grades, new alloys with enhanced damping properties were obtained. The principles of alloying of alloys in the work are based on the study of the phase diagrams of Fe – C, Fe – Si, Fe – Mn, Fe – Cr, Fe – La, Fe – Ca, Fe – V, Fe – Ni. State diagrams determine in equilibrium the phase composition of the alloy depending on the temperature and concentration of the components and allow qualitatively characterizing many physical-chemical, mechanical and technological properties of the alloys.

Casting was made in the chill mold. Casting in the chill mold compared with the sand form has several advantages: the relative durability of the form and accelerated cooling of the casting in it, a sharp reduction or almost complete elimination of the consumption of molding materials; an increase in the removal from the molding site by 2-6 times, an increase in labor productivity by 1.5-6 times, a decrease in surface roughness, an increase in the accuracy of castings, an increase in the density of castings, a reduction in profit margins and often even their elimination [15].

Based on the analysis of installations for the study of vibration (level of vibration acceleration, total level of vibration acceleration) properties of the alloys, the device "KazNTU" -2 was selected for a comprehensive study of the vibration properties of plate steel samples [6] (figure 1).

Table 1 – Purpose and general characteristics of standard steels [7]

Steel	Purpose
15ХГН2ТА 15Х2ГН2ТА 15Х2ГН2ТРА	Disks, sprockets, gears, connecting rods, crosses, forks, fingers, gears, shafts, cam couplings, covers and other parts of geological exploration techniques.
20ХГНТР 25 Х2ГНТА	Responsible details of exploration equipment, gears, crosses, levers, etc.

Table 2 – The chemical compound of the investigated steels

Mark of steels, alloys	Chemical compound, %								
	C	Si	Mn	Cr	Ni	Ti	S	P	Fe
							no more		
15ХГН2ТА	00,13-0,18	00,17-0,37	10,7-1,0	≤0,7-1,0	–	–	0,035	00,035	The rest
20ХГНТР	00,18-0,24	00,17-0,37	10,8-1,1	≤0,4-0,7	–	–	0,035	00,035	The rest
GGR-1	00,2	00,2	00,8	11,0	00,35	00,15	0,045	00,04	The rest
GGR-2	00,3	00,3	00,75	11,0	00,45	00,18	0,045	00,04	The rest
GGR-3	,0,3	00,3	11,0	11,0	00,55	00,20	0,045	00,04	The rest

Table 3 – The mechanical properties of the investigated steels

№	Mark of steel	$\sigma_в$	Impact strength KCU, J/cm^2	δ_5	ψ	$\sigma_т$, MPa
				%		
				not less		
1	15ХГН2ТА	1330	127	11,5	59,5	1180
2	20ХГНТР	1200	80	9	50	1000
3	15Х2ГН2ТА	1380	127	12	58	1190
4	15Х2ГН2ТРА	1320	120	14	62	1190
5	GGR-1	1400	140	13	25	1300
6	GGR-2	1350	145	14	30	1250
7	GGR-3	1400	140	12	35	1320

The installation works as follows. The ball-drummer 6 was installed on an inclined plane 5. The ball-drummer 6 rolls down from the inclined plane 5 and makes a free fall into the geometric center of the plate sample 3. The ball-drummer 6 rebounds from it and enters the receiver of the balls 11. The noise from the impact of the striker ball 6 and sample 3 is recorded by the OCTAVE-101A sound level meter 12. Sample (plate) 3, oscillating in the interweaving of nylon yarns 1 creates a vibration, which is estimated by the device model "Bruel & Kjer" model 22048. The tension of the sample nylon threads 1 is always constant, since the load 10 controls this tension. The height of the fall of the ball can be changed using the screw mounting rack drummer 15. The entire system of mounting the sample 3 and the ball-striker 6 is installed on the frame 2, which with the help of the uprights 13 is located at a certain height above the floor.

In the measurements, steel (ШХ15) impact balls of the following diameters were used: 9,5 mm; 12,7 mm; 15,2 mm; 15,8 mm and 18,3 mm (mass of balls, shock, respectively: 2,5 g; 5 g; 9 g and 25 g).

At the installation, steel lamellar (50x50x5 mm) specimens were examined.

The vibration acceleration levels were measured in the range of 31,5-31500 Hz, the total vibration acceleration level - according to the "Lin" characteristic.

The mass of the ball, the density of the sample, the distance from the point of impact to the sample, the thickness of the sample are interrelated according to [8]:

$$m \langle 4{,}6 \cdot \rho \cdot l \cdot h^2, \tag{1}$$

where m – mass of lamellar-sample, g; ρ – density of material lamellar-sample, g/cm^3; *l* – distance from impact point to nearest edge of sample plate, cm; *h* – thickness of material lamellar-sample, cm.

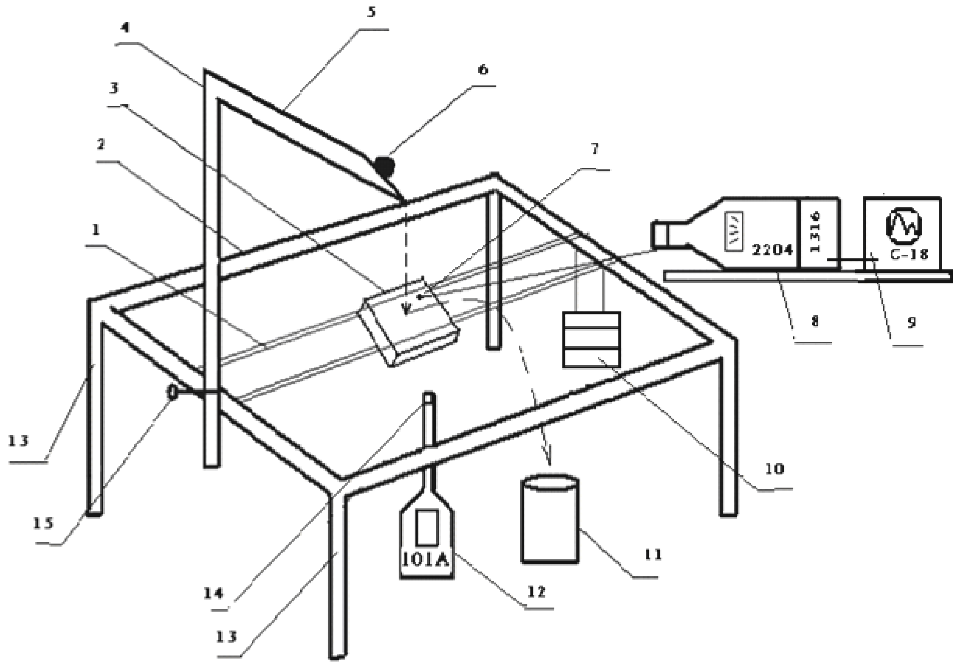

Figure 1 – Device "KazNTU-2" for the study of the vibration properties of solid plate (lamellar) samples [6, 18]:
1 – nylon thread; 2 – frame; 3 – lamellar (50x50x5 mm) sample; 4 – frame stand; 5 – inclined plane; 6 – ball-drummer;
7 – Vibration sensor of "Bruel&Kjer" vibrometer model 2204; 8 – vibrometer "Bruel&Kjer" model 2204;
9 – oscilloscope C-18; 10 – load; 11 – ball receiver; 12 – noisemeter "OCTAVE -101A"; 13 – frame stands;
14 – microphone of noise meter "OCTAVE -101A"; 15 – fastening pin rack screw

The correction for the change in the vibration signal from atmospheric pressure was carried out using a pistonphone of the brand PF-101. The air temperature and humidity in the laboratory were kept constant. Vibration measurements were found as the average of five measurements.

We also carried out mathematical processing of the experimental results and the determination of confidence intervals in accordance with the method [9]. Before starting, the adjustment of the measuring path was carried out by checking the sound pressure levels of the reference sample.

Vibration characteristics of the investigated standard steels 15ХГН2ТА, 20ХГНТР, 15Х2ГН2ТА and new damping alloys GGR-1, GGR-2 and GGR-3 are presented in tables 4, 5 and in figures 2, 3.

Table 4 presents the vibration characteristics of the samples (plates with size 50x50x5 mm) from standard steel 15ХГН2ТА, 20ХГНТР, 15Х2ГН2ТА, 15ХГН2ТРА after collision with impact balls with diameters d = 9,5 mm, d = 12,7 mm, d = 15,5 mm and d = 18,3 mm of steel ШХ15.

The nature of vibration acceleration levels (VAL) of standard steel 15ХГН2ТА, 20ХГНТР, 15Х2ГН2ТА, 15Х2ГН2ТРА has the following features:

- vibration acceleration levels of the samples studied vary in the range of 61-128 dB;
- maximums of vibration acceleration levels are observed at frequencies of 31,5 Hz, 63 Hz and 125 Hz;
- minimum levels of vibration accelerations of samples are typical for frequencies of 250-31500 Hz (61-68 dB);
- maximum values of the vibration accelerations of the compared samples are characteristic in collisions with a hammer-ball with a diameter of d = 18,3 mm;
- minimum values of the vibration acceleration levels of the compared samples are typical in collisions with impact balls with diameters d = 9,5 mm and d = 15,2 mm;
- maximum levels of vibration acceleration according to the "Lin" characteristic for samples 15ХГН2ТА, 20ХГНТР, 15Х2ГН2ТА, 15Х2ГН2ТРА are observed during collision with impact balls with diameters d = 12,7 mm and d = 18,3 mm (125-129 dB).

In the study of the sound emission characteristics of alloys, amplitude-dependent damping of vibration acceleration was found. Amplitude-dependent damping of vibration acceleration (ADDV) consists in the fact that when a ball striking a larger mass hits a sample, it generates a level of vibration acceleration of a smaller value than when a ball striking a smaller mass collides.

Table 4 – Vibration characteristics of standard steels (plates 50x50x5 mm) after casting

Mark of steel	Diameter of ball-drummer, d, mm	Vibration acceleration levels, dB, in octave bands with geometric average frequencies, Hz											TVAL, dB
		31,5	63	125	250	500	1000	2000	4000	8000	16000	31500	
15ХГН2ТА	9,5	85	104	86	65	64	63	61	64	65	70	68	105
	12,7	90	106	88	68	69	65	65	63	68	69	70	107
	15,2	88	106	90	67	75	68	67	62	67	68	71	108
	18,3	91	109	88	68	77	69	68	63	68	69	72	110
20ХГНТР	9,5	91	108	85	71	75	68	65	64	61	62	72	110
	12,7	91	114	82	73	76	69	69	65	62	64	77	115
	15,2	93	116	88	75	77	70	70	66	64	68	78	118
	18,3	94	122	85	78	75	72	72	67	68	70	80	124
15Х2Н2ТА	9,5	88	104	78	62	69	70	62	67	66	65	64	106
	12,7	85	109	89	72	71	69	66	68	67	64	66	110
	15,2	86	117	91	66	74	65	68	68	69	66	68	118
	18,3	90	120	96	67	73	64	69	70	70	66	71	122
15Х2ГН2ТРА	9,5	91	117	92	70	66	71	60	62	66	71	72	118
	12,7	97	122	96	71	72	68	64	69	67	72	73	125
	15,2	98	126	98	72	77	66	65	70	67	73	74	128
	18,3	98	128	100	74	78	65	69	72	68	74	77	129

In steel 15ХГН2ТА ADDV it is observed at frequencies of 31,5 Hz (drummers 12,7 mm and 15,2 mm); 63 Hz (drummers 12,7 mm and 15,2 mm); 125 Hz (drummers 15,2 mm and 18,3 mm); 250 Hz (drummers 12,7 mm and 15,2 mm); 4000 Hz (drummers 9,5 mm and 12,7 mm); 8000 Hz (drummers 12,7 mm and 15,2 mm); 16,000 Hz drummer 9,5 mm; 12,7 mm; 15,2 mm; 18,3 mm).

In steel 20ХГНТР ADDV is observed at frequencies of 31,5 Hz (drummers 9,5 mm and 12,7 mm); 125 Hz (drummers 9,5 mm; 12,7 mm; 15,2 mm and 18,3 mm); 500 Hz (drummers 15,2 mm and 18,3 mm).

In steel 15Х2ГН2ТА ADDV it is observed at frequencies of 1000 Hz (drummers 9,5 mm and 12,7 mm); 500 Hz (drummers 15,2 mm and 18,3 mm); 4000 Hz (drummers 12,7 mm and 15,2 mm); 16,000 Hz (drummers 9,5 mm; 12,7 mm; 15,2 mm and 18,3 mm).

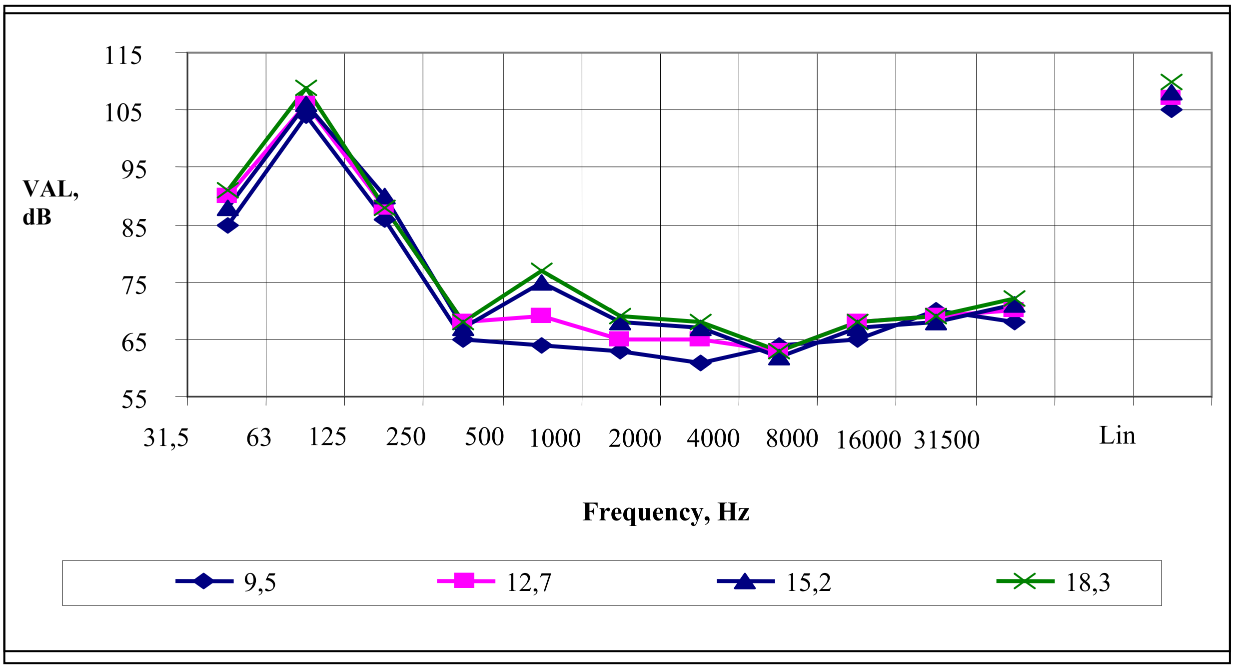

Figure 2 – Characteristics of vibration accelerations of the sample 15ХГН2ТА at impact

In steel 15Х2ГН2ТРА ADDV it is observed at frequencies of 31,5 Hz (drummers 15,2 mm and 18,3 mm); 1000 Hz (drummers 12,7 mm; 15,2 mm and 18,3 mm); 8000 Hz (drummers 12,7 mm and 15,2 mm).

Figure 2 shows the characteristics of the vibration accelerations of the 15ХГН2ТА sample at impact. In accordance with figure 2, it is maximum at a frequency of 31,5 Hz, 63 Hz, 125 Hz at impact 15ХГН2ТА sample with a hammer-ball with a diameter of d = 15,2 mm and 18,3 mm VAL = 90-109 dB, and minimal with a 15ХГН2ТА impact with a ball-drummer with a diameter of d = 15,2 mm VAL = 62 dB.

In figure 3 shows the characteristics of the vibration accelerations of the developed alloy sample GGR-1 at impact.

Table 5 – Vibration characteristics of the developed steels (plates 50x50x5 mm) after casting

Mark of steel	Diameter of ball-drummer, d, mm	Vibration acceleration levels, dB, in octave bands with geometric average frequencies, Hz											TVAL, dB
		31,5	63	125	250	500	1000	2000	4000	8000	16000	31500	
GGR-1	9,5	80	99	81	65	65	62	62	65	66	68	64	100
	12,7	82	100	79	66	68	64	65	68	69	70	65	102
	15,2	83	104	82	68	70	66	67	69	71	71	66	105
	18,3	85	107	83	70	72	67	68	71	72	73	68	108
GGR-2	9,5	81	100	80	66	66	64	65	64	68	70	67	102
	12,7	83	102	82	68	69	65	67	66	70	71	68	103
	15,2	85	106	83	69	71	66	67	66	70	71	69	108
	18,3	86	108	85	70	73	68	69	67	71	78	70	110
GGR-3	9,5	80	109	79	67	65	63	66	66	69	71	68	110
	12,7	79	111	79	69	66	65	67	68	70	73	69	112
	15,2	82	113	80	70	67	68	69	70	72	74	70	115
	18,3	85	117	82	72	69	70	71	71	73	75	72	119

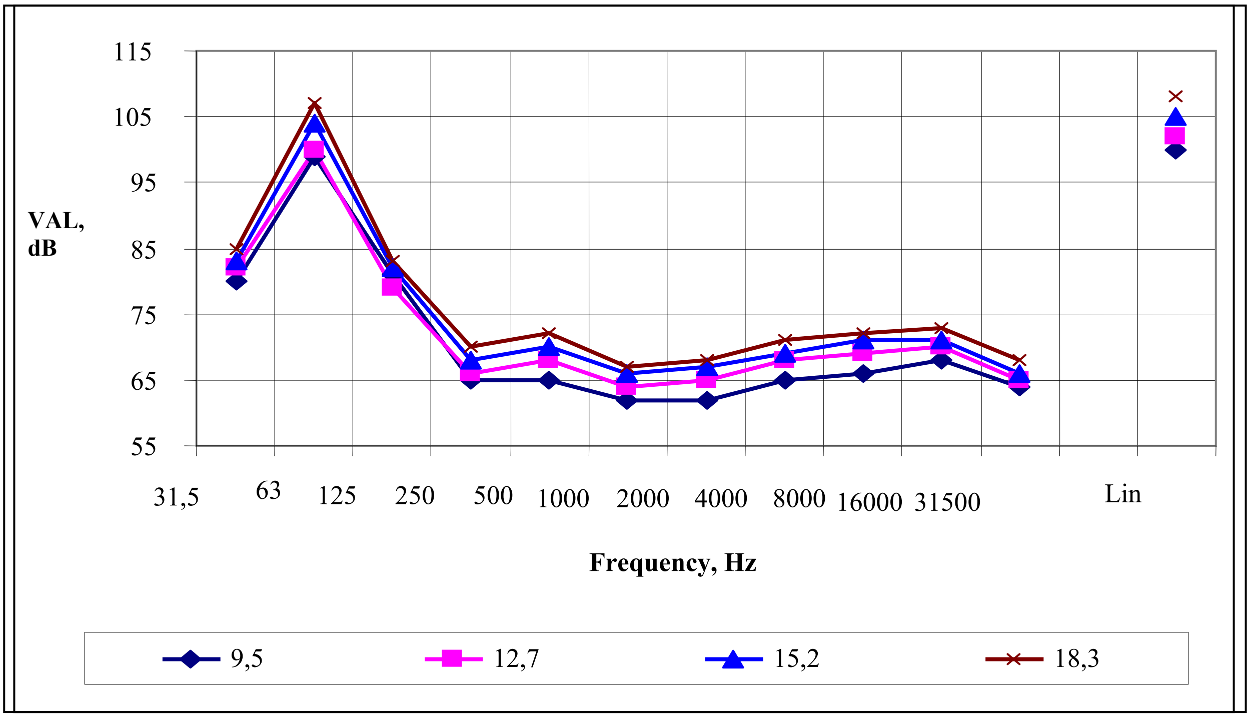

Figure 3 – Characteristics of vibration accelerations of the sample GGR-1 at impact

Conclusion. The choice of the chemical compound of the GGR-1 alloy made it possible to obtain an anti-vibration damping alloy having a quenching martensite structure. It is recommended to use it for exploration equipment parts (drilling rigs, drill rod, drilling blade, adapters for drilling head, drill pipe, etc.).

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ГЕОЛОГИЯЛЫҚ БАРЛАУ ЖАБДЫҚТАРЫНЫҢ БӨЛШЕКТЕРІНЕ АРНАЛҒАН ТИІМДІ ФИЗИКАЛЫҚ-МЕХАНИКАЛЫҚ ҚАСИЕТТЕРГЕ ИЕ ДЕМПФЕРЛІК ҚОРЫТПАЛАРДЫ ДАЙЫНДАУ

Шуды бәсеңдетудің ең тиімді жолдарының бірі ол шуды пайда болу көзінде төмендету. Мұндай әдістерге соққылы механизмдерді соққысыз түрге алмастыру, тісті берілістерді ременді берілістерге ауыстыруды жатқызуға болады. Шуды пайда болу көзінде бәсеңдету тәсілдерінде демпферлік материалдарды қолдану ұтымды болып табылады. Бейметалдар да (пластмассалар, ағаш, полиэтилен және т.б.), түсті металдар қолданылуы мүмкін.

Бірақ та, геологиялық барлау саласында шуды пайда болу көзінде бәсеңдету үшін темір негізіндегі демпферлік металды материалдарды қолдану өзекті болып табылады.

Жұмыста келесі негізгі міндеттер қойылды: геологиялық барлау жабдықтарының бөлшектерін дайындауда қолданылатын 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25 Х2ГНТА стандартты болаттардың, сонымен қатар ГГР-1, ГГР-2, ГГР-3 жаңа демпферлі қорытпаларының акустикалық және дірілдік қасиеттерін бағалау көзделді.

ГГР-1 қорытпасының химиялық құрамы шыныұтыру арқылы мартенситті құрылыммен дірілге қарсы демпферлік қорытпа алуға мүмкіндік берді. Аталған қорытпаны геологиялық барлау жабдықтары бөлшектеріне (бұрғылау құрылғылары, бұрғылау штангасы, бұрғылау күрегі, бұрғылау басының өткізгіштері, бұрғылау құбыры және т.б.) қолдануға ұсынылады.

Түйін сөздер: шу, діріл, демпферлеу, геологиялық жабдықтар, механикалық қасиеттер, акустикалық және дірілдік қасиеттер, химиялық құрам, жабдық, тәжірибелік қорытпалар.

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СОЗДАНИЕ ДЕМПФИРУЮЩИХ СПЛАВОВ С ОПТИМАЛЬНЫМИ ФИЗИКО-МЕХАНИЧЕСКИМИ СВОЙСТВАМИ ДЛЯ ДЕТАЛЕЙ ГЕОЛОГОРАЗВЕДОЧНОГО ОБОРУДОВАНИЯ

Аннотация. Одним из эффективных методов снижения шума является гашение его в источнике возникновения. К таким методам следует отнести замену ударных механизмов на безударные, замену зубчатых передач на клиноременные и т.п. Наиболее приемлемым методом снижения шума в источнике возникновения является использование демпфирующих материалов. Могут быть использованы неметаллы (пластмассы, древесина, полиэтилен и др.), цветные металлы.

Однако наиболее актуальным для снижения шума в источнике возникновения в геологоразведочном отрасле является применение демпфирующих металлических материалов на железной основе.

В настоящей работе была поставлена задача – оценить акустические и вибрационные характеристики стандартных сталей 15ХГН2ТА, 15Х2Н2ТА, 15Х2ГН2ТРА, 20ХГНТР, 25 Х2ГНТА , которые используются для изготовления деталей геологоразведочного оборудования, новых демпфирующих сплавов ГГР-1, ГГР-2, ГГР-3.

Выбор химического состава сплава ГГР-1 позволил получить демпфирующий антивибрационный сплав, имеющий структуру мартенсита закалки. Его рекомендуется использовать для деталей геологоразведочного оборудования (буровые установки, буровая штанга, буровая лопатка, переходники на буровую головку, труба буровая и др.).

Ключевые слова: шум, вибрация, демпфирование, геологоразведочные оборудования, механическое свойства, акстические и вибрационные характеристики, химический состав, установка, экспериментальные сплавы.

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