ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ
АКАДЕМИЯСЫ» РҚБ

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН»

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

4 (466)

JULY – AUGUST 2024

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

Clarivate Analytics

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

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.

«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

«Известия РОО «НАН РК». Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 4. Number 466 (2024), 33–47
https://doi.org/10.32014/2024.2518-170X.423
UDC 681.518.5

© V.V. Gerasidi[1*], R.G. Dubrovin[1], V.V. Kukartsev[2,3], T.A. Panfilova[4], G.V. Stas[5], 2024
[1]Admiral Ushakov Maritime State University, Krasnodar region, Novorossiysk, Russia;
[2]Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia;
[3]Bauman Moscow State Technical University, Moscow, Russia;
[4]Siberian Federal University, Krasnoyarsk, Russia;
[5]Tula State University, Tula, Russia.
E-mail: gerasidivv@yandex.ru

BOOST SYSTEM DIAGNOSTIC PARAMETERS OF COHERENT GAS PISTON INSTALLATIONS OF MINING ENTERPRISES

Aleksey V. Lisachenko — lecturer, Admiral F.F. Ushakov State Maritime University, Novorossiysk, Russia
E-mail: alexx.liss@yandex.ru, https://orcid.org/0009-0007-9537-3692;
Ruslan G. Dubrovin — Cand. Tech. Sc., Associate Professor, Admiral F.F. Ushakov State Maritime University, Novorossiysk, Russia
E-mail: r.g.dubrovin@yandex.ru, https://orcid.org/0000-0001-7316-8072;
Vladislav V. Kukartsev — Cand. Tech. Sc., Associate Professor, Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia; Bauman Moscow State Technical University, Moscow, Russia
E-mail: vlad_saa_2000@mail.ru, https://orcid.org/ 0000-0001-6382-1736;
Tatyana A. Panfilova — Candidate tech. Sciences, Associate Professor, Siberian Federal University, Krasnoyarsk, Russia
E-mail: tpanfilova@sfu-kras.ru, https://orcid.org/0009-0003-9537-8128;
Stas Galina Viktorovna — doctor of technical sciences, professor, Tula State University, 300012, Russia
E-mail: galina_stas@mail.ru, https://orcid.org/0000-0003-1604-1467.

Abstract. The article provides an analysis of the control of parameters and technical operation of KGU (coherent gas piston installations) of mining enterprises in the country. Due to the harsh operating conditions and the high level of dynamic load in mountainous conditions, most of the fuel system and boost system elements are used. The purpose of the work is to substantiate the method of assessing the technical condition of turbochargers of mining engines based on the control of vibration parameters in operation. The work revealed that there are no regulatory documents for monitoring the technical condition of the vibration parameters of a TC with a rotor rotation frequency of more than $p_{tc} \geq 30 \cdot 10^3$ min^{-1} mining engines. The paper proves the need to develop a control technique that would establish vibration levels not only for the TC, but also for the engine, the KGU generator, taking into account the coefficient of operation in mountainous conditions. The paper presents some test results of the installation at the facility of operation, an assessment of its technical condition was carried out, taking into account the coefficient of operation in a quarry.

Keywords: mining enterprise, gas pumping unit; gas turbine unit; parametric diagnostics; technical condition

© В.В. Герасиди[1*], Р.Г. Дубровин[1], В.В. Кукарцев[2,3], Т.А. Панфилова[4], Г.В. Стась[5], 2024

[1] Адмирал Ф.Ф. атындағы Мемлекеттік теңіз университеті. Ушакова, Ресей, Новороссийск;
[2] Академик М.Ф. Решетнев атындағы Сібір мемлекеттік ғылым және технология университеті, Красноярск, Ресей;
[3] Н.Е. Бауман атындағы МТУ, Мәскеу, Ресей;
[4] Сібір федералды университеті, Красноярск, Ресей;
[5] Тулалық мемлекеттік университеті, Тула, Ресей.
E-mail: gerasidivv@yandex.ru

ТАУ-КЕН КӘСІПОРЫНДАРЫНЫҢ ГАЗ ПОРШЕНЬДІ ҚОНДЫРҒЫЛАРЫНЫҢ ҚЫСЫМ ЖҮЙЕСІНІҢ ДИАГНОСТИКАЛЫҚ ПАРАМЕТРЛЕРІ

Лисаченко Алексей Владимирович — оқытушы, адмирал Ф.Ф. Ушаков атындағы Мемлекеттік Теңіз университеті, Новороссийск, Ресей
E-mail: alexx.liss@yandex.ru, https://orcid.org/0009-0007-9537-3692;
Дубровин Руслан Геннадьевич — т.ғ.к., доцент, адмирал Ф.Ф. Ушаков атындағы Мемлекеттік Теңіз университеті, Новороссийск, Ресей
E-mail: r.g.dubrovin@yandex.ru, https://orcid.org/0000-0001-7316-8072;
Кукарцев Владислав Викторович — т.ғ.к., доцент, академик М.Ф. Решетнев атындағы Сібір мемлекеттік Ғылым және технологиялар университеті, Красноярск, Ресей; Н.Е. Бауман атындағы МТУ, Мәскеу, Ресей
E-mail: vlad_saa_2000@mail.ru, https://orcid.org/ 0000-0001-6382-1736;
Панфилова Татьяна Александровна — т.ғ.к., доцент, Сібір федералды университеті, Красноярск, Ресей
E-mail: tpanfilova@sfu-kras.ru, https://orcid.org/0009-0003-9537-8128;
Стася Галина Викторовна — т.ғ.д., профессор, Тула мемлекеттік университеті, Тула, Ресей
E-mail: galina_stas@mail.ru, https://orcid.org/0000-0003-1604-1467.

Аннотация. Мақалада еліміздің тау-кен кәсіпорындарының КМУ (когерентті газ поршенді қондырғылар) параметрлерін бақылау және техникалық пайдалану талдауы берілген. Таулы жағдайларда ауыр жұмыс жағдайлары мен динамикалық жүктеменің жоғары деңгейіне байланысты ақаулардың көпшілігін отын жүйесі мен суперзарядтау жүйесінің элементтері алады. Жұмыстың мақсаты — жұмыс кезінде діріл параметрлерін бақылау негізінде тау-кен өнеркәсібінің қозғалтқыш турбокомпрессорларының техникалық жағдайын бағалау әдісін негіздеу. Жұмыста тау-кен өнеркәсібінің қозғалтқыштарының роторының айналу жылдамдығы ntk ≥ 30-дан жоғары ТК діріл параметрлері бойынша техникалық жағдайды бақылауға арналған нормативтік құжаттардың жоқтығы анықталды. Жұмыста тау жағдайында жұмыс істеу коэффициентін ескере отырып, тек ТК үшін ғана емес, сонымен қатар қозғалтқыш пен КМУ генераторы үшін діріл деңгейлерін белгілейтін басқару әдістемесін әзірлеу қажеттілігі дәлелденді. Жұмыста жұмыс орнындағы қондырғыны сынаудың кейбір нәтижелері берілген, оның техникалық жағдайы карьер жағдайындағы жұмыс коэффициентін ескере отырып бағаланған.

Түйін сөздер: тау-кен кәсіпорны, газ айдау қондырғысы; газ турбиналық қондырғы; параметрлік диагностика; техникалық жағдайы

© В.В. Герасиди[1], Р.Г. Дубровин[1], В.В. Кукарцев[2,3], Т.А. Панфилова[4], Г.В. Стась[5], 2024

[1]Государственный морской университет имени адмирала Ф.Ф. Ушакова, Новороссийск, Россия;
[2]Сибирский государственный университет науки и технологий имени академика М.Ф Решетнева, Красноярск, Россия;
[3]МГТУ им. Н.Э. Баумана, Москва, Россия;
[4]Сибирский федеральный университет, Красноярск, Россия;
[5]Тульский государственный университет, Тула, Россия.
E-mail: gerasidivv@yandex.ru

ДИАГНОСТИЧЕСКИЕ ПАРАМЕТРЫ СИСТЕМЫ НАДДУВА ГАЗОПОРШНЕВЫХ УСТАНОВОК ГОРНОДОБЫВАЮЩИХ ПРЕДПРИЯТИЙ

Лисаченко Алексей Владимирович — преподаватель, Государственный морской университет имени адмирала Ф.Ф. Ушакова, Новороссийск, Россия
E-mail: alexx.liss@yandex.ru, https://orcid.org/0009-0007-9537-3692;
Дубровин Руслан Геннадьевич — к.т.н., доцент, Государственный морской университет имени адмирала Ф.Ф. Ушакова, Новороссийск, Россия
E-mail: r.g.dubrovin@yandex.ru, https://orcid.org/0000-0001-7316-8072;
Кукарцев Владислав Викторович — к.т.н., доцент, Сибирский государственный университет науки и технологий имени академика М.Ф Решетнева, Красноярск, Россия; МГТУ им. Н.Э. Баумана, Москва, Россия
E-mail: vlad_saa_2000@mail.ru, https://orcid.org/ 0000-0001-6382-1736;
Панфилова Татьяна Александровна — к.т.н., доцент, Сибирский федеральный университет, Красноярск, Россия
E-mail: tpanfilova@sfu-kras.ru, https://orcid.org/0009-0003-9537-8128;
Стась Галина Викторовна — д.т.н., профессор, Тульский государственный университет, Тула, 300012, Россия
E-mail: galina_stas@mail.ru, https://orcid.org/0000-0003-1604-1467

Аннотация. В статье приведен анализ контроля параметров и технической эксплуатации КГУ (когерентных газопоршневых установок) горнодобывающих предприятий страны. В связи с тяжелыми условиями эксплуатации и высоким уровнем динамической загруженности в горных условиях большую часть отказов занимают элементы топливной системы и системы наддува. Целью работы является обоснование метода оценки технического состояния турбокомпрессоров двигателей горной промышленности на основе контроля вибрационных параметров в эксплуатации. В работе выявлено, что нормативных документов контроля технического состояния по вибрационным параметрам ТК с частотой вращения ротора более $n_{тк} \geq 30 \cdot 10^3$ мин$^{-1}$ двигателей горнодобывающей промышленности не существует. В работе доказана необходимость разработки методики контроля, которая бы установила уровни вибрации не только для ТК, но и двигателя, генератора КГУ с учетом коэффициента работы в горных условиях. В работе приведены некоторые результаты испытаний установки на объекте эксплуатации, проведена оценка ее технического состояния с учетом коэффициента работы в условиях карьера.

Ключевые слова: горнодобывающее предприятие, газоперекачивающий

агрегат; газотурбинная установка; параметрическая диагностика; техническое состояние

Introduction

Since 1871, MWM has been designing and manufacturing environmentally friendly gas engines and generator sets in Mannheim (Germany) for the mining industry. MWM is one of the leading and most renowned brands in the field of gas engines and generator sets from 400 to 4500 kW installed in the mining industry (Kondrat'ev et al., 2016; Kondratiev et al., 2022; Evdokimov et al., 2024). Mining gas engines operate on a wide range of gaseous fuels, such as natural gas and non-natural gas (eg landfill and sewer biogas). Mining power plant auxiliary equipment refers to the development, design and supply of equipment used in conjunction with generator sets for the construction of power plant workshops and other auxiliary enterprises of the mining industry for the extraction of natural resources (Stepanenko et al., 2017; Borodavkin, 2021; Grishin, 2021; Kamenskikh, 2021; Nakaryakov, 2021; Parshakov, 2021).

An analysis of the control of parameters and technical operation of CGU in the mining industry, taking into account severe operating conditions and a high level of dynamic load, shows that the majority of failures are caused by the fuel system and the engine pressurization system. So, for example, when the KGU operated for 13,630 hours at one of the country's mining enterprises for the extraction of minerals, the destruction of the fastenings of the TC structure and the upper part of the engine gas exhaust system began to occur (Fig. 1), then an emergency stop of the KGU occurred, since the TC pumps not only air into engine cylinders, but also gas (Kondrat'ev et al., 2022). The cause of the faulty condition of the TC was increased vibration at the engine speed. Due to high vibration, the insulation of the gas exhaust tract behind the fuel pump was destroyed, and then the fastenings of the CGU structure as a whole were destroyed (Karlina et al., 2023). Due to the fact that the operation of the CGU in mountainous conditions with increased vibration led to the breakthrough of gases into the environment and triggered a gas leak alarm, this caused an emergency shutdown of the CGU. The consequence of this accident was the engine was taken out of service for six months to carry out major repairs, purchase a new fuel pump and replacement spare parts. The cost of all operating expenses amounted to about 4.5 million rubles.

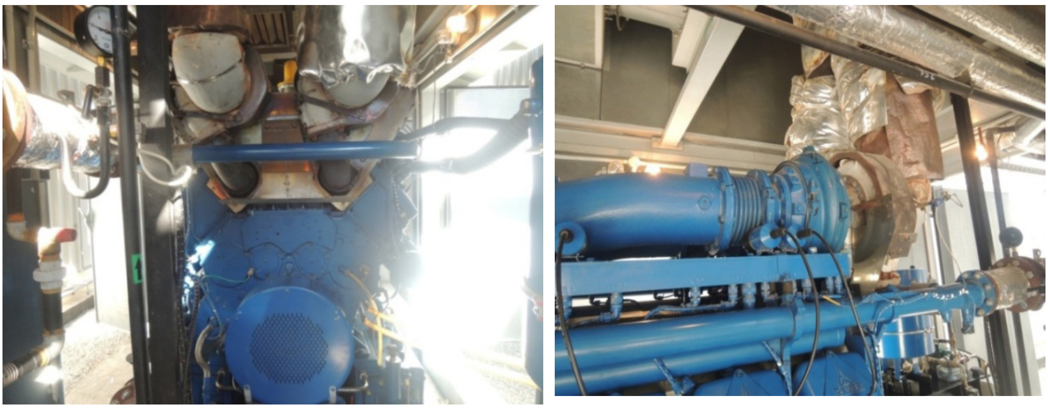


Fig. 1. Destruction of the structure of the gas piston installation NCG2020V20 (MWM) of one of the country's mining enterprises for the extraction of minerals

The purpose of the work is to substantiate a method for assessing the technical condition of turbochargers of mining engines based on monitoring vibration parameters in operation.

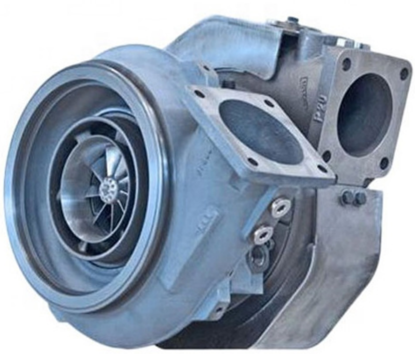
Materials and object of study. Analysis of literary sources shows that today a large number of works are devoted to monitoring the technical condition and operation of modern mining engines (Martyushev et al., 2023b). However, these modern and reliable engines fail if not properly operated. Scientific works (Palyanitsina et al., 2021; Korshak et al., 2019; Korshak et al., 2020) examine modern methods and technologies in the field of technical diagnostics, maintenance and repair of elements of mining machines and equipment, including vibration parameters. In the works (Martyushev et al., 2023b), stands are developed and patent research is carried out, including methodological aspects of vibration standards for turbochargers of mining engines.

The elements of the supercharging system of MWM CGU engines (power 1000 kW, 12 cylinders, rotation speed 1500 rpm (25 Hz)) are turbochargers (TC) from ABB brand TPS 52E01 (Fig. 2).

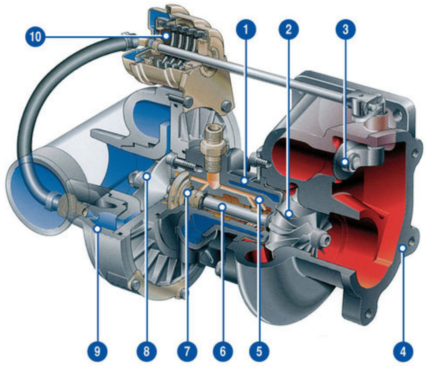
A special feature of the design of TC mining engines are plain bearings and a hydrodynamic thrust bearing, which are lubricated under pressure from the engine oil system (Fig. 2, b). The TC housing has channels for supplying and draining oil, and on some types of TC there are channels for liquid cooling. To prevent oil from entering the gas-air path from the oil cavity, seals are installed (Martyushev et al., 2023a).On the turbine side, a seal with a spring expansion ring is usually used. A ring made of special cast iron or steel is installed motionlessly in the housing and slides along the shaft groove with very small end clearance. On the compressor side, a similar design is generally used (Nikolaev et al., 2015a; Nikolaev et al., 2015b; Martyushev et al., 2023c).

For all its apparent simplicity, the TC is a very complex unit. The rotor at operating speeds is “flexible” - its operating frequency exceeds its own frequency of oscillation, so its rotation occurs in “floating” bearings capable of damping resonant vibrations at critical frequencies. The high rotation speed of the TC rotor (from 20,000 to 60,000 min-1), high dynamic and temperature loads, taking into account mountain conditions, necessitate very precise manufacturing of TC parts and the use of special materials and technologies (Pshenin et al., 2023; Kusimova et al., 2023; Korshak et al., 2023).

When the engine operates at low loads, taking into account the operating coefficient in mountain conditions, the energy of the exhaust gases is not enough to achieve the required boost pressure. Accordingly, poor-quality mixture formation occurs in the cylinder. Combustion products, along the path of the gas exhaust tract, settle on the walls and blades of the turbine, which, first of all, can lead to imbalance of the TC rotor, a decrease in the flow section area, as a result of which the gas pressure in front of the turbine increases. Also, when the engine operates taking into account the operating coefficient in mountainous conditions at idle speed or at low loads with a dirty filter, a vacuum is formed not only at the inlet to the compressor, but at the outlet from it. If this condition continues for some time, the oil will begin to be sucked out of the TC bearing housing and enter the engine intake manifold. Failure of the TC is usually associated with improper operation and the use of low-quality oil, which cokes in the TC, closing the lubrication holes of the bearings, which leads to scuffing, damage, and accelerated wear of the bearings, taking into account the operating coefficient in mountain conditions.



a)



b)

1 – bearing housing;

2 – turbine wheel;

3 – bypass valve; 4 – turbine housing; 5 – oil channels;

6 – rotor shaft; 7 – bearing; slip; 8 – compressor wheel; 9 – compressor housing;

10 – pneumatic actuator of the bypass valve

c)

Fig. 2. Turbocharger brand TPS 52E01 of the KGU engine from MWM NCG2020V20 with a power of 1000 kW, 12 cylinders, rotation speed 1500 min^{-1} (25 Hz) from one of the country's mining enterprises for the extraction of minerals: a) photo; b) device; c) installation location of vibration sensors on the engine turbocharger housing

The vibration method is based on a method that is widespread throughout the world, based on measuring vibration parameters. This is due to the fact that vibration is a consequence of the action of disturbing forces and, accordingly, the vibration signal carries information about the state of the mechanism, its kinematic connections and individual components. At the same time, the theory and practice of analyzing vibration signals has now been so developed that it is possible to obtain reliable information on almost any defect in installation, manufacturing or wear and tear of operation in mining conditions and eliminate vibration if evaluation criteria have been developed.

Object of control. Turbocharger with a radial-axial turbine from ABB Turbo-System Ltd, type TPS52E01 with a maximum rotation speed of 60x103 min^{-1} (1000 Hz) at KGU2, KGU5, KGU6 at one of the country's mining enterprises for the extraction of minerals.

Control conditions:

Operating mode of KGU2: n = 25 Hz = 1500 rpm, Ne = 550 kW = 0.55 Nenom.

Operating mode of KGU5: n = 25 Hz = 1500 rpm, Ne = 550 kW = 0.55 Nenom.

Operating mode of KGU6: n = 25 Hz = 1500 rpm, Ne = 700 kW = 0.7 Nenom.

Control scheme: Figure 2, c.

The control is carried out using measuring instruments:

Noise and vibration analyzer: portable device VIBXPERTII.

Results and discussion

To assess the operating condition of turbochargers with a radial-axial turbine from ABB TurboSystem Ltd, type TPS 52E01 with a maximum rotation speed of 60x103 min^{-1} (1000 Hz) KGU2,5,6, taking into account the operating coefficient in mountain conditions, the following types of processing of vibration signals in the vertical (Z) were performed), transverse (X) and axial (Y) directions: spectrum of vibration acceleration in a wide band from 1 to 25,600 Hz, with the number of lines 25,600; vibration velocity spectrum in a wide band from 1 to 5,600 Hz, with a number of lines of 5,600; temporary vibration acceleration signal from 1 to 40,000 Hz with a recording time of 2500 ms, sampling frequency 131,072 Hz.

Also, a comparative analysis of the vibration spectra of the GKU2 TK was carried out; the operating time after the overhaul is 2000 hours.

In Figure 3, as an example, shows the vibration signals of a mining enterprise engine at the level of the crankshaft in the vertical direction z obtained from the device without processing.

In Fig. 4–6 show the vibration signals of KGU2,5,6 of the mining enterprise at the control points indicated in Fig. 2, c. These signals are the beginning of the reporting point of the history of vibration data of a technical device and the change in the technical condition of the vehicle during operation. Currently, there are no regulatory documents for assessing the technical condition of turbines with a rotor speed of more than ntk≥ 30x103 min-1 based on vibroacoustic parameters of ROS. Thus, to analyze the vibration of TC KGU5,6, we will consider the reference readings of TC KGU2 of a mining enterprise, the operating time of which after overhaul is 2000 hours.

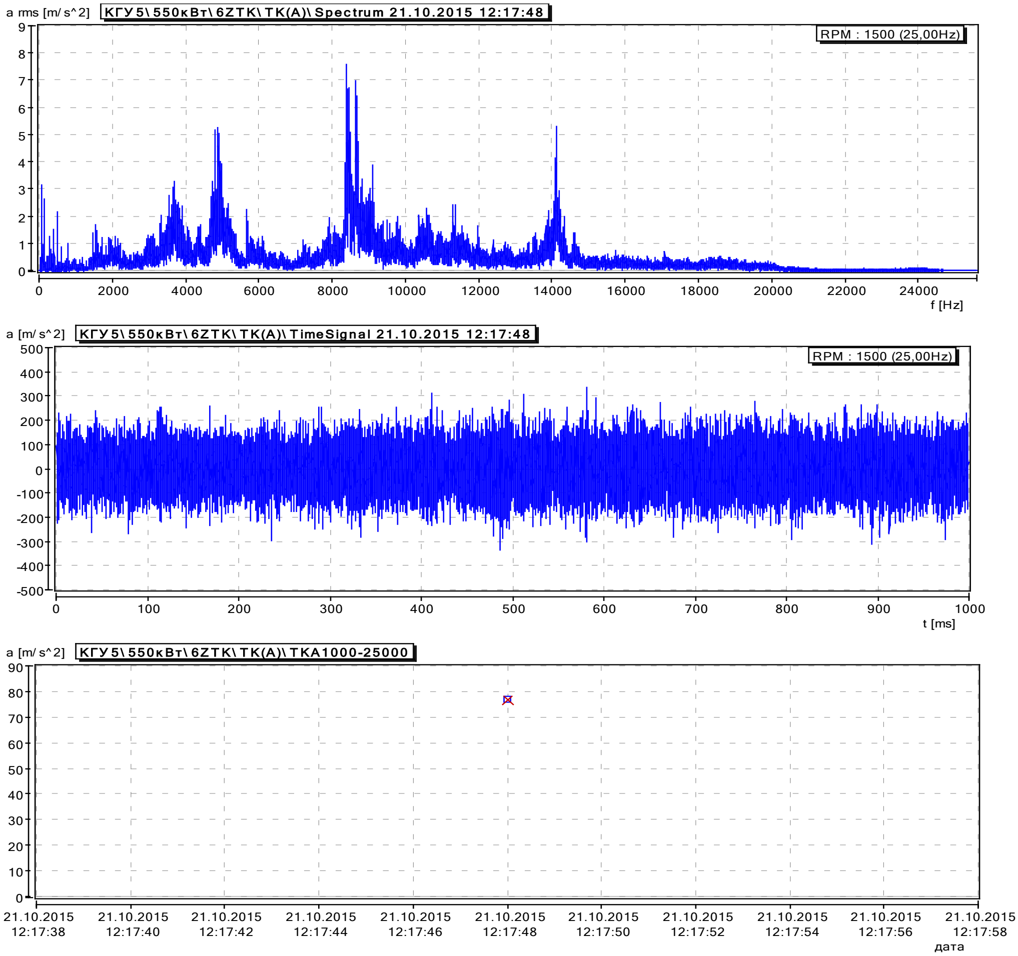
During vibration measurements, the load distribution between two CGUs of a mining enterprise is in automatic mode, and accordingly the load quickly changes from 0.5 to 0.7 Nenom. In this regard, in Fig. 2–4 showed the frequency ranges corresponding to the reverse frequency (fo), half-turn (1/2fo) and the second harmonic (2fo) of the reverse frequency of the TC KGU2,5,6 mining enterprise at the characteristic loads of the power plant, taking into account the operating coefficient in mining conditions. In these ranges, maximum vibration velocity values were also adopted. From Fig. 4–6 it is clear that:

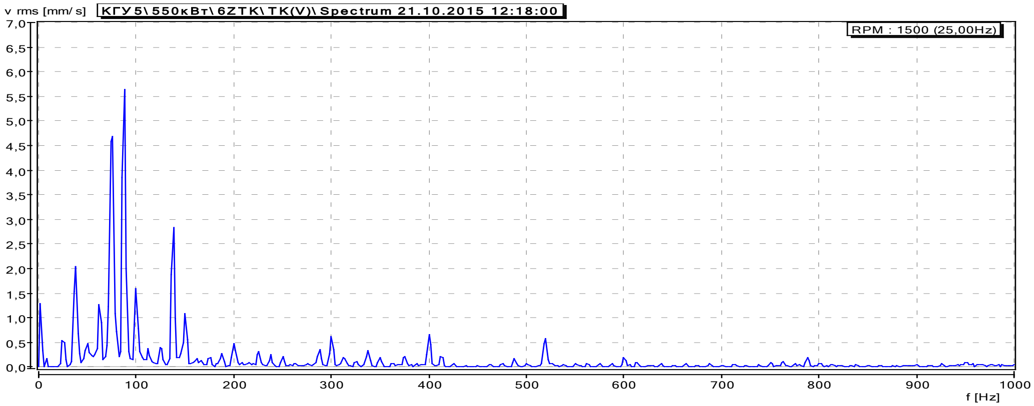
– the rotation frequency of the TC at a load of 0.55Nenom (550 kW) is in the frequency range from 550 Hz (33,000 min^{-1}) to 700 Hz (42,000 min^{-1}); 0.7Nenom (700 kW) from 700 Hz to 800 Hz (48,000 rpm);

– vibration velocity spectra of the TC in the axial direction (y), in the established frequency ranges corresponding to fo, 1/2fo, 2fo constitute the maximum vibration velocity values in relation to the vertical (z) and transverse (x) directions, for example, the fo value of the KGU 5 TC at load 0.55Nenom (550 kW) is 0.96 mm/s (Fig. 5, b);

– vibration velocity spectra of the TC in the transverse direction (x), in the established frequency ranges corresponding to fo, 1/2fo, 2fo are minimal values and change little with increasing load, this is due to the fact that, in the transverse direction, the TC is rigidly attached to the internal combustion engine frame ;

– vibration velocity values at the rotation frequency fo of TC KGU5.6 in all directions z, x, y do not exceed 1 mm/s (Martyushev et al., 2023a; Martyushev et al., 2023b;) .





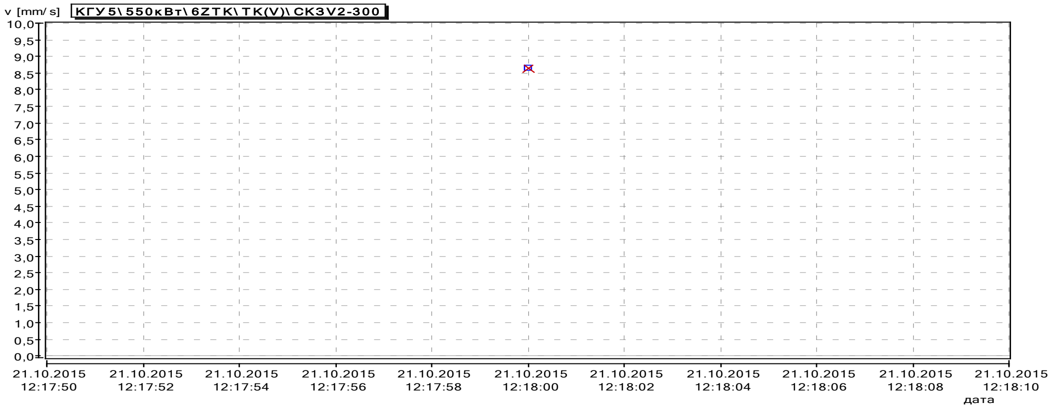
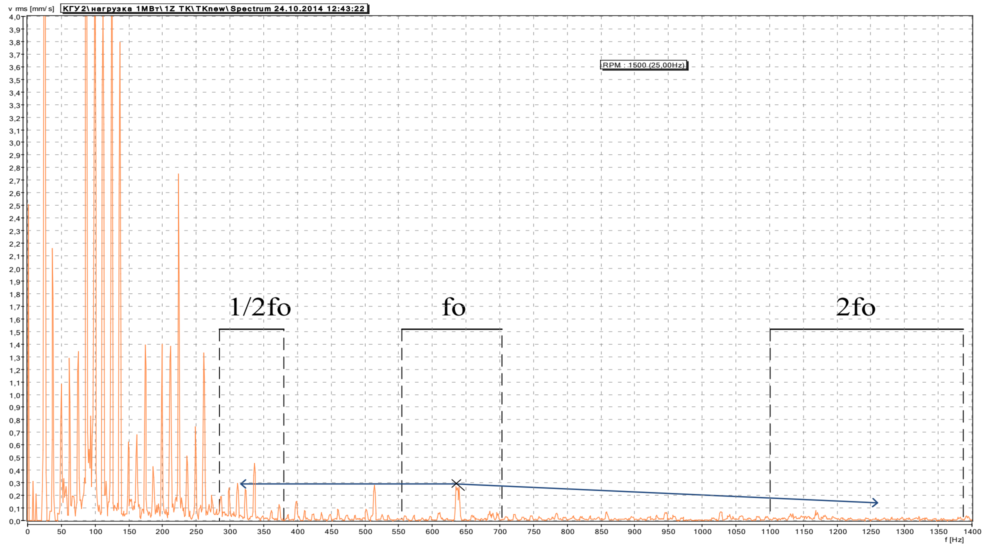
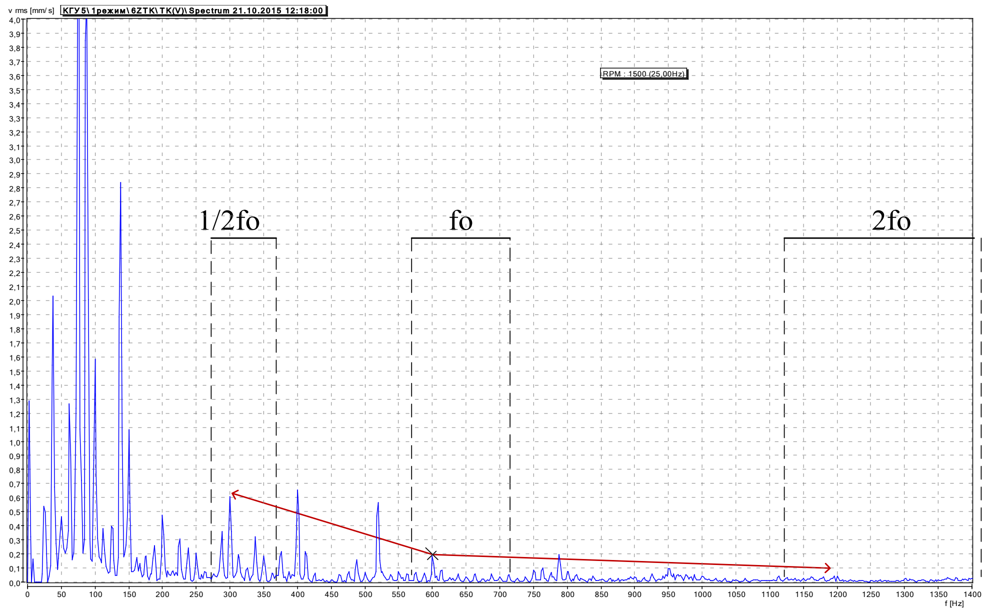


Fig. 3. Vibration signal at point 1Z at a load of 0.55 N_{enom} KGU5 of a mining enterprise for the extraction of minerals

a)


v rms [mm/ s]
КГУ2\нагрузка 1МВт\1Z TK\TKnew\Spectrum 24.10.2014 12:43:22
RPM : 1500 (25,00Hz)
1/2fo
fo
2fo
f [Hz]

b)


v rms [mm/ s]
КГУ5\1режим\6ZTK\TK(V)\Spectrum 21.10.2015 12:18:00
RPM : 1500 (25,00Hz)
1/2fo
fo
2fo
f [Hz]

c)

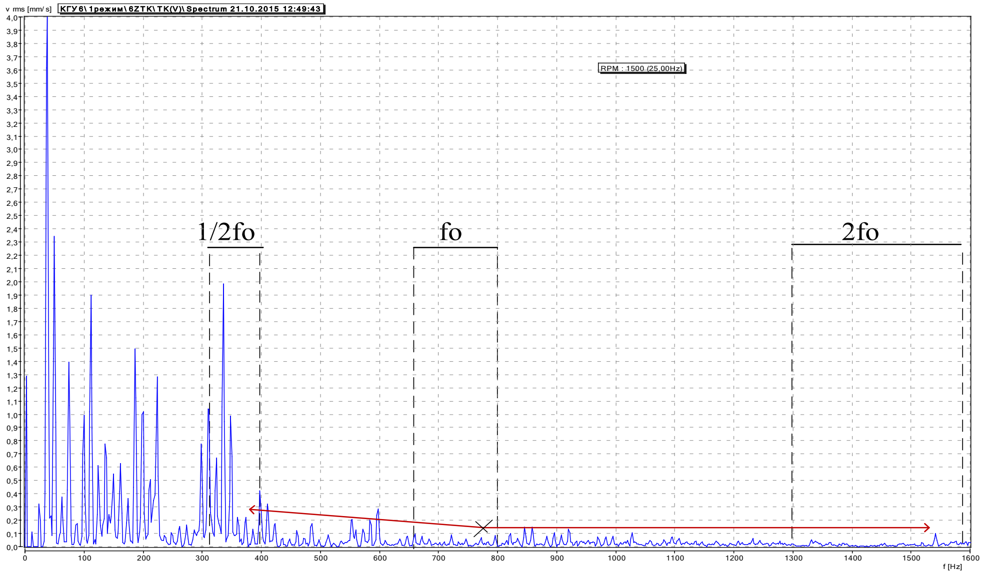
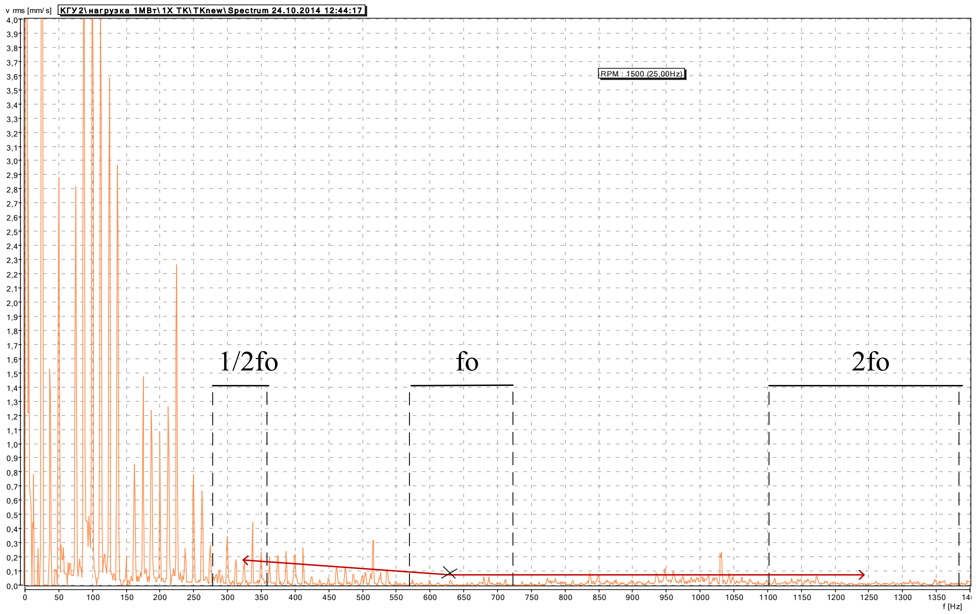
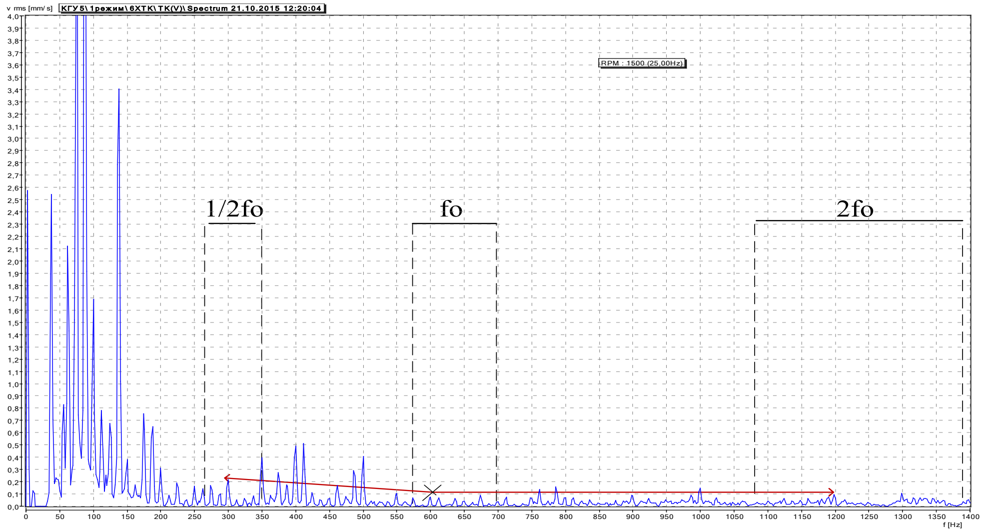


Fig. 4. Vibration velocity spectra in the vertical direction (z) of turbocompressors of a mining enterprise: a) KGU2 (0.5Ne); b) KGU5 (0.55Ne); c) KGU6 (0.7Ne)

a)



b)



c)

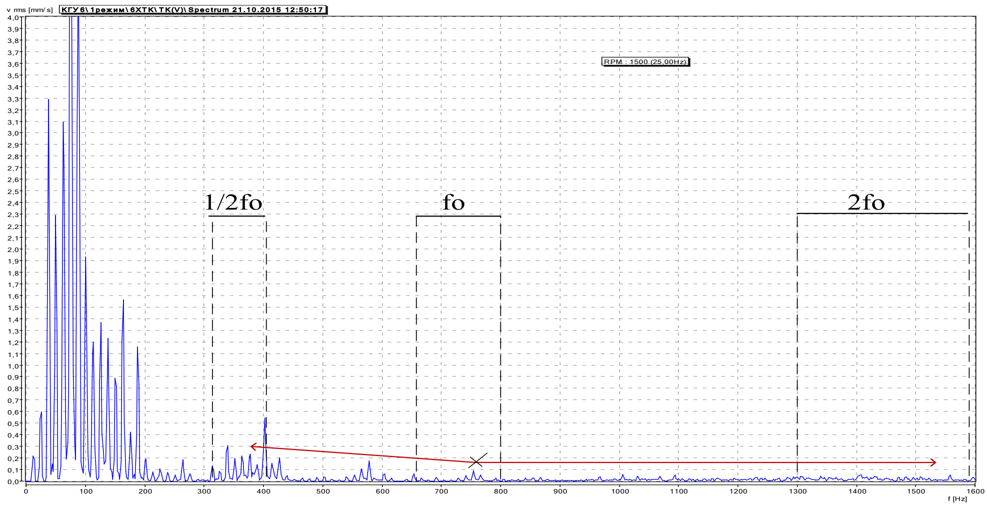
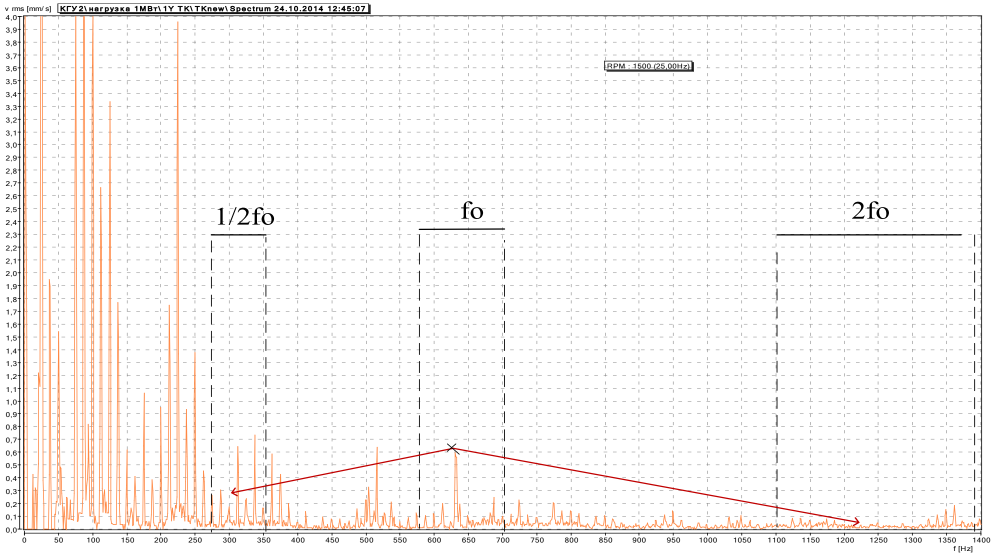
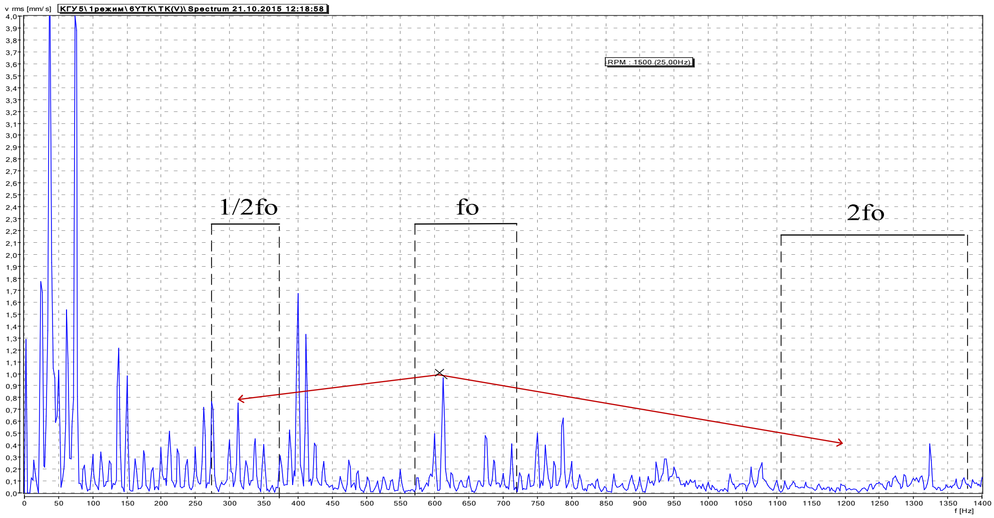


Fig. 5. Vibration velocity spectra in the transverse direction (x) of turbocompressors of a mining enterprise: a) KGU2 (0.5Ne); b) KGU5 (0.55Ne); c) KGU6 (0.7Ne)

a)


1/2fo
fo
2fo
RPM : 1500 (25,00Hz)
f [Hz]

b)


1/2fo
fo
2fo
RPM : 1500 (25,00Hz)
f [Hz]

c)

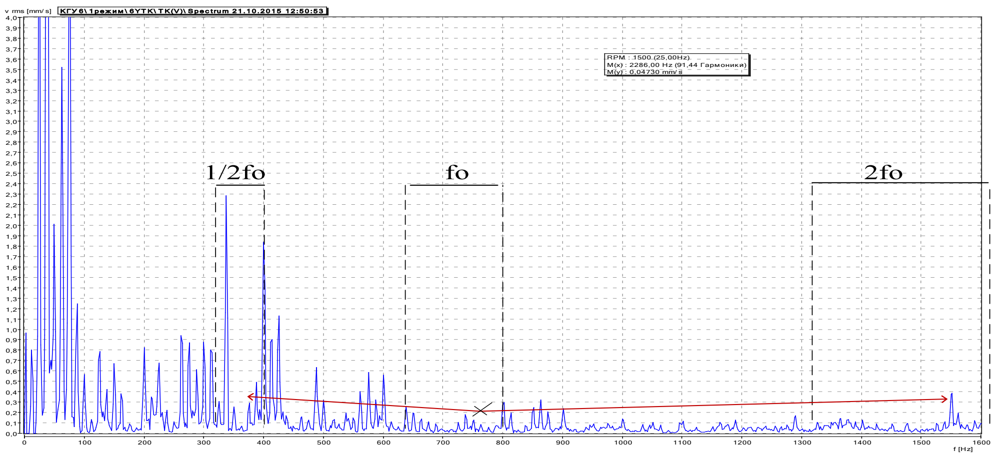

1/2fo
fo
2fo
f [Hz]

Fig. 6. Vibration velocity spectra in the axial direction (y) of turbocompressors of a mining enterprise: a) KGU2 (0.5Ne); b) KGU5 (0.55Ne); c) KGU6 (0.7Ne)

Conclusion

In accordance with the work performed, the following conclusions can be drawn:

1. Currently, there are no regulatory documents for monitoring the technical condition of vibration parameters of fuel engines with a rotor speed of more than ntk ≥ 30•103 min–1 of CGU engines in the mining industry.

2. The rotation frequency of the TC is in the range from 600 to 700 Hz at an engine load of 0.5 Nenom and is 1000 kW. This is very important, because the design of the TC, taking into account the operating coefficient in mountain conditions, is made in such a way that the rotation speed of the TC shaft can only be measured using vibration parameters.

3. The values of vibration velocity in all directions (z, x, y) at the rotational frequencies of the TC in the range of 600–700 Hz are no more than 1 mm/s, which indicates good shaft balancing and the same technical condition of all the studied TC KGU 2.5 ,6 mining enterprise.

4. The design of the GPU of a mining enterprise is designed in such a way that the source of vibration of the TC is the engine.

5. It is necessary to adjust the engine mounts and check the bearing assemblies of the engine crankshaft (thrust bearing and frame bearings).

6. It is relevant for the CGU of a mining enterprise to develop a control method that would establish vibration levels not only for the heating equipment, but also for the engine and generator of the CGU, taking into account the operating coefficient in mining conditions.

REFERENCE

Alymenko N.I. (2019). Operation of internal combustion engines in mines. *Mining Echo*, 2019. — No. 1. — Pp. 72–78. https://doi.org/10.7242/echo.2019.1.16.

Borodavkin D.A. (2021). On the issue of normalizing microclimatic conditions at the potash mines of OJSC Belaruskali. Mining Echo, 2021. — No. 4. — Pp. 96–101. https://doi.org/10.7242/echo.2021.4.27.

Grishin E.L. (2021). Gas Mode in the modern concept of mine ventilation. Mining echo, 2021. — No. 4. — Pp. 101–104. https://doi.org/10.7242/echo.2021.4.28

Kondrat'ev V.V., Rzhechitskij E.P., Shakhrai S.G., Karlina A.I., Sysoev I.A. (2024). RECYCLING OF ELECTROLYZER Evdokimov S.I., Golikov N.S., Pryalukhin A.F., Kondratiev V.V., Mishedchenko A., Kuzina A.V., Bryukhanova N.N., Karlina A.I. STUDYING FLOTATION OF GOLD MICRODISPERSIONS WITH CARRIER MINERALS AND PULP AERATION WITH A STEAM-AIR MIXTURE. Minerals, 2024, —14. — P. 108. DOI: 10.3390/min14010108

SPENT CARBON-GRAPHITE LINING WITH ALUMINUM FLUORIDE REGENERATION. Metallurgist, 2016, — 60(5–6). — Pp. 571–575. DOI: 10.1007/s11015-016-0333-4

Kondratiev V.V., Sysoev I.A., Kolosov A.D., Galishnikova V.V., Gladkikh V.A., Karlina A.I., Karlina Y.I. (2022). DEVELOPMENT AND TESTING OF THE THERMOELECTRIC THERMAL ENERGY CONVERSION DEVICE IN THE CONDITIONS OF EXISTING ALUMINUM PRODUCTION. Materials, 2022. — 15(23). — P. 8526. DOI: 10.3390/ma15238526

Karlina A.I., Karlina Y.I., Kondratiev V.V., Kononenko R.V., Breki A.D. (2023). STUDY OF WEAR OF AN ALLOYED LAYER WITH CHROMIUM CARBIDE PARTICLES AFTER PLASMA MELTING. Crystals, 2023. — 13(12). — Pp. 1696. DOI: 10.3390/cryst13121696

Kondrat'ev V.V., Kolosov A.D., Guseva E.A., Martyushev N.V., Karlina A.I. (2022). REDUCTION OF EMISSIONS OF RESINOUS SUBSTANCES IN EXTRACTION OF ALUMINUM BY ELECTROLYSIS. Metallurgist, 2022. — 66(7). — Pp. 1001–1005. DOI: 10.1007/s11015-022-01412-0

Kamenskikh A.A. (2021). Development of mathematical models of ventilation schemes for the Darasunsky mine. *Mining Echo*, 2021. — No. 4. — Pp. 105–113. https://doi.org/10.7242/echo.2021.5.28

Korshak A.A., Nikolaeva A.V., Nagatkina A.S., Gaysin M.T., Korshak A.A., Pshenin V.V. (2020). Method for predicting the degree of hydrocarbon vapor recovery at absorption. Science and Technologies. Oil and Oil Products Pipeline Transportation, 2020. — 10(2). — 202–209. doi:10.28999/2541-9595-2020-10-2-202-209

Korshak A.A., Pshenin V.V. (2023). Determination of parameters of non-pump ejector gasoline vapor recovery unit. Science and Technologies. Oil and Oil Products Pipeline Transportation, 2023. — 13(1). — 25–31. https://doi.org/10.28999/2541-9595-2023-13-1-25-31

Korshak A.A., Vykhodtseva N.A., Gaysin M.T., Korshak A.A., Pshenin V.V. (2019). Influence of operating factors on the performance of oil vapor recovery adsorption plants. Science and Technologies. Oil and Oil Products Pipeline Transportation, 2019. — 9(5). — 550–557. https://doi.org/10.28999/2541-9595-2019-9-5-550-557

Kusimova E., Saychenko L., Islamova N., Drofa P., Safiullina E., Dengaev A. (2023). Application of machine learning methods for predicting well disturbances. Journal of Applied Engineering Science, 2023. — 21(1). — 76–86. DOI:10.5937/jaes0-38729

Martyushev N.V., Malozyomov B.V., Filina O.A., Sorokova S.N., Efremenkov E.A., Valuev D.V., Qi M. (2023). Stochastic Models and Processing Probabilistic Data for Solving the Problem of Improving the Electric Freight Transport Reliability. *Mathematics*, 2023. — Vol. 11. — P. 483. — P. 3317. https://doi.org/10.3390/math11234836.

Martyushev N.V., Malozyomov B.V., Kukartsev V.V., Gozbenko V.E., Konyukhov V.Y., Mikhalev A.S., Kukartsev V.A., Tynchenko Y.A. (2023). Determination of the Reliability of Urban Electric Transport Running Autonomously through Diagnostic Parameters. *World Electr. Veh. J.*, 2023. — No. 14. — P. 334. https://doi.org/10.3390/wevj14120334.

Nakaryakov E.V. (2021). Field studies of the mine atmosphere during the operation of equipment with internal combustion engines. *Mining Echo*, 2021. — No. 4. — Pp. 113–118. https://doi.org/10.7242/echo.2021.6.28

Parshakov O.S. (2021). Results of a study of the mine ventilation network of a mine in the Norilsk industrial region. *Mining Echo*, 2021. — No. 4. — Pp. 119–128. https://doi.org/10.7242/echo.2021.7.28

Palyanitsina A., Tananykhin D., Masoud R. (2021). Strategy of water-flooding enhancement for low-permeable polymictic reservoirs. Journal of Applied Engineering Science, 2021. — 19(2). — 307–317. doi:10.5937/jaes0-29693

Pshenin V.V., Zakirova G.S. (2023). Improving the efficiency of oil vapor recovery units in the commodity transport operations at oil terminals. Journal of Mining Institute, 2023. — 265. — Pp. 121–128. https://doi.org/10.31897/PMI.2023.29

Stepanenko V.P., Belozerov V.I. (2017). Prospects for the use of combined power gas turbine units in the mining industry. *Mining Information and Analytical Bulletin*, 2017. — No. 5. — Pp. 178–189.

CONTENT

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the originality detection service Cross Check http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will onh accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

ISSN 2518-1483 (Online), ISSN 2224-5227 (Print)

http://geolog-technical.kz/en/archive/

Подписано в печать 15.08.2024.
Формат 60x88$^{1}/_{8}$. Бумага офсетная. Печать - ризограф.
15,0 п.л. Тираж 300. Заказ 4.

РОО «Национальная академия наук РК» 050010,
Алматы, ул. Шевченко, 28, т. 272-13-19