

ISSN 2518-170X (Online)

ISSN 2224-5278 (Print)



«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ  
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ  
«ХАЛЫҚ» ЖҚ

# Х А Б А Р Л А Р Ы

---

---

## ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ  
АКАДЕМИИ НАУК РЕСПУБЛИКИ  
КАЗАХСТАН»  
ЧФ «Халық»

## N E W S

OF THE ACADEMY OF SCIENCES  
OF THE REPUBLIC OF  
KAZAKHSTAN  
«Halyk» Private Foundation

**SERIES**

**OF GEOLOGY AND TECHNICAL SCIENCES**

# 5 (466)

**SEPTEMBER – OCTOBER 2024**

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

---

---

*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. Web of 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.*

### **Бас редактор**

**ЖҰРЫНОВ Мұрат Жұрынұлы**, химия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, «Қазақстан Республикасы Ұлттық ғылым академиясы» РҚБ-нің президенті, АҚ «Д.В. Сокольский атындағы отын, катализ және электрохимия институтының» бас директоры (Алматы, Қазақстан) **Н = 4**

### **Ғылыми хатшы**

**АБСАДЫКОВ Бахыт Нарикбайұлы**, техника ғылымдарының докторы, профессор, ҚР ҰҒА жауапты хатшысы, А.Б. Бектұратындағы химия ғылымдары институты (Алматы, Қазақстан) **Н=5**

### **Редакциялық алқа:**

**ӘБСАМЕТОВ Мәліс Құдысұлы** (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, «У.М. Ахмедсафина атындағы гидрогеология және геоэкология институтының» директоры (Алматы, Қазақстан) **Н = 2**

**ЖОЛТАЕВ Герой Жолтайұлы** (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, Қ.И. Сатпаев атындағы геология ғылымдары институтының директоры (Алматы, Қазақстан) **Н=2**

**СНОУ Дэниел**, Ph.D, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры (Небраска штаты, АҚШ) **Н = 32**

**ЗЕЛЬТМАН Реймар**, Ph.D, табиғи тарих мұражайының Жер туралы ғылымдар бөлімінде петрология және пайдалы қазбалар кен орындары саласындағы зерттеулердің жетекшісі (Лондон, Англия) **Н = 37**

**ПАНФИЛОВ Михаил Борисович**, техника ғылымдарының докторы, Нанси университетінің профессоры (Нанси, Франция) **Н=15**

**ШЕН Пин**, Ph.D, Қытай геологиялық қоғамының тау геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі (Пекин, Қытай) **Н = 25**

**ФИШЕР Аксель**, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) **Н = 6**

**КОНТОРОВИЧ Алексей Эмильевич**, геология-минералогия ғылымдарының докторы, профессор, РФА академигі, А.А. Трофимука атындағы мұнай-газ геологиясы және геофизика институты (Новосибирск, Ресей) **Н = 19**

**АГАБЕКОВ Владимир Енокович**, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры (Минск, Беларусь) **Н = 13**

**КАТАЛИН Стефан**, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) **Н = 20**

**СЕЙТМҰРАТОВА Элеонора Юсуповна**, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, Қ.И. Сатпаев атындағы Геология ғылымдары институты зертханасының меңгерушісі (Алматы, Қазақстан) **Н=11**

**САҒЫНТАЕВ Жанай**, Ph.D, қауымдастырылған профессор, Назарбаев университеті (Нұр-Сұлтан, Қазақстан) **Н = 11**

**ФРАТТИНИ Паоло**, Ph.D, Бикокк Милан университеті қауымдастырылған профессоры (Милан, Италия) **Н = 28**

---

**«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/>

© «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ, 2024

### **Главный редактор**

**ЖУРИНОВ Мурат Журинович**, доктор химических наук, профессор, академик НАН РК, президент РОО «Национальной академии наук Республики Казахстан», генеральный директор АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского» (Алматы, Казахстан) **Н = 4**

### **Ученый секретарь**

**АБСАДЫКОВ Бахыт Нарикбаевич**, доктор технических наук, профессор, ответственный секретарь НАН РК, Институт химических наук им. А.Б. Бектурова (Алматы, Казахстан) **Н = 5**

### **Редакционная коллегия:**

**АБСАМЕТОВ Малис Кудысович**, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан) **Н = 2**

**ЖОЛТАЕВ Герой Жолтаевич**, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, директор Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) **Н=2**

**СНОУ Дэниел**, Ph.D, ассоциированный профессор, директор Лаборатории водных наук университета Небраски (штат Небраска, США) **Н = 32**

**ЗЕЛЬТМАН Реймар**, Ph.D, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Англия) **Н = 37**

**ПАНФИЛОВ Михаил Борисович**, доктор технических наук, профессор Университета Нанси (Нанси, Франция) **Н=15**

**ШЕН Пин**, Ph.D, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай) **Н = 25**

**ФИШЕР Аксель**, ассоциированный профессор, Ph.D, технический университет Дрезден (Дрезден, Берлин) **Н = 6**

**КОНТОРОВИЧ Алексей Эмильевич**, доктор геолого-минералогических наук, профессор, академик РАН, Институт нефтегазовой геологии и геофизики им. А.А. Трофимука СО РАН (Новосибирск, Россия) **Н = 19**

**АГАБЕКОВ Владимир Енокович**, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь) **Н = 13**

**КАТАЛИН Стефан**, Ph.D, ассоциированный профессор, Технический университет (Дрезден, Берлин) **Н = 20**

**СЕЙТМУРАТОВА Элеонора Юсуповна**, доктор геолого-минералогических наук, профессор, член-корреспондент НАН РК, заведующая лабораторией Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) **Н=11**

**САГИНТАЕВ Жанай**, Ph.D, ассоциированный профессор, Назарбаев университет (Нурсултан, Казахстан) **Н = 11**

**ФРАТТИНИ Паоло**, Ph.D, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия) **Н = 28**

---

**«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 соединений.*

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/>

© РОО «Национальная академия наук Республики Казахстан», 2024

### **Editorial chief**

**ZHURINOV Murat Zhurinovich**, doctor of chemistry, professor, academician of NAS RK, president of the National Academy of Sciences of the Republic of Kazakhstan, general director of JSC “Institute of fuel, catalysis and electrochemistry named after D.V. Sokolsky» (Almaty, Kazakhstan) **H = 4**

### **Scientific secretary**

**ABSADYKOV Bakhyt Narikbaevich**, doctor of technical sciences, professor, executive secretary of NAS RK, Bekturov Institute of chemical sciences (Almaty, Kazakhstan) **H = 5**

### **E d i t o r i a l b o a r d :**

**ABSAMETOV Malis Kudysovich**, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, academician of NAS RK, director of the Akhmedsafin Institute of hydrogeology and hydrophysics (Almaty, Kazakhstan) **H=2**

**ZHOLTAEV Geroy Zholtaevich**, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, director of the institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) **H=2**

**SNOW Daniel**, Ph.D, associate professor, director of the laboratory of water sciences, Nebraska University (Nebraska, USA) **H = 32**

**ZELTMAN Reyamar**, Ph.D, head of research department in petrology and mineral deposits in the Earth sciences section of the museum of natural history (London, England) **H = 37**

**PANFILOV Mikhail Borisovich**, doctor of technical sciences, professor at the Nancy University (Nancy, France) **H=15**

**SHEN Ping**, Ph.D, deputy director of the Committee for Mining geology of the China geological Society, Fellow of the American association of economic geologists (Beijing, China) **H = 25**

**FISCHER Axel**, Ph.D, associate professor, Dresden University of technology (Dresden, Germany) **H = 6**

**KONTOROVICH Aleksey Emilievich**, doctor of geological and mineralogical sciences, professor, academician of RAS, Trofimuk Institute of petroleum geology and geophysics SB RAS (Novosibirsk, Russia) **H = 19**

**AGABEKOV Vladimir Enokovich**, doctor of chemistry, academician of NAS of Belarus, honorary director of the Institute of chemistry of new materials (Minsk, Belarus) **H = 13**

**KATALIN Stephan**, Ph.D, associate professor, Technical university (Dresden, Berlin) **H = 20**

**SEITMURATOVA Eleonora Yusupovna**, doctor of geological and mineralogical sciences, professor, corresponding member of NAS RK, head of the laboratory of the Institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) **H=11**

**SAGINTAYEV Zhanay**, Ph.D, associate professor, Nazarbayev University (Nursultan, Kazakhstan) **H=11**

**FRATTINI Paolo**, Ph.D, associate professor, university of Milano-Bicocca (Milan, Italy) **H = 28**

---

**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/>

© National Academy of Sciences of the Republic of Kazakhstan, 2024

NEWS of the National Academy of Sciences of the Republic of Kazakhstan  
SERIES OF GEOLOGY AND TECHNICAL SCIENCES  
ISSN 2224-5278  
Volume 5. Number 466 (2024), 23–35  
<https://doi.org/10.32014/2024.2518-170X.442>

UDC 681.518.5

**V.V. Gerasidi<sup>1</sup>, R.G. Dubrovin<sup>1</sup>, O.I. Kukartseva<sup>3,4</sup>, I.A. Panfilov<sup>2,4</sup>,  
V.V. Tynchenko<sup>2,3,4</sup>, 2024.**

<sup>1</sup> Admiral Ushakov Maritime State University, Krasnodar region,  
Novorossiysk, Russia;

<sup>2</sup> Reshetnev Siberian State University of Science and Technology,  
Krasnoyarsk, Russia;

<sup>3</sup> Siberian Federal University, Krasnoyarsk, Russia;

<sup>4</sup> Bauman Moscow State Technical University, Moscow, Russia.

E-mail: [gerasidivv@yandex.ru](mailto:gerasidivv@yandex.ru)

## **ANALYSIS OF TECHNICAL OPERATION OF CATERPILLAR ENGINEERING CORPORATION ENGINES IN INDUSTRY**

**Gerasidi Viktor V.** – Candidate of Technical Sciences, Associate Professor, Admiral F.F. Ushakov State Maritime University, 353924, Novorossiysk, Russia, e-mail: [gerasidivv@yandex.ru](mailto:gerasidivv@yandex.ru), ORCID: <https://orcid.org/0009-0008-1673-3192>;

**Dubrovin Ruslan G.** – Cand. Tech. Sc., Associate Professor, Admiral F.F. Ushakov State Maritime University, Novorossiysk, Russia, e-mail: [r.g.dubrovin@yandex.ru](mailto:r.g.dubrovin@yandex.ru), ORCID: <https://orcid.org/0000-0001-7316-8072>;

**Kukartseva Oksana I.** – Bauman Moscow State Technical University, Russia, Moscow; Siberian Federal University, Krasnoyarsk, Russia, e-mail: [gutova\\_ok@mail.ru](mailto:gutova_ok@mail.ru), ORCID: <https://orcid.org/0009-0001-2109-3299>;

**Panfilov Ilya Aleksandrovich** – Ph.D., Associate Professor, Siberian State University of Science and Technology. M.F. Reshetnyova, Russia, 660037, Krasnoyarsk; REC Artificial Intelligence Technologies, Bauman Moscow State Technical University, Russia, Moscow, e-mail: [crook\\_80@mail.ru](mailto:crook_80@mail.ru), ORCID: <https://orcid.org/0000-0002-4322-5408>;

**Tynchenko Valeria Valerievna** – Cand. Tech. Sc., Associate Professor, Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia; Siberian Federal University, Krasnoyarsk, Russia; Bauman Moscow State Technical University, Moscow, Russia, e-mail: [vtynchenko@sfu-kras.ru](mailto:vtynchenko@sfu-kras.ru), ORCID: <https://orcid.org/0000-0002-9701-7460>.

**Abstract.** The paper analyzes the technical operation of caterpillar engineering corporation engines in industry. Currently, new developments of Cat technology with mechanical power transmission are one of the advanced technologies for operation control in the segment of diesel-electric machines. A wide range of engines allows you to install, for example, the "C32" and "SAT3500" series on mining dump trucks. The engines meet Tier 3 standards for exhaust gas toxicity through the use of ACERT (Advanced Combustion Emissions Reduction Technology) technology. During operation, malfunctions and accidents of modern engines

occur, which lead to the shutdown and downtime of the equipment as a whole. The paper presents statistics of failures of Caterpillar engine components during 10 years of operation. visual and parametric control and defecation were performed to analyze the accident. The results of computer diagnostics were obtained, the authors, 20 hours earlier before the accident, made it possible to compare the same values taken immediately after the accident. To identify the causes of the accident of the C 32 automobile engine, types and methods of non-destructive testing were applied, taking into account the coefficient of operation in a quarry.

**Keywords:** car engine, diagnostics, load, engine defects, dump truck.

**В.В. Герасиди<sup>1</sup>, Р.Г. Дубровин<sup>1</sup>, О.И. Кукарцева<sup>3,4</sup>, И.А. Панфилов<sup>2,4</sup>,  
В.В. Тынченко<sup>2,3,4</sup>, 2024.**

<sup>1</sup> Адмирал Ф.Ф. Ушаков атындағы Мемлекеттік теңіз университеті,  
Ресей, Новороссийск;

<sup>2</sup> М.Ф. Решетнева атындағы Сібір мемлекеттік ғылым және технология  
университеті, Красноярск, Ресей;

<sup>3</sup> Сібір федералды университеті, Красноярск, Ресей;

<sup>4</sup> Н.Е. Бауман атындағы МТУ жасанды интеллект технологиясының ғылыми  
орталығы, Мәскеу, Ресей.

E-mail: gerasidivv@yandex.ru

## **ТАУ-КЕН ӨНЕРКӘСІБІНДЕГІ САТЕРПИЛЛАР МАШИНА ЖАСАУ КОРПОРАЦИЯСЫНЫҢ ҚОЗҒАЛТҚЫШТАРЫНЫҢ ТЕХНИКАЛЫҚ ЖҰМЫСЫН ТАЛДАУ**

**Герасиди Виктор Владимирович** – т.ғ.к., доцент, Адмирал Ф.Ф. Ушаков атындағы Мемлекеттік теңіз университеті, Ресей, Новороссийск, E-mail: gerasidivv@yandex.ru, ORCID: <https://orcid.org/0009-0008-1673-3192>;

**Дубровин Руслан Григорьевич** – т.ғ.к., доцент, Адмирал Ф.Ф. Ушаков атындағы Мемлекеттік теңіз университеті, Ресей, Новороссийск, e-mail: r.g.dubrovin@yandex.ru, ORCID: <https://orcid.org/0000-0001-7316-8072>;

**Кукарцева Оксана Ивановна** – Н.Е. Бауман атындағы МТУ жасанды интеллект технологиясының ғылыми орталығы, Мәскеу, Ресей; Сібір федералды университеті, Красноярск, Ресей, e-mail: gutova\_ok@mail.ru, ORCID: <https://orcid.org/0009-0001-2109-3299>;

**Панфилов Илья Александрович** – т.ғ.к., доцент, М.Ф. Решетнев атындағы Сібір мемлекеттік Ғылым және технологиялар университеті, Красноярск, Ресей; Н.Е. Бауман атындағы МТУ жасанды интеллект технологиясының ғылыми орталығы, Мәскеу, Ресей, E-mail: crook\_80@mail.ru, ORCID: <https://orcid.org/0000-0002-4322-5408>;

**Тынченко Валерия Валерьевна** – т.ғ.к., доцент, М.Ф. Решетнев атындағы Сібір мемлекеттік ғылым және технология университеті, Красноярск, Ресей; Н.Е. Бауман атындағы Сібір федералды университеті, Красноярск, Ресей; Н.Е. Бауман атындағы МТУ жасанды интеллект технологиясының ғылыми орталығы, Мәскеу, Ресей, E-mail: vvtynchenko@sfu-kras.ru, ORCID: <https://orcid.org/0000-0002-9701-7460>.

**Аннотация.** Мақалада caterpillar engineering corporation қозғалтқыштарының өнеркәсіптегі техникалық жұмысы талданады. Қазіргі уақытта

Механикалық қуат берумен Cat технологиясының жаңа әзірлемелері дизельдік-электрлік машиналар сегментіндегі жұмысты басқарудың озық технологияларының бірі болып табылады. Қозғалтқыштардың кең ассортименті, мысалы, "С32 "және" SAT3500 " серияларын тау-кен самосвалдарына орнатуға мүмкіндік береді. Қозғалтқыштар ACERT (Жану Шығарындыларын Азайтудың Озық Технологиясы) технологиясын қолдану арқылы пайдаланылған газдардың уыттылығы бойынша 3-Деңгей стандарттарына сәйкес келеді. Жұмыс кезінде заманауи қозғалтқыштардың ақаулары мен апаттары орын алады, бұл тұтастай алғанда жабдықтың тоқтап қалуына әкеледі. Мақалада Шынжыр табанды қозғалтқыш компоненттерінің 10 жыл жұмыс істеген кездегі істен шығуы туралы статистика келтірілген. Апатты талдау үшін визуалды және параметрлік бақылау және дефекация жүргізілді. Компьютерлік диагностиканың нәтижелері алынды, авторлар апаттан 20 сағат бұрын апаттан кейін бірден алынған мәндерді салыстыруға мүмкіндік берді. С 32 автомобиль қозғалтқышының апатының себептерін анықтау үшін карьердегі жұмыс коэффициентін ескере отырып, бұзбайтын сынақтардың түрлері мен әдістері қолданылды.

**Түйін сөздер:** автомобиль қозғалтқышы, диагностика, жүктеме, қозғалтқыштың ақаулары, самосвал.

**В.В. Герасиди<sup>1</sup>, Р.Г. Дубровин<sup>1</sup>, О.И. Кукарцева<sup>3,4</sup>, И.А. Панфилов<sup>2,4</sup>,  
В.В. Тынченко<sup>2,3,4</sup>. 2024.**

<sup>1</sup> Государственный морской университет имени адмирала Ф.Ф. Ушакова, Новороссийск, Россия;

<sup>2</sup> Сибирский государственный университет науки и технологий им. М.Ф. Решетнёва, Красноярск, Россия;

<sup>3</sup> Сибирский федеральный университет, Красноярск, Россия;

<sup>4</sup> НОЦ Технологии искусственного интеллекта МГТУ им. Н.Э. Баумана, Москва.

E-mail: gerasidivv@yandex.ru

## **АНАЛИЗ ТЕХНИЧЕСКОЙ ЭКСПЛУАТАЦИИ ДВИГАТЕЛЕЙ МАШИНОСТРОИТЕЛЬНОЙ КОРПОРАЦИИ CATERPILLAR В ГОРНОЙ ПРОМЫШЛЕННОСТИ**

**Герасиди Виктор Владимирович** – к.т.н., доцент, Государственный морской университет имени адмирала Ф.Ф. Ушакова, 353924, Новороссийск, Россия, E-mail: gerasidivv@yandex.ru, ORCID: <https://orcid.org/0009-0008-1673-3192>;

**Дубровин Руслан Григорьевич** – к.т.н., доцент, Государственный морской университет имени адмирала Ф.Ф. Ушакова, Новороссийск, Россия, e-mail: r.g.dubrovin@yandex.ru, ORCID: <https://orcid.org/0000-0001-7316-8072>;

**Кукарцева Оксана Ивановна** – НОЦ Технологии искусственного интеллекта МГТУ им. Н.Э. Баумана, Москва, Россия; Сибирский федеральный университет, Красноярск, Россия, e-mail: gutova\_ok@mail.ru, ORCID: <https://orcid.org/0009-0001-2109-3299>;

**Панфилов Илья Александрович** – к.т.н., доцент, Сибирский государственный университет



науки и технологий им. М.Ф. Решетнёва, Красноярск, 660037, Россия; МГТУ им. Н.Э. Баумана, Москва, 105005, Россия, E-mail: crook\_80@mail.ru, ORCID: <https://orcid.org/0000-0002-4322-5408>;

**Тынченко Валерия Валерьевна** – к.т.н., доцент, Сибирский государственный университет науки и технологий имени М.Ф. Решетнёва, Красноярск, Россия; Сибирский федеральный университет, Красноярск, Россия; НОЦ Технологии искусственного интеллекта МГТУ им. Н.Э. Баумана, Москва, Россия, E-mail: vvtynchenko@sfu-kras.ru, ORCID: <https://orcid.org/0000-0002-9701-7460>.

**Аннотация.** В работе проведен анализ технической эксплуатации двигателей машиностроительной корпорации Caterpillar в промышленности. В настоящее время новые разработки техники Cat с механической силовой передачей являются одной из передовых технологий контроль эксплуатацией в сегменте дизель-электрических машин. Широкий модельный ряд автомобильных двигателей позволяет устанавливать, например, серии «С32» и «CAT3500» на карьерные самосвалы. Двигатели отвечают нормам Tier 3 по токсичности отработавших газов благодаря использованию технологии ACERT (Advanced Combustion Emissions Reduction Technology). В процессе эксплуатации происходят неисправности и аварии современных двигателей, которые приводят к остановке и простоям оборудования в целом. В работе приведена статистика отказов элементов автомобильных двигателей самосвалов фирмы «Caterpillar» в течение 10 лет эксплуатации с учетом коэффициента работы в условиях карьера. Для анализа аварии были выполнены визуальный и параметрический контроль, дефектация. Получены результаты компьютерной диагностики, авторами, за 20 часов ранее перед аварией, позволили сравнить такие же значения, снятые сразу же после аварии. Для выявления причин аварии автомобильного двигателя марки С32 были применены виды и методы неразрушающего контроля с учетом коэффициента работы в условиях карьера.

**Ключевые слова:** автомобильный двигатель, диагностика, нагрузка, дефектации двигателя, карьерный самосвал.

**Introduction.** The large engineering corporation Caterpillar is introducing its internal combustion engines to the facilities of large open pit mining operations in Russia. The corporation introduced its first quarry off-road dump truck in 1962. Nowadays new developments of Cat machinery with mechanical power transmission are one of the advanced technologies of operation control in the segment of diesel-electric machines. A wide model range of engines for mining road transport allows to install, for example, series "C32" and "CAT3500" on mining dump trucks (Fig. 1). The engines meet the Tier 3 (Palyanitsina, et al., 2021; Korshak, et al., 2019; Korshak, et al., 2020) exhaust emission standards through the use of ACERT (Advanced Combustion Emissions Reduction Technology). It covers four engine systems for exhaust emission reduction and addresses the fuel system, the combustion process, the engine air intake system considering the application

factor of quarry operation and the implementation of an electronic monitoring and control system.

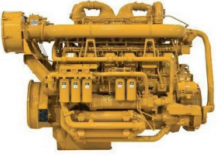

			
			
<p>Rated power C32: 1007 kW at 2100 min<sup>-1</sup> Engine type: V-12, 4-stroke diesel engine D/S: 145 / 162 mm Working volume: 32.1 litres Maximum torque range: 6166 N.m at 1400 min<sup>-1</sup></p>	<p>Rated power of CAT 3508: 746 kW at 1800 min<sup>-1</sup> Engine type: V-8, 4-stroke diesel D/S: 170 / 190 mm Working volume: 34.5 litres Maximum torque range: 4263 N.m at 1450 min<sup>-1</sup></p>	<p>Rated power of CAT 3512: 1119 kW at 1800 min<sup>-1</sup> Engine type: V-12, 4-stroke diesel engine D/S: 170 / 190 mm Working volume: 51.8 litres Maximum torque range: 6210 N.m at 1400 min<sup>-1</sup></p>	<p>Rated power of CAT 3516: 1492 kW at 1800 min<sup>-1</sup> Engine type: V-16, 4-stroke diesel engine D/S: 170 / 190 mm Working volume: 69 litres Maximum torque range: 8391 N.m at 1400 min<sup>-1</sup></p>

Fig. 1. Photos of Caterpillar career automobile engines

However, malfunctions and accidents of modern engines occur in the quarry environment during the operation considering the operation factor, resulting in stoppage and downtime of the overall equipment (Balovtsev, et al., 2024; Korshak, et al., 2023; Kusimova, et al., 2023; Pshenin, et al., 2023).

The purpose of the work is to develop a statistical, classified, generalised database on information of parameter values and collection and analysis of failures and malfunctions of automobile engines taking into account the coefficient of application of work in quarry conditions.

**Materials and object of research.** Analysis of literature sources shows that today a large number of works are devoted to the study of thermal parameters and operating conditions of mining power equipment and their elements (Gendler, et al., 2016; Gridina, et al., 2022; Klyuev, et al., 2024; Ligotsky, et al., 2024). In the works (Kondrat'ev, et al., 2016; Kondratiev, et al., 2022; Evdokimov, et al., 2024) non-destructive testing methods are analysed and methods of recognition of

technical condition of mining equipment are created. The works (Kondrat'ev, et al., 2022; Karlina, et al., 2023; Malozyomov, et al., 2024a; Malozyomov, et al., 2024b) describe the experience of operation including repair of mining equipment.

Table 1 presents failures and malfunctions of elements of automobile engines of the firm "Caterpillar" taking into account the coefficient of work in the conditions of the quarry.

Table 1 - Failure statistics of Caterpillar water supply elements over 10 years of operation, taking into account the coefficient of application of work in quarry conditions

Engine model	Node name	Number of failures	Operating time, hours	Cost of part(s), RUB
CAT C32	Fractured connecting rod of cyl. no. 4. Caused replacement of the cylinder block	2	22300	Cylinder block - 22 000 000 p.
	TC cartridge failure	12	8200	Cartridge - R850,000.
	Nozzle pump	6	6800-12000	Nozzle pump - 230 000 p.
	Loss in TC seals	4	22000-17200	Cartridge - R450,000.
	Fastening bolt pump nozzle	6	3000-18500	Nozzle pump - 230 000 p.
	Failure of electrical wiring	10	0-16000	
CAT C32	Failure of the pump nozzle mounting bolt	2	12000	Nozzle pump - 230 000 p.
	Valve mechanism	1	15600	Kingpin - 100,000 p.
	Gas compensator	26	13000-17000	120 000 p.
	Failure of the cylinder head mounting bolt	2	12000	23 000 p.

Fig. 2 shows that the majority of failures occur in the supercharger system and the engine timing mechanism. As examples, let's consider some failures on CAT engine systems.

**Theoretical Provisions.** Let's consider one of the examples of failure of automobile engine of the quarry dump truck of firm Caterpillar of mark C32 with capacity 1200 kW with working time of 3074 hours. To investigate the nature of engine failure, it is necessary to analyse and apply the coefficient of operation in quarry conditions and completeness, according to its purpose (Bosikov, et al., 2023; Gridina, et al., 2023; Gridina, et al., 2022; Zharikov, et al., 2022). The engine is equipped with a modern local system of control and diagnostics of operating parameters during operation (Martyushev, et al., 2023; Rodionov, et al., 2022). All information obtained during operation is stored and processed in the electronic control unit (ECU).

The BEU can fulfil the following functions:

- collects and stores information from all installed sensors on the engine;
- stores the engine operating history, including maintenance, repairs and accidents for the entire period of operation.
- controls the engine by changing the cycle fuel flow rate and performs diagnostic tests to detect malfunctions and errors in the fuel system components;

- makes decisions if certain parameters reach permissible limits and performs actions: "WARNING", "LOAD REDUCTION", "STOP".

Modern electronic control system of "Caterpillar" company is shown in Fig. 2.

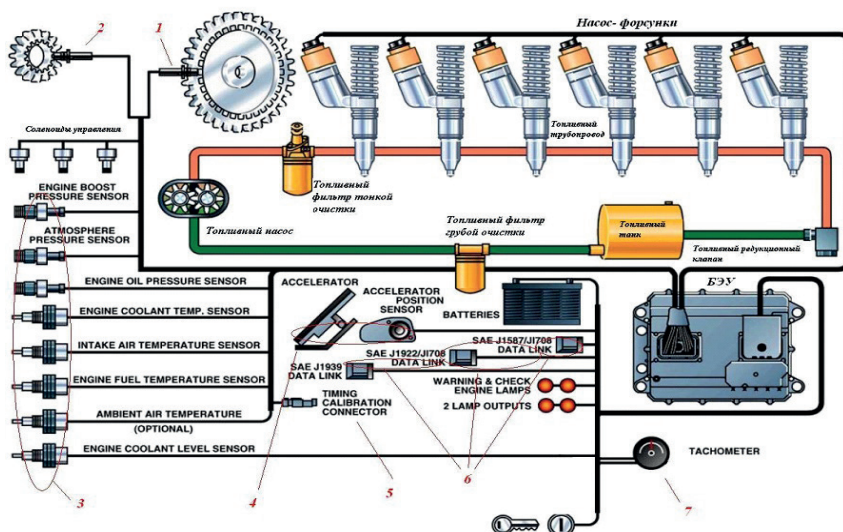


Fig. 2. Electronic engine management system C3:

- 1 - crankshaft speed sensor; 2 - camshaft position sensor; 3 - controlling elements of the control system; 4 - speed regulator; 5 - connecting output for the calibration device; 6 - SAT data transmission channel; 7 - engine speed indicator

The engine under test has sensors (analogue and digital sensors), which transmit a signal to the ECU (Table 2). Analogue sensors continuously monitor temperature and pressure, and send information to the electronic system in the form of changing voltage in the direct current (DC) network. Table 2 shows that all sensors are labelled, have an operating range and a measurement error of less than 5 %.

Caterpillar software licence CAT ET installed on the operator's service computer. In order to read and transmit all the data described above, it is necessary to connect to the ECU through an adapter (Fig. 3).

Table 2 - Main characteristics of sensors of standard control and measuring devices, used in the system "Caterpillar" automotive engine of a dump truck

Sensor name	Measuring range	Output signal	Measurement error
MBS 5100 pressure transmitters	0-600 bar	4-20 mA	0.5% of the upper measuring limit
Low pressure transmitter MBS 9300	40-250 mbar	4-20 mA	at 25 °C from $\leq \pm 0.5 \leq \pm 2.0 \%$
Temperature sensor MBT 5560	-50-200 °C	4-20 mA or proportional 10 - 90% of supply voltage	$\leq \pm 1.0\%$ of the upper measuring limit

MBT CAT temperature sensor	0-900° C	4-20 mA or proportional 10-90% of supply voltage	< ± 1.0% of the upper measuring limit
Crankshaft speed sensor	0-2400 min <sup>-1</sup>	12.5 V single pole magnetic generator	< ± 1.0% of the upper measuring limit




Fig. 3. Location of connection of elements of the BEU system:  
 1 - service computer with CAT software; 2 - adapter connecting the engine ECM and the computer; 3 - electronic control unit ECM







Results and Discussion. In this connection, visual and parametric inspection and defecting were performed to analyse the accident. The results of computer diagnostics obtained by the authors, 20 hours before the accident, allowed us to compare the same values taken immediately after the accident.

The following types and methods of non-destructive testing were applied to identify the causes of the failure of the automotive engine of the C32 dump truck: visual inspection and defection, dismantling and computer diagnostics.

Visual inspection and defection: external inspection of engine, defecting part of exhaust and intake manifold; defecting oil cover, cylinder No. 4; defecting parts and assemblies of valve train mechanism; defecting plate "spacers" of cylinder cover No. 4; defecting block inspection cover, cylinder No. 4; inspection, defecting of the block in the area of the 4th cylinder, the block has significant destruction in the area of water cooling channels, oil line, seating places of the cylinder sleeve; lower cover and connecting rod bearing, cylinder No. 4; defecting of the cylinder piston group, cylinder No. 4: - piston, pin, connecting rod, bushing; oil nozzle (tab. 3).

Table 3 - Photos of faulty parts and their defect detection of an emergency automobile engine of a C32 dump truck with a power of 1200 kW

№	Fault photo	Note
1		the firing section of cylinder head No. 4 shows significant piston impact marks and significant mechanical damage, valve seat failures

2		Bearing condition is satisfactory, there are operational rubs
3		piston: the head has significant mechanical damage to the firing part; traces of increased temperature due to forced rubbing on the cylinder sleeve, complete destruction of the skirt.
4		
5		shows signs of overheating on the surface
6		connecting rod: has significant body fractures in more than four parts; there are traces of connecting rod fracture in the head bearing area (rough surface, crystalline structure, virtually no plastic deformation)
7		

8		complete destruction, rubbing marks on the bushing fragments
---	---	--

Dismantling of engine parts: part of the exhaust and intake manifold; oil cover of the valve train mechanism, cylinder No. 4; dismantling of the valve train mechanism; dismantling of the cylinder cover, cylinder No. 4; defecting the firing part of the cylinder cover; dismantling of the "spacer" plate of the cylinder cover No. 4; dismantling of the lower connecting rod bearing cover; cylinder piston group, cylinder No. 4: piston, pin, connecting rod, bushing (Table 3).

Computer diagnostics of dump truck engine showed the following engine failure errors: E173 High Exhaust Temperature Warning; E101 High Crankcase Pressure Warning; E020 High Engine Oil Temperature Warning; E021 High Exhaust Temperature Derate; E013 High Crankcase Pressure Shutdown.

The following was detected during the engine defect test:

1. The firing section of cylinder head No. 4 shows significant piston impact marks and significant mechanical damage, valve seat failures.

2. The condition of the bearing is satisfactory; piston: the head has significant mechanical damage to the firing part; traces of increased temperature due to forced rubbing against the cylinder sleeve, complete destruction of the skirt; pin: has traces of overheating on the surface; connecting rod: has significant destruction of the body in more than four parts; in the area of the head bearing there are traces of rupture of the connecting rod (rough surface, crystalline structure, virtually no plastic deformation); sleeve: complete destruction.

3. Rubbing marks are observed on the sleeve fragments. The block has significant destruction in the area of water cooling channels, oil line, cylinder sleeve seats; block oil nozzle is destroyed.

During inspection through the inspection hatch from the engine crankcase, "revealed" chipping of the lower edge of the cylinder sleeve adjacent cylinder #3, with cylinder #4.

**Conclusion.**

1. According to the results of inspection of parts and assemblies of the dump truck engine, analysis of the documents submitted on the date of the report, the damage to the parts of the engine cylinder No.4 described in the paragraphs of this report may be the result of violation of the integrity of the piston of the cylinder No.4 when the engine is operating at maximum load ( $100\%N_{e_{\text{НОМ}}}$ ) at a speed less than nominal ( $1528 \text{ min}^{-1}$ ), i.e. the mode of uncharacteristic load on the engine from the speed of rotation is possible (it is necessary to carry out additional research). Since the

piston is composite and has different metals in its arrangement (steel, aluminium), uneven rubbing against the cylinder mirror with the appearance of interatomic bonds in dissimilar materials occurred. According to the chronology of the next events, there is an increased temperature of the exhaust gases, which increases the overload mode of cylinder No. 4. Presumably, first of all, the piston wear parts get into the zone between the valve plate and the seat, there is a mechanical stress on the exhaust valves. The movement of the collapsing piston, there is a death of valves and jamming of the piston (in the course of movement from the TMT). The nature of the fracture of the connecting rod in the area of the head bearing shows that the rupture occurred instantly, riveting and fluidity of the metal observed in these places is minimal. Impact shears and shear lip are observed in the second fragment of the fractured connecting rod as a consequence of the fracture.

2 Based on the nature of destruction of: cylinder head, sleeve, piston and connecting rod it can be assumed that the accident of the dump truck engine occurred due to jamming and destruction of the piston as a result of temperature rise of the material of parts at an uncharacteristic load of  $100\%N_{e_{\text{ном}}}$  from the engine speed close to the maximum ( $1528 \text{ min}^{-1}$ ). Due to low operating time of motor-hours the possible cause of piston destruction is factory defect of the part (piston).

3. As a result of inspection of cylinder No. 4 by the nature of fracture there is a need to defect the paired group No. 3 to make a representation of the destruction of parts and confirmation of the possible cause of failure of the automobile engine of the dump truck.

4. Car engine torsional vibration damper inspection.

5. To determine the suitability of the remaining parts of the engine (parts of the CSP, CMM, crankshaft, crank shaft, cylinder head, mounted mechanisms), it is necessary to perform a complete disassembly of the car engine of the dump truck and perform colour and magnetic defectoscopy, geometric belonging according to the nominal dimensions of the parts and assemblies under study.

6. In accordance with the purpose of the mechanism, to develop a methodology for monitoring the technical condition of thermophysical, vibration and tribological parameters of the car engine in operation, taking into account the coefficient of application of work in quarry conditions.

#### References

Balovtsev S.V., Merkulova A.M. Comprehensive assessment of buildings, structures and technical devices reliability of mining enterprises // MIAB. Mining Inf. Anal. Bull. – 2024. – № 3. – Pp. 170-181. [https://doi.org/10.25018/0236\\_1493\\_2024\\_3\\_0\\_170](https://doi.org/10.25018/0236_1493_2024_3_0_170)

Bosikov I.I., Klyuev R.V., Khetagurov V.N., Silaev I.V. Comprehensive assessment of hydrodynamic processes in the Klinskoye Quarry with the use of their control methods in rock masses // Sustainable Development of Mountain Territories. – 2023. – Vol. 15. – № 2. – Pp. 284-297. <https://doi.org/10.21177/1998-4502-2023-15-2-284-297>

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, pp. 108. DOI: 10.3390/min14010108



Gendler S.G. The justification of new technique ventilation at contraction of working with two exits in soil surface. *Eurasian Mining*, 2016, V. 2, pp. 41-44. DOI: 10.17580/em.2016.02.10

Gridina E., Kovshov S., Borovikov D. HAZARD MAPPING AS A FUNDAMENTAL ELEMENT OF OSH MANAGEMENT SYSTEMS CURRENTLY USED IN THE MINING SECTOR. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, 2022, (1), pp. 107–115. DOI: 10.33271/nvngu/2022-1/107

Gridina E.B., Borovikov D.O. Identification of the causes of injuries based on occupational risk assessment maps at the open-pit coal // *MIAB. Mining Inf. Anal. Bull.* – 2022. – № 6–1. – Pp. 114–128. [https://doi.org/10.25018/0236\\_1493\\_2022\\_61\\_0\\_114](https://doi.org/10.25018/0236_1493_2022_61_0_114)

Gridina E.B., Borovikov D.O. Improving the safety of the working personnel of a quarry located in difficult mining and geological conditions of the Far North // *MIAB. Mining Inf. Anal. Bull.* – 2023. – № 9–1. – Pp. 149–163. [https://doi.org/10.25018/0236\\_1493\\_2023\\_91\\_0\\_149](https://doi.org/10.25018/0236_1493_2023_91_0_149)

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

Klyuev R.V. System analysis of calculation methods for power supply systems in quarry points // *Sustainable Development of Mountain Territories.* – 2024. – Vol. 16. – № 1. – Pp. 302–310. <https://doi.org/10.21177/1998-4502-2024-16-1-302-310>

Kondrat'ev V.V., Kolosov A.D., Guseva E.A., Martyushev N.V., Karlina A.I. 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

Kondrat'ev V.V., Rzhchitskij E.P., Shakhrai S.G., Karlina A.I., Sysoev I.A. RECYCLING OF ELECTROLYZER 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. DEVELOPMENT AND TESTING OF THE THERMOELECTRIC THERMAL ENERGY CONVERSION DEVICE IN THE CONDITIONS OF EXISTING ALUMINUM PRODUCTION. *Materials*, 2022, 15(23), pp. 8526. DOI: 10.3390/ma15238526

Korshak A.A., Nikolaeva A.V., Nagatkina A.S., Gaysin M.T., Korshak A.A., Pshenin V.V. 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., Vykhodtseva N.A., Gaysin M.T., Korshak A.A., Pshenin V.V. 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. doi:10.28999/2541-9595-2019-9-5-550-557

Korshak A.A., Pshenin V.V. 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. doi:10.28999/2541-9595-2023-13-1-25-31

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

Ligotsky D.N., Argimbaeva K.V. Technology for the sectional formation of an anthropogenic deposit with its subsequent mining using a hydraulic pull shovel // *Sustainable development of mountain territories.* – 2024. – Vol. 16. – № 1. – Pp. 111-121. <https://doi.org/10.21177/1998-4502-2024-16-1-111-121>

Malozomov B.V., Martyushev N.V., Kukartsev V.V., Konyukhov V.Y., Oparina T.A., Sevryugina N.S., Gozbenko V.E., Kondratiev V.V. Determination of the Performance Characteristics of a Traction Battery in an Electric Vehicle. *World Electr. Veh. J.*, 2024, no. 15, p. 64. <https://doi.org/10.3390/wevj15020064>

Malozomov B.V., Martyushev N.V., Sorokova S.N., Efremkov E.A., Valuev D.V., Qi M. Mathematical Modelling of Traction Equipment Parameters of Electric Cargo Trucks. *Mathematics*, 2024, vol. 12, p. 577. <https://doi.org/10.3390/math12040577>.

Martyushev N.V., Malozyomov B.V., Kukartsev V.V., Gozbenko V.E., Konyukhov V.Y., Mikhalev A.S., Kukartsev V.A., Tynchenko Y.A. 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>

Palyanitsina A., Tananykhin D., Masoud R. 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. Improving the efficiency of oil vapor recovery units in the commodity transport operations at oil terminals. *Journal of Mining Institute*, 2023, 265, 121-128. <https://doi.org/10.31897/PMI.2023.29>

Rodionov V.A., Karpov G.N., Leisle A.V. Methodological approach to the need to assess the explosion and fire hazard properties of sulfide-containing polymetallic ores // *MIAB. Mining Inf. Anal. Bull.* – 2022. – № 6–1. – Pp. 198-213. [https://doi.org/10.25018/0236\\_1493\\_2022\\_61\\_0\\_198](https://doi.org/10.25018/0236_1493_2022_61_0_198)

Zharikov S.N., Kutuev V.A.I. Interrelations between technological processes of open-pit mining // *Sustainable Development of Mountain Territories.* – 2022. – Vol. 14. – № 3. – Pp. 479-485. <https://doi.org/10.21177/1998-4502-2022-14-3-479-485>

## CONTENT

<b>A.O.Baisalova, A.V. Dolgoplova, R. Seltmann, E.E. Akbarov, M.A. Mashrapova</b> ROGRAPHIC AND MINERALOGICAL FEATURES OF THE KARAGAILY-AKTAS RARE METAL DEPOSIT (SOUTH KAZAKHSTAN REGION).....	6
<b>V.V. Gerasidi, R.G. Dubrovin, O.I. Kukartseva, I.A. Panfilov, V.V. Tynchenko</b> ANALYSIS OF TECHNICAL OPERATION OF CATERPILLAR ENGINEERING CORPORATION ENGINES IN INDUSTRY.....	23
<b>K. Yelemessov, D. Baskanbayeva, L. Sabirova</b> OPTIMIZATION OF TECHNICAL MEANS AND TECHNOLOGICAL PROCESSES OF GAS COMPRESSION FOR THE MINING INDUSTRY OF THE REPUBLIC OF KAZAKHSTAN.....	36
<b>D. Karaivanov, M.F. Kerimzhanova, M.E. Isametova, N.S. Seiitkazy, G. Turymbetova</b> INVESTIGATION OF KINEMATICS AND POWER OF COMPOSITE PLANETARY GEARS FOR WIND TURBINES.....	47
<b>A.Zh. Kassenov, A.Zh. Taskarina, K.K. Abishev, A.D. Suleimenov, D.D. Alipbayev</b> COMBINED TOOL FOR CUTTING INTERNAL THREADS OF TUBING....	63
<b>Z.A. Kutpanova, D.O. Kozhakhmetova, G. Baiseitov, A.Dolya, G.A. Uskenbayeva</b> ROUTE CONTROL AND COLLISION AVOIDANCE FOR MULTIPLE UAVS IN A SMART CITY CONTEXT USING GEOGRAPHIC INFORMATION SYSTEM.....	71
<b>I.Yu. Matasova, Yu.S. Kuznetsova, T.A. Panfilova, V.S. Tynchenko, S.V. Tynchenko.</b> FEATURES OF THE BEHAVIOR OF ROCKS IN THE UNDERGROUND FIELD DEVELOPMENT.....	94
<b>M. Nurpeisova, B. Mingzhasarov, K. Temirkhanov, Y. Kakimzhanov, Zh. Nukarbekova</b> GEODETIC MONITORING OF DEFORMATION PROCESSES AT KAPCHAGAY HYDROPOWER PLANT.....	107

<b>L. Nurshakhanova, S. Zakenov, A. Zakenova</b> TECHNOLOGIES OF WATER-GAS IMPACT ON THE RESERVOIR USING SIMULTANEOUSLY PRODUCED PETROLEUM GAS.....	118
<b>T.K. Salikhov, A.I. Abekeshev, G.O. Abisheva, Zh.B. Issayeva, . M.B. Khussainov</b> STUDY OF THE ECOSYSTEM AND UNIQUE NATURAL OBJECTS OF THE CHINGIRLAU DISTRICT OF THE WEST KAZAKHSTAN REGION USING GIS TECHNOLOGIES.....	128
<b>V.V. Sirota, S.V. Zaitsev, M.V. Limarenko, D.S. Prokhorenkov, A.S. Churikov</b> THERMOMECHANICAL PROCESSING OF MINERAL RAW MATERIALS TO PRODUCE $La_{1-x}Sr_xMn_zO_3$ POWDER WITH PEROVSKITE STRUCTURE.....	155
<b>A.V. Taranov, A.D. Mekhtiyev, F.N. Bulatbayev, Y.G. Neshina, V.S. Balandin</b> PNEUMATIC LOAD HOISTS FOR MINERAL TRANSPORTATION FROM MINES.....	167
<b>Y.A. Tynchenko, B.V. Malozyomov, V.V. Kukartsev, M.A. Modina, G.L. Kozenkova</b> APPLYING ELEMENTS OF A TOTAL EQUIPMENT CARE STRATEGY TO ANALYZE THE OPERATION OF MINING MACHINERY.....	178
<b>O.G. Khayitov, J.B. Toshov, K.T. Sherov, B.N. Absadykov, M.R. Sikhimbayev</b> OIL AND GAS POSSIBILITY OF THE CENTRAL GRABEN OF THE BUKHARA-KHIVA PALEORIFTS AND ITS PERSPECTIVES.....	191
<b>Z.I. Chernenko, M.A. Mizernaya, I. E. Mataibayeva, N.A. Zimanovskaya</b> GOLD ORE DEPOSITS ASSOCIATED WITH CARBONATE FORMATIONS (EAST KAZAKHSTAN).....	201

## **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 described work 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](http://publicationethics.org/files/u2/New_Code.pdf)). To verify originality, your article may be checked by the Cross Check originality detection service <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 only 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 сайтах:

**[www.nauka-nanrk.kz](http://www.nauka-nanrk.kz)  
<http://www.geolog-technical.kz/index.php/en/>  
ISSN 2518-170X (Online),  
ISSN 2224-5278 (Print)**

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*

Редакторы: *Д.С. Аленов, Ж.Ш. Әден*

Верстка на компьютере *Г.Д. Жадыранова*

Подписано в печать 15.10.2024.

Формат 70x90<sup>1/16</sup>. Бумага офсетная. Печать – ризограф.  
18,0 п.л. Тираж 300. Заказ 5.