

Evaluation of the Technical Condition of Auger Equipment Units by Vibration Inspections

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Abstract—The article describes the design and operational factors leading to failures in mounting groups of the modern auger equipment. At the same time, the operating experience was considered of using antifriction bearings with solid lubricant antifriction filler (AFZ) having self-lubricating and self-sealing properties in various mounting groups. The changes in bearing clearances with AFZ as potential sources of high-frequency oscillations were assessed, also potential sources of low-frequency high-amplitude oscillations were identified in the design. As a result, the impact of mounting groups of the auger equipment on the change of the availability condition in the process of performance was assessed using vibration-based diagnostics method. The design of the mounting group with AFZ without end covers was proposed. Application of such a mounting group increases the service life of bearing support in the areas inaccessible for maintenance and repairs resulting in reduced labor intensity, energy and financial costs.

Keywords—auger equipment; mounting group; technical condition; vibration inspection.

I. INTRODUCTION

Extension of the scope of modern mining equipment includes a solution of vital problems of some industries. Of particular importance modern tunneling technology and equipment are for the mining, oil, gas and construction industries [1-7].

The process of operation of the equipment is associated with the change of its technical condition and a fault detection and removal of which involves considerable investment of time and financial resources. In this situation, special importance is the process of diagnosis and identification of its residual life [8-10].

A set of interrelated design and operational factors has an influence on the quality of the forecast for operating condition of auger equipment's units during vibration surveys in its operation.

In confirmation of this, at an early stage at the T.F. Gorbachev Kuzbass State Technical University in the departments of mining machines and systems and information and automated production systems, the operational experience was gained in mounting groups for various purposes equipped with ball bearing designs with the solid lubricating antifriction filler (AFZ). They are carried out on the basis of standard ball bearings by filling the free internal space with pasty antifriction compound followed by curing, the formation of

clearances between the cured filler and subsequent running-bearing parts [11].

The main advantage of this type of bearings making them different from other technical solutions in this area, is the self-lubrication and simultaneous execution of the self-sealing of the friction zone defined by small clearances between the cured AFZ and the bearing rings. In fact, the AFZ performs the function of the double slit up-compacting, which actualizes the use of bearings of this type, for example, in mounting groups screw units of horizontal boring machine (fig. 1), unattended into the space of bored well, especially when installing wells with moistening of bored products [12].

Due to the fact that the increase in size of the clearance in the bearing with the AFZ in the operation, as well as any wear process refers to phenomena more difficult to describe analytically using parametric complexes appeared-one to appropriate its experimental study with subsequent reliability checking of the results.

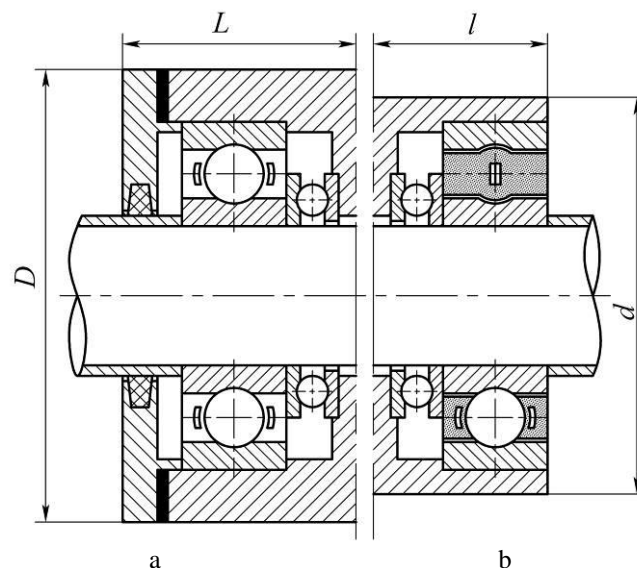


Fig. 1. Comparative dimensions of the screw support units of augers: (a) with standard bearings; (b) with AFZ bearings

II. MATERIALS AND METHODS

Hours bearing life was carried out on a test machine CDB-72. With a view to the protection of the solid filler from the oil pollution, as well as providing a natural for this type of bearing the heat sink the hydraulic system of loading and lubrication of the bearings was replaced by a system of loads and lever arms with variable length. The values of fixed radial load during the experiment were taken to be its own weight of the bearing unit of the testing machine in increments of 0 ... 7000 N in conditions of non-transition on the other bearing failure criteria, other than the principal. Construction of the test head and the main shaft housing changed in such a way as to ensure ease of visual observation and quick release bearings for the second periodic non-destructive testing.

For non-destructive testing changes in size of the clearance in the process of use of the resource used X-ray method, a block diagram is shown in fig. 2a. It is based on the weakening of the intensity of X-rays in passing through the bearing controlled. This provides the documentary control.

The radiation produced by the source 1 and directed from the opening of the glove box 2 X-ray machine RUP-200-5-2, passes through the test bearing 5 marks 6, 7 and sensitivity of standard-recorded photograph graphically on X-ray film such as RT-5, contained in cassette 8. The quality of the X-ray image is controlled by the signal transmission X-ray's vidicon

9 type LI-423 via the amplification unit 10 and the scanner 11 on the screen 13 of X-ray television complex PTU-39. The radiation intensity is regulated by gate 3 and a filter 4. To protect the operator and the environment from the harmful effect of radiation is provided biological protection 14. The documents to be further investigated, is obtained X-ray 12. The intensity variation is expressed in changing the degree of photographic darkening areas of X-ray that integrate the incident radiation corresponding to the location of the test gaps.

Schematic diagram of the measurement values of the bearing clearances with AFZ on rent-diffraction patterns using a photometer IFO-451 is shown in fig. 2b. Power AC 6 of the photometer is set to a frequency modulation of the light beams, reinforcing the only variable component. Luminous flux from the source 1 is split into a measurement branch and reference branch. The light beam of the measuring branch consistently permeates the mask 3, tapering analyzed band in surface precision Floating radiographs 2 and the movable photometric wedge 4. The flows of both branches alternately pass through the cutouts in the disk sector-modulator 8, a rotating actuator 9, falling on the photodetector 7. If the streams are different, the circuit used in the anode photomultiplier FEU-17A fuses-repeats ripple current, which leads through the amplifier 6 and the drive 5 to move the photometric wedge 4 and the automatic recorder pen 10.

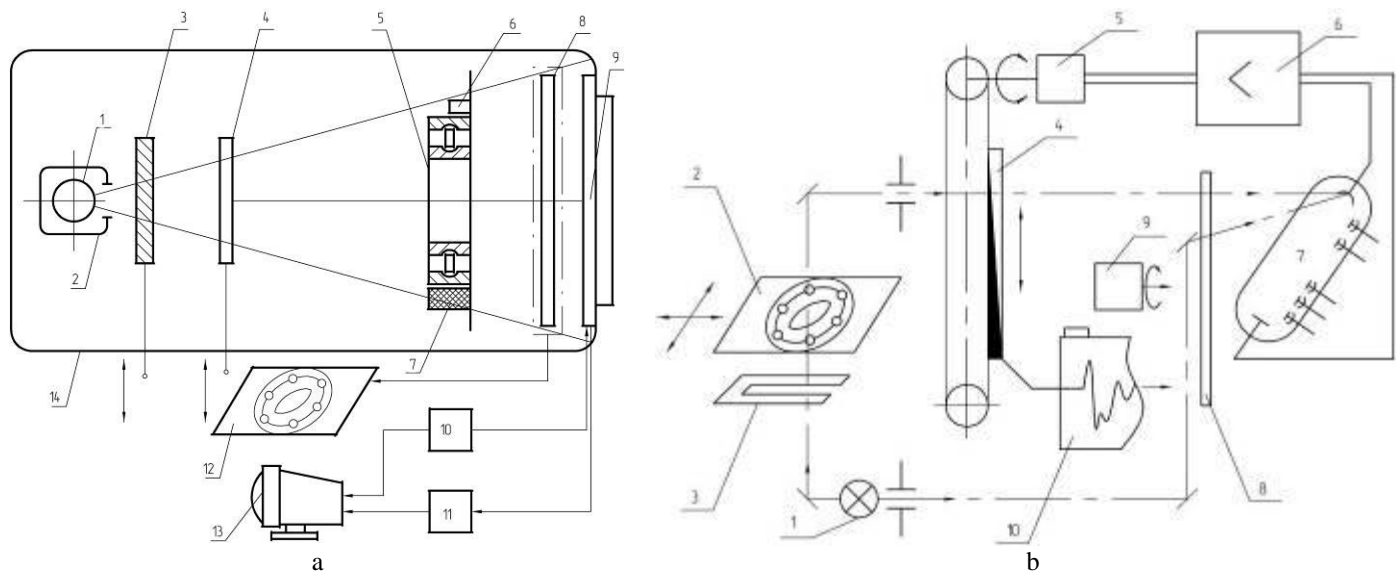


Fig. 2. The measurement of values of the bearing clearance with AFZ: (a) schematic diagram of the radiographic NDT method for size of the clearance; (b) schematic diagram of the measurement of values of clearance

Possibilities of wear processes were observed experimentally, in the form of polynomial regression models, the 3rd conducive to algebraically properties of these functions and their curves - the presence of specific areas that may reflect different intensities of wear condition of the absence of extremum of reflecting wear irreversibility of the process; lack of sloping area of the inflection point. Fig. 3 shows graphic interpretation of changes in the clearance between the AFZ and the inner ring and between the outer ring and the AFZ, depending on developments.

The above poster experiment and mathematical interpretation allowed to develop a model to predict the bearing clearances with AFZ as resource developments, having a form of polynomials of order 3:

$$\delta^{(k)}(L) = \delta_0^{(k)} + \sum_{i=1}^3 b_i^{(k)} \left(\frac{P}{C} \right) \cdot L^i, \quad (1)$$

where $\delta_0^{(k)}$ - initial gap is based in section; $b_i^{(k)} \left(\frac{P}{C} \right)$ - regression coefficients, which depend on the relative load.

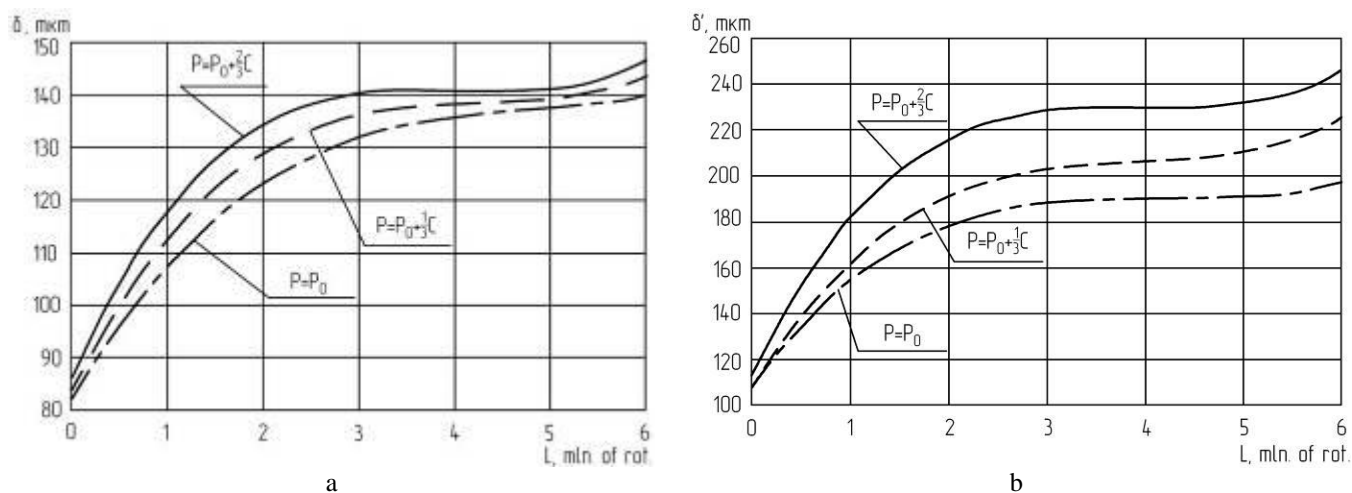


Fig. 3. Change in the clearances depending on the accumulated resource: (a) between the AFZ and the inner ring; (b) between the AFZ and the outer ring

Strict requirements to reduce radial and axial dimensions while simultaneously centering axis relative to the screw sections of the casing axis are presented to numerous support-centering bearing units (fig. 4a). Industrial tests of auger machine implemented in Kuzbass conditions showed that the drive unit

equipped with standard ball bearings and radial seals does not meet the requirements, the gap between the device and the rays of the inner surface of casing string reaches 5 mm. The situation is complicated by the large number of nodes on the data assembled screw put.

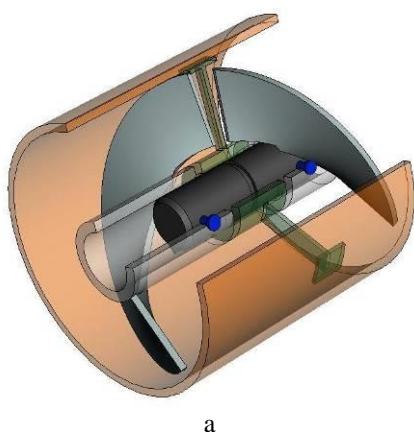


Fig. 4. Typical bearing units of auger equipment: (a) support-centering bearing unit; (b) traverse of the drill slip lock

Fig. 4b is a perspective view of the slip yoke to drill the lock screw in the discharge zone of the composition of the drilling products.

Construction of these units on the basis of traditional common-engineering methods does not allow to avoid the appearance of clearances, leading to high-amplitude low-frequency-oscillation processes in the system, especially under the pressure penetration in large quantity of moistened material drilled out.

The above species multiple sources of oscillations in systems lead to worst health indicators and the need for technical service. Further improvement of the auger equipment should be directed towards the fullest possible diagnosis of the state of its components and mechanisms.

III. RESULTS

To evaluate the technical condition and operational properties of the auger equipment set must be a comprehensive study of the mode of operation in an industrial environment in the operation of prototypes auger machines [13].

Control of the technical condition of support units is of particular importance for averting-rotation crashes. It is obvious that the systematic monitoring of their co-standing will allow for assessment of technical condition on the basis of quantitative criteria for assessing compliance with the level of vibration in the support-centering bearing units permissible levels [14]. Prevention of failures can be intermittent assistance, but the frequency of these works does currently not sufficiently substantiated. Therefore, the analysis of changes in the technical condition of the support units, based on the vibration data, provides the rationale for the timing of the

preventive measures that help reduce the proportion of sudden failures. Control of vibration measured on bearing housings

of the unit in three mutually perpendicular directions: vertical, horizontal and axial (along the rotation axis), fig. 5.



Fig. 5. Scheme of vibration measurement: (a) points on the gear rotator 2-9 – gear bearings, 10 - the bearing assembly tool joint; (b) vibration analyzer «Agat-M»

The sensor is mounted so that its surface directly was operated by mechanical vibrations of the bearing. The sensor senses the mechanical vibrations of the bearing, with less impact vibration excited by the other nodes, and parts of the unit measurement of vibration on the thin-walled portion of the housing and covers unacceptable.

Frequency of control measures depends on the technical-states of the object and set the order of diagnostic measurements.

In the process of carrying out diagnostic studies recorded the following parameters of vibration:

- rms vibration velocity (V_e , mm / s) bearing housings electric drive;
- peak acceleration gear bearing housings.

It is assumed that the parameters to be measured must be within the ranges given in Table 1.

TABLE 1. Control parameters of vibration-acoustic signal at the nodes auger machine

Unit	Parameter	Frequency range (Hz)	Dynamic range	Measurement error (%), not more
Electric drive	V_e	10...1000	0.1...30 mm/s	± 6
	a_p	300...10000	0.1...200 m/s ²	± 6
Gearbox	V_e	10...1000	0.1...30 mm/s	± 6
	a_p	300...10000	0.1...200 m/s ²	± 6
Boring lock	V_e	10...1000	0.1...30 mm/s	± 6
	a_p	300...10000	0.1...200 m/s ²	± 6

In operation, the frequency of subsequent control measurements is set after the evaluation and prediction of technical condition of the auger equipment. The maximum

interval between measurements, depending on the results of the last control measurement was adopted no more: requires action - 7 days; warning - 1 month; permissible and acceptable renovated - 3 months [15].

Analysis of the spectrum of the vibration signal received on the bearing unit auger installation showed that the most probable defects are: shells, cracks, the wear of the rolling elements, distortions, cage destruction and violation of the bearing lubrication. All of these lesions cause an increased level of vibration at the nodes of auger equipment and untimely their elimination could lead to accidents-Term failure, which in turn will result in costly repairs and reduce the manufacturer-of works on the construction of a horizontal well.

This is caused by the imperfection of the design of the drilling of the lock case. During operation, the housing and depressurization occurs ingress of degradation products, which leads to jamming and bearings to more intensive percolation passing processes.

To improve performance, reduce mechanical vibrations and negative effect of vibration on components rotationally feeder auger wave-us in the department of mining machines and complexes of the Kuzbass State Technical University designed bearing unit (fig. 6), which allows to eliminate of foregoing shortcomings due to the use of this design in the radial ball bearings with the AFZ.

Fig. 7 shows a comparison of vibration levels on the bearing units in the construction of which used traditional design bearings and bearings with the AFZ.

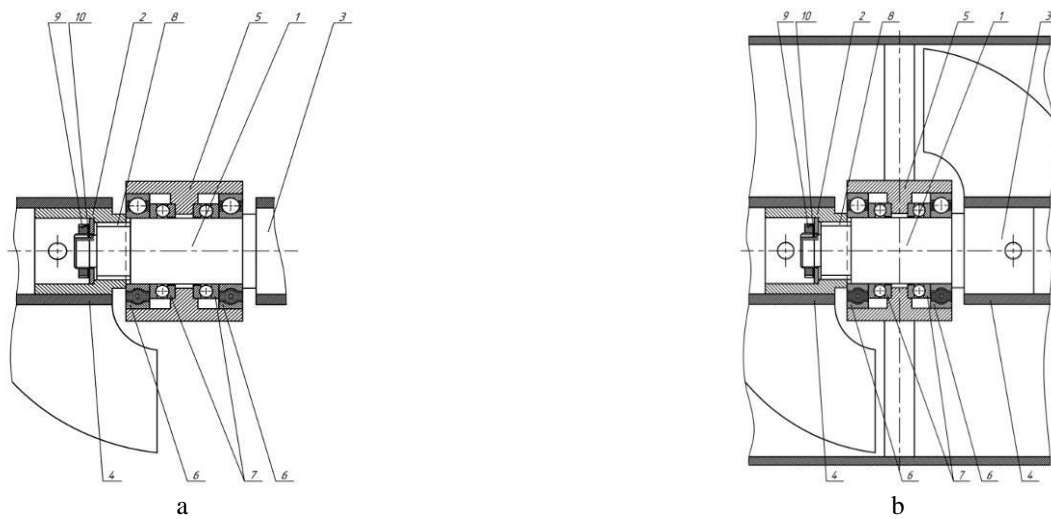


Fig. 6. New bearing units: (a) drilling lock unit; (b) sectional drilling tool unit

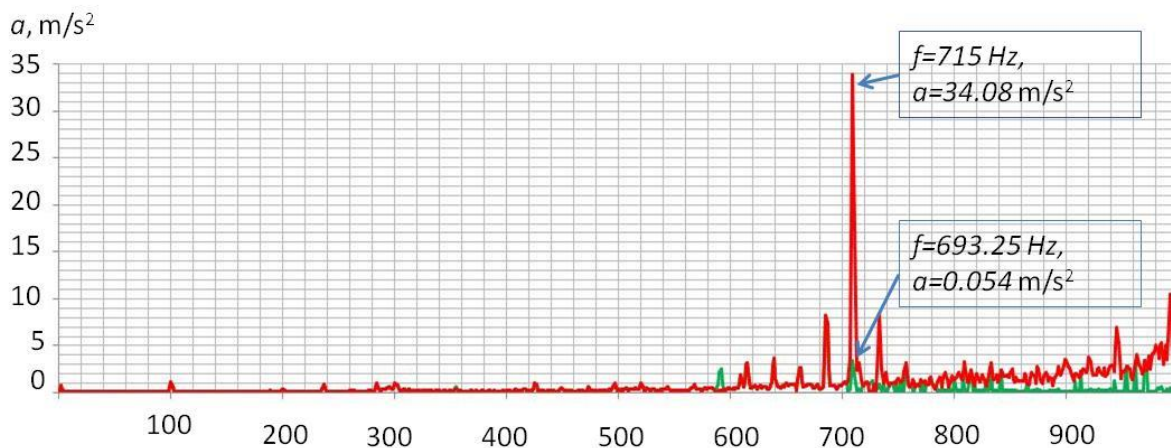


Fig. 7. The result of measuring the vibration level on the bearing unit, new conventional bearings and radial bearings with the AFZ

As can be seen from fig. 7 peak vibration levels using bearings with the AFZ is significantly lower than with conventional bearings.

IV. CONCLUSIONS

The studies have shown that the use of radial bearings with AFZ without end caps in the mounting groups of the rotary feeder and auger tool for two-stage drilling of horizontal boreholes restricts getting the degradation products in the internal space in the moving parts of bearings, and reduces the level of vibration in the bearing assembly of the tool joint. In addition, it increases the service life of bearings supports in areas inaccessible for maintenance and repairs resulting in reduced labor intensity, energy and financial costs.

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THE 8TH RUSSIAN-CHINESE SYMPOSIUM COAL IN THE 21ST CENTURY: MINING, PROCESSING AND SAFETY

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Foreword

The 8th Russian-Chinese Symposium “Coal in the 21st Century: Mining, Processing and Safety” was organized jointly by T.F. Gorbachev Kuzbass State Technical University (Russia) and Shandong University of Science and Technology (China), which have had a long-term partnership of 25 years. The event was designed to promote the development of the Russian-Chinese scientific and technical cooperation in the field of mining including high-technology coal mining and deep coal processing, reduction of anthropogenic impact on the environment, production and operation of modern equipment, means and methods of industrial safety in the coal industry, as well as modern technologies of construction and modernization of the coal industry operations.

The symposium brought together the leading Russian and Chinese scientists working in the field of coal, heads of coal-mining companies, industrial safety professionals, managers and specialists of the government. The Symposium participants expanded their scientific and business contacts in the field of mining and defined new promising areas of research and engineering research aimed at the development of the coal industry.

We are confident that the 8th Russian-Chinese Symposium “Coal in the 21st century: Mining, Processing, Safety” will contribute to a new quality of relations between the scientists of Russia and China in the field of the mining science for the benefit of the two countries. We sincerely thank the local and foreign scholars who provided their support to the Symposium and all the authors who submitted their papers for publication.

Vladimir A. Kovalev

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Table of Contents

Foreword	v
----------------	---

Section 1. Advanced technologies in construction and upgrading of coal mining enterprises

Resource approach to the estimation of international cooperation in integrated development of calciphyre deposits <i>Kamkicheva Olga, Voznaya Anna, Mikhailova Tatyana, Gribanova Galya</i>	1
Research on secondary support time of soft rock roadway <i>Duohua Wu, Weiguo Qiao, Weijie Song, Pershin Vladimir</i>	5
Roadway support optimization by improved BP neural network and numerical simulation <i>Jun Wang, Yunliang Tan</i>	11
The prediction of distribution characteristics of the in-situ stress for Liuhuanggou mine field <i>Shi Yongkui, Ding Yonglu, Wang Xiaomeng, Xu Mingwei</i>	17
Research on development law of overburden rock fracture in steeply inclined and very thick coal seam mining <i>Weimin Cheng, Lulu Sun</i>	21
The improved construction of reinforced-concrete support of slope mouth <i>Pershin Vladimir, Vojtov Michail, Budnikov Pavel</i>	27
“Lean production” in the coal mining industry <i>Mikhalchenko Vadim, Rubanik Yuri, Osokina Natalia, Mikhalchenko Anna</i>	33
Lean governance as a condition for the creation of intellectual coal industry <i>Zaruba Natalyi, Egorova Natalyi</i>	39
A new method for studying the roadway stability <i>Zhongcheng Qin, Shengchao Wang, Xin Yu, Bin Cao</i>	45
Application of SCADA systems in the coal mining industry <i>Samorodova Lyudmila, Lyubimov Oleg, Yakunina Yulia</i>	50
Justification of requirements for crushed rock for open-pit automobile road topping <i>Shabaev Sergey, Boyko Dmitriy</i>	55
The research in the use of monolithic concrete for the mine construction <i>Gilyazidinova Natalia, Rudkovskaya Nadezhda, Santalova Tatiana</i>	62
Filling of the vertical mine workings with the autoclave slag-concrete <i>Uglyanitsa Andrey, Solonin Kirill</i>	66

Prestressing method of rigid joints in multi-storey steel frame mining <i>Vershinin Dmitry, Dobrachev Valery</i>	72
Dynamic models of deformation of crustal blocks in the area of development of coal deposits - the basis of the information security of their development <i>Solovitskiy Aleksandr</i>	80
Rock destruction with volumetric compression <i>Gogolin Vyacheslav</i>	86
Considering behind limit deformation for calculation of coal pillars parameters by finite element method <i>Ermakova Inna, Pirieva Natalya</i>	90

Section 2. Increasing open-pit and underground coal mining efficiency

Evaluation model for the level of development of work organization system in coal mines <i>Koroleyva Tatiana, Grigashkina Svetlana</i>	95
The necessity and ways to develop the methodology of management decision making support for innovative development of mining regions in Russia <i>Lazarenko Sergey, Dubov Georgiy, Zykov Andrei, Shirokolobova Anastasia</i>	100
Methods and schemes of opening-up the quarry fields at various bedding conditions of deposits <i>Kolesnikov Valery</i>	104
The improvement of the Bunton construction of mine-shaft equipment <i>Kopytov Aleksandr, Pershin Vladimir, Voitov Michail, Wetti Ahmed</i>	108
Adaptive technology of using backhoes for full coal extraction <i>Tyulenev Maxim, Khoreshok Alexey, Garina Ekaterina, Danilov Sergey, Zhironkin Sergey</i>	111
Influence of service conditions of quarry dump trucks on the thermal state large-size tires <i>Kulpin Aleksanadr, Stenin Dmitriy, Kultayev Evgeniy, Kulpina Evdokya, Borovtsov Valeriy</i>	116
The evaluation of production safety of coal-mining region <i>Kudrevatykh Natalya, Sheveleva Oksana</i>	120
Social technologies for management: opportunities for coal-mining enterprises <i>Zonova Olga, Nekhoda Evgeniya, Slesarenko Ekaterina</i>	125
Organization and assessment of efficiency of intra corporate control in the large coal mining company <i>Kucherova Elena, Tyuleneva Tatyana, Cherepanova Natalya</i>	130
Research on impact characteristics of inclined coal-rock composite body <i>Yunliang Tan, Yubao Zhang</i>	135
Clustering and emergent features of the regional economics of the Kemerovo Region <i>Bereznev Sergey, Kumaneeva Maria, Makin Maksim</i>	139

Justification of efficiency of heavy dump trucks effectiveness in open pit mines according to operating life criterion of the back axle <i>Panachev Ivan, Shirokolobov Georgiy, Kuznetsov Ilya, Shirokolobova Anastasia</i>	144
Using innovative technologies of 3D modeling for advanced planning of reclamation results <i>Aksenova Olesya, Pachkina Anna</i>	149
Influences on pressure releasing by blasting breaking hard roof <i>Wei Zhang, Yunliang Tan, Weiyao Guo, Shitan Gu, Dianrui Mu, Shanchao Hu</i>	153
Study on the distribution law of front abutment pressure of long fully-mechanized working face in deep mine <i>Yuguo Ji, Xianjun Wang, Yongpei Zhou, Xiantang Zhang</i>	159
Simulation and field measurement study on roof strata behavior of fully mechanized caving face <i>Weitao Liu, Wencheng Song, Jianning Wang</i>	163
Displacement back analysis based on GA-BP and PSO-BP neural network <i>Dongdong Gu, Yunliang Tan</i>	169

Section 3. Industrial safety in coal industry

Electrophysical monitoring of the processes of electroosmotic treatment of soil from oil pollution on laboratory installations <i>Shabanov Evgeniy, Prostov Sergey</i>	175
Debit gas in well as a comprehensive indicator of gas permeability of the coal seam <i>Shevchenko Leonid</i>	184
Analytical prediction of stability of earthfill dam <i>Bakhaeva Svetlana, Guriev Dmitriy</i>	188
Technical audit of external power supply networks of coal mines in the Kemerovo Region <i>Zakharov Sergei, Voronin Vyacheslav</i>	193
Impact assessment of mining and geological factors of Kuzbass coal mines on the level of their power consumption <i>Zakharova Alla, Lobur Irina, Shauleva Nadezda, Borovtsov Valeriy</i>	198
Determination of seismic safe distances during mining blasts with consideration of a dominant vibration frequency <i>Novinkov Aleksey, Tashkinov Aleksandr, Protasov Sergey</i>	202
Modeling of geomechanical processes case of uneven settling of foundations constructions <i>Sokolov Mikhail, Prostov Sergey</i>	206
Stabilization control techniques for a roadway in deep high-stress soft surrounding rock <i>Hu Jin-tan, Lin Deng-ge, Zhao Ru-mei</i>	213

Research on simulation and field measurement technology of floor mining failure depth <i>Wencheng Song, Chunbo Zhao, Guang Li, Donghui Wang</i>	220
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Section 4. Coal mining equipment. Production and operation

Enhancement of efficiency of the magnetic suspension of belt conveyor <i>Zacharov Aleksandr, Chepikov Pavel</i>	229
The power characteristics of the reversible radial crowns with disk tools for roadheaders of selective action <i>Mametyev Leonid, Khoreshok Alexey, Tsekhin Aleksandr, Mukhortikov Sergey, Borisov Andrey</i>	233
Conditions for minimum dynamic loading of multi-brake hoists <i>Khoreshok Alexey, Tyulenev Maxim, Vöth Stefan</i>	239
Evaluation of the technical condition of auger equipment units by vibration inspections <i>Mametyev Leonid, Drozdenko Yuriy, Lyubimov Oleg</i>	246
The diagnostics of motor-wheel gears of quarry dump trucks based on bearing wear monitoring <i>Kudrevatykh Andrey</i>	252
Evaluation of the open pit vehicles loading influence on the reliability of motor – wheel reducers <i>Stenin Dmitriy, Stenina Natalia, Bakanov Alexander</i>	256
Reducing dynamic loads of mining machinery electric drive at starting <i>Eshchin Evgeniy, Sokolov Igor</i>	260
Calculation and justification parameters of strengthening technology to produce drill rig shaft gear on the basis of mechanics of technological inheritance <i>Blumenstein Valeriy, Ferranti Alina</i>	265
Computer system for electric drives fault diagnosis of mining shovels <i>Kashirskikh Veniamin, Gargayev Andrey, Zavyalov Valeriy, Semykina Irina</i>	274
Research on the support technology of bolt and cable in deep high stress roadway <i>Weijie Song, Weiguo Qiao, Pershin Vladimir, Duohua Wu, Yanzhi Li</i>	280

Section 5. Deep coal processing. Coal chemistry. Gasification. Ecology

The role of innovative technologies in solving Kuzbass coal industry geo-ecological problems <i>Kovalev Vladymir, Khoreshok Alexey, Litvin Oleg</i>	287
Regarding one estimation of the technical condition of the selective headers <i>Kovalev Vladymir, Khoreshok Alexey, Gerike Boris, Meshkov Anatoliy</i>	291
Study of sulfur oxide reduction during combustion of coal-water slurry <i>Murko Vasiliy, Karpenok Viktor, Senchurova Yuliy, Tailakov Oleg, Khyamyalyainen Veniamin</i>	297

Cleaning the flue gases of thermal coal power plants from sulfur and nitrogen oxides <i>Shilyaev Mihail, Bogomolov Alexandr, Dvorovento Igor, Sysolyatin Andrey, Kryukov Sergey, Chemakin Maksim</i>	301
Investigation of the sorption properties of ore materials for the removal of sulfur dioxide from exhaust flue gases of power plants <i>Shikina Nadezhda, Teryaeva Tatyana, Ismagilov Zinifer, Khairulin S.R., Kuznetsov Vladimir, Rudina N.A.</i> ...	306
The development of gas energy potential of coal deposits as the necessary step towards the Russian coal industry modernization <i>Lazarenko Sergey, Dubov Georgiy, Shirokolobova Anastasia</i>	312
Catalysts for nitrogen oxides removal from flue gases <i>Shikina Nadezhda, Tailakov Oleg, Ismagilov Zinifer</i>	318
Justification of a method for determination of gas content in coal seams to assess degasification efficiency <i>Tailakov Oleg, Kormin Alexey, Zastrelov Denis, Utkaev Evgeniy, Sokolov Sergey</i>	324
Research in the propping agent for the hydraulic fracturing cracks for the methane extraction from the massive coal seams <i>Baev Mikhail, Khyamyalyaynen Veniamin</i>	330
Methodological bases of advanced geo-ecological problems resolving in neo-industrial clusters <i>Tyulenev Maxim, Lesin Yury, Vik Svetlana, Zhironkin Sergey</i>	333
Evaluation of the coking capacity indicator of coking coal concentrates based on the research of non-volatile residue strength via determination of the coking chemical products yield <i>Vasileva Elena, Cherkasova Tatyana, Subbotin Sergey, Nevedrov Aleksandr, Papin Andrey, Kolmakov Nikolay</i>	337
Dependence of the yield of chemical coking products from coal concentrates on their nature <i>Vasileva Elena, Cherkasova Tatyana, Subbotin Sergey, Nevedrov Aleksandr, Papin Andrey, Kolmakov Nikolay</i>	342
Coal waste as raw material for production of rare and trace elements <i>Cherkasova Tatiana, Cherkasova Yelizaveta, Tikhomirova Anastasia, Bobrovnikova Alyona, Papin Andrey, Nevedrov Aleksandr</i>	347
Operational reliability of corrosion protection of structures in industrialized region <i>Cherkasova Yelizaveta, Zolotuhina Natalia, Goryunova Irina, Bulanova Tatyana, Chenskaya Valentina</i>	350
Producing mesitylene by dehydrotreatment of C ₉ -aromatics distilled from coal pyrolysis products <i>Petrov Ivan, Tryasunov Boris</i>	353
Mechanochemical capture of carbon disulfide by magnesium-carbon composite <i>Bogu Liu, Qianqian Zhang, Pei Liu, Haipeng Chen, Hao Yu, Shixue Zhou</i>	361
Estimation of gross regional product losses due to the influence of environmental factors (in the context of an industrial region) <i>Petr Kosinskiy Petr, Vladimir Merkur'yev, A.V. Medvedev</i>	366

Environmental safety management of a coal mining enterprise <i>Golofastova Natalya, Mikhailov Vladimir, Galanina Tatiana</i>	372
Transformation of the ecological-economic system of the coal mining region <i>Mikhailov Vladimir, Golofastova Natalya, Seredyuk Ilya</i>	377
Effect of binder on chemically bonded fly ash aggregate based on Kuzbass coal combustion products <i>Alexander Zhikharev, Aleksey Kargin, Andrey Uglanica</i>	383
Numerical simulation of gas flow based on three-dimensional reconstruction using computed tomography <i>Xiangyu Chu, Gang Wang</i>	386
Sulfur transfer characteristics and pyrolysis simulation in the coal polygeneration process <i>Yaqing Zhang, Jialong Zhu, Peng Liang</i>	393