

## Innovative techniques and technologies for the mining industry – conclusions from the KOMTECH-IMTech 2020 Conference

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**Słowa kluczowe:** konferencja, górnictwo, bezpieczeństwo pracy, innowacyjność, maszyny górnicze, cyberbezpieczeństwo, internacjonalizacja

**Abstract:**

A review of selected papers, presented during the 21<sup>st</sup> International Scientific-and-Technical Conference KOMTECH-IMTech “Innovative techniques and technologies for the mining industry in the aspect of safety, efficiency and reliability” are described in the article. During twelve conference sessions forty-four papers, concerning work safety in the mining industry, minerals’ extraction systems, state-of-the-art control, monitoring and diagnostic systems of machines and equipment, cyber-security, new solutions of hydraulic systems, new generation, highly efficient haulage assemblies for longwall systems, hoisting machines, a recovery of minerals, preparation systems, an improvement of mining personnel’s qualifications and an internationalization of the Polish circum-mining sector, were presented. Special attention should be paid to the special session oriented onto a presentation of information about a roadway driving technology with use of a Bolter Miner, and also onto debates concerning the mining industry in future as well as a demand for innovations from the future mining industry.

**Streszczenie:**

W artykule przedstawiono przegląd wybranych referatów wygłoszonych podczas 21. Międzynarodowej Konferencji Naukowo-Technicznej KOMTECH-IMTech „Innowacyjne techniki i technologie dla górnictwa w aspekcie bezpieczeństwa, efektywności i niezawodności”. Podczas dwunastu sesji konferencyjnych zaprezentowano czterdzieści cztery referaty dotyczące bezpieczeństwa pracy w górnictwie, systemów wydobywczych, nowoczesnych systemów sterowania, monitoringu oraz diagnostyki maszyn i urządzeń, cyberbezpieczeństwa, nowych rozwiązań układów hydraulicznych, nowej generacji systemów posuwu wysokowydajnych kompleksów ścianowych, maszyn wyciągowych, odzysku minerałów, systemów przerobczych, poprawy kwalifikacji pracowników górnictwa oraz internacjonalizacji polskiego sektora okołogórniczego. Na szczególną uwagę zasługuje tematyka sesji specjalnej, ukierunkowanej na prezentację technologii drążenia z zastosowaniem kombajnu urabiająco-kotwiącego Bolter Miner, a także debaty na temat górnictwa przyszłości oraz potrzeby innowacyjności w aspekcie przyszłości górnictwa.

### 1. Introduction

Since 1999 the KOMAG Institute of Mining Technology has organized international scientific-and-technical conferences from the KOMTECH cycle, oriented onto innovative techniques and technologies for the mining industry in the aspect of safety, efficiency and reliability. For two years the conference name has been KOMTECH-IMTech. Due to severe pandemic restrictions, caused by the SARS-CoV2, the conference organizers decided to implement an electronic form and offer all the presentations and debates on line. The conference covered a broad spectrum of scientific, research and technical subjects, enabling an exchange of knowledge and professional experience among representatives of academia, research institutes, producers of mining machines and equipment as well as end-users from mines. In total about 4000 viewers participated in the conference, watching

presentations and asking many interesting questions. Such a big number of participants can be regarded as a real success, considering the circumstances and a new form of this cyclic conference. The conference was bilingual: in Polish with a simultaneous translation into English. It is worth mentioning that 830 people followed the sessions in the English version. Foreign participants were from Australia, Chile, India, Romania and Slovenia. The conference co-organizer was Jastrzębska Spółka Węglowa S.A. (Jastrzębska Coal Company J.S.C) which was responsible not only for the technical side of this challenging undertaking at a big scale, but its representatives also gave an extremely valuable scientific input in a form of interesting and stimulating presentations. One of the sessions concerned widely understood hydraulic issues. The main presenters from the INOE 2000 – Subsidiary Hydraulics and Pneumatics Research Institute in Bucharest (Romania) concentrated on predictive maintenance of hydrostatic drive systems, tests of flow and pressure pulses in oscillating hydraulic intensifiers, monitoring proportional directional valves in hydraulic drive systems and on a modernization of the Fluid Power field through an integration of intelligent equipment.

The KOMTECH-IMTech 2020 Conference was initially planned as one of the key events, enabling to celebrate the 70<sup>th</sup> Anniversary of the KOMAG activity. Two papers, included in the Conference programme, presented the role of the Institute in shaping work safety in hard coal mines and its achievements in the field of environmental protection over the years 1950-2020. Special attention was paid to the research projects' results oriented onto a creation of safe, reliable design solutions of mining machines and equipment as well as of safe work environment. There was also some information about innovative technical solutions, which obtained awards and were distinguished by domestic and foreign experts at fairs, exhibitions and competitions in Poland and abroad.

## 2. Review of papers

### 2.1. Session 1 – Technology of driving roadway workings with use of a Bolter Miner

The subject-matter of this inaugural session concerned roof-bolting technology – a case study at the Budryk Mine. The presentations were oriented onto a design of the roof-bolting supports, a summary of a research project with special attention paid to challenges, experience and conclusions as well as to a presentation of experience, resulting from using a roof-bolter for cutting hard rock.

The other part of the session consisted of two debates on mining in future and also on the demand of innovations and the future of the mining industry. It was very interesting to hear opinions of experts representing Jastrzębska Spółka Węglowa S.A., Tauron Wydobywanie S.A., Wyższy Urząd Górniczy, Lubelski Węgiel BOGDANKA S.A., Główny Instytut Górnictwa, Politechnika Śląska, FAMUR S.A., CARBOAUTOMATYKA S.A., Polska Technika Górnicza S.A. and Instytut Chemicznej Przeróbki Węgla. The debates were moderated by Prof. Dariusz Prostański and Dr. Bartosz Polnik from the KOMAG Institute of Mining Technology.

### 2.2. Session II – Cyber-security

In this session the papers and presentations covered the IT/OT cyber-security system based on CP4S Qradar and the system of PAM class, the Journey to Cloud containing a question, if it is a must to migrate to a public cloud, the IBM Cloud Pack for Applications – the platform of innovativeness and the system Ewidencja EX as a state-of-the-art tool of an efficient aid in the Asset Management Process at the Jastrzębska Spółka Węglowa S.A.

### 2.3. Session III – State-of-the-art control, monitoring and diagnostic systems of machines and equipment

The main subjects of the session included a replacement of control systems due to an implementation of digital inverter drive technology in opencast mining machines, principles of using simple electrical equipment in intrinsically safe circuits and also a dissipated monitoring and diagnostic system to be applied in photovoltaic power-stations. In the case of digital inverter drive technology the issues concerned problems with starting opencast machines supplied with AC drives equipped with frequency converters and voltage inverters, built on the basis of IGBT transistors

controlling induction motors [11, 12]. The control algorithms implemented digital structures of control systems with PID controllers. Incorrect settings caused vibrations during a machine operation, which were the reasons of cracks in machine components, forcing downtimes due to mechanical damages. The presentation on using simple electrical equipment in intrinsically safe circuits enabled to get acquainted with conditions and requirements which these devices must meet, if they are to be used in intrinsically safe systems [7, 8, 25]. The experience of the KOMAG Division of Attestation Tests, Certifying Body confirmed problems with incomplete or incorrect documentation which is supplied in the case of simple electrical equipment.

#### **2.4. Session IV – Work safety in the mining industry**

The session started with a paper on the role of the KOMAG Institute of Mining Technology in shaping work safety in hard coal mines [6, 15, 16, 17, 22]. Then the subject of an improvement of work safety and a communication of small working groups, using the VR environment network, was presented and the information about the AutoInvent – an innovative system, aiding mine surveyors, increasing work safety and efficiency, was given.

The role of the KOMAG Institute in shaping work safety in hard coal mines was highlighted. Special attention was paid to the results of scientific, research and development projects concerning safe, reliable and operator-friendly solutions of machines and equipment for extracting and processing minerals, mainly hard coal. A creation of safe work environment due to an implementation of diagnostic and monitoring devices as well as sophisticated trainings of machinery operators contributed to an awareness increase as regards work safety. It should be highlighted that work safety in mines has always been one of the Institute's top priority objectives. An indicator of fatal accidents for one million tons of extracted coal, reflecting the safety level was 8.64 in 1945. For a comparison it is worth giving these indicators for the Polish mines in the years: 2018 and 2019, i.e. 0.24 and 0.21 respectively.

#### **2.5. Session V – New solutions of hydraulic systems**

This session was dominated by scientists and researchers from the INOE 2000 – Subsidiary Hydraulics and Pneumatics Research Institute in Bucharest, Romania. Their presentations were oriented onto a modernization of Fluid Power field through an integration of intelligent equipment, monitoring proportional directional valves in hydraulic drive systems, predictive maintenance techniques enabling a reduction of hydrostatic drive systems' wear and an assessment of flow and pressure pulses in oscillating hydraulic intensifiers.

As regards a modernization of Fluid Power field it was possible to get detailed information about two smart devices designed by the IHP, i.e. a proportional directional valve and a digital actuator as well as about two smart laboratory stands, one of servo-valves and one of digital hydraulic cylinders. An introduction of sensors, electronic blocks and software algorithms contributed to an improvement of functional performance of machines. In the case of an incorrect operation the local smart device provides error codes using various communication protocols: RS 232, CAN, Fieldbus and Modbus. The paper concentrated on a structure of a monitoring and diagnostic module for monitoring proportional directional valves in hydraulic drive systems [3, 5]. It should be highlighted that predictive maintenance techniques play a very important role in the process of identifying wear of technical systems, enabling to avoid failures [4]. Using three methods of predictive maintenance, namely infrared tomography, vibration analysis and oil analysis, the authors presented the results of their research work and tests on an example of hydraulic pumps [10]. In the case of an assessment of flow and pressure pulses in oscillating hydraulic intensifiers (miniboosters) the authors presented a test stand construction, enabling to determine flow and pressure pulse characteristics, their impact on a uniform displacement of hydraulic cylinders' load as well as functional characteristics in dynamic and stationary operational modes of pumping units with embedded miniboosters [20, 27].

The latest paper in this session concerned an optimization of a hydraulic system for a briquetting machine.

## 2.6. Session VI – Mining systems

The programme of this session included five papers on various mining and geological subjects such as temporary powered roof supports to be used in a development of roadway workings, a system for a withdrawal of a powered roof support unit from the row and its transportation from the working in the process of a longwall liquidation, an analysis of wear of powered roof support elements after a long period of operation in the aspect of their technical condition assessment, an analysis of mining-and-geological conditions in longwalls from the point of view of introducing pressure monitoring of powered roof supports and a strength analysis of cycloidal gear wheels system with a new concept of power transmission. In the case of temporary powered roof supports, applied in the process of roadway development, the author presented some reasons which cause that they are not commonly used worldwide [9, 14]. However, there are attempts to develop new solutions of temporary powered roof supports, to be used in roadways, as they give a chance for increasing efficiency of roadway development operations.

An innovative system for a withdrawal of powered roof support units from a row and their transportation from the working during the longwall liquidation was presented. Three variants of this system were discussed in detail [2]. Two protective roof support units, connected to a special platform, using the beams of the advancing system, are used in this solution. The platform enables a rotation of the withdrawn roof support. Some advantages and disadvantages of the system are shown [13]. In the case of wear of powered roof support units, after a long period of operation, some information was given about methods of technical assessments, used at the KOMAG Laboratory of Tests [18, 21]. The results of thickness measurements of metal sheets, of thicknesses of canopy brace, of gob shield and base are presented. The measurements of openings diameters of the main articulated pairs were analyzed as well. The percentage loss of metal sheets thicknesses in the result of corrosive and abrasive wear was determined. It was found that despite the loss in metal sheets thicknesses and an increase in sizes of bolt connections, the roof support units passed the strength and fatigue tests at the KOMAG accredited laboratory [24, 26].

## 2.7. Session VII – KOMTRACK – a new generation haulage assembly of highly productive longwall systems

The session consisted of seven presentations, six of them concerned the KOMTRACK system. Detailed information about the design of an innovative haulage assembly of highly productive longwall systems, in the result of the KOMTRACK research project, was given by researchers from the KOMAG Institute who developed this solution. Then the results of functional tests were discussed. It was interesting to get acquainted with analyses of kinematic and dynamic cooperation of a friction pair in the case of the KOMTRACK assembly. The information about the material, manufacturing technique, tooling and casting of the haulage segments of a shearer was also given. This block of presentations was ended with a programme of tests in underground conditions of the Piast Mine.

The seventh paper in this session concerned a review of methods for a recognition of coal and rock interfaces to automatize a longwall shearer operation [23, 28]. One of the key issues, faced by mines at present, is how to increase productivity of longwall faces. It is obvious that R&D projects should be focused on a shearer which plays a crucial role in the production process of coal. An accurate recognition of the shearer's cutting pattern is an indispensable condition enabling to develop a system for automatization of coal extraction from a longwall face [1]. A review of the methods of coal and rock interface identification, together with a presentation of advantages and disadvantages of each method, was an interesting contribution to the subject-matter of the KOMTECH-IMTech Conference.

## 2.8. Session VIII – Internationalization of the Polish circum-mining sector

This session was oriented onto a presentation of the Polish mining sector expansion possibilities. Representatives of the KOMAG Institute developed a concept of a small opencast gold mine and they shared their experience with the Conference participants.

## 2.9. Session IX – Hoisting machines

The session was started with metrological aspects of measurements of an elevator installation in a mine shaft. It was indispensable to select an appropriate method for measuring real stresses in the shaft reinforcements, generated by the elevator cabin. Implemented technical solutions and operational parameters of built-in transportation devices for a vertical men-riding in the Regis Shaft of the Wieliczka Salt Mine were discussed [29]. Then a use of magnetometry for diagnostics of electric elevators, used in the mining industry on the example of the Regis Shaft, was presented.

Innovative solutions of the MWM Elektro Company, for use in mine shaft winders, attracted an attention of a big number of the Conference participants. The session ended with a presentation of technological hoisting machines used for an execution of specialistic shaft operations.

## 2.10. Session X – Recovery of minerals

This session was dominated by researchers from the KOMAG Institute of Mining Technology who shared their knowledge and scientific experience related to a recovery of coal small grains from post-mining waste, using a technology of an autogenous suspension bed, to a determination of contents of rare earth elements in hard coal and in power station waste, to a new design solution of the radial thickener Ø30 of KOMAG type and to tests of rare earth elements contents in selected materials.

## 2.11. Session XI – Preparation systems

The session started with a presentation of 70-year activity of the KOMAG Institute of Mining Technology for the benefit of environmental protection [6,15]. Special attention was paid to the projects oriented onto dust and noise control, but in particular onto an environmental protection of post-mining sites and other areas badly affected by the industry. A review of research projects included KOMAG achievements in the scope of reducing noise emissions to the environment such as acoustic baffles and active acoustic silencers. The awards and distinctions, obtained by KOMAG and its researchers at various exhibitions, fairs and competitions, confirm an innovative character of these technical solutions.

A very interesting presentation concerned new implementations of jigs for coking and steam coal, developed in a collaboration with Carbo-Eco and Fugor Companies. The Company Nord Napędy Polska gave a presentation on its activity in the domain of preparation systems and the BEFARED J.S.C. presented its solutions of preparation machines and equipment.

## 2.12. Session XII – Development of qualifications in the mining industry

The last session of the Conference was dedicated to the state-of-the-art training systems offered by JSW Szkolenie i Górnictwo (JSW Training and Mining), Ltd.

The first presentation in this session concentrated on the sectoral frame of qualifications in the mining industry. Then a role of Virtual Reality in a process of employees' professional development was discussed in the aspect of market qualifications for the mining sector.

The session was finished with a summary of the KOMTECH-IMTech 2020 Conference made by Prof. Dariusz Prostański, Director of KOMAG Institute of Mining Technology and Dr. Artur Dyczko, Vice-President of Jastrzębska Spółka Węglowa S.A. (Jastrzębska Coal Company, J.S.C.)

## 3. Summary and conclusions of the KOMTECH –IMTech 2020 Conference

The summary and conclusions were expressed not only by the Conference organizers, but also by two distinguished experts: Prof. Stanisław Prusek, Director of GIG – Central Mining Institute and Mr. Artur Wasil, Director of Bogdanka Mine.

Prof. Prostański thanked all the Conference participants, but in particular the presenters of the submitted papers. He expressed his gratitude to Dr. Dyczko and his Team for such a fruitful collaboration in organizing the Conference. Everybody spoke highly about the session on Bolter Miner technology. Prof. Prusek gave some information about mining and geological problems experienced

during an implementation of this technology in the Budryk Mine. Prof. Prostański declared that KOMAG was ready to solve problems related to mechanical aspects of this technology. Mr. Wasil expressed an opinion that it was a very good idea to have one session dedicated exclusively to a Bolter Miner. Dr. Dyczko highlighted the fact that the Conference presented the state-of-the-art mining knowledge offered in an electronic, convenient and safe form. Prof. Prusek mentioned the achievements of the Bogdanka Mine in implementing the plow technology. Afterwards Mr. Wasil expressed his interest in implementing innovative technologies, including a Bolter Miner technology. This interest also concerns electromobility as in his opinion a mine is a logistic enterprise. All these actions will contribute to an increase of a production efficiency. Both KOMAG and GIG offered their assistance and support in implementing innovative technologies; GIG as regards rock mechanics and KOMAG in the scope of mechanical, mechatronic and hydraulic issues.

Mr. Wasil thanked for the words of appreciation, addressed to him and to his employees. He said that Bogdanka was ready to follow the steps, undertaken by the JSW S.A. as regards innovative technologies and a vision of a future development. Unfortunately, the pandemic of SARS-CoV2 obstructed a realization of ambitious development plans, concerning a search of methods for increasing the production efficiency, following the example of the British mining industry. Looking for best practices, it is indispensable to eliminate physical work to the biggest possible extent and to test a behaviour of the rock mass in a more precise way. So far there has been insufficient information, so an installation of monitoring devices seems to be essential. Horizontal pressure is a real issue as well as the issues of bed separation. Hazardous situations should be avoided any time. A serious engineering work is required to change an approach to the rock mass. It is absolutely necessary to strengthen the rock mass to increase a functionality of roadways. Some problems with a horizontal deformation are experienced. In the case of a multi-seam extraction with use of bolting supports, there is no experience in the world. There are plans to apply a Bolter Miner in a 400-meter longwall face. It is also a challenge as regards a ventilation system. The participants of the discussion highlighted the role of collaboration from Lubin to Lublin via Jastrzębie. The Bogdanka Mine will announce its development strategy in a couple of days. Prof. Prusek expressed his opinion about testing the rock mass. So far these tests have been underestimated. Sometimes only one hole is drilled and general conclusions are drawn as regards the whole panel. In the JSW S.A. measurements of the stress tensor were taken and such measurements are planned for the Bogdanka Mine, too. According to the experience, gained in Poland so far, it has not been possible to achieve an advance similar to that in the USA or in Australia due to the faults in the seam. Roof bolting technology gives extremely positive effects in the case of a longwall face development, when a single seam extraction is conducted. One roadway can be developed with use of the roof-bolting technology and the other one-with use of standing supports.

The project at the Budryk Mine included testing of the rock mass, training, use of best materials and a precise execution of the jobs. Monitoring played a very important role. Plow faces have already been mentioned by the participants of this panel discussion. Both the Bogdanka Mine and the JSW S.A. are experienced in using this technology.

Prof. Prostański mentioned two devices, designed at the KOMAG Institute, the PCA haulage unit and the GAD suspended locomotive, both having very good operational parameters. Discussing the issue of increasing production efficiency, he informed about the project, realized by KOMAG in collaboration with the Central Mining Institute, concerning a transportation of workers with increased speed to achieve a longer effective work-time of miners.

Dr. Dyczko and Prof. Prostański thanked the participants of the discussion, all the presenters and such a big group of viewers.

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