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KOMAG activities in the domestic and international research areas

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Abstract:

The paper presents some information about the scientific, research and technical potential of the KOMAG Institute of Mining Technology. Some examples of achievements in the domain of machines and equipment for underground mining and preparation of minerals are given. Testing activities in the KOMAG accredited laboratories are highlighted, among others tests of powered roof supports, hydraulic executive elements, safety of products. Research project results, concerning widely understood environmental protection, are described.

For more than seventy years KOMAG has been an important scientific base for the mining industry, offering innovative solutions and competing successfully on the Polish and foreign markets with other research organizations of similar type. Its scientific and technical output includes over 6000 technical documentations of machines and equipment implemented in Poland and abroad as well as over 4400 patents and utility patents which confirm an innovative character of technical solutions developed at KOMAG.

Keywords: mining machines, testing potential, research projects, certification



1. Introduction

Last year the KOMAG Institute of Mining Technology celebrated the Jubilee of its seventy year activity. An establishment of the Institute was preceded by organizational-and-formal activities oriented onto changing not only the name of the organization, but also the scope of its functioning. The history of the Institute dates back to 1950, when the Central Office of Projects, on the base of the Minister's of Mining Regulation, dated 5th May, was transformed into the Design Office of Mining Machines. It was the first step towards a creation of organizational and technical forms of design and testing base for the Polish mining industry, tending towards a revival after the World War II, for a mechanization of exploitational processes of hard coal and a creation of mining machinery industry.

During the seventy-year period several changes of the name and subordination of the Institute took place. Since January 1, 2009 KOMAG has been operating as the Institute of Mining Technology, at present supervised by the Minister of the State Assets [1].

Scientific research and technical projects, realized at KOMAG, include mechanical and mechatronic systems, among others, machines and equipment for an underground exploitation of deposits, mechanical preparation of minerals as well as the systems of supply, control, diagnostics and monitoring of machines and equipment. Concepts, projects and technical documentations of machines and equipment, having a broad scope of applications as well as expert opinions, concerning a selection of machines and equipment for complex functions and tasks but also specific conditions of their location and operation, are developed. Model, laboratory and industrial tests are also conducted. The research projects and tests are oriented onto increasing life and reliability of machines and equipment as well as work safety and ergonomics.

Specialistic research and testing activities, realized in the accredited laboratories, among others in the scope of testing powered roof supports, hydraulic executive elements, tests of products' safety and material engineering are also carried out.

Some research projects concern a widely understood environmental protection in mining, post-mining and in other industrial areas.

The projects, realized at the Institute, also incorporate technology transfers, standardization, a protection of intellectual and industrial property rights and a certification.

The scope and subject-matter of research-and-development projects have been subject to modifications and up-dating since the beginning of the KOMAG activity, which resulted from the current demand of developing industry subject to restructuring processes.

KOMAG has been and still is an important scientific base for the mining industry, including the mining machinery industry. As one of few organizations, despite dynamic economic changes, it operates on the base of the Polish capital and competes successfully on the Polish and foreign markets with other research organizations of similar scope of activity.

An unquestioned output of the 70-year activity of the KOMAG Institute encompasses over 6000 technical documentations of machines and equipment implemented in mines of minerals in Poland and abroad as well as over 4400 patents and utility patents which confirm an innovative character of technical solutions developed at KOMAG.

An achievement of such a high position of the Institute in the domestic and international research areas was possible due to a close collaboration with producers and users of machines and equipment for the mining industry and also with technical universities, research-and-development institutes, mining supervisory organizations and local administration. The synergy effect of the scientific and industrial sectors includes products and services which are safe for a user and environment friendly.

In the process of creating state-of-the-art machines and equipment the IT and telecommunication technologies are used. Mechatronic systems, in which diagnostic and monitoring systems as well as robotics play an essential role, are generated. Computer-aided designing and other methods, called engineering of knowledge, are commonly used. Due to these activities the KOMAG Institute takes an active part in the process of building the economy based on knowledge and innovations.

The KOMAG strategy takes into consideration future needs of users and producers of machines and equipment for the mining industry, offering interdisciplinary research and testing services as well as advisory activity. An important trump is a young, ambitious staff of scientific, research and

engineering-and-technical employees of broad competences. Industrial partners of the Institute from the branch of mining machines and equipment come from big capital groups and on the other hand they represent a group of medium, small and micro enterprises. A collaboration with industrial partners is realized at the support of the State Agency of Entrepreneurship Development. The results of research projects, realized by KOMAG, are used in particular by: the Polska Grupa Górnicza S.A. (Polish Mining Group, J.S.C), the Jastrzębska Spółka Węglowa S.A. (Jastrzębska Coal Company J.S.C.), the Tauron Wydobycie S.A. (J.S.C.), the Węglokoks S.A. (J.S.C.) and Lubelski Węgiel Bogdanka S.A. (J.S.C.)

2. Potential of the KOMAG Institute in the aspect of challenges of market-oriented economy

The mission of KOMAG includes a creation of innovative solutions for the economy. In the vision KOMAG is defined as a research institute of organizational-and-proprietary structure adapted for the market activity in the European Research Area. The Institute's organizational culture creates a friendly climate for generating new ideas and for realizing innovative activities i.e. transforming new ideas into new products.

2.1. Subject and scope of the KOMAG research activity

The subject of KOMAG activity encompasses a realization of scientific, research and development projects in the field of mechanization of extracting and beneficiation processes as well as in the field of air protection, surface protection and waste management connected with mining and processing of minerals, adapting the research projects results to an industrial application.

The projects are developed, among others, in the following fields:

- smart mechatronic systems,
- innovative solutions controlling hazards and increasing work safety,
- innovative transportation systems for conveying people in minerals' production plants,
- technologies and technical means for a beneficiation and a classification of minerals,
- environment management in industrial areas,
- technologies and methods for environmental protection,
- smart solutions in supply, control, diagnostic and monitoring systems of machines and equipment,
- innovative hydraulic and pneumatic systems of machines and equipment,
- innovative drive systems.

The KOMAG Institute also realizes research-and-development projects, based on contracts concluded with producers of machines and equipment, their users and authorities of towns, communes and other customers in the scope given below:

- winding machines and equipment,
- transportation equipment,
- powered roof supports,
- power hydraulics and hydraulic systems,
- cutting and auxiliary machines,
- explosion-proof equipment,
- equipment for ventilation and dust control in roadway workings,
- equipment for “small mechanization”,
- electric equipment of explosion-proof machines and equipment,
- mechatronic systems for machines and equipment,
- Internet of Things.

2.2. Research and testing potential

The research and testing potential of the KOMAG Institute of Mining Technology includes personnel and material resources grouped in divisions, laboratories and departments. Scientific, research and testing projects are conducted there. These activities are aided by organizational departments, taking an active part in the projects planning and management processes as well as in the processes of quality and knowledge management. A crucial role in these activities is played by the testing potential gathered in the Institute laboratories.

Three accredited testing laboratories are active in the organizational structure of the KOMAG Institute of Mining Technology. They which conduct tests according to the scope of their accreditation.

- the Laboratory of Tests,
- the Laboratory of Applied Tests,
- the Laboratory of Material Engineering and Environment.

2.2.1. The Laboratory of Tests

A construction of a new testing hall with unique, as regards the world scale, test rigs for testing powered roof supports (Fig. 1) in the eighties of the last century and with the rigs for testing legs and high-pressure hydraulic elements of mining machines (Fig. 2) in the nineties, and also of hydraulics valves (Fig. 3) formed the grounds for a creation of bases, enabling to conduct research projects on extremely important issues of safety in the mining industry [2, 3].



Fig. 1. A view of the rig for testing powered roof support units [3]



Fig. 2. A view of the rig for testing legs and elements of high pressure hydraulics for mining machines and equipment [3]

The Research Laboratory has a certificate of the Polish Center for Accreditation (PCA), obtained in 1995 in the scope of complex tests of powered roof supports units (Certificate No. AB 039), according to EN 1804-1;2;3 European Standard. At present the Laboratory of Tests realizes as follows:

- rig tests of powered roof supports for certification purposes (new or modernized support units) in the framework of the technical condition assessment (support units in operation),
- tests of power and control hydraulics elements,
- strength tests of products and construction materials.

During over 25 years of accreditation the Laboratory of Tests has performed approximately 3.500 accredited tests of all types of construction products, contributing to an improvement of work safety both in the underground mines as well as in other industries.

At the test rigs of the Laboratory of Tests over 400 types of powered roof support units were tested based on the orders of industrial partners from Poland and abroad. Research-and-development projects, oriented onto methods and means, minimizing the effects of the rock bursts and bumps and

thus improving safety in a significant way as regards longwall mining systems, were conducted as well. The results of tests, carried out in the Laboratory, are used by domestic and foreign producers and users of powered roof supports as well as of the elements of power and control hydraulics. Besides, in the Laboratory several hundred tests of hydraulic pipelines, friction props, clamps, steel sprags, mesh linings and chock supports were realized.

In the Laboratory of Tests new test rigs are under construction. Testing methods, control systems of testing processes, checking and keeping archives processes are subject to modernization. The testing infrastructure enables to watch the tests on-line. The undertaken modernization activities up-grade significantly the method of conducting tests and thus they increase customers' satisfaction.

2.2.2. The Laboratory of Applied Tests

The Laboratory of Applied Tests was established in 2001 in the result of separating a certain part of tests and measurements, supporting a realization of scientific, applied and industrial projects. Initially its scope of activity covered measurements of mechanical, electrical, hydraulic and pneumatic quantities. Rig tests of dust collecting machines and equipment were conducted on a specialistic rig, located at KOMAG. In course of time the scope of conducted tests encompassed vibroacoustic measurements, measurements of dust contents, and tests of power consumption of drive systems of machines used for mining minerals. Obtaining the accreditation of the Polish Center for Accreditation (PCA) by the Laboratory (Certificate No. AB 665), enabled to realize tests connected with certification processes. In this scope the Laboratory closely collaborates with the KOMAG Division of Attestation Tests, Certifying Body. At present the Laboratory of Applied tests offers as follows [4,5]:

- tests of equipment for conformity with the ATEX Directive – Fig. 3,
- measurements of acoustic and vibration parameters,
- measurements of electrical quantities,
- testing the intrinsic safety of circuits,
- measurements of electrostatic, mechanical and geometrical quantities,
- environmental tests and climatic tests,
- tests of IP protection code,
- tests of geometrical structure of surface,
- aging tests of elastomers,
- tests of electric drives,
- tests of hydraulic, pneumatic and mechanical systems,
- measurements of quick-changing processes and response time,
- measurements of light intensity,
- tests of machines and equipment as regards certification,
- tests of electronic devices as regards thermal shock.

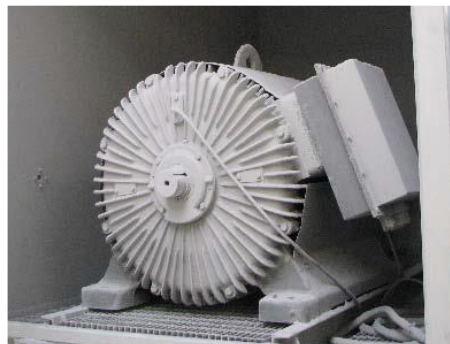


Fig. 3. Tests in the dust chamber for conformity with the ATEX Directive – IP code

The Laboratory extends the scope of offered tests continuously and takes an active part in inter-laboratory comparisons, improving the quality of offered testing services. It has also been taking an active part in a realization of research, development, research-and development and targeted projects.

2.2.3. The Laboratory of Material Engineering and Environment

The Laboratory of Material Engineering and Environment was established in 2006. Using the technical and financial means of the Institute, the documentation was elaborated and specialistic, mechatronic test rigs were constructed. Taking an advantage of the financial means, granted by the Ministry of Science and Higher Education, the Laboratory was equipped with testing-and-measuring apparatus. In February 2008 the Laboratory obtained the accreditation of the PCA - the Polish Center for Accreditation (Certificate No. AB 910) and its scope was extended. At present the Laboratory of Material Engineering and Environment conducts the following tests [6,7]:

- material tests of metal elements of machines and equipment and elements of furniture in the scope of chemical composition and corrosion resistance,
- tests of dangerous chemical substances in materials used in consumers' products (Fig. 4),
- tests of resistance of plastics to light radiation and atmospheric impacts,
- climatic tests of textiles,
- tests of consumers' products,
- tests of global and specific migration of articles having contact with food for conformity with the requirements of the EU Regulation No. 10/2011,
- tests of electric and electronic equipment for conformity with the requirements of the RoHS 3 Directive,
- tests of packaging's for conformity with the requirements of the 94/62/EU Directive,
- tests of surfaces of sports fields and playgrounds for conformity with the requirements of the REACH Regulation and of the standards,
- tests of dangerous chemical substances in materials used in consumers' products,
- safe use of products for children (Fig. 5).

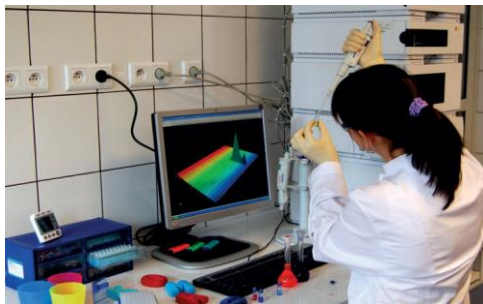


Fig. 4. Test rig for testing chemical compositions of products



Fig. 5. Test rig for testing a safe use of products for children

Now three accredited testing laboratories, functioning in the structure of the KOMAG Institute, act on the basis of flexible scopes; which allows testing laboratory to make changes in methodology and other parameters which fall within the competence of the laboratory as confirmed by the accreditation body. The experience, gained from the ten-year period of applying such scopes, is a proof that such a system is efficient and useful [8].

3. Scope of the KOMAG research activity

According to the statute of the KOMAG Institute of Mining Technology the scope of the Institute's basic activity includes as follows:

- a realization of research and development projects,
- an adaptation of research and development projects' results to industrial needs,
- an implementation of research and development projects' results to industrial practice.

Development of machines and equipment

Technical achievements in the field of machines include, among others, shearers and monorails (Fig 6). As far as shearers are concerned the KSW-750E. The KSW-880 E and the KSW-800NE (Fig 7) should be mentioned.



Fig. 6. Haulage unit of the GAD-1 suspended monorail [9]



Fig. 7. KSW-800 NE longwall shearer [10]

The research and design projects, concerning innovative solutions of mining machines and equipment, also include:

- tunnelling machines and roadway equipment,
- hydraulic and pneumatic systems for machines,
- pneumatic machines and devices for so called “small mechanization” such as: drill rigs, drill jumbos, bolting devices, loaders, drills, hydraulic hammers,
- devices for transport of materials and personnel,
- hoisting as well as cutting-and-transport machines,
- conveyor, wheeled, stranded, and rail-mounted transport systems with use of different drive technologies, including, among others, belt and scraper conveyors,
- advanced drive and control systems, including diesel drives,
- bunkers and devices for a storage of loose materials, gravitational chutes and spouts,
- pump systems for hydrotransport.

An important part of activity covers research-and-development projects concerning spraying devices used in the processes of cutting and haulage. The spraying devices reduce methane explosion and coal dust explosion hazards, being efficient at a simultaneous reduction of consumption of water indispensable in these processes. Some examples of developed and implemented solutions for a longwall shearer, for a longwall system, for a heading working and for a transfer area in the conveyor system of the run-of-mine haulage are shown in Fig. 8, 9, 10, 11 and 12.

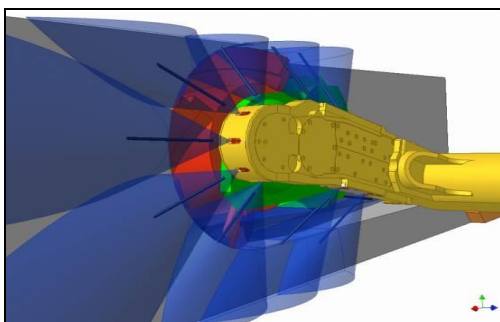


Fig. 8. Computer simulation of operation of the air-and-water spraying installation built in the RW-200N ranging arm of the KSW-460NE shearer [11]



Fig. 9 Air-and-water spraying installation built in the RW-200N ranging arm of the KSW-460NE shearer [11]

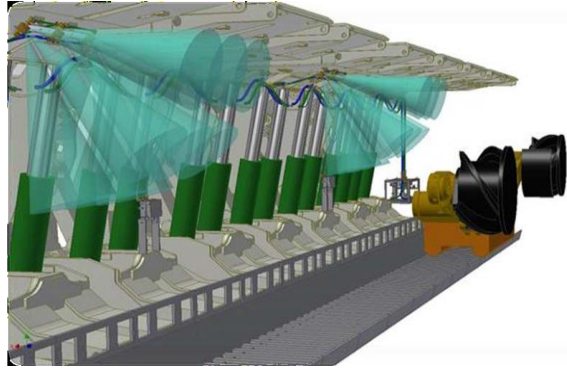


Fig. 10. Visualization of the longwall air-and-water spraying system of KOMAG type [12]

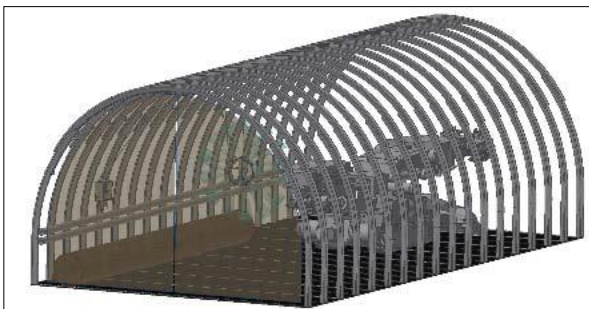


Fig. 11. Visualization of the EMZ-BRYZA roadway dust barrier [12]

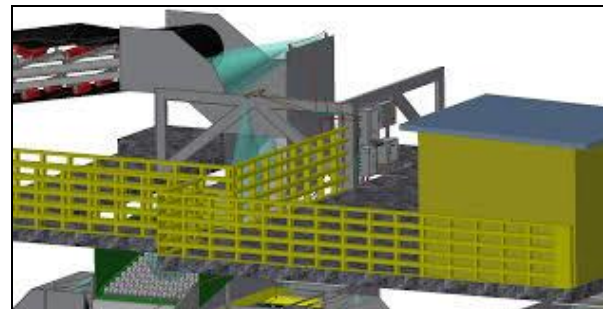


Fig. 12. Visualization of a part of the NEPTUN spraying system – a transfer point in the area of raw coal bunkers [13]

Besides, in this field KOMAG renders services in the scope of technical consultancies, analytical and computational services with use of computer technologies and it elaborates analyses, technical assessments and expert opinions in the scope of selecting machines and equipment for an application in specific mining and geological conditions.

Apart from the innovative design solutions presented above, some information on powered roof supports should be given as well.

KOMAG conducts research-and-development as well as implementation projects in the field of powered roof supports, including an elaboration of new and a modernization of the existing powered roof support units, units of supports for a special application (e.g. supports of crossings: longwall and roadway), individual supports of special designation (e.g. rescue supports), systems of hydraulic supply and control and an installation of pipelines.

Three types of the KOMAG shield supports were implemented for a mechanization of longwall faces of the height from 1.0 to 5.0 meters.

In 1978 the FAZOS Factory started a production of the chock-and-shield supports: FAZOS-12/28/Oz and FAZOS-15/31-Oz elaborated at KOMAG. The GLINIK Factory started a manufacture of the GLINIK-08/22-Oz and GLINIK-05/15-Oz supports. A development of the design and production of powered roof supports caused that in the seventies of the last century over 22,000 of the FAZOS-12/28-Oz powered roof support units were produced.

Two examples of powered roof supports, used at present, are shown in Fig 13 and Fig. 14.



Fig. 13. KHW 12/28-POz/Pp powered roof support unit [14]



Fig. 14. HYDROMEL 16/34-POz powered roof support unit [14]

At present 3D methods of designing and numerical calculations with use of the FEM method are applied in the process of developing designs of powered roof supports.

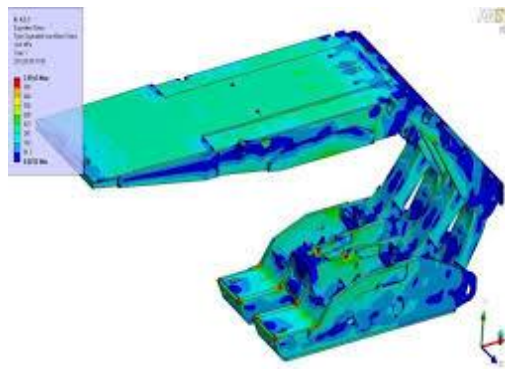


Fig. 15. An example of using the Finite Elements Method (FEM) in the designing process of a powered roof support unit [14]

KOMAG also offers services concerning technical consultations, analytical and computational services, using computer technologies. It also elaborates analyses, technical assessments and expert opinions from the scope of selection, design, manufacture and exploitation of powered roof supports.

Presenting development processes of machines and equipment of KOMAG preparation systems of minerals which plays a significant role in the KOMAG scope of activity, should be mentioned.

KOMAG conducts research-and-development, design and implementation projects in the field of processing minerals (Fig. 16), in particular a development of concepts, projects and documentations of devices such as: pulsating jigs for coal beneficiation and a recovery of coal from coal waste, bucket conveyors, classifiers (Fig. 17), crushers and grinding mills, screens, sizers, automatic samplers and dewatering centrifuges. Over the period from 1955 to 2020 technical documentations of over 320 beneficiation devices (new and modernized ones), including over 200 separators in the pulsating water medium, were elaborated. The jigs operate in Polish and foreign hard coal mines in Brazil, China, India, Romania and Vietnam, and their modified constructions are used in production plants of aggregates. A modification of jigs construction enabled to apply them for processing mine waste deposited on dumps. Due to an improved construction of jigs it is possible to recover simultaneously the coal which is in the waste and full-value aggregates used in building or road-construction technologies.



Fig. 16. Beneficiation node at the Budryk Mine after modernization [15]



Fig. 17. Pulsatory classifier of dividing and separating organic and mineral impurities from natural aggregates [16]

KOMAG also offers services in the scope of technical as well as analytical-and-computational consultancies, using the latest computer technologies. It elaborates analyses, technical assessments and expert opinions in the field of processing minerals. It conducts author's supervision of manufacture and start-up of the designed machines and equipment and it also offers testing of preparation processes of minerals in the laboratory, half-technical and industrial scale.

Outstanding technical achievements concern environmental technologies and vibroacoustics. Some examples are shown in Fig 18 and 19.



Fig. 18. Silencer of the air draw and ejector installed at the Jankowice Mine [17]

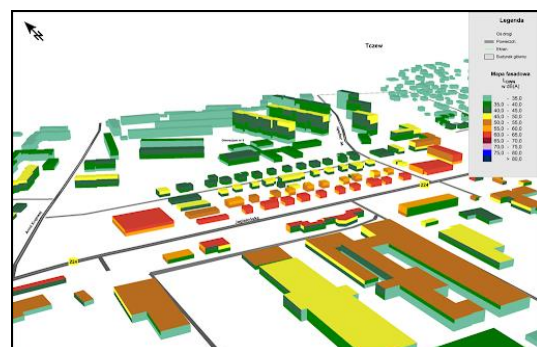


Fig. 19. Acoustic map of one of the roads in the Pomorskie Voivodeship [18]

Models of acoustic field distribution in closed spaces, in the areas of urban agglomerations, transport systems and of industrial plants in the aspect of environmental impacts were widely used. The same concerns acoustic maps and programmes of environmental protection against noise, means of reducing noise and vibrations connected with a modernization of cubature objects, projects of land development calculations of costs and take-off activities.

As it has already been mentioned projects on mechatronic systems are oriented onto automation systems for machines, equipment, technologies and computer applications of testing, communication, internet character and also of sensor system solutions. One of the outstanding achievements concerns a development and an implementation of the GATHER data software, incorporated in the system of electronic identification of elements of powered roof supports (Fig 20). The researchers are able to realize complicated mechatronic projects, taking advantage of their experience in mechanical engineering, automation, IT and electronics. At their disposal they have specialistic test rigs, enabling to construct the designed systems and their complex testing before an industrial implementation (Fig. 21).

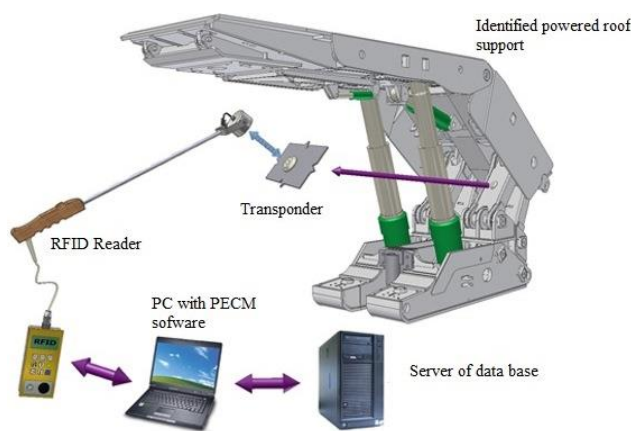


Fig. 20. Electronic identification of elements of powered roof supports [19]



Fig. 21. Control system of the laboratory test rig

4. Accredited Body Certifying Products

The KOMAG scope of activity also covers assessments and certification of products, conducted at the Division of Attestation Tests, Certifying Body which is [20]:

- the accredited body certifying products No. AC 023 which conducts a certification of machines and equipment mainly designed for an application in mining plants in accordance with the scope of accreditation,
- the notified body No. 1456 which conducts conformity assessments with three Directives:
 - 2006/42/WE (testing of WE type),
 - 2014/34/UE (module B: testing of UE type, module D: conformity with the type, based on ensuring the quality of a production process, module F: conformity with the type based on the product verification, module C1: conformity with the type based on internal control of production and testing of products under supervision, module E: conformity with the type based on ensuring the product quality, module G: conformity based on the unit verification),
 - 2009/488/WE (testing of type – module B).
- the body conducting tests and assessments of products subject to approvals for an application in mining plants on the base of Article 113, Item 3 of the Act from 9th June 2011 – Geological and Mining Law – realizes tests and assessments in the scope of:
 - elements of mine shaft hoists, among others, hoisting machines and conveyances, pulleys, suspension gears of hoisting ropes, load-carrying suspension gears of hoisting conveyances, shaft signaling and communication devices,

- products used in the workings of underground mining plants, among others, rope transport devices, suspended monorails, floor-mounted railways and their subassemblies; mine cars as well as vehicles with a diesel drive for transportation of personnel; electric machines and equipment and switchgear for the voltage above 1 kV of AC or above 1.5 kV of DC; communication, safety and alarm systems as well as integrated control systems of mining and face systems; conveyor belts.

5. International collaboration

For many years KOMAG has been collaborating, on a large scale, with over fifty foreign scientific-and-research organizations, universities, enterprises and companies from Spain, the Netherlands, Germany, Portugal, Romania, Slovenia, Hungary, United Kingdom, Finland, Latvia, Ukraine, the Czech Republic, Greece, Bulgaria, the Slovak Republic and France. This collaboration has concerned, in particular, the research areas of priority character, supported by the European Commission in the framework programmes such as: health, energy, new materials and IT as well as ecology.

The KOMAG representatives take part in the activities of international research organizations such as the European Association for Coal and Lignite – EURACOAL, the Research Fund for Coal and Steel, the Coal Advisory Group of the European Commission and in the European Standardization activities within the CEN/TC 196/WG-3: Machines for underground mines – Roof support. KOMAG also participates in the activities of the following working groups: Safety of Toys and Equipment for Explosive Atmospheres. The objectives of the undertaken research projects, oriented onto a realization of the basic strategic tasks, aim at an integration with the European Research Area in the scope of designing, testing and manufacturing of machines and equipment as well as an increase of competitiveness of Polish technical solutions on the European market. A high scientific position of the Institute in the European Research Area was officially confirmed, when KOMAG was acknowledged to be the Centre of Excellence in the scope of state-of-the-art and reliable mechanical systems which are operator and environment friendly within the V Framework Programme of the European Commission. International scientific and research projects of innovative character are directly co-financed by the financial sources of the Research Fund for Coal and Steel, the HORIZON 2020, the Erasmus and the Programme HORIZON EUROPE, started this year, which opens new possibilities for a development of research projects, in particular on reducing environmental foot print, improving circularity in extractive and processing value chains, raw material preparation for clean steel production, raw materials for EU strategic autonomy and successful transition to a climate – neutral and circular economy, sustainable and innovative mine of the future, innovative solutions for efficient use and enhanced recovery of mineral by – products from processing of raw materials [21].

Presenting the achievements of the KOMAG Institute in the field of international collaboration, an organization of cyclic scientific-and-technical conferences and workshops, which are one of the tools contributing to a dissemination of specialistic knowledge and a promotion of innovations, should be mentioned. An organization of such undertakings, their subject-matter, coherent with the priority development directions of knowledge in Europe, a participation of best specialists from Poland and from foreign countries have a positive impact on the image of the KOMAG Institute and its perception as a modern scientific-and-research Institute, having an important position in the international research area and playing an important role in the development process of the economy based on knowledge and innovations.

6. Awards and distinctions granted to KOMAG

One of the appreciation forms, confirming the significance and innovativeness of KOMAG results of scientific, research and technical projects, includes awards and distinctions obtained at different exhibitions and competitions in Poland and abroad. A few examples of such outstanding achievements in recent years are as follows:

- Silencer of air draw and ejector.
- BH 300B-HYDKOM 75 Loader.
- KOGASTER intrinsically safe control system.

- Air-and-water pressure instalation.
- PECM system with the GATHER module.
- Auxiliary mine transport arrangement.
- Ventilation system of objects of low acoustic emission.

The above mentioned innovative solutions were awarded at the International Warsaw Exhibition of Innovations -IWIS, the Poznan Fairs, the World Exhibition of Innovations, Brussels Innova, iENA, Concours Lepine, EUROINVENT, INTARG®, the International Fair of Mining, Power Industry and Metallurgy Katowice. They were also awarded by the Minister of Science and Higher Education.

7. Final remarks and conclusions

A scientific development of employees is an important priority objective of the KOMAG Institute. A well-educated staff, having a creative approach to challenges, expressed by the state-of-the-art industry and the requirements of legal regulations concerning the activity of scientific organizations, has a decisive impact on the position and rank of the Institute. The programme of the KOMAG employees' scientific development, which has been active for 20 years, plays an important role in the process of shaping the staff potential.

A system of doctoral, preliminary and "Young Scientist" grants enables young employees to enter the path of a scientific development. Under a supervision and care of the Director's Advisors' Team in which there are professors, representing different branches of science, young employees identify scientific objectives, scope and methodology of their future doctoral theses. At present six KOMAG employees work on doctoral theses of practical application oriented onto solving particular problems experienced by the Institute.

Dynamically changing economic and social conditions force KOMAG to meet more and more sophisticated requirements of interdisciplinary character. The main requirement, which has a big significance for the process of the Institute further development, includes a creation and an industrial implementation of technologies, mechanical and mechatronic systems, automation and robotics oriented on to safer and more efficient gaining of minerals.

Economic conditions determine changes in innovative activities which require an introduction of regular up-dating and extending corrections of the KOMAG strategic objectives. The last document, concerning the Institute development strategy, encompasses the period till the year 2025 [16]. It incorporates the requirements of the Industry 4.0 which are related to a different business model of companies and branches of industry. The KOMAG strategy is oriented onto an application of the state-of-the-art, smart information technologies and automation at each stage of the product manufacture, starting from the phase of design, through tests, production and maintenance as well as recycling. Sensor technologies, Internet of Things and Big Data Sets, Computational Clouds and telecommunication technologies, enabling a rapid data transfer, will be implemented onto practice. An introduction of digital transformation will encompass all the areas of the KOMAG activity.

The strategy of KOMAG activities till the year 2025 is concentrated on the research fields, where the Institute reached the world level, participating in the process of constructing the ecosystem of innovations and of the e-economy. It includes directions of smart specializations in the scope of safety, energy, natural environment and waste management. Nine objectives are determined: Innovativeness, Commercialization, Occupational Safety, Safe Use of Products, Environmental Protection, International Collaboration, Staff Development, Promotion of Innovations - Knowledge Share, Finance, Social Impact of System.

In the scope of creating innovative technologies and technical means, the KOMAG Institute of Mining Technology will continue a close collaboration with Polish and foreign scientific and industrial partners. An essential role will be played by industrial partners. A collaboration with them will be carried out within contracts, scientific-and-industrial networks, technological platforms, centres of advanced technologies.

Over seventy years of the KOMAG history obliges for a realization of the strategic objectives which guarantee a high position of the Institute in the Domestic and European Research Areas and

an extension of collaboration with producers and users of machines and equipment in the scope of technical and technological solutions which are safe as well as operator and environment friendly.

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