

## Seventy-year activity of the KOMAG Institute in support of environmental protection

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Abstract:

Seventy years of interdisciplinary activities of the KOMAG Institute of Mining Technology in support of widely understood environmental protection are presented in the article. The research and development projects oriented onto subject-matter of environmental protection and realized within the framework of the statute, research, research-and-development, ordered, thematic as well as testing-and-servicing activities are described. The article also contains some information about a dissemination of knowledge on environmental protection during the KOMEKO scientific and technical conferences which have been organized by KOMAG since the year 2000.

Streszczenie:

W artykule przedstawiono siedemdziesiąt lat interdyscyplinarnych działań Instytutu Techniki Górniczej KOMAG w zakresie szeroko rozumianej ochrony środowiska. Opisano projekty badawczo-rozwojowe, ukierunkowane na tematykę ochrony środowiska, zrealizowane w ramach działalności statutowej, projektów badawczo-rozwojowych, zamawianych, celowych oraz działalności badawczo-usługowej. Artykuł zawiera również informację na temat dzielenia się wiedzą, dotyczącą ochrony środowiska, podczas konferencji naukowo-technicznych z cyklu KOMEKO, organizowanych przez KOMAG od 2000 roku.

### 1. KOMAG Institute of Mining Technology – a short history of a seventy-year activity

The KOMAG Institute of Mining Technology was established on 1<sup>st</sup> January 2009 [1], but its history dates back to 1950. An establishment of the Institute was preceded by organizational activities changing both the name of the organization as well as the scope of its activity. In 1950 Centralne Biuro Projektów (Central Bureau of Projects) was transformed into Biuro Konstrukcji Maszyn Górniczych (Design Bureau of Mining Machines). In 1953 the name was changed for Centralne Biuro Konstrukcji Maszyn Górniczych (Central Design Bureau of Mining Machines) with its seat in Gliwice. In 1957 Centralne Biuro Konstrukcji Maszyn Górniczych and Instytut Mechanizacji Górnictwa (Mining Mechanization Institute) established in 1951, were combined. In the result of such a combination Instytut Doświadczalno-Konstrukcyjny Przemysłu Węglowego (Experimental-and-Design Institute of Mining Industry) was established. In 1958 its name was changed into Zakłady Konstrukcyjno-Mechanizacyjne Przemysłu Węglowego (Design-and-Mechanization Works of Mining Industry). An increasing demand from the mining industry caused a dynamic development of ZKMPW. Within a few years new organizational branches were added such as: Zakład Elektroniki Górniczej (Plant of Mining Electronics) in Tychy, Elektrometal in Cieszyn, Zakład Budowy Maszyn Doświadczalnych (Construction Plant of Experimental Machines) and Zakład Cybernetycznych Kompleksów Górniczych (Plant of Cybernetic Mining Systems) in Biskupice. The M300 Experimental Mine and the Jan Experimental, Automated Mine in Katowice were included in the ZKMPW structure. Then Ośrodek Szkolenia Maszynowego (Centre for Machine Training), functioning within this organizational structure was transformed into Zakład Doskonalenia Kadr (Plant

of Personnel Improvement). The next reorganization was implemented in 1975. The Construction Plant of Experimental Machines, the M300 Experimental Mine and the Plant of Personnel Improvement were separated from the Design-and-Mechanization Works of Mining Industry, establishing Centralny Ośrodek Projektowo-Konstrukcyjny Maszyn Górniczych KOMAG (KOMAG Central Design-and-Construction Organization of Mining Machines) in Gliwice. This organization obtained the status of a research-and-development centre, subordinated to the POLMAG Association of Mining Machinery Industry. Then KOMAG became the design, research and development base for all the factories in the POLMAG Association. They were: FAMUR, FAZOS, TAGOR, RYFAMA and GEORYT. In all those factories KOMAG had its local design branches [2].

The Ośrodek Projektowo-Technologiczny Maszyn Górniczych ORTEM (ORTEM Design-and-Technical Centre for Mining Machines), with its seat in Mikołów, was incorporated into KOMAG in 1979. This change caused that the KOMAG scope of activity was broadened by the subject-matter of a production technology of mining machines and equipment as well as by the subject-matter of production organization and management. The name was changed into the Centrum Konstrukcyjno-Technologiczne Maszyn Górniczych KOMAG (KOMAG Design-and-Technological Centre of Mining Machines). In the result of the next rearrangement, conducted in March 1990, the Centrum Mechanizacji Górnictwa KOMAG (KOMAG Mining Mechanization Centre), a research-and-development organization was set up.

In the consolidation process of research-and-development organizations, supervised by the Minister of Economy, the Ośrodek Badawczo-Rozwojowy Reduktorów i Motoreduktorów REDOR (REDOR Research-and Development Centre for Reducers and Motoreducers), with its seat in Bielsko-Biała, was included into KOMAG in 2005 and in 2006 the Ośrodek Badawczo-Rozwojowy Budownictwa Górniczego BUDOKOP (BUDOKOP Research-and-Development Centre for Mining Construction), located in Mysłowice, was incorporated by KOMAG.

Due to significant broadening of the KOMAG scope of activity, the name of the organization, did not reflect a broad spectrum of the scientific, research and technical activity, conducted by KOMAG, within innovative solutions for the economy. Taking this fact into consideration, a letter of application was sent to the Ministry of Economy with a request of approving the change of the name, i.e. Centrum Mechanizacji Górnictwa KOMAG (KOMAG Mining Mechanization Centre) into Instytut Techniki Górniczej KOMAG (KOMAG Institute of Mining Technology).

In the first years of its seventy-year lasting history the research-and-design projects were mainly oriented onto machines and equipment for mining coal seams. The subject-matter and scope of these projects were developed within years. At present scientific, research and technical projects, realized at KOMAG are oriented onto mechanical and mechatronic systems such as: machines and equipment for underground exploitation of mineral resources, mechanical preparation of minerals as well as supply, control, diagnostic and monitoring systems. The developed conceptions, projects and technical documentations of machines and equipment, are adapted for an execution of required functions and tasks in the in-situ mining and geological conditions. Model, laboratory and industrial tests are conducted to increase life, reliability, operational safety and ergonomics of mining machines. Several projects deal with, widely understood, environmental protection, in particular as regards mining sites and also other areas badly affected by the industry. Since 1950 more than 1100 technical documentations of machines and equipment, applied in mines of minerals in Poland and abroad, have been generated. More than 4400 patents and utility patterns, obtained so far, confirm an innovative character of KOMAG technical solutions.

The scope and the subject-matter of the research-and-development projects have been modified and up-dated since the beginning of the KOMAG activity which resulted from a current demand of the developing and restructuring industry. In general, the thematic scope of the projects can be presented as follows:

- a development of innovative mechanical solutions for longwall and road-heading systems of minerals' mining,
- shaping of smart work environment in the mining industry,
- a development of innovative systems for horizontal and vertical transportation and for men-riding in mines of minerals,

- an improvement of technologies and technical systems for a beneficiation and classification of minerals,
- a development of innovative mechatronic solutions supporting production processes of minerals,
- a development of innovative solutions reducing hazards and increasing work safety,
- an environmental management of industrial and urbanized areas according to the strategy of sustainable development,
- a development of technologies and methods for environmental protection,
- a development of technologies of using and dumping waste,
- a development of techniques and technologies for a management of natural heat sources-geothermics, hydrothermics and aerothermics,
- “clean” technologies ensuring safety of energy supplies,
- a creation of smart solutions according to Industry 4.0,
- a use of smart solutions in supply, control, diagnostic and monitoring systems of machines and equipment,
- a use of innovative hydraulic and pneumatic systems for machines and equipment,
- a development of innovative drive systems,
- an improvement of the management system and a development of methods and procedures of products’ conformity assessment,
- an expansion and modernization of the Institute testing infrastructure,
- a generation and a development of testing methods and procedures,
- an application of new construction materials and new manufacturing technologies.

In the mentioned thematic fields the Institute realized:

- the statute activity within research tasks, “Young Scientist” grants, initial grants, doctoral and post-doctoral grants,
- research-and-development projects, targeted and ordered projects financed from different external sources,
- European projects with different foreign and domestic partners,
- service, expert and specialist activity,
- training activity.

The KOMAG Institute of Mining Technology has three specialist accredited testing laboratories equipped with the state-of-the-art apparatus:

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

and the Division of Attestation Tests, Certifying Body.

The Institute collaborates with foreign partners from Spain, the Netherlands, Germany, Portugal, Romania, Slovenia, Hungary, Great Britain, Finland, Latvia, Ukraine, Czech Republic, Greece, Bulgaria, Slovakia and France. It is a member of three clusters: Cluster of Mining Machines, Silesian Cluster of Design and Cluster of Culture and Industrial Tourism. It participates in the activities of three technological platforms, in particular in the Polish Technological Platform “Environment”.

## 2. KOMAG activities in the scope of clean coal technologies

One of the most important activities in environmental protection includes clean coal technologies (CCT). These technologies aim at an improvement of coal extraction, preparation, processing and utilization and at an increase of acceptance of these processes from the point of view of their impact on the natural environment. This classical definition comes from the publications of the International Power Organization and the World Coal Institute (since 2010 it has been the World Coal Association) [3, 4]. The term “clean coal technologies” relates to the “whole coal chain” starting from the coal

extraction to a utilization of the waste after its use. Four main subdomains of the CCT are distinguished:

- coal extraction taking into consideration sustainable management of resources together with coal preparation understood as a process of preparing coal for being used, most often it is so called coal mechanical preparation,
- coal transport and depositing,
- use of coal (in power engineering and in coal processing), together with all the activities reducing a negative impact of coal usage on the environment (apart from the issues of wastes and “semi-products”),
- management of “residues” from coal usage, i.e. different type of wastes, and also semi-products, suitable for a further economic use.

As far as this scope is concerned, the role of the KOMAG Institute of Mining Technology is crucial, because since its very beginning mechanical preparation of hard coal and other minerals has been an essential field of its activity. In this scope the segment of machines and equipment for a beneficiation of the run-of-mine in heavy medium (DISA separators) and in pulsating water environment (jigs) belongs to the most important ones. Over the years 1955-2019 technical documentations of more than three hundred twenty separators (new and modernized ones), including over two hundred separators in water pulsating environment [5], were elaborated. At present the jigs of KOMAG type for a beneficiation of different grain classes are under construction. They include OM fines jigs for grain class 20-0(0.5) mm, OS medium-size grain jigs for grain class 80(50)-0(0.5) mm and OZ grain jigs for grain class 120-20 mm. The jigs have different modifications resulting from the users' requirements and installation conditions. Jigs are operated in Polish and foreign hard coal mines – in Brazil, China, India, Romania and Vietnam and their modified constructions – in production plants of aggregates. A modification of jigs' design enabled to use them for processing of extraction waste deposited on dumps. Due to an improved design of jigs, it is possible to regain coal which is contained in the waste and also aggregates which can be used in the construction industry or road construction technologies. An example of such a classifier is shown in Fig. 1. It is operated in the Plant of Aggregates in Przechlebie [7]. A list of jigs, designed in the years 1955-2019 and implemented in the Polish hard coal mines, production plants of aggregates and with a destination for export, is presented in Table 1 [6].

A development of pulsatory jigs' design over years consists in an improvement of technical solutions, aiming at changing technical parameters, which have an essential impact on operational advantages, including quality of obtained coal, production capacity and exploitative costs of a beneficiation process. The conducted research-and-development projects concerned a wide scope of activities, which resulted in innovative technical and technological solutions. Over the years a design of jigs' working compartments, of pulsatory valves, of sieve decks, of control systems of pneumatic rams and of the systems collecting beneficiation process products was developed. A unique, authors' System of Pulsatory Jig Control of the KOMAG type (KOGA) together with a bucket conveyor in a jig beneficiation node [6, 8] was implemented. Many innovative solutions are protected by patents.

A design modernization results from many projects realized within the framework of research tasks of the statute activity “Young Scientist” grants, initial and doctoral grants. Some research-and-development, targeted and ordered projects, financed from different external sources, and also European projects with a participation of different foreign and domestic partners, were conducted. An active role of the KOMAG specialists, dealing with a preparation of minerals in the scope of service expert and specialist activities, should be highlighted. As far as the subject-matter of minerals' preparation is concerned four doctoral procedures were successful. It is worth mentioning that an innovative design solution of a pulsatory classifier obtained the prize at the Fair of Power and Metallurgical Industry in Katowice, in 2007.

The changes of selected parameters in the result of a design development, which can be seen over the period of several dozen years of designing jigs of KOMAG type, are presented in Table 2.





**Fig. 1.** K-102 No.2 pulsatory classifier built in the installation for a reclamation of extractive waste dump [7]

**Table 1.** List of jigs of KOMAG type designed over the years 1955-2019 [6]

Period of production	Type of jig	Place of installation
1955-1970	OBM12, OBM15, OBSZ15, OBZ10, OBZ12	Hard coal mines: Anna, Dębieńsko, Knurów, 1-Maja, Nowy Wirek, Mysłowice, Rydułtowy, export to China, India and Vietnam.
1971-1985	ODM10, ODM18, ODZ15, OM12, OM12-2, OM12-3, OM12-3S, OM12G3, OM12P3, OM12L3, OM18P3, OM18L3, OM24-3, OM24D, OM24B3, OM24D3, OZ18L, OZ12, OZ12L, OZ12P3, OS36D3, OZ36D3, OC8, OC10	Hard coal mines: Bogdanka, Borynia, Dębieńsko, Gliwice, Halemba, Knurów, Krupiński, Jankowice, Makoszowy, Marcel, Pniówek, Dymitrow, Rydułtowy, Sońnica, Staszic, Wujek, Szczygłowice, Wawel, Zabrze, Zofiówka, Moszczenica, export to Brazil, India and Romania.
1986-2014	OM8L2e, OM8L2E, OM10L2E, OM15P3E, OM12P3E, OMPE-3x6,5, OM18L3E, OM18P3E, OM20P3E, OM20L3E, OM24P4E, OM24L4E, OM24D3E, OS24D3E, OM30-3E, OM18 3x8, OM30D3E, OS30D3E, OM30, OZ18, OZ18L3E, KOD Jig	Hard coal mines: Andaluzja, Anna, Barbara-Chorzów, Bogdanka, Borynia, Budryk, Dębieńsko, Halemba, Jastrzębie, Jas-Mos, Knurów, Krupiński, Marcel, Pniówek, Rozbark, Rymer, Rydułtowy-Anna, Sońnica, Staszic, Szczygłowice, Wawel, Wujek, Zofiówka, export to Czech Republic and India. Budryk for stone removal.
2003-2018	Pulsatory classifiers: K-100, K-150, K-50, K-80, K-101, K-102, K-151	KSM Ltd in Borzęcin, PPMD KRUSZBET, J.S.C. in Suwałki, PRInż. Surowce Ltd. in Januszkowice, PUHM „M +” Ltd. in Kędzierzyn Koźle, Gravel Mine Bierawa, PRESTO Emil Potręć, Rokitno, Rent-Pol – Przezchlebie
2014-2019	OM30, OS18L, OS18P, OM15L, OM15P, OS4, OM20, OS18L OS18P, OM24, OM15L i OM15P	Hard coal mines: Sońnica, Krupiński, Pniówek, Budryk, Zofiówka, ZG Eko-Plus, ZG Sobieski.

**Table 2.** Changes of selected technical parameters of KOMAG type jigs designed over the years 1960-2018

Parameter characterizing the jig	Years of production			
	1960	1970	1975	2018
	Type of jig			
	OBM12	ODM18	OM24	OM24
Nominal capacity, t/h	125	250	500	640
Unit capacity (for 1m <sup>3</sup> of sieve),t/h	10.5	14.0	20.8	26.7
Jig weight, t	120	70	40	41
Consumption of compressed air, m <sup>3</sup> /min	200	140	100	90
Consumption of water, m <sup>3</sup> /h	1800	1200	1000	900
Total installed power of equipment, kW	250	200	130	110
Imperfection coefficient	0.20	0.16	0.15	0.15

In the scope of the coal mechanical preparation KOMAG design-and-research projects also concerned hydrocyclones, for example a type-sites of hydrocyclones “water only” of diameters: 300, 225 and 150 mm, screens and crushers. They are essential elements of technological preparation systems. Design projects from this scope, based on technical documentations, were implemented into industrial practice successively.

Thus the activity of the KOMAG Institute of Mining Technology, in the scope of clean coal technologies, consists in improving machines and equipment for use in mechanical preparation plants in mines which enables to obtain beneficiated coal of high quality parameters and when used in plants of aggregates – to liquidate the mining waste dumps as well as to gain valuable sources for an industrial use.

### 3. Dissemination of knowledge on environmental protection

Presenting KOMAG achievements in the scope of environmental protection, it is worth giving some information about the KOMEKO scientific and technical conferences which have been organized by the Institute since the year 2000 (since 2019 it has been named KOMEKO-IMTech). KOMEKO-IMTech is oriented onto innovative and environment friendly techniques and technologies for processing of minerals. The thematic scope of this conference is broad and it incorporates:

- rational management of minerals in preparation and processing systems,
- latest technologies of minerals' preparation,
- new materials and technologies for a production of preparation machines,
- new design solutions of preparation machines,
- smart mechatronic systems supporting preparation processes,
- automation of preparation processes,
- systems of control, diagnostics and visualization of processes,
- harmful factors in preparation processes – control of hazards,
- ecological aspects in preparation processes,
- modernization trends of preparation plants,
- problems of safety and health protection in preparation plants,
- recovery and processing of industrial wastes,
- innovative technologies of extractive waste management,
- coal gasification technologies,
- methods of production and use of alternative fuels,
- recultivation, revitalization and remediation of degraded post-mining sites,

- beneficiation and gaining rare earth elements,
- systems of supervision, visualization and inventory control of post-mining and revitalized sites,
- closed-loop economy,
- water management.

Organized every year, cyclic conference meetings of Polish and foreign scientists, researchers, representatives of machinery producers and of end-users of minerals' preparation machines and equipment as well as specialists from widely understood environmental protection field, enable to exchange experience and present scientific, technical and implementation achievements realized by scientific and industrial organizations. In total about two thousand participants have taken part in twenty KOMEKO conferences organized so far. Four hundred ninety five papers were presented and published. Descriptions of the achievements, presented during these conferences, were published in a form of conference proceedings, monographs and they were also published in the KOMAG Quaterly "Maszyny Górnicze" (Mining Machines). In 2019 some of the presented papers (nineteen) were published in English in the conference proceedings IMTech – Innovative Mining Technologies, in a form of Open Access in the IOP Conference Series: Materials Science and Engineering, Volume 545.

#### 4. Summary

The activities of the KOMAG Institute of Mining Technology, conducted during nearly all the period of its functioning, respond to needs and development trends of science and technology in the scope of environmental protection. These activities give extremely valuable research results which are beneficial for the national economy and also for each citizen of our country, who lives in this environment.

The undertaken activities effectively reduce, and in many cases eliminate, hazards generated by an industry development. A multi-year experience of the KOMAG researchers, a significant role of the Institute, which is highly appreciated both in Poland and abroad, confirm its high scientific, technological and technical position in the European Research Area.

All the achievements of the past contribute to a further development of the KOMAG Institute of Mining Technology, strengthening its position in all the spheres of activities described in this article.

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