



Review / Praca przeglądowa

A historical overview of the activities of the Research Workgroup on Explosive Techniques, Łukasiewicz Research Network – Institute of Industrial Organic Chemistry in Krupski Młyn

Rys historyczny działalności Grupy Badawczej Techniki Wybuchowych Sieć Badawcza Łukasiewicz – Instytutu Przemysłu Organicznego w Krupskim Młynie

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Abstract: *The article presents the history of activity of the Łukasiewicz Research Network – Institute of Organic Industry - Explosive Techniques Research Group in Krupski Młyn, formerly known as the Institute of Organic Industry – Branch in Krupski Młyn. It describes the development of its research potential and infrastructure, scientific and research efficacy, and experimental production of explosive materials for civilian and special purposes.*

Streszczenie: *Przedstawiono historię działalności Sieci Badawcza Łukasiewicz – Instytut Przemysłu Organicznego – Grupa Badawcza Techniki Wybuchowych w Krupskim Młynie, wcześniej Instytut Przemysłu Organicznego – Oddział w Krupskim Młynie. Opisano rozwój jej potencjału badawczego i infrastruktury, efektywność naukowo-badawczą, produkcję doświadczalną środków zawierających materiały wybuchowe dla celów cywilnych i specjalnych.*

Keywords: *Łukasiewicz Research Network – Institute of Organic Industry, Explosive Techniques Research Group in Krupski Młyn, materials incorporating explosives*

Słowa kluczowe: *Sieć Badawcza Łukasiewicz – Instytut Przemysłu Organicznego, Grupa Badawcza Techniki Wybuchowych w Krupskim Młynie, środki zawierające materiały wybuchowe*

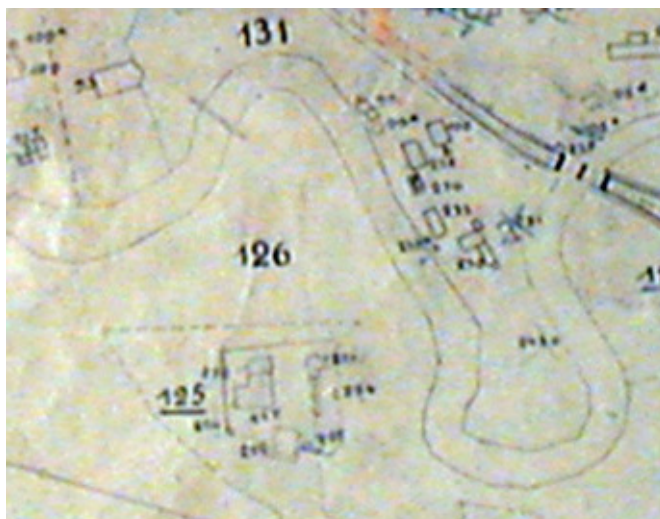
1. Introduction

The Łukasiewicz Research Network – Institute of Organic Industry (Łukasiewicz-IPO) – Explosive Techniques Research Group in Krupski Młyn is the successor of the Third Branch Department of the Institute of Applied Chemistry in Warsaw. The Third Branch Department of the Institute of Applied Chemistry in

Krupski Młyn, as one of the Branch Departments of the Institute of Applied Chemistry in Warsaw (renamed as the Institute of Organic Industry as of 1 January 1958), was established by the Resolution of the Praesidium of the Government no. 482/55 on 3 September 1955 and the Board of the Minister of Chemical Industry on 14 February 1956 [1, 2]. The Department was planned and established in a location with an explosive production heritage. It was located on a leased several-hectare property, in Explosives Factory no. 3 in Krupski Młyn (later: Zakłady Tworzyw Sztucznych “Nitron” S.A., at present: NITROERG S.A.), in the facilities of the original factory laboratory (Figure 1).



(a)



(b)

Figure 1. Access gate to Explosives Factory no. 3 in Krupski Młyn (a) and location of the original factory laboratory in Krupski Młyn (b)

Explosives Factory no. 3 in Krupski Młyn (later: Nitron S.A., at present: NITROERG S.A.) continues the operations of the “Lignose Sprengstoffwerke GmbH” explosives factory established in 1874. Figure 2 is the original view of the factory. In the foreground are the facilities of the first laboratory of the explosives factory, which at present hosts the Explosive Techniques Research Group, Łukasiewicz-IPO.

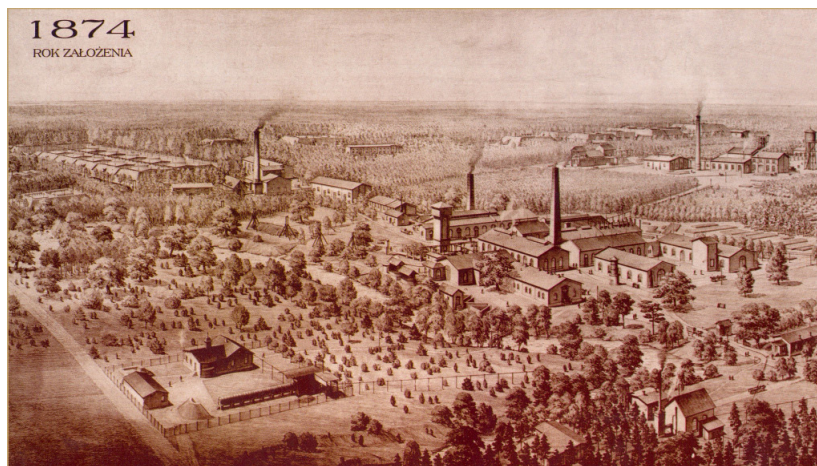


Figure 2. View of the establishment of the “Lignose Sprengstoffwerke GmbH” factory in Krupski Młyn (1874) [2]

The founder and the first manager of the Institute Branch in Krupski Młyn was Wiktor Załachowski (Figure 3). He managed the Branch until 1976. Then, the Branch was managed by Róża Przybylik and after she retired in 1996, by Wiesław Skóra. From 2002, the position of manager of the Institute Branch was held by Zenon Wilk [2]. Since 1 April 2019, the Institute of Organic Industry has operated as part of the Łukasiewicz Research Network. The Branch of the Institute of Organic Industry in Krupski Młyn was replaced with the Explosive Techniques Division, renamed to the Explosive Techniques Research Group on 1 May 2021. Once Zenon Wilk retired (July 2021), the position of manager of the Explosive Techniques Research Group in Krupski Młyn has been held by Sławomir Ball.



Figure 3. Wiktor Załachowski (1907-1976) – founder and first manager of the Institute Branch in Krupski Młyn

From the beginning of operations of the Branch Institute, its infrastructure and research facilities were systematically expanded. In 1960-1970, due to the efforts of the first manager, the research facilities were expanded in close co-operation with the “Nitron” factory. The Institute Branch, based on the explosives climate research station and experimental tunnels, began its research on safe explosives for the mining industry. In the following years (1970-1980), a new Branch expansion concept was developed, intended to be completed in two stages. The first stage, the purpose of which was to prepare the site for proper construction works, to secure the logistics on the site and to expand the laboratory, was completed. The second stage, however, which included the construction of a modern research network and firing chamber, was not fully completed due to the changes in priorities in central investment plans. In the following years, as part of the Institute’s own investments, new facilities and research stations were gradually built. The infrastructure was expanded by adding an administration building, explosives warehouses and a new research laboratory with experimental production facilities (Figure 4).

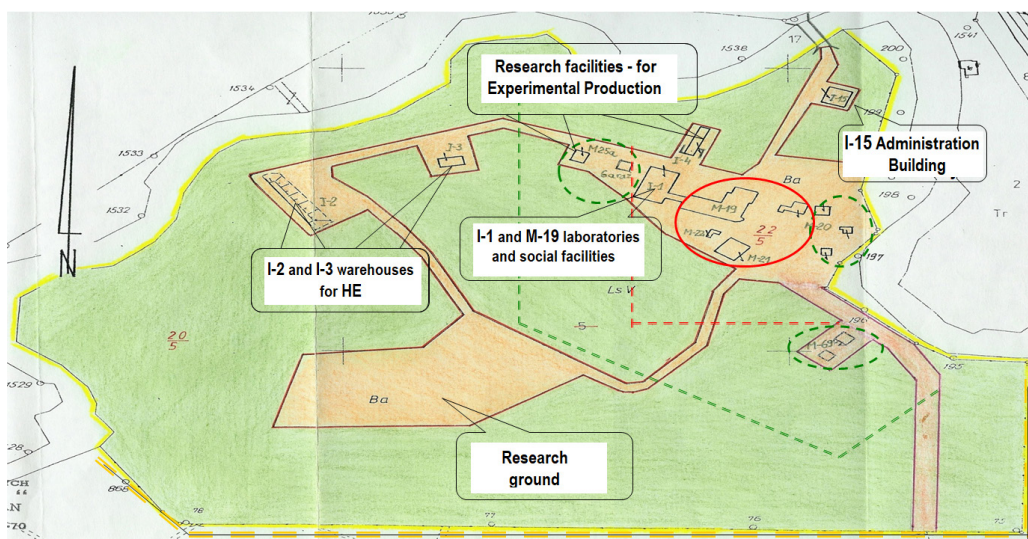


Figure 4. Operations of the Institute Branch in Krupski Młyn – used area and infrastructure development plan (1956-1972-1976)

In 2003, the Directorate of the Institute of Organic Industry in Warsaw decided to acquire the existing leased area (12 ha) from ZTS “Nitron” S.A., with all infrastructure managed by the Institute Branch in Krupski Młyn. Also in 2003, the Branch in Krupski Młyn obtained a licence from the Ministry of Internal Affairs and Administration (no. B-036/2003) to produce and trade explosives, weapons, munitions and products and technologies for military or police use. This significantly expanded the further growth opportunities of the Branch and the Institute, particularly those related to the research base, which became useful to all explosives groups, both in the Institute and in other research centres. In the following years, activities were undertaken and completed related to the full independence of the Branch from factory installations. Own/independent installations were upgraded or built: central heating, water supply and hydrant systems, own/independent electrical connection (cable with HV/LW-15/0.4kV switchgear) and own/independent ICT cable and fibre connections (broadband Internet).

In 2005, the Institute Branch in Krupski Młyn obtained a “GIG Quality Assurance Notification” (no. OQ5EXPQ002 of 27 April 2005), issued by the Notified Body, the Central Mining Institute, thus confirming the quality of production of explosives for civilian use as per Directive 93/15/EC. Henceforth, the Institute in Krupski Młyn had the right to label its products with the CE mark. In 2006, the ISO 9001 Quality

Management System was implemented and certified, and for special production purposes, the Institute obtained a certificate of conformity with AQAP 2110 requirements. Quality management systems are maintained and subject to continuous validation. They confirm the high quality of experimental and special production and the credibility of the research conducted by the Łukasiewicz-IPO – Explosive Techniques Workgroup in Krupski Młyn.

2. Scientific and research activities

The scientific and research activities of the Institute in Krupski Młyn, over the past 68 years, were primarily for customers, such as: opencast mining, coal and oil, explosives manufacturers, machine industry, aviation industry and special production customers (military and police) [3]. It should be emphasised that the entire domestic range of blasting materials for oil extraction and geophysics was developed and brought to production by the Institute in Krupski Młyn, in collaboration with the Oil and Gas Institute – National Research Institute in Kraków. The collaborative activities of the two institutes date back to the 1960s, when the former Oil Institute (at present: the Oil and Gas Institute – National Research Institute) created a unit to solve problems related to the technology of opening drill holes by shot firing and the implementation of new technologies in that area. Experimental production technologies were gradually implemented to application, for example in the production of temperature-resistant detonating cord for oil extraction, pressed charges for borehole mining and production of pressed shaped charge inserts from metal powders [4-16]. For other sectors, such as opencast mining and machine industry, shot products for cutting pipes at a wide range of diameters, charges for explosive pipe expansion in heat exchanger replacement, linear shaped charges in lead alloy coating for cutting steel structures and shaped charges for crushing rocks and mining works, were developed and brought to production [17-30].

The basic scientific activities of the Institute in Krupski Młyn include, above all, continuous development projects, charter projects or subsidised projects, aimed at modernising the explosives technologies in use, improving product quality and operational safety, as well as improving test methods. Explosive products were improved by the introduction of additives, for example fluoropolymers, to improve their operational safety and properties [31-33]. Linear flexible cutting charge technology based on explosives with added polymer adhesive and new designs of shaped charges with multi-layer reaction inserts, were developed. Research was conducted on pressure generating fuels in fracking systems for borehole mining [34-37].

Recently, a consortium of the Air Force Institute of Technology/Boryszew S.A. – Nylonbor Branch, pursued a research project “Development of flare technology and cassettes to launch them, as per the requirements STANAG 4687 for the passive defence of manned aerial platforms”. The consortium, lead by the Warsaw University of Technology – Heat Technology Institute, completed the task titled “Development of a gas-dynamic control module for precision missile guidance”.

Research work on the chemistry and technology of explosives and their testing at the Łukasiewicz-IPO – Explosive Techniques Workgroup in Krupski Młyn, have been presented at International Scientific Conferences „*IPOEX Explosives. Research – Application – Safety*”, International Seminars „*New Trends in Research of Energetic Materials*” in Pardubice (Czech Republic) and other, which were organized by: Institute of Industrial Organic Chemistry, Łukasiewicz-IPO, the Central Mining Institute, AGH University of Science and Technology (Kraków, Poland), Military University of Technology (Warszawa, Poland), Military Institute of Armament Technology (Zielonka, Poland) and the Oil and Gas Institute – National Research Institute (Kraków). Some works were published in, for example, „*Central European Journal of Energetic Materials*” [14, 18] and „*Materiały Wysokoenergetyczne*” [27, 29]. Over the years of activity a series of other studies has been published in branch periodicals or monographs, both national [2, 4, 7, 32, 34, 36] and international [9, 11, 12, 16].

2.1. Łukasiewicz-IPO research facilities in Krupski Młyn

Over the entire period of activity, the research facilities of the Institute in Krupski Młyn have been under continuous development. At present, the Explosive Techniques Workgroup has very comprehensive test capabilities of high energy materials and their applications. For testing purposes, it has appropriate sites and equipped test stations which meet occupational safety requirements. Explosive tests are performed as per PN-EN standards and proprietary methods, including individual customer requirements/needs. Some of these test sites and developed proprietary test methods are unique nationwide [13, 15, 22, 25] (Figures 6 and 7).

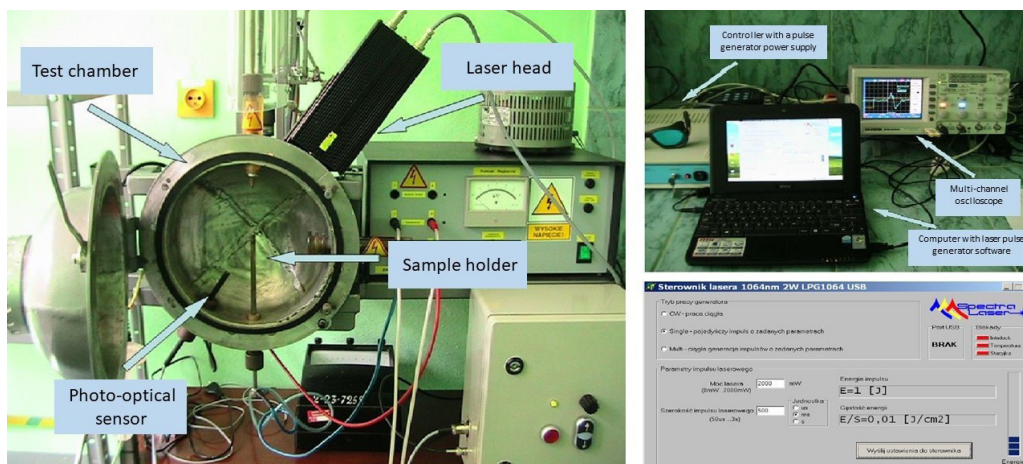


Figure 6. Electrical spark and laser radiation sensitivity explosives testing stations

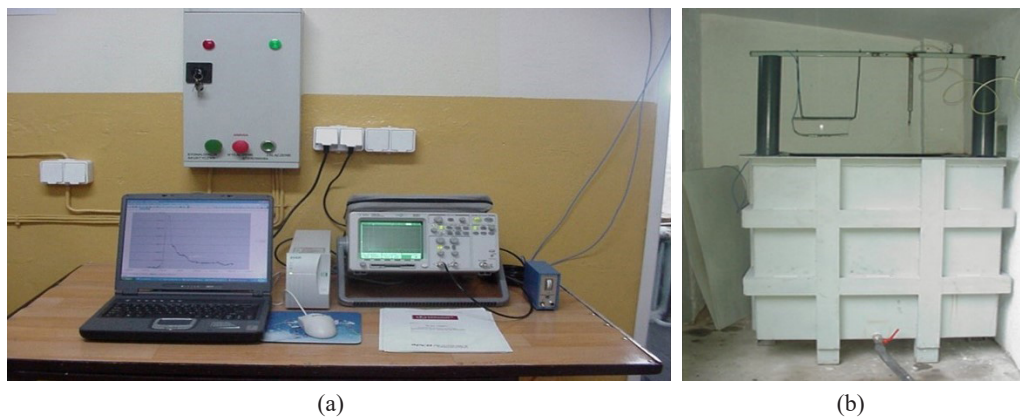


Figure 7. Igniter and primer testing station – determining the initiating capabilities equivalent (underwater explosion test method): apparatus for measuring the pressure of a shock wave (a) and water tank (b)

In addition, the Explosives Techniques Research Group in Krupski Młyn has a site for testing the reliable operation of shaped charges, a unique nationwide facility for electromagnetic explosives testing designed to determine the bulk velocity of detonation products, a ballistic pendulum for testing energy/work/explosives and proprietary methods for determining post-explosion blast wave pressure in air (Figure 8). The Łukasiewicz-IPO is a statutory transport classification unit (RID and ADR) for the transport of dangerous goods (European Agreement concerning the international carriage of dangerous goods) based on applicable regulations [26]. Some of these tests are performed on site at the Institute in Krupski Młyn (Figure 9).

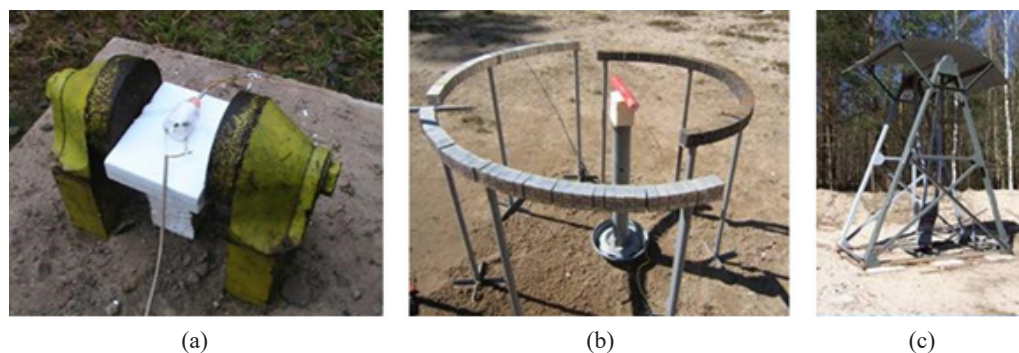


Figure 8. Site stations of the Institute in Krupski Młyn – selected unique test methods: electromagnetic explosive testing – determination of detonation products bulk velocity (a), determination of post-explosion blast wave pressure and energy directions in air (Held test) (b), and ballistic pendulum – energy/work/explosives testing (c)

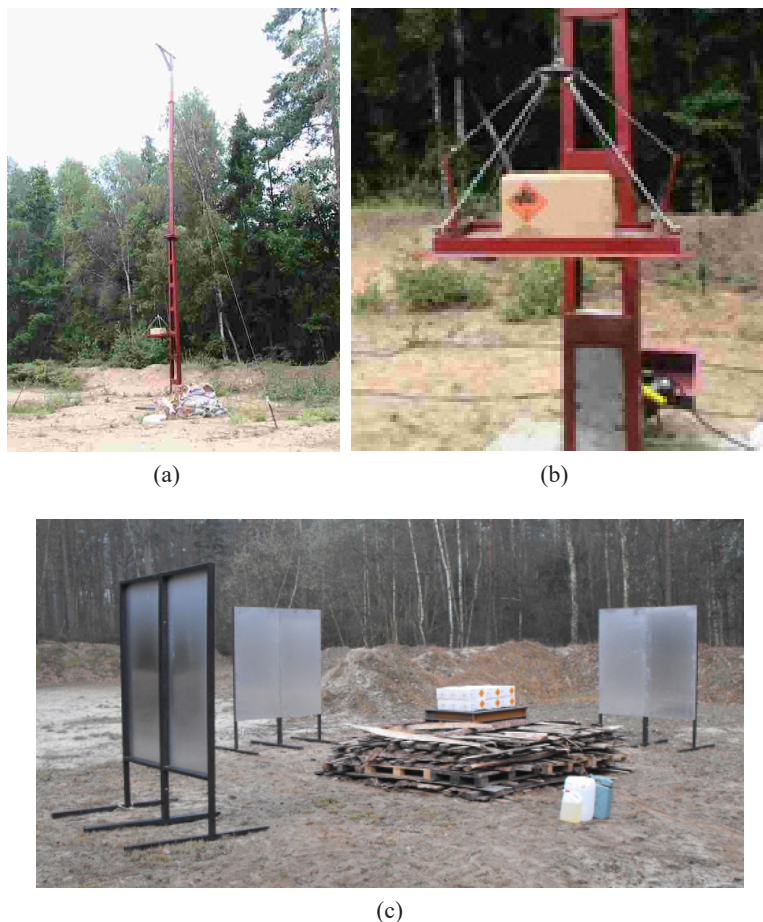


Figure 9. Facilities for ADR transport classification testing on site at the Institute in Krupski Młyn: explosives transport packages 12 m drop test (a, b) and explosives transport packages combustion test (open flame test) (c)

2.2. Łukasiewicz-IPO experimental production in Krupski Młyn for civil and special purposes

The Łukasiewicz-IPO – Explosive Techniques Workgroup in Krupski Młyn has technological stations for the safe experimental production of different types of blasting materials (pneumatic and hydraulic presses from 0.5 to 3.5 t), for pressing explosive charges (safe hydraulic press 64 t). It has a suitable station with instrumentation for pressing products from metal powders and other materials (e.g. production of shaped charge inserts in accordance with proprietary technologies) and a 100 t hydraulic press. For testing and experimental production of pyrotechnics and fuels, the Institute in Krupski Młyn has a separate safe station with an 80 t hydraulic press. This installation enables testing and experimental production of various products for civilian and special use, e.g. fitting pyrotechnic components which generate smoke, light, heat or fire-extinguishing aerosol (Figure 10).



Figure 10. Station for pressing pyrotechnic products and product examples

The Łukasiewicz-IPO – Explosive Techniques Workgroup in Krupski Młyn, utilising small volume and implementation production, offers special explosive products. On introduction into the market they have the required approvals of the Higher Mining Office and certificates issued by the Central Mining Institute. The production range includes shaped charges for perforating bore-holes, for explosive cutting of pipes in a wide range of diameters, linear cutting charges for cutting steel structures, crushing rocks and special mine works (Figure 11). The Explosive Technologies Workgroup in Krupski Młyn performs numerous works and provides test services for national defence purposes. In recent years, it has been the manufacturer of special small size igniters and primers for special purposes (Figure 12).



Figure 11. Product examples: linear cutting charges and axial-directional shaped charges (for perforating)



Figure 12. Examples of special small size products

3. Summary

- ◆ The Łukasiewicz Research Network – Institute of Organic Industry – Explosive Techniques Workgroup is a research centre with almost 70 years of experience, comprehensive research facilities and infrastructure. It is a manufacturer of unique products for civilian and special purposes.
- ◆ It cooperates with other research and economic units in testing high energy materials which use special explosive products in their activities. In addition, the Institute in Krupski Młyn is actively involved in educating personnel for the explosives industry by organising training and seminars for specialists and internships, for high energy materials speciality students and undergraduates of technological universities. It has an ongoing agreement on scientific and research co-operation with the Silesian University of Technology in Gliwice.

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