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**CONFORMAL THERMOSTATING OF HIGH-PRESSURE  
DIE CASTINGS WITH THE INCREASED TIGHTNESS**

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with at least a little time to look for signs  
of the much-awaited Spring**

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**CONTENTS/ SPIS TREŚCI:**

**Krzysztof FIGURSKI, Łukasz PASIERB, Jarosław PIEKŁO,  
Andrzej BURBELKO:** ..... 2

Conformal thermostating of high-pressure die castings  
with the increased tightness

Termostatowanie konformalne wysokociśnieniowych  
odlewów o podwyższonej szczelności

**Marcin RÓŻEWICZ:** ..... 8

Mycotoxins in cereal grain as a result of infection of cereals  
by *Fusarium* fungi

Mykotoksyny w ziarnie zbóż efektem porażenia zbóż przez  
grzyby z rodzaju *Fusarium*

**Nadia GUZIŃSKA, Edyta KORDIALIK-BOGACKA:** ..... 14

Market of fermented beverages in Poland

Rynek napojów fermentowanych w Polsce

**Andrzej BĄBIK, Halina PODSIADŁO:** ..... 18

Vision system test bench

Stanowisko badawcze systemu wizyjnego

**Paweł JAMSKI:** ..... 22

Solution of water and sewage management in recycling  
of plastics

Rozwiązanie gospodarki wodno-osadowej w recyklingu  
tworzyw sztucznych

**Izabela KOPTOŃ-RYŃNIC:** ..... 27

To be as Wolański, that is, how to meet the dreams of the  
young age when being a boy and inventor of space drives

Być jak Wolański, czyli jak spełniać marzenia młodości  
będąc chłopcem i wynalazcą kosmicznych napędów

**EVENTS**

**March 4<sup>th</sup> – World Engineer's Day** ..... 34

4 marca – Światowy Dzień Inżyniera

**30<sup>th</sup> anniversary edition of plebiscite for the title  
of "Golden Engineer"** ..... 35

30. Jubileuszowa edycja plebiscytu o tytuł „Złotego Inżyniera”

**Inauguration of the celebration of the 230<sup>th</sup> anniversary  
of the birth of engineer General Józef Bem  
– March 14, 2024 Tarnów** ..... 38

Inauguracja obchodów 230. rocznicy urodzin gen. J. Bema  
– 14 marca 2024 r. Tarnów

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# CONFORMAL THERMOSTATING OF HIGH-PRESSURE DIE CASTINGS WITH THE INCREASED TIGHTNESS

## TERMOSTATOWANIE KONFORMALNE WYSOKOCIŚNIENIOWYCH ODLEWÓW O PODWYŻSZONEJ SZCZELNOŚCI

**Summary:** In the paper, the exemplary concept, together with the analysis of the obtained results from the experimental trials of thermostating using the conformal system in the cold-chamber high-pressure die casting process of aluminium alloy, was described. Construction of the experimental system of thermostating channels, mapping the surface of the cavity, as being placed in the core, shaping the internal geometry of casting with a required increased tightness was performed. The results of the numerical simulations for a given case and the results of the experiments and RTG examinations of the castings made on a real system, utilizing the designed cores, performed in increment technology from steel 1.2709 were submitted.

**Keywords:** HPDC, aluminium alloys, thermostating, conformal systems, RTG examinations

**Streszczenie:** W pracy przedstawiono przykładową koncepcję wraz z analizą otrzymanych wyników z prób eksperymentalnych dla konformalnego układu termostatowania odlewniczej formy wysokociśnieniowej do odlewania zimno-komorowego stopów aluminium. Dokonano konstrukcji doświadczalnego układu kanałów termostatujących odwzorowujących powierzchnię wnęki formy, umieszczonych w rdzeniu kształtującym wewnętrzną geometrię odlewu o wymaganej podwyższonej szczelności, przedstawiono wyniki symulacji numerycznych dla danego przypadku oraz wyniki doświadczeń oraz badań RTG odlewów wykonanych na rzeczywistym układzie wykorzystującym zaprojektowane rdzenie wykonane w technologii przyrostowej z stali 1.2709.

**Słowa kluczowe:** HPDC, stopy aluminium, termostatowanie, układy konformalne, badania RTG

### The assumptions of conformal thermostating

In technology of manufacturing the high-pressure castings from light-metal alloys, each element of technological process is important from the viewpoint of quality and repeatability of production; however, the process of thermostating of pressure form, the related equipment and the system of channels in form seems to be dominating. The conditions for cooling down of metal in mold affect not only the physical properties, quality and aesthetics but first of all, the price of final product what is significant for the profitability of production and profits of the company. In the time of absolute struggle for maintaining the profitability of production, each new technology, causing the abbreviation of time of production of the elements from aluminium or zinc alloys, with the preservation of the assumed quality is invaluable and very quickly finds the application in a wide group of producers. When observing the development of machines and thermostating technologies of tools, we may see that it goes in two directions: extreme abbreviation of the time of cooling down and obtaining of new properties of high-pressure castings via aware and controllable creation of the appropriate surface of temperature

in the particular parts of the pressure mold so as it could have a local effect on the structure (directional crystallisation).

### Methods of conformal thermostating of casting tools

The method of thermostating of pressure molds and the employed fittings and equipment are linked with the type of casted alloy, parameters of alloy (temperature of liquid, degree of degassing), size of the formed element and the number of mold cavities (which is connected with the size of a tool and system of thermostating) and the requirements set for the final product. In the case of castings from aluminium alloys, the pressure mold should be heated up even to temperature of ca. 200°C. The successive criterion is connected with the requirements set for the final product and concerns the dimensions and their tolerance, repeatability of a cycle, shape deformation and high quality of the product's surface. All the mentioned factors determine the project and performance of the tools such as the injection mold and choice of the equipment for its thermostating. The system of thermostating of the mold includes the following elements and subunits:

- system of thermostating of pressure mold (cooling channels are performed within the mold),
- the external cooling equipment, supplying the cooling medium to pressure mold.

The task of thermostating devices is to prepare appropriately the thermostating liquid (heating up to the required temperature), and then, to transport it via pressure channels to the pressure mold, where, using the cooling channels' systems, the exchange of heat between the mold heated by liquid metal and cooling liquid is carried out. The effectiveness of heat exchange is determined by the size of mold (its thermal capacity), difference of temperature between mold and liquid metal, material of the mold (heat conductivity), construction of the thermostating system (distribution of channels, their cross-section and length), the type of the employed thermostating medium and performance of the thermostating equipment.

The system of channels by which the thermostating medium flows is especially important element of pressure die casting molds. The mentioned channels should be placed possibly near surface and their system should ensure rapid heat exchange. Their cross-section should be found between 8–14 mm [1]; it is dependent, *inter alia*, on the distance from the neighbouring channels and the size of mold and by this, the quantity of the heat necessary for its removal from mold during the technological process.

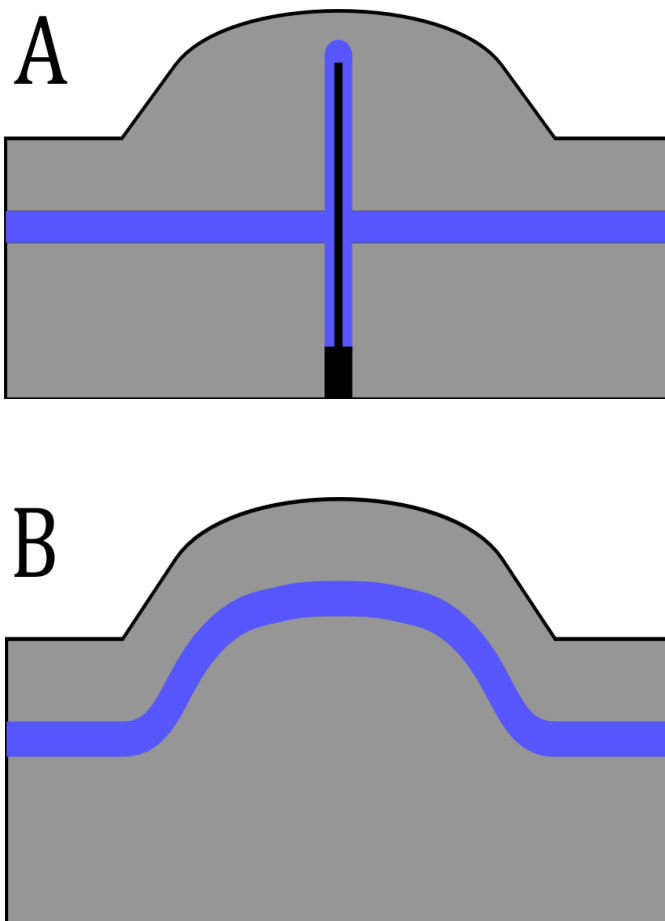


Fig. 1. Traditional thermostating channels with the application of baffle (A) and conformal channels, produced in additive technology (B)

There are many constructional solutions of pressure die cast molds where the shape of cavity (cavities), the system of ejectors or other functional elements of mold disables the correct running of cooling channels. In such cases, the elements of molds, cavities (inserts) or parts (cores) are produced with the application of the so-called additive technologies, facilitating performance of thermostating channels in any cross-section and in any shape.

The additive technology methods originate from the methods of rapid prototyping (RP) where it consists in a quick production of very complicated shapes of elements with a big precision, at a very short time. At present, the time for introduction of new projects for long-run production of pressure die castings is very short and the limitations are caused only by the technologies of producing the prototypes and tools. When striving at the abbreviation of the mentioned time, the constant development of Rapid Tooling (RT) methods is something like a natural consequence of the quick prototyping. The application and development of the discussed methods allows a rapid and flexible answer to the needs and requirements of the customers (change in the shape of tools) and moreover, it allows obtaining the measurable profits, resulting from the abbreviation of production time and reduction of costs. The additive methods of tool production are one of RT varieties [2], [3]. One of the applications includes production of inserts/cores of pressure molds with any system of thermostating channels is respect of their cross-section and run inside the molds. It gives the unlimited possibilities in designing and production of cooling systems adjusted to the shape of the generated casting, giving simultaneously, in certain cases, the abbreviation of the time of its cooling and by this, the cycle time by even 20% [4].

The complete time of the process of the high-pressure die casting is mostly dependent on the length of the stage of cooling down the casting in the mold. The mentioned time is necessary for obtaining (by the liquid metal, crystallizing in the mold) of the sufficient temperature, enabling its safe removal without the change in geometry and the structure, which guarantees obtaining the assumed strength and utility properties. The effective cooling of the pressure mold is very important as it affects not only the time of the cycle but also the quality of the produced castings [5]. The traditional cooling channels are usually performed as simple opening, drilled in a bloc of the mold what causes geometric limitations of their shape and run and by this, in the flow of cooling liquid and heat receipt in the particular areas. In the present paper, the example of the modern method for production of pressure molds, with the application of the s-called additive technologies of direct melting of metal powders with laser application, has been submitted.

### The research problem

The particular case of the pressure die castings, requiring the application of conformal thermostating systems refers to the castings for the products requiring the increased tightness. The assumption of the conducted research provided the improvement of the process and rise of the quality of the high pres-

sure die castings, constituting the casted element of mechanism dealing with the liquid under increased pressure. Casting of the mentioned type must be characterized by the provided repeatable low number of casting defects in mass production, occurring at internal surface which has a direct contact with the liquid in the targeted (final) product. Defects, the elimination of which is indispensable for ensuring the repeatable quality of the product include, first of all, gas porosity and shrinkage porosity which may affect the tightness of the product.

The assumed goal of the conducted operations provided moving away the porosities generated in the casting as far as possible from the external walls of its geometry and forcing the fragmentation of microstructure of casting grains, causing the strengthening of resistance in critical zone from the viewpoint of product's functionality. Fig. 2. represents the exit system of the cores' thermostating, as fixed in the cavities of the high-pressure mold; the internal geometry of the castings as shaped by the mold cores, is a zone requiring the increased tightness, being sealed in the final product and being endangered to direct and continuous contact with the liquid.

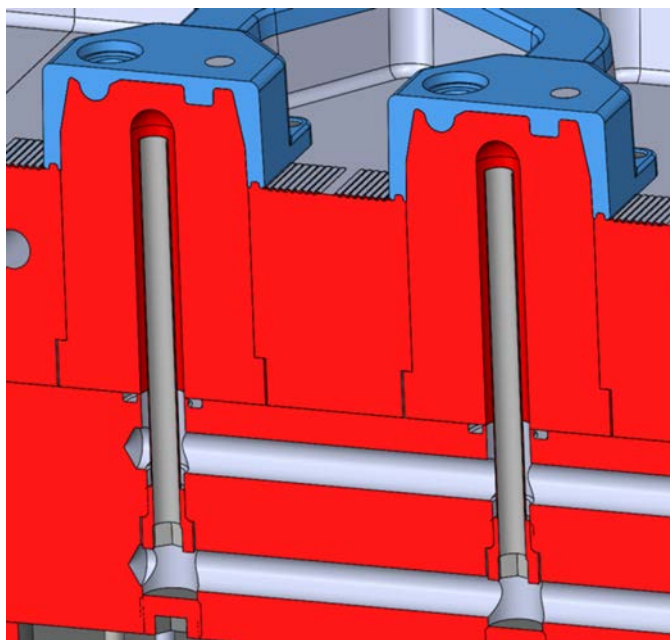


Fig. 2. Traditional system of thermostating applied to the cores of mold; at the cross-section of two cavities of the mold, there were marked the castings together with the gating system (blue colour)

The boundary condition of the implemented research included the application of the existing four-cavity casting mold intended for the high-pressure die casting of silumins. Each cavity of the mold was equipped with the exchangeable molding core, mapping the internal geometry of the casting.

In the original system, the mold used a traditional system of thermostating the cores, performed in a form of holes, drilled in the mold cores, equipped with the Meusburger nozzles E211196 [6] supplying the thermostating medium in the core's axis. The adopted assumption provided a lack of the change

in process parameters excluding the time of coagulation and cooling of the castings. The casting process for a given mold was implemented in cold-chamber high-pressure die casting machine Frech K510. Fig. 3 illustrates a movable part of the mold, employed in the conducted experiments, in 3D graphical form generated from CAD documentation.

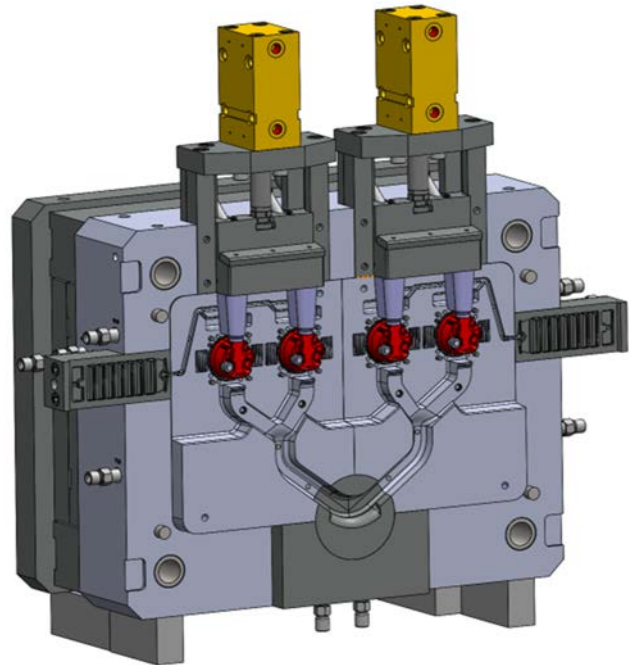


Fig. 3. 3D model of a movable part of the HPDC die casting mold, employed in the studies; cores have been marked by red colour

## Methodology of the experiment

The adopted assumption of the method of improving the quality of the casting consisted in the application of the conformal system of thermostating in the mold-shaping cores. On the grounds of the earlier developed solution and elaborations [7], the concept of the system of channels, capable to be placed inside the geometry of shaping core was developed, assuming also lack of modification of its external geometry and connection of thermostating liquid system.

It was also adopted that the core with the conformal channels was performed in accordance with the earlier developed and verified [7] method, using print technology 3D SLM from the steel with the commercial mark "MS1", being the equivalent of hot work tool steel, with marking 1.2709.

The system of channels was designed to achieve the possibly highest length and most effective conformal mapping of external surfaces of molding core, distanced by 3 mm. In the case of horizontal planes, there was undertaken the decision about introducing the complicated geometry of the channel so as to fill the available space as much as possible, with the simultaneous preservation of minimal distances between the channels, being equal to 3 mm.

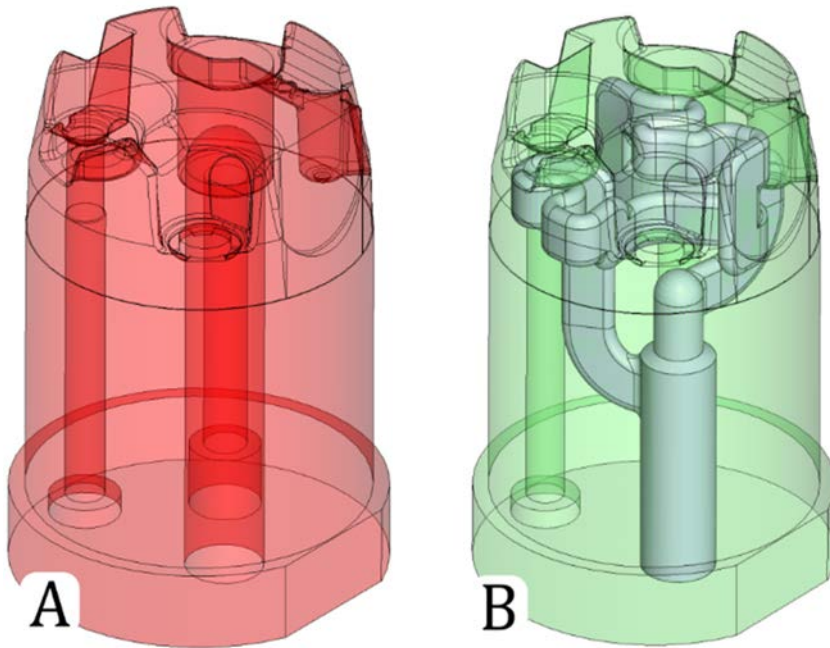


Fig. 4. Model 3D CAD in half-transparency of the core with the traditional thermostating system, with the space for single nozzle in the hole in the middle (A) and core with the conformal thermostating system (B)

The developed cores were produced in 3D printing technology, and then, subjected to heat treatment and finishing treatment with the aim to obtain the appropriate mapping of the expected geometry and the appropriately low roughness of the top layer, facilitating their correct assembling and work in the die casting mold.

A series of the trials was carried out in foundry equipment. The nearly eutectic alloy of aluminium ENAC-44300 acc. to PN-EN 1706 was employed. The choice of casting material was dictated by the requirements of the Customer, ordering the production of the castings. The temperature of material in heating furnace of the casting machine was equal to 750°C.

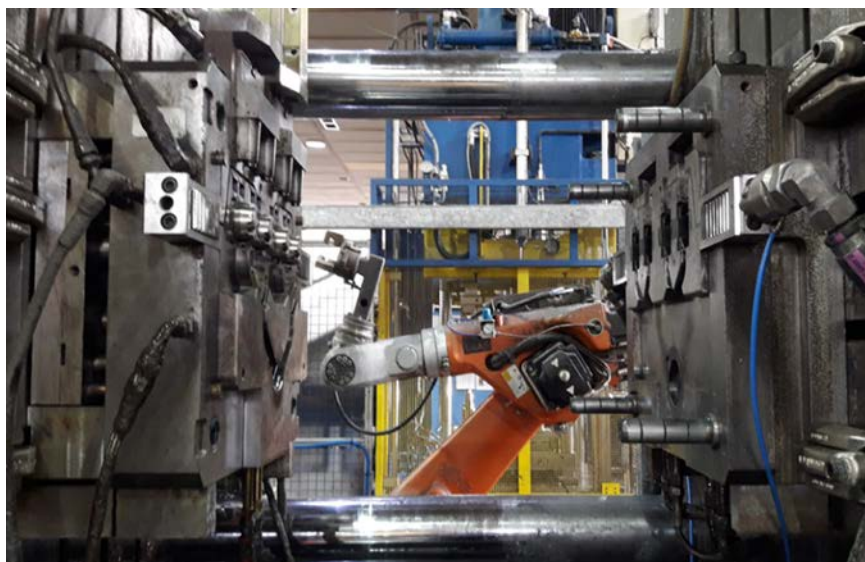


Fig. 5. Casting mold equipped in cores with conformal thermostating system, assembled on casting machine Frech K510

The conducted experiments included production of the castings in the mold, equipped with cores with the traditional cooling system as well as conformal cores, with the possible minimization of the number of the introduced process variables. The temperature of the liquid in thermostating system amounted to 60°C. The oil was used as medium. The traditional system of thermostating of molding inserts also employed oil as medium. Thermostating was ensured owing to equipment Robamat Thermocast 5212, integrated with the casting station. In order to eliminate the porosity as much as possible, casting with the application of vacuum, ensured by Fondarex device, connected to cavities of the mold via the geometry of cooling vents, was employed.

The the casting machine ran in automatic cycle; the castings together with the gating system were removed from the cavity of the mold, using the industrial robot, and were, in automatic cycle, placed in bath with ambient water to be cooled down; then, they were placed on the press, where the residues of gating system and burrs were automatically removed.

During the studies, the manufacturing series of die castings from the mold equipped with traditional cores as well as the cores with the conformal channels were performed. The castings produced during the first 20 start-up cycles of machines during the mass production were discarded due to lack of the full thermal stabilisation of casting tool. From among the castings performed after start-up, the samples were collected for the needs of the tests of their properties.

### The results of the conducted studies

As early as at the design stage, in order to verify the potential effectiveness of the considered system, a series of numerical simulations for a set casting process with the support of ProCAST software [8] was carried out. One of the verified aspects included the distribution of temperatures inside the core during its work in a casting mold what allowed stating that the developed cores would not be endangered to decrease of the strength, caused too high working temperature. Verification embraced different temperature parameters of thermostating system for the cycle including the cores. Fig. 6 shows the exemplary result of simulation for temperature of 70°C, being the upper value, reachable by thermostating device, at the planned setting up of 60°C. It is

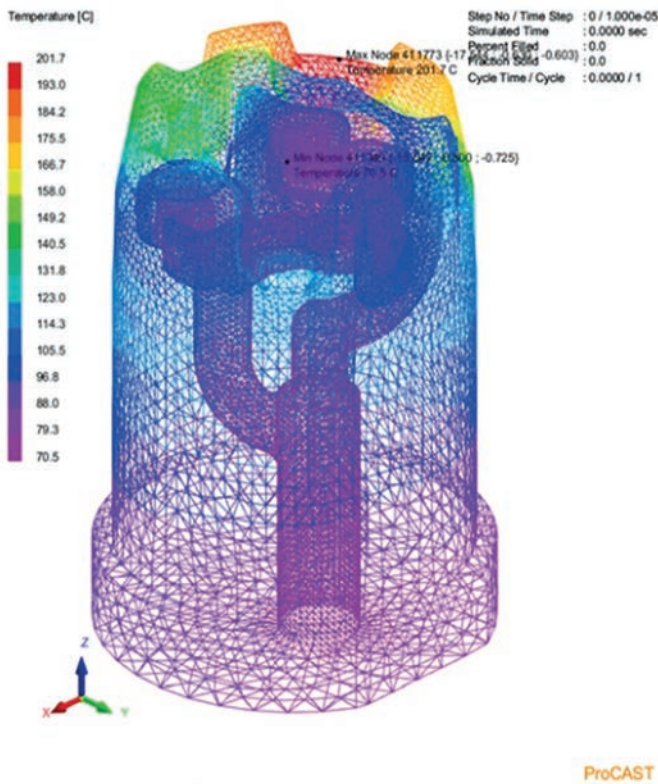


Fig. 6. Distribution of temperatures in the core with the conformal channels for the set temperature of liquid, equal to 70°C

visible that the maximum temperature of the core reached 201.7°C what was recognized as a safe value for the structure of steel from which the cores were produced.

The performed castings were verified in respect of porosity, using X-Ray examination; mechanical properties were checked by the tests of hardness and tightness. The dimensional properties were tested as well. Any changes in dimension deviations, resulting from the casting process were not found.

X-Ray images, in the quantity of 12 pcs from each casting, coming from the both types of the cores were analysed in respect of possible tightness defects of the casting process. The greatest participation of porosity was observed in the site directly at the filling gate. In the case of the castings with the application of the cores with conformal system, it was found that the larger porosity areas were separated; the single pores had smaller volume and did not have the tendency to mutual linking. Any direct decrease of the porosity volume was not observed but the obtained result may positively affect the key aspect of the final product, the tightness, which mainly depends on the obtained castings. Fig. 7. represents the photographs of the exemplary castings, selected from among the tested samples due to the greatest participation of the revealed porosity. A zone at the filling gate was marked in the photos. For comparison, the X-ray image of the casting with the application of the conformal system of thermostating shows the product after machining, considering, *inter alia*, after-drilling of the hole, placed directly in a critical zone of porosity.

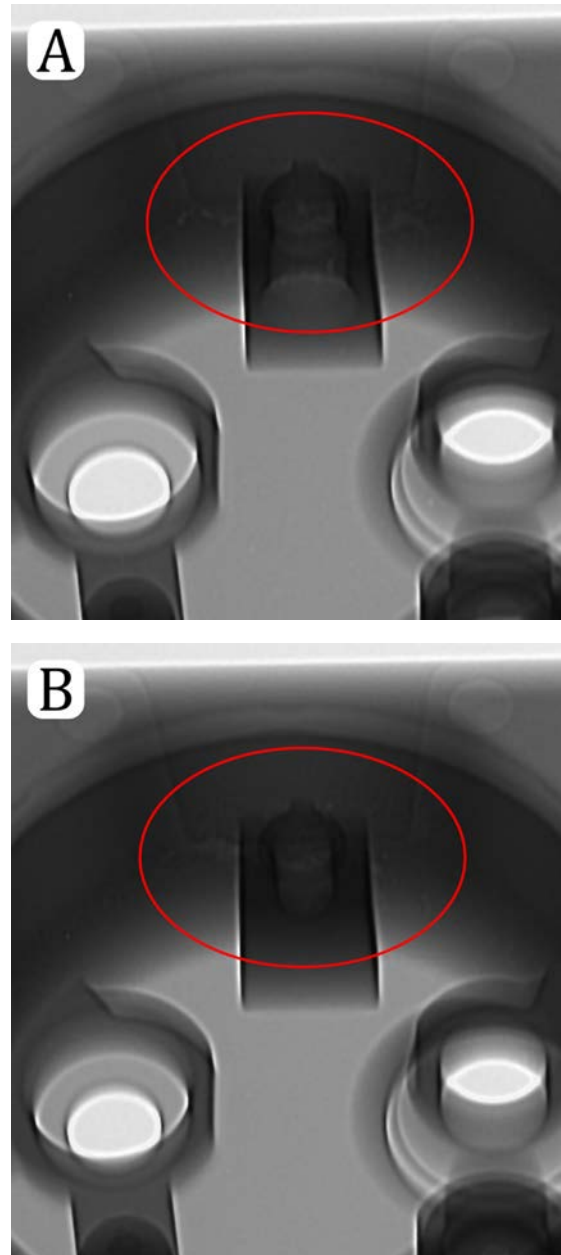


Fig. 7. X-Ray image with filter, highlighting the defects (Bosello HDI) of the casting, with the application of the core with conformal system (A) casting after the operation of after-drilling of the whole in the marked zone, the core with the traditional system (B); red outline means the zone with the observed highest participation of porosity, situated directly at the filling gate

## Discussion of the results and conclusions

On the grounds of the obtained results, it was stated that the application of conformal system of thermostating the cores affected positively the quality of the obtained castings and the process parameters, potentially having also the effect on the prolongation of the tool's durability.

From the tightness viewpoint, the castings, obtained from the mold equipped with the experimental thermostating system were characterized by a better distribution of porosity which was shifted from the critical zone and disintegrated. There was observed a lack of the effect of thermostating on dimensional



properties what is a crucial property from the point of view of designing the casting molds. On the stage of construction, the correct anticipation of casting shrinkage is indispensable.

The results of the experiments indicate that in the case of the castings where the application of the traditional thermostating system which would well map the geometry of the casting is impossible, the performance of molding elements or their parts such as cores in technology of print 3D, with the consideration of conformal channels may be recommended.

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# MYCOTOXINS IN CEREAL GRAIN AS A RESULT OF INFECTION OF CEREALS BY *FUSARIUM* FUNGI

## MYKOTOKSYNY W ZIARNIE ZBÓŻ EFEKTEM PORAŻENIA ZBÓŻ PRZEZ GRZYBY Z RODZAJU *FUSARIUM*

**Summary:** Fungal diseases are an important factor limiting the yield of cereals, but also reduce the quality of the grain obtained. Fungi of the genus *Fusarium* are among the most important pathogens and cause, among other things, fusarium head blight. Their particular harmfulness lies not only in the reduction of yield, but also in their production of harmful metabolites called mycotoxins. Mycotoxins are defined as harmful substances produced as secondary metabolites by mould fungi. The problem of mycotoxin contamination of cereal grains relates to their high harmfulness to humans and animals. This is due to the fact that cereals are an essential raw material in the production of human food and animal feed. Infection by *Fusarium* fungi and its determined by a number of factors, the main ones being weather conditions during ear formation, grain formation and harvesting. One of the most important methods of preventing mycotoxin formation is fungicide protection of cereals. The aim of this paper is to discuss the problems associated with fusarium head blight and its effects associated with mycotoxins, the factors determining their synthesis, mechanisms of prevention and the impact of their content in grain and feed on animal health and productivity.

**Keywords:** mycotoxins, fungal diseases of cereals, fusarium head blight, cereal grain, food safety, toxicity

**Streszczenie:** Choroby grzybowe są ważnym czynnikiem ograniczającym plonowanie zbóż, ale także obniżają jakość uzyskiwanego ziarna. Wśród licznych patogenów roślin zbożowych jednymi z ważniejszych są grzyby z rodzaju *Fusarium*, które powodują m.in. fuzariozę kłosów. Szczególna ich szkodliwość polega nie tylko na obniżeniu plonowania, ale także produkcji przez nie szkodliwych metabolitów nazywanych mykotoksynami. Pod pojęciem mykotoksyny definiuje się szkodliwe substancje, powstające, jako drugorzędne (wtórne) metabolity produkowane przez grzyby pleśniowe. Ważność problematyki dotyczącej skażenia ziarna zbóż mykotoksynami związana jest z ich wieloaspektowym toksycznym wpływem na organizmy ludzi i zwierząt. Wynika to z faktu, że zboża stanowią podstawowy surowiec w produkcji żywności dla ludzi oraz pasz dla zwierząt. Porażenie przez grzyby *Fusarium* uwarunkowane jest wieloma czynnikami, przy czym za główne uznaje się warunki pogodowe w trakcie wykształcania kłosów i ziarna. Jedną z ważniejszych metod zapobiegającą tworzeniu mikotoksyn jest ochrona fungicydowa zbóż. Celem niniejszej pracy jest omówienie problematyki związanej występowaniem fuzariozy kłosów oraz ich skutków związanych z występowaniem mykotoksyn, czynników warunkujących ich syntezę, mechanizmów zapobiegania oraz wpływu ich zawartości w ziarnie i paszy na zdrowie i produktywność zwierząt.

**Słowa kluczowe:** mykotoksyny, choroby grzybowe zbóż, fuzarioza kłosów, ziarno zbóż, bezpieczeństwo żywnościowe, toksyczność

### The problem of *Fusarium* head blight in cereals during field growth

*Fusarium* head blight is a fungal disease that occurs in many areas of the world and is considered one of the main factors affecting the quantity and quality of the grain yield obtained. It is caused by fungi belonging to the genus *Fusarium* mainly *F. culmorum* and *F. graminearum* [6] Fungi of the genus *Fusarium*, as anamorphic fungi are called mould fungi (they do not form spores). The fungi multiply, resulting in significant yield loss, as well as deterioration in yield quality [54]. They are well adapted to changing soil and atmospheric conditions and have a high tolerance to abiotic factors in the environment, and thrive in a large temperature range, i.e. 0–30°C. *Fusarium* head blight occurs on all cereal species in our climatic zone (wheat, rye, triticale, oats, barley, maize).

Infestation of ears by *Fusarium* fungi causes a reduction in yield, resulting from a lower weight of 1.000 grains, number of grains per ear and grain weight per ear. The fungi cause a reduction in commercial and consumption value by altering the chemical composition of the grain. Fungi of the genus *Fusarium* have the ability to form mycotoxins, resulting in the accumulation of toxins in the grain even before harvest. The most mycotoxigenic species include *F. graminearum* and *F. culmorum*. In Poland, deoxynivalenol, nivalenol and zearalenone are the most common in cereal grain.

The reason for the fairly common occurrence of fusarium head blight is the high proportion of cereal crops in the structure and the limited rotation in the field. In general, cereals are grown in succession and it results in the accumulation of crop residues with the pathogenic pathogen in the soil [3; 40]. Infection of plants by mycotoxigenic fungi and their production of mycotoxins results

in a defence response. As a result of biological transformation, which involves a series of enzymatic reactions, free mycotoxins are converted into less harmful compounds, called modified mycotoxins. Transformed mycotoxins have also been referred to as masked mycotoxins because their altered chemical structure renders them undetectable in standard detection methods for free mycotoxins [35]. They do, however, pose a problem in the feed production chain, as their non-detectability results in grain feed material being approved for use because it meets the requirements of low mycotoxin content. However, they pose a further problem for animal health due to the fact that they are metabolised in the gastrointestinal tract or liver to primary, free forms that are harmful.

The occurrence of fusarium head blight in cereal crops is most often identified by characteristic symptoms. At the earing stage, an early blanching of the husks in the ears and a light pink colouring are observed. These are the first symptoms of *Fusarium* infection. Visual assessment and determination of the ear infestation index have so far been the only methods for assessing the infestation and degree of resistance of individual cereal cultivars to fusarium head blight. Nowadays, attempts are being made to implement modern, more reliable and objective assessments. One of these is remote sensing. The method is based on comparing images of healthy plants with patterns of infested plants and of infested plants with patterns of healthy plants. The resulting images of plant patches are then used as a basis for analysing wavelength histograms, as well as for calculating indicators based on them to assess crop health [33]. The use of remote sensing can be used to create health maps of *Fusarium*-infected cereals [20].

### Prevention of *Fusarium* infestation

The severity of fusarium head blight is highly dependent on weather conditions [46] forecrop [29; 52] nitrogen fertilisation and weed control [53]. According to Doohan et al. [17] and Czaban et al. [15], the degree of ear fusarium head blight infection is highly dependent on weather conditions (temperature and humidity). Weather conditions are a factor that determines the infection of wheat grain by *Fusarium* to a greater extent than the variation in tillage systems. Fusarium head blight risk assessment and models to predict the occurrence of this disease are based on weather conditions during the period from flowering to early milk maturity [17]. Also, wheat cultivation technology influences *Fusarium* ear infection. Czaban et al. [15] indicate that ears and grain of wheat from sites with intensive cultivation technology were most severely infested. Inoculation of spelt wheat grain [26] and spring barley grain [5] by *Fusarium* fungi was lower in the organic system compared to the integrated and conventional systems.

Research by other authors [12] confirms that weather conditions were a stronger factor influencing grain infection by *Fusarium* fungi than variation in cultivation systems. Łukanowski and Sadowski [29] showed that winter wheat kernels grown in the organic system were significantly less infested by *Fusarium*

fungi than in the integrated and conventional systems. In other studies [5; 26] the colonisation of cereal grains by *Fusarium* fungi was also lower in the organic system compared to the integrated and conventional systems.

A modern method of counteracting *Fusarium* infestation is the use of preparations containing effective micro-organisms. This is one of the alternative, biological methods of controlling fungal pathogens based on the beneficial action of bacterial strains. Scientific studies have shown that certain bacterial strains can be as effective in reducing fungal diseases as the active substances contained in fungicides. A study by Wachowska et al [49] showed that bacteria of the genus *Sphingomonas* inhibited the growth of fungi of the genus *Fusarium* as effectively as a triazole fungicide. The possibility of using effective microorganisms to protect against *Fusarium* infestation was investigated by Starzyk and Wiśniewska [44]. The researchers, in a field experiment growing spring wheat of the Zebra cultivar susceptible to fusarium head blight, sprayed the plants with a preparation containing effective microorganisms. The results of this study showed that the use of effective microorganisms is an effective method in controlling fusarium head blight. Another biological method is also the use of mycoviruses. These can be used, as potential biocontrol agents for phytopathogenic fungal diseases of cereals including bioprotection against *Fusarium* [42]. Potential viruses multiplying on *Fusarium* fungi are included in the family *Fusariviridae* [27]. The identification of useful virus strains useful against *Fusarium* fungi and the possibility of their use in the biological cultivation of cereals is currently underway. Researchers are also trying to determine which viruses can multiply on different strains of *Fusarium* fungi, and which viruses have limited abilities and can only multiply on a specific *Fusarium* species [56].

As awareness of the harmfulness of mycotoxins has increased, measures have begun to be taken to eliminate the threat from these substances. One of the main countermeasures is limiting the possibility of mould growth. This concerns the protection of plants, mainly cereals, from infection during growth in the field, but also the correct storage conditions for grain and its products. An important element of prevention is the prevention of plant infection during the growth period in the field, which prevents the formation of mycotoxins and their accumulation in the grain [2]. Among the species most pathogenic to cereals are species of the genus *Fusarium*, infecting cereal ears and maize cobs. The increase in the degree of contamination of cereal grain with mycotoxins formed by *Fusarium* species is caused by the increasing use of cereal cultivation in monocultures, disregarding the traditional crop rotation. The use of a suitable crop rotation on the site is, after the influence of the weather, one of the most important factors limiting the development of mycotoxigenic fungi [14]. Post-harvest residues of plants infected in the previous season are a reservoir of spores of the mould fungus type *Fusarium graminearum*. Crop rotation is, therefore, one of the most important methods recommended to reduce the risk from *Fusarium* sp. [22]. The cultivation system also influences the degree of plant infestation and mycotoxin content. Several techniques are used during tillage, but ploughing is the most

common. When ploughing is carried out, the surface layer of soil together with crop residues is turned over and ploughed to a depth of 10 to 30 cm. In this way, the possibility of pathogenic fungal growth is reduced. Topsoil cultivation to a depth of 10 to 20 cm, in which part of the harvest residues are mixed with the soil, is also practised. Ploughless cultivation with direct seeding into the stubble is also increasingly used. However, this results in an increased risk of fungal diseases due to the accumulation of fungal spores on harvest residues in the topsoil. It is therefore advisable to remove or burn the crop residues, which can reduce the likelihood of the plant material (grains) becoming infected with *Fusarium* pathogen suspension. However, a number of studies show that ploughless tillage results in increased deoxynivalenol levels in wheat at subsequent harvests [45; 50]. The mycotoxin content is also influenced by the tillage system used. Compared to conventional cultivation, organically grown wheat grain contains more mycotoxins [31]. However, this is also dependent on weather conditions. In the years with higher temperatures and lower rainfall, which creates conditions less favourable for fungal growth, plants grown in the both systems can have comparable and low mycotoxin concentrations [30]. Sowing date and density are also one of the factors determining the degree of *Fusarium* infection. The probability of infection increases when the time of cereal earing is synchronised with the timing of the release of mould spores. Therefore, making changes to the sowing date of cereals or the time of maturity can significantly affect the degree of contamination of cereals by moulds and mycotoxins. In the case of maize, earlier sowing dates in particular areas often result in lower levels of contamination, but seasonal weather changes can reduce this potential benefit [39]. Fertilisation is also one of the factors considered to influence the susceptibility of plants to fungal infections. It is indicated that excess nitrogen in the soil increases the frequency of infection of grains with *Fusarium* fungi. However, this depends on the chemical form of nitrogen used (urea, ammonium nitrate or calcium nitrate) [55]. Crop weed infestation is also considered to be one of the factors influencing the increased degree of mycotoxin content in cereal grains. Some weed species are also believed to be reservoirs of spores of the fungus family *Fusarium* sp. This is, therefore, an explanation for the correlation between a higher degree of weed infestation in crops and fungal infection of wheat ears. Also, the residual green matter of the weeds increases the content of plant residues infested with mycelium and thus creates favourable conditions for propagation with propagules (vegetative form of propagation – propagules). In addition to fungicide protection, one of the most important methods is also the breeding of new cultivars showing higher resistance to infestation, also through the use of biotechnological methods. Genetically modified maize cultivars that show resistance to European corn borer feeding are also less susceptible to fungal infestation and therefore contain fewer mycotoxins. This is confirmed by the results of a study by Tekielka and Grabarkiewicz [47]. In a 2-year experiment, the cited authors found lower mycotoxin content in GM cultivars compared to conventional cultivars. Selvet [39] analysing the average degree of infestation of cobs by fusarium head blight

of different cultivars showed varying degrees of infestation. The most severely infested cultivars were Junak and Baca. The lowest concentration of deoxynivalenol was found in 2006 and 2007 in the GMO cultivar MON 810. The highest concentration of deoxynivalenol was found in the Proсна cultivar. In the case of wheat, it was possible to obtain lines that provided cultivars resistant to *Fusarium* sp. but, unfortunately, the quality of the grain obtained and the agronomic properties were reduced, which resulted in these lines not being registered. However, among the already existing breeding lines of many cereal species, there are lines that are more or less susceptible to the aforementioned fungal pathogens. This demonstrates the diversity of traits responsible for resistance to infection and the potential for further selection and breeding work. Additionally, the fact that genes responsible for traits relating to resistance to fusarium infections in wheat have been identified [9; 32; 41] is helpful for this purpose. These traits are often located together with the genes determining morphological traits of the plant. Since there are many methods of preventing *Fusarium* head blight, but no single effective one, it is worth combining them all to maximise the potentially greatest preventive effect. Weather conditions are the factor most conducive to infestation and which is impossible for the farmer to control. However, it is worth combining those elements that are possible. These include the appropriate selection of cultivars characterised by high resistance, appropriate cultivation and crop rotation applied in the field, and balanced fertilisation can significantly contribute to reducing the risk of mycotoxin infestation [1].

## Characteristics of mycotoxins

Each group and species of fungi produces mycotoxin types specific to it. These have varying toxic effects. *Fungi* of the genus *Fusarium* produce mainly zearalenone, fumonisins, deoxynivalenol and trichothecene toxins [7].

In the available scientific literature, the identification of the mycotoxin group of harmful substances dates back to 1711, when the toxic effects of ergot were first identified. Another landmark date was also 1960, when a mass death of turkeys on one farm was found to be caused by feed contaminated with aflatoxin [13]. Subsequently, poisoning was also found in other livestock species such as ducks, pigs, cattle and horses. The cause was the feeding of feed that contained peanut meal contaminated with aflatoxin in its composition [16]. This was when there was an increased scientific interest in mycotoxins. In the following years, numerous papers were published on this group of substances.

Although mycotoxins constitute a numerous group of substances; the same mycotoxin can be produced by many different fungal species, as well as not necessarily by all strains of a given species. It also happens that one species of fungus produces several types of mycotoxins.

What mycotoxins have in common is that they are all produced by mould fungi and have toxic effects on human and animal organisms, but they differ in terms of their chemical structure. This determines the toxicity and effect in the body

of a particular mycotoxin. These toxins pose two risks – acute poisoning and the risk of developing chronic poisoning. Chronic effects develop due to the accumulation of toxins in the body or as a result of the accumulation of minor morphological or biochemical damage within organs [24]. Therefore, a number of scientific studies are devoted to the chemical structure and toxicological characterisation of mycotoxins. Such knowledge is an indispensable prerequisite, the basis of any strategy to combat mycotoxins, both in terms of methods to prevent mould growth and to protect products from contamination. This is a significant problem occurring worldwide [36].

In addition to the free forms of mycotoxins, there are so-called modified mycotoxins [18]. This creates the problem of definitively estimating the total content of mycotoxins, as only their free forms are detected, and thus routine testing methods cause underestimates. Modified mycotoxins are formed as a result of biotransformation of parent forms, among others, in plants by coupling toxins to hydrophilic compounds (e.g. amino acids, sugars) or by bacterial or fungal metabolism (e.g. reduction) [8]. During plant growth, when infestation by *Fusarium* fungi occurs in a defence response, the plant recognises the mycotoxins and starts a defence process. During this process, the free mycotoxins undergo a glycosylation process. This process involves the combination of a free mycotoxin molecule with a glucose molecule by means of the enzyme glycosyltransferase. Another metabolic pathway in plants that neutralises the harmfulness of mycotoxins is the coupling of mycotoxins to a sulphur molecule effectively neutralising their toxic effects [4].

The presence of modified mycotoxins can be of great toxicological importance, as some may exhibit toxicity higher than the basic forms, or they may be released into their parent forms in the gastrointestinal tract of animals and humans. Modified mycotoxins can be formed by plant defence systems (e.g. DON-3-Glc, zearalenone-14-glucoside (ZEN-14-Glc), nivalenol-3-glucoside (NIV-3-Glc), HT-2-glucoside (HT-2-Glc)), bacterial metabolism (deepoxy-DON), fungal metabolism (e.g. 3-acetyl-deoxynivalenol (3-Ac-DON), 15-acetyl-deoxynivalenol (15-Ac-DON)), animals (e.g. formation of aflatoxin M1 from aflatoxin B1). These forms are formed when plants protect themselves from the free forms of mycotoxins by converting them into the form of more polar metabolites that are less toxic to them. This process occurs while plants are still growing in the field when infestation with *Fusarium* fungi occurs; mycotoxins such as DON, ZEN, FB1, FB2, T2, HT-2 and nivalenol (NIV) are the most commonly metabolised by plants. Of all the modified forms of mycotoxins determined to date, the most data exist on the occurrence of DON-3-Glc. The ratio of DON3-Glc to the unmodified form ranges from 20 to 70% [35].

Cereal cultivation has two main purposes - for human food and for livestock feed. Mycotoxin contamination of food and feed is highly dependent on environmental conditions, which can inhibit or accelerate mould formation and growth. Contamination can occur at any stage of production (plant development, harvest, handling, storage and transport). Another problem is that mycotoxins are low molecular weight, weakly polar compounds

and are not broken down during the technological processes used in grain processing [43]. They do not decompose at high temperatures. They can enter the human body through the oral route by direct ingestion of contaminated grain products, or by consuming products from animals fed with mycotoxin-contaminated feed. These toxins accumulate in soft tissues such as the liver, kidneys and also in muscle. In detoxification processes taking place in the body, chemical forms of mycotoxins are changed into another chemical form with weaker toxic properties [28]. An example is the discovery that dairy cows fed feed containing aflatoxin B1 excrete its derivative aflatoxin M1 with their milk. Until now, it was thought that milk and milk products from organic production could contain aflatoxin. This view was linked to the belief that restrictions on the use of fungicides resulted in an increase in mycotoxin content in grain for feed. However, some studies contradict this and even show that mycotoxin levels are lower in organic milk [51]. Exposure of livestock to zearalenone leads to urogenital disorders, while acute or chronic poisoning can cause permanent damage to the organs of the reproductive system, such as degenerative changes of the testes, ovarian atrophy, infertility and abortions. The contamination of food of animal origin (mainly milk and meat) with mycotoxins from *Fusarium* is currently low, due to the continuous monitoring of these products for their safety, starting with the feed raw materials through the testing of food products [37].

Mycotoxins are toxic and pose a health risk to all animals. The greatest sensitivity to mycotoxin contamination of feed is found in poultry and pigs [19]. Both these groups of animals also receive complete feeds with a high proportion of cereal grains, which is also important in exposing them to ingestion of high levels of mycotoxins. However, scientific results indicate some species differences in sensitivity to the toxic effects of different mycotoxins. Poultry show less sensitivity to fumonisins in their feed than pigs and horses. This is related to the difference in the degree of absorption of this mycotoxin in the digestive tract [23]. Furthermore, among poultry it is noted that there is also a differential sensitivity to fumonisin. Turkeys and ducks are much more susceptible to poisoning than chickens [48].

Death occurred in horses fed feed that contained aflatoxin-contaminated maize, and extensive liver necrosis was found following autopsy. The chemical analysis of the maize performed showed aflatoxin B1, B2 and M1 at concentrations of 114, 10 and 6 µg/kg, respectively (Vesonder et al., 1991). In contrast, as suggested by the study of Schulz et al. [38] horses are less sensitive lower than 1 mg/kg deoxynivalenol than other animal species. Ruminant animals (cattle as well as goats and sheep), whose diet is based on roughage, mainly hay and green fodder, are less likely to ingest higher amounts of mycotoxime derived from every cereal grain. In addition, they are to some extent protected by the partial ability of the rumen microflora to detoxify mycotoxins [34].

In relation to the issue of the toxicity of mycotoxins to humans and animals, there is a need for preventive mechanisms. As it is inevitable that the risk of these substances is completely eliminated, the most effective method, apart from agrotechnical methods, is the constant control of the level of contamination of

cereals. The multitude of factors influencing mycotoxin content makes it necessary to test each batch of grain to determine the mycotoxin content against the permitted standards.

The detection of batches exceeding the limits allows cereals and cereal preparations to be rapidly withdrawn from the market. The wide variety of mycotoxins and their toxic effects, and their possible synergistic interaction by compounding the harmful effect, is also a significant problem. The synergistic interaction of two or more mycotoxins may cause the sum of their content in cereals, their processing products and feed, to cause even greater harm to humans and animals [11].

One solution to reduce the uptake of mycotoxins into the system is the use of probiotics, which, through their adsorption, reduces their bioavailability in the intestinal lumen, prevents their absorption into the bloodstream and protects organs and tissues. The bound probiotic-microbe complex is excreted, but the effective operation of this mechanism requires a constant supply of probiotic with feed [10]. In an experiment conducted on dairy cows, it was found that the addition of *S. cerevisiae* yeast to feed contaminated with aflatoxin B1, reduced the excretion of its metabolite aflatoxin M1 with milk [21]. A method of protecting animals from the negative effects of feed containing mycotoxins is the use of detoxicants. These are preparations based on aluminosilicates or activated carbon that bind mycotoxins into stable complexes. The binding of mycotoxins prevents them from being absorbed in the intestines into the system and they are eventually excreted in the faeces. However, with significant contamination of feed with mycotoxins, the use of detoxifiers proves ineffective [25].

## Conclusions

Mycotoxin content is an important indicator of grain quality. Achieving as low content as possible is the goal in order to protect human and animal health. Measures taken in this direction include breeding cereal cultivars resistant to fusarium head blight, using appropriate fungicide protection and good agricultural practice. The weather pattern during especially earing, which is unpredictable and impossible to modify, is also an important factor. As many factors influence the mycotoxin content of grain, continuous laboratory monitoring of grain batches destined for feed purposes is necessary as before. With the detection of new forms of mycotoxins, so-called modified forms, the development of analytical methods for their detection is a necessary direction. Important methods of protecting animal health against the negative effects of mycotoxins are the use of feed additives. These include probiotic preparations and detoxifiers. As mycotoxins are a constant threat, further research is needed to find effective mycotoxin-binding agents such as sorbents and detoxicants in both in vitro and in vivo studies.

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# MARKET OF FERMENTED BEVERAGES IN POLAND

## RYNEK NAPOJÓW FERMENTOWANYCH W POLSCE

**Summary:** The contemporary market of fermented beverages is experiencing dynamic growth. In this article three groups of fermented beverages: cider, kombucha, and plant-based dairy alternatives, will be examined. Cider, known for its use of native apples, is becoming increasingly popular, with producers combining innovation and tradition in their products. Kombucha, a refreshing tea-based drink, is gaining the market with its potential health benefits. The trend of reducing the consumption of animal products opens new perspectives for plant-based food and dairy alternatives, including kefir. The article presents current market producers, challenges, and innovations introduced in the production of the aforementioned fermented beverages.

**Keywords:** fermented beverages, cider, kombucha, plant-based dairy

**Streszczenie:** Współczesny rynek napojów fermentowanych przeżywa dynamiczny rozwój. W artykule zbadane zostaną trzy grupy napojów fermentowanych: cydr, kombucha oraz roślinne zamienniki produktów mlecznych. Cydr, znany z wykorzystania rodzimych jabłek, cieszy się coraz większą popularnością, a producenci łączą w swoich produktach innowację i tradycję. Kombucha, orzeźwiający napój na bazie herbaty, zdobywa rynek dzięki swoim potencjalnym korzyściom zdrowotnym. Trend ograniczania spożycia produktów pochodzenia zwierzęcego otwiera nowe perspektywy dla roślinnych zamienników żywności i nabiału, w tym kefiru. W artykule przedstawiono aktualnych producentów rynkowych, wyzwania i innowacje wprowadzone w produkcji wyżej wymienionych napojów fermentowanych.

**Słowa kluczowe:** napoje fermentowane, cydr, kombucha, nabiał roślinny

### Introduction

According to the lexical term, fermentation is an enzymatic process of transformation of chemical compounds present in the foods with the participation of microorganisms. For many centuries, it was solely used for food preservation. Currently, it is mainly used to impart interesting sensory characteristics, enrich food products with alcohol, or health-promoting properties to. In Poland the fermentation process is tied to a multi-generational tradition, and as a result, it is associated with diverse regional products. Nevertheless, openness to new flavors and discoveries shapes the domestic market, leading Poles to include a wide variety of fermented foods and beverages in their daily diets. This article will present a few types of fermented beverages well-known to Poles, as well as those that are gaining popularity.

### Cider

Cider is a fermented alcoholic beverage with an alcohol content of up to 8.5%. It is produced using various apple varieties and yeast. Due to legal regulations, Polish ciders must contain at least 60% apple juice, which distinguishes them with a higher fruit content from ciders produced in most other European countries. Poland, being a global leader in apple production, often uti-

lizes apples in processing. The lack of dedicated apple varieties for cider production and the ability to use more than 2 apple species provide flexibility in formulation for this alcoholic beverage [1]. Selecting the right apple varieties and microorganisms for fermentation are crucial aspects of cider production.

Cider is experiencing a two-fold faster pace of sales value growth compared to alcoholic beverages as a whole, comparing 2021 to 2022. This product still represents a niche in the market, accounting for 0.12% of the domestic alcoholic beverage market. However, as the overall sales value of alcoholic beverages declines, an increase in cider sales value is observed [2]. This trend has been noted by some breweries that have started introducing apple-based beers. Experts from The Association of Employers The Polish Wine Council remind consumers to read product labels to choose original ciders, thereby supporting the development of cider producers. The Polish government promises to abolish excise taxes on ciders to support national products. The resolution went to the parliament, but due to a change in its composition in September 2023, the bill was not considered.

Over the years, the cider market has undergone significant development. Polish cider makers have mastered the production of this beverage on a large scale, supplying both domestic and foreign markets. The most recognizable brand in Poland is Cydr Lubelski, produced by the company AMBRA S.A. This brand





Fig. 1. CyderInn available in three variants: dry, semi-dry, and apple with rose. [<https://cydrownia.net.pl/ciderinn/>]

holds approximately 50% of the cider market share [3]. Their consistent product offering includes three varieties of apple cider and one pear cider called perry. Another Polish producer increasingly appearing on store shelves is CYDROWNIA S.A. Their portfolio includes cider brands: CyderInn, Dzik, and Dzik 0%. CyderInn adopts a classical approach to cider production, using 100% apple juice. It is available in three variants: dry, semi-dry, and apple with rose. The brand Dzik is obtained from Polish wild apples and pears. Dzik 0% represents an innovative approach to the market by introducing non-alcoholic cider. Additionally, they offer sensory-interesting products, enriching the classic apple cider flavor with options such as maracuja or lemon grass. Through the sale of Dzik and Dzik 0% bottles, they support the Łąka Foundation. Collaborative initiatives with various foundations are increasingly adopted by producers, successfully encouraging consumers to purchase their products.

Craft cideries are also gaining popularity and recognition in global competitions. The production of high-quality cider is attracting an increasing number of enthusiasts. The "Polish Craft Ciders Association" actively engages in efforts to integrate the craft cider community and takes actions to regulate legal regulations that will promote the development of cider production. Polish craft ciders have been awarded prizes in international competitions. Chyliczki Cider is a family-owned craft cidery. They offer a variety of apple-based beverages, categorizing them into two types: sparkling and ice ciders. The same production methods used for sparkling wines are employed, and each bottle matures for a minimum of 8 months. Radosny Cider is a young craft cidery located near Wrocław. The foundation of Radosny's production relies on the use of only old apple varieties and wild yeasts. Cider makers enthusiastically experiment with production technologies, employing various vinification methods. Each of their products is characterized by a low-intervention production ap-

proach, meaning minimal interference in the natural fermentation and maturation process. The result is the production of high-quality natural ciders.

Cider, as a beverage, is an example of a product with a rich and enduring heritage and traditions. However, in response to changing consumer preferences and emerging trends, cider has seen a significant increase in popularity. The production of this beverage is natural and supports the Polish industry. Furthermore, its natural version serves as a source of fiber and polyphenols. Additionally, due to the success of craft ciders in international competitions, these beverages will gain prestige and exert pressure for the release of high-quality products into the

market. The use of different apple varieties, fermentation methods, or flavor additives can expand the market, creating products that cater to every consumer group. Additional growing marketing support contributes to increased awareness of the product and higher interest from potential consumers.

## Kombucha

Kombucha is a fermented beverage obtained by fermentation of sweetened tea (*Camellia sinensis* L.) with microorganisms such as acetic acid bacteria, lactic acid bacteria, and yeast that collectively form the Symbiotic Culture of Bacteria and Yeast (SCOBY). Fermentation can transform nutritional components of tea into acetic acid, lactic acid, and ethanol [4]. Beverages available on the market are classified as non-alcoholic but, depending on the specifics of production, there may be trace amounts of ethanol in the beverage, ranging from 0.02% (v/v) to 0.5% (v/v). Various types of tea are used for kombucha production. Black and green teas are most popular due to their universal flavor. Kombucha made from herbal teas is also available, but it is manufactured less frequently due to slower microorganism growth and lower enzymatic activity [5]. Potential health-promoting properties, including antioxidant and anti-diabetic properties, cholesterol reduction, immune system support and liver detoxification, are the qualities that have decided about its widespread popularity [6].

The global kombucha market, valued at 2.56 billion USD in 2021, is steadily expanding. Projections for 2025 anticipate growth to the range of 3–5 billion USD, with a forecasted surge to 11.4 billion USD after another five years. Increasing consumer awareness and changes in regulatory laws may further boost interest in kombucha, that is the real belief that creates the next moves of developing new food products [7].

The chemical composition of kombucha varies based on tea type, their concentration and fermentation time, among others. Challenges for producers include achieving repeatability of chemical parameters and sensory properties since any variations in fermentation conditions alter the microbial consortium. Therefore, the National Centre of Research and Development awarded a grant to a consortium of Fabryka Lemoniad, FL Group Ltd and Lodz University of Technology to run the innovative technological project "Development and implementation of innovative kombucha production technology" (POIR.01.01.01-

429 00-0910/20-00), which, among others, aims to stabilize taste and aroma attributes and extend kombucha shelf life. The project incorporates cold extraction of tea leaves to achieve a high concentration of bioactive compounds and employs newly screened strains of microorganisms [8].

The kombucha market in Poland is booming, with several manufacturers offering a variety of fermented teas with many additives. Leading companies include M Wolska sp. j. – Meduzyna, offering unpasteurized kombucha from organic farming, VIGO kombucha with live bacterial cultures and added ginger, cucumber, and coriander, and Majestea, providing a wide range of flavored kombucha. New companies on the market start to introduce innovative flavor combinations. Pasieki Rodziny Sadowskich offers kombucha with rose, mint, honey or pomegranate. A sparkling kombucha flavored with wild strawberry, which is an alternative to sparkling wines, is their new product. The Kisi Kisi brand is another Polish kombucha innovator. It uses uncommon raw materials for its kombucha, such as the herb of fireweed or hemp. The increased interest in this product in Poland has been noticed by foreign companies. As a result, products from Capitan Kombucha or Komvida can be already found in Polish stores.



Fig. 2. Sparkling kombucha flavored with wild strawberry as alternative to sparkling wines. [<https://pasiekisadowskich.pl/kombucha-musujaca#galleryName=productGallery,imageNumber=3>]

Recognition of kombucha by consumers, the diversification of flavor variants and rapidly growing competition are the trends observed in the Polish market. Manufacturers are also noticing the possibility of producing non-alcoholic alternatives to alcoholic beverages just like the aforementioned strawberry kombucha as a non-alcoholic substitute for sparkling wines. The production of this beverage on an industrial scale is a challenge that is being worked on not only in the centers of companies, but also in

scientific units. It is therefore a matter of time before kombucha meets the permanent offer of most grocery stores.

## Plant-based dairy alternatives

Plant-based alternatives to animal products, including dairy, are gaining popularity due to sensory acceptability and positive health impacts. Reducing cholesterol levels is one of the reasons to decrease the consumption of animal products, among other factors. Although Kefir has origins in the Caucasus, it is a Polish fermented dairy national treasure. This product has a long-standing tradition, and its market in Poland is currently experiencing a resurgence. Kefir is the most popular potential source of probiotics, with a mild and refreshing taste. Originally, it was made from cow's milk subjected to fermentation using a consortium of microorganisms known as kefir grains [9].

Polish people are well acquainted with plant-based alternatives, with 82% having heard of them, and over 30% consuming them occasionally. Plant-based kefir is the third most popular choice among Polish consumers [10]. The global market for dairy product substitutes is expected to increase from USD 21.4 billion in 2020 to USD 36.7 billion in 2025 [11]. In Poland, where kefir has a strong tradition, its availability is on the rise, while in Western Europe, it is gaining popularity as an innovation. It is estimated that the global kefir market will grow by 60.4% from 2021 to 2028 [12].

Qualitative research on plant-based kefir is ongoing, with producers and scientists working on it. The product's concept is based on the idea that its texture and flavor should imitate that of dairy milk. Production challenges are focused on stability and the fermentation process. Sensory and manufacturing factors depend mainly on the raw materials used as a base. The most popular ones are the same as those used for milk alternatives: soy, nuts, or oat flakes are the basis, but there are also new options based on coconut milk or chickpeas [13]. The ProBioVege



Fig. 3. Oil press cakes and prototypes of non-dairy milk alternatives [<https://www.facebook.com/photo.php?fbid=312584037564046&set=pb.100064373551199.-2207520000&type=3>]

project, aimed at producing innovative plant-based dairy alternatives, including kefir is being developed as part of a project funded by the National Centre for Research and Development under the Leader XI programme. Scientists use oil press cakes, which are the remains of pressing oilseeds such as flax, amaranth, or black cumin, to produce the base for plant-based alternatives. These products have a pure composition, are rich in bioactive ingredients, fiber, and contain beneficial microflora [14]. The sustainable development approach in the production of vegan products is an additional important factor influencing the attractiveness of these products.

Roślinny SuperFood and Mleczni Bracia are examples of Polish artisanal producers of plant-based dairy products. Both companies offer coconut milk-based kefir alternatives [15]. These products are available in specialty vegan food stores or can be ordered online. Polish store shelves primarily feature products from foreign companies. The Spanish company NaturGreen offers kefir in its product range. They use almond, coconut, or cashew as the base for their products. Additionally, they offer kefirs enriched with fruits.

Kefir has gained recognition due to its sensory and health properties, becoming an integral part of the Polish diet. Hence, the need for the development of this product category to increase its accessibility to a wider range of consumers. An important aspect of the future development of vegan kefir is minimizing the price gap between animal-based products and their plant-based counterparts. Therefore, the search for alternative products for use as base for fermentation is currently a hot topic among scientists and manufacturers.

## Conclusions

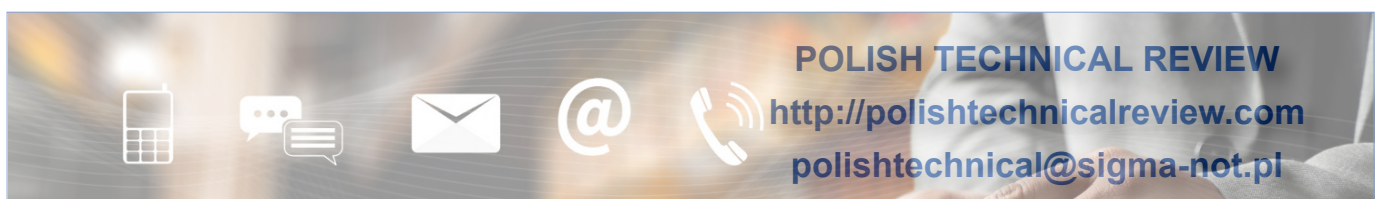
Despite the already diverse market for fermented beverages in Poland consumers expect its further growth and novelties on store shelves. The combination of innovation with tradition has created a second life for cider and kefir. Meanwhile, the desire to explore Eastern cuisine has brought kombucha to the market. Each of the products discussed has great potential for development but requires a connection between industry and academia to better understand and optimize production processes.

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## VISION SYSTEM TEST BENCH

### STANOWISKO BADAWCZE SYSTEMU WIZYJNEGO

**Summary:** The present paper is the third part in our consideration of the following issue: attempts to compare the work of the detection sensor with the ZFV vision system in the packaging labelling project.

**Keywords:** labeller, detection sensor, ZFV vision system, packaging

**Streszczenie:** Artykuł jest trzecią częścią w naszym rozpatrywaniu zagadnienia jakim jest próba porównania pracy czujnika detekcji z systemem wizyjnym ZFV w procesie etykietowania opakowań.

**Słowa kluczowe:** Etykieciarka, czujnik detekcji, system wizyjny ZFV, opakowania

To perform the studies, the measuring test bench was completed on the grounds of ROTO labeller, designed by RMPAK company; it was modified for the research purposes. Its scheme is found in Fig. 1. The mentioned equipment was assembled as a whole at the territory of the company. It is constructed from the commercial elements, coming from contractors as well as being performed independently. RMPAK company deals with designing and construction of production lines for the needs of individual customer. In the period of striving at continuous improvements and seeking for optimal solutions, the mentioned company is interested in stating in what situation the vision camera should

be installed and in what conditions the photoelectric sensor should be employed. It is also important to decide whether a type of the used label has the influence on the performance of the labelling line. In the tests, the following equipment was used ROTO labeller with the following elements:

- labelling head
- turntable
- separator
- transporter
- LCD screen

Their construction and the principle of operation are given below.

The labeller has a stable foundation 9 with the possibility of regulating the height in order to adjust to the existing packing line. On the framework, transporter 10 with the adjustable rate of moving is assembled. The indicated set allows transport of packaging, one after another. The packaging is separated from the remaining ones using set of separators 5, and then it is transported to the site where the sensor of product 8 starts the sequence of labelling. Then, the pressure rollers 3 keep the packaging on turntable 7 which facilitates labelling of round packaging all around owing to introduction of rotary movement. The sensor of label 4 transmits the signal of readiness to labelling head 6. In the control cabinet 2 there is a control panel owing to which it is possible, in a simple way, to change the parameters of work of the equipment.

Before commencing the labelling of the products, it is necessary to adjust the successive sub-units to a specified product using regulations and to make appropriate adjustments in control panel. The next

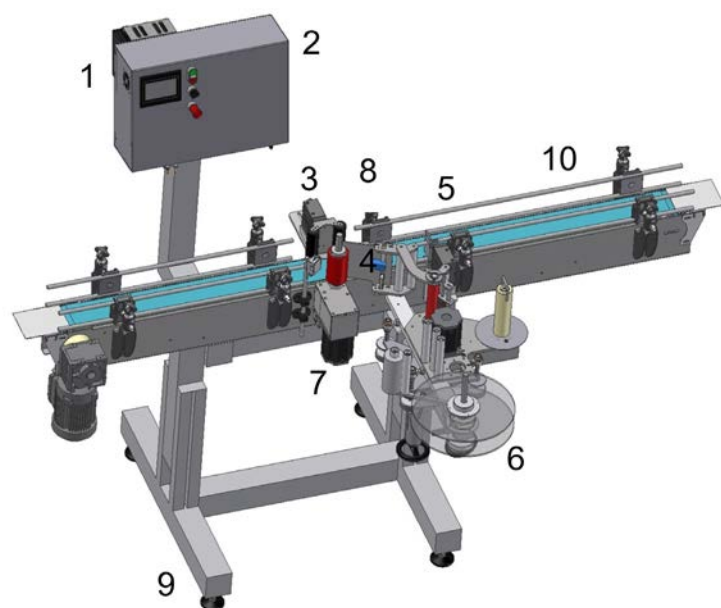


Fig. 1. ROTO labeller

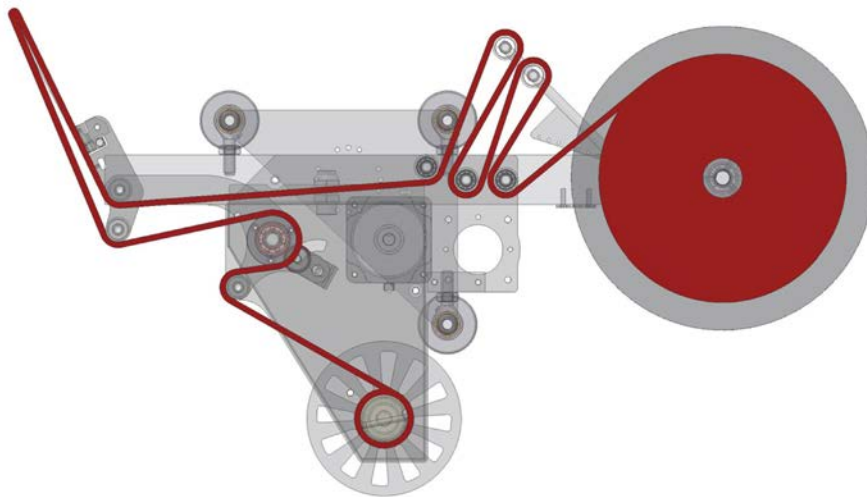


Fig. 2. Sticker as an instruction for the correct winding of the label tape

head; therefore, the instruction in a form of sticker is placed on the discussed set, what is illustrated in Fig. 2.

To conduct the tests, the measuring bench has been prepared; the materials for the tests have been collected, as well.

Within the frames of the conducted tests, the systems of camera and of photoelectric sensor were assembled on articulated Magic Arm. A special system of mounting for labeller was also performed and employed; it is illustrated in photos 1 and 2.

The mentioned arm enabled the stable positioning of the equipment in the required working space of the transporter.

It assured the elimination of errors connected with the undesired vibrations of the sensors.



Photo 1. Sensor mounted on the articulated arm



Photo 3. Camera setting panel assembled with adjustable mount



Photo 2. Camera mounted on the articulated arm



Photo 4. Switch box

stage includes verification whether the tape (ribbon) of the device is stretched and performance of the eventual regulation. The degree of the tape's tension is especially significant for the work of the equipment at higher speed. The correct application of the labelling tape has the effect on the efficient operation of the



Photo 5. Labeller ready to perform the tests



Photo 6. Calibration of the camera in the image from the label



Photo 7. A comparative set of labels prepared for measurements

After completion of the particular components, the total labeller was mounted; it is given in Photo 5. For the purposes of the discussed tests, the control panel was performed (Photo 4) facilitating the non-invasive change from the vision system to photoelectric system. It abbreviated significantly the time of

retooling the machine for the successive tests.

In the final stage of preparations, camera should be calibrated and its control panel should be programmed what is illustrated in Photo 6.

For the tests, different types of labels were employed; their examples are given in Photo 7.

The following above labels, with the specified features were taken into consideration:

- label 1 – big, regular, on paper substratum,
- label 2 – small, regular, on paper substratum,
- label 3 – small, low and long, on paper substratum,
- label 4 – medium, 3D print, on foil substratum,
- label 5 – medium, transparent, on film substrate,
- label 6 – big, irregular shape, on paper substratum.

The application of labellers is justified when we have to deal with production above 10 000 pcs. Due to the mentioned reasons, a series consisting of 100 pcs of packaging was used in comparative studies; they were appropriately labelled. Then, the correctness of packaging labelling was checked and the calculations were carried out. On the grounds of the calculations, the diagrams concerning quality of labelling were plotted in percentage values. It enabled drawing the conclusions. When changing the adjustments of working parameters of the transporter and labelling head, we may obtain different speed of labelling, according to a type of packaging and size of the label. Therefore, a different speed of transporter work was employed during the measurements in order to check whether the rate had the influence on the correctness of labelling the packaging.

The labels used in the tests are shown in photos 8–13.



Photo 8. Label no. 1

Label 1 has big dimensions and regular shape as its height is similar (in value) to its width. It is employed on packaging made from plastics, e.g. 2-litre container destined for liquid for cleaning the floor. It is die-cut on paper substratum, it contains flat print with a distinct contrast of colours and also, with characteristic images.



Photo 9. Label no. 2

The successive label, marked with number 2 is small and has a rectangular shape. It is mainly employed on small glass packaging, such as varnish for nails. It is wound on paper substratum, without characteristic images; it has a distinct black band. The print on the label is flat.



Photo 10. Label no. 3

Label no. 1 is characterized by a great disproportion between a small height and a significant length and is printed with a flat print. It is coloured in soft shades; it contains, however, a black rectangle and some pictures. It has a paper substratum and is employed on metal packaging such as, for example, tins for preserved food products.



Photo 11. Label no. 4

Label marked with number 4 has rounded corners; its upper edge has also a shape of arc. It is produced with the application of 3D overprint technology. Its graphic layout is abundantly

decorated and multicoloured. The substrate is made from foil because it is mainly applied on plastic or glass bottles intended for beverages.



Photo 12. Label no. 5

Label no. 5 is transparent, so it is diaphanous and is also employed on foil substratum. Its medium dimensions are quite similar each other, in two-colour shades. It is applied on packaging made from plastics or paper, intended for the products with a lowered temperature and containing e.g. ice-cream.



Photo 13. Label no. 6

Label marked with number 6 has irregular shape and is big. It is applied on big plastic packaging with oval cross-section such as e.g. container for liquid intended for cloth rinsing. It is multicoloured, with few characteristic symbols. The substratum is made from paper.

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# SOLUTION OF WATER AND SEWAGE MANAGEMENT IN PLASTICS RECYCLING

## ROZWIĄZANIE GOSPODARKI WODNO-OSADOWEJ W RECYKLINGU TWORZYW SZTUCZNYCH

**ABSTRACT:** In the time of dynamic development of polymer material's recycling, the effective treatment of waste water generated during the process of cleaning the above mentioned renewable raw materials has become a very important problem. Recycling of polymer plastics allows the reuse of raw materials which, in turn, contributes to reduction of demand for new materials. In order to play a role of sustainable solution, industry must, however, focus its attention not only on production of recyclates but also on the effective and safe treatment of water used during the manufacturing processes. In this document we will discuss the complex solution of the problem

mentioned above. This paper presents authorial solution in respect to treatment of waste water, arising during the process of plastics cleaning subjected to the recycling. Attributing to the application of advanced technologies and strategies, suggested solution is aimed not only at effective removal of contamination but also, to minimize the quantity of consumed water and the resulting waste. Discussed solution is a step towards sustainable processing of plastics, limiting its negative effect on the environment, and, at the same time, keeping the high standard of purity of the produced material.

### Introduction

In the light of the rising problems connected with the global pollution, recycling becomes a key element of activities, aiming at limitation of the negative effect of man on our Planet. The problem of waste, especially of plastic waste is nowadays one of the most urgent ecological problems; the mentioned type of waste is generated today in enormous quantities due to the application of the materials of this type in a very wide spectrum of everyday use products. In the context of recycling, processing of polyethylene films such as LDPE, LLDPE or HDPE has become especially significant area. In the connection with their universal presence in everyday life, the mentioned foils and films become a permanent load to ecosystems, affecting negatively the state of the environment. Contamination of the environment with the discussed materials concerns not only humans but also numerous animal species which suffer from penetration of plastics to their natural habitats. Here we should pay attention to meaningful profits, resulting from recycling of plastics, with the special consideration of polyethylene materials. The reuse of raw material and especially production of re-granulate does not only contribute to environmental protection but also brings countless economic advantages. The re-granulate is an alternative to tra-

ditional granulate as it is characterized by similar parameters; therefore, it may be employed and reprocessed with a success. As it was earlier mentioned, it makes this product a good alternative to plastics in many industrial applications. Due to the fact that most of the waste films are soiled and joined together, there is a necessity to employ multiple stage cleaning process, facilitating their further processing. Washing of recycling-subjected films is complicated and is connected with considerable water consumption. It also generates another problem for industrial plants: what to do with the resulting sewage? When answering the above mentioned question PFTechnology; with location in Wierzbica near Radom, presents the authorial solution in a form of installation for pre-cleaning of process water coming from plastic recycling plant. The mentioned solution is a result of long-time research and practical experience, gained during this period. Implementation of the suggested solutions does not only solve the problem connected with the resulting waste water but also allows for effective treatment of consumed films and reduction of the amount of generated solid waste.

The treatment process of sewage coming from cleaning of flakes includes multiple stages, demonstrated at the draw (Fig. 1), aiming at effective removal of contamination and recovery of pre-treated liquid. The process commences with



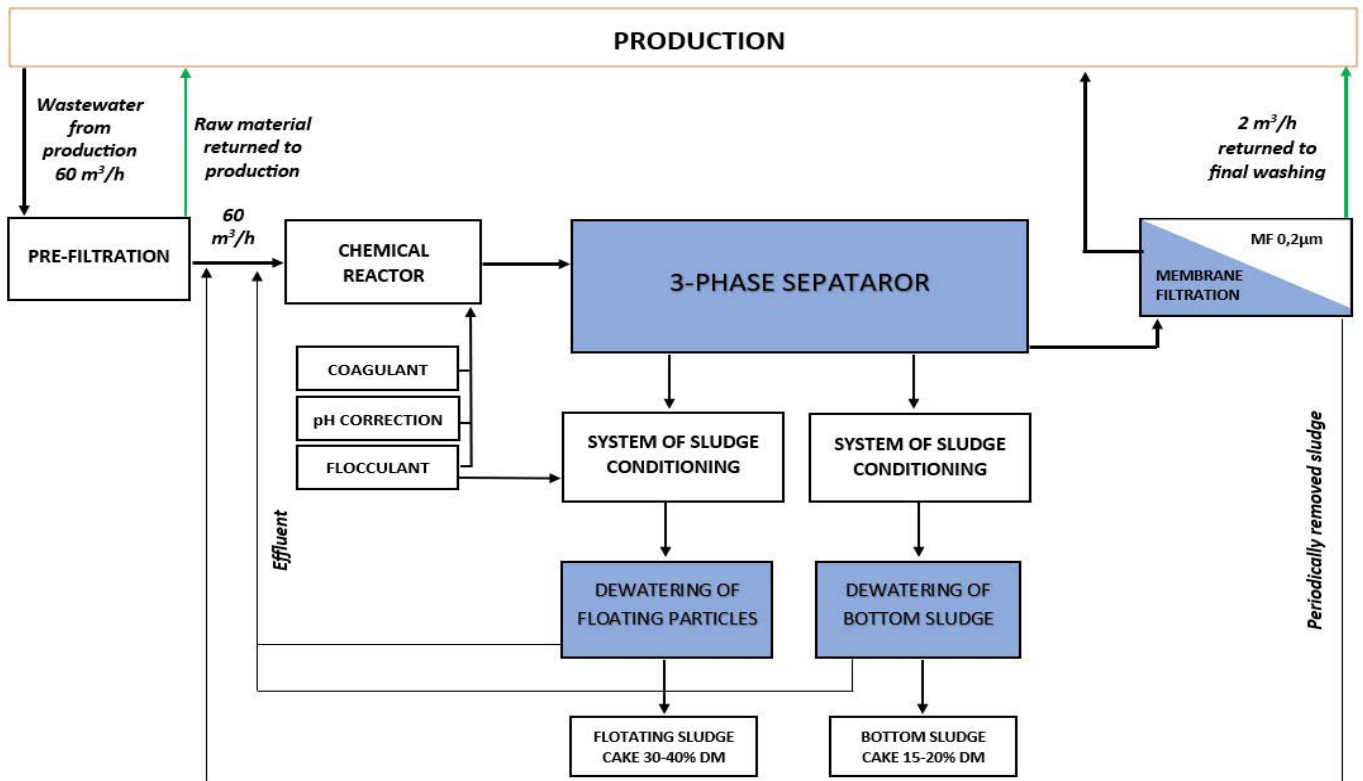


Fig. 1. Diagram of the installation for pre-treatment of wastewater from recycled plastics

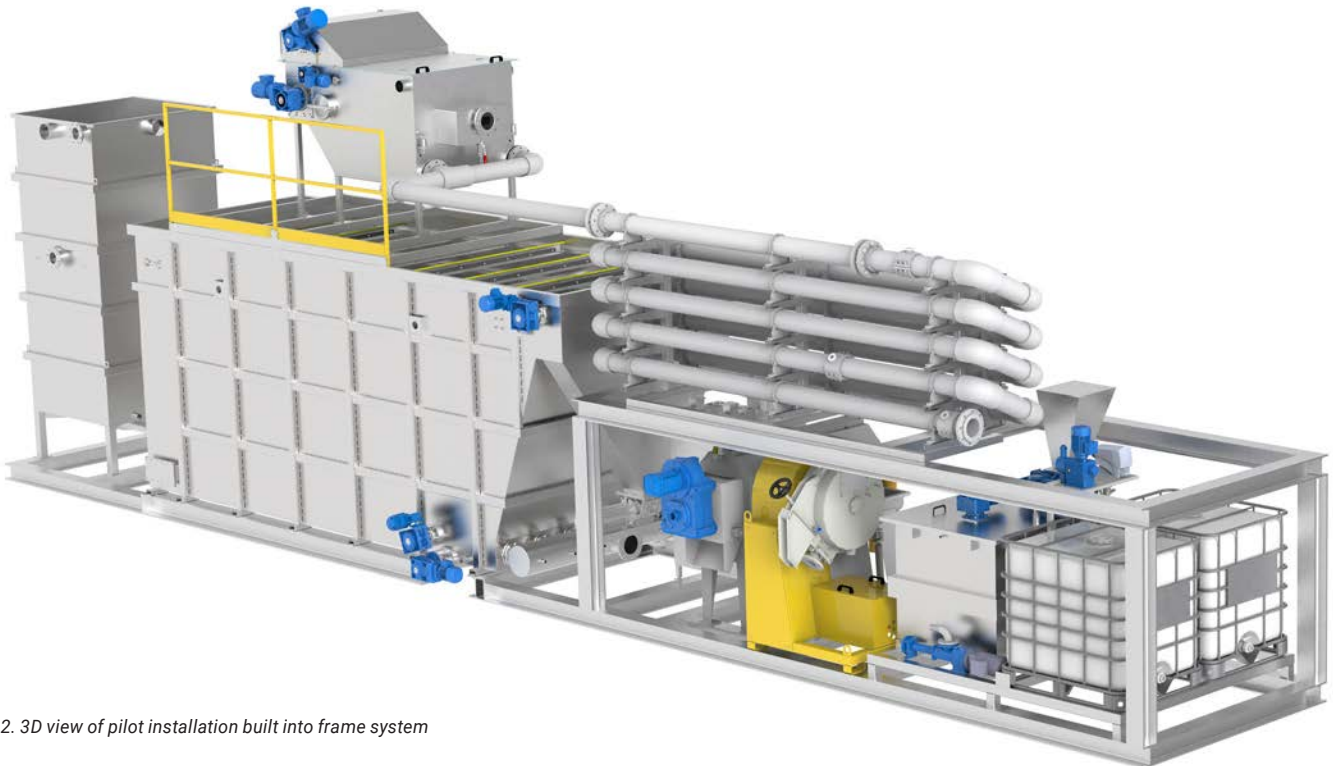


Fig. 2. 3D view of pilot installation built into frame system

the mechanical pre-filtration, adapted to the characteristics of sewages and the needs of the customer/further process. It should be mentioned that PFTechnology has more than 20-year experience in respect of production of complete filtration systems. Preliminary filtration of the wastewater may be carried

out in many stages, e.g. with the aim to separate greater particles of recyclate with the possibility of returning them to production. Then, the sewage is subjected to chemical treatment, consisting of effective separation of water-insoluble particles. Waste water prepared here is then directed to 3 phase separator where the

appropriate system of fine bubble aeration is employed; the mentioned system facilitates effective separation of the pre-treated wastewater from floating and bottom sludges. It should be stressed that the application of fine-bubble flotation with the respectively selected size of bubbles of floating gas ensures greater contact surface. It makes more effective adsorption of solid particles and, in consequence, the effective treatment of contaminated water and recovery of the pre-treated liquid for its further processing. Purpose of the discussed process is to separate three phases: floating particles sludge, bottom sludge and pre-treated liquid. It is worthy to mention that it is a key question for the effective treatment of waste water and recovery of the partially treated liquid for further treatment according to the suggested method.

The separated materials both the bottom and floating one, are removed from the separator unit with the use of removing systems and then, they are subjected to dehydration using specially designed dehydration equipment. The obtained effluent is again directed to the chemical treatment stage. The pre-treated liquid in 3-phase separator is subjected to microfiltration at the level of 0.2  $\mu\text{m}$ , eliminating the particles of contamination below this size. It should be stressed that in spite of the fact that the degree of liquid purity does not allow discharge of such effluent to the ground waters, it gives the liquid optimal quality suitable for its re-use in the washing of foil flakes or for the supplementation of the system. The level of microfiltration has been selected as a result of economical analysis.

When a necessity of more accurate pre-treatment of the liquid arises, e.g. in order to discharge it to the sewer system or even to enable its discharge to the ground waters, there is a possibility of increasing the degree of filtration.

In the context of satisfying the standards of discharge to sewage system, especially elimination of chlorides, sodium and

other salts, it is suggested to employ nanofiltration. It should be however mentioned that decision on the choice of microfiltration was not accidental due to the possibility of the reclaimed liquid reusal retentate what is consistent with the aim to increase the effectiveness of installation. Nanofiltration allows the separation of most pollutants, but may lead to the creation of a concentrate stream that is difficult to recycle and constitutes another technical and economic challenge. In practice, one reasonable solution includes subjecting the concentrate to vitrification, i.e. melting in plasma arc. PFTechnology has already commenced the studies in this respect.

The installation was designed and constructed in modular system, on the frame, in three linked segments (Fig. 2). Such solution assumes a complete mobility, easiness of connecting and launching at the customer's site. The idea of the above mentioned construction, facilitates an easy of access and eventual exchange of components, this installation solution was created during the conducted research, aiming at the choice of the optimal configuration of the equipment.

Modular system constructed in this way allows conducting of full-scale, long-lasting tests at the customers who wish to improve the effectiveness of work in their plants.

## Analysis of operating work of the installation

Studies conducted between 2020 to 2023 allowed PFTechnology to determine the effectiveness of pretreatment in relation to multi-stage degree of preliminary treatment of waste water coming from recycling plant. Significantly, there was observed a very high correlation between the type and degree of contamination of the processed waste/input material in the recycling plant and the degree of contamination of raw waste water at the entrance to installation. The contaminated waste water derived

Tab. 1. Selected results of analysis performed with minimal doses of coagulants and flocculants

	Analyzed sewage	Tested parameter				
		pH	Total suspended solids (TSS)		COD	
			[mg/l]	Percentage reduction [%]	[mg/l]	Percentage reduction [%]
Sample 1 from recycling of clean industrial film	Raw waste water	7,7	207,6	-	262,3	-
	After phase separator	6,9	79,3	61,8	153,3	41,6
	After membrane filtration	7,2	22,7	89,1	54,8	64,3
Sample 2 from processed film, transparent	Raw waste water	6,9	811	-	1329	-
	After phase separator	6,8	180,7	77,7	218,3	83,6
	After membrane filtration	6,8	25,67	96,8	41,3	81,1
Sample 3 from processed film, mix	Raw waste water	7,6	1170	-	961,0	-
	After phase separator	7,4	284,4	75,7	326	88,5
	After membrane filtration	7,3	21,6	98,2	63,5	80,5
Sample 4 of highly soiled agricultural film	Raw waste water	7,8	3200	-	919	-
	After phase separator	7,3	240	92,5	276	70,0
	After membrane filtration	7,4	27,6	99,0	76,1	72,4



Photo 1. Comparison of effluent samples – raw effluent (left) and effluent after phase separator (right)



Photo 2. Comparison of effluent samples – effluent after membrane filtration (left) and effluent after phase separator (right)

from washing of the foil flakes of agricultural origin was most demanding in respect of the conducted process.

In respect to evaluation of effectiveness of the treatment process, the samples of the raw waste water from the main stream, the effluents pre-treated in 3-phase separator and after membrane filtration, were collected. The results of the tests are given in Table 1 and are referred to the waste, coming from processing of different batches of films. Analyses of the results were concentrated on specific parameters with stress on the level of total suspension which is a significant indicator of the quality of treatment process. Comparison of the samples enabled assessment of the effectiveness of preliminary treatment of raw effluent with a high variation and supplied information on the effectiveness of the whole treatment system.

As far as the content of total suspended solids (TSS) is concerned, it was possible to reach maximum ca. 90% reduction after passage via 3-phase separator. Additional microfiltration allowed cleaning the liquid and obtaining reduction equal to ca. 99% in relation to the raw effluents. Reaching such high reduction is however not economically justified as it would result in more frequent necessity of membrane replacement. To ensure the long durability of membranes, we should not treat the liquid with the TSS content higher than 300 mg/l because it may contribute to their fouling. Additionally filtrated liquid must be absolutely deprived of substances, containing oils, greases or other fats.

The discussed installation has also the task of limiting the generation of waste. To this end, the isolated sludge particles:

bottom and floating ones were tested in aspect of dry matter content at the exit from dehydrating presses. It should be mentioned that the mass properties of the floating particles are similar to mass of the liquid what was a quite big challenge which was reached after the application of the appropriate dehydration process. The mean results of the dry matter content, as obtained during the tests were equal to 18.33% for bottom sludge cake and 33.31% for the floating sludge cake (Table 2). The above measurements confirm the effective work of dehydrating equipment and supply the important data on the reduction of the mass of the generated sludges, having a direct effect on the reduction of the mass of resulting waste.

Tab. 2. The results of the measurements of dry matter content in sludges

No. of sample	Percentage dry matter content in tested sample	
	Bottom sludge cake	Floating sludge cake
1	20,58%	30,62%
2	15,15%	32,77%
3	19,25%	36,53%
Mean	18,33%	33,31%



Photo 3. Floating particles in the phase separator



Photo 4. Dewatered sludge

## Summing up

Recycling of polymer plastics is the indispensable process nowadays, what, in turn, generates the necessity of seeking of effective solutions to protect the environmental resources and reduction of expensive methods of its implementation. The solution submitted by PFTechnology connected with the preliminary treatment of the effluents and their reuse in a form of technological water in the industrial processes enables a considerable reduction of operating costs of recycling plants, with the preservation of the principle of sustainable development. Reduction of above mentioned cost is directly connected with the reduction in consumption of fresh water in the process of

washing foil flakes and with the decrease of the amount of waste, mainly in a form of the separated dehydrated sediments.

During the long-lasting tests, we observed an additional, very positive application effect of the discussed installation, and namely, the elimination of unwanted odours resulting from the effluents generated during processing of foil flakes of different origin. In it's studies, PFTechnology confirmed the possibility of complete removal of the above mentioned odours. Currently PFTechnology is conducting test and studies with application of such solution in real life.

The application of the discussed innovative technology, developed by PFTechnology, will enable the effective solution of many problems, existing now in many enterprises from the plastics recycling sector.

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# TO BE AS WOLAŃSKI, THAT IS, HOW TO MEET THE DREAMS OF THE YOUNG AGE WHEN BEING A BOY AND INVENTOR OF SPACE DRIVES

## BYĆ JAK WOLAŃSKI, CZYLI JAK SPEŁNIAĆ MARZENIA MŁODOŚCI BĘDĄC CHŁOPCEM I WYNALAZCĄ KOSMICZNYCH NAPĘDÓW

The present paper is a continuation of the article which was published in the previous edition of Polish Technical Review. It is a story about Prof. Piotr Wolański from Warsaw University of Technology, a visionary who – apart from the problems concerning combustion, explosions and space drives – was able to give the positive energy and passion to the students as well as his collaborators all over the world. How it happened that a boy from a small, mountainous settlement “reached the stars”, becoming the inspiration to the younger generations? The authoress of paper concentrates her attention on the motivating aspect, being perceived from the viewpoint of Professor as well as his pupils and also, she gives the floor to the mentor himself.

According to Dante Alighieri, *Three things remain with us from paradise: stars, flowers and children*. For Piotr Wolański, born in August Sunday in 1942 in Milówka at Żywieckie district, the mentioned three paradise attributes constituted the integral company since his early childhood. Family of this extremely witty young man made their living from agriculture as well from the salary of father of Prof. Wolański – a surveyor who before the war gained the championship of Poland in chess compositions. Most probably, young Peter inherited the passion to solve the problems and gumption to science just from his father. The future Professor was not the only one child in the family as he shared the rooms with his three siblings: older brother Adam and sister Barbara and younger sister Krystyna. As it was revealed later, all of them received higher education. In their family house, a great attention was paid to development of interests and, consequently, the pressure was laid on science what was not a rule in the post-war Poland. When being a pupil of primary school, Piotr, as revealing the greatest interest in mathematics and physics and the related sciences, experienced his first scientific fascination which had the influence on the whole his life. At the middle of the fifties, he had the occasion to see a start of American rocket



Photo 1. Piotr Wolański (first from the left) with the parents: Joanna and Eustachy and the siblings in the native locality Milówka. Next to him, older brother Adam Wolański and two sisters: Christine and Barbara

Source: Home archives of Prof. Wolański

“Aerobee”. Although it was only a relation transmitted in the Film Chronicle which he saw at the local movies “Tęcza” (in English: “Rainbow”), the mentioned impulse was enough for construction of rockets and design of space drives to become his life passion. The flammable cellulose photographic films were the fuel for the model rockets, constructed by young Piotr. He received them from the priest Henryk Hubner, catechist and teacher of photography of the future Professor. What else was the motivation for him, stimulating the continuation of further learning?

As since the primary school until the end of secondary school he helped – together with his siblings – in agricultural work, and, *inter alia*, in cow grazing, driving of horses, crop harvesting or mowing, at the area there the level of plots, situated even 2 km from his house reached 200 m above the level of Milówka. The exhausting character of the mentioned work, as being performed usually manually, strengthened the decision of Piotr

**PROF. PIOTR WOLAŃSKI, PHD, ENG.**  
(1942–2023)



Professor of Warsaw University of Technology (PW) and Aviation Institute (Łukasiewicz Research Network). Since 1966, related to Warsaw University of Technology where he defended his PhD thesis at the Faculty of Power and Aeronautical Engineering in 1971. In 1979 he obtained the title of habilitated doctor and in 1988 – the title of professor of technical sciences.

In the years 1987–1990 he was the dean of his native faculty; 1981–2012 – Head of the Division of Aircraft Engines at the Institute of Heat Engineering. In the years 2002–2005, Vice-Rector for Science at the Warsaw University of Technology. From 1990 to 1994 – President of Polish Astronautic Society; after termination of the cadence – Honorary President of the mentioned association. Since 1995 – the member of the Committee of Cosmic and Satellite Studies of Polish Academy of Sciences. In 2003, he became the President of the mentioned above committee for the successive 4 cadencies. Since 2019 – the Honorary President of the Committee. The member of Warsaw Scientific Society – Department IV of Technical Sciences. In the years 2016–2022 – the member of the Executive Committee of Engineering Academy in Poland. The member of the Council of the National Centre for Research and Development in the period of 2014–2018. He was also the member of the International Astronautical Academy (IAA) and also, of the Council of the Polish Space Agency (2015–2020). A visionary who made the enormous contribution to Polish space sector when outlining the series of areas for future development and hypotheses: on the origin of Moon, or decay of dinosaurs. In his scientific activity he undertook the problems connected with the combustion and the methods for diagnostics of combustion processes, explosions, combustion engines and collisions with celestial bodies. The discoverer of diffusion ignition, developing the area of cosmos drives and rockets of repeated use. Under his patronage, the first Polish satellite called PW-Sat was constructed at Warsaw University of Technology. The direction of studies: "Aviation and Cosmonautics" became the permanent direction of the studies at Polish technical universities. He was appreciated abroad as the lecturer, *inter alia*, at Michigan University in Ann Arbour (USA), at Northeastern University in Shenyang (China) and at Nanyang Technological University (Singapur). Doctor *honoris causa* of Azerbaijan State University of Petroleum and Industry in Baku (1997) and the Józef Dąbrowski Technical Military Academy in Warsaw (2015). Laureate of many awards, including the Award of the Minister of Science and Higher Education for the lifetime achievements, the award of the aviation environment "Blue Wings" (2016) for the overall achievements in respect of cosmic scientific and didactic activity. One of the most frequently cited authors of scientific publications, being found at the list of the World's TOP 2% Scientists.



Photo 2. Launching of the rocket with the fuel coming from cellulose photographic films. Source: Home archives of Prof. Wolański

about change of his life style. As he said – *I was very interested in space and didn't want to work hard in agriculture, this motivated me to pursue higher education.* Thinking of Piotr Wolański was so much focused on the heaven spheres that even the nearest secondary school, situated at the distance of half-an-hour by train and 3 km from railway station (which he chose for the continuation of his education in Żywiec) bore *nomen omen* the name of the great Pole and astronomer – Mikołaj Kopernik, whose jubilee of the 550<sup>th</sup> birth anniversary was solemnly celebrated in 2023. The analogy to the famous name of the astronomer appeared in the Professor's life also in 2014, at the seat of the Unites Nations Organization in Vienna where – owing to his initiative – a copy of the painting by Jan Matejko, "Astronomer Kopernik, that is, conversation with God" was unveiled.

In 1957 when he attended the 9<sup>th</sup> class of the secondary school (lyceum), launching of the first artificial Globe satellite had place; it was "Sputnik-1". As he said in his autobiography – *It may be said that already then I was in friendly relations with the Space.* After launching the first and the second Sputnik, the editorial office of the periodical "Świat Młodych" (in English: "The World of the Youth"), the weekly for the school pupils, has announced the competition about the space topics: *Astral expedition*. I was awarded with the 3<sup>rd</sup> place in this competition and the award was monthly pioneer campus in Bulgaria (Złote Piaski near Warne). It encouraged undoubtedly the future student of the Faculty of Aviation at Warsaw University of Technology (1960) which was transformed into the Faculty of Power and Aeronautical



Photo 3. Piotr Wolański at the Astronautic Congress in 1964

Source: Home archives of Prof. Wolański

Engineering in November 1960. During the next years which were described in detail in the article "Professor Wolański – cosmic authority, the pearl of Polish Science" (Polish Technical Review 4/2023), Professor reached the successive level of scientific and professional career; he participated in various bodies and assemblies which gave him the experience necessary at the University as well as in the Institute of Aviation where he was employed since 1992. He listened always to the people and was open to challenges and various situations. His readiness to cope with the unforeseeable circumstances was almost the fate challenge when meeting the persons who being once univocally identified with the widely understood space industry. As early as during his studies, during the "Aviation Salon" in Paris, he made the connaissance with Yuri Gagarin – the first man in the cosmos space. The circle of the persons who became known

personally to him included, *inter alia*, Walentyna Tierszokowa (Valentine Tereshkova) – the first woman in cosmos and the only one who made the cosmic flight alone (as a single person), Scott Parazynski – the cosmonaut of Polish origin, or John F. Hall – NASA Director, expert of Polish Space Agency, who after the end of the Professor's cadence as the Chairman of the Committee of Space and Satellite Research of Polish Academy of Sciences in 2019, sent the following letter: *You rocked! You have done so much for Poland in space. There is no one – not anyone in Poland – who has accomplished so much for all of us across the years. Through your many decades of hard work and dedication, you have opened the path for all of us here in Poland, and we will now follow it to wonderful conclusion on missions to the Moon, Mars, and beyond. Many thanks to you for the privilege of calling you my friend along this exciting journey.* In the collection of photos of Professor, there is also found a personalized autograph of Neil Armstrong – the first Man on the Moon.



Photo 4. Doctor P. Wolański with the model of Space Shuttle

Source: Home archives of Prof. Wolański

Professor Piotr Wolański as the lecturer of the Faculty of Power and Aeronautical Engineering of Warsaw University of Technology and, also, the patron and creator of **Students' Space Association at Faculty of Power and Aeronautical Engineering**, transmitted his knowledge vividly and patiently. Dr Adam Okniński, Eng., – doctoral student of Professor and nowadays Director of the Centre of Space Technologies at the Aviation Institute **Łukasiewicz Research Network** recalls: – *Through his words and actions, he always encouraged us to work hard and set up ambitious goals. Also to do the work now, not to postpone – in the future we might not have time. After returning from foreign visits, Professor Wolański would share his materials and show us what other leading units were doing. He argued, "Well, if they could do it, so can we". Professor promoted also the activity, exceeding our basic duties*



Photo 5. Prof. Piotr Wolański after the ceremony of transfer of the copy of the painting "Mikołaj Kopernik (Nicolas Copernicus) – the conversation with God" by Jan Matejko, and of the model of satellite "BRITe-Lem". Source: Home archives of Prof. Wolański

To Prof. Wolański with much thanks!



Photo 6. Dedication of astronaut Scott Parazynski for Prof. P. Wolański  
Source: Home archives of Prof. Wolański

– publications, obtaining scientific titles or degrees, activities in the international organizations and participation in the competitions. Owing to his support and urging, I attended in the activity of many prestige bodies. During the recent years, he told me to promote the young promising scientific works, similarly as he was doing. After the meeting during which we decided on the further plans of activities, and with which he was satisfied, he

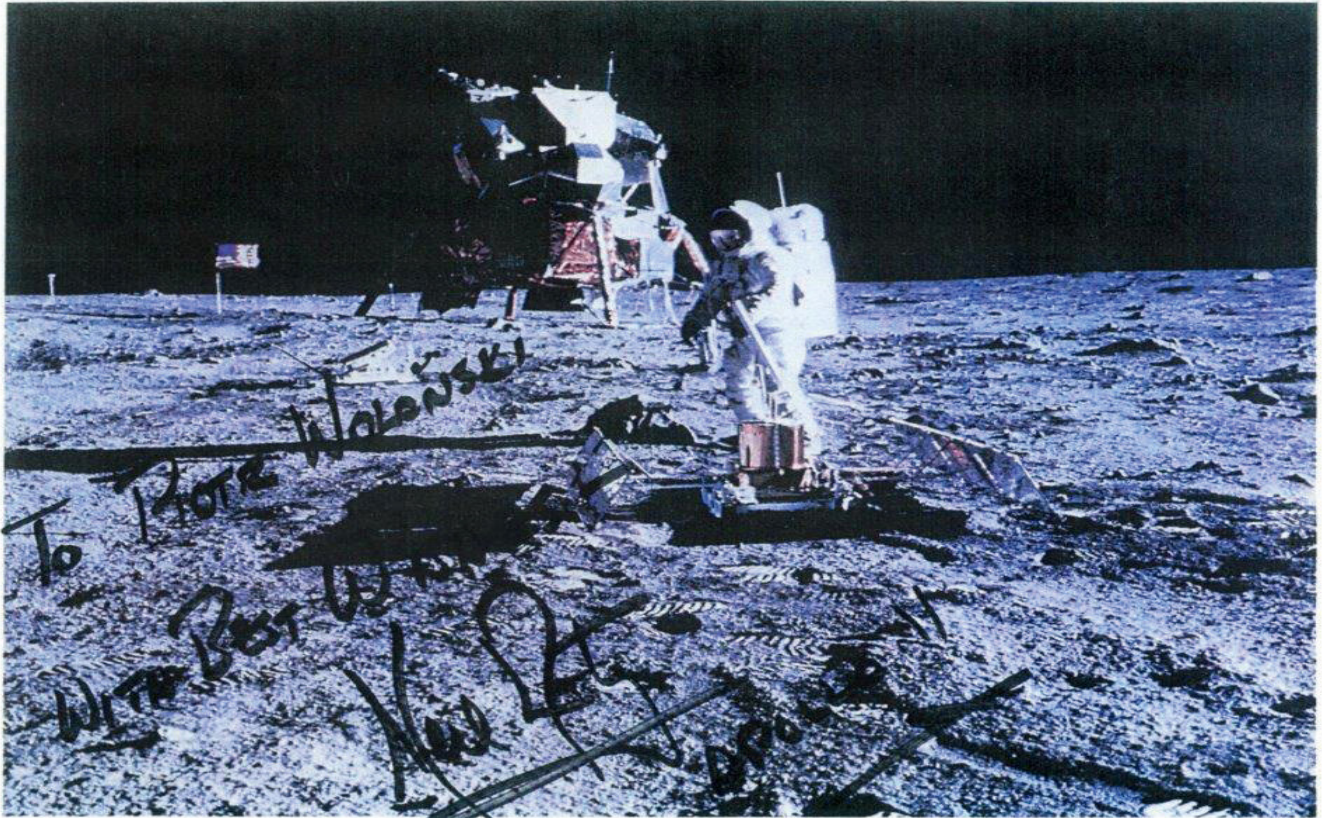
said: "It's cool, Mr. Adam". And he adds: – I will remember Professor as outstanding scientist, being also open to young people, and as a kind-hearted man. He had a series of international scale-achievements about which we must remember and speak. As Professor reminded often his mentor – Prof. Stanisław Wójcicki, so we, his pupils, will remind him forever. Professor Wolański was a patriot; he stressed the achievements of Polish science in the development of space technologies all over the world. Apart from historical achievements of pioneers dating back to some centuries ago, he showed and promoted not only the achievements obtained at the Warsaw University of Technology and at the Institute of Aviation but also in the total national space sector.

The viewpoint of Professor Wolański in respect of science development and its creators may be known owing to the interview granted to Bulletin of Warsaw University of

Technology in 2013 – *Scientific condition in the contemporary world is dependent on a few aspects. Certain studies, not only in astronautics, may be carried out when we have instruments and equipment which allow implementing such studies. Even if someone had the most magnificent brain but had been lacking the mentioned apparatus, he would not reach the discussed target. On the other hand, if someone has the best instruments, and does not have a brilliant mind, he will be not able to reach the discussed aim. In the United Europe, we have an access practically to everything. It is dependent on our predispositions to implement the goals. The Poles are already present in the European institutions such as CERN or ESA and although we are at the beginning of this path, I am sure that they work at the equivalent level and sometimes even at the better one. I repeat it to all my students that of they have any doubts, they should deprive of them because the level of our learning is, in many aspects, comparable and the result are the same. We should be only mobilized to work; then, we will be able to obtain much. There is no reason to feel inferior to the West. When answering to the question whether Polish people will fly to cosmos, Professor anticipated, in a certain way, the events which occurred ten years later after the interview. – I am convinced that the Poles will fly and it won't be one but many my countrymen. The development of the cosmic space – from the perspective of humanity – has been just commenced. I am very optimistic in this respect. I think that I won't fly personally, although Senator Glenn when being at my age made this journey.*

The first Pole who was found on the geocentric orbit was, of course, gen. Mirosław Hermaszewski (1941–2022) who during the mission of Sojuz 30-Salut 6 in 1978 encircled the Earth 126 times; during this mission, together with the Russian astronaut, Piotr Klimuk they conducted biological experiments, including those ones concerning the reaction of organism to zero gravity state, and performed geophysical studies e.g. observations of aurora borealis. Later on, he told about his experiences during





"That's one small step for a man, one giant leap for mankind."

Photo 7. Dedication of astronaut Neil Armstrong for Prof. P. Wolański

Source: Home archives of Prof. Wolański

the numerous meetings and became fully involved in popularization of astronautics. Just before the death of gen. Hermaszewski, Sławosz Uznański became selected and included to the group of the reserve astronauts of the European Space Agency (ESA), participating in the mission to the **International Space Station (ISS)**. On September, 1, 2023, he joined the European Astronaut Corps (EAC). To-day, we know almost certainly that 39-years old engineer and PhD holder from Łódź University of Technology, graduate of Université de Nantes, Université d'Aix-Marseille and worker of CERN (**The European Organization for Nuclear Research**), as being already the project astronaut (not reserve) will carry out various experiments at ISS and will test the solutions, developed by Polish research units. More than 22500 people from all member states sent in their application. One of them was the Spanish, Pablo Álvarez Fernández who was the graduate of Warsaw University of Technology, and came from the native Faculty of Professor Wolański, i.e. Faculty of Power and Aeronautical Engineering. Fernández was included to the basic corps of ESA astronauts.

Almost prophetic words of Professor about the future which is fulfilled at our presence in the context of the future exploration of the Space and including Polish accents are the proof how careful observer he was and how he believed in the creative power of the young people. Director of the Aviation Institute **Lukasiewicz Research Network** Dr Paweł Stężycki, Eng., when talking with the authoress of the article stressed a great personality of Prof. Wolański and said about him in a metaphoric way: – *A man with*

*such size of hat occurs very rarely. I treat it as the honour for me, as something extraordinary that I had the pleasure to stay with him and talk in private so many times. In the reminiscences of director of the Institute where Prof. Wolański had been employed since the early nineties of the 20<sup>th</sup> century, the theme of time also appears; Professor treated it with a specific attitude. – He had a low tolerance for laziness; he respected the time and did not like to waste it for meaningless activities. He knew the value of time and spoke about that it could not be calculated into any money. He was very diligent and laborious and required the same from others, irrespectively of the degree of their talents. The undertaken efforts and the consequence in action were fundamental. Professor appreciated it very much. It was the mentioned earlier, hard "highlander's way of life" which he experienced himself at his childhood. One of the last talks of Stężycki and Wolański concerned establishment of the foundation or grant by his name which would support young, clever scientists, acting in the field of rocket, or general space technologies. The funds would come from the Institute, Warsaw University of Technology and from voluntary contributions of friends, family and other persons familiar to Professor. Starting up of the mentioned initiative is planned for 2024. – We talked about it exactly 4 days before his death, perhaps he felt something. He wanted to leave behind him the measurable support for the students, facilitating them development of their passions – his passions.*

Professor Piotr Wolański contributed to creation of **Polish Space Agency, POLSA** which owes its present name to him.

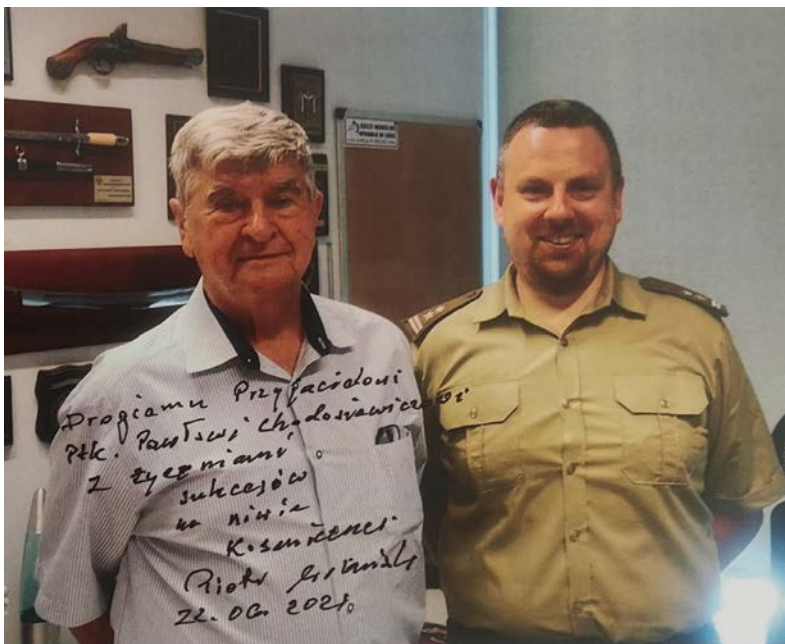


Photo 8. Prof. P. Wolański and Colonel Dr P. Chodosiewicz, Eng  
Source: Archives of Colonel Dr P. Chodosiewicz, Eng.



Photo 9. Sławosz Uznański  
Photo: Tomek Gola, POLSA

As it is recalled by Colonel Dr Paweł Chodosiewicz, Eng., expert from **Space Safety Department of POLSA**, for whom Professor was the lecturer, mentor and friend – He was one of the main spokesmen of establishing Polish Space Agency. He knew that the national industry, scientific-research, simply the total Polish space sector cannot be effectively developed without the mentioned institution. After foundation of the Agency, Professor had been the member of the Council of POLSA, until his last days of life he supported the space sector in all aspects and domains. And he adds – There is no doubt that the silhouette of Prof. Wolański has been permanently recorded in the history of Polish and also, international cosmos. We cannot forget about what he had done for science. His achievements were, are and will be studied, cited and quoted many times. He educated not only many students but also the innumerable number of young people will take inspiration from his work. His life showed that in order to achieve success in the international scale, you must be first of all, yourself, a man open to others. The implementation of the goal by any possible ways, without paying attention to the environment is for weak people and Professor Wolański certainly did not belong to such people. What type of man he was, then? According to Colonel Chodosiewicz, Professor was the open man, unusually positive, and, moreover, speaking directly what his concern was, including also very expressive statements. He never refused helping, both in didactic as well as in private sphere. The scientific titles were not “disturbing” for him; he did not promote them; on the contrary, he was modest in this respect. He had a big respect in the scientific environment and he was very well recognized. He had a great respect to military uniform. During different official meetings when we talked about the topics connected with defense, he used to say teasingly: Mr. Colonel, I cannot express the opinion on it, I obtained only the degree of corporal cadet in the army”. Professor

was not only able to transmit the possessed, enormous knowledge but he was also very social and eloquent person, the life and soul of the party. He liked to tell the jokes and, also various stories from professional and private life, referring also to his native Milówka where he always loved to come back. He kept promises expect perhaps the only one – he was expected to be at my PhD dissertation; unfortunately, it had place after his death but I think that he was present even there spiritually.

The similar reminiscences concerning Professor Wolański come from Dr Aleksandra Bukała, Director of **Department of Strategy and International Cooperation of POLSA** whose memory about this outstanding person reaches as early as his family house where she had the occasion to meet Professor for the first time. – I had known him since a child because my father was also a graduate of Faculty of Power and Aeronautical Engineering at Warsaw University of Technology. Their paths of scientific work were crossing many times what, with the time elapse, had been transformed into friendly relations. Professor was a frequent guest in our house and when I began my adventure with the space sector (more seriously in 2012), our relations gained a professional – vocational nature. For me, he was always a person with the enormous knowledge and such knowledge which should be taken into consideration, even when I could not agree with it initially as I knew that it was justified and supported by many years of experience. In spite of the fact that the path of professional career of Mrs Bukała ran irrespectively of the discussed connaissance, when we met during the official meetings, she reminded a “biting” language of Professor. – I remember the situation from the post-graduate studies on cosmos which were hold by Professor Wolański. A group of the students submitted the material about the program of space shuttles. The quality of the presentation was not the highest one, even for amateur. Professor



Photo 10. Poster on the occasion of the 550<sup>th</sup> anniversary of birth of Mikołaj Kopernik (Nicolas Copernicus)

Source: POLSA

waited until the end and summed up it in tart words: “you are not even able to copy correctly the information from Wikipedia” – she reminds. According to Mrs BuKała, the uncompromising nature of Professor in the field of knowledge and science consisted, *inter alia*, in the precise formulation of the statements in accordance with the principle: *if I do not know, I do not comment*. Owing to the unaffected attitude of Professor, POLSA is to-day a serious partner at the international forum and meets his dreams on building the strong cosmic sector in Poland with a strong and competent Cosmic Agency.

Polish technical science derives, *inter alia*, from the solutions, suggested at the native universities although it would be difficult to conduct the considerations about the development of cosmic industry without the discovery of scientist from Warsaw University of Technology, Prof. Jan Czocharlski (1885–1953). It refers to the method for production of mono-crystalline silicone. Due to this fact, Professor Czocharlski became the precursor of the production technology of integrated circuits, indispensable in production of electronic elements. As the recognition of his merits, Warsaw University of Technology runs the **Competition for the Jan Czocharlski Award** for the best graduate diploma and PhD thesis. The mentioned award may be granted also for the outstanding scientific achievements and/or applied work in the field

of activity of Prof. Jan Czocharlski, including, *inter alia*, processes of crystallization and recrystallization, studies on the structure and properties and application of single crystals and, also, metals and alloys. Many years later, another scientist from the **Faculty of Automotive and Construction Machinery Engineering at the Warsaw University of Technology**, Prof. Mieczysław G. Bekker – creator of terra mechanical engineering – became the constructor of Lunar Rover Vehicle (LVR) in Apollo program where, in particular, he was responsible for the driving system of the mentioned device. On the other hand, the penetrator MUPUS, being constructed with the cooperation of the scientists from the **Faculty of Materials Science and Engineering of the Warsaw University of Technology**, participated in Rosett/Philae mission (2004–2016). The integrated circuit Rosettabis, as employed in the above vehicle, was designed at the **Institute of Microelectronics and Optoelectronics of the Warsaw University of Technology (PW)**. MUPUS was activated after landing on the nucleus of Comet 67P/Czuriumow-Gerasimenko where he was drilled in the Comet’s ground. On the 5 of May 2018, the start of the NASA mission InSight had place, aiming at examination of the internal structure of Mars. The scientists from the Warsaw University of Technology participated also in the preparation of the device which helped to examine the Red Planet. We should also mention two students’ satellite, being launched into cosmos: PW-Sat1 (2012) – the first Polish artificial satellite and PW Sat 2 (2018). They were produced at the Students Astronautic Circle of the Faculty of Power and Aeronautical Engineering at Warsaw University of Technology. The mentioned Circle was guided by Prof. Piotr Wolański. Recently, the students associated in the discussed Circle, undertook the trial to examine the effect of UV light on the samples of composites and effect of cosmic irradiation on solar panels. The project “CURIE” was qualified to the international programme BEXUS, implemented by the **German Aerospace Center** and **Swedish National Space Board**, in cooperation with the **European Space Agency (ESA)**.

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*The source of quotations from the statements of Dr Paweł Stężycki, Eng. and Dr Adam Okniński, Eng., comes from the talks and own correspondence of the author of the present paper, Izabela Koptoń-Ryniec, as being conducted in October and November 2023 and with Colonel Paweł Chodosiewicz and Dr Aleksandra BuKała in February 2024.*

# MARCH 4<sup>TH</sup> WORLD ENGINEER'S DAY

## 4 MARCA ŚWIATOWY DZIEŃ INŻYNIERA

**“Engineering solutions for the sustainable world” – it was the motto of this year’s International Day of Engineer which has been celebrated for 5 years in more than 100 countries, promoting the achievements of the creators of technology. Polish Federation of Engineering Associations NOT combined the mentioned ceremony with the solemn celebration of the 30<sup>th</sup> jubilee edition of the plebiscite of Technical Review (year of foundation – 1866) for the title of Golden Engineer. The Honorary Patronage of the mentioned event was taken over by the Marshall of the Sejm (Polish Parliament), Szymon Hołownia and the Minister of Science – Dariusz Więczorek.**

Honouring the outstanding Polish engineers with the prestigious title – Diamond, Golden and Silver Engineer, was held in Warsaw House of Engineer. During the jubilee sessions, there were also granted the prestigious distinctions – Golden Engineer of 30 years. Traditionally there was also granted the title of Honorary Golden Engineer to the persons who when having already a diploma of engineer or technician, obtained the meaningful success in other areas.

Handing over the statuettes to the laureates of the plebiscite was preceded by the lecture of Prof Dr Ryszard Tadeusiewicz, the former Rector of AGH University, entitled: “Artificial Intelligence – Chances or Threads?” and the speech of Prof. Dr hab. Teofil Jesionowski, Eng, the President of the Conference of the Rectors of Polish Technical Universities, the rector of Poznań University of Technology on “Education of the Engineer of the Future”. – *The contemporary engineering is the key to the future. Artificial intelligence, robotics, ICT, bioengineering, quantum and space technologies are only the examples of the areas of engineering knowledge which change our world very quickly. We owe the civilization progress to unusual imagination and creativeness of the creators of technology. Each device employed in our everyday life is also their creation. The World Engineering Day for Sustainable Development, as being universally called the International Day of Engineer is the occasion to show the mentioned achievements* – Ewa Mańkiewicz-Cudny, the President of Polish Federation of Engineering Associations NOT summed up the event.

The initiative to establish 4<sup>th</sup> day of March as the holiday which has to stress the role of the creators of technology and meaning of their work for the society, came from the international organi-



zations, participating in the **World Engineers Convention (WEC)** in Melbourne, in November 2019. As early as since the beginning of 2020, Polish Federation of Engineering Associations NOT participated actively in the celebrations, in the cooperation with the Conference of the Rectors of Polish Technical Universities and Engineering Academy in Poland.

More and more engineering environments participate and support the popularisation of this important holiday under the patronage of the Federation. We should also stress here the role of Polish universities which at their own account prepare a rich program of celebrating the International Day of Engineer.

Link to transmission:

<https://www.youtube.com/watch?v=wuUC34UJS9s>

Source: <https://not.org.pl>

# 30<sup>TH</sup> ANNIVERSARY EDITION OF PLEBISCITE FOR THE TITLE OF "GOLDEN ENGINEER"

## 30. JUBILEUSZOWA EDYCJA PLEBISCYTU O TYTUŁ „ZŁOTEGO INŻYNIERA”

**“Engineering solutions for the sustainable world” – it was the motto of this year’s International Day of Engineer which has been celebrated for 5 years in more than 100 countries, promoting the achievements of the creators of technology. Polish Federation of Engineering Associations NOT combined the mentioned ceremony with the solemn celebration of the 30th jubilee edition of the plebiscite of Technical Review for the title of “Golden Engineer”.**

– *The combination of the World Engineering Day with the summing up of the 30<sup>th</sup> edition of the plebiscite of Technical Review for the title of Golden Engineer renders to the both ceremonies the exceptional nature. For the first time, such combination had place the last year and it will become our constant tradition because in the both events we show the outstanding achievements and contribution of the creators of technology* – Ewa Mankiewicz-Cudny, the President of PFEA NOT said during opening of the solemn Gala. The ceremony was attended, *inter alia*, by Andrzej Dera, the Secretary of the State at the Office of the President of the Republic of Poland, Maria Mrówczyńska, the Under-Secretary of the State at the Ministry of Science and Higher Education and by the members of the Government of Poland from different years, and also, by the high-ranking state officials, rectors of universities, directors of the research institutes, academic teachers and laureates of the previous and present edition of the plebiscite.

The President of the Federation reminded that the initiative to establish 4<sup>th</sup> day of March as the exceptional holiday, which has to stress the role of the creators of technology and meaning of their work for the society, came from the World Federation of Engineering Organizations (WFEO) during the Congress in Melbourne in 2019. Polish Federation of Engineering Associations NOT in the cooperation with the Conference of the Rectors of Polish Technical Universities and Engineering Academy in Poland participated actively in the mentioned celebrations.

*The idea of the discussed holiday is very coherent with the assumptions of the plebiscite of Polish Technical Review for the title of Golden Engineer. The 30th jubilee plebiscite is the occasion for reminding its history from the first one in 1994 until today* – Ewa Mańkiewicz-Cudny reminded. – *When our plebiscite was “5 years old”, the editorial team together with the so-far laureates decided to grant the special title on the occasion of the round jubilees of*



*the plebiscite. After 10 years of existence of the plebiscite a big group of its laureates connected with the editorial office, “prompted” how to distinguish the creators of technology from different domains. Thus, the new categories and the title of the Young Engineer were introduced. The Club of the Golden Engineers of Tech-*



tical Review was established. It was then decided as purposeful to award the persons with the diploma of technician or engineer who gained the success in other areas. Their achievements are the confirmation of great possibilities, existing owing to technical education. The so-far awarded laureates of the Honorary Golden Engineers include, inter alia: famous opera singers, pen people, journalists, cabaret artists, sportsmen, medical officers, bankers and, also, politicians.

The silhouettes of this year's laureates of the prestigious title: Diamond, Golden, Silver and Distinguished (Bronze) Engineer

(Technical Review, PT) and also Young Engineer (Junior) were presented in 2023 in the mentioned periodical, being published for 158 years. The Laureates chosen by the readers of the Polish technical Review were honoured during a solemn Gala in Warsaw House of Engineer which was erected owing to the contributions of engineering environment 119 year ago.

The Diamond Engineer title of 2023 came to Prof. Dr hab. Jerzy Lis, eng. - the scientist, academic teacher and organizer of science, specialist in materials engineering and chemical technology, member-correspondent Of Polish Academy of Sciences, Rector of AGH University, activist of the Association of Engineers and Technicians of Construction Materials Industry.

Six outstanding creators of technology were distinguished by the title of "Golden Engineer" and the same number of the candidates received the title of "Silver Engineer", there persons were distinguished and four received the title of the "Young Engineer". In the jubilee edition of the plebiscite, the following candidates were honoured with the prestigious title of "Golden Engineer of 30 years": Prof. Dr Andrzej Targowski, Eng, pioneer of the application of computer science in Poland, Prof. Dr hab. Ryszard Tadeusiewicz, Eng, three-time Rector of AGH University, Engineer Waldemar Pawlak, MSc., Senator, twice-time Prime Minister and Member of Parliament of a few cadences, and Dariusz Kruk, construction engineer and employee of STRABAG and TRAKCJA SA companies.

Traditionally, the title of "Honourable Golden Engineer" is also granted to the persons who possess a diploma of engineer or technician made a great success in other domains. Such distinction was granted to former Vice-Premier in the period of 2000-2001, Janusz Steinhoff, the President of the National Economic Chamber Marek Kłoczko, outstanding composer and author of the texts – Mirosław Kowalewski and great fan of aviation and cosmonautics, Adam Bisek.

Handing over the statuettes to the laureates of the plebiscite was preceded by the lecture of Prof. Dr hab. Ryszard Tadeus-



### LAUREATES OF THE PLEBISCITE FOR "GOLDEN ENGINEER 2023"

#### DIAMOND ENGINEER

Prof. Dr hab. Jerzy Lis, Eng.

#### GOLDEN ENGINEERS

Engineer Henryk Bukalski – constructions  
 Engineer Małgorzata Dulewicz, MSc. – innovations  
 Engineer Grzegorz Kędzierski, MSc. – infrastructure  
 Prof. Dr hab. Leszek Kieltyka – science  
 Prof. Dr hab. Leszek Rafalski – management  
 Engineer Ryszard Trykosko, MSc., – manager

#### SILVER ENGINEERS

Engineer Teresa Bilińska, MSc. – innovations  
 Dr hab. Eugeniusz Turyk, Eng., – science  
 Engineer Kazimierz Ruszniak, MSc. – energetics  
 Engineer Waldemar Rudowski, MSc. – infrastructure  
 Engineer Łukasz Pytlarczyk, MSc. – medical technology  
 Dr Dariusz Raczkowski, Eng. – association activist

#### DISTINCTIVE ENGINEERS

Engineer Dagmara Pastuszek, MSc. – innovations  
 Engineer Przemysław Polechoński, MSc. – manager  
 Engineer Ryszard Piotr Kowski – medical technology

#### YOUNG ENGINEERS

Dr Daria Kepsu, Eng.  
 Engineer Adam Szymański, MSc.  
 Dr Anna Zielińska, Eng.  
 Engineer Łukasz Źrodowski, MSc.

#### GOLDEN ENGINEES OF 30 YEARS

Prof. Dr Andrzej Targowski, Eng.  
 Prof. Dr hab. Ryszard Tadeusiewicz, Eng.  
 Engineer Waldemar Pawlak, MSc.  
 Engineer Dariusz Kruk

#### HONORARY ENGINEERS

Dr Janusz Steinhoff, Eng.  
 Engineer Marek Kłoczko, MSc.  
 Engineer Mirosław Kowalewski, MSc.  
 Adam Bisek



iewicz, the Rector of AGH University in the years 1998–2005, entitled "Artificial Intelligence – Chances or Threads?" and the speech of Prof. Dr hab. Teofil Jesionowski, Eng, the President of the Conference of the Rectors of Polish Technical Universities, the rector of Poznań University of Technology on "Education of the Engineer of the Future".

The Honorary Patronage of the mentioned event was taken over by the Marshall of the Sejm (Polish Parliament), Szymon Hołownia and the Minister of Science – Dariusz Wieczorek.

Source: [www.not.org.pl](http://www.not.org.pl)

# INAUGURATION OF THE CELEBRATION OF THE 230<sup>TH</sup> ANNIVERSARY OF THE BIRTH OF ENGINEER GENERAL JÓZEF BEM – MARCH 14<sup>TH</sup>, 2024 TARNÓW

INAUGURACJA OBCHODÓW 230. ROCZNICY URODZIN INŻYNIERA GENERAŁA JÓZEFA BEMA – 14 MARCA 2024 R. TARNÓW

Tarnów, as the hometown of Józef Bem and also his resting place, has the special honor of taking care of the memory of this outstanding Pole. And it was in Tarnów on his birthday, i.e. March 14, 2024, that the inauguration of the nationwide celebration of the Bemowski Year took place.

The Tarnów celebrations were attended by representatives of both Polish and Hungarian authorities, organizations and

associations, as well as representatives of business, science and culture.

The honorary patronage of the event was taken by the Ambassador of Hungary - Mrs. Orsolya Zsuzsanna Kovács and the Deputy Prime Minister, Minister of National Defense – Mr. Władysław Kosiniak-Kamysz

Source: [www.not.org.pl](http://www.not.org.pl)





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