WYDAWNICTWO SIGMA-NOT

POLISH TECHNICAL REVIEW

4/2023

SCIENCE AND INDUSTRY IN A COUNTRY OF CHANGES

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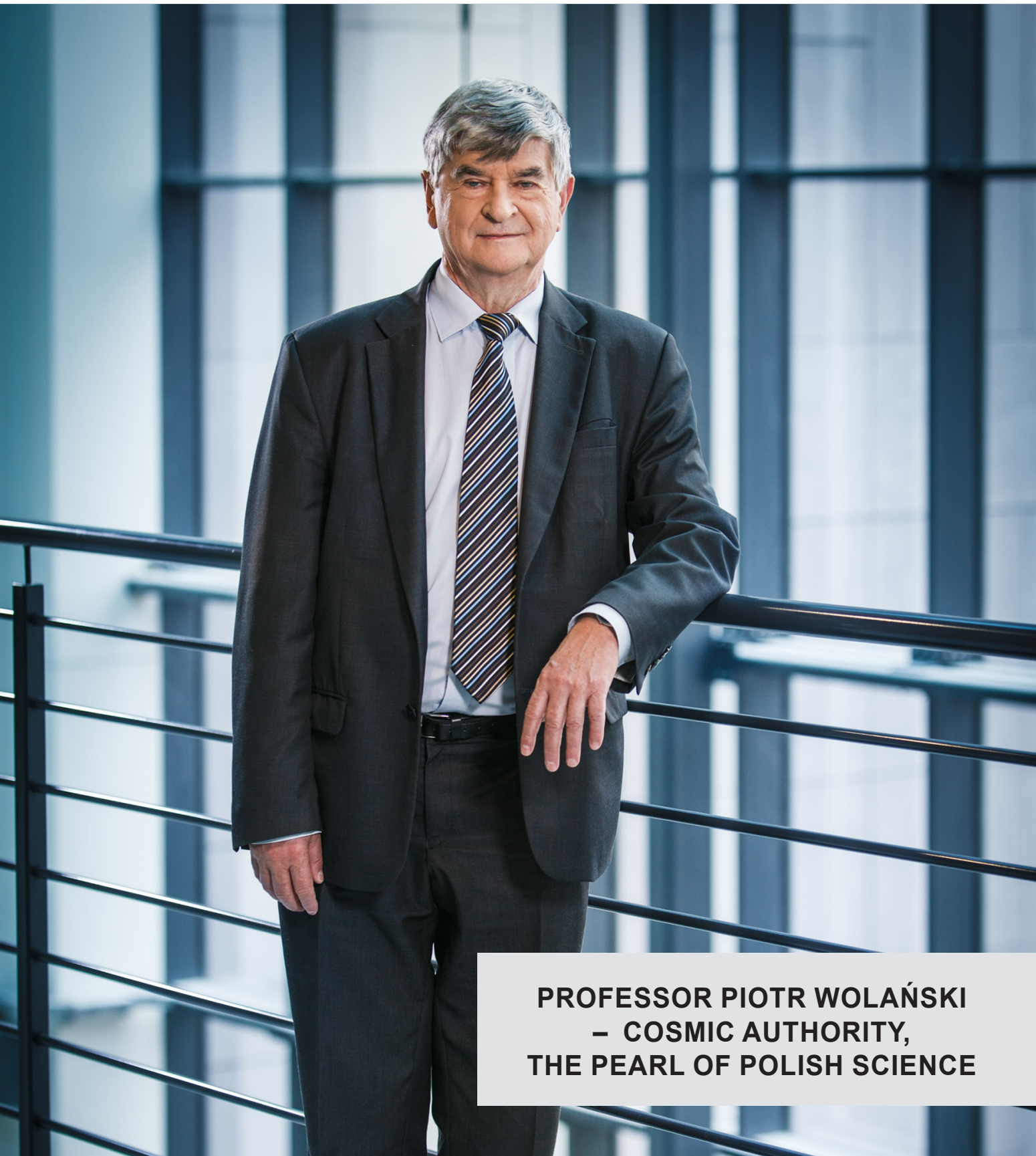

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TITLE OWNER/WŁAŚCICIEL TYTUŁU:
National Council of Federation of Engineering Associations NOT
Federacja Stowarzyszeń Naukowo-Technicznych Naczelna Organizacja Techniczna
Czackiego Street 3/5, 00-043 Warsaw
phone: +48 22 250 22 22
www.enot.pl, e-mail: sekretariat-prezes@not.org.pl

PUBLISHER/WYDAWCA:

WYDAWNICTWO *SIGMA-NOT*

SIGMA-NOT Publishing House Ltd.
Wydawnictwo Czasopism i Książek Technicznych
SIGMA-NOT Spółka z o.o.
Ratuszowa Street 11, 03-450 Warsaw
phone: +48 22 818 09 18, +48 22 818 98 32
www.sigma-not.pl
e-mail: sekretariat@sigma-not.pl

EDITOR'S ADDRESS/ADRES REDAKCJI:
Ratuszowa Street 11, 03-450 Warsaw
phone: +48 22 818 09 18, +48 22 818 98 32
www.polishtechnicalreview.com,
e-mail: polishtechnical@sigma-not.pl

DTP COMPOSITION/SKŁAD I ŁAMANIE:
SIGMA-NOT Publishing House Ltd.
Wydawnictwo Czasopism i Książek Technicznych SIGMA-NOT Spółka z o.o.
Ratuszowa Street 11, VII p., 03-450 Warsaw
phone: +48 22 818 09 18, +48 22 818 98 32
www.sigma-not.pl, e-mail: sekretariat@sigma-not.pl

OPEN ACCESS QUARTERLY e-ISSN 2657-6716 SINCE 1964

CONTENTS/ SPIS TREŚCI:

Polish Technical Review in database:

Index Copernicus ICV 2022 = 97,28 **ERIH+** **MEiN 40 points**

Prof. Ph.D. Jacek SOSNOWSKI

DOI: 10.15199/180.2023.4.1

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INFLUENCE OF THE CORRECTION COILS ON THE ELECTRON'S BEAM FOCUSING IN FEL'S ACCELERATORS

WPŁYW CEWEK KOREKCYJNYCH NA SKUPIANIE WIĄZEK ELEKTRONÓW W AKCELERATORACH FEL

Summary: *In this paper, the optimization of the solenoid construction in free electron lasers (FEL), modern class of accelerators used for more deep investigations of materials structure has been reviewed. The solenoid is used for magnetic focusing of the electron beam, while the efficiency of this process is dependent on magnetic induction profile of solenoid. The process of beam focusing is usually implemented by using the magnetic yoke. In the present paper the application of the correctional coils for the purposes of the magnetic induction profiling has been analyzed. The physical principle of the magnetic method of the electron beam focusing has been discussed, as well.*

Keywords: *free electron lasers, correctional coils, magnetic induction profile, optimization*

Streszczenie: *Artykuł poświęcony jest optymalizacji konstrukcji solenoidów w laserach na swobodnych elektronach (FEL), nowoczesnej klasie akceleratorów wykorzystywanych do precyzyjnych badań struktury materiałów. Ten solenoidalny elektromagnes służy do magnetycznego skupiania wiązki elektronów, a efektywność tego procesu zależy od profilu indukcji magnetycznej elektromagnesu. Często proces ogniskowania wiązki realizowany jest za pomocą jarzma magnetycznego. W artykule przeanalizowano zastosowanie cewek korekcyjnych do celów profilowania indukcji magnetycznej. Przedstawiono także fizyczną zasadę magnetycznej metody skupiania wiązki elektronów.*

Słowa kluczowe: *lasery na swobodnych elektronach, cewki korekcyjne, profil indukcji magnetycznej, optymalizacja*

Introduction

The continuous progress in the scientific devices' parameters, necessary for development of basic and applied research requires more and more advanced apparatus construction. The present paper is dedicated to analysis of the optimization of the solenoids construction in modern free electron lasers (FEL) facilities.

Physical approach

The solenoid arrangement, the purpose of which is to focus the electronic beam, is an important part of the electron gun in FEL accelerators. It is shown in Fig. 1.

The process of focusing the electron beam is graphically shown in Fig. 2; it illustrates the interaction of electron bunch with fringe fields of solenoid, changing then electron movement at the opposite directions at upper and bottom part of solenoid, leading to its final shrinkage, as is indicated by green colour in the right part of Fig. 2.

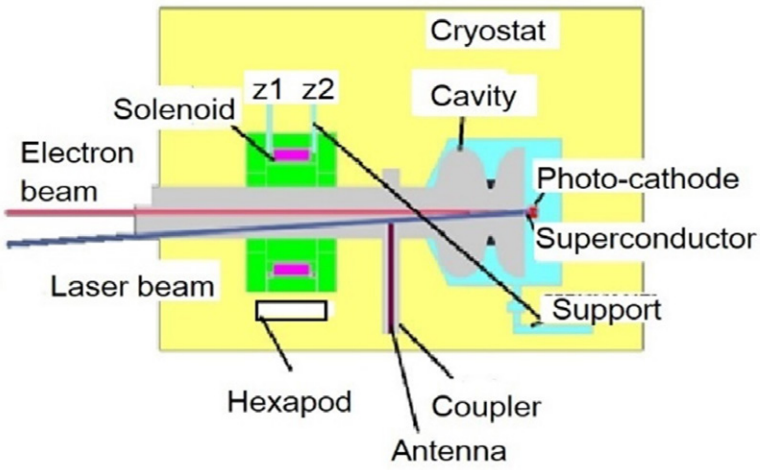


Fig. 1. Schematic view of the electron gun in modern FEL accelerator

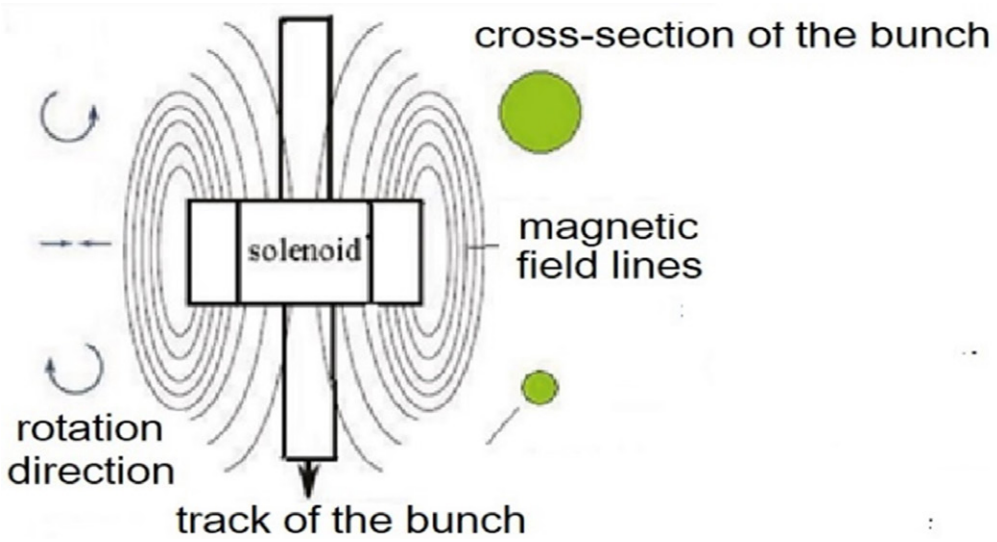


Fig. 2. The physical principle of the electron bunch movement through the solenoid

Mathematic model

Mathematical description of magnetic focusing an electron beam with envelope σ is based on the following [1] general equation:

$$\sigma'' + \frac{qE_{acc}}{mc^2\beta^2\gamma}\sigma' + K_r\sigma - \frac{\kappa_s}{\beta^3\gamma^3}\frac{1}{\sigma} - \left(\frac{\varepsilon_{n,rms}}{\beta\gamma}\right)^2\frac{1}{\sigma^3} = 0 \quad (1)$$

Here σ describes the bunch size, $\varepsilon_{n,rms}$ is averaged emittance, symbol ' denotes the derivative, m is electron mass, q electron charge, c light velocity, while β= v/c reduced electron velocity and $\gamma = 1/\sqrt{1-\beta^2}$. κ_s is beam perseverance, E_{acc} is average accelerating gradient, while the third term in Eq. 1 describes the radial focusing forces. The discussed equation has been significantly reduced in [2] in the considered case of the description of the movement of axial electrons in magnetic field of the solenoid and neglecting any other forces acting on the beam.

$$\sigma" = -\left(\frac{qB_z}{2mc\beta\gamma}\right)^2\sigma \quad (2)$$

We integrate then Eq. 2 on the distance of solenoid length as it is between z_1 and z_2, taking into account that we are interested in the variation of the electron bunch size at the output of solenoid. Assuming then that inside of solenoid bunch envelope is approximately constant, we obtain expression 3 describing the variation on the external end of solenoid z_2 the electron beam size and then its focal length f:

$$-\frac{\sigma'(Z_2)}{\sigma} = \frac{1}{f} = \left(\frac{q}{2mc\beta\gamma}\right)^2\int_{Z_1}^{Z_2} B_Z^2\,dz \quad (3)$$

where z_1 and z_2 are the positions of the beginning and end of the solenoid along z axis, as shows Fig. 1. So Eq. 3 allows finally explicitely to join focal length of electron beam f with integral from square value of axial magnetic induction in the solenoid according to Eq. 4, in the right side of which there have been inserted numerical values of fundamental physical parameters, such as electron mass, electron charge:

$$Int = \int_{z1}^{z2} B_z^2\,dz\,[T^2\cdot mm] = \frac{4(m_e\beta c)^2}{q^2 f(1-\beta^2)}\left[\frac{kg^2m^2}{s^4A^2\,\mathrm{m}}\right] = 11{,}645\cdot 10^{-6}\frac{\beta^2}{(1-\beta^2)}\cdot\frac{1}{f(m)}[T^2\cdot \mathrm{m}] \quad (4)$$

The dependence of the focal length on the value of integral (Int) from Eq. 4 is shown in Fig. 3, as the function of electron velocity in the respect to the light velocity. So large values of the electron beam velocity indicate on the relativistic features of the appearing here processes, in the time scale of the femtoseconds.

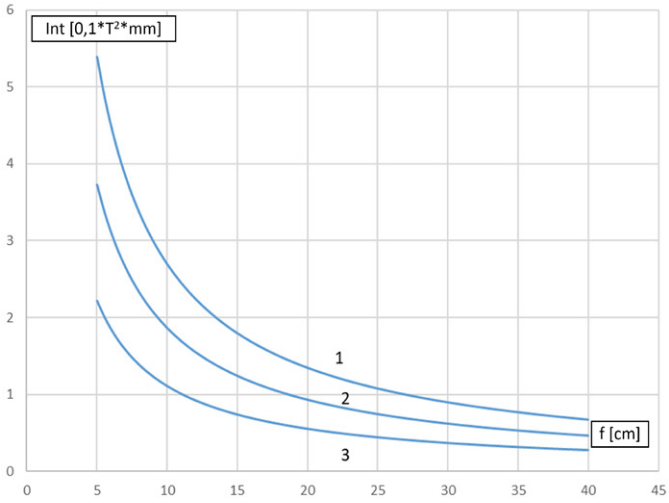


Fig. 3. The dependence of the focal length of the solenoid on the value of the integral from square of magnetic field Int, according to Eq. 4. Individual curves are dependent on the electrons velocity expressed in light velocity c units: (1) β = 0,95c, (2) β = 0,93c, (3) β = 0,89c

Results of calculations magnetic induction distribution in solenoid with correctional coils

As it follows from the curves shown in Fig. 3 the required value of the focal length of the solenoid is dependent on the value of integral Int, determined by the square of the profile of axial component of the magnetic induction along the solenoid length. Magnetic field profile should be optimized, in such a way that magnetic field profile of solenoid will be of the form of Gaussian distribution with a fast decay at the solenoid ends, in order do not exceed the limits allowable for the undisturbed operation of superconducting cavities. In FEL construction built in Helmholtz-Zentrum Berlin [3] it is suggested also that solenoid should provide integrated square of axial component of magnetic induction, according to Eq. 4 of the range 1 [T^2·mm].

Frequently for this aim of forming the magnetic induction profile of solenoid, the iron yoke has been employed [3]. In the present paper, the alternative method of using the internal correctional coils in common electric circuit for that purpose is analyzed.

For magnetic induction profiles calculations the finite element method (FEM) was used. In this method it is necessary to choose the boundary conditions. Three cases were considered: of the vanishing on the boundary the perpendicular to surface magnetic induction, or of appearing any barrier of magnetic field at the surface and in third case of vanishing the magnetic potential A on surface. The results of calculations of the magnetic induction distribution in solenoid with internal correction coils are presented in the considered case of ΔH = 210 [A/m] in Fig. 4 (a) and in Fig. 4 (b) of the vanishing on the boundary the perpendicular to surface magnetic induction. The results of calculations indicated that it is a large similarity between the magnetic induction lines profiles, in the both shown cases, as well as for the case of the vanishing on the surface the magnetic field potential A. Thus, in further calculations there has been applied just this third boundary condition.

The results of calculation magnetic field lines in simple solenoid of the internal diameter 3,7 cm and length 24 cm, is shown in Fig. 5, while the profile of magnetic induction distribution for that case and current density $j=10^6$ A/m^2 is given in Fig.6.

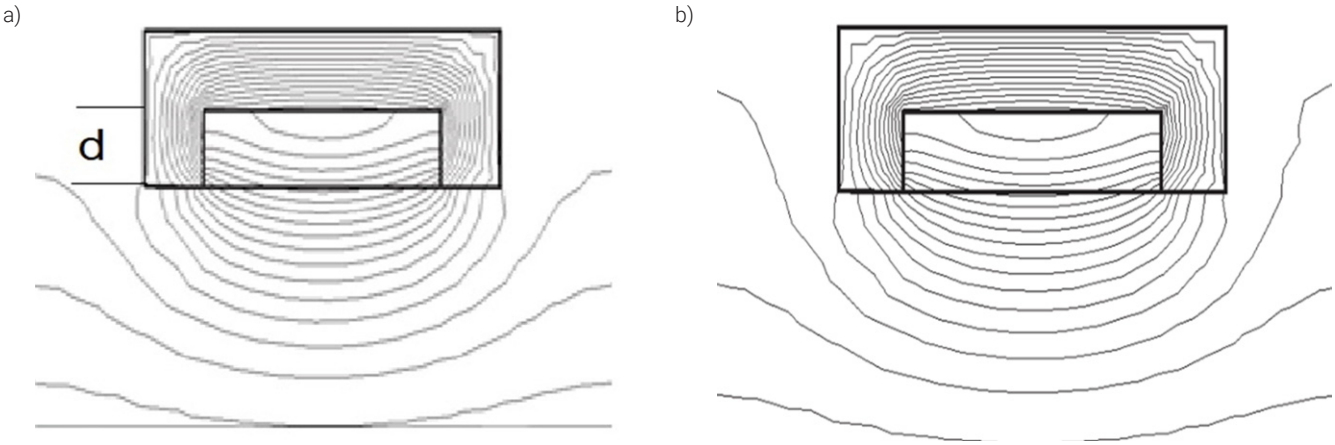


Fig. 4. Influence of the boundary conditions on magnetic induction lines in solenoidal electromagnet with internal correction coils. Part (a) ΔH = 210 [A/m], part (b) vanishing of perpendicular component of magnetic induction B_n

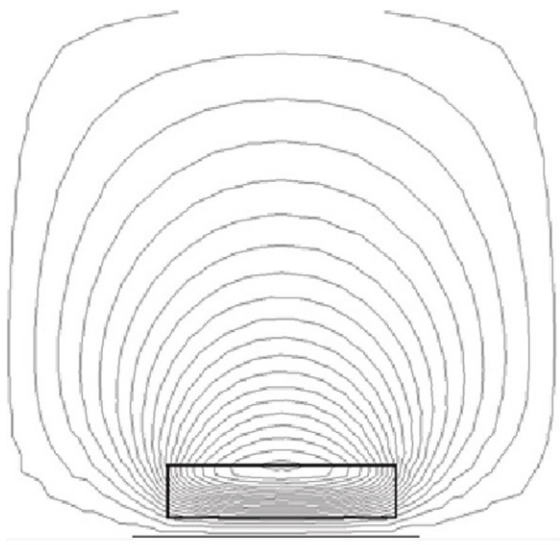


Fig. 5. Magnetic field, lines in the cross-section of the simple solenoid construction, with axis of the solenoid denoted by thin, straight line

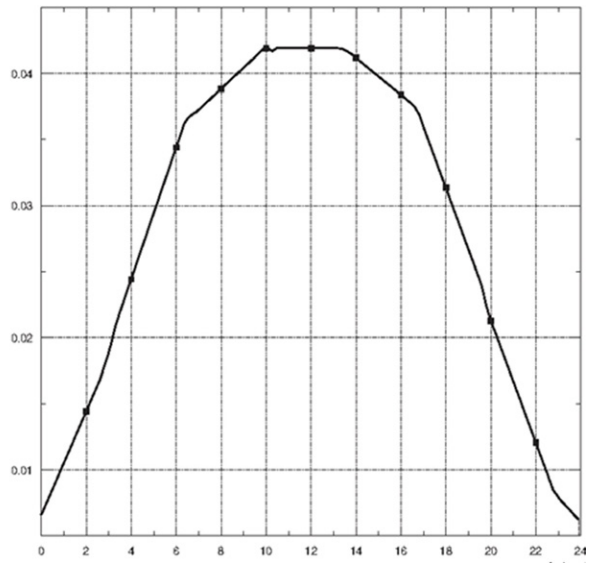


Fig. 6. Axial magnetic induction profile in [T], in simple solenoid for current density $j=10^6$ A/m^2

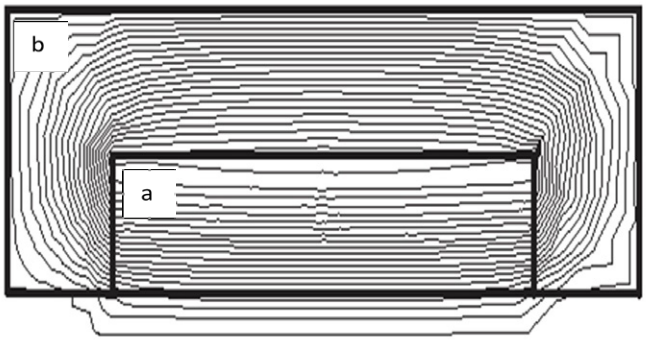


Fig. 7. Profiles of magnetic field lines in solenoid (a) with iron yoke (b), for $j=10^6$ A/m^2

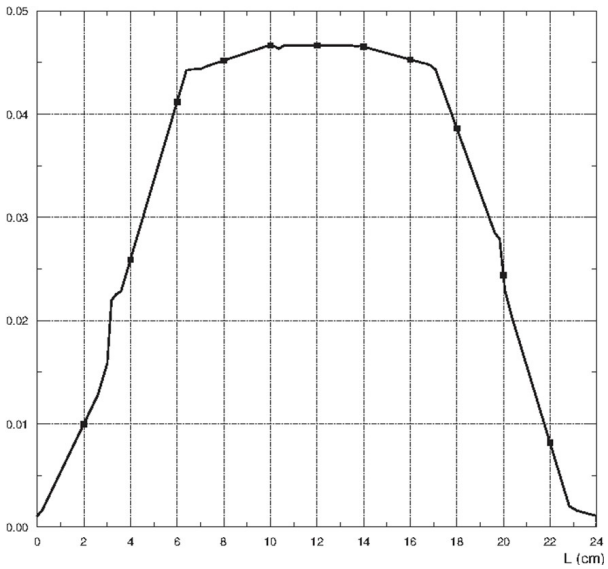
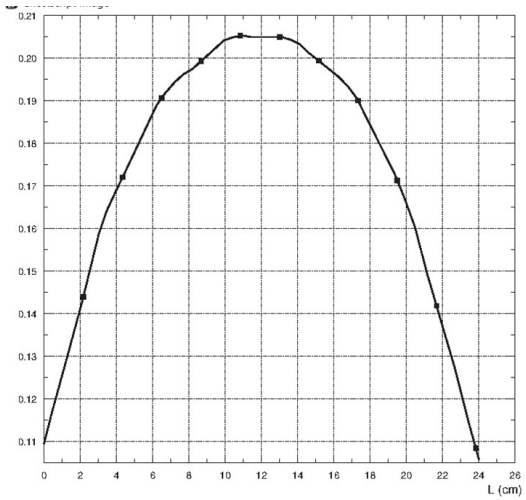


Fig. 8. Magnetic induction profile in [T], along z axis in centre of solenoid with iron yoke, for current density $j=10^6$ A/m^2

The value of the integral from magnetic induction distribution given by Eq. 4 is for this simple solenoid shown in Fig. 6 and current density j=10^6 A/m^2 equal to 0,0255 T^2 mm, while for the solenoid with iron yoke shown in Fig. 7 is increasing to 0,031 T^{2}mm. These are smaller values than for constructed in HZB FEL accelerator and can be increased by enhancing the transport current density, for instance by using superconducting coils. The values of the focal length for that case are equal according to Fig. 3, f = 43 cm for simple solenoid and f =33 cm for solenoid with iron yoke and electrons velocity β = 0,89c.

a)



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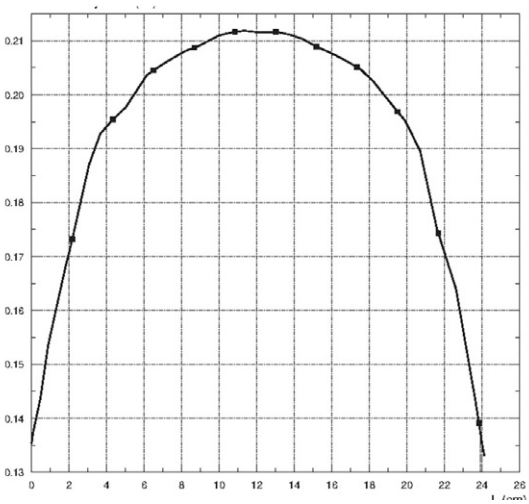

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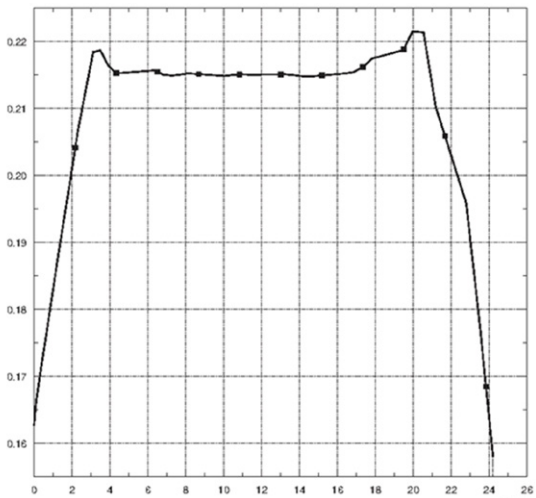

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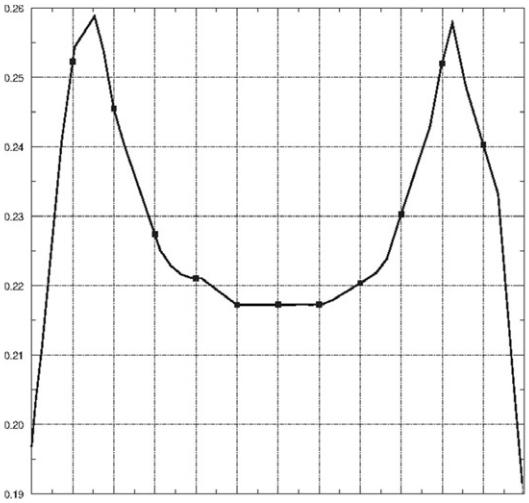

Fig. 9. Magnetic induction profile in Tesla, along z axis in centre of (a) simple solenoid, (b) for solenoid with correction coils of the thickness t = d/3, according to Fig. 4 notation, (c) t = 2d/3, (d) t = d, and current density $j=5\cdot10^6$ A/m^2

As it follows from Fig. 9, the correction coils significantly influence the magnetic induction distribution in solenoidal magnet, allowing to receive this way appropriate field profile, by using much less material than in the yoke case. It is especially important for the superconducting solenoids, which require the cooling power. Comparison of Figs. 9a-c indicates that more flat induction distribution profile can be obtained along the solenoid using compensation coils. But too large correction coils create the sharp variation of magnetic induction profile, which is not a required effect from the point of view of stable flow of electron beam. Not too high values of the magnetic induction of the range 0,22 T, are connected with the current density $j = 5 \cdot 10^6$ A/m^2, which is, in fact, the maximum allowable for copper wires value.

Conclusions

In the present paper, the application of internal correctional coils in the process of focusing electron beam in FEL-s type accelerators has been investigated. The discussed method has been compared with the use of magnetic yokes, much heavier construction, the effect of which is important from the point of view of the materials' consumption and cooling power, especially for superconducting coils. It was shown that the precise profiling of correction coils is necessary at the aim to receive a smooth run of the total magnetic induction distribution.

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Article reviewed
Received: 16.11.2023 r./Accepted: 30.11.2023 r.

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DOI: 10.15199/180.2023.4.2

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PROBLEMS OF DESTABILISATION OF THE CEREAL MARKET IN POLAND RELATED TO THE WAR SITUATION IN UKRAINE

PROBLEMATYKA DESTABILIZACJI RYNKU ZBÓŻ W POLSCE ZWIĄZANEJ Z SYTUACJĄ WOJNY NA UKRAINIE

Summary: *The aim of the study was to assess the current situation and prospects for counteracting the destabilisation of the cereal market in Poland as a result of importing large quantities of cereals from Ukraine. The assessment indicates a high risk of a decrease in profitability of grain production in Poland and market destabilisation, which may threaten food security in Poland. The resulting additional surplus of domestic production raised by imported grain significantly depresses the price and causes concern among farmers. Possible solutions to this problem include strict control of the quantity of imported grain from Ukraine and control of its re-export to destination countries such as the North African region. This requires infrastructural investments to improve transport and re-export through the port of Gdansk and the application of solutions already implemented by Romania, i.e. double licensing of grain quantities. In the current situation, actions aimed at increasing domestic grain consumption by increasing the stock of poultry and pigs are also beneficial, which will effectively remove the oversupply of grain from the market.*

Keywords: *cereal market, production profitability, cereal imports, cereal grain*

Streszczenie: *Celem pracy była ocena obecnej sytuacji i perspektywy przeciwdziałania destabilizacji rynku zbóż w Polsce na skutek importu znacznej ilości zboża z Ukrainy. Dokonana ocena wskazuje na wysokie ryzyko spadku opłacalności produkcji zbóż w Polsce oraz destabilizacji rynku co może zagrozić bezpieczeństwu żywnościowemu w Polsce. Powstająca dodatkowa nadwyżka ziarna krajowej produkcji podniesiona dodatkowo o importowane ziarno znacząco obniża cenę i powoduje obawy rolników. Możliwe rozwiązania tego problemu obejmują ścisła kontrolę ilości sprowadzanego ziarna z Ukrainy i kontrolę jego reeksportu do krajów przeznaczenia jakim jest region Afryki Północnej. Konieczne do tego są inwestycje infrastrukturalne usprawniające przewóz i reeksport przez port w Gdańsku oraz zastosowanie rozwiązań wdrożonych już przez Rumunię, czyli podwójnego licencjonowania ilości zboża. W obecnej sytuacji korzystne są także działania zmierzające do zwiększenia zużycia krajowego zboża poprzez zwiększanie pogłowia drobiu oraz trzody chlewnej co w efektywny sposób będzie zdejmowało z rynku nadpodaż ziarna.*

Słowa kluczowe: *rynek zbóż, opłacalność produkcji, import zbóż, ziarno zbóż*

Introduction

Before the war, two-thirds of Ukrainian exports were realised through ports on the Black Sea and the Sea of Azov. In terms of agricultural production, this figure was over 90%. Ukraine is one of the world leaders in cereal exports, especially maize and wheat, as well as barley and rapeseed. Important for the country was the annual sale of cereal grains to dawn markets, valued at US$12.3 million [3]. The aggression launched by Russia resulted in the occupation of some Ukrainian ports and the blockade of other ports, which were the main trade route for the export of a significant part of grain production (European Council). This has prompted the need to find alternative export routes. To facilitate the trade, in May 2022, the EU established the so-called solidarity corridors, in which Poland and Romania played a central role. The importance of Ukrainian ports on the Danube and transit from them via Romania became crucial (the port of Constanta handled in 2022. 8.2 million tonnes of Ukrainian grain, which accounted for approximately 21% of Ukraine's total exports of this product, estimated by Kiev at 38.3 million tonnes), with the other alternative export route being the overland route via Poland. The route through Poland was designed to deliver Ukrainian grain to the Gdansk terminal. The mentioned terminal plays an important role in the export of grain from Poland (the handling capacity of this terminal is about 5 million tonnes of grain per year), and now also in the possible transit of Ukrainian grain to European and non-European countries (mainly to North African countries). The unblocking of the corridor and efficient export of Ukrainian grain from Poland is a key issue for Polish

grain producers. Experts in the grain market, including feed, say that in the absence of any prospect of a rapid end to hostilities in Ukraine and the restoration of Ukrainian grain exports from the Black Sea ports, the need for the development of land transport of agricultural commodities through EU countries will become stronger. The very situation associated with the possibility of a significant proportion of grain transported from the Polish-Ukrainian border remaining will have a significant impact on the development of grain purchase prices on the Polish market. In 2021, grain imports from Ukraine to Poland amounted to 0.06 million tonnes, while after the situation with the port blockade, they already amounted to 2.45 million tonnes [4]. The additional oversupply of grain on the Polish market, where domestic production also has the oversupply which we have to export, is associated with a deep market destabilisation and social unrest.

The situation regarding the blockade of cereal exports is also taking its toll on global markets and causing significant price fluctuations, especially for wheat. After almost 1.5 years of turmoil in the grain market, the price of wheat on the MATIF exchange has returned to the level of January 2022, i.e. before the outbreak of the war in Ukraine. In January 2022, the wheat price on the MATIF exchange averaged €226/tonne; the highest price had to be paid in mid-May 2022 was equal to approximately €366/tonne of wheat, i.e. higher by more than 38%. The scale of fluctuations in the price of wheat on the European market, also on the global market, was difficult to predict. Under the described conditions, food and feed wheat processors were concerned about further increases in the post-harvest period, causing the purchase price to keep climbing until last November. At present, the situation is stabilising somewhat, but price fluctuations, which are also linked to global turbulence, continue to cause significant price fluctuations. As recently as in July, wheat was fetching € 264.75 per tonne on the Paris MATIF exchange, whereas on 8 September it was fetching € 214.75 per tonne on the MATIF exchange, down by almost 19%. In July, wheat was traded at US$ 279.34 per tonne on the CBOT in Chicago, but at the beginning of September was traded at US$ 210.35, down by almost 25%. It is well known that grain prices in Poland are highly dependent on prices on world stock exchanges. This is because we have an overproduction of cereals in Poland and we need to export this surplus. And exports are linked to prices on global markets. The Grain and Feed Board predicts that Poland will harvest around 34 million tonnes of grain this season, of which domestic consumption will manage 24-26 million tonnes of both consumption and feed grain. A surplus of about 10 million tonnes should be exported, with another 4-5 million tonnes of grain from the previous harvest remaining in storage; a total of about 15 million tonnes. The additional surplus of cereal grain, especially wheat and maize, is putting strong downward pressure on prices in the domestic market. Representatives of Polish grain producers are demanding from the state authorities an urgent extension of the logistic infrastructure (transport, warehouses, port wharves), which would improve grain exports – both of their own grain surplus, but also grain transit from Ukraine. The lack of interest so far in developing this infrastructure was due to the fact that most of the country's grain surplus was exported to Western European countries by land. As a result, 5-6 million tonnes of grain could be exported and this allowed the supply-demand balance, and thus prices, to be maintained on the domestic market. The authorities therefore saw no need to expand this infrastructure, and grain producers have so far not been interested in lobbying for the expansion of the road infrastructure and port handling facilities. The current uncertain situation and the failure to foresee a possible end to the conflict in Ukraine means that there is no clear decision to start investing in infrastructure expansion, especially as this would have to be done from the state budget without assistance from the European Union. In addition, looking from a long-term perspective, investment in infrastructure requires a significant amount of money and implementation time. It is also doubtful that once the transport of grain from Ukraine via the former Black Sea route is made possible, transit through Poland and the Baltic Sea would continue. Russia's temporary agreement and commitment to transport grain via the Black Sea improved the situation for a while, but it later withdrew from the grain agreement and destroyed some of the infrastructure (warehouses, handling facilities) for grain exports in Ukrainian ports. Rebuilding this infrastructure will also take time, indicating that it is necessary to seek a consensus and solution to the problem in both the short and long term.

Ukraine has stepped up its efforts in preparing alternative export routes, including overland via EU countries. However, the lack of regulation on the part of the EU authorities to safeguard the demand-supply balance and the associated profitability of production in the internal grain markets of the border countries is causing a number of additional tensions. The problem of destabilisation also affects other countries. Hungary and Romania, as countries bordering Ukraine, have the same problem of the increased exports of Ukrainian grain to their domestic markets. In the case of Hungary, imports in 2021 were equal to 0.02 million tonnes and in 2022 – 0.49 million tonnes – an increase of 24.5 times. A similar problem is faced by Romania where the scale of the increase in imports is even greater – 0.002m tonnes in 2021 to 1.3m tonnes in 2022 – an increase by 650 times. Some countries, such as Greece, have seen their imports fall by up to nine times due to the port blockade. Although such a situation is causing global turmoil and problems, there is still no will to solve it on the part of decision-makers. In particular, the European Commission is not looking for an effective solution to the overland transport of Ukrainian grain to EU countries and then – possibly - to African countries: lack of infrastructure, high

transport and storage costs and an overabundance of grain in the EU. Ukraine's neighbouring countries have announced that they will block grain imports from Ukraine if the EC does not guarantee that the grain will only transit through their territory to Baltic, Mediterranean or North Sea ports. In Poland, the above declarations are fostered by the disastrous situation on the grain market in Poland: it has been a long time since the purchase price of wheat offered by purchasers was so low. In view of this problem, the only solution in this situation seemed to be an extension of the ban on grain imports to Poland, which is also being considered by other countries struggling with intensive grain imports from Ukraine. At the same time, intensive attempts are being made to solve the problem of Ukrainian grain exports via transport routes through the Black Sea. Among others, China, India and Turkey, as well as southern European countries (Italy, Spain) are interested in importing Ukrainian grain. Any attempts to positively solve this problem are being blocked by Russia, which is demanding the early withdrawal of economic sanctions imposed on the country.

As grain is a food commodity of strategic importance to the people of many countries, especially North Africa, many countries are looking for individual strategies to address the possibility of importing grain from Ukraine. North African countries in particular need significant imports of wheat from Ukraine. They fear internal conflicts due to the lack of bread, and it was the lack of bread that was the spark that ignited the revolutionary changes in the North African countries a few years ago. Nowadays, too, grain can be an important impetus for change even of a political nature, as evidenced by the unexpected resignation of the Prime Minister in Tunisia due to a shortage of bread, or rather a shortage of wheat to bake it. The consequences of the Ukrainian grain blockade so far can also be seen in other countries in North Africa and the Middle East [9]. This is especially true for countries that are highly dependent on grain imports from Ukraine, such as Somalia and Benin, which has 100 per cent of its wheat from Ukraine, and Egypt with 82 per cent. In view of this, in order to prevent destabilisation of the region, Israeli ships have appeared in the Black Sea and are ready, despite Russian threats, to take Ukrainian grain from the Danube ports of Romania. Cover for the mentioned ships is provided by US military aircraft. The return of Ukraine to effective food exports is very important not only for EU countries, but also for third countries. For the EU it is a fundamental security factor, but also on Ukraine's role in food supplies, for many countries which ensures relative political stability in the world [7].

Another problem facing Polish cereal producers, which is linked to the war situation in Ukraine, is the rising cost of fertilisers. Russia plays a key role in the fertiliser trade. Almost 17% of Russia's total fertiliser exports go to EU countries. As a result of the economic sanctions imposed on Russia, the loss of 17% of the existing supply of fertilisers on the market has resulted in a significant increase in their price by the cost of grain production. Thus, a situation has been created in which the costs of cereal production increase as a result of the higher price of fertilisers, while the purchase price of grain decreases due to oversupply on the internal market, and the situation is further aggravated by grain imported from Ukraine.

Possibility of stabilising grain prices on the Polish market

Domestic cereal grain production, as in other European Union countries, is mainly used for feed purposes. On average, approximately 17 million tonnes of cereals were used for feed purposes in the 2017/2018- 2019/2020 seasons, or 62% of total domestic consumption. Wheat, maize and barley were mainly used for feed, with 20.8; 17.6 and 14.7% of the total cereals used for feed, respectively. It should also be noted that in the case of maize and barley, about 70% of the national harvest was used for feed, and in the case of wheat, 39% [1]. Wheat is used to a lesser extent for fodder purposes due to its extensive food use for baking bread, rolls and cakes. In addition, it has a higher price, which is why triticale is used more for fodder. Cereal grains are the basic raw material for the production of feed used in the feeding of various livestock. They account for 60 to 80 % of the raw material composition of compound feeds, which depends on their current price and quality. This high proportion in the feed is due to their high nutrient content, especially starch, which is a very good source of energy. In addition, cereal grain also contains a certain amount of protein. According to data from the Central Statistical Office [10], in 2021 the total feed production was 10, 598 million tonnes. A decisive share, 60%, was feed mixes for poultry, 24% for pigs. These two branches of livestock production - poultry production related to the production of eggs and poultry meat and pig farming are among the most grain-intensive. The production of feed for these groups of animals requires a constant supply of grain raw materials, which form the basis (up to 70% of the raw material composition) of the feed mixture [11]. The increase in poultry production has led to changes in the demand for the species structure of grain. Species that are less useful in the production of feed for this group of animals have seen a decrease in cultivated area. In the structure of industrial feed production, poultry feeds have the largest share, which is related to the significant population of this group of livestock. The share of poultry mixtures in the overall production of industrial feeds for livestock varies from year to year, but is at the level of 58-66% [8]. The significant poultry population in Poland is conducive to the significant use of domestic grain production has a positive effect on the stabilisation of its prices. In addition, the significant export of broiler chicken meat, with Poland being the leading producer in the European Union of this meat, positively

affects the economy. The increase in poultry production results in significant stabilisation and has prevented the collapse of the cereal market as a result of the reduction in the pig population in Poland. Intensive and large-scale poultry production consumes significant amounts of domestic grain production for feed for this group of animals [8]. The purchase costs and the relation of its price to the price obtained per kg of livestock have a significant share in the overall costs, and are therefore the main element of the profitability calculation of this branch of production, while they may be subject to direct control by the poultry livestock producer [5]. Adequate supply of impact cereals and their favourable price have influenced increasing poultry meat production over the years. However, large-scale poultry production requires the consumption of significant amounts of energy especially for the process of artificial egg incubation, as well as heating buildings in autumn, winter and spring and cooling in summer. Increased energy prices have resulted in increased production costs and an apparent reduction in the poultry population relative to 2020 [10]. This fact will further reduce cereal consumption and has exacerbated somewhat the problems of the cereal market. Therefore, in order to maintain stability on the cereal market, it is important to provide state support to poultry breeders so that the stocking of animals is maintained at the current level, which should prevent the negative situation on the cereal market from worsening. In addition, it is also necessary to support pig breeders in order to increase the number of pigs, which should also increase the consumption of cereals for feed and have a positive impact on the stabilisation of the cereal market. The need to support pig farmers was also recognised by the Ministry of Agriculture and Rural Development, which supported this group of agricultural producers in 2022. Agricultural producers at risk of losing their financial liquidity due to restrictions on the agricultural market caused by the war in Ukraine [6] could apply for funding. The development of pig farming is important from the point of view of stabilising the cereal market, the more so is the prospect of its development, as less pork is produced in Poland than the market demand shows. The meat shortage is supplemented by imports from other EU countries. In 2021, pork imports reached 574.365 tonnes and were 4 per cent higher than in the same period in 2020. This indicates that there is an opportunity for domestic pork production to expand, which will increase the consumption of grains from domestic production. In particular, this is an opportunity to reduce the amount of grain from smallholder farms that grow cereals. The maintenance of pigs by these farms, which will be used for feed for them, reduces the amount of grain on the market balancing the supply and demand situation.

The European Union policy imposes an obligation on member states to use raw materials from renewable sources for energy purposes. Under Polish climatic and economic conditions, raw materials of plant origin are becoming more important. In this context, cereal grain that does not meet the quality requirements for milling and bakery and feed processing can be used for energy purposes. The grain is a valuable raw material for bioethanol production [2]. It is extracted from agricultural renewable feedstocks and then used as a fuel additive. Cereal grain is a very efficient feedstock for bioethanol production. However, different cereal species have different grain energy yields. In the context of Ukraine's significant imports of two cereal species-wheat and maize-these have the highest bioethanol yields.

In addition to the aforementioned solutions to the surplus of grain on the Polish market and the destabilisation of grain prices associated with grain imports from Ukraine, the fall in grain prices and farmers' fears about the profitability of grain production are creating pressure to seek ad hoc solutions, isolating the domestic market within the Community framework, which further disrupts the flow of goods within the single market and increases the risk of economic activity on the domestic market. Spotty road and rail investments at border crossings are not enough. What is needed is cooperation, a long-term strategy and decision-making. Otherwise, Poland will cease to be competitive on world markets in an area that is today the engine of our economic development – the export of agri-food goods. One of the most important investments is to be an agri-food terminal in the port of Gdansk. It is expected to improve the export of agri-food goods by sea, but also to be an effective solution to the problem of grain imports from Ukraine to Poland and its re-export to North African countries. The dual licensing procedure currently introduced by Romania may also be a beneficial solution. This procedure consists of a bilateral licence for a certain amount of grain from Ukraine and a second licence from Romania for the same amount of grain as the Ukrainian licence. This is a much more favourable solution than a total ban on grain imports, offering the chance to control the internal grain market and maintain good bilateral relations between the countries.

Conclusions

The armed conflict between Russia and Ukraine has destabilised the grain market in Poland, which is linked to the closure of the current export routes for Ukrainian grain via the Black Sea to the countries in the North Africa. The alternative route goes through Poland and onward transportation from the port of Gdansk. Investment in infrastructure and streamlining the re-export of Ukrainian grain with a simultaneous system of double licensing of the quantities imported to Poland seems to be the best solution in the current situation, when there is no possibility of resolving the conflict and unblocking the Black Sea ports in the short term. At the same time, in order to protect

Polish farmers from low grain prices and destabilisation of the market, actions should be taken to stimulate animal production, mainly of poultry and pigs, which should ensure stabilisation of the grain market due to the removal of a significant surplus of grain. An increase in the consumption of cereal grain, especially of grain that does not meet the quality requirements, may also be supported by the production of biofuels; in an energy crisis, they may further improve the situation in this respect.

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Article reviewed
Received: 4.10.2023 r./Accepted: 13.10.2023 r.

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DOI: 10.15199/180.2023.4.3

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MODERN TECHNICAL AND TECHNOLOGICAL SOLUTIONS EMPLOYED IN MILK PRODUCTION

NOWOCZESNE ROZWIĄZANIA TECHNICZNO-TECHNOLOGICZNE STOSOWANE W PRODUKCJI MLEKA

Summary: *The aim of the present paper was to analyze the modern technical and engineering solutions, utilised in milk production and their effect on development of dairy farms. The analysis was carried out on the grounds of literature review. The data concerning the cow population in Poland, milk market were submitted and modern technologies in farm buildings (milk barns) were described. It has been demonstrated that livestock buildings and modern solutions are the important element, ensuring as high welfare level of the dairy cattle.*

Keywords: *agriculture, cattle, housing systems, feeding systems, milking systems, modern solutions*

Streszczenie: *Celem niniejszej pracy była analiza nowoczesnych rozwiązań techniczno-technologicznych stosowanych w produkcji mleka i ich wpływ na rozwój gospodarstwa na podstawie przeglądu literatury. Przedstawiono dane dotyczące pogłowia krów w Polsce, rynku mleka oraz opisano nowoczesne technologie w budynkach gospodarskich (oborach). Wykazano, że bardzo ważnym elementem zapewniającym wysoki dobrostan bydła mlecznego jest budynek inwentarski i nowoczesne rozwiązania. Przekłada się to na wyniki produkcyjne i ekonomiczne.*

Słowa kluczowe: *rolnictwo, bydło, systemy utrzymania, systemy karmienia, systemy doju, nowoczesne rozwiązania*

Introduction

Dairy cattle husbandry in Poland is one of the basic sectors of agricultural production and the participation of cow milk in the purchase of animal products is 77.9%. Jankowski and Sosnowski [12] inform that specialization of farms and production concentration, the increasing size of dairy herds as well as increase of milk cow performance are the factors which make that milk production is a stable and permanent source of farmer's incomes.

Milk production is the most important branch of agricultural economy in Poland and it plays a role of raw material source for the dairy industry. Milk products are the indispensable raw material for food and pharmaceutical industry. Polish dairy industry has adapted for many years to varying market conditions which, in effect, resulted in production concentration and milk processing. Modern technological resources, a high quality of raw milk and dairy products have contributed to competitiveness of Polish industry on the international market. The competitiveness of West-European agriculture which is highly productive as well as the necessity of keeping high sanitary and veterinary standards and of detailed understood animal welfare, implementation of the national programme of compensations paid to smaller producers for giving up milk production and, also, economic turbulences at the global market, are the factors which also have contributed to concentration of milk production in Poland [24].

Milk production is, however, dependent to a great degree on climate conditions, including the amount of precipitations and the length of plant vegetation period. Parzonko [2013] informs that in Poland there are good natural conditions cattle breeding and milk production due to its favourable location in a moderate climate zone. The lowland territories which are dominating are the perfect habitat for cultivation of fodder plants, used in cow feeding.

The costs of milk production in the dairy farms are undoubtedly the aspect determining milk production profitability [23].

The cows reach sexual maturity at the age of 1.5–2 years and then, they are subjected to insemination. Gestation lasts for 9 months during which milk udders commence milk production. After parturition, the cows produce milk, which is rich in nutrients, minerals and antibodies. It is colostrum which is not suitable for human consumption; therefore, the cows are not milked in the mentioned period. Milk is very valuable for a calf

because it determines his immunity. To increase the yield of the produced milk, the cows are again inseminated after 90 days from the parturition; then, irrespectively of their physiological state, they are still milked. About the 7th month, the drying period is commenced, i.e. the cows are not milked in order to become stronger before the next delivery.

In 2021, in spite of the decrease of cow population, the mean milk performance was increased; it varied at the level of 6540 litres per head. It resulted in 14.4 billion litre of the produced milk [12, 24].

To reach good results in milk production, a widely understood progress in necessary. It has been noticed for many years in cattle management and production of high quality milk. The development of modern technologies which are connected with rearing of dairy cattle and milk production is to-day the integral part of Polish agriculture. The appropriate application of modern tools and modern technologies, opening to all innovations mean improvement of manufacturing processes and facilitation of undertaking the decisions being most important for the farmers. Due to the fact that a dairy cattle breeding is especially hard and labour-consuming work, the utilization of modern tools and widely understood progress allows the considerable improvement of milk production economics and, by this, reaching higher profits at the lower labour outlays [24].

The farmers, who have observed the changes on the dairy market and the changes in the effective management, are aware that the already made investments, or those ones anticipated for the nearest future, have and will have the meaningful influence on profitability of milk production in the future.

Literature review

Dairy cow population and milk market in Poland

Milk production is one of the most important production sectors in Poland. Due to the fact that it is a source of existence of many agricultural farms and is the basis for the national dairy industry, it has a great economic meaning. The products coming from milk processing (dairy products) are the indispensable raw material in many domains, not only of food industry but also, of pharmaceutical and cosmetic industries. Polish dairying has followed for many years the varying market conditions, what brought about to the present concentration of production and processing of milk. The modern technological basis and high quality of the raw milk are the factors of the competitiveness of Polish dairy industry at the international market [14, 23].

Poland occupies the third place (after Germany and France) in the ranking of the dairy cow population in the European Union, although in 2020, a small decrease of the number of cows was observed. the data of the Main Statistical Bureau (GUS) show that in June 2020, the population of dairy cow varied at the level of 2 218 000 heads and one year earlier, in 2019 – it was 2 222 436 heads. Diagram 1 illustrates the level of dairy cow population in Poland in the years 2004–2020.

The data found in Figure 1 show the decrease in dairy cow population since 2008. In 2014 and in 2015, dairy cow population amounted to 2.3 million cows whereas in 2015 it was decreased to 2.1 million heads.

Due to different reasons, including those economic and environmental ones, milk production in Poland is concentrated in its east and central parts (Figure 2).

At the territory of the Mazovian Voivodeship, it comes from 22% of the total dairy cow population; in the Podlaskie Voivodeship – 20%; in the Wielkopolskie Voivodeship – 14%; in the Łódzkie and Warmia and Mazury Voivodeships – 8% in each; in the Kuyavyan-Pomeranian Voivodeship – 6% and the Lubuskie Voivodeship – 5%.

The mentioned above voivodeships include more than 83% of the total number of national dairy cattle population and the implementation of milk supplies at their territory oscillates around 86%.

The lowest percentage of dairy cows in Poland in 2020 was found in the Lubuskie Voivodeship (13%), Low-Silesian Voivodeship (25%) and West-Pomeranian Voivodeship (27%).

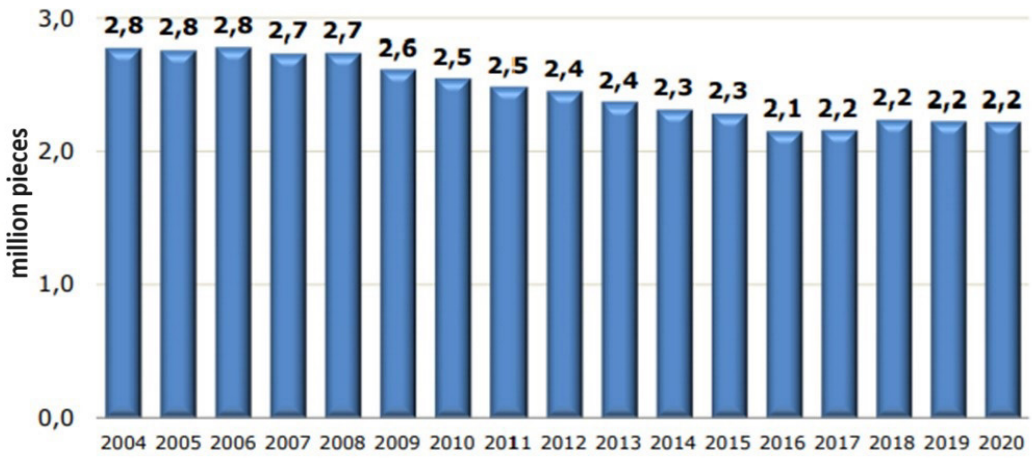


Fig. 1. Dairy cow population in Poland in the years 2004-2020
Source: KOWR 2021 [13]

In the table, the population of dairy cows in the years 2013 – 2020 in the particular voivodeships has been presented.

The analysis of the data contained in Tab.1 allows the confirmation that the population of the dairy cows in the earlier mentioned voivodeships is the highest one. We may also see the relationship of the level of cattle population in the particular voivodeships in 2020 as compared to 2019. It

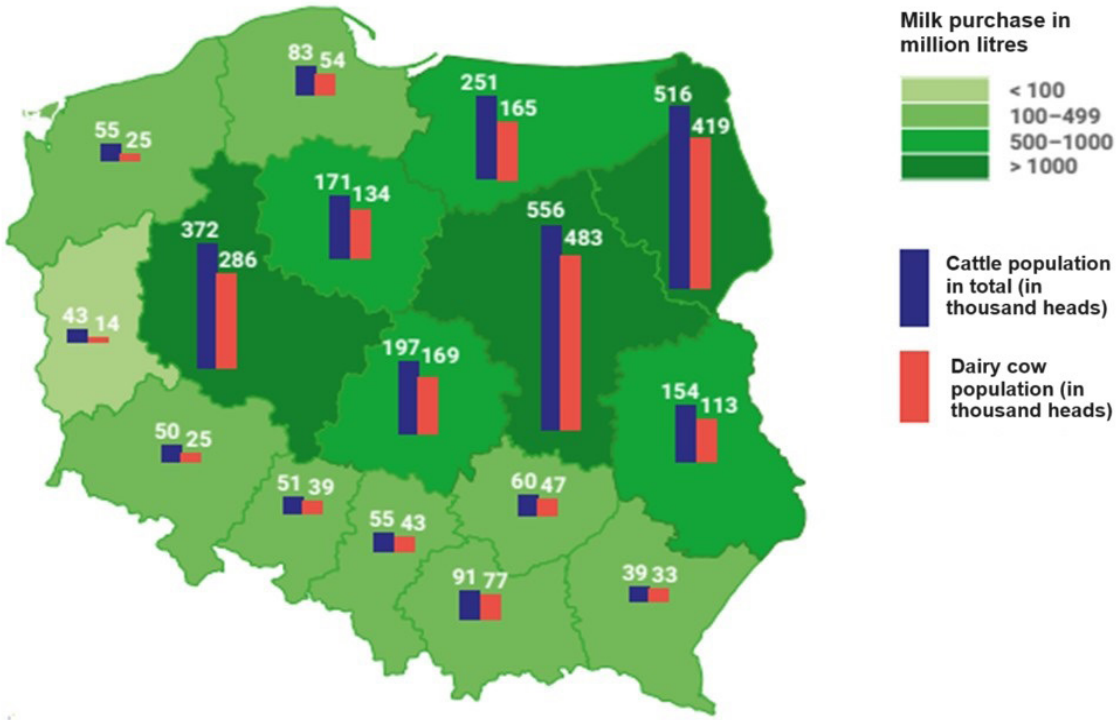


Fig 2. Cattle and dairy cow population and milk purchase in Poland in 2020 in the particular voivodeships
Source: KOWR 2021 [13]

Table 1. Population of dairy cows in 2013-2020 in the particular voivodeships in Poland

POLAND	2013	2014	2015	2016	2017	2018	2019	2020	Change,% 2020/2019
	2.361	2.310	2.279	2.146	2.154	2.233	2.221	2.218	-0.2
Low-Silesian	32	32	30	28	27	27	26	25	-6.7
Kuyavyan-Pomeranian	152	148	155	151	136	152	158	142	-10.0
Lubelskie	145	145	142	130	133	127	122	119	-1.9
Lubuskie	18	19	14	13	15	15	13	13	-1.3
Łódzkie	187	200	185	175	177	183	182	180	-1.1
Małopolskie	94	85	84	82	75	81	76	80	4.6
Mazovian	518	515	490	458	468	500	539	498	-7.5
Opolskie	40	41	40	40	38	40	38	38	6.0
Sub-Carpatian	59	54	53	48	45	42	36	36	0.3
Podlaskie	449	428	445	415	434	443	432	436	1.1
Pomeranian	66	64	62	58	59	60	55	58	5.0
Silesian	46	44	43	42	42	43	43	45	2.9
Świętokrzyskie	61	59	59	53	51	51	47	47	-0.1
Warmia and Mazury	176	180	172	167	171	185	462	171	5.7
Wielkopolskie	292	267	277	261	261	261	162	171	11.6
West-Pomeranian	25	27	26	25	22	23	23	27	13.9

Source: KOWR 2021 [13]

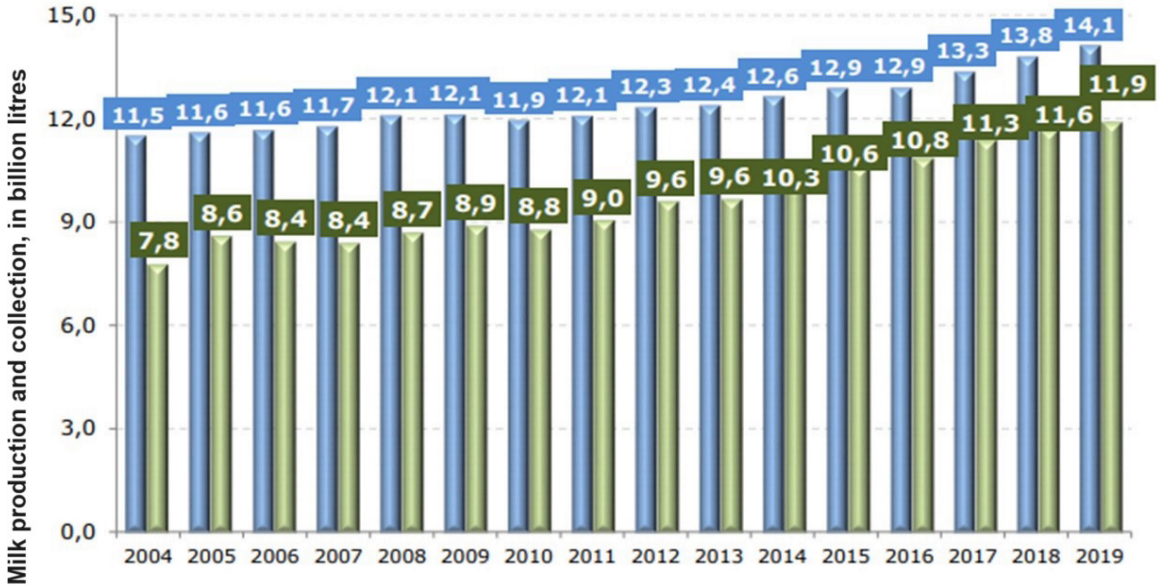


Fig. 3. Milk production and collection in Poland in the years 2004-2019
Source: KOWR 2021 [13]

was increased the most in the Opolskie, Warmia and Mazury and Pomeranian voivodeships. The greatest decline was found in the Kuyavyan-Pomeranian and Mazovian voivodeship.

Poland is found at the top of the meaningful milk producers; it occupies the 5th place in the EU and the 12th place in the world. The national dairy industry has a significant participation in GDP generation by the agricultural sector. Milk production in 2019 reached the level of 14.1 billion litres and it was higher than in the preceding year.

Diagram 3 shows milk production and collection in Poland in the years 2004–2019.

In 2020, milk collection was found at the level of ca. 8.3 billion litres whereas in 2021, the market entities collected 1.022 million litre of raw milk in September. In 2021, the prices of milk were shaped at the level of 150.52 PLN/hl, i.e. by 13% higher than in 2020. The highest prices were obtained in the Podlaskie Voivodeship (153.77 PLN/hl) and in the Lubuskie Voivodeship (153.39 PLN/hl). The lowest prices for milk were paid in the Małopolskie Voivodeship (138.01 PLN/hl and the Łódzkie Voivodeship (142.13 PLN/hl). The population of the dairy cattle in December 2021 oscillated at the level of 2 289 thousand heads [18].

In 2021, milk collection was equal to 12 117 million litres; a little more than in 2020. The greatest declines were observed in the Warmia and Mazury Voivodeship (607.5 thousand litres), in the Kuyavyan-Pomeranian Voivodeship (536.8 thousand litres) and the Wielkopolskie Voivodeship (456.7 thousand litre). The greatest quantity of milk from other voivodeships came to the Podlasie. The mentioned amount oscillated at the level of 1 902 million litres [15].

The average price of milk collection in 2021 (for 12 months) amounted to 157 PLN/hl and was somewhat higher than the price in 2020 [18].

Infrastructure and modern technologies in the farm buildings – dairy barns

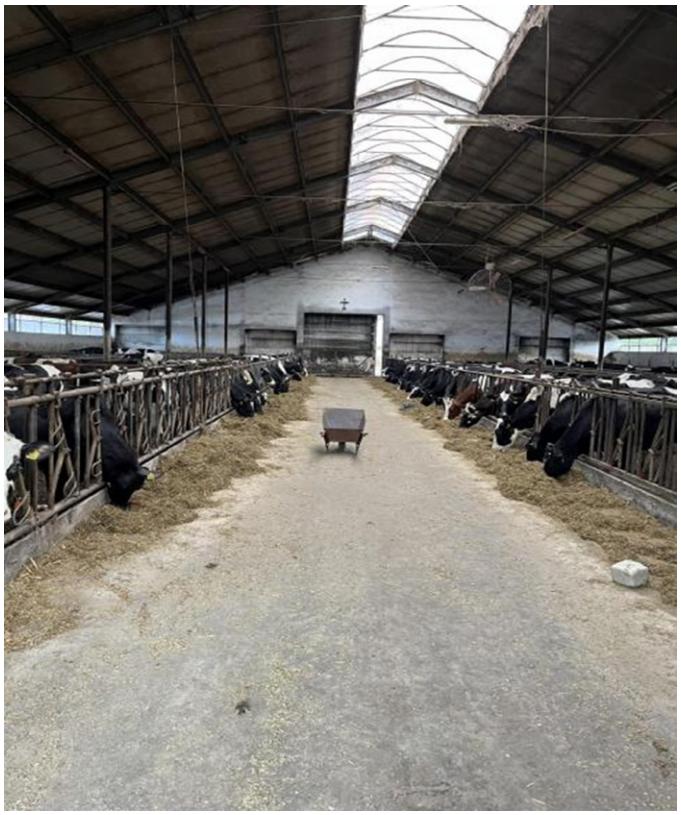
Dairy cattle husbandry as well as the production and economic effects of the mentioned management are strictly connected with the structure of agricultural farms which are specialized in the discussed production [3].

The contemporary milk production in the commercial scale is characterized by the application of more and more modern technical infrastructure and the solutions, being the premise for a high yield and limitation of labour outlays as well as improving the quality of the obtained milk [1].

Agricultural practice show that the utilization of the potential of modern equipment and technologies is fully justified in each zone of the milk barn, including also the area of milking [17], removal and collection of manure [6] as well as in preparation and administration of feeds [7]. On the other hand, Fiedorowicz and Mazur [6] pay attention to the microclimate conditions in the livestock buildings.

In the system of the dairy cattle housing, we may distinguish two basic solutions of keeping the cows in the barns: tying stalls and loose housing. When choosing the type of dairy barn, we take the size of the herd, economic conditions, animal welfare, and safety of work into consideration. If the stocking density of the cattle herd is 30 heads, the cost of building the loose housing barn and tying stall is similar. The difference can be visible in the case of 60 animals, in favour of a loose barn [29].

Loose housing barn has many advantages and the animals are kept in the way similar to the natural one what is very favourable for their performance. In the discussed barn, the cows have a freedom of moving and a contact with other cows. Milking is carried out in the separate premises. From among the



Fot. 1. The cows in a loose barn
Source: photography of the authors

Fot. 2. The cows in the tying stalls
Source: photography of authors

loose barns, we may distinguish the following types:

- with the separate part for feeding, with a deep litter and with the collective laying part;
- with boxes which meet the feeding and laying function simultaneously;
- with the separate part for laying and for feeding.

The loose barns facilitate getting up and down of the cows in their specific way and the number of stalls must be adequate to the number of animals. The loose barn with the deep litter consists of two parts, separated each other with the steps: for lying and for feeding, with the dimensions of 3–3.5 m. The surfaces of the beds must be adapted to the number of the kept animals provided that there is 5 m^2 of bed per each animal. The litter may be employed on the beds but there are also used slotted floors. Boxes in the barns must give the possibility of free moving for the cows; the floor may have a litter or may be litter-free. In the latter case, a plastic matte may be used. In situation of kombi-boxes, feeding is carried out on laying bed. The kombi-boxes are situated on two sides of feeding corridor and they are adjusted to the size of animals (110–120 cm x 170–180 cm).

A special attention should be paid to the standings in tied type of barns as they should not be too short or narrow because they lower the condition of the cow and restrict her movements.

The tether must give the possibility of forward movement for the cow, free standing up and lying down and backward movement. The length of the tether must force the cow to keep the head over the feed trough when lying. If the standing is slotted, it must protect from damage of udders. In such barns, the standings are long and short. In the case of litter-free floor, they are usually short (180–190 cm). They are selected in such a way that the legs of the cow are at the distance of 10 cm from the edge. Keeping such distance makes that the faeces of the animal will pass to the manure channel.

Long standings (210–250 cm) are recommended for parturition or for treatment. They are more difficult in respect of keeping cleanness and in the contaminated standing, soling of the udder and mastitis occur more frequently.

The modern buildings, as adjusted to animal needs, have to ensure for the animals:

- appropriate lighting coming from the day or artificial light;
- the required air exchange;
- keeping the appropriate temperature;
- safety and protection from unfavourable atmospheric conditions;
- protection from humidity from the floor and the accumulated animal faeces (manure);
- removal of slurry from the standings, presence of installations and equipment adapted to the destination of the premises;
- the appropriate conditions for service and care.

In the agricultural farms, specialized in cattle breeding and milk production (dairy farms), the equipment for supply of feeds are indispensable. The correct organization of feeding facilitates the service of the herd and saves the time of work in the farm [19].

The mixing feed wagon is the equipment which makes the work considerable easier. It has the application in two technologies of cattle feeding; in TMR and PMR system. TMR system supplies the complete feeding ration, fully mixed, the composition of which includes maize and straw silage, haylage from grass, concentrate and feed additives. The ration is completely mixed; the cow has no possibility to choose the bites but she eats the whole portion. PMR system supplies the lower quantity of feed components to the cow [2].

Application of feed wagon causes a rapid and effective preparation of feed for animals and its precise dosage. The discussed equipment mixes accurately the components of the feed and makes that they are not subjected to lumping. It occurs owing to its robust construction, based upon the significant elements. Bulk storage container which is made from a thick sheet metal plays the important role as the feed is prepared inside it. It should be resistant and capacious and the mentioned capacity should be adapted to the needs of a given farm. Its shape and dimensions must be so selected as to prevent feed loss and facilitate its precise mixing [10, 26, 27].

The mixers (agitators) and knives are the successive necessary elements of feed wagon, which guarantee a precise cutting and accurate disintegration (grinding) of feed composition. The mentioned elements have also influence on the readiness of the cows for consumption of feed. Therefore, grinding of the feed is the element which affects the effectiveness of milk production in the indirect way. Due to intensive use, the edges of the knives are subjected to a quick wear, they may become dulled; therefore, they should be controlled and depending on the needs, replaced [30, 31].

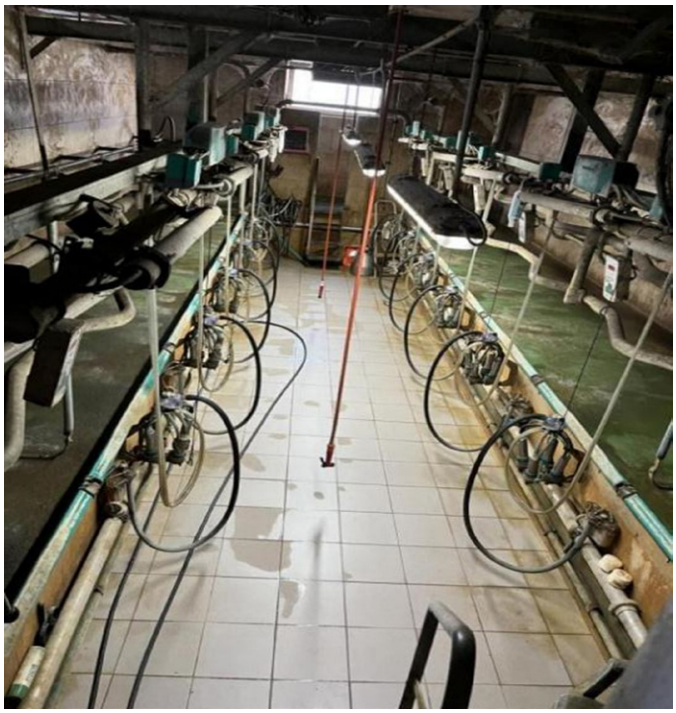
Feed wagons not only mix and comminute the feed but also facilitate its supply to the cows in a direct way. It is possible owing to the equipment of machine in the special discharge openings or the tapes (belts) which ensure the uniform and effective dosage of feed.

The feeding station, adjusted to automatic feeding has a great meaning in feeding of the cows. It consists in adaptation of the quantity of administrated concentrates to the needs of individual cows, equipped with the so-called transporters. With the help of the mentioned equipment, the reader if the feed station identifies the animal, so each of the cows receives the precisely measure amount of feed. The work of the feed station is steered by the computer system; owing to this fact, the time-consumption of feeding becomes considerably limited. The agricultural practice recommends the application of one feed station for 25–30 animals in loose barn system, with one programme, controlling the work of four stations [11, 27].

The most important equipment in preparation and administration of feed in cattle feeding system include as follows [2, 7, 20]:

- knife cutter of silage;
- jaw selector of silage;
- selector of silage with loading box and feeder for supply of feed;
- wagon for loading and disintegration of bales and supply of hay or straw;
- stationary chopper of bales;
- electric cutter of bales;
- trailer cutter of straw or hay bales;
- developer and spreader of straw;
- chopper of straw bales with spreader.

The modern technologies in dairy cattle management are connected with milking. Manual milking has become replaced by mechanical milking of cows. Głowacka-Wołoszyn et al. [8] inform that such milking has the influence on improvement of the quality and quantity of the obtained milk. During the milking in tying stall system, there are employed bucket milking machines and pipeline installations.



Fot. 3. Milking parlour of "herringbone" type
Source: photography of authors

During milking with the application of churn milking machine, the milk is collected in the bucket and after filling, it is poured to cooler. On the other hand, in the case of milking with the use of pipeline milking machines, the milk is transported to cooler by pipelines.

In the loose stall systems, milking is performed mainly in the milking parlours, differing in the number and situation of milking stands. The output expressed as a number of the milked cows by the milkman at the time unit [16, 25] is the important element of milking parlours.

The mentioned milking parlours are the premises where milking of cows is carried out with the application of milking machines. Owing to this equipment, obtaining and treatment of milk coming from a few or several dozens of cows is decisively less labour - and time-consuming. The milking parlours make the work easier, more comfortable and more effective. It allows milking 9 cows per hour at one milking stand and in the more modern milking parlour it is possible even to milk 18 cows per hour at one stand [22, 25].

We may distinguish a few types of milking parlours:

- "herringbone";
- "tandem";
- "rotary ("carrousel");
- "side-to-side" [2].

Milking parlours of "herringbone" type are offered in two versions: -30° – the cows are milked from the side and 60° – the cows are milked from the rear. Each of the mentioned versions ensures the milkman a perfect access to the animals and the

distribution of the milking stands guarantees the optimal and convenient position for the cow and for the milkman. The milking stands are adapted to the anatomic condition of the cow. The construction of the milking parlour itself is integrated with the components of milking technique.

The milking parlours of "tandem" type are characterized by side position of the cows during the milking. The cows stand at the separate stands and the milkman may freely observe the whole herd. Such type of milking parlour allows individual treatment of the cows, easy control of the state of their health and allows quick noticing of all irregularities in cow.

"Carousel" is a sort of milking parlour, it is very practical for big herds; it has 12 or more milking stands. The performance of the discussed type of milking parlour is 100–120 cows per hour for one milkman and for two – the milking performance is increased up to more than 200 cows per hour.

The milking parlour of "side-to-side" type is distinguished by the parallel arrangement of the cows next to each other and milking is carried out from the rear. It gives the possibility of easier attachment and take–off of the cluster of the milking machine. Position of the cows during milking abbreviates the dimensions of the milking parlour, and by this, the distance which the milkman has to pas during milking. The cows leave the milking parlour via the rotary gate, rotating by 180°, or 360°. The baffles or fencing in the milking parlour ensure comfort to the cows and the labour efficiency to the operator. The main advantages of the discussed solution include the system of a quick exit, easy access to the cows and convenient milking.

In every agricultural farm, the tractors are the necessary equipment. Their purchase is connected with the investing capital for many years. The trailers are employed in different types of work:

- general work in farm (supply with production means, sale of the products, work at the yard of the farm);
- field work.

The demand on tractors with different equipment is greatly differentiated in terms of 100 farms as well as per 100 ha of agricultural land. It is connected with the territorial distribution of the farms, according to their area.

In each farm, there are tractor loaders, serving for daily removal of manure from the slurry channels, removal of manure from the barns with a deep litter, formation of prism at the dung yard, loading of spreaders of lime and fertilizers, work which is connected with movement of silage, straw and hay etc. The loaders work as fitted to the trailers or they are suspended. The front-end loaders are most frequently employed [9].

The farms are also equipped with trailer forklifts (loaders), facilitating lifting the loads, placed on pallets or in the containers. They give the possibility to move them into small distances, and later, placing them on low agricultural trailers. Load capacity of the lifts oscillates within the limits of 600–1400 kg and the height of lifting up is 1.8–2.7 m. The discussed equipment is suspended at the supporter of the front axis of tractor. The rear lifts are placed on the three-point system of suspension of the tractors [2].

Within the farms, there are also many other machines or equipment employed such as ploughs, harrows, skinning aggregates, spreaders of fertilizers, spreaders of mineral fertilizers, spreaders of manure, slurry tankers, cereal drills, single-seed drills, field sprinklers, mowers, grain combine-harvesters and others.

Szewczyk [28] informs that the level of technical equipment of agricultural farms is determined by agrarian structure of the region, structure of cultivations or commodity range of the farms.

We should also pay attention to monitoring which may be considered as a certain modern technology in agriculture. Monitoring in the agricultural farms has a greater and greater meaning. The systems of monitoring, situated in the barns must, however, be characterized by the increased resistance of the equipment due to unfavourable environmental conditions which occur in the barns. High nitrogen concentration is greatly unfavourable for electronic components and has a negative effect on the time of their failure-free work. A high effectiveness of failure-free work may be obtained owing to the appropriate choice of the equipment which meets the severe standards of tightness IP.

Monitoring in the agricultural farms plays the important role and is a quickly returnable investment. Installation of cameras brings many advantages and one of them includes protection of agricultural machines from vandals and thieves. The monitoring not only protects the property of the farmers but also helps in breeding of animals which requires day-and-night care, e.g. waiting for parturition, the possibility of passing outside the farm or in the case of disease. All this may be controlled from the outside of the barn, even outside the farm. the correctly chosen equipment, ready to work under the difficult conditions, stores the records of the events for a long time; owing to this fact the farmer may prove his arguments if needed, before respective institutions or insurers.

Discussion

After the accession of Poland to the European Union, many farmers had to modernize their farms because in the member states of the EU a high attention is paid to the animal welfare. Most of the barns before 2004 did not meet the requirements of the contemporary technologies and did not ensure the correct conditions for management of the herd. Besides it, a high quality milk production requires time and attention. It necessitates also health and welfare of animals, and undertaking the appropriate decisions in accordance with the aims of the breeders.

Dairy husbandry in Poland is the most important agricultural sector of economy. Borusiewicz and Kapela [4] state that high performance of cows, together with the optimally low labour-consumption of handling with the animals is the basis for profitability of raw milk production.

The authors add that in the case of dairy cows, apart from feeding which decides on cattle productivity, the conditions of animal life as well as genetic determinants of milk performance, are the significant elements.

Neja [21] believes that the livestock building is the basic element of animal protection; this opinion was also confirmed by the owners of farms where the studies were carried out.

Many breeders and researchers express the opinion that loose barn system of management as compared to tying stall system has the advantage in respect of animal welfare and mechanization and automation of work, especially of milking. The loose barn system ensures also integration of animals within a group and, also, the unlimited movement in the barn. For the attendants, the work is also easier.

Conclusions

On the grounds of the analysis of literature and the available data, we may formulate the following conclusions:

1. The livestock building together with the modern solutions which improve behaviour of animals is a very important element of cattle protection and its health state
2. Modern technological solutions abbreviate the time of work of the farmer and increase the performance of the cattle
3. Installation of modern solutions in the barns is equivalent with obtaining the optimal conditions of cattle welfare and milking hygiene. It is reflected in production and economic results.
4. Computerisation and monitoring are the factors which make the work of the farmers much easier and improve simultaneously the safety of the herd. The users of computer programmes and monitoring have the permanent access to all information as well as parameters concerning quality and quantity of milk and health state of the herd.

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Article reviewed
Received: 14.12.2023 r./Accepted: 22.12.2023 r.

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DOI: 10.15199/180.2023.4.4

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SENSOR CHARACTERISTICS

CHARAKTERYSTYKA SENSORÓW

Summary: *The present paper is the second part of our consideration of the following problem: an attempt to compare the work of the detection sensor with the visual ZFV vision system in the packaging labelling project*

Keywords: *sensor, detection, ZFV vision system, packaging labelling project*

Streszczenie: *Niniejsza praca stanowi drugą część rozważań nad następującym problemem: próba porównania pracy czujnika detekcyjnego z wizualnym systemem wizyjnym ZFV w projekcie oznakowania opakowań.*

Słowa kluczowe: *czujnik, detekcja, system wizyjny ZFV, projekt oznakowania opakowań*

Introduction

Processing of a given physical size into easily measurable electrical quantity is obtained by the sensors. The modern optical sensors are getting smaller and, at the same time, they are characterized by a greater working space and more precise possibilities of determining the switching points as compared to the older models. Greater and greater challenges lead to production of more and more complex vision sensors which detect not only the presence, colour or patterns but also, markers. At present, the sensor is more and more frequently equipped also with the interface for digital communication networks.

Sensor characteristics

The diversity of available solutions from among the sensors forces the need of classifying the sensors. The basic classification – according to the principle of sensor functioning – is as follows:

- mechanical
  - lever-type
  - toothed
  - spring
  - lever-spring
- optical
  - opticators
  - interferential sensors
  - optimeters
- electrical
  - electro-contact
  - induction
  - capacitive
  - photoelectrical
- pneumatic.

Due to the energy source of measuring signal, i.e. activation, the sensors are classified into:

- passive,
- active.

According to the application, we can distinguish the sensors of:

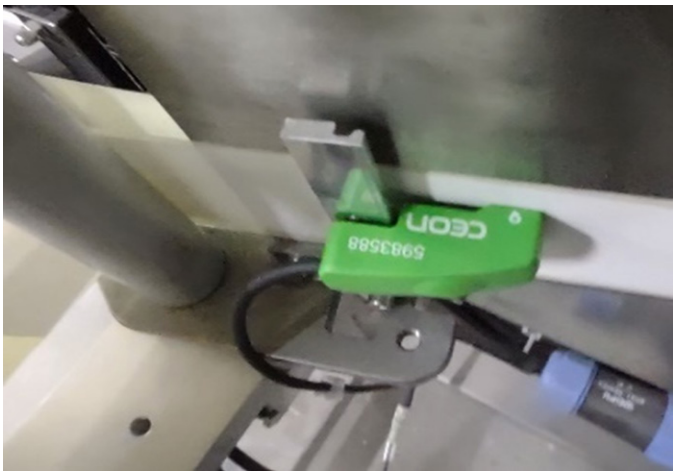
- label
- product.

The sensors can be also classified according to the generated signal:

- generative, and
- parametric.

There will be presented below the examples of the sensors, employed in labelling process: labels, product and colour.

The intelligent sensor of labels CEON as being visible in photos 1 and 2 allows the reliable identification and a precise



Fot. 1. Label sensor mounted on the measuring station

positioning of labelled materials. It is dedicated to paper labels as well as also for thin, transparent of metallised labels. The coins with the nominated value of 5 PLN, as presented in photos 2 and 4, were aimed at the presentation of the size of the sensors.

Fot. 2. Comparison of the size of the CEON sensor and the coin

The discussed sensor is positioned in such a way that the presence of the label is signalized. Diode of the sensor inform about the current state of the switch, i.e. it emits light in during the detection of labels and is extinguished in the breaks in this process what enables the current control of the correctness of the sensor's work. The discussed equipment is self-learning unit, equipped with the mode of work and mode of adjusting. All adjustments are performed using one button.

The sensor of the product, as being illustrated in photos 3 and 4, is responsible for supply of information on the presence of the labelled product on the transporter of the labelling machine. It sends the signal allowing the start of labelling head.

The most common applications of the mentioned above sensor include the detection of a foreign body placed in a certain

Fot. 3. Product sensor mounted on the measuring station

Fot. 4. Comparison of the size of the Pepperl+Fuchs sensor and the coin

area. In the discussed system, the sensor is linked with a light source which is a transmitter, being often integrated in one casing. If any object is found on the optical route between the transmitter and receiver, the change in light intensity will take place and it may be detected. Depending on the construction of optical path, the light stream becomes interrupted, reflected or dispersed. We use often synchronic diodes working at infrared as transmitter; owing to this fact, the output signal is greatly independent on the external light because the visible light can be easily filtered out. Under the difficult conditions, there are employed the reflection sensors of light barrier, working with the red light, emitted by light diode because it is easy to notice such light stream and the point which it falls on.

For such purposes, we may employ visible light, laser light as well as infrared light. The scheme of its functioning is given in Fig. 1.

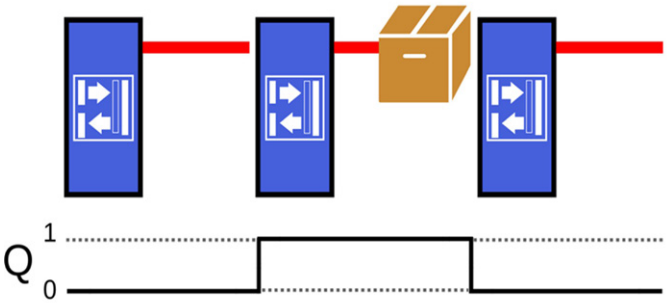


Fig.1. The principle of operation of the product's sensor

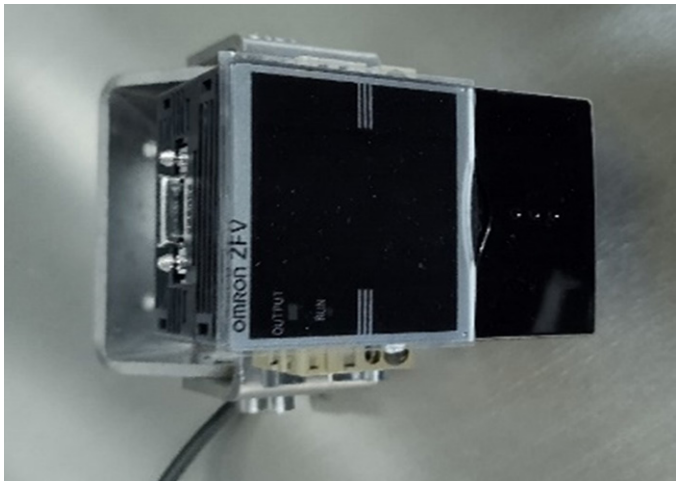
Gradually, when the labels become more and more sophisticated and the shape of packaging is more differentiated, a difficulty appears with obtaining the univocal response from the sensor: whether a given product is found in the appropriate position in relation to labelling head. In such situation, we use detection of the image or detection of its edges. To increase the entropy, i.e. quantity of information transmitted by the image,

the discussed method employs – to a certain degree – the tools of clearing (sharpening) the image, facilitating its automatic analysis. The colour sensors, illustrated in photo 5 play the mentioned role with a success. They are able to detect the colour of the image surface as well as its shape [1]. The sensors emit the red, green and blue light to the controlled objects, calculate the chromatic coordinates of the reflected radiation and compare them with the earlier memorized default (reference) values. If the colour values are found within the set tolerance band, the switching exit is activated.

Fot. 5. KEYENCE colour sensor

The vision system contain also the set of image sensor and converter of images' analysing, being commonly called camera which is illustrated at photo 6. Its application together with the converter given in photo 7 enables the storage of few detectable images in the memory. It is also possible to use a few measuring methods of colour, considering its positions, range, mark, width and brightness.

Fot. 6. Omron ZFV camera



Fot. 7. Omron ZFV Converter

Summing up

The discussed sets enable detection of the products which are difficult to be analysed when using photoelectric colour sensors. The problem is, however, that the complexity of their construction has a greater market value and affects a final price of the labelling equipment. Due to these reasons, it is worthy to determine the profitability limit of the application o the particular positioning systems.

Literature:

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Article reviewed
Received: 18.07.2023 r./Accepted: 31.07.2023 r.

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PROFESSOR PIOTR WOLAŃSKI – COSMIC AUTHORITY, THE PEARL OF POLISH SCIENCE

PROFESOR PIOTR WOLAŃSKI – KOSMICZNY AUTORYTET, PERŁA POLSKIEJ NAUKI

Prof. dr hab. Piotr Wolański (1942–2023) was one the most outstanding Polish scientists of the recent decades, a visionary who brought the enormous contribution to Polish sector of space science when outlining a series of perspective area of development and hypotheses: those ones concerning the origin of the Moon, or decay of dinosaurs. In his scientific activities, he undertook the subjects connected with the problems of combustion and the methods of diagnostics of combustion processes, explosions and engines, and the collisions with the celestial objects. Space drives, development of multi-use rockets and transfer the discussed knowledge to the students were translated into the defined implementations. The first Polish satellite PW-Sat was constructed under the guidance of the Professor at Warsaw University of Technology and the study direction "Aviation and Space Science" became the permanent specialization in the faculties of Polish technical universities.

If we had wanted to describe Prof. Piotr Wolański in a few words, it would be a very difficult task at least as much complicated as the field of his interest, or even as space – impenetrable, and at the same time, open to exploration. To get know Professor, it is not enough to reach to the sources; he always was inclined to the facts (as being the engineer) but the real knowledge about him comes from the persons with whom he spent the time, who he could rely on and who appreciated not only his vast knowledge but also his attitude to other persons. His approach was always friendly, non-schematic, and open to different points of view. As being husband, father and grandfather as well as a boss and associate-in-work, he was unusually modest and person, as well as great authority for his students and for the scientists from around the world. How was his way to the stars commenced?

He was born on 16, August, 1942 in a picturesque countryside Milówka, situated among the mountains where the nearness of the heaven seemed to fall nearly on the head. When he was still a pupil of the primary school, he saw a start of American rocket "Aerobee" during the emission of Polish Film Chronicles in a local cinema "Tęcza" (Rainbow). He undertook then the decision about becoming the constructor of rockets. The fascination with the rocket technology was quickly transformed into construction of model rockets where the flammable cellulose photographic films served as a driving material. – *He came back repeatedly to Milówka eagerly for all his life. He found there rest and respite. It was the place when he discovered his first love to space which occurred to become his greatest hobby and destination* – Ewa Wolańska, Professor's daughter says. When he was a pupil of the Mikołaj Kopernik Secondary School, he has the occasion to observe – in media

Fot. 1. Professor Piotr Wolański. Source: Łukasiewicz – Aviation Institute

Fot. 2. Laboratory Centre of Rocket and Satellite Drives in Łukasiewicz – Aviation Institute, opened on 24.10. 2023; Prof. Piotr Wolański has contributed to its opening. Source – Łukasiewicz – Aviation Institute

– a start of the first artificial satellite of the Earth – "Sputnik-1". After graduation of the school, he commenced the searches for the appropriate direction of the studies which would satisfy his interests. He chose the Faculty of Aviation at Warsaw University of Technology which became transformed into Faculty of Power and Aeronautical Engineering in 1960 when he commenced his studies. His specialisation was "Aviation engines" although his diploma informed about the specialisation "Mechanical engineering". The subject of his diploma thesis was construction of anti-tank missile because according to the opinion of his promote, the space rocket would not fit on the drawing board. He graduated in 1966 and at the same time, he began to work at the parent faculty, at the Institute of Heat Engineering, Chair of Industrial Combustion Engines and Aeroengines. The knowledge which allowed him to develop successfully his talent was based upon the strong foundations of Warsaw University of Technology and, on the other hand, it was a result of his attempts aimed at development of his interest. As early as during the first year of his studies he became the member of Polish Astronautic Society, Department in Warsaw and after few years, he became its President. In 1964, he participated in IAF Astronautic Congress in Warsaw where, for the first time, he got familiarized with the world level of science and technology in this respect. In 1965, during the visit at the Paris Air Show he met personally Yuri Gagarin.

In the seventies, he obtained a scientific title of Doctor (1971), submitting the dissertation entitled: "Stabilisation of dust-carbon flames by unstreamlined bodies"; then, the degree of *doctor habilitatus* (1979) ("Dynamics of ignition of gas mixtures"), occupying the posts of assistant-trainee (1966–1967), assistant (1967-1969), senior assistant (1969–1972), lecturer (1972–1981). In the middle of the seventies, he formulated a hypothesis on formation of the continents as a result of collision of big asteroids and the Earth, or the hypothesis on formation of Moon as an effect of a similar phenomenon. The other catastrophes such as e.g. decay of dinosaurs could be also the result of the collision of other celestial bodies with our Planet. The mentioned hypothesis was suggested by Professor and published in Polish scientific periodicals much earlier than the recognised and popularized later (after few years) theory of Walter Alvarez. When the quick computers appeared in Poland, Prof. Wolański and Prof. Karol Jach from Military University of Technology performed the numerical calculations of the mentioned type of collisions.

Fot. 3. The first field tests of rocket BURSZTYN in 2K version and of a mobile rocket launching construction WR-2. Central Polygon of Air Forces in Ustka, October 2022, Photo. Łukasiewicz – Aviation Institute

In 1979, he left for 9-month practise at the University of Michigan in Ann Arbour where he cooperated with Prof. W.C. Kauffman, Prof. J.A. Nichols and M. Siechel at the Aerospace Department. During the successive years, he visited the University again,

Fot. 4. Professor Piotr Wolański was the creator of the greatest conference dedicated to space drives – Development Trends in Space Propulsion Systems. Photo. Łukasiewicz – Aviation Institute

including the years 1990–1991 as a visiting professor. The work at the University of Michigan facilitated him to get many American grants, implemented later at Warsaw University of Technology. When he came back in 1979, he became the dean for students' affairs and later on, for general matters. During the next decade, he worked at the post of assistant professor (1981–1989); in 1981, he became the head of the Unit for Aviation Engines and he stayed at this post for more than 30 years (up to 2012). In the eighties, he introduced the elements of rocket drive elements within the subject of "Fuels" included into specialisation "Aviation Engines". The lectures on rocket engines were included to the subject "Aviation Drives". In the years 1987–1990, Professor was the Dean of the Faculty of Power and Aeronautical Engineering; in 1989, he received a title of the associate professor and in 1993 – the tile of full professor. He was also the Member of the Senate (1999–2002) and the Senate Commission for Foreign Relations at Warsaw University of Technology (1987–1990 and 1999–2002). The words of the Dean, Prof. Dr hab. Janusz Frączek, Eng., characterize the best the silhouette of Professor Wolański: – *The Faculty of Power and Aeronautical Engineering owes its prestige, recognition and high appreciation to its Great Professors. One of the most outstanding persons was Professor Piotr Wolański. His research and educational activity was always connected with the Faculty where he left the lasting trace in almost every aspect of activity. The achievements of professor in the area of combustion engines, detonation, explosions and aerospace made that he became the world-wide authority in the mentioned domain. The satellites and developments of rocket technology became his recognition sign in Poland as well as all over the world.*

In the years 1990–1994, Professor played a function of the President of Polish Astronautic Society, which he undertook after the cadence of General Mirosław Hermaszewski, the first Pole in the space (1978). In the middle of the seventies, he participated in the lectures of Professor Wolański within the frames of "INTERCOSMOS" space programme at the Military Institute of Aviation Medicine. Since 1994, he had been the Honorary President of Polish Astronautical Society. In 1995, he was elected as the member of the Space Research Centre of Polish Academy of Sciences (PAN) and four years later – the Vice-President of the mentioned Centre (From March 2003 until 2019, he was its President and later, the Honorary President).

In 1994, owing to the attempts of Professor Wolański (Professor of Warsaw University of Technology), the teaching of "astronautics" within the frames of inter-disciplinary studies in this domain was commenced at Warsaw University of Technology. In 1996, the Student Space Association was organized at the Faculty of Power and Aeronautical Engineering. Professor Wolański was its guardian from the beginning until 2016. The mentioned Association has contributed, *inter alia*, to signing the treaty on the associated membership of Poland and ESA (PECS – Plan for European Cooperating States). It was signed on April, 27, 2007 owing to *inter alia*, all-Poland action for collecting the signatures under the open letter addressed to the Minister of Economy of the Republic of Poland. Apart from the rockets and Mars rovers, the most ambitious and known projects of the mentioned Association include a series of satellites PW-Sat, being designed and constructed according to the CubeSat standard, what enables sending them into space in the standardized ejectors as the addi-

Fot. 5. Rocket ILR-33 BURSZTYN ("AMBER") – the first rocket in the world, employing hydrogen peroxide above 98% as antioxidant. The project was initiated by Prof. Piotr Wolański. Photo. Błażej Marciniak. Source: Łukasiewicz – Aviation Institute

tional load of the rockets. Until now, two satellites have been constructed: PW-Sat – the first Polish artificial satellite launched into orbit on 13, February, 2012 during the first flight of Vega rocket within the frames of the educational project developed in the Education Bureau of the European Space Agency; and PW-Sat2 – placed on the orbit on 3 December 2018 by mediation of Falcon 9 rocket. At present the work is carried on the third satellite, the main aim of which is to test the authorial drive of warm-gas type solution. In 1991, Professor Wolański commenced cooperation with the Institute of Aviation (Research Network Łukasiewicz) where he had worked for more than 30 years (in the period of 2000–2002 he was the Chairman of the Scientific Council of the mentioned Institute). At the Institute he had the relationships with the Laboratory of Space Technologies, which was created by him in 2007; he had been its guardian for many years. As Dr Adam Okniński, Eng., director of the Centre for Space Technologies said – *the team consisted of few persons, chosen by professor from his students which – under his guidance – carried out earlier the feasibility studies in the field of rocket technology at Warsaw University of Technology. During the first years of the team functioning, Professor inspired regularly the workers to deal with the most perspective research problems, often effectively anticipating the technological trends and needs of the global sector. Owing to Professor, it was possible to obtain the first foreign grant in respect of ecological space drives what has remained one of the specialisations of the Institute. After the accession of Poland to the European Space Agency in 2012 (with the significant contribution of Professor), the discussed team began to develop. Together with the growing role of the work concerning space technologies, there was created the Centre of Space Technologies (in 2014). To-day, the discussed Centre employs more than 110 persons and is occupied only with the rocket technologies and space drives – the subjects being near for Professor.* Coming back to the years spent at Warsaw University of Technology and the first contact with Professor Wolański under the activity of Student Space Association and the subject: "Cosmonautics", and later, on the occasion of doctoral dissertation (promoter: Prof. Wolański), Dr Okniński mentions that – *Professor Wolański was undoubtedly professional authority but at the same time, he was very open and shared his knowledge and ideas with others very eagerly. From the time perspective, I think that he allowed us consciously to commit the errors in order to learn on the grounds of our mistakes within the frames of our own projects* – he adds.

At the Aviation Institute, Professor Wolański developed his work on the utilization of ecological driving materials in rocket engines, including the application of highly concentrated and pure hydrogen peroxide. He was also the prominent specialist in the field of the studies on combustion engines and, in particular, those ones utilizing the process of rotating detonation (Rotating Detonation Engine, RDE). He cooperated also with Mitsubushi, Nagoya University (Japan) in the above respect and patented the idea with Prof. T. Fujiwara and with Mitsubishi Heavy Industry Ltd. Dr Paweł Stężycki, Eng., the managing director of the Aviation Institute mentions Professor as a great visionary – *Piotr knew that in technology it is necessary to find a niche and to become the best in this niche. I agree with this opinion, not only in respect of rocket technologies or space problems in general. He helped also to choose a few such directions of the studies, including, inter alia, drives of small rockets for launching of loads to space. He anticipated that scientific experiments or small satellites as well as their launching into space would become more available. Therefore, the research of the scientific team was just oriented to the mentioned problems. To-day, the Centre of Space Technologies at the Aviation Institute is the important R&D centre of rocket and satellite drives. We have implemented many projects of the European Space Agency, in particular in the domain of fuels and drives. It should be stressed that in the previous years, Poland – as the first country in the world – launched a rocket which utilized the phenomenon of spinning detonation in combustion chamber. We avoid detonation under the normal conditions as a sudden increase of pressure and temperature may destroy construction of the engine's combustion chamber. On the other hand, there are the studies which show that if we overcome the discussed phenomenon, its efficiency may be increased by a few or several percent. It is a crucial situation, isn't it? The dimension and, consequently, the weight of the discussed engine may be considerably decreased what is a key condition in the case of space or aviation technologies. A similar attempt was undertaken by Japan but the researchers launched the rocket at the height, speeded it up and started. They did not obtain, however, the engine thrust greater than the weight and in connection with this fact, its start from the earth was not possible. And we have done it! Piotr had the crucial knowledge for development of the mentioned technology. He was, therefore, often invited to foreign symposia to the USA, Japan or China. He was eager in sharing the knowledge but he expected the reciprocity what was not popular in the commercial enterprises. He was also invited by NASA but in China he was more highly estimated.*

Professor Piotr Wolański has also contributed to creation of the study direction: "Aviation and Space Science" which was commenced in 2005 and implemented successfully in Polish techni-

Fot. 6. Prof. P. Wolański receives 39. Medal of Warsaw University of Technology from Prof. Jan Szmidt, the Rector of Warsaw University of Technology (December 2014)

Fot. 7. Prof. Piotr Wolański delivers a speech during the ceremony of awarding with the 39. Medal of Warsaw University of Technology. Photo. Izabela Koptoń-Ryniec, Warsaw University of Technology

cal universities. In a new Millennium, he played also a function of Pro-Rector for Science Affairs at Warsaw University of Technology (2002–2005), the member of the Programme Committee of A.S. Dekaban Foundation (from 2002; in the years 2002–2016 as its President); the member of the Strategic Advisors of the Rector of WUT (2012–2016); the Chairman of the Council of the Interdisciplinary Education of PhD holders (the post-doctoral studies) in the field of Rocket Technologies (2012–2016), since 2016 – the member of the Council). When presiding to the Committee for Space and Satellite Studies of Polish Academy of Sciences, he was the person, who held the mentioned position for the longest time, i.e. in the years 2003–2019; he represented the Committee at the international forums, in the UN and the International Astronautical Federation (IAF) for the successive four cadencies. In the period of 2012–2014, he played a function of the second vice-chairman of the UN Committee of the Peaceful Uses of Other Space, COPUOS) the member of which Poland has been since 1958. During the initial period of presiding to the Polish delegation to sessions of the Subcommittee and UN COPUOS in Vienna, Professor Wolański was the only one Pole; since the moment of Poland's accession to the European

THE REMAINING SELECTED ACHIEVEMENTS OF PROFESSOR PIOTR WOLAŃSKI:

- Discovery of the so-called diffusion ignition, that is, the process of self-ignition of gas, flowing out from installation of high-pressure reservoir. The ignition occurs during mixing of hot air (heated up in the shockwave, generated by the flowing gas) with cold gas which is flowing out. At present, the discussed process is tested in aspect of safety in the case of failure of high-pressure reservoirs of hydrogen in the systems of power supply systems in electric cars with fuel batteries.
- The studies of the dust explosions, which brought about to generation of the "School of dust explosions". They also initiated the series of "Dust explosion colloquia". The author and co-author of many pioneering undertakings concerning initiation and propagation of mechanisms of dust explosion. The first statement of the possibilities of detonation of the mixture of the grain dusts and air and the layer of carbon dust at oxygen atmosphere. The manager of many projects in the mentioned area, owing to grant of the US Department of Agriculture. ("Grain Dust Explosion and Control", 1987 – 1993).
- The pioneering experiments concerning the effect of the baffles on the process of passage to the detonation DDT in gas mixtures and detonation of hybrid mixtures. The determination of the effect of the shape and size of the baffles on the acceleration of the flame and the process of passing to detonation as well as illustration of the effect of neutral grains of the sand, corundum etc., on a considerable acceleration of the flame and passage to the detonation. Addition of the relatively great grains to the mixture generates a micro-turbulence what causes a considerable acceleration of the flame. In the case of higher Mach numbers, there are additionally generated the hot spots, facilitating the acceleration of the flame and passage to detonation. The author and co-author of pioneering work on detonation of hybrid mixtures of dusts, gas and drops of liquid fuels and air.
- The studies on the application of Stream Pulse Jet Ignition (PJS) in piston engines. The study oriented to ignition of poor flammable mixtures in piston engines, the experiments and numerical simulations, carried out in cooperation with Professor A.K. Oppenheim from the California University in Berkley, USA.
- Development of optical methods and ultra-rapid photography techniques for testing the flames and explosions. Designing and supervision of performance of 4 Schlieren systems with 150-300 mm diameters, 2 interferometers (Michelson and Mach-Zender), techniques of ultra-rapid stroboscopic laser photography, drum cameras, etc. Also, development of the process of visualization of flames, using Electric Computer Tomography (3-D Electrical Capacitance Tomography, ECT) for the application Pratt&Whitney company, USA and Canada.

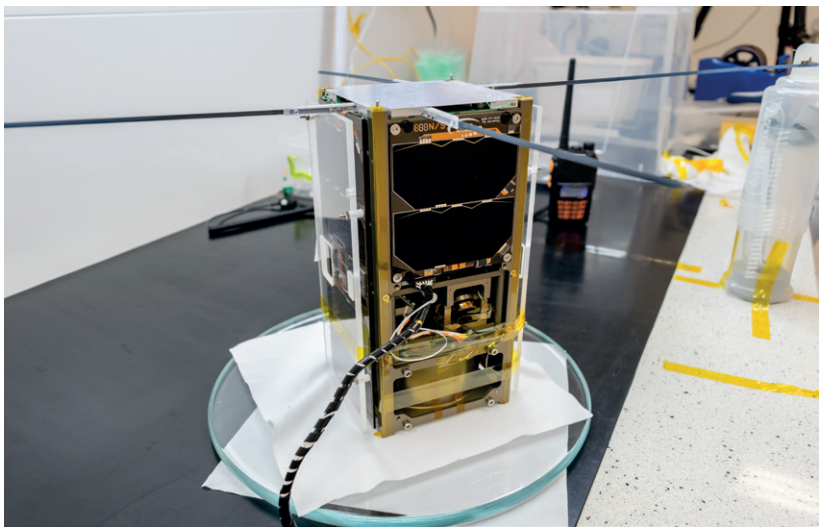
Source: P. Wolański, Piotr Wolański . My space activity – recollections. Scientific Publishing House of the Institute of Aviation, Warsaw, 2019

Fot. 8. Prof. P. Wolański with the title of "Golden Engineer" – the third person from the right in the lower row (March 2023). Photo: Janusz Kowalski NOT

Space Agency he was already one from many and he was very happy about it. Professor was also the Member of the International Astronautical Academy (IAA) and in the years 2001–2006 – the Member of the Consulting-Coordinating Team for Cosmic Space at the Prime Minister of the Republic of Poland and the Member of the Council of the National Centre for Research and Development (2014–2018). Professor Wolański made also a significant contribution to the choice of the official name of Polish Space Agency (founded in 2014); in the period of 2015–2020, he was the Member of the Council. The mentioned institution used the abbreviation POLSA, coming from English translation of Polish name (Polish Space Agency). Professor was also one of the initiators of memorizing Mikołaj Kopernik at the seat of the UN Organization in Vienna where in June, 2014, the copy of the picture by Jan Matejko, presenting the mentioned outstanding astronomer, was unveiled. There was also shown the model of satellite "LEM". The both exhibits have remained the only one sign of Poland's presence in the UN as the bust of Maria Skłodowska-Curie, shown at the exposition, was offered by the French. In the years 2016–2022, Professor acted as the member of the Executive Committee of Engineering Academy in Poland.

During the 30th meeting of the General Assembly of AIP (14, March, 2016), the Aviation Institute honoured professor with the distinction Blue Wings. The award was granted for the whole outstanding aviation-space teaching and scientific activity in Poland as well as abroad. The mentioned prestigious distinction was handed during the central ceremonies on the occasion of Aviation Day on 28 August, 2016. – *I remember that when I was a small girl and attended school, our house was always visited by many collaborators of daddy: professors, important persons from the space sector, from Poland as well as from other countries. It was for me an unusually developing and, at the same time... quite normal. I think that owing to such meetings, the thread of understanding which was commenced by my Father in the scientific circles was extremely strong later on* – the daughter of Professor reminds.

Apart from belonging to the elite group of the persons connected with the space, he was the ordinary Member of Warsaw Scientific Society – the VIth Department of Engineering Sciences, the Member of the Committee of Thermodynamics and Combustion of Polish Academy of Sciences (1983–2019), the initiator and the first Chairman of Polish Combustion Institute (PIS) since 1995. In the period of 1995–2004, he was the president and since the honorary President of the mentioned organization. The enormous knowledge, practical approach to solving of the problems and a perfect contact with the people made that he was readily invited to different conferences and lectures. Prof. Wolański was, *inter alia*, a visiting professor in the following places: Northeastern University, Shenyang, China, 1999-2004; University of Michigan, 1982, 1990-1991; NTU, Singapore, 2008; Kunming, University of Science and Technology, China, 2016. His scientific achievements were twice appreciated and he obtained the honorary title of doctor *honoris causa* of the



Fot. 9. Student Satellite PW-Sat2. Photo: PW-Sat2. https://pw-sat.pl/do-pobrania/ https://www.flickr.com/photos/pwsat2/ licence for photo PW-Sat2: https://creativecommons.org/licences/by-sa/2.0/ PW-Sat2_Integrated_PR-9

Fot. 10. Funeral of Prof. P. Wolański – the wreath from the students of Student Space Association, Faculty of Power and Aeronautical Engineering, Warsaw University of Technology (August 2023) Photo: Izabela Koptoń-Ryniec, Warsaw University of Technology

national University of Petroleum and Industry in Baku (Azerbaijan) in 1997 and Military University of Technology in Warsaw, in 2015. In the delivered then laudation, Professor Bogdan Zygmunt indicated his *talent to inspire the young people to undertake the ambitious tasks and challenges, to effective creative work and courageous confrontation with the achievements of analogical teams all over the world.* Apart from the mentioned above titles, Professor was awarded, inter alia, with the first medal "A.K. Oppenheim Price" ICDERS, in Ann Arbor, USA, for the contribution to the studies of explosions (1989); with the Dionizy Smoleński medal, granted by The Committee of Thermodynamics and Combustion of Polish Academy of Sciences (PAN) (2012), and with the medal of Warsaw University of Technology (no 39) for "significant contribution to space teaching and research at Warsaw University of Technology" (2014). At the state level, he was honoured with the Golden Cross of Merits, granted by the President of the Republic of Poland for *"the achievements in 20-years' activity as academic teacher"* (1987); with the Medal of the Commission of the National Education (2000); with the Golden Cross of Merits of the Minster of the National Defence (2001); with the Knight's Cross, awarded by the President of the Republic of Poland for "*the contribution and achievements in scientific research and education*" (2005); with the Award of the Minister of the National Science and Education for the whole activity in respect of scientific studies" (2012). During the 29th edition of the plebiscite "Golden Engineer", organized by the editorial house of the Polish Technical Review within the frames of Polish celebration of the International Day of Engineer (March, 3, 2023), he received a title of Golden Engineer in category "Constructions". He was the author of several hundred publications and public appearances. Since 2022, he had been found in the "World's TOP 2% Scientists", evaluated by Stanford University in cooperation with Elsevier and the SciTech Strategies, i.e. in 2% of the most widely cited scientists all over the world.

He passed away on 31, August 2023, due to a chronic disease. Until his last days, he was professionally active. He was buried on 4, September at Military Cemetery at Warsaw Powązki. His funeral was attended by family and friends, numerous group of students, co-mates in work, collaborators, representatives of university authorities from Poland, including Warsaw University of Technology, and from the world, inter alia, from China and Singapore and all those for whom he was the authority. – *I think that the total society of the Faculty (MEiL) feels very strongly the loss, caused by the passing away of professor. He was a part of our scientific and academic identity and it will be very difficult to accept this enormous loss* – the Dean of the Faculty of Power and Aeronautical Engineering of WUT, Prof. dr hab. Janusz Frączek, Eng., says. The daughter of Professor, Ewa Wolańska recollects: – *Father was active until the end and up to his last moments of life; even during the advanced stage of his disease, he tried to stress a role of Poland in space industry and promoted various Polish projects. During the last week of his life, he still intensively worked on Monday at the Institute of Aviation and he died on Thursday.*

In November 2023, Professor's friend, Adam Bisek, organized a meeting "Memory and honour for Professor Piotr Wolański" in Wrocław. Among the guests, there were inter alia: John F. Hall – long-time NASA director, Dr Paweł Stężycki, Eng., – Director of the Aviation Institute Łukasiewicz, Dr Michał Wierciński – Vice-President of Polish Space Agency. – *It was a nice recognition for us. I think that their presence is the evidence of recognition and memory and, at the same time, a perfect cooperation during his life* –Professor's daughter says. And she adds: – *Father had a deep belief in a sense of work and further development of science, he always stressed the role of mutual relationships between the people what, in combination with optimism aimed at exceeding the successive borders, has brought fantastic effects. I know that he tried to transfer his enthusiasm to his students. He often repeated that we have very good human reserves, good staff, he spoke about the WUT or the Aviation Institute with a pride. As we knew how he loved his parent faculty, we put the badge of the Faculty of Power and Aeronautical Engineering into the lap of his jacket and he passed away with it into the space, being still not available for us...*

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The source of quotations from the statements of Prof. dr hab. Janusz Frączek, Dr Paweł Stężycki, Eng., Dr Adam Okniński, Eng., and Ewa Wolańska 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.

DECLARATION OF THE WORLD CONGRESS OF ENGINEERS – WEC23

DEKLARACJA ŚWIATOWEGO KONGRESU INŻYNIERÓW – WEC23

The 7th World Engineers Convention, organized by the Czech Association of Scientific and Technical Societies (CSVTS) in cooperation with the World Federation of Engineering Organizations gathered the leading engineers from the entire world. The aim of WEC23 was to find the answer to the question: how to manage with the urgent challenges of our Planet, and to examine how the technological innovations and transdisciplinary approach may bring the profits to sustainable development of the environment, societies and economy in order to ensure the safe, fair, healthy and peaceful future.

We should take the following into consideration:

- The goals of the UN Sustainable Development ensure the frames, which facilitate meeting the unprecedented global challenges facing the humanity and are a threat to our future welfare and quality of life
- Engineering community has a duty to make the contribution to reaching the aims and fining the solutions
- The climate change is the most critical and urgent problem of our time,
- Strengthening of the relationships between education, science, engineering and politics is indispensable if we have to reach the Goals until 2030
- Covid-19, War in Ukraine and energetic crisis have make us aware of the necessity to develop the resistance to the safety threats and also, social concerns
- There is a strict relation between engineering and life which may bring the unusually positive contribution to development of the world
- Governments, business and industry have to cooperate in order to accelerate the positive changes
- The natural resources of the Planet our limited and biological diversity is facing the serious dangers
- We need innovative engineering to develop circular economy
- Engineering has a key meaning in ensuring the necessary change of paradigm and it will require common efforts to increase the number of graduates of engineering directions of the studie.

The Delegates to WEC23 declare that the engineers will:

- deal with agriculture and natural resources and develop the solutions which enable keeping the equilibrium between energy, water, food, fertility of soils and deforestation
- develop the solutions mitigating a negative effect of human activity on ecosystems and species
- ensure that computers, robots, artificial intelligence (AI) and other technologies will be utilized in the responsible, ethical and safe way and shall not cause any damages
- take more active role in solution of the problems connected with cyber-safety and privacy problems
- contribute to improvement of energetic safety by development, implementation and keeping the systems and technologies ensuring the reliable and resistant supplies of energy
- develop the innovative technologies, indispensable for ensuring reliability, safety and cost-effectiveness of developing energetic systems, based on the renewable energy sources
- improve the technologies of energy storage and develop the intelligent networks facilitating the effective and flexible energy distribution
- develop and implement the technologies, strategies and solutions, reducing GHG emission and eliminating the causes of global warming up
- support the education of engineers, their professional devel-

opment and training in the field of new technologies in the industrialized and developing countries
- develop low-energy and low-emission technologies and industrial processes, ensuring a low consumption of materials, recycling, waste management and support of circular economy
- develop the technologies and solutions which create the possibilities for generation of income for marginal societies
- design medical equipment and develop the technologies of health care system which improve the diagnostics, treatment and access to medical care, especially in the remote sites of the world
- Develop the technologies and systems which strengthen the position of women in economic, social and educational aspects
- try to ensure the access to clean water and sanitary solutions
- develop the infrastructure available for disabled persons
- enter into work on the technological solutions in respect of preventing the criminality, execution of law and of justice systems
- design and construct effective and friendly-to-environment transport networks such as public transport, bicycle paths and the routes for pedestrians, and also, ensure the passage to electric and hybrid vehicles and to alternative fuels
- support the sustainable development of cities *via* cooperation with architects, with the aim to create the multi-functional objects which limit the need of long routes to work place, encouraging to pedestrian and bicycle moving.

The engineers are the masters of creativity. They find the new methods for solving the problems of their workaround, creating simultaneously the ingenious protection from failures and minimizing a risk, in order to maximize the resistance, functionality and performance.

It should be stressed that the engineers have adopted this important Declaration in Prague where, in 1707, Christian Josef Willenberg founded the world's first engineering institution, dealing with education. It made the background for development of engineering school all over the world.

Prof. Daniel Hanus
The President of CSVTS

Prof. Jose Vieira
The President of WFEO

Source: https://www.wec2023.com/
https://not.org.pl/

THE 29TH INTERNATIONAL SCIENCE CONFERENCE

THE PROBLEMS OF SUSTAINABLE AGRICULTURE, PROTECTION OF RURAL AREAS, WATER RESOURCES AND ENVIRONMENT

PROBLEMY ZRÓWNOWAŻONEGO ROLNICTWA, OCHRONY OBSZARÓW WIEJSKICH, ZASOBÓW WODNYCH I ŚRODOWISKA

On September 26–28, the 29th International Scientific Conference was held at the Institute of Technology and Life Sciences – the National Research Institute in Falenty. The Conference was carried out under the patronage of the Minister of Agriculture and Rural Development, Robert Telus. The title of the Conference was: "The problems of sustainable agriculture, protection of rural areas, water resources and environment".

During the Conference, the following problems were discussed and analysed:

- sustainable agricultural development, circular economy, with the consideration of the environmental protection and also, counteracting the climate changes;
- innovative technological solutions for the sustainable agricultural production, including animal one, together with renewable energy sources (OZE) and with the particular consideration of the application of agricultural micro bio-gas producing plants;
- innovative and effective agricultural production;
- management of natural resources and soils and natural environment protection;
- water and sewage economy and waste management and elements of technical rural infrastructure;
- protection and ecology of waters, contamination of water and effect on biodiversity.

On 26 September 2023, the plenary lectures concerning water at the rural areas were held; then, the participants of the Conference had the excursion to the Nature Reserve Raszyn Ponds, with a practical show of Moldaenke GmbH company.

On 27 September 2023, the lectures were divided into topic sections: sustainable agriculture and energetics and renewable energy sources (OZE) at the rural areas. In the same day, there was also presented the poster session, covering the subjects of agricultural production, OZE and water.

Fot. 1. Dr. Eng. Andrzej Seliga, Ph.D. Eng. Kinga Borek, Ph.D. Eng. Kamila Mazur

Fot. 2. In the middle, facing Dr. Hab. eng. Adam Koniuszy

The last day of the Conference, i.e. 28 September, 2023 – was dedicated to scientific workshops on the choice of statistical methods in the scientific papers, the data analysis and uncertainty of the measurements.

During the 29th Conference, the presentations developed on

Fot. 3. Ph.D. Eng. Kamila Mazur, Ph.D. engineer Jan Kamionka, prof. Wacław Romaniuk, prof. Bożena Nowakowicz-Dębek

Fot. 4. Ph.D. Eng. Wacław Strobel on the left

Fot. 5. Conference participants

the occasion of the 75th anniversary of foundation of the Institute of Construction, Mechanization and Electrification in Agriculture (IBMER) were submitted. It was also 70 years since foundation of the Institute of Amelioration and Grasslands (IMUZ) from the fusion of these mentioned two Institutes, the Institute of Technology and Life Science was created in 2010. Then, since 2021, the Institute received a status of the National Research Institute.

During the period of 1948–2010, IMER (Institute of Mechanization and Electrification in Agriculture), later on IBMER was occupied with the creative work, scientific and implementing activity in the following areas:

- agricultural engineering for the needs of agricultural farms with a different size;
- automation (robotization) and electrification of farms, including development of non-conventional energy (OZE, renewable energy sources) especially obtaining and application of biogas;
- agricultural building, with the particular consideration of agricultural farms, specialised in animal production and also, vegetal production;
- environmental protection, and, in particular, sewage management at the mountain and sub-mountain territories, technological standards in agriculture, especially in animal production in respect of the requirements, resulting from the accession of Poland to the European Union.

IMUZ, as founded in 1953, obtained the following tasks (recorded in its first Statute):

- conducting the scientific-research work in the field of agricultural ameliorations and the treatment of permanent grasslands, and in particular:
- shaping of the agricultural environment via regulation of soil and water conditions and affecting the climate by forestation, planting of trees and other treatments;
- amelioration of grasslands and arable land (including vegetables cultivation) and depressive areas
- meadow and pasture economy, on permanent grasslands,
- technique of agricultural ameliorations with the particular consideration of work mechanization;
- supply of the centres of agricultural production in water;
- utilization of water energy on small water courses.

All the mentioned above activities were generally implemented during the whole period of the Institute's existence.

During the Conference, more than 40 lectures in Polish and English were delivered. The topic sessions conducted during the Conference may be summed up with the following statements:

- there is a need of further development of agricultural farms according to the principle of the sustainable technologies, with the particular consideration of introducing the innovations, reasonable management of fertilizer components, including natural fertilizers (manure) and energy production from the alternative sources and also, waste coming from agri-food processing;
- it is necessary to take care of the water protection in the country and all over the world due to its limited resources, inter alia, owing to the choice of the appropriate
- management methods.

The 29th International Scientific Conference was attended by 80 participants from the country and abroad, representing the following institutions:

— National Centre for Support of Agriculture;
— International Academy of the Applied Sciences in Łomża;
— West-Pomeranian University of Technology in Szczecin;
— Warsaw University of Life Sciences (SGGW) in Warsaw;
— The Hugo Kołłątaj University of Agriculture in Cracow;
— The University of Life Sciences in Poznań;
— The University of Life sciences in Lublin;
— Institute of Gardening – the National Research Institute;
— Institute of Flow Studies of Polish Academy of Sciences in Gdańsk;
— Moldova University of Technology in Kiszyniów, Republic of Moldova;
— Ferganski Institute of Technology, Fergana, Uzbekistan.

and, also private entrepreneurs:
— Moldaenke GmbH, Kiel, Germany;
— Ekotechnologie Ltd.;
— Stomil Bydgoszcz S.A.;
— TESTMER, Warsaw, S.A.;
— WOLF System Ltd.

The partner of the 29th International Scientific Conference was the National Centre for Support of Agriculture which gave its professional and financial support.

Organization of the Conference was also possible owing to the co-organizers:
— Chair of Engineering of Renewable Energy Sources of the West-Pomeranian University of Technology in Szczecin;
— International Academy of the Applied Sciences in Łomża;
— Warsaw University of Life Sciences.

The sponsors of the Conference were:
— Moldaenke GmbH, Kiel, Germany;
— WOLF SYSTEM Ltd;
— TESTMER Warsaw S.A.

Medial patronage:
— Polish Technical Review (periodical);
— Internet daily B2B "Teraz Środowisko";
— Internet Portal Agropolska.pl;
— 'Wodne Sprawy' journal ("Water Matters").

On the grounds of the papers, sent by the participants of the 29th International Scientific Conference, two monographs will be published:
1. Monograph: "*The selected problems of sustainable agriculture, including the renewable energy sources and environment protection*"
2. Monograph: "*Problems of sustainable development in agriculture, including renewable energy production and environment protection*".

The 29th International Scientific Conference was related by the Interactive TV Agronews.com.pl. The materials are available at the following address:

Fot. 6. Ph.D. Eng. Kamila Mazur, prof. Wiesław Dembek, Ph.D. Eng. Kinga Borek, Ph.D. Eng. Anita Konieczna

Fot. 7. Prof. Wiesław Dembek

Fot. 8. Ph.D. Eng. Wacław Strobel, prof. Bohdan Dobrzański

https://www.youtube.com/watch?v=gc9hACnNN9s

We express our words of gratitude to the Partner, Co-organizers, Sponsors, Patrons and Participants for the support and active participation in the Conference!

SETTLEMENT OF THE 12TH EDITION OF THE COMPETITION „INNOVATION LAUREL 2022'2023"

ROZSTRZYGNIĘCIE XII EDYCJI KONKURSU „LAUR INNOWACYJNOŚCI 2022'2023"

On October, 26, 2023, in the Warsaw House of Engineer NOT, there was held the solemn Gala of the XIIth edition of the Stanisław Staszic Competition for the best innovative products – LAUREL OF INNOVATION 2022/2023.

The aim of the mentioned Competition, organised by the Federation of Scientific and Engineering Association NOT is to promote the modern products, technologies and services. The idea which was leading the discussed undertaking was the conviction that the promotion of innovative products and their creators and help in the implementation of the innovative solutions is the key for the development of Polish economy. The mentioned innovative ideas and products are expected to make the contribution to the economic development and competitiveness of Polish economy.

The Competition was covered by the patronage of the Ministry of Infrastructure, The Chief Measures Office; the National Centre for Research and Development, the Patent Office of the Republic of Poland, the Office of Technical Surveillance, Polish Academy of Sciences, Polish Agency for Entrepreneurship Development, Office of the Marshal of Mazovian Voivodeship and medial partners of a group of periodicals.

Apart from the laureates and the accompanying persons, the guests and the participants of the Gala were the Presidents, directors, managers or the representatives of patrons and partners,

the representatives of the world of science and economy as well as the members of the Board of FSNT-NOT and the representatives of scientific and engineering associations.

Promotion of innovative technologies and products, their authors and the aid in the implementation of innovative solutions is a key to the civilization development – Ewa Mańkiewicz-Cudny, the President of the Federation of Scientific and Engineering

GOLDEN LAUREL OF INNOVATION 2022/2023

- Central Institute for Labour Protection – National Research Institute
- Eco Loght Biosafety P.S.A.
- HARPO Ltd.
- KGHM Polska Miedź S.A. Division Polish Copper Plant Głogów
- KGHM Polska Miedź S.A. Division Hydrotechnical Plant

SILVER LAUREL OF INNOVATION 2022/2023

- Institute of Car Transport
- MEDISENSONIC S.A.
- Marine Fishing Institute – the National Research Institute
- NEXERA Ltd.
- The Research Network Łukasiewicz – Institute of Non-Ferrous Metals
- The Research Network Łukasiewicz – Cracow Institute of Technology and partner: JG Group Ltd.

BRONZE LAUREL OF INNOVATION 2022/2023

- Institute of Petroleum and Gas – the National Research Institute
- The Research Network Łukasiewicz – the Industrial Institute of Automation and measurements PIAP
- PCO Ltd.
- Military Institute of Armament Technology

Association NOT and the member of the Competition Jury, stressed in her appearance. – *The statuettes which will be just now handed to the laureates for their best ideas, solutions and inventions are only the symbol and expression of the gratitude for their great contribution to all discussed activities. Work of engineers requires enormous determination and talent. One should have an unusual imagination as to invent such innovative solutions. Gabriel Narutowicz compared the engineers to the Creator as they create something that nobody made it before. I thank you very much for this creativity and extremely responsible work and which you further success and congratulate to all distinguished persons.*

The Jury of the Stanisław Staszic Competition for the best innovative products "Innovation Laurel 2022/2023" as guided by the Vice-President of FSNT-NOT, Dr hab. Tadeusz Pawłowski, Eng., has awarded the Laurels for the innovative projects in 10 competition categories. The statuettes, being popularly called "Staszic", were handed to the invisted laureates of the 12th edition of the Competition.

The ceremony was enriched with the artistic part which was traditionally conducted by known and popular actress, Madame Laura Łącz.

Source: https://liderzyinnowacyjności.com/laury-innwacyjności-wreczone-laureaton-xii-edycji-konkursu/