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APPLICATION POSSIBILITIES AND PROPERTIES OF PLASTIC MIXTURES BASED ON BIODEGRADABLE POLYMERS

MOŻLIWOŚCI STOSOWANIA ORAZ WŁAŚCIWOŚCI MIESZANIN TWORZYWOWYCH NA BAZIE POLIMERÓW BIODEGRADOWALNYCH

Summary: *in this study, an attempt was made to develop generalized conclusions based on previous publications regarding research on the processing possibilities and analysis of the mechanical properties of PLA and TPS polymer mixtures and the possibility of modifying TPS with calcium carbonate. An in-depth analysis of the obtained results turned out to be quite interesting. Further research is necessary to explain the phenomena occurring when mixing two biodegradable polymers, where a certain synergism and the impact of the filler on the polymer matrix are observed.*

Keywords: *biodegradable polymers, polylactide, thermoplastic starch, mechanical properties*

Streszczenie: *w niniejszym opracowaniu podjęto próbę opracowania uogólnionych wniosków na podstawie wcześniejszych publikacji dotyczących badań nad możliwością przetwórstwa oraz analizy właściwości mechanicznych mieszanin polimerowych PLA i TPS oraz możliwości modyfikacji TPS węglanem wapnia. Pogłębiona analiza uzyskanych wyników okazała się dosyć intersująca. Konieczne są dalsze badania polegające na wyjaśnieniu zjawisk zachodzących podczas mieszania dwóch polimerów biodegradowalnych, gdzie zaobserwowane pewien synergizm oraz odziaływania napełniacza na osnowę polimerową.*

Słowa kluczowe: *polimery biodegradowalne, polilaktyd, skrobia termoplastyczna, właściwości mechaniczne*

Introduction

Polymeric materials have become synonymous with progress and modernity. They dominate almost every area of life and economy, and it is difficult to imagine today's world without these materials. Apart from the benefits brought by the development of polymer chemistry and technology of their processing, they also pose a certain problem related to their accumulation in landfills. Degradation of the discussed materials in the natural environment takes an unimaginably long time and poses a significant threat to living organisms [1–5].

An alternative to traditional polymer materials is the development of the so-called biodegradable polymers, which constitute a kind of revolution both in processing and in application. The discussed materials, unlike traditional plastics, can undergo the so-called biological degradation in natural environmental conditions [6–8]. This means that they do not create a lasting burden on the environment, provided that they are also produced from renewable raw materials. This is important when considering the problem of so-called global pollution and its negative impact on water, soil and marine ecosystems [9–10]. The packaging industry undoubtedly has great expectations for these materials, where there is a particular need to use ecological materials that can be easily disposed of and do not leave any lasting waste. Biodegradable packaging can be produced from materials such as PLA (polylactic acid, also known as polylactide) or less durable thermoplastic modified starch (TPS) [11–15]. Biodegradable petrochemical plastics may also be an alternative, but in this case we cannot talk about the so-called "green chemistry" [16–20].

The idea behind the development of biodegradable polymer materials included mainly their applications, but also processing processes, which should be the same or similar to those used in the case of traditional plastics [21–24]. It facilitates the adaptation of existing machines without costly modifications, but only by appropriate selection of technological process parameters. Most biodegradable plastics are compatible with existing production infrastructure [25–28]. This advantage facilitates the introduction of these materials to the market [29–32]. With the growing interest in the so-called ecological substitutes for traditional plastics, investments in research on new or existing biodegradable materials are attractive to many research centres, which leads to the creation of new innovative solutions and technologies in the

field of application, modification and improvement of the properties of these materials while maintaining their biodegradable nature [33–36]. There is a certain contradiction here – on the one hand, durable and resistant products are expected that meet different standards depending on the field of economy. On the other hand, it is expected that after a period of use, the product will degrade in the natural environment without affecting it [37–40].

Biodegradable polymer materials are a revolution in the plastics industry, providing ecological alternatives to traditional plastics. As technology continues to advance, they can be expected to play an increasingly important role in various sectors of the economy.

Main biodegradable polymers

The main representatives of biodegradable polymer materials that arouse the greatest interest due to their origin, properties and possibilities of use are polylactide (PLA) and thermoplastic starch (TPS).

Both of these materials are sometimes called "double green", which means that they are produced from renewable raw materials (corn, other cereals), and that they biodegrade in the natural environment after a period of use [41–43]. It can be stated that currently the achievements of chemical synthesis in the production of these materials are ahead of detailed knowledge of their properties, both processing and operational [44–45]. In other words, processors and mechanical engineers are "out of step" with the chemical industry. Therefore, it is advisable to investigate the possibilities of processing and using these materials in order to, on the one hand, optimize the production process and, on the other hand, strive for waste-free operation.

Polylactide (PLA)

Polylactide (PLA) is a thermoplastic linear polyester, completely biodegradable under industrial composting conditions, which is a process of biological transformation of organic materials, including biodegradable plastic packaging, into simple substances that do not pose a threat to the natural environment. This process takes place under controlled conditions, usually on a large scale, in specially designed industrial installations. In this process, appropriate conditions must be met, such as temperature, humidity, ventilation, mixing and pH. The mentioned parameters are monitored and controlled to create an optimal environment for the microorganisms responsible for decomposition. PLA is practically non-biodegradable under home composting conditions. This is, in a way, an advantage that gives quite a lot of possibilities of its use, but also a disadvantage [46–48].

Generally, PLA can be processed using typical processing technologies such as injection, thermoforming, extrusion and extrusion blow molding [49–52]. This material is obtained by condensation polymerization of lactic acid or cyclic lactides. Lactic acid, as a preliminary product, is obtained by bacterial fermentation of starch, most often from corn or milk processing [52–55]. Its main application is in the packaging industry, medicine and agriculture. Due to its processing parameters and the lack of release of harmful substances during this process, it is widely used in 3D printing technologies. PLA currently constitutes almost 40% of all currently known and used biodegradable polymers [56–58]. Its properties are similar to polystyrene. It is a stiff, brittle material. Its brittleness temperature is approximately 57°C and its flow temperature ranges between 170–180°C. It has a good transparency and gloss. It has good strength properties and low elongation at break (approx. 3–4%). Its disadvantage, but also its advantage, is easy water sorption, which affects the biodegradation process, but drying before processing is necessary [60–63].

Its disadvantage also includes low impact strength, which disqualifies it from many applications. In order to improve it, various fillers are introduced into pure PLA, both of natural origin such as plant fibers, wood flour, various nut shells and mineral fillers such as magnesium and aluminium hydroxides, calcium carbonate or phosphogypsum. Extensive research is also carried out on mixing PLA with other materials [64–66]. The research used PLA with the trade name Ingeo Biopolymer 3100HP from NatureWorks (USA).

Thermoplastic starch (TPS)

Thermoplastic starch (TPS) is a polymer material that is fully biodegradable both in home and industrial conditions. The material is mainly obtained from potatoes or corn [67–69]. Like PLA, it is called "double green". TPS is characterized by a high degree of homogeneity and favourable mechanical properties. Products made of it have good shape stability. TPS is commercially available in the form of granules ready for processing using traditional methods such as injection or extrusion. Thermoplastic starch is intended for the production of packaging, foil, garbage bags and disposable products such as cutlery and plates [70–72]. Thermoplastic starch is obtained by breaking the layered structure of native starch and transforming the partially crystalline structure into an almost completely amorphous and homogeneous material.

The crystalline structure of starch can be destroyed by the combined action of mechanical and thermal factors, which occurs during processing. This material has many advantages, first of all, it is fully biodegradable in all conditions; it does not leave any toxic substances during decomposition. Its properties and application depend on the plasticizer used and its botanical origin. The disadvantages include low resistance to moisture and average or even poor mechanical properties [73–76]. The research used TPS with the trade name Envifill MB173 manufactured by Grupa Azoty (Poland).

Description of conducted research work

In the papers [77–80] the subject of research on processing and properties, mainly mechanical, of two types of mixtures was discussed. Mixtures of the two biodegradable plastics mentioned at the beginning, PLA and TPS, and a mixture of

TPS and the inorganic filler $CaCO_3$. The presented research focused mainly on the mechanical parameters of the obtained mixtures. Strength, deformability and Young's modulus were tested for various mixture proportions as a result of static tensile tests. Hardness, impact strength and water absorption were also measured. Detailed results and their analysis can be found in [77–80]. This study presents some generalizing conclusions indicating the possibilities and directions of research on these biodegradable plastics, their mixtures and other modifications.

Therefore, attempts were made to investigate the properties of PLA mixtures with another, fully biodegradable material – thermoplastic starch (TPS). The experimental results prove that TPS as a component of the TPS/PLA mixture has a very positive effect on all the tested properties. The brittleness of pure PLA (which was its main drawback) has been removed, resulting in the resulting material being much less susceptible to cracking than pure PLA. The impact strength of pure PLA and pure TPS is approximately 10 kJ/m^2, while the 50/50 mixture has impact strength of 30 kJ/m^2, which is an amazing result and proves strong synergistic phenomena. Such strengthening of the obtained material was a bit of a surprise, because even the professional literature is very limited in this area.

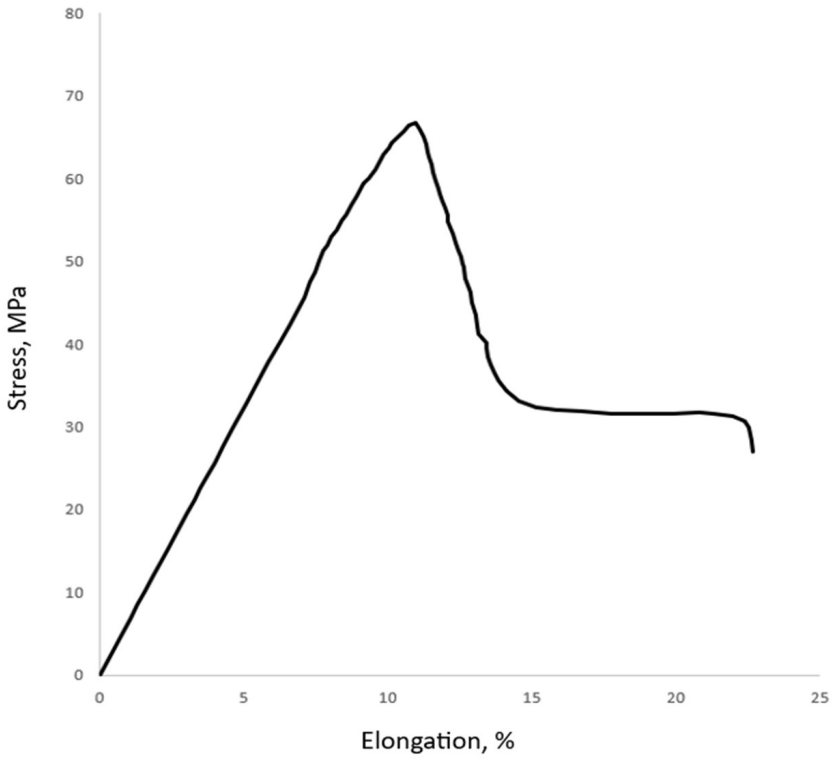

Fig. 1. Static tensile curve for a mixture of 50% wt. TPS + 50% wt. PLA

This is undoubtedly one of the further directions of more detailed research explaining the mechanism of mixing PLA and TPS and the phenomena occurring during this process. These studies require more advanced measurement equipment.

In the case of hardness, the differences are not too big. The hardness of pure TPS is lower than that of pure PLA. Therefore, the hardness of mixtures with a higher PLA content is approximately 62 degrees on the Shore "D" scale, while the hardness of TPS itself is approximately 55 degrees on the Shore "D" scale. Here, it would also be worth conducting further microscopic tests to possibly confirm when the matrix is PLA and when TPS, how both materials interact with each other and what phases they create.

Regarding water absorption, the following aspects should be taken into account: on the one hand, high water absorption is a disadvantage because it causes a change in the shape of the product and, therefore, dimensional instability. On the other hand, high water absorption is an advantage because it contributes to a high tendency to biodegradability. In the case of the tested materials, higher water absorption is characteristic of mixtures with a higher TPS content. Since the tested materials are mainly used as packaging, where easy biodegradability is a priority, the final conclusion is that TPS as a component in a mixture with PLA improves the quality of the material compared to pure PLA. TPS reduces brittleness and improves biodegradability.

The results of strength tests on a tensile testing machine confirm the above conclusions. Both PLA and TPS are characterized by a similar nature of stretching curves. Figure 1 shows an example tensile curve for a 50/50% mixture wt.

After an almost straight line course, after reaching the maximum, preparation and then breaking take place. The results show that TPS slightly reduces strength (63 MPa for PLA, 57 MPa for TPS) and quite significantly reduces Young's modulus (1100 MPa for PLA, 666 MPa for TPS). However, these decreases can be accepted due to the above-mentioned significant improvement in impact strength and biodegradability.

An alternative solution to modifying biodegradable polymers by mixing them may be the use of appropriate fillers. In this case, filling the TPS starch with powdered calcium carbonate $CaCO_3$ was used. Although it is not a biodegradable material, it is environmentally neutral. It is the main component of, for example, limestone rocks (Kraków-Częstochowa Upland, Poland).

Calcium carbonate (CaCO3) Omyalene 102-M-OM from OMYA (Switzerland) was used as the filler. It is in the form of a concentrate (granulate) containing 85% wt. natural calcium carbonate and approximately 10% wt. polypropylene and 2–5% wt. polyethylene.

Therefore, the influence of the content of this filler on the properties of the composition was examined. The proportions used were 10, 20, 30 and 40% wt. filler. First of all, the impact strength increased significantly, from 10 kJ/m^2 for pure TPS

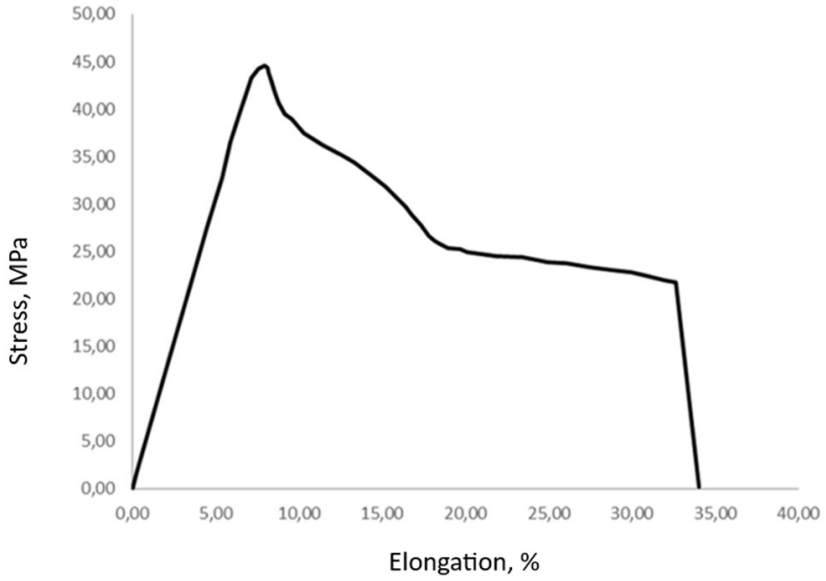

Fig. 2. Static stretching curve for a mixture of 80% wt. TPS and 20% wt. $CaCO_3$)

to about 35 kJ/m^2 for each of the fillings used (regardless of whether it was 10% wt. or 40% wt). This is a very interesting and unexpected result, requiring further research and phenomena occurring between the TPS matrix and the filler molecule.

The hardness was the highest for the content of 20% wt. $CaCO_3$ (over 57 degrees on the Shore scale "D"), while for 40% wt. it was only just over 53 on the Shore "D" scale.

However, water absorption increased dramatically – more than twice. Summarizing the results of static stretching, it can be stated that the nature of the stretching curves was similar for all compositions, as exemplified in the figure. 2

Young's modulus showed some correlation with hardness. Its maximum value was for a filler content of 10–20% weight. However, the strength decreased significantly from 57 MPa for pure TPS to 30 MPa for 40% TPS weight filler content. Ultimately, it can be assumed that the filler content is approximately 20% weight is optimal. It combines maximum impact strength, hardness and Young's modulus with a slight decrease in strength and good water absorption.

Conclusions

Biodegradable polymers are undoubtedly an alternative to traditional plastics. Extensive research on both the chemistry of these materials and their processing contributes significantly to their promotion. It is also worth emphasizing the changing legal regulations regarding the use of polymer materials. This also influences and even forces research into new materials and their modifications. It is also worth emphasizing that the production of these materials is also associated with environmental impact by modifying plants so that more substances can be obtained from them for the production of these polymers. This is not entirely a favourable phenomenon and requires detailed analysis. Also, using them for a short time and "throwing" them into the compost involves a financial loss. Therefore, it is definitely worth conducting research related to the processing, modifications and more rational use of these materials in which quite a large amount of energy was put into their production. These materials are too valuable not to seek new and broader applications for them.

The use of typical machines to prepare polymer mixtures and basic tests of mechanical properties provide the basis for further, in-depth research. Already at this stage we can observe certain phenomena and mechanisms related to the interaction of two biodegradable polymers in the mixture and the filler on the polymer matrix. The reinforcement in the TPS/PLA mixture is particularly interesting, where the phenomenon of synergy has been observed. This means that the final effect of the mixture is greater than the sum of the effects that would be expected based on the individual properties of each of these polymers. In the case of a TPS/PLA blend, the synergy phenomenon can have various manifestations and causes, but in general it means that the blend exhibits better properties than expected based on the properties of both components separately.

The phenomenon of synergy in mixing TPS/PLA may be the result of complex interactions between both components and appropriate processing conditions. Further research and analysis may help to better understand the mechanisms of this phenomenon and use them to design materials with even better properties. The reinforcement of the TPS/PLA mixture can be adapted to specific requirements, allowing you to obtain a material with the desired mechanical, aesthetic and functional properties.

In the case of TPS modification with a filler in the form of powdered calcium carbonate, research confirms that this type of mixtures can be successfully processed and calcium carbonate is a good filler. The analysis of stretching curves and other mechanical properties allows indirect identification of phenomena occurring between the filler and the TPS matrix. This provides the basis for further research work including microstructural analyses.

Summing up the analysis of the work carried out on the properties of biodegradable polymer mixtures, it can be concluded that there is a solid basis for the thesis that these materials will continue to develop dynamically in various directions to increase their effectiveness and application possibilities. Research on these materials is innovative and brings benefits related to a more rational use of not only traditional polymer materials, but also biodegradable ones.

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BENEFITS OF STRIP-TILL IN WINTER WHEAT CULTIVATION

KORZYŚCI ZASTOSOWANIA UPRAWY STRIP-TILL U PSZENICY OZIMEJ

Summary: *Winter wheat, as a cereal of greatest economic and food importance, is grown on the largest area of arable land in Poland. The great importance and significant acreage under cultivation result in a search for the methods of cultivating the discussed cereal which would ensure a sufficiently high yield and its quality and, at the same time, bring measurable economic and environmental benefits. One of such methods meeting the mentioned above requirements is strip-till, also referred to as strip cropping. This cultivation method has a number of multifaceted benefits. The application of this cultivation method has a positive impact on the yield and quality of winter wheat grain with simultaneous positives such as reduced fuel consumption and environmental benefits in the form of improved soil quality and reduced carbon dioxide emissions. The aim of this study was to synthesise the current state of knowledge on yield and its quality in winter wheat cultivated using the strip-till method on the basis of the available scientific literature and the results of our own research.*

Keywords: *Strip-till, cultivar, cropping systems, winter wheat, yield, grain quality*

Streszczenie: *Pszenica ozima jako zboże o największym znaczeniu ekonomicznym oraz żywnościowym jest uprawiana na największym areale użytków rolnych w Polsce. Duże znaczenie i znaczny areał uprawy powodują, że poszukuje się metod uprawy tego zboża, które zapewniłyby dostatecznie wysoki plon i jego jakość, a jednocześnie przynosiły wymierne korzyści ekonomiczne i środowiskowe. Jedną z takich metod, która spełnia te wymagania jest strip-till określany również jako uprawa pasowa. Ten sposób uprawy niesie za sobą szereg wieloaspektowych korzyści. Wykorzystanie tej metody uprawy wpływa korzystnie na plon i jakość ziarna pszenicy ozimej przy jednoczesnych pozytywach takich jak: zmniejszenie zużycia paliwa oraz korzyści środowiskowe w postaci lepszej jakości gleby oraz obniżonej emisji dwutlenku węgla. Celem pracy była synteza obecnego stanu wiedzy dotyczącej plonu oraz jego jakości u pszenicy ozimej uprawianej metodą strip-till na podstawie dostępnej literatury naukowej oraz uzyskanych wyników badań własnych.*

Słowa kluczowe: *Strip-till, odmiana, systemy uprawy, pszenica ozima, plon, jakość ziarna*

Introduction

Wheat is a cereal species of a very high economic importance. In Poland, its cultivation in 2021 was at the level of 2.391 thousand hectares, of which a significant part was the winter variety (91%). The large area under wheat cultivation gives a high self-sufficiency in terms of internal market demand. In 2021, the wheat grain harvest reached 12119.0 thousand tonnes, of which 10907.1 thousand tonnes (90%) was the grain from winter wheat cultivation. Converting the yield per capita gives about 300 kg of wheat grain per year, while back in the 1980s it was 117 kg. The significant increase in wheat yields is the result of breeding progress combined with the application of modern solutions associated with the use of appropriate agrotechnology. Attention is also now being paid not only to the quantity of the grain obtained, but also to its quality and to reducing the negative effects of tillage on the environment. This is also reflected in the agricultural policy pursued by the European Union in the form of incentives promoting practices aimed at reducing carbon dioxide emissions from agriculture and promoting the so-called carbon farming. This term is understood as agricultural practices that realise a reduction in global carbon dioxide emissions and its uptake from the atmosphere, through the implementation of recommended agronomic practices. The main objective is to achieve a negative carbon balance through increased carbon sequestration in the soil. This creates the opportunities for ecological benefits with positive impacts on the soil health. A practice that embraces carbon farming is the use of simplified cultivation and the abandonment of traditional ploughing. Strip-till tillage disturbs the soil structure much less and does not damage the soil macropores so that the soil microbial balance is not disturbed either [18]. This is due to the higher number of macroaggregates by up to 51–54% in strip-till than in conventional plough tillage [22]. The popularisation of knowledge and benefits is influencing an increase in the number of proponents of strip-till among Polish producers, but the use of the traditional plough tillage system is still most popular. Encouragement to extend the use of reduced tillage is provided by pro-environmental payments referred to as eco-schemes, which are a component of direct payments, which also include tasks related to the use of reduced tillage. The implementation of these obligations is mandatory for the Member State, but voluntary for the farmer. The abandonment of plough tillage is most often carried out by farms with a large cultivated area, but simplified tillage is increasingly being used on smallholder farms as well. A particular type of reduced tillage that combines the advantages

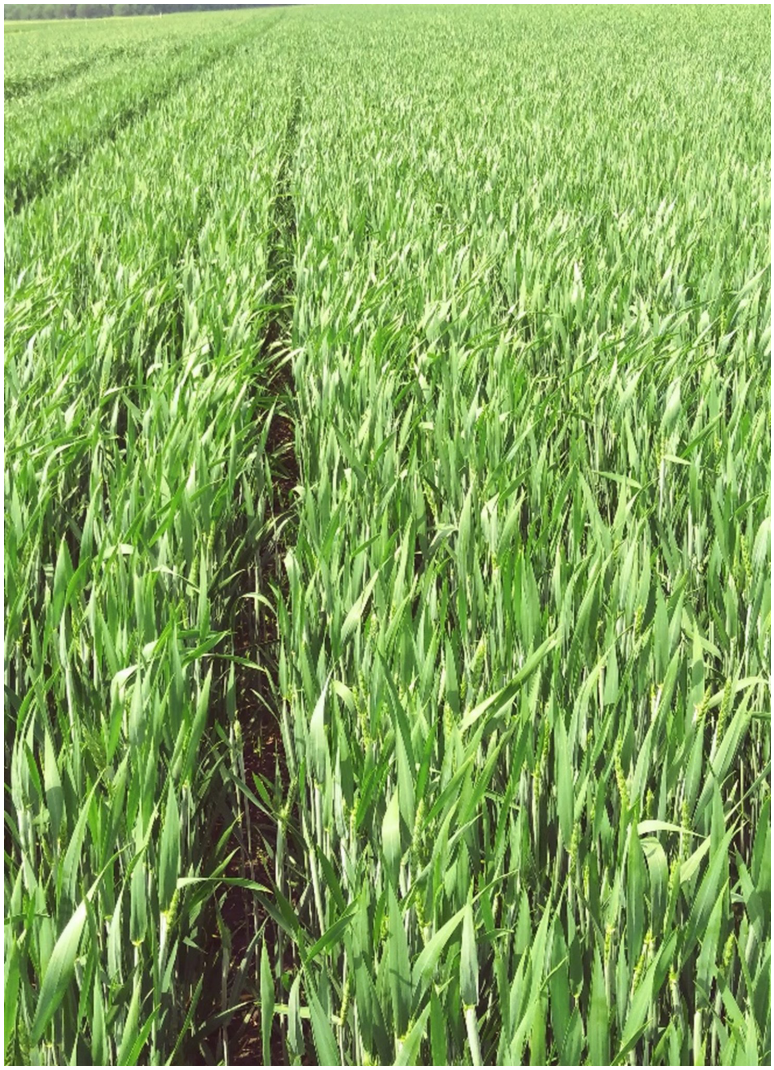

Photo 1. Intercropping with uncultivated soil provides an opportunity for plants to lean into this space and benefit from the greater availability of light (by M. Różewicz)

of plough and ploughless tillage is strip-till (also referred to as strip-till). The popularisation of this type of cultivation is also linked to the development of technical advances increasingly in the machinery industry, the latest proposals of which concern machinery that allows strip-till combined with seeding. The advantages of this method include: aeration of the soil in the rhizosphere, faster heating of the soil in the cultivated strip, prevention of loss of clay and silty soil particles – responsible for the soil sorption complex (the so-called wind erosion). The positives including faster soil warming are particularly important in cool climate zones, significantly increasing crop yields by an average of 3.64% compared to no-tillage [7]. In addition, the use of reduced tillage with leaving a large amount of crop residue in the field significantly contributes to the reduction of greenhouse gas emissions in wheat production [10]. New technologies in the design of strip-till machinery allow for the management of crop residues which, however, do not impede plant growth [3].

Scientific literature on strip-till cultivation in Poland is scarce. Preliminary studies carried out so far on the possibility of using strip-till sowing of wheat in Poland have shown beneficial effects of strip-till technology on winter wheat plants, their yield and grain quality, which became apparent especially in years with unfavourable agrotechnical and habitat conditions [26]. This is also confirmed by studies by other authors conducted in different countries [5]. Taking into account the increasingly frequent agricultural droughts and the economic importance of wheat cultivation, further research on this cereal species in strip sowing, is justified. Creating optimum conditions for plants reduces intraspecies competition for water and nutrient resources in the soil. In addition, uncultivated rows provide plants with the opportunity to benefit from greater light availability (due to the so-called marginal effect – photo 1), which also plays an important role in the intensity of photosynthesis, promoting better nutrition, disease resistance and lodging [9]. It also determines adequate green matter accumulation and higher productive tillering. It affects higher yield, but is also a factor in wheat's competitiveness with weeds. Wheat plant tillering is determined by the varietal factor [8], but is also related to sowing density. A factor that is important and differentiates the yield obtained and its quality is the genetic factor - cultivar. In the breeding of wheat cultivars, significant progress has been noticed in Poland for several years, but the use of the yield-forming potential of new cultivars is closely related to the applied cultivation technology [19]. This is indicated by numerous studies on the yield of individual wheat cultivars, both by the Central Research Centre for Cultivar Testing and scientific research [20, 29]. Biological progress in breeding new wheat cultivars has resulted in yield stability. The selection of a suitable cultivar is one of the non-input factors influencing crop yields, but it must be linked to the optimally selected cultivation technology and the prevailing habitat conditions [30].

A problem that implies the introduction of simplified arable farming is also the increasing problem of drought. The traditional ploughing system causes soil loosening and deterioration of water conditions by significantly drying out the soil. Drought is one of the most important environmental factors inhibiting photosynthesis and reducing plant growth and productivity. Both the cropping system itself and the wheat cultivar grown in it affect photosynthetic rates [28]. High temperatures with low rainfall during the growing season cause significant yield losses in wheat. Due to an increase in average temperature over the years and a warming climate in different regions of the world, it becomes necessary to adapt cropping systems to the changes taking place. Photosynthesis, carbon assimilation and transpiration are major determinants of the carbon balance and growth of wheat, and high temperatures and lack of soil water, significantly reduce the efficiency of these processes. The creation of suitable habitat conditions can to some extent minimise the negative effects of high temperatures on photosynthesis and thereby reduce yield losses [23].

Strip-till wheat cultivation and yield and quality

Farmers who are interested in introducing strip-till technology on their own farms may be encouraged by the range of benefits that from it. These include both the yield itself and the economic benefits associated with reduced fuel consumption and the ability to meet ecoschemes, as well as environmental benefits such as improved soil properties and reduced environmental impact. A study by Cheng et al. [2] showed that the use of strip-till and controlled-release nitrogen fertiliser contributes to better yields, reducing costs, and increasing income, while meeting the environmental objective. Studies show that wheat grown in strip-till system yields more than wheat grown in no-till and conventional systems. A study by Jaskulska and Jaskulski [16] shows that winter wheat gave a similar grain yield to that grown in the plough system, but definitely higher than in no-till. The higher grain yield obtained by Jaskulska and Jaskulski [15] in strip-till technology was due to better emergence of wheat grains, which translated into a higher number of ears and grain weight per ear. The findings of the cited authors regarding better emergence can be linked to the reported higher soil moisture found in strip-till. Similarly, Hossain et al [12] found higher wheat grain yield in strip-tillage compared to conventional (plough) tillage. Considering that adverse weather conditions will become more frequent during the growing season, research to determine the most effective methods under such conditions, seems very justified. According to research conducted by Saldukaitė-Sribikė et al [27], the additional introduction of ploughing or minimum tillage prior to strip-till does not result in higher winter wheat yields, but only increases fuel consumption and carbon dioxide emissions into the atmosphere. Previous research has shown that the factor that differentiates the productive and economic effects of strip-till can depend on genetic factors. This is due to their physiology related to their ability to grow and develop at a certain density. Strip sowing creates a special situation for wheat plants, where plants sown in two rows next to each other are separated by inter-rows of greater width. In our own research, it has been shown that the applied variation in post-harvest cultivation and cultivar have a significant effect on the yield obtained. The abandonment of post-harvest tillage by using only strip-till did not significantly affect the yield of the cultivars Desamo and Metronom, while in the case of the cultivar Formation, abandoning the previously applied ploughing reduced grain yield by 0.77 t/ha (9%) [24]. Thus, an important element of yield maximisation in the case of winter wheat cultivation in strip-till technology, is the appropriate choice of cultivar. The reason for the variation in the yield of cultivars is the role of the genetic factor in shaping the productivity of the cereal canopy caused by the different degree of resistance of cultivars to stem base and root diseases. These diseases are more prevalent under conditions of limited cultivation and left crop residues without being ploughed in, so cultivars showing higher resistance will also show higher yields. As demonstrated by the study of Chiriță et al. [4], as the intensity of soil tillage decreases in winter wheat, it affects the yield reduction compared to plough tillage, the lowest being with zero tillage. The combination of suitable tillage and cultivar is therefore the main factor influencing yield. Mainly through better emergence and plant density per unit area, as well as number of ears and grain per ear especially in years with less favourable weather conditions [14]. A comparison of the results of our own research [24] on the yield obtained with the research of other authors [26, 27], showed that the forecrop plays an important role in the yield of winter wheat in strip-till cultivation (Table 1). In our own research where the forecrop was winter wheat, performing prior ploughing before applying strip-till resulted in higher yields than conventional strip-till without prior post-harvest cultivation. On the other hand, studies by Różniak [26] and Saldukaitė-Sribikė et al [27] showed that when the forecrop is oilseed rape, winter wheat showed a higher yield in a traditional strip-till than with a pre-till. Oilseed rape can be a good forecrop for wheat in strip-till because higher seed yields are also recorded for this species when strip-till is used [13]. The

Table 1. Winter wheat yield as a function of pre-crop and post-crop applied

Forecrop	Post-harvest cultivation	Grain yield (t/ha)	Author
Rapeseed	Ploughing	6,95	[27]
		9,07	[26]
Wheat		7,88	[24]
Rapeseed	Cultivation	6,96	[27]
Wheat		7,41	[24]
Rapeseed	Zero-tillage	7,27	[27]
		8,98	[26]
Wheat			[24]

cultivation of winter wheat following one another, reduces the grain yield in subsequent years [21], so proper crop rotation is an important element that has an impact on the yield obtained. Growing wheat one after another caries an increased severity of diseases, especially fungal diseases [11], which can affect yield reduction.

In addition to the yield obtained, equally important in the case of wheat is its quality, which determines the use of the grain for food purposes. According to a study obtained by Jaskulska et al [17], the application of strip tillage or traditional ploughing does not affect the quality traits of wheat grain, such as protein and gluten content in grain, sedimentation value, and volume and bread weight. The authors found that grain quality was more influenced by weather conditions in particular years. In contrast, their own research showed that traditional strip-till cultivation influenced a higher sedimentation index value, but did not affect gluten amount, gluten index and falling number [25]. The significant increase in sedimentation index in strip-till cultivation indicates that grain with good baking value can be obtained in this system. In contrast, Różniak [26] found a favourable effect of strip-till cultivation on total protein and gluten content. Strip-till as a compromise between ploughing and no-till is beneficial. According to a study by Buczek [1], grain yield and grain quality parameters such as gliadin and total glutenin content, are higher than without tillage. However, Dolijanović et al. [6] indicate that the conservation tillage system has a more favourable effect on the mineral composition of wheat grain. Grain from no-tillage contained more macronutrients (K and P) and, micronutrients such as Cu, Fe and Zn.

Conclusions

The cultivation of winter wheat with strip-till technology as one of the variants of conservation tillage, which combines the advantages of both plough and no-till, will gain popularity in Poland. This is related both to the positive impact on grain yield, but also to the reduction of labour input, as soil tillage, fertiliser application and sowing can be carried out in a single pass. It also allows for better economic and environmental results related to reduced fuel consumption and carbon dioxide emissions. This cultivation also contributes to increased grain yield in years with less favourable weather conditions. The use of this cultivation method compared to conventional ploughing, does not negatively or positively affect the quality of the yield. An important factor modifying the yield and its quality in the case of wheat is the cultivar. The right choice of winter wheat cultivar determines the positive effect of yield increase and its quality. However, proper crop rotation must be maintained, as growing winter wheat one after the other reduces yields. An additional incentive to make wheat strip-till cultivation more widespread, is also the possibility of implementing an ecoscheme within the framework of carbon farming. At present, there are no precise data showing the scale of the acreage under strip-till winter wheat cultivation, but many factors suggest that this crop will become much more popular in the near future.

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DEVELOPMENT AND ANALYSIS OF THE DESIGN OF AN INNOVATIVE HYDRAULIC CONCRETE MIXER WITH A CAPACITY OF 9 m^3

OPRACOWANIE I ANALIZA PROJEKTU INNOWACYJNEJ BETONOMIESZARKI HYDRAULICZNEJ O POJEMNOŚCI 9 m^3

Summary: *An innovative structure of a road concrete mixer with a capacity of 9 m^3, with the reduced weight, control and measurement system and an innovative modular aerodynamic cover of the front bracket was developed and analysed. The research work included the design of the structure, numerical analysis, bench tests in laboratory conditions and operational tests in real conditions.*

Keywords: *hydraulic concrete mixer truck, own bodywork, aerodynamic cover of the front bracket, control and measurement system*

Streszczenie: *Opracowano i poddano analizie innowacyjną konstrukcję betonomieszarki samochodowej o pojemności 9 m^3, o zmniejszonej masie, z układem kontrolno-pomiarowym oraz innowacyjną modułową osłoną aerodynamiczną wspornika przedniego. Prace badawcze obejmowały projekt konstrukcji, analizę numeryczną, badania stanowiskowe w warunkach laboratoryjnych oraz badania eksploatacyjne w warunkach rzeczywistych.*

Słowa kluczowe: *betonomieszarka hydrauliczna, zabudowa własna, osłona aerodynamiczna wspornika przedniego, układ kontrolno-pomiarowy*

Introduction

The publication describes the result of a complex process of research included in the project entitled "Construction of a 9 m^3 truck concrete mixer with advanced design and innovative functional solutions", with the number POIR.01.01.01-00-1738/20.

The motivation to undertake this research work was the dynamic development of the construction industry, and above all the branches of industry including the production of specialized vehicles as well as machinery and equipment employed in the construction industry, which was widely reflected in the published optimistic forecasts for the construction and investment market. Therefore, the complex process of analysing the state of the issue and inventorying the existing construction and material solutions in the area of hydraulic concrete mixers was carried out, on the basis of which the area and scope of improvement of the key functionalities of the concrete mixer's own construction was determined owing to the application of original innovative solutions.

The innovative development project was developed [1, 3, 4, 6, 7, 9] and subjected to preliminary verification by means of numerical FEM and CFD analysis [2, 11]. The results of the numerical research provided the basis for the production of test models of the bodywork, which were subjected to a complex process of bench tests in laboratory conditions using a dedicated specialized test stand.

The last stage of the research was operational tests in real conditions carried out for the prototypes of innovative mixers produced on the basis of the results of the above-mentioned research works, which were placed on the chassis of specialized vehicles rented for this purpose for hydraulic concrete mixers with a capacity of 9 m^3.

Concept, design and numerical analyses of innovative construction of concrete mixer

The analysis of the condition of the issue and the review of the materials that can be applied, including primarily sheets and profiles made of specific metal alloys, resulted in the design of innovative key elements of the bodywork, i.e. the supporting frame, brackets – front and rear, mixer drum with a mixing and unloading spiral and other necessary components. A complex exploration of CAD models according to the design assumptions

was carried out in order to develop the resulting structure of the complex development. A visualization of the original solution is shown in Figure 1.

Fig. 1. Visualization of the innovative construction of the concrete mixer

The developed CAD models of the key components of the bodywork, i.e. frame, brackets and drum, were subjected to a numerical analysis of stress distribution using the finite element method (FEM) [2] – Figure 2.

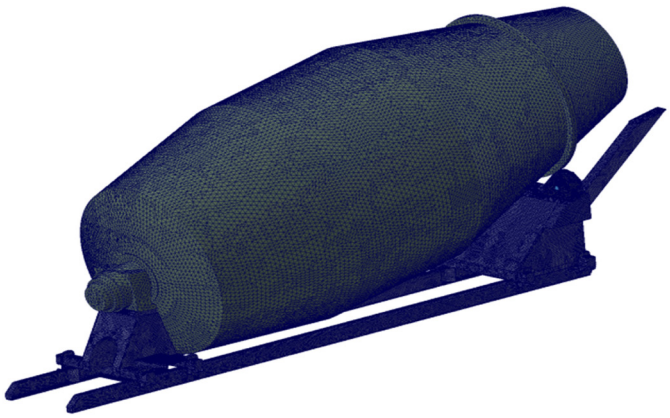

Fig. 2. FEM model of the innovative construction of concrete mixer

The results of the FEM analysis in the form of key parameters, i.e. reduced stresses, safety factor and displacement, confirmed the possibility of producing test models for bench tests according to selected construction and material variants [2].

In parallel, a previously unused modular system of an innovative aerodynamic cover for the front bracket was developed – the visualization is shown in Figure 3.

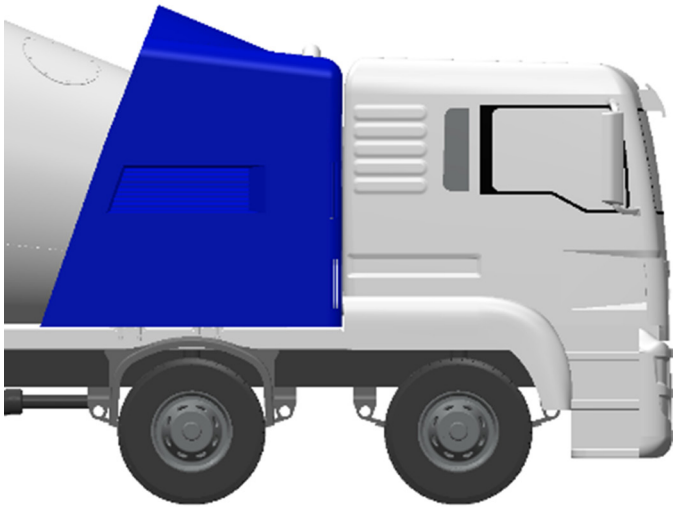

Fig. 3. Visualization of the innovative aerodynamic cover of the front bracket of the mixer body work

The new functionalities of the cover include an increase in the operational safety of the concrete mixer through adequate insulation of the area of the complex hydraulic drive system of the mixer drum, improved a aesthetics, the so-called vehicle design in line with contemporary trends, including references to the current appearance of trucks, and above all, improving the ai resistance coefficient and, consequently, reducing fuel consumption [12, 13].

The developer solution was verified during CFD numerical analysis – flow testing (Fig. 4) [11].

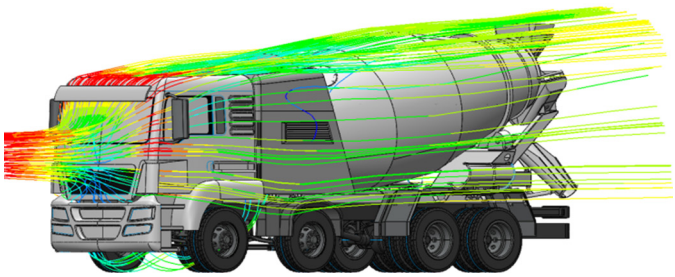

Fig. 4. Results of CFD analysis of a hydraulic road concrete mixer with a capacity of 9 m^3 with an innovative aerodynamic cover of the front bracket

The results determined by numerical CFD flow analysis showed a measurable improvement in the drag coefficient Cd in relation to the previously used standard body without the innovative aerodynamic cover of the front bracket – 0.87 for the vehicle with the cover and 0.92 for the standard body.

The results of the numerical research provided the basis for the development and production of real world research models of the innovative construction of the concrete mixer.

Stationary tests in laboratory conditions

The next stage of the work was the testing of innovative concrete mixers' construction produced on the basis of the above results on a dedicated, specialized test stand, developed for individual needs and according to the author's assumptions.

A complex series of bench tests made it possible to determine a number of individual values of functional parameters, selected at the design Assumption stage as key in the process of fatigue tests of the support frame, front bracket and rear bracket. A selected summary of results for the full t test cycle of a given body set is provided in Table 1.

Table 1. Selected summary of the results of field tests of innovative mixer construction

No.	Aggregate weight [t]	Number of Cycle Hours	Own body weight [kg]			
			strain gauge			
			1 Left front	2 Right front	3 Right rear	4 Left rear
1	0	5	977.91	1059.41	939.47	867.21
2	2	15	1473.86	1565.02	1444.64	1360.48
3	6	15	2470.35	2697.75	2440.82	2235.08
4	10	25	3397.48	3662.96	3519.31	3264.25
5	14	30	4323.58	4687.64	4594.81	4237.97
6	16	50	4657.59	5065.97	5272.75	4847.69

No.	Load [MPa]			
	strain gauge			
	1 Left front	2 Right front	3 Right rear	4 Left rear
1	9.23	9.99	8.86	8.18
2	13.90	14.76	13.63	12.83
3	23.31	25.45	23.03	21.09
4	32.05	34.56	33.20	30.79
5	40.79	44.22	43.35	39.98
6	43.94	47.79	49.74	45.73

No.	Axial run out [mm] Sensor position-tracking	Radial run out [mm]				Vibration level
		Sensor position				
		1 Anterior cone	2 Centre band	3 Neck cone	4 Mouth cone	
1	1.13	0.75	0.80	0.77	0.74	1.39
2	1.14	1.00	1.12	1.03	0.97	1.41
3	1.15	1.20	1.47	1.24	1.16	1.50
4	1.2	1.49	1.77	1.55	1.46	1.40
5	1.26	1.71	1.93	1.74	1.70	1.51
6	1.3	1.92	2.20	1.95	1.89	1.53

No.	Deflection [mm]			
	Sensor position			
	1 Anterior cone	2 Centre band	3 Neck cone	4 Mouth cone
1	0.00	0.00	0.00	0.00
2	1.40	1.60	1.49	1.33
3	2.42	2.77	2.58	2.30
4	3.70	4.23	3.94	3.52
5	5.13	5.86	5.46	4.87
6	6.15	7.03	6.55	5.84

Fig. 5. An example of the welded joint analysis process

The analysis of the results of the bench tests showed the improvement of the determined values of individual parameters in relation to the standard body subject to verification as part of the previous own works during the implementation of the commissioned service tasks. This includes radial run-out, axial run-out, and deflection, which can be determined in a standard service procedure. Many of the currently operated concrete mixer bodies subjected to the analysis were characterized by up to a dozen percent increase in the parameters in question. Therefore, it was found that the developed structural and material solutions of the body elements show, *inter alia*, an increase in mechanical strength and the associated extended service life.

During the bench tests, an advanced verification of the welded weld was also carried out in characteristic areas – stress concentrations determined by numerical FEM analysis – with the use of specialized equipment. No damage was found after the bench fatigue testing process, which also confirms the key assumptions of the project. An example of a weld seam analysis process is shown in Figure 5.

Bench tests in laboratory conditions – the determined results confirming the key assumptions of the project – resulted in a decision to carry out the last stage of work, i.e. the manufacturing and assembly of prototypes of innovative mixer bodies on the chassis of special vehicles in order to carry out a comprehensive series of operational tests in real conditions.

Operational tests in real conditions

Prototypes of the innovative own body were installed according to a standard procedure in a dedicated area of chassis of specialized vehicles – hydraulic concrete mixers trucks – Figure 6.

Fig. 6. Vehicle for operational testing of an innovative self-built mixer body work

The comprehensive operational tests in real conditions included the acquisition and analysis of the results of the tests in question based on the data from the test vehicle work cards, records from the installed measurement/control system and comments of the operators of the vehicles, as well as physical verification and assessment of the degree of wear in real conditions' operation.

The tests in the real conditions were carried out according to the assumed schedule, including, first of all, a specific number of man-hours for the selected concrete mixers, including the number of trips in full loading conditions, the number of loading/unloading processes, the type of transported material and its weight. It was assumed that the test vehicles should carry out their standard cycle of transporting the concrete mass, namely loading under the concrete plant, transport to the target construction site, unloading the concrete and returning to the base. At the same time, a minimum working time of 100 hours was determined in real conditions for each of the concrete mixers with innovative mixers.

The culmination of the operational tests were the final tests of the mixer prototypes on a specialized test stand in laboratory conditions – a detailed analysis of the degree of wear, including the measurements under the assumed load.

The results confirmed the achievement of the assumed objectives and provided the basis for the development of final conclusions.

Final conclusions

The implementation of a comprehensive test procedure for the innovative construction of the own hydraulic concrete mixer truck with a capacity of 9 m^3 made it possible to determine the key results, which unambiguously confirm the achievement of new functionalities *via* the application of construction and material solutions that have not been used so far in the area before the subject.

The developer solution showed a reduction in weight and material consumption for the key components of the body, i.e. the support frame, front bracket and rear bracket at the level of 10.596% compared to the previously used standard body design. In addition, in the process of numerical analysis of the FEM stress distribution as well as bench and operational tests, an increase in the service life of the innovative development at the level of 18.8% was shown.

The last parameter, according to the project's assumptions, was the reduction of fuel consumption. Owing to the above-mentioned reduction of the curb weight of the body and the application of an innovative aerodynamic cover of the front bracket confirmed by the numerical CFD analysis, the level of reduction of fuel consumption by a specialized vehicle – a hydraulic concrete mixer equipped with an innovative bodywork at the level of 7.37% was achieved, which was finally confirmed in standard operating cycles carried out as a part of tests in real conditions.

Summary

The selected results of the research work prepared for the purposes of this publication, including the design and analysis of the structure of an innovative construction of an innovative hydraulic concrete mixer truck with a capacity of 9m^3, confirm the achievement of key parameters of milestones provided for the implemented project.

An innovative product has been developed with new functionalities resulting directly from the application of previously unused proprietary solutions in the field of building one's own concrete mixer. The above men-tioned parameters achieved in the course of the work are of key importance in both ecological and economic aspects for market recipients. Moreover, it should be emphasized that the application of the innovative aerodynamic cover of the front bracket measurably improves the aesthetics of the vehicle, bringing its external design closer to modern trucks.

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AUTOMATED WATERING PLATFORM FOR THE USE IN GREENHOUSES AND PLANT NURSERIES

ZAUTOMATYZOWANA PLATFORMA DO PODLEWANIA DO UŻYTKU W SZKLARNIACH I SZKÓŁKACH ROŚLINNYCH

***Summary**: The article deals with the automation of the watering process in cultivation of plants in greenhouses, tunnels, and plant nurseries. This paper introduces the patents and products related to watering systems as well as their characteristics and applications. Then, a new platform for automatic crop watering is presented, the design of which has been submitted for protection in the Polish patent office, under the number P.427964. Described construction is destined, inter alia, for the purpose of complementing the system that allows automatic control and monitoring of mushroom cultivation process.*

***Keywords**: mushroom cultivation, patent description, process automation, watering platform*

***Streszczenie**: Artykuł dotyczy automatyzacji procesu nawadniania w uprawie roślin w szklarniach, tunelach i szkółkach roślin. W artykule przedstawiono patenty i produkty związane z systemami nawadniającymi, ich charakterystykę i zastosowanie. Następnie zaprezentowano nową platformę do automatycznego nawadniania upraw, której projekt został zgłoszony do ochrony w polskim urzędzie patentowym pod numerem P.427964. Opisana konstrukcja przeznaczona jest m.in. jako uzupełnienie systemu umożliwiającego automatyczne sterowanie i monitorowanie procesu uprawy pieczarek.*

***Słowa kluczowe**: uprawa pieczarek, opis patentu, automatyzacja procesu, platforma do podlewania*

Introduction

In the recent years, the development of widely understood agricultural engineering is virtually inseparable from the cultivation process automation [1]. Automation of various processes included in a production chain allows them to become more efficient and less engaging for the human operator [9]. The cultivation of plants being grown in greenhouses or in plant nurseries is no exception in this regard [8].

That is why the paper presents the automated watering platform destined for such use. The design of the described project is currently under protection by the Polish Patent Office, under the number 238890 [3]. The described construction is destined *inter alia* for the purpose of complementing the system that controls and monitors mushroom cultivation process in an automated manner [4].

Recent patents on watering devices

Patent literature contains a description of many interesting watering solutions. The most interesting of them are described below.

One of the exemplary watering devices is an adjustable plant watering apparatus described in [14], in which inside the tank and the water dispenser there is a container rotatably mounted so that it can be emptied when filled. The unit provided with a floating piston, located inside the chamber, allows regulating the flow rate of water into the container by changing the level of water in the chamber, while the outlet opening in the chamber carries water to the container.

Other solution for watering (and feeding) system for plants is described in [5]. It comprises a container enclosing a platformed water reservoir, housing a water supply unit, a fertilizer dispensing unit, a nutrient conveying wick and a water level indicator unit, all of which are interacting to provide automatic and adequately measured amounts of nutrients to the plants, embedded in soil on top of the platformed water reservoir.

A customizable potted plant watering apparatus described in [13] is made up of a variety of interconnecting parts to form one or more separate elongate trays which are arrange in any fashion but generally one above the next. Each tray section is adapted for supporting one or more potted plants. The trays are interconnected by flexible tubes so that when water is introduced into an upper tray it flows downwardly into subsequent lower trays.

When the trays are attached at both ends to end sections, they form a finished shelf into which water may be introduced to hydrate and feed the plants by root absorption. The end sections are held in place by a snap on cover which also engages a screen to provide an effective watering tray and a clog free system.

Another invention is a tool for watering of flowers [2], consisting of a bar with a fork hanger at the end, in which a rocker is hinged on the pins, to which a handle is attached in the form of a tubular fitting, equipped with two side projections in the middle part, and on the shorter end with an internal thread cooperating with the thread on the container in bottle form. One arm of the rocker arm is connected with the rod by means of an elastic element, while the other, opposite arm is connected by a rod with a one-sided lever mounted on the rod. An extension cap is attached to the longer end of the handle.

Next interesting system is described in [12]. It is a mobile, enclosed plant growing apparatus including a plumbing/irrigation system. The plumbing/irrigation system includes a modularized reservoir system, light tight piping, growing buckets, risers, and sprinklers. A liquid nutrient solution is pumped from the reservoir system, through the piping, into the buckets through the risers, exiting from the sprinklers.

A plant watering system including a tray having a platform thereon in which a water absorbent mat is located is described in [10]. The mat extends into the tray in which water is located and water is absorbed from the tray into the mat by capillary action. The plants are located on the mat and are provided with water directly to the plant bottom and water is available to provide humidity to the leaves. A stackable arrangement is provided so that one tray can be stacked on top of another one.

The last exemplary solution is apparatus for drip-watering of pot plants known from [11]. It is characterized in that it has a container which is a plastic bottle turned upside down with a filler opening at the bottom, and a drainage tube is placed in the cap, connected to a distribution manifold, the ends of which are provided with the filters that are placed over the pots, the tank being attached with clamps to a vertical hanger and resting on its bottom part corresponding to the shape of the neck of the tank.

All the above discussed designs are characterized by their motionless, while one of the main features of the proposed watering platform is its mobility.

Design of the automated watering platform

Figure 1 shows a general view of the entire automated watering platform, being the main subject of the article. Figure 2 shows the arrangement of elements on the platform, and Figure 3 shows a bottom view of the platform.

The base for the device consists of a support frame (1), serving as a watering platform carrier and wheels (2) that should be properly selected, i.e., considering the type of ground. The platform is driven by stepper motors (3) controlling the chain transmission system (4), which allows the support frame to move forward and backward. The stepper motor (5) and gears (6) are responsible for the torsion of the support frame. The entire system is controlled by an actuator installed in the control cabinet (7). In the centre of the frame there is a guide (8) on which a movable watering platform (9) with sprinklers (10) is installed. Platform (9) is also equipped with the sensors (13) responsible for a proper movement (finding the track).

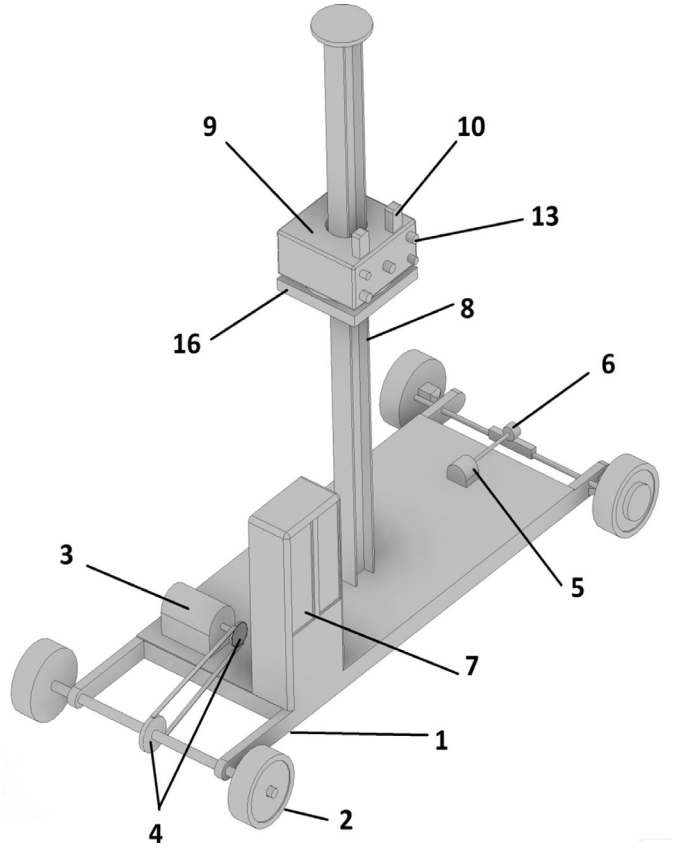

Fig. 1. Automated watering platform – general view

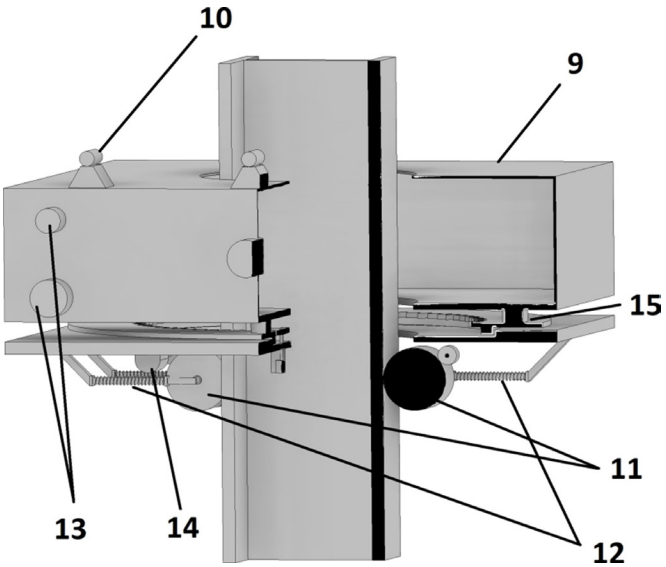

Fig. 2. Cross-section and arrangement of elements on the watering part

Figure 2 shows the main executive element of the watering platform, i.e., the rotatable watering part that consists of pressure wheels (11) with a spring (12), which are parts responsible for stabilizing the watering element consisting of sprinklers (10) and previously mentioned sensor system (13). The motor (14) is responsible for moving the platform (9) up and down.

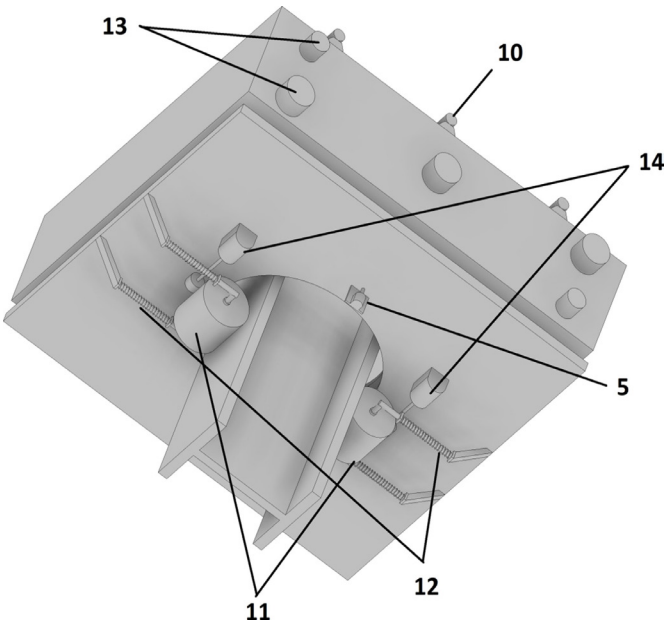

Fig. 3. Bottom view of the watering platform

Figure 3 shows again the motor (14) responsible for raising and lowering the watering part, and a motor (5) being used for rotating the rotatable watering part.

The principle of operation of the presented watering device is as follows. The platform, after programming its operation and installing sprinklers that are appropriate for a given crop, is placed in the workplace, and then started. It drives to the cultivation site in a programmed manner with the use of motors and a drive (Fig. 1, elements 2, 3, 4, 5 and 6). Based on the analysis data from the sensors (13), it finds the crop and starts watering while moving forward. The platform allows the watering of multi-level crops, in which case, after completing the watering of one level, the height of the platform is changed accordingly (by means of the motor (14)).

Depending on the used software, it is possible to irrigate both single-level crops (e.g., tomatoes, cucumbers) and several-level crops (e.g., mushrooms).

Summary and conclusions

Automation of processes included in the sequence of activities that make up the cultivation of various types of agricultural products, plays an increasingly important role in widely understood agriculture.

One of the processes that could be automated is watering, which is a labour-intensive and repetitive activity. That is why we proposed the new device, i.e., automated watering platform.

The key advantages of the presented construction are speed and precision of watering, what translates into savings resulting from both the optimization of plant irrigation and reduction of labour costs. Another advantage of the presented construction is its mobility, distinguishing it from the known solutions in the field of automatic crop irrigation, some of which are described in section 2 of this paper.

The innovative nature of the described watering platform is confirmed by its application to the patent office and in consequence, its protection [3].

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TAKING MEASUREMENTS OF THE DETECTION SENSOR USED IN THE LABELLING PROCESS

WYKONANIE POMIARÓW CZUJNIKA DETEKCJI UŻYWANEGO W PROCESIE ETYKIETOWANIA

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

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

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

Słowa kluczowe: *pomiar, czujnik detekcji, system wizyjny ZFV, etykietowanie, opakowania*

Introduction

To perform the analysis, with the aim to obtain the answer to the thesis assumed in the title of the present paper, the measurements were in two types of positioning systems A and B. The study A was performed with the use of vision camera while the study B was carried out using photoelectric sensor.

As to make the measurements comparable for the particular labels, the same measuring criteria were employed in all cases. Thus, after performing the series of labelling of 100 pcs of packaging, using the positioning system with vision camera (study A), the switch was changed from position ZFV into KAY position and then , the study B was carried out with the series of 100 pcs of packaging, as well. It was marked on the packaging in what point the beginning of label was to be found. Each sequence was performed for one label at three different speeds of transporter: 10 m/min, 15m/min and 20m/min. In a final stage of the study, the correctness of laying the label was considered. The following criteria were employed:

- correct labelling, i.e. the label is commenced at the correct site;
- defective labelling, i.e. the labels are glued but with the shift in relation to the beginning of the packaging;
- lack of label when the packaging has not been labelled.

Ensuring of a smooth functioning of the machine, that is efficient performance of the tests was possible owing to the help of the additional persons in a role of assistant.

Positioning as performed with the use of camera

Label no 1 has distinct drawings, owing to which camera catches them easily and the packaging is correctly labelled; it may be observed in Table 1 and Figure 1.

Table 1. The results obtained during labelling with label no 1

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	98%	97%	96%
2.	Defectively labelled	2%	3%	4%
3.	Lack of label	0%	0%	0%

Fig. 1. Diagram of labelling with label no 1

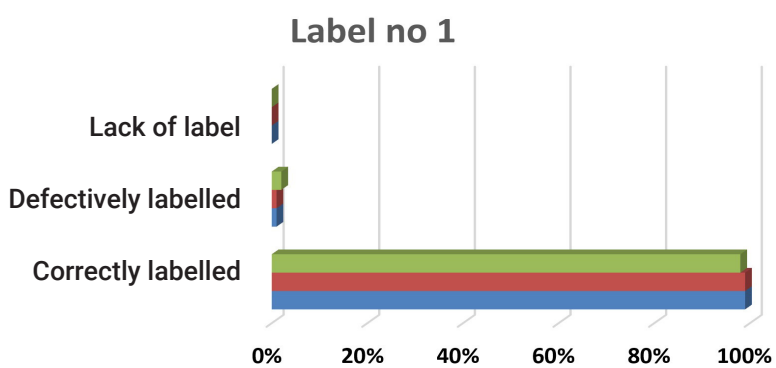

Fig. 2. Diagram of labelling with label no 2

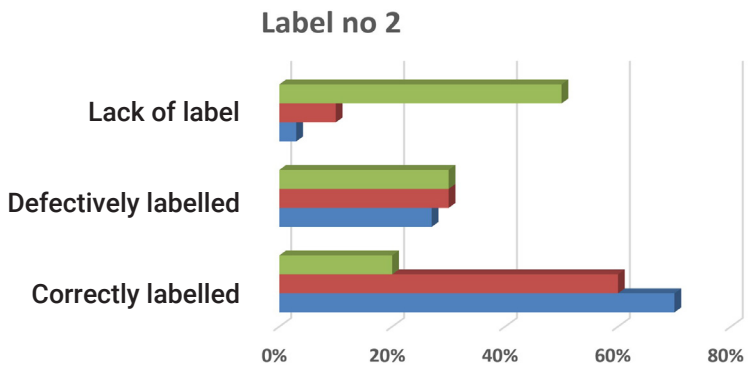

Table 2. The results obtained during labelling with label no 2

No.	V of transporter [m/m/in]	10	15	20
1.	Correctly labelled	70%	60%	20%
2.	Defectively labelled	27%	30%	30%
3.	Lack of label	3%	10%	50%

Fig. 3. Diagram of labelling with label no 3

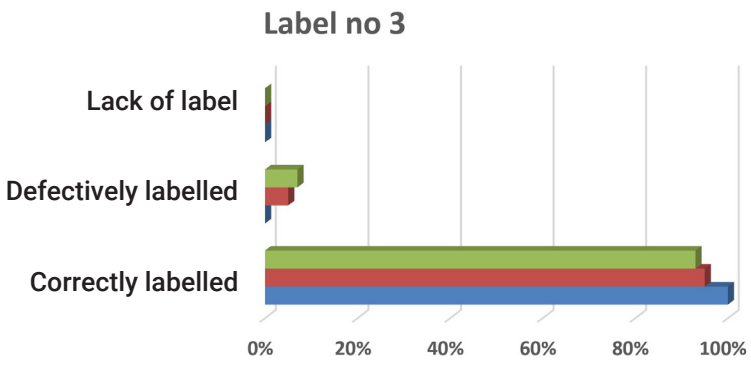

Table 3. The results obtained during labelling with label no 3

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	100%	95%	93%
2.	Defectively labelled	0%	5%	7%
3.	Lack of label	0%	0%	0%

Fig. 4. Diagram of labelling with label no 4

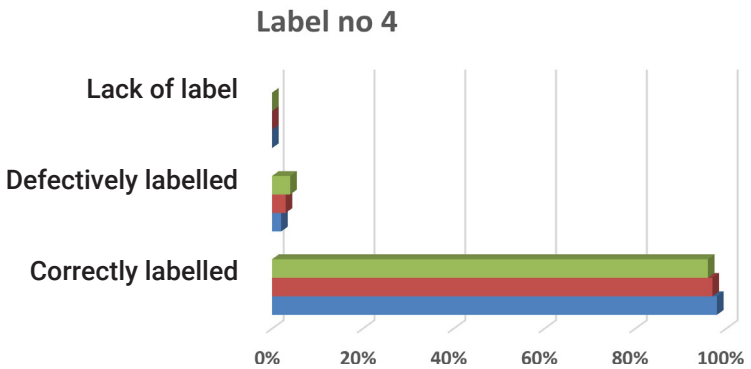

Table 4. The results obtained during labelling with label no 4

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	98%	97%	96%
2.	Defectively labelled	2%	3%	4%
3.	Lack of label	0%	0%	0%

Defectively labelled single pieces were treated as casual error because the measurements were not carried out under strictly controlled laboratory conditions, but only in the manufacturing hall.

Label no 2 has no distinct symbol in overprint, so it is difficult to be calibrated by camera. The obtained results have been presented in Table 2 and Figure 2.

For low speed values, the camera is still able to catch a signal but together with the increase of the speed, it "looses", in a certain way, the packaging, causing a big number of non-labelled packaging pieces.

Label no 3 contains a characteristic image owing to which the camera catches its position very well. It has been illustrated in Table 3 and Figure 3.

The length of a single label prolongs the cycle of labelling of a single packaging but it has no impact on the correctness of the labelling process itself.

Label no 4 is performed in 3D printing technology; it is, however, equipped with the characteristics symbols which the camera was tuned to. It has been reflected in the results shown in Table 4 and Figure 4.

Fig. 5. Diagram of labelling with label no 5

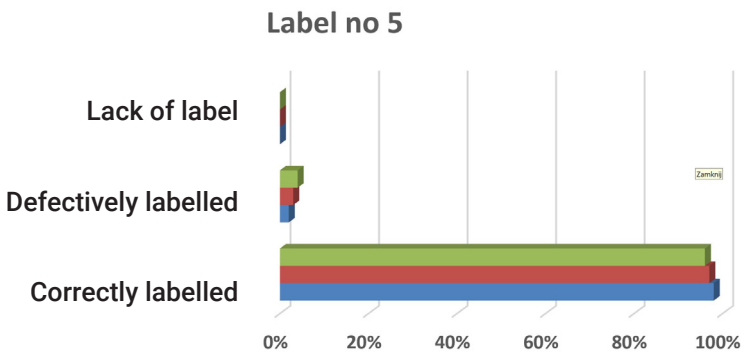

Table 5. The results obtained during labelling with label no 5

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	98%	97%	96%
2.	Defectively labelled	2%	3%	4%
3.	Lack of label	0%	0%	0%

Fig. 6. Diagram of labelling with label no 6

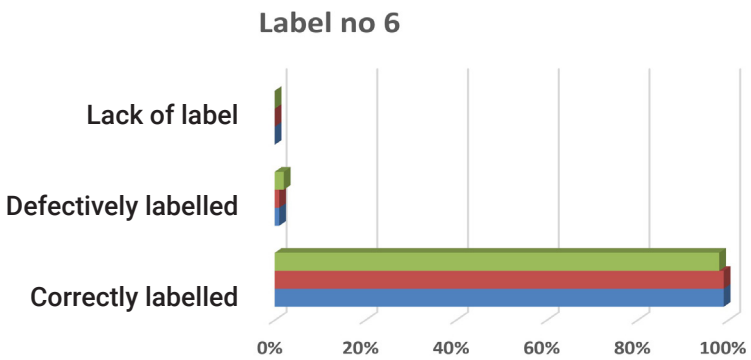

Table 6. The results obtained during labelling with label no 6

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	99%	99%	98%
2.	Defectively labelled	1%	1%	2%
3.	Lack of label	0%	0%	0%

As it can be seen from the obtained results, camera coped very well with the discussed innovative solution in relation to labels.

The successive label marked with number 5 was performed on film substratum and besides it, on transparent film. In spite of this fact, the code bar is visible; it served as a symbol for camera. The obtained results are found in Table 5 and Figure 5.

In spite of its appearance and material of the label, the camera had no problem with detection and positioning of the label on packaging.

The shape of label no 6 was irregular but it had characteristic symbol facilitating calibration of camera what was reflected in the results contained in Table 6 and Figure 6.

Camera was tuned to a square with flag, what facilitated its correct work. On the ground of this fact, it may be stated that the shape of label did not affect the yield of the vision system during positioning. The labelling process ran correctly, irrespectively of the employed velocity of transporter.

Positioning with the use of sensor

The sensor was calibrated on the field of a wide square in label no 1. The obtained results are found in Table 7 and Figure 7.

The sensor performed positioning correctly for low speed values. Together with the rise of velocity, the number of defectively labelled packaging was increasing.

Fig. 7. Diagram of labelling with label no 1

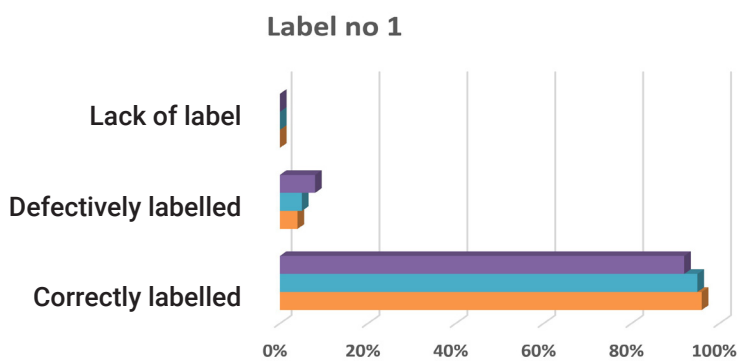

Table 7. The results obtained during labelling with label no 1

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	96%	95%	92%
2.	Defectively labelled	4%	5%	8%
3.	Lack of label	0%	0%	0%

Fig. 8. Diagram of labelling with label no 2

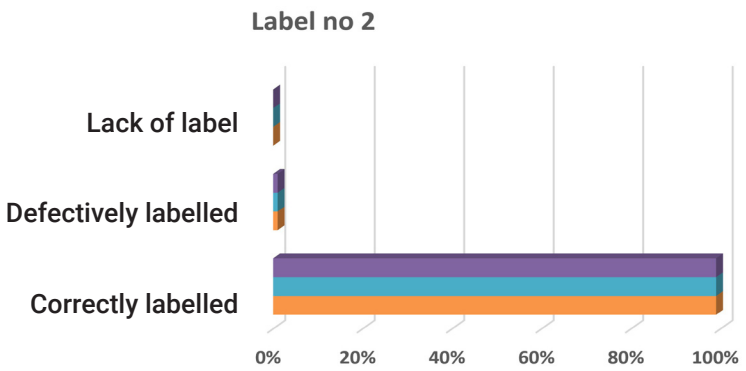

Table 8. The results obtained during labelling with label no 2

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	99%	99%	99%
2.	Defectively labelled	1%	1%	1%
3.	Lack of label	0%	0%	0%

Fig. 9. Diagram of labelling with label no 3

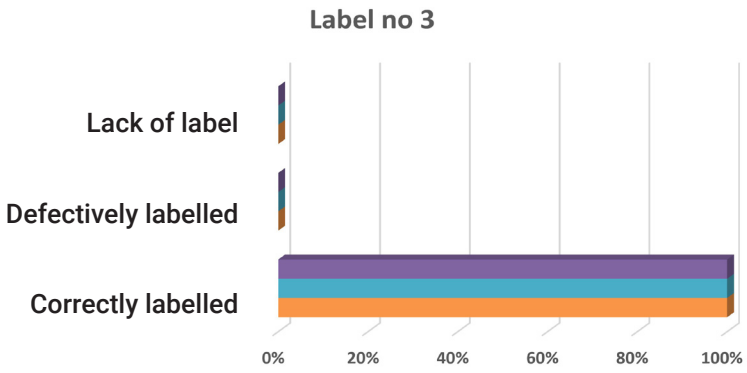

Table 9. The results obtained during labelling with label no 3

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	100%	100%	100%
2.	Defectively labelled	0%	0%	0%
3.	Lack of label	0%	0%	0%

Fig. 10. Diagram of labelling with label no 4

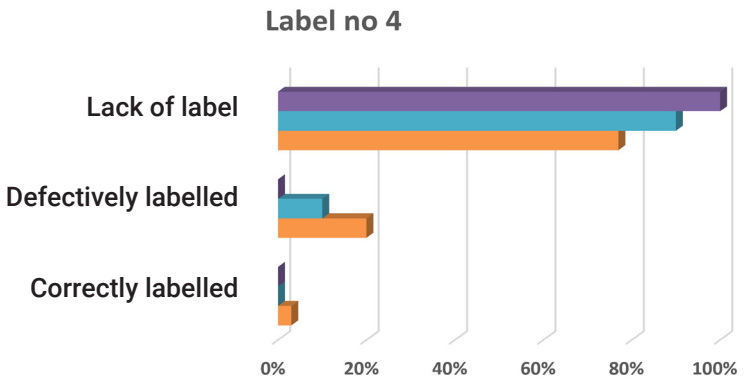

Table 10. The results obtained during labelling with label no 4

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	3%	0%	0%
2.	Defectively labelled	20%	10%	0%
3.	Lack of label	77%	90%	100%

In label no 2, we can see a characteristic black line which is in a strong contrast with the remaining graphic of the label. The results of positioning with the use of the sensor are given in Table 8 and Figure 8.

In the discussed above case, the sensor caught easily the mentioned difference what allowed his correct work, even at the increased velocity.

Label no 3 has a black rectangle in its graphical form; it is very suitable for catching by the sensor; it is well visible in Table 9 and Figure 9.

When taking the obtained results into consideration, it was found that the length of the label has a favourable impact on the work of the sensor because even at the high velocity values labelling was correct.

Label no 4 was performed in 3 D printing technology and due to this fact, the sensor has big problems with the receipt of return signal. It was reflected in the results found in Table 10 and Figure 10.

The results have confirmed that the discussed type of label excludes the application of the described system of positioning.

Fig. 11. Diagram of labelling with label no 5

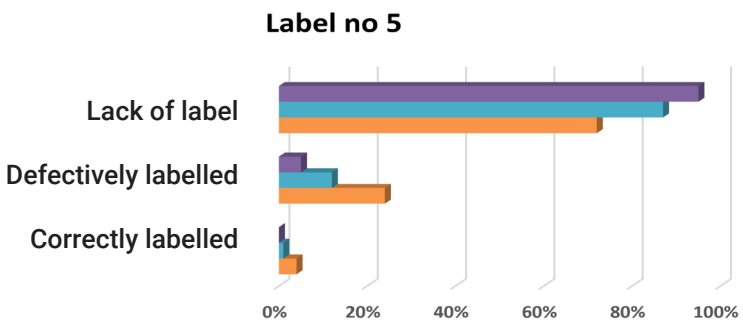

Table 11. The results obtained during labelling with label no 5

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	4%	1%	0%
2.	Defectively labelled	24%	12%	5%
3.	Lack of label	72%	87%	95%

Fig. 12. Diagram of labelling with label no 6

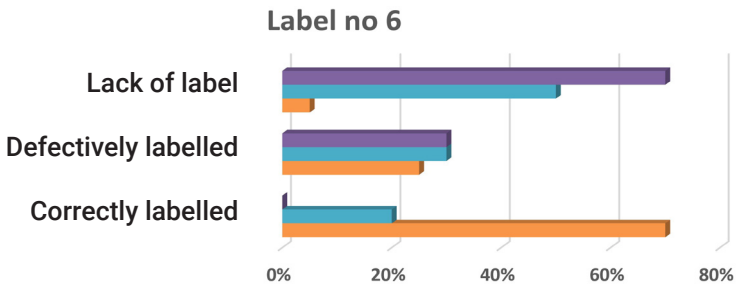

Table 12. The results obtained during labelling with label no 6

No.	V of transporter [m/min]	10	15	20
1.	Correctly labelled	70%	20%	0%
2.	Defectively labelled	25%	30%	30%
3.	Lack of label	5%	50%	70%

Label no 5 has not any contrast fields on its surface, therefore, the sensor had big problems with its catching. It resulted in a low effectiveness what was demonstrated in the results given in Table 11 and Figure 11.

The application of the sensors in the discussed type of label did not work.

For multi-colour label (i.e. number 6), at low veolocity values, the sensor was not capable of catching every packaging. It is well visible in the obtained results given in Table 12 and Figure 12.

Together with the increase of the velocity, the sensor had the troubles with finding the contrast fields what can be well demonstrated in Figure 12.

Conclusions

When taking into account the obtained results, it can be concluded that the vision system at a high speed value makes more errors, which results from the speed of the camera processing the image into an impulse. The camera, as having the comparative image in its memory, compares it each time with the one obtained during the current work. This takes a certain amount of the time needed for the image processing by the camera system, and therefore, it increases the time needed to send the pulse to the labelling head.

Based on the research, it can be concluded that the photoelectric sensor was very good at such situations, because it immediately obtained an impulse that controlled the head. However, many models of labels made in new technologies, such as 3D or transparent are currently entering the market. The sensor evidently failed to cope with these during the research carried out in this study.

The industry also employs the labels that do not have clearly contrasting elements. This causes the sensor to have trouble recognizing the end and start of the label. Comparing the size of the labels, it can be seen that this parameter has no major impact on the effectiveness of labelling. Based on the experience gained during the performed measurements, it can be seen that the way of matching the components with each other has a significant impact on the accuracy of labelling.

Sensor systems are currently the most widely used in the market, but they are gradually being replaced by advanced vision systems. This change is not very dynamic as vision systems are still an expensive investment. For these reasons, when designing a labelling machine, each designer needs to know which labels the labelling line is intended for.

Thus, it should be recognized that the packaging positioning system in labellers depends on the type of labels used.

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Principal scientific topics of the Conference:

- sustainable agricultural production, circular economy, taking into account environmental protection, organic farming, counteracting climate change;
- nature protection in rural areas and water ecology, water pollution and impact on biodiversity;
- water, sewage and waste management in rural areas;
- biotechnology and plant physiology of rural areas;
- rational water management in drainage facilities, low water retention
- management of natural resources including soil;
- biotechnology and plant physiology of rural areas;
- renewable energy in rural areas, including the acquisition and use of agricultural biogas and methods of managing post-fermentation residues, reducing greenhouse gas and ammonia emissions from plant and animal production;
- innovative and smart agriculture;
- technologies ensuring animal welfare, low-emission and low-energy livestock construction, reducing energy consumption and increasing production efficiency.

The basic conference fee is PLN 1400, while for participants without a presentation, chapter in a monograph, and for PhD students, we provide discounts. The fee includes the costs of reviews of the articles provided by you, editorial work, printing, sending the monograph to the address provided by the Participants and providing on-line transmission. We encourage you to prepare an article in the form of a monograph chapter (20,000 characters), for which you are entitled to 20 points of the Ministry of Education and Science.

Moreover, for all Conference participants, the *Journal of Water and Land Development* JWLD offers a 20% discount for publishing an article (www.jwld.pl). After acceptance and positive reviews, we plan to publish the selected 3 articles in the last issue of 2024, and the remaining ones in the first issue of 2025 (the order will be determined by the earlier date of sending the works to the Publishing House).

Deadlines:

Until August 12, 2024 – sending an application to the conference with an abstract
Until August 30, 2024 – payment
Until September 30, 2024 – submitting articles to the Journal of Water and Land Development
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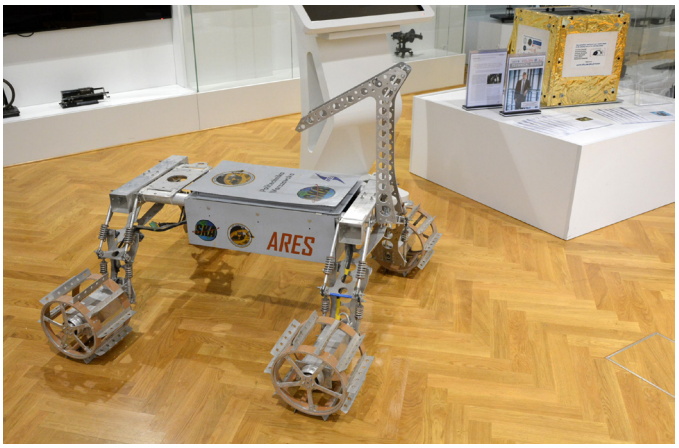
THE EXHIBITION "PROFESSOR PIOTR WOLAŃSKI – MAN AND WORK"

WYSTAWA "PROFESOR PIOTR WOLAŃSKI – CZŁOWIEK I DZIEŁO"

On May 9, 2024 the exhibition "Professor Piotr Wolański – man and work" opened at the Warsaw University of Technology Museum. The exhibition includes memorabilia related to the Professor's space activities and achievements, such as: photos with dedications by NASA astronauts, medals and diplomas documenting the activity of prof. Piotr Wolański at the international forum.

The exhibition at the Warsaw University of Technology Museum presents the profile of prof. Piotr Wolański not only as a valued scientist and inventor, but also as a man inspiring generations of young scientists in the country and around the world. The numerous memorabilia he left behind will allow us to recall the Professor's most important achievements, while also being a testimony to his involvement in the development of Polish cosmonautics. It is worth recalling here that prof. Piotr Wolański contributed to the selection of the official name of the Polish Space Agency, established in 2014, which from then on was to use the abbreviation POLSA, from the English translation of the Polish name (Polish Space Agency). The professor was also one of the initiators of the commemoration of Nicolaus Copernicus at the headquarters of the United Nations in Vienna, where in June 2014, a copy of Jan Matejko's painting "Mikołaj Copernicus – Conversation with God" was unveiled, depicting this outstanding astronomer and the model of the "LEM" satellite.



Both exhibits are still the exclusive sign of Poland's presence in the UN, because the bust of Maria Skłodowska-Curie on display was donated by the French.

In the opening month of the exhibition, specifically on May 21, World Space Day falls. Therefore, in addition to the souvenirs made available, among others, by the Professor's family or the Łukasiewicz Research Network – Institute of Aviation, the exhibition will feature, among others, rovers or models of the PW-Sat 1, PW-Sat 2 satellites developed by the Student Astronautical Club at the Faculty of Energy and Aviation Mechanics, of which the Professor was the founder and supervisor.

Articles about the Professor Piotr Wolański by Izabela Koptoń-Ryniec, which appeared in Polish Technical Review in issues 4/2023 and 1/2024, can be found on magazine's website: http://polishtechnicalreview.com.

Source: https://www.muzeum.pw.edu.pl

The Main Building of Warsaw University of Technology
The Main Audience Hall level, left cloister
Pl. Politechniki 1

The exhibition is available to visitors from May 9 to August 31, 2024

THE 50TH ANNIVERSARY OF THE TECHNICAL KNOWLEDGE OLYMPIAD

JUBILEUSZ 50-LECIA OLIMPIADY WIEDZY TECHNICZNEJ

There have been almost 1000 laureates selected during 50 years of organizing the Olympiad of Technical Knowledge (OWT) by the Federation of Scientific –Engineering Association of NOT. All the mentioned events were attended by thousands of pupils of secondary schools (technical ones and lyceums, as well). In the school year 2023/2024, the mentioned Olympiad was held first time in the changed formula as Technical Knowledge Olympiad – Engineering in Electrical Power Technology. The conducted earlier competition in two topic groups – mechanical-constructional and electric-electronic problems has been limited to the questions of electric power engineering after the recommendations of the Ministry of Education and Science.

On the 3 June 2024, during the solemn Gala held in the House of Engineer in Warsaw, the 50th edition of the Olympiad was summed up and its 13 laureates were awarded. They originated from the large group of the participants. The best finalist was Piotr Pawlik from the Group of Technical Electric Schools and Lyceums in Krosno; he gained the maximum number of 100 scores in final competition for solving of the tasks. The victory in the Olympiad assures the entrance to the chosen technical university for the laureates without examination.

The Jubilee Gala, as being conducted by Mr Janusz Kowalski, had the exceptional character. It was attended by many outstanding guests and social activists, involved for the years, in organization of Olympiad of Technical Knowledge. There were present the teachers and guardians who motivated the youth to participation in the Olympiad, the authors of the tasks and the members of the Jury and the representatives of association movement and its agendas and, also, the members of the Chief Committee of OWT-IWE with its Chairman, Prof. dr. hab. Stanisław Wincenciak, Eng. The event was also participated by the representatives of the Regional Organizational Units, without which the implementation of the Olympiad would be impossible, and, also the secretaries and members of the Regional Committees of OWT who arrived with the Olympic idea to thousands of schools and pupils.

From among the invited guests, the solemn Gala was attended, *inter alia*, by the following persons: Piotr Zakrzewski – the Vice-President of the Patent Office of the Republic of Poland; Dr Janusz Niedziółka – the Head of the Office at the Department of Strategy, Qualifications and Vocational Education at the Ministry

of the National Education; Dr Hubert Cichocki – the President of the Scientific Research Network Łukasiewicz – the partner of the Olympiad; the representatives of higher education schools: Doctor of Medical Sciences, Bożena Piechowicz – the Rector of the University of Applied Sciences in Siedlce; Prof. dr hab. Rafał Dańko, Eng. – Pro-Rector for Student Affairs at AGH; Dr hab. Tadeusz Dziubak, Eng., University Professor – Deputy Dean for Scientific Affairs at the Department of Mechanical Engineering of Military Technical University, and also, the representatives of the sponsors: Jan Rosiński – the Chief Technologist in Toruńskie Works of Dressing Materials, SA; Jan Koblak – the Chairman of the Supervising Council of HORUS-ENERGIA company; Sławomir Smoktunowicz – from Department of Communication of Polish Power Engineering Network S.A.; Zofia Tyszkiewicz – the specialist for Educational Projects of Foundation ADAMED.

– For a half of the century, the Olympiad of Technical Knowledge had passed different organizational and territorial changes but it was always addressed to the pupils interested in science, technology and engineering profession – Ewa Mańkiewicz-Cudny, the President of FSNT-NOT said in her inauguration speech. – *The Olympiad opened always the way to the start for the youth to the technical universities. All my predecessors had paid a great attention to its organizing, encouraging the pupils of the secondary schools to participate in this extremely important competition. From among 990 laureates during the past 50 years, the majority of them obtained the great success in engineering and technical professions. As being the creators of technology, they have introduced many innovative solutions; they patented their inventions and became the outstanding scientists. They proudly stress the role which OWT played in their life. To-day we are focusing on other problems than those dating back to few decades before but the will to improve the world has always connected and it connects nowadays all creators of technology. I think that in the perspective of few years, a part of you undoubtedly will become the members of our organization which covers 40 scientific-technical associations and includes ca. 80 thousand engineers and technicians. You are the great hope that the movement of scientific-engineering associations, as lasting for 200 years, will be still actively developing.*

When congratulating the present laureates, the President of FSNT-NOT added: – *I really do hope that you will continue this beautiful idea as the expression of the care of the well-being of the whole humanity, the future generations and our planet, and ensuring the lasting peace all over the world.*

The idea of the Olympiad of Technical Knowledge and its aims have not been changed for 50 years – Prof. Dr Hab. Wojciech Radomski, Eng. stressed in his appearance. He recollected the history of this event. It was organized for the talented young people who want to tie their future with the profession of engineer of technician.

– I am only worried about the fact that during the period of organizing OWT, one third of all students in Poland represented technical directions and now, we can observe a significant decrease of this phenomenon – Professor added. – *I would like that the Olympiads could motivate again the youth to greater interest in the studies on technical directions. Together with the participants of OWT, laureates, teachers and scientific environment, we are one great Olympic Family which should grow and develop constantly. The success of*

organizing it for 50 years is a merit of ambitious and talented youth as well as the teachers and guardians who develop the passion for science in the young people. It is only a pity that the Ministry of the National Education does not appreciate too much this valuable initiative. It has only a patronage for few years on the Olympiad but is does not support it financially. Nobody receives any means for its organization. The work is performed honourably, with the awareness of its role in the education and development of Poland. Professor thanked all the persons involved in organization of OWT for their efforts and wished the Olympiad to survive the successive 50 years.

The appreciation for the level of knowledge of the laureates, their interest and great engagement of the teachers was also expressed by other participants of the solemn Gala; *inter alia*, by Piotr Zakrzewski – Vice-President of the Patent Office of the Republic of Poland who paid also attention how the protection of intellectual and industrial property was important for the creators of technology. In turn, Dr Hubert Cichocki, the President of the Research Network Łukasiewicz – partner of OWT encouraged the young people to become interested in the participation in the program "Olympiad Laureates in Łukasiewicz; the youth meets the experience there". – *We are here in a very wide team and represent different institutions but we are all aware how important is the cooperation of public administration, business and science* – he stressed.

After the appearances of organizers and patrons of the 50th edition of the Olympiad of Technical Knowledge – Engineering in Electrical Power Technology, the President Ewa Mańkiewicz-Cudny and Prof. Stanisław Wincenciak handed the diplomas and awards to 13 laureates.

The first award went to Piotr Pawlik from the Group of Technical Electric Schools and Lyceums in Krosno; **the second place** was granted to Rafał Kmiotek from the Defenders of Polish Post Group of Communication Schools in Gdańsk; **the third place** *ex aequo* was granted to Dominik Jarosławski from the Stanisław Staszic II Lyceum in Lublin and to Adam Sienkiewicz from the Duchess Anna Jabłonowska de domo Sapieha II Lyceum in Białystok. The complete list of the laureates is available on the page of Olympiad.

– *I was lucky that the tasks occurred to be very easy for me* – Piotr Pawlik, the winner of maximum number of scores (100) in OWT assured. – *The first task concerned electronics which has been the subject of my interest since primary school; in the second task, I invented ad hoc the formula in order to solve the problem in the best way. The task consisted in the selection of the number of photovoltaic panels and wind turbines as the costs of implementation of such undertaking could be most optimal for 10 years of exploitation. According to the invented formula I considered different variants and combination and I obtained a very good result. It decided on the success of my idea. I gained the maximum number of scores and obtained a free entrance (student's "index") to AGH. I encourage all to participation in OWT as it opens the way to the dreamed studies.*

The culmination of the ceremony was distinction of the persons with the special merits for OWT and awarding them with diplomas, medals and golden and silver honorary badges of NOT. The highest distinction of NOT – the Piotr Drzewiecki Medal was granted to Professor Wojciech Radomski.

The discussed above solemn event was possible owing to the engagement and efforts of many persons as well as owing to the support of our sponsors and partners. In behalf of Federation SNT-NOT, Regional Committees and the Chief Committee of OWT, the leading host of the ceremony paid the words of gratitude to pedagogic teams of many schools, universities, authors of the tasks to be solves and the members of the Jury, the Regional Organizational Units of NOT, the Ministry of the National Education and the sponsors of the Olympiad: Polish Electric Power Engineering S.A., Toruńskie Works of Dressing Materials S.A., Foundation Adamed, companies Horus-Energia, Stern Weber, MZGOK Konin; partners: the Research Network Łukasiewicz, Association for the Support of Polish Technology, House of Engineer in Warsaw, Publishing House of SIGMA-NOT, company NOT- Informatyka (Computer Science), the National Museum of Engineering and portal: Leaders of Innovativeness.

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

THE 37TH COMPETITION "NUMERUS PRIMUS INTER PARES"

37 KONKURS "NUMERUS PRIMUS INTER PARES"

On May, 23, 2024, during the Gala of Young Innovator as being held in Warsaw House of Engineer NOT, the diplomas and distinctions, summing up the 37th Competition *Numerus Primus Inter Pares*, organized by the Society for Culture and History of Technology, were handed to the laureates.

The aim of the Competition Numerus Primus was to select the best edition of technical and popular-technical periodicals from the previous calendar year in respect of popularization of knowledge and engineering culture.

The Jury of the Competition, as acting under the guidance of Prof. dr. hab. Czesław Waszkiewicz, Eng., doctor *honoris causa*, appreciated highly the professional and graphical level and the editorial form of all 23 journals, being sent to the present, 37th edition of the Competition.

In the group of periodicals, promoting science and technology, The Jury granted the **title of laureate – Numerus Primus Inter Pares to no 12 of journal "Elektronika dla wszystkich"**, as being published by Corporation AVT Ltd.

In the same category, **the distinction** was granted to periodical: **Doradca – Małopolski Informator Rolniczy, no 1 – 2/2023**, as being published by Małopolski Agricultural Advisory Centre.

In the group of specialist journals, the title of laureate – Numerus Primus Inter Pares – was granted to "**Przegląd Odlewnictwa", no 11-12/2023**, published by the Association of Polish Foundry Technicians and Engineers (STOP).

The Jury granted also **the distinction** in the mentioned above category for periodical **"Przemysł Chemiczny", no 10/2023**, published by SIGMA-NOT.

The diplomas and distinctions were handed to the laureates in common by Professor Czesław Waszkiewicz – the Chairman of the Jury and Engineer Bronisław Hynowski – the President of the Society for Culture and History of Technology.

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

FINAL OF THE 17TH EDITION OF THE COMPETITION "YOUNG INNOVATOR 2023/2024"

FINAŁ 17 EDYCJI KONKURSU „MŁODY INNOWATOR 2023/2024”

On 23 May, 2024, the summing up of the 17th edition of the Competition “Young Innovator” was held in the House of Engineer in Warsaw (WDT-NOT). The event was attended by the guests from the Ministry of the National Education, the representatives of the President of the Patent Office of the Republic of Poland, and of the sponsors: Dr Maciej Wieloch – the President of the Company INFINI ASI and Mrs. Renata Hawrylik from MEDISENSONIC S.A. and also, the Jury of the Competition, as headed by Mrs. Ewa Mańkiewicz-Cudny – the President of FSNT-NOT. There were also present the Presidents of FSNT-NOT companies: Mrs Magdalena Borek-Daruk and Mrs. Anna Rybacka-Dybcio from SIGMA-NOT Publishing House and Mr Jerzy Rożek from WDT-NOT.

However, the laureates of the Competition were the most important participants of the mentioned ceremony – the pupils of primary schools, secondary school and vocational technical schools and their tutors under whose direction the projects and work, sent to the competition, were performed.

Not only was the Jury highly surprised by the choice and topics of the mentioned projects. When Mr Janusz Kowalski – who conducted the summing up – was reading the names of the laureates and the subjects of their work, the surprise and disbelief was visible. It has place especially among the guests of the discussed event: “so young people coped with such problems”. The given below examples might constitute the contents of professional periodical, popularizing the knowledge, or they could become

the subjects of the lectures and presentations during the conferences, organized by respectable scientific units. The subjects were, *inter alia*, as follows: **"Hybrygen – a mobile, hybrid and zero-emission current generator"; "Rhizobiotic – innovative fertilizer which does not contribute to water eutrophication and facilitates control of ethylene in plants"; "Educative hydrogen power plant"; "Skin without fear – application of AI for diagnostics of skin changes"; 'Aqua Guardian – Baltic Barriers of the Future"; "Active prosthesis of hand, controlled by bioelectric pulses"; "The 8th SENSE – remote, self-teaching system of monitoring and detection of sounds for the deaf persons"**.

The list of the laureates is available at the page www.not.org.pl in folder: Olympiads and Competitions: https://not.org.pl/olimpiady-i-konkursy.

After the mentioned above presentation, the host of the event paid the words of gratitude to the Ministry of the National Education and to the sponsors: Toruńskie Works of Dressing Materials SA, INFINI ASI Ltd., MEDISENSONIC S.A.; the donors: Foundation of PKO Bank Polski; the partners of the competition: House of Engineer in Warsaw (WDT-NOT), SIGMA-NOT Publishing House, NOT-Informatyka LTD., Association for the Support of Polish Engineering, and portal "Leaders of Innovativeness". The words of thanks were also expressed to Regional Organizational Units of NOT in Bialystok, Gdańsk, Kalisz, Kielce, Cracow, Łódź, Olsztyn, Radom, Poznań, Tarnów, Rzeszów, Słupsk and Szczecin which participated in the organization of the 2nd stage of the Competition "Young Innovator 2023/2024".

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

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