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Dear Readers!

We would like to present you with the fourth issue of Scientific Quarterly Packaging Review, the magazine focused on scientific research, developmental activities and technological progress in the packaging industry in Central and Eastern Europe. Packaging for food production is a key industrial segment – and this periodical is developed for Poland and neighboring countries.

In this magazine we present scientific findings and professional achievements from bona fide scientists. The articles highlight the focused efforts of those professionals on all issues related to packaging science working in research centers and the most innovative companies in both Poland and abroad. We inform and report on scientific conferences and tradeshows. We are also a bridge between science and business – by communicating technological innovations we hope to make breakthroughs executable throughout the industry.

One example of successful cooperation between a research center and a packaging manufacturer is our cover topic – the innovative Ecolure metallization technology, implemented at Dot2Dot company. The fruit is an impressive packaging produced with respect for the environment and resources.

We invite you to share your R&D projects in Packaging Review pages!

Anna Naruszko, M.Sc. Graduate of the Institute of Printing at Warsaw University of Technology (currently the Department of Printing Technologies, Faculty of Mechanical and Industrial Engineering, Warsaw University of Technology). Editor-in-chief of the monthly trade magazines "Poligrafika" and "Opakowanie", CEO of Alfa-Print Sp. z o.o, publisher of these magazines and of the scientific quarterly "Packaging Review".

Drodzy Czytelnicy!

Przed Państwem czwarte wydanie kwartalnika naukowego Packaging Review, prezentującego działania badawczo-rozwojowe oraz postęp technologiczny w branży opakowaniowej w Europie Środkowo-Wschodniej. To jeden z kluczowych - szczególnie dla polskiej gospodarki, stojącej produkcją żywności, ale i dla krajów ościennych - segmentów przemysłowych.
Na łamach czasopisma prezentujemy naukowe i zawodowe osiągnięcia naukowców dotyczące całokształtu zagadnień związanych z opakowaniami, pracujących w ośrodkach badawczych i najbardziej innowacyjnych firmach zarówno w Polsce, jak i za granicą. Informujemy o targach i konferencjach naukowych oraz je relacjonujemy. Jesteśmy także pomostem łączącym naukę z biznesem – popularyzując innowacje sprawiamy, że mają one szansę na wdrożenie i zastosowanie w przemyśle.
Jednym z przykładów udanej współpracy na linii ośrodek badawczy – producent opakowań jest nasz okładkowy temat – innowacyjna technologia metalizacji Ecolure, wdrożona w firmie Dot2Dot. Owocem jest efektowne opakowanie wyprodukowane z poszanowaniem środowiska i zasobów.
Zapraszamy do dzielenia się projektami badawczo-rozwojowymi na łamach Packaging Review!

Mgr inż. Anna Naruszko. Absolwentka Instytutu Poligrafii Politechniki Warszawskiej (obecnie Zakład Technologii Poligraficznych, Wydział Mechaniczny Technologiczny PW). Redaktor naczelna miesięczników branżowych „Poligrafika" i „Opakowanie", prezes zarządu Alfa-Print Sp. z o. o, wydawcy tych miesięczników oraz kwartalnika „Packaging Review".

Packaging Review

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ECOLURE – BEAUTY AND SUSTAINABILITY IN ONE IN LIGHT OF TODAY'S CHALLENGES FOR THE PACKAGING MARKET

ABSTRACT: Today the packaging design and production is vastly driven by the aspect of sustainability, which is not merely a consumer trend, but a necessity to meet the goals of sustainable growth, as well as the legal demands imposed by EU regulations. Packaging manufacturers are challenged to continuously seek new ways of providing products compliant with modern demands.
Ecolure is an example of a sustainable paper packaging solution that is recyclable and compostable while still maintaining the metallized shine of a traditional PET-laminated board.
Key words: sustainable paper packaging, laminated packaging, metallized packaging, eco-friendly packaging technology, PET lamination, research packaging project

STRESZCZENIE: Obecnie w projektowaniu i produkcji opakowań ogromną rolę odgrywa aspekt zrównoważonego rozwoju, który nie jest jedynie trendem konsumenckim, ale koniecznością do spełnienia postawionych celów ekologicznych, a także wymagań prawnych narzuconych przez regulacje unijne. Producenci opakowań stają przed wyzwaniem ciągłego poszukiwania nowych sposobów dostarczania produktów zgodnych z aktualnymi wymaganiami. Ecolure jest przykładem zrównoważonego rozwiązania w zakresie opakowań papierowych, które nadają się do recyklingu i kompostowania, a jednocześnie zachowują metaliczny połysk tradycyjnego arkusza laminowanego PET.
Słowa kluczowe: zrównoważone opakowania papierowe, opakowanie laminowane, opakowanie metalizowane, ekologiczna technologia pakowania, laminacja PET, projekt badawczy opakowania

GLOBAL PACKAGING MARKET TRENDS

The leading trends at the global market of packaging may be classified in five categories: production trends, demand trends, trends in respect of packaging functionality, technological trends and the ones connected with the environment protection. For the needs of the present paper, the attention will be focused on the latter mentioned trend. Care for the natural environment is the most important trend on the packaging market which will have a deciding impact on further development of the packaging sector. Therefore, the attempts are undertaken aiming at the reduction of its negative influence on the environment and transformation of the packaging sector towards the Circular Economy. EU Directive 2019/904 of the European Parliament and of the Council of 5 June 2015 on the reduction of the impact of certain plastic products on the environment identifies 6 main trends in aspect of the sustainable development and environmental protection. The mentioned trends include:

– Eco-design, understood as the design of new products, with consideration of their complete life cycle. In the context of the products, listed in Annexes to Directive 2019/904 it means product design destined for recycling, minimization of the mass of the products, productre-use in the same or another value chain and obtaining of mono-material for manufacture

- Alternative materials – in the context of single-use plastic products, it is referred to replacing materials with similar or better properties and functionality, for example, paper, wood, glass, natural materials, bio-composites (multi-material composites, using paper and bio-plastics), materials derived from agricultural and forest waste and by-products, food products, etc.
- Reusable packaging
- Zero Waste
- E-commerce – especially in the context of fast-moving goods, for packaging of which the so-called single-use plastics are used
- The concept of the Sharing Economy (also in relation to packaging).

ECO-DESIGN OF PACKAGING IN THEORY

The trend of eco-design of packaging is well illustrated by a new line of DOT2DOT products, called Ecolure. Before discussing the mentioned products, let's learn more precisely what eco-design is.

According to standard PKN-ISO/TR 14062:2004, eco-design means "inclusion of environmental aspects in the design and development of a product". Eco-design is, therefore, the supplementation of the main elements, considered in standard process, such as safety, functionality, ergonomics, resistance parameters or costs, plus two additional factors: evaluation of impact on the environment and perspective of the complete life cycle. In practice, it means the development of a new or improved version of packaging with a smaller impact on the environment. Eco-design, as being an instrument of minimizing the influence on the environment, has already been considered for many years as the priority measure in the field of the EU as well as Polish strategies. The development of guidelines in respect of designing the eco-friendly packaging, their ecological optimization and minimization of potential food losses connected with packaging is aimed at reduction of environmental impacts resulting from production, use and recycling of the used packaging. They should also give a guarantee that they meet the requirements connected with the appropriate protection of the packaged products and safety of their use. It has been confirmed by many documents and, in particular, by the package of activities concerning the circular economy, as created by the European Commission.

ECO-DESIGN IN PRACTICE

DOT2DOT, as a packaging manufacturer , cooperates with customers from many sectors of the economy with a focus on the beauty and food industries. It is more and more frequently visible how strong a pressure is exerted by the clients who expect packaging to be sustainable without the loss of its visual values at the same time. On the one hand, we have to deal with the legal regulations, approximating the introduction of the provisions from the successive directives of the European Union concerning packaging and packaging waste. On the other , we must consider

PIC.1 : ONE OF THE LEADING TRENDS AT THE GLOBAL MARKET OF PREMIUM PACKAGING IS ECOLOGY.

also market trends and choices made by the consumers in favour of sustainable packaging. Answering contemporary market's expectations DOT2DOT has developed a concept called DOT2GREEN which places focus of all activities undertaken by the company to be aimed at minimizing the impact of packaging on the environment. Within the frames of DOT2GREEN an innovative project, "Development of innovative and eco-friendly cardboard packaging with optical protection on the metallised substrate", has been developed and successfully implemented as a result of a two-year research and development work . It was financed within the frames of the competition of the National Centre for Research and Development. The assumptions of the project include the development and manufacture (in pilot-scale line) of paper packaging that would be free of plastic and, simultaneously, would be attractive owing to a shiny metallic layer. The departure from traditional lamination with PET film as the inseparable underlying component in favour of the new sustainable solution could neither cause loss of visual quality for laminate, nor lower the functional properties of the packaging. During the industrial stage of the project, the Research & Development staff of the company developed the assumptions for production of new eco-friendly packaging. The process is commenced from coverage of cardboard with glue and laying

PIC 2: ECOLURE IS AN EXAMPLE OF A SUSTAINABLE PAPER PACKAGING SOLUTION THAT IS RECYCLABLE AND COMPOSTABLE WHILE STILL MAINTAINING THE METALLIZED SHINE OF A TRADITIONAL PET-LAMINATED BOARD.

the laminate; the successive stage includes removal of the PET layer from the laminate. The prepared sheets are subjected to the stages of overprinting and varnishing, punching, moulding and gluing of the final packaging shape. The R&D team, supported by two research units (Warsaw University of Technology, Institute of Mechanical Engineering and Printing and the Łukasiewicz Research Network –Łódź Institute of Technology) tested the products made from traditional laminate and the products with the metallised layer without PET layer (hereinafter being called Ecolure), as manufactured in the laboratory conditions. The tests included also materials used in performance of the samples.

The results of the stage of industrial tests were as follows:

- the types of the applied metallised transfer and traditional foil are characterized by highly comparable mechanical parameters;
- degree of gloss (measurement at angle of 20o) for all foils exceeds value of 200 GU (Gloss Units);
- it was found that the application of transfer foil in the composition of laminate as compared to the traditional film did not have any significant effect on the change in the resistance parameters of laminates (resistance to stretching and elongation at maximum stretching force);
- it was confirmed that overprinting with offset inks of LED UV type also did not have any effect on mechanical properties of laminates; the adhesion of overprint and quality of printing with inks LED UV in test laminates with the use of traditional and transferable films was comparable;
- the level of global migration for the test laminates with transferable foil was found significantly lower the admitted limit of 10 mg/dm^2;
- the test laminates with transferable film, as compared to those ones with the traditional foil, obtained also the comparable results in respect of the following parameters: smoothness, soaking of aluminium in cardboard, sensory evaluation (for standard substance – chocolate) and barrier to water.

The positive results of the laboratory stage of the project allowed entrance to the developmental stage and manufacture

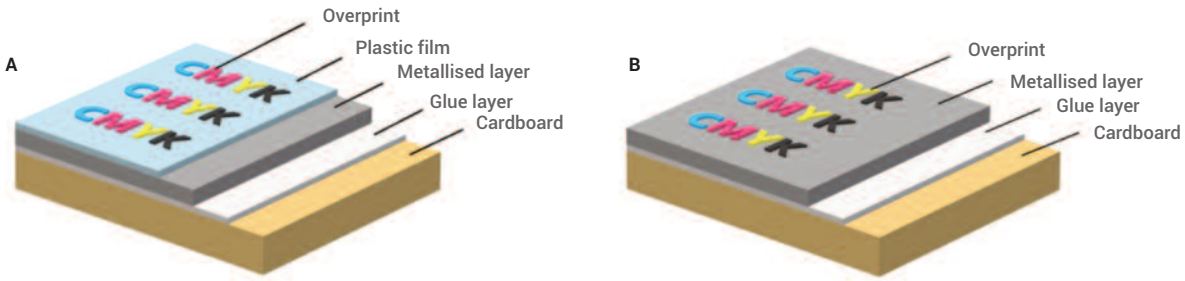

FIG. 1. COMPARISON OF THE STRUCTURE OF PRINTED LAMINATES WITH TRADITIONAL METALLISED FOIL (A) AND TRANSFERABLE FILM (B)

of packaging. When designing the pilot-scale line for manufacture of Ecolure products, the guiding factors included the results of the tests from the first stage such as temperature threshold for the implementation of effective process of lamination and the lower limit of the pressure of metallised transfer film exerted on the cardboard during lamination. The amount of appropriate glue was chosen in order to conduct the correct lamination process. The studies on the influence of the time between the process of laminating and delaminating on the effectiveness of delaminating were carried out; the negative impact on the quality of final laminates was not found. The technology of removal of the transferable film without damage of the metallised layer in manufacturing conditions was improved.

The correctness of arrangement of pilot-scale line was confirmed by production of several series of packaging. Additionally, the LED UV technology was chosen for over printing due to the lower effect on the environment in comparison to UV technology. The stability of LED UV printing process for the packaging on the metallic layer Ecolure was examined. The overprint of the traditional laminate is carried out on PET film; in the case of Ecolure it is performed directly on the metallic layer; hence, there is a necessity of verifying the correctness of overprint and its stability.

All packaging samples (printed with LED UV ink) were characterized by a high resistance to light effect. After 40 hours of exposure to UV light, the change in CMYK colours was lower than value ΔEab 5: for overprint of magenta ink, the observed change in colour was equal to 4 (ΔEab = 4.04) and for the remaining colours (C, Y, K) the values of change in colour were decisively lower. The effect of light caused a minimum change in gloss of packaging – the gloss was decreased maximum by ca. 10% of initial value. Additionally, the results of the resistance tests confirmed that the packaging with overprint on laminate with transferable film and lacquered with LED UV inks obtained the positive results in respect of resistance to abrasion.

SUMMING UP

After the completion of the research project DOT2DOT is able to offer the Ecolure packaging where the eco-friendliness has many following aspects:

- **Certificate of recycling** – the possibility of reprocessing together with other paper materials
- **Certificate of compostability** – possibility of subjecting a given packaging to the industrial composting process
- **Reduction of carbon footprint by almost 6% in relation to packaging obtained by traditional method** – index of carbon footprint for packaging made in technology with transferable film at the level of 57.5 kg CO_2 eq.
- **Lower energy consumption of overprinting and lacquering process even by 50%**. Ecolure packaging are produced with the utilization of LED UV printing technology which is characterized by a lower energy intake and owing to it, lower energy consumption as compared to the IR drying technology (hot air) by ca 10% or UV – more than 50%.
- **Elimination of ozone during processes in printing machine** – the application of LED UV technology does not cause generation of ozone as in the case of UV technology.

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The described work was carried out within the frames of the project DOT2DOT SA, co-financed by the European Union from the means of the European Fund of Regional Development under the Program; Intelligent Development. The project was implemented in the frames of the competition of the National Centre for Research and Development" "Fast Path".

REVIEWED ARTICLE

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STUDIES OF THE FACTORS AFFECTING THE PROCESS OF LASER MARKING OF CARDBOARD PACKAGING

ABSTRACT: Studies of the carbon dioxide laser marking process on cardboard packaging are presented. Approbation of the technological process of marking was carried out at different power of the laser beam and the speed of its movement. The optimal marking mode is set (laser radiation power 12 W and speed 240 mm/s), which provides the smoothest and clearest line edges. With such modes of laser processing, only the surface layers of the cardboard are destroyed, but the internal structure remains intact. It has been confirmed that the quality of laser marking is affected by the characteristics of the material, in particular its morphological surface structure. On the basis of the system and technical analysis, the factors influencing the quality of laser marking were determined, which were grouped into three groups: characteristics of the laser beam; properties of the base material; conditions of interaction of laser radiation with the material.
Key words: laser marking, packaging, cardboard, microscopy, surface structure,quality

STRESZCZENIE: Przedstawiono badania procesu znakowania laserowego dwutlenku węgla na opakowaniach kartonowych. Dokonano aprobację procesu technologicznego znakowania przy różnej mocy wiązki laserowej i prędkości jej ruchu. Ustawiony jest optymalny tryb znakowania (moc promieniowania lasera 12 W i prędkość 240 mm/s), który zapewnia najgładsze i najdokładniejsze krawędzie linii. Przy takich trybach obróbki laserowej niszczone są tylko powierzchniowe warstwy tektury, ale struktura wewnętrzna pozostaje nienaruszona. Za pomocą badań mikroskopii elektronowej potwierdzono, że na jakość znakowania laserowego mają wpływ właściwości materiału, w szczególności jego morfologiczna struktura powierzchni. Na podstawie analizy systemowej i technicznej określono czynniki wpływające na jakość znakowania laserowego, które obejmują trzy grupy: charakterystyki wiązki laserowej; właściwości materiału bazowego, warunki oddziaływania promieniowania laserowego z materiałem.
Słowa kluczowe: znakowanie laserowe, opakowanie, karton, mikroskopia, struktury powierzchni, jakość

INTRODUCTION

The contemporary development of technology makes the producers obliged to create and introduce perfect quality control systems for the products, their identification and logistics. In connection with this situation, there is a need of multi-level marking of the manufactured products, with the aim to deliver the obligatory and optional information about production to the consumer. Nowadays, there are known different technologies for marking of the products. It includes, in particular, mechanical contact marking (extrusion or incision, cutting, perforation, engraving and use of stamp), thermal marking (melting and burning); thermo-transfer printing; digital printing (ink-jet) and electrochemical process. From among the mentioned above technologies, laser marking occupies the important place (carbon-dioxide laser or semiconductor laser). It is employed in many applications – for marking of the production date and expiration date (Best before...) of food products on their packaging, labelling of packaging for medicinal products, cosmetics, bar codes, symbols, logos, eco-signs, etc. [1-3].

The advantage of laser marking includes the rate of placing the information and the possibility of marking in hardly accessible sites and, also a lack of direct contact of mechanical impact on the products what prevents their damage. There are, however, the increased requirements concerning a high detail of the text, precise transmission of small letter types and images.

Physical principle of laser marking consists in the interaction between falling laser beam and the used packaging materials; it is dependent on three componential factors – values of reflected, absorbed and penetrating rays. The reflected and penetrating beam renders energy to the material to be marked. The absorption capacity is dependent on the length of the wave of the falling beam which determines its power. When the wavelength is decreased, the energy of laser irradiation is increased. The absorbed energy is used for vibration or electronic induction or for performance of photo-chemical reactions.

As affected by CO_2 laser irradiation in the IR area at spectrum of ca. 9.6 – 10.6 nm, being absorbed by a given material, its local heating up, melting or evaporation takes place at the site of passage of laser beam. The mentioned processes are based on untypical structural and stage transformations of a given material; they are generated as a result of extremely high rates of its heating and later cooling down under the conditions of laser irradiation.

The elements which play here the important role include: values of density, strength of laser irradiation, the possibility of saturation of surface layers with the environment elements, increase of the density of dislocation in the irradiation zone and other effects. Laser gas tube, in which the laser beam is indicated, is the main element of laser equipment.

Under the influence of strong laser irradiation, different physical and chemical processes occur in the employed materials; their nature and type are determined by temperature, time and rate of heating and cooling of material. The mentioned factors are dependent on energetic and geometric characteristics of the laser beam, properties of the processed material and geometric shape and weight (mass) of the product, technological scheme of its processing, etc. [4].

During laser marking of the products, the packaging materials absorb laser irradiation and transform it from the light energy into heat energy. The general scheme of CO_2 laser is given in Fig.1.

THE SUBJECT AND METHODS OF THE TESTS

The subject of the test covered the process of laser (CO_2) marking of cardboard packaging.

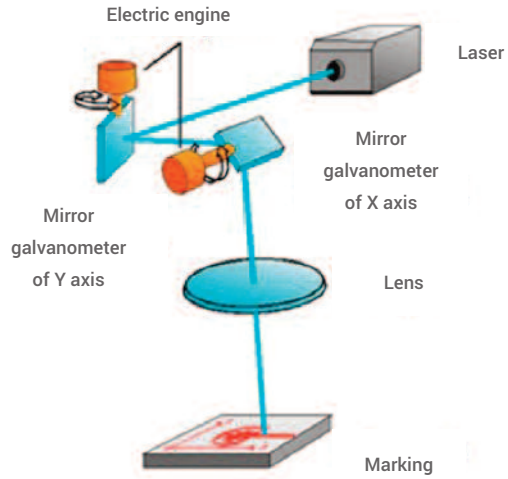


FIG.1. SCHEME OF MARKING WITH CO_2 LASER [5]

In the tests, Kromopak GC2 cardboard (producer: Mayr-Melnhof Karton, Slovenia) was used. It was produced from primary cellulose fibres (FBB) with the double chalked layer; the upper and lower layer was composed of chemical whitened cellulose and waste paper; the middle layer was mechanical mass; the composition was as follows: primary fibres – 60%, industrial waste paper – 30%, surface coating – 10%. Such cardboard is employed in packaging of cosmetics, medicinal products, personal hygiene products and foodstuffs. Technical characteristics of cardboard are given in Tab.1 [6].

Overprint on the cardboard was performed in offset sheet machine HEIDELBERG Speedmaster SM 74-5+L using Corona GA5015 ink (produced by Huber Group).

The experimental studies of laser marking process were carried out in machine of TS1390 model. The control panel of laser installation is equipped with monitor that displays the rate, power and time of work and volume of file; it also enables change of the processing parameters during the work. The driver facilitates work with the programmes: CorelDraw,

TAB.1. TECHNICAL PROPERTIES OF CARDBOARD (ACCORDING TO ISO 187)

density, ISO 536, g/m^2	350
Thickness, ISO 534, µm	572
Rigidity L+W 50 – longitudinal direction, N/m, DIN 53121	61.3
Rigidity L+W 50 – transverse direction, N/m, DIN 53121	27.2
Rigidity (L+W)/V(md x cd)	40.8
Whiteness, ISO 2470, %	87

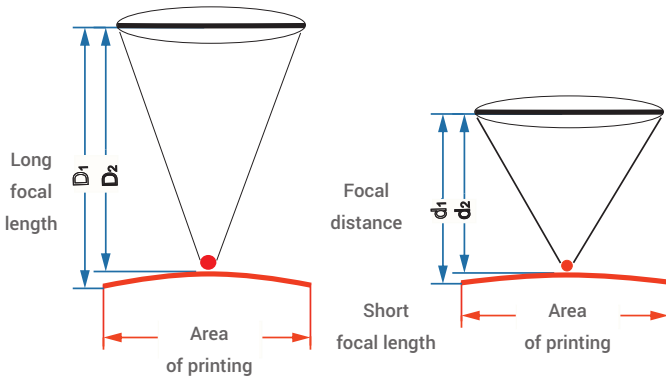
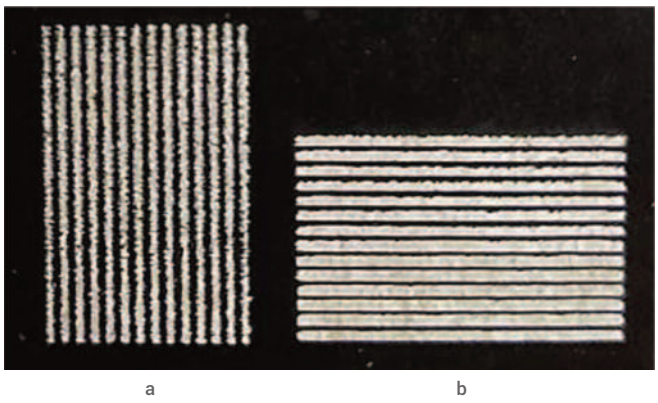


FIG.2. CALCULATION OF FOCAL LENGTH DURING LASER MARKING

AutoCad and LaserCut what ensures the effectiveness of work with the variable data (logo, bar codes, numbers, and different texts of marking and typing letters). The built-in memory allows the storage of files in laser machine and work without computer, causing the performance of the program from the memory of laser machine. The process of marking is fully automated.

Technological process of marking was conducted at the following parameters: power from 12 to 20 W and the rate of the beam motion during marking from 140 to 240 mm/s, marking step was equal to 0.635, width of the line of laser irradiation (laser seam) amounted to 0.05 – 3 mm; the frequency of laser irradiation impulses was 10 kHz. During laser marking of the packaging, the choice of focal length is the important parameter. The discussed technology allows the choice of the lens with large (Fig. 2a) and small (Fig. 2b) focal length. The larger focal distance means greater area of marking and larger focusing. The shorter focal length means smaller marking area and narrower sharpness.



a b

FIG.3. SAMPLE OF LINE OF LASER MARKING, THICKNESS OF 1 POINT IN LONGITUDINAL (A) AND TRANSVERSE (B) DIRECTION ON THE SURFACE OF CARDBOARD COPY, PRINTED WITH BLACK OFFSET INK

It is known that in order to ensure the reliable readout of bar codes, it is necessary to create the bars which will be in contrast, depending on the surface of material. To examine the coarseness of the cardboard surface without marking and in the areas of marking, the profiles were sampled in longitudinal and transverse direction. They were then evaluated on the grounds of curvature characteristic of material element according to standard DINO ENISO 13565-2. To these ends, the studies of the morphology of the surface of overprints were carried out. The studies utilized profilegraph MICRO MEASURE 3D the work of which is based upon the contactless method. Profilegraph has software, digital camera, allowing the magnification of the image of the surface of the tested sample; it enables also the visual choice of the site of measuring the roughness. The three-dimensional image is obtained as a result of multiple scanning of the surface.

The structure of the surface of the copies was examined in the light microscope BIOLAM at maximum magnification of the lens x 2500 and photography was made using a special adapter in digital camera Olympus E520 with the image resolution of 10 megapixels.

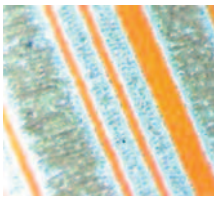
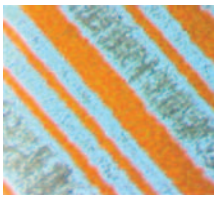
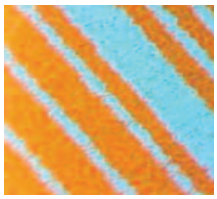
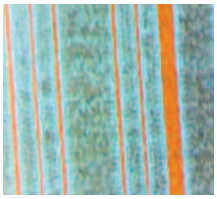
THE RESULTS OF THE STUDIES

The precision of mapping of bars and spaces which contain the indispensable coded information is the important parameter of the quality control of bar codes, determining the correctness of their verification. Quality indices, which are employed in evaluation of bar code lines, include as follows: width, density, sharpness, edge equality, etc.

All bar codes have linear parameters and their permitted deviations, specified in the standard. Bar code may be applied on different materials, so the quality of mapping the bars will be dependent on the character of their structure. The most possible deviations of geometric dimensions of bar code elements should be smaller than those admitted for the code [1, 7].

The possible shades of bar code colours are determined by the colour of internal structure of cardboard and its upper layer. The thinnest line of bar code corresponds to 1 module what

TAB.2.

Modes				
P (w)	V (mm/s)	Images generated by CO_2 laser	Photographs	Photographs
20	200			
17	200			
14	140			
12	200			
12	240			
14	240			

corresponds to 0.33 mm. Therefore, 1 mm-thick line contains 3 modules. The bar codes with the following combinations are well readable: blue on white, yellow and orange; green on white, yellow and orange, and brown on white, yellow and orange. We cannot read out red bar codes on light-green and light-brown colours, red on golden, blue and light-brown colours and orange colour on golden and yellow on white.

The task consisted in determination of technological modes of marking which were carried out at the stage of launching the earlier developed program; it should contain such modes as frequency of laser irradiation pulses; rate of the beam motion; width of laser irradiation line (laser seam); power of laser irradiation. The coordinates of marking are set in accordance with the arrangement of the future image.

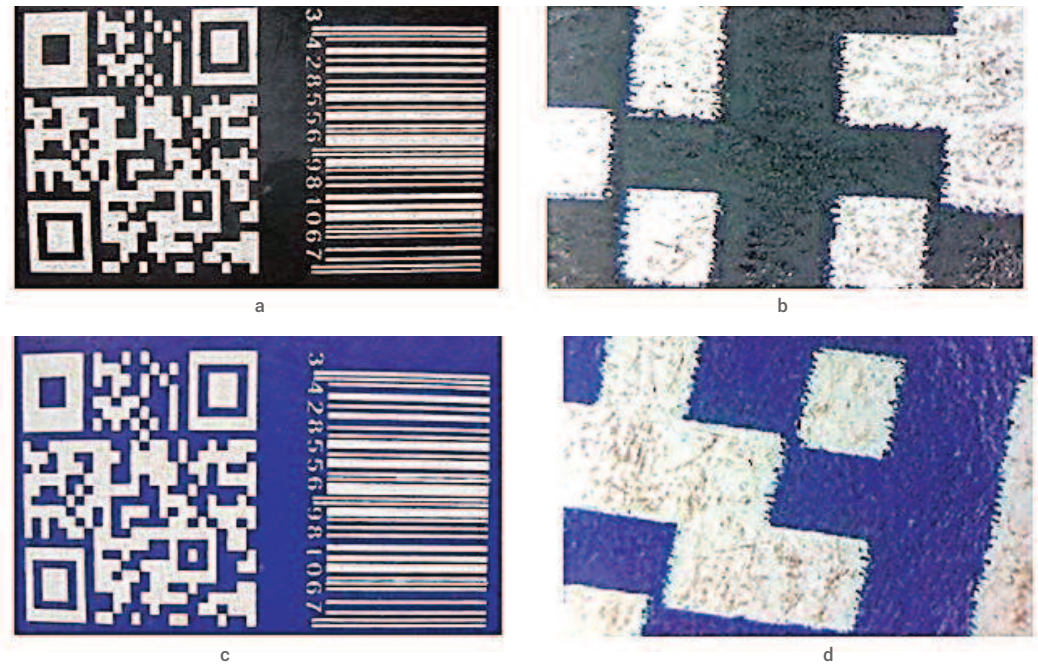


FIG.4. SAMPLES OF BAR CODES (A, C) AND THEIR MICRO-PHOTOGRAPHS (B, D X 100),
GENERATED BY LASER MARKING ON THE SURFACE OF CARDBOARD AT MODES: POWER 12 W AND RATE 240 MM/S

To evaluate the quality of the seam of laser marking, 14 lines with thickness of 1 point were marked on black background, both in longitudinal (Fig. 3a) as well as in transverse (Fig. 3b) direction in relation to the axis of laser tube.

From the analysis of the discussed marking it is followed that the lines contain the irregularities (zigzags) in both directions; and in the case of longitudinal direction, they are somewhat greater. Small precision of the line when engraving thin elements in longitudinal direction results from the fact that laser has not time for reaching the full power. The results of the measurements of line edges show that the periods of oscillation in longitudinal and transverse direction are different.

Due to above reasons, placing of packaging in transverse or longitudinal direction in relation to the axis of laser beam must be carried out with the consideration of the image character. The process of marking the bar codes QR and UAN-13 was tested on cardboard GC-2, printed on brown and orange background (Table 2).

As it is followed from analysis of bar codes, the smoothest and most equal edges of lies are ensured by the following modes of laser treatment – power of irradiation P=12W and rate V=240 mm/s where the surface layers of cardboard are destructed nut the internal structure remain intact. In connection with this fact, the following marking was performed on the cardboard materials, overprinted in black and blue colour, employing the following modes: power 12W and rate of marking 240 mm/s (Fig.4).

As a result of the tests it was confirmed that the colour of the surface of cardboard packaging had an effect on contrast and readability of marking. The contrast of codes is considerably greater on blue, black and brown background and smaller on yellow colour. The studies revealed that the presence of

FIG.5. EXAMPLE OF BAR CODE ON CARDBOARD GC-2
(MODES OF LASER MARKING: POWER P=14 W, RATE V=240 MM/S)

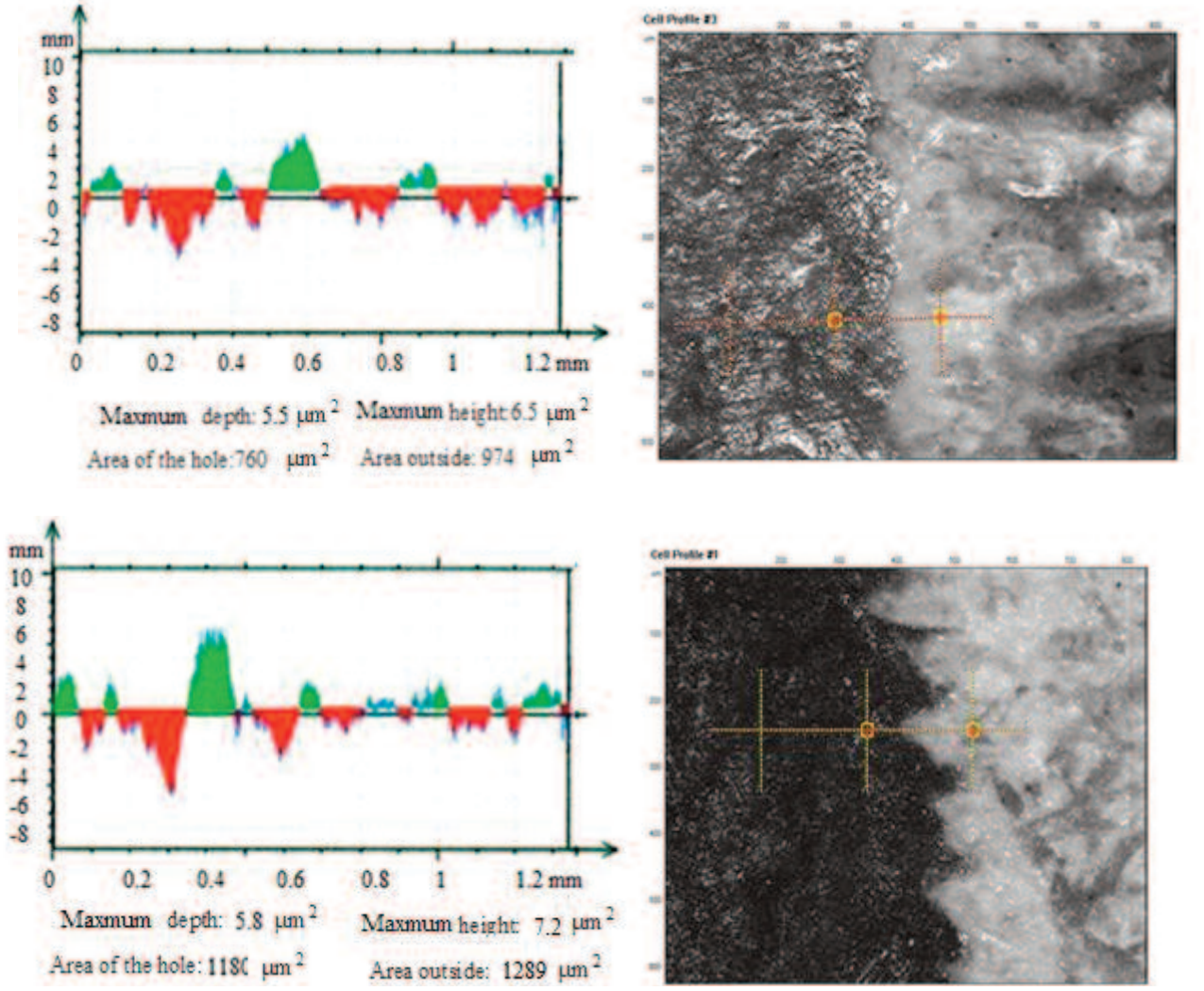


FIG.6. PROFILE OF THE AREA OF OVERPRINT (1A AND 1 B) AND TOPOGRAPHY OF SURFACE (2A AND 2 B) AT THE MODES OF LASER MARKING: A): P=12 W, V=240 MM/S; B): P=14 W, V=240 MM/S.

three-layer chalked layer on the surface of the cardboard has a positive impact on the quality of marking, increased the readability and precision of the images.

The increase of power up to 14W leads to deep removal of upper layer of ink and coating and destruction of internal structure of cardboard (Fig.5).

The quality of laser marking is affected by properties of a given material, and in particular, the structure of its surface, thermal conductivity, density, absorption capacity which is , in turn, dependent on the roughness of the surface, chemical composition of material, its temperature and presence of coating. In connection with this fact, the studies of the microstructure of cardboard surface were carried out before and after laser marking (Fig.6).

The analysis of the surface revealed the change in the roughness in the sites of laser marking. The mentioned change was also dependent on the modes of marking.

The analysis of profilegrams allowed determining the inequalities in the sites of laser marking. The results of the tests are given in Tab.2.

The examined surface of cardboard GC2-2 is characterized by the mean degree of the surface irregularity (-5.5 up to +6.5 µm) what is an evidence of uniform arrangement of structural elements of bleached and chemo-thermo-mechanical cellulose fibres and lack of large macro-irregularities. On the surface of the texture, however, we can observe partially thin, deep slots. The parameter of roughness, Ra, is equal to 0.426 µm. In the sites of laser marking, the mentioned roughness parameter (Ra)

TAB.2. MORPHOLOGICAL PARAMETERS OF OVERPRINT SURFACE

RA IS ROUGHNESS, RZ = MEAN DEPTH OF ROUGHNESS, SW = SURFACE OF CONVEXITY, SZ = SURFACE OF DEPRESSION

Cardboard GC2	Modes	Ra, µm	Rz, µm	Sw, µm^2	Sz, µm^2
Surface of overprint before laser marking	–	0.426	5.5	974	760
Surface after laser marking	P=12 Вт; V=240 mm/s	0.942	6.5	1289	1180
Surface after laser marking	P=14 Вт; V=240 mm/s	1.23	13.2	1476	2014

increases up to 0.942 µ; the surfaces of convexities Sw and depressions Sz are also increased respectively to 1289 µm^2 and 1180 µm^2 (at mode of marking – 12 W and rate 240 mm/s). In the case of laser beam amounting to 14 W, the surface Sw is equal to 1476 µm^2 and Sz increases to 2014 µm^2.

SUMMING UP

The analysis of the experimental studies revealed that the process of laser marking the bar codes includes many factors and many criteria. From the viewpoint of systemic analysis, the factors affecting the laser marking may be classified in three groups.

The first group of factors is composed directly by characteristics of the laser beam which generates a source of heat. The most important parameters of the laser beam during surface treatment are the length of the irradiation wavelength, shape and size of the focus of the "point" and character of the distribution of irradiation in the "focusing point". Depending on the power used, the mode of continuous irradiation or pulsation is possible. The pulsation work considers energy, time of action, shape and frequency of pulses; in the conditions of scanning – amplitude, frequency and possibility of scanning. Polarization is classified into linear or circular type.

The second group of factors includes characteristics of the laser substrate material and, in particular, its surface structure, thermal conductivity, heat capacity, density, absorption capacity, which, in turn, is dependent on surface roughness,, chemical composition of a given material, its temperature and the presence of coating. Chemical composition of coating, its thickness and dispersion will have, of course, the impact on the absorption process and transmission of irradiation energy.

The third group of factors covers characteristics of the conditions of laser irradiation effect exerted on material: time of the impact, kinematics of a relative motion, temperature and chemical composition of the centre and angle of the beam falling on the material's surface.

Therefore, to determine the formal relationships between the factors and parameters, the process of laser marking may be described using three-level model. It would contain the geometric parameters of codes on the higher level; the weight of the impact and effectiveness of the code readout (to facilitate verification) at the second level; the third level would contain the resistance to mechanical wearing and deformations of the image created by laser.

All the mentioned above factors have the direct or indirect impact on the quality of laser marking; therefore, they require further deepened studies.

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ACTIVE AND INTELLIGENT FOOD PACKAGING REVIEW PAPER, PART 1

ABSTRACT: In the present paper, the role and tasks of food packaging were discussed. The definitions, functions, forms and principles of intelligent and active packaging acting have been presented. The application of intelligent and active packaging in food industry has been characterized. The newer and newer generations of active and intelligent packaging are the future of food packaging systems. The development and application of new packaging generations will be greatly dependent on perceiving the benefits, coming from their utilization by the consumers. At present, the costs connected with the introduction of intelligent element into packaging are high.

Key words: active and intelligent packaging, application, food

STRESZCZENIE: W artykule przedstawiono rolę i zadania opakowań do żywności. Podano definicje, funkcje, formy oraz zasady działania opakowań inteligentnych i aktywnych. Scharakteryzowano zastosowanie opakowań inteligentnych i aktywnych w przemyśle spożywczym. Powstające coraz to nowsze generacje opakowań aktywnych i inteligentnych stanowią przyszłość opakowalnictwa żywności. Rozwój i stosowanie nowych generacji opakowań będą w dużej mierze zależały od postrzegania korzyści płynących z ich wykorzystania przez konsumentów. W chwili obecnej koszty związane z wprowadzeniem elementu inteligentnego do opakowania są wysokie.

Słowa kluczowe: opakowania aktywne i inteligentne, zastosowanie, żywność

ROLE AND TASKS OF PACKAGING

Packaging is an integral part of product, it decides on its attractiveness and quality and protects from the external conditions and possible mechanical damages. Dynamic increase of the role of packaging contributes to constant improvement of manufacturing methods and the ways of their production. The design enterprises and the companies-producers of food packaging compete with each other; invent new shapes, forms, sizes, conveniences in respect of utility function of a given packaged product (e.g. the possibility of multiple utilization of function: open, close, the way of opening etc.). The packaging companies use different packaging materials which attract the customer to their product and, in consequence, encourage to the purchase. Packaging is one of the best means of advertisement, owing to which the entrepreneur may obtain new, confidential and loyal customers. The dynamic technical and technological development and the increase of the manufacture of food processing articles contribute to a greater demand on packaging [1, 4].

The exemplified trends and technologies of fresh meat packaging for the years 2020-2028 have been given in Fig.1. They concern the type of the packaged meat (beef, poultry and pork), the employed technologies or packaging techniques (under vacuum, in a modified atmosphere) as well as the regions of the world. The mentioned prognoses include especially meat packaging in such regions as North America, Latin America and the West Europe [2, 11, 24].

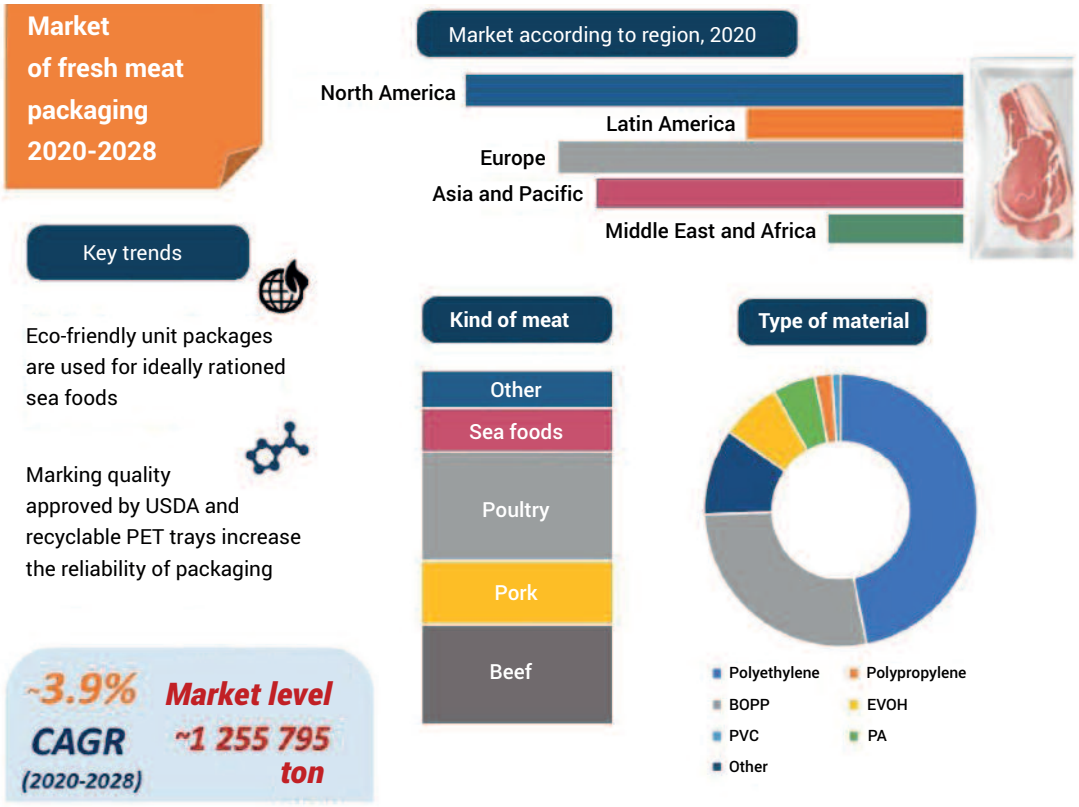

FIG.1. PROGNOSES FOR MARKET OF FRESH MEAT PACKAGING FOR THE YEARS 2020-2028 ACCORDING TO THE REPORT OF TRANSPARENCY MARKET RESEARCH [11. 24]. EXPLANATIONS: USDA – DEPARTMENT OF AGRICULTURE OF THE USA, CAGR – INDEX OF ANNUAL GROWTH RATE; BOPP – BIAXIAL ORIENTED POLYPROPYLENE; PVC – POLYVINYL CHLORIDE; PA – POLYAMIDE, EVOH – ETHYLENE-VINYL ALCOHOL

The basic task of packaging is to make a border between the packaged product and the surrounding environment. It facilitates the limitation of the impact of external environmental factors on the products inside the packaging. The traditional packaging materials such as plastics, glass or paper/cardboard are designed in such a way as to ensure their neutrality in relation to the packaged products. Modern packaging must play the additional, active functions, mainly in order to ensure the safety and high quality of the products. Such packaging contains substances which affect the atmosphere inside the packaging or have the interactive influence on the packaged products.

Each packaging should be adapted to the properties of a given product. Foodstuffs belong to a specific group of the products which are subjected to constant chemical changes (e.g. rancidity of fat, degradation of vitamins as affected by oxygen and light etc.) as well as also, physical processes (e.g. water evaporation or its absorption). Additionally, certain food products such as fish or coffee emit a strong smell, the other ones e.g. butter or bread, absorb foreign smells [15].

The expiration date (best before...) has a very significant meaning for the packaged food. It is equally important for the food consumer and the processor that the mentioned date could be as long as possible and the product inside could be safe and attractive. Unfortunately, we may state the multiplication of microorganisms, responsible for deterioration of foodstuffs, especially in the case slightly processed food products, being transported over long distances, It is, therefore, important to introduce such packaging to the market which would limit the growth of undesired microflora and ensure food safety [43].

Demographic changes, life style, environmental protection and development of outlet markets during the recent years, have contributed to newer and newer requirements in relation to packaging. On the one hand, we expect the increase of its

protective functions, preventing natural contamination, and on the other hand, protection from contamination of the packaged product. Thus, the search for new solutions such as increase of the tightness and barrier of the packaging as well as more restrictive methods of testing of the content of toxic substances in the packaging materials, generate a problem which the packaging industry is faced with.

The increasing requirements of the consumers concerning the purchase of safe, minimally processed foods as well as the extended time of its storage under the home conditions mobilize the food industry to introduce a new generation of packaging – active, intelligent or appropriate food packaging systems, adapted to a type of product.

ACTIVE AND INTELLIGENT PACKAGING

Active and intelligent packaging has been more and more frequently utilized in food industry all over the world. In Poland, the discussed generation of packaging has not been universal yet; it is not well known, as well. Nevertheless, the producers of foodstuffs become more and more interested in the mentioned above products. The application of active and intelligent packaging results also from the interest of aware consumers in high quality foods, and their health safety and their new preferences which affect the changes in the approach to food packaging [5, 17, 45]. Moreover, the development and employment of active and intelligent packaging systems in Europe contributes to improvement of competitiveness of the European foodstuffs as well as packaging industry in relation to the USA, Australia and Japan [35].

In Commission Regulation (EC) No 450/2009 of 29 May 2009, there were established specific requirements for the marketing of active and intelligent materials and articles intended to come into contact with food. It was stated that "active materials and articles" mean materials and articles that are intended to extend the self-life or to maintain or improve the condition of the packed food. They are designed to deliberately incorporate components that that would release or absorb substances into or from the packaged food ofr the environment surrounding the food [38].

INTELLIGENT PACKAGING

According to the definition given in Commission Regulation (EC) No 450/2009 of 29 May 2009,: "intelligent materials and articles mean materials and articles which monitor the condition of the packed food or the environment surrounding the food" [38]. From the definition it is followed that the task of the intelligent packaging is to ensure for the user obtaining the reliable and fair information about the conditions under which the food is stored. It refers also to integrity of the packaging. The intelligent packaging, therefore, extends the communicating function of the traditional food packaging, additionally informing the consumer about the changes, detected in the packaging or its environment [4, 15].

In contrary to the active packaging, the intelligent packaging is not aimed at release the substance to food product; therefore, it is usually placed on the external side of the packaging material and is properly separated from the product by a functional barrier, i.e. the layer which makes the migration of substance from the outside of the barrier to the product impossible.

The intelligent packaging consists in monitoring of the conditions under which the packaged food is found with the aim to deliver the information about its quality during transport and storage. Such packaging plays the following intelligent functions: detection, feeling, recording, tracing and, first of all, application of scientific logics in order to facilitate undertaking the decisions concerning extension of the shelf-life of the product, improvement its quality, delivery of information and warnings against the possible problems. The intelligent packaging does not have the impact on the foodstuffs, that is, does not release the monitoring indicators to the packaging, containing the product. It only provides the customer, seller or producer with the information about the state of the product [5, 8, 26, 50].

The intelligent materials appear mostly in a form of indicators. We can distinguish the following indicators: temperature, oxygen, freshness of the product, carbon dioxide and the presence of pathogens. The indicators give also the "history" of the temperature ("traceability of temperature") during the storage of a given product in the whole distribution chain. The principle of indicator's functioning consists in presentation of the information based upon the visual signal [6].

TAB.1. THE SELECTED APPLICATIONS OF THE INTELLIGENT PACKAGING IN FOOD INDUSTRY [4, 19, 30]

Indicator	Principle of acting	Information	Application
Gas sensor (CO_2 and O_2)	Chemical pH indicators and dyes, chamical and mechanical reactions	About the storage conditions, leakage of the packaging	Food packed in modified and controlled atmpsphere
Time-temperature (TTI)	Chemical, enzymatic and mechanical reactions	About the conditions of storage	Food product, requiring preservation of the temperature regime
Biosensor	Chemical pH indicators, dyes reacting with metabolites of microorganisms	About microbiological quality of food	Easily deteriorating foods
RFID System	Emission of radio waves	About the site of the product in the supply chain	Universal, for all types of food

At present, functions of the intelligent packaging are mainly implemented by three methods: using sensors, indicators and RFID system. The mentioned solutions differ from each other not only in construction but also the quantity and type of the data which may be introduced, downloaded as well as transferred [5].

For the discussed type of packaging, there are employed the materials which due to their specific composition absorb different compounds; it is dependent on the indicator (internal or external) which changes its colour and informs about the change in the composition of the atmosphere inside the packaging or about the changes occurring on the surface of the product itself [4]. Time and temperature integrators (TTI), freshness indicators and leakage indices may be employed as indicators [4, 14, 19].

TIME AND TEMPERATURE INTEGRATORS (TTI – TIME-TEMPERATURE INDICATORS)

The indicators of time and temperature integrator (TTI) are used with the aim of continuous monitoring of the current temperature of the product and its environment. Temperature is one of the most important factors, deciding on the appearance of unfavourable physico-chemical changes and the presence of microorganisms in the product which requires storage under refrigerator conditions e.g. in meat, fish and dairy products. The principle of TTI functioning consists in the irreversible change in its properties as affected by temperature higher than the set value, or as a result of thermal effect, accumulated during the storage and transport. The consequence of the mentioned change is visual effect, proportional to its intensity; it is most frequently expressed as discoloration of the surface of the label. It is especially important in the case of frozen products and chilled food, e.g. fresh meat, stored in a cold room or a frozen product. The mentioned indicators allow, inter alia, registration of temperature rise in the cold room or temporary thawing of the product what causes the change in the colour of the indicator. IIT enables also monitoring of any deviations from optimum temperature during the total distribution period and, simultaneously summing up their intensity and time of occurrence. Signal of integrator informs indirectly about the abbreviation of the period, being safe for the quality of the time of food storage [13, 23].

The application of time and temperature indicators (TTI) which are reliable, precise and characterized by a relatively simple construction, allows forecasting the remaining period of the shelf-life of the food product, based on the time of its exposure to the temperature above the admitted values. TTI indicators facilitate the mentioned control in the case unit products [45]. The principle of their functioning consists in the irreversible change in colour, as affected by too high temperature. The mechanism of the discussed change of colour relies on the chemical and/or microbiological reactions [4, 32]. At present, all over the world, there are known following three types of integrators:

– Life Line™ - is consists of polymer, being situated inside a circle, surrounded with a reference ring. The darker colour

of polymer in the central part informs the consumer that the packed product is not suitable for consumption due to the expiration date which is placed on the packaging;

- 3M Monitor Mark® – signalizes the change, e.g. in temperature by a coloured ring (or band) moving on a white background. It is an effect of physical diffusion of the solution with the chemically changed colour. Such type of indicator signalizes the moment of exceeding the temperature higher than that one which is recommended for the product to maintain the appropriate quality. The mentioned moment is signalised by a red colour of indicator;
- Label Vitsab® – activation of the indicator occurs by destruction of the partition between two elements, i.e. liquid containing the lipolytic enzyme and its lipid substrate and pH indicator. Together with the change in pH value, the dye added to the system changes the colour from green into sharp-yellow or orange-red.

TTI indicators are already employed for packaging of food requiring refrigeration in many European countries. The self-adhesive labels may be found, inter alia, on packaging with fresh meat, butcher's products, poultry, fish, salads and dairy products [4, 5, 31, 32].

FRESHNESS INDICATORS

Freshness indicators are the second group of intelligent packaging. They differ mainly from TTI (time-temperature integrator) in that the quality of the product is signalised by direct reaction to the change in the composition of the atmosphere inside the space of the packaging, or to the changes occurring on a surface of the product itself. Freshness indicators detect the presence of metabolite of microorganisms such as carbon dioxide, sulphur dioxide, ammonia, amines, hydrogen sulphide, organic acids, ethanol, toxins and enzymes. In the discussed method, there are used electronic and optical detectors and also, colour compounds generated in reaction with the substances absorbed from the inside of the packaging. Labels Fresh Tag®, intended for signalizing freshness of fish and fish products and of the packed poultry elements have been most widely applied. They contain plastic liner with the ring fixed inside (from the side of packaging). The ring contains chemical substance, being in a direct contact with the gases, which diffuse from the inside of the packaging and it creates a colour reaction with volatile amines, resent in the gas. Together with the increase of amine concentration, the sharp-yellow stain is shifted on thermometric scale of the ring, thus determining the quality of e.g. meat product. There are also the systems, reacting to different types of pathogenic bacteria, e.g. *Salmonella spp.*, *Campylobacter, Listeria spp.*, or *Escherichia coli* [4, 6, 46, 47].

The advantages of the indicators of such type include relatively simple construction, low cost, practically lack of the possibility of any interference (manipulation). The drawback may cover the necessity of performing the additional protection during packaging, often short period of their functioning, so such instruments must be properly stored on packaging before their installation [6].

INDICATORS OF LEAKAGE (FAILURE OF TIGHTNESS)

In the packaging which is not hermetical, the protecting effect of modified atmosphere on the product is decreased and the microbiological and health danger for the consumer is increased. The indicators of measurement of oxygen and carbon dioxide content in the packaging may be used for monitoring of food quality, in particular, meat and meat products, fish and fish products and dairy products. The principle of functioning of the discussed indicators consists in the change of their colour as a result of chemical or enzymatic reaction. Blue methylene is the most frequently employed oxidising-reducing colour in tightness indicators in relation to oxygen. Indicators of carbon dioxide serve for monitoring of the amount of the mentioned gas e.g. in meat products, packed in MAP atmosphere. The example of CO_2 indicator is, for example, Reflex indicator, produced in a form of label. The mentioned indicator is used for determination of the desired composition of gas mixture and identification of shortcomings connected with the improper functioning of gas supplying equipment [17, 24, 31, 39].

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STEFAN JAKUCEWICZ, D.Sc., Ph.D., PROF. EMERITUS

11TH EDITION OF SAFE PACKAGING CONFERENCE

On 17-18 November 2022, the Eleventh Conference: Safe Packaging" was held. The mentioned event came back to Sopot after 4 years but this time, the place of the meeting was Sheraton Hotel.

The mentioned Conference was, as usual, organized by editorial offices of monthly magazines Opakowanie and POLIGRAFIKA. During the event, eleven lectures were delivered and one discussion panel was arranged. The Conference lasted for two days – the second day was destined for visit at J.S. Hamilton Laboratory in Gdynia. It was attended by more than 200 participants.

The partners of this year's edition were the following companies: Bank Pekao SA, Bobst, eProductivity Software, J.S. Hamilton, Heidelberg, Hubergroup, Kurz, Metsä Board, PC Print, Vinfoil and ML Polyolefins. On Wednesday (16 November) at the evening, J.S. Hamilton Laboratory organized the welcome cocktail party for the participants of the Conference at the legendary Sopot SPATIF.

During the conference, 10 very interesting lectures on a very high professional level were delivered. The mentioned lectures were classified into three problem blocs; after each of them, the session of questions and answers was arranged. The subjects of the presentation were, as usual, connected with the widely understood conception of "safe packaging".

Traditionally, each of the speakers understood the mentioned problem in a different way, so the presentations concerned different subjects. As being the person who has held all so-far organized conferences, I may state that the subjects presented during the present edition, were very interesting, modern and on a high professional level. Year by year, the mentioned level goes up and the range of the conceptions of safe packaging becomes wider and wider.

In the first block, 3 lectures were delivered (including 2 doubles with different problems but approximating to the main lecture).

The first speaker was **Andrzej Kunstetter from Heidelberg** Poland who presented very interesting lecture: **"Safe and eco-friendly design of packaging"**. It was the presentation of safety of packaging from the beginning of its production. The Author indicated the critical moments (points) during design of cardboard packaging where the committed error eliminated a given packaging from further process or made it practically unsuitable. The discussed lecture indicates and classifies (as a catalogue) the sites – points of the design process which are most crucial for the whole process of manufacture of cardboard packaging and during which any mistakes or errors should not take place. The presentation of **Marek Chmielewski** was a short supplementation of the discussed lecture. It showed the safety of the product owing to the protection with self-adhesive label (with hologram, QR code, special inks, etc.). In the opinion of the author, the intact label is only an evidence of non-opening of the package but it does not give a guarantee of authenticity of the packaged product. Nowadays, all self-

adhesive protections of this type, being called seals, are very easy to become falsified. The Author suggested solution "Multidot" to be printed on self-adhesive label (seal). It is the solution of Heidelberg company, serving the needs on respect of hidden marking and protection of the products for the benefit of producer and consumer. Everything may be falsified but Multidot is more difficult and at present, unprofitable for the counterfeiters.

The successive appearance entitled **"Whether improvement may be eco-friendly? Trends in packaging manufacture"** by **Paweł Kusiński from Vinfoil company** and by **Marcin Suchocki from PC Print** concerned cold transfer embellishment of packaging (packaging overprints), material and machines for running the mentioned above process. It also indicated the decrease of the loads for the environment in connection with the application of new materials. The Dutch company Vinfoil is the producer of machines for cold transfer. Since 2007, it has produced as many as 95 mentioned machines. In Poland, there are 6 installations. The difference between the cold transfer and cold foil consists in the fact that in the first case, only aluminium pigment of 2 µm thickness is transferred from protective foil, having also thickness of 2 µm. In the case of cold foil (cold stamping) we have to deal with the protective foil PET 12 and the laminatede surface in the case of the complete coating. In cold transfer, only ca. 2 g/m^2 of pigment (most frequently, dyed aluminium) is transferred on the packaging what gives thickness of 2 µm. Paper (cardboard) packaging with such quantity of pigment is suitable for recycling. The process of cold transfer may be also performed


ANDRZEJ KUNSTETTER


MAREK CHMIELEWSKI


PAWEŁ KUSIŃSKI


MARCIN SUCHOCKI


MIROSŁAW KOTT


PAWEŁ KOCIK

in printing machines, having two towers or two free printing assemblies. In the first set, glue is laid on and the transfer of pigment layer from the foil is carried out. In the second set, lacquer is laid. At present, there are already protective foils of 6 µm thickness instead of 12 µm cold foil. It means a sustainable development: 6 µm less of PET foil as waste. All materials, as being described above, are produced by Kurz company.

The third presentation included two lectures of the representatives of **Bobst company**. **Mirosław Kott** delivered the lecture: **"Era of digital production from BOBST Connect"**, dedicated to remote digital supervision of machines by Bobst company during their production and their remote diagnosing and repair. BOBST Connect is a complex digital solution, increasing productivity of packaging manufacture. It was designed with the aim to utilize the data, generated by machine, improving quality and output in the whole production cycle.

The discussed equipment offers many functions and functionalities which may help to optimize production at each stage.

The second lecturer, **Paweł Kocik** presented the lecture **"NOVAFOIL 106: the successive step in the evolution of hot-stamping"**. It is the newest equipment for hot-stamping, produced by BOBST company. Until now, 6 machines of this type have been produced. There is no such installation in Poland yet. The discussed machine is characterized by a lower energy consumption and lower working temperature. NOVAFOIL 106 machines are characterized by vertical (longitudinal) direction of hot-stamping and transverse (perpendicular to the previous one) direction. It is a novelty, allowing a considerable saving of energy and materials (foils in this case). Hot stamping, in this case, is functioning independently in both mutually perpendicular directions. It is also saving of foil and its carrier.


KRZYSZTOF MRÓWCZYŃSKI


MONIKA NOJSZEWSKA


PIOTR ORLIŃSKI

Briefly speaking, we obtain a considerable reduction of the waste.

After lunch break, the **Head of the Department of Macro-economic Analyses, Krzysztof Mrówczyński**, presented the lecture, which was developed by the team of analysts from Bank Pekao SA. Its title was: **"Sector of packaging in the period of economic turbulences"**. In the mentioned lecture, financial situation of packaging sector in Poland and in the EU, with the particular highlighting of the sector of packaging made from wood and paper was discussed. The situation in the whole mentioned sector with the classification into particular types of packaging materials was presented. Summing up of the lecture included the developmental perspectives for packaging sector in 2023. The lecture contains several dozen figures and diagrams; the decision-makers of the packaging sector should get familiarized with e development of Bak Pekao SA.

The next appearance was entitled: **"Good data are the way to the right decisions"** by **Monika Nojszewska from eProductivity Software**. The mentioned above company (ePS) is the world leader in the field of complex software solutions for packaging sector. The Author presented the continuously developing system of solutions for packaging and print under the name of Packaging Suite. It is a modular workflow system, developed for the producers of cardboard boxes, labels, wide film and extruded products. The names of the particular segments correspond with the names of the sections in the company.

ERP (Enterprise Resource Planning) Radius is a heart of the system. It collects the data from the manufacturing hall (BI, Business Intelligence) and gathers them at a real time (AC4D). In general, the Radius system for packaging includes: marketing, obtaining of order (e-commerce, CRM (customer relationship management), production management (pricing, order management, ordering of work, due invoices, tools, purchase, resources management, costs). The first three sections are named "Integration with Pre-press Esko/Hybrid". The successive parts of ERP Radius system include pre-production (planning, connection of the work, prepress) and data collection (AC4D). The mentioned sections are integrated with financial systems. The successive departments (Data Collection and Postproduction) create the reports "Business Intelligence (BI). The utilization of the systems, collecting the precise data at a real time and BI with their registration and analysis of the

ROBERT KUCZERA

ADAM FOTEK

EMILIA TARŁOWSKA

THE FINAL ITEM ON THE PROGRAMME WAS A PANEL DISCUSSION ON "THE ROLE OF PLASTIC PACKAGING AND PACKAGING WASTE IN A CIRCULAR ECONOMY" THE SITUATION ON THE PLASTICS RECYCLING MARKET WAS DISCUSSED BY: EMILIA TARŁOWSKA, DARIUSZ SYKUTERA PH.D., AND KRZYSZTOF NOWOSIELSKI. THE DISCUSSION WAS MODERATED BY ANNA NARUSZKO

process effectiveness facilitates obtaining of the so-called good data, i.e. complete information on production and its control.

The successive lecturer, Piotr Orliński from Metsä Board submitted the lecture **"Business safety owing to the appropriate choice of substrates"**. The cooperative Metsälitto is the owner of Metsä Board. Its members, in the number of ca. 100 000 persons, are the owners of the forests. The mentioned fact has an impact on the total manufacturing activity of Metsä Board. In connection with it, the multi-layer cardboards and liners are produced from primary fibres (cellulose and BCTMP – bleached chemi-thermomechanical pulp), deriving from processing of wood, obtained from own plantations. The wood comes from certified forests and is a renewable raw material. The choice of such raw materials and replacement of plastic coatings with natural ones produced on their own guarantees and assures the possibility of producing the cardboard packaging intended to be in direct contact with the foodstuffs. Metsä Board produces multi-layer cardboards of FBB (folding boxboard) type in four variants: natural non-coated, coated with optical bleaching agent, coated without optical bleaching agent and coated of premium type. There are also produced cardboard for gastronomy FSB (food service board) and white liners. In production of barrier cardboards, the barriers made from plastic materials have been replaced, in certain cases, by the barriers produced from natural substances. Idea of the company consists in production of light (reduction of the weights) and, at the same time, rigid cardboards by the appropriate choice of raw materials and structure of cardboard. The products of Metsä Board concern are identifiable and are characterized by a repeatable quality, they are suitable for recycling; owing to the application of sustainable development, their production is characterized by relatively small carbon footprint, decreasing year by year.

The successive appearance was dedicated to inks for printing on packaging of foodstuffs. The lecture "**Responsible choice of the components for production of food packaging"** was delivered by **Robert Kuczera from hubergroup Polska**. The mentioned lecture was dedicated to discussion of the inks which serve for overprinting of food packaging. Generally, they are inks named MGA (abbreviation of German phrase: Migration und Geruch Arm, what means inks with a low migration level and low own smell). hubergroup concern has been occupied in production and studies of MGA inks for 30 years. Just 30 years ago their first offset series was developed. Nowadays, there are produced offset MGA inks for printing of food packaging, together with the special additives and acrylic lacquer. Instead

of vegetal and mineral oils, the discussed inks contain special esters of fatty acid HV. The mentioned esters possess the branched particle which blocks their migration throughout the pores of paper. MGA inks do not contain classical metallic siccatives. MGA Natura inks are especially produced for foodstuff packaging. There is also available MGA UV intended for sheet offset and MGA Flexo UV for flexographic printing. The recent achievements of hubergroup include sheet offset inks MGA DFC for packaging in direct contact with food products. The lecturer presented a series of inks with different properties, destined for printing of food packaging which, depending on the requirements, may be consciously chosen by the printer.

Adam Fotek from J.S. Hamilton was the successive speaker. In his lecture entitled **"What we should pay attention to when evaluating the printed packaging intended for food products?"**, he presented the most important changes and trends with which we will be encountered in the nearest future. They include as follows:

- publication of German regulations concerning inks and lacquers;
- development of the change in Annex 10 to Swiss Ordinance;
- French rules concerning MOSH/MOAH;
- changes in SUP (Single-Use Plastics);
- increase of the participation of plastics coming from recycling;
- Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment;
- meeting of the Committee of Technical Adaptation of SUP;
- products manufactured by the water dispersion technology shall be considered as plastics and, therefore, shall be covered with the range of SUP Directive 2019/904.

The last professional item of the Conference agenda included **discussion panel "The role of plastic packaging and plastic packaging waste in the circular economy"**, organized by **ML Polyolefins**.

The situation on the recycling market was discussed by the following participant: **Emilia Tarłowska, Manager of Communication and Public Relations in Plastics Recyclers Europe**, **Prof. Dariusz Sykutera from the Faculty of Production Technologies of Bydgoszcz University of Technology and Krzysztof Nowosielski, commercial director and the proxy at ML Polyolefins**. Emilia Tarłowska delivered a short presentation, illustrating the present legal status – it will be the subject of a separate article. The discussion was guided by **Anna Naruszko, the Editor-in-chief of two monthly magazines**: POLIGRAFIKA and Opakowanie. During the discussion, it was stressed that the new regulations concerning recycling, including mechanical method of PET treatment and the methods of recycling in the circular economy system have been introduced. The interlocutors wondered from where the recyclers would gain the material for processing.

The mentioned discussion was professional and fruitful.

After dinner, the ceremony of granting the PCE (Packaging Circular Economy) certificates was organized by ML Polyolefins company.

On November 18, after breakfast, there was organized a visit to Laboratory J.S. Hamilton. Its aim was to get familiarized with the newest research tools and their capabilities. The equipment made a very high impression on the visitors.

ANNA NARUSZKO, M.Sc.

K 2022 – INNOVATION DRIVER FOR THE GLOBAL PLASTICS AND RUBBER INDUSTRY

Multitude of concrete solutions, machines and products for the transformation towards a circular economy were presented at K 2022, that took place October 19th-26th 2022 in Messe Düsseldorf.

K in Düsseldorf has once again fulfilled highest expectations. It continues to be the most international, complete and innovative trade fair of the global plastics and rubber industry – says **Erhard Wienkamp, Managing Director at Messe Düsseldorf**. – *The trade fair has impressively demonstrated just how valuable face-to-face networking, chance meetings and physical brand and product experiences are. We are very satisfied to see that K 2022 succeeded in sending out strong signals as an innovation driver of the industry and that our exhibitors did business with a high number of international customers with great decision-making powers.*

176,000 trade visitors from all continents travelled to their most relevant sectoral event in Düsseldorf. At over 70% the proportion of international guests at K 2022 remained at a constantly high level.

The verdict from **Ulrich Reifenhäuser, Chairman of the Exhibitor Advisory Board at K 2022**, is also very positive: *After hardly any trade fairs could take place worldwide also on a national level over the past three years, K 2022 was all the more eagerly anticipated as the world's No. 1 trade fair of the plastics and rubber industry and succeeded in providing fresh impetus in all sectors of our industry. The many, in part, unexpected concrete contract negotiations held at the trade fair speak for themselves!*
The current unpredictability and uncertainty of events does make for a tight situation in the sector overall, but this did not

do any harm to exhibitor commitment and visitor interest, quite on the opposite: *Especially now in turbulent times and where the plastics industry is undergoing transformation towards the circular economy K 2022 was the ideal place to jointly and actively chart the course for the future*, sums up Ulrich Reifenhäuser.

It was especially the wealth of new technology developments that raw materials producers, machine manufacturers and plastics processors presented for implementing the circular economy, resource conservation and climate protection that thrilled the trade visitors. Commenting on this Ulrich Reifenhäuser says: *It can be clearly felt that all companies have embraced the need to take on social responsibility and think about plastics in a sustainable way from the beginning of the process chain. The variety of solutions, machinery and products for transformation towards a circular economy presented at K 2022 was incredible.*

The trade visitors at this year's K travelled from 157 nations to the Rhine. Next to Germany, those European countries strongly represented on the visitors' part included the Netherlands, Italy, Turkey, France, Belgium, Poland and Spain. With 42% of visitors coming from overseas, the reach of K is as high as usual among the international trade audience. While visitors from the East Asian region, in particular, were less well represented than at K three years ago due to the currently more difficult conditions in those countries on account of quarantine regulations, numerous visitors from the USA, Brazil and India were welcomed at K 2022.

For around two thirds of all visitors polled machinery and plant construction ranked first in terms of interest. 57% and, hence 5% more than at K 2019, said they were interested in raw and auxiliary materials, with recyclates and bioplastics being particularly popular. For 28% semi-finished products and technical parts made of plastics and rubber were the main reason for coming (multiple responses possible). Over 70% of all visitors come from top and middle management.

Top marks were given by visitors to K 2022 for the completeness of its ranges and its mapping of the entire supply chain. 98% of all professionals stated they had fully achieved the goals associated with their visit.

During the eight trade fair days it became clear that this year's K was right on target with its selection of hot topics, circular economy, climate protection and digitalisation. In terms of investment intentions, machinery and equipment for processing and recycling stood out at 43%. The focus was particularly on sustainability, but also on circular economy and energy/ /resource efficiency in production. Around 40% of decision-makers said they were looking into the topic of decarbonisation.

IN TERMS OF INVESTMENT PLANS, MACHINERY AND SOLUTIONS FOR PROCESSING AND RECYCLING WERE INDICATED BY 43% OF RESPONDENTS.

SUSTAINABILITY WAS THE MAIN FOCUS, AS WELL AS CIRCULAR ECONOMY AND ENERGY/RESOURCE EFFICIENCY IN PRODUCTION.

THE CURRENT UNPREDICTABILITY AND GEOPOLITICAL UNCERTAINTY IMPACT PLASTICS INDUSTRY, BUT THIS HAS NOT HURT EXHIBITOR ENGAGEMENT AND VISITOR INTEREST.

The K specials, which also focused on the three hot topics, were also very well received. The official special show, 'Plastics Shape the Future', focused on the economic, social and ecological challenges and potential solutions around the K guiding topics in high-calibre discussions and lectures, and this show was well attended throughout. The Circular Economy Forum, where the VDMA and 13 of its member companies impressively demonstrated the importance of technology in the implementation of the circular economy in the plastics industry, scored points with the international audience with live demonstrations and a great deal of well-founded knowledge as well as detailed information on the topic.

At this year's K in Düsseldorf, there was also a lot of discussion about the global production language, OPC UA. This standard allows the processing parameters of the machinery and equipment involved to be coordinated more precisely and in a more targeted manner. This, in turn, is considered an important prerequisite for optimised circular management. 40 companies from eight countries participated in an OPC UA demonstration project at the trade fair.

At the Science Campus both exhibitors and visitors at K 2022 were provided with a condensed overview of scientific activities and findings in the plastics and rubber sector. Numerous universities, institutes and funding bodies offered opportunities for direct dialogue here.

The offer of the Plastics Training Initiative (KAI) was used by many pupils, trainees and students to gather information on the job profiles and career opportunities in the plastics industry. The next K Düsseldorf will be held from 8 to 15 October 2025.

176,000 TRADE VISITORS FROM ALL CONTINENTS TRAVELLED TO THEIR MOST RELEVANT SECTORAL EVENT IN DÜSSELDORF. AT OVER 70% THE PROPORTION OF INTERNATIONAL GUESTS AT K 2022 REMAINED AT A CONSTANTLY HIGH LEVEL.

Packaging Review

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  - ensure that there is no conflict of interests – they should have no personal relationships or business relations with Authors,
  - keep any information regarding the content and opinion confidential.
- When the Reviewers are chosen, the Editor-in-Chief sends them a written offer with either a short description or an abstract of the article, defines the range of reviews and sets a deadline.
- If the Reviewers accept the offer, the Editorial Board provides them with a full version of the article and an obligatory peer review report.
- Reviewers' personal details are classified and they can be declassified only at the Author's request and with the reviewer's permission in case the review is negative or the article contains arguable elements. Once a year, the Editorial Board publishes in its journal the full list of the Reviewers cooperating with the journal.
- Once the review process is complete, the Reviewer delivers electronic version of the review by e-mail and the Editorial Board:
  - informs the Author that the review has been submitted to the journal (when the reviewer states that the article does not require corrections or it requires only minor editorial corrections),
  - forwards the review with critical comments to the Author, who is encouraged to make corrections suggested by the reviewer. If the Author disagrees with certain remarks, he/she is under obligation to prepare response letter substantiating his position.
  - sends the revised article to the Reviewer again, if the Reviewer finds it necessary.
- The Editorial Board makes the final decision about publishing the article based on analysis of the review and the revised version of the article that the Author has resubmitted.
- If one of the reviews is negative, the Editor-in-Chief makes decision about rejection of the article or invites an additional reviewer so as to get an extra opinion before making a decision. When both reviews are negative, the Editor-in-Chief rejects the article.
- The final version of the article is sent to the Author.
- Non-scientific articles do not need to be reviewed and they are accepted for publication by the Editor-in-Chief.

INFORMATION FOR THE AUTHORS

We kindly ask to submit to the editorial office author's application form available at www.packagingreview.eu with contact details, a title of the proposed article, number of pages, illustrations and tables as well as a brief abstract. After receiving information about the acceptance of the proposed article please submit the entire text prepared according to the editorial instructions as well as a complete declaration form. Submitted articles are subjected to editorial assessment and receive a formal editorial identification number used in further stages of the editorial process. Every submitted article is reviewed. Publication is possible after receiving positive reviews.

GUIDELINES FOR PREPARING THE ARTICLES

- Articles for publication in „Packaging Review" should have scientific and research character and focus on innovations, trends and challenges of the industry.
- Articles must be original, not previously published (if the article is a part of another work i.e. PhD thesis, habilitation etc. the information about that should be placed in the reference section).
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- If the problem is extensive, it should be it split into few articles for separate publications.
- Articles should be of a clear and logical structure: the material should be divided into parts with titles reflecting its content. The conclusions should be clearly stated at the end of the paper.
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- The article should not exceed 10 pages (1 page – 1 800 characters).
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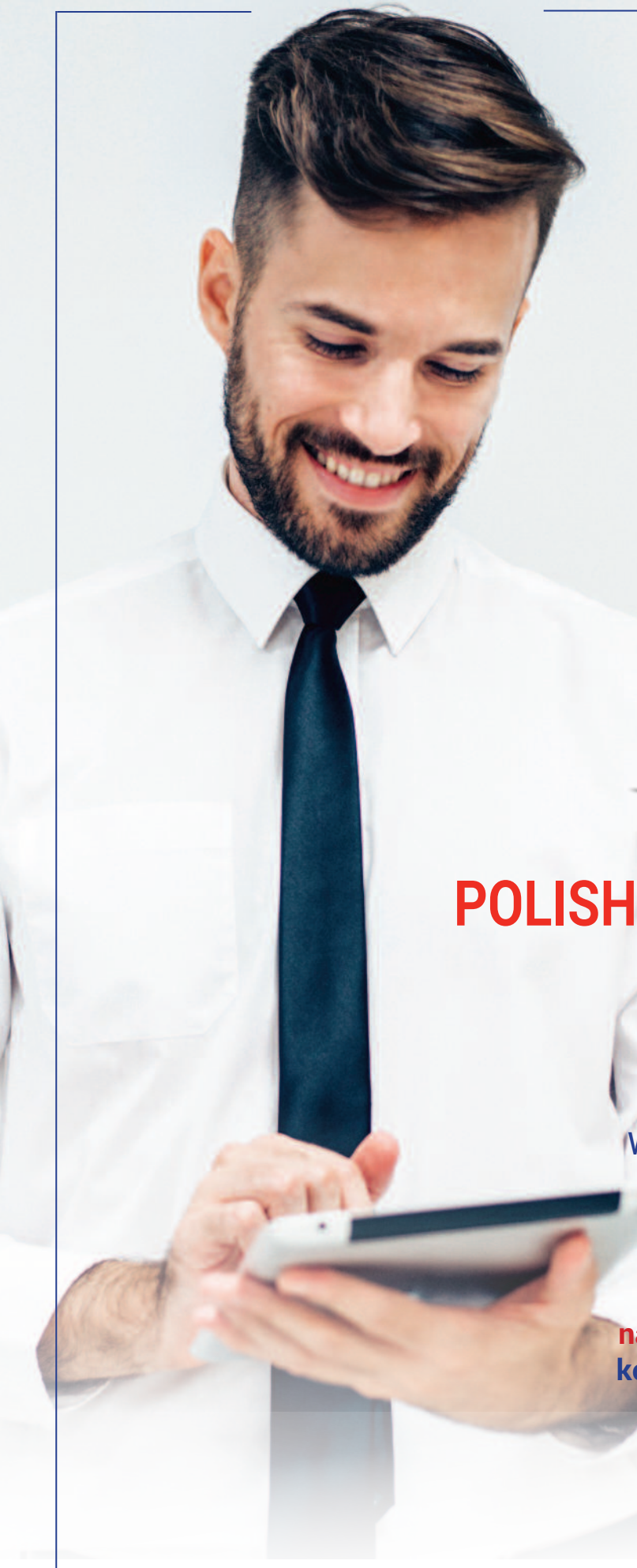

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