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ANALYSIS OF ENVIRONMENTAL IMPACTS OF COSMETIC PACKAGING USING LIFE CYCLE ASSESSMENT

Safe packaging CONFERENCE 15

November 5-7th, 2025

SOPOT

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Dear Readers!

The 15th edition of the "Safe Packaging" conference, organized by Alfa-Print publishing house, will be held on November 5-7 at the Sheraton Hotel in Sopot.
Over the years, the concept of "safe packaging" has evolved and changed its scope at successive events. Fifteen years ago, attention was mainly paid to the quality of packaging in the context of protection and recognition of the packaged product and the usability of the packaging itself. Great emphasis was placed on the barrier properties of the packaging and the migration of various compounds into and out of the packaging.
Today, in accordance with EU trends, most of the speeches are devoted to the environmentally sustainable production of packaging, which translates into protecting the environment from excessive waste. I am convinced that this year's conference will continue this direction. This approach to packaging safety is an attempt to replace most plastic packaging with paper products and film barrier coatings with coatings based on natural raw materials, i.e. plant extracts and processed natural materials such as starch. The trend of the future is also to minimize production waste by using artificial intelligence to control production processes.
We are already inviting you to the 15th edition of the Safe Packaging Conference – save November 5-7 in your calendars!

Stefan Jakucewicz, D.Sc, Ph.D, Prof. emeritus Warsaw University of Technology. A graduate of Łódź University of Technology in the field of cellulose and paper technology, as well as Warsaw University of Technology in the field of printing. From 1974 he was a researcher at TU Warsaw. Since September 2018 he has been a pensioner. The editor of the sections in the periodicals: Opakowania (Packaging) and Przegląd Papierniczy (Paper Review). Research interests: printing materials science, paper technology and printing techniques of various substrates, with particular emphasis on plastics and the production of printed packaging, production of banknotes and postage stamps (security prints), certification of new base materials for both classic and digital printing techniques. Author or co-author of over 300 scientific articles published in Ukrainian, Slovak and German national journals, and 70 scientific and scientific-technical books published in Polish, German, Slovak and Ukrainian.

Drodzy Czytelnicy!

W dn. 5-7 listopada br. w hotelu Sheraton w Sopocie odbędzie się 15. edycja konferencji „Bezpieczne Opakowanie", zorganizowanej przez wydawnictwo Alfa-Print.
W ciągu lat pojęcie „bezpieczne opakowanie" ewaluowało i podczas kolejnych wydarzeń zmieniało swój zakres. Piętnaście lat temu zwracano uwagę głównie na jakość wykonania opakowania w kontekście ochrony i rozpoznawania pakowanego produktu oraz użyteczność samego opakowania. Duży nacisk kładziono na właściwości barierowe wykonanych opakowań oraz migracja różnych związków do i z opakowania.
Dziś zgodnie z unijnymi trendami większość wystąpień poświęcona jest zrównoważonej środowiskowo produkcji opakowań, co się przekłada na zabezpieczenie środowiska przed obciążeniem odpadami. Jestem przekonany, że tegoroczna konferencja będzie kontynuowała ten kierunek. Takie podejście do bezpieczeństwa opakowań jest próbą zastąpienia większość opakowań z tworzyw sztucznych produktami papierowymi oraz foliowych powłok barierowych powłokami opartymi na surowcach naturalnych tj. wyciągach roślinnymi i przetwarzanych materiałach naturalnych np. skrobi. Trendem przyszłości jest też minimalizacja odpadów produkcyjnych dzięki zastosowaniu sztucznej inteligencji do sterowania procesami produkcyjnymi.
Już dziś zapraszamy na 15. edycję konferencji Bezpieczne Opakowanie – zapiszcie Państwo 5-7 listopada w swoich kalendarzach!

Dr hab. inż. Stefan Jakucewicz, em. prof. PW. Absolwent Politechniki Łódzkiej w zakresie technologii celulozy i papieru oraz Politechniki Warszawskiej w zakresie poligrafii. Od 1974 roku pracownik naukowo-dydaktyczny Politechniki Warszawskiej, od września 2018 emeryt. Redaktor działowy w czasopismach „Opakowanie" i „Przegląd Papierniczy". Zainteresowania naukowe: materiałoznawstwo poligraficzne, technologia papieru oraz techniki drukowania różnych podłoży ze szczególnym uwzględnieniem tworzyw sztucznych i produkcji opakowań drukowanych, produkcji banknotów oraz znaczków pocztowych (druki zabezpieczone), atestacja nowych materiałów podłożowych przeznaczonych tak do klasycznych, jak i cyfrowych technik drukowania. Autor lub współautor ponad 300 artykułów naukowych opublikowanych w czasopismach krajowych, ukraińskich, słowackich i niemieckich oraz 70 książek naukowych i naukowo- technicznych wydanych w językach polskim, niemieckim, słowackim i ukraińskim.

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ANALYSIS OF ENVIRONMENTAL IMPACTS OF COSMETIC PACKAGING USING LIFE CYCLE ASSESSMENT (LCA)

ANALIZA WPŁYWU OPAKOWAŃ KOSMETYCZNYCH NA ŚRODOWISKO Z WYKORZYSTANIEM METODY OCENY CYKLU ŻYCIA (LCA)

ABSTRACT: This article examines the environmental aspects of cosmetic packaging, with a focus on the application of Life Cycle Assessment (LCA) as a tool for understanding its impacts on the environment and guiding eco-design strategies. LCA methodologies provide a comprehensive framework to evaluate packaging materials, from production to disposal, enabling the comparison of traditional and innovative solutions, such as the implementation of (bio)degradable polymers and/or recycled materials in cosmetic industry packaging. Recent advancements in packaging design and recycling technologies have contributed to improvements in resource efficiency and waste reduction. However, there are still challenges in applying LCA methods consistently, particularly when assessing bio-based materials. By incorporating eco-design principles, promoting recycling, and utilizing LCA insights, the cosmetics industry can work towards reducing its environmental impact and promoting more sustainable practices. This paper emphasizes the necessity for ongoing innovation and interdisciplinary collaboration in the development of sustainable packaging solutions that optimize the functional properties of materials while aligning with consumer demands and minimizing negative environmental impact.
Key words: sustainable cosmetic packaging; recycling; (bio)degradable polymers, life cycle assessment; LCA; eco-design

STRESZCZENIE: W niniejszym artykule przedstawiono zagadnienia związane z oceną cyklu życia (z ang. Life Cycle Assessment – LCA) w zakresie opakowań kosmetycznych oraz ich wpływu na środowisko, jak również wspierania strategii eko-projektowania.
Metodologia LCA stanowi kompleksowe narzędzie oceny materiałów opakowaniowych na każdym etapie ich cyklu życia – od produkcji po utylizację, co umożliwia porównanie tradycyjnych i innowacyjnych rozwiązań, takich jak zastosowanie polimerów (bio)degradowalnych oraz materiałów pochodzących z recyklingu w opakowaniach kosmetycznych. Ostatnie postępy w projektowaniu opakowań oraz rozwój technologii recyklingu przyczyniły się do poprawy efektywności wykorzystania zasobów i redukcji ilości odpadów, zgodnie z zasadami gospodarki o obiegu zamkniętym. Niemniej jednak nadal występują trudności w stosowaniu metod LCA w sposób spójny, szczególnie przy ocenie materiałów pochodzenia biologicznego.
Poprzez wdrażanie zasad eko-projektowania, promowanie recyklingu i wykorzystywanie wyników analizy LCA, przemysł kosmetyczny może dążyć do zmniejszenia swojego wpływu na środowisko oraz wspierać bardziej zrównoważone praktyki w produkcji i wykorzystaniu opakowań.
Niniejsza praca wskazuje na konieczność wprowadzania innowacji oraz współpracy interdyscyplinarnej w celu opracowania zrównoważonych rozwiązań opakowaniowych, które łączą funkcjonalność, oczekiwania konsumentów oraz cele środowiskowe.
Słowa kluczowe: ekologiczne opakowania kosmetyków, recykling, polimery (bio)degradowalne, ocena cyklu życia produktu, LCA, eko-projektowanie

COSMETIC MARKET INSIGHTS

Cosmetics are beauty and personal care products designed for skin cleansing and enhancement. These products contribute to improving an individual's overall appearance. The rising global awareness regarding personal appearance and well-being is a significant factor propelling the expansion of the cosmetics industry [1]. Currently, the skincare sector is valued at several billion euros. In 2019, the global cosmetics market was worth $532 billion and it was expected to increase to $758.05 billion by 2032. In 2023, the Asia Pacific region led the market, holding a 39.53% share [2].

Europe is the largest cosmetics market in the world. According to Euromonitor International, the value of the European market increased by 1.5% in 2019, reaching EUR 79.8 billion. The United States and China follow Europe in market size. Among European countries, Germany leads with a turnover of EUR 14 billion, followed by France, Great Britain, and Italy. In Europe, skincare and personal care products account for more than half of the retail market value, with shares of 27.1% and 24.8% respectively in 2019. The European cosmetics industry employs 207,000 people directly and 1.6 million in related sectors, with 63% of the workforce being women. The sector is quite fragmented, consisting of large corporations as well as approximately 5,900 small and medium-sized enterprises.

The demand for cosmetic products has steadily increased, transforming them from luxury items into everyday essentials. This surge in demand is also boosting their success in the e-commerce market. [3]. Growing consumer demand for sustainable products and the unpredictable nature of the environment are pushing companies to adopt sustainable practices beyond traditional financial goals. Companies are enhancing their products and packaging to be more environmentally friendly in response to consumer and environmental demands [4]. Thus, there is increasing concern and interest in green cosmetics worldwide and also due to environmental issues, animal welfare, and health and hygiene considerations. Definitions of green cosmetics often highlight "green," "natural," "organic," or "bio cosmetics," while others focus on the rising use of green cosmetics and the growing interest in online shopping among consumers [5]. Over time, consumer concern for the environment has increased, influencing their purchasing patterns for cosmetics. A focus on a healthy lifestyle and maintaining a clean environment is shifting consumer mindsets, leading them to prefer healthy, safe, and chemical-free products. Environmental deterioration has made consumers understand the importance and necessity of buying green or sustainable products [6].

SUSTAINABILITY IN THE COSMETICS INDUSTRY: A COMPREHENSIVE APPROACH

When creating a sustainable product, its value is boosted by additional features compared to regular products. Producers working towards sustainable development aim to balance social, economic, and environmental aspects, focusing on areas they can currently influence. If the focus is on environmental improvements, the product will be labeled as ecological, bio or natural. If it addresses social ethics, it will be known as a socially responsible or innovative product due to new improvements. Products with quality certifications like Ecocert, Cosmebio, BDIH, and COSMOS are perceived as high-quality.

These products are considered sustainable to different extents, achieving the level of sustainability possible at that time. The effort to balance these aspects is ongoing continually reaching higher standards [7].

The cosmetics industry is adopting various solutions aligned with sustainable development principles and goals. Companies aim to communicate the outcomes of their sustainability efforts through products known as sustainable cosmetics. While the concept of sustainable development is well-established in academic literature, the term sustainable cosmetics is not yet widely recognized or legally defined. It lacks sufficient clarity and recognition among consumers, sellers and distributors [8].

TYPES AND FUNCTIONS OF COSMETICS PACKAGING

The primary function of packaging is to safeguard the product from external factors. For liquid, loose products, and cosmetic preparations, packaging remains integrally associated with the product throughout its entire life cycle. The variety of cosmetics

packaging depends on the consistency of the product, its purpose and form of application. These include bottles (with or without dispensers), roll-on packaging (with a dispensing ball), jars, boxes, tubes, sticks (for lip products), and sachets. Packaging must also provide information on the product's composition, weight, and expiration date. Proper labeling is crucial, particularly for self-service sales. Additionally, packaging fulfills promotional and marketing roles; the form, color, size, material, and aesthetics often influence consumer choice, especially for cosmetic products [9].

Some cosmetic companies update their packaging every 1-2 years to align with changing market trends, often boosting sales in the process. The packaging should evoke positive emotions, attract attention, and convey a sense of prestige and luxury. However, managing the waste generated after the cosmetic's use presents a separate issue. Waste management methods include recovery (such as recycling and energy recovery) and landfilling [10]. In relation to packaging waste, recovery is defined as deliberate activities that aim to reduce the amount of waste deposited in landfills through the industrial use of this waste to obtain energy and raw materials. The selection of the recovery method should be economically justified and depends on the type of packaging material used, the origin of the waste and its possible toxicity. Energy is recovered through combustion, among others conventional plastics, paper, wood and multi-material packaging that includes plastics and paper as ingredients.

Despite the essential role of packaging in ensuring product safety and functionality, all packaging impacts the environment. Therefore, efforts should be made to minimize the negative environmental effects of our actions and choices. Since packaging always leaves an environmental footprint, there is no such thing as 100% ecological packaging. Some packaging options are more sustainable than others. While biodegradable packaging is often considered the most eco-friendly, multiple factors determine the environmental impact of packaging materials. A sustainable product or packaging is designed to meet current needs without compromising the ability of future generations to meet theirs. This continuous process of improvement ensures that sustainability goals are progressively achieved [11-13].

THE BASICS OF LIFE CYCLE ASSESSMENT

Life cycle assessment (LCA) is a widely used methodology for systematically evaluating the potential environmental impact of a product throughout its entire life cycle, as per the international standard ISO 14040-14044. This assessment considers various stages from raw material extraction to end-of-life (EoL), including material processing, product manufacturing, transportation, use, and disposal. Depending on the system under evaluation, different LCA approaches can be carried out. Regarding the definition of the system and the definition of its temporal, geographical and technological boundaries, the most common approaches are the (i) *cradle-to-grave* (which includes all the life cycle phases, from the raw materials extraction to the recycling and disposal), and the (ii) *cradle-to-gate* (which leave out of the analysis some life cycle phases). The cradle-to-cradle approach evaluates the entire life cycle, till the use of secondary raw materials recovered in the end-of-life [14].

An LCA involves four main steps:

1. Goal and scope definition
2. Life cycle inventory
3. Life cycle impact assessment
4. Results interpretation and improvement

Upon completing the assessment, the identified environmental issues can be addressed to enhance the product's sustainability [15].

LCA has been applied to various packaging materials, including wood, plastic, PET bottles, biomass-based and oil-based plastics, beverage packaging, multilayer polymer bags, and bioplastics for food packaging. LCA is also recommended for verifying new packaging designs environmental performance [16].

To compare the environmental impact of newly developed bioplastics with petroleum-based plastics, the method of LCA was commonly employed. Over the past two decades, LCAs on biobased plastics has been widely discussed by the scientific community, and some studies highlighted that there is no

consensus on the true environmental sustainability of biobased plastics compared to fossil-based ones. This uncertainty comes mainly from different LCA approaches and assumptions, highlighting the need for standardized approaches to accurately assess the impact of biobased plastics [17-18]. However, some environmental issues have already been demonstrated and, in many cases, biobased plastics result in lower greenhouse gas emissions and reduced non-renewable energy use compared to their petroleum-based counterparts [19]. However, performing LCAs on bioplastics presents significant challenges due to numerous uncertainties about the life cycle of these relatively new materials [20].

In recent years, numerous studies have utilized LCA to examine the production of biodegradable polymers such as polylactic acid (PLA) and polyhydroxyalkanoates (PHAs) [21-23]. Additional research has provided further insights into the environmental impacts of these materials. For example, Spierling et al. highlighted the benefits of biobased plastics in terms of greenhouse gas emissions and non-renewable energy use [24]. Furthermore, Zheng and Suh provided a comprehensive review of LCA studies on bioplastics, indicating the potential and challenges of these materials in sustainable development [25]. The results obtained in some cases were unexpected and contrary to the anticipated environmental benefits of biodegradable polymers.

Previously, Gerngross [26] compared the fossil fuel requirements for producing PHA with those for polystyrene, concluding that PHA production demands significantly more fossil fuel. The author also questioned the environmental benefits of producing PHA from corn. While Akiyama et al. [27] demonstrated that producing PHB and P(3HB-co-HHx) from soybean oil and corn-derived glucose results in lower CO_2 emissions and reduced energy requirements compared to petrochemical-based polymers. Kim et al. [28] explored these discrepancies and suggested that the environmental benefits of producing PHA via corn fermentation are comparable to those of polystyrene production.

A comprehensive view of the environmental impacts and benefits associated with the production and use of biodegradable polymers, offering valuable insights for further research and development in this field were also formulated in the following papers [29-30].

SUSTAINABLE COSMETIC PACKAGING: INSIGHTS FROM LIFE CYCLE ASSESSMENT STUDIES

With the rapid increase in cosmetic sales, there is a corresponding growth in waste from cosmetic packaging after use. Globalization and simplified supply chains have shifted the trend from reusable to single-use packaging. [31]. This shift underscores the need for a deeper consideration of the human-environment relationship within the circular economy framework. Reducing the environmental impact of packaging throughout its life cycle – from material selection to recycling and reuse – is central to the circular economy's goals [32].

As cosmetic companies increasingly recognize the importance of sustainability and strive to make their packaging more environmentally friendly, it is crucial to understand that different brands prioritize various packaging attributes to enhance sustainability. The main cosmetic packaging attributes considered in literature and by various brands include the weight of packaging, material composition, energy usage, and disposal methods at end-of-life (EoL) [33].

Several recent studies have underscored the direct relationship between the weight of cosmetic packaging and its environmental impact [34-35].

The literature and market studies consistently highlight the significant environmental impact of the cosmetic industry, particularly due to the high demand for cosmetic products and the associated packaging. Despite ongoing efforts by brands to enhance sustainability, the issue of cosmetic packaging waste remains prevalent. Discrepancies across studies can be attributed to factors such as product type, geographical location of manufacturing, and differences in evaluation methodologies. While numerous studies focus on assessing individual sustainable initiatives, there is a notable gap in comprehensive assessments that compare the efficacy of different sustainable strategies. This gap underscores the need for further research aimed at developing and implementing more effective approaches to mitigate the environmental impact of cosmetic

FIGURE 1. MODEL FOR THE DEVELOPMENT OF SUSTAINABLE PACKAGING ADAPTED FROM [36].

packaging [16, 30, 32]. An interesting model development path (Figure 1) for introducing sustainable packaging to the market was developed by Manu Dube and Sema Dube in [36].

To bridge the gap between consumer perceptions and the actual environmental impact of packaging, effective communication and education about the benefits of sustainable packaging are essential. Designing packaging that encourages proper reuse and recycling, while also highlighting its environmental benefits, can positively influence consumer behavior. The design phase is critical, as it determines the environmental impact of the entire product lifecycle, making it more decisive than other stages. By prioritizing sustainable design, the cosmetic industry can significantly reduce its environmental footprint.

Additionally, the SPOT methodology, as outlined by L'Haridon et al. [5], provides a strategic framework for integrating life-cycle assessment (LCA) principles into product and packaging design. This approach helps identify and mitigate environmental hotspots across the lifecycle, supporting more effective eco-design strategies.

Incorporating consumer behavior into LCA and sustainable design is crucial, as it can significantly impact the use phase and overall environmental performance. For example, packaging design that facilitates ease of use or signals recyclability could directly influence consumer behavior during the use phase, which is a critical part of a product's lifecycle. In the case of cosmetic packaging, these design choices can lead to better waste management practices, such as increased recycling rates, and influence how consumers interact with the product itself.

In summary, sustainable design in the cosmetic industry should focus on influencing consumer behavior through packaging design, ensuring it supports more sustainable product use and disposal practices. While most research on sustainable packaging has focused on food-related products due to their direct impact on human health, there is a growing recognition of the environmental impact of cosmetic packaging. Studies show that, in some cases, packaging has a greater environmental impact than the ingredients themselves. For instance, in certain cosmetic products, the material used for packaging may contribute more significantly to the environmental footprint than the active ingredients [37]. Thus, the sustainability of cosmetic packaging needs more attention [37-40].

CONCLUSIONS

This study highlights the importance of Life Cycle Assessment (LCA) in evaluating and improving the sustainability of cosmetics and their packaging. The cosmetics industry faces significant challenges, particularly regarding the environmental

impact of packaging and the adoption of biodegradable materials. While LCA has proven effective in assessing these impacts, the lack of standardization and the complexity of comparing bio-based and fossil-based materials complicate efforts to establish clear sustainability benchmarks.

A key finding is the critical role of the product design phase in determining the environmental footprint of cosmetics, reinforcing the importance of eco-design principles and circular economy practices. Effective consumer engagement and education are also essential, as informed choices can significantly influence sustainability outcomes. By adopting a comprehensive approach that combines innovative materials, rigorous assessment methodologies, and consumer-centered strategies, the cosmetics industry can make meaningful progress toward reducing its environmental impact while meeting evolving market demands.

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IMPROVING THE TECHNOLOGY OF BRAILLE APPLICATION USING VACUUM FORMING METHOD

UDOSKONALANIE TECHNOLOGII APLIKACJI BRAILLE'A Z WYKORZYSTANIEM METODY FORMOWANIA PRÓŻNIOWEGO

ABSTRACT: Technical and technological preconditions to create an advanced vacuum forming technology to apply Braille for vision impaired people are described, analyzed and grounded. A block diagram of the advanced vacuum forming technology is presented, the special feature of which is the use of a combined mould, which is made of cardboard by laser engraving method, which ensures the necessary quality, durability, and low cost. A block diagram of the calibration of the combined mould production process is presented. Methods of moulds production to apply modified Braille font by using advanced vacuum forming technology are developed.
Key words: vacuum forming method, advanced technology, Braille font, relief dot images, laser engraving, cardboard mould, tactile perception

STRESZCZENIE: W artykule opisano, przeanalizowano i uzasadniono techniczno - technologiczne przesłanki do stworzenia zmodernizowanej technologii formowania próżniowego do nanoszenia czcionki Braille'a dla osób z dysfunkcją wzroku. Przedstawiono blokowy schemat doskonalszej technologii formowania próżniowego, której wyróżnikiem jest zastosowanie łączonej formy wykonanej z tektury metodą grawerowania laserowego, zapewniającej wymaganą jakość, trwałość i niski koszt. Przedstawiono blokowy schemat kalibracji procesu wytwarzania formy łączonej. Opracowano metody wytwarzania form do nanoszenia zmodyfikowanej czcionki Braille'a z wykorzystaniem ulepszonej technologii formowania próżniowego.
Słowa kluczowe: metoda formowania próżniowego, zaawansowana technologia, czcionka Braille'a, obrazy wypukłych punktów, grawerowanie laserowe, forma tekturowa, percepcja dotykowa

It is known that Braille font has certain features, in particular, it cannot convey the entire range of properties of a regular font, and these properties reflect the specifics of the information that is conveyed by this font. It can be assumed that not only the text, but also the typeface is a carrier of content to some extent, for example, words/sentences, emphasizing certain features. Thus, the set for selecting words or content units with a certain purpose is quite significant – one can vary the typeface (VII basic groups), size (font), inclination (straight, inclined, italic), contrast (contrast, medium contrast, low contrast), saturation (light, semi-bold, bold), – by width (narrow, standard and wide) and other parameters – creating a contour or shadow or providing a colour [1]. Classic Braille does not have such capabilities.

Ways (methods) of highlighting a part of the text (actually highlighting/strengthening the content of a separate

word/words) in Braille are highly limited - the use of additional symbols (the use of functional symbols that precede numbers or case change; multi-cell symbols consisting of two or more symbols, which separately have their own functions), and physical, chemical and mathematical symbols form complex and cumbersome structures.

Based on the above, the idea arises to solve at least part of the described negative features of the classic Braille font, namely, to improve the technology in order to create a "non-standard" Braille font with enhanced capabilities.

One of the ways to implement such an idea is to modify the top of the Braille element, which can have the following shapes: vertical cross, cross "at 45 degrees", vertical and horizontal lines, triangles "left, right, up, down", rectangles, squares/rectangles of different sizes, circles of different diameters – this will lead to an increase in the number of non-similar Braille characters and/or an improvement in the Braille perception.

There are prerequisites for creating such a font, since technologies have appeared that can mass-produce small volumetric elements with a random shape (3D printing, UV varnish) [2]. In our case, vacuum forming technology is used. Taking into account the certain simplicity of the vacuum forming method and the relative cheapness of the equipment, the problem of manufacturing cheap moulds that can be produced quickly and that would have sufficient durability is extremely important [3].

GENERALIZED BLOCK DIAGRAM OF THE IMPROVED BRAILLE PRINTING TECHNOLOGY

One of the factors that is taken into account when applying the vacuum forming method for Braille application is the possibility of creating not only a relief dot font on the sheet, but also a relief image that, for example, accompanies the text. Thus, vacuum forming method can be used to create a table, a signed image or book, and such products have obvious advantages over products created on paper.

One proceeds from the reasoning that Braille parameters must meet certain standards (national standards and regulations or industry requirements or recommendations regarding the labelling of medicine packages, labelling of buttons in elevator cabins, etc.) [4]. By parameters in this case, all geometric dimensions are meant – the distance between lines, letters and symbols, the distance between Braille elements (dots), as well as the diameters of the base and height of Braille elements.

In general, the process of Braille application according to our technology is presented in the block diagram in Fig. 1. A feature of our advanced vacuum forming technology is the use of a combined mould, which is made of cardboard by laser engraving technique.

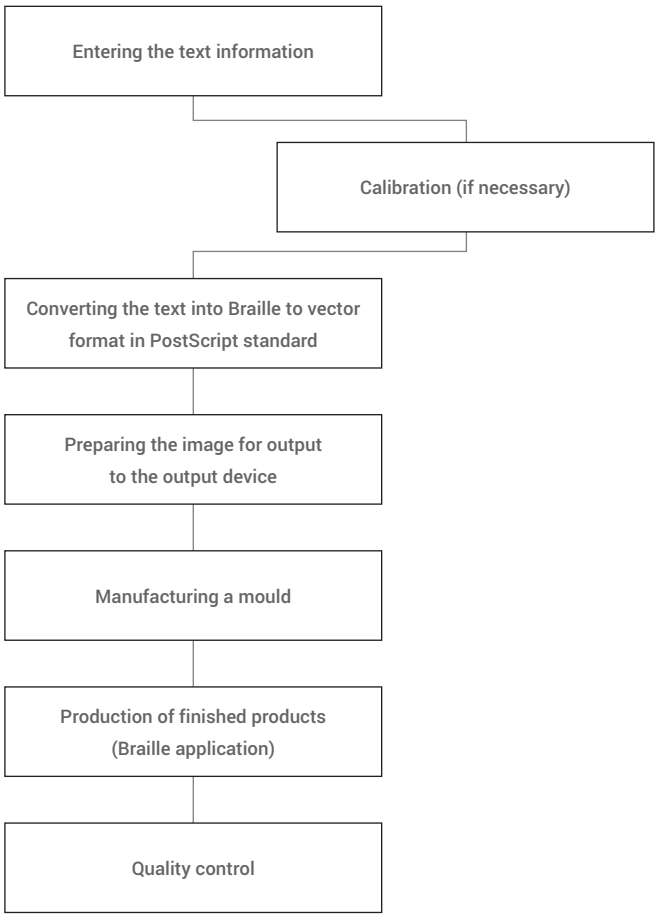


FIG. 1. BLOCK DIAGRAM OF THE IMPROVED BRAILLE APPLICATION PRINTING TECHNOLOGY (OUR OWN DESIGN)

Separate attention should be paid to the process of calibration of technological operations. Parameters such as the diameter of the laser beam and its power, the movement speed of the laser beam relative to the mould material and the properties of

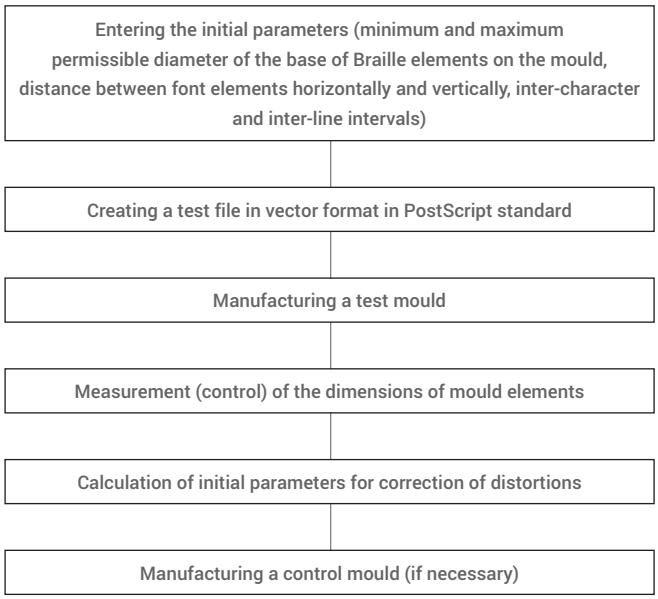


FIG. 2. BLOCK DIAGRAM OF CALIBRATION (OUR OWN DESIGN)

the mould material during the burning process, and possibly the features of the design and software of the laser engraver lead to a distortion of the hole diameter that corresponds to the Braille element. It should be noted that the deviation of the actual size from the required size can be quite large – up to 0.2 mm, which is unacceptable for our technology. This fact confirms the need to calibrate the technological process to ensure the product quality in terms of compliance with the geometric parameters of the Braille font, namely the diameter of the base of Braille elements. The block diagram of the calibration stage is presented in Fig. 2.

Original software is developed for manufacturing moulds intended for the production of samples containing Braille:

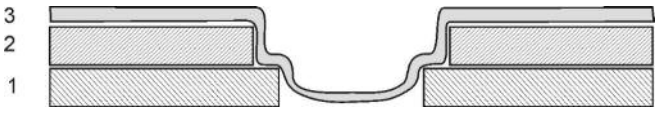


FIG. 3. LOCATION OF THE TWO PARTS OF THE MOULD (1, 2) AND THE MOULDED MATERIAL (3) IN BRAILLE MANUFACTURING PROCESS BY THE ADVANCED VACUUM FORMING METHOD (OUR OWN DESIGN)

– software for the synthesis of a PostScript file [5] with an analytical description of Braille elements (and the corresponding distances between the elements) with different diameters of the base of the Braille element for the purpose of calibrating the technological process of manufacturing products by the vacuum forming method and intended for import into a random software environment with PostScript language support;
– software for translating text in ASCII codes into Braille text and synthesizing the corresponding PostScript file with an analytical description of Braille elements with a fixed diameter of the base of the Braille element and intended for import into any software environment with support for the PostScript language.

AN IMPROVED VACUUM FORMING PROCESS FOR BRAILLE WITH A MODIFIED TOP USING A COMBINED CARDBOARD MOULD

Manufacturing a combined cardboard mould consists of the following stages:

1. Creating an image of "the first (upper) cardboard matrix" and "the second (lower) cardboard matrix" in a graphic editor in vector format.
2. Manufacturing "the first (upper) cardboard matrix" and "the second (lower) cardboard matrix" by the laser cutting (laser engraving) method.
3. Combining "the first (upper) cardboard matrix" and "the second (lower) cardboard matrix" and their mutual fixation.

The preparation of the mould for the production of products by the vacuum forming method is carried out on a computer in the CorelDraw environment using the original software, the prototype of which is described [6, 7]. The peculiarity of the software implemented in the Borland Pascal v.7.0 environment is that 2 files are created, in which the holes that must be cut are described by PostScript means [7]. The mould is made by the laser engraving method using the laser engraving machine "LaserPro C180 II".

According to the selected method of Braille manufacturing [8], two parts of the combined cardboard mould (upper matrix and

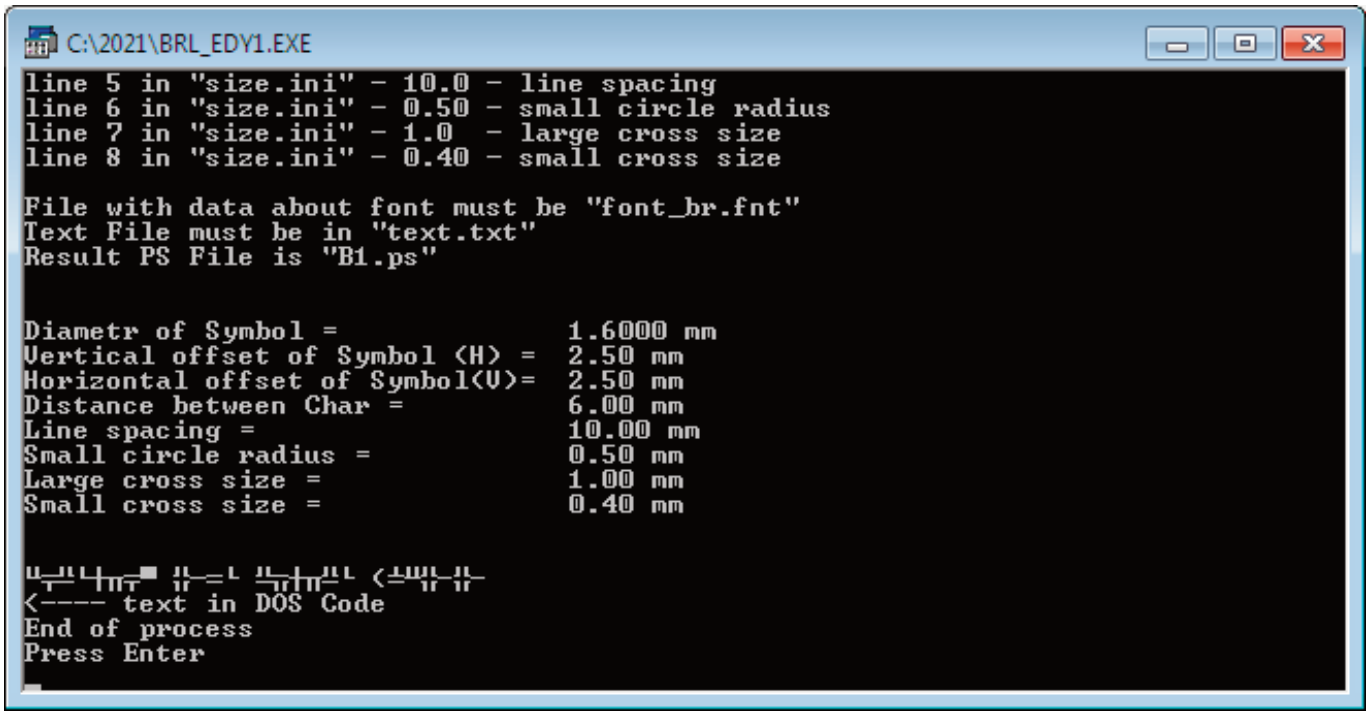


FIG. 4. A FRAGMENT OF FORMATION OF A POSTSCRIPT FILE (OUR OWN WORK)

lower matrix) are manufactured, the lower matrix (1, Fig. 3) forms the top of the Braille element, the upper matrix (2, Fig. 3) forms the base of the Braille element and contacts the films (3, Fig. 3), on which the font is reproduced.

The formation of a PostScript file with an analytical description of the tops of Braille elements is carried out taking into account the shape of the top of the Braille element (Fig. 4). So, as it is already known, the top of the Braille element in the form of a circle is described by the well-known construction [6] "newpath X Y R 0 360 arc stroke" (with such parameters, an arc of a circle is made with the center at the point (X, Y) and the radius R from the angle 0 to the angle 360). Only if, for example, for the base of Braille element R=0.8 (for the diameter 1.6 mm), then for the top of Braille element R=0.4 (corresponding to the diameter 0.8 mm).

More cumbersome, but not too difficult, is the description of the top of a Braille element of the type "rectangle", "triangle", and, especially, "cross". The analytical description of the top of the Braille element "cross" is presented in Fig. 5.

View of the adjacent moulds of a Braille element in PostScript-file «GSView for Windows» file viewer (Fig. 6).

It should be pointed out that both parts of the mould can be the same. In this case, one will get the usual free formation

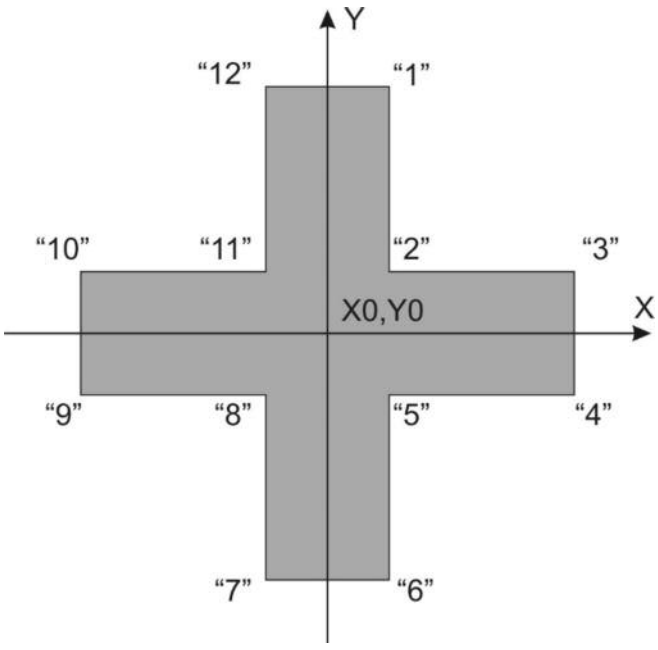


FIG. 5. ANALYTICAL DESCRIPTION OF THE TOP OF THE BRAILLE ELEMENT "CROSS" (OUR OWN DESIGN)

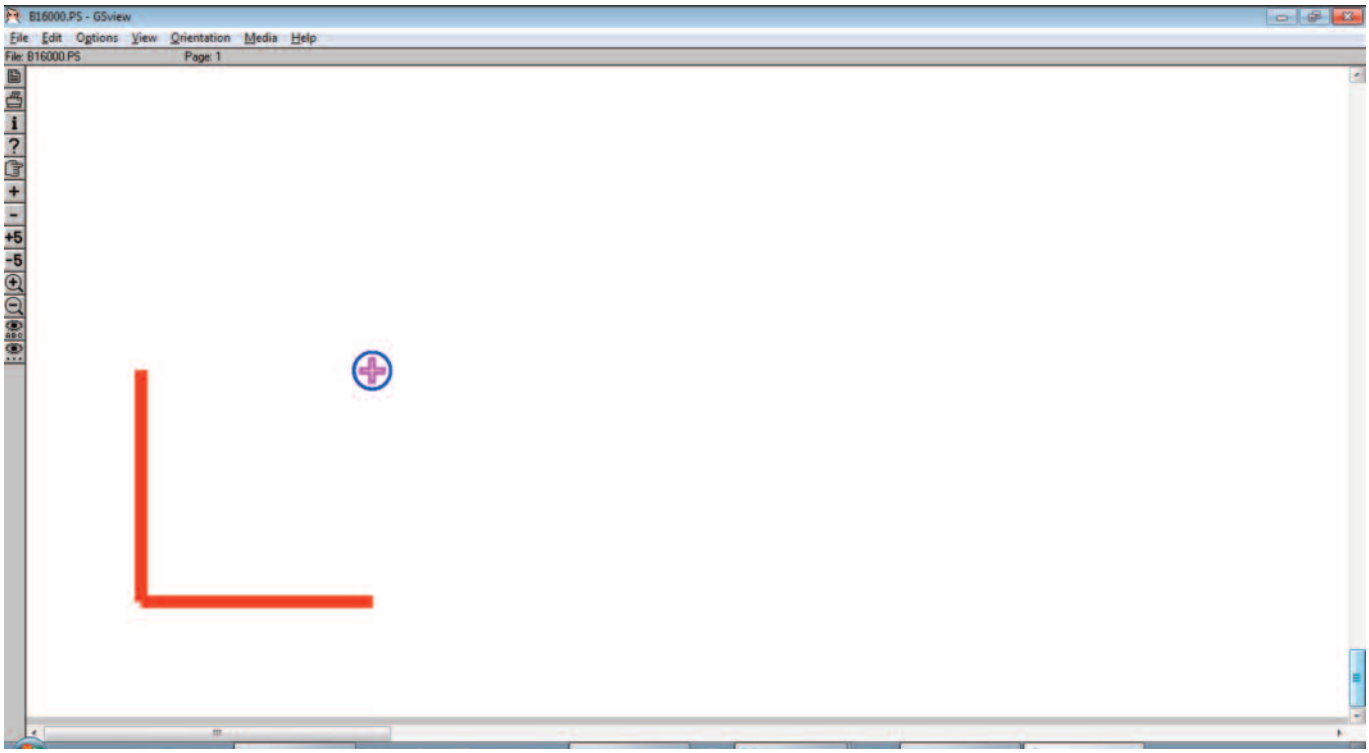


FIG. 6. VIEW OF ADJACENT MATRICES OF COMBINED MOULDS OF A BRAILLE ELEMENT (OUR OWN WORK)

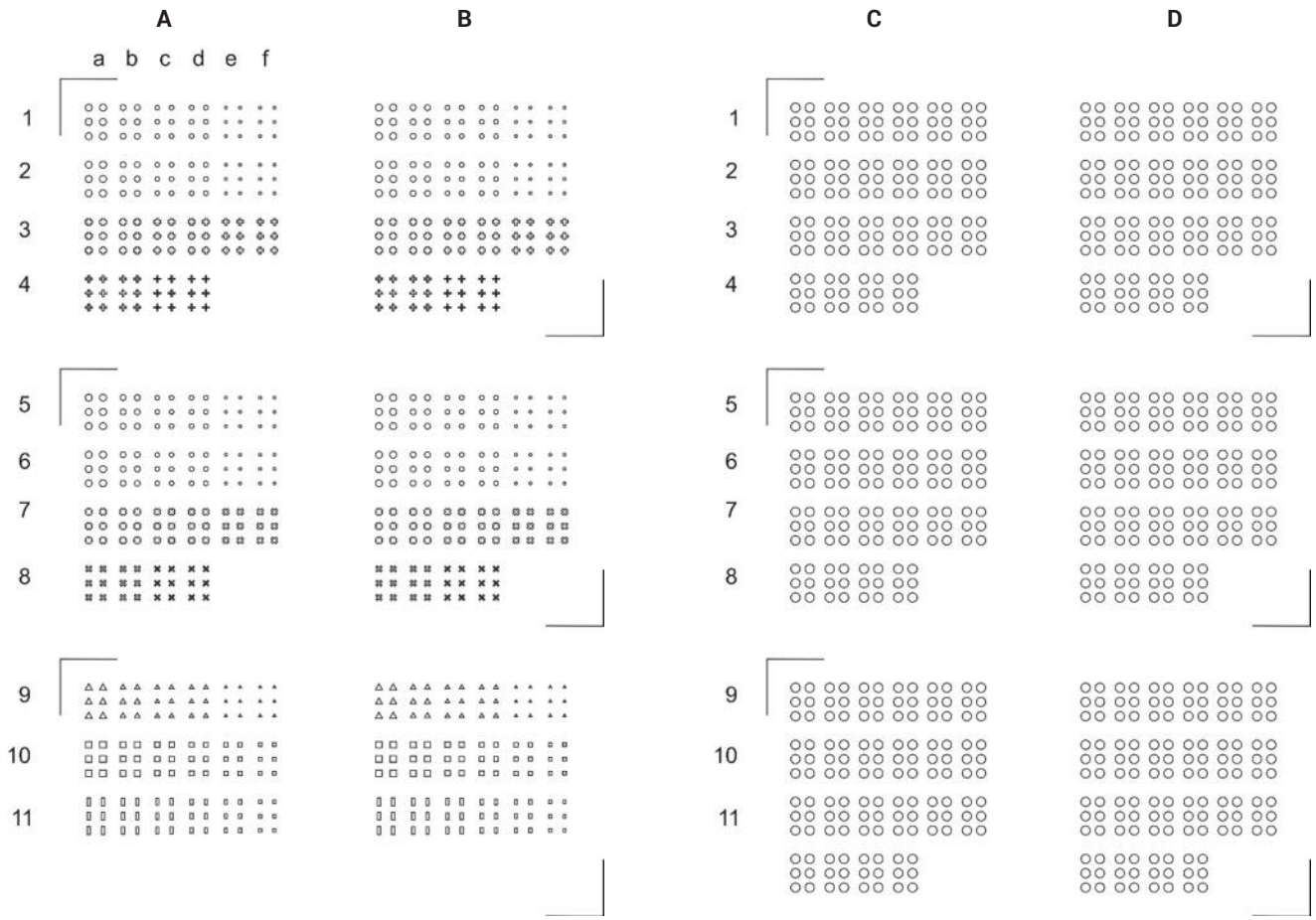
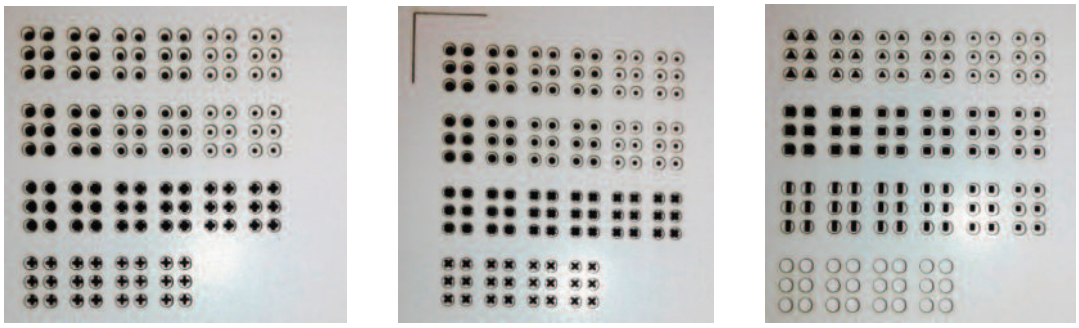


FIG. 7. IMAGE OF THE MOULD FOR BRAILLE ELEMENTS FORMATION WITH DIFFERENT TYPES OF TOPS (OUR OWN WORK)



A B C

FIG. 8. PARTS OF AN ACTUAL MOULD: A - LINES1-4, B - LINES 5-8, C - LINES 9-11 (OUR OWN WORK)

using a cardboard mould. Taking into account the peculiarities of publications in Braille (for example, small editions), it can be argued that the use of a cardboard mould will make it possible to make the process of manufacturing high-quality small-edition products with Braille by the vacuum forming method cheaper.
In order to test our assumptions, a combined cardboard mould is made. The thickness of the upper matrix is 0.255 mm (coated paper Volume Gloss), the lower one is 0.5 mm (electric cardboard) or 0.255 mm (coated paper Volume Gloss). Taking into account the specifics of the technology, the thickness of the "lower" matrix should be bigger than the expected height of the top of a Braille element, in our case the thickness is 0.4 mm. The material of the upper matrix is glossy paper 250 g/m^2. Figure 7 presents the top view – A, B – lower matrix, C, D – upper matrix.
Columns A and B as well as C and D are identical, respectively.
Figure 7 description.
C = D – all holes with the diameter of 1.6 mm

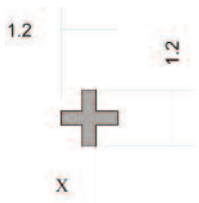
Lines 1, 2, 5 and 6 – round holes with a diameter 1,2 mm (column a); 1,0 mm (column b); 0,8 mm (column c); 0,8 mm (column d); 0,5 mm (column e); 0,5 mm (column f)

Lines 3, 4, 7 and 8 – holes are of "cross" type, sizes «X» are given in Table 1.

Lines 7 and 8 have holes of a "cross" type, similar to the holes in lines 3 and 4 but rotated by 45 degrees.
Line 9 has holes in the mould of an equilateral triangle, the size of the side is 1,2 mm (column a); 1,0 mm (column b); 0,8 mm (column c); 0,8 mm (column d); 0,5 mm (column e); 0,5 mm (column f).
Line 10 has holes in the mould of a square, the size of the side is 1,12 mm (column a); 1,02 mm (column b); 0,92 mm (column c); 0,82 mm (column d); 0,72 mm (column e); 0,62 mm (column f).
Line 11 has holes in the mould of a rectangle with sizes 1,4x0,56 mm (column a); 1,3x0,52 mm (column b); 1,2x0,52 mm (column c); 1,0x0,52 mm (column d); 0,8x0,52 mm (column e); 0,6x0,52 mm (column f).

Fig. 8 shows parts of an actually manufactured mould (a) – lines 1-4, (b) – lines 5-8, (c) – lines 9-11 and an additional line with round holes with a diameter 1,6 mm only on the upper matrix to create Braille element in the form of a cylinder.

TABLE 1.

		a	b	c	d	e	f
	Line 3 («cross»)	0,6 mm	0,6 mm	0,5 mm	0,5 mm	0,4 mm	0,4 mm
	Line 4 («cross»)	0,3 mm	0,3 mm	0,2 mm	0,2 mm		

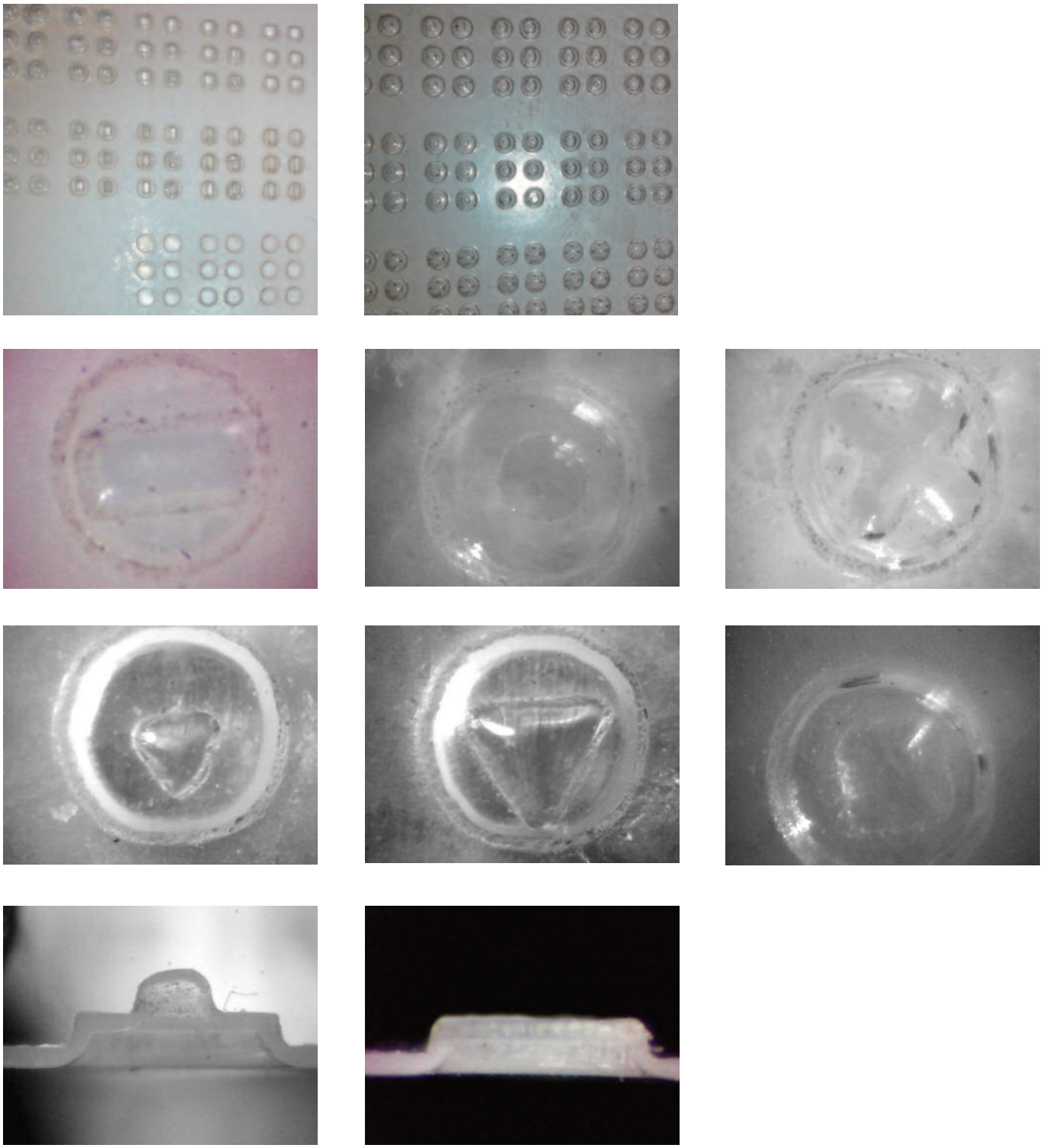


FIG. 9. PHOTOS OF VARIOUS VERSIONS OF BRAILLE ELEMENTS: A, B – GENERAL VIEW OF A PART OF A MOULDED PAGE/(A) – USING THE MOULD, FRAGMENT OF WHICH IS SHOWN IN FIG.3.12 (B), (B) - USING THE MOULD, FRAGMENT OF WHICH IS SHOWN IN FIG.3.12 (C)/; PHOTOS OF BRAILLE FONT ELEMENTS WITH THE TOP IN THE MOULD OF: (C) – RECTANGLES, (D) – CIRCLE, (E) – CROSS, (F,G) – TRIANGLES OF DIFFERENT SIZES, (H) – A SQUARE, AND PHOTOS OF CROSS-SECTIONS: (I) – BRAILLE ELEMENT WITH THE TOP OF "CIRCLE" TYPE (SEE CURRENT FG.), (D) AND (J) - BRAILLE ELEMENT WITH THE TOP OF "CYLINDER" TYPE WITH THE HIEGHT OF 0,25 MM IN CASE WHEN LOWER MATRIX IS "CLOSED" (SEE FIG. 3.12, C, AND CURRENT FIG. B, LOWER ROWS) (OUR OWN WORK)

Fig. 9 represents photos of various versions of Braille font elements, made with the help of the moulds represented on the photos in Fig.8.

CONCLUSIONS

Advanced vacuum forming technologies for Braille application, with the formation of a modified top of the Braille element in particular, (vertical cross, cross "at 45 degrees", vertical and horizontal lines, triangles "left, right, up, down", rectangles, squares/rectangles of different sizes, circles of different diameters, etc) allow: 1) to ensure the necessary durability of moulds, quality and efficiency of products production for people with vision problems, to increase the economic efficiency of the technological process; 2) to improve the tactile perception of relief-dot images for people with vision problems due to the modification of the tops of Braille elements [8]; 3) to increase number of combinations of dissimilar elements due to the fact that additional types of images (circle, square, triangle, etc.) are formed on the top of the Braille element, which are tactilely perceived by people with vision problems [9, 10].

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SAFETY OF CONSUMER HEALTH AND LIFE VS. SUSTAINABLE DEVELOPMENT IN FOOD PLASTIC PACKAGING SECTOR

MIĘDZY BEZPIECZEŃSTWEM DLA ZDROWIA I ŻYCIA KONSUMENTA A ZRÓWNOWAŻONYM ROZWOJEM W BRANŻY OPAKOWAŃ DO ŻYWNOŚCI Z TWORZYW SZTUCZNYCH

ABSTRACT: Quality and safety are the key issues on which the attention of the food producers must be focused. At the same time, however, the second problem becomes also significant, i.e. running of the activities in conformity with the principles of sustainable development. When introducing the successive legislative regulations, the European Union expects adaptation of food packaging production to the principles consistent with the conception of sustainable development. It is however, a great challenge for the food packaging producers.
Key words: packaging safety, plastics, sustainable development, recycling

STRESZCZENIE: Jakość i bezpieczeństwo to kluczowe zagadnienia, na których skupiać się musi producent opakowań do żywności. Jednocześnie jednak na znaczeniu zyskuje druga kwestia, czyli prowadzenie działalności zgodne z zasadami zrównoważonego rozwoju. Unia Europejska wprowadzając kolejne regulacje prawne oczekuje dostosowania produkcji opakowań do żywności do zasad zgodnych z koncepcją zrównoważonego rozwoju. Dla producentów opakowań do żywności to jednak wielkie wyzwanie.
Słowa kluczowe: bezpieczeństwo opakowań, tworzywa sztuczne, zrównoważony rozwój, recykling

INTRODUCTION

Globalization, urbanization and growing awareness of the consumers determine the development and changes in food packaging sector. The consumers live quickly, want to live more and more comfortably, but simultaneously, they are more and more aware of the consequences of such life for the Planet. We think more and more frequently about the future generations in the context of their safe life and access to the environment. The consumers expect the so-called sustainable environment, that is, consistent with the principles of environmental design. More often, it is not a fashion or news but the necessity which becomes more widely legally regulated. Such is the purpose of the successive regulations, introduced in the European Union. At the same time, the materials or products, intended to have a contact with food should be manufactured in accordance with the good manufacturing practice (GMP), their contents cannot penetrate to food in the quantities, creating a risk to human health; they cannot also cause the unacceptable changes in the content of foods and their organoleptic properties [6]. In production of food packaging, only materials and substances admitted to production of packaging intended to have contact with food, may be employed [3]. The mentioned factors affecting also the sanitary safety are connected with the wider and wider application of different materials and print inks in production of packaging and, also, of different packaging systems. They may contribute to the increase of the number of dangerous bacteria in the packaged food product; the presence of the mentioned microorganisms may affect human health [1, 6].

Improper handling with packaging may be a source of physical, microbiological and chemical contamination and become a risk to the consumer health. The mentioned risk includes the migration of dangerous substances from plastics or undesired relationships between packaging and packed product [5]. The additional, till now unknown problem concerns the necessity of introducing the recycled raw materials to production of packaging materials. It is a great challenge for the producers not only from the technological viewpoint but also that one connected with ensuring safety for the consumer health and life. The purpose of the present publication is to show the complexity and multi-aspect problem of adapting the producers to meeting the requirements of the introduced legal regulations in infrastructural and raw material areas and the related financial problems as well as the awareness of the consumers.

BASIC PROBLEMS CONNECTED WITH SAFETY AND SUSTAINABLE DEVELOPMENT

According to the Regulation of the European Parliament and of the Council (EU) 2023/988 of May 10, 2023 on general product safety, the economic operators are obliged to place only safe products on the market. Such a high level of safety should be primarily achieved through the design and the features of the product, taking into account the intended and foreseeable use and conditions of the use of the product. The remaining risks, if any, should be alleviated by means of certain safeguards, such as warnings and instructions. Safety of a product should be assessed with the consideration of all its relevant aspects, and in particular, its characteristics such as physical, mechanical and chemical characteristics and its presentation, and also, specific needs and risks which the product represents for certain categories of consumers who are likely to use the products, in particular children, older persons and persons with disabilities. The mentioned risks can also include the environmental risk insofar as it poses a risk to the health and safety of consumers. Moreover, if specific information is necessary to make products safe for a certain category of persons, the assessment of the safety of the products should take into consideration also the presence of that information and its accessibility. The safety of all products should be assessed taking into consideration the necessity for the product to be safe over its entire lifespan.

In December 2024, the Council of the European Union adopted officially a new Regulation on packaging and packaging waste (PPWR – Packaging and Packaging Waste Regulation), constituting a revolutionary change in the approach to the issue of packaging in the whole European Union. The mentioned regulation does not require the implementation in the national legislation as it has a direct application at the territory of the entire European Union. The particular countries may apply more sharp rules which cannot be however contradictory to the Regulation itself. It concerns all types of packaging, produced from all types of materials. It is connected with other regulations concerning waste management such as Single Use Plastic Directive (SUP), Extended Producer Responsibility (Polish: ROP) and deposit system. The discussed regulation contains many aspects of design, manufacture, turnover and final utilization of packaging. It assumes the reduction of the quantity of the produced waste and increase of the level of recycling. PPWR is a legal regulation, changing the current rules concerning packaging and packaging waste, obligatory in the European Union. At present, Directive on Packaging and Packaging Waste (PPWD) is a binding regulation; it was adopted in 1994 and was amended many times. In 2022, the European Commission suggested a review of PPWD records. After having stated that it does not prevent effectively the increase of the amount of packaging waste and does not reduce the impact of packaging on the environment, the new Regulation on packaging and packaging and packaging waste (PPWR) being more ambitious as compared to the so-far Directive was suggested.

The discussed regulation is one of the meaningful elements of the European Green Deal, the main target of which is to make our Continent the first zero-emission continent all over the world. To achieve such goal, it is undoubtedly necessary to resolve and implement many rules, aiming at the limitation of the impact of economies on the environment. One of such examples includes the regulations striving at reduction of the quantity of the packaging waste.

From among the most important assumptions concerning the discussed domain, we should mention, inter alia, minimization

of the weight and volume of packaging, avoidance of unnecessary packaging and doubtful substances in respect of their safety (it is referred especially to packaging intended to have a contact with food and containing per- and polyfluoroalkyl substances, perfluorinated alkylated substances, PFAS). The mentioned assumptions include also setting the requirement according to which 65% of the packaging content of plastic bottles must come from recycling up to 2040. Moreover, the new regulations introduce many limitations concerning e.g. application of single-use plastic packaging in the case of fruits and vegetables having a weight lower than 1.5 kg, food served in hotels and restaurants, single packaging for e.g. seasonings, sugar, sweet cream etc. The important part of the limitation of packaging waste quantity includes also a duty of enabling a free use of own consumer containers to be filled with the cold or hot drinks or ready-to-use meals. The discussed regulation establishes the new binding aims in respect of the re-use to 2030 and the orientation targets for 2040. The mentioned aims differ according to the type of the packaging used by the operators (e.g. binding goals at the level of 40% for transport and sale packaging and 10% for bulk packaging). According to the new regulations, takeaway food-offering companies will be obliged to offer to the customers the possibility of bringing their own containers to be filled with cold or hot drinks or ready meals, without the additional payment. In turn, the requirements concerning labeling, marking and information (e.g. on the composition of material or the contents of recycled materials) should facilitate classification and making the choice and decision undertaken by the consumers. It would serve making the society more aware and active in favour of the environment. Moreover, the Regulation lays a duty on the producers to utilize the recyclates and defines the content of secondary raw materials in the packaging. Thus, by 1, January 2030 or 3 years from the date of entry into force of the implementing act (depending on which date is the latest) the minimum content of any plastics coming from recycling in plastic packaging shall be as follows:

– 30% for contact-sensitive packaging made from polyethylene terephtalate (PET) as the major component, except single-use plastic bottles for beverages;
– 10% for contact-sensitive packaging made from plastic materials other than PET, except single-use plastic bottles for beverages;
– 30% for single-use plastic bottles for beverages;
– 35% for plastic packaging other than those mentioned above.

In turn, by 1 January 2040, any plastic part of packaging placed on the market shall contain the minimum recycled material content equal to 50%, 25%, 65% and 65% respectively, recovered from the post-consumer plastic waste, classified according to packaging type and format.

The successive regulations, as being introduced in the European Union, are the necessity because the results of the conducted studies are alarming. In 2022, the independent report was developed by SYSTEMIQ and ordered by Plastics Europe, one of the leaders of the European branch associations[1]. The report was aimed at assessing the current progress and estimating the potential of different levers allowing to pass to the targets of the European Union – zero net emission of carbon dioxide and circular economy system by 2050. In the Report, there was indicated inter alia that the plastic packaging and the plastic household articles, as collected via municipal solid waste were characterized by a low circularity (17% and 1%, respectively). In 2020, from 22.0 Mt demand on packaging and household articles made from plastic, 20.6 Mt went to the waste system during one year. From the economic viewpoint it means that ca. 95% of the economic value of the mentioned materials passes to economy after one short cycle of use. It is mainly caused by the growing preferences for convenient single-use application in combination with a low probability of recovering the materials in the present system. The analysis showed that from 20.6 Mt of the plastic waste, produced by

1 Plastics Europe keeps a close cooperation with the national associations, connected with the plastics industry, acting in Europe as well as over the world. The organization associates more than 100 member companies the total participation of their production of all polymers produced in the European Union (EU27) as well as in Norway, Switzerland, Türkiye and Great Britain amounts to more than 90%. Plastics Europe cooperates also at the global level via the World Plastics Council – WPC) and Global Plastics Alliance-GPA).

the mentioned two sub-systems, only 14 % was subjected to recycling in 2020 whereas the recycling indicators are generally presented as being higher. They were estimated at 42% in 2018 for household, industrial and commercial packaging; it refers, unfortunately, to the quantities collected for recycling and not the quantities being actually subjected to recycling. The present infrastructure of the waste recovery in Europe is insufficient to cope with the great amounts of the municipal plastic waste, dispersed in millions of the households what creates a serious challenge for collection and sorting and the resulting quality of the contribution to recycling process. Recycling may be an effective way for reduction of the harms to the environment but the products must be appropriately designed. Chemicals, additives, mixed packaging materials and food contamination make that recycling is difficult and expensive. At present, high quantities of plastic packaging cannot be economically recycled, especially in the case of multilayer, multi-material packaging and most of the household articles which are sent directly to disposal. Based on the historical trends and convergence with the forecasts of demand increase, it is assumed that generation of the waste from packaging and household articles made from plastics will be increasing by 1% per year up to 2050. At the present trajectory, more than half of the waste from packaging and household articles will be directed to combustion plant in 2050; it is, unfortunately, a linear system which contributes to the increase of greenhouse gases (GHG) emission. But the assumed target is striving at circular economy. The scenario to reach the circular economy system has been presented in Fig.1. One of the Report's conclusion is, inter alia, that the coming 3-5 years are critical for appropriate measures to be undertaken. Long cycles of technological maturity and freezing of investment outlays

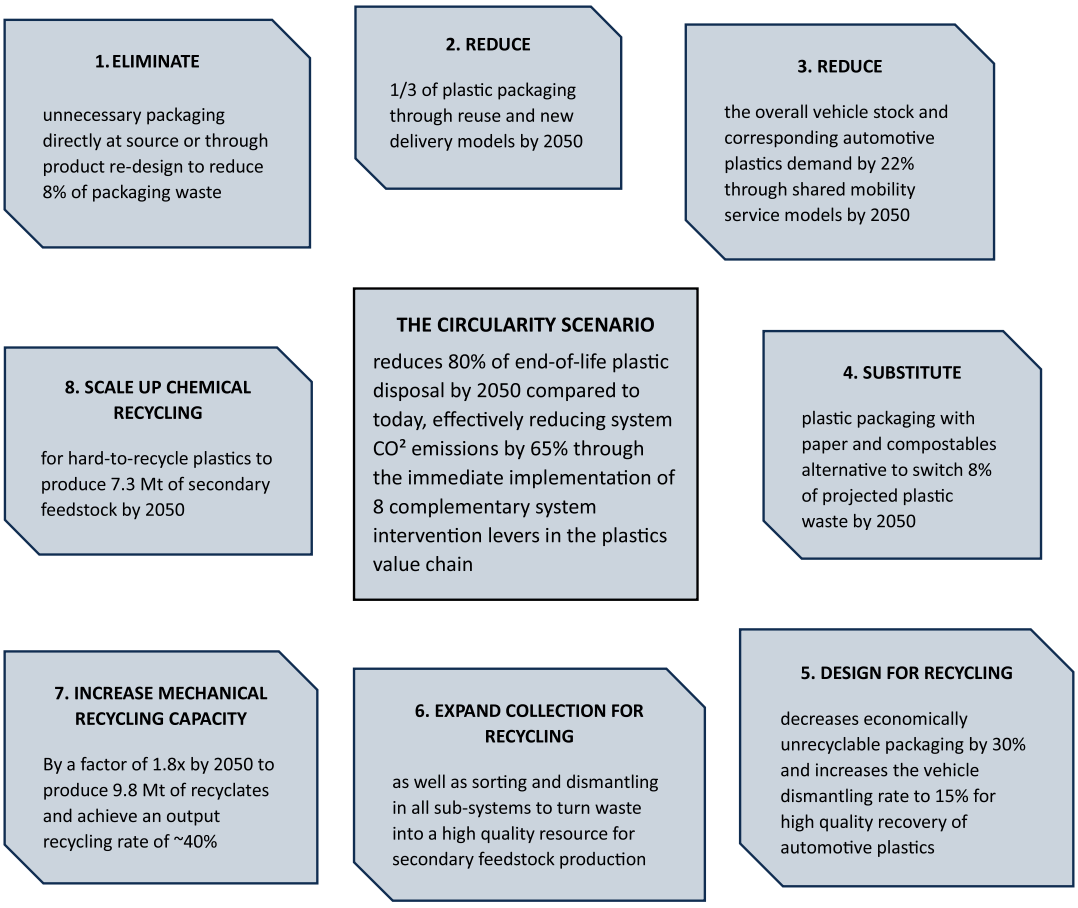

FIG.1. THE CIRCULARITY SCENARIO – 8 COMPLEMENTARY SYSTEM INTERVENTION LEVERS IN THE PLASTIC VALUE CHAIN

SOURCE: RESHAPING PLASTIC EUROPE

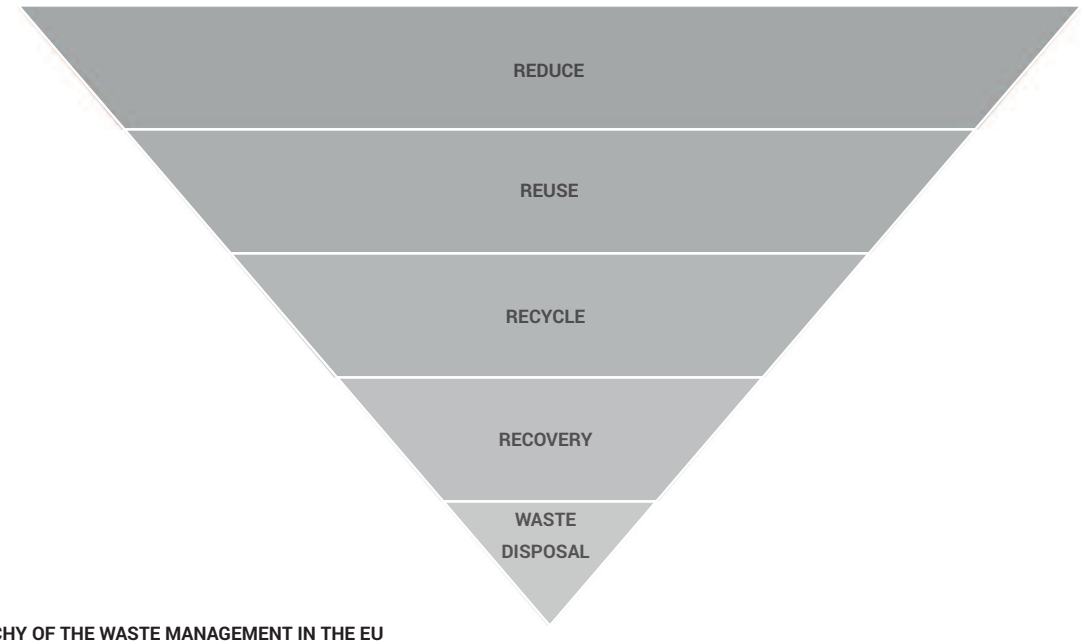

FIG.2. HIERARCHY OF THE WASTE MANAGEMENT IN THE EU

SOURCE: HTTPS://WWW.CONSILIUM.EUROPA.EU./PL/POLICIES/PACKAGING/#RISE, ACCESS 04.01. 2025

on big infrastructural investments mean that the decisions undertaken at the beginning of the twenties of the 21st century will decide whether the European plastic system will reach circular economy and zero net emission by 2050 [7].

The European Union takes care, first of all, for preventing the production of packaging. If it is not possible, the packaging should be re-used, recycled or the their energy should be recovered (Fig.2). The EU regulation will concern all packaging, irrespectively of the material employed and all the packaging waste, irrespectively of their origin (production, processing, retail sale or households).

Recycling is now considered as one of the options of reducing the impact of packaging on the environment, both in the aspects of the recycled raw materials' usability and of the suitability of packaging for recycling. Whether recycling may be employed in order to maintain the material in circular system and to produce new packaging for food is greatly dependent on the type of material. The properties such as colour, smell and stability may be become changed. Moreover, the chemical safety may be endangered as the material coming from recycling has a considerably greater capability to transfer contamination. The method of recycling has also a great meaning. When choosing the method of plastics disposal, we should think over the economic justification of the undertaken choice. If we want to recognize recycling as profitable, we must remember that the costs born during the preparation of material for recovery cannot exceed the values which will be achieved for a final product. We should consider which method is the most suitable for our waste [4]. The reasonable economy requires determination of the quality of available waste, the existing technologies and the economic calculus. The producers may have the trouble just with the last mentioned element because the increase of the costs of packaging, as caused by the introduction of the recycled materials, should be passed on to the consumers. The producers may have, therefore, the problems with fixing the final prices and their approval by the users [2].

It is also worthy to mention another aspect i.e. knowledge and education. The studies carried out among the inhabitants of Great Britain revealed that the consumers took care about their contribution to environment protection[2]. The problem lies, however in lack of the knowledge concerning classification of the waste, recycling and general uncertainty in the context of the undertaken action. Education is necessary so that the people – irrespectively of their age – begin to perceive the waste sorting and recycling

2 The study was ordered in September 2024 by DS Smith. It had a form of all-national questionnaire, conducted by OnePoll on the representative group of 2000 inhabitants of Great Britain

as not the wastage of materials but as recovery of resources. We must undertake the solution of the discussed problem in order to be sure that the persons from each generation will know how can they participate in the discussed activities [11].

CONCLUSIONS

The choice of the packaging model with the most circular system should be the key target of the producers of food packaging. The circular model would recognize the profits coming from the packaging made from renewable materials and having a high suitability for recycling. It would be possible to utilize the potential of packaging in the area of safety as well as in recycling suitability. The entry into force of the Packaging and Packaging Waste Regulation will be one of the most significant changes concerning packaging waste management during the recent years. On the one hand, it will contribute to the reduction of the quantity of the generated waste but on the other hand it will add many additional duties and costs to the market participants. Till now, the producers of food packaging were obliged to put the safety of the consumer at the first place, and now, additionally, they will have also to think about the application of the recycled componential materials; it will require the increased awareness in the area of safety of the consumer health and life.

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BETWEEN INNOVATION AND SUSTAINABILITY: FOCUS ON MATERIALS AND RESEARCH AT IPACK-IMA 2025

One of the most significant challenges facing the packaging market, an industry that has been engaged for years in the search for sustainable solutions, is the study of materials. The creation of innovative packaging – which reduces the consumption of raw materials and cargo space in transport and, as a result, reduces CO_2 emissions and waste production – is combined with the search for ever more environmentally friendly solutions that are nevertheless able to provide identical protection in every market into which they are introduced. All packaging materials are tested in research, from which the best solutions are selected – those that fully exploit the properties that ensure food safety, stability – and therefore effectiveness – of pharmaceuticals, protection during transport and correct preservation at each stage of the process.

The IPACK-IMA trade fair, which will take place at the Fiera Milano Rho exhibition centre from 27-30 May 2025, will focus its attention on material innovations: more than 200 companies will present specialised proposals for eco-friendly and smart materials that are able to cater for sustainable production and rationalization needs.

Trade fair exhibitors will present a wide range of material solutions. They will be assisted by IPACK-Mat – Packaging Materials for Product Development brand – a project aimed at easily identifying companies present in the exhibition halls that offer primary, secondary and tertiary packaging materials, either exclusively or in combination with machines and plants.

IPACK-Mat's main partner is CONAI, which has reaffirmed its interest in sponsoring the project. *Working with IPACK-IMA is a great chance for CONAI to promote sustainability in the packaging industry. The fair is a place in which innovation, technologies and sustainability can meet, providing companies with new ideas and solutions for rising to the challenges of the circular economy. One of the commitments of CONAI is also to support companies in adopting production models that are ever more effective at garnering resources and reducing environmental impacts by encouraging a packaging approach that is not only functional but also responsible* – comments **Ignazio Capuano, the Chairman of CONAI**.

From materials that stop food waste to those that ensure food safety, the connection with the world of certification is inevitable and necessary. That is why the exhibition section IPACK-IMA Lab – Solutions for Product Testing & Certification, organized in cooperation with the Italian Institute of Packaging, will be proposed again with the aim of giving space to laboratories, certification and research institutes specializing in the quality and conformity tests linked to MOCA regulations, materials and objects that may come into contact with foodstuffs.

Like IPACK-IMA, we feel the need to create a space dedicated to service businesses, to laboratories and to consultancy firms that use technology but find it hard to establish their identity and make their presence felt. These considerations gave rise to IPACK-IMA Lab, a hub that creates a space for people who offer vital packaging services and have high profile regulatory and technical competencies. For this reason, we decided to combine the display side with the opportunity to share information and content in a series of events – declares **Francesco Legrenzi, the head of the Italian Institute of Packaging**.

On show, therefore, will be a network of selected and accredited companies for running specific tests on the barrier properties of materials, which will not only have a dedicated space with purpose-built stands, but also the opportunity to organize a presentation speech in the event schedule of the show. This makes IPACK-IMA Lab a cutting-edge laboratory for packaging at IPACK-IMA.

The companies that have already signed up for IPACK-IMA 2025 Among the exhibiting companies in the industry, focused on certification, sustainability and new materials, there are many active players already registered, including: Agroblu, Arcoplastica, Botta, Cartotecnica Postumia, Cavanna Spa, Centro qualità carta lucense, Cristalpack, CSI, Goglio, Grifal, Gruppo Fabbri, Gruppo Seda, Ilpra, Labanalysis, Plastotecnica, Propagroup, Remi Tubi, Roboplast, Sacchital, Saes Coated Films, Sdar Pack, Teghleef Industries SPA, Tiber Pack, Tuv SUD, Ulma Packaging, Verbano Film, Volmar Packaging Srl.


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THE 10TH JUBILEE EDITION OF WARSAW PACK FAIR IS NEARING

On 8-10 April 2025, Ptak Warsaw Expo in Nadarzyn will become the centre of the European packaging industry, hosting the 10th jubilee edition of Warsaw Pack Expo. This is Poland's largest trade fair for packaging and packaging technology, which for years has been recognised both at home and abroad.

The event provides a unique opportunity to meet representatives of leading companies, packaging machinery manufacturers and distributors, logistics and warehousing specialists, packaging designers, quality managers and experts from various industries. Its editions serve not only as a place to establish new business contacts, but also a space for exchanging experiences, discussing innovations and presenting state-of-the-art technologies.

One of this year's key elements of trade fair programme will be the Warsaw PackTech Conference, a series of accompanying events that will introduce participants to the most important issues related to the future of the packaging sector. The conference will include the 6th Packaging Industry Congress organised by the Polish Chamber of Packaging, which will focus on the challenges and trends shaping the industry in coming years. An equally important highlight of the programme will be the conference 'Regulations, research, image – a comprehensive look at the packaging industry', prepared by Creative Packaging Group.

Its speakers will address topics related to rapidly changing regulations, research into new materials and issues of branding and sustainability in the industry. This will be complemented by a Trends and Exhibitor Presentations Panel, giving its

THE EVENT PROVIDES A UNIQUE OPPORTUNITY TO MEET REPRESENTATIVES OF LEADING COMPANIES, PACKAGING MACHINERY MANUFACTURERS AND DISTRIBUTORS, LOGISTICS AND WAREHOUSING SPECIALISTS, PACKAGING DESIGNERS, QUALITY MANAGERS AND EXPERTS FROM VARIOUS INDUSTRIES

attendees a chance to learn about innovative products and solutions currently shaping the market. The culmination of the conference, however, will be the Trade Fair Medal Ceremony, organised by Ptak Warsaw Expo in the Trade Fair Studio, during which the most innovative and groundbreaking solutions presented in Nadarzyn will be honoured.For years, the Warsaw Pack has consistently followed global trends and responded to the growing interest in ecology and sustainability. More and more emphasis is being placed on environmentally friendly technologies, the development of biodegradable and compostable packaging and the search for innovative solutions, with the aim of reducing the negative environmental impact of packaging production. Poland has been at the forefront of this effort in Europe for years, and Warsaw Pack provides a platform for companies to showcase their most environmentally friendly products and exchange knowledge about upcoming regulations and challenges. Ecological materials, intelligent recycling systems and modern packaging production technologies will all be at the centre of this year's discussions and presentations.

DETAILED INFORMATION ON THE PROGRAMME, THE LIST OF EXHIBITORS AND THE CONDITIONS OF PARTICIPATION CAN BE FOUND ON THE OFFICIAL EVENT WEBSITE: WWW.WARSAWPACK.PL. DON'T MISS THIS UNIQUE OPPORTUNITY TO BE PART OF THE BIGGEST PACKAGING INDUSTRY EVENT IN POLAND AND CENTRAL EUROPE. SEE YOU AT WARSAW PACK 2025!

The growing scale of the event is the best evidence of the important role it plays in the industry. The previous edition of Warsaw Pack welcomed over 23,000 visitors and 511 exhibitors from 54 countries, demonstrating the international nature and reputation of the event. This year's edition promises to be even more impressive – the organisers are expecting a significantly higher number of exhibitors and visitors, making Warsaw Pack one of the highlights of the global industry calendar. Exhibitors will showcase the latest technologies in packaging process automation, intelligent quality control systems and innovative materials that are revolutionising the market. It will be supplemented by premiere demonstrations of state-of-the-art packaging machinery and production lines that could change the way the sector operates in the coming years.

The fair takes place at Ptak Warsaw Expo, the largest trade fair and congress centre in Central Europe. It has six modern exhibition halls and a spacious car park with 15,000 parking spots, making it an ideal venue for international events. Its location near Warsaw provides convenient access for both domestic and international participants.

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- 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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- 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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