

Запропонована модифікація поверхні офсетного і крейдованого паперу за допомогою спеціального покриття (праймеру), який забезпечує високу якість струменевого друку, зокрема штрихових кодів. У цифровому струменевому друці з використанням чорнил на водяній основі важко досягти потрібної якості друку на звичайному папері. Струменевий друк широко використовується при виготовленні персоналізованої упаковки і етикетки. У зв'язку з тим, що такого виду продукція містить надрукований штриховий код, необхідно забезпечити його функціональність (зчитування) після друкування.

Праймер забезпечує контрольований процес встутування чорнила при струменевому друці, внаслідок чого підвищується якість друкування. З цією метою був використаний склад праймеру на основі водного розчину інтерполімерного комплексу полівінілового спирту (ПВС) і полівініліролідону (ПВП).

Досліджено вплив праймера, який містить різну кількість інтерполімерного комплексу на зміну крайового кута змочування надрукованого паперу.

На паперах з праймером і без праймера отримано відбитки методом струменевого друку та проведена оцінка якості надрукованих ліній і штрихового коду. Визначені такі показники якості ліній як: ширина ліній на відбитку, розмитість на границі лінія-папір, нерівність (широковатість) країв ліній та оптична щільність. Досліджено також вплив праймера на якість надрукованого штрихового коду способом струменевого друку.

Результати досліджень дозволяють забезпечити високу якість друкування штрихових кодів на звичайних паперах методом струменевого друку. Використання праймера сприяє поліпшенню якості друкування ліній і штрихових кодів. Клас якості штрихового коду збільшується з найнижчої (недопустимої) оцінки 0 (F) на папері без праймера до оцінки 2 (C) на папері з праймером, що гарантує його зчитування сканером на упаковці

Ключові слова: струменевий друк, праймер, полівініловий спирт, якість друку, штриховий код, лінія штриха

EFFECT OF THE PRIMER ON BARCODE QUALITY IN INK-JET PRINTING

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Received date 26.12.2019

Accepted date 28.01.2020

Published date 24.02.2020

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1. Introduction

The quality of barcodes is determined by the print quality and optical characteristics of the basic bar lines. The printed barcodes, specifically their structure, the size of lines and spaces [1], as well as the barcode quality [2] in general, must meet international standards. The barcode quality is strongly dependent on print preparation (a digital file and the print molds), a printing technique [3], the materials used in the printing process [4], specifically the structure of their surface [5], as well as a barcode position on packaging and labeling products [6].

A barcode could become an effective means of identifying and protecting an article provided its creation and location take into consideration the printing process peculiarities, the properties of materials used, the shape, weight, terms of logistics and storage.

For imprints, the principal quality parameter is color. As regards the packaging and labeling products, and an equally important parameter is the quality of the barcode and line (bar) that a barcode is composed of.

The barcode makes it possible to encode information (digital and letter-based) as a set of vertical lines. The one-dimensional barcodes (1D) quality is assessed according to the ISO/IEC 15416 "Automatic identification and data capture techniques – Bar code print quality test specification – Linear

symbols" [7]. The barcode quality assessment is based on an analysis of the profile of its lines and spaces (gaps between lines) and is performed using special devices called barcode verifiers.

Ink-jet printing is now widely used in the manufacture of customized packaging and labeling products. The ink-jet printing process implies that the line consists of separate droplets of ink. Liquid inks interact with a paper surface by moisturizing it, spilling at its surface, and penetrating the depth of the paper. The character of the interaction and therefore the print quality depend on the type of paper used. A barcode symbol contains key information about the product. To read the information, the codes must be scanned. If a barcode quality is high, the probability of a scan error is lower while the duration of scanning and reading the code is less. Therefore, it is a relevant task to conduct research aimed at obtaining a high quality of barcodes printed on conventional types of paper by using an ink-jet printing method.

2. Literature review and problem statement

Initially, a digital ink-jet printing technique, as well as electric photography, implied the use of paper of special quality. At the current stage of development, an important trend is an application of conventional offset paper (coated

or non-coated) in digital printing systems. The issue of quality at ink-jet printing on conventional paper has been investigated in a series of papers. Thus, work [8] investigated the impact of conventional printing papers on ink-jet printing quality and showed that conventional offset paper ensured the good reproduction of lines and drying rate, but did not make it possible to obtain saturated colors. Coated paper can provide a good color saturation, but it is not properly compatible with inks for ink-jet printing, as evidenced by the high tendency to stain and smear. The paper containing a surface layer based on silicon oxides provides the best quality of ink-jet printing, but it is too expensive. The results of studies into color gamut on the prints obtained by an ink-jet printing method using water inks and UV curable inks are reported in works [9, 10]. In the case of aqueous-based inks, acceptable print quality was received only on high-density coated paper [9]. It is shown in [10] that the color gamut on the prints received in special paper, intended for ink-jet printing (with a special coating at the surface of the paper), is much larger than the color gamut of the prints made on uncoated paper.

Thus, when using water inks for printing on paper media, the quality of paper has a significant impact on the quality of imprints. Therefore, a special receiving coating on paper is required to obtain a good print quality when using water inks. However, it is important to know how the ink-receiving coating interacts with the inks during printing; this information is lacking in the literary sources cited above.

The ink-receiving layers in special papers designed for ink-jet printing typically consist of the hydrophilic polymer and filler (a white pigment). The effect of calcium carbonate and silicon oxide fillers on the ink-paper interaction was investigated in papers [11, 12]. It was determined that the coating using a filler based on silicon oxides better retains the inks in the near-surface layers and thus improves the optical density of printing, reducing ink show through on the paper reverse side and reducing the phenomenon of ink bleeding at the border of two colored surfaces [11]. Similar results were reported in work [12], in which it was determined that the surface of the paper with a coating based on silicon oxides ensured an even distribution of pores and better wetting. In addition, such coatings contribute to the faster absorption of an ink solvent and keeping it at the surface. The fillers that are used in the ink-receiving layers of paper for ink-jet printing, in addition to having an impact on the mechanism of ink-paper interaction, had to, first of all, improve the optical characteristics of the paper. Therefore, the role of a binder in the ink-receiving layers of paper for ink-jet printing is interesting given that the binder itself can be used as a primer, which could be applied to standard paper just before the printing process.

Polyvinyl alcohol (PVOH) and starch are often used as a hydrophilic polymer in the ink-receiving layers of paper. Both binders have good adhesion strength. These substances are mainly used to bind pigments (fillers) in paper coatings and to ensure good wetting of the substrate. The binder used in ink-jet paper coatings also has a big impact on print quality. Comparative studies were conducted in [13] into the effect of paper surface coatings binders (cation starch and polyvinyl alcohol) on the quality of ink-jet printing. The results demonstrated that the use of PVOH provides the best trade-off between print color gamut and the accuracy of the reproduction of graphic elements, including the form of a line. The effect of the

degree of partially hydrolyzed polyvinyl alcohol, used as a binder in paper coatings, on print quality was described in works [14, 15], whose authors determined that as the PVOH hydrophobicity increases, the degree of ink absorption decreases, which contributes to their localization at the top of the coating structure. However, in study [14], the printing process was simulated by immersing a PVOH film into aqueous-based inks, which does not accurately reflect the process of paper-ink interaction under actual printing conditions. Based on the tests of a print's optical density, it was concluded [15] that the coatings based on partially hydrolyzed PVOH provide better print quality; however, as regards digital printing, the print quality requires a more detailed analysis, including the line quality parameters, which the authors did not consider.

Interesting results were obtained when studying the use of a mixture of ethylene vinyl acetate and PVOH as a binder [16]. The combination of these two polymers in a paper coating allows for a more efficient, in terms of print quality, the process of absorbing aqueous-based inks, compared to coatings containing either ethylene vinyl acetate or PVOH. Thus, the mixture of the two polymers in the binder can optimize the properties of coating in the paper for ink-jet printing. However, even though the cited article reports the results of line print quality, the line quality was assessed only visually.

The aqueous-based inks, being cheap and environmentally friendly, are widely used in industrial printing equipment (sheet and roll inkjet printing machines) and some types of plotters. However, given a high price, the use of a special paper with a coating does not resolve the issue of quality industrial printing. At present, one can highlight the following ways to obtain high quality on conventional paper in modern ink-jet printing systems:

- 1) the use of special coatings (primers) applied to paper just before the printing process in a printing press. The primer can be applied in a solid layer using flexographic printing devices based on an anilox roll (Fujifilm JetPress, Heidelberg Primafire, Kodak Stream, etc.), or selective layer ("drop under the drop"), by using an additional print-head (Canon Canon Océ VarioPrint i300);

- 2) the use of special solid inks, which are melted and applied to the paper in liquid form during printing. On paper, a drop of ink coagulates without penetrating deep into the porous surface of the paper, thus creating an intense print (Océ Crystalpoint Technology, Xerox Phase Change Inks);

- 3) a combination of the use of special inks and an indirect transfer of inks to paper at elevated temperatures (applying a heated transfer tape). For example, in one of the ink-jet printing variants, nanographic printing, the inks carried by a transfer tape stick to the surface of the paper, providing the high print quality (Landa machines).

The most affordable one is the method involving a primer. Hydrophilic polymer solutions can be used as a primer. Work [17] assessed the influence of primers based on the interpolymeric polyvinyl alcohol complexes on the change in the structural properties of the paper surface and the color gamut of the prints obtained by an ink-jet printing method. However, the work did not examine the print quality of a line and a barcode, which is an important element of packaging and labeling products.

Therefore, it would be expedient to study the impact of a primer on the quality parameters of the line and the barcode quality in general.

3. The aim and objectives of the study

The aim of this study was to investigate the effect of a special coating based on the interpolymetric complex of polyvinyl alcohol (PVOH) and polyvinyl pyrrolidone (PVP), which was used as a primer applied to paper, on the print quality of the line and a barcode by an ink-jet printing method.

To achieve the set aim, the following tasks have been solved:

- to determine the water contact angle on papers without the primer and with the coating including the primer containing a different amount of the interpolymetric complex;
- to assess qualitative parameters of the line printed on the examined paper with and without the primer: a line width, a line edge blurriness, a line edge raggedness, and optical density;
- to assess the quality of barcodes printed on the examined paper with and without the primer.

4. Research methods and materials

4.1. Materials used in the research

Two types of paper were used to investigate the impact of the primer on print quality: the 80 g/m² offset paper Amber Kostrzyń and the 170 g/m² coated paper. The composition of the applied primer was based on the interpolymetric complex of polyvinyl alcohol (PVOH) and polyvinyl pyrrolidone (PVP) with a molecular weight of 12,000±2,600 [18]. Water solutions of the interpolymetric complex PVOH and PVP of different percentages (10 %, 12 %, 14 % and 16 %) were studied, further designated as 10 % (PVA+PVP), 12 % (PVA+PVP), 14 % (PVA+PVP) и 16 % (PVA+PVP). Solid layers of the primer solutions, 5 μm thick, were applied to the examined paper. The printer Epson Stylus Photo 1410 was used to print, without the use of color profiles, on paper with the primer and without the primer, 5 prints for each combination (paper+primer). The aqueous-based inks (paint in ink-jet printing) was used in the printing process. The prints tested contained graphic images in the form of 150 μm lines and the EAN-13 barcode.

The prints were examined for the quality of the line; the quality of the barcodes was assessed. In addition, a static angle of wetting the surface of the paper with and without the primer was determined.

4.2. Procedure for studying a water contact static angle, the line and barcode quality

The PG-X (Thwing-Albert Europe) goniometer was used to determine the static angle of wetting the surface of the paper with and without the primer. The study involved a static measurement mode with a possibility to measure 5 images within 30 seconds. Drops

of distilled water in the volume of 4 pl. were applied to the surface of the tested sample using a micro-pump embedded in the capillary; the built-in CCD camera recorded the wetting angle.

The line quality parameters on the prints were evaluated using the digital IAS 1000 quality analyzer (*Qea*) [19]. The measurement principles imply that the device takes a digital photo of the printed line and then the software generates the profile of the line being tested. Based on the profile, parameters such as a line width (*W*), blurriness (*B*) at the edge of the line, line raggedness (*R*), and optical density (*D*), are determined [20, 21]. Line width (*l*) is the average line width value, measured from edge to edge at the predefined reflectance coefficient threshold along a normal line (at least 600 measurements per inch). The measurements used a 60 % reflection threshold (Fig. 1).

$$W = \frac{1}{N} \sum_{k=1}^N (\text{left edge threshold position}) - (\text{right edge threshold position}). \tag{1}$$

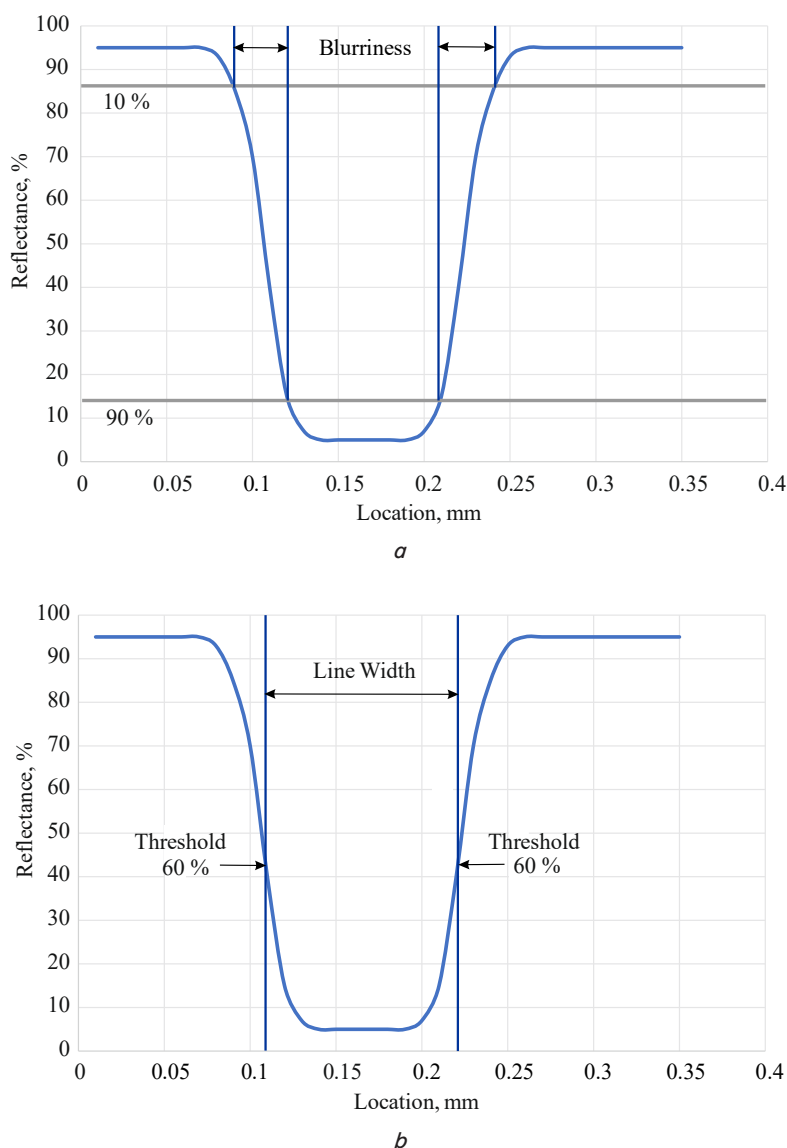


Fig. 1. The line profile and measured parameters: *a* – line width; *b* – line blurriness

Line blurriness is the parameter that determines the width of the transition zone from the most ink-saturated print inside the line to the unprinted substrate. For comparison, the profile of the line without blur is shown in Fig. 2. The line raggedness (R) is defined as the standard deviation of the residual representation of a line that extends beyond the boundaries of a perfectly straight line at 60 % of the reflectance threshold that determines the width of the line, Fig. 3, (2).

$$R = \frac{1}{N} \sum_{j=1}^N \sqrt{\frac{1}{k-1} \sum_{i=1}^k (\text{residuals from a line})^2}. \quad (2)$$

The line blurriness and line raggedness are determined for the left and right edge: the averages are determined.

Mathematical interpretation of the results from measuring the line quality parameters employed software for the digital quality analyzer IAS 1000.

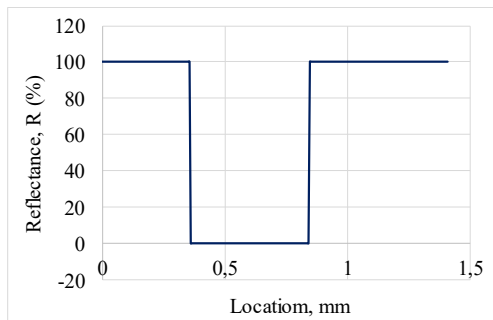


Fig. 2. Line profile without blurriness

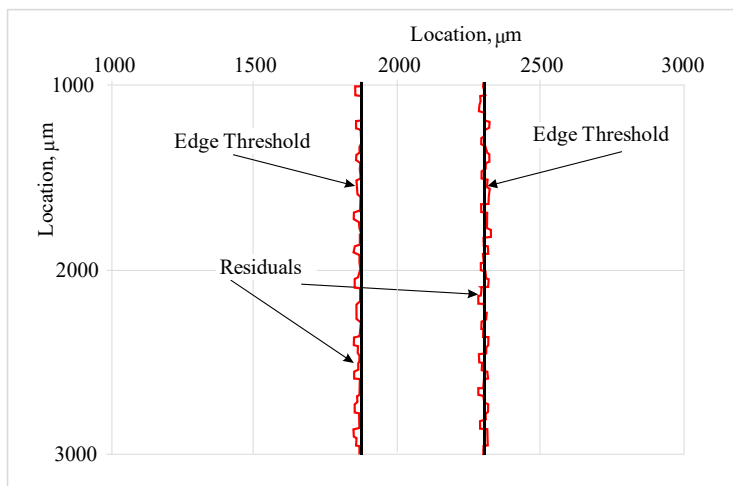


Fig. 3. Determining line raggedness

The barcode quality printed on paper with and without the primer was assessed by the REA ScanCheck 3 verifier in accordance with the requirements of the ISO/IEC 15416 standard [5]. The principal measured parameters are decoding, symbol contrast (SC), minimum reflectance (R_{min}), minimum edge contrast (EC_{min}), modulation (MOD), defects ($Defects$), decodability (V). The symbol contrast, modulation, and defects are rated for classes in the range of 4 to 0; the minimum reflectance and the minimum edge contrast are assessed only for class 4 or 0. The parameter

values and their correspondence to different classes are given in Table 1.

Table 1

Barcode parameters assessment [5]						
Class	R_{min}	SC	EC_{min}	MOD	Defects	V
4	$\leq 0.5R_{max}$	$\geq 70\%$	$\geq 15\%$	≥ 0.70	≤ 0.15	≥ 0.62
3	–	$\geq 55\%$	–	≥ 0.60	≤ 0.20	≥ 0.50
2	–	$\geq 40\%$	–	≥ 0.50	≤ 0.25	≥ 0.37
1	–	$\geq 20\%$	–	≥ 0.40	≤ 0.30	≥ 0.25
0	$> 0.5R_{max}$	$< 20\%$	$< 15\%$	< 0.40	> 0.30	< 0.25

The verifier evaluates the quality of a barcode and assigns it one of the following classes/estimates: A (3.5–4), B (2.5–3.5), C (1.5–2.5), D (0.5–1.5), F (below 0.5), where A corresponds to maximum print quality, and F corresponds to unacceptable quality (reject). The final estimate corresponds to the estimate of the measured parameter, which has the lowest rating. The minimum symbol quality grade is “C”. The symbol class is given with the working wavelength and aperture used. The class designation should be presented in the $G/A/W$ format, where G is a full symbol class, A is the aperture number, W is the wavelength of radiation in nanometers. Each code was scanned 10 times; the full symbol class (G) is the mean arithmetic of reflectance profile classes when scanned along each of the ten paths. The REA ScanCheck 3 verifier used a laser with a 630-nm wavelength and an aperture of 0.152 mm, which corresponds to reference number 06. Mathematical statistics and processing in the STATISTICA 12.0 software were used to interpret the results from the barcode quality studies.

Thus, in this work, the barcode quality was investigated applying a comprehensive procedure, which implies the evaluation of the print quality of a separate line and a barcode in general.

5. Research results

5.1. Results of studying the impact of the primer on water contact angle

Experimental studies have shown that on conventional offset paper the presence of the primer with different content of the interpolymeric complex (PVA+PVP) has led to better wetting of the surface. The contact angle dropped from 90° (on paper without the primer) to about $65\text{--}74^\circ$ (on paper with the primer) at the initial wetting stage (Fig. 4, a). The presence of the primer on the coated paper did not have a significant impact on the change in the wetting angle (Fig. 4, b), the water contact angle on paper with and without the primer is within $60\text{--}67^\circ$. On both types of paper, a close angle of wetting is achieved owing to the primer.

The results of this study allow one to argue that the use of the proposed primer makes it possible to obtain the similar hydrophilic characteristics of the surface of different types of paper, which may testify to the progress of identical processes in the interaction between an aqueous-based ink and paper.

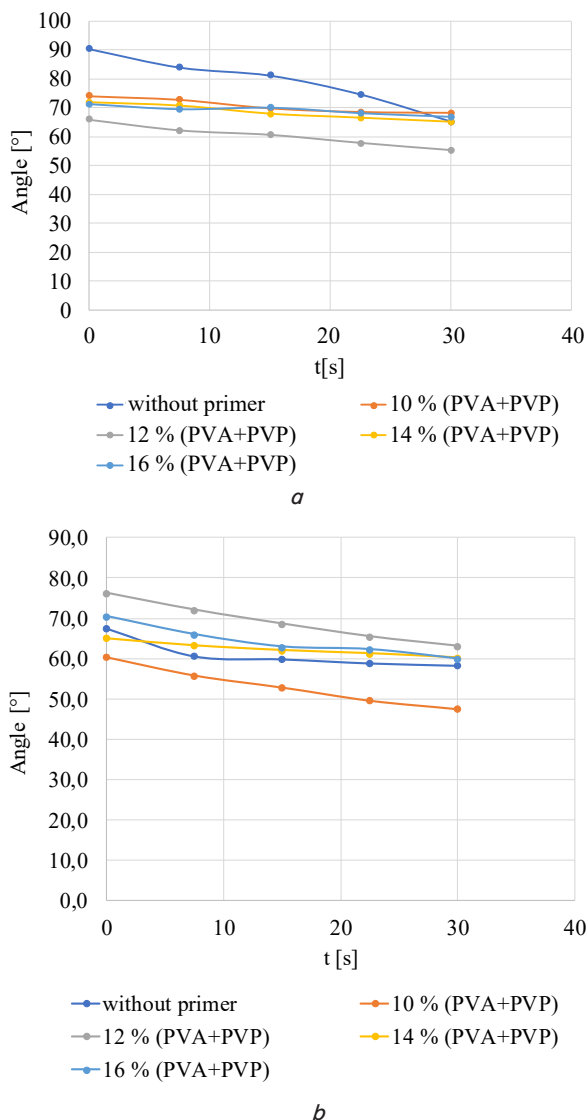


Fig. 4. The angle of wetting the surface of the paper: *a* – offset; *b* – coated

5. 2. Results of studying the line quality parameters

The use of primers based on the examined interpolymeric complex improved the reproduction characteristics of the line on the prints obtained on both offset paper and coated paper. The print on the coated paper without the use of the primer was characterized by the largest increase in the width of the line. Thus, on offset paper, the width of the bar line was 187 μm , and on coated paper – about 216 μm .

It was experimentally confirmed that the use of primers with different concentrations of the interpolymeric complex led to a significant reduction in the width of the line. A line printed on coated paper using a primer with the 10 % and 12 % interpolymeric content is smaller in width than the line printed on offset paper (Fig. 5). Reducing the width of the line on the print should have a positive impact on the print quality of the barcode, as it would result in less distortion in the width of the gaps between the lines in the barcode.

As regards other characteristics of the line (Table 2, Fig. 6, 7), the primer’s positive effect on line edge alignment (reducing line irregularity) and increasing the optical density of the line was observed. Blurring the edge of the line in

the case of printing on paper with and without the primer is almost at the same level.

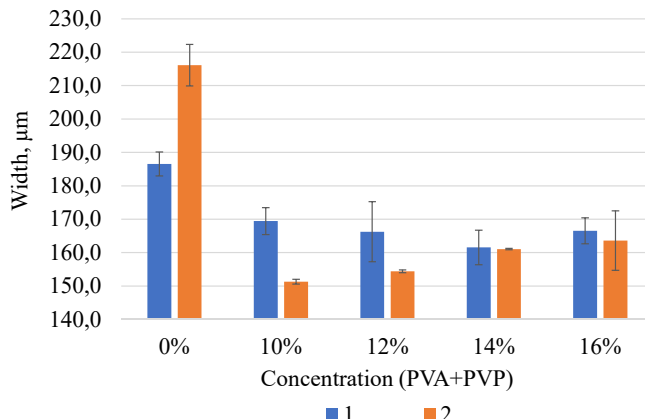


Fig. 5. The width of the line printed on paper: 1 – offset; 2 – coated

It can be assumed that the increase in optical density was caused by that the presence of a primer does not make it possible for inks to penetrate deeply into the paper. This is confirmed by a microscopic study shown in Fig. 8, where one can see that in the case of paper without the primer inks penetrate deep into the structure of the paper, and on paper, with the primer, the print is at the surface of the paper. In addition, the presence of the primer was the reason for the smaller spill of the line on the surface of the paper, especially for the case of coated paper, which caused a significant reduction in its width.

Table 2

		Line quality parameters		
Paper	Primer	Line quality parameters		
		<i>R</i> [μm] (OS)*	<i>B</i> [μm] (OS)*	<i>D</i> [-] (OS)*
offset	no primer	10.7 (4.6)	135.8 (25.9)	0.80 (0.09)
	12 % (PVA+PVP)	8.7 (3.9)	108.6 (10.8)	1.12 (0.07)
coated	no primer	18.9 (7.3)	66.83 (17.2)	0.93 (0.06)
	12 % (PVA+PVP)	10.5 (2.5)	70.9 (8.7)	1.13 (0.06)

Note: * – rms deviation

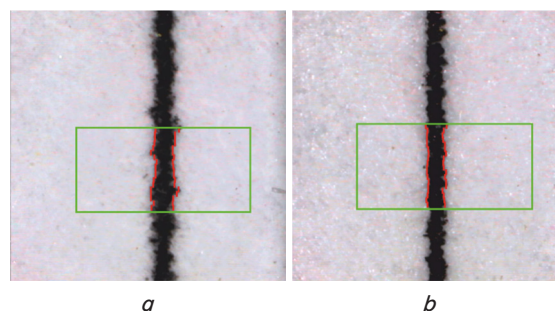


Fig. 6. The measured line fragment on offset paper: *a* – without the primer; *b* – with the primer, 12 % (PVA+PVP).

The width of the larger length of the measurement field rectangle is 1.632 mm. Microphotograph was acquired at the device IAS 1000 (Qea)

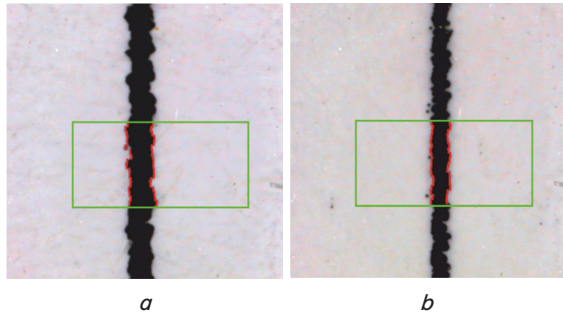


Fig. 7. The measured line fragment on coated paper:
a – without the primer;
b – with the primer, 12 % (PVA+PVP).

The width of the larger length of the measurement field rectangle is 1.632 mm. Microphotograph was acquired at the device IAS 1000 (*Qea*)



Fig. 8. Cross-section of the print on coated paper:
a – without the primer;
b – with the primer, 12 % (PVA+PVP)

Thus, this study has shown that inks in printing a line spill less on the surface of the paper with the primer and penetrate less into the structure of such paper. As a result, the printed bar line has the best geometric and optical parameters.

5. 3. Results of studying the barcode quality

Paper with the primer, containing 12 % of the interpolymeric complex, and without the primer, was used by an ink-jet printer to print the EAN-13 barcode. The results from studying the barcode quality parameters and the final estimate of the code are given in Table 3.

Barcode quality parameters

Parameter	Barcode parameters estimate, on paper:			
	offset, no primer	offset, with the primer	coated, no primer	coated, with the primer
Decoding	4	4	4	4
Symbol contrast (<i>SC</i>)	3.0 (68 %)	4.0 (71 %)	3.0 (68 %)	4.0 (72 %)
Minimum reflectance (<i>R_{min}</i>)	4.0 (4 %)	4.0 (1 %)	4.0 (8 %)	4.0 (1 %)
Edge contrast (<i>EC_{min}</i>)	4.0 (30 %)	4.0 (36 %)	4.0 (38 %)	4.0 (42 %)
Modulation (<i>MOD</i>)	1.0 (44 %)	2.0 (51 %)	2.1 (56 %)	2.2 (59 %)
Defects	4.0 (11 %)	4.0 (15 %)	4.0 (10 %)	4.0 (15 %)
Decodability (<i>V</i>)	0 (17 %)	2.0 (37 %)	0 (10 %)	2.1 (43 %)
Grade/class	0.0/06/670 (F)	2.0/0.6/670 (C)	0.0/06/670 (F)	2.1/06/670 (C)

The presence of the primer on paper had the greatest impact on such barcode print parameters as decodability (*V*), modulation (*MOD*), and symbol contrast (*SC*). The barcode printed on paper without the primer received the lowest grade of 0 (F) due to the fact that the decodability parameter was rated “0” for both papers under study (offset and coated) without the primer. A barcode rated below the 0.5 estimate

would have a large number of “non-readable” reflectance profiles; it is unlikely that any equipment could decipher such a code. The decrease in decodability and modulation may be due to the excessive increment of the bar width that occurs on both types of paper without the primer. On prints obtained on the offset and coated paper with the primer, the width of the line decreases by about 20 % and 30 %, respectively, (Fig. 5), compared to prints without the primer. In addition, the irregularities of the edge of an element, inherent in the barcode prints on paper without the primer, can cause a decoding error. The primer also improved the symbol contrast parameter by increasing the optical density of the printed bars. On the examined paper with the primer, the symbol contrast grade increased from “3” to “4.”

Thus, the use of the primer has improved the barcode quality printed by an ink-jet printing method. The barcode grade increased to Class 2(C) compared to the unacceptable 0 (F) grade received on the primer-free paper.

6. Discussion of results of studying the effect of the primer on the line and barcode print quality in ink-jet printing

The proposed primer, based on the interpolymeric complex of polyvinyl alcohol and polyvinyl pyrrolidone, makes it possible to obtain high-quality printing regardless of the surface properties of imprinted paper. Such a result is achieved owing to that the presence of a primer layer on paper changes the process of ink–paper interaction. When ink interacts with paper, there are the processes of wetting, adhesion, and ink absorption into the structure of the paper. Wetting and absorbing processes would be crucial for the optical and geometric parameters of print quality. Typically, printing on paper is not accompanied by any issues related to the adhesion of an aqueous-based ink. The use of the proposed primer has made it possible to receive the close values of the water contact angle on different types of paper (Fig. 4). In addition, the distribution of inks in the near-surface layers of paper

Table 3

is important. The primer limited the penetration of ink into the depth of the thickness of the paper (Fig. 8). The ink remained in the near-surface layer of offset and coated paper, which made it possible to obtain high values of optical density. Thus, the applied primer has enabled obtaining close optical (optical density) and geometric (width, blur, and raggedness) characteristics of the line print (Fig. 5, Table 2) on different types of paper.

However, the quality of a barcode, which is composed of a set of lines and spaces of a certain width, is evaluated by a much larger number of parameters than the line print quality.

By using a comprehensive barcode quality assessment procedure employing the REA ScanCheck 3 verifier, it has become possible to objectively assess the impact of the primer on the barcode print quality printed by an ink-jet printing method. As shown by the study results (Table 3), the use of the primer has significantly improved the barcode print quality on both types of the examined paper.

It should be noted that the works cited in chapter 2 proposed the hydrophilic polymers mainly to be used as a binder for the ink-receiving layers of special paper for ink-jet

printing, while the primer proposed in this work, based on the interpolymeric complex of polyvinyl alcohol and polyvinyl pyrrolidone is recommended for applying on paper surface in a jet printing machine just before the printing process. However, the limitation of the current study is the fact that the primer layers were applied in the laboratory. Therefore, further research will be aimed at investigating the impact of semi-industrial and industrial techniques of applying a primer on paper. In ink-jet printing machines, the primer is applied using anilox (raster) rolls. It is expedient to test the effects of such anilox characteristics as specific volumetric capacity and screen ruling on print quality at IGT printability test machines and in an ink-jet printing machine.

In addition, in the future, it is advisable to conduct more in-depth studies of the interaction between a liquid and paper, as studying the angular wetting angle did not produce any exhaustive explanation of the processes taking place at the ink-paper interface; they would exert a decisive impact on print quality.

The study reported here can be used in practice. The obtained results of the modification of the surface of offset and coated paper with the help of a special primer could be used in the process of ink-jet printing in printing houses that specialize in the manufacture of packaging and labeling products.

7. Conclusions

1. The use of the primer has made it possible to change the hydrophilic properties of conventional offset and coated paper, resulting in a similar angular wetting angle on both types of the examined paper.

2. Determining the quality parameters of the line printed by an ink-jet printing method has confirmed the positive impact of the primer on print quality. The accuracy of line width reproduction and the intensity (optical density) of the line have improved significantly. The increase in the line width decreased from 36 μm to 16 μm for offset paper, and from 56 μm to 5 μm for coated paper, while optical density increased by about 20–40 % for prints on offset and coated paper, respectively, compared to prints, made on these papers without the primer. To a lesser extent, the primer had an impact on line edge blurring and line raggedness.

3. The application of the primer has improved the barcode print quality. On paper with the primer (offset and coated), the grade of the ink-jet-printed barcode increased to class 2 (C) compared to the unacceptable 0 (F) grade obtained on primer-free papers. The primer had a positive impact, primarily on such barcode parameters as decodability, modulation, and symbol contrast.

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