УДК 681.625.92 DOI: 10.30837/2663-9564.2025.2.11

METHODS FOR IMPROVING PRINT QUALITY FOR KONICA MINOLTA 6085 DIGITAL PRINTING PRESS

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Abstract

The paper examines the use of different raster structures with different dot shapes, taking into account the typical recommendations of printing press manufacturers and the features of the Konica Minolta 6085 printing press to improve the quality of printed products. The use of various rasterization technologies allows solving not only the classic problems of moir formation, graininess, improving the smoothness of halftone printing, etc., but also more specific problems. The use of different forms of raster dots in digital printing can be used to expand the color gamut; the combination of stochastic rasterization, different forms of dots and high-precision line screen allows you to simulate various printing processes and make better quality color proofs. Based on the results of the evaluation, recommendations were developed for the selection of types of rasters according to the types of originals and materials.

Key words: digital printing; assessment; quality; stochastic; raster; rasterization; line screen.

1. Introduction

Improvement of printed product quality is an important issue for printing enterprises. At the same time, quality control in digital printing companies is usually carried out only by the print operator, visually based on the principle of "like/dislike" or "close to the layout", as there are no clear, officially recognized criteria for evaluating digital print quality. A relevant issue is the study of methods for improving print quality for digital printing press. One of these approaches is to use various methods of rasterization with a specified line screen.

The purpose of the work is to investigate ways for improving print quality for the Konica Minolta 6085 printing press through additional rasterization capabilities.

In order to achieve the goal, it is necessary to perform the following tasks:

- investigate the characteristics of digital printing that may influence print quality;
- develop test images for experimental printing;
- select digital printing quality indicators;
- select printing materials for studying the quality of digital printing;
- conduct an evaluation of the prints;
- develop recommendations for choosing types of rasters based on types of originals and materials.

The study was conducted at the printing company LLC «Drukarnia Madrid» in Kharkiv, Ukraine on the Konica Minolta 6085 printing press, using the most popular printing materials at the company.

2. Digital image parameters that affect print quality

Due to the absence of national standards for digital printing, the analysis of its quality is subjective. The engineering evaluation of digital printing quality is carried out using the international standard ISO/IEC 24790:2017 [1], which assesses the accuracy of font, line, and spot reproduction. This document applies to human-readable monochrome documents produced by printers and copiers. However, the standard does not address the quantitative values within which measurements are to be made, does not provide a methodology for creating a test object, calibrating equipment, or a list of parameters necessary for evaluating different printing technologies.

The concept of quality implies a set of properties or characteristics, and is therefore defined by a single value [2]. The quality assessment of a printed image is most often carried out by experts, who draw conclusions by combining technical data with their subjective evaluations [3]. Digital printing is a reproduction of the original, which allows for the selection of reference values for the test-object indicators, specific to each of the chosen parameters. In order to calculate the quality indicator and then the overall quality index, each print quality parameter on the test strip will correspond to its own test object. According to the analysis of works [2, 4-16], the quality of digital image printing is influenced by parameters such as resolution, dot shape, line screen, raster rotation angle, etc.

1. Resolution.

The selected resolution affects the file size on the disk, the speed of processing the document in the image editing program, and the time it takes to print.

The resolution at which the image is to be sent to the output device is called the output resolution and is determined by the spatial frequency of the raster. In the field of digital prepress, there is an empirical rule stating that the output resolution should be equal to twice the line screen of the raster (300 ppi (Pixels Per Inch) for a raster with a line screen of 150 lpi (Lines per inch)).

2. Raster Line Screen.

The number indicated in the printing press specifications as the resolution is the number of real dots that the machine prints per inch (for example, 600 or 1600 dpi (Dots Per Inch)). The number of raster dots per unit length is referred to as the line screen. The line screen is measured in lpi.

The ratio of the output device's resolution to the raster line screen determines the size of the raster cell's sides, measured in printer dots. The maximum number of dots in a printing press that form a raster dot equals the square of the cell's side length.

The quality of halftone reproduction depends on the tonal range. However, at least 150 shades of gray are required for this, while high-quality printing requires a much larger number of halftones to be rendered (Table 1).

Table 1 – Recommended line screens for printing

lin/cm	lpi	Publication type
12-24	30–61	raster images of printers
24-48	61–122	illustrations in newspapers
48-60	122–152	magazine illustrations
60-80	152–203	advertising and artistic publications
80-120	203–305	special editions and stereo printing

The sharpness and clarity of the image improve with an increase in line screen, and the visibility of the raster decreases. However, the number of reproduced gradations and the smoothness of tone reproduction are reduced if the line screen is increased without a corresponding reduction in the level of inherent visual noise in the platemaking and printing processes. The choice of line screen value can be considered correct if it ensures an optimal balance between different quality indicators, such as image sharpness and tone smoothness. A quantitative expression of this compromise ratio is the value of the relative areas of the minimal dots and spaces [2, 15]. Additionally, the line screen should be selected in accordance with the material on which the printing is performed.

3. Dot Shape.

Ensuring the accuracy of reproducing print elements and minimizing the size of gaps is a fundamental criterion for optimizing the process of raster image printing. At the same time, originals may vary significantly in nature. Some may primarily contain fine details and contours with an absence of background, while others may require accurate tone rendering without noticeable transitions, rather than fine details in the images. It's clear that for the first type of images, where small details predominate, a higher line screen is used, as suggested by the aforementioned standard method. On the other hand, for "soft" images, it is desirable to slightly reduce the line screen while simultaneously maximizing the number of shades that can be reproduced. Therefore, in order to improve print quality, various dot shapes can also be used depending on the type of images and materials on which the printing is performed. The main types of raster structures for Konica Minolta 6085 printing press are shown in Figure 1 [6, 11, 17].

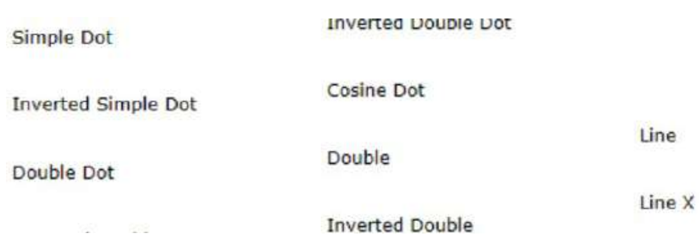

Fig. 1. Types of raster structures for Konica Minolta printing press

Following control tools are used for quality control during the prepress stage and printing process [18, 19]:

a) TECHKON SpectroPlate Digital Microscope is used for checking the shape of raster dots. It is designed for measuring the parameters of analog and CTP plates, printing films, and printed impressions;

b) X-Rite 518 Spectrodensitometer is used for monitoring the printing process and determining print quality parameters. Its functions include measuring optical density, dot gain, area of raster dots, contrast, trapping, etc.;

c) Eye-One Pro UV Cut Spectrophotometer is used for controlling color reproduction accuracy and creating printing profiles. It is designed for measuring the spectral characteristics of light and provides the ability to obtain color information in various color systems.

3. Quality indicators of digital printing

The purpose of the research is to select technological parameters for improving the quality of digital printing in the context of an operating enterprise. Therefore, a simplified scheme of comprehensive analysis is entirely acceptable, where individual quality indicators that are specific to this production are analyzed. After calculating the quality indicators, the obtained values are compared with the reference value, and conclusions regarding quality are made. A comprehensive quality assessment includes visual evaluation by the consumer, instrumental evaluation, and the use of physical quality indicators of prints obtained through printing on Konica Minolta 6085 printing press.

It is necessary to investigate the impact of various image parameters (resolution, line screen, dot shape, etc.) on the quality of digital printing.

As mentioned earlier, the quality of digital printing results is usually evaluated visually, as there are no clear, officially regulated evaluation criteria. Therefore, the issue of assessing print results is particularly relevant, especially in cases where printing is done with non-reference parameters. That is, each printing press has settings recommended by manufacturers for the most common materials, such as offset or coated paper, etc. However, more than half of the jobs are performed on other materials, such as design papers, printing films, self-adhesive materials, etc. Developing quality indicators that account for additional settings in digital printing, as well as recommendations for using additional printing modes for different materials, is a crucial task for a printing company that aims to attract and retain its clients [20].

There were 12 parameters identified during the analysis of works devoted to the quality of digital printing [6, 10, 11, 14, 15], according to which researchers evaluated digital printing (see Table 2).

Table 2 – Digital printing evaluation criteria

No	Evaluation criteria	Print characteristics
1	Absence of excessive background optical density	The background should be clean
2	Overall print uniformity	It should not contain poorly printed, overly light or dark spots
3	Normal optical density of the image	The print should not appear overloaded or oversaturated
4	Clear gradation reproduction	All transitions should be clearly visible
5	Satisfactory image resolution	Small details should be clearly noticeable when examined closely
6	Sufficient print resolution	The print should appear sharp, with no blurring of contours
7	Font reproduction quality	Reproduction of the smallest font sizes and high-quality letter elements
8	Gloss	Distributed evenly across the entire print area
9	Degree of toner adhesion to the substrate	The ink should not flake off or wash away with water
10	Color gamut	A high-quality print should include all colors from the layout
11	Reproduction of memorable colors	Memorable colors should be reproduced realistically
12	Image contrast	Reproduction of the lightest and darkest shades

According to the set task, it is not necessary to consider all the indicators for quality assessment. Indicators related to background density or print resolution are not critical, as high-quality printing equipment and materials are used for the experiment. Therefore, some indicators will not be calculated, but their visual examination will be conducted in order to gather information for developing recommendations for printing.

After analysis, items 6 and 9 from Table 2 were excluded from consideration, as printing is carried out using high-quality printing press with high resolution, which ensures both sufficient print resolution and good adhesion. Item 1 (background optical density) will be investigated to confirm the quality of the printing materials, but this parameter will not be considered for the overall assessment. Instead, it is proposed to calculate image contrast as the difference between the maximum and minimum optical densities of the image. Increasing the line screen leads to the reproduction of a more saturated image, thus increasing the contrast. Therefore, this indicator has been included for consideration. Item 8 (gloss) will be assessed visually. Printing is performed on materials with different surfaces, so this indicator is not always necessary. It is suggested to add gray balance, which provides an understanding of the consistency of primary and auxiliary color triads (their overlaps) in highlights, halftones, and shadows, i.e., the image's balance in the achromatic component. Its reproduction also depends on the set line screen and dot shape, so it will be evaluated visually, and the analysis of this indicator will be considered in the recommendations. The evaluation of the uniformity of solid print area is especially important when printing images with large solid areas. This parameter should be controlled, which is confirmed by many researchers of print quality.

The following final nomenclature of indicators has been chosen for the study:

- halftone reproduction (print linearity);
- optical density of the image;
- font reproduction quality;
- contrast;
- color deviation;
- print uniformity;
- color gamut.

4. Development of a test image for assessing the quality of digital printing

Test images were developed based on the analysis of various test images recommended in the literature [3, 21] and used in production for digital printing testing. Based on the print format, two layouts were designed – the first one is for the analyzing and visual evaluating the images, and the second one is for determining the main indicators for assessing digital print quality. The test objects were divided into two categories in order to conduct both subjective and objective analysis of digital print quality. The subjective evaluation was performed by experts and then compared with quantitative indicators.

Accordingly, the developed test images included test objects for the quantitative assessment of quality indicators (print uniformity, print linearity, contrast, color gamut, color deviation) and elements for visual evaluation by experts (images in RGB and CMYK color systems for assessing the reproduction of memorable colors, a scale for evaluating gray balance, test objects for font quality control, and objects with gradient fills for visual assessment of print linearity).

The developed test images with control elements were printed on selected materials with specified line screen parameters and different dot shapes, as shown in Figure 2.

Linearity, as one of the most important quality indicators, was assessed by the number of halftones reproduced. A scale with various relative dot sizes ranging from 0 to 100% was used. The scales were designed for both primary and secondary colors (see

Figure 2.1). For visual control of gradient linearity, scales with linear and radial gradients were used (see Figure 2.2). In order to assess color reproduction accuracy, the Ugra/Fogra Media Wedge V3 control scale was used (see Figure 2.3).

The reproduction of memorable colors is crucial for accurate color representation in paintings and photo reproductions. It was controlled based on the corresponding images (see Figure 2.4). Another indicator is gray balance (see Figure 2.5).

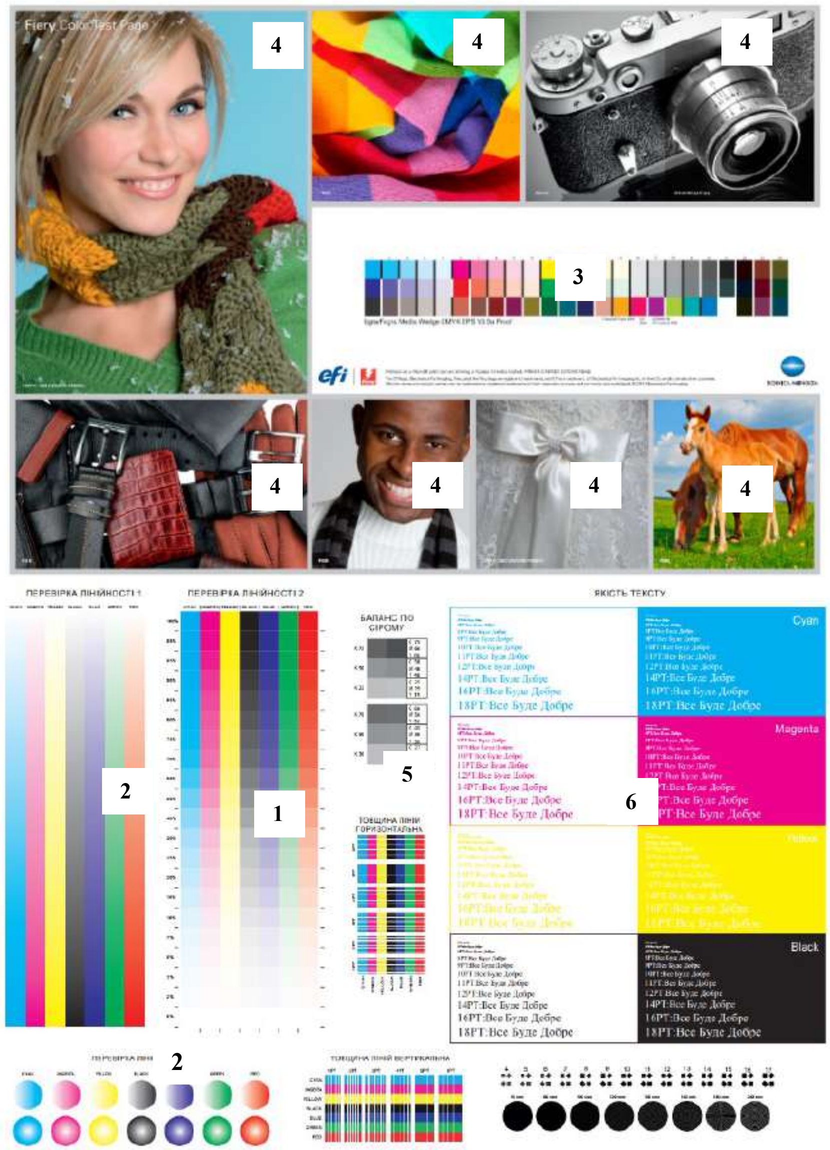

Fig. 2. Test images

The test object for determining print uniformity consists of printed solid areas of primary colors, placed both along the length and width of the print. They are also used for controlling text "reversal". Four optical density measurements were made in both the horizontal and vertical directions (see Figure 2.6).

Contrast is defined as the difference between the maximum and minimum optical densities of the image. In order to calculate contrast, scales are required to control light and dark shades with maximum and minimum optical density values (see Figure 2.2).

5. Selection of printing materials

Materials used at the enterprise were considered for the experiment. The analysis of orders allowed for the selection of materials most commonly chosen by customers:

1. Coated paper, glossy surface, density 170 g/m²;
2. Coated paper, matte surface, density 150 g/m²;
3. Coated cardboard, matte surface, density 300 g/m²;

4. Linen embossed textured cardboard, linen, density 230 g/m²;
5. Constellation Snow Lime textured cardboard, dot, density 280 g/m²;
6. Plike White design paper, smooth texture (properties similar to plastic), density 330 g/m²;
7. Self-adhesive paper.

All of these materials above are classified as high-quality papers. Design paper and textured cardboard were selected for studying the potential for improving print quality on these materials.

Printing was carried out with line screens of 150, 200, and 300 lpi during the experiment. After analyzing the screening technologies and the characteristics of raster structures, the following dot shapes were selected: Round, Square, Rhomboid, Line, Double Dot.

6. Print Quality Evaluation

After printing the samples, a preliminary expert evaluation of the prints was conducted.

Considering the tasks set for the research, five experts working in digital printing companies were selected: a designer, a technologist, a manager, a print operator, and a head of the production department. The main criteria for selecting experts included options as formal indicators (e.g., position, years of experience in the industry, etc.), success in previous evaluations (clear understanding of the tasks set, adequate and fair assessment), and familiarity of the expert with other group members (trust in the results of other experts, personal responsibility to other participants). Expert assessments are required for comparison with the results of instrumental control and calculations. An expert survey was conducted for the visual evaluation of the obtained images, in which experts determined the nomenclature of quality indicators for digital printing.

Taking into account the experts' level of expertise, the ranking method was preferred. For each expert, the task was to number the prints on different materials from 1 to 7, where 1 represents the worst quality, and 7 represents the best one. In doing so, experts assessed both objective indicators (e.g., gradation characteristics, print uniformity, gray balance) and subjective quality indicators (reproduction of memorable colors, gloss and texture of the surface, etc.).

The expert evaluations of the prints on different materials are shown in Table 3.

Table 3 – Evaluation of material samples by experts

Printing Material	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Sum	Rank
	Designer	Technologist	Manager	Print operator	Head of Prod. Dept.		
Coated paper, glossy surface	7	5	7	6	6	31	2
Coated paper, matte surface,	5	6	5	5	5	26	3
Coated cardboard, matte surface	6	7	6	7	7	33	1
Textured cardboard, linen	1	1	2	1	1	**6**	**7**
Textured cardboard, dot	2	2	1	2	2	**9**	**6**
Design paper	4	3	4	3	3	17	5
Self-adhesive paper	3	4	3	4	4	18	4

The lowest scores were given to textured printing materials (highlighted in bold). According to the experts, the additional rasterization capabilities could not improve the print quality on these materials. Thus, they will not be used in further research.

After the preliminary analysis, key indicators that have a significant impact on the quality of digital printing with additional settings were identified, shown in Table 4.

Table 4 – Results of refining the nomenclature of print quality indicators

Print quality indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Sum	Rank
	Designer	Technologist	Manager	Print operator	Head of Prod. Dept.		
Halftone reproduction	6	7	5	7	6	31	2
Optical density of the image	1	3	1	2	2	**9**	**6**
Font reproduction quality	2	1	2	1	1	**7**	**7**
Contrast	3	4	4	4	4	19	4
Color deviation	7	5	7	6	7	32	1
Print uniformity	5	6	6	5	5	27	3
Color gamut	4	2	3	3	3	15	5

Experts survey results in Table 3 illustrate that the optical density of the image and font reproduction quality received the lowest scores and were excluded. The maximum optical density is measured and affects the image contrast. Therefore, only this indicator was left. Font reproduction quality will be evaluated visually. This parameter is of interest in terms of reproducing finer line screen or other dot shapes, but it does not impact the final print quality. Each of these indicators has a threshold value, and exceeding it indicates a defect. The baseline and threshold values of the parameters [2, 5, 6, 15] are determined based on practical recommendations from printing equipment manufacturers and print regulatory documentation (see Table 5).

Table 5 – Baseline and threshold values of individual indicators

№	Print quality indicator	Baseline (reference) value	Threshold value of indicator	
			min	max
1	Gradations of reproduction	71	50	–
2	Contrast	45	30	–
3	Color gamut	11511	9750	–
4	Color deviation	3	–	4
5	Print uniformity	0,017	–	0,024

Gradation reproduction or print line screen can be assessed by the number of halftones reproduced during printing. For this purpose, a scale with varying relative sizes of the halftone dot from 0 to 100% is used. The analysis was conducted using a method based on calculating the thresholds of lightness difference in each area and took into account the tonal reproduction characteristics at different parts of the gradation curve (highlights, halftones, and shadows) [11] (see Table 6).

Table 6 – Results of optical density measurement and line screen calculation

Dot Shape	Line Screen	$D_{background}$	$D_{25\%}$	$D_{75\%}$	$D_{100\%}$	N
Round	150 lpi	0,07	0,24	1,61	2,57	88,7
	200 lpi	0,07	0,23	2,28	2,59	119,5
	300 lpi	0,08	0,24	2,41	2,61	125,2
Line	150 lpi	0,07	0,3	2,1	2,69	115,0
	200 lpi	0,08	0,29	2,36	2,61	125,3
	300 lpi	0,07	0,27	2,53	2,61	133,3
Square	150 lpi	0,07	0,26	2,35	2,63	124,4
	200 lpi	0,07	0,23	2,39	2,57	124,6
	300 lpi	0,08	0,24	2,6	2,74	134,5
Rhomboid	150 lpi	0,07	0,25	1,76	2,64	96,4
	200 lpi	0,08	0,25	2,39	2,62	124,8
	300 lpi	0,08	0,25	2,47	2,67	128,7
Double Dot	150 lpi	0,07	0,21	2,51	2,67	129,5
	200 lpi	0,07	0,14	2,48	2,64	124,5
	300 lpi	0,07	0,13	2,5	2,66	125,0

Line screen for all prints meets the specified evaluation criteria, i.e., it exceeds the reference value. However, visual assessment shows better results for lower line screen. As the line screen increases, the amount of ink also increases, which expands the dynamic range but results in too dark areas. In order to improve this parameter, it is necessary to create specific printing profiles that compensate for this non-linearity.

In order to analyze the print contrast on selected print materials, the relative contrast indicator was used. It provides a balance between the maximum optical density in solid print areas and the minimal dot gain in the image. To determine the relative contrast value in digital printing, the relative area of the 75% halftone field is measured, as this field lies on the critical boundary of the "gray" zone, where most halftones are located.

Below are the values of relative contrast for digital printing on various materials, determined experimentally and recommended in regulatory documents [22]:

- plain paper – 23-25;
- calendered paper for offset printing – 30-35;
- coated paper for offset printing – 40-45;
- printing film – 35-40.

The contrast of coated paper is taken as the reference value. Contrast of calendered paper for offset printing is taken as the limiting value (see Table 7).

A zero contrast value indicates complete ink spread in the 75% halftone field, which, in turn, signifies the "loss" of all details in the dark part of the image.

The obtained results show a very low relative contrast value for prints with screen rulings of 200 and 300 lpi. This is explained by the high ink coverage at higher line screens. It is recommended to use a line screen greater than 150 lpi, along with compensation curves and appropriate profiles. The best contrast values were shown by prints with Round and Rhomboid dot shapes. The worst results were observed for the Double Dot shape. Color gamut allows for the assessment of the maximum number of colors that a digital printing press can reproduce on selected substrates (print color gamut) with specified additional parameters.

During subtractive synthesis, which is applied in ink and toner printing, the color gamut is formed in the shape of a hexagon. The vertices of this hexagon correspond to the primary process colors (cyan, magenta, yellow) and the colors resulting from their pairwise overlaps (blue, green, red). Increasing the color gamut area enables the reproduction of a wider range of colors.

We will calculate the color gamuts of the selected print material with different dot shape settings at the maximum line screen. Having mathematically calculated the projection area of the color gamut onto the a*b* plane, we will compare the color gamuts for different dot shapes and draw conclusions regarding the quantitative evaluation of the color gamut as the result of the experiment (see Table 8).

Table 7 – Calculation of relative print contrast

Dot Shape	Line Screen	$D_{100\%}$	$D_{75\%}$	*K*
Round	**150 lpi**	2,57	1,61	**37**
	200 lpi	2,59	2,28	12
	300 lpi	2,61	2,41	8
Line	150 lpi	2,69	2,1	22
	200 lpi	2,61	2,36	10
	300 lpi	2,61	2,53	3
Square	150 lpi	2,63	2,35	11
	200 lpi	2,57	2,39	7
	300 lpi	2,74	2,6	5
Rhomboid	**150 lpi**	2,64	1,76	**33**
	200 lpi	2,62	2,39	9
	300 lpi	2,67	2,47	7
Double Dot	150 lpi	2,67	2,51	6
	200 lpi	2,64	2,48	6
	300 lpi	2,66	2,5	6

Table 8 – Calculation of color gamut

Dot Shape	Line Screen	8
Round	300 lpi	13387,52
Line	300 lpi	13768,16
Square	150 lpi	13301,06
	200 lpi	13393,918
	300 lpi	**14037,56**
Rhomboid	300 lpi	13486,49
Double Dot	300 lpi	12569,05

According to the calculated results of this parameter, the largest color gamut is observed in the print with the Square dot shape. We will calculate the gamut for screen rulings of 150 lpi and 200 lpi for this dot shape.

As seen, the difference between these values is quite small (see Table 5), so it can be concluded that printing with a lower screen ruling will also give satisfactory results.

The best values for this parameter are found in the Square and Line dot shapes. The lowest value is observed for the Double Dot shape.

The calculations of the projected areas of the color gamuts are presented in Table 9. We will also determine the projected area of the color gamut for the reference sample (see Table 10).

Table 9 – Color coverage values for coated cardboard

Color/ Dot Shape	**Round**			**Square**			**Rhomboid**			**Line**			**Double Dot**		
	L	a	b	L	a	b	L	a	b	L	a	B	L	a	b
Cyan	46,5	-26	-59,2	46,2	-26,5	-59,6	46,4	-26,4	-59,5	46,4	-25,9	-59,4	46,4	-26,4	-59,5
Magenta	46,4	74,4	-4,5	46	75,6	-4,8	46	75	-4,7	46,5	74,3	-4,8	46	75	-4,7
Yellow	89,1	-10,2	95,4	89,4	-10,42	97,3	89,6	-10,3	97	89,1	-10,2	95,9	89,6	-10,3	97
Black	8,8	-0,3	-0,3	6,9	-0,2	0	8,1	-0,2	-0,2	8,7	-0,2	-0,3	8,1	-0,2	-0,2
Red	47,7	63,4	52,7	46,6	65	53,7	46,8	63,3	53,9	47,7	63,4	53,1	46,8	63,3	53,9
Green	41,9	-66,8	19,4	41,2	-69,6	20,7	41,5	-68,1	20,9	40,9	-65,8	19,3	41,5	-68,1	20,9
Blue	19,1	19,6	-42,6	17,8	20,9	-43,3	18,5	20	-43,5	18,2	20	-42,3	18,5	20	-43,5
Color coverage area	**13387,52**			**14037,56**			**13486,49**			**13768,16**			**12569,05**		

Table 10 – Lab coordinates of the reference sample

Color	L	a*	b*
Cyan	67	-36	-45
Magenta	61	66	-5
Yellow	96	-6	88
Black	7	5	21
Red	57	65	43
Green	61	-61	28
Blue	39	11	-44
Color gamut of the reference			11511

The color coordinates of the reference value were obtained by measuring the Lab coordinates of the original file of the developed test image in Adobe Photoshop. The analysis performed shows that all samples exceed the reference value. Printed prints with square and linear dot shapes have the widest color gamut (greater dynamic range). This allows for printing with photorealistic quality as well as reproducing bright and saturated colors. A comparison of these gamuts with the offset printing range for coated paper shows a very close match. The only noticeable difference is in the yellow colors. The saturated and bright colors are well reproduced during printing, which is also confirmed by visual evaluation.

Color deviation is a property of the system to reproduce colors, where the degree of match between the original colors and the print ones is proposed to be evaluated using the color difference metric, ΔE. Two-tone or three-tone scales can be used for color control. The color differences are shown in Table 11.

Calculation of color reproduction accuracy showed a mismatch of this criterion for all prints with higher line screens. Negative results will be considered when developing recommendations for improving the printing process quality. The best color difference value can be noted for prints with linear and round dot shapes at 150 lpi line screen. The poorest result was observed for the double dot (16.32), which significantly exceeds the threshold limits.

Table 11 – Color deviation

Dot Shape	Line Screen	ΔE
Round	150 lpi	2,82
	200 lpi	3,5
	300 lpi	7,2
Line	150 lpi	2,57
	200 lpi	4,34
	300 lpi	9,86
Square	150 lpi	2,9
	200 lpi	4,6
	300 lpi	10,08
Rhomboid	150 lpi	3,5
	200 lpi	5,02
	300 lpi	11,2
Double Dot	150 lpi	8,7
	200 lpi	11,15
	300 lpi	16,32

Print uniformity is an indicator, which allows the assessment of the uniformity of solid area, that is particularly important when printing images with large solid areas. Although modern digital printing usually handles solid print area well, this parameter should still be monitored, as many print quality researchers confirm [23].

Print uniformity is calculated as the arithmetic average of the macro-heterogeneity of printing in both horizontal and vertical directions, which corresponds to the standard deviation. The obtained print uniformity values are summarized in Table 12.

All obtained values meet the specified quality criteria. Results indicate that modern digital printing no longer exhibits the defect of print uniformity issues, as it did previously. In order to fully represent the printing features with additional settings, a visual assessment of font quality, gray balance, etc., is required. Additionally, expert evaluation of the printed samples should be conducted in order to check the reproduction of memorable colors, line resolution, and other indicators that can be visually assessed.

Table 12 – Print uniformity indicators

Dot Shape	Line Screen	*M*
Round	150 lpi	0,0096
	200 lpi	0,0020
	300 lpi	0,0082
Line	150 lpi	0,005
	200 lpi	0,0058
	300 lpi	0,005
Square	150 lpi	0,0058
	200 lpi	0,002
	300 lpi	0,0096
Rhomboid	150 lpi	0,0082
	200 lpi	0,0058
	300 lpi	0,002
Double Dot	150 lpi	0,0058
	200 lpi	0,005
	300 lpi	0,0096

After performing instrumental analysis of the quality indicators, the following ranking of prints by dot shape can be established:

- 1 – Rhomboid;
- 2 – Line;
- 3 – Round;
- 4 – Square;
- 5 – Double Dot.

In order to confirm the obtained results, visual evaluation of the prints was conducted by a group of experts for print sets with different dot shapes. Their ranking corresponds to the results obtained (Table 13).

Table 13 – Results of refining the nomenclature of quality indicators

Dot Shape	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Sum	Rank
	Designer	Technologist	Manager	Print operator	Head of Prod. Dept.		
Round	3	2	2	3	4	14	3
Line	5	3	4	5	3	20	2
Square	2	4	3	2	2	13	4
Rhomboid	4	5	5	4	5	23	1
Double Dot	1	1	1	1	1	5	5

7. Conclusions

The research conducted in this work allows to draw conclusions and recommendations regarding the successful use of various raster structures and additional settings of digital printing presses in order to enhance print quality and expand printing capabilities.

The analysis of different raster structures usage demonstrated that various forms of raster dots can produce a microrelief visible to the naked eye on the print's surface. This can simulate a textured material on ordinary coated cardboard. This approach can partially solve the problem of printing on textured materials. Printing of solid areas or fine image details on textured cardboards is not possible without a loss of quality. Therefore, clients of digital printing companies can be offered the option to use regular materials with raster simulation, for example, for creating covers. Additionally, these materials are significantly cheaper than design cardboards.

Experiments with different line screens demonstrated that usage of higher line screens significantly expands the color gamut and increases image contrast. However, without specially created profiles, this leads to considerable color reproduction distortions. We obtain very saturated and vivid colors but with unsatisfactory color accuracy. This factor must be taken into account when fulfilling orders where precise color reproduction is required by the client. In such cases, it is recommended to reduce the screen ruling to 150 lpi, as opposed to the standard settings. This will somewhat reduce the color gamut coverage but will achieve the necessary color accuracy. Additionally, it is advisable to create printing profiles for the most commonly used materials (especially textured ones) for further work.

The use of high line screens is recommended when the client requires so-called “acid” shades, which are very popular colors nowadays.

The obtained results also confirmed that fonts look good on almost any background up to 4-point size. A 2-point font size looks clearly only on a white background but it almost blends into the colored background on the reversal. However, this should not be considered as a disadvantage, since in practice, texts printed in fonts smaller than 6 points size are very rarely used – they are difficult to read, especially with the naked eye. It is recommended to use higher line screens and additional font customization options for reproducing microfonts.

Additionally, for more effective collaboration with clients, it is also recommended to develop a catalog showcasing examples of advanced printing capabilities.

Usage of different raster structures with various line screen options is one way to improve print quality without additional financial costs, while simultaneously expanding the product range and attracting consumer’s interest.

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Надійшла (Received) 05.09.2025
Прийнята до друку (accepted for publication) 20.09.2025

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Способи підвищення якості друку для цифрової друкарської машини Konica Minolta 6085

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Анотація

В роботі проведено дослідження особливостей використання різних растрових структур з різною формою точки з урахуванням типових рекомендацій виробників друкарських машин та особливостей друкарської машини Konica Minolta 6085 для підвищення якості друкованої продукції. Застосування різних технологій растрування дозволяють не тільки вирішувати класичні проблеми утворення муару, зернистості, поліпшення плавності друкування напівтонів тощо, але й більш специфічні задачі. Застосування різних форм растрових точок в цифровому друці можна використовувати для розширення колірної гами; комбінація стохастичного растрування, різних форм точок та високої лініатури дозволяє імітувати різні друкарські процеси і робіти більш якісні кольоропроби. Для оцінки якості друку розроблено показники якості цифрового друку та зроблено кваліметричне та експертне оцінювання зразків. За результатами оцінювання розроблені рекомендації щодо вибору видів растрів за видами оригіналів та за матеріалами.

Ключові слова: цифровий; друк; оцінка; якість; стохастичний; растр; растрування; лініатура.