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COLOR COORDINATES AND COLOR COVERAGE ASSESSMENT OF COLOR IMAGES PRINTED ON THE SURFACE OF MULTI-LAYER PACKAGING PAPERS

Yeshbayeva Ulbosin Jamalovna[1], Djalilov Anvar Abdugafarovich[2], Safaeva Dilafruz Ro'zmatovna[3], Turaev Fazliddin Muhiddinovich[4]

[1]Doctor of Technical Sciences, Professor, Department of Chemical Technology, Namangan Institute of Engineering and Technology, Namangan, Uzbekistan
[2]Senior teacher, Department of Technology of printing and packing industry, Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan
[3]Senior teacher, Department of Technology of printing and packing industry, Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan
[4]Assistent teacher, Department of Technology of printing and packing industry, Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan

Abstract: The article examines the physical and mechanical characteristics of new types of multilayer paper and cardboard for packaging products; research of printing properties of types of paper for packaging products; In order to ensure the high quality of color images in the copy, the parameters of offset printing in the printing house were studied, and in practice the possibilities of using these types of multilayer paper and cardboard in the printing industry were described in detail.

摘要：本文考察了新型包装产品用多层纸和纸板的物理机械特性； 各类包装纸印刷性能研究； 为了保证复印件彩色图像的高质量，研究了印刷厂胶印的参数，并在实践中详细描述了在印刷行业中使用这些类型的多层纸和纸板的可能性。

Introduction. The fact that the packaging industry has developed at a high rate in the last 10 years and has become one of the leading products of the printing market is an unproven fact. Every product that is produced today usually has its own packaging, which is one of the hallmarks of distinguishing a product for the consumer.

In our country, new packaging materials and products are emerging, the design and exterior decoration of packaging is improving, manufacturing technologies are improving, equipment and process facilities are being updated [1-3].

The types of papers used for packaging in the printing industry and their interaction with dyes are still relevant today. We need to constantly monitor the quality of the paper and paints that come into the enterprise and their interactions. The study of the interaction of new types of paper and cardboard with dyes, which are recommended for printing packaging products in the printing industry, and the scientific substantiation of the results indicate the relevance of this research work.

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About the authors：Yeshbayeva Ulbosin Jamalovna

Corresponding author- *Email:

Experimental research. In the course of this research, experimental samples of new composite multilayer paper and cardboard were prepared in 4 different variants using secondary fiber semi-finished products. The composition of the prepared paper mass differs from each other by a fibrous composition. Samples weighing ≈150 g / m2 were prepared in the usual way on Rapid laboratory equipment (Germany). In paper samples, acrylic emulsion was added as an adhesive at a rate of 1.5% of the total paper mass. The possibility of using this emulsion as a film-forming polymer on the surface of composite papers was studied. The following paper samples were prepared for the study (Table 1).

Table 1

Multi-layered paper and cardboard options for research

Experimental paper, ≈150 g/m^2	Composite composition (glued in acrylic emulsion)), %		
	Top layer 40-55 °ShR		Bottom layer 21-28 °ShR
	PS, %	MPAN, %	MS-5B, %
For example №1	80	20	100
For example №2	70	30	100
For example №3	80	20	100
For example №4	80	20	100

* PS - cotton cellulose

** MPAN – recycled polyacrylonitrile

*** MS-5B – secondary waste waste paper type

The main purpose of scientific work Analysis of the printing properties of new types of multilayer paper and cardboard for packaging products, obtained on the basis of research, as well as the quality of the copies printed on the surface of this paper and cardboard by offset printing and the factors affecting them consists of In order to ensure high-quality color reproduction in the copy, it is necessary to study the color coordinates and color coverage parameters of offset-printed copies in printing.

The printing properties of the multilayer papers under study: weight, thickness, smoothness, tear length and moisture per square meter were studied. The results obtained are presented in Table 2.

Table 2

The parameters of the paper used to model the dye transfer

Experimental paper, ≈150 g/m^2	Thickness, mm	Smoothness, seconds	Break length, m	Humidity, %
For example №1	0,24	42	2230	5,7
For example №2	0,21	43	2350	5,9
For example №3	0,22	45	2352	5,5
For example №4	0,25	41	2325	6,6

An analysis of the results obtained showed that the tensile strength of the paper depends not on the strength of the individual components, but on the strength of the paper structure formed in the process of paper production. Sample papers №2 and №3 have high mechanical strength. This fact is explained by the fact that these samples have an optimally balanced composition of the fiber, which ensures maximum inter-fiber adhesion.

Minimal4 The minimum value of the strength index for paper samples is descriptive, which is explained by the maximum of the secondary waste fibers in the fiber composition. This indicates that a large amount of waste is added to the fiber base as a cheaper element to replace cellulose fibers.

The assessment of the quality of the product in accordance with the requirements of the state standard was carried out using GOST 18510-87 "Wrapping paper" as a basic example. In accordance with the nomenclature of standard indicators, the absolute values of the quality indicators of the samples of packaging paper studied by standard methods were determined (Table 2).

The effect of ink transfer on the cost of ink transfer. The ability of paper to absorb printing ink and its depth of absorption into the thickness of the sheet depends on a number of factors, which are determined by the structure of the paper, in particular the properties of the paper and the ink. In the same printing method, the porosity of the paper and the viscosity of the ink are the most important factors [4-6].

A test copy of the IGT model was used to model the dye transfer process. After printing, the sample was dried and its optical density was measured. The thickness of the paint layer in the copy was determined using the following formula:

$$h_H = \frac{M_1 - M_2}{S \cdot d} \cdot 10^4 \text{ [mkm]}$$

where M_1 is the weight of the printing mold with the ink before printing, g; M_2 - weight of the printing mold after pressing, g; S - area of the printed copy 21x5 cm; d is the density of the dye, assuming 1 g / m^3

The data show that there is an integral relationship between the structural and optical properties of printed materials. There is a linear relationship between the degree of adhesion of the experimental paper and its effect on swelling. This is explained by the fact that the addition of adhesives to the primary fibrous materials increases the adhesion of the surface (i.e. top layer) fibers, thereby reducing the swelling ability of the base due to the filling of the hollow capillaries with adhesive solutions. This creates a film on the surface of the absorbent material. That is, the dye remains on the surface of the paper without penetrating into the internal pores of the paper, and the optical density values have high values (sample papers №1 and №3) Table 3.

Table 3

Results of paint transfer modeling

Experimental paper, ≈150 g/m^2	M_1 Weight of the roller painted before printing, g	M_2 The weight of the roller after pressing, g	K_{per} Paint on paper, g (paint transfer)	Optical density	
				D	h

For example №1	140,2 490	140,2 443	1,17	1, 68	43, 19
For example №2	140,2 516	140,2 447	0.183	1, 72	40, 43
For example №3	140,2 572	140,2 490	2,05	1, 94	48, 76
For example №4	140,2 506	140,2 430	1,9	1, 72	41, 47

The results of the study show that the optical density of the specimens varies from 1.68 to 1.94 when the thickness of the dye layer is increased from 40 to 48 microns.

In the next step, the optical densities of three identical dye layers of the same thickness were measured using a spectrophotometer on the color control scales of the test object obtained on the printing equipment. For four-color offset printing, ISO 12647-2 adds blue (C), red (M), and yellow (Y) in their two overlaps: red (MY), green (CY), and blue (CM) and optical density were measured at the superimposition (CMY) of the triple dye layers.

Table 4
Measurement of optical densities of paint layers

Experimental paper, ≈150 g/m^2	Optical density of the paint layer, D						
	C	M	Y	MY	CY	CM	CMY
For example №1	1,54	1,31	1,33	1,63	1,32	1,55	1,87
For example №2	1,46	1,25	1,32	1,19	1,25	1,27	1,50
For example №3	1,64	1,47	1,34	1,79	1,42	1,75	2,07
For example №4	1,29	1,27	1,22	1,29	1,25	1,27	1,36

As a result of the research carried out in this work, it was once again confirmed that the accuracy of the printed elements in the copy depends on the structural characteristics of the printed material. From the results obtained (Table 4) it can be concluded that the values of the optical densities of the primary colors in the copies printed with triad dyes comply with European standards.

Evaluate the color coverage of images in printed copies. In printing, color formation is performed using a set of subtractive synthetic dyes: yellow, red, blue, and black, and they are called triad dyes. The triad is chosen in such a way that they can be used to create as many colors as possible, as well as individual colors [7].

Under the conditions of a specific technological process and the constant properties of the paper on which the printing is carried out, the color coordinates and color coverage will have the characteristics of triad inks. In this part of the study, the color coordinates and color coverage of the printed image were studied [8].

Insufficient saturation of dyes is due to their absorption in three zones of the spectrum. The farther away from the locus the colors formed by the pairing of the dyes are, the lower the saturation of the triad dye. That's the wrong thing to do. Printed copies were evaluated on a CM 3600d spectrocolorimeter and the results are shown in Figure 1. The color coordinates were calculated using the appropriate formulas for the color coordinate values.

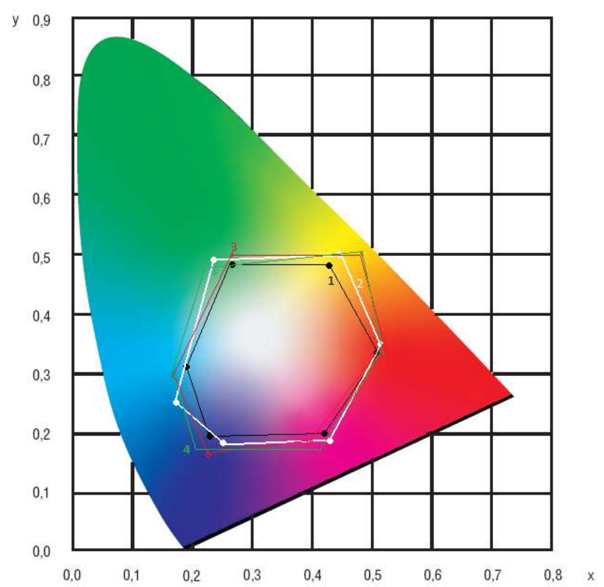

Figure 1. Color coordinates in the XYZ diagram

The polygons in the figure are close to each other, but the polygon obtained on the experimental paper №1 is smaller than the polygon obtained as a result of the experiments on the paper №3, the figure obtained on the experimental paper №3 on the paper №1 and №4 larger than the shape obtained. Analysis of the color coordinate results for printed copies allows us to draw conclusions about the similarity of dye acceptance and color transfer capabilities in all multilayer experimental paper types.

Evaluate the color coverage of experimental copies using equal contrast systems. Perceptions of closely related colors, expressed in the form of specific points that are not far from each other in color space, are the basis for evaluating small color differences. As the distance between them increases, so does the difference in color. A graph that assumes color differences that is equally contrasting with respect to color boundaries can be obtained by modifying a graph that is not equally contrasting [9].

In this study, the CIELUV system, recommended by MKO for the assessment of small color differences, is used. The main advantage of this system is that it does not depend on input and output devices. This is an important positive factor in typography, as it allows the evaluation of differences in not only single colors but also colors of any resolution [10].

To determine the value of DE in CIELAB, the following quantities are determined: L - brightness (or brightness) of the color; a and b are color coordinates or color difference coordinates. These parameters are calculated using the appropriate XYZ coordinates.

$$L = 116\left(\frac{Y}{Y_0}\right)^{\frac{1}{3}} - 16,$$

$$a=500\left[\left(\frac{X}{X_0}\right)^{\frac{1}{3}} - \left(\frac{Y}{Y_0}\right)^{\frac{1}{3}}\right],$$

$$b=200\left[\left(\frac{X}{X_0}\right)^{\frac{1}{3}} - \left(\frac{Z}{Z_0}\right)^{\frac{1}{3}}\right],$$

where X, Y, Z are the color coordinates of the sample under study; X_0, Y_0, Z_0 are the coordinates of the colorimetric light source.

The color differences fused with dE or DE represent the smallest distance between points that correspond to the colors being compared in a three-dimensional Lab space. In the CIELAB system, the value of color difference or color contrast is determined analytically by the coordinates of the points according to the following formula [11-12]:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

where L is the change in brightness; a - color change from green to red; b is the change in color from blue to green.

In this study, color differences were identified for samples printed on experimental multilayer paper ≈150 g / m2. Figure 2 shows a color diagram based on the results obtained.

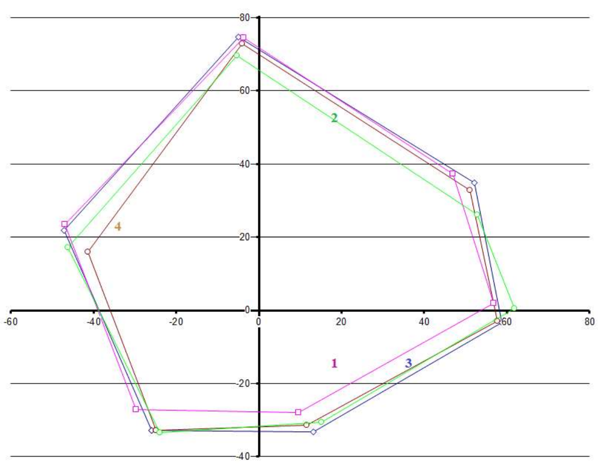

Figure 2. Color coverage in the LAB diagram

The test scale, developed with the basic colors of mathematical models, was printed on experimental multilayer paper. Areas of the same color were compared to assess the quality of color formation. The blue field in the original is compared to blue in the copy, red to red, and yellow to yellow. If DE = 0, the colors are physically the same, but in real life the probability of complete similarity is almost zero. The task of printers is to create physiologically accurate colors, that is, to adjust the reproduction process so that the copies look like the original (Table 5).

Table 5

Calculate color difference

For example paper type		Color	L	a	b	ΔE
№1	1	blue	61,53	-31,37	-39,77	$\sqrt{4{,}08} = 2{,}01$
№2	1	blue	60,07	-30,24	-38,95	
	Δi		1,16	1,13	0,82	
	$(\Delta i)^2$		2,13	1,28	0,67	
№2	2	red	51,22	49,17	30,58	$\sqrt{0{,}50} = 0{,}71$
№3	2	red	51,12	48,67	30,07	
	Δi		0,10	0,50	0,49	
			0,01	0,25	0,24	
№3	3	yellow	87,32	-2,55	82,99	$\sqrt{4{,}74} = 2{,}17$
№4	3	yellow	86,08	-1,97	81,30	
	Δi		1,24	0,58	1,69	
	$(\Delta i)^2$		1,54	0,34	2,86	
	$\Sigma\Delta E_{o'r}$=4,89:3=1,63					

Initially, the color difference or contrast value was calculated separately for each color, and then the arithmetic mean of the three values obtained was calculated. ΔE=1,63 indicates that the color is excellent.

Conclusion

An analysis of the results obtained during the study showed that the tear resistance of multilayer paper depends not on the strength of the individual components, but on the strength of the paper structure formed during the paper production process.

There is an integral relationship between the structure and optical properties of printed materials. There is a linear relationship between the degree of adhesion of the experimental paper and its effect on swelling. This is explained by the fact that the addition of adhesives to the primary fibrous materials increases the adhesion of the surface (i.e. top layer) fibers, thereby reducing the swelling ability of the base due to the filling of the hollow capillaries with adhesive solutions.

The optical density of the printed copies is the highest on №3 sample papers. The color coordinates for the printed copies were found and their color coverage was evaluated. Color coverage LAB and color coordinates XYZ indices №4 Polygons obtained on experimental paper №3 and №2 are smaller than polygons obtained on multilayer experimental papers, №3 Indicators obtained on experimental paper № Experiments have shown that at 1 and №2 it is much larger than the shape obtained on paper.

From the results it can be concluded that the values of the optical densities of the primary colors in the copies printed with triad dyes correspond to the indicators of European standards. Experiments have shown that this new type of multilayer paper and cardboard can be recommended for printing multi-color packaging products during the printing process.

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