Color Evenness and Color Gamut of Prints Produced by Direct Imaging Technology

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***Abstract**: Since digital technology appeared in the Graphic Artz, it has made a considerable improvement and takes positionf of more and more area in the production of print media products. The main reason for this success that it can satisfy the newest costumer demans, namely short run, excelent quality, economical printing and the production of the personalized products. As every parts of the business life, costumor of he printing isdustry too wants to have products fast, in good quality and at a low price.While at first most of the printers refused the digital printing, today already it is determinant part of the print industry. Much more printinghouse knows that for increasing of their championship need to invest in digital technology.*
During our research we performed instrumental tests of test prints printed on papers with different surface features. The prints were prepared on Océ CPS800 Platinum printing machine.

***Keywords**: DI technology; color difference; color gamut*

1 Introduction

Printing industry has significantly changed during the past decades. New processes and digital printing systems appeared besides traditional printing technologies. The quality of prints made by digital equipment using different printing technologies is substantially influenced by the print carrier applied and the type of ink, the sheet-guiding system, and the transfer and fixation of the ink on the print carrier. The quality of the product the given digital printing technology is capable of printing is important to know.

Océ Direct Imaging (DI) technology enables direct imaging. The print image is created by the effect of electrical potential difference using the principles of magnetism instead of an electrostatic procedure. Using this technology it is possible to print on print carriers that have different features (offset paper, glossy

or mat art paper, creative papers, transfer paper, manifold paper, self-adhesive paper, weather and UV resistant self-adhesive films, paper with non tearable plastic base, label papers).

2 OCÉ Direct Imaging Technology

In Océ Direct Imaging the print image is created not with an electrostatic procedure but by means of voltage difference based on a magnetic principle. The "spirit" of equipment operating with DI technology is a metal cylinder (DI drum) the surface of which is coated with a non-conductive epoxi layer (Figure 1). Equally spaced grooves are created on the epoxi layer as a result of imaging. The number of grooves specifies the resolution capability of the equipment axially (perpendicularly to the direction of paper forwarding). The next step of the imaging process is to apply epoxi resin into the grooves which create a so called ring electrode. Subsequently, surface formed on DI drub is smoothed and coated with a silicone oxide (SiOx) layer. A control unit is located within each drum, by means of which the ring electrodes may be separately controlled, so the voltage causes the ring electrodes with magnetic properties to attract or to repel the toner. The technology applies a magnetic, one component opaque toner. The toner is forwarded to the surface of DI drum by a magnetic cylinder, then the surplus toner is removed by a magnetic image cylinder located near the magnetic cylinder from the drum. A magnetic blade perpendicular to the surface is located within the cylinder, which creates a strong magnetic field at the given point, attracting thereby the toner. Subsequently, the surplus toner is forwarded from the counter-rotating magnetic cylinder to the toner feeding unit, and becomes reusable [1] [2].

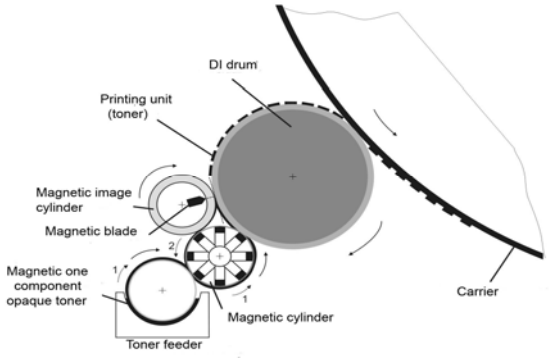

Figure 1
Imaging unit of Océ Direct Imaging technology

3 Investigation Methology

Printing of test figures was made under normal operating circumstances in the following way:

- location digital plant of Szinkron Digital Nyomdaipari Kft,
- printing machine: Océ CPS 800 Platinum digital printing machine,

  t=21 ºC, RH 39-44%
- number of copies: 5 prints per each

Colorimetry of the test prints was made with spectrophotometer X-rite SpectroOne and automatic test figure reader X-rite Eye-one iSis 7 days after the printing. Circumstances of the measurements were as follows:

- D50/2°/Abs/ black underplate.

The test prints were made on six substrates of different type and color, including the a wide scale of papers and cardboards, such as coated and uncoated art papers, dull, embossed and striped creative media, offset, colored and volumenised papers (Table 1).

In this recearch work we investigate quality of prints produced on Oce CPS900 digital press operats with Direct Imaging technology. We complite investigation of testprints produced these presses, and comparison of color evenness and color gamuts with measurements.

Table 1

Used substrates

No. of samples	Designation of media	Type of media	Mass/sq. m g/m^2
1.	Color Copy Mondi	Art paper, coated, glossy	250
2.	Opti Image	Art paper, dull, smoothed	250
3.	OptiGraph	Offset paper, high whiteness	80
4.	Dali	Creative, uncoated, fine striped, felt marked	250
5.	Opti Colours Mondi	Couleur, light yellow, wood free	80
6.	GardaPat Classic	Volumenised (1,4), velvety surface	135

4 Results and Discussion

4.1 Investigation of Color Evenness

From the aspect of print quality it is a key factor during printing of color pieces that the colors of the individual prints should be identical and match as far as possible in series printing of the copies [3]. Measurements were made on the four printing basic colors, i.e. cyan, yellow, scarlet and black tone strips in the printing direction and in direction perpendicular to the printing direction on the test prints. During the colorimetry the tone strips of A3 test print in the printing direction and in direction perpendicular to the printing direction were measured at three different points, on the left side, in the middle and on the right side (Figure 2).

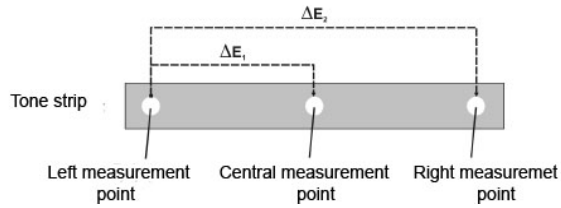

Figure 2
Measurement points of tone strips of test prints

The lowest (0.20) color difference value was measured on tone prints of the test rints in the printing direction, and the highest (3.02) value was measured in case of yellow colour.

Color differences measured on the applied substrats are hardly noticeable for the human eyes, except for Gardapat Classic volumenised papers, where the color difference is already noticeable in case of scarlet, yellow and black colours. (Table 2).

Table 2
Color difference values measured on the right side of tone strips perpendicular to the printing direction in comparison to the left side

No. of samples	C	M	Y	K
	Color difference, ΔE_2			
1.	1,38 (0,62)	2,03 (1,12)	0,77 (-0,10)	1,03 (1.03)
2.	0,29 (-0,20)	1,25 (0,62)	0,33 (0,07)	0,60 (0,59)
3.	0,62 (0,39)	0,34 (-0,01)	0,88 (-0,15)	0,75 (-0,74)
4.	0,26 (0,26)	1,15 (0,69)	3,02 (-0,60)	0,92 (0,91)
5.	0,83 (0,16)	1,42 (0,33)	1,17 (0,37)	0,75 (0,75)
6.	0,72 (0,58)	2,31 (0,73)	2,90 (-0,37)	2,12 (2,11)

Remark: in the brackets are the lightness values (L^*)

In case of tone prints perpendicular to the printing direction the lowest color difference value was observed in case of cyan colour of Opti Image art paper (0.45), while the highest one was observed in case of black color of Optigraph offset paper (Table 3).

Table 3
Color difference values measured on the left side of tone strips perpendicular to the printing direction in comparison to the right side

No. of samples	C	M	Y	K
	Color difference, ΔE_2			
1.	0,62 (-0,54)	2,18 (-0,53)	2,90 (-0,95)	1,91 (1,91)
2.	0,45 (-0,36)	2,75 (0,00)	1,13 (-0,82)	2,56 (2,56)
3.	1,05 (-0,93)	2,75 (-1,12)	1,44 (-1,04)	4,19 (4,19)
8.	1,66 (-1,36)	2,21 (-0,68)	1,81 (-0,97)	2,22 (2,22)
9.	0,48 (-0,09)	1,61 (-0,70)	1,34 (-1,20)	3,49 (3,49)
10.	0,55 (-0,22)	1,73 (-0,41)	1,83 (-1,05)	0,55 (0,45)

Remark: in the brackets are the lightness values (L^*)

4.2 Reprodusible Color Gamut

Based on the reproducible color range we can get information which of ten different paper types used for the tests (art, offset, creative, colored and volumenised papers) offers a higher color reproduction possibility with the application of opaque toner used on Océ CPS800 Platinum digital printer. A3 test prints allowing simulation of colour space that can be created with CYMK colours were made for the determination of reproducible colour ranges on the medias. Totally 1,488 pcs of field with different coloring, brightness and saturation (horizontally 32, vertically 48) are found on the test figure. Two pieces of software were used for the processing of the measurement data: Profilemaker Professional 5.0 and Profileeditor 5.0.

On the basis of the results we found that the medias under examination were able to show the most colors at brightness value 50 among brightness values 25, 50 and 75 (l*) presented by us. Color Copy Mondi glossy, coated art paper had the greatest color space among the ten different types of media under examination, while Opti Colours Mondi colored paper had the lowest one.

Conclusions

During the test of color evenness, on tone prints made in the printing direction we found that the measured color differences were hardly noticeable to the human eyes, except for value measured at Dali creative cardboard's yellow color (3.02). Perpendicularly to the printing direction Optigraph offset paper and Opti Colours Mondi colored paper exceeded value $\Delta E_{ab}^* = 3.00$, so the change of color evenness became well visible. Comparing the reproducible color ranges we

observed that in case of similar types of media the color ranges were almost identical. Among all medias Color Copy Mondi glossy, coated art paper had the greatest coloor space.

Based on the visual controls we can state that the 3 point font shows a print well visible to the naked eyes on the positive and negative fields of different medias in case of text elements. During the examination of the photos we could see that the human skin colours were more yellowish and reddish than normally, while the blue eye was oversaturated on each media. During the visual control of the color evenness of the basic colors stripes were observed in the printing direction in case of five basic colors of Color Copy Mondi cardboard, except for yellow and green colours.

To summarise the above we can state that the best results were obtained with art papers, while the worst ones with creative medias in the majority of the tests.

The DI technology applied by the machine significantly expands the reproducible colour range with the seven colours used for printing and provides color fidelity and stable reproduction.

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