Influence of Ink Drying on Solid Body of Colours Achieved on Matte-Coated Paper Base

Marta Gajadhur, Halina Podsiadło

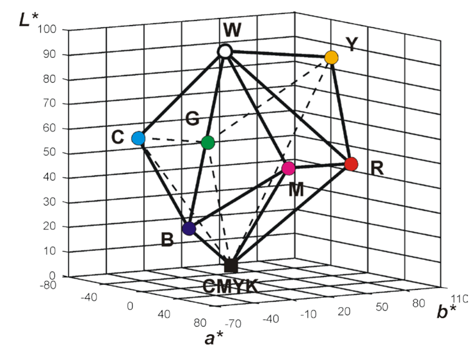
This report is a presentation on the effect of the ink drying process of primary printing inks: cyan, magenta, yellow and black on a volume of solid body of colours, colour coordinates and colour differences in the CIELAB space. Experiments were performed with different ink film thicknesses. Special attention was given to nine thicknesses within the 0.5 – 2.9 [μm] range.

Spectrophotometric values of colour coordinates (*L*, a*, b) of the obtained prints allowed to determine the volume of nine solid bodies in the CIELAB space for the ink film thicknesses specified**

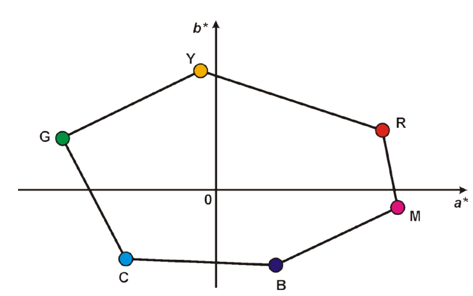
Introduction

The solid body of colours was represented – as was formerly mentioned – in the CIELAB space, which is one of the most often used in printing. This space was built from six tetrahedrons defined in the CIELAB space (Fig. 1 a, b) by coordinates of primary (C, M, Y) and secondary (M+Y=R, C+Y=G, C+M=B) colours and points of white (base white W) and black (K, CMY or CMYK).

Figure 1:



a) the solid body of colours in the CIELAB colour space determined by primary and secondary colours and black and white coordinates



b) projection of the CIELAB space on the a^*b^* plane

The volume of one of the six tetrahedrons defined by the coordinates of the points: C (cyan), G (green), W (base white) and CMYK was calculated by means of a formula as the determinant of the square matrix (1). The change in the size of a solid body of colours due to the ink drying process was calculated both in CIELAB and percentage values.

$$V = \frac{1}{6}\begin{bmatrix} c_{L^*} & c_{a^*} & c_{b^*} & 1 \\ g_{L^*} & g_{a^*} & g_{b^*} & 1 \\ w_{L^*} & w_{a^*} & w_{b^*} & 1 \\ cmyk_{L^*} & cmyk_{a^*} & cmyk_{b^*} & 1 \end{bmatrix} \quad (1)$$

of a solid body of colours due to the ink drying process was calculated both in CIELAB and percentage values.

$$\text{Ä}E^*_{ab} = \sqrt{(\text{Ä}L^*)^2 + (\text{Ä}a^*)^2 + (\text{Ä}b^*)^2} \quad (2)$$

where:

$\Delta L^*, \Delta a^*, \Delta b^*$ – deviations of colour parameters L^*, a^*, b^* of the CIELAB space between values measured before and after drying of the ink.

Experiment

Materials and laboratory setup

Tests were carried out with matte-coated woodfree paper base Proxima Matt of the grammage 200 g/m2 selected according to ISO 12647-2. For the purpose of the study the following offset printing Resista Eco 9500 Michael Huber inks were used: cyan (43 F 9500), magenta (42 F 9500), yellow (41 F 9500) and black (49 F 9500). The measurements of CIELAB colour coordinates were undertaken with the sample lying on a white backing and with a SpectroEye GretagMacbeth spectrophotometer using the following settings: D50 illuminant, 2° observer, 0°/45° measuring geometry. The measurements were carried out in the temperature 21°C, without the use of a polarization filter: 10 seconds after printing and 96 hours after printing.

Preparation of samples

Paper strips were printed using a printability tester IGT C1. Printing ink was applied onto the IGT device by means of a pipette with a precision of up to 0.01 [cm3]. The ink was rubbed on the grinding set for 4 minutes, then the forming roll was put for 1 minute against the printing set. The printing form with a film of deposited ink was weighed, with precision of up to ±0,0001 [g]. in an air-conditioned room on an analytical balance Metler Toledo AG 204. After printing, the form was weighed again to determine the amount of ink transferred onto the paper. The IGT C1 device was washed after each printing operation, then the ink was applied again on the grinding set. The thickness of ink film on the sample printed was calculated by means of formula (3) [1]

$$d = \frac{(m_1 - m_2)}{S \cdot g} \cdot 10^4 \qquad (3)$$

where:

d – thickness of the overprint ink film [µm],
m1 – mass of the plate cylinder with ink before printing [g],
m2 – mass of the plate cylinder after printing [g],
S – surface area of overprint [cm2],
g – mass density of printing ink [g/cm3].

Overprinted strips were prepared for primary colours (cyan, magenta, yellow, black) in a wide range of ink film thicknesses, and then also for the secondary colours (magenta + yellow, cyan + yellow, cyan + magenta) for nine different film thicknesses. The total number of tested samples was 595 (C 235, M 120, Y 34, K 30, M+Y 36, C+Y 27, C+M 59, CMY 36, CMYK 18). Ten measurements were taken for each sample, and an arithmetical mean was accepted as the final result.

This preparation of samples methodology was described in the previous articles [References no. 2, 3] by the authors of this paper.

Results and Discussion

The experimental studies have pointed out that the colour gamut significantly decreases due to the ink drying process. It may be caused among the others by the process of ink penetration [4]. The change in the size of a solid body of colours due to the ink drying process was calculated both in CIELAB and percentage values. (Fig. 2, 3). The most remarkable shift in the colour gamut – about 60000 CIELAB units – was obtained for the solid body of colours with the black point, achieved by application of only the black ink, whereas the smaller decrease – about 35000 units – in the case of black point, was achieved by application of three (C+M+Y) or four (C+M+Y+K) inks. The equivalent dependencies calculated in percentage values are about: 13% – K, 8% – CMY and 7% – CMYK reproduction.

Furthermore, the studies concluded that gamut reduction increases with thicker ink film thickness.

The colour difference (ΔE^*_{ab}) was calculated by means of the deviation of (*L*, a*, b**) coordinates measured immediately after printing and after drying of the ink. The colour differences of primary (C, M, Y, K) and secondary colours as well as CMY and CMYK as a function of deposited ink film thickness are presented in the Figures 4 and 5 (see next page).

The bigger change in colour was observed for primary, rather than for secondary inks, whereas the biggest was observed for such primary inks as yellow (Y) and black (K) and the smallest for blue (C+M), CMY and CMYK colours.

Conclusions

The results of these studies concluded that the ink drying process strongly influences *L*, a*, b** values of the primary and secondary colours, while it has a much smaller influence on the CMY and CMYK colours. Consequently, this remarkable shift of colour coordinates causes a reduction of solid body of colours defined in CIELAB space.

The colour gamut decreases with the ink drying process about 7-8% in the case of a solid body with black point determined by the application of three (C+M+Y) or four inks (C+M+Y+K), and about 13% in the case of black point achieved by applying only the black ink. Moreover, the smaller reduction is observed for thinner ink film thickness.

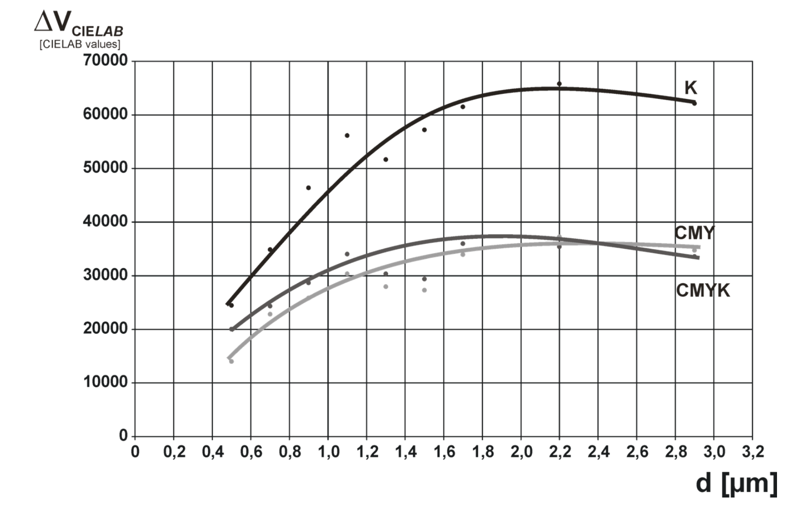


Figure 2:
CIELAB volume of colours of overprints (first and second order colours, point of white and black: K, CMY or CMYK) reduction expressed in CIELAB values as a function of deposited ink film thickness

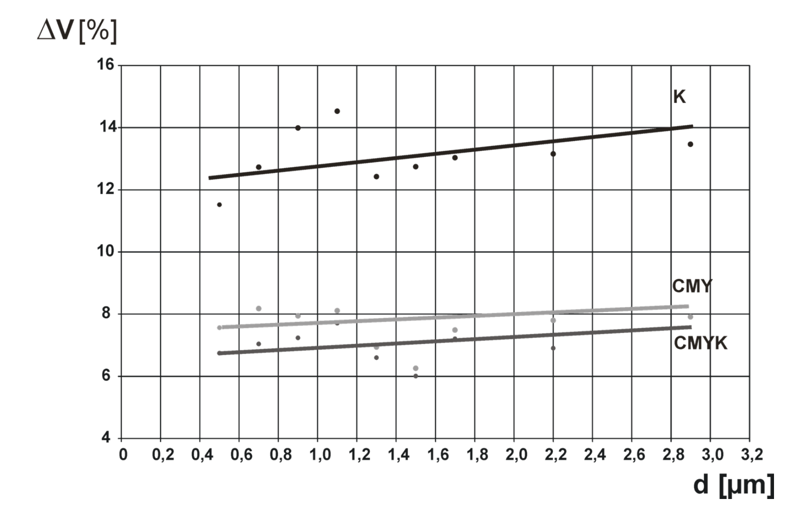


Figure 3:
CIELAB volume of colours of overprints (first and second order colours, point of white and black: K, CMY or CMYK) reduction expressed in percentage values as a function of deposited ink film thickness

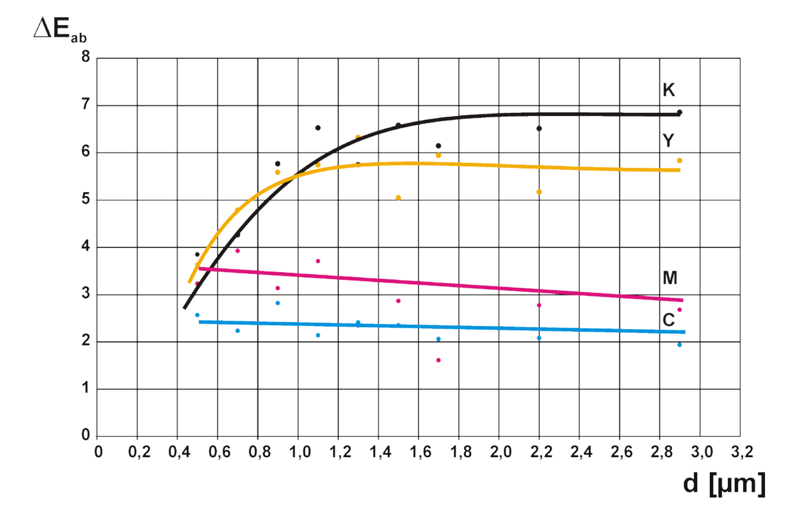


Figure 4:
Colour differences (ΔE^*_{ab}) of process inks (C, M, Y, K) due to ink drying process as a function of deposited ink film thickness

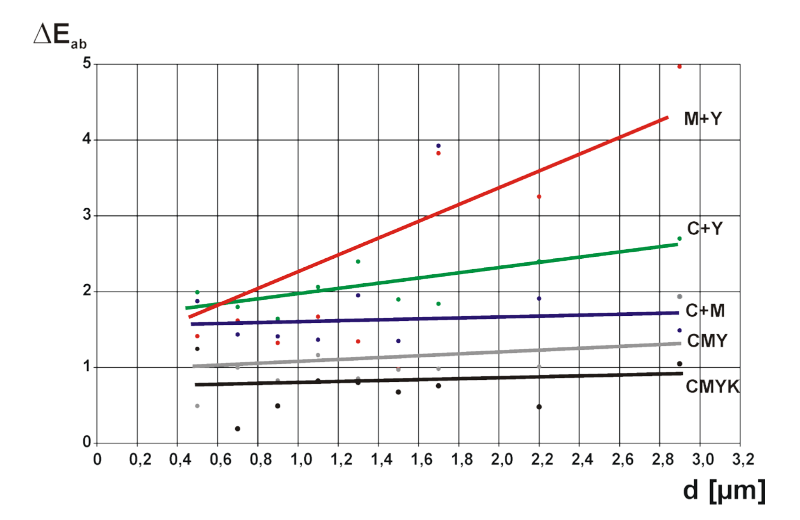


Figure 5:
Colour differences (ΔE^*_{ab}) of secondary (Red, Green, Blue), CMY and CMYK colours due to ink drying process as a function of deposited ink film thickness

(first received: 30.01.2009)

References

[1] SO 2846-1, Graphic technology – Colour and transparency of printing ink sets for four colour printing – Part 1: Sheet-fed and heat-set web offset lithographic printing, 2006.

[2] Gajadhur M., Podsiadło H.: The ink film thickness optimization in offset printing for the matte-coated paper base, Proceedings of III Scientific and Technical Student and Aspirant Conference, Warsaw 2008, 19-24

[3] Dąbrowa T., Gajadhur M.: Colour gamut of a press print and dependence of the basic attributes of overprint colours on the process ink film thickness, Surface Coatings International Part B: Coatings Transactions, United Kingdom 2006, Vol 89, 305-314

[4] Yang L., Kruse B.: Chromatic Variation and Color Gamut Reduction due to Ink Penetration, Proceedings of TAGA conference, San Diego 2001

[5] ISO 2834-1, Graphic technology – Laboratory preparation of test prints – Part 1: Paste inks, 2006

Marta Gajadhur

Warsaw University of Technology Faculty of Production Engineering, Institute of Mechanics and Printing, Department of Printing Technology, ul. Konwiktorska 2, 00-217 Warsaw, Poland

m.gajadhur@wip.pw.edu.pl

Halina Podsiadło

Warsaw University of Technology Faculty of Production Engineering, Institute of Mechanics and Printing, Department of Printing Technology, ul. Konwiktorska 2, 00-217 Warsaw, Poland

h.podsiadlo@wip.pw.edu.pl