Comparison of Optimal Inking of Process Colors Obtained by Two Different Methods for LWC Paper Printed on Heatset Offset Press

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Defining of optimal inking in the offset printing process is one of the most important conditions for achieving of high quality and predictable results. Besides defining the exact values of optimal inking, expressed by D_v, applying the method of maximum print contrast for the different combinations of printing substrate-offset printing press-ink, it is also necessary to check whether these values can result in correct colour characteristics, expressed by CIE Lab of the main ink types – C, M, Y and K. In order to achieve the goals of the experiment, a number of measurements have been performed (from under-inking to over-inking) for defining the optimal inking by the method of maximum print contrast. Also, the colour coordinates CIE Lab have been defined and the respective corresponding density of the fields, at which the smallest colour difference is achieved between the measured fields and the colour values in CIE Lab included in the ISO Standards for colour characteristics of inks for offset printing. A comparison has been made between the optimal inking results obtained by the two methods. The analysis of the D_v results achieved by the two methods also compares the values of the print contrast, the tone value increasing (dot gain), etc. It also gives some recommendations of practical importance.

1. Introduction

One of the most important factors, influencing the offset image quality is the ink quantity onto the printed sheet. This ink quantity depends on the specific combination printing substrate-printing machine-ink.

The major methods exist on determination and control of inking:

1. Method for determination of optimal inking density – D_v, based on maximal print contrast [1]. From the measured values [2] of the ink density in the solid D_v and the ink density in the halftone screen D_R one can calculate the relative printing contrast. In doing so, it is preferable to measure the D_R value in the three-quarter tone; in this research 80%. Its main purpose is to produce as deep as possible colours with the highest ink quantity, while keeping the dot gain in the admissible limits and it is characterized by good quality of the prints' dark tones.

2. Method based on colourimetry, aiming at gaining of color levels for C, M, Y and Black as defined in the ISO standards [3, 4, 5]. These standards provide the following interpretation. Density values can be very valuable for process control during a print run, where the instrument, the ink and the print substrate remain the same (see ISO 13656 [4]). However, in a general situation, density values do not define a colour to the required degree. Therefore, for the purpose of ISO 12647-2, reflection density values are only recommended for the determination of tone values. Following ISO 13656, the production press operator first achieves the correct colour of the solids on the press, then reads the densities with the instrument from the OK print. The densities are then used as target values for process control during the production run. According to the ISO 12647-2 [3], the leading method for inking determination is the colourimetry, while the densitometric measurements appear to be informative only.

2. Experimental

The major goal of this experiment was to determine and compare the inking for CMYK, for two various treatments – the maximal print contrast method expressed as D_v, and the colourimetric method defined as per the ISO standards [3, 4, 5] for LWC paper, printed on Heatset printing press.

The test form that have been used contains different control strips and elements: solid patches for C, M, Y, K, two color overprint patches, 40% and 80% dot gain patches [6, 7], slur/doubling control elements and etc. All measuring components are with screen ruling value 60 cm^{-1}. During the experiments were used printing plates FUJI LH-PCe Brilia 1005x680mm, obtained via linearised and curved (calibrated) [8] CtPlate device Kodak Trendsetter Quantum II. This curved plates [9] are only valid for the specific combination of ink, paper, print pressure, blanket for which it was originally calculated. If the same work is printed on another press, using different ink or paper, the characteristic curve can differ significantly. The paper that has been used is Galerie Brite 60 g/m^2, SAPPI, Inks - Maxink Phantom HD OHD 9300. ISO 12647-2 [3] requires use of an ink set that conforms to ISO 2846-1 [5]. The inks, used in experiment were tested in and they conforms to ISO 2846-1 (all standard requirements for colour, transparency and ink film thickness range).

The printing machine, which has been used, is web offset heatset press KOMORY SYSTEM 40.

A densitometer D19C and spectrophotometer SpectroEye of GretagMacbeth (now X-RITE) have been used for measuring of optical density, print contrast, dot gain and the colour characteristics in the CIE Lab color system. All measurements are in accordance with ISO 12647-1[10]: D50 illuminant, 2° observer, 0/45 or 45/0 geometry, black backing and in accordance with [11, 12, 13].

Colour characteristics (averaged) of used paper (print substrate color) measured on ten different places are in accordance with ISO 12647-2 [3] tolerances (L±3, a±2, b±2).

In the above-mentioned conditions, were printed series of samples characterized by gradual smooth changes in ink quantity – from under-inking to over-inking.

In order to achieve the goals of the experiment, series of measurements of D_v and Print Contrast have been performed (from under-inking to over-inking) for defining the optimal inking by the method of maximum print contrast for Cyan, Magenta, Yellow and Black. An analysis of the experimental results was performed using statistical and regression methods [14, 15, 16, 17]. After performing statistical analyses of obtained results, some of data with big deviations have been eliminated [17, 18]. The all obtained curves (Fig. 1-4) are from polynomial type. The results show that the polynomial curve type fits better to experimental data, than other types of mathematical models – Gaussian equation and Parabola equation. The obtained statistical analyses [14, 15, 16] of results for determination coefficient - R^2 and examinations of R^2 significance show that in this case the polynomial model is better than others.

3. Results and Discussion

The experimental data, representing the changes in the print contrast – C (the ordinate axis on the left side on figures), depending on the D_v for the process colors, are given in Figures 1, 2, 3 and 4.

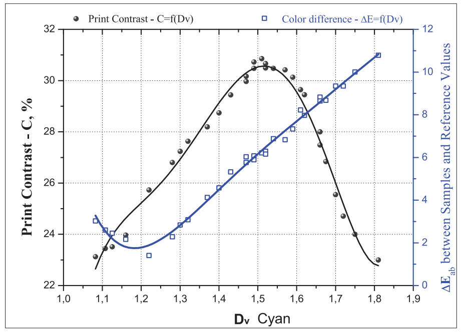

Figure 1: C=f(D_v), ΔE_{ab}=f(D_v) for Cyan

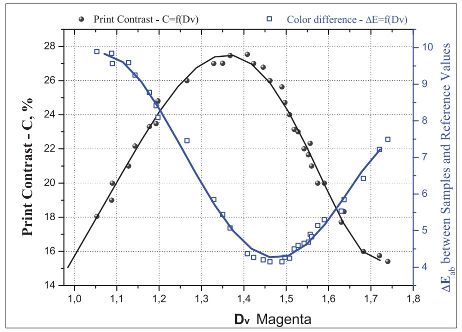

Figure 2: C=f(D_v), ΔE_{ab}=f(D_v) for Magenta

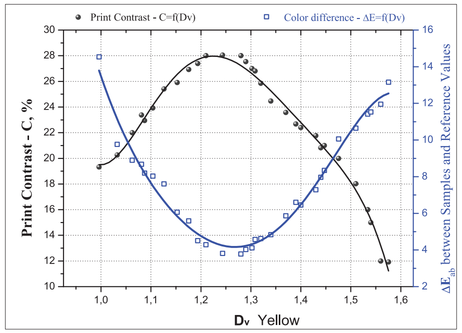

Figure 3: C=f(D_v), ΔE_{ab}=f(D_v) for Yellow

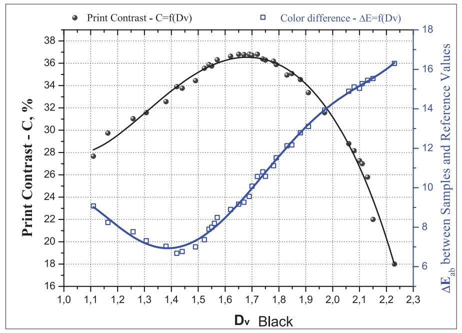

Figure 4: C=f(D_v), ΔE_{ab}=f(D_v) for Black

The graphs show clearly visible peaks, visualizing the maximal value of the print contrast and its corresponding D_v. The optimal inking has been defined through the optical density of 100% solid patch – D_v. Experimentally defined values (calculated from the polynomial curve) for optimal quantity of printing ink for the LWC paper are shown in Table 1.

Type of paper	Dv (Optimal density defined by maximal print contrast method)			
	Cyan	Magenta	Yellow	Black
LWC	1.52	1.36	1.23	1.68

Table 1: Experimentally defined values for optimal quantity of printing ink by the Print Contrast Method

In order to determine the inking via the second methods, series of colourimetric measurements were performed on printing sheets with different ink quantity (from under-inking to over-inking). The major goal was to determine the ink quantity, which provides the smallest colour difference (ΔE_{ab}) according to the reference values defined in ISO 12647-2 [3].

Figures 1, 2, 3 and 4 represent graphically the dependence of ΔE (colour difference between measured values in CIE Lab for solid patches for C, M, Y, K with varying ink quantity and the reference colour values from ISO 12647-2) to D_v. To achieve better visualization of the experimental data, at the figures 1, 2, 3 and 4, the colour differences – ΔE_{ab} are presented on second ordinate (the ordinate axis on the right side on figures).

The curve that connects the values of the measurements shows the changes in ΔE from reference values, depending on the printing ink quantity. All graphics show that the curve lies at a determined distance close to the reference value. This distance represents the smallest ΔE_{ab} between the experimental data and the standard values as per ISO. According to [3, 5], the printing process must be performed with ink quantity, which corresponds to the colour in the CIE Lab system characterized with this smallest ΔE.

Table 2 presents the relevant (corresponding) optical densities – D_v to the smallest values of ΔE, obtained from the experiment (calculated from the polynomial models).

Paper	Cyan		Magenta		Yellow		Black	
LWC	ΔE_{min}	Corresponing D_v	ΔE_{min}	Corresponing D_v	ΔE_{min}	Corresponing D_v	ΔE_{min}	Corresponing D_v
	1.75	1.18	4.24	1.47	4.16	1.27	6.93	1.39

Table 2: Experimentally defined values for smallest colour differences – ΔEmin and relevant ink quantity defined by D_v

Analyses of the achieved results shows:

It is clearly visible from the graphs that for some of the colours exist relatively big differences between the values of D_v, where K has highest levels, and D_v where ΔE has lowest levels.

The experimental results and the comparison of the data in Tables 1 and Table 2 shows that the optimal inking, determined by the two methods differ substantially for Cyan and Black. A relatively big difference in D_v is observed – about 0.34 units for Cyan, and 0.29 units for Black. While for others colours the difference is smaller - 0.11 units for Magenta and for Yellow 0.04 units difference for obtained ink quantity defined by D_v.

4. Conclusions

The results achieved are important from practical point of view. They lead to the conclusion that it is necessarily not only to achieve the maximal accuracy of reference colours from ISO standards, but also taking into strict consideration the concrete printing conditions – as dot gain, print contrast, screen frequency, type of printing press, ink properties (viscosity, adhesion to substrate) etc.

It is clearly visible from the experimental results and graphs that exist relatively big differences between the values of D_v, where print contrast has highest levels, and D_v where ΔE has lowest levels. This means that the implemented two different methods for inking determination result in different levels for D_v.

According to the recommendations of the ISO standards, the leading issue is to achieve of the reference colour values for C, M, Y, K, while the concrete technological printing process conditions are not taken into consideration, for example – dot gain, type of printing plates, ink types, printing paper specificity, printing press, screen frequency etc.

The inking process, as determined by the maximal contrast method takes into account all above mentioned technological conditions, except for the ink color characteristics.

Both methods for inking determination have their advantages and disadvantages. The advantages of one of the methods appear to be disadvantages of another one.

In order to reach the level of maximal accurate colour reproduction, the condition to achieve colour characteristics C, M, Y, K is not sufficient, without taking into consideration the concrete technological conditions. Taking into account the concrete printing conditions for determination of the inking, but without considering ink colour characteristics would not lead us to predictable results too.

From the point of view [1, 19] of the human perception, it is very important to achieve maximal accurate reproduction of key tones that could be fulfilled only if the Print Contrast method is implemented.

The experimental results lead to the idea that it is necessarily to take into consideration both methods for inking determination, while the best performance from the viewpoint of accuracy of colour reproduction is the generation of ICC colour profiles. The experience has shown that during the ICC profile application, both concrete technological conditions and ink color characteristics are taken into consideration.

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