THE INFLUENCE OF INK SEQUENCE ON COLOR GAMUT

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Abstract: A test form was printed on a 4-color press in order to examine the influence of two process ink color sequences on the subsequent printed color gamut. It was found that the sequence black, cyan, magenta, yellow produced better trapping of the 2-color overlaps; but on the other hand, the yellow, magenta, cyan, black sequence produced 4-color blacks that were more neutral. A sequence of cyan, magenta, yellow, black is suggested as the normal choice for production work.

Introduction

An earlier study (Field, 1983) of ink color sequence in four color printing, concluded that sequence did influence the appearance of process color reproductions. In particular, the study showed that the hue of two-color overprints shifted towards the second-down color, and that the maximum density of a reproduction was reduced if yellow was the last color printed in the sequence.

The 1983 study relied on ink rollouts produced under laboratory conditions. It was recognized at the time that full-scale press tests should be conducted to validate the findings. The current study was conducted on a 4-color press in order to evaluate the color differences between the yellow, magenta, cyan, black (YMCK) and black, cyan, magenta, yellow (KCMY) sequences. The earlier study had identified these sequences as those most likely to produce the most extreme differences in color appearance.

Experimental

A Heidelberg 4-color MOVP press was used in the experiment. This press has unit-type construction and, consequently, has a common distance between each printing unit.

Approximately 3000 sheets of coated paper were printed using unit-tack inks. The tackvalue was 14. One-half the

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sheets were printed in the YMCK sequence while the other half were printed in the KCMY sequence.

The test form contained an RIT Process Ink Gamut (PIG) Chart, a GATF Gray Balance Chart (which included dot gain scales), three pictorial subjects, a color bar, twelve GATF Star Targets, and four GATF Halftone Gray Wedges. The printed form measered 19" x 25½".

A primary concern during the experiment was that ink trap problems could influence the results, thus making it difficult to isolate the effects of color sequence. It was recognized that improved trapping could be realized by using a different ink set for each sequence. The unit-tack inks were chosen because the same set could be run in any sequence with satisfactory trapping.

The primary color densities of every tenth printed sheet were measured and recorded. Samples having similar densities for the YMCK and KCMY sequence were selected for analysis. An X-Rite 328 densitometer with the Preucil Apparent Trap equation was used to measure ink trap. A HunterLab Spectrocolorimeter was used with the FMC-2 color difference equation to characterize the color differences between the printed PIG charts. The gray balance was evaluated under ANSI PH2.32-1972 standard lighting.

Results

The analysis stage of the project was separated into two parts: one for the overprint colors and the other for the 4-color solids. In practice it was difficult to find two press sheets (one for each sequence), that had identical solid densities. The sheets chosen for analysis were those having close solid ink densities for two of the three primaries. For example, YMCK and KCMY sheets were selected with similar yellow and cyan densities so that comparisons could be made of the green overprints. Table I presents the density, apparent trap, and color difference calculations for the selected samples.

Several YMCK and KCMY sheets were analyzed as part of the 4-color solids study. The 3-color solids (YMC, YMK, YCK, MCK, and the reverse sequences) were also measured. The results of these measurements are presented in Table II. Samples 1 and 6 were selected for colorimetric analysis of the 4-color solids because the visual densities of these steps were identical.

Table I

2-Color Overprint Analysis

Red Overlap

YMCK		KCMY	
Yellow	0.87	Magenta	1.28
Magenta	1.20	Yellow	0.93
Trap	76%	Trap	84%

Color Difference of MY from YM

RG 15.73 YB 0.91 DL -8.63 DE 17.97

Green Overlap

YMCK		KCMY	
Yellow	0.87	Cyan	1.31
Cyan	1.34	Yellow	0.92
Trap	87%	Trap	89%

Color Difference of CY from YC

RG -5.80 YB -9.77 DL -6.17 DE 12.93

Blue Overlap

YMCK		KCMY	
Magenta	1.20	Cyan	1.29
Cyan	1.34	Magenta	1.15
Trap	72%	Trap	90%

Color Difference of CM from MC

RG -12.60 YB -2.07 DL -7.02 DE 14.57

It was difficult to achieve good trap, particularly of magenta over yellow, when using the YMCK sequence. The trap improved when the ink film thickness (IFT) of the yellow was reduced, but the subsequent reproduction was desaturated in yellows. The original intent had been to keep the IFT the same for all colors by using the same target "invisible number" on the GATF Dot Gain Scale for all colors. In practice, however, the "invisible number"

Table II

3- and 4-Color Densities - Selected Samples

	1	2	3		4	5	6
YMC	1.05	1.00	0.94	CMY	1.48	1.24	1.44
YMK	1.52	1.53	1.55	KMY	1.80	1.57	1.48
YCK	1.65	1.69	1.63	KCY	1.85	1.67	1.59
MCK	1.95	1.87	1.92	KCM	1.89	1.78	1.87
YMCK	1.87	1.62	1.74	KCMY	1.93	1.79	1.87
K	1.35	1.36	1.43	K	1.64	1.47	1.53

Color Difference, 4-Color Solid, Sample 6 (KCMY) Compared to Sample 1 (YMCK)

RG -28.13 YB -6.64 DL 2.27 DE 29.14

will shift due to changes in IFT as well as ink-water balance changes and printing pressure differences.

The gray balance analysis showed that gray balance for YMCK and KCMY was the same up to the 50% dot level of cyan. Trapping problems restricted the usefulness of the analysis of the darker gray balance chart tone steps.

Conclusions

It was found to be very difficult to isolate the contributions of ink opacity and trap efficiency from the appearance of the red, green, and blue 2-color overprints. It is conceivable that a laboratory experiment could be devised to isolate these effects, but with today's almost exclusive use of 4-color presses to produce process color work, the findings may not reflect reality. The traps for the red and blue overlaps were better under the test conditions for the KCMY sequence. The trap for green was not dependent on sequence, probably because of the longer delay between the cyan and yellow printing units as compared to the yellow-magenta or magenta-cyan units.

It should be noted that the color difference calculations for the green and blue overlaps show similar DE values despite the substantial difference in trap; however, the hue shift (RG -12.60) is a more valid indicator of color difference in this case.

The KCMY sequence produced a greenish cast over the 4-color solids. This effect was substantial and stood out as the major disadvantage of the KCMY color sequence.

Trapping problems influenced the 3-color densities of the YMCK sequence when yellow was one of the three colors in question. The 4-color densities obtained with YMCK were similar to those obtained when using KCMY.

In order to minimize the disadvantages of YMCK and KCMY a trial production standard ink sequence of CMYK is suggested. The selection of this sequence was made with the assumption that black will trap satisfactorily over yellow.

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Literature Cited

Field, Gary G.
1983 "Color Sequence in Four-Color Printing", TAGA Proceedings 1983, pp. 510-517.