Spot Color Matching for Digital Package Prototyping

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Abstract

Packaging printing is a huge market, both domestically and globally; it touches every aspect of consumers' lives. Nearly everything consumed requires some form of a package that serves practical purposes, like portability and protection, as well as marketing purposes – to catch the attention of shoppers and to distinguish a product from its competitors. Recently, the trend in the packaging industry includes shorter run lengths and work with fast turnaround times. Digital packaging breaks away from the traditional print technologies for package production and uses digital equipment to optimize quality, reduce turnaround time, and reduce costs for lower volume products (Franklin, 2010). In packaging printing, specific color inks are often used to meet specific requirements of customers. The main purposes of this experimental study are to (1) examine the quality of spot color reproduction with using Presstek 34DI digital offset printing press for digital package prototyping, and (2) establish printing workflows for digital package production. The Presstek 34DI digital offset printing press was calibrated and linearized before the experiment. Printing was controlled by the Momentum RIP. The plates were imaged at 175 lpi and 300 lpi using Euclidean dot shape. Two C1S paperboards were used in the study: 10-pt and 12-pt. Color management with ICC profiles is used to investigate the reproduction of specific spot colors. It was found that the average ΔE_{ab} values of tested print combination are in the range of 13 to 14. About 20 - 25% of Pantone colors can be reproduced with ΔE_{ab} lower than 8.0. Further investigation will include possible testing on an UV wide-format inkjet printer with a third party RIP to pursue a better spot color matching.

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1. Introduction

The package printing is one of large segments of the industry, second to commercial printing. In North America digital carton volumes will grow by 37.4% and flexible packaging by 62.6%, while corrugated will be 5.3% higher in 2015, according to the report by Sean Smyth, Print Consultant, Smithers Pira (Smyth, 2015). According to another recent report by Smithers Pira, the global market for digital printed packaging is forecast to be worth over $12.2 billion by 2016 – ballooning to over $15.3 billion by 2018. The growth is driven by the changing demands of packaging buyers with more varieties and packaging sizes; leading to shorter runs that digital technology produces economically (McEnaney, 2014; Peck, 2012).

Digital print technology is dramatically changing the packaging/prototyping market. Shorter lead-time, significantly lower costs, and greater flexibility are some benefits of digital technology. Designers can quickly produce variations of packaging designs or experiment with new concepts without incurring the high costs and longer lead-time of traditional analog systems. Print service providers also have an opportunity to scoop up short run and prototyping work that's well suited and more cost-effective when produced digitally (Franklin, 2010, Balentine, 2013).

Digital print technology allows for printing directly to the same substrates used in long-run jobs and offer faster turnarounds. Packaging work is among the most color critical in the industry. Matching corporate and brand colors is essential, as is the ability to accurately reproduce spot colors (McEnaney, 2014). With digital printing, color reproduction is controlled and maintained within the raster image processor's ICC workflow, which also supports Pantone spot color look-up tables to provide the closest CMYK equivalent. Digital also means variable data, which provides the opportunity to create specialized custom package with minimal costs. Today, digital packaging also can incorporate QR codes and image recognition, which allows apps to connect and promote activities and offers further interaction with smartphone users (Peck, 2011; Franklin, 2012; Smyth, 2015).

2. Methodology

Color consistency is a must in packaging. Color management is critical. Brand colors must match, spot on. In order to examine the spot color matching capability and establish a printing workflow for digital package prototyping, sets of test samples were prepared.

Equipment and Materials

In this study a Presstek 34DI digital offset printing press was used with soy-based inks from Toyo Ink Company. Printing was controlled by the Momentum RIP. Two C1S paperboards were used in the study: 10-pt and 12-pt. Table 1 provides basic properties of paperboards used in this study. All tested paperboards contain optical brightener agent (OBA).

Paperboard	Size	Basis Weight	Gloss	Brightness	Colorimetric values
10-pt C1S	26*40-in	133lb	55	94	94.14, 1.63, -6.17
12-pt C1S	26*40-in	155lb	55	94	93.76, 2.08, -7.43

Table 1: *Properties of tested paperboards*

Test Target Design

Spot colors from the Pantone color guide were used to design the spot color test chart (Figure 1) for this study. L*a*b* values of Pantone color swatches were used as target values. Adobe Photoshop CC 2014 was employed to generate the spot color test chart in digital form.

Figure 1: *Spot Color Test Chart*

Press Calibration

The Presstek 34DI digital offset printing press was calibrated and linearized before the experiment. Creating new calibration curves allow operators to alter the plate imaging for optimizing printing (Presstek, 2005, Rich, 2004). The plates were imaged at 175 lpi and 300 lpi using Euclidean dot shape. Screen angles were set as cyan at 15, magenta at 75, yellow at 0 and black at 45. Press speed is 5500 SPH. In this study, four new calibration curves were established for the tested line screen rulings (175lpi and 300 lpi) and paperboards (10-pt and 12-pt). The first set of plates were imaged without any curve adjustment. A test file with tonal scale is imaged with no calibration and printed to desired density (cyan: 1.48; magenta: 1.44; yellow: 1.02; black: 1.60). The press sheet is measured for dot percentage by an X-Rite 500 series spectrodensitometer at illuminant D50 and 2° observer. The calibrated curve was then created in the Calibration Manage. The test file is re-RIPed using the calibration curves, imaged and printed. Figure 2 illustrated graphs of calibrated curves for four output combinations.

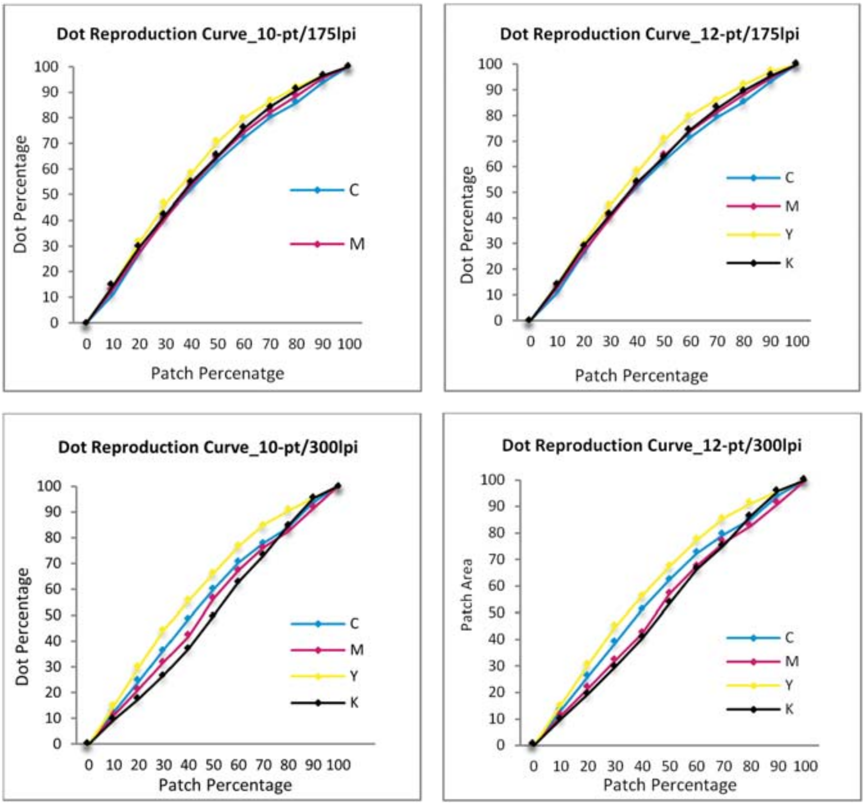

Figure 2: *Calibrated curves for tested output combinations*

Printing

The press was set to manufacturer's specification. The set of plates were imaged with calibrated curves applied. The first press run provided data for creating an ICC profile for the press run with a specific combination of line screen ruling and substrate. An ECI2002 CMYK chart was printed and measured with a X-Rite i1iO Spectrophotometer, operated by GretagMacbeth Measure Tool 5.0.10 software. The measurement files were used to generate profiles using GretagMacbeth ProfileMaker Pro 5.0.10. These profiles were used to compare the device gamut and to investigate reproduction of specific spot colors. During each press run, the ink density was balanced out across the paperboards to 1.02 for the yellow, 1.44 for the magenta, 1.48 for the cyan, and 1.60 for the black.

In the second press run, the designed spot color test target was printed with ICC profile on 10-pt and 12-pt paperboards with different line screen ruling settings. ICC profile conversion was done by using Adobe PhotoShop. Press speed and other press settings were kept consistent throughout the first and second press run.

Spot Color Matching Capability Analysis

The quality of spot color matching was evaluated in terms of the color difference (ΔEab) in L*a*b* color space. The color gamuts of the tested paperboards were compared using ColorThink Pro 3.0.3 software.

3. Results and Discussion

Table 2 lists color-related attributes of tested paperboards. Among four tested print combinations, 12-pt paperboard with 300 lpi print combination yielded higher optical densities and produced a wider color gamut. The overall average of optical densities of the 12-pt/300lpi print combination were 1.39 for cyan (C), 1.45 for magenta (M), 1.13 for yellow (Y), and 1.59 for black (K). The 12-pt/175lpi print combination produced lower optical densities, while the 10-pt/175lpi print combination yielded a smaller gamut volume. Overall, 300 line screen ruling tends to yield higher optical densities, while 12-pt paperboard tends to have larger color reproduction variability.

	10-pt/175lpi		12-pt/175lpi		10-pt/300lpi		12-pt/300lpi	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Cyan (C)	1.38	0.01	1.33	0.05	1.39	0.02	1.39	0.05
Magenta (M)	1.50	0.02	1.47	0.04	1.47	0.02	1.45	0.15
Yellow (Y)	1.10	0.02	1.11	0.03	1.11	0.02	1.13	0.04
Black (K)	1.47	0.04	1.30	0.04	1.54	0.03	1.59	0.08
Color Gamut	394,263	7,345	397,145	13,452	421,710	6,067	430,133	13,997

Note: S.D. represents Standard Deviation (Sigma).

Table 2: *Color-related attributes of tested paperboards*

The graphs of color gamut with L*a*b* values of target spot color data for tested print combinations are shown in Figure 3, Figure 4, Figure 5 and Figure 6, respectively. There are some spot colors in the test charts that are out of color gamut of the test paperboards. In other words, those high-saturated colors are difficult to be duplicated on those paperboards.

***Figure 3:** Color Gamut of 10-pt/175lpi print combination*

***Figure 4:** Color Gamut of 12-pt/175lpi print combination*

***Figure 5:** Color Gamut of 10-pt/300lpi print combination*

***Figure 6:** Color Gamut of 12-pt/300lpi print combination*

Table 3 and Figure 7 summarize ΔEab comparison for tested print combinations. The average ΔEab values of each print combination are 13.67, 13.88, 13.25, and 13.80, respectively. Figure 6 shows spot color reproduction capability of tested print combinations. The 300 line screen ruling can reproduce about 6.45% of Pantone colors with Eab lower than 4.0, while 175 line screen can only reproduce around 1.61% to 2.96% of Pantone colors with ΔEab lower than 4.0. About 25.27% of Pantone colors can be reproduced with ΔEab lower than 8.0 when the 10-pt/175lpi print combination was applied. The spot color swatches with ΔEab less 4 listed in Appendix I.

	Average ΔEab	ΔEab < 2	ΔEab < 4	ΔEab < 8	Min. ΔEab	Max. ΔEab
10-pt/175lpi	13.67	0%	2.96%	25.27%	2.05	39.32
12-pt/175lpi	13.88	0%	1.61%	23.39%	2.39	39.69
10-pt/300lpi	13.25	0.81%	6.45%	23.25%	1.25	41.31
12-pt/300lpi	13.80	0.54%	6.45%	21.64%	1.23	41.10

Table 3: *Summary of ΔEab comparison for tested print combinations*

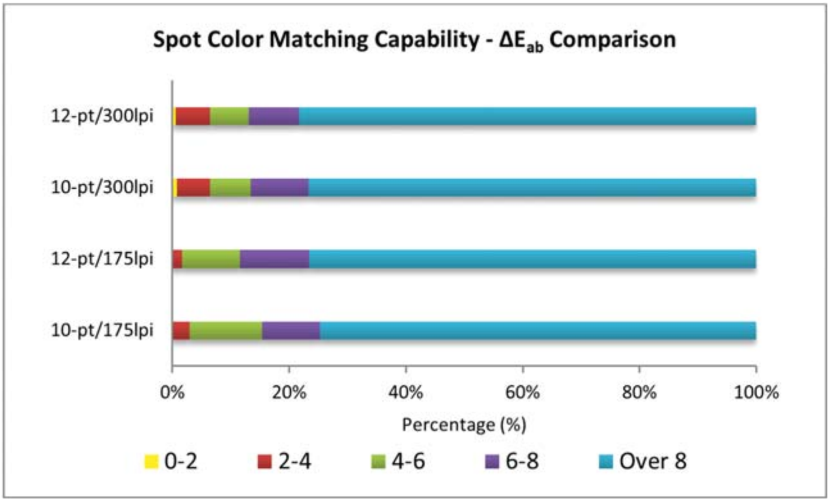

Figure 7: *Spot color matching capability for tested print combinations*

4. Conclusions

Overall, 12-pt paperboard with 300 lpi print combination yielded higher optical densities and produced a wider color gamut, while having larger color reproduction variability. The 10-pt paperboard with 300 lpi print combination, on the other hand, tends to have less variation in color reproduction. The average ΔEab values of tested print combination are in the range of 13 to 14. About 20 - 25% of Pantone colors can be reproduced with ΔEab lower than 8.0.

In this study, all the tested prints were controlled by the Momentum RIP with limited color management functions. ICC profile conversion was performed by using Adobe PhotoShop CC2014. This one time color matching function limited the spot color matching ability for the tested press. Further investigation will include possible testing on an UV wide-format inkjet printer with a third party RIP to pursue a better spot color matching.

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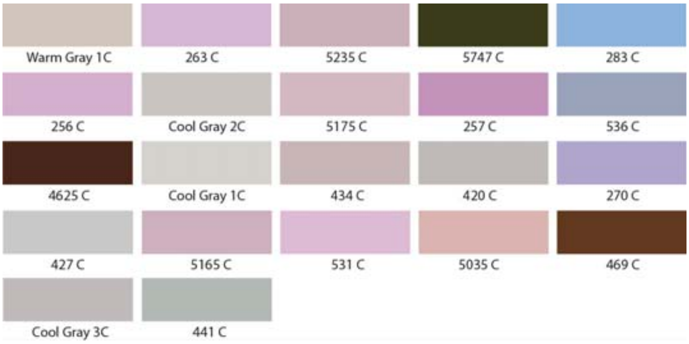
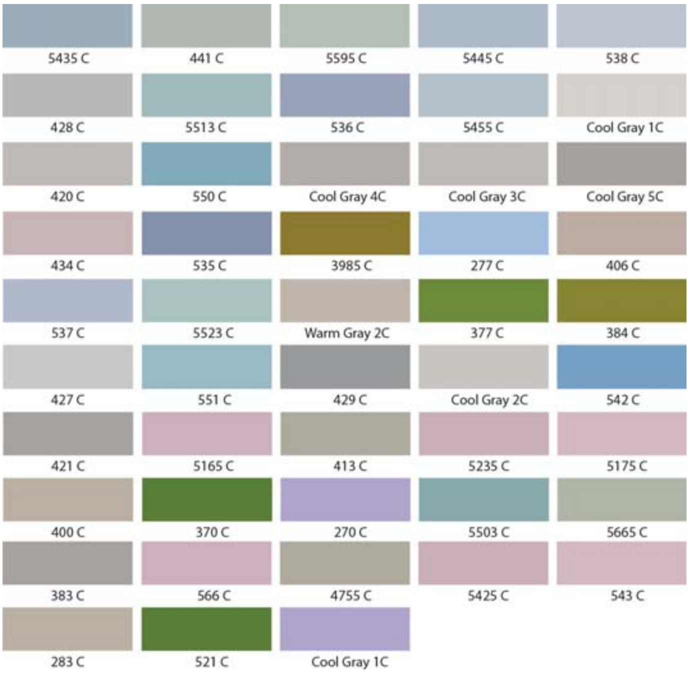
Appendix 1. Spot color swatches with with ΔEab less 4



A. 10-pt/175lpi print combination

B. 12-pt/175lpi print combination



C. 10-pt/300lpi print combination

D. 12-pt/300lpi print combination