Color Gamut Extension on 4-color Sheet-fed Offset Press Using Ink Fountain Divider Methodology

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Abstract

The purpose of this study is to investigate a new way to utilize a wide format 4-color offset press to print a wider color gamut. Printing with 7 color creates a wider color gamut with more vivid area and more depth in color. This methodology could be used on the Heidelberg SM CD74 or any other wide format 4 color offset press to output 4+ color job with less trimming waste and wider color gamut.

In this study, a test chart was created with i1 Profiler. The test chart was printed on Heidelberg SpeedMaster CD 74 on glossy coated paper. The press was setup with 2 color inks on the second, third and fourth unit by using an ink divider in the middle of each ink fountain tray. The C, M, Y, K, Pantone Orange, Violet and Green will be printed with 2 passes on the same side of substrate, flipped from left to right, bottom to up.

This method of printing will lead to huge enhancement in the measured color gamut, which in this case provided by the KCVMOGY (Black-Cyan-Violet-Magenta-Orange-Green-Yellow) inks. However, this print method will also reduce the width capacity of the substrate on this press to half of its current capacity. For example, the biggest substrate width of Heidelberg CD 74 is 74cm, with the 7-color setting, the biggest substrate width will be 37cm instead.

The printed results will be characterized by measuring the CIELAB values and the reflectance spectra with an X-Rite i1iO spectrophotometer with 45°/0° geometry. Profile Maker will be used to make the ICC profiles for the ink and substrate combinations. Color volumes will be created by ColorThink Pro. The KCMY color gamut and KCVMOGY color gamut will be compared accordingly.

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Introduction

Color Gamut

One of the most important reasons of increased print quality is the use of inks with a high coloring feature [1]. The film thickness of the ink should be below 2μm during printing [2]. The critical point is the direct effect of ink film thickness on print quality and color gamut. Ink absorption of paper and drying are the other important factors [3]. It is also very important to have suitable solid ink density values for the used paper surface to achieve the desired print quality and color gamut. When the optimum amount of ink that is transferred onto the paper is set, the print quality as well as the color gamut will increase.

Sheet-fed Offset press color gamut

The reproduction of a full-color image usually starts with the separation of the colors into cyan, magenta, yellow and black. These YMCK tints are called processes colors, and they are printed on paper for 4 times to create a full tone image. The total tones and shades the four-color can create is called color gamut.

Current method of offset gamut extension

There are two methods that have been widely used to research offset color gamut extension. The first way is using spot colors on a 7-unit offset press. However, compared to the 4-color offset press, the initial investment on the press is relatively high.

Another method is to conduct dry trap spot colors on a 4-color offset press. This method can achieve extended gamut with a lower cost. However, the dry trap leads to slow turnaround and limited cost-effectiveness.

The novelty and significance of the proposed methodology

The ink divider method will reproduce 7-color gamut by dividing each ink fountain with ink dams, so that each unit can produce dual color. The advantages of this method include no cost on 7-color press; it also enables small print shop with capacity of printing 7 color job with fast turnaround.

Experimental Procedures

Test Chart Creation

A 7-color patch set was created using the advanced version of i1 Profiler. The size of the test chart was set to 9.5 x 19 inches, which is half width of the press sheet. The spot colors information, which is orange, violet and green, are entered to i1Profiler. Then an .eps file with 7 colors was generated by the I1 Profiler. The file can only be opened in Adobe Photoshop as a .dcs file. In Photoshop, the seven color can be manipulated through individual channels (Figure 1).

Test Photo Creation

After the test chart is printed and scanned by i1Profiler, an ICC color profile will be created. To test and measure the extended color gamut of the 7-color system, a test photo that are heavily in orange, violet and green is created (Figure 2). The test photo will be printed by 4-color process and 7-color process respectively, then read, measured and calculated for their color gamut for comparison.

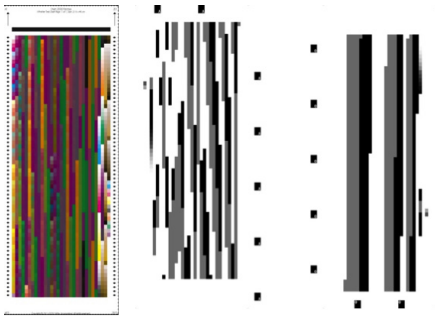

Figure 1. *The test chart consists of 7 colors with 7 channels*

Figure 2. *The test photo for color gamut comparison*

Materials and Devices

Printing Machine: Heidelberg Speedmaster CD74
Screen method: Stochastic FM
Screen Resolution: 10 μm
Screen Angle: cycle through screen angles to avoid moiré pattern
Plate: Kodak Sonora Processless plate
Paper: 135gsm Dull Coated
Ink: Heidelberg Saphira process: Cyan, Magenta, Yellow, Black; Heidelberg Saphira Spot: Orange, Green, Violet.
Density Measurements: X-Rite Spectrophotometer, i1Profiler, ColorThink Pro.

Test Chart Production

The press was washed twice, to clean the process ink residues from previous 4-color job. Followed by manually check each print unit to see if process ink residues remain in the unit where orange, violet and green will be fed. Any remaining process ink residue was hand-cleaned with solvents.

The ink tray is set with dams in the center, to separate two inks from mixing (Figure 3). Depends on the L* values of each ink, the 7 colors are fed into the 4 units in descending order of the L* value (Table 1). This is done according to the rule of best trapping where darkest ink prints first, lightest prints last [4].

	O.S.	L* values	D.S.	L* values
Unit 1	K	10	G	58
Unit 2	V	19	O	61
Unit 3	M	50	M	50
Unit 4	C	57	Y	94

Table 1. *The ink settings of 7 color in the 4 print units*

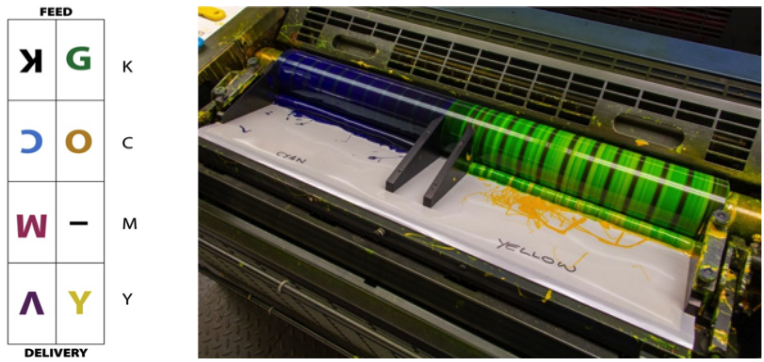

Figure 3. *The schematic layout of ink settings (left) and print unit 2 (right)*

After the ink dams are set and secured on each unit according to the arrangements illustrated in Figure 3, four offset plates are mounted on each unit. The press is operated to print at the speed of 3500 sheets per minute. Four pulls are made to adjust the density to dull coated standards [5]. Once the target density is reached, operate the press to print 100 sheets under the same pressure and speed.

The 100 good sheets were collected from the delivery pile, then flipped from left to right side, and placed on the feeder. The sheets are flipped in work and turn, which means the gripper side was changed from top to the bottom.

To optimize the registration on the test chart, the side guide is also switched from the operator side to the driver side, so that the sheets are squared from the same corner by the three-point-alignment register system. The 100 good sheets are printed under the same conditions with the same density targets. Prior to chart measurements, the inks are cured by the microwave.

Oscillator Challenge

Read the test chart by using I1Profiler. After the first round of scanning, the i1Profiler showed it can't recognize the test chart with too much color variance. This is due to the gradually mixing of the two colors in one ink tray.

On the offset press, each printing unit is equipped with four oscillators (Fig. 4). During the press run, the oscillators move laterally to spread ink evenly across the inking train. The main challenge for divided inking train with dual colors is that the rollers behind ink fountain roller get contaminated with the dual color. This ink mixtures lead to the color variance that confuses the i1Profiler during the color scanning for the test chart.

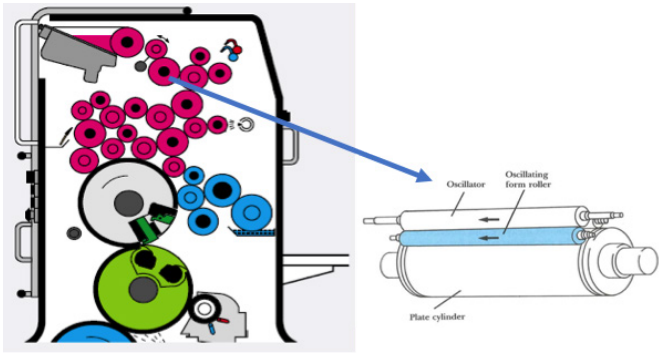

Figure 4. *The schematic picture of the oscillators in offset press*

The oscillator's moving range can be adjusted for 4 levels, including fully disengaged. After consulting the Heidelberg technicians, we managed to disengage all the oscillators in each unit. The disengaged oscillator fully stopped moving laterally on each printing unit, thus minimizing dual colors ink mixing through the inking train.

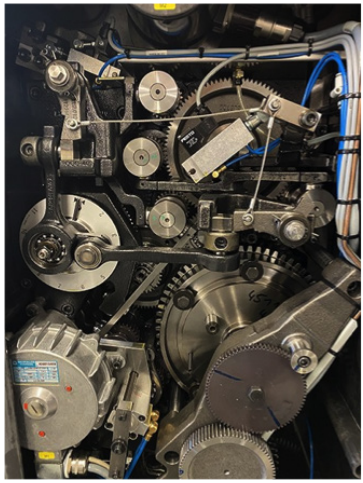

Figure 5. *The side view of the inking train from driver side*

Test Chart Reproduction for Second Run

After the disengagement of the oscillators in all three printing units that are divided by the ink dam, a second press run was operated to reproduce the test chart. The ink dividing is significantly improved after oscillator disengagement (Figure 6). The dual colors ink stayed clear from each other on the designated half ink tray on each unit.

Figure 6. *The ink tray shows no mixing after oscillators are disengaged*

The press is operated under the same conditions of speed and press to print the test chart. However, ink wasn't fed across the inking train uniformly with oscillators fully stopped. As a result, obvious ink stripes showed on the press sheets.

Unfortunately, the Heidelberg SpeedMaster CD 74 cannot be partially defeated. There are other offset presses that have variable oscillation options. As a result of the oscillator problem, we were unable to make a color gamut comparison. We were forced to stop and reconsider our option and next steps.

Conclusion and Future Work

There have been many innovative researches on offset color gamut extension. Although we didn't fully deliver the proposed research objectives, we did learn a lot on the offset operations, press mechanism and problem shooting along the research process. We take pride in Cal Poly's Learn by Doing motto and are fully committed to this learning model in our future research.

In order to deliver the color gamut comparison of the 7-color and 4-color process, we plan to run a dry-trap version of the same job. We will run the colors in the darkest-to-lightest order as either 4-then-3 or vice versa. Then the same test photo will be reproduced on a 4-color process run. I1Profiler will be used to compare the gamut differences.

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