

Color Reproduction Control for Large-scale Offset Press Printing System

Makoto Matsuki, Hiromi Nagase** and Toru Sadakata**
**NTT Printec Co., R&D Section,*
Iruma-shi, Saitama, Japan
*** NTT Directory Services Co., Telephone Directory Division,*
Tokyo, Japan

Abstract

According to remarkable increase of color printing in newspaper and telephone directory, it becomes necessary to obtain same color reproduction for same photographs or advertisements printed by several printing factories distributed over the country. As several types of printing presses and plate making methods are used in the factories, it is difficult to obtain good color matching between the factories. In order to control color reproduction of this type large-scale printing system, paper and ink colors are standardized, then a standard tone reproduction curve proportional to L* of CIELAB are introduced. For each printing press, deviation from this curve is corrected by dot gain correction of output devices such as film setter and CTP setter.

Introduction

According to remarkable increase of color printing in newspaper or telephone directory, same color photographs or advertisements are often printed by several printing factories and distributed over the country. In Japan, telephone directory is printed at 6 factories using several types of web offset presses manufactured by 4 companies. For this type large-scale printing system, same photographs or advertisements should be reproduced as same color. But it is very difficult, because, color reproduction characteristic depends on printing press type, machine set up, plate making method, and ink property. In order to obtain same color reproduction for the printing presses of this system, color reproduction control method is studied. According to this study, a standard tone reproduction curve is introduced and deviation of each press from this standard curve is corrected by dot gain correction of output devices such as film setter and CTP setter.

Printing System

This printing system for telephone directory is semantically illustrated in Figure 1. In this system, 6 printing factories distributed over from Tohoku to Kyushu areas are used. Color advertisement data are prepared at more than 10 prepress sites also distributed over the country. These data are transferred and stored to a central database. At the printing factories, these advertisement data are merged with the main body data and recorded on a film or CTP plate as ISO A4 size 8 to 32 page up image. In the printing process, this image is printed on uncoated paper using cold set web offset press. One four colors double-sided unit may produce 500 to 700 folds per minute, that contain 32 or 64 color pages per fold. There are some variations in inking unit structure of those presses depended on manufactures, such as long roller train like for commercial printing, short train like for newsprint. There are also some variety in plate making according to the factories. Some factories already installed CTP (Computer To Plate) system, but others are using film and negative working plate. According to these variations, each press shows slightly different tone reproduction characteristic. Therefore, we have been tried to introduce a standard color reproduction curve and control the reproduction characteristics of these presses.

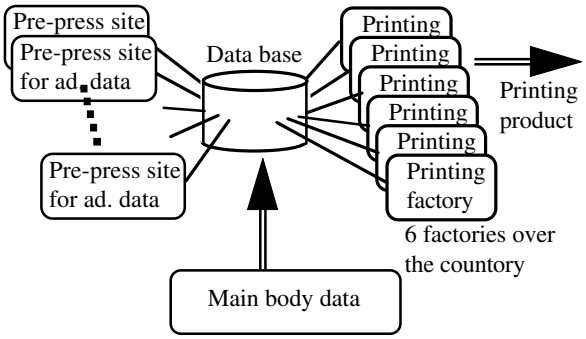

Figure 1. Printing system for telephone directory

Control Methods for Color Reproduction

Basic Printing Characteristics

For newspaper or telephone directory printing in Japan, negative working plate (n-type plate) is usually used, in which exposed area becomes image and inking area.

Reproduction characteristic of this plate is different from positive working plate (p-type plate) commonly used for commercial offset printing and CTP plate that is directly recorded by digital data. Reproduction sequence of n-type plate system is shown in Figure 2[1]. Dot gain at each step is semantically shown in Figure 3. In this figure, dot gain of CTP plate system is also shown as broken lines.

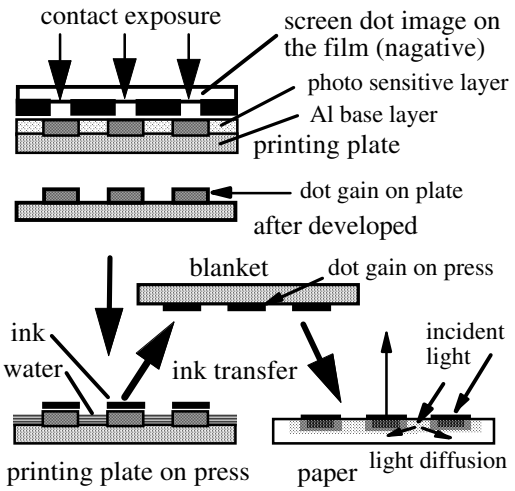

Figure 2. Screen dot reproduction process.

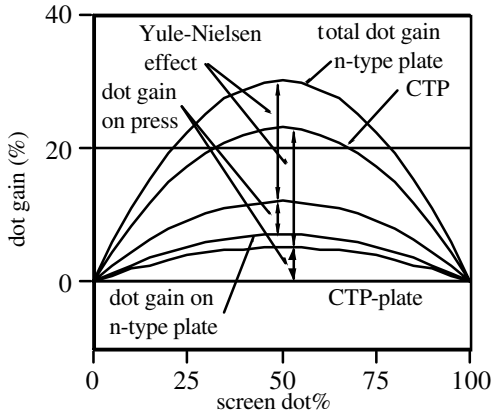

Figure 3. Dot gain in the reproduction process

Screen dot image recorded on a film is transferred to a photo-sensitive layer of a printing plate by contact exposure. In this step, size of exposed halftone dots and thin lines are slightly increase, by light penetration to unexposed area. At development process, unexposed area of the photo-sensitive layer are washed out and light exposed area is left and becomes oil attractive area. After this step, non-imaging area is treated by gumming solution and becomes hydrophilic. On the press, dampening water and ink are supplied to this plate. Non-imaging area is covered by dampening water and ink image is created on the oil attractive area. This ink image is transferred to a blanket and then to a paper surface. Dot shape of the ink image is slightly changed by plate to blanket and blanket to paper contact transfers. This dot gain is relatively small, but affected by the press structure, machine set up, and ink property.

Then, the ink image on the paper is observed and measured by a densitometer. Measured density of the image becomes darker than the expected value from actual dot area ratio on the paper, according to optical dot gain, well known as Yule-Nealsen effect[2].

According to these steps, total dot gain becomes about 30% for n-type plate system. Large part of this gain is caused by optical. As optical dot gain is mainly affected by paper optical property, it becomes almost constant when same printing paper is used. Remaining part is mechanical and it may be varied by plate type, machine structure, machine set up and ink property. An example of dot gain variation according to plate type is shown in Figure 4. N-type plate curve is estimated from measured p-type plate data for 175 lpi screening that is usually used for commercial printing. This figure clearly indicates the plate type effect to the dot gain.

Additionally, thickness of each ink layer at two or three inks overlaid area may be changed by ink physical property and printing sequence. This phenomenon known as ink trapping affects color reproduction of this area.

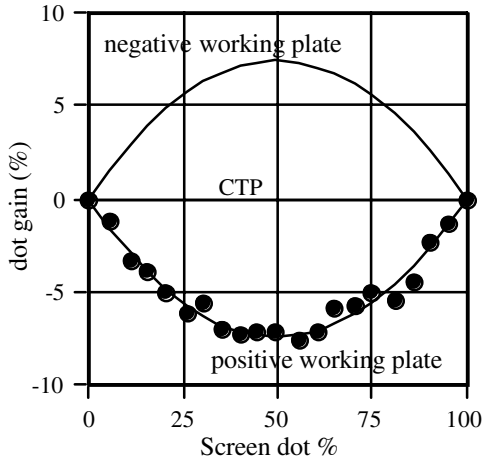

Figure 4. Dot gain variation according to plate type (175 lpi screening)

Basic Method For Tone Reproduction Control

For obtaining same color reproduction on these offset presses, it is the base to standardize printing paper, ink color, solid density, screen ruling, and color sequence. In this system, 85 lpi screen ruling and following color sequence and solid densities are used; M = 0.8, C = 0.8, Y = 0.65, Bk = 1.0. Although, these parameters are fixed, tone reproduction and trapping characteristics may vary by other parameters such as plate type, machine structure, and ink property, as mentioned in the previous section.

In order to suppress these variations, a standard color reproduction characteristic and a well-defined correction method are required. There are two candidates for this correction as shown in Figure 5. First one is to use ICC profile and second one is to use dot gain correction of the output devices such as film setter and CTP setter. In first method, both tone and trapping characteristics can be corrected by using 3D or 4D LUT. But it needs large data amount for processing and has some processing difficulties on black ink, as the three component connecting color space is used for ICC profile system. And it also needs some expertise for obtaining accurate ICC profiles for these presses. On the other hand, the second method is very simple and does not require additional software processing, though it can not correct trapping characteristic. As not so much correction may be expected for the trapping under the condition to use same ink colors, same color sequence, and same printing paper, the second method is selected. In order to realize the second method in this system, the standard tone reproduction curve is introduced and deviation from this curve in each press is corrected by dot gain correction of the output devices such as film setter and CTP setter.

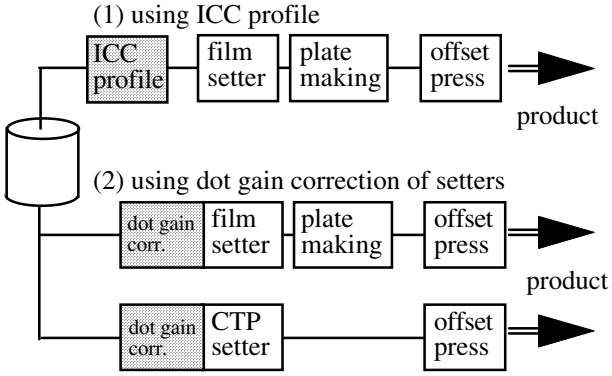

Figure 5. Two reproduction correction method for this system.

Tone Correction

In order to introduce this tone correction method, it is necessary to define the standard curve at first. As this standard curve also affects scanner set up, we should consider not only dot gain correction of film and CTP setters, but also scanner. Most of scanners used in prepress area are designed for commercial offset printing as their base. As eight bits per component CMYK signal does not have so much room for tone jumps at highlight area, when some tone corrections are used, tone correction should be small as possible for scanner, setters and total system.

Following three candidates were studied for this system. These curves are shown in Figure 6.

1) dot % linear
   In this curve, 50 % tone value area is reproduced as 50 % value that is calculated from its density value using Murray & Davice equation.
2) L* linear
   In this curve, reproduced L* value of CIELAB at a black ink tone patch relates linearly to input dot %. This curve is almost same as the tone reproduction curve of usual commercial offset printing.
3) Average of n-type plate
   This curve is the average of tone reproduction curves of cold set web offset presses with n-type plate in the factories.

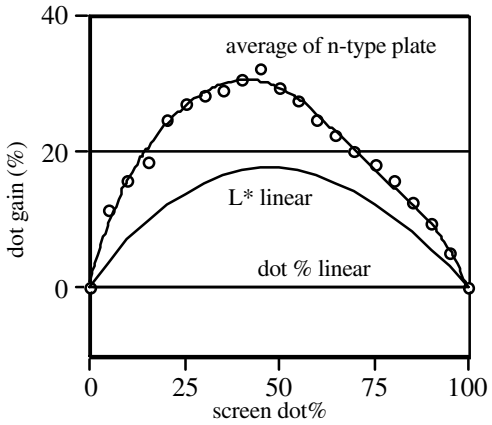

Figure 6. Three candidates of the standard tone reproduction curve

Required correction amounts for these candidates are calculated using Figure 3 case and summarized in Table 1. Dot % linear curve requires large amount of correction for each stage, and its direction is reverse between scanner and setters. Average of n-type plate requires zero or small amount of correction for film setter, that depends on the set up of each press. But, it requires 7 and 11 % corrections for scanner and CTP setter respectively as reverse direction. On the other hand, L* linear curve requires 6 to 11% correction only for setter and almost zero for scanner. Then, it does not contain reverse direction corrections as the total.

Table 1. Correction amount for three candidates of standard tone curve

	correction amount (%) at 50% screen dot		
tone curve type	Scanner	Film setter	CTP setter
(a) Dot % linear	+ 17	- 23	- 19
(b) L* linear	0	- 11	- 6
(c) Average of n-type plate	- 11	0	+ 7

According this comparison, L* linear curve indicates better characteristics for tone correction. Additionally, as L* linear curve corresponds human lightness scale, this curve can show smoother shading than other curves, when same number of tone levels are used. And use of L* linear curve is suitable for tone compression of scanned image data. An example of black ink's tone reproduction curve of usual

commercial offset printing is shown in Figure 7. Reproduced L* value has a linear relation to input dot % except dark area. As black solid density of commercial offset printing is 1.6 or higher, the scanned image data for commercial offset printing should be converted to meet this system's density range. Using L* linear curve for this system, reproduction values are almost linearly compressed in L* space as shown in Figure 7. Image data compression in uniform color space as CIELAB is frequently used for gamut compression[3]. According to these discussion, L* linear curve is selected as the standard tone reproduction curve for this system. It may also make possible to use scanned data for commercial offset printing without large tone correction except UCR set up that may relate ink receiving capacity of the printing paper.

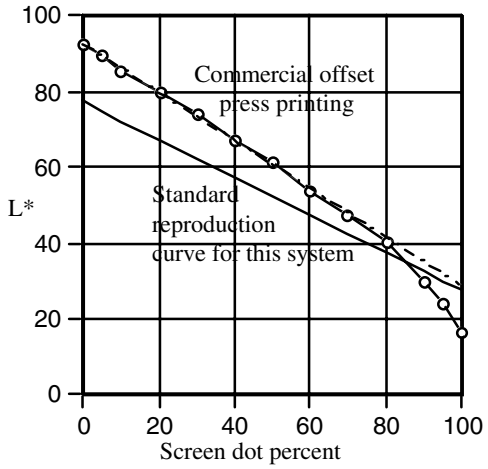

Figure 7. Dot % and L relation of commercial offset press printing and the standard reproduction curve of this system.*

Conclusion

In order to control color reproduction of the large-scale printing system such as telephone directory printing system, a standard tone reproduction curve proportional to L* of CIELAB was introduced. For each printing press, deviation from this curve was corrected by dot gain correction at output devices. We are now testing this tone correction method on the telephone directory printing in Japan.

References

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Biography

Makoto Matsuki received his Master degree in Physical Information Engineering from the Tokyo Institute of Technology in 1974 and joined to the Electrical Communication Laboratories of Nippon Telegraph and Telephone Corporation. He worked on research and development of NIP system for facsimile and standardization of color facsimile. Since 1995 he has worked at NTT Printec Co.. His work has mainly focused on the color reproduction of offset press printing and high quality image communication. He is a member of the IS&T and the Imaging Society of Japan.