

Tone Reproduction Characteristics of Offset Press Printing

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Abstract

In order to obtain color matching between DDCP and offset press printing, it is important to know the printing characteristic of the press system. In this paper, we report its tone reproduction and ink transfer characteristics. Its dot percent signal has good tone reproduction characteristic corresponds to human lightness scale, especially for film and positive working plate system. But this characteristic is slightly changed by printing plate type such as negative working plate and CTP. Ink transfer ratio from blanket to paper is near 20% level and quite different from that of NIP system.

Introduction

Offset press printing is one of the high quality color reproduction system. Its reproduction quality is one of the targets of Non Impact Printing (NIP) system. In the actual work in the offset press printing, it is not so common to use electric feedback system for stabilizing color reproduction. This work is mainly done by press operator to compare print out with the sample print "proof" and manipulate keys of the inking units. As the proof is usually printed by flat bed proof press, its reproduction characteristic is slightly different from the press. This means that it is difficult to match all colors of the print to those of the proof. Therefore, press operator usually seek perceptual matching on the important areas of the print.

Some sophisticated printing system can measure color control bar on the print and feedback this data to the inking units automatically. In order to do this control, it is necessary that the proof has the same color reproduction characteristic of the press. One method is to print the proof by the same press. Another is to use DDCP (Direct Digital Color Proofer). DDCP is one of the NIP system and possible to print the proof directly from digital data. Some types of DDCP can also simulate screen dots, using high resolution laser recording system.

In order to introduce DDCP to the press printing system, color matching between DDCP and the press is very important. For sufficient color matching, it is necessary to know printing characteristics of the offset press printing. In this paper, we report tone reproduction and ink transfer characteristics of the offset press printing. We also report the tone reproduction change that depends on printing plate such as positive and negative working plates and CTP plate.

Structure of Sheetfed Offset Press

For high quality printing, sheetfed offset press and positive working plate that is exposed its background image area, are mainly used. Its basic structure and screen dot reproduction processes are illustrated in Figure 1 and 2 respectively.

Printing plate is prepared following steps from image data. Image data is prepared as CMYK screen dot percent data in prepress process. Film recorder generates screen dot image by this data and records on a film as positive image. Then, this dot image is transferred to printing plate by contact exposure. In development process, light exposed areas of the photo-sensitive layer are washed out and unexposed dot image areas are left and become oil attractive areas. In this process, dot size is slightly reduced (about 8 % at 50 % screen dot) by the light penetration to unexposed areas.

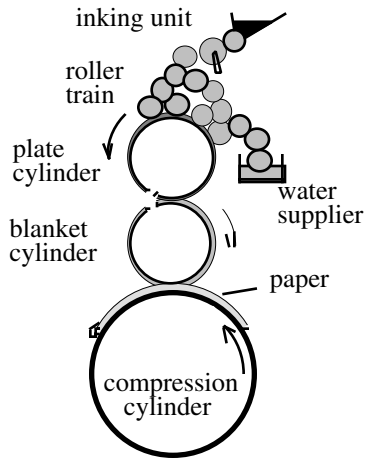

Figure 1. Structure of sheetfed offset press

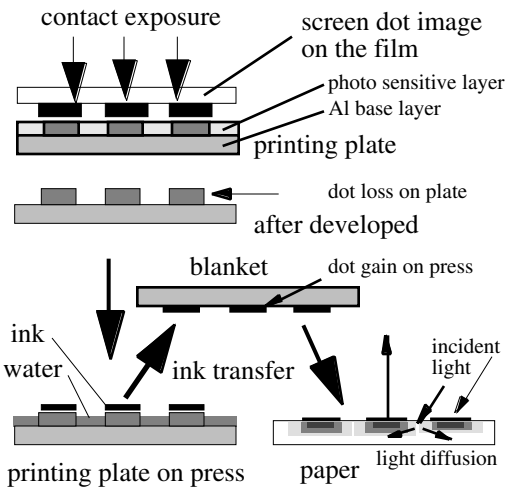

Figure 2. Screen dot reproduction process

On the press, ink and water are supplied to the plate through roller trains from the inking unit and the water supplier. Ink image is created on the oil attractive areas on the plate by attractive and repulsion force of ink and water. This ink image is transferred to the blanket and then transferred to the paper surface. Dot size of the ink images slightly expanded by plate to blanket and blanket to paper contact transfers. In each ink image transfer, dot size expansion is several percent order, therefore actual dot size on the paper does not change so much from that on the firm at 150 or 175 l/inch screen. These dot loss and gain are illustrated in Figure 3.

Four color press is constructed from four units of this type press. Color inks are transferred sequentially. As all color inks are printed without sufficient interval for drying, transfer ratio of the ink printed on other ink layers changes from that of on the paper. This unexpected transfer rate change, is called "trapping". This characteristic is quite different from that of high-end DDCP such as laser thermal transfer type DDCP that can transfer color materials independently from other colors.

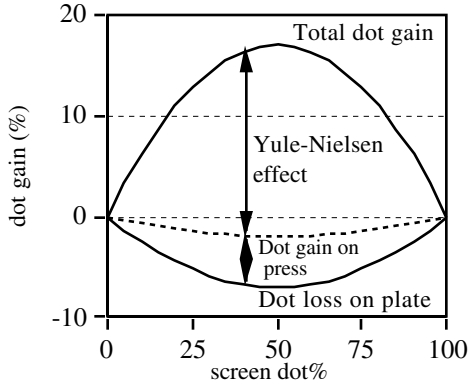

Figure 3. Dot loss & gain in the reproduction process

Tone Reproduction

CMYK screen dot percent system is well known device dependent system. An example of tone reproduction curve of black ink is shown in Figure 4. This characteristic is slightly darker than a calculated curve from dot area percent at mid-tone. This darkness corresponds to 10 to 20 % dot gain and consists of dot loss and gain in each reproduction process shown in Figure 2 and 3. Main part of this dot gain is caused by Yule-Nielsen effect[1)] that comes from light diffusion in the paper. This non-linearity is important for high quality reproduction. This characteristic can be plotted as the dot percent and L* relation shown in Figure 5. This graph shows that dot percent relates almost linear to L*. It means dot percent signal corresponds to human lightness scale. Therefore, this dot percent signal system can show smooth shading without tone jump, and it can use relatively small number of tone levels such as 200 to 255.

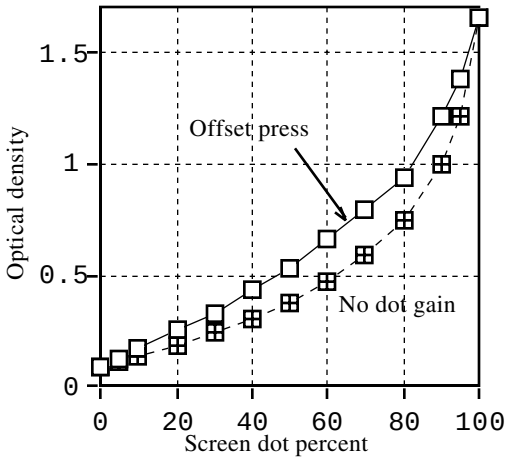

Figure 4. Dot percent and optical density relation of offset press printing

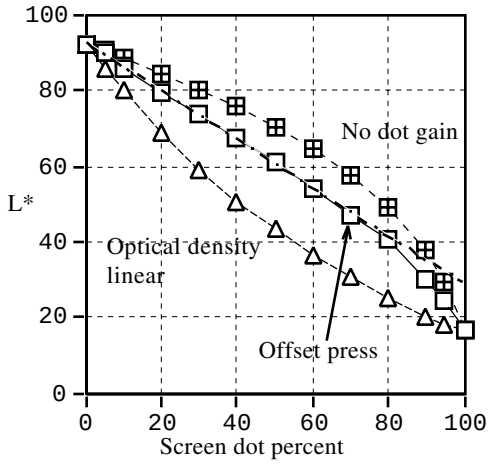

Figure 5. Dot percent and L relation of offset press printing*

In this discussion, tone reproduction characteristic was explained on the system that uses film and positive working plate. There are two other plate making types, CTP and film with negative working plate. In CTP system, dot image on a plate is generated directly from image data, therefore dot size may relate almost linear to image data. Film with negative working plate system is usually used for newspaper and telephone directory printing. In the system, dot image areas are exposed and background areas are not exposed. Therefore, dot size on the plate slightly expands by the light penetration to unexposed area. This dot gain is nearly same as the polarity inverted curve of the dot loss on the positive working plate. Measured value on the positive working plate and its fitted parabolic curve are shown in Figure 6. Estimated curves for CTP and negative working plate are also shown in this figure. They also affect tone reproduction characteristics, they are shown in Figure 7.

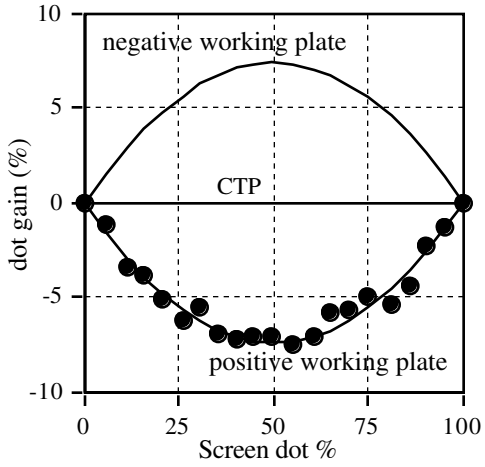

Figure 6. Dot loss and gain on press plate

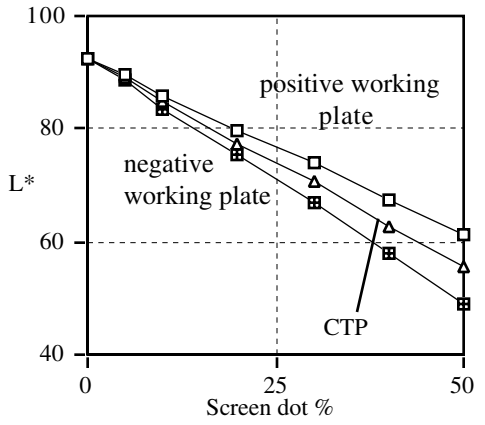

Figure 7. Tone reproduction dependence on plate types

CTP and negative working plate show steeper characteristics at highlight area. It means they have some risks on tone jumps in highlight area, if we use small number of tone levels such as 200 to 255 for dot generation. Therefore the system that uses CTP or negative working plate should use higher than 8 bits such as 12 bits internal data for dot generating process.

Ink Transfer Characteristics

In order to match color characteristics of offset press and DDCP, it is important to use same or same type colorant and same reproduction curves. But it is not sufficient for color matching. According to trapping characteristic, color difference occurs on two or three color mixed area. It is important to study ink transfer mechanism from blanket to paper for clarifying trapping characteristic.

First order approximation, ink transfer depends on ink thickness and attractive force of blanket and receiving sheet. Attractive force may change by surface coating especially for plastic sheet. If different type sheets are contained in one stack, unexpected density change may occur. Such example is shown in Figure 8. In this test, UV fixing ink, polyester plastic sheets with different coatings are used. One test stack is consisted of 6 or more different coating plastic sheets and 20 paper sheets between plastic sheets. Optical density decreases at plastic sheet and slightly increases at paper sheets just after it. Density decrease may depend on surface attractive force change. Density increase may depend on ink thickness increase on the blanket.

Assume linear relation between density and ink thickness and ink transfer characteristic as shown in Figure 9, we can calculate ink transfer ratio from blanket to paper.

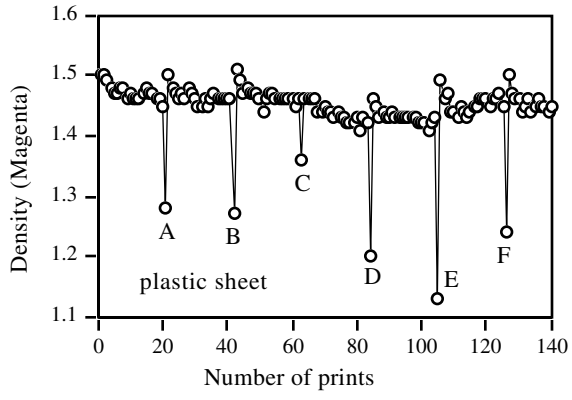

Figure 8. Optical density chage in the test print

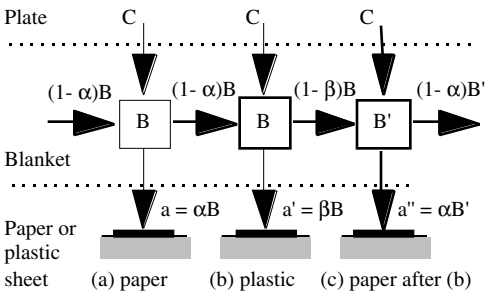

Figure 9. Ink transfer between plate, blanket and sheets

In this figure, following notations are used.

C : ink supply from the plate,
(In this calculation, it is a constant.)
B, B' : ink amount on the blanket before transfer to the sheet,
a, a', a": printed ink amount on the sheet,
α : ink transfer ratio to the paper sheet,
β : ink transfer ratio to the plastic sheet .

According to this figure, α becomes as follows;

$$\alpha = (a'' - a) / (a - a').$$

If substitute the data of plastic sheet (E) in Figure 8, α becomes 20%. This is one of the different characteristics from electro-photographic printer, in which more than 90% of developed toners are transferred to the paper using electrostatic forth.

This low ink transfer ratio also relates start-up characteristic of offset press system. For example, some part of printed ink in the first unit will be removed by the blanket in the next unit until ink transfer becomes equilibrium state. Then offset press system require more than 50 sheets for start-up.

Conclusion

In this paper, we report some characteristics of offset press printing system, in order to obtain better color matching with DDCP. Offset press system has good tone reproduction characteristic corresponded to human lightness scale. But this characteristic may be changed by printing plate type. Ink transfer characteristic of offset press system is quite different from that of NIP system. Its transfer ratio from blanket to paper is near 20% level.

References

1. J. A. C.Yule and W. J. Nielsen, *Proc. Tech. Assoc. Graphic* Arts **3,** 65-76 (1951).

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.