

Recent Progress in Electrophotographic Digital Color Marking

Yasuji Fukase
Fuji Xerox Co., Ltd., Kanagawa, Japan

Abstract

The environment in marking technologies is changing drastically. The most obvious transition is the networked document exchange throughout the world. Marking technologies are therefore being increasingly forced to treat digital image data. A key message from the past 49th IS&T Non Impact Printing conference was "over the Internet printing", in other words "from print and distribute to distribute and print". We must, therefore, consider the future direction of marking technologies from this viewpoint.

In this paper, trends in marking technology will be discussed. In particular, the importance of matching the image processing system to a particular marking process, and the compatibility between image and substrate (paper) quality will be stressed.

Introduction

Digital color xerography products and technologies in Japan were reviewed by Takiguchi at the 1996 IS&T NIP conference. He indicated that the level of xerographic image quality was now close to that of offset printing, but that some differences still exist. Recent marking technology progress since Takiguchi's review will be discussed in this present paper. However, xerography years are like elephant years, although Web years are like dog years (George Lynch: HP) , so that technical innovation in this short period has not been remarkable. Therefore, based on an analysis of recent products and technologies, trends in electrophotographic technology will be discussed and compared with other marking technologies.

Recent Products and Technology Topics

In 1996, monochrome laser printers shifted to the higher (20-30) PPM market segment, and their functions changed to network printing. "Mopier" from HP is a typical new product in this segment. In Japan, digital xerography copiers have come into wide use as multifunction PPC's, and their shipment rate was over one-third of the whole PPC market in 1996. Regarding digital color printing, tandem xerographic engine products (both copiers and printers) have been introduced in the market from several companies as was described in Takiguchi's preprint. The following list highlights newcomers with unique technologies including other marking processes.

A-Color 936 (Fuji Xerox)

This product is the successor to A-color 935, and was introduced in February 1997. Although the color print speed remains at 9 ppm (the same as A-Color 935), color reproduction performance has been remarkably improved by new scanner image data processing (non-linear color masking), and a new color matching algorithm/device (a direct look-up table for color mapping called 3D-ACCT:Three Dimensional Advanced Color Conversion Technology).

LIMOS 900/ CF 900 (Minolta)

This color copier was first shown at the Seybold Seminars 96 in Boston, and was shipped in May in the Japan and US markets. DASH-LIMOS (Dot Auto Layout with Screen Hybrid Laser Intensity Modulation System) technology was developed and introduced for improved tone reproduction quality and stability. This new image processing system provides 256 gradations for each pixel. It can control laser intensity modulation every 1/4 pixel with a reduced laser spot diameter (2/3 size than its predecessor).

Photo Quality Ink Jet Printers (HP, EPSON, Canon)

From last autumn to this winter, new concepts have emerged in the ink jet market. In particular, photo finish or photo-like quality printers using low density colors of ink or pairs of high and low density colors. The aim of these inks is reduced graininess in highlight image areas, and a higher tone reproduction performance. Special papers for ink jet have further improved image quality by enabling smooth and glossy surfaces similar to that of photographic prints.

MD-2300S/J (Alps Elec.)

This product was introduced in September 1996 and is a wax and dye sublimation hybrid thermal transfer printer which has a 600dpi micro DOS (Deposition On Silicone) thermal head and an ability to control thermal energy modulation (256 gradations). This printer can make conventional color prints on plain paper and also photo-like color prints (dye sublimation mode) on special over-coated paper for fade-proof images.

Trends in Marking Technologies

Concentrate or spread

The continued need for improvements in tone reproduction in highlight areas is due to the high sensitivity of the human eye to low levels of structured variations in low density images. Originally, digital color copiers used simple

line screens for halftoning which absorbed vibration of mechanical noise in the process direction and produced a high addressability with analogue screen generators. It has been the best screen algorithm for electrophotography. However, it gives poor tone reproduction stability in highlight areas where the latent image is unstable and the electrostatic contrast is low.

Recently, to improve this problem, many kinds of hybrid (dot and line -like) screening technologies have been developed. These include HIEST (Fuji Xerox), Dash-Limos (Minolta: mentioned above) and other digital dot screen color printers (Chromapress, E-Print and Canon LBP2030 etc.). These technologies have the same objective, that is to control low frequency noise in low density images, and to optimize high contrast latent images. As a result, these systems have achieved higher image quality (tone reproduction and graininess) and image stability.

On the other hand, ink jet printer makers have introduced "low density colors" inks for photo-like quality printing. This technology also improves graininess and halftone reproduction. However, the ink jet approaches are quite different from those of electrophotography. Low contrast (density) ink is applied at increased spatial frequency in highlight image areas, or ink drop dot on dot is used for density modulation.

The cause for this difference between these two marking systems is the minimum size of inking particles or drops. In electrophotography, the visual noise caused by mass variations of inking material (toner) for 1 pixel is greater than that of the noise caused by screen frequency. In the ink jet case, the screen noise is larger than that of the variation in ink drop volume. In both cases, the screen algorithms and marking processes must be jointly optimized for improvement of print quality.

Various Substrates and Quality

The methods of making visible images on a substrate can be classified into two types: one is the transfer type (xerography and ink jet are typical) and another is the in-situ type (photo print etc.). The transfer type can be further divided into two types. One type requires a special substrate to receive the image (e.g., dye sublimation). Until recently, the print quality of the transfer type has been of a relatively low level but its cost is low. In-situ or special substrate types can provide higher print quality.

Now, however, improvements in the transfer type process have enabled production of high quality images. Although improved transfer prints are still not equal to real photographic print quality, a majority of customers consider them to be "photo-like". This impression is enabled by substrate properties such as surface gloss (roughness), thickness, weight and other senses of touch. The transfer type marking technology also enables the use of various printing substrates in one hard print device.

This is an important point for a marking technology, because users must pay total print costs (print device hardware/software, and consumables including paper). Generally, print quality depends on paper surface quality and is proportional to paper cost.

In an age of Internet printing or "distribute and print", marking technologies must meet various user requirements, and accommodate the various content of networked image data. As in the case of ink jet, thermal transfer products also strive to merge quality and cost as mentioned above. In the future, the image quality impact of interactions between marking materials and substrates will be increasingly important.

Standardize and Customize

WYSIWYG (what you see is what you get) is an important subject in the document creation and printing environment. "You" and "you" meant the same person in the early DTP stage, but now, "you" and "you" can be different persons at a long distance using many kinds of displays and printers. In digital copiers and printers, image data are expressed as two basic values: sampling pitch (resolution) and quantization level (dynamic range). The system value of color reproduction (e.g., L*a*b*) will be standardized for communication. The function of any mark-ing device is to print image data on substrates with a high fidelity and high stability for an adequate cost. Therefore, image data should be pre-treated or tuned in order to opti-mize the performance of the marking process, based on the properties of the imaging substrate and the marking process.

The A-Color 3D-ACCT image processing technology mentioned earlier, has a direct look-up table for color map-ping on a chip. This has enhanced the reproduction ability and has gained a higher precision of color repro-duction (one third of the color difference of its predecessor). Also, it has enabled the simulation of printing (press) output color or CRT display color for WYSIWYG (in the printer mode). However, it still needs a stability controller like C-Tracs (Customer Tone Reproduction Auto Calibra-tion System—a printed test pattern is read with the input scanner , and used to calibrate process settings) to guarantee quality.

Ideally, marking processes must be inherently robust. In practice, however, recent improvements in image quality have been greatly enabled by process controls and image processing as described above. In the future, continued breakthroughs will likely come from an improved under-standing of the process of digital imaging.

Future in Electrophotography

In prehistoric times, Mammoths could not adapt to new and drastic changes in their environment, and many new animals took their place. While future marking technologies must also have many variations, electrophotography is still a candidate with a strong potential since it is a "light" process based on light and small sized inking materials, and is applicable to a wide range of marking substrates. Many image quality barriers still remain, but electrophotography will retain its major position.