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DIGITAL ELECTROPHOTOGRAPHY WITH IMPROVED PRINTED COLOR QUALITY

ROSSITZA SARDJEVA & TODOR MOLLOV

Technical University Sofia, Branch Plovdiv Graphic Arts Printing Speciality, Sofia, Bulgaria

ABSTRACT

Electro-photography is one of so called non-impact printing technologies, named as digital printing. It is master-less technology where there is not intermediate carrier of information. The great advantage of digital printing is possibilities to change printing information after cycle by cycle of process and to print variable data of information. The specific feature here is dry powder colorants - toners, which can be differentiated by dispersion size.

In this paper we take a close look at the color capabilities of a current high-speed electro-photographic digital press Nexpress2100 Plus, manufactured by Kodak. As a result we found a large color gamut for three different types of paper, reproducing pleasing color images in frequency modulated screening with process colors CMYK dry toners. Printed tests by digital printing platform are included. Thus we are able to assess the printed results visually to form our analyses regarding image quality of dry toner digital EP printing technology. Upon visual and quantitative analyses the paper concludes that digital Kodak Nexpress2100 Plus has shown the potential of approaching offset commercial printing.

KEYWORDS: Color, Digital, Electro-Photography, Gamut, Image, Quality

INTRODUCTION

Electro-photographic printing method (EP) is a type of digital printing, one of computer-to-print technologies. EP presses on the base of dry toners, use variable image carrier, photoreceptor, coated with photoconductive layer which is imaged by a digitally controlled imaging unit with laser impulses. The latent charged image, stored on the photoreceptor, is inked with dry toner particles and then transfers directly or via intermediate belt to the paper. Inking takes place by inking units that transfer the fine toner particles in a noncontact manner to the photoconductive drum through electric potential differences (electric fields) and thus image becomes visible. For this reason the inking system is also referred to as developing unit.

During printing process there is a contact between the toned information carrier and the paper, but without impact, so this type of printing is considered to as non-impact printing (NIP).[1] Requirement here is that toner to be anchored on the paper in order to become stable print image, through melting by heat and pressure (fusing and fixing). In this way toner is fixing on the substrate.

In EP it is of fundamental importance that the toner images are absolutely dried after the print process. So finishing processes (folding, collating, stitch) can be done in-line.

In many cases, commercial printers have embraced electro-photography dry or liquid toner as a way to address the time and costs associated with shorter runs as well as new variable data requirements.

In EP dry toners digital printing Kodak Nexpress2100 Plus is a leader in the market. Its performance matches original specifications. A number of products that can be used on the fifth printing unit of the Nexpress Digital Press, such as dimensional printing, coatings, MICR printing, light black HD dry ink, and better custom color match are all possible.

The modularity of the Nexpress2100 Plus press enables flexibility and wide range of application. Create additional revenue streams and attract new customers by configuring the press with a Kodak Nexpress2100 Plus fifth imaging unit, which not only delivers spot color, watermarking and protective coating but also enables high-impact glossing.

In digital printing such as electro-photography (EP) optical densities (gray levels) of tonal element can be achieved by combination of film thickness and element size. In this way can be received reproduction with larger tonal interval and in four color printing larger color gamut.. Halftone gradation of images in EP depends on the type of toners (dry or liquid) and quantity, penetration, smoothness of the printed substrates and also thermal fusing process and press configuration. The print quality is also affected by the particle size of toner, its geometric form and chemical/physical structure.[1] Nowadays are known already very narrow particle-sized toners, with stable electronic process, with constant re-imaging and thus can produce print by print very high quality, free of quality fluctuations, with good image reproducibility. [2]

In addition, due to such digital printing technologies like Computer-to-Print, it became theoretically possible to apply stochastic screening (FM) for half-toning of images for many printing products targeted in different market segments. Generally, in order to print a continuous tone (halftone), it must first be transformed into a so called bitmaps. The transformation from continuous tone into a bitmap image is referred to as half-toning named screening process.

In the different approaches for screening are two main methods: Amplitude Modulated (AM) and Frequency Modulated (FM). In AM the distance between the halftone dots is constant (periodical screening), and the different tonal values are reproduced by varying the size (amplitude) of the halftone dots. In FM the dot size is constant and the number of dots varies on the different distance (frequency), irregularly spaced, depending of original. With this technology, small dots are distributed on a surface in such a way that the required gray value appears as an average value, whereas distribution is completely random compared to the normal halftone dots. For this reason, frequency-modulated screening is also referred to as stochastic screening.

A larger color gamut can be reproduced in the print through the combination of density modulation with frequency-modulated screening. Hence, the combination of FM modulation with density modulation aims to optimize the reproduction of detail and color. [1]

In FM color half-toning there is no need for rotated screens and the rosette and moiré patterns are generally avoided, since the screen patterns are no longer regular and periodic. An advantage of FM screening is that color register variations – especially in homogeneous color areas with multicolor structures – prevent color variations or make them less obvious.[1]

However, FM color halftones can sometimes give a somewhat “grainy” appearance and cluster-effect (in the darkness). In the same time the printers are not always willing to apply such screening methods in their practice because of the small spot size of the laser beam makes higher requirements and higher attention on the whole processes including printing.

Depending on the technical point of view and having in mind the advantages of FM screening it can be successfully applied in digital printing technology as electro-photography for example, where there are substantial prerequisites for this, as improved digital workflow algorithms and high qualitative powder toners. To have good results in digital printing with FM screening require a special attention of applying ICC profiles and standardization with the Color Management System, including to the printing press. [3] Widely used tools for standardized printing are color profiles according to the ICC standard based on FOGRA characterization data and the ISO 12 647 -2.[4] [5] The European Color

Initiative (ECI) recommends color profile for every paper. In our case it is ICC profile for coated paper in three different grades. The paper category establishes the target for an optimal screening resolution.[3]

PROBLEM DEFINITION

The purpose of the presented study is to show the improved printing quality using digital electro-photographic Kodak Nexpress2100 Plus printing system (Table 1), by applying stochastic (frequency modulated) screening for half-toning in prepress process.

The study is processed by second generation FM screen like Kodak Staccato DX Screen. For optimum of FM performance is used Kodak square spot Imaging technology devices, where depending upon its capabilities and screening algorithm, we have used 20 μm stochastic screening dots.[6] In principal the relation between the factors of screen ruling (screen frequency), addressability (resolution), and gray values, determine printing quality as well as in the case of digital imaging.

With the application of all screen attributes we have carried out two printing tests – one test file is the *IT8.7/3 Random characterization target for device profiling* and for quantitative analysis [Figure 1], with suitable control elements and then produced real printing for full colored commercial magazines. The other test file is for visual analysis (Figure 2). Key elements of the methodology consist calibrating the Kodak Nexpress2100 Plus designing test forms containing CMYK images and color-managed pictorial images, printing tests forms, using different type of papers and performing quantitative and visual analyses.

The structure of publishing system is compatible to requirements of working area, where operators in prepress can work individually or in a team. The way of job organization is reflected in fully digitalized workflow, as follow: the ready-made files, written in PostScript software, page after page, are received in prepress via Kodak In-Site Internet connection. Then processing is realized by using Kodak Prinergy management system which is accepted as a modern PDF based dynamic multi-stage workflow that receive data to be edited, convert into another format, and complete the various workflow steps automatically. Workflow of this type start with the transfer of single digital pages and control them as far as outputting. Also here is used a Kodak Darwin special software for personalization of print products, which is one of the main advantages in digital printing like EP. [7]

Here there are many advantages: guaranteed file quality, without of any size restrictions. Due to this is possible to eliminate the whole risk of eventual losses of information and damages of physical carrier. Further, the ability for definition of such conditions like way of editing, additional information and easiest online form, control of online files approving, all these procedures are advantages of workflow model. RIP-ing, imposing, proofing, and imaging can be taken place in various locations at the same time.

PROBLEM SOLUTION

There are two aspects of color evaluation: colorimetric assessment of characterization data sets and visual comparison of pictorial color images. The main importance is that the conclusions from one analysis support the other.

Tests were printed by electro-photographic dry toner press using 20 μm dots stochastic screening. The same files were output by three types of papers using the same printing platform. For achieving of trusty colors it must assure correct color management. The right way for this purpose is making the color profiles according to ICC, valid to the whole process – from prepress to press. For the current condition it is done by creation the ICC profile for our system, combination of machine – substrate - inks.

Table1: The Features of Kodak NexPress 2100 Plus

Features	Possibilities	Extra Possibilities
Feeder	Sheet fed printer	Expanded feeder
Modular option	5 printing sections, CMYK+L, with Clear Dry Ink coating or RGB; Clear Dry Ink system apply a clear layer of dry ink which diffuses light to improve quality.	Clear Dry Ink coating provides superior smoothness to the prints by decreasing any screen noise which may be visible
Print rate:	single sided 4/0 or 5/0 – 2100 A3 sheets/h; double sided printed speed, 4/4 or 5/5, is half of single sided	or 4200 A4 sheets/h
Type of papers	Coated, grade 80-350 g/m2, matte coated, glossy coated, cast coated and textured, wood free, recycled paper, including a wide selection of standard offset papers	uncoated, 60-350 g/m2,special substrates: uncoated, matte coated and glossy coated labels, paper-back transparencies and select opaque foils
Size of paper	max: 356 x 520 mm	min: 279 x 200mm
Imaging technology	ROS system , 600 dpi Dry toner EP, non-toxic and easily recycled	multi-bit (up to 8-bit with 256 levels of exposure through the compl. data path)
Screen	Classic HD, Classic, Line, Optimum, Supra	Kodak Staccato DX
Air	t° ~23 ^{0} C	air humidity- 55%

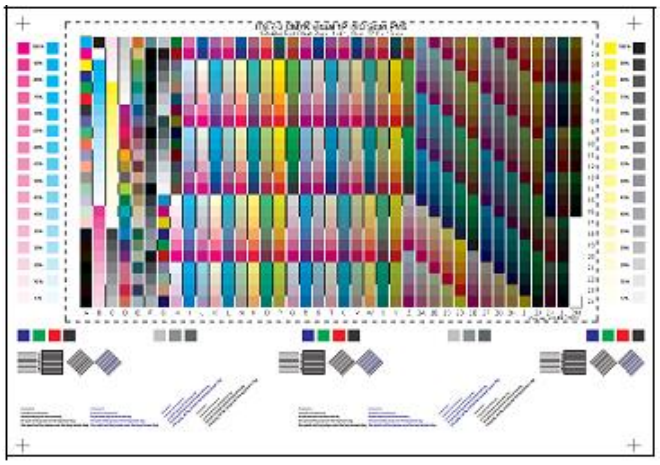


Figure 1: IT8.7/3 Visual Test-Form for Measuring

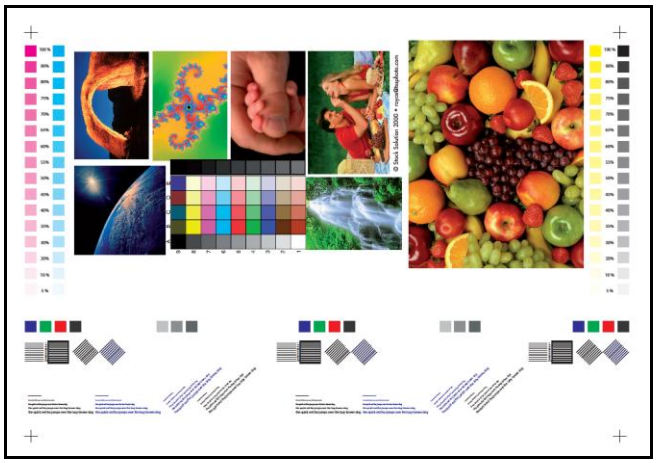


Figure 2: Test-Form for Visual Analyses

This profile is detailed combination of colorimetric description of color reproduction abilities of the printing system. In this paper are presented the results of color gamut obtained by EP digital system Kodak Nexpress2100 Plus, using three type of papers: coated glossy paper, grade 90, 130, 250 g/m^2 (gsm). For this purpose have been used two test forms (Figure 1, Figure 2)

The characterization data set from IT8.7/3 target was used to assess overall color deviation (ΔE) between two data sets by measuring (ili0) patches of single, double and triple inks films for gray balance; gradation patches for all process colors and etc. Also, it was used to evaluate color gamut volume difference and hue and chroma differences as well, using X-Rite measuring tool.

A Kodak Nexpress2100 Plus press ICC profiles were built using X-Rite Profile Maker 5 from average data set at 240 TAC, comparing the Kodak Nexpress2100 Plus press ICC profiles for three type of papers. A 2D comparison of the color gamut (Figure 2) provide info regarding hue and chroma differences between the color spaces of three type paper, printed on Nexpress2100 Plus EP press. After measuring with obtained results we generate ICC profiles for three types of papers using software i1Profiler and Profile Maker 5.0.5b in standardized conditions (D50). Then these ICC profiles have been visualized by Profile Editor 5.0.5b and compared.

RESULTS

On the Figure 3 we see different profile regarding different substrates: white - ICC profile for cardboard 250 gsm; green - for coated paper 130 gsm; yellow- for coated paper 90 gsm. The same can be observed on the 3D color gamut body of different papers (Figure 4).

We see that the color gamut of the cardboard is larger compared to other papers. The two paper grades of 90 and 130 gsm have very similar color gamut. This range can be explained by the difference between grade composition of papers and cardboard.

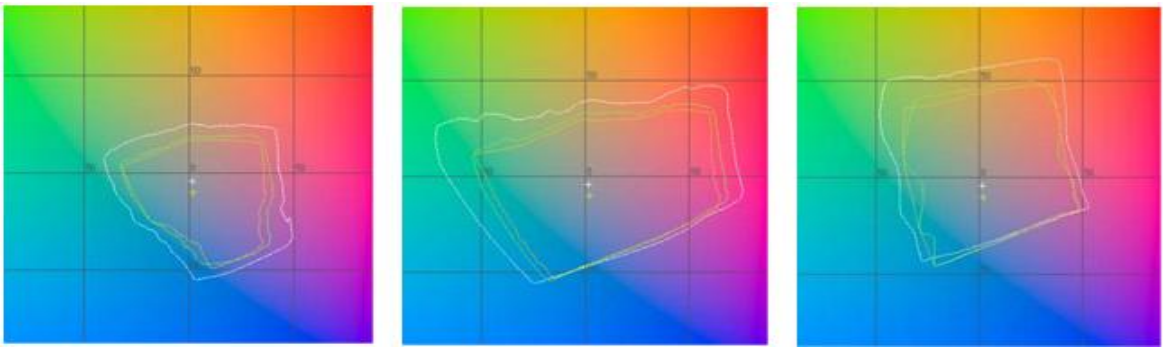
On the whole the higher color gamut is obtained in the middle tones where the lightness values are L=46 - 61%. Here the cardboard gamut is larger, only in the blue-violet area it becomes very closed to papers color gamut. On the interval values of L 46% to 61% the whole examined printouts have largest areas and then color gamut become accordingly smaller and smaller (L-89%).

On the whole in blue-violet field two papers have almost the same color gamut which is too close to those of cardboard. The majority of the reproducible colors are in the higher positive and part of negative values of the CIEa*b*. The major hue difference among CMYK toners is in the red, yellow field.

There are additional differences in green, blue regions of the space. There are CMY near neutral patches in the characterization (IT8.7/3) target. Upon printing, if the patch has similar colorimetric values on the samples of different papers, the gray balance is preserved. When the neutrals are aligned, hue shift is minimized.

While there may be differences in color gamut between three grade papers printouts, color images printed on Nexpress2100 Plus EP press can still have the same visual appearance. For instance, if image highlight, gray balance and the image shadow are similar to each other, then perceived color differences, reproduced by the three papers, are likely to be small.

On the other hand have been compared perceived color differences among the test pages printed by different types of papers. We can conclude that color patterns in the whole of the images do not show substantial visual differences.



(a) (b) (c)

Figure 3: 2D Gamut Comparison in Different Papers on Three Cross Sections of Lightness: a) L=31%; b) L= 46%; c) L= 61%

Printouts on the cardboard, grade 250 gsm is a little bit difficult to match due to paper substrate. Under standard viewing conditions, a larger visual difference is seen between the fruits. (Figure 2) Using this EP press with fine types of process CMYK toners we see greener grapes and darker neutrals in the paper page.

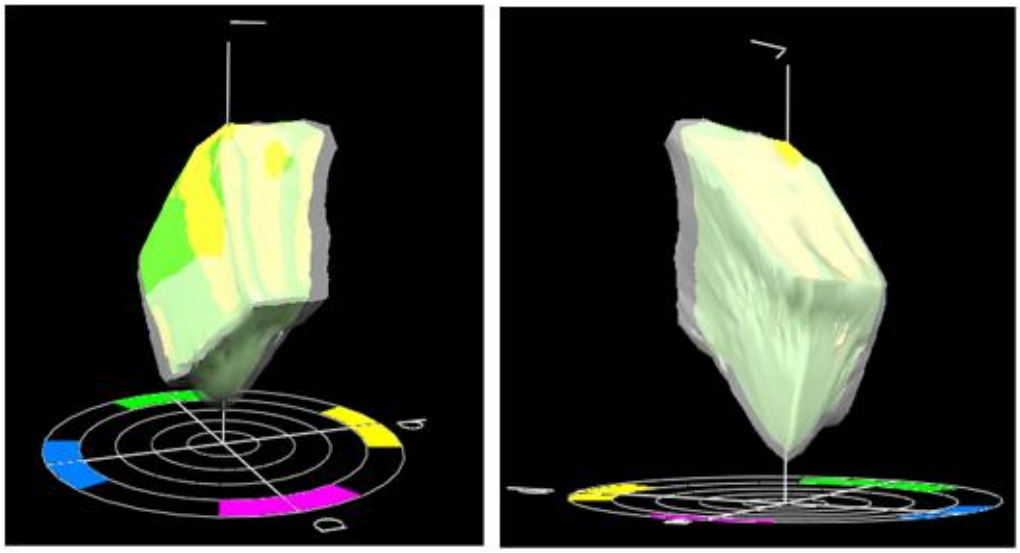


Figure 4: 3D Color Gamut of Different Papers

CONCLUSIONS

This papers was to find out how the Kodak Nexpress 2100 Plus is calibrated and to evaluate its color gamut in relation to an offset standard. Upon experimentation and results it was found that the Kodak Nexpress2100 Plus produces very high print quality of a standard offset printing condition. In addition, the Kodak Nexpress2100 Plus press can match a standard offset printing closely by using a device link ICC profile.

The larger color gamut has cardboard grade 250 gsm. This means that on this substrate can be reproduced more saturated colors compared to the other papers. Papers grade 90 and 130 gsm have almost same color gamut which is accepted as an advantage since it can be substitute each other if in case.

All this is the result of the larger device color gamut associated with the Kodak Nexpress2100 Plus digital color press that led the way in innovation for productive digital color printing.

This paper is a trial to show how to improve printing quality in digital dry toner electro-photographic commercial printing. When printers are entering digital, an electro-photographic dry toner Kodak Nexpress2100 Plus may become the better digital production color solution.

The fully modular NexPress2100 Plus can be configured to the printing requirements. The press allows to apply wide range of substrate types, sizes, weights and thicknesses, printing on coated or uncoated paper - select from a light substrates for statements, invoices and technical documentation, select from an equally wide range of heavy substrates for direct mail applications, point of purchase signage and packaging, print posters and book covers on the largest sheet sizes.

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AUTHOR'S DETAILS

Dr. Rossitza Sardjeva is working for Technical University Sofia, br. Plovdiv, as an Associated Professor of Graphic Arts Printing Specialty, where she teaches students for bachelor and master educational degrees.

Also she is a lecturer for many years in Book Publishing Department of Journalism Faculty in Sofia "St. Kl. Ohridski" University. Her scientific interests are in the field of printing technologies and printing materials as well, where she has a long experience.

Todor Mollov is one of the successful graduated of "master" degree student and his diploma was managed by Dr. Sardjeva.