



Screening Technologies in Digital Printing

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ABSTRACT

Digital dry toner electrophotography (EP) is the best technology for applying different screening methods - traditional amplitude modulated (AM) screening and non-periodic frequency modulated (FM) screening.

Today the advent of digital printing has paved the way for short run print jobs and personalized prints. One of the best example of digital printing is EP where is possible to print with dry toner colorants changing information from cycle to cycle. All these features allow printing so called variable data of information (VDP), producing personalized products or printing on demand (PoD).

Key words: amplitude, digital printing, electrophotography, frequency modulated, screening

1. INTRODUCTION

Digital printing also is referred to as dynamical type of printing on the contrary to static conventional printing with permanent carrier of information named printing plate. In digital printing the output device is a printer - powerful professional press, which must create image for every page, print by print, without necessity of printing plate, e. g. this is a master-less technology.

Electrophotographic printing systems (EP) is a type of digital printing, one of so called computer-to-print technologies. EP printers on the base of dry toners use variable image carrier, photoreceptor, coated with photoconductive layer which is imaged by a digitally controlled imaging unit, by 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 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). Requirement is 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 Electrophotographic dry toner digital

printing 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. Development of digital printing has paved the way for short run print jobs and personalized prints, it allows to print so called variable data of information (VDP), or prints on demand (PoD). Nowadays the print quality generated by electrophotographic system is definitely at high level, including substantial improvement of color prints becoming comparable to conventional sheet-fed offset printing and even better than that of web offset.

All this statement is proven by the results of the tests we have carried out using industrial EP digital system Kodak NexPress2100 Plus. (Table 1) The quality is affected by toner's particle size, geometric form and chemical and physical structure. Now already are known very narrow particle-sized toners and with stable electronic process with constant re-imaging and thus can produce very high print quality, print by print, free of fluctuations, with good image reproducibility. [1]

Kodak NexPress2100 Plus is a 5-coloured single-pass system, comprises of successive five imaging and printing units for each process colors. To print a multicolor image, the printing sheet passes through five printing units to receive toner and this happens in one pass. The imaging speed corresponds to the printing speed.

2. PROBLEM DEFINITION

In the current digital printing technologies (CtPrint) there are virtually no limits to the practical application of variable screening methods.

Generally the change to the tone value can be done three-dimensionally: through the area of the dots (amplitude), through the space of the equal dots (frequency) and through the thickness of the ink film like in conventional gravure printing and in non-impact printing technologies such as electrophotography or inkjet. [2] With EP printing technologies in which the ink can be transferred to the paper in varying amounts from dot to dot, a tone value is created by modulation of the ink film thickness and optical density modulation is achieved. Also halftone gradation of images in EP depends on the type of toners, their quantity, penetration, smoothness of the printed substrates and thermal fusing process as well.

On the other hand in digital EP systems the print quality depends on addressability data of the imaging system (dpi, number of pixels per inch), number of gray values, given per

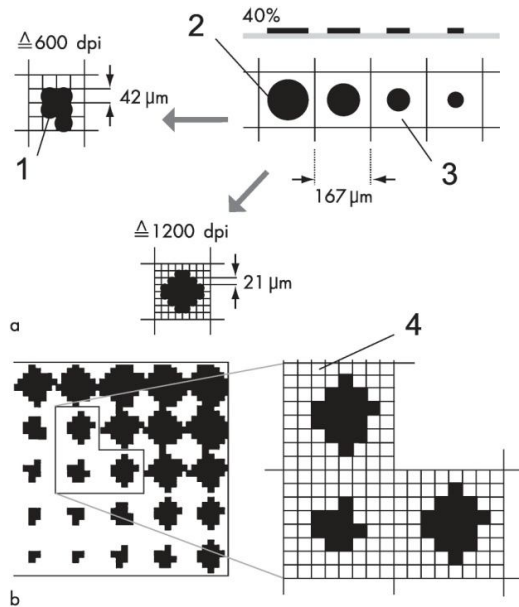


Figure 1: Reproduction of tonal gradation with AM and FM screening: a.) analog AM dots (2, 3) b.) AM dots structure assembled by pixels with different resolution (1, 4)

pixel and the toner technology used. [1] The possible reproduction of very fine structures is determined by the addressability (resolution) and the reproduction of tonal values and gamut as gray values per pixel. The higher the addressability the more accurate the reproduction of the dots shapes. (Fig.1)

Print quality depends also on the quality of the shape of the individual image elements (pixels) and on the screening method. Frequency modulated screening (FM) and its importance for graphic arts increased definitely in last ten years, when has been totally involved computer-to-plate and computer-to-print technologies and respectively digital workflow in prepress. Appearance of second generation of FM screens such as *Staccato Satin FM screen*, definitely improved print quality of this type of screening. With FM technology the smallest reproducible pixel can generate the dot for FM. The tone values are simulated by varying the dots distance in the spacing of the pixels cell size. Individual dots are combined into clusters according with very complex algorithm for FM screening. Small equal 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. While in AM screening is applied supercell process which tries to match the specified screen angles in order to minimize additional pattern (moiré), in FM screening has no screen angles. Here appearance of disturbing moiré and rosette pattern coming from traditional periodical screening is almost impossible, which is the great advantage of FM screening. Only in some cases there is a minimal risk for additional pattern because of the periodic pixel cell structure.[2]

With traditional amplitude modulated screening (AM) the individual dots are spaced at equal distances from one

another and only the dot size changes (amplitude). (Fig.1) In FM screening dots have the same size, but are irregularly spaced, referred to as stochastic screening. What is more in FM screening color separations make multicolored images less susceptible to very seldom problem caused by register deviations.[3]

So FM screening is hardly suitable for high quality, full colored illustrative printing products. However the widespread of FM screen requires further developments in prepress technologies and a different way of thinking about the whole digital workflow, from prepress to press processes.

3. PROBLEM SOLUTION

This article is a trial to show the improved printing quality in digital dry toner electrophotographic commercial printing field with digital Kodak NexPress2100 Plus system.

Table1: Main characteristics of Kodak NexPress2100 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 A ₃ sheets/h; double sided printed speed, 4/4 or 5/5, is half of single sided	or 4200 A ₄ sheets/h
Type of papers	Coated, grade 80-350 g/m ² , matte coated, glossy coated, cast coated and textured, wood free, recycled paper, including a wide selection of standard offset papers	uncoated, 60-350 g/m ² , 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%

The study is processed by help of FM Kodak Staccato DX Screen and AM with screen ruling of 300 lpi.

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.

This type of workflow starts with the transfer of single digital pages and controlling them as far as outputting. It is accepted as a modern PDF-based, dynamic multi-stage workflow with numerous advantages. This means that the ready-made files, are received in prepress via Kodak In Site Storefront Web-to-Print connection, avoiding the risk of eventual losses of data of physical carriers like CD, DVD, flash etc. Also is used a Kodak Darwin special software for personalization of print products, which is one of the main advantages of digital printing like EP. [4]

In the same time such procedures as input, editing, control of online files, PDF, virtual color proof can be done automatically. Then follow the various steps like imposing, trapping, RIP-ing and print outputs, all these doing in various locations at the same time. The structure of electronic system is compatible to requirements of working area, where operator in prepress can work individually or in a team.

The real printing job has been implemented on Kodak NexPress2100 Plus, digital production color press, using dry ink technology, allowing jobs flexibility up to finishing processes. The main features of digital print system are shown in Table 1.

The consideration that the main parameters, defined the printed quality are Solid Inks Densities (SID or D_v) and Tonal Value Increase (TVI) are absolutely valid here. So we have measured these values and received data are accepted as criteria to make comparison related to half-toning quality obtained by help of AM and FM screening technologies with described above conditions.

The measurements of the main parameters have been done according to ISO 12 647-2:2004, using by Deep Eye (X-rite) spectrophotometer and special control strip. [5] Measured values of TVI are compared in two cases: for Staccato DX FM screening and for traditional AM screening with screen ruling of 300 lpi.

Further, in an aim of this research has been used wood free coated glossy paper (WFC), for digital printing, grade 130 gsm.

4. EXPERIMENTAL RESULTS AND DISCUSSION

The reproduction color results achievable on the examined conditions are shown in Table 2 and Fig. 2, 3, 4. The results show that when printing on coated wood free paper, the reproducing ability of Kodak NexPress2100 Plus is enough high, without large deviation regarding screening technology.

In the way of this study have been received fully predicted printing results within the whole technological chain. To make comparison of the results in traditional AM screening of 300 lpi and in the FM screening with

Table 2: Tonal values increase (TVI) in AM and FM screening

	TVI - AM				TVI – FM Kodak Staccato DX			
	Cyan	Magenta	Yellow	Black	Cyan	Magenta	Yellow	Black
D _v	1,56	1,59	1,44	1,52	1,47	1,56	1,46	1,55
%	%	%	%	%	%	%	%	%
2	0	0	0	0	0	1	2	0
5	3	2	0	2	4	7	7	4
10	7	7	5	8	6	10	12	6
15	12	11	8	12	9	11	14	8
20	15	14	12	16	15	13	15	11
30	19	18	19	21	20	17	19	18
40	21	20	23	23	21	21	21	21
50	24	22	24	23	22	22	22	24
60	23	22	23	22	20	22	19	22
70	18	18	20	18	18	20	18	16
80	15	14	14	15	13	14	13	13
90	8	7	8	8	7	8	6	6

Kodak Staccato DX, where the small dot size of around 20 μm is applied, can be conclude: the continuous tones and respectively TVI are too closed for all process colors (Cyan, Magenta, Yellow), without a large deviation. It can be explained by rather high screen ruling in AM (300 lpi) which is almost compatible with the minute dots in FM screen. FM half-toning methods generally do not use halftone dots (different amplitude), screen ruling in lpi (line per inch) is not used here and therefore only the print resolution (in dpi) is relevant.

For black half-tones can be said that with AM screen are obtained a higher values in the whole tone range except

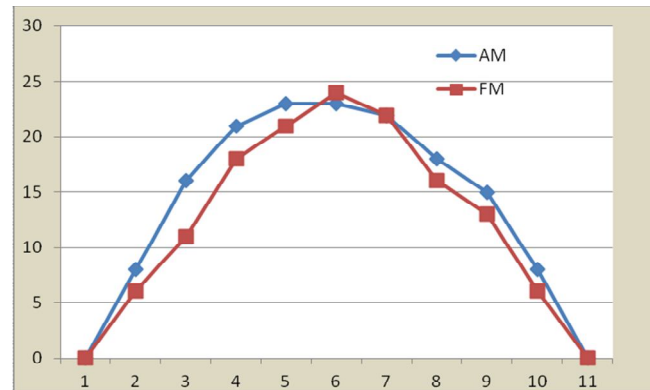


Figure 2: TVI for Black in different screening on Kodak NexPres2100 Plus

middle tones (50%), where a very small (1%) tonal value increase of FM is available.

The results of TVI in the highlights up to 30% with AM, is visible higher. (Fig.2)

For different process colors the results are more or less fluctuated. (Fig. 3, 4) Middle tone values for cyan and yellow with AM screen are definitely higher compared to the same with FM screen, while for the very highlights in magenta and particularly in yellow, TVI for FM screen are above those of AM screen.

The same can be said and for the darkness in magenta (80%), but middle tone values in magenta are almost equal with two screening technology. For the rest of tone range some deviations are occurred.

About results of solid densities we see higher value for black and yellow fields for the case of FM and for cyan and magenta in AM, densities are definitely higher.

In order to print solid areas, the diameter of an individual image dot must be greater than the width of the pixel cell. The smallest pixel screen ruling corresponds to the distance between the pixels (pitch). [2]

Evidently the whole results are due to the toner quality and electrophotographic way of printing. (Table2) The advantage of the examined Kodak NexPress2100 Plus digital printing over the quality reproduction ability can be attributed to the large color strength of CMY dry toners and the stable toner transfer, fusing and fixing to the paper that provides permanently high saturation of solid fields including excellent darkness for black.

The finding is that the quality and print reproducing of the all prints made on the coated wood free paper is compatible between each other and too closed to those specified in the sheet-fed offset printing.

FM screening also referred to as non-periodic, where all screened dots have the same size, but the distance between them varies corresponding to the color values in the data, can be successfully applied in digital EP printing with dry toner process.

Perfect quality level obtained in Kodak NexPress2100 Plus digital printing also is due to the integrated proven imaging

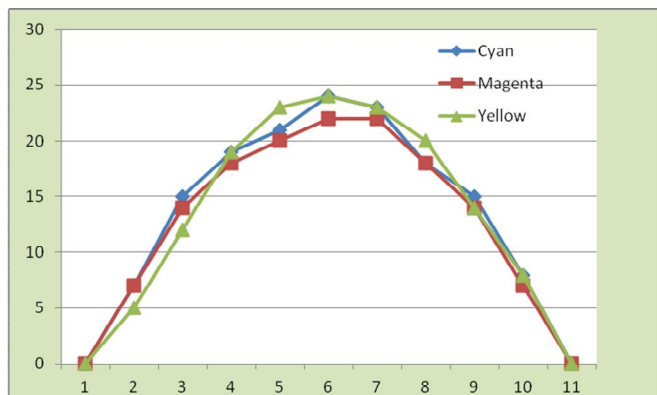


Figure 3: TVI on the NexPress2100 Plus prints with AM screening for CMY

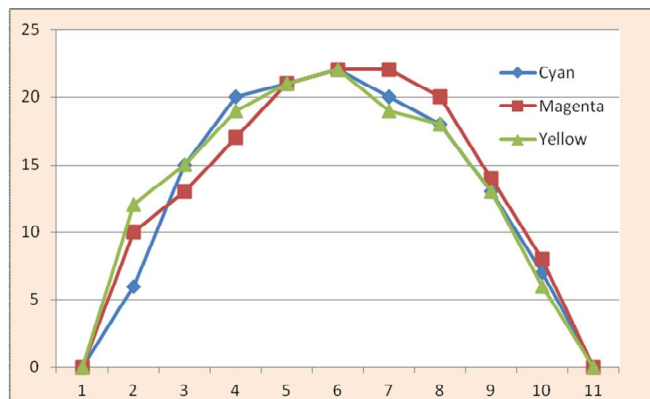


Figure 4: TVI on the NexPress2100 Plus prints with Kodak Staccato DX for CMY

system, guaranteed 256 levels (2^8) of exposure through the complete data path. In digital EP systems the print quality depends on addressability data (resolution in dpi), gray levels per pixel and of course on the toner technology used.

This means that halftone gradation of images in EP depends on the type of toners and their quantity, particle size, penetration, smoothness of the printed substrates and also on thermal fusing process.

Analysing these results (Kodak Nexpress digital EP) can be concluded, there are significant differences compared to the same parameters in conventional offset sheet fed printing.[3] To have good results in sheet fed offset with Staccato screening require a special attention of applying ICC profiles and standardization with the Color Management System, including to the printing press and ability to apply compensation curves for plate making to assure predicted quality. [6]

Printed results are without compromising of density, TVI and printed colors are trustworthy and visual perception was very satisfied. Frequency modulated Kodak STACCATO screening enables high fidelity, consistent presswork that exhibits fine details, without gray level limitations, or abrupt jumps in tone.

5. CONCLUSION

Two screening technologies AM and FM have been compared in described conditions of EP Kodak NexPress2100 Plus printer. To make comparison between AM and FM screening can be said that the very small spot size of the laser beam in FM makes higher demands on the whole printing process.

As for tonal values increase in two different screening technologies for dry toner EP digital environment conditions can conclude, there is not sufficient differences when applied high screen rulings in AM screening and very small dots for FM screening.

Also on the base of the whole results can be said that FM methods is proper as a better way for reproducing fine details, specific structure as human skin, face, different fabrics, while

the AM method is suitable for reproducing slowly varying images tones.

Digital dry toner electrophotography is the best technology for applying different screening methods - traditional amplitude modulated screening and non-periodic frequency modulated screening and Kodak NexPress2100 Plus is a very good solution for this. This way can print short runs in commercial, publication, and even packaging products.

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