

A Study of Colour Reproduction Capability in Digital Dry Toner Electro-photography Compared to Smart Offset

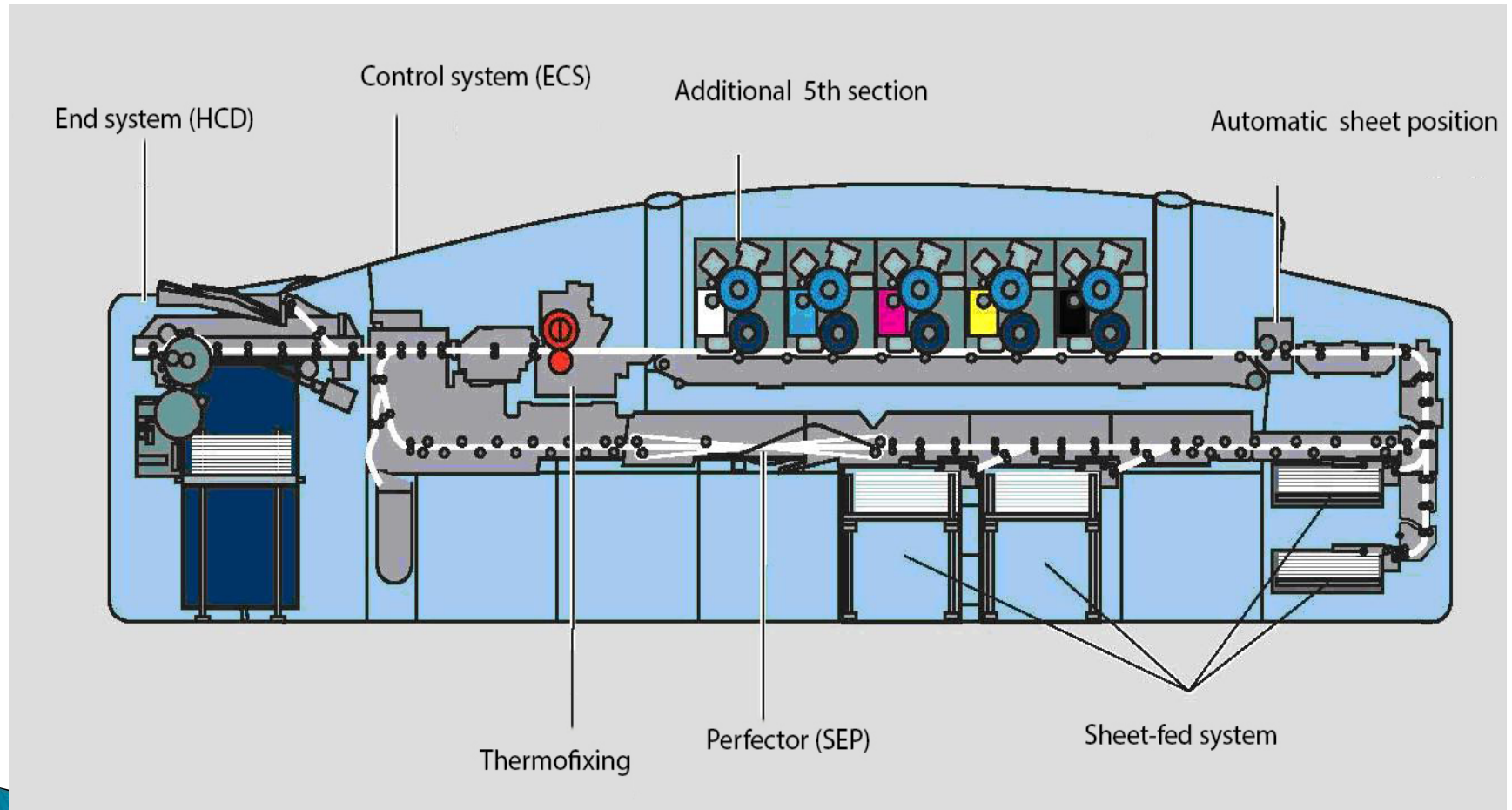
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Purpose

- ▶ In this paper we take a close look at the colour capabilities of a current high-speed electro-photographic digital dry toner Kodak Nexpress2100 plus system.
- ▶ For this we tried to define the colour gamut for three different types of paper, quality of their reproducing colour images with process CMYK dry toners.
- ▶ Also we have assessed consistent colour uniformity of the prints during the run.

Kodak Nexpress 2100 Plus



Kodak Nexpress 2100 plus

- ▶ Kodak NexPress2100 Plus is a single-pass system, comprises of successive five imaging and printing units for each process colour.
- ▶ To print a multicolour image, the printing sheet passes through four (+1 spot) printing units to receive toner and this happens in one pass, simultaneously – single pass.
- ▶ The imaging speed corresponds to the printing speed.
- ▶ The Kodak Nexpress2100 Plus is a highly versatile digital press providing the best all-runs performance. This press is able to provide standard CMYK finish and Clear Dry Ink outputs.

Capacity of the Printing System

- ▶ Speed: 4/0, 5/0 – 2100 A₃ sheets/h or 4200 A₄ sheets/h;
- ▶ Perfector speed in 4/4 or 5/5 is ½ of those in single side printing;
- ▶ Possibility to use variable type of papers, grade 60-350 g/m² (coated, uncoated);
- ▶ Max size of paper sheets - 356 x 520 mm ;
- ▶ Imaging – ROS, 600 dpi, dry toner EP- non toxic and easily recycled, multi-bit (up to 8-bit, 256 gray levels);
- ▶ Screening possibilities: Classic HD, Classic, Line, Optimum, Supra, and FM Kodak Staccato DX;
- ▶ Air: t° ~23 C; humidity – 55%

Kodak Nexpress 2100 plus performance matches original specifications. A number of products that can be used on the fifth printing unit of the 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. 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.

EP Nexpress 2100 plus

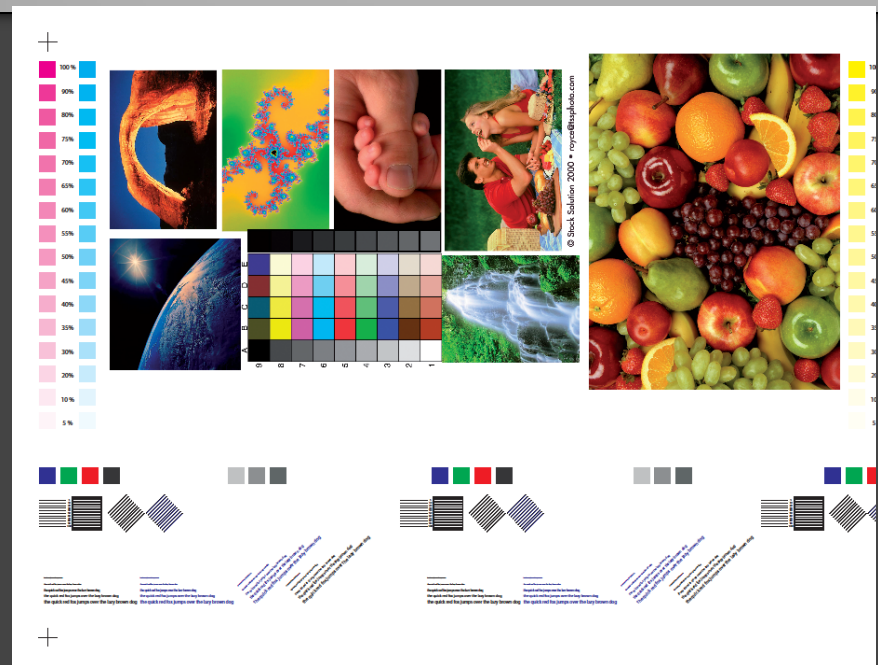
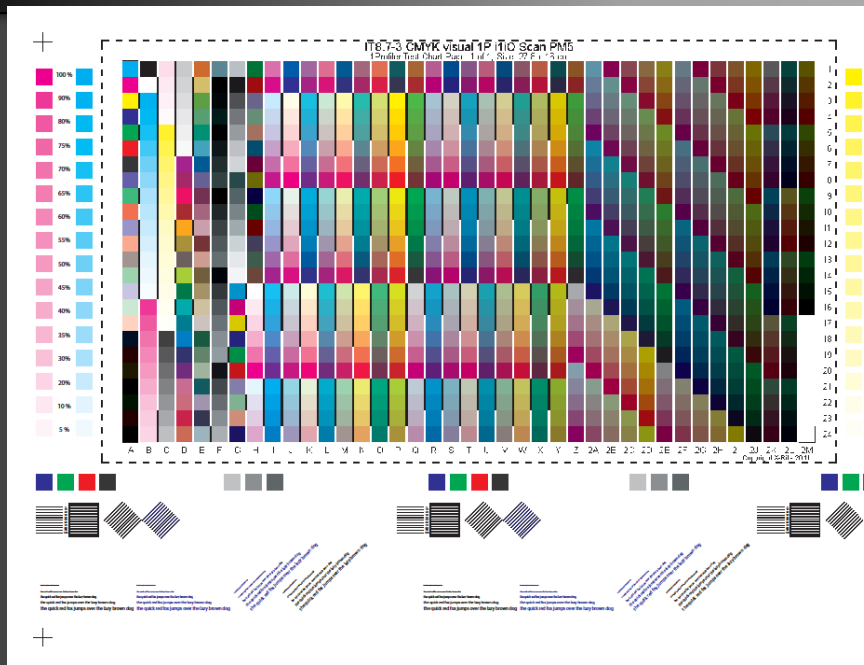
- ▶ Halftone gradation of images in EP depends on the type of toners and quantity, penetration, smoothness of the printed substrates and also thermal fusing process and press configuration.
- ▶ The print quality is also affected by the particle size of toner, its geometric form and chemical/physical structure. 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.

The objective of the paper experimental is to examine image quality of Kodak Nexpress2100 plus

- ▶ In particular, our purpose is to find out how Kodak Nexpress can print pleasing colour images from legacy CMYK files and how this press can match colour closely to a digital smart offset with direct imaging inside the machine.
- ▶ For this purpose have been used test files as a characterization target for device profiling and for quantitative analysis.

Experimental

- ▶ The test files are two - two test forms (Fig.1) with series of test patches to be measured.
- ▶ Two test-forms are printed from the top and bottom of the page, on the high quality paper type - wood free coated (WFC), three different grades: paper 1 – 90 gsm, paper 2 - 130 gsm and paper 3 - 200 gsm.
- ▶ After printing the results of data characterization IT8.7-3 Visual are scanned by spectrophotometer and measured separately for every three kinds of papers.



Test forms, generated for the analysis

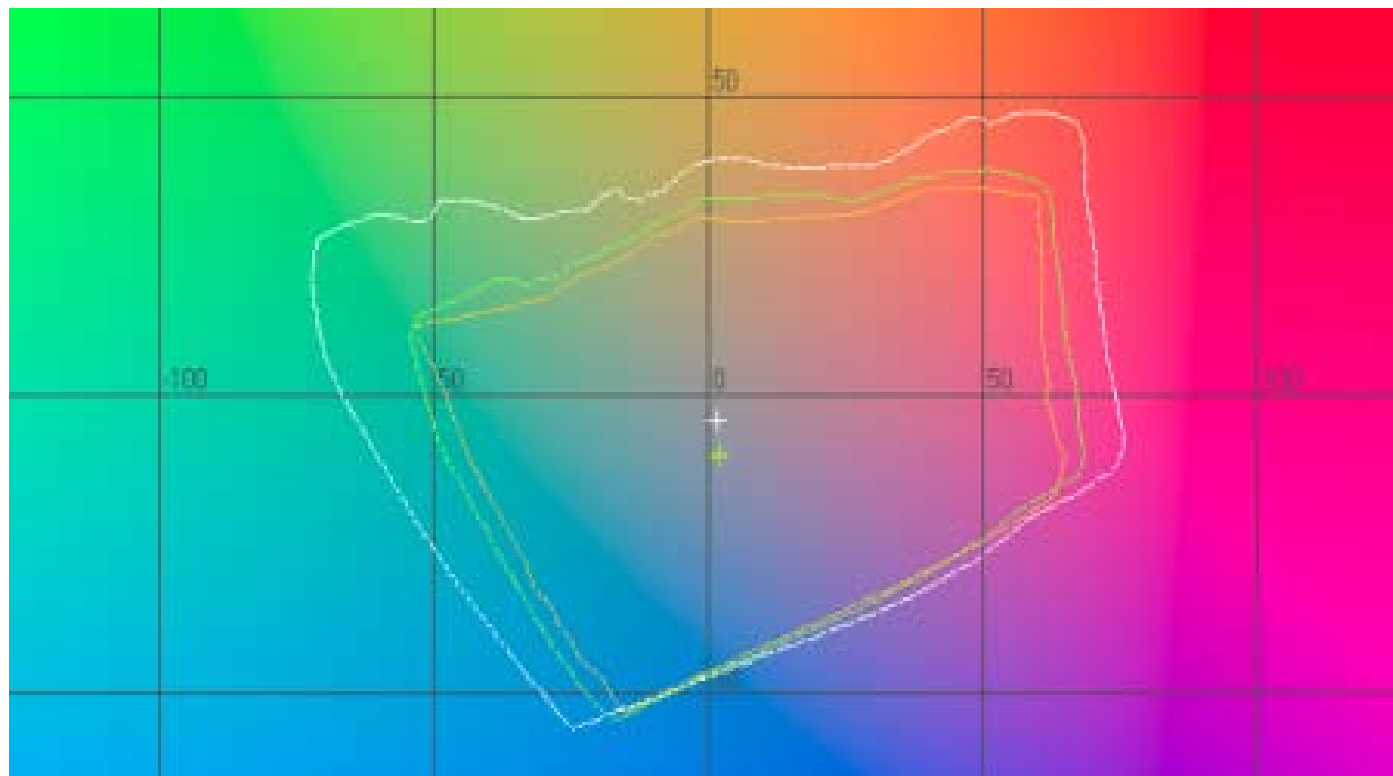


a.) Test Chart IT8.7-3 Visual , b.) Test form-2

RESULTS

Colour gamut for each grades of papers:

yellow line – paper 1, green line – paper 2, and white line – paper 3



Color Gamut

- ▶ On the base of the results can be concluded that paper 3 (200 g/m²) has a largest colour gamut, then paper 2 (130 g/m²) and in the end - paper 1(90 g/m²). It is clearly seen that paper types 3 have the largest colour gamut;
- ▶ Then on the different values of L, the colour gamut become different, keeping the same range – paper 3, paper 2 and paper 1.
- ▶ Only in the blue-violet area paper 1 and paper 2 have the same gamut as paper 3.

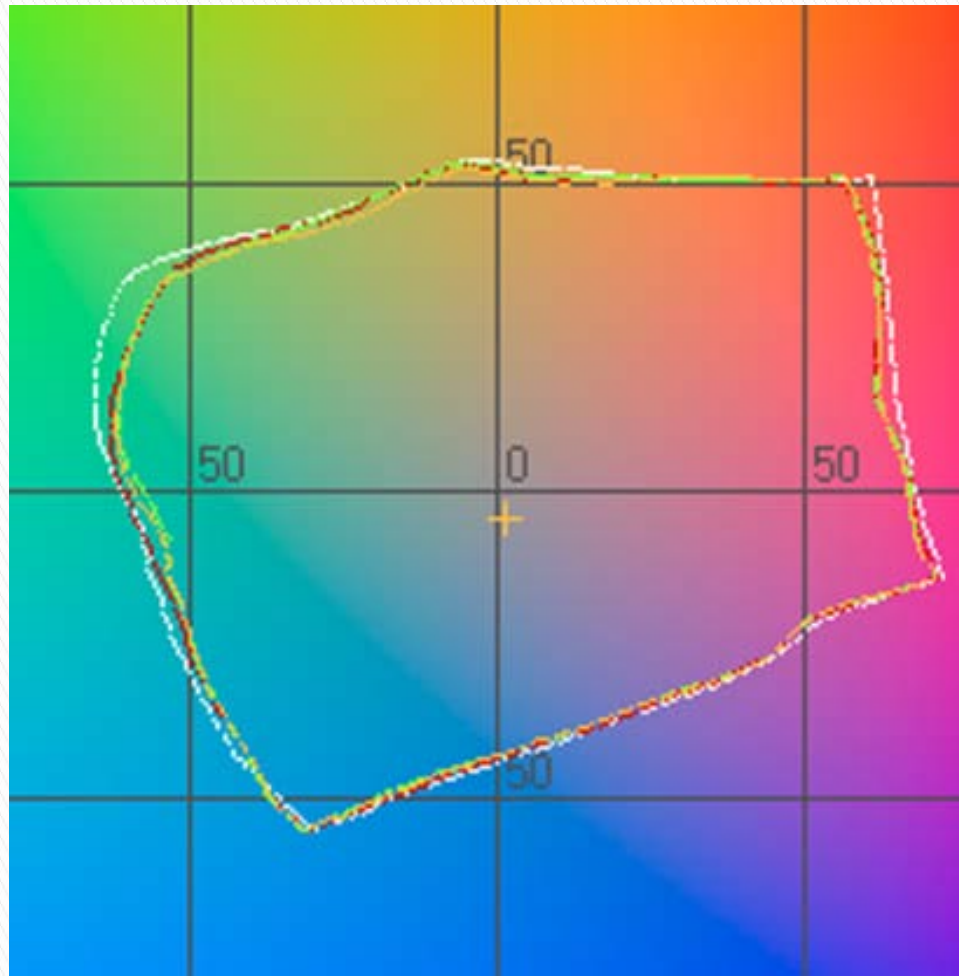
Results

- ▶ The relevant conclusion is that the biggest colour gamut is for paper 3 – WFC, glossy grade 200 g/m²;
- ▶ This means that on this substrate can be reproduced more saturated colour compared to other kinds of papers;
- ▶ That is why further research we have done on this paper (number 3).

On the other hand, to be assess **consistent colour uniformity** from the first print to the last, it is relevant to be compared different samples printed on the same paper and the same conditions - whether they are identical:

we take paper 3 (WFC, glossy, 200 g/m², sample 1 – single side print and other three double-sided samples - 2, 3, 4.

For these printed samples we have measured: colour gamut through test-scale IT8.7-3 Visual, and then we have compared different samples on the base of colour deviation ΔE_{00} , calculated by i1Profiler.



Evaluation of the Consistent Color Uniformity

sample 1- white line, sample 2- red line, sample 3- green line; sample 4 – orange line

Results

- ▶ There are very insignificant differences which are not important for receiving identical printing quality.
- ▶ Can be seen that for all double sided printouts the difference is not noticeable at all. All three printed double-sided samples have almost the same colour gamut.
- ▶ The difference is between one sided sample 1 and other three double-sided samples - 2, 3 and 4. There is a little difference only in the blue-green area, what is not essential.
- ▶ Conclusion is: analysed paper samples reproduced identical, very satisfied colours of all area and this result proves that operators no longer have to stop the machine and change the developer, resulting in greater machine availability and productivity.

Results

- ▶ On the base of the results shown can be concluded the colour gamut of different samples, printed on the same paper - grade 200 g/m² , is almost overlapped, which is an indicator that all printouts are identical, without colour variations, with almost equivalent colour gamut and finally with colour reproduction quality.
- ▶ This result shows Nexpress2100 plus colour reproduction capability is very acceptable.

Colour Deviation

- ▶ On the base of calculated colour deviation can be said that average colour deviation is minimal between samples 2 and 3, e. g. the colour perception of these printouts are equal.
- ▶ More distinctive deviation exists between samples 3 and 4, but here also the average ΔE_{00} is less of one (0,80) and therefore the deviation is not noticeable.
- ▶ On the whole, ΔE_{00} for these three double sided samples is less of one, which is not essential.
- ▶ ΔE_{\max} from all measured patches is between samples 3 and 4. It is $\Delta E_{00}=3,60$, but if ignore 10% of patches with the max colour deviation, for the rest of 90% measured patches, ΔE_{\max} is 1,35, which is satisfied.

Patches/ ΔE	average ΔE_{00}		Standard deviation		ΔE_{\max}	
2/3	measured	number of patches	measured	number of patches	measured	number of patches
All patches	0,65	928	0,38	928	2,94	928
90% of lowest	0,56	835	0,26	835	1,13	835
10% of highest	1,45	93	0,35	93		

	average ΔE_{00}		Standard deviation		ΔE_{\max}	
2/4	measured	number of patches	measured	number of patches	measured	number of patches
All patches	0,80	928	0,48	928	3,60	928
90% of lowest	0,68	835	0,31	835	1,35	835
10% of highest	1,84	93	0,48	93		

Patches/ ΔE	average ΔE_{00}		Standard deviation		ΔE_{\max}	
3/4	measured	number of patches	measured	number of patches	measured	number of patches
All patches	0,80	928	0,48	928	3,60	928
90% of lowest	0,68	835	0,31	835	1,35	835
10% of highest	1,84	93	0,48	93		

Conclusion

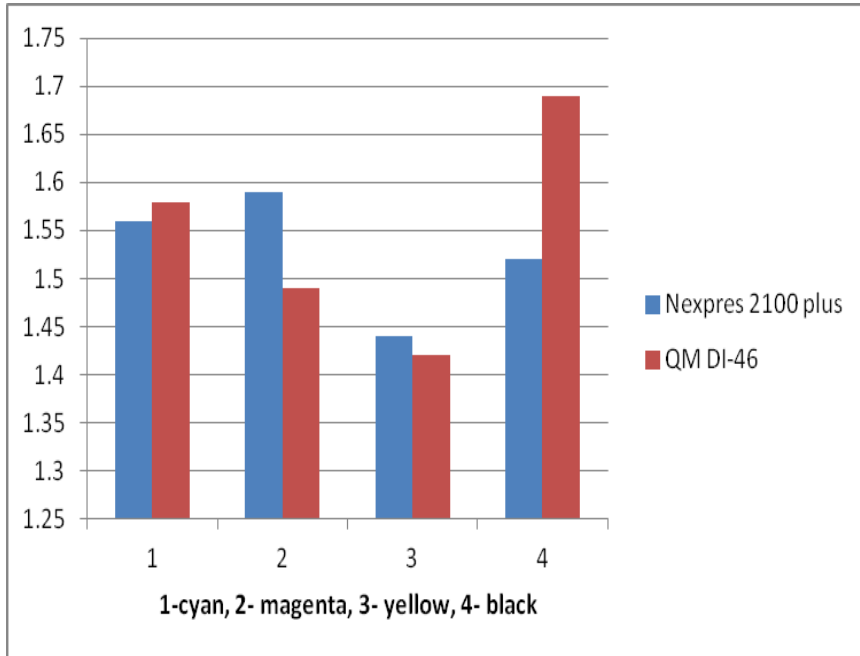
- ▶ All results have shown that printed samples are identical towards their colour deviation.
- ▶ This is important for considering the colour reproduction quality received from digital dry toner EP Nexpress2100 plus is constant, reliable repeatable, nonetheless that permanent carrier of image in this NIP technology is missed.

Comparison

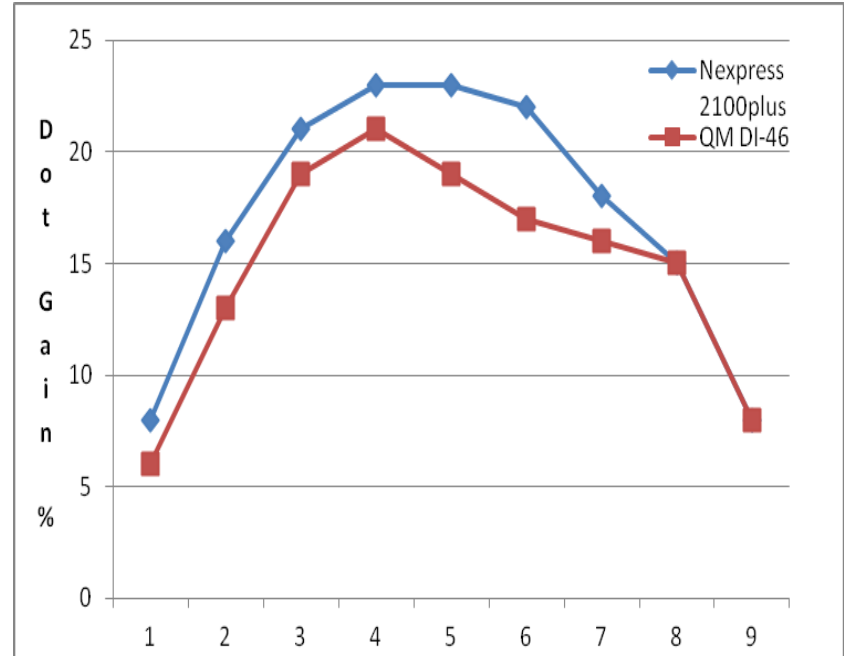
- ▶ *Every press, be it digital or litho, can be susceptible towards their print quality - density values, color variations, streaks and so on.*
- ▶ The whole colour reproduction results received of this digital dry toner EP printing platform have demonstrated the potential of approaching high print quality;
- ▶ This was proved by interpreting some parameters in relation to Heidelberg Quick master DI-46 - sheet-fed waterless offset press.
- ▶ Have been used the same three types of papers;
- ▶ Then most acceptable paper (WFC, glossy, 200 g/m²) have been compared by the values of several parameters - solid inks densities and dot gain and color gamut.

Dot Gain %	10 % Nex	10 % QM	20 % Nex	20 % QM	30 % Nex	30 % QM	40 % Nex	40 % QM	50 % Nex	50 % QM	60 % Nex	60 % QM	70 % Nex	70 % QM	80 % Nex	80 % QM	90 % Nex	90 % QM
C	7	9	15	12	19	16	21	23	24	21	23	18	18	16	15	14	8	7
M	7	7	14	12	18	17	20	20	22	19	22	17	18	15	14	14	7	7
Y	5	5	12	11	19	16	23	19	24	17	23	16	20	14	14	13	8	6
K	8	6	16	13	21	19	23	21	23	19	22	17	18	16	15	15	8	8

Solids for WFC glossy, 200 g/m²



Dot Gain for Black on the paper 200 g/m²



COMPARISON

Comparison

- ▶ Towards solid inks densities (SID) can be said that for black is observed definitely high values of density on QM DI-46 compared to digital dry toner electro photographic printing.
- ▶ The same can be said for cyan, but here is not so distinctive difference. But in magenta and yellow the results are completely opposite – optical densities for solids are higher for Nexpress2100 plus, what can be explained by fine toner quality particles.

Comparison

- ▶ Dot Gain is different for different printing platforms for the whole process colours, but there is definite trend for this parameter.
- ▶ Comparison of the measured dot gain values in the lightness and in the very darkness, have shown some compatibility between two printing platforms. In the areas of very lightness (10%) dot gain is almost equal for two cases;
- ▶ But since 20% of the values up to 40%, dot gain is bigger for the Nexpress2100 plus compared to QM DI-46. In the middle tones (40-50%) is observed the same trend, the exception is only for cyan of 40% tones where this value is smaller for digital printing.
- ▶ Then up to 70% of tones dot gain for digital Nexpress2100 plus again are above of those for smart offset DI.

Comparison

- ▶ All these results can be explained also having in mind that Heidelberg QM DI -46 has a waterless offset printing process, where dot gain values will be predicted as lower as possible.
- ▶ Also an additional reason in dry toner technology is fusing and fixing process by pressure and heating.

SUMMARY

- ▶ Upon experimentation and analyses, it was found that the Kodak Nexpress2100 plus produces pleasing color print quality. Having this digital platform makes it an attractive option for print service providers;
- ▶ The image quality of digital color output matches and even surpasses some parameters of smart offset;
- ▶ This digital electro-photographic dry toner system enables significant gains in image quality, productivity and growth for print jobs, due to the platform's flexibility.

As the quality of digital press is increased, this is referred to as high-value applications. Example of print products that place an emphasis on attractive image quality are: *calendars, greeting cards, postcards, magnets, plastic ID cards, yearbooks and adding personalization to any or all of these items makes them even higher-value applications.*

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