Paper-Related Innovations and the Impact on Digital Production Printing

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Abstract

Today the common reputation of the paper business is that of a technically mature industry with, if any, long innovation cycles. A closer look into this industry, however, discloses that paper and paper properties are still far from being constant. Paper properties are rooted in a complex system of diverse requirements: cost pressure, restrictive legal regulations, keen competition, and new demands from customers (printer, converter, publisher, and end-consumer), which result in perpetual process and quality improvements as well as the development of new products with different properties. This paper gives an overview of recent developments in the industry and their possible impact on electrophotographic devices. Special emphasis is given to runability and printability of some of these new products on a Kodak NexPress S2500 digital production color press, and the results were compared to the data obtained from conventional papers of the same market segment.

Introduction

Today the common reputation of the paper business is that of a technically mature industry with a long history beginning with the production of papyrus about 5000 years ago. Typical development trends for such industries at the declining stage of the industry life cycle focus on cost reduction and efficiency improvements. And in fact these two topics have been on the agenda of this industry for many years. A closer look into this industry, however, discloses that paper and paper properties are still far from being steady. Paper properties are rooted in a complex system of diverse requirements: cost pressure, restrictive legal regulations, keen competition, and new demands from customers (printer, converter, publisher, and end-consumer), which result in perpetual process and quality improvements as well as the development of new products with different properties. The most impressive changes in recent decades were, for example

- the change from acid to neutral/alkaline papermaking and connected to this the increased usage of calcium carbonate as filler and synthetic sizing agents such as AKD and ASA;
- the change in bleaching technology from chlorine to chlorine dioxide, hydrogen peroxide, and ozone;
- the increased usage of recycled fibers even for graphic papers;
- the worldwide breakthrough of microparticle retention systems;
- the rapid growth of film press technology and the development of Film Coated Offset (FCO);
- the rollout of closed-loop process control systems in the paper mills with dramatic increase of paper quality;
- and last but not least, the emergence into the market of papers with lower basis weights and higher filler content or the introduction of new paper grades such as copy papers and inkjet papers.

Some of these changes had an immediate impact on the subsequent process steps, and because the printing industry was not always the main driver for these changes, there is a need for adaptation of the print engines to these new circumstances. This is even truer for the relatively "small" print technologies, which gain less attention from the paper mills in comparison to the established processes such as offset or rotogravure. Therefore, for the (digital) printing industry it is important to track and to actively attend to the developments in the paper industry to take advantage of the new opportunities or to be prepared for major changes in the market.

There are a number of recent new products from the paper industry. Out of these the introduction of "Tempo" from Sappi, "Neox" from Mondi, and "Nanoo" from Advanced Papers attracts much interest in the market. Therefore, these products were selected for a test on a Kodak NexPress S2500 digital production color press and the results were compared to the data obtained from conventional papers of the same market segment. (In addition, developments such as curtain coating or "stone paper" will be presented at the NIP conference.)

Tested Materials

NanooMatt

NanooMatt from Advanced Papers was introduced in 2007. The material is produced by applying a thin layer of chemically modified precipitated calcium carbonate (PPC) to the surface of a high bulk paper. Thereby the applied quantity of <2 g/m² [1] per side is rather low in comparison to the usual amount of sizing agent or coating material, which is at least 6 g/m² per side. The size of the chemically modified particles is in the range of 100–200 nm (see figure 1).

Under the header "small particles, big impressions," Advanced Papers claims superb print quality on offset presses with simultaneously higher volume, better opacity, and a more pleasant surface feel in comparison to other papers in the market. A new version of this product called NanooPrint, with an application quantity of about 5 g/m² on each side, was announced recently [2] and this seems to be a clear sign that these kinds of papers will not be a temporary phenomenon.

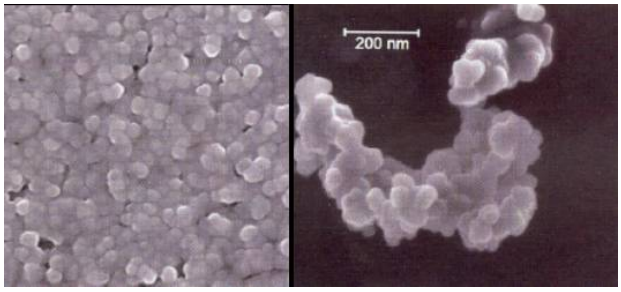

Figure 1. *SEM micrographs of chemically modified precipitated calcium carbonate particles. Left side: Aligned particles on the paper surface; right side: agglomerated particles (pictures provided by Advanced Papers).*

Neox

Neox is a new product for the color laser market from Mondi that also utilizes nanoparticles to enhance the paper properties. Unlike Nanoo, the nanoparticles in this "nanohybrid technology" are bound to standard coating pigments such as grounded calcium carbonate (see Figures 2 and 3). The creation of these nanopigment agglomerates is essential to assure suitable paper-coating formulations. The nanoparticles are produced by Topchim and commercialized under the "NanoTope" brand [3].

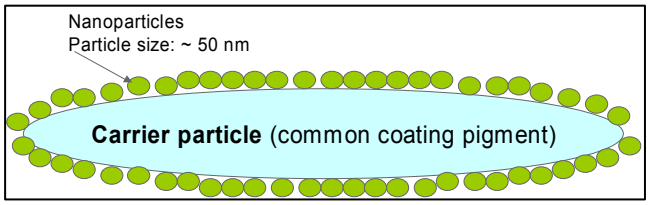

Figure 2. *Schematic sketch of NanoTope bound to a carrier particle.*

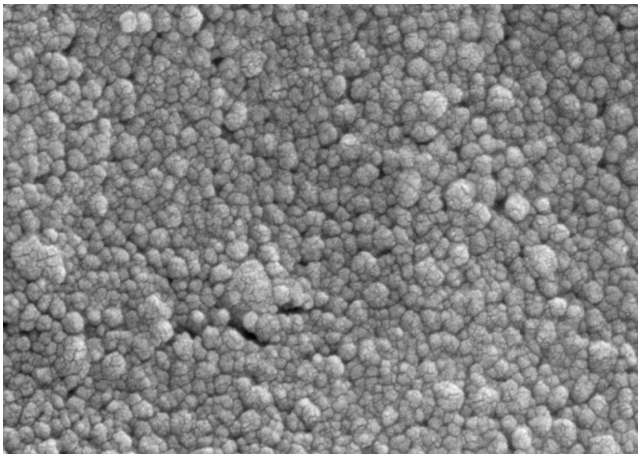

Figure3. *SEM micrograph of nanohybrid particles (picture provided by Mondi).*

The used NanoTope is based on Poly Styrene Maleimide (SMI) and is an emulsifier-free dispersion of low particle size plastic pigments with an average particle size of about 50 nm. During the paper production process the NanoTope particles remain stable and do not film-form. According to Mondi, this new paper unites the benefits of uncoated paper (high degree of whiteness and stiffness, easy processing in and after printing) with those of coated paper (paper gloss and smooth surface feel, hence image sharpness and density.)

Tempo

Sappi surprises the market with a new product called "Tempo". They claim outstanding drying characteristics, which were already confirmed by tests from other companies. According to Sappi these new properties were achieved by the special selection of inorganic fillers and by incorporation of traces of organic transition metal complexes such as $Mn^{2+/3+}$ into the coating color. Because of the improved drying rates the amount of offset powder can be reduced considerably or can be eliminated totally. The new coating shall allow one to simplify the printing process and provide much shorter converting times and reprinting times when compared with common silk-coated papers [4].

The performance of these three papers was compared with three other well-known papers on the market.

Color Copy from Mondi was chosen because of the high reputation of this product in the digital printing market. Color Copy is the benchmark for high-quality uncoated paper and is used as a calibration paper for many digital printers in Europe (e.g., Canon Image Press 7000, Kodak NexPress M700 digital color press, Kodak Digimaster digital production system, diverse Océ printers, etc.).

MaxiSatin is a wood-free double-coated paper from UPM Nordland with a silk finish. This paper is one of the large sellers in the market and is used in most European countries.

ProfiGloss is for many years the European standard calibration paper for the Kodak NexPress digital production presses. It is a triple-coated paper from Sappi with a gloss finish.

Table 1 shows an overview of the substrates that were used in the performance tests.

Table 1: Overview of substrates used in the performance test.

	Nanoo Matt 100	Color Copy 100	Neox 110	MaxiSatin 135	Tempo 135	ProfiGloss 135
Type	Uncoated	Uncoated	Uncoated	Coated Matte	Coated Matte	Coated Gloss
Grammage [g/m²]	100	101	109.9	135.3	135	135.2
Thickness [µm]	142	107	98	117	107	94
Density [g/cm³]	0.70	0.94	1.12	1.16	1.26	1.44
Gloss [G60U]	3.6	5.5	8.4	12	5	35.8

Results and Discussion

Tests were performed on a Kodak NexPress S2500 digital production color press equipped with one high-volume tray and five imaging units (see Figure 4). A number of special sensors were installed to monitor paper-handling relevant data during the test runs. The S2500 press contains several substrate-dependant parameters, which can be set individually for each substrate in order to ensure good runability and print quality. However, for these test purposes the same substrate-dependant settings were used for all papers. Color management was disabled to minimize any influence of engine-dependent parameters to the results. Paper size for all papers was SRA3. All tests were done with grain short papers.

Paper handling performance

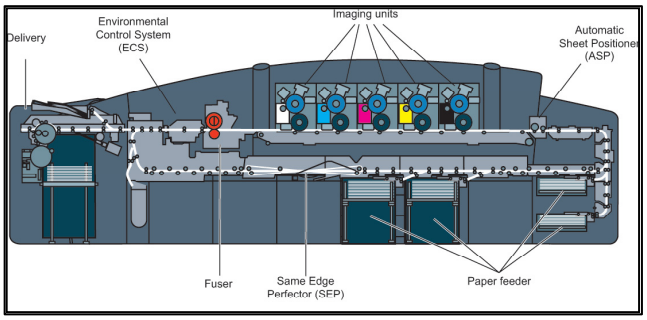

Figure 4. *Paper path of KODAK NexPress 2500 Press equipped with four paper deliveries and high-capacity delivery*

The S2500 press draws its substrates from four trays. Various substrate types and sizes with a format up to 356 × 520 mm can be combined within a single print job. These different substrates then must reliably be transported through the whole engine. For this purpose all common paper transport mechanisms are used: vacuum transport, belt transport, moving of paper with rollers, and transport of paper with the help of a web on which the paper is fixed electrostatically. The reliability of such transport mechanisms depends on a number of different substrate properties, which varies from paper type to paper type. Particularly substrate porosity, substrate size, grammage, curl, and coefficient of friction have an influence to this process.

The feed performance of the six substrates was evaluated by monitoring the skew of the sheets directly after the feeding process (see Figure 5). For each paper the range of measured skews and the average skew is shown. As indicated in Figure 5 all of the skew values were within the limits of ±1°, whereas for all new papers the calculated average skew was very close to 0°. With a very close skew distribution and an average skew of nearly 0° NanooMatt was the out-performer in this category.

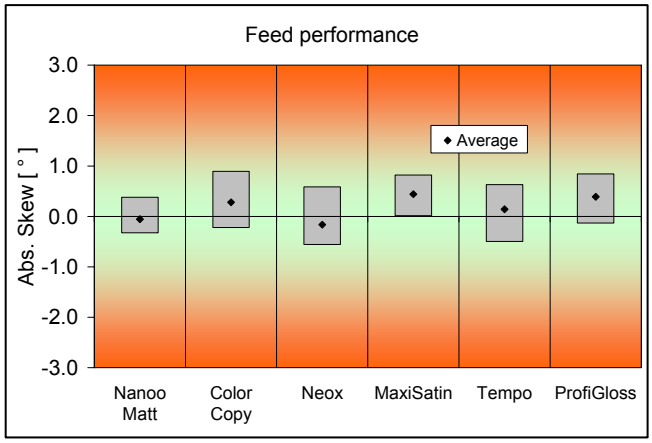

Figure 5. *Range of measured skews of sheets directly after the feeding process for various papers*

The next important paper-handling parameter is the alignment of the sheets on the paper transport web. Because a skew of the sheets on the web corresponds directly to the image-to-sheet skew on the final prints, a very tight skew distribution with an average skew around 0° is desirable. This alignment is done by the automatic sheet positioner (ASP). In this unit the sheet width, the position of the sheet, and the sheet skew are measured. After that the alignment of the sheet to the desired values is performed in a two-stage process. This ensures high image-to-sheet skew and front-to-back registration performance [5].

Figure 6 shows the average skew for each paper grade on the paper transport web. In addition, the skew distribution is presented.

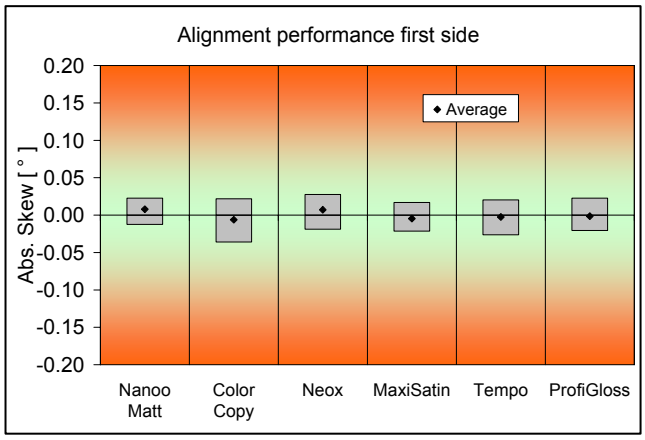

Figure 6. *Alignment of the sheets on the paper transport web for various papers*

No clear differences can be seen between the new papers compared to the well-known standard papers. In general the ASP was able to align all of the tested grades very close to the desired skew values of 0°, regardless of the differences in grammage, type, or roughness. It is noticeable that the NanooMatt again impresses with its narrow skew distribution.

Another important subunit of the S2500 press is the Kodak NexQ same edge perfector. In this unit the sheets are flipped on the long edge, so that the same edge of the sheet is used for registering both the front and the reverse side [6]. Figure 7 shows the skew difference of sheets before the same edge perfector and after the unit. The skew difference is a measure for the capability of the SEP unit to handle different substrates. Again, none of the tested substrates shows any issues during these tests.

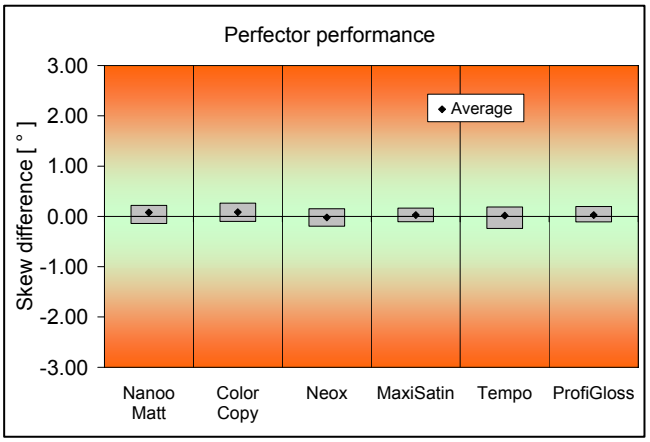

Figure 7*. Skew difference of sheets before the same edge perfector and after the unit*

Gloss and Density

In general, on Kodak's production engines the print gloss of prints can be adjusted to different levels by changing fusing temperatures and/or contact times to different values [7]. Usually these fusing parameters are set individually for each substrate to values that ensure good toner adhesion and minimize differential gloss. However, to achieve a better comparison of all papers the same fuser settings were used in this study. The samples for these measurements were prepared in the four-color mode. Print gloss was measured at 60° on patches with 100% K and 280% dry ink laydown. The results of these measurements are shown in Figure 8. The print gloss on uncoated papers like NanooMatt and Color Copy is significantly lower than that on coated papers such as ProfiGloss or MaxiSatin. This is a common observation for uncoated papers. Surprisingly, the print gloss on (the uncoated) Neox is much higher and reaches the values of coated papers. This is true for the 100% K patches as well as for the patches with 280% laydown. In this case it seems that the special treatment of the fibers with the nanohybrid particles actually helps to increase the print gloss.

NanooMatt with its rough surface shows the lowest print gloss values of all papers, while on the special coated Tempo the highest gloss values were measured.

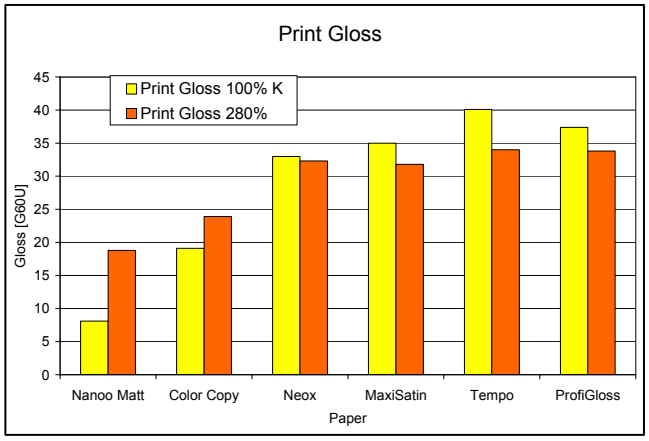

Figure 8. *G60 print gloss on patches with 100% K and 280% dry ink laydown on different paper grades*

Density measurements also indicate that the uncoated Neox behaves more like a coated rather than an uncoated paper (see Figure 9; Color Management was disabled for these tests to minimize any influence to the results). The achieved density for the 100% patch is much higher on the Neox material compared to the densities of the other uncoated papers. There is no detectable difference between the Tempo and the other coated papers. NanooMatt shows density values below 1.2. Therefore, this paper is not the best choice for most high-quality applications.

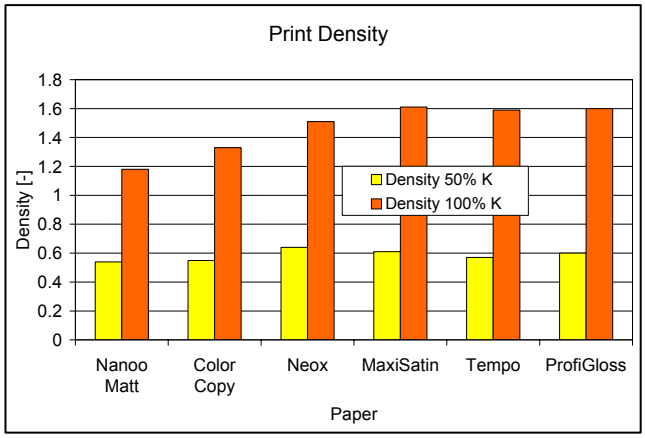

Figure 9. *Density values of 50% K and 100% K patches on various papers*

Summary

Paper handling and printability of three new papers on the paper market (NanooMatt, Neox, and Tempo) were tested on a Kodak NexPress S2500 digital production color press and the results were compared to the data obtained from conventional papers of the same market segment. All papers show excellent runnability. Particularly, the NanooMatt from Advanced Papers impresses with its narrow skew distribution. The print gloss on the uncoated Neox is much higher than that of other uncoated grades and reaches the values of coated papers. In this case it seems that the special treatment of the fibers with the nanohybrid particles actually helps to increase the print gloss. The NanooMatt with its rough surface shows the lowest print gloss values of all papers, while on the special coated Tempo the highest gloss values were measured. The achieved density for the 100% patch is much higher on the Neox material compared to the densities of the other uncoated papers. This also indicates that Neox behaves more like a coated rather than an uncoated paper.

Acknowledgments

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Author Biography

Johann Weigert holds a Ph.D. in Chemistry from the Technical University of Darmstadt, where he worked on papermaking chemistry and chemical modification of pulp. He joined NexPress GmbH, now the Kiel plant of Kodak Graphic Communications GmbH, in 1999. Since then he has worked on several paper-related topics and was responsible for paper qualification and the development of the paper qualification program for the Kodak NexPress digital production color presses. Currently, he is Senior Process Engineer within R&D with special focus on substrate/engine interactions.