Advantages of form adjustment in Xeikon FA-toner for high speed digital color printing

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Abstract

Chemically produced toner (CPT) is dominating the majority of new product introductions in the desktop, home and office market. Making toners in liquid phases prior to drying and blending them, results in some advantages. In particular this enables developing simpler and cheaper printing machines. However, today it is still very difficult to meet the high end demands for graphic arts printers using this CPT technology; the benefits achieved when using polyester toners (adhesion, gloss, charge, pigment wetting,...) can not be matched (with CP-toners). Up till now, CPT is present in none of the high end high speed printing machines, which all use melt pulverized toner (MP-toner) (or also named traditional produced toner (TP-toner)) based on polyester. This paper shows the advantages when form adjustment (FA) is applied on traditionally produced polyester toners for high speed color printing. Combining the best of both production technologies !

Form Adjustment - from rock to perfect round

We investigated different degrees of shape modification during high speed digital color printing. In figure 1 the different shapes are shown with SEM-pictures. We have been studying two different types of traditional produced toners (one of the actual Xeikon toner systems and a non shape modified toner system with the same composition as the FA-toner, except for the additives). This composition was also used for making the potato shape (FA-toner) and the perfect round shaped toner. In dual component machines we have to take into account that the residence time of the toner drastically changes depending upon the page coverage that is applied (see table 1). Customers using our presses want to have the freedom to switch from job to job, totally independent upon the image content they have been printing or wanted to print.

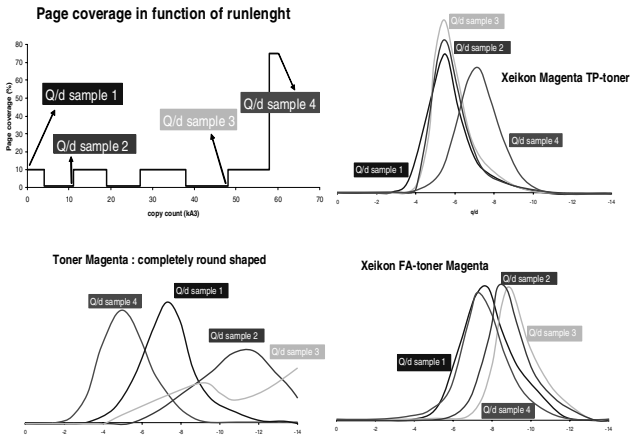

Figure 2. Q/d profiles of different toners (see Figure 1) during printing at the same speed, but different percentage of page coverage

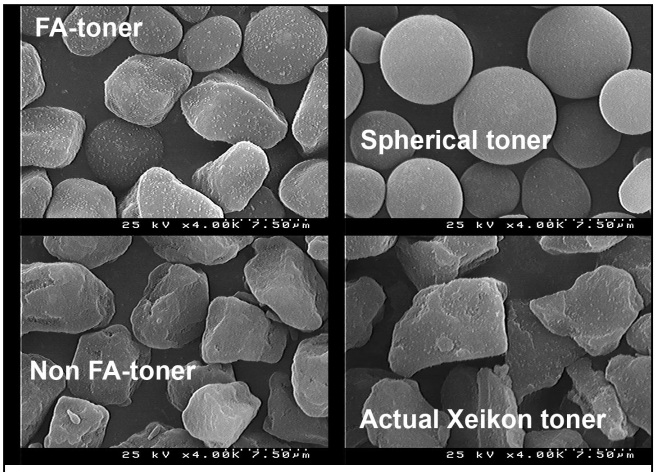

Figure 1. Different toners used in the tests. The spherical toner, Non FA-toner and FA-toner had the same internal composition.

The type of charge controlling agents and charge limitation agents have a big influence on the charge built up when fresh toner is fed into the developing unit and as well on the final charge obtained when the toner is activated for longer times. In figure 2 we demonstrate the Q/d changes when different page coverages are applied. The first graph shows a Xeikon toner which has been produced traditionally. By implementing the right components and surface additives we can perfectly control the charge changes quite independent from the printed page coverage. In our electrostatically assisted brush OPC cleaning system we did not observe any decrease in cleaning efficiency as a function of used shape of the toner formulation, but we are well aware this is different when scraper blade cleaning is used.

Table 1. Residence time in X5000 developing unit

Page coverage	flow (mg/sec)	time in developer unit
1%	4	8 hours
12 %	35	42 minutes
75 %	200	7 minutes

When using a spherical toner particle, we found out that it is very difficult to control the charging behavior. The charge dramatically increases when printing low page coverages and decreases rapidly when printing high page coverages. We think that the toner is too mobile and continues to pick up charges when the activation is applied for a long time (low page coverage). This induces very high Coloumb attraction forces between carrier surface and toner resulting in difficulties to maintain the right image density, because too high potential fields are needed to transfer the toner from the carrier to the photoconductor surface. Supplementary to

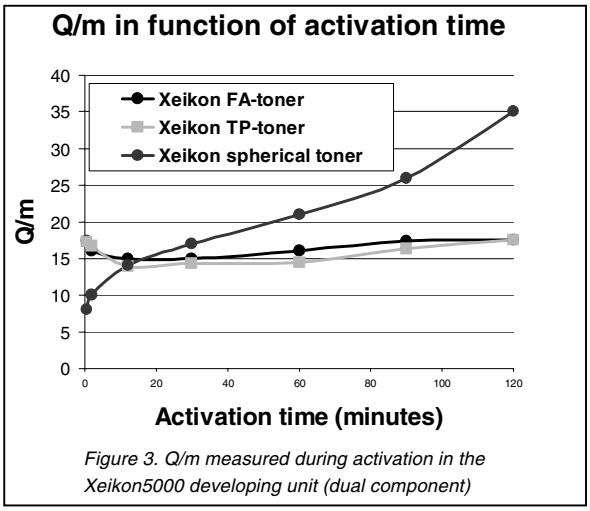

Figure 3. Q/m measured during activation in the Xeikon5000 developing unit (dual component)

that it becomes also difficult to transfer the toner from the photoconductor to the final substrate which reduces the transfer efficiency and increases the toner consumption. When switching to high coverage printing, the charge level of the toner decreases and creates a lot of background noise because of the presence of non and wrong charged toner. It is generally known that charging of toner particles is induced by friction and mechanical collision of the toner particle with the carrier surface. When the particles are too spherical, a lot of movement takes place without creating friction and collisions. Too spherical particles are facing two problems ; they pick up charge slowly and do not stop being charged. The difference with the potato shaped toner system is quite remarkable. It has the advantages of the shape modification with respect to image quality and transfer behavior, but keeps the more controlled charging of the traditional produced toner. This stable charging cannot only be determined in measuring the Q/d but is also very clear when Q/m as a function of activation time is measured in an off line developing unit (see figure 3).

Life time of developer

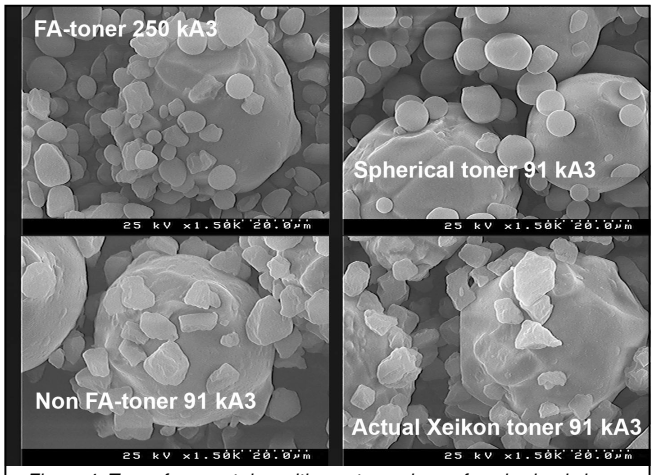

Figure 4. Toner fragment deposition onto carrier surface is clearly lower when form adjusted toner is used

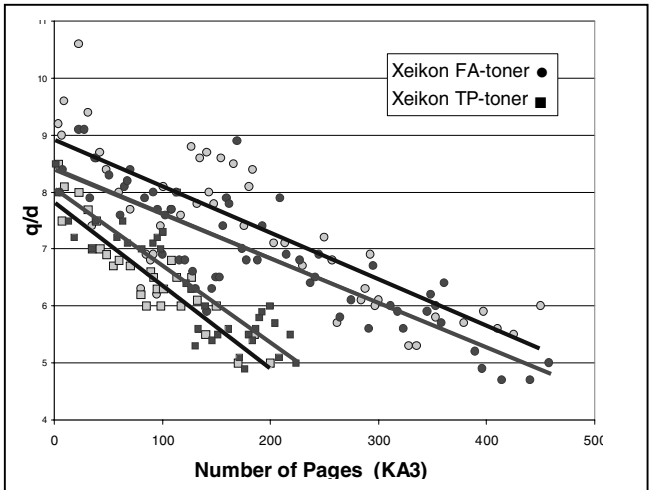

Figure 5. Q/d-value as function of developer age. The values measured are function of small variations in toner concentration and depend on the residence time in the developer unit. But difference in

The applied morphology change results in fewer contact points of the toner particle with both carrier surface and photoconductor surface. The fact that less contact points are present also results in less irreversible toner adhesion onto the carrier surface when the developer is used for longer times. This can be seen on SEM pictures taken of the surface of the carrier after different lifetimes (figure 4). The charging properties of the developer are less changed over time because the surface of the carrier stays cleaner and the tribo process is thus less disturbed. The drop in mean value of the Q/d is also less pronounced with FA-toner compared to traditionally produced toner, which also proves the same statement (Figure 5 ; showing both cyan and magenta Q/d values as a function of lifetime).

Image quality – Transfer efficiency – Color gamut increase – Drum life

Due to the shape modification, which results in less contact points with both carrier and photoreceptor, the ease of development and image quality is drastically improved. This is expressed in several image defects which now have been resolved to a great extent. One of them is hollow characters (an image defect that can occur when two toner layers are on top of each other and the second toner layer is not transferred very well (see figure 6). The one pass duplex® principle gives perfect data matching front to back and also perfect (front to back) registration control, because the paper transport is also guiding the movement of the OPC-drums. When thicker media are used for printing, this results in an increase of pressure on the toner developed on the drum, prior to final transfer to the paper. When the toner particles are adhering too much to the OPC drum, transfer efficiency is decreased, resulting in damaged image (see also figure 6). This adhesion is a function of the shape and the amount of contact points of the toner to the OPC drum. The Change over from a TP-toner system to a FA-toner system resulted in an increase of transfer efficiency from 90 % to 94 % (taken as a mean value in a print run using different thickness of paper during a run of 250 kA4).

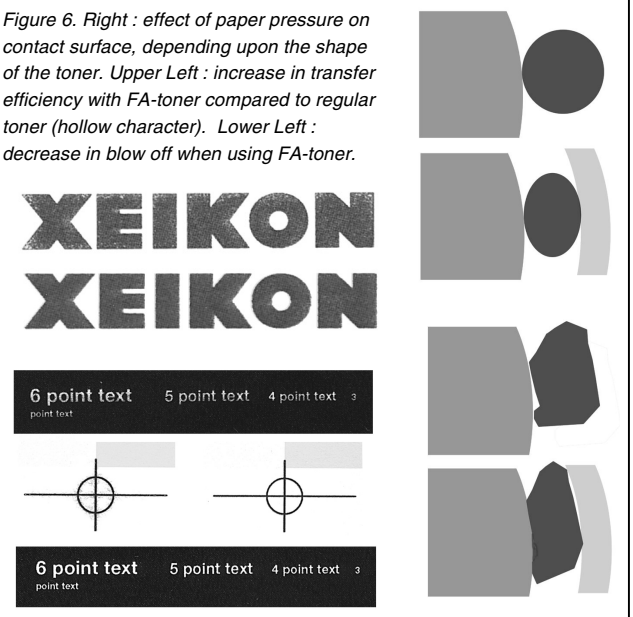

Figure 6. Right : effect of paper pressure on contact surface, depending upon the shape of the toner. Upper Left : increase in transfer efficiency with FA-toner compared to regular toner (hollow character). Lower Left : decrease in blow off when using FA-toner.

An additional advantage of shape modification is the fact that toners are more easily developed. For the same charge of the toner we need less potential difference on the drum in order to transfer the toner from the carrier surface to the OPC surface. This is seen when two toner systems are compared (non shape adjusted versus shape adjusted) having the same q/d charge distribution. The amount of LED light needed to develop a full density patch with FA-toner is 60 % less compared to a TP-toner system with the same charge! This more gentle development results also in less toner blow off when multiple toner layers are put on top of each other. White text is now better kept open when surrounded by multiple toner layers. (See also figure 6). Another advantage is the overall presence of toner which results in no depletion during the development and a perfect response to the latent image on the photoconductor. This is explained by the increased mobility of the toner particles inside the magnetic brush.

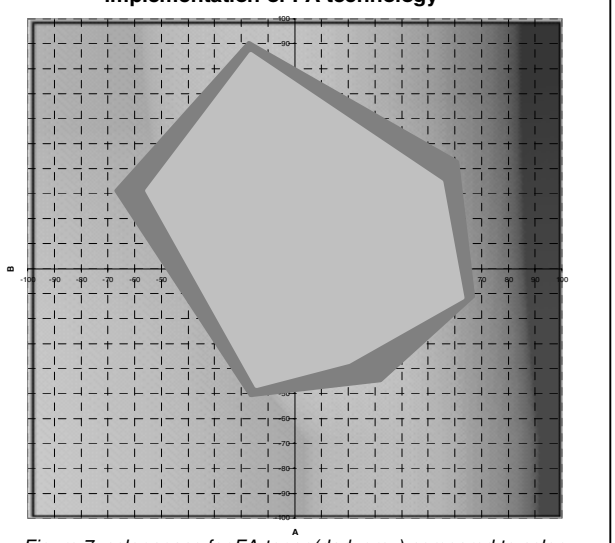

Figure 7. color space for FA-toner (dark grey) compared to color space of non forma adjusted toner (light grey). The composition of both toners is equal, only the shape and surface additives are different in order to make toners that could be used for printing in a Xeikon5000.

At last but not least, we also noticed that we could drastically reduce the amount of surface additives. The decrease in total adhesion forces makes this possible. This fact has multiple benefits. We noticed an increase in color gamut (see figure 7) combined with a reduction in toner consumption of 8 % (independent from the increase in transfer efficiency). The Xeikon digital printing engines use non contact IR fusing. We could observe a more easy "kinetic" melting process and thus also much better spreading of the toner particles upon different substrates. This creates thinner toner layers and makes more efficient use of the amount of pigment encapsulated in the toner particles. Besides the more efficient use of toner, the cleaning frequency of the drums also decreased because less toner material and additive material was irreversibly deposited onto the surface. This is perfectly compatible with the same observation with respect to the toner deposition onto the carrier surface.

Measuring circularity

Implementing shape modification is one thing, making every time the same shape is another challenge. By using new type of analytic equipment (Sysmex FPIA 3000[4]) one can measure both size distribution and shape distribution. From each particle a picture is taken on which both size and shape is determined. In figure 8 (upper) we show some examples of circularity numbers derived from the pictures taken. In figure 8 (mid and lower) we compare two distributions ; one from the current Xeikon toner (lower) and the new FA-toner system (upper). From these figures one can observe that the new toner system is smaller and more homogeneous in size. If we compare the circularity, then it is clear that the values closer to 1 are more present in the new FA-toner system. The mean value for circularity for the two toner systems is respectively 0,938 versus 0,971 for FA.

Paper recycling

A lot of the paper material that is digitally printed is quite short living (personal direct mail, transactional, promotional,…). This means that the paper is showing up quite rapidly in the paper recycling stream. The deinking aspects of the toner material that is used to form the image is therefore of utmost importance[1]. Some numbers[2] : Each ton of 100 % recycled paper saves 4100 KWh of energy (is equivalent to the yearly energy need for one house), saves 2,3 cubic meters of landfill space, saves 31800 liters of water (the equivalent of 31 tons of paper fills an Olympic swimming pool) and prevents of 1763 kg of carbon dioxide entering into the air. The total global yearly recycled amount of paper is more than 170.000.000 tons ! The new FA-toner polyester system is even better for deinking compared to the actual polyol toner system, which was already found acceptable by the deinking industry[3].

Flexibility

The approach chosen by Xeikon allows the toner designers to perform the shape modification on different toner formulations.

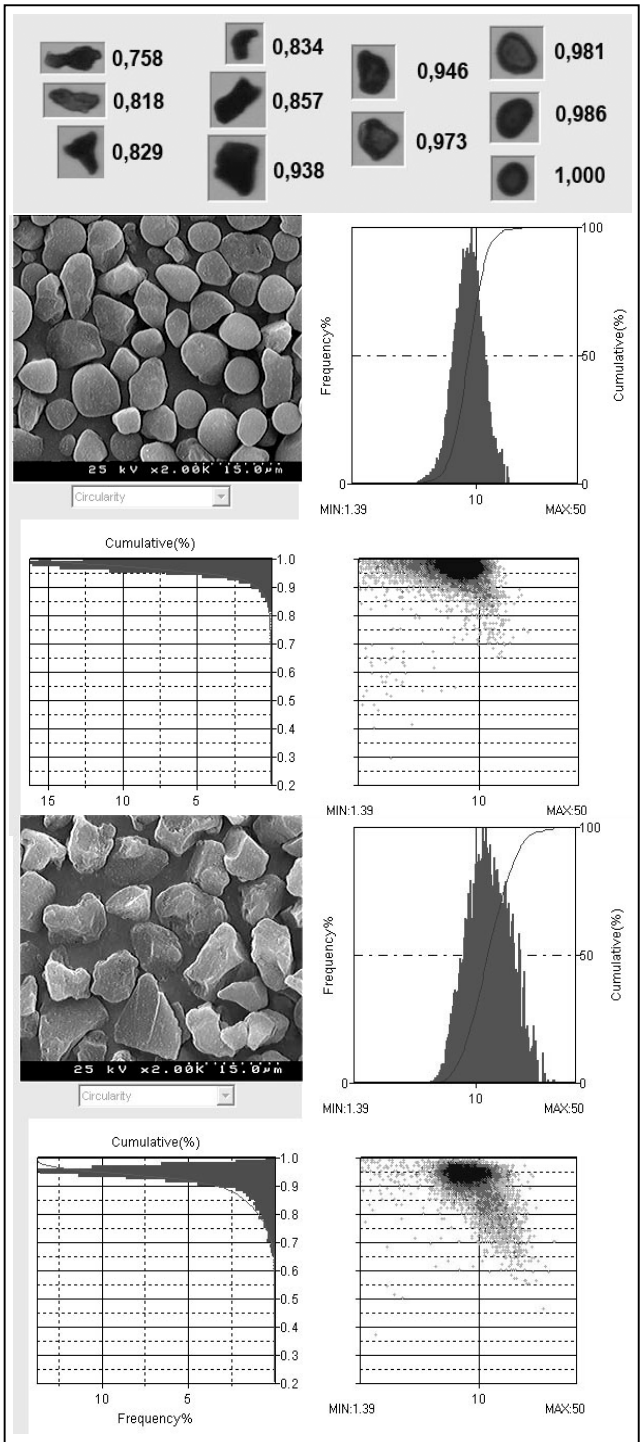

Figure 8. The Sysmex FPIA 3000 equipment measures both the size and the circularity of each individual toner particle. Besides the size distribution, the shape or circularity distribution is also produced. Upper ; different shapes of toner particles with their circularity value. Mid ; both size and circularity distribution of the Xeikon FA-toner, Low ; same measurement on actual Xeikon toner. It can be seen that the FA-toner is somewhat smaller and has a more narrow particle size distribution. When looked at the circularity, the FA-toner is mainly located above 0,95.

Besides the CMYK toners, also a complete set of spot color toners was prepared. Green, orange, red and blue were developed and will be offered to the market to be used in the fifth station of the Xeikon5000. Above that the toner engineers also applied the FA-technology to clear and white toners. The latter can be used for creating opaque white surfaces on transparent foil or can be used for security applications. The former gives the customer the possibility to create gloss effects and to introduce colorless marks that respond blue when security light is used and when the printing has been done on substrate without optical brighteners. These gloss marks also cannot be picked up using scanning equipment.

Additionally to the flexibility of choosing the basic composition of the toner material, we also can influence the degree of roundness and the kind of shape which we find most suited for the intended application and performance.

Conclusion

The Xeikon branded machines will be equipped with a new state of the art toner system, hereby being the first to implement shape modified polyester toner into the upper high speed digital color production printing segment. By doing this we combine the benefits of the rounded shape typical present in CPT-toners with the benefits of real polyester polymer systems. Field trials have shown that high demanding customers appreciate all the benefits that come along with this new toner system. With this approach Punch Graphix shows again that innovation still is possible, also in the field of traditional produced toner. We have shown and explained in this paper that shape modification needs to happen in a very controlled way, especially in dual component developing systems with huge life time expectancies and large variations in page coverages.

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Bibliography

Lode Deprez is Vice President Toner & Developer Group at Punch Graphix International. In this organization he is responsible for both R&D and toner production. He received his PhD in organic synthesis at the University of Ghent in 1990. He was active during 9 years in the R&D development department of Agfa in the field of printing plates for CTP applications. From 1999 he joined the toner department and became responsible for this group before it moved to Xeikon in 2000.