

Industrial Digital Printing using EleJet™ Technology

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Abstract

The EleJet™ print technology is an example of a direct electrostatic printing (DEP) process specially adapted for industrial digital printing applications.

The key characteristics include a source of charged toner particles with narrow charge to mass distribution and well behaved fluidity, a global back electrode that attracts the charged toner particles from the toner source to the paper or intermediate receiver, and a particle modulator (printhead) in between the toner source and the (intermediate) back electrode. The modulator is made of a plastic body with passing holes surrounded by control electrodes.

In this electrostatic process the distance between the toner source, toner modulator, and (intermediate) image receiver is kept constant by dynamic adjustment. Pulse width modulation is used in combination with rather low addressability to achieve high image quality.

The combination of sufficient printing speeds with dynamic distance control and good toner design makes EleJet™ printing an excellent technique for Industrial Wide Format applications.

Introduction

EleJet™ is a direct electrostatic printing (DEP) process where the image is formed directly on a final or on an intermediate image receiver. The technique has been invented by Pressman[1] in 1972, and it has been further improved by other companies including Xerox, Brother, Array Printers, Agfa-Gevaert, Sharp, Hewlett Packard, etc… In the literature DEP has also been described as Powder Jet, Toner Jet, TonerJet™, XeroJet™, Toner Ejection Printing, and Toner Projection Printing.

The principle of EleJet™ printing is depicted in figure 1: a toner source delivers charged toner particles through the printhead structure, consisting of a polymeric substrate with apertures and at least one set of control electrodes, to the image receiving member in front of a back electrode.

The toner image applied on the image receiver is fixed so that the image adheres well to the paper fibers.

Due to the propulsion field present between the toner source and the back electrode, the (negatively) charged toner particles are attracted to the receiver upon the back electrode. This propulsion field is altered by the control electrodes present around the apertures in the printhead structure. In that way the toner flux from the toner source to the back electrode is time-modulated, resulting in a varying amount of toner particles adhering to the receiving member.

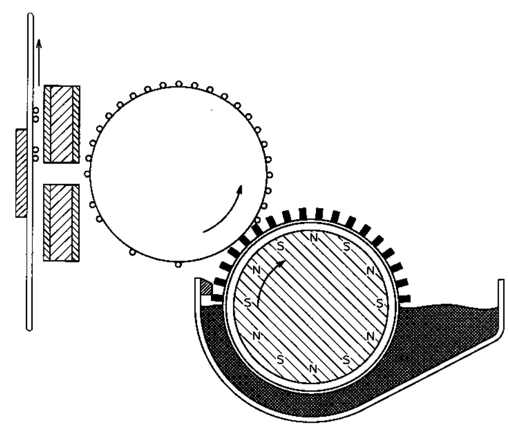

Figure 1. EleJet™ principle

Industrial Wide Format Printing

The main requirements for industrial wide format printing include low consumer cost with easy, reliable and high quality printouts. Due to the viewing distance of the large format prints, the image quality is not so much determined by the image resolution, as it is for images printed for the SOHO use, but more by the density resolution and density fluctuations in the images. These qualities must be constant from swath to swath, from image to image, from the first run to the last run. These image quality and reproducability aspects are much more important than the lowest possible device price.

Since EleJet™ printing has the possibility to deliver varying amounts of toner to the receiver, it is an interesting technique to combine high image quality with rather low addressabilities.

In figure 2 a (double A0-size) test pattern for wide format printing is shown, making it clear that the main target for wide format industrial printing is to provide images with constant overall density and quality.

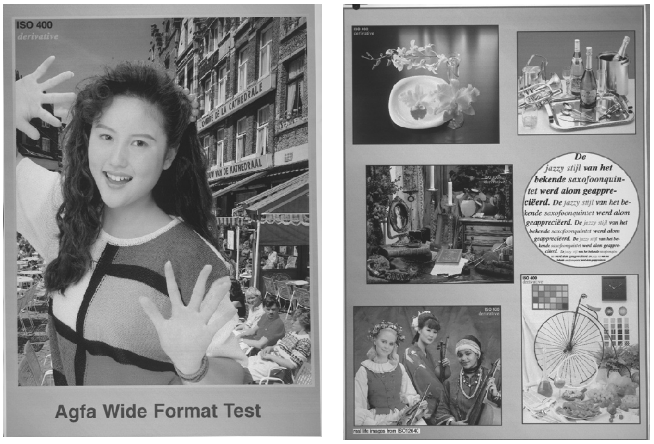

Figure 2. Wide Format test pattern

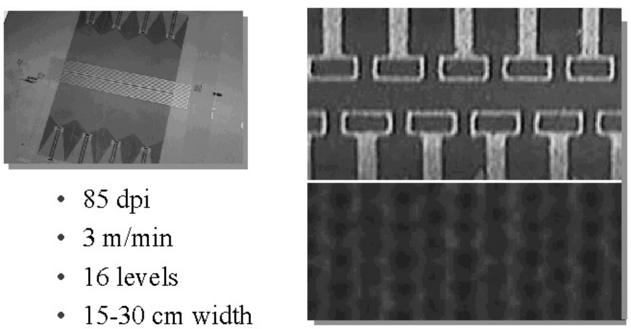

Figure 3. EleJetTM printhead structure

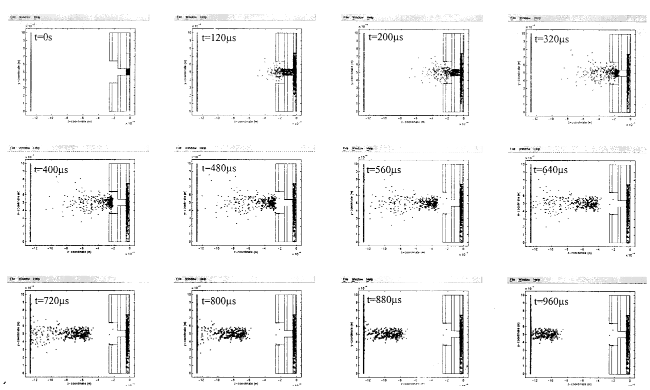

Figure 4. Dynamic particle motion analysis

Printhead Structure

Figure 3 shows a printhead structure used for printing large format images as depicted in figure 2.

This printhead structure consists of a 50 µm thick polyimide foil with rectangular apertures of 120 x 360 µm, a rectangular shaped control electrode around these apertures and a common shield electrode with a central 1260 µm free zone. This hybrid printhead structure is derived from the original printhead as disclosed in US 3 689 935,[1] but the position of the shield electrode is altered so that the toner flux (as a result of the local electric fields) is better directed towards the receiving member.

Further optimization of geometry and layout is helped by finite element simulations.[2] In figure 4 an example of a dynamic statistical analysis is shown. Here a toner cloud is created by putting an AC-field upon the toner source and individual particle movement is simulated under the presence of the “open” and “closed” control electrode voltages: i.e. 0 or +280 V.

Dynamic Nip Adjustment

The most critical distance in EleJet™ printing is the distance between the toner source and the printhead structure. Variation in this distance leads to variation in toner flux and therefor in variation in printing density. For that reason it is important to keep the surface of the printhead structure as flat as possible and to keep the surface of the toner source at constant distance. The first target can be achieved by stretching the printhead structure over a “trampoline” frame,[3] for the second target only very expensive manufacturing procedures can cope with high tolerances in nip-distance unless a dynamic nip adjustment is used by making contact between the toner source and the printhead structure. Many different ways of producing dynamic nip contact have been described in the literature: e.g. direct contact between the isolation layer of the printhead structure and the toner source,[4] a scraper blade placed orthogonal to the printing direction and in contact between the printhead structure and the toner source,[5] a spacer blade placed in the printing direction and in contact with both the printhead structure and the toner source but outside of the aperture zone,[6] etc. have been shown. All these examples have one big disadvantage, i.e. the charged toner layer is made to frictionally contact the printhead structure which can lead to toner smearing, toner degradation and toner charge influence. In order to prevent this, it has also been described[7] to make a dual dynamic system, in which both contact between the printhead structure and the intermediate back electrode is made, as well as contact between the toner source and the intermediate back electrode. This results in a dynamically adjusted printing nip without frictional contact over the toner layer on the toner source.

Toner Adhesion

The problem with any toner source is that a small amount of wrong-sign-toner (WST) is present in the toner supply. These toner particles behave unexpected in the provided electrostatic fields leading to unwanted toner deflection paths in the toner flux and resulting changes in image density and image sharpness. By using a printhead structure with large openings in the shield electrode zone and a conventional applicator for electrophotography using non magnetic monocomponent toner, after a relative short period of time, exhaustive toner adhesion to the back side of the printhead structure is obtained, leading to extensive image deterioration (figure 5). The best way to improve the toner adhesion problem is providing toner particles and a toner proces with better control over the charge-to-mass-ratio of the charged toner particles. Combination of a magnetic brush comprising two-component developer in combination with a toner concentrating roller (called a charged-toner-conveyer – CTC) proved to give the best results.

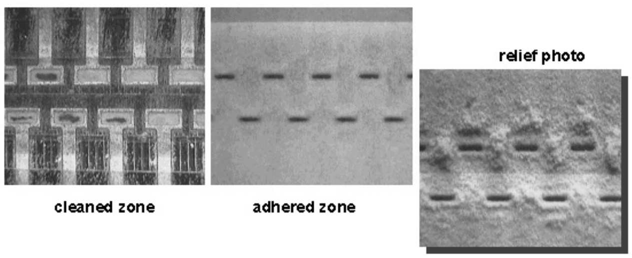

Figure 5. Toner adhesion upon EleJet™ printhead

Toner Depletion

For printhead structures having multiple rows of printing apertures the first row of printing apertures can "consume" more charged toner particles than the second row which has to select charged toner particles from a toner roller that is already partly exhausted. As a result the printing density through said last row of printing apertures is diminished. This leads to white stripes in the printing direction and is commonly described as "toner depletion". In figure 6 a printout of a gray wedge is shown on a HP laserprinter and on the ITO F-Fax 385D fax using TonerJet™ technology.

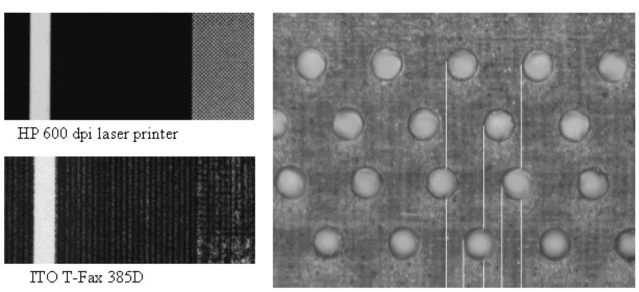

Figure 6. Toner depletion as shown in ITO T-Fax 385D

As indicated above the geometry of the printhead structure can be adapted so that convergence or divergence in the toner path can be enhanced. An other way of improving the toner depletion is the use of deflection electrodes that can deflect the straight toner path to a left and right direction. The main drawback however is printing speed which drops as the deflection mechanism is introduced. Various deflection mechanisms and printhead structures comprising deflection electrodes have been described.[8-11]

If toner adhesion is minimized then we found that with printhead structures that only comprised 2 rows of printing apertures, good grey level density areas could be printed by using a shading correction for both rows. So the difference in toner supply for both rows can be compensated by adjusting the time modulation.

Toner Characteristics

The best results were obtained by using two-component developer of the type used in the Agfa CHROMAPRESS™ printer, in an applicator comprising a magnetic brush and a CTC-roller. The characteristics of the toner were adapted for extremely narrow charge-to-mass-(q/m)-distribution, constant and reliable q/m-value, and excellent toner flow characteristics. Q/m-values above |-17 µC/g| cause a dramatic drop in D_{max} and reduced sharpness of printed lines, under |-7 µC/g| a dusting problem occurs leading to image fog and nozzle blocking. If the adhesion between the toner and the surface of the toner source is too high, then again loss in D_{max} and uneveness in images is obtained.

It is thus clear that tuning of the physicochemical and rheological properties of the toner particles is extremely important for obtaining good printing results.

Compared to nonmagnetic monocomponent toner processes, the magnetic brush – CTC combination scores extremely good in terms of avoiding toner adhesion to the printhead structure and as a result in terms of image quality and reliability.

Printing Results

Different test patterns and real-size (A0) large format images were printed with different commercial large format printers (Vutek airbrush printer, NUR Blueboard continuous ink jet printer, Idanit piezo ink jet printer, 3M Scotchprint electrostatic printer) and a prototype EleJet™ printer using printheads with an intrinsic resolution of 85 dpi at 16 grey levels, as described above.

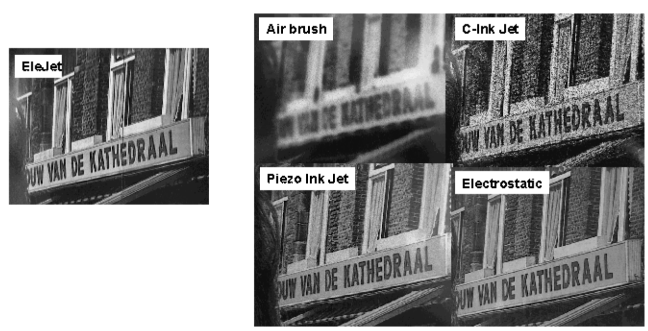

Figure 7. Comparison of wide format printing results

Due to the combination of a relatively high number of gray levels with a moderate resolution, an excellent image quality at high printing speed is obtained. An AC-field of 1600 V^{ptp} at 3.0 kHz with a DC-offset of +180 V is applied to the sleeve of the CTC-roller. The distance between the printhead structure and the CTC-roller is 260 µm. To the sleeve of the magnetic brush, located at 750 µm from the surface of the CTC-roller, a DC voltage of +155 V is applied. A DC voltage of +1250 V is applied to the back electrode that is located at 1000 μm from the surface of the printhead structure and over which the paper is travelling at a linear speed of 3 m/min. The control-IC's are switching in a time-modulating way from the +280 V of the coupled power supply, to 0V. A DC voltage of +130 V is applied to the shield electrode.

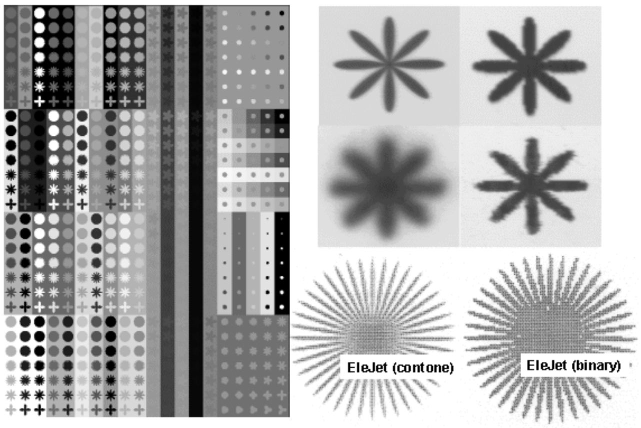

Figure 8. Comparison of wide-format-printed objects

Figure 8 shows an example of printouts of technical originals in which the object rendition is visualized for images printed with these different printing techniques.

It is clear that acceptable image quality is realized by using binary 300 to 600 dpi printing technology, but also by using 16 level 85 dpi printing technology using printhead structures with relative large aperture sizes.

Conclusion

EleJet™ technology is an excellent example of a dry printing technology wherein an optimized compromise between resolution and contone levels has been implemented.

Furthermore, the relatively large printing apertures are fed from a toner source with well-behaved toner particles so that toner adhesion and resulting image degradation can be reduced to a minimum level.

Only the combination of using an optimized toner (relatively low charge-to-mass- ratio with narrow distribution, high toner fluidity) with an optimized toner applicator (magnetic brush – CTC assembly) and a printhead structure derived from the original Pressman invention, leads to sufficient reliability, required for industrial wide format digital printing applications.

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Biography

Guido Desie got a Ph.D in the laboratory of Prof. De Schryver at the K.U.Leuven, in the field of physicochemical analysis of enzymatic systems. In 1987 he joined Agfa Gevaert, Belgium, where he was involved in R&D of physical properties of film materials. From 1991 he was involved in R&D of Ink Jet and Toner based digital printing techniques. He is co-author of about 25 granted patents mainly in the fields of Ink Jet and Toner Jet printing.