The Future Potential of Digital Electrophotography

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Abstract

Today, production scale digital electrophotographic printing has the performance level of low-end offset printing, both in terms of speed and quality. The rapid development will gradually lead to achievement of a certain level that is sufficient for current printing applications. This study addresses the issue of the potential of electrophotographic technology.

The development of ink jet technology from its original identity as a personal printing and coding method to wide format industrial and photographic printing has been phenomenal. Today, ink jet technology is a unique tool in digitalizing the manufacturing process in the electronics industry, and offering a low cost high speed option. If this route provides a model, could it also be the route for the future of electrophotography? Or, phrased in another way, is there hidden potential in electrophotography which could be harnessed to generate something else than just printed images. What are the similarities in the development of both of these digital processes? And at which critical points do they perhaps go to totally different directions? Or do they possibly coexist in hybrid printing solutions?

This paper tries to open the discussion around the above questions using an analytical model. Different forms of electrophotography such as powder and liquid based methods are assessed. Control of optical, electrostatic and, mass and heat transfer phenomena in a variety of configurations are considered as the key components and enablers for the future development of electrophotography.

Introduction

There is no doubt that the market share of both digital technologies, ink jet and electrophotography is increasing rapidly as the demand for fast, cheap and high quality customised print output grows. The customisation of jobs by variable information and on-demand production of updated contents is the core of nearly every business sector such as direct marketing, advertising, publishing, packaging, labeling, business-to-business communication and other industrial applications. These are already pushing the development of these technologies to the directions that fulfill the need of those applications. Speed, quality and performance factors, which -at the end- determine the cost per job, are the driving forces behind the rapid development of these technologies.

In general terms, obtaining high speed means sacrificing the quality and vise verse. If the quality and speed reach a satisfactory level for image printing, other applications such as deposition of conductive polymers may benefit from further development. Different features of each method such as one being dry and another liquid-based, could contribute an added value and/or solution for certain problems. A hybrid combination could be accomplished in any logical order[1]. For instance, a layering process by dry toner and then patterning by additive non-contact ink jet.

Ink jet Development Model

The development of ink jet technology as a digital, flexible, additive, non-contact and wide format printing method has already been utilized in deposition in the electronics industry. The manufacturing scale has not been achieved, but the success is observed at the laboratory scale, where different conductive polymer materials are modified as functional materials, for processing by ink jet method. The diagram in Figure 1A shows the development route of ink jet technology.

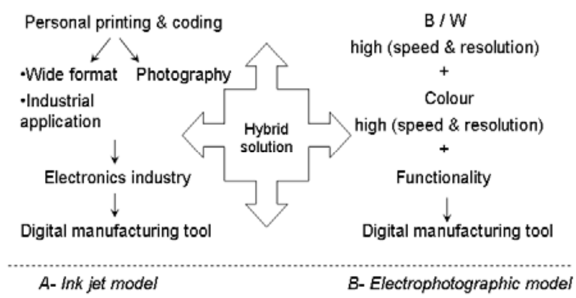

Figure 1. The development models of digital methods, ink jet and electrophotography.

The great advantage is associated with low cost production at high speed and the appropriate liquids in which the conductive polymers are diluted (dissolved) to form electronic ink. Ink jet is appealing because personal ink jet printers are very cheap, flexible and easy to work with, with fewer process parameters than in electrophotography. As a result, ink jet machines have been subject to extensive experimental trials in the deposition of several functional materials for many feasible applications.

Electrophotographic Model

Electrophotography is a very sophisticated and at the same time complicated technology. Seven process stages are involved to complete a full imaging process. There are different technologies for each of the seven sub-processes. If certain technology considered to be used, it must be optimised and integrated with the rest of the sub-processes in order to produce a synchronised printing process. Single step optimisation is done according to the duty of the sub-system, based on the sub-process parameters, and the material properties of which the sub-system is made of. Several dynamic phenomena are involved in the process; optical, electrostatic and, mass and heat transfer, they are intertwined and interoperated along the process with help of mechanical motion to produce the final print in a cost effective and fast manner without harm to human and environment. These are the key elements of the analytical model developed to assist the development in any configuration related to electrophotography.

Assigning the above model requires every detail for each part and sub-process. For example, in dry toner technology, image quality is determined by many factors such as toner and paper properties, and each of the seven stage parameters. Further, the speed and output quality are limited by some of the factors such as laser wavelength, optical and electrostatic system, photoconductor's sensitivity, critical electrical and thermal properties of paper or any other substrate used, and toner material and particle size. It is possible to increase the resolution by using short wavelength laser with effective optical and other systems to achieve high latent image addressability[2], but to a certain level, the toner particle size will play the major role in determining the final image resolution. This is -of course- regardless of the fusing sub-system effects.

The toner particle can be produced in a size range of less than 2 microns, but with less than 5 microns it will lose its reological properties and cannot be controlled by any optimisation in printing process.[3] This kind of problems and/or limitations evident in dry electrophotography, were solved by liquid toner technology, where the process becomes leaner, faster, cleaner, and the image quality is printed better on wider verity of substrates.[4] The solution is achieved by reducing the number of process stages, and optimizing the parameters to ensure that melting the toner particles, drying the hopping liquid and transferring the image to the substrate are all done at one stage with full efficiency.[4]

Additional to the colorant pigments and other additives the thermoplastic polymer resin as a binder is the major part of a toner mixture. This mixture has to be chosen to produce electrical and thermal properties suitable to the sub-processes parameters involved in the toner preparations such as charging and developing the toner onto the photoconductor, and then transferring and fusing it into the substrate.

Some functional materials such as polyaniline, is already diluted with liquid and processed by ink jet. If it will be processed by electrophotography, then at which view this conducting polymer should be seen? This material could replace all or portion of the toner powder or liquid. The sub-systems and parameters should be optimized to achieve desired quality using new mixture. In this case the printing process is now approaching a digital manufacturing tool for functional applications.

Conclusions

This paper tries to open scientific discussion to find the limitations of future development in electrophotography, and foresee the feasibility of this technology or a part of it in the electronics and conductive polymer industry and in augmenting printing matter with new functionality.

The analysis suggests that the existing technologies may have hidden potential to undertake the process of functional materials. Electrophotography offers a lot of latitude for customizing toners.

References

1. Kipphan H., *Handbook of Print Media*, pp. 721 & 765, HEIDELBERG, Springer (2001).
2. Melnyk R, *Higher resolution for Color Laser Printers and Copiers: Why and How*, ICIS'02 Tokyo, pp 496-498.
3. AL-Rubaiey H. et al., *The Influence of Flash Fusing Variables on Image Fixing Quality*, ICIS'02 Tokyo, May, 2001, pp 575-577.
4. Chatow U., *The Fundamental of Indigo's Digital Offset Color Printing Process and How It Rivals Mechanical Offset Printing*, pp 21-25, DPP2001, May 13-16, Antwerp, Belgium.

Biographies

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