Printer Technology : Evolution and Future Prospects

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In our daily activities, at work and elsewhere, we are always benefiting from the advantages of materials recorded on paper. In the office, our work is based on the use of reports, memos, circulars, and other documents. And in recent years, it has become common practice to print out documents created on a computer, or information downloaded from the Internet. Then there are, of course, the print-based media, such as newspapers, magazines, and books. The main features of documents recorded onto paper are : readability, handleability, preservability, searchability, transportability, and processability.[1] Paper documents are particularly easy to read and this, allied with the fact that are easy to handle and to preserve - once something has been transferred to paper, it stays there - means that they provide an interface for visual information that is excellently suited to human beings.

If paper is currently the best interface for use by people, then printers are the devices which record information from computers onto that interface, and the increasing number of pages printed out to paper are testament to the way that paper has been able to display its excellent characteristics as a medium, with the advent of computers and printers.

Printers are developing at immense speed in the direction of high image quality, compact design, low price, high-speed output, and colour printing. The range of printer applications is growing ever wider, with a whole range of different printing methods being used to satisfy various requirements and conditions. As well as domestic and office use, printers are being used to produce tickets, barcodes, posters, signboards, and much more. Here, I would like to take a look at the evolution of printer technology.

The evolution of printer technology

Since printers serve to record electronic information onto paper, then we also have to consider the history of the technology used to create and transmit that electronic information. The range of information handled has expanded with the advances made in LSI, processing and digital camera technologies, and printer technology has developed in response. Many different principles and methods have been researched and developed in the field of printer technology, and a range of different principles and methods have also been used in the market. The first development was an electric version of the typewriter, a mechanical printer using moving type (or "impact printer"). Various printing systems using technologies other than impact printing were also investigated, to meet demands for faster printing speeds

and broader printing capabilities, including kanji characters, for instance. The term "non-impact printing technologies" was coined to cover all those systems outside the predominant field of impact printers, and the 1st International Congress on Advances in Non-Impact Printing Technologies was held in Venice, Italy, in 1981. This year's conference (2003) is the 19th and is being held under the title of "NIP 19 International Conference of Digital Printing Technologies". In recent years, this conference has developed into a major event involving several hundred participants, not only from the fields of printing technology-related materials and process technologies, but also image processing technologies and applied technologies as well. This illustrates the way that non-impact technology has grown beyond the areas of materials, devices and system applications, and expanded into broader areas of technology.

Various physical and chemical mechanisms have been researched for possible application to non-impact printing. Systems using light, heat, static electricity, pressure, chemical reactions, and so on, have been developed, but the most recent trends have been towards inkjet or electrophotographic printers, in terms of market sector, and towards liquid or powder based dye/pigment. Fig.1 shows a comparison between inkjet and electrophotographic printing. Printer technology is required to affix a dyeing material to a sheet of paper accurately in the pattern of an image or text. Compared to inkjet technology, electrophotographic printing involves a relatively complex mechanism involving 6 separate processes: charging, exposure, development, transfer, fixing and cleaning, as illustrated in Fig. 1. In the case of colour printing, it is more complex still, requiring the formation of four toner images.
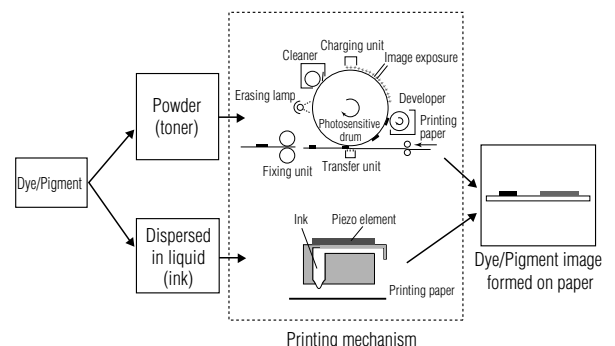

Fig. 1   Comparison of the two main printing technologies

Ink is a liquid and has a drawback in that the special type of paper must be chosen to ensure suitable quality, but in domestic applications, it is considered to meet requirements satisfactorily enough in terms of printing quality and volume. Powder (toner), on the other hand, has a key advantage in that it can be used with any type of paper, although in colour printing, further improvements in image quality and capacity are expected. If quality, in particular, can be brought to the levels of professional printing, and print speed and per page costs can be improved, then this type of printer could gain an extremely broad range of application.

Electrophotographic printing based on powder dye/pigment is the main printing method used commercially today, but the basic recording process used has not changed since its invention by Carlson in 1938. However, huge advances in materials, mechanism design, and processing technology have combined to allow massive improvements in performance and functionality, leading to today's compact printers which achieve high speed and high print quality.[2] For example, with research into many different methods for the optics systems used to scan over the photosensitive drum, printers are currently being fitted with laser scanners and LED arrays. This last device enables a solid-state design which eliminates moving parts, such as rotating mirrors, and the like, and whilst the first trial printer fitted with an LED array achieved only 10 dots/mm (254 dpi),[3] steady efforts to achieve higher image quality have produced the 1200 dpi LED arrays [4] which can be found in commercial printers today. This compact light scanning mechanism is capable of focussing a sharp light image across the whole scanning range, and overall, this scanning system is close to ideal.

From the viewpoints of image quality, device design and image durability, the developing stage is very important. Today, new toners manufactured by polymerisation, which is suitable for achieving small particle size, are being used alongside the traditional toners made by crushing. With moves towards even better image quality, reduction in toner particle size will continue in the future and the usage of polymerised toner is set to increase. Liquid development is also being reassessed as a means to achieving high image quality. I would identify the key areas of future development to be high-resolution optical scanning methods, and the developing methods required to extract the full capabilities of these scanning methods.

Apart from electrophotography, there are other powder-based (toner-based) printing methods, such as TonerJet ® [*1], which form a toner image directly onto the paper. These systems still have many problems to resolve, but the simplicity of their printing mechanism makes them an attractive subject for future development.

The challenge from display technology

Recently, there has been a great deal of discussion about digital paper (electronic paper), one of the new technologies relating to printers.[5] Paper is an outstanding interface, but it does not allow rewriting. A display, on the other hand, although capable of depicting moving pictures, does not as yet have the same readability as paper, or its flexibility. Research efforts have been aimed at coming up with something that covers both of these media. The many proposals include a system using movable toner, a gyricon which causes spheres with different optical reflectivity on either side to rotate, or the use of electrophoretic deposition.

In the ubiquitous society, we can expect people to show an increasing desire to see the information they obtain displayed immediately on media that are as easy to read and handle as paper. Someday in future, there may well come a time when we read our newspapers on display media which are the same size as today's newspapers, and as easy to handle, but which incorporate reception and display functions.

Future prospects

This paper has looked at the evolution of printer technology and the outlook for printer related technologies. In the future, manufacturers will be required to meet various demands, such as achieving higher image quality and more compact designs, whilst meeting environmental concerns. Paper is easy to read and handle, and its non-eraseability gives a psychological feeling of security, and for these reasons, I can see it continuing to play a central role.

As Internet and mobile device-related technology advances, in addition to improving image quality, printing speed, etc., we will need to centre our research and development efforts on the achievement of information systems which make full use of the characteristics of paper and take account of how we humans think, and how we perceive and react to things, both at work and during our other daily activities.

■ References

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4) Winner of 2001 Technology Prize awarded by The Imaging Society of Japan.

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*1) TonerJet is a registered trademark of Array Printers AB.