High-Speed Color Laser Printing

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Abstract

The market expectation to high-speed color laser printing technology is growing every year, and the boundary between large volume printing within offices and industrial printing is finally about to disappear.

Big factors for such changes are
1. Rapid development of network environment,
2. Improvement of on-demand printing performances, realized by evolution of polymerization toner, related technologies and other technologies such as image-processing,
3. Improvement of color image quality,
4. Realistic prices and so on.

From now on, more and more information will be digitalized, and when customers stick to output on paper, key points of customer requests would be that they can print on any type of paper, at high speed, with high quality and with high reliability, completed with a nice range of finishing procedures. Therefore, it will be important to further scale down toner particles, lower particle adhesion, and enable low-temperature fixing.

In the high-speed color laser beam printer domain, therefore, technologies with polymerization toner as a core technology will surely gain more importance.

Introduction

Dr. C.F. Carlson succeeded his invention experiment of the electrophotographic (EP) process in 1938, and 66 years since have already passed. Even today, however, the EP system reigns over the world of digital information as the main equipment of document output because the system has basically great potential capability in principle. In recent global transitions called digitization and color conversion, the EP system has reached the present leading position through various technical innovations.

In this paper, firstly I would like to describe the role of the information equipment in business of today and focus on the color laser printing market trend and its requirements. Secondly, I will summarize current technical innovations in EP supporting the color laser printing market. Finally, I would like to propose how to provide expansive new value in this domain responding to a request from the customers worldwide.

Market Trend

The business environment surrounding an information equipment industry has changed rapidly in all aspects including technology, market and competition, as shown in Figure 1. It is thought that especially the evolution of computer environment technology and the spread of Internet are changing the customer's print workflow itself. That is, the digitalized information runs around the world instantly, and it is processed and outputted everywhere in the world. The enlarged informational reproduction is just happening. Needless to say, the information is based on color and a wide variety of printout capability is required starting from personal printer to office MFP and high-speed POD output devices. Further technical innovation of color laser printing is expected from the market, as the central equipment. Especially, the high-speed color laser printer is requested to advance further for the new print business, which include online bookmaking and short turn around printing.

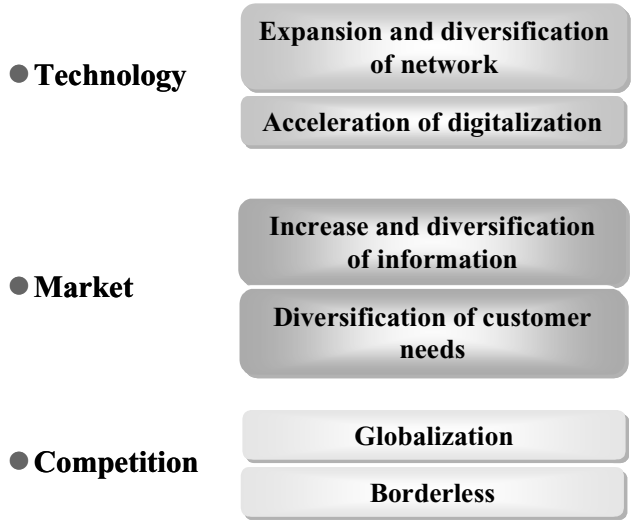


Figure 1. Business environment surrounding an information equipment industry

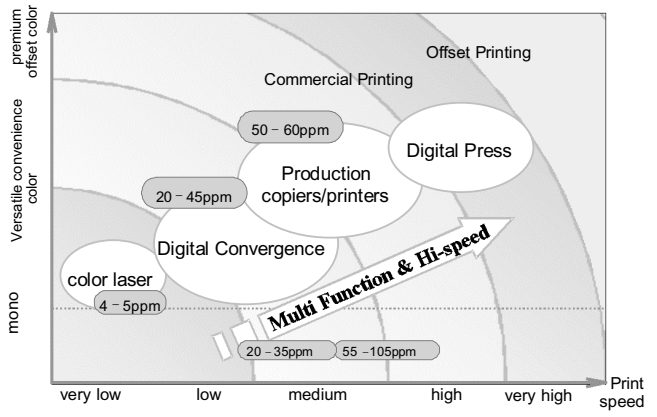


Figure 2. Diversification of printout capability and corresponding equipments

The Progress in Digital EP Technologies

Since the launch of the first digital color copier in 1987, color EP technology has made remarkable progress continuously. One of the concrete proofs can be shown in its image quality. We feel ashamed when we now look at a print sample of the early years. A few years later, we will feel the same when looking at a present print sample. The other progress, such as the extension of its print speed and its performance has satisfied the diverse user needs by diversifying each fundamental technology correspondingly. Reliability has been improved by sustained studies and cooperation among every engineer in mechanics, materials and electronic hard- and software. Major market surveys report that most customers are satisfied with the reliability of their color EP peripherals.

Figure 3 shows the trend of the progress in speed of color EP products. Early products were targeted only for a creative or advanced office. Till about 1995, major makers have brushed up their first models and established their color EP technologies gaining advantage in image quality and reliability. After 1995, color EP market began to separate into three regions;

1. Low-end compact machines for SOHO
2. Conversion from B/W MFPs for middle office
3. High speed machines for POD

Main technical subjects required in the low-end region were downsizing of the four-cycle mechanics and practical designing of the imaging cartridge utilizing non-magnetic single component color developing method.[1] These technologies allowed large-scale manufacturing of low priced engines around 1997. Further downsizing and cost down has since been going on.

In the middle office region, it is the most important issue how to suppress cost per page of a color machine to a level of B/W MFP's in order to convert current B/W machine into a color machine. Improving durability of consumables and decreasing amount of toner consumption by improving transfer efficiency and utilizing small particle sized toner have been investigated continuously. As a result, practical use of small sized polymerized toner started in the products for middle office and it is now expanding to the low-end and into POD machines.

The period from end of 2000 to beginning of 2001 was a turning point of changing major engine technology for middle office from four-cycle system to compact tandem. At this time, CP2150 (Canon), CF2001 (Minolta) and DPC2220 (Xerox) were delivered one after another. CF2001, DPC2220 and their successors are the compactly designed tandem engines made possible by applying intermediate transfer belt.[2,3] Intermediate transfer belt has also improved reliability of image quality by reducing the dependence on a variety of transfer materials. These machines triggered the following stream of developing compact tandem engines. Since the period, various tandem engines have been proposed shown in figure 4.

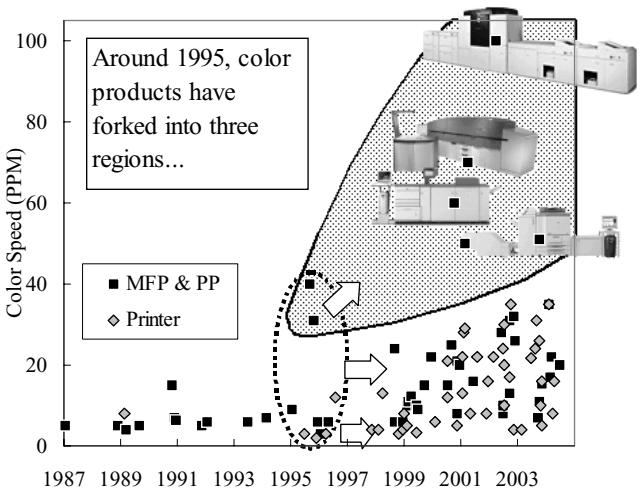


Figure 3. Trend in color EP products (only new or upgraded engines are plotted)

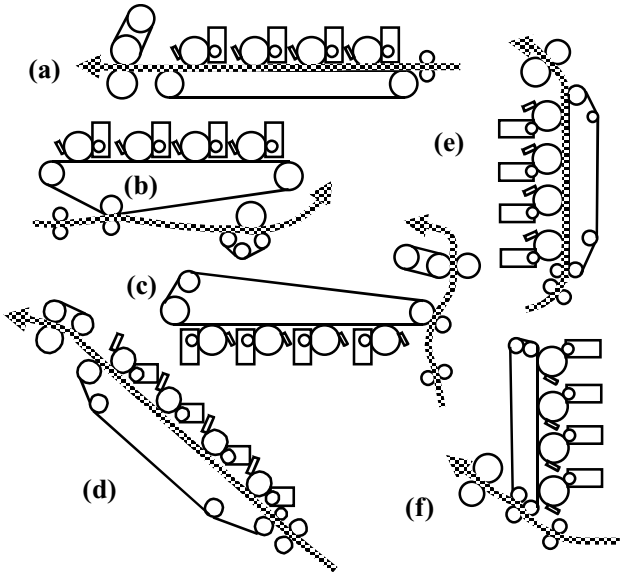


Figure 4. Various layouts of typical tandem engines, which are delivered recently

In the area of high-speed engines, a pioneer appeared around 1995. After Xerox launched CDT60 in the latter half of 2000, a new market for POD has been cultivated and now this market is expected to grow for EP as a substitute of short-run offset printing. In this region, further quality and reliability improvement is required. Nowadays, small sized polymerized toner has been utilized up to 50 ppm and further extension is expected.

Key Technologies for High-Speed Color EP

High-Speed Tandem Engine

The essential issue to increase reliability of the high-speed tandem engine is the applicability to various types of paper, which may be used in the POD market. Every device and its layout should be designed for meeting above requirement. One effective choice is to design the straight and simple paper path from the paper supply to the exit for stable paper transportation. Another is to apply an intermediate image-receiving device on which 4 color images are superimposed. By applying such a device, stability of image quality against the paper variety is expected to be improved because 4-color toner images are transferred to the paper all at once.

Figure 5. Konica Minolta 8050

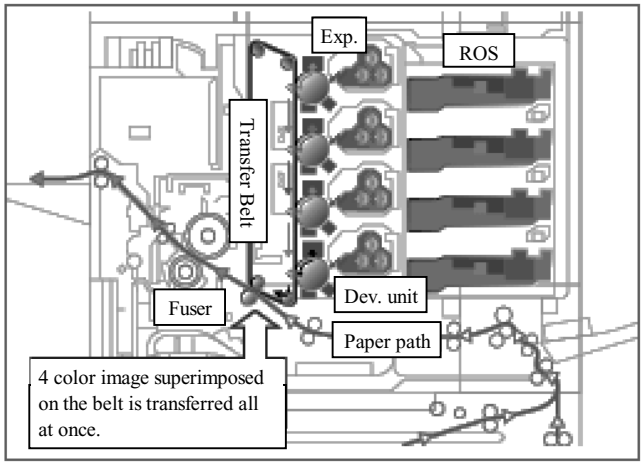


Figure 6. Cross section of 8050 EP process

The fact that recent high-speed color EP engines, such as CDT60V (Xerox),[4] iGEN3 (Xerox)[5] and 8050 (Konica Minolta),[6] are employing such concept suggests a direction of designing a tandem engine suitable for these segments. As an example, Konica Minolta 8050 and its cross section is shown in figure 5 and figure 6. One of the advantages is that 4 color imaging units are designed compactly in the vertical direction to suppress the machine size appearance.

Precisely Controlled Laser-Scanning Units

Exact image registration is a key for designing laser-scanning units of a tandem EP engine. Nowadays, automatic correcting technology is realized for detecting and controlling the registration by a combination of mechanical and electrical methods. Stable quality in image registration is achieved by utilizing these methods. Figure 7 shows one of the mechanical correcting methods for the leaning of scanning line.[7] These correcting methods are precisely controlled by a registration algorithm based on the results of an automatic detecting system. The automatic correcting technology for registration successfully provides not only improving image quality but also saves time and waste of consumables required for the expert's maintenances.

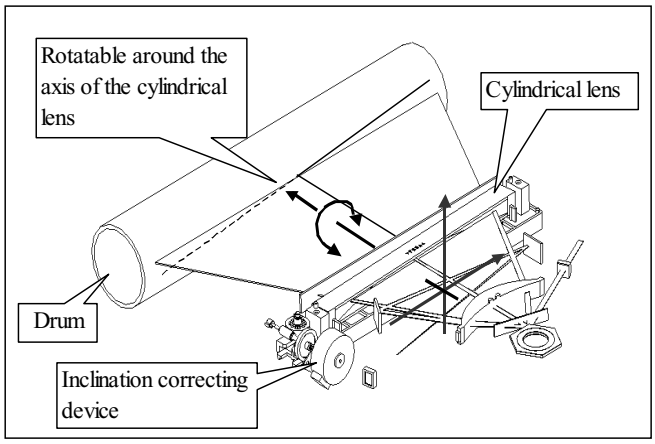
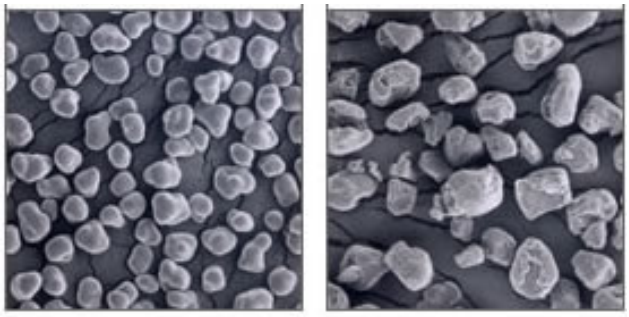


Figure 7. Mechanism for correcting the inclination of the scanning line applied in 8050

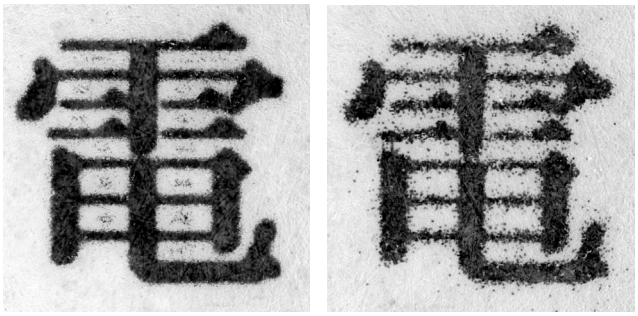
Chemical Toner and Developer

It is well recognized now that downsizing of toner particle is effective for improving image quality. Especially chemical toner produced by a method of emulsion polymerization and coagulation has advantages in creating fine and uniform particles easily and in controlling the shape of toner as intended from nearly spherical to non-spherical.[8] These advantages provide improved characteristics in the EP process such as cleaning, transfer and toner charging as well as reproduction of high-quality images in text, fine lines and halftones. Figure 8 shows SEM photographs for comparing toner shape and size between polymerized toner produced by the above method and conventional toner. Figure 9 also shows the comparison in text image between them.



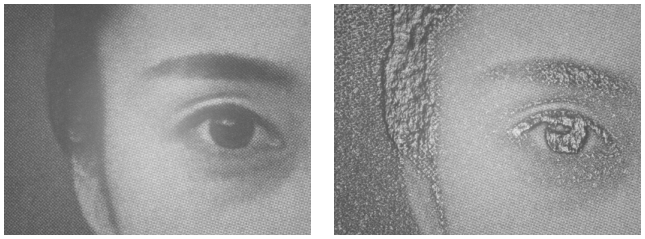
(a) (b)

Figure 8. Comparison in shape between (a) polymerized toner, D50=6.5μm, and (b) conventional (pulverized) toner, D50=8.5μm



(a) (b)

Figure 9. Comparison in image between (a) polymerized toner, D50=6.5μm, and (b) conventional (pulverized) toner, D50=8.5μm



(a) (b)

Figure 10. Comparison in gloss appearance between (a) polymerized toner with oil-less fusing and (b) conventional (pulverized) toner with oil-applying fusing

Further advantage of the polymerized toner is in its fusing ability. The polymerized toner enables containing a higher amount of wax as a releasing agent than the conventional toner. This increases its releasing ability without decreasing its mechanical strength. The advantage provides a non-oil fusing system and clears the troubles caused by defects of the oil-supplying unit. The gloss of the image by the non-oil fusing system appears to be on a proper level since the difference in gloss between toned area and the paper is small and its appearance is similar to the offset printing image. Figure 10 shows the comparison in gloss appearance between the polymerized toner image using non-oil fusing unit and the conventional toner image using fusing oil. The latter image looks worse by the non-uniform reflection in dark areas.

EP Process Units Employing Polymerized Toner

To show the real performance of the downsized polymerized toner, several EP process units and related technologies have been improved.

It is said the key in the developing unit to improve image quality and reliability is the realization of a high-efficiency developing method and an improved regulating device to assure a thin and uniform developer layer with low-stress on the particles.[9] These parameters are also applied to the unit employing polymerized toner with smaller particle size. For the high-speed engine, a progress of mixing device is shown in Figure 11.

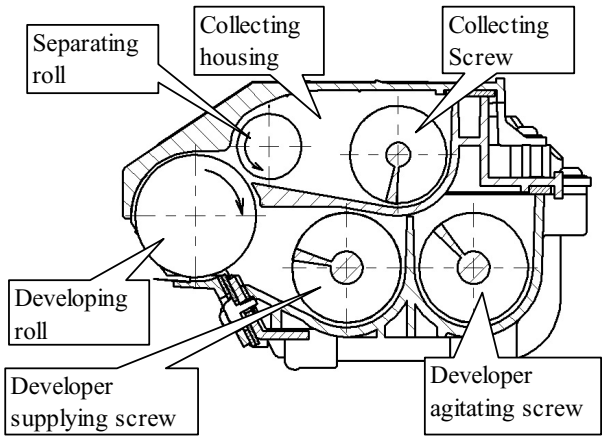


Figure 11. Schematic diagram of 8050 developing unit which is designed for a high-speed (50ppm) printing process

Key to the improvement of the transfer unit is suppressing noise caused by discharging or non-uniformity of the transfer electric field. Further improvement for precise controlling of the transfer electric field will be studied to cover a wider variety of transfer materials.

In the fusing unit, avoiding paper degradation such as blisters but keeping proper fixing strength and gloss uniformity is a key for the high-speed engine. Adaptation of fusing condition to the melting characteristics of polymerized toner will be further studied.

Not only improvement of each EP process unit but also following technologies are important such as:

1. EP controlling system for stabilizing image reproduction by organizing each subsystem to the unit
2. Image processing technology adapted to the EP reproduction characteristics
3. Image evaluation method and analyzing method as foundation technologies of improving image quality

The most important key is to integrate these various technologies into one printing system with efficiency. Each company belonging to the EP industry has studied these

subjects for a long time. Present success in color laser printing machines is the fruit of their efforts and the positive competition mind. Future advances in color EP technologies can be expected.

Future

All kinds of documents and information are changed into digital format. This accelerates the knowledge sharing over the network environment. Under this circumstance, color laser printing devices are predicted to expand their market by means of their handy print out capability.

The first step of market expansion is the conversion from monochrome MFP to color MFP in the office. As in figure 12, I predict that color MFP will grow rapidly for the next few years. As for the production area, I predict that color laser printing devices go toward their market formation; they will establish their market position and the color laser printing business will grow constantly.

The first step described above will create the following phenomena, which are seen already in some progressive offices today:

1. The quality of color laser printout will be recognized as the standard in the office.
2. It will be natural among businesspersons to produce and distribute color documents instantly at any place, ubiquitous environment.

These phenomena will be the trigger of the second step for color laser market expansion. It involves the light production market, which covers the crossover area between the production printing area and office high volume printing area, and the progress of high-speed color printing device, which is the mainstream in the light production area. Currently the light production area creates attention as it replaces the small size offset printing market. On the other hand, the color MFP based color printing environment is very convenient for business leaders to create own color document and produce distribution copies quickly on site. By fusion of these needs the color laser print volume will enlarge furthermore.

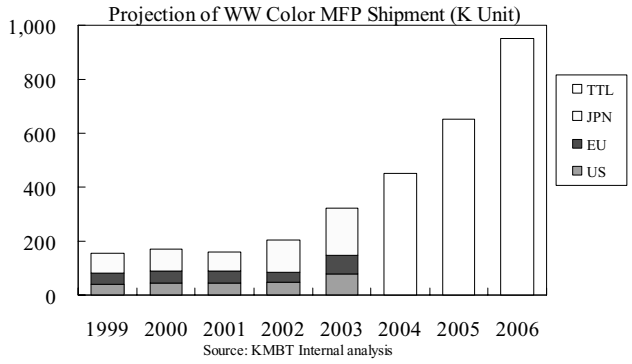


Figure 12. Projection of worldwide color MFP market

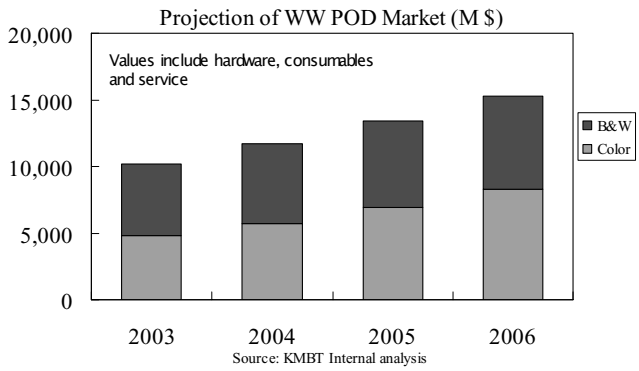


Figure 13. Projection of light production printing market, value base

The expected improvements in the light production area are to establish quality and reliability that satisfies requirements from both the offset printing market and the MFP based printing market. As regards the image quality, the toner functional advancements are important, therefore investments into smaller, lower consumption and higher uniformity toner will continue. As for figure 14, it predicts the expectation for more functional advancement possibilities so that the chemical toner will be more propagated.

After a long history of EP process there are still possibilities to improve the reliability by improvement of EP technology, especially the computer simulated process analysis, the optimized design scheme studies, functional material improvements and process control improvements.
I expect further progress of EP technologies and believe that Konica Minolta Business Technologies will participate in this progress.

We will continue to endeavor how to provide more additional value to the end user from a customer viewpoint, besides technical development viewpoint, since I believe that such business model approach is our mission.

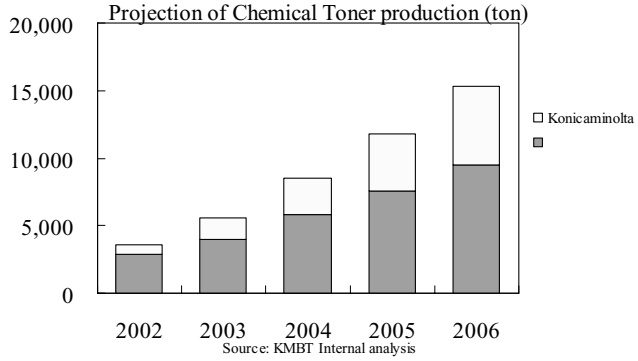


Figure 14. Projection of polymerization toner production by manufacture

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Biography

Shoei Yamana is Executive Director of MFP Sales & Marketing HQ in Konica Minolta Business Technologies. He received a bachelors' degree in commerce from Waseda University and joined Minolta in 1977. In 1996 he was promoted General manager of Corporate Strategy Division. In 2001 he was appointed CEO in Minolta QMS. In 2002 he was promoted Executive Officer in Minolta. Since Aug. 2003 he has been Senior Executive Officer in Konica Minolta Holdings. He is a member of Policy Planning Committee in Japan Business Machine and Information System Industries Association (JBMIA).