

Electrophotography – Small, Medium, Large Offices

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Abstract

More than sixty years have passed since C. F. Carlson invented xerography. Copiers and printers have been contributing to the improvement of productivity in all kinds of offices over those sixty years. Now technology advancements have made it possible to move from light lens to digital, from black & white to color, and from stand-alone products to networked appliances. Variable data and/or image can be printed in high quality at high speed with ease of use. The networked MFP accessible or operated by anyone, anywhere, and at anytime will move into the main stream in the office. Based on technical predictions of print quality, box cost, running cost, reliability, speed, and eco-friendliness for office copiers and printers, let's discuss whether electrophotography will remain dominant for another decade!

Introduction

What kind of technology will survive as an office print technology for the next generation? This theme is very interesting for myself who has been developing technologies and products based on electrophotography. In the low speed area, ink jet technology has entered many offices with taking advantage of the low cost and eco-friendly features. But ink jet is not favorable in plain paper print quality, duplex printing, and productivity. To solve them, it is required to produce pigment ink and wide-width print head in commercial base. On the other side, low cost approach is very active in electrophotography. It is said that we would go into intense survival race. When it comes to middle/high speed territory in offices, it is more than probable that electrophotography will keep up the competitive edge to other technology.

Hard Copies in Offices

Recent development of internet/intranet has brought the days of all kinds of machine connected to the network regardless of the scale of office. It activates the distribution of electronic documents instead of hard copies of document. In consequence, copying work decreases and printer output is on the increase, like it or not. Documents are colorized from its preparation stage by using PC's. Legacy documents

are also computerized. It is frequently seen in office so-called fusion of paper and digital document. Judging by these circumstances, it will be obvious that a print from electronic documents not from paper becomes popular. A hard print will be used as a transient throwaway media rather than for archive. What is required is to be capable of printing on any paper in high quality at less expense. Since network expansion has made the boundaries between small office and large office less definite, it will be required everyone is able to print on anything at any time anywhere.

Office Needs and Electrophotography Innovation

(1) Color Printer Cost Reduction

Reasonable cost is required for office products; i.e. box cost and running cost. General approach to lower box cost is to reduce processes, weight, and size. Weight saving would be the most efficient among them. Box cost correlates closely with weight as shown in Fig. 1¹.

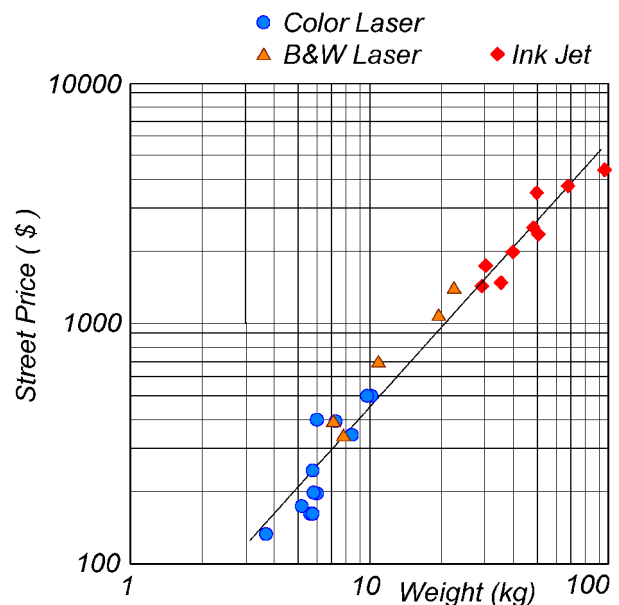


Figure 1. Street Price vs Weight

In 2000, some color printers are already available for less than \$2,000 at street price, and the cost will be further reduced in future. As for running cost, reducing both toner material cost and its consumption is effective. Spherical toner is a good example, which is recently applied to enhance transfer efficiency. Another example is to use fine toner to save toner consumption. But I must note that fine toner of less than 5 micron in diameter would narrow the latitude in every xerography process. Every component of CRU (Customer Replacement Unit) has been made long-lived, and CRU will become just one of machine parts. Toner would become the only one thing to be replaced in ultimate consequence.

(2) Print Quality Enhancement

Fig. 2 shows the trend of image quality improvement in ink jet and color laser printers. The value shown is an average of preference score on text, graphs, and photographs.

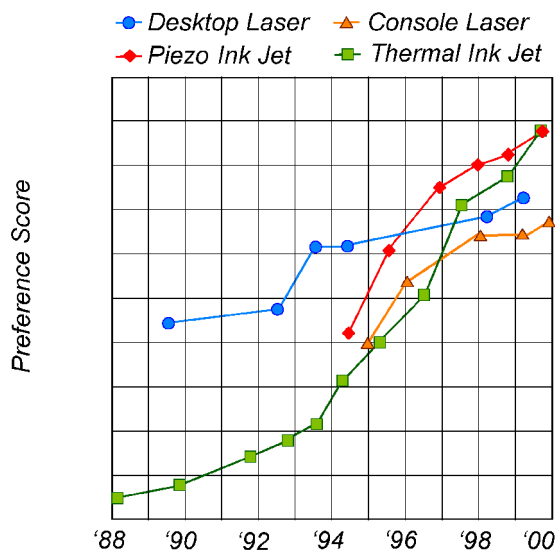


Figure 2. Print Quality Trend

Both printers are continuously improved, but ink jet shows rapid tendency because the initial quality at the market introduction was extremely low. Image quality has been enhanced by technology improvement as follows:

1. Resolution improvement
2. Fine ink drop
3. Dilution ink

Resolution increases from 180 dpi in the early '90th to 2400 dpi in the latest products by fine jetting device and highly precise print head scanning technology. Resolution contributes to enhance text image quality and to ensure gray scale. To improve image quality further, dot size on paper is to meet the resolution. Work on finer ink drop is being

advance by the increase of resolution. Thus, ink drop volume is reduced from 100 pl in initial stage to 3 pl today by making jetting nozzle finer and reducing ink path.

In the early '90th, ink jet dot was large and size-fixed. Its color density was high. You needed to leave a distance between each dot in low-density image area, resulting in high space frequency and graininess deterioration. In the late '96, dilution ink was introduced. With successfully improved resolution, fine ink drop significantly improved graininess.

The similar enhancement is ongoing for color laser printer as well. There are roughly two activities:

1. Resolution improvement
2. Fine toner

Resolution increased from 400 dpi in '90th to 1200 dpi in the latest products by laser scan line of high density. Since color laser uses solid toner for development, image on paper has a certain pile height. Reducing the pile height leads to decreasing image defect, that is, fine toner contributes image quality enhancement. In fact, toner diameter is miniaturized from 9 μm in '90th down to 6.5 μm today.

Both ink jet and color laser will continue to improve their image quality. Plain paper image quality would be the most important to ink jet. You would need to constrain image feathering at the image fringe on plain paper and to keep image density from decreasing caused by ink penetration into the paper. To achieve them, ink-focused improvement is expected.

(3) Productivity

Fig.3² shows the productivity trend. Ink jet data is based on the print of business chart in normal mode.

There are three activities to successfully improve the color productivity in color laser, which are the change from multi-pass to single-pass, process speed enhancement, and electric power saving. Since multi-pass uses a single photoreceptor, four-fold process is required at the photoreceptor to handle four colors; cyan, magenta, yellow, and black. That is why the productivity declines in 1/4 of that of mono print. Single-pass is structured by four photoreceptors, thus its color productivity does not go down. Process speed, which is rotational speed of photoreceptor, is increased from 50 mm/sec in '98 to 100 mm/sec in 2000.

Office appliance needs to have its electric power consumption less than 1.5 kVA. Energy saving is a key to productivity. By fuser improvement, low-loaded drive, and so on, the upper limit of productivity moves from 12-13 ppm in '98 to 21-25 ppm in 2000. For further enhancement, energy saving would be the most important.

Ink jet productivity is closely related to jetting nozzle count, jetting frequency, and print head scanning speed. The number of nozzles per color in average increases from 130 in '96 to 300 in 2000, and jetting frequency is also from 8 kHz to 12 kHz.

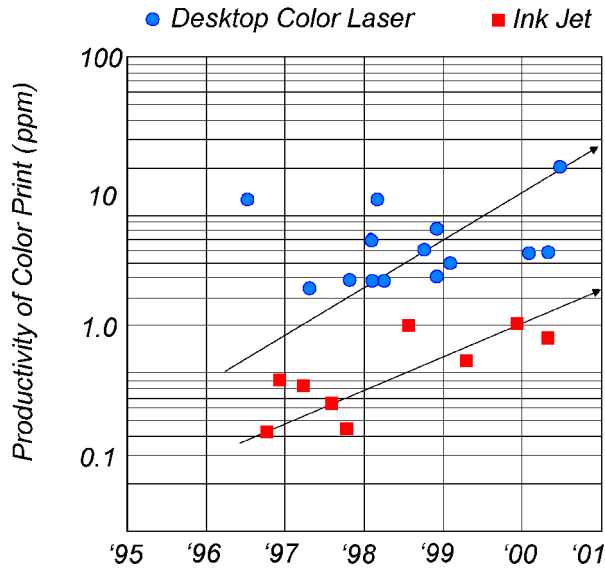


Figure 3. Productivity Trend

Today, ink jet productivity rises to the almost same level of that of color laser in '97. But there are severe problems for further speed-up. Increase of jetting nozzle or jetting frequency causes increase of thermal storage at print head, resulting in temperature raise. Since ink temperature beyond a certain extent affects printing, you must need to prevent the thermal storage. It would be required to further improve jetting power and energy efficiency.

Increase of the nozzle makes print head larger and heavier. You may need scanning technology to accurately handle the heavy print head at high speed. The biggest problem is to dehydrate paper. Ink contains a large amount of water and it is not possible to dehydrate paper by natural drying any more at high productivity. An external mechanism would be needed for dehydrating.

Not only technical barrier on ink jet is very high, but also the mentioned above contradicts to the intrinsic advantages of ink jet which are simple architecture and compact. It means the gap gets narrower between ink jet and color laser that is in process of downsizing and cost reduction.

(4) Ecology

Recently, consciousness for the environmental conservation is remarkably elevated, and attention is also paid to office environment improvement. Office appliances are now environmentally required to be low consumption in electric power, compact, low emission of CO₂, and recyclable. For better office environment, less noise and no harmful waste are preferred.

Ink jet is excellent in the mentioned above. For color laser as well, various activities are carried out such as downsizing, energy saving, less noise, and less ozone.

An ongoing approach to energy saving is to reduce energy consumption efficiency to a fraction of that of present. Fig. 4 shows the trend of warm-up time. Majority in the early '90th was approximately 500 sec, but today benchmark achieves 75-90 sec by making fuser roll thinner. Warm-up time is expected to be less than 60 sec in 2001. It will end up achieving instant-on equivalent to that of mono printer.

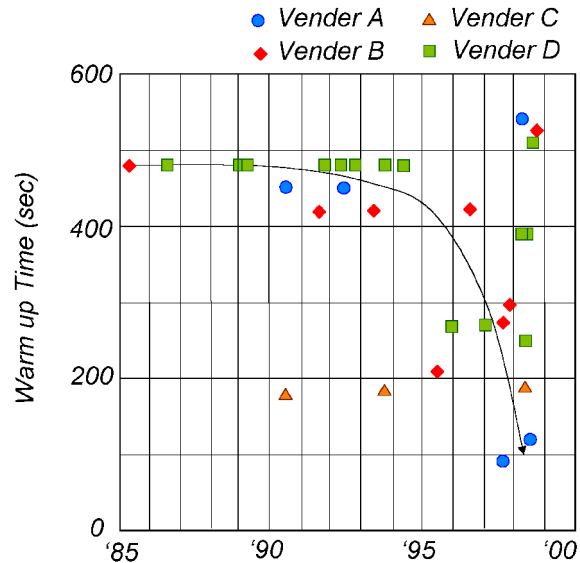


Figure 4. Warm up Time Trend

Long-lived photoreceptors and developer units are highly requested to reduce waste and to improve recyclability. Current photoreceptors and developer units are replaced after a certain volume of printing. Making them long-lived to the same level as machine body will accelerate the development such technology that you don't need replace or dispose.

Although ink jet is intrinsically ecology, speed enhancement would possibly cause enlargement of machine body and an increase of electric power consumption. To cope with this problem would become important for future.

(5) Value Added to Hard Copy

It is said that the copy/print rate in office will not grow on a large scale because of the trend of digital document and environmental issues. Research on electronic paper is also active. Depending on its result, paperless office would be realized. But paper remains to be used due to the excellent nature, that is, visibility, flexibility, and easy-to-carry.

Conclusion

As mentioned above, electrophotography is expected to continue to advance as a marking technology in offices. That is because it is superior to other marking technology in

total including image quality, cost, reliability, eco-friendliness, and network-ability. But ink jet technology is becoming a major player in and around SOHO market. Technology competition will be intensified between electrophotography and ink jet for small/medium offices.

Reference

1. The Hard Copy Observer and Others
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Biography

After graduating from Fukui University Japan in 1972, Mr. Kiyoshi Saito joined Fuji Xerox Research & Development Department. Since then he has been developing xerographic engines for Fuji Xerox7s copiers and printers. He has most recently been focusing on the development of color products, especially contributing to the development of DocuColor 4, DocuColor 12, DocuColor 40 and the recently launched DocuColor 2060. His current position is general manager of Research & Development Center at Document Product Company, Fuji Xerox. He is a member of the IS&T and the Imaging Society of Japan.