High-speed Color Printer Engine

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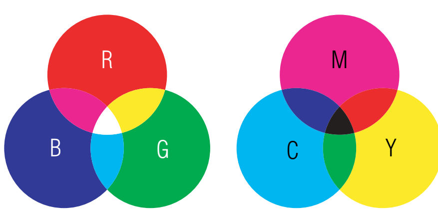
The demand for color printers is increasing steadily as more and more people add color to office documents. The market for color printers is diverse, ranging from office use to design use, and is becoming increasingly competitive in terms of functionality to print better-looking documents more quickly and more easily.

The high-speed color printer engine recently developed by Oki Data uses the functions described in this paper to enable the printing of better-looking documents faster and more easily.

Color Electro-photographic Printing Method

Display devices such as televisions and computer monitors synthesize colors using the three primary colors red (R), green (G), and blue (B), as shown in Figure 1 (a) using additive color mixing, where the mixture of all three colors produces white. In contrast, the electro-photographic color printer produces color using the three color toners shown in Fig. 1 (b), yellow (Y), magenta (M) and cyan (C), using subtractive color mixing where the mixture of all three colors produces black. A black (K) toner is added to these colors to increase the color depth and to reduce the amount of toner consumed.



(a) Additive color mixing (b) Subtractive color mixing

Fig. 1 Color Display Methods

When image data (RGB) is printed, it is separated into the four colors (YMCK), and colors and shapes are reproduced by clusters of dots, as shown in Fig. 2, where the smaller the dots, the richer the reproduction. In this regard, in addition to 600 dot per inch solutions, Oki Data's product line also includes 1200 dot per inch high-resolution print capability.

Faster

Color overlay methods can be divided broadly into the intermediate transfer method and the SinglePass Color®*1) method. The intermediate transfer method first forms the four color images sequentially in an intermediate transfer unit, and then transfers that color image to the paper all at once. In this method the speed of color printing falls to one quarter that of units which make monochrome images.

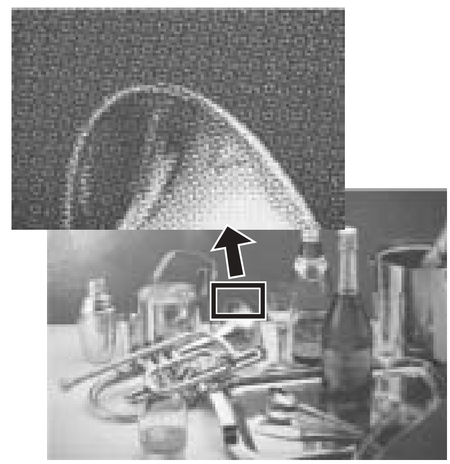


Fig. 2 A Print Sample (enlarged)
From ISO/JIS-SCID, Wine and Cooking Utensils (ISO400)

In contrast, the SinglePass Color® method, as shown in Fig. 3, has four color imaging units lined up sequentially along the paper feed path, and these units overlay the colors directly on the paper. Because the Single-Pass Color® method produces all of the individual color images simultaneously, the color printing speed is the same as the speed of each imaging unit, making it possible to increase the speed of color printing.[1), 2)]

To make the newly-developed high-speed color printers suitable for high-speed printing in office environments, SinglePass Color® technology enabled by a set of 4 digital LED heads was adopted and paper speed was increased. As a result, even higher printing speeds-37 PPM for monochrome printing and 30 PPM for color printing (assuming A4 paper)-were achieved. The basic specifications for the new engine are given in Table. 1.

In addition to increased speed, attention was given to reducing running cost and easing the burden on the global environment. This was accomplished by adopting a structure for the imaging units wherein the image drums are separate from the toner cartridges, making it possible to replace the toner cartridges only.

*1) Single Pass Color is a registered trademark of Oki Data Corporation.

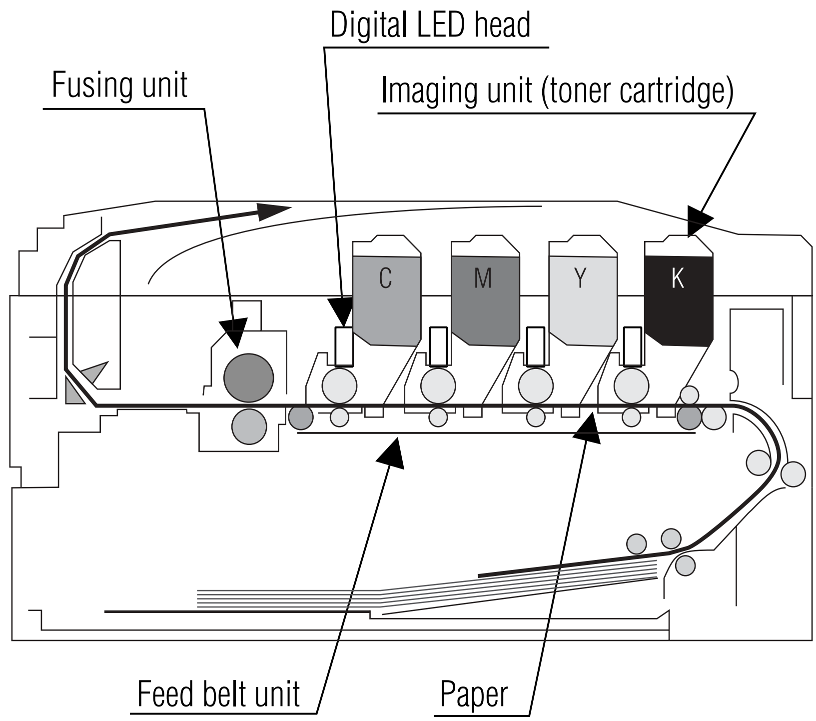


Fig. 3 Cross-sectional Diagram of a Single-pass Color Printer

Table. 1 Basic Specifications

		A3 Extended Printer		A4	
Print method		Full color electro-photographic method using a set of four digital LED heads.			
Imaging method		Dry toner single component non-magnetic imaging.			
Fusing method		Heat roll thermal fixing method			
Printing speed		Color: 30 pages per minute (A4 long edge feed)		Color: 20 pages per minute (A4 short edge feed)	
Normal paper/copy mode		Monochrome: 37 pages per minute (A4 long edge feed)		Monochrome: 24 pages per minute (A4 short edge feed)	
Resolution	Printing resolution (dpi)	1200 x 1200 dpi	600 x 600 dpi 1200 x 600 dpi	1200 x 1200 dpi	600 x 600 dpi 1200 x 600 dpi
	LED dot pitch (dpi)	1200 dpi	600 dpi	1200 dpi	600 dpi
Type of paper		Normal paper, specialty paper (transparencies, postcards, label paper, envelopes)			
Paper Tray		Multipurpose tray, first tray Option tray (second tray, third tray, large capacity tray)			

Improved Focus Accuracy

To obtain sharp images, the distance between the LED head and the photosensitive drum must always be maintained at the specified value so that the focal point of the LED head is on the photosensitive surface of the photosensitive drum.

With conventional distance-maintaining mechanisms, the distance between the two was established by seating the LED head, which was adjusted to a reference distance by a distance adjustment member, on a seat on the ID frame that supported the photosensitive drum. In this approach, it was difficult to eliminate variation in the distance between the two, due to the effects of the accuracy of the ID frame dimensions and the accuracy of the diameter and runout of the photosensitive drum.

The new mechanism for maintaining distance between the LED head and the photosensitive drum, however, provides several advantages over conventional distance-maintenance mechanisms. With this approach, the LED head rests directly on the photosensitive drum, separated by a spacer, and the following benefits are achieved:

(1) The effects of the tolerances of the ID frame have been eliminated.

(2) The effects of the tolerances of the diameter of the photosensitive drum have been eliminated.

(3) The effects of the photosensitive drum runout have been eliminated.

The LED head rests directly on the photosensitive drum through a spacer, so the LED head tracks with any variability in the diameter of the photosensitive drum and tracks with any runout as it rotates, keeping a constant distance between the two. In this way, using the new mechanism, accuracy of the focal point is improved, insuring consistently sharp images.

Automation of the Print Density Compensation Function

Color reproduction in an electro-photographic color printer is subject to subtle influences from a variety of factors such as the sensitivity of the photosensitive drum, the static electrical characteristics of the toner, and the environment where the printer is used. The colors produced by the printer will change gradually over time, making it impossible for the color printer to reproduce the same colors consistently. In particular, replacing the toner cartridge or the imaging unit will affect the operating conditions, so it is essential to calibrate the color whenever such replacements are done.

In conventional equipment, the user calibrates the printer by printing a test pattern and then inputting adjustment values using an operating panel after examining the test pattern. Fig. 4 shows the method that has been used. In the case shown in the figure, accurate color calibration is difficult because manual adjustments are required and because of the type of paper required for making the adjustments.

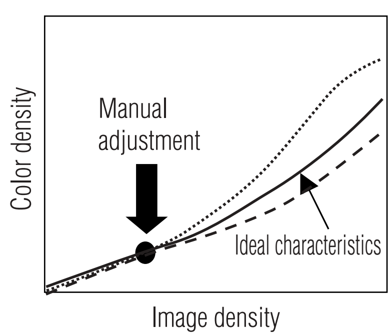


Fig. 4 Manual Adjustments

In the newly developed print engine, an optical sensor detects changes in the color density caused by changes in the environment or in the toner, etc., and uses an automatic calibration function to compensate for these changes automatically. On the other hand, it is still possible to perform color density calibrations manually, making it possible to respond to changes in color due to conditions that cannot be predicted automatically.

Color density compensation operations comprise two major steps. In the first step, the hardware control parameters are adjusted based on the color densities in each of the KYMC colors, as detected by the optical sensor, thereby reducing variability in the color density.

In the next step, the color density determined in the first step is measured again and the color density information is forwarded to the image data generator. In this step the image data generator makes adjustments to the color density in the software based on this information.

The color density compensation function described above is able to provide consistent color reproduction with a consistent color density by absorbing the impact of variability in the characteristics of the toner cartridges and imaging units.

Handling Special Media

The printer is provided with various preset printing modes for handling a variety of print media, such as printing modes for various thicknesses of print media, modes for printing on transparencies, and so forth.

On the other hand, in addition to print media that can be printed using the standard print modes, the user may also want to print on any of a broad variety of other print media, such as print media based on film materials, specialty label paper, or the like.

Oki Data’s newly developed printer engine is equipped with functions that make it possible to set additional combinations of print operation control parameters, ensuring high-quality printing over a broad range of such specialty media.

This increases the variety of print media that can be used with the printer.

Automatic Control of the Toner Fusing Temperature Based on Paper Thickness Measurements

Conventionally, users selected from a menu of four different paper thicknesses, “Thin,” “Standard,” “Somewhat thick,” or “Thick,” to input the paper thickness data into the printer driver where the toner fusing temperature was determined based on the paper thickness data as shown in Fig. 5. Because there were only four different temperature settings for fusing the toner, the temperature control for fusing the toner caused a stair-step pattern, rather that staying centered in the desirable temperature range for fixing the toner. However, increasing the speed of printing, for example, reduces the width of this desirable temperature range, increasing the likelihood that the print process will go outside of the desirable range. Likewise, if the user selects the paper thickness incorrectly, there may be problems with print quality because the toner is not adequately fused due to insufficient heating.

Oki Data’s newly developed high-speed color printer, on the other hand, is equipped with a mechanism that detects the paper thickness automatically. The paper thickness is measured by reading the change in position of an optical position sensor resulting from a mechanical movement caused by the thickness of the paper. The fusing temperature is controlled based on the paper thickness data thus obtained.

Fig. 6 shows an example of controlling the fusing temperature. The paper thickness data measured by the sensors described above is inputted into a paper thickness-fusing temperature optimization control algorithm that calculates the optimal fusing temperature for that paper thickness, based on a pre-set band for the desirable fusing temperature as a function of paper thickness (the gray area in the figure). This makes it possible to optimize the fixing temperature automatically based on the paper that is used.

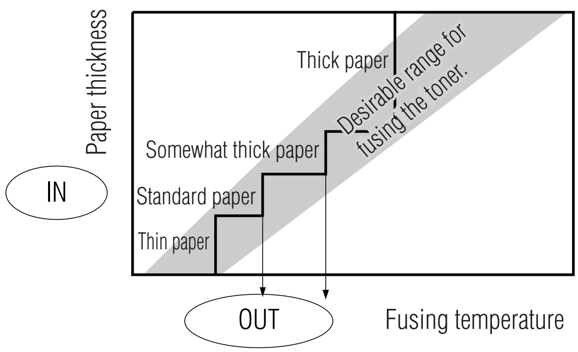


Fig. 5 User Input

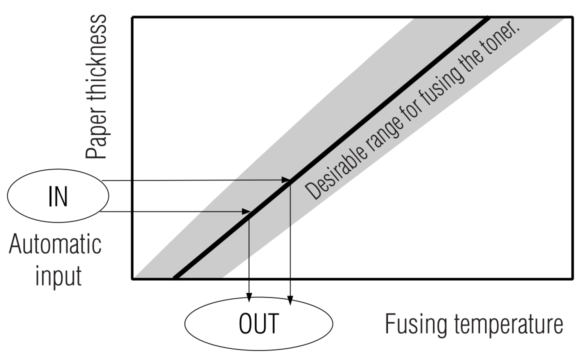


Fig. 6 Fusing Temperatures are Set Automatically

Conclusion

This paper has discussed the new functions of Oki Data's newly developed high-speed color printer engine. This printer engine not only increases the speed of printing through the use of the SinglePass Color® method, but also increases print resolution and utilizes automatic print density and paper thickness measurements for automatic feedback functions to provide the precise color reproduction required in color printers. Moreover, it does all this in a user-friendly way. Further technology development is underway in order to provide even more advanced high-speed printer engines. With a motto of "faster, better-looking, and easier to use," our technology developments are aimed at providing user-friendly, high-speed printing solutions.

■ References

1) Nakajima, et. al: "SinglePass Color Printer Using Digital LEDs," Oki Technical Review in Japanese, No. 185, Vol. 68, No. 1, pgs 124-127, January 2001

2) Yamamoto, et. al: "Color Electro-photographic Printer Engine," Oki Electric Research and Development in Japanese, No. 178, Vol. 65, No. 2, pgs 17-22, May, 1998

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