A Color Printer Solution

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In 2000, Oki Data introduced its second-generation color printers into the market.

At the time, our printers featured the world's fastest printing speeds. After improving the paper transfer functions, we knew that we could enter markets that were different from those of monochrome printers (including markets that were not included in our preliminary market study), especially with our A3-size printer. Although our original product design concepts focused on OA users, we also wanted to target graphics users. There were many uses for color printers that we were unable to predict beforehand, especially the use of color printers as capital goods for production operations.

Some representative features are described below.

(1) Since the printers are full-color printers, print results that are close to those of normal offset printing can be expected. Use in short run operations is possible (cases where the printer is used as an alternative because the small number of copies involved would result in higher costs if offset printing were applied).

(2) Complex print data can be printed out with little waiting because the printing speed for color documents is 21 pages per minute and because processing of color data has been accelerated with a special LSI chip.

(3) The printers are superior for handling thick and rigid media because the printers are configured with a linear paper transfer path.

Ever since the monochrome printer era, Oki Data's LED printers have been known under the Microline brand (market recognition is close to 80%) in digital graphics fields (which are generally called desktop publishing or DTP). In addition to these traditional markets, there has been an increase in the number of cases in which the printed materials themselves are sold. There has been a similar increase in the number of general customers who see the printers in stores and want to purchase them.

We found out that color printers are also being used for in-house printing at companies, such as for internal bulletins and simple catalogs. We were also able to enter the POP market, which refers to printed materials that are designed for their advertising and selling effects. These printed materials include supermarket price displays and sale promotions.

The characteristics of each market as seen from a color printer viewpoint are shown in Table. 1.

Electro-photographic color printers achieve full-color by layering developed toner through four printing processes. Previously, a printing method called 4-cycle printing was the predominant method used. For example, in A4-size printing, four color toners were layered onto an intermediate transfer drum that had a diameter of about 10 centimeters, and that result was transferred to a sheet of paper or some other medium (Fig. 1). Oki Data, on the other hand, adopted the "tandem 4" method, which has various merits. (This method transfers the toner directly onto the paper through four layered transfers. See Fig. 2.) With the tandem 4 method, in principle printing was no longer restricted by the length of the print medium. When such printers were first sold, this method was the first of its kind in the industry. Currently, however, nearly all color printer engine manufacturers provide products that use the tandem method. In the POP market, this feature is being used for printing onto long media, such as 900-millimeter or 1200-millimeter paper.

Table. 1 Features of special color printer markets

Market	Characteristic	Required performance
DTP	Color reproduction close to that of offset printing Frequent use of relatively thick media Printing to A3 elongated size Large data size per page Used predominantly in a Macintosh environment	Appearance close to printing press output Ability to handle thick paper Printing on A3 elongated paper High-speed image data processing EtherTalk support
POP	Frequent use of thick media Banner printing High-density printing with primary colors Large-volume printing Accurate color reproduction for company logos, etc.	Ability to handle thick paper Banner printing function Durable under continuous, high-density printing conditions Reliable/stable batch printing of mass data Fine color adjustment function
Medical	Printing to medicine packets Large-volume printing desirable, for prescription printing, etc. Sensitivity to consumable costs	Wrinkle prevention method Stable batch printing of mass data Low-cost consumables
Short run	Thick, glossy type media used relatively often Fastest possible engine speed Various media sizes ranging from posters to business cards	Print quality with thick and coated paper High-speed print performance Improved support for various media sizes
In-house printing	Speed requirement Sensitivity to cost per page	High-speed print performance Low-cost consumables

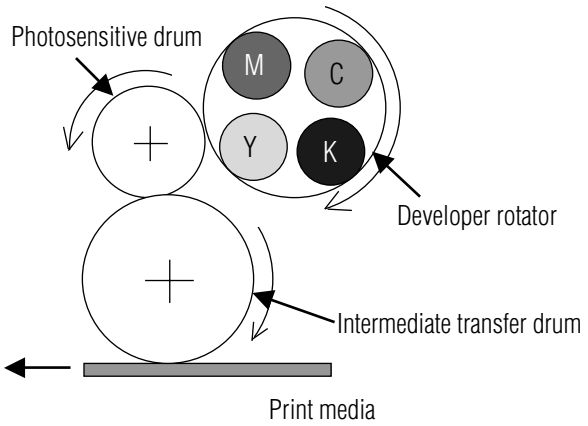

Fig. 1 Descriptive diagram of a 4-cycle engine

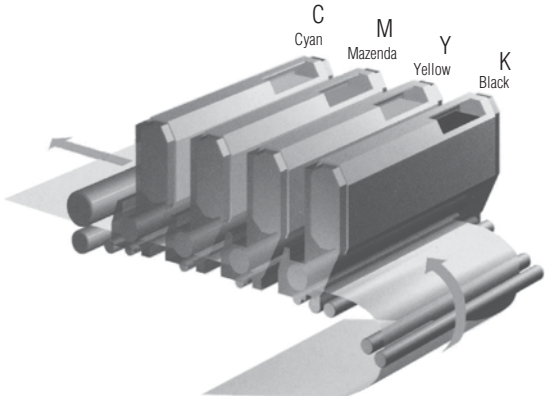

Fig. 2 Descriptive diagram of the "tandem 4" method

As shown in Photo. 1, the printers are equipped with hoppers (multi-purpose trays) and stackers (face-up stackers) that allow the printer to transfer the print medium without bending it at either the in-feeding side or the ejection side. Consequently, being able to construct a "straight path" that allows the medium to be transferred without bending became a feature of our color printers. The printers could therefore transfer thick and rigid plastic media, as well as thick media such as cardboard. This capability gave Oki Data an edge over our competitors.

In electro-photographic printers, electrostatic latent images are formed by light on the surface of the photosensitive drum, toner is fused to (developed onto) those positions, and the toner is transferred to the paper to produce the printed material.

At Oki Data, we employed light-emitting diode (LED) print head technology, which had been developed earlier at OkiElectric. Even now, the LED head technology is superior to the laser method. Its reliability is superior because there are no moving parts, miniaturization is easier because there are no mechanical parts, and theoretically the resolution can be enhanced because the size of light spots can be made smaller than the size of laser spots. By taking advantage of these characteristics,

Phot. 1 Straight media transfer path

we succeeded in developing the world's smallest class of color printers. Moreover, there remains the possibility of developing an even more compact printer design.

This article describes products that take advantage of these characteristics as well as application products that use the features of electro-photographic color printers and have newly entered the market.

Banner Paper Support

(1) Characteristics of the market

We held business negotiations with an OEM user from the U.S. and were able to provide them with what they wanted.

In the oil prospecting industry, a basic requirement is the capability of printing geological strata data for ongoing drilling projects onto banner paper up to 200 feet (about 60 meters) long. Previously, heat-transfer thermal printers were used for this purpose. However, with thermal printers, the printer itself was inexpensive, but the costs of the ink and paper used were high. Companies therefore began asking for an alternative product.

Having heard that Oki Data products supported banner printing, the OEM user called us for a consultation. The fact that Oki Data had sold this customer A4-size products for use abroad led to the initial contact. We launched a formal investigation to determine whether we could support the company's request.

(2) Problems in responding to the user's requirement with standard machines

With normal printer specifications, the maximum paper length is 900 millimeters. Compared to this, 60 meters can essentially be thought of as an infinite length. To print on paper of infinite length involved four major issues:

a. Command system

The page is a basic concept of all normal printer control commands (page description language or PDL). In 900-millimeter banner printing, the commands could be used to handle a paper size of 900 millimeters, but 60 meters was too long for the commands to handle. We had to build a new command system.

b. Underrun

The printer engine had to supply image data through a video interface and without breaks. If the engine was unable to supply data at the required timing, underrun would occur and a broken image would result. Therefore, we had to develop a means to avoid this problem, under conditions which are also affected by the data transfer speed of the host, whether it be a personal computer or a workstation.

c. Skewed media feeding

If normal media is fed obliquely, the print comes out slanted on the media but no other problems occur because the media has a finite length and the subsequent sheets are not affected. However when media of infinite length is used, even a slight skew problem would lead to endless skewed feeding. In other words, the media would drift away from the printing area and might break or become jammed. Therefore realization of zero-skew feeding was necessary.

d. Control of fuser speed

As described earlier, a normal fuser applies heat and pressure to cause the toner to adhere to the media, and a means of transferring the paper to the fuser was necessary. Oki Data's color printers use electrostatic force to make the media adhere to the rotating belt as it transfers the media. In fact, the media is transferred by both the belt and the fuser. Ideally, both the belt and the fuser would transfer the media at the same speed. However, the actual transfer speeds are different because of the variations in the accuracy of each part. If the fuser is faster than the belt, either the media is stretched between the belt and fuser and eventually tears, or the fuser or belt stops operating. Conversely, if the transfer speed of the belt is faster than that of the fuser, sagging develops in the media between the belt and the fuser. As the amount of sagging increases, the media contacts other parts, unfused toner moves around on the media, and smudging occurs.

TIPS Basic Glossary

Underrun

The personal computer sends commands for placing characters and graphics to various positions on the page. The image processing program of the printer creates a virtual print surface in memory and uses commands to draw images with bitmap information (color information for each point). Meanwhile, the printer engine draws the above image with toner on the media one line at a time, while the media is fed along. When the printer draws an image on the media while it is receiving data, it must plot the image into memory faster than the media transfer speed. Otherwise, a problem such as the omission of required data occurs. This condition is called underrun.

(3) New developments needed to support banner printing and our development results

a. Command system

Since fewer engineering manhours would be required for development if we used the normal PDL instead of designing special commands, we developed a method that would enable continuous printing while maintaining the page concept. In other words, we prepared a mode in which the printer "skips" any "blank spaces" between pages and we made the application send a command that selects this mode before sending the data. We had the data processing program perform normal processing, but we also had it close up spaces between pages when it presented data to the video interface. With this method, the host computer simply divides the continuous print data into page units and sends the data in PDL format. Therefore, there was no need to change the normal page processing. For the data processing program of the printer, we only had to add a process that skips blanks between page data after the page data is edited. In other words, we were able to realize a solution with only minimal changes to the previous programs (Fig. 3).

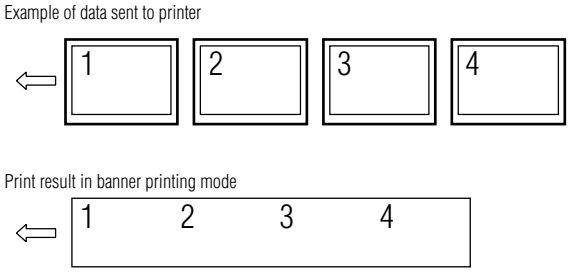

Fig. 3 Conceptual diagram of skipping blanks between pages

b. Underrun

Theoretically, all print data can be plotted in memory even if the data covers 60 meters worth of media. However, economically, this is not an effective method. It would be better if we could present the data for that image as the required video data and at the timing required by the engine, while that image data is being plotted into memory. We therefore decided to change the data processing at the printer to the fastest possible method and also to limit the data formats of the host computer (PC or etc.)

The specific developments are described below.

1) As shown in Fig. 4-1, color data is normally sent to the printer by representing the three basic light colors red (R), green (G), and blue (B) by a numeric value for each color. The RGB data actually goes through various color conversion processes and is finally converted to toner amounts for the four colors yellow (Y), magenta (M), cyan (C), and black (K), and then conveyed to the engine through the video interface. We developed a specification that skips all of these processes. Instead, the data from the host is first expanded into YMC bitmap data and then sent to the engine. Even for the internal process, the data is sent directly to the video interface without adding any conversions (Fig. 4-2).

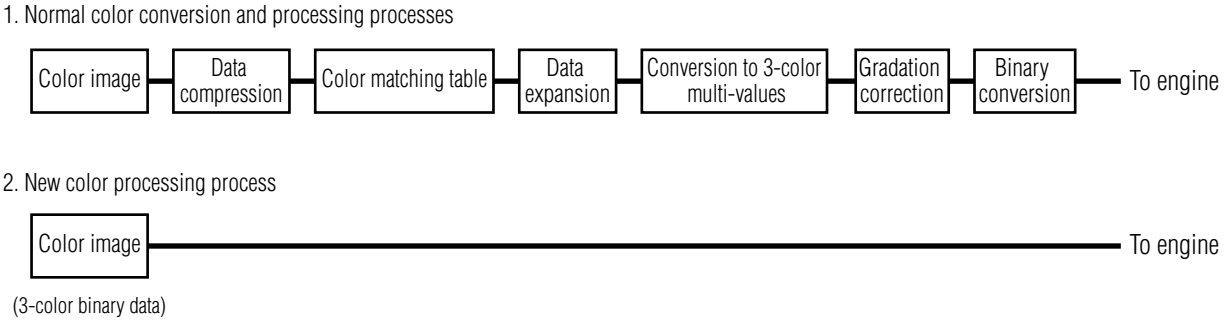

Fig. 4 Color data processing processes

2) Normally, there is no problem with the above setup. However, we considered the case in which the processing speed of the host computer does not keep up with the printing speed, and we prepared a mode that temporarily stores data to the hard disk drive (HD) in the printer. As an even safer method (safe against underrun), we prepared a mode that stores all 60 meters worth of data, in expanded video data format, to the HDD.

These developments allowed us to avoid underrun.

c. Oblique media feeding

As mentioned earlier, Oki Data's color printers use a belt to transfer the media. If the motion of the belt became skewed, the belt would come off the rollers driving it, but the belt is designed so that it does not become skewed. Therefore once the media is transferred to the belt without any skew, the printer should theoretically be able to transfer the media forever without any skew. In reality, however, a slight skew may occur when the paper is fed, and the skew increases until the paper eventually tears after about one meter of printing.

We found that an effective means of avoiding this phenomenon was to install at the media in-feeding location a long paper guide so that the sides of the media could not move. In fact, the customer created a special front feeder based on this experimental information (Photo. 2).

Phot. 2 Front feeder for banner paper

d. Control of fuser speed

Although this was the final remaining issue, we found out during the design evaluation that we would not be able to use only one speed setting and thus avoid all the effects of belt production variation, fuser production variation, and variation in print patterns (we knew that the optimum fuser speed differs depending on whether print density is high or low). In the end, we avoided the problem by changing the fuser speed according to the amount of media sagging between the belt and the fuser.

In actual operation, sagging develops both on the top and the bottom because the paper is folded when stored. Since the printer could only detect sagging in one direction (top) due to mechanical limitations, we could not avoid smudging at the folds when the sagging direction switched from down to top. We struggled with this problem but we were finally able to control the media path so that downward sagging does not occur.

(4) User's Evaluation

We submitted our final proposal to the customer in September 2002 and obtained approval.

The user is extremely happy because a prototype printer is already being used in actual operations. At this time, no other electro-photographic printer product that supports "endless media" has been developed.

Medicine Packet Printing Market

(1) Market characteristics

When we receive medical service, we usually get the medicine we need by presenting a prescription to a pharmacy. In Japan, the pharmacy usually places the medicine in a special bag called a medicine packet before handing it to the customer. Attention is being focused on a service that prints the medicinal effects and usage instructions of each drug on the medicine packet. Ensuring safety against side effects if the wrong dosage is taken is viewed as a social issue, and the government is even offering assistance to companies who are working on providing prescription drug information to consumers.

In many cases, several drugs are prescribed on one prescription and the need to represent the drugs with different colors (for example, "the medicine in the red package" or "a certain color capsule") has increased so that mistakes can be prevented. The text and

monochrome information used in the past is no longer sufficient to respond to this need, and a demand for color printing has emerged.

Large pharmacies that are closely associated with large hospitals sometimes handle 2,000 customers in a day. We can therefore say that there is a very valid reason for wanting to prevent drug dispensing mistakes.

One of the features of this market is that printing is not limited to medicine packets alone. In many cases, the same information is printed onto plain paper that must be inserted in the packets. In other words, often the information is printed alternately on medicine packet, plain paper, medicine packet, plain paper, etc.

In addition, pharmacies often use packets that have different color borders to classify the different types of medicine, such as “medicine to be taken internally” and “medicine for external application.” Such pharmacies are requesting printers to have as many paper trays as possible to handle this large number of media types. Although the situation differs depending on the size of the pharmacy, many pharmacies cannot allocate enough space to install an A3-size printer and are thus requesting A4-size printers.

Except for special-use printers, the A4-size printers manufactured by Oki Data and competitor companies only support a maximum of three trays (including the standard printer tray and expansion trays).

(2) Problems in responding to such requirements with standard machines

a. Tray expandability

Even with Oki Data’s A4-size printers, the tray configuration can only be expanded to a total of three.

b. Wrinkle prevention

Medicine packets tend to develop wrinkles when information is printed on them. The wrinkles are a side effect of measures to enhance the separation of plain paper from the fuser roller when toner is applied to the paper. It was difficult for us to sell printers to users who did not tolerate wrinkles.

c. Stability

Since a relatively heavy printer unit is placed on a relatively light paper tray (when there is little paper), the printer structure was unstable and overturned easily. Confirming safety and taking necessary countermeasures thus became necessary. Compared with A3-size printers, A4-size printers are especially unstable because of their narrow width.

(3) New development items needed to support this market

a. Tray extension

Different Oki Data departments got together to discuss how we could support the user request for a maximum of five trays. We ended up adopting a method that supports the new tray configuration with a control program, without adding many hardware changes. We decided to dedicate each expansion tray motor to the trays of one paper-supply level and the level above it only. For example, in a 5-tray configuration, the motor for the Level 5 tray drives the trays down to Level 4, while the Level 3 and Level 2 trays are driven by the Level 3 motor.

Consequently, during continuous printing with a 4-tray or 5-tray configuration, the average printing speed drops. However, we found through discussions with users that this is not a problem for medicine packet users.

b. Wrinkle prevention

Unlike regular envelopes, medicine packets do not have a flap and one side is completely open. Therefore, the two sheets of paper that form the packet can shift in the fuser section, and the buildup of these shifts can result in wrinkle formation. Oki Data’s color LED printers use heat and pressure to cause the toner to adhere to the media. On a microscopic level, the toner, which is a pigment-containing plastic, is melted by rubber rollers that are heated to a temperature ranging from 150_ to 180_ C, and the toner is fused onto the media by pressing the roller onto the media with spring pressure. To add heat and pressure more efficiently, we have placed a heated roller on the opposite side of the media (the side to which the toner is not applied).

Depending on the heat, surface status, and other conditions of the top roller, the media may fuse to the roller. We therefore have to ensure that the media separates from the roller. As shown in Fig. 5, this is done by using different degrees of hardness for the top and bottom rollers. This difference forces the media to be ejected in a slightly downward direction, relative to the horizontal.

When printing is performed on the medicine packets in question, the roller hardness difference described earlier causes wrinkles to form. To solve this problem, we used materials of the same hardness for both the top and bottom rollers. Since the separation characteristic degrades with media types that are difficult to separate from the roller (generally thin media), we have added restrictions on the print media. Of course we have checked that the target users for this printer do not need to use thin media types like those that cause problems.

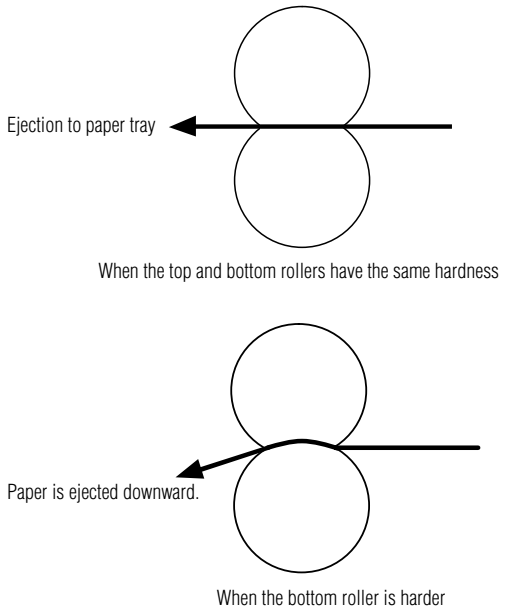

Fig. 5 Hardness difference between top and bottom rollers

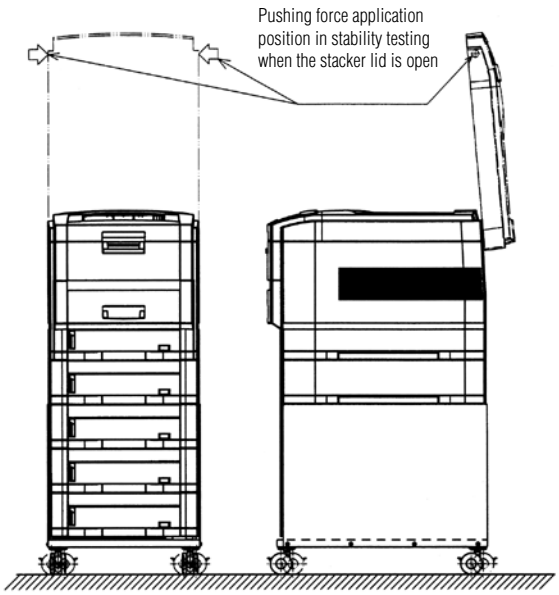

Fig. 6 Descriptive diagram, showing the case of the cover being fully opened

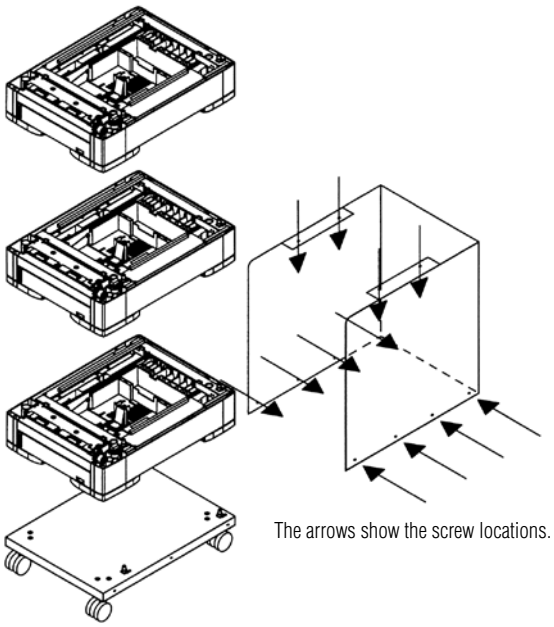

Fig. 7 Structure of A4 multi-level trays

c. Stability

Safety guidelines for product overturning are prescribed in IEC 950, which is an international standard. We decided that the printer should satisfy this standard and should otherwise be made as safe as possible.

As shown in Fig. 6, the worst case is when the user pushes the highest part of the printer cover when the cover is fully open. When we worked on a plan to prevent overturning of the printer, our target was to make sure that the printer would not overturn even when tilted at a certain prescribed angle.

Specifically, we enclosed and secured the lower three trays with sheetmetal panels from the top and bottom (Fig. 7). We used sheet metal to connect the back sides of the 3-tray section and printer body. This method allowed us to realize the target stability (safety against overturning) without requiring additional fabrication steps in manufacturing the printer body.

(4) User's Evaluation

The printer described in this article is not a printer that pharmacies purchase directly. The printer is installed at the end-user pharmacy through system vendors as a component of a pharmacy-related system that also handles prescription data management. When we presented this proposal to such system vendors, they informed us that the factor for achieving product distinction in such printers is a configuration that supports up to five trays. Several companies have already adopted this configuration for their printers.

In addition to the application examples described in detail in this article, there are numerous other cases where we have responded to users' requests (which vary considerably in the scope of required product modifications) and have thus gained their satisfaction.

We will apply the experiences we have gained through these cases to develop future products. We also recognize the importance of basic designs that allow us to respond quickly to user requests with only a minimal amount of customization.

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