Ultra Compact High Definition LED Color Printer

Koji Aida Shinichi Otani Masahiko Shimosugi
Nobuo Wakasugi Hiroaki Kawahara

The market of color page printers is growing rapidly year after year. This rapid growth is driven by a low-end segment, with printers US$500 or less (refer to **Figure 1** below, products priced US$500 or lower are included in the categories of Desktop and Very Small Work Group products). The competition has been introducing low-speed and low-price four-cycle machines (products requiring four developing cycles for each sheet of color printing) in this segment, however, in the year 2005, Company H introduced a new tandem machine that outputs eight pages per minute (color and monochrome), which has resulted in fierce competition ever since.

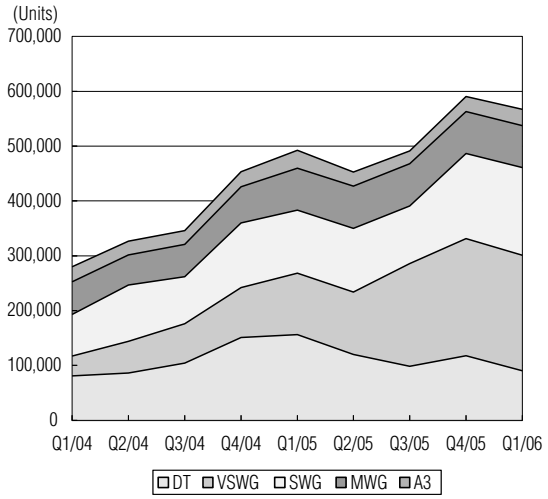

Fig. 1 Number of color page printer units shipped for each market segment in Europe and US

In order to enter into this market segment, which dominates more than half of the color page printer market and continues to grow, Oki Data developed the C3400n model, a new ultra compact high definition LED color printer incorporating a tandem system (**Photo 1**).

Product concept and targeted market

(1) Current status of color page printer market

The low-end color printer market segment that provides products priced US$500 or lower is expected to dominate the majority of the overall color printer market and further growth is anticipated. Therefore, it is essential for Oki Data to be able to produce a product with a competitive edge in this market segment in order to sustain and enhance our position as a major participant in the color page printer market. It is for this reason that Oki Data developed a new ultra compact high definition LED color printer that was subject to overall cost reductions, while achieving a high-speed and high graphic quality, which are features of tandem system printers.

Photo 1 Ultra compact high definition LED color printer C3400n

(2) Product concept

The following aspects were emphasized during the development stage since the product will be introduced to a market segment with the highest demand for low pricing.

① Low costing

Costs were reduced, primarily through a reduction in the number of parts and miniaturization of the parts and components to realize a street price of US$500 or less.

In spite of such efforts Oki Data was not satisfied to be merely a market leader in product prices but also to be one providing a higher performance and more added value, offering products at a price higher than the competitors in order to sustain a standard or a faster printing speed and higher printing quality in comparison with the existing models, while refusing to compromise on these issues in any way.

② Higher speeds

It was possible to realize a product that can print 16 pages per minute for color and 20 pages per minute for monochrome by taking advantage of the tandem system while striving to miniaturize the product and reduce costs. This is obviously the fastest printer in its class.

③ Higher printing quality

In spite of the fact that it is a low cost printer, it affords a high printing quality through the use of the same new high definition toners and LED printheads implemented in the higher class models.

④ Design

An innovative design concept called "S3" was adopted to develop this new product. This "S3" concept is based on "simple, solid and smart" design elements which enabled us to deliver a desirable and differentiated product.

(3) Product positioning

Four-cycle systems have been adopted for most products offered by the competition in the low-end color printer market and their output speed is four to five pages per minute for color printing. Even the tandem system model available from Company H only outputs eight to ten pages per minute. Two of our models are available as newly developed products, one printing 12 pages per minute for color and 16 pages per minute for monochrome and the other prints 16 pages per minute for color and 20 pages per minute for monochrome. They are both priced higher than models offered by the competitors (prices indicated in **Fig. 2** represent prices for both models for sale in Europe, which have been converted into US dollars).

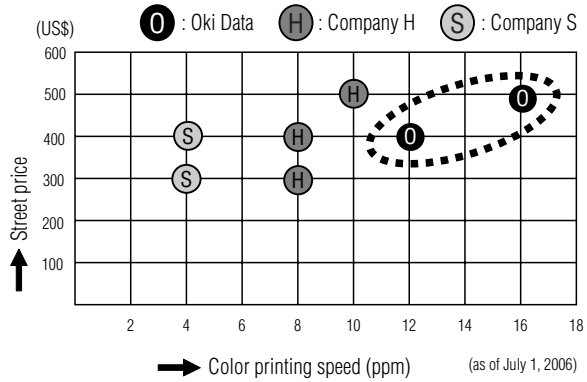

Fig. 2 Positioning of products

(4) Summarized specifications of printers

The main specifications are shown in **Table 1**.

Table 1 Main specifications (higher class models)

Printing method		High definition LED color printer
Printing speed	Color	16 ppm
	Monochrome	20 ppm
LED head resolution		600 dpi
Printing width		A4/Letter
Paper supply capacity	First tray	250 sheets
	Manual feed	One sheet
External dimensions (W × D × H)		372 × 478 × 290 mm
Weight (including consumables)		21 kg
Local host interface		USB 2.0
Network functions		Standard

ppm: pages per minute; dpi: dots per inch.

Key technologies for developing compact and light tandem mechanism

(1) Miniaturization and weight reduction of printers

Our aim was to produce a light-weight and compact printer, which can be installed and used casually on a desk. Through the miniaturization of major components and a reduction in the number of parts and components , both in terms of types and pieces, we succeeded in reducing the volume of the printers to two-thirds and the weight to four-fifths, in comparison with conventional printers that offer similar output speeds (see **Fig. 3** and **Table 2**). More specifically these include:

① The pitch between the drums was reduced due to a reduction in the diameter of the image drums and by adopting new high definition LED printheads.

② The fuser was miniaturized through the adoption of a belt-driven fuser system.

③ The component mounting efficiency was increased through the integration of the engine control board and controller board into one substrate as well as by reviewing the board arrangements.

④ The mechanism was simplified through selective reductions to necessary functions in order to reduce the number of parts and components.

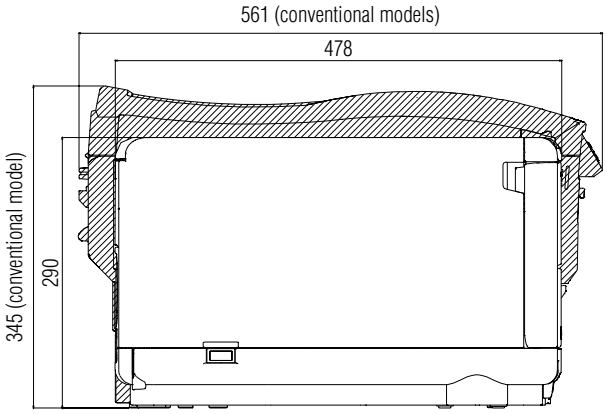

Fig. 3 Device size comparisons

Table 2 Part and component type (comparison by setting conventional unit as 100)

	New compact model	Conventional model
Molded components	98	100
Sheet metals	87	100
Shafts	5	100
Procured parts (rubber, film)	92	100
Cables	100	100
Motors	70	100
Circuit Board	110	100
Springs	100	100
Screws (screws, fasteners, pins)	50	100

(2) Miniaturization and reduced cost of image drum (ID) unit

The diameter of the image drum has been reduced from the conventional 30 mm to 24 mm. Furthermore, the diameter of other various rollers has also been reduced in an attempt to miniaturize the ID units by arranging

more compact rollers. This made it possible to reduce by 7 mm the pitch of the image drum units from 72 mm of conventional models to 65 mm. The total effect resulting from the three points of the pitch was a reduction by 21 mm in the depth of the product (**Fig. 4**).

Miniaturization was accomplished without deterioration to the functions or performance of the product. This resulted in our ability to offer products that provide a printing quality, which rivals the quality of higher class models.

In order to reduce costs, the materials and molded structures were reviewed with suppliers, starting with the initial stages of development, whereas parts and material costs were reduced through miniaturization, processing costs were slashed and suitable materials were adopted from the correct sources in accordance with the intended usage.

This unit has a long service life rivaling that of conventional models and this was achieved through the use of parts and components with a proven track record in terms of durability.

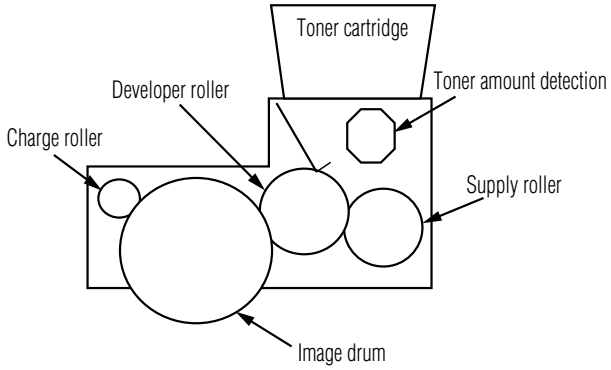

Fig. 4 Cross sectional diagram of image drum unit

(3) Development of new compact fuser unit

An image is fixed and coloration is achieved on paper when the fuser section heats, fusing the layered toner images on paper with the application of pressure. The section that applies pressure on the paper (nip) of conventional models is comprised of two rollers, the heat roller and pressure roller, above and below the paper. Since our fuser unit uses a belt as the pressure-applying component, the thermal capacity of the heating elements was reduced by 52% by combining the belt and a heat roller with a thinner thickness and smaller diameter, while maintaining the necessary amount of nip for fusing. As a result we succeeded in miniaturizing the unit, reducing its volume by 20% and shortening the warming up time by 33%, even though the printing speeds continue to be the same as conventional models.

(4) Noise reduction

Conventional four-color image drums are driven by four stepping motors, one for each color. We were able to reduce noise by simultaneously driving the four-color image drums using a single brushless DC motor, a feature available in a model of a higher class developed at the same time.

Furthermore, a layout effective for inhibiting the emission of sound from the motor was possible through an arrangement with the brushless motor inside the metal plate frame.

Fans were used for the fuser, low-voltage power supply and control board respectively, of conventional models, however, by using the air flow simulations to review the PCB layout we were able to cool the fuser, the low-voltage power supply and control board all with a single fan.

The fan is also located at the back of the product in order to ensure that the fan noise, which may be unpleasant to users, will not be evident even when the product is placed on the side of a desk (**Fig. 5**).

By implementing the aforementioned countermeasures we were able to reduce the noise level to 1/2 the acoustic pressure in comparison with conventional products that have the same printing speeds.

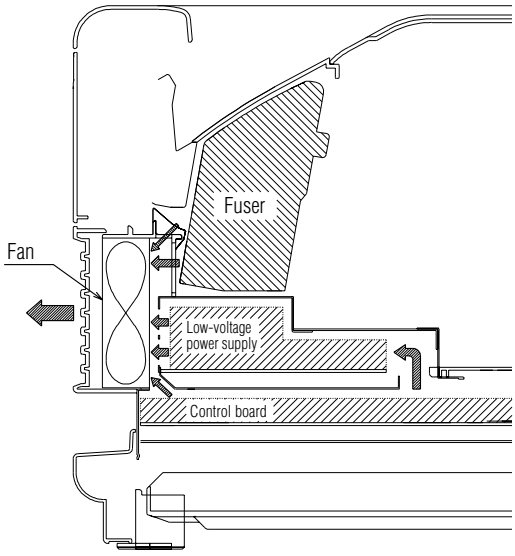

Fig. 5 Air flow

(5) Adopting four-level gradation system

In recent years inkjet printers have been realizing a photographic printing quality that rivals conventional silver films and they are still evolving.

In the years since realization of the photographic image quality was set as a target for color page printers, activities have been ongoing, such as the improvement of the electrophotographic process and image data processing. In order to realize a photographic image quality, technologies for a 32-level of gradation at 600 dpi and a 16-level of dot gradation at 1,200 dpi were developed for the high definition LED printheads control method, which were adopted for the top class color LED printer model.

This dot gradation technology was also implemented on new low-end models. The development of a four-level gradation printing method was considered to be the feasible maximum number of gradation levels for low-end color LED printers without increasing the costs.

With the conventional dot gradation technology, not only was five-bit information, corresponding to the 32 levels of gradation, necessary for printing data for each

dot sent to the high definition LED printheads, but a further eight bits were necessary for information relating to longitudinal compensation and density curve linearity compensation, which would lead to increased costs for memory and data transfer circuits.

Our system limits the number of gradation levels to four levels. The linearity of the density curve was improved by such means as combining the strobe time. Cost increases were inhibited through a reduction to two bits in the amount of data per dot due to such action.

As a result of the aforementioned efforts a four-level gradation printing method was realized through an extremely simple means of combining two sub-dots, large and small, to express each dot. In order to sustain compensation accuracy for color registration and to improve gradation levels both at the same time the actual printing resolution adopted was 600 X 2,400 dpi.

By performing four-level gradation printing the number of screen lines increased, making it possible to achieve a photographic quality with lesser noticeable screens. Furthermore, the increase in data capacity was limited to an extent that did not involve any increase in costs.

Key technologies for firmware control

(1) GDI (Graphic Device Interface) model

The recently developed printers are low cost models primarily intended for entry-level users. For this reason they are available only as GDI models in which the gains derived from conventional models have been fully utilized.

(2) Duplex printing feature

A manual duplex printing feature was created for two-sided printing in order to reduce the size and cost of the product. Instructions on the printing procedures have been added to the help screen of the printer driver so that the manual printing feature is easier to understand.

(3) Network feature

A firmware was also developed in-house for the network feature that is standard with these printers.

(4) Status page printing feature

The status page used to verify the printer status, including the status of consumable usage or paper types for setups, was divided into items to make it much easier to read. Furthermore, with this feature a status page is automatically printed when the power is turned on and at the time a consumable item has reached its service life.

Key technologies of driver utility

(1) New printer driver functions

Mac OS®*3) 9 now also supports the printer driver of conventional GDI printers for Macintosh®*3) computers, along with Mac OS®*3) X. Furthermore, a printer driver supporting the Windows®*2) XP Professional x64 Edition that was launched this spring has already been released.

Other than these a photo mode to accommodate photographic printing was also added as an optional selection for printing.

(2) New features of utilities

The interface connection available with conventional products was USB only and the status monitor used to verify the condition of the printer from personal computers was also compatible with USB connections. Since network connections are standard with these printers, however, a status monitor that supports its use over a network was developed.

Conclusion

The new printer was developed with an emphasis on design not just to make it more compact and lighter. Based on the S3 concept using two tone colors and rounded shapes, the product is made to appear smaller, demonstrating just how simple yet reliable the product is. In recent years the styling and color tones of office environments have undergone some changes. Printers require new distinctive design direction which adapts to such environment.

Oki Data will continue to develop products which deliver exciting and impressive true end user benefits.

Authors

Koji Aida: Oki Data Corporation, Non-impact Printer Business Div., Mechanics Development Center, Mechanics Development Dept.-1, Team-1, Team Leader.

Shinichi Otani: Oki Data Corporation, Non-impact Printer Business Div., Process Development Center, Process Development Dept.-2, ID Development Team-4, Team Leader.

Masahiko Shimosugi: Oki Data Corporation, Non-impact Printer Business Div., Strategic Technology Development Center, Basic Technology Development Dept., Basic Technology Development Team, Deputy Team Leader.

Nobuo Wakasugi: Oki Data Corporation, Global Solution Div., General Manager-Planning.

Hiroaki Kawahara: Oki Data Corporation, Non-impact Printer Business Div., Color Non-impact Printer Development Center, General Manager-Planning.

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