New Technologies for High Durable/Reliable Photoconductor Unit in Color MFP

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Abstract

In the shift from monochrome to color multi function printers (MFPs) in recent years, demands for durability, reliability, and print quality continue to glow. In order to meet such demands, we have developed new technologies for a photoconductor unit equipped with a small particle size of polymerized toner. The technologies include a high-durable photoconductor reinforced with inorganic filler, the non-contact charging system with a hard roller, and a new cleaning system containing the function-separated lubricant application device. The technologies assure high reliability and a long lifetime under various conditions of usage and have been introduced to the imagio MP C4500/3500 series.

Introduction

The digital full color multi function printers (MFPs) have been rapidly infiltrated into business offices in recent years, with improvements of the quality and the stability of the printing images. Especially the use of polymerized toners, the shape and the size distribution of which can be controlled, has been contributed to the high-resolution image.

In contrast, because of a difficulty in cleaning performance with small particle size toners, reliable photoconductor units (PCUs) with high cleaning ability are desired.

In the present work, we describe our new technologies for a PCU introduced to the imagio MP C4500/3500 series, which assure high reliability and a long lifetime with various conditions of usage.

Product background

The imagio MP C4500/3500 series are the middle/high-speed digital color MFPs developed on a common platform in pursuing high productivity, reliability, image quality and usability. Table 1 shows basic specifications of the imagio MP C4500/3500 series.

Table 1. Basic specifications of imagio MP C4500/3500.

		imagio MP C4500	imagio MP C3500
Paper sizes		A3/DLT～Post-card(A6)	
Warm-up time		Less than 29 seconds(at 23℃)	Less than 25 seconds(at 23℃)
First print speed (A4_LEF)		Full color:Less than 6.5 seconds Black&White:Less than 3.9 seconds	Full color:Less than 8.0 seconds Black&White:Less than 4.9 seconds
Printing speed per min (A4_LEF)		Full color:45 cpm Black&White:40 cpm	Full color:35 cpm Black&White:35 cpm
Paper weights	Standard tray	60～216 g/m^2(55～185 kg)	
	Bypass tray	6～256 g/m^2(55～220 kg) Duplex:64～169 g/m^2(55～145 kg)	
Paper capacity	Standard	550 sheets×2+100 sheets(Bypass tray)	
	Option	max:3100 sheets(with LCT)	
Input capacity		3200 sheets	
ARDF capacity		100 sheets	
Dimensions(W×D×H)		670×677×760 mm	
Weight		Less than 110 kg	
Toner		PxP color toner	
Large-touch panel		Large-color-TFT 384000 pixels	
Animation-guidance		Supply/unit-operating&JAM-operating	
HDD		80 GB	
Energy consumption efficiency		Less than 70 Wh/h	Less than 50 Wh/h
Power consumption: Off-mode		1.5 W(Basic) 8 W(SP-model)	
Power consumption: Low-power-mode		1.5 W(Basic) 9 W(SP-model)	

Concepts of development

In the technical development of the image processing engine of the imagio MP C4500/3500 series, we have attached much importance to durability and reliability under various environments and use conditions. In order to evaluate the characteristics of durability and reliability, we have carried out various performance evaluation tests, including the Quality Engineering Method, and simulations. In the technical development of the PCU, we have especially focused on the following points:

1. Cleaning ability for small particle polymerized toner by adopting the high durable photoconductor and the function-separated lubricant application device
2. Ease of maintenance and replacability by adoption of a compact and lightweight
3. Robust design against various hazards

In the MFP system of the imagio MP C4500/3500 series, a small particle size of polymerized toner, "PxP color toner", has been used. The PxP color toner is an oil-less toner produced by ester elongation polymerization. Low temperature and oil-less fusing have been achieved with a polyester binder resin, which contains wax inside. The PxP color toner, which has a small particle size and narrow distribution of particle size and electric charge, enables a fine-dot reproductivity with a low pile height of the toner.

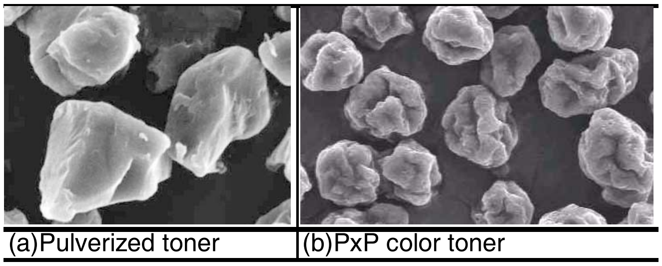

Figure 1. *SEM images of toner particles (×2000).*

High-durable photoconductor: FR-OPC (Filler Reinforced-Organic Photoconductor)

Figure 2 shows the structure of the FR-OPC equipped on of the imagio MP C4500/3500 series. Conventional OPCs consist of a substrate, an under coat layer (UL), a charge generation layer (CGL) and a charge transport layer (CTL), and don't have an over coat layer (OCL). In case of the conventional OPCs, gradual wear of the outermost CTL affects their characteristics of charge and photo-induced discharge, and therefore growth of the wear predominantly determines the lifetime of the OPCs.

Compared with them, the FR-OPC has the OCL, which includes a hard inorganic filler in a CTL-like layer, for improvement of the wear resistance.

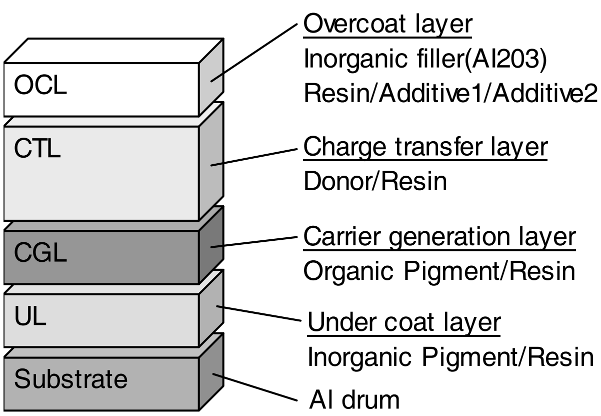

Figure 2. *Structure of FR-OPC.*

Shown in Figure 3 is the relation between the wear depth and the surface friction coefficients (μ) of OPCs with or without the OCL under various conditions of lubricant application. The wear depth of the FR-OPC is less than that of the OPC without the OCL and is stably low against fluctuation of μ . The result shows that wear resistance is improved by the OCL.

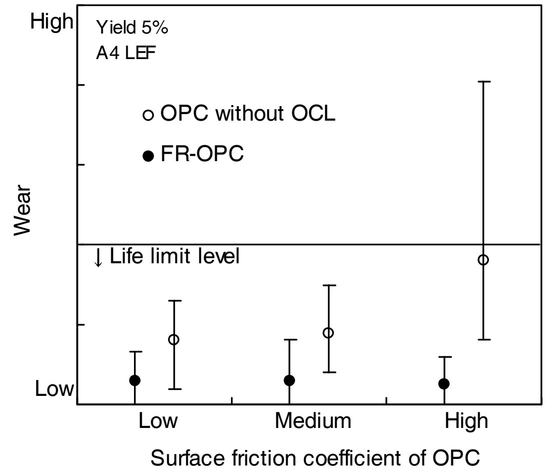

Figure 3. *Wear depth of OPC.*

On the other hand, OPCs are required to have high reliability, i.e. high quality images are stably retained under various use conditions. In actual use environment, there is a possibility that OPCs are exposed to various gases, including acidic gases such as NO_x. In our research, we found that NOx gases, which are easily generated from kerosene heaters, cause the image blurring on the surface of OPCs. In response to the problem, the tolerance of the FR-OPC to NOx gases has been reinforced by addition of an acid-scavenging donor (AS donor) to the OCL. Figure 4 shows the effect of the AS donor under the environment of high-density NO_x gases. The result indicates that the AS donor is effective for preventing image blurring and can provide good image quality.

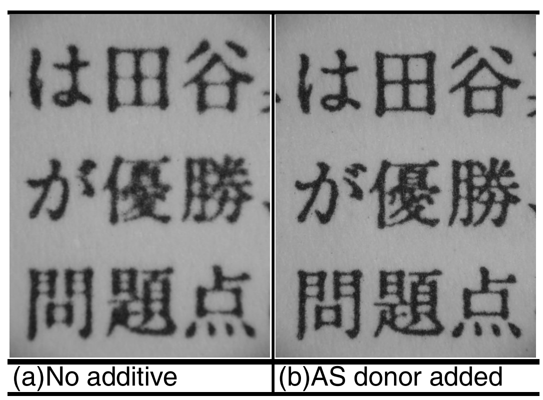

Figure 4. *Tolerance of NO_x.*

Charging process

Figure 5 shows the configuration of the PCU of the imagio MP C4500/3500 series. For the purpose of improving resistance to pollution of a charging roller and prevention of contaminations, we have adopted the hard-type non-contact charging roller for the PCU with using AC/DC superposition.

Furthermore, by using a numerical analysis for the bending of the roller due to its own weight and the pressure applied to both ends of the roller, as shown in Figure 6, the roller configuration is designed to have a small deviation of pressure in the axial direction, and to maintain a constant gap.

As a result, we have provided the PCU which can stably realize uniform charging on the FR-OPC.

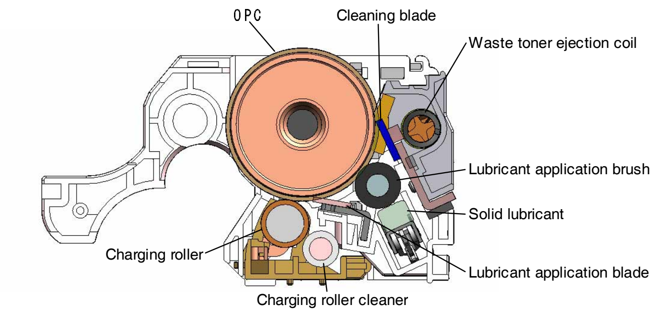

Figure 5. *The configuration of PCU.*

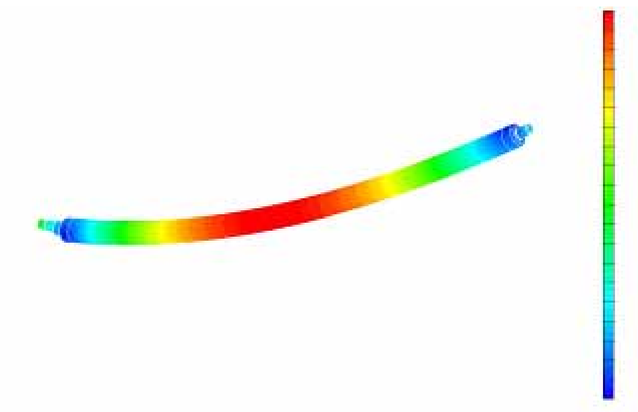

Figure 6. *The simulation of bending of charging roller.*

Cleaning and lubricant application

Cleaning

In the PCU of the imagio MP C4500/3500 series, the cleaning performance of the small particle size of the polymerized toner is improved by applying a lubricant on the OPC surface, which lowers the μ and reduces adhering of toner. Though cleaning performance becomes well by applying a lubricant, wear of a cleaning blade is increased because the surface of FR-OPC is very hard.

The important factors of wear property of the cleaning blade are lubricant application quantity, process speed, blade material, welding pressure, additive formula of toner, etc. Here we introduce the relation between blade characteristics and wear depth. Reducing rebound resilience can prevent deformation of blade edge and augmenting the modulus at 300% elongation can strengthen resistance characteristics of deformation of the blade. By using materials that satisfy these characteristics, high durability cleaning blade is obtained.

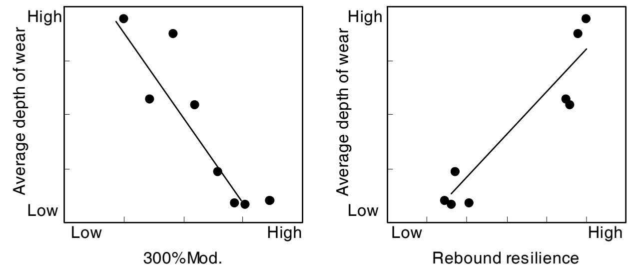

Figure 7. *The relation of blade characteristics and wear depth.*

Function-separated lubricant application device

The function-separated lubricant application device is an implement, where cleaning function and lubricant application function is separated by arranging a lubricant application device next to a cleaning blade. At first remaining toner and contaminations are removed at the cleaning unit from the OPC surface after image processing, and then a solid lubricant is uniformly applied to the clean OPC surface with an application brush. Furthermore, by the lubricant application blade next to the brush, the uniformity of lubricants attached to the OPC is more improved.

The function-separated lubricant application device can keep the OPC surface μ low at any coverage of output image, which is important for cleaning small particle polymerized toners.

Figure 8 shows a comparison of the OPC surface μ at various coverage of image between the function-separated lubricant application device and conventional one. We can confirm that the function-separated lubricant application device is very advantageous about stabilization of the OPC surface μ.

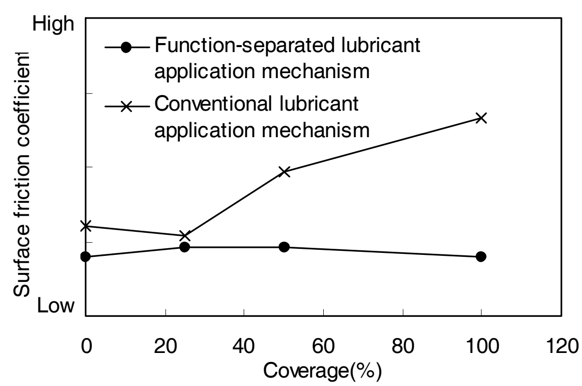

Figure 8. *The coverage dependence property of surface friction coefficient of OPC.*

Next, we describe efficiency of lubricant application. The upper limit of lubricant volume that can be equipped to a PCU is restricted due to costs and layouts. Therefore, reducing consumption of lubricants as well as high stability is important for extending the unit lifetime. Shown in Figure 9 is a comparison of amount of lubricant consumption at various coverage of image between the function-separated lubricant application device and a conventional system. The function-separated lubricant application device realizes the compatibility between low consumption and stable application.

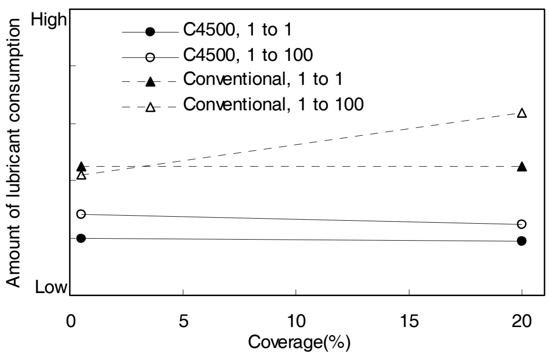

Figure 9. *Influence of the coverage of images and print duty on amount of lubricant consumption.*

The lubricant application blade is a rubber blade, and is arranged in the trailing arrangement. The arrangement has merits of flexibility of layouts and small torque compared to a counter one. The additional effect of removal of contaminations has been obtained by using the lubricant application blade.

In conventional systems, the pressings up of a solid lubricant was performed with springs or its own weight, where the amount of lubricant consumption was widely changed depending on the variation of welding pressure. In the PCU of the imagio MP C4500/3500 series, a novel arm-type pressing up mechanism, which enables a constant welding pressure, is equipped. The pressing up mechanism has dramatically improved the temporal stability of the lubricant application (Figure 10).

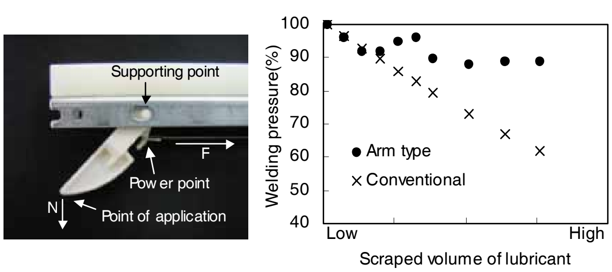

Figure 10. *Arm type lubricant pressing up mechanism and its temporal stability of welding pressure.*

The variation of lubricant application conditions on the OPCs induces reduction of the OPC lifetime and deterioration of image quality, because it causes charging roller pollution and film formation of contaminations on the OPC surface. Therefore, uniform application of lubricants on the OPC surface is necessary. Consequently, we have used the Quality Engineer Method to determine the condition that enables uniform application in various environments. By visualizing and quantifying a lubricant on the OPC surface with the fluorescence microscope, parameters for a stable application of a lubricant against various error factors have been considered (Table 2). As the result, it becomes obvious that rotation direction, liner velocity and fiber density of the application brush affect stabilization of the lubricant application in this experiment.

Table 2. Control factors of the function-separated lubricant application device.

Control factor	Level1	Level2	Level3
Rotation direction of brush, liner velocity	Against, low	Same, high	-
Fiber characteristics of brus	Conductive, high resistance	Conductive, low resistance	Nonconductive
Fiber density of brush	Low	Medium	High
Fiber length	Low	Medium	High
Extrusion length of applicaion blade	Low	Medium	High
Thickness of application blade	Low	Medium	High

Summary

We have developed a high durable and high reliable photoconductor unit by adopting many novel technologies. Numerical simulation and the Quality Engineering Method have helped a lot in developing the unit and have reduced product development period and cost effectively.

References

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Author Biography

Tadashi Kasai received his Master Degree in chemistry from the University of Osaka Prefecture and joined Ricoh Company Ltd. in 1999. Since then he has been working in research and development section at Ricoh Company Ltd. In recent years, he has been engaging in development of color electrographic engine. He is a member of the Imaging Society of Japan.