

Solution for the Retransfer Mechanism of Color Imaging Process

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Abstract

In electrophotographic process, the system to transfer several times is used for the color image formation. The phenomenon[1,2] that toner images has formed already on the recording medium returns to photoconductive drum was confirmed, and it is clear that this phenomenon is found conspicuously on the photoconductive drum where the toner does not exist. The electrification charge inside of toner image on recording medium is uneven, and this is thought so that an electric field formed at the toner transfer end point works to the direction that seems to return one part of toner on recording medium to photoconductive drum. In this work we theoretically analyze the electrification voltage inside of toner image at the end point of toner transfer, it is clear the reason why toner return to photoconductive.

Introduction

With high quality and high speed of color copier or color printer, high precision and high toner transfer rate system is required. Generally, for making color images, the transfer method for a color image on the photosensitive layer to the recording media every color image is introduced[3,4]. However, when the toner is transferred to the recording media after the second transfer, it is observed the phenomenon that the toner image that has been transferred on the recording media goes back to photosensitive layer. This is called "retransfer". The retransfer causes that image density is low and image quality is bad due to a lot of waste toner. Therefore, there are many disadvantages in environment. This paper shows that the surface potential difference of photosensitive layer, toner layer, and recording media layer before and after transferring clarifies the retransfer mechanism, and the optimization of electrostatic characteristics on every layer for reducing the retransfer becomes possible by calculating the surface potential difference every layer.

Experimental

Experimental Unit

Fig.1 shows the device to experiment the retransfer phenomenon. The toner image has been formed already on the recording medium gripped electrically on the transfer belt. The next color toner formed on the photoconductive drum by applying voltage to the conductive roller is transferred to recording medium, and so color images are formed successively. The toner on the recording medium is black color of two-component, the toner on the photoconductive drum is magenta, and the transfer belt is dielectric, and conductive roller is low resistive sponge roller.

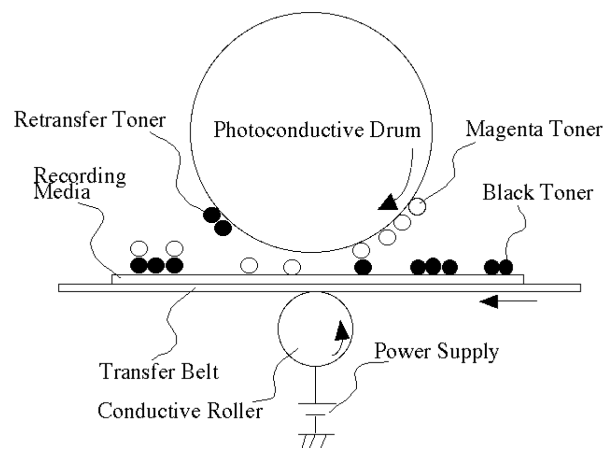

Figure 1. Experimental Device

The Experimental Method

The solid image is formed on the recording medium, and the line image of several cm width is formed on the photoconductive drum. We let the experimental device stop in the middle of transferring from the photoconductive drum to the recording medium, and observe the toner which has remained on the photoconductive drum after transfer.

As the result, it is confirmed that the black toner don't return to the region where the toner image is formed on the photoconductive drum, and the black toner returns to the region where the toner image is not formed on the photoconductive drum. So we observe how the quantity of retransfer toner to the photoconductive drum varies by changing applied voltage to conductive roller.

The toner which has returned to photoconductive drum is gathered with tape and we measured the density of tape.

Experimental Results

Fig. 2 shows the results that measured the density of toner which has returned to photoconductive drum by changing applied voltage to the conductive roller. The recording medium are paper and overhead transparency. In the case of paper, as the applied voltage is high, we understand that the density of retransfer toner to photoconductive drum becomes high. and it is clear that the density of retransfer toner of thin paper is higher than that of thick paper, too. In the case of transparency, the density of retransfer toner doesn't change for applied voltage, and is about 0.1.

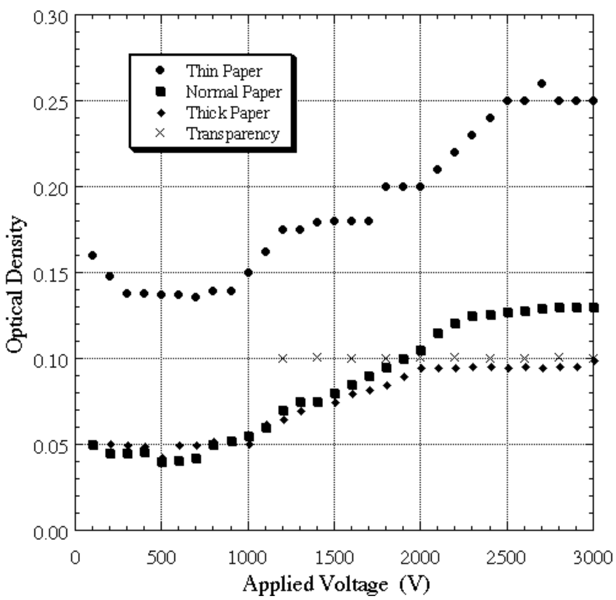

Figure 2. Retransfer Density on the photoconductive drum

Table 1 shows the results that measured average q/m of toner which exists on the each media. The applied voltage to the conductive roller is 2500V in the value of Table.1. The toner on the photoconductive drum and each recording media before transfer is negative charge. On the other hand, the retransfer toner to photoconductive drum is positive charge in the each recording media.

Table 1. The Average of Toner q/m on the every media.

On the Photoconductive Drum (befor Transfer)	On the Recording Media (befor Transfer)		Retransfer Toner on the Photoconductive Drum	
	Paper (Thin)	Transparency	Paper (Thin)	Transparency
-20μC/g	-57μC/g	-25μC/g	54μC/g	30μC/g

So we measure toner q/m distribution[5] on the photoconductive drum and recording medium before transfer. As the results it is clear that most toner are negative charged, but several toner are positive charged. One expects that the positive charge toner inside of the toner image that has been transferred on the recording media returns to non-image region on the photoconductive drum selectively. In other words, as the toner image on the recording media contacts with non-image region on the photoconductive drum, the electric fields occur inside of the toner image, it seems to explain that a few positive charge toner inside of it return to the photoconductive drum according to the strength of electric field. From these experimental results, we expect that the quantity of retransfer toner to photoconductive drum changes by a kind of recording media and the strength of applied voltage. So we calculate the electric field at the toner transfer end point, and try to physically relate with the electric field strength and the quantity of retransfer toner. In this experiment, the electric potential of non-image region on photoconductive drum is -450V.

Theoretical Analysis

Contact Electrification

In this section the mechanism of electrification of toner image is analyzed for the device of Fig.1. The toner image is electrified by applying a voltage to the conductive roller, and letting the photoconductive drum come into contact with the toner image. Contact electrification[6] consists of Paschen discharge followed by charge injection (Fig.3). As the toner image approaches the photoconductive drum, Paschen discharge takes place in the air gap, and charge is supplied the toner image until the voltage on the toner image reaches a fixed value. Thereafter, charge is injected between the toner image and the photoconductive drum.

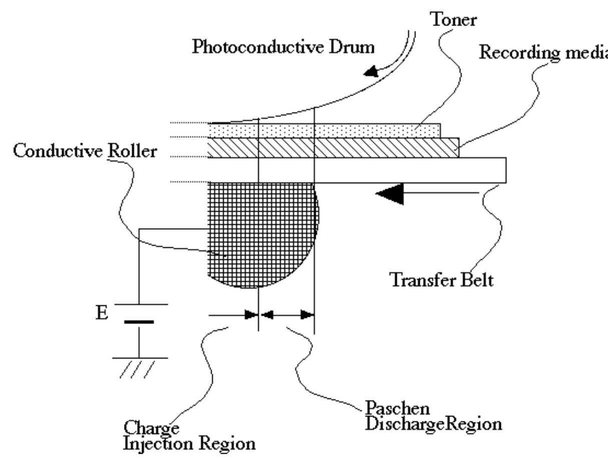

Figure 3. The Mechanism of Contact Electrification

Paschen Discharge

As the toner image and photoconductive drum approach each other, the electric field in the air gap increases, and Paschen discharge take place. When a positive voltage is applied to the conductive roller, negative charge is supplied the toner image. The voltage of the air gap Vg, of thickness dg, is

$$Vg = \frac{dg(E - Vbb - Vpp - Vtt + Voo)}{\left(dg + \frac{db}{\varepsilon b} + \frac{dp}{\varepsilon p} + \frac{dt}{\varepsilon t} + \frac{do}{\varepsilon opc}\right)} \quad (1)$$

where Vbb is the voltage of transfer belt, Vpp is the voltage of recording media, Vtt is the voltage of toner image, Voo is the voltage of photoconductive drum, db,dp,dt and do are the thickness of transfer belt, recording media, toner image and photoconductive drum, ε_b, ε_p, ε_t, and ε_{opc} are the specific permittivity of transfer belt, recording media, toner image and photoconductive drum . We take the Paschen discharge curve to be

$$Vg = 312 + 6.2dg \tag{2}$$

Paschen discharge takes place at the point where (2) intersects (3). If the electrification voltage on the toner image increases further, Paschen discharge occurs until (3) is consistent with (2).

Charge Injection

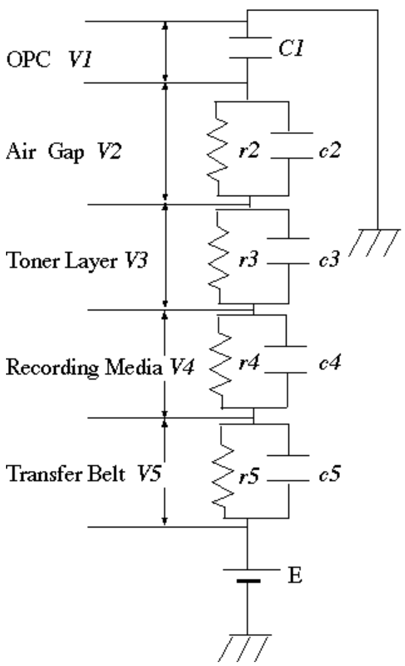

Figure 4. Equivalent Circuit for Charge Injection

Fig. 4 shows the equivalent circuit of the charge injection region in Fig. 3. The electrification voltage V3 resulting from charge injection satisfies (3), (4); we calculate the electric field in the toner image from V3.

$$c1\frac{dV1}{dt} = \frac{V2}{r2} + c2\frac{dV2}{dt} = \frac{V3}{r3} + c3\frac{dV3}{dt} = \frac{V4}{r4} + c4\frac{dV4}{dt} = \frac{V5}{r5} + c5\frac{dV5}{dt} \tag{3}$$

$$E = V1\ V2 + V3 + V4 + V5 \tag{4}$$

Calculation Results

Fig. 5 shows the results that calculate electric field inside of the toner image at the toner transfer end point. The cross axis is the applied voltage to the conductive roller, the vertical axis is the electric field inside of the toner image. The direction of electric field is the positive from the toner image to the photoconductive drum. The negative charges are applied on the recording media, so that letting the recording media grip the transfer belt. Therefore, the applied voltage to the conductive roller is too low, the inverse electric field occurs. Thinner paper, the electric field inside of toner image becomes big for same applied voltage, and its increase ratio is bigger, too. Consequently the electric field inside of toner image changes more sensitively for applied voltage. In the case of transparency, less than 2000V in applied voltage, the electric field inside of toner image is same as a thick paper, but more than 2000V, the electric field is bigger than that of thick paper.

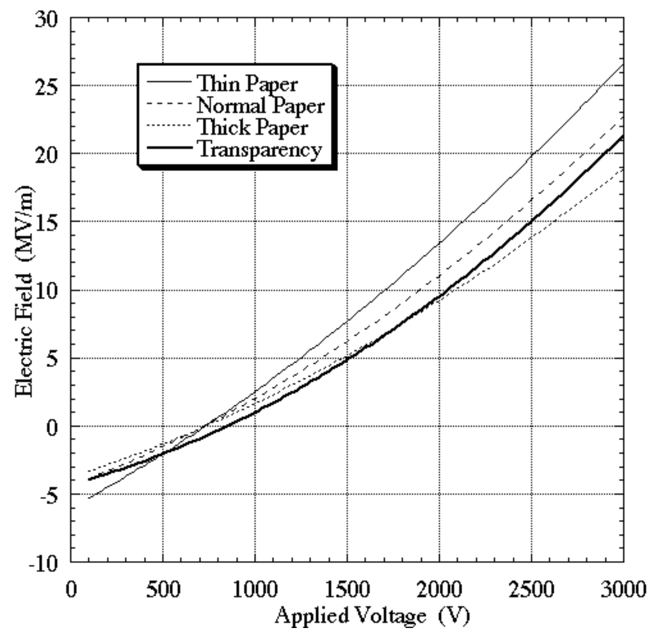

Figure 5. Electric Field in the Toner Layer

Discussion

1. The results that the electric field inside of toner layer is calculated and experimental results are the same tendency. In other words the higher electric fields inside of toner image, the more toner returns to photoconductive drum. It is commonly known that the force of toner F in the electric field E is

$$F = qE \tag{5}$$

In the fixed electric field, the charge of toner is small, the force against toner is small, too. Using the thin paper, the electric field inside of toner image is big, the low charge toner on the recording media is easier to return to photoconductive drum . So that the retransfer toner density on the photoconductive drum is high. And we found that much toner returns to photoconductive drum so that the increase ratio of electric fields is big.

2. Using the transparency, although the electric field strength inside of toner image changes , the quantity of retransfer toner does not change. In other words the quantity of retransfer toner is not correspond to the change of electric field. We expect that the charge of toner on the

recording media varies by changing the physical characteristic of recording media.

Conclusion

1. We clarified the mechanism of toner retransfer, and furthermore, that is different by kind of recording medium. In order to reduce the retransfer toner, we have to decrease the variational ratio of electric field for applied voltage. As the concrete methods, one adjusts electrical potential on the photoconductive drum or recording medium, and selects the best physical characteristic of each material used for transfer system.
2. In these experiments and analyses, we do not totally estimate the retransfer toner and the transfer efficiency. We would like to estimate these relations, and build the suitable transfer system in future.

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Biography

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She graduated Chiba University on 1992. Since 1992, she has been research and development scientist of Sharp Corporation. Her main research interests are image forming devices and electrostatic application. She is a member of The Society of the Electrophotography of Japan.

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