Control Characteristic of Conductive Toner Cloud by an Aperture Electrode

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Abstract

The printing technology that uses the toner, such as the electrophotography, is necessary for our life. However, the efforts for realizing a simpler mechanism are important because the electrophotography printing mechanism is complex. The mechanism has 6 processes. To decrease the processes is considered one of good approaches for realizing improvement.

To control toner cloud by a pair of electrode has been proposed. As a fundamental data, the control characteristics of single aperture electrode are important. The single aperture has also a possibility of application. In this study, the toner cloud is generated between the aperture electrode and dented electrode by voltage application and the dependence of toner amount passing through the aperture on outer electric field is obtained. It is found that as the thickness of the aperture electrode increases, the range of the electric field of the state in which toner can not pass through becomes wide.

Introduction

In non-impact printing process, control of toning material is important point. It is important to control properly quantity and position in which a toner particle adheres to a paper, in order to print high quality image.

Electrophotographic technology can obtain high speed, high-resolution and high-quality in a plain paper printing.

Electrophotography is a main technology of toner printing, but its printing mechanism is complicated.

It is worth to study a possibility of simpler mechanism. Many attempts to realize simpler printing mechanism have bean carried out.[1-4] Toner cloud beam printing (TCB) has seen proposed and studied.[5-8]

The conductive toners confined between electrodes using the dented electrode move up and down, and generate toner cloud between electrodes by electric force. Toner beam is extracted from toner cloud generated by controlling the electric field applied to control electrodes. Then, the toner beam is projected to paper to form dots by such a simple printing mechanism. If TCB realizes, development of small copying machine and printer will be attained by the simple mechanism. We reported that toner dot formation is controlled by controlling application voltage of each electrode in last year.[9] However, "OFF" condition is not understand well.

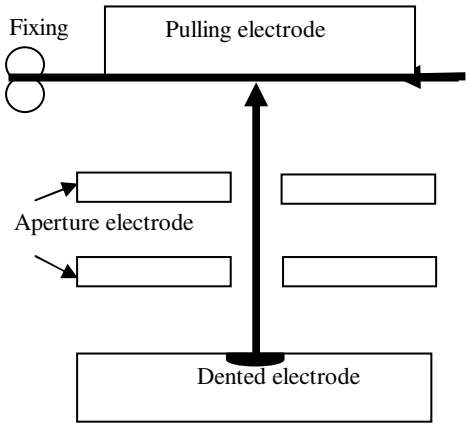
On this report, focusing the thickness of electrode, "OFF" condition is studied on single electrode. The single electrode of aperture has a possibility of application to form conductive particle image by scanning the aperture electrode.

Toner Cloud Beam Printing

Toner Cloud Beam printing method is shown in Fig. 1. The setup for this principle includes the dented electrode, lower control electrode, upper control electrode and pulling electrode being placed parallel.

From the dented electrode, conductive toner moves upward and downward by electric force under the electric field. It forms toner cloud and is confined between control electrode and dented electrode. When the voltage of upper electrode is less than the lower electrode, the toner can not pass the control electrode; it is "OFF "state. But, when the voltage of upper control electrode is higher than the lower control electrode, toner will pass through control electrode and adhere to paper; it is "ON" state. TCB development technology is using these two states.

Fig.1 The principle of TCB.



Experimental

Figure 2 shows the experimental system of this study. In order to investigate toner cloud control characteristic of aperture electrode, one aperture electrode is studied. Experimental conditions are shown in Table 1.

The voltage which applied to dented electrode TJ, and GC means the voltage applied to upper control electrode. As for "OFF" state (generating toner clouds but no adhering toner to paper), the voltage GC is controlled to be negative. The applied voltage duration is 1 second.

Next, ON state is investigated. The experimental conditions are shown in Table 2.

Table 1 Voltage conditions of experiment 1.

The size of a hole (mm)	Thickness (mm)	TJ (V)	GC (V)
0.5	0.05	-550	-200
	0.1		-150
	0.2		-100
	0.3		-50
	0.4		-25
	0.5		0

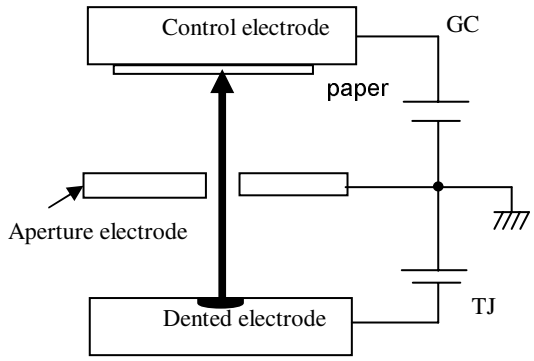


Fig. 2 *Schematics of experiment.*

Table 2 Voltage conditions of experiment 2.

TJ (v)	OFF state (v)	ON state (v)	On state time (s)
-550	-25 and -50	50	1
		100	
		150	
		200	
		250	
		300	
		350	
		400	

Results and Discussions

Figure 3 shows the toner dot size dependence on the applied voltage to the control electrode in the negative voltage range. It is found that the toner dot size increases even as the voltage changes to negative direction. This reason why toner dot generated although the electric field is against the toner upward motion is considered that the charge of the toner which contacts aperture electrode changes to inverse polarity. So, toner can reach paper on the control electrode. It is noted that the thickness of electrode has big effect to toner control characteristics.

Figure 4 shows the dot size dependence on the applied voltage in the positive region on the case of "OFF" state -25V. It is found that toner can pass the aperture as the increase of the control electrode voltage. It is also found that the dot size increases as the thickness of the electrode decreases. Figure 5 shows the dot size dependence on the applied on the case of "OFF" state -50V. It is found that the nearly same results are obtained compared with Fig. 4 and that the threshold voltage of dot formation shifts a little bit to higher voltage.

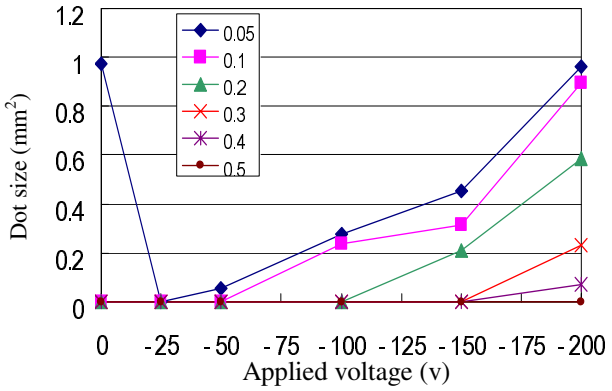


Fig. 3 *Toner dot size dependence on applied voltage in the negative range*

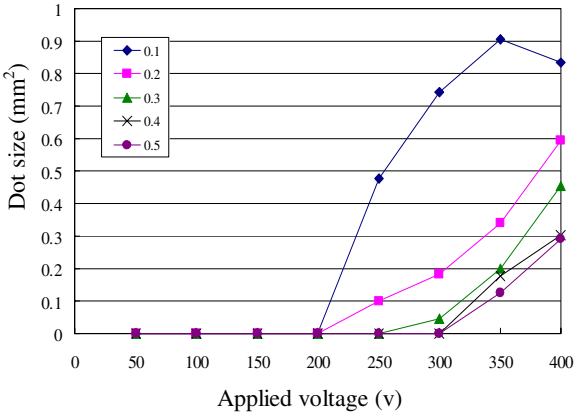


Fig. 4 *Toner size dependence on applied voltage in the positive range*

("OFF" conditions: -25v).

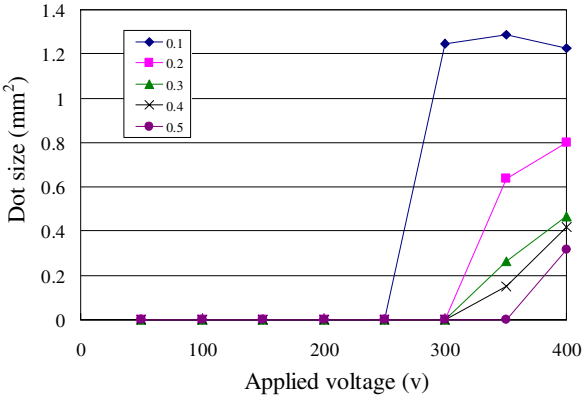


Fig. 5 *Toner size dependence on applied voltage in the positive range*

("OFF" conditions: -50v).

Electric Field Analysis

To understand the toner control characteristics, electric filed analysis around aperture electrode are carried out on "OFF" state and "ON" state. The voltage and electrode conditions are as follows, "OFF" state: dented electrode -550V, control electrode -400V and the thickness of electrode 0.5mm, 0.1 mm; and "ON" state: dented electrode -550V, control electrode 400V and the thickness of electrode 0.5mm, 0.1mm. The electric field analyses are carried out by ELFIN (ELF Co., Japan). Figure 6 and 7 show the equipotential line of "OFF" state of the thicknesses of electrode 0.5 and 0.1mm, respectively. From Fig. 6, the toner which jumps from the dented electrode can not pass through the aperture if the toner does not contact the aperture electrode, because toner is charged negatively at the electric conduction from the dented electrode and negative charge accepts against force in the upper area. However, when toner contacts the aperture electrode, toner can change its charge due to the charge exchange with electrode. From Fig. 6, it is guessed that even the toner contacts aperture electrode, toner contacts in the influence of under electric field. So, the toner which contacts aperture of electrode will jumps to downward. However, from Fig. 7, when electrode thickness is 0.1mm, from Fig. 7, toner contacts the aperture of the upper electric field influential area, so some toners can move upward. These results agree well with the experimental results of Fig. 3.
Figure 8 and 9 show the equipotential line of "ON" state of the thicknesses of electrode 0.5 and 0.1mm, respectively. From the comparison of these figures, it is understood that as the thickness of electrode increases, very low electric field area increases and that the amount of toner passing through the aperture decreases. These results also agree well with the experimental results shown in Figs. 4 and 5.

Conclusions

To understand the fundamental controlling characteristics of conductive toner cloud by aperture electrodes, the characteristics of single aperture electrode is investigated. The amount of toner passing through the aperture is strongly influenced by the thickness of the electrode. On the “OFF” state, which is important in realizing printing mechanism, it is found that the voltage range of “OFF” state increases as the thickness of the electrode increases.

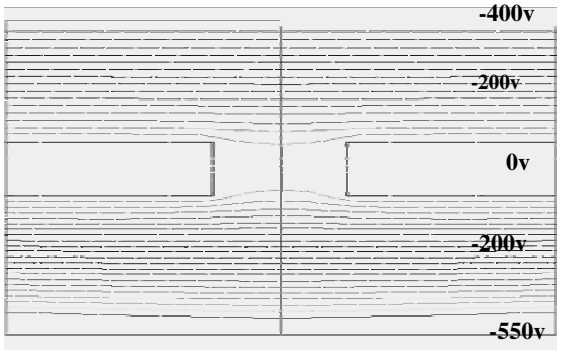


Fig.6 *Equipotential lines of “OFF” state, electrode thickness 0.5mm.*

Fig.7 *Equipotential lines of “OFF” state, electrode thickness 0.1mm.*

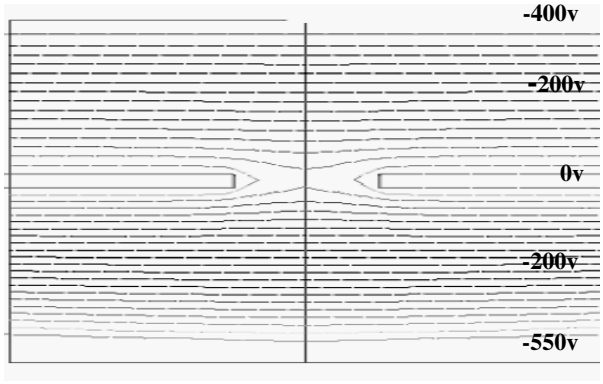


Fig.8 *Equipotential lines of “ON” state, electrode thickness 0.5mm.*

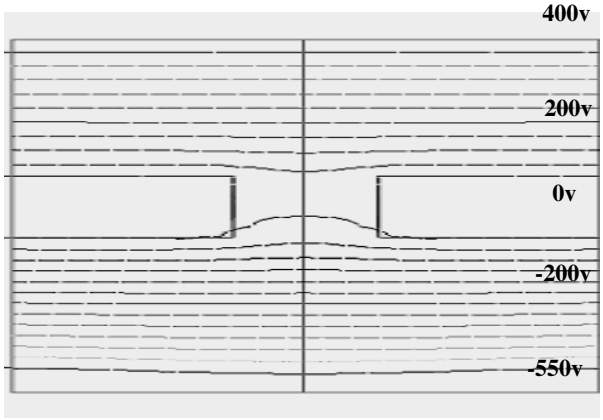
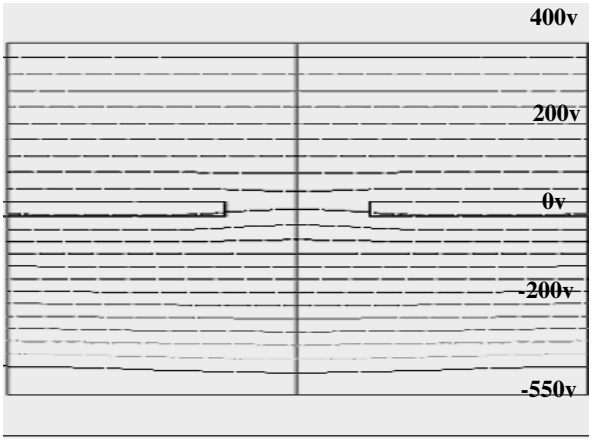


Fig.9 *Equipotential lines of “ON” state, electrode thickness 0.1mm.*



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