A Study of Transfer Process by Observation of Discharge Light Emission

Tomoko Takahashi, Sadayuki Iwai and Masami Kadonaga
Imaging Technology Division, Ricoh Co., Ltd., Yokohama, Kanagawa, Japan

Abstract

Observations of light emissions of electrical discharges are carried out by a model experimental setup of two movable plates with electrodes. Light emissions of the electric discharges are observed in a real dark room while the plates are approaching and separating. The observations of light emissions are carried out under various applied voltages and corresponding measurements of the transfer efficiency are done. The light emissions occur when the applied voltage is higher than the limit value, and once discharges happen, the transfer efficiency begins to decrease. The results show the electric discharges cause the reduction of the transfer efficiency and a retransfer is due to the electrical discharge in a nip of transfer.

Introduction

Image degradation during a transfer must be avoided for a high quality imaging process. In the imaging process with the intermediate transfer media, image defects in the transfer process are enhanced, because of two times toners transfer. Another serious problem in a transfer process is a retransfer, which makes an image degraded. The retransfer is a typical phenomenon in a color printing process; the first color toners, which have transferred on the intermediate transfer belt, come back to photoconductor from the transfer belt when the second color toners move to the intermediate transfer belt.

Relations between the degradation in transfer process and electrical discharges have been studied by many researchers.[1-3] The measurement of electrical discharges is done by detecting as current intensity from a photo multiplier by Hyakutake.[4] It is shown that a retransfer is caused by air ionization during the transfer process by Iwakura[5]. However an observation of electrical discharges is not carried out yet. In this study light emissions of electrical discharges during a transfer process are observed. The relations between discharges and imaging degradation, together with the relation between discharges and retransfer phenomena are made clear.

Experimental

Schematic diagram of the experimental set up is shown in Fig. 1. The apparatus consists of a glass plate with electrodes as a photoconductor, and a piece of a transfer belt on a metal electrode as a transfer media. The electrodes on the glass plate are made of ITO (Indium Tin Oxide) and an overcoat layer of polycarbonate, so as to observe the discharges phenomena through the transparent media. A pattern of the electrodes on the glass plate is shown in Fig. 2. At first, toners are deposited on the overcoat by a developer, and they moved to the transfer belt. During this transfer process, we observe discharge light emissions through the glass plate. Two image intensifiers are used in a real dark room to observe the feeble lights of the discharges. The feeble lights focused on the input window of the image intensifier are amplified and the image is recorded by a video camera through a inclined mirror above the transparent media.

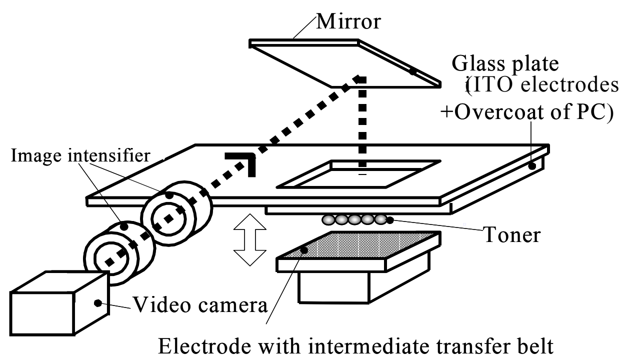


Figure 1. Schematic diagram of the experimental setup electrodes.

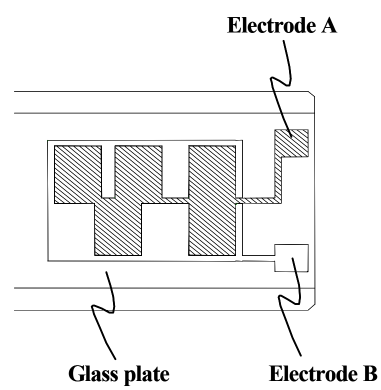
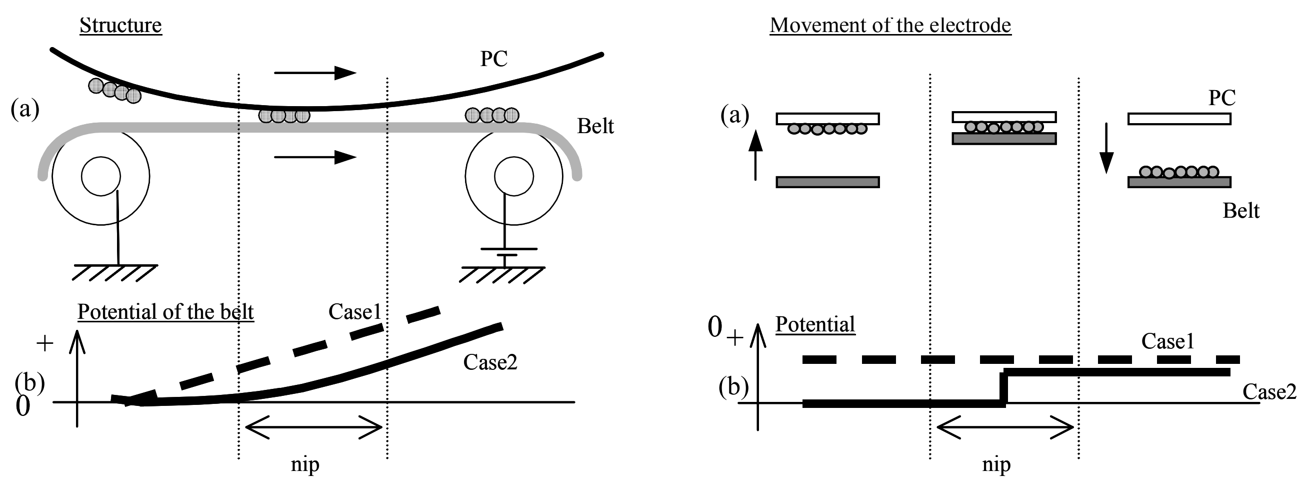


Figure 2. Figure of a glass plate with the electrodes.

Two procedures are necessary to transfer; one is an approaching the transfer belt to the toners and the other is a forming of electrical field. To simulate a transfer process an applied voltage and a movement of electrodes are synchronized. Three stages of the transfer process and corresponding calculated potential are shown in Fig. 3 schematically, for the case of real machine (I) and the experiment (II) respectively. As shown in I(a), toners are transferred from the photoconductor to the intermediate transfer belt at the nip. The photoconductor and the intermediate transfer belt move to the direction of arrows with the same speed in this diagram. A voltage for the transfer is applied to one of two rollers that stretching the intermediate transfer belt, and the potential gradient is formed. This potential distribution is effected by the resistance of the belt. The typical two states of electric field are shown in I(b); the solid line shows the potential of the belt of the higher resistance, and the broken line shows that of the lower resistance. In the case of the lower resistance, the electrical field is effective at an air gap of the inlet of the nip between the photoconductor and the intermediate transfer belt. In the experiment (II), the movement of the electrode with transfer belt and timing of the applied voltage are arranged in the considering the real machine, focusing on the air gap between the photoconductor and the intermediate transfer belt. While the electrodes approach and separate each other, the toners transfer from the upper electrode to the lower electrode (a). The potential of the lower electrode is turned on at two different timing (b), a constant voltage is applied to the lower electrode during transfer in the Case1 of low resistance, an applied voltage is turned on when the two electrodes are contact in the Case2 of high resistance.

In order to know the relations between transfer efficiency and electrical discharges, observations of the light emissions and corresponding measurements of the transfer efficiency are carried out for various conditions. In this experiment, two electrodes made of ITO on the glass plate are set at the same potential, and electrode is set at various voltages for two cases (Case1, Case2).

To understand the retransfer phenomenon, experiments are carried out as follows; (1) Toners deposited on the glass plate move to the intermediate transfer belt at the same electric conditions. Constant voltage is applied to the electrode with the intermediate belt, where as the ITO electrodes on the glass plate are connected to the ground. The same toner layer is formed on the intermediate belt with this process. (2) The glass plate, which has no toner layer approaches and separates from the belt with toners. In the second process, the timing of turning on the voltage applied on the belt is varied in two patterns, as stated above. Several applied voltages to the ITO electrode are tested in the second process.



(I) Schematic diagram of the first transfer region

(II) Schematic diagram of experiment

Figure 3. Comparison of the machine to the experimental setup.

Results and Discussions

The example images of the electrical discharge light emissions through the toner layer with image intensifier for different gap are shown in Fig. 4. These pictures are amplified automatically, so the intensity is not linier to the real phenomenon. The larger white spots show the light emissions, and the scattering tiny points are noises caused in the observations. They are observed while the belt approaches the glass plate and contacts with it in the Case1. In the Case2, these are observed while the belt contacts with the glass plate and separates from it. Table 1 shows light emission occurrences under the several experimental conditions. Figure 5 shows the relations of discharge gaps with light emission for applied voltages in the Case1, when the zero of gaps are set at the contact point of the toners and the transfer belt. A line is the Paschen line showing a limit of discharge. It is shown the largest gap of the light emissions appearance is predicted from the Paschen line.

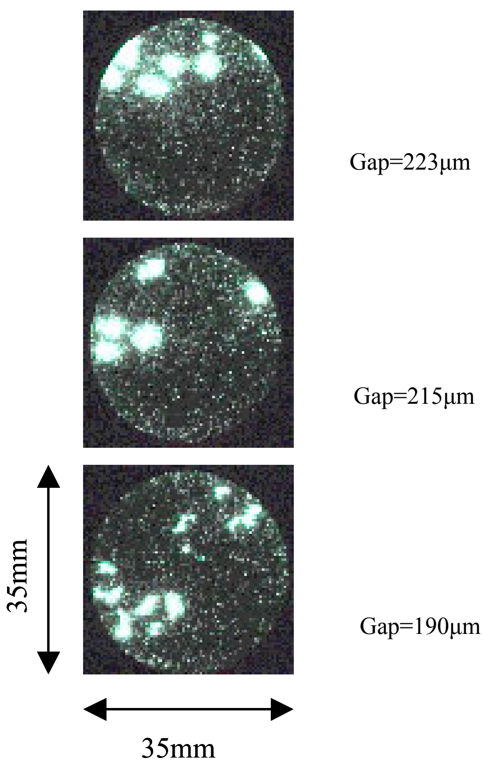


Figure 4. The light emission during the transfer process (applied voltage=1600V).

The relations between transfer efficiency and an observation of the electrical light emission are shown in Fig. 6. In both cases (Case1, Case2), the transfer efficiency decreases when the electrical light emissions is observed. This result shows the decreasing of the transfer efficiency is due to the electrical discharge; the electrical discharge makes the toner charge changes to the opposite polarity. From the measurement of an electrical charge, the toner charge polarity is turned positive when the applied voltage is larger than 1000V (an electrical discharge occurs), gives an evidence to the consideration (Fig. 7).

Table 1. Condition of the Experiment

	Case1		Case2	
Applied voltage (V)	Approaching	Contact	Contact	Separating
400	X	X	X	X
600	—	X	X	X
800	X	x	X	X
1000	X	O	X	O
1100	—	—	O	O
1200	O	O	O	O
1400	O	O	O	O
1600	O	O	O	O

O observed x not observed — not test

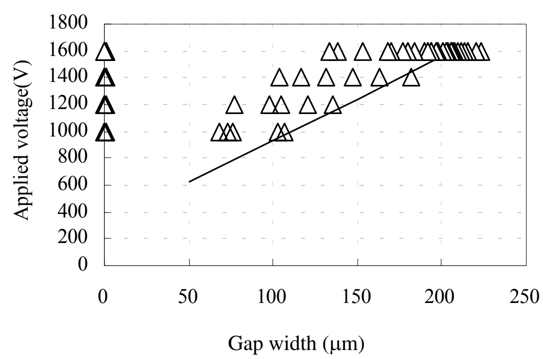


Figure 5. Gaps between the glass plate and the transfer belt when the light emission is observed.

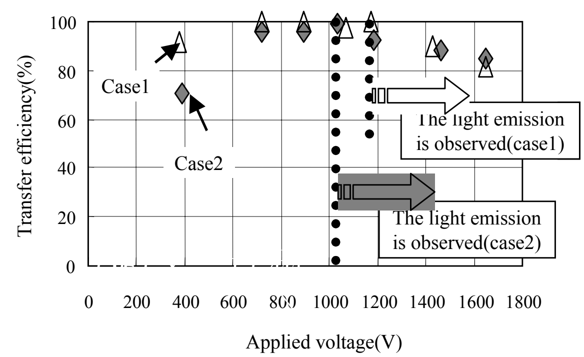


Figure 6. Relationships between the transfer efficiency and the electric discharges.

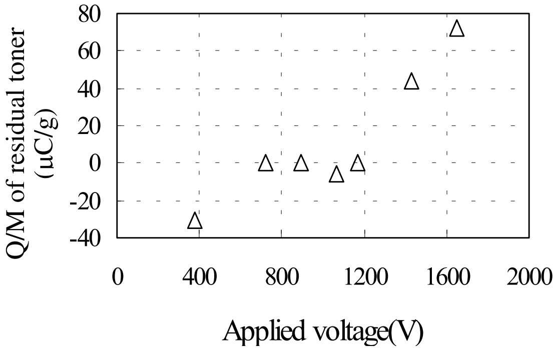


Figure 7. Relationship between the applied voltage and Q/M of residual toner.

It is shown in Fig. 8, that the retransfer toner levels at various applied voltages of the ITO electrodes when the transfer belt with the toner layer approaches the ITO electrodes. An applied voltage of the electrode with transfer belt is constant (+800V). The level of retransfer toner is expressed numerically by the ratio of area where the retransferred toner is deposited on the ITO side.

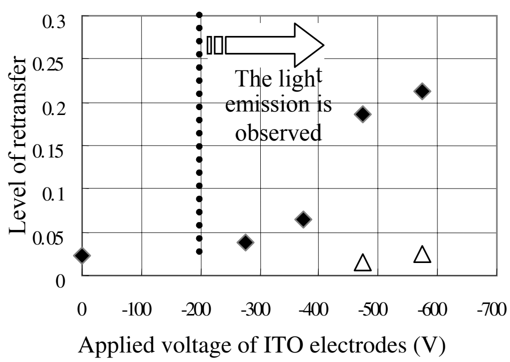


Figure 8. Relationship between the applied voltage and level of retransferred toner.

This experiment describes a transfer of second color toners in a real machine, the applied voltage of the ITO electrodes suggest a potential of non-image area. In the Case2, the levels of retransfer increases as the applied voltage become lower, although the levels of retransfer in the Case1 are constant. On the other hand, the observation of the electrical discharge emissions can be seen at the different positions of the electrodes between Case1 and Case2 (Table1), however they are observed during the same applied voltages, lower than –200V, in both conditions. The retransfer phenomenon occurs only the electrical discharges appear when the electrodes contact. Converting the results to a real machine, the retransfer is due to the electrical discharge at the nip only.

Conclusion

An electrical discharge emission during a transfer can be observed through image intensifiers using the experimental set up. The observation makes clear the relations between an electrical discharge and a reduction of transfer efficiency. Once the electrical discharge is observed while electrodes is approaching or contacting, transfer efficiency decreases gradually. Converting these phenomena into the real machine, the electrical discharge occurs at the inlet and inside of the nip.

The retransfer phenomena have a relation with the electrical discharge in the transfer nip. Only a case of an electrical discharge is observed during the electrode contact, a retransfer increases.

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Biography

Tomoko Takahashi obtained her bachelor's degree in image science from Chiba University in 1986. Since that year, she has been working in electro-photography development department imaging technology division at Ricoh Co. Ltd. She is a member of The Society of the Electrophotography of Japan.