A Study of Separating Discharge in the Belt Transfer System

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Introduction

Corona chargers have been widely used to transfer an image from photoconductor to paper. But the image-transfer process using them has several problems such as unstable feeding of paper and a large amount of ozone emission. Especially the latter problem has recently become a more serious concern from the environmental view point. It is desired that the image-transfer system functions without ozone emission. The belt transfer system[1,2] is one of the image-transfer systems used in electrophotography processors. In this process, paper clings to the electro-resistive belt, and is stably fed through the processor. Transfer voltage is applied to the belt and the image is transferred while the paper goes through the nip between the photoconductor and the belt. Since little discharge is generated in the belt transfer system, little ozone is emitted. It also provides stable paper feeding at high speed. However, electrical discharge may occur between the paper and the transfer belt when the paper is separated from the belt under particular conditions. Since the discharge causes image degradation, it is important to clarify the discharge mechanism and its effect on image degradation.

Objective

The objective of this research is to find the requirement for prevention of the image degradation due to separating discharges[3,4] between the paper and the transfer belt.

The Belt Transfer System

The belt transfer system is shown in Figure 1. The paper is held on the electro-resistive belt and fed under the photoconductor. This assures stable and fast paper feeding. Toner is transferred from the photoconductor to the paper at the nip between the photoconductor and the belt. In the image-transfer system using a corona charger, the electric field is applied by the charge deposited on the back of the paper by corona discharge. In case of the belt transfer system, the voltage on the electro-resistive belt generates the electric field for the image-transfer instead of the charge. Thus there is no need to use a corona charger and unnecessary discharge is almost completely suppressed in the generation of the electric field. Therefore little ozone is emitted in this system. Since a high voltage is applied to the back of the belt, a weak discharge occurs in the vicinity of the nip between the paper and the photoconductor, and charges the paper with the same polarity as the toner. The charge on the paper flows away through the paper and the belt under high temperature and humidity. When these values are low, the paper resistance is so high that the charge remains on the paper. Thus separating discharges may occur when the charged paper is separated from the belt. These discharges may degrade the image which has not yet been fixed on the paper.

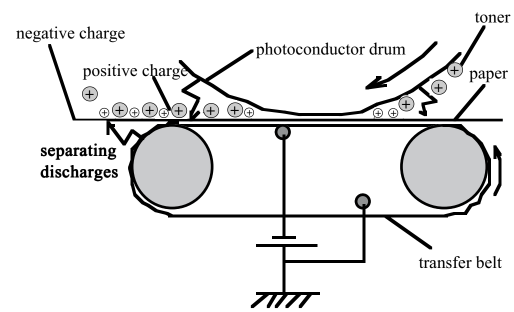


Figure 1. The schematic diagram of the belt transfer system.

Experimental Methods

The relationships among the transfer conditions, the separating discharges and the image degradation are investigated experimentally. PET{poly(ethylene terephthalete)} sheets with 100[μm] thickness are used instead of paper because they have a more stable resistance than paper. Figure 2 shows the sequence of the experiment. A transfer belt is set under a PET sheet which is cleaned with alcohol beforehand. The back of the belt is grounded by the electrode. The radius of the electrode edge, where the PET sheet is separated from the belt, is 8[mm]. The first process of the experiment is to charge the sheet by a corona charger as shown in Figure 2(a). This process corresponds to the discharge at the entrance of the nip between the paper and the photoconductor in the real transfer system. The second process of the experiment is to develop the sheet. A image with a size of 100*40[mm] is formed on the sheet (Figure 2(b)). This corresponds to the toner transfer from the photoconductor to the paper in a real photocopier. Then the sheet is charged again by the second corona charger (Figure 2(c)). This corresponds to the discharge at the exit of the nip between the photoconductor and the paper. The last process of the experiment is to slide the electrode and separate the belt from the sheet (Figure 2(d)). The sliding speed is 2.5[mm/s] and the sliding distance is 30[mm]. This last process corresponds to the separation of the paper from the belt. The polarities of the toner and the applied voltage of the two corona chargers are positive. The experiments are carried out under the environmental conditions of 20[ºC] and 10[%RH].

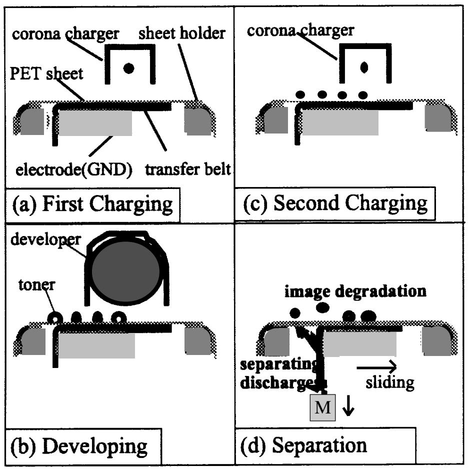
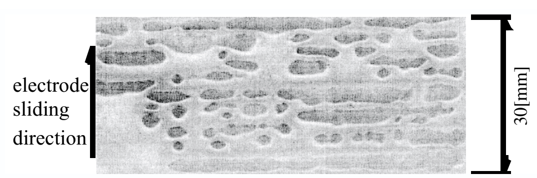


Figure 2. The sequence of the experiment .

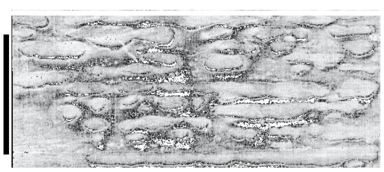
Results

Image Degradation Due to Separating Discharges

When the electrode is slid after forming the image on the sheet, the image degradation occurs with the movement of the electrode as shown in Figure 3(a). Also the discharge pattern of the opposite surface is obtained by cascade development[5] after sliding the electrode. It is shown in Figure 3(b). As the shape of the degraded image is in good agreement with the discharge pattern, the image degradation is due to the separating discharges.



(a) Degraded Image (image side)

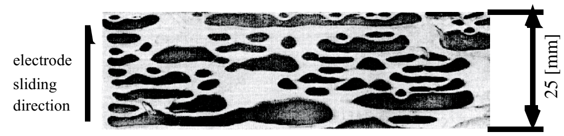


(b)Discharge pattern (back side)

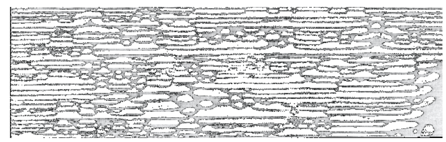
Figure 3. Agreement between degraded image and discharge pattern.

Relationship Between the Sheet Potential and Separating Discharges

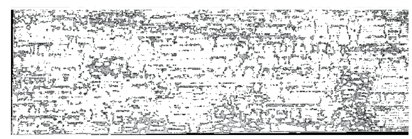
The change in the discharge pattern of the back of the sheet against the sheet potential before the separation(Vs) is observed. When Vs is close to 0[V], separating discharges and image degradation do not occur. The image degrades with an increase in Vs. When Vs is nearly 250[V], the im age degradation is evident. As shown in Figure 4, the stripes of the discharge pattern become smaller when Vs becomes higher. But the stripe discharge pattern is not observed when Vs is higher than about 750[V]. The same tendency is also observed in the image degradation pattern on the image side of the sheet. The image degradation does not occur when Vs is higher than about 750[V].



(a)Vs=240[V]



(b)Vs=420[V]



(c)Vs=650[V]

Figure 4. Change in the discharge pattern by Vs.

The potential distribution of the back of the sheet is measured using a high resolution electrostatic surface potential meter.[6] Figure 5 shows the potential distribution measured along the electrode sliding direction. The surface potential is measured at intervals of 32[µm]. It is found that high potential sections and low potential sections exist alternately on the back of the sheet at low Vs (Figure 5(a),(b)). When Vs is high, the potential is not so variable, as shown in Figure 5(c). The interval of the potential change becomes shorter with an increase in Vs. The tendency of the repetition of the potential is very similar to that of the discharge pattern (Figure 4). As shown in Figure 5, it is also found that the difference between the maximum and the minimum value is smaller when Vs is higher. Figure 5(c) shows the potential distribution in the case of Vs = 715[V]. There is little potential unevenness in Figure 5(c). These results show that the discharge occurs so stably as to charge the back of the sheet uniformly when Vs is high.

The discharge gap is calculated by means of the partial capacitance model of the system and Paschen's law.[7] Figure 6 shows the calculated relationship between Vs and the discharge gap. It is shown that the separating discharges do not occur in the case of Vs < 206[V]. When Vs is higher than 206[V], the separating discharges occur and the discharge gap becomes smaller with an increase of Vs. Considering the results of the experiments and the calculations, the separating discharges should occur at the small gap in order to prevent the image degradation.

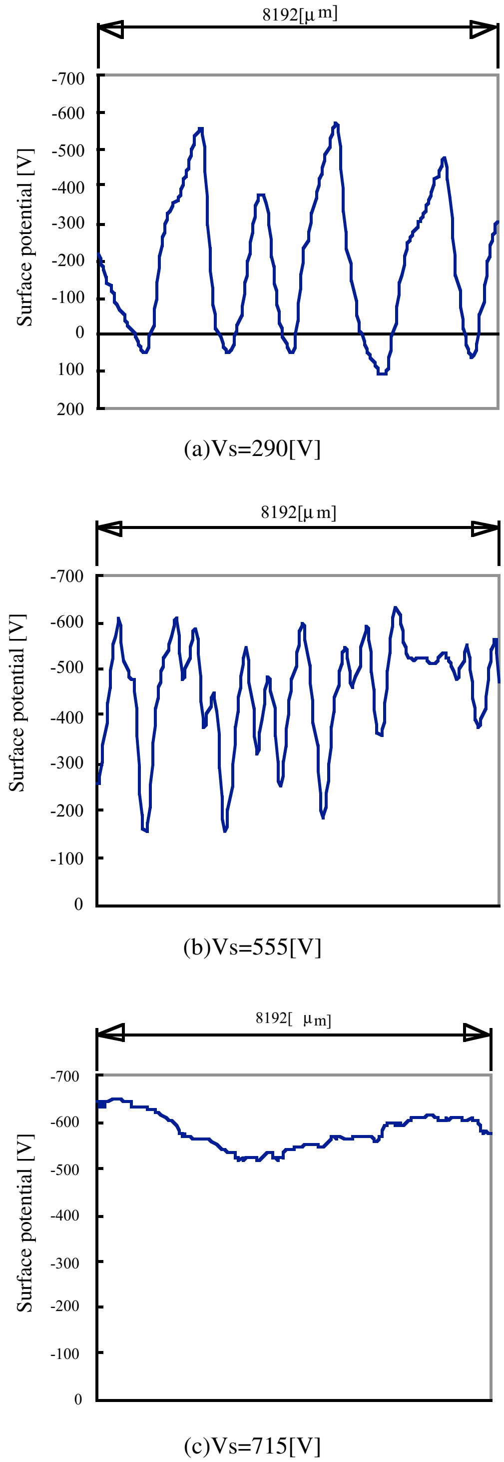


Figure 5. Potential distribution.

Observation of the Discharge Light Emission

The separating discharge light in this experiment is invisible to the naked eye even in the darkroom, and it is observed using image intensifiers. Transparent PET sheets are used in this experiment. The undeveloped sheets are separated from the belt after being charged. Figure 7 shows the result of the observation from the viewpoint above the sheet. The shape of the discharge light is in good agreement with that of the discharge pattern shown in Figure 4. In the case of low Vs, large intermittent light emission is observed (Figure 7(a)). With Vs increasing higher, the emission interval becomes shorter and the shape of the light becomes thinner, as shown in Figure 7(b). Under the conditions in which image degradation does not occur, weak continuous light emission is observed.

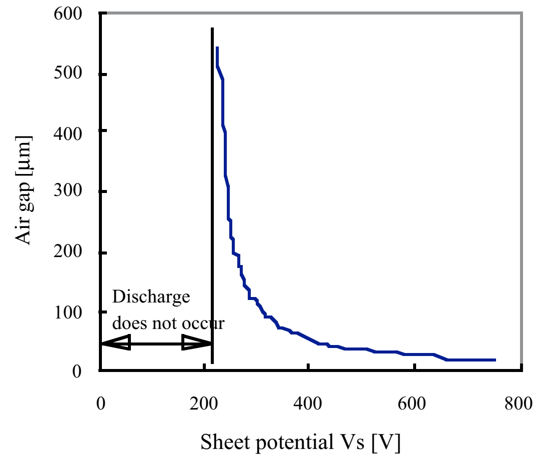


Figure 6. Calculation result.

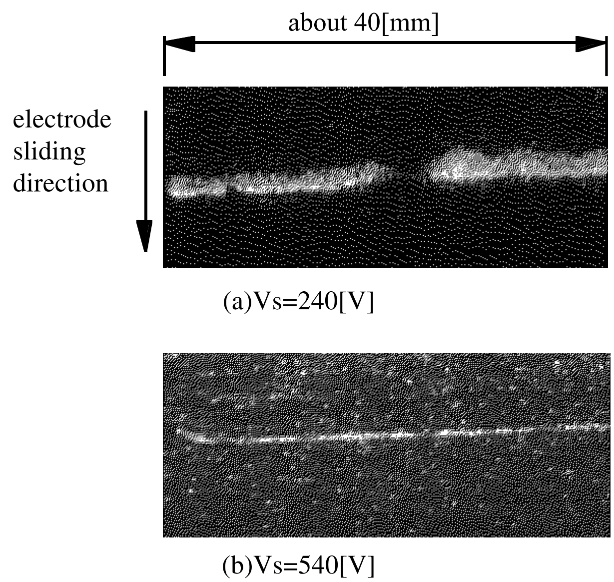
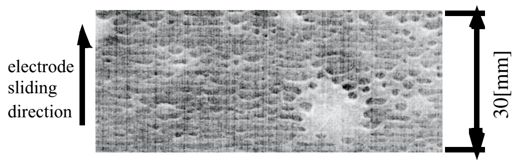


Figure 7. Discharge light emission.

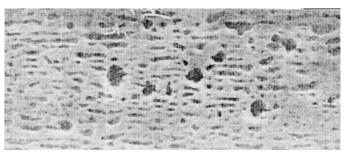
The Influence of the Separating Curvature

The influence of the separating curvature on the separating discharges is investigated. The separating curvature is determined by the shoulder of the electrode. Figure 8 shows the result of the experiment using two electrodes with different shoulder radii. The degraded image obtained by the R40 electrode shows two different patterns. One is striped and the other is round. The round pattern may be due to the second separating discharge since it is formed a little after the striped one. The striped pattern is formed when the first discharge occurs at the small gap. The voltage at the separation gap increases with the separation and is over the break-down voltage even after the first discharge.

Thus the second discharge occurs heavily at the large gap and the large round pattern is formed (Figure 9). The discharge light emission is observed in order to ascertain these two types of discharge. The straight-type emission and the round-type emission are at a distance as shown in Figure 10. It shows that the two different discharges occur at the different gaps. Although the separating curvature of the electrode shoulder is one of the important factors that affect the separating discharge, its effect is smaller than that of Vs. In fact, when Vs is high enough, the image degradation does not occur with any separating curvatures.



(a)R2 electrode



(b)R40 electrode

Figure 8. Influence of the separating curvature.

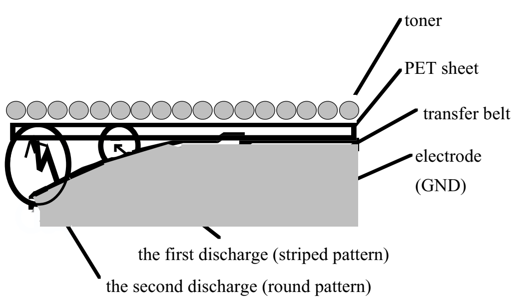


Figure 9. Mechanism of the second discharge.

Conclusion

The relationship between the sheet potential before the separation (Vs) and the separating discharges is investigated. The strong correlation between Vs and the separating discharges is found. When Vs is low, local strong discharge occurs intermittently and the image is extremely degraded. The separating discharges become continuous and weak when Vs is high. In the belt transfer system, charging the paper with a high voltage before the separation from the belt realizes excellent image-transfer without image degradation.

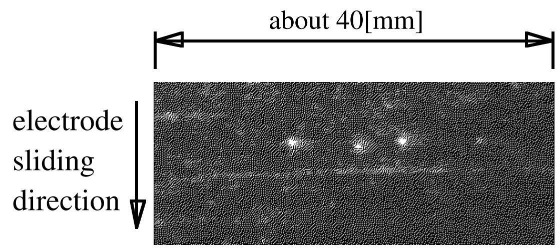


Figure 10. The second discharge light emission.

Acknowledgments

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