Surface-Potential-Decrease Phenomenon of Photoreceptor in Electrophotographic Mono-component Impression Development Process

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Abstract

Surface-potential-decrease phenomenon occasionally occurs by the interaction between the development roller and the photoreceptor via toner in the non-magnetic mono-component impression development process. The surface-potential-decrease phenomenon was investigated by using polymerized styrene-acrylic resin and pulverized polyester toners. The surface-potential-decrease is much larger with the styrene-acrylic resin toner than the polyester resin toner. The surface-potential-decrease phenomenon may be originated from two causes, one is the tribocharging between toner and photoreceptor, and the other is the charge injection to the photoreceptor through the toner. The order in the triboelectric series between photoreceptor and toner resin is most important. It is preferable for the reduction of the surface-potential-decrease phenomenon and the stability of development process that the toner resin is neutral to the photoreceptor in the order of the triboelectric series.

Introduction

Non-magnetic mono-component impression development process has become the main process of personal use laser printers because of its simple composition. The theoretical analysis of the development in this process has been advanced, and the toner mass transferring to the photoreceptor was theoretically estimated by calculation. The experimental results of toner mass transferred to the photoreceptor showed a good agreement with the theoretical values.

The theoretical estimation suggests that if the toner charge-to-mass ratio, q/m, is too high, fog occurs often by the normally charged toner. However, the fog on the paper originated from this reason may occur even though q/m is much lower than the theoretical value. For example, when the development roller rotates with the same direction of the photoreceptor and/or the development roller is pressed too strongly against the photoreceptor, the fog on the paper occurs more often. Namely, when the interaction between the development roller and the photoreceptor is strong, fog occurs more easily.

The difference between the theoretical and the experimental values, at which the fog occurs, may be caused by the surface-potential-decrease phenomenon of photoreceptor. Actually the decrease in surface potential of photoreceptor brings about fog in the images. However, there are few reports about the influence of development process on the surface potential of the photoreceptor as well as about the interaction between the photoreceptor and the development unit.[1] This paper describes the surface-potential-decrease phenomenon in the photoreceptor and its influence on the generation of fog.

Experiment

Development Unit

Figure 1 shows the scheme of the fundamental process unit used in this study. The developing roller is made of silicon rubber whose surface is coated with urethane-based resin to improve the tribocharging of toner and the durability against friction. The supply roller is made of conductive urethane foam rubber. The toner-regulating blade is made of stainless steel. An organic mono-layer photoreceptor of positive type is employed. Two kinds of toners were used in this study. One is a non-magnetic polymerized toner, whose resin is styrene-acrylic, and the other is a pulverized polyester toner. Both are positive type.

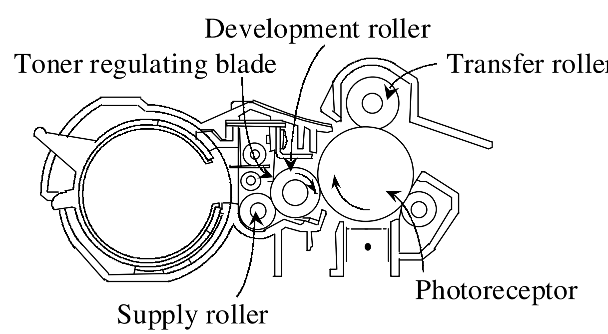

Figure 1. Fundamental process unit used in this study

The DC bias voltage expressed as Vb is supplied to the development roller. The metal substrate of photoreceptor is grounded. The photoreceptor was corona charged to be 900V at the beginning, but it may be changed through development process.

It should be noted here that the photoreceptor moves in opposite direction with the development roller at the contact area. The peripheral speeds of development roller and photoreceptor are about 100 mm/s and 50 mm/s, respectively.

The development roller is pressed to the photoreceptor by a spring at the right side of the development roller. There are a group of gears to rotate the development roller at the other end of the development roller, which presses the development roller to the photoreceptor while the development roller is rotating. The balance of left and right pressures of the development roller to the photoreceptor is adjusted by changing the strength of the spring.

Two kinds of springs are used is this study. One is a normal spring, and the other is a strong spring. Toner charge and fog were measured at the both ends of the development roller, spring side and gear side.

Measurement

It is necessary to measure both of surface potential of the photoreceptor and toner charge and toner mass on the development roller in order to investigate the influence of development process on the photoreceptor and the toner. For the measurements of the surface potentials of the photoreceptor, the probe of a surface potential meter is placed at the position of the transfer roller as shown in figure 2. The surface potential is measured by removing the development roller.

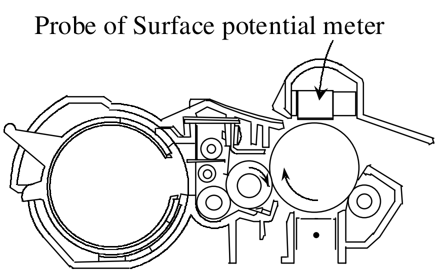

Figure 2.Measurement of surface potential of photoreceptor

The change in the properties of toner layer by the interaction between photoreceptor and toner is evaluated by measuring m/a and q/m at two points on the development roller, before and after the touch to the photoreceptor as shown in figure 3. The toner mass and the toner charge of the toner layer are measured by a suction type Faraday-cage, and the area of the toner layer is measured by tape-stripping-method.

In this paper, the gray background is evaluated as follows: The toner forming the gray background on the photoreceptor is caught on a clear adhesive tape, and then the tape is put on a white paper. The same clear tape catching no toner is put on the same white paper for reference. The reflectance of the two tapes on the white paper is measured by a reflect meter (TC-6MC Tokyo Densyoku Co., Ltd.). The gray background is evaluated by the difference between the reflectance of the two tapes, expressed as ΔY.

All measurements were carried out without light exposure.

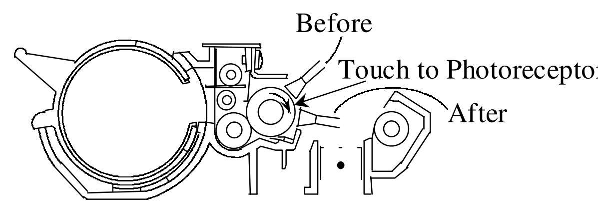

Figure 3. Measurement of q/m

Results and Discussion

Styrene-Acrylic Resin Toner

First, the surface-potential-decrease phenomenon was investigated by using the polymerized toner made of styrene-acrylic resin.

Figure 4 shows the surface-potentials at the spring-side of the photoreceptor as a function of the development voltage, Vb. These results show occurrence of the surface-potential-decrease phenomenon after touching the development roller. As the development voltage decreased, the surface-potential-decrease became remarkable. The surface-potential-decrease was larger for the strong spring than for the normal spring.

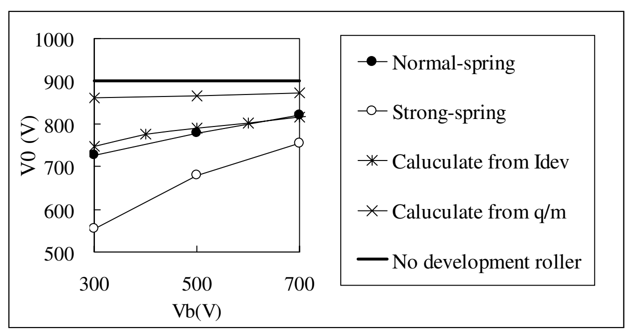

Figure 4. Surface potential of the photoreceptor as a function of Vb

The evaluation value of the gray background, ΔY, is plotted as a function of Vb in figure 5. When the Vb increased close to the surface potential of photoreceptor, the gray background consisting of the toner charged with normal polarity turned remarkable. The gray background occurred when Vb was 900V for the normal spring, while it occurred when Vb was 800V for the strong spring. The strong pressure of the development roller to the photoreceptor makes the gray background formed by the normally charged toner noticeable.

Figure 6 shows the development current, Idev, as a function of Vb. The values of decrease in surface potential calculated from Idev and the capacity of photoreceptor agree well with the experimental values shown in figure 4.

Figure 7 shows q/m before (solid line) and after (dotted line) the touch to the photoreceptor as a function of Vb. It was found that the q/m increased by the touch of the development roller to the photoreceptor. The q/m after the touch was about 1.4 and 1.7 times as large as that before the touch for the normal and strong springs, respectively. The ratio of increase in q/m was independent of Vb.

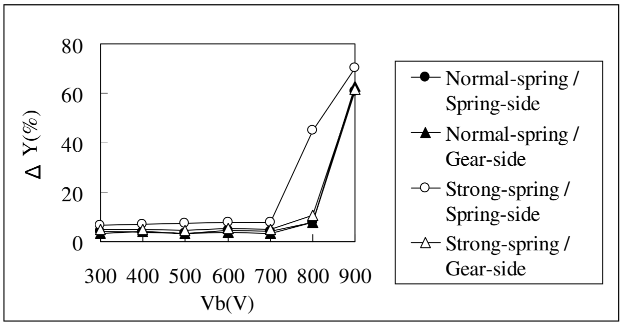

Figure 5. ΔY as a function of Vb, by which the fog on the photoreceptor is evaluated

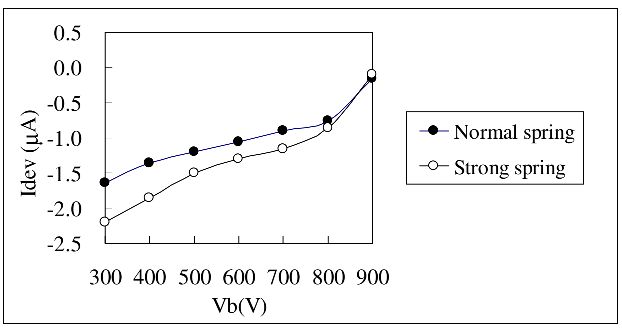

Figure 6. Development current, Idev, as a function of Vb

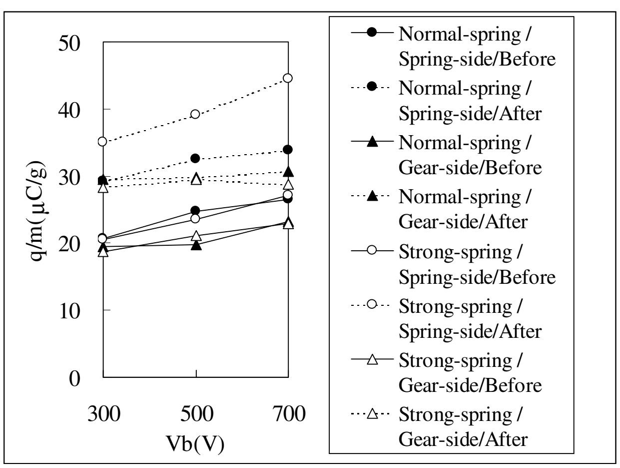

Figure 7. q/m as a function of Vb

The increase in q/m is considered to be caused by tribocharging between toner and photoreceptor. By using the increase in q/m of toner and the capacity of photoreceptor, the decrease in surface potential of photoreceptor can be reduces. However, the calculated value of the surface-potential-decrease is much smaller than the experimental results.

These results suggest another mechanism of the surface-potential-decrease phenomenon, that may be the charge injection from the development roller to the photoreceptor through the toner layer. The tribocharging between toner and photoreceptor is hardly influenced by Vb. On the other hand, the charge injection to the photoreceptor is influenced by Vb. The decrease in surface potential by the charge injection grows large with a decrease in Vb.

Polyester Resin Toner

Similar measurements were curried out by using a pulverized polyester toner to investigate the cause of the surface-potential-decrease phenomenon more in detail. Figure 8 shows the surface-potentials as a function of Vb for the polyester resin toner. The surface-potential-decrease phenomenon scarcely occurred for the normal spring in this case. The ΔY is plotted with Vb in figure 9. When Vb was 900V, ΔY for the polyester resin toner was smaller than that for the styrene-acrylic resin toner. As the pressure of the development roller to photoreceptor increased, ΔY decreased, contrary to the styrene-acrylic resin toner.

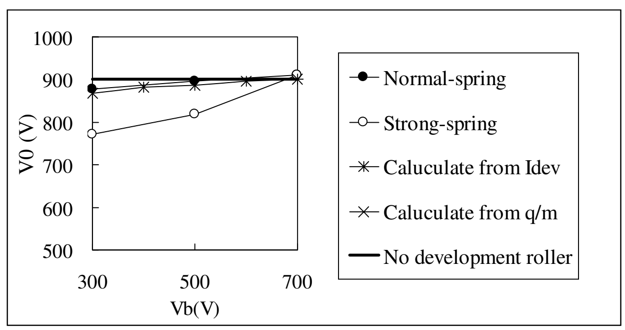

Figure 8. Surface potential of the photoreceptor as a function of Vb

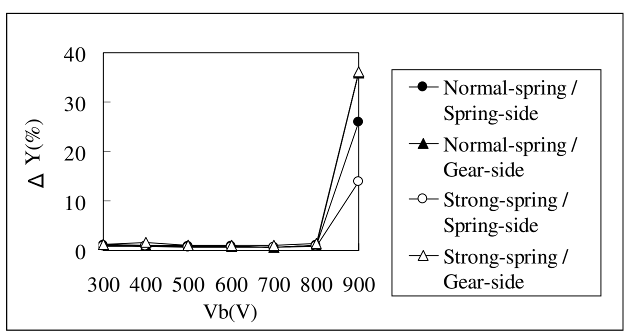

Figure 9. ΔY as a function of Vb, by which the fog on the photoreceptor is evaluated

Figure 10 shows q/m on the development roller as a function of Vb before and after the touch of the development roller to the photoreceptor. The touch of the development roller to the photoreceptor scarcely changed the toner q/m.

On the other hand, hairline image at the both ends disappeared for the polyester resin toner. The disappearance of hairline image became more remarkable when using the strong spring. The disappearance of hairline image did not occur with the styrene-acrylic resin toner.

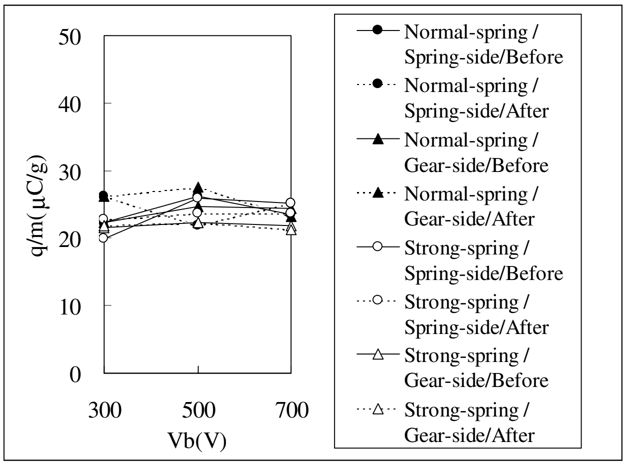

Figure 10. q/m as a function of Vb

Discussion

Experimental results described above indicate that charge exchange between the toner and the photoreceptor is the cause of the surface-potential-decrease phenomenon. The resin of toner seems to play an important role in the phenomenon. Actually, the surface-potential-decrease is large with the styrene-acrylic resin toner, and much small with the polyester resin toner. Furthermore, the order of the triboelectric series between photoreceptor and toner resin is another important factor for the charge exchange between the toner and the photoreceptor.

The surface-potential-decrease phenomenon may be originated from two causes. One is the tribocharging between toner and photoreceptor, and the other is the charge injection from the developing roller to the photoreceptor through the toner layer. The styrene-acrylic resin is positive to the photoreceptor in the order of the triboelectric series, because q/m of the toner increases by the friction with the photoreceptor. The tribocharging between photoreceptor and toner resin is hardly influenced by Vb.

The charge injection to the photoreceptor is also related to the order of the triboelectric series between photoreceptor and toner resin. If the order in the triboelectric series between photoreceptor and the styrene-acrylic resin reversed, the charge injection to the photoreceptor would become little.

On the other hand, the polyester resin is slightly negative to the photoreceptor in the order of the triboelectric series.[2,3] Though q/m of the toner hardly changes by the friction with the photoreceptor, some properties at the strong spring are contrary to the styrene-acrylic resin, for example, the change of ΔY and the disappearance of hairline image at the strong spring. Therefor, it is important for the reduction of the surface-potential-decrease phenomenon and the stability of development process that the toner resin is neutral to the photoreceptor in the order of the triboelectric series.

Conclusion

1. The surface-potential-decrease is much larger for the styrene-acrylic resin toner than for the polyester resin toner. The resin of toner is the main cause of the surface-potential-decrease phenomenon.
2. The surface-potential-decrease phenomenon may be originated from two causes. One is the tribocharging between toner and photoreceptor, and the other is the charge injection to the photoreceptor through the toner.
3. The order in the triboelectric series between photoreceptor and toner resin is most important. It is preferable for the reduction of the surface-potential-decrease phenomenon and the stability of development process that the toner resin is neutral to the photoreceptor in the order of the triboelectric series.

References

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Biography

Shougo Sato received the B.Sc. and M.E. degrees from Nagoya University, Nagoya Japan, in 1986, and 1988, respectively. In 1988, he entered Brother Industries, Ltd. Since then he has been working for research and development of the electrophotographic process. In 2001, he entered the Ph.D course of graduate school of Science and Engineering of Ibaraki University as a part time student. His research interest includes a non-magnetic mono-component developing system.