Property of Toner Layer on Developing Roller for Mono-Component Developing System

Akira Shimada, Research and Development Center, Ricoh Printing Systems, Ltd., Hitachi, Ibaraki, Japan; Masahiko Saito, Design and Development Division, Ricoh Printing Systems, Ltd., Hitachi, Ibaraki, Japan; Yuichiro Sano, Mechanical Engineering Research Laboratory, Hitachi, Ltd., Hitachinaka, Ibaraki, Japan

Abstract

*Property of toner layer on a developing roller for mono-component developing system has been investigated using a compact draw-off type instrument that measures toner charge and toner mass amount. The developing unit consists of a developing roller made of aluminum, a toner supply roller, and a blade, which controls the mass amount and the tribocharge of toner applied on the developing roller. The toner consists of polyester resin particles, which includes color agent, charge control agent, and external additives of silica. The charge measurement of toner on the developing roller is performed by directly absorbing toner particles with the absorption nozzle of the instrument. The toner mass amount on the roller surface is obtained simultaneously from the amount of toner absorbed into the absorption nozzle. The pushing pressure of the blade on the developing roller, the surface roughness of the roller, and external additives on toner surface affect the toner mass amount of the toner layer on the roller as well as the charge amount of the toner layer. It is found in this study that the charge to area ratio, which is a product of the toner charge and the toner mass amount on the developing roller, is very important to determine charging properties of toner particles***.**

Introduction

The developing process, which forms toner images on a photoreceptor, is one of the most important processes in the electrophotography. When C. F. Carlson invented the electrophotography in 1938, the developing method used in his invention was one of non-magnetic mono-component developing methods.[1] Afterwards, for a long time, two-component developing method, which uses the developer mixed with toner and carrier, has become a main current of developing process in the electrophotography, though various non-magnetic mono-component developing methods such as fur brush development and impression development were proposed.[2] However, a non-magnetic mono-component developing method was reviewed again as it entered 1990's, because this developing method was good for small copiers and laser printers.[3] Also, this developing method is good for a small color laser printer. Now, it is a main current technology of the developing method in small monochrome and color laser printers.

In the non-magnetic mono-component developing method, it is important to make the amount of toner charge and the toner mass amount of toner layer on the developing roller uniform and steady. To achieve steady toner layer on the developing roller in the non-magnetic mono-component developing method, the research on the toner particle design and the improvements concerning the development device design are actively done now. We have developed a compact draw-off type instrument for measuring toner charge.[4] The instrument can measure the charge to mass ratio (q/m) of both two-component and mono-component developers. Toner charge and toner mass amount of toner layer on the developing roller for a non-magnetic mono-component developing system have been investigated with the compact draw-off type instrument. This paper describes relationship between these properties of toner layer and the conditions in the mono-component developing unit.

Experimental

Figure 1 shows the structure of the developing unit with a non-magnetic mono-component developing method. The developing unit consists of a developing roller made of aluminum, a toner supply roller, and a blade, which controls the mass amount and the tribocharge of toner applied on the developing roller. A toner layer on the developing roller is formed in this developing unit as follows:

1. Toner particles in the toner hopper are transported to the supply roller side by the paddle.
2. Toner particles are transported to the developing roller side, and adhere to the developing roller by the supply roller.
3. Toner particles on the developing roller are carried to the restriction blade (SUS board with a polyurethane rubber bonded together) touched by rotating the developing roller, and these toner particles receive electrostatic charge by passing the blade, and the thickness of the toner layer is restricted.

Figure 2 shows an expansion of the blade area of this developing unit shown in Fig. 1. The pushing pressure of the blade on the developing roller, the surface roughness of the developing roller, and external additives on toner surface affect the toner mass amount of the toner layer on the roller as well as the charge amount of the toner layer.[3] In this paper, some relationship between these conditions of the developing unit and the property of toner layer are focused on.

The q/m measurement for the mono-component developer is performed by directly absorbing toner particles on the developing roller surface with the absorption nozzle of the compact draw-off type instrument as shown in Fig. 3. Therefore, the toner mass amount on the developing roller surface could be obtained simultaneously from the amount of toner absorbed into the absorption nozzle.

The toner used in this experiment consists of polyester resin particles, which include color agent, charge control agent in these resin particles, and two kinds of external additive of silica on these particle surfaces as shown in Fig. 4. The average diameter of the toner particles is about 8 µm.

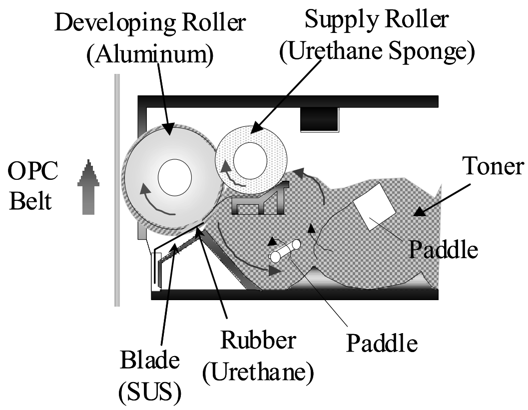


Figure 1. Structure of developing unit with non-magnetic mono-component developing method.

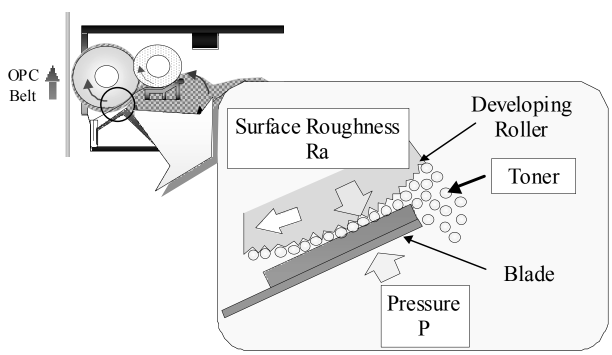


Figure 2. Structure of the blade area in the developing unit.

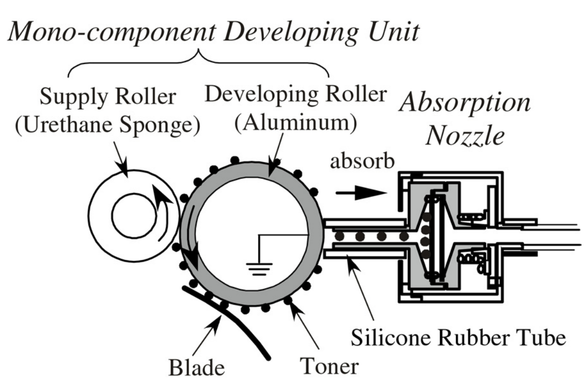


Figure 3. Measurement methods of q/m and TMA.

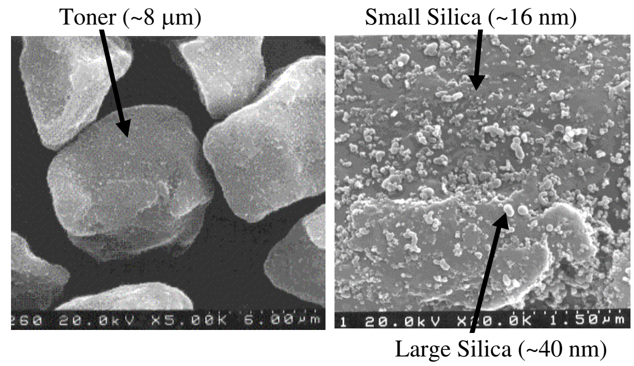
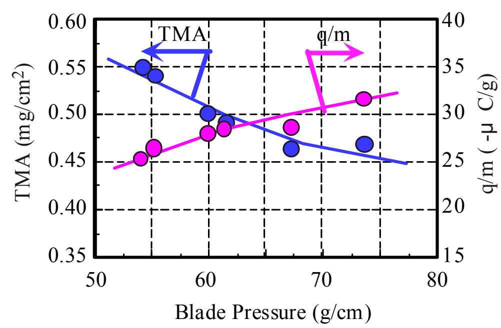


Figure 4. SEM photographs of toner surface.

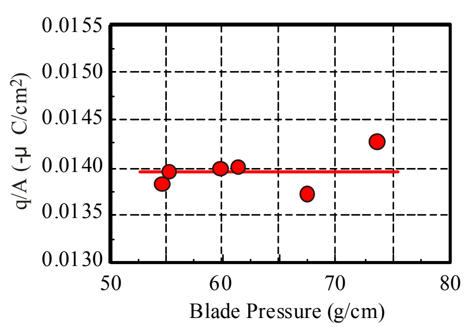
Results

Pushing Pressure of the Blade

Figure 5 shows a result of examining the relationship between the charge to mass ratio (q/m) of the toner layer on the developing roller and the pushing pressure of the blade; and the relationship between the toner mass amount (TMA) of the toner layer and the pushing pressure of the blade. The pushing pressure of the blade has been changed by the bending angle of the SUS blade. When the pushing pressure of the blade is increased from 55g/cm to 75g/cm, the TMA on the developing roller decreases. On the other hand, the q/m of the toner increases slightly. This is understood that the space between the blade and the developing roller decreases when the pressure of the blade is increased. Then the restriction power and the friction power to toner particles increase. As the result, the TMA decreases and the q/m increases. However, the charge to area ratio (q/A), which is a product of the q/m and the TMA on the developing roller, is almost constant.



(a) Blade pressure versus TMA and q/m.

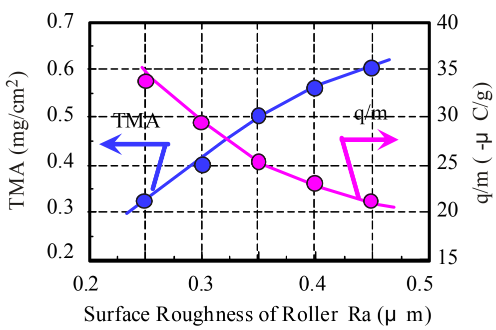


(b) Blade pressure versus q/A.

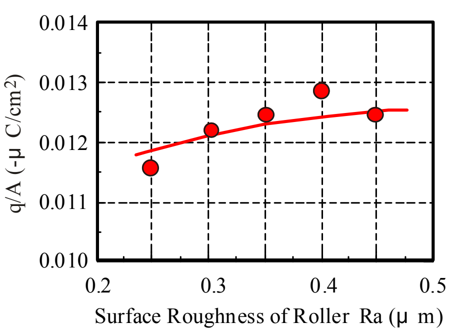
Figure 5. Pushing Pressure of blade versus toner property.

Surface Roughness of the Roller

The relationship between the property of the toner layer and the surface roughness of the developing roller is examined. Figure 6 shows the result. The surface of the developing roller used in this study is made rough uniformly by the sand blasting method. Roughness Ra (the arithmetic mean) on the surface of the developing roller is measured with a contact type surface roughness meter. From the results shown in Fig. 6, it is found that the TMA increases proportionally according to increase of the roller surface roughness, and the q/m deceases according to increase of the roller surface roughness. However, the q/A is almost constant. In this developing method, the TMA and the q/m are affected largely by the surface roughness of the roller. This is understood that the roller surface roughness makes one of the driving forces of the toner transportation.



(a) Surface roughness of roller versus TMA and q/m.



(b) Surface roughness of roller versus q/A.

Figure 6. Surface roughness of roller versus toner property.

External Additives on Toner Surface

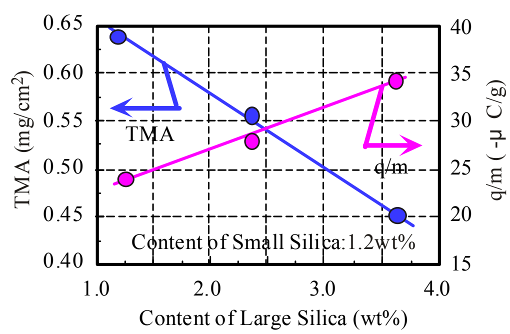
The relationship between the property of the toner layer and external additives on the toner surface is examined. External additives such as silica and titania are used in general for adjusting flowability and tribocharge of the toner in the electrophotography. In this experiment, two kinds of silica with a different particle size and a different hydrophobic coating are used. The large silica, which diameter is about 40nm, is treated with DSP (Dimethlysiloxane). The small silica, which diameter is about 16nm, is treated with DDS (Dimethlydichlorosilane).

How two kinds of silica influenced to the TMA and the q/m are examined. Figure 7 is a result of the TMA and the q/m when the content of the small silica is fixed at 1.2wt% and the content of the large silica is changed from 1.2wt% to 3.6wt%. It is found that the TMA decreases greatly when the content of the large silica is increased, and the q/m increases along with the content of the large silica. However, the q/A is almost constant.

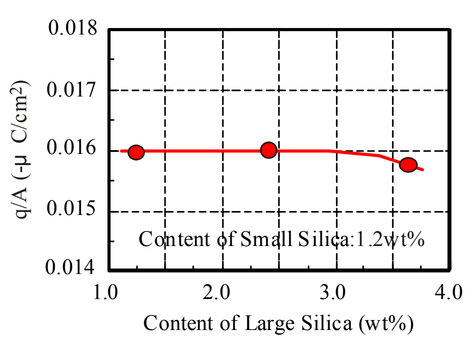
On the other hand, when the content of the large silica is fixed at 2.4wt% and the content of the small silica is increased from 0.6wt% to 1.8wt%, both of the TMA and the q/m increase as shown in Fig. 8. Therefore, in this case the q/A also increases according to increase of the content of the small silica.

It can be said that two kinds of silica used in this experiment has the following functions.

1. The large silica greatly gives the influence to the flowability of the toner. Therefore, the influence is hardly given to the q/m though the TMA decreases greatly when the content of the large silica is increased.
2. The small silica greatly gives the influence to the tribocharge of the toner. Therefore, the q/A increases when the content of the small silica is increased.

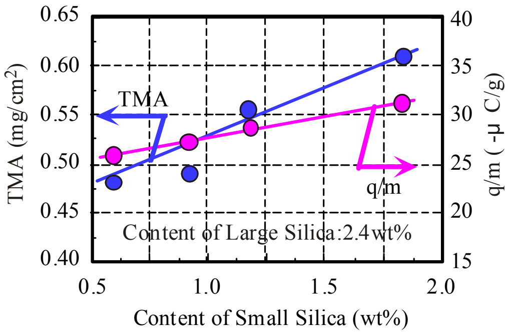


(a) Content of large silica versus TMA and q/m.

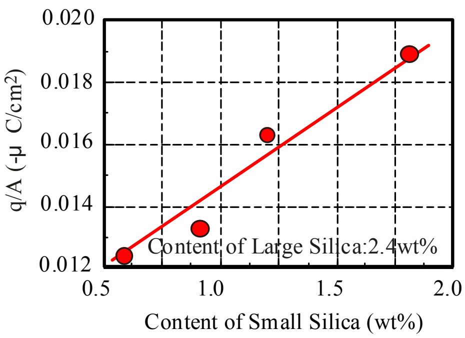


(b) Content of large silica versus q/A.

Figure 7. Content of large silica versus toner property.



(a) Content of small silica versus TMA and q/m.



(b) Content of small silica versus q/A.

Figure 8. Content of small silica versus toner property.

Conclusion

Property of toner layer on the developing roller for a non-magnetic mono-component developing system has been investigated using the compact draw-off type instrument for measuring toner charge and toner mass amount. As a result, the following conclusions are obtained:

1. The pushing pressure of the blade on the developing roller, the surface roughness of the developing roller, and external additives on toner surface affect the TMA of the toner layer on the roller as well as the q/m of the toner layer. The TMA and the q/m can be controlled by arrangements of these conditions.
2. External additives influence the property of the toner layer for the non-magnetic mono-component developing method largely. It is found that two kinds of silica with a different particle size and a different hydrophobic coating in this experiment have different properties as follows:
   - The large silica treated with DSP greatly gives the influence to the flowability of the toner. Therefore, the influence is hardly obtained to the q/m though the TMA decreases greatly when the content of the large silica is increased.
   - The small silica treated with DDS greatly gives the influence to the tribocharge of the toner. Therefore, the charge to area ratio (q/A), which is a product of the toner charge and the toner mass amount on the developing roller, increases when the content of the small silica is increased.
3. It is found that the q/A is very important to determine charging properties of toner particles.

References

1. R. M.Schaffert, "Electrophotography", Focal Press (1975).
2. R. C.Miller, Jr., IBM J. RES.DEVELOP, 38, p.252 (1984).
3. A. Shimada, T. Miyasaka, and M. Saito, Proceedings of 3rd International Conference on Imaging Science and Hardcopy, p.137 (1998).
4. A. Shimada, T. Miyasaka, and T. Uehara, Proceedings of NIP 18, p.632 (2002).

Author Biography

Akira Shimada received his B.E. degree in electronics from Shinshu University (1977) and his M.E. degree in electronic physics from Tokyo Institute of Technology (1979). In 1979, he joined Hitachi, Ltd., Japan. Since 2004, he has worked in Ricoh Printing Systems, Ltd., Japan. Since 1979, he has been engaged in research and development of imaging processes using electrophotogra-phy. He received his PhD from Tokyo Institute of Technology (2005) and he is a member of the Imaging Society of Japan.