

Design of Toner for Electrophotographic Printers and Copiers with a Collected Toner Recycle Function (T.R.F.)

Takayuki Sano
R&D in Chemical product Division, Tomoegawa Paper Co., Ltd
Shizuoka, Japan

Abstract

Recently, the demand for electrophotographic printers and copiers with a collected toner recycle function (T.R.F) has increased due to the growing concern of waste toner disposal.

Toner used in a T.R.F. system is subject to high pressure by each segment of the electrophotographic process. As a result, image quality defects such as low image density and high background may arise. In order to overcome these potential issues, the binder resin and additive treatments were studied, and excellent ways were found to design a toner for use in a T.R.F. system.

In regards to the binder, the key is the stiffness of the resin. It is well known that increasing the high molecular weight portion of the resin imparts stiffness to the binder, however this method decrease the ability of the toner to fuse properly at lower temperatures. The designed toner however, maintains an excellent balance between durability and low temperature fusing by utilizing low melt point waxes. As for the additive treatment, extraordinary methods were utilized for the designed toner in order to minimize any triboelectric charge variation normally resulting from the T.R.F. process. Thus it is concluded that the newly design toner is useful in the T.R.F. system.

Introduction

In ordinary electrophotographic printers and copiers, the photoconductor cannot transfer toner to the paper completely due to several factors. During the copy process, the toner that is not transferred to the paper and remains on the photoconductor is scraped off and collected in the cleaning unit. This is called ”collected toner”. The amount of collected toner differs depending on the system, but generally, it represents 10 to 25 percent of the consumed toner. In most cases, this collected toner is simple disposed of after it is cleaned from the system. This is because the characteristics between the collected toner and the supplied toner are different. If the collected toner is used as supplied toner, image quality defects such as low image density and high background may arise.

Recently, due to the growing concern of industrial waste and the reduction of unit cost, the demand for electrophotographic printers and copiers with a collected toner recycle function(T.R.F.) has increased. Therefore, there is a growing need for a toner that has been designed to function in a T.R.F. system.

The goal in designing a toner for T.R.F. is to achieve the same characteristics from the collected toner as had by the supplied toner. Typically, the main difference between the two toners is the triboelectric charge. The copy process causes this difference, when the toner is mixed with the carrier, it is subjected to significant pressure and in the cleaning unit where the untransferred toner is scraped from the photoconductor causing a difference in particle size. This pressure also affects additive treatments. The change in particle size refers to the increase in the fineness of the particles ground by the pressure. The pressure differentiates the way the additives are attached to the toner, causing peeling and burying.

This toner design deals with the stiffness of the binder by addressing the molecular weight distribution of the resin. It is well known that increasing the high molecular weight portion of the resin imparts stiffness to the binder, however this method decreases the ability of the toner to fuse properly at low temperatures. Therefore, by utilizing a low melt point wax, the designed toner maintains a balance between durability and low temperature fusibility. As for the additive treatment, a technique that minimizes any triboelectric charge variation normally resulting from the T.R.F. process will be mentioned.

The appearance of black spots on the image that were caused as a result of cohesion between the toner and paper dust were not discussed, because mechanical treatment was necessary. Finally, it must be mentioned that it is desirable to minimize the load on the toner in a T.R.F. system.

Experimental

Identifying When the Toner Destined to be Collected is Subjected to Pressure

Collected toner is subjected to high pressure when it is mixed with the carrier (fig.1). Once developed and not transferred, it is affected once again when it is scraped from the photoconductor in the cleaning section. These two processes, creating high pressure, cause a difference in particle size and affect the way additive treatments are attached to the toner, which eventually differentiate the collected toner from supplied toner in regards to triboelectric charge.

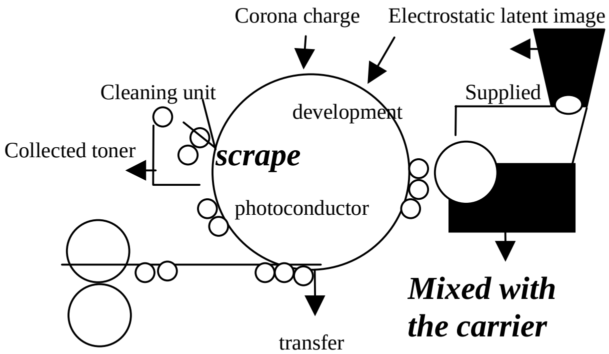

Figure 1. Two processes creating high pressure

Analysis of the Collected Toner

The supplied toner and collected toner in a machine without T.R.F. were compared.

1. Composition

There is a subtle difference in the amount of resin, CCA, wax, and carbon between the two toners, however, the differences are considered to be within the normal variation of the composition level. The difference in the composition level will not create any problem if the materials in each toner are dispersed uniformly.

2. Particle Size (Figure 2)

An increase in the fine particle content of the collected toner may be observed.

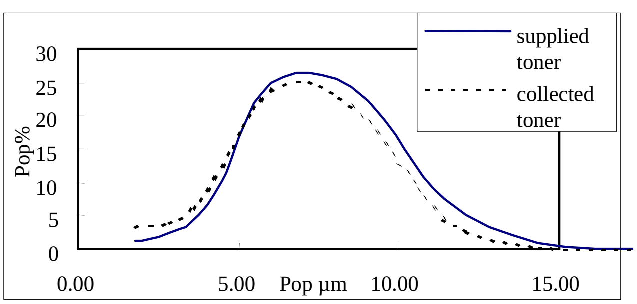

Figure 2.

3. Triboelectric Charge (Figure 3)

The triboelectric charge of the collected toner is lower than the supplied toner.

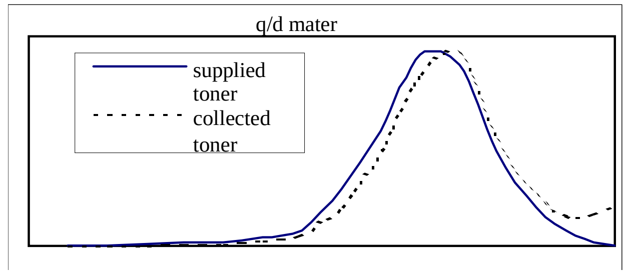

Figure 3.

4. Bulk Density comparison (Table 1)

Bulk density comparison of collected toner is decreased.

Table 1.

Supplied toner	collected toner
0.333 g/cm3	0.289 g/cm3

5. Additive Treatment Adhesiveness

Additional treatments are barely observed on the surface of the collected toner.

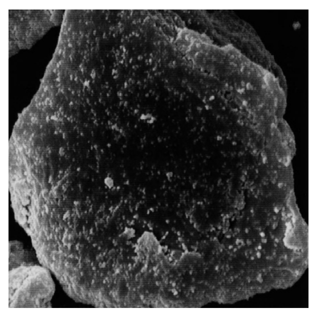

Figure 4a. Supplied toner

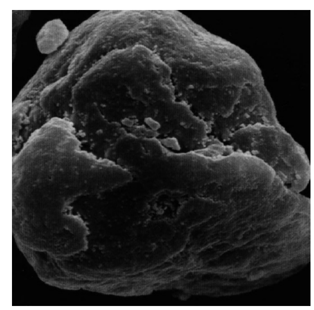

Figure 4b. Collected toner

As observed in evaluations 1 through 5, the collected toner is subjected to pressure caused by the copy process, increasing the amount of fine particles and changing the way the additives adhere. These changes significantly impact the triboelectric charge, resulting in the differing characteristics from the supplied toner. If the pressure were restricted, the collected toner could be re-used and obtain similar results to that of supplied toner.

Design of the Resin

The Distribution of the Molecular Weight and the Occurrence of Fine Powder

Using resin of the same composition, samples with different molecular weight ratios were created. Each sample was ground to a particle size of 150-250µm in a mechanical grinder. These samples were than placed in the grinder once again, and ground for 30 seconds. The particle size was then measured.

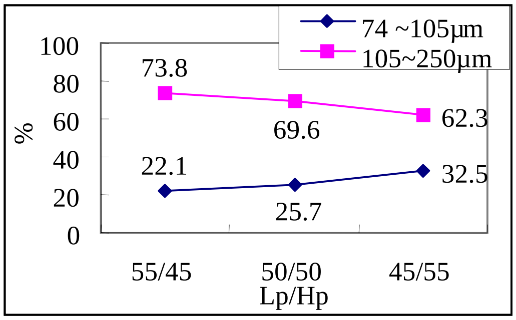

Figure 5.

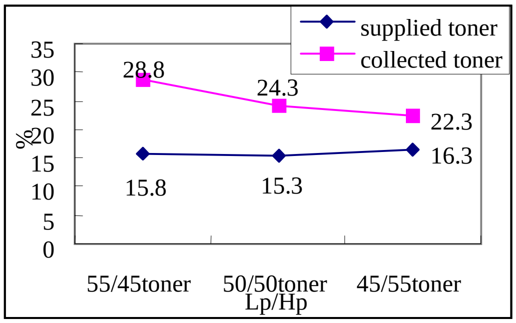

Figure 6.

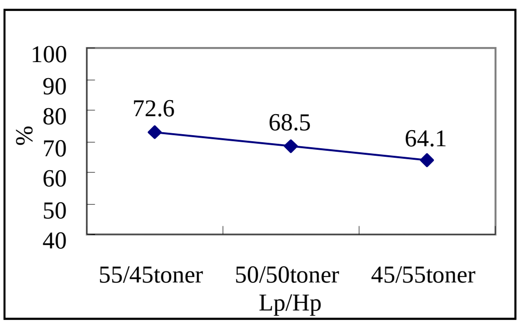

Figure 7.

The finding show that the sample with lower ratio of high molecular weight to low molecular weight is less durable and creates a larger quantity of fine powder. A similar occurrence can be expected when the toner is subjected to pressure.

Distribution of Molecular Weight and Occurrence of Fine Powder within the Copy Machine

Utilizing a toner with the resins used in example 1) and adjusting the particle size, life tests were conducted and the particle size of the supplied and collected toners were measured. The amount of fine powder (Population<5µm) was then compared.

As expected from the result of example 1) the amount of fine powder created from the resin with a low ratio of high molecular weight portion to low molecular weight portion was greater than the others.

Distribution of Molecular Weight and Fusibility

The toners used in example 2), were fused to paper at a temperature of 170 degrees centigrade, and the fused image was rubbed with and eraser to test the ability of the toners to fuse.

As a result of these three evaluations, the toner with the higher ratio of high molecular weight portion was more durable, but the ability to fuse properly at lower temper-atures was decreased. However, when 3% of a low melt point wax was added to the toner with an Lp/Hp ratio of 45/55, it was found that the fusibility ratio increased to an acceptable 73.1%.

In this second experiment, the toner created had a fine powder content of 16.0% as the supplied toner, and the resulting collected toner had a fine powder content of 23.8%. By utilizing this method, the designed toner maintains a balance between durability and low temperature fusing. The low melt point wax used in the experiment was a paraffin wax. Natural wax such as carnauba may produce similar results

How Additive Treatments Adhere to Toner

Additive treatments such as silica enhance the toner with the necessary triboelectric charge and fluidity. It is also well known that the extent to which the additives adhere to the toner influences these characteristics. As were observed in the previous experiments and evaluation, the way the additive treatments adhere to the collected toner is clearly different from way they adhere to the supplied toner. In order to improve the quality of the collected toner, the way additive treatments adhere to the supplied toner must be examined.

Adhesiveness of Silica Gauged by Different Intervals of Mix Time

Silica was added to the toner at a level of 0.6wt%, and the level of Adhesiveness was visually observed at different time intervals. (Refer to Figure 8-a,-b,-c)

At the 5second interval, slight cohesion of the silica is observed. At the 30second interval, the silica is seen to adhere uniformly. At the 10minute interval, no silica is seen on the surface of the toner.

Comparison of Supplied Toner and Collected Toner by the Adherence of Silica

Print quality tests were conducted between the toners from the 30sec.and 10min. exposure experiments, and then comparisons were made between the supplied toner and the collected toner.

1. Triboelectric Charge (µC/g)

With the supplied toner, the longer the exposure to the additive treatments, the lower the triboelectric charge. However, with the longer exposure, the difference between the triboelectric charge of the supplied toner and the collected toner is much less.

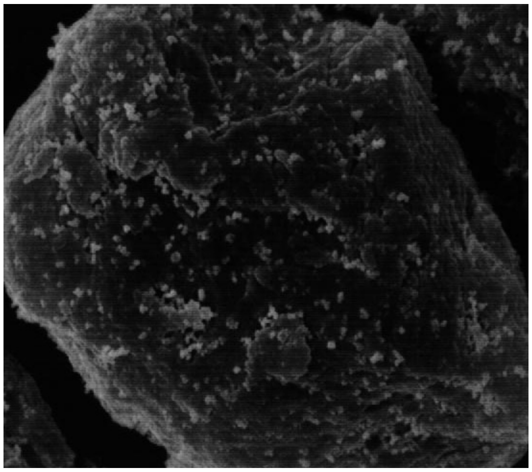

Figure 8-a Additive treatment at 5seconds

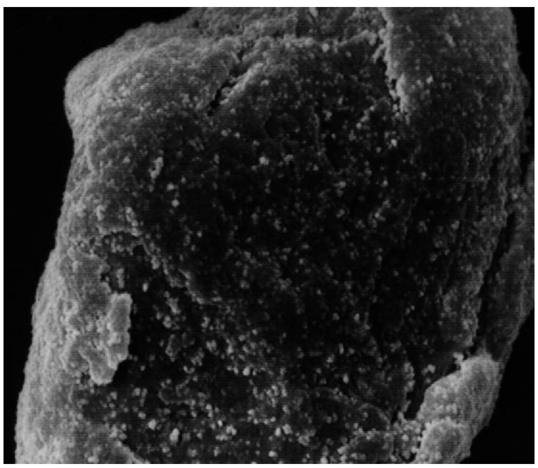

Figure 8-b Additive treatment at 30seconds

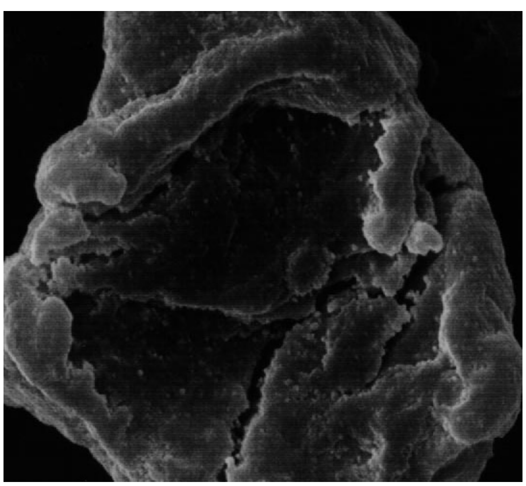

Figure 8-c Additive treatment at 10minuties

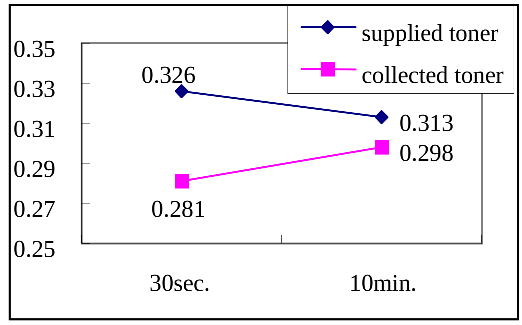

Figure 9.

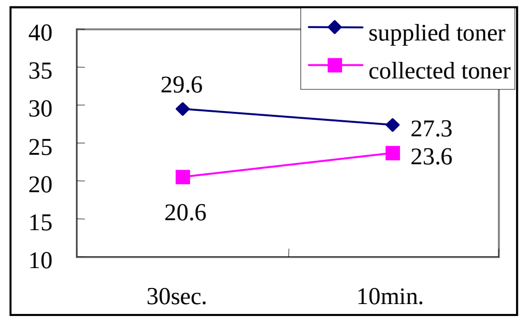

Figure 10.

2. Bulk Density (g/cm³)

With the supplied toner, the longer the exposure to additive treatments, the lower the bulk density. The difference between the supplied toner and the collected toner is the least with the toner exposed longer.

Under these conditions, the characteristics of the collected toner such as triboelectric charge and bulk density may be brought closer to those of the supplied toner. However, the type of silica and the duration of the additive treatments must be adjusted to overcome the negative impact on the supplied toner, such as lowered triboelectric charge and bulk density.

Conclusion

The goal of designing a toner for a T.R.F. system is to bring the characteristics of the collected toner closer to those of the supplied toner. The main difference between them is the particle size and the way the additive treatments adhere. These differences may be effectively overcome by designing the appropriate resin and adjusting the way the additive treatments are added.

In Summary

- Increase the amount of high molecular weight portion of the resin
- Supplement the ability of the toner to fuse properly with a low melt point wax

- A longer time interval is required for the additive treatments
- Supplement the lowered fluidity of toner with a variety of treatments

Toner that is designed in accordance with these guideline can continue to provide a stable image quality when utilized in a T.R.F. system.

Biography

Takayuki Sano received his B.E. in Department of Image Science Faculty of Engineering from Chiba University in 1987. He joined Tomoegawa Paper Co., Ltd. in 1987 working on R&D in Chemical Division. His current interests are toners for high-speed process.