Influence of Paper Dust on Electrophotographic Images in Mono-component Impression Development Process

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Abstract

The fog image shaped as the fiber-type paper dust on the background occurs under the combination of the mono-component impression development with the cleaner-less system. Occurrence of fiber-shaped fog images was studied by using two types of printers. The microscope observation of the fiber-shaped fog image indicates that many toner particles stick to the fiber-type paper dust on the photoreceptor and there are many toner particles without paper dust on the paper. The occurrence condition of the fiber-shaped fog image is different between the two different processes. The fiber-shaped fog image has periodicity in with-rotation printer, while no periodicity in counter-rotation printer. The fiber-type paper dust is collected by the development roller and this collected paper dust causes the fiber-shaped fog images in counter-rotation printer. The toner pressure pushes the fiber-type paper dust with toner out of the development room and the fiber-shaped fog image occurs in counter-rotation printer. The fiber-type paper dust is not caught by the development roller and kept turning with rotation of the photoreceptor in with-rotation printer. The paper dust is corona charged with positive polarity after scorotron charging device. However, it should be charged negatively, if it can not be caught by development roller. The styrene-acrylic polymerized toner can be considered to makes the paper dust tribocharged negatively at the place where the photoreceptor rubs against the development roller in with-rotation printer.

Introduction

Non-magnetic mono-component impression development process has become one of the most popular processes of the laser printer for personal use, because it has some advantages especially of its simple composition.

In the other hands, the cleaner-less development system, in which the development roller collects the residual toner on the photoreceptor after the transfer process, is known for its simple composition, too. The impression development process is well congenial with the cleaner-less development system.[1]

However, this combination of the impression development with the cleaner-less development suffers some undesirable influence of paper dust. The paper dust reaches the development process area with the rotation of photoreceptor and has some influence on the development process.

The paper dust consists of the fiber-type dust and the powder-type dust. Both of these two-types of paper dusts often give some serious damages to the development process and cause some problems of the printing image. We discuss about the influence of the fiber-type paper dust on the printing images in this report.

One of some problems, which occur in the combination of the impression development with the cleaner-less development, is occurrence of the fog images of the shape of fiber-type dust on the background.

We used two types of laser printers. The processes used in those two types of printers are different with each other in two points. One is the difference of the rotation directions of a photoreceptor and a development roller. One printer used in this study, in which the photoreceptor and development roller rotate in different direction (clockwise and anti-clockwise) is referred as with-rotation printer (Brother Ind. Ltd., HL-1240) in this paper. The other printer, in which the photoreceptor and development roller rotate in the same direction, is referred as counter-rotation printer (Brother Ind. Ltd., MFC-4800). The other difference in these two types of printers is toners. The with-rotation printer employs a polymerized styrene-acrylic toner, and the counter-rotation printer employs a pulverized polyester toner.

The fog image of the shape of the fiber-type dust occurs in these two printers under the special conditions, but the mechanisms of the occurrence are different with each other.

Experiment

Construction of Each Process Unit

Figures 1 and 2 show the scheme of the process unit of with-rotation printer and counter-rotation printer, respectively. Table 1 gives the fundamental characteristics of the two process units. As described above, there are two remarkable differences between these two processes. One is the difference of toner, and the other is the difference of the rotating directions of the photoreceptor and the development roller.

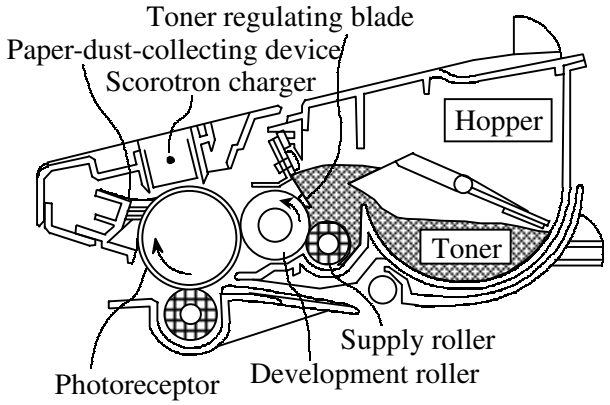

Figure 1. Scheme of the process unit in with-rotation printer

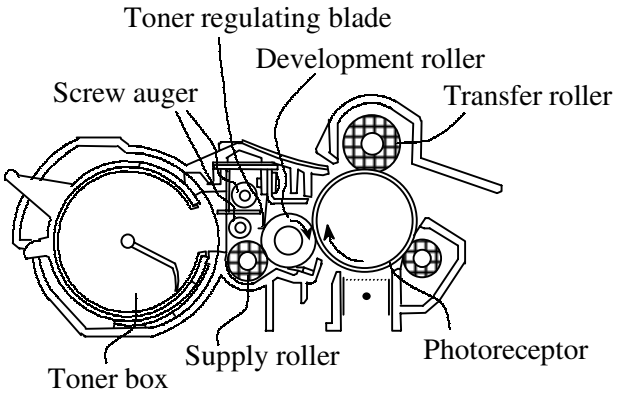

Figure 2. Scheme of the process unit in counter-rotation printer

Table 1. Fundamental characteristics of two kinds of process units

		With-rotation printer	Counter-rotation printer
Toner	Method	Polymerization	Pulverization
	Polymer	Styrene-acryl	Polyester
Development roller		Polymer coating	Coating free
Rotating direction		With	Counter

The common systems of these two printers are the non-magnetic mono-component impression development process and the cleaner-less development system. Both of the two printers commonly use a dispersion-type mono-layer OPC with positive polarity, a positive toner and a supply roller made of conductive urethane foam rubber. The difference between the polymerized toner and the pulverized toner was discussed by Yanagida et al.[2] The development roller is a urethane-based polymer coated roller and the toner regulating blade is made of silicon rubber, in with-rotation printer, while the roller is coating free and the blade is made of stainless steel, in counter-rotation printer.

The fog image of the shape of the fiber-type dust hardly occurs in these two printers under normal condition.

Experiment In With-Rotation Printer

First, experimental procedures and results are described for the with-rotation printer. The process unit of with-rotation printer is provided with a paper-dust-collecting device touching the photoreceptor as shown in figure 1. This device is constructed with a brush and non-woven cloth. When this device was removed, the fiber-shaped fog image occurred.

The fiber-shaped fog image occurred in the period of 94 mm. This period of 94 mm corresponds to the peripheral length of the photoreceptor.

Figures 3 and 4 show the microscope images of the toner forming the fiber-shaped fog image in with-rotation printer. These images were taken by a laser microscope (Keyence Co.: VK-9500). Figure 3 shows the toner particles on the photoreceptor before transfer process and figure 4 shows the toner particles on the paper after transfer process.

Many toner particles stick to the fiber-type paper dust on the photoreceptor. There is no paper dust on the paper, although there are many toner particles on it. It is realized that many toner particles are transferred from the photoreceptor to the paper, but the paper dust is not transferred. Consequently, the fiber-type paper dust is kept on the rotating photoreceptor.

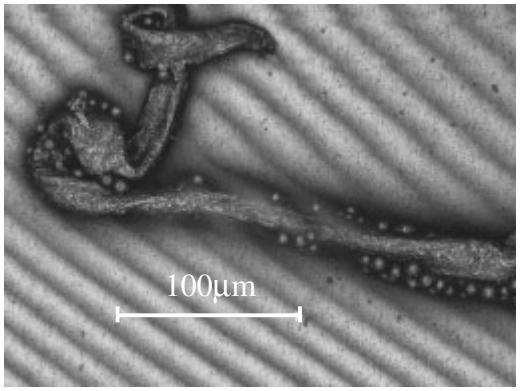

Figure 3. Microscope image of fiber-shaped fog image on the photoreceptor in with-rotation printer

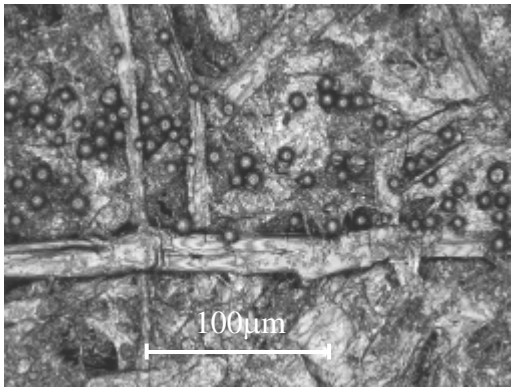

Figure 4. Microscope image of fiber-shaped fog image on the paper in with-rotation printer

Experiment In Counter-Rotation Printer

Next, experimental results for the counter-rotation printer are described. The fog image of the shape of the fiber-type dust never occurs in counter-rotation printer under the normal condition. It occurs under the special condition. If the two screw augers are stopped, the fiber-shaped fog image occurs immediately around the centerline of paper. It has no periodicity in counter-rotation printer. These screw augers make the toner circulate inside the development room.

Figures 5 and 6 show the microscope images of the toner particles forming the fiber-shaped fog image in counter-rotation printer. Figure 5 shows the toner particles on the photoreceptor and figure 6 shows the toner particles on the paper.

Similar to with-rotation printer, the many toner particles are transferred from the photoreceptor to the paper, but the paper dust is not transferred, too. However, it has no periodicity. The paper dust seems to be removed by one of the process devices from the photoreceptor.

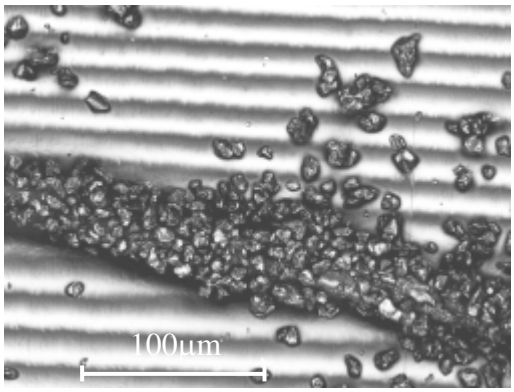

Figure 5. Microscope image of fiber-shaped fog image on the photoreceptor in counter-rotation printer

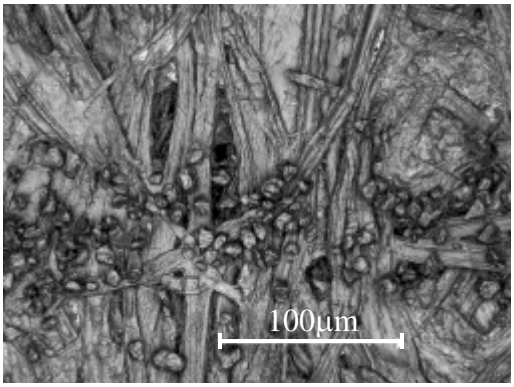

Figure 6. Microscope image of fiber-shaped fog image on the paper in counter-rotation printer

Discussion

Discussion About Counter-Rotation Printer

There is remarkable difference between these two processes. The fiber-shaped fog image has periodicity in with-rotation printer, but no periodicity in counter-rotation printer. The fiber-type paper dust on the photoreceptor is removed by one of the process devices in counter-rotation printer. It is necessary to clear the process device collecting the paper dust.

We investigated inside of the development room more in detail by removing the development roller in counter-rotation printer. Many fiber-type paper dusts with toner were found inside the development room. The development roller is considered to catch the paper dust.

The paper dust on the photoreceptor after transfer roller is charged with negative polarity, because the polarity of transfer current is negative. Then the paper dust is charged positively after passing the scorotron charging device for charging the photoreceptor, because the polarity of corona current is positive. Consequently the paper dust is charged with positive polarity at the development aria. Therefore the paper dust is caught by development roller, because of the electric field caused by the bias voltage of development roller. This is reasonable result. It can be concluded that the fiber-shaped fog image in counter-rotation printer is caused by the fiber-type paper dust inside the development room.

When the rotation of two screw augers stop, the fiber-shaped fog image is influenced from the existence of the toner box.

Figure 7 shows the number of the fiber-shaped fog image as a function of printing number of sheets when the toner box was attached and detached. The fiber-shaped fog image increases when the toner box is attached, while the fog image decreases without the toner box.

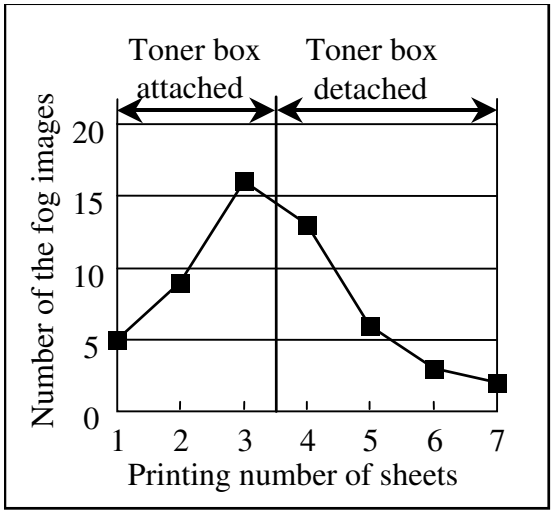

Figure 7. Number of fiber-shaped fog image as a function of printing number of sheets

This phenomenon is related to the pressure of the toner inside the development room. The pressure of toner pushes the fiber-type paper dust with toner out of the development room. The pressure of the toner inside the development room increases by the supply of the toner from the toner box. When the two screw augers rotate, the pressure is reduced, and it decreases when the toner box is removed.

The pressure near the toner regulation blade may give a great influence on this phenomenon.

Discussion About With-Rotation Printer

The fiber-shaped fog image has periodicity in with-rotation printer. The fiber-type paper dust is not caught by anything and kept turning with rotation of the photoreceptor.

The paper dust is charged with positive polarity after the scorotron charging device. However, it should be charged negatively, if it can not be caught by development roller. We investigated this phenomenon more in detail by exchanging toners between with-rotation printer and counter-rotation printer to clear this contradiction.

Experiment with Toner Exchange

The polyester pulverized toner was charged into the development device of with-rotation printer and the styrene-acrylic polymerized toner was charged into the development device of counter-rotation printer.

The fiber-shaped fog image did not occur in both cases. In other words, the fiber-shaped fog image occurred in only the combination of the styrene-acrylic polymerized toner with the process unit of with-rotation printer which has no paper dust collecting device.

Summarizing all the experimental results described above, we would like to propose the following hypothesis.

The fiber-type paper dust interacts with the styrene-acrylic polymerized toner at the place where the photoreceptor rubs against the development roller. The styrene-acrylic polymerized toner makes the paper dust tribocharged with negative polarity. The development roller cannot catch the paper dust charged negatively.

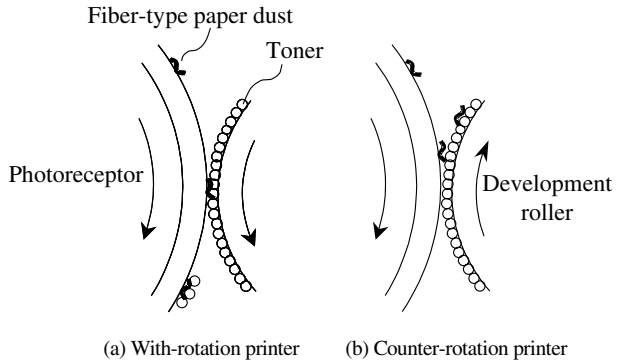

Figure 8. Behavior of fiber-type paper dust during development process

The reason why the fiber-shaped fog image does not occur in the combination of the styrene-acrylic polymerized toner with the process unit of counter-rotation printer is explained by the fact that the paper dust is caught by the development roller before it rubs against the development roller as shown in figure 8.

Conclusion

By using two types of laser printers, occurrence of fiber-shaped fog images was studied, and following results were obtained.

1. The fog image shaped as the fiber-type paper dust on the background occurs under the combination of the impression development with the cleaner-less development.
2. Many toner particles stick to the fiber-type paper dust on the photoreceptor and are transferred from the photoreceptor to the paper, while the paper dust is not transferred.
3. The occurrence condition of the fiber-shaped fog image is different between the two different processes. The fiber-shaped fog image has periodicity in with-rotation printer, while no periodicity in counter-rotation printer.
4. The fiber-type paper dust is collected by the development roller in counter-rotation printer and causes the fiber-shaped fog image. The toner pressure pushes the fiber-type paper dust with toner out of the development room and then the fiber-shaped fog image occurs.
5. The fiber-type paper dust is not caught by the development roller and kept turning with rotation of the photoreceptor in with-rotation printer. The paper dust is charged with positive polarity after scorotron charging device. However, it should be charged negatively, if it can not to be caught by development roller. The

styrene-acrylic polymerized toner is estimated to make the paper dust tribocharged negatively at the place where the photoreceptor rubs against the development roller.

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.