Non-magnetic Mono-component Impression Developing Process with Polymerized Toner of Positive Polarity

Shougo Sato and Mitsuru Horinoe
Brother Industries, Ltd., Nagoya, Japan

Abstract

The process used in HL-1240 was developed in optimizing the fine fluidity and the fine tribo-electric charging ability of polymerized toner of positive polarity. These advantages made the combination of the non-magnetic mono-component impression developing process and the cleaner-less developing process possible. Optimization of the materials used for the developing roller and the toner-regulating blade enabled both the fog image and the residual toner on the photoreceptor to become almost nothing. The cleaning roller is unnecessary for HL-1240 under this condition. As the printing speed becomes faster, the residual toner on the photoreceptor increases. When it is up to 25 ppm, the cleaning roller becomes necessary to prevent the ghost image. Furthermore, the cleaning roller improves the durability of the photoreceptor with grinding it moderately. The laser printers produced by Brother Industries, Ltd. are classified into the process with cleaning roller and the process without cleaning roller. These processes are used for the office and workgroup laser printer and the personal laser printer, respectively.

Introduction

A non-magnetic mono-component impression developing process has become one of the most popular processes of the laser printer for personal use. This type of process has many advantages, for example, a simple structure, compact size and fine image quality. But it is difficult to develop the toner used in this type of process because it needs to be tribo-electric charged quickly. If tribo-electric charging the toner is not quick in this type of process, several problems occur on the output image, for instance a fog image and a ghost image.

On the other hand, a cleaner-less developing process has become popular, too. It is the method that the developing roller collects and re-uses the residual toner on the photoreceptor after the transfer process. This type of process makes a laser printer simple and compact. Fine fluidity and quick tribo-electric charging are necessary for the toner used in this type of process.

The impression developing process is well congenial with the cleaner-less developing process.[1] The combination of the mono-component impression developing process with the cleaner-less process is the most reasonable process in the laser printers for personal use.

Polymerized toner of positive polarity is suitable for the impression cleaner-less developing process because it has fine fluidity[2] and it can be tribo-electric charged quickly.[3,4] The spherical shape of the polymerized toner causes its fine fluidity. Charge control agent (CCA) is considered to exist near the surface in the polymerized toner and the styrene-acrylic resin is fit for the toner of positive polarity, so the polymerized toner of positive polarity is charged quickly.

Several laser printers using the non-magnetic mono-component impression cleaner-less developing process have been developed in Brother Industries, Ltd. These printers are utilizing the advantages of the polymerized toner of positive polarity effectively.

It is discussed in this paper why the materials of a developing roller and a toner-regulating blade are selected for these printers and what is given by these selections. Finally, it is discussed about a future subject.

Structure and feature of HL-1240

Structure of HL-1240 and its process unit

HL-1240 produced by Brother Industries, Ltd. is the laser printer whose process is the non-magnetic mono-component impression cleaner-less developing process using the polymerized toner in positive polarity. Figures 1 and 2 show the appearances of HL-1240 and its process unit, respectively. Figures 3 shows the scheme of this process unit. The printing speed of HL-1240 is 12 ppm at letter size paper.

This printer is compact, and it is easy to exchange its process unit. The process unit is exchanged through the opening in front of the printer as shown in figure 4.

This printer has another feature that its process unit is separated in two pieces, that is to say, the developing unit and the photoreceptor unit, as shown in figure 5. This feature makes a running cost of HL-1240 low. The cleaner-less developing process is suitable for the process

unit separated into two pieces. Because an ordinary process unit needs a container for waste toner and the container must be large in the separated process unit.

Figure 1. Appearance of HL-1240 used in this study.

Figure 2. Appearance of the process unit of HL-1240.

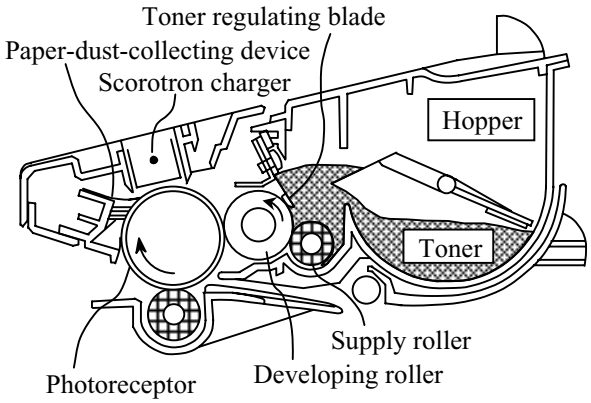

Figure 3. Scheme of the process unit of HL-1240.

Developing process of HL-1240 and its feature

The developing process of HL-1240 was designed so that the advantages of the polymerized toner of positive polarity might become the maximum and the weak point might become the minimum.

The cleaning roller is unnecessary for the process of HL-1240, because the polymerized toner of positive polarity has so fine fluidity and it is tribo-electric charged so quickly. Both the fog image on background and the residual toner after transfer are nearly zero in HL-1240.

Figure 4. Photograph of HL-1240 which front cover is opening.

Figure 5. Separating the process unit of HL-1240.

There are some reasons by which the materials used for the developing roller and the toner regulating blade are selected. It is important for the materials to adjust the tribo-electric charge of toner. The developing roller is made of silicon rubber and its surface is coated by urethane-based material. The urethane-based material is fitted for tribo-electric charging the toner in positive polarity. The toner-regulating blade is made of silicon rubber because it has fine ability to tribo-electric charge the toner.

Figure 6 shows the evaluation values of the fog image on background, ΔY, and the residual toner after transfer process, $\Delta T/R$, as a function of printing number of sheets. There are little fog image and little residual toner on the photoreceptor in HL-1240, and so the cleaning roller is unnecessary and the paper-dust-collecting device does not become dirty with toner.

In this paper, ΔY and $\Delta T/R$ are evaluated as follows: The toner forming the fog image on the photoreceptor or the residual toner after transfer 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.). ΔY and $\Delta T/R$ are evaluated by the difference between the reflectance of the two tapes.

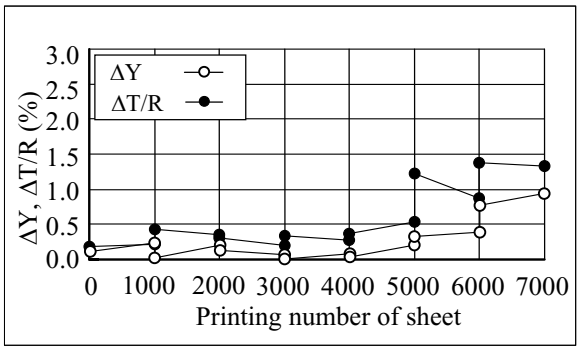

Figure 6. The fog image and residual toner on the photoreceptor in HL-1240.

Exchanging the material in HL-1240

The experiment exchanging the materials used for the developing roller and the toner regulating blade is expected to clarify any other reasons why the materials are selected.

At first, the developing roller was exchanged from the coated silicon rubber to a non-coated silicon rubber. The non-coated developing roller was ground by the toner which entered between a seal and the developing roller, and cracks arose on the developing roller. The toner leaked from the cracks. Figure 7 is the photograph of the non-coated developing roller and cracks. This image is taken by a laser-microscope (Keyence Co.: VK-9500).

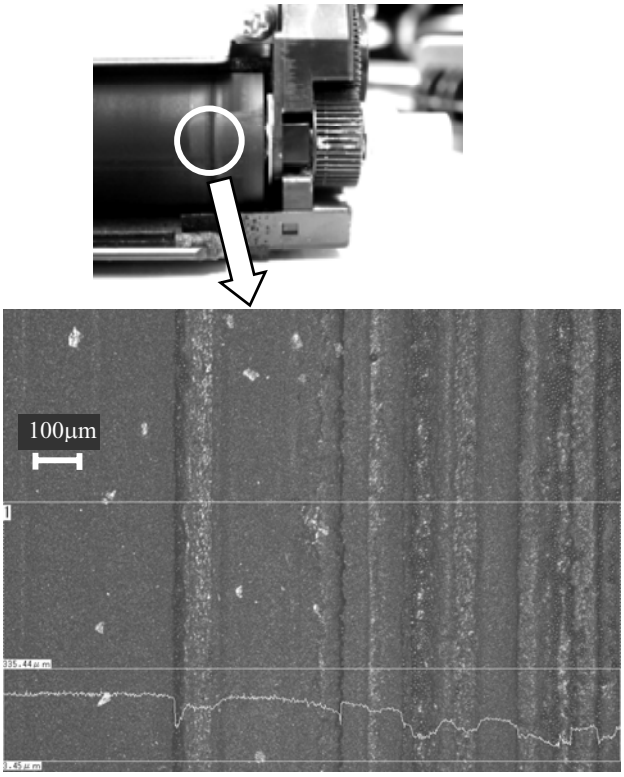

Figure 7. Photograph of the non-coat developing roller and cracks.

Silicon rubber tribo-electric charges the toner quickly, but it is ground so easily that the cracks arise on the developing roller. So it is necessary to coat the surface of developing roller.

The second, the toner-regulating blade was exchanged from silicon rubber to urethane rubber. When the toner-regulating blade was made of urethane rubber, the fog image and the residual toner existed very little on the photoreceptor like the time of using the silicon rubber, as shown in figure 8.

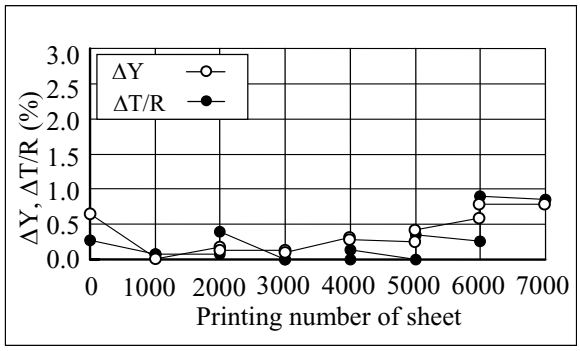

Figure 8. The fog image and residual toner when the toner-regulating blade is made of urethane rubber.

In this case, another problem occurred that the image density was uneven along the horizontal line of the image, as shown in figure 9. Such an unevenness is generated, since urethane rubber is hardly ground. Silicon rubber is ground moderately, so such an unevenness is not generated in the normal developing process.

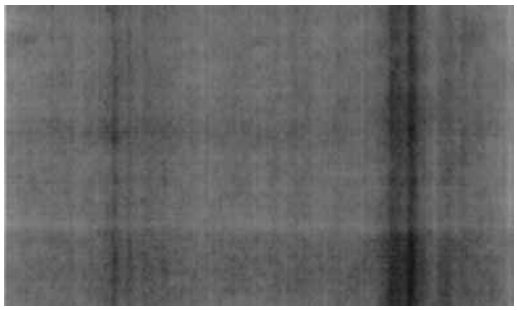

Figure 9. The image was printed out when the toner-regulating blade is made of urethane rubber.

As a result of these experiments, it turns out that the materials used in HL-1240 are the best combination. The coat of the developing roller is hard enough to be hardly ground and the toner-regulating blade is soft enough to be ground moderately.

Influence of printing speed on image

Experiment when printing speed is 20ppm

In this section, the influence of printing speed on image is discussed. It is expected that the process unit is improved corresponding to the rise of printing speed.

The fog image and the residual toner on the photoreceptor were measured when the printing speed increased from 12 ppm to 20 ppm. HL-5050 improved in the printing speed from 17 ppm to 20 ppm was used for this experiment. Figure 10 is the appearance of HL-5050 used in this study.

Figure 11 shows the result of this experiment. It is realized from this graph that the fog image is almost fixed in zero to the increase in printing speed, however, the residual toner tends to increase. The ghost image which arise from the residual toner does not occur in this printing speed.

Figure 10. Appearance of HL-5050 used in this study.

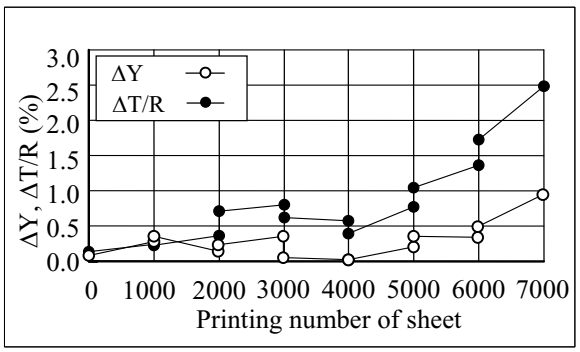

Figure 11. The fog image and residual toner when printing speed is 20 ppm.

Improvement corresponding to more than 20 ppm

As the printing speed becomes faster than 20 ppm, the residual toner increases further and damages the image quality. The ghost image caused by the residual toner sometimes occurs at the period of 94 mm in the printing speed more than 25 ppm. The period of 94 mm corresponds to the peripheral length of the photoreceptor. So a cleaning roller is necessary for the process in the printing speed more than 25 ppm.

Figure 12 shows the scheme of the process unit used in HL-6050 whose printing speed is 25 ppm. There is a cleaning roller in this process unit inevitably. Figure 13 shows the appearance of HL-6050.

The cleaning roller enables the laser printer to print out faster than 25 ppm. The printing speed of HL-7050 is 30 ppm. Figure 14 shows the appearance of HL-7050.

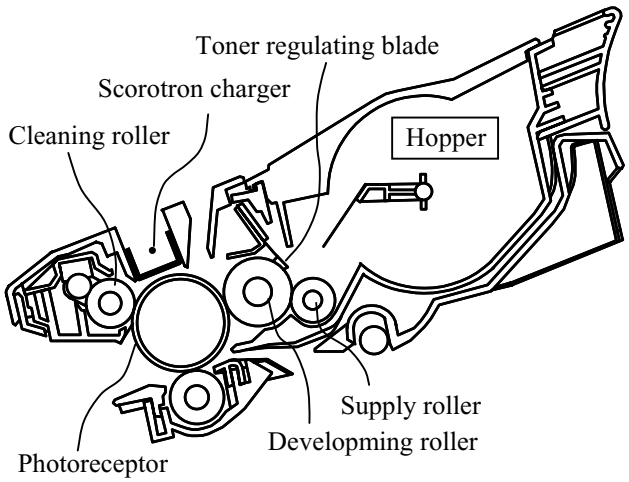

Figure 12. Scheme of the process unit used in HL-6050.

Figure 13. Appearance of HL-6050.

Figure 14. Appearance of HL-7050.

The cleaning roller also has a good effect on the durability of the photoreceptor because the cleaning roller grinds the photoreceptor moderately and refreshes its surface. In using the cleaning roller, the photoreceptor's life becomes longer.

Figure 15 shows the graph that plots the lineup of the laser printers produced by Brother Industries, Ltd. The vertical axis and horizontal axis of this graph express the life of photoreceptor and the printing speed, respectively. This lineup is classified into two types of processes, which are the process with cleaning roller and the one without cleaning roller. The process with cleaning roller is used for the office and workgroup laser printer, which has high durability of the photoreceptor and high-speed printing. The process without cleaning roller is used for the personal laser printer.

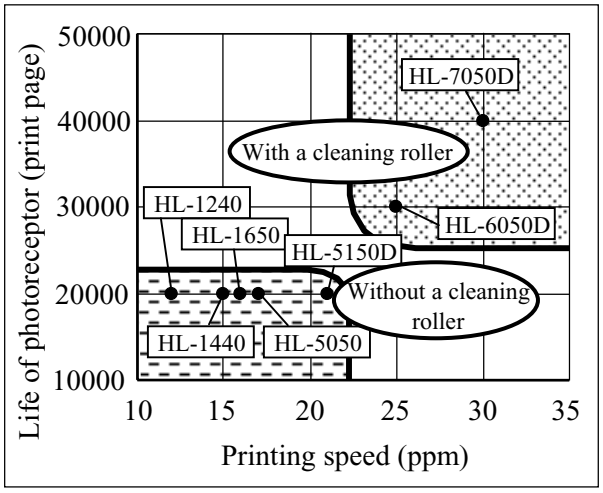

Figure 15. Lineup of the laser printer produced by Brother Industries, Ltd.

In the future, the process without the cleaning roller is expected to progress toward diagonal right in the lineup of the laser printer and to be used for the office and workgroup laser printer, as shown in figure 15. It is necessary to reduce the residual toner for this purpose.

Conclusion

The process used in HL-1240 was developed in optimizing the fine fluidity and the fine tribo-electric charging ability of the polymerized toner of positive polarity. Optimization of the materials used for the developing roller and the toner-regulating blade enabled both the fog image and the residual toner on the photoreceptor to become almost nothing. The cleaning roller is unnecessary for HL-1240 under this condition.

As the printing speed becomes faster, the residual toner on the photoreceptor increases. When it is up to 25 ppm, the cleaning roller becomes necessary to prevent the ghost image. The cleaning roller improves the durability of the photoreceptor with grinding it moderately.

The laser printers produced by Brother Industries, Ltd. are classified into the process with cleaning roller and the process without cleaning roller. These processes are used for the office and workgroup laser printer and the personal laser printer, respectively.

In the future, it will be necessary to decrease the residual toner in the printing speed of 25 ppm or more and the process without cleaning roller is expected to be used for the office and workgroup laser printer.

References

1. Masahiro Hosoya, Mitsunaga Saito, Tsutomu Uehara, Proc. IS&T's 7th Int. Cong. on Advances in NIP Technologies, pg. 113. (1991).
2. Noboru Yanagida, Takahiro Takasaki, Jun Hasegawa, Proc. PPIC/JH'98, pg. 46. (1998).
3. Shougo Sato, Manabu Takeuchi, Proc. IS&T's NIP18 Int. Conf. on Digital Printing Technologies, pg. 738. (2002).
4. Shougo Sato, Manabu Takeuchi, Proc. IS&T's NIP19 Int. Conf. on Digital Printing Technologies, pg. 86. (2003).

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 Ibaraki University, graduate school of Science and Engineering, and he received the D. Eng. degree from Ibaraki University in 2004. His research interest includes a non-magnetic mono-component developing process.