Single Component Non-Magnetic Development System for High-Speed Desktop Printer

Jong Moon Eun, Hyun Cheol Lee, Ki Jae Do, Hyun Wook Bae, and In Cheol Jeon
Samsung Electronics Co., Ltd.
Suwon, Korea

Abstract

In general, two-component development system has been widely used for high-speed printing machines because of its high reliability, durability, and color printing ability. Recently, the printing speed of desktop printer has been increasing and price has been dramatically decreasing in response to the market needs. However, two-component development system has a limit in reducing its cost when it is applied to desktop printer.

Otherwise single component non-magnetic development system has been proposed as an alternative for desktop laser printer because of its low cost, small size, and color printing ability. In particular, there has been considerable attention on non-contact type single component developing method due to its high image resolution.

There are several problems such as image quality, reliability, durability, and toner contamination in the machine as printing speed of development system increases. These problems have been improved remarkably by optimizing properties of developing roller, formulation of toner, and thin-layer-forming mechanism of metering blade.

However, one of the unsolved problems in non-contact type development system is the contamination in the machine by scattered toner particles that come from the airflow between photoconductive drum and developing roller.

In this research, we investigated and analyzed the non-contact type single component non-magnetic development system for high-speed machine. We experimentally studied the effect of toner layer, toner charge and developing gap. We also calculated the airflow in the developing apparatus by numerical simulation.

Introduction

A number of non-contact type development systems have been developed for a long time since a remarkable increase in various graphics and photo image printings.

In U.S. Pat. 3,232,190, transfer type development system is disclosed in which the charged toner are stored on a donor member and development is accomplished by transferring the toner from the donor to the image regions on the photo conductive surface across a finite air gap between donor and image surface.[1]

In U.S. Pat. 3,866,574, J.M. Hardennrook and his coworkers disclose a developing apparatus by providing a donor member that is adjacent and in spaced relationship to a photoreceptor and providing means for applying a pulsed bias to donor member.[2] The applied pulse is a combination of a short intense electrical pulse to release toner from the donor and starts it towards the photoreceptor and a nominal bias to prevent background development.

Magnetic developing method is disclosed to enhance print quality in U.S. Pat. 4,292,387, a latent image is developed by subjecting a magnetic developer to the action of an electric field and applying a low frequency alternating voltage to the developing gap.[3]

In U.S. Pat. 4,342,822, N. Hosono and his coworkers disclose a method and apparatus for image development, wherein a space gap between a latent image holding member and a developer carrying member is made wider, at a developing section, than thickness of the developer layer on the surface of the developer carrying member, and both members are opposed each other for developing operation, and wherein the developer is composed of electrically insulated toner particles.[4]

In U.S. Pat. 4,600,295, an image forming apparatus is disclosed in which square wave developing voltage is applied to developer carrying member instead of the conventional sinusoidal AC developing bias.[5] Such square wave developing bias reduces the moving energy of the toner and prevents the discharge between developing sleeve and photoconductive drum.

Visualization study of an interaction between airflow and scattering toner is well described by K. Uchida in the two-component development system.[6]

Measurement and analysis of toner motion in the development process is presented by J. Hirabayashi in the single component non-contact type development system.[7] The quantified toner traces allow us to obtain more accurate model to predict toner scattering in the development process.

A number of researches and developments have been focused on the non-contact type single component development system because of its low cost, small size and high resolution printing quality.

However, the contamination in the machine by scattered toner particles that come from the airflow between photoconductive drum and developing roller is one of the most difficult problems as the printing speed is increased.

This paper is to provide a development system for high-speed desktop printer that is free of the contamination.

Configurations of Development System

In general, non-contact type single component nonmagnetic development system can be characterized by three basic mechanisms: (1) The thin layer forming of the toner on the developing roller, (2) The uniform triboelectric charging of the toner on the developing roller without wrong signed toner, (3) Electric field control system across a gap between developing roller and photo conductive drum.

In the case of non-contact type development system, the reciprocating motion of the toner particles between photoconductive drum and developing roller occurs by AC Bias electric field.

Some toner particles deviate from developing zone by viscous airflow due to the rotation of the photoconductive drum and developing roller.

We introduced the propeller system to prevent toner scattering from the developing zone along the airflow. The new developing apparatus is shown in Fig. 1 and the configuration is summarized in Table 1.

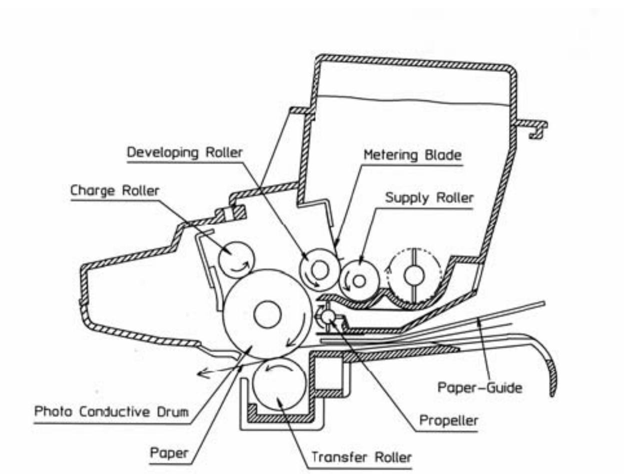


Figure 1. Cross-section drawing of the developing apparatus

Table 1. The Configuration of Development System

No.	Items	Description	Specification
1	Printing speed	40 ppm	Letter size
2	Resolution	1200/600 dpi	Address-ability

Experimental

To investigate the characteristics of the contamination due to scattered toner particles by the airflow between the photoconductive drum and developing roller, we set up experimental developing apparatus for non-contact type single component development system.[8,9]

Measurement of the Charge of Toner (q/m)

It is important to measure the charge of toner (q/m) on the developing roller in the developing zone. We measured toner charge (q) and mass (m) of toner layer on the roller in each case, subsequently we calculated the charge of toner (q/m) based on the mass of toner on the surface of the roller.

We used suction-type Faraday Cage through 0.8μm filter with 0.5MPa pressure to collect toner from the roller and to measure toner charge by electrometer, respectively.

Measurement of the Mass of Toner (m/a)

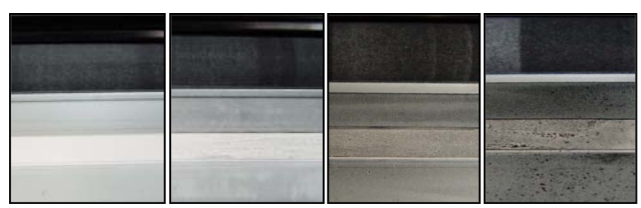
The toner layer can be described as the mass of toner (m/a) based on the surface area of the toner layer on the roller. We measured mass (m) of the toner that was collected from the toner layer on the developing roller in fixed area, subsequently we calculated the mass of toner (m/a) based on the area of the toner layer on the roller.

Measurement of the Contamination in the Machine

The contamination in the machine by scattered toner particles was observed during the printing operation on the paper guide as shown in Fig. 1. The ranks of the contaminations were clarified as shown in Table 2 and in Fig. 2.

Table 2. The Ranks of the Contamination Level

Rank	Description	Remark
0	No contamination	Excellent
1	A very little contamination	Acceptable
2	A little contamination	Not Acceptable
3	Contamination	Problem
4	Serious contamination	Serious Problem
5	Very serious contamination	Serious Problem



Rank 0 Rank 1 Rank 3 Rank 5

Figure 2. The degree of contamination in the machine due to the scattered toner particles

Results and Discussion

The Effect of Toner Layer on Contamination

The contamination level decreases as the mass of toner (m/a) on the developing roller decreases as shown in Fig. 3.

However, it is very difficult to decrease the mass of toner less than 0.4mg/cm^2 due to toner stress and low image density. We found that the mass of the toner was around 0.6mg/cm^2 to obtain enough image density and reliability.

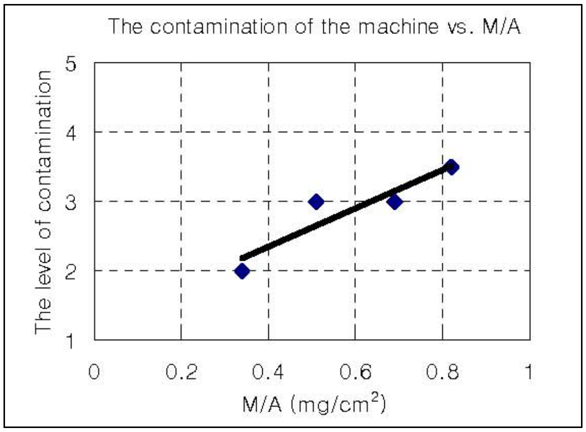


Figure 3. The contamination level as a function of M/A (mg/cm^2) on the developing roller

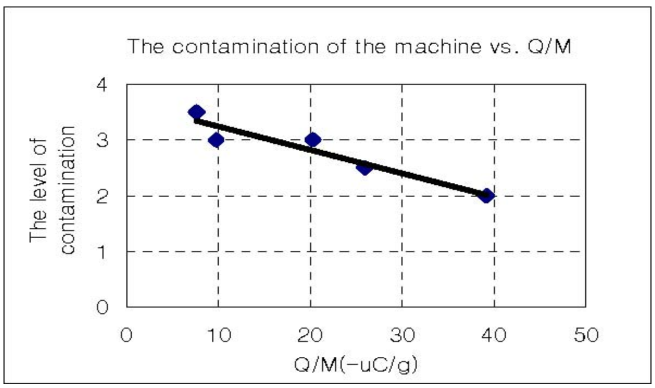


Figure 4. The contamination level as a function of Q/M (-µC/g) on the developing roller

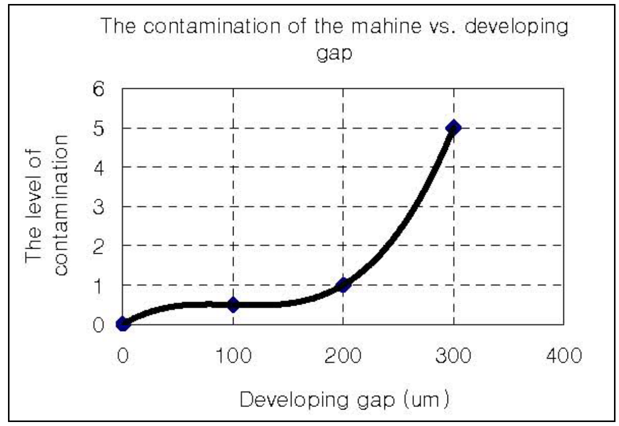


Figure 5. The contamination level as a function of developing gap

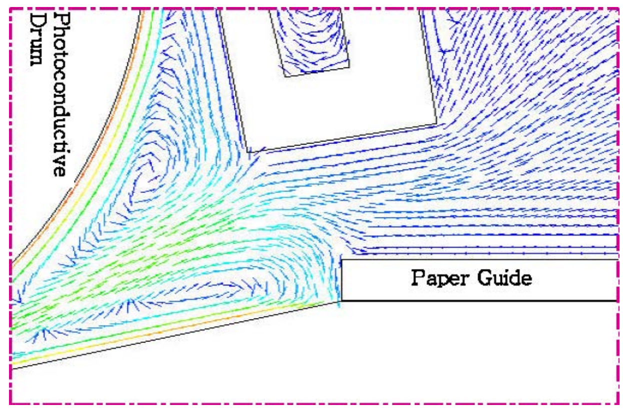


Figure 6. The result of viscous airflow simulation in the development process around paper guide

The Effect of Toner Charge on Contamination

The trend of the contamination based on the toner charge is shown in Fig. 4. The contamination level decreases as the toner charge (q/m) on the developing roller increases.

However, it is very difficult to increase the toner charge more than 30(-µC/g) due to low image density. We found that the level of toner charge was around 20(-µC/g) to obtain enough image density.

The Effect of Developing Gap on Contamination

The Fig. 5 shows that the level of contamination was evaluated as a function of developing gap. It was found that the level of contamination increases dramatically with an increase of developing gap. It means that we need to reduce the developing gap to avoid the contamination of the machine. However, it seems no reduction the developing gap due to the breakdown of AC Bias voltage.

The Characteristics of the Contamination in the Machine

We found that it is difficult to remove contamination by adjusting of toner layer, toner charge and developing gap. Therefore we need to evaluate another effect such as the airflow in the developing zone.

The airflow in the developing apparatus was calculated by FEM method. A numerical simulation in transfer region shows that the airflow by the photoconductive drum collides with the viscous flow by the recording media, forming some re-circulation zones and an airflow toward paper guide as shown in Fig. 6.

From the simulation result, we predict that most of the scattered toner particles would be deposited on the paper guide. This is a good agreement with our experimental result as shown in Fig. 7.

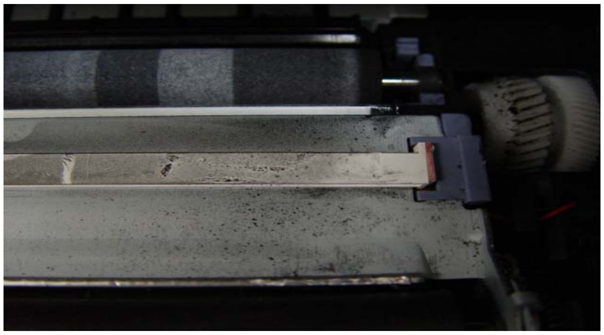


Figure 7. The contamination of the machine on the paper guide after printing operation without the propeller system

The Improvement of the Contamination in the Machine

We introduced the propeller system to prevent toner deviation from the developing zone due to viscous airflow. The propeller system makes additional airflow against the direction of photoconductive drum movement.

Even though there is the reciprocating motion of the toner particles in the development process, the viscous airflow can't carry toner particles due to the reverse airflow generated by the propeller system.

In addition, we improved contamination by turning off AC Bias voltage during non-printing area because it could not make any reciprocating motion of the toner particles.

To verify the development system in this study, we performed running test with parameter values obtained from optimization process. We succeeded in 40ppm printing operation without any contamination problems in the machine. We found that there is no contamination in the machine as shown in Fig. 8.

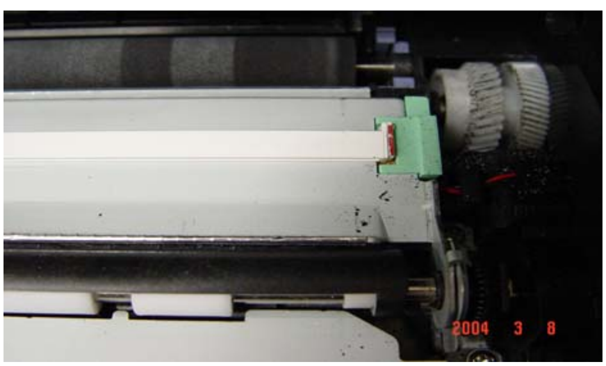


Figure 8. The contamination level of the machine on the paper guide with the propeller system

Conclusion

The characteristics of the contamination of machine in non-contact type single component development system depend on the characteristics of the viscous airflow as well as the timing control of the electric field.

Our experimental investigation can be useful to understand the critical parameters to prevent the contamination from the toner scattering at the developing zone. It was found that there is no contamination due to the viscous airflow at high speed printing machine with 40ppm.

It is also necessary to understand the characteristics of the airflow in order to remove the contamination of machine in non-contact type single component system.

Incidentally, we introduced the propeller system, which makes additional airflow against the direction of photoconductive drum movement. It leads to reduce contamination level. In addition, we can improve contamination by turning off AC Bias voltage during non-printing area because it prevents reciprocating motion of the toner from the developing roller.

Consequently, we can achieve high-speed development system that is free of contamination.

References

1. Robert W. Willmott, Method and Apparatus for Copying, U.S. Patent 3,232,190 (1966).
2. James M. Hardennrook, et al., Xerographic Developing Apparatus, U.S. Patent 3,866,574 (1975).
3. Junichiro Kanbe, et al., Magnetic Developing Method under A.C. Electric Bias and Apparatus Therefor, U.S. Patent 4,292,387 (1981).
4. Nagao Hosono, et al., Method for Development Using Eletric Bias, U.S. Patent 4,342,822 (1982).
5. Koji Suzuki, et al., Image Forming Apparatus, U.S. Patent 4,600,295 (1986).
6. Keisuke Uchida, Visualization Study of an Interaction Between Airflow and Scattering Toner, Proceedings of IS&T's NIP 18 International Conference on Digital Printing Technologies, pg. 36. (2002).
7. Jun Hirabayashi, Measurement and Analyses of Toner Motion in the Development Process, Proceedings of IS&T's NIP 19 International Conference on Digital Printing Technologies, pg. 18. (2003).
8. Jong Moon Eun, et al., An Experimental Design for Non-Contact Type Single Component Non-Magnetic Development System, Proceedings of IS&T's NIP 18 International Conference on Digital Printing Technologies, pg. 17. (2002).
9. Jong Moon Eun, et al., An Experimental Design for Non-Contact Type Single Component Non-Magnetic Development System, Proceedings of IS&T's NIP 19 International Conference on Digital Printing Technologies, pg. 13. (2003).

Biographies

Jong Moon Eun received his M.S. degree in Mechanical Engineering from Seoul National University, Korea, in 1986 majoring fluid mechanics. He has been developed several kinds of printers at Samsung Electronics. He has been involved in system development of laser beam printing system using electro-photographic process since 1990, and his work is focused on development system for high-resolution print quality.

Hyun Cheol Lee received his M.S. degree in Mechanical Engineering from Yonsei University, Korea, in 1988 majoring heat transfer analysis. He has been involved in system development of laser beam printer at Samsung Electronics since 1988, and his work is focused on developing system analysis.

Ki Jae Do received his B.S. degree in Electronic Engineering from Chungnam National University, Korea, in 1989. He has been involved in system development of laser beam printer at Samsung Electronics since 1989, and his work is focused on developing electrophotographic process. Lately he is very interested in high-resolution printing based on single component developing method.

Hyun Wook Bae received his B.S. degree in physics from SungKyunKwan University, Korea, in 1991. He has been involved in system development of laser beam printing system at Samsung Electronics since 1991, and his work is focused on developing electrophotographic process. Lately he is very interested in high-resolution printing based on single component developing method.

In Cheol Jeon received his M.S. degree in Mechanical Engineering from KyungHee University, Korea, in 1992 majoring mechanical properties analysis. He has been involved in system development of laser beam printing system at Samsung Electronics since 2002, and his work is focused on the development of toner cartridge.