液体現像剤を用いたフルカラー電子写真プリンタにおける高画質化技術

High Quality Imaging Technology in Electrophotographic Full Color Printer Using Liquid Developer

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要 旨

電子写真の高画質化・高解像度化は，液体キャリアに微粒子トナーを分散させた液体現像剤を用いることによって達成可能である．しかし液体現像は，液体現像によって画像形成された感光体上のトナー像を転写材に転写する際，液の介在に起因する像が流れること，及び画像面積によって最適転写条件が異なることなどいくつかの問題がある．
これらの問題を解消し高画質を達成するため，“セットローラ”と，“転写材加圧機構”を開発した．“セットローラ”は，転写前の感光体上のトナー像にグロー放電を用いて電荷を与える事により，トナー像の凝集力を高める機構である．また“転写材加圧機構”とは，転写部より前もって転写材を感光体に押し付けることにより，画像パターンに依存せず良好に転写させる機構である．これらの技術を採り入れ，高速デジタルフルカラープリンタを試作し，高画質フルカラー画像を得た．

ABSTRACT

High quality and high resolution images can be obtained by applying a liquid developer whose major components are liquid carrier and submicron toner particles suspended in the carrier. However, the liquid development process still has some problems relating to the transfer process. The first is image disorder occurring due to the disturbance of the liquid developer when the image is transferred to the image carrying medium. The second is that optimum transfer condition of various image patterns is not constant.

To solve these problems and keep high image quality, a “set roller” and a “transfer medium pressure mechanism” have been developed. The “set roller” can tightly pack the toner particles by glow discharge before transfer to the medium. The “transfer medium pressure mechanism” is image transfer system regardless the type of image pattern by pressing the transfer medium to the photoconductor just before the transfer position. Applying these technologies, the high speed digital full color printer and the high quality color image have been realized.

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1. Introduction

In recent years, electrophotography using liquid developer is attracting a good deal of public attention with the progress in development of full color printers[1]. This technology can realize high resolution and high image quality being similar to offset printing.

The liquid developer consists of a liquid carrier and submicron toner particles suspended in the carrier. However, liquid developer still have some problems relating to the transfer process. The first is image disorder. The appropriate quantity of the liquid carrier is necessary to keep a fine image quality. The second is the variation of transfer condition. The optimum transfer condition of a line pattern is different to that of a solid pattern.

To solve these problems, we have developed two new technologies relating to the transfer process. The first is a technology that packs toner particles onto the photoconductor. We call this phenomenon "set". The second is a belt pressure technology to prevent discharge between the paper and the photoconductor. As a result of these improvements, high image quality and high resolution have been obtained.

2. Technical description

2-1 Outline of printer

Figure 1 is a schematic illustration of an electrophotographic system using a liquid developer. Four photoconductors are arranged vertically and paper is fed upwards on a feeding belt. The transferred image is fixed by a heated roller. The feeding belt is wiped by a belt cleaning web.

Figure 2 shows one station of this system. A latent image formed by charging and exposure is developed by the development roller into a toned image. This toned image consists of toner particles and liquid carrier. Some liquid carrier is necessary to transfer but excess carrier causes image blurring, so that excess liquid carrier associated with the toned image should be squeezed by the squeeze roller. The squeezed image is packed tightly by discharging from the set roller. The packed toner image is transferred to paper fed by a feeding belt. A pre-transfer pressure mechanism is arranged before the transfer roller to press the paper against the photoconductor. A foam roller and a blade are used for cleaning the photoconductor. The foam roller re-disperses the residue of the transferred images and a blade scrapes away the remaining developer.

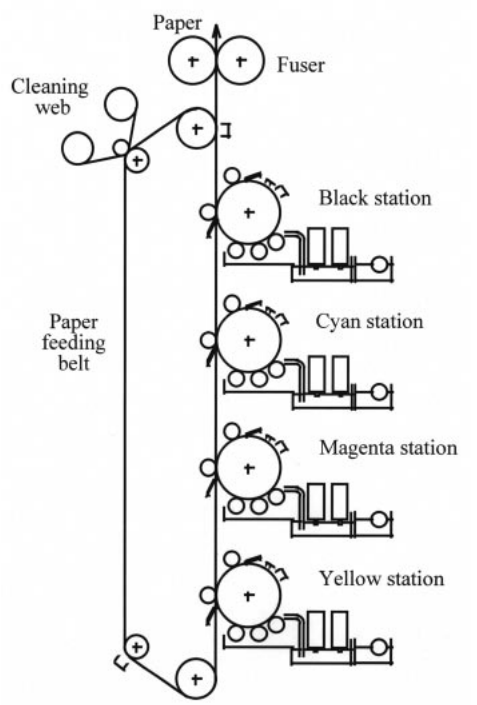

Fig.1 Schematic illustration of electrophotographic system using liquid developer

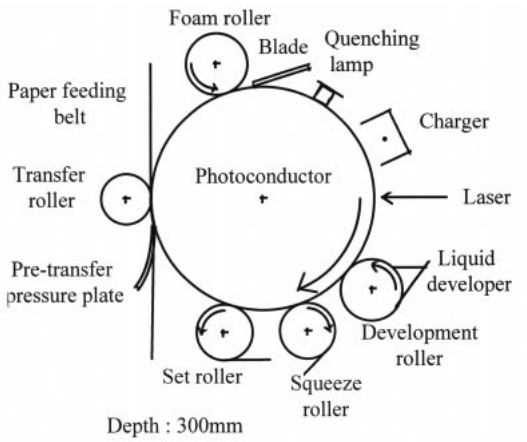

Fig.2 Schematic illustration of electrophotographic system using liquid developer

2-2 Set toned image on the photoconductor

Image disorder is one of the problems in the transfer process. We have developed a technique for increasing the cohesion of toner particles on the photoconductor with the object of preventing this problem. In order to increase cohesion between toner particles, a local electric field is generated with glow discharge by applying high voltage.

An extended view of the set roller is shown in Fig. 3. The set roller is located opposite to the photoconductor. The gap is approximately 70 um. The material of this roller is aluminum. Its surface is anodized to insulate because of the high voltage applied to the set roller. There is an air gap between the developer on the photoconductor and the set roller. A scraper is placed against the surface of the set roller to remove waste toner or liquid carrier. About 1000 V of the same polarity as the toner is applied to this set roller.

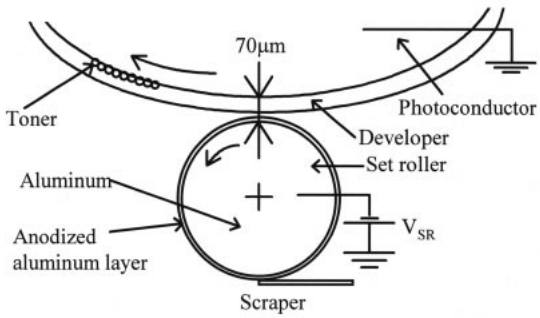

Fig.3 Extended view of set roller

Figure 4 is the toned image developed using a liquid developer on a photoconductor. The line width is about 340 um. Figure 5a, 5b are the transferred images without and with set respectively. The transferred image with set is not disturbed, as compared, without set. When the toned image is set, it is transferred to paper accurately.

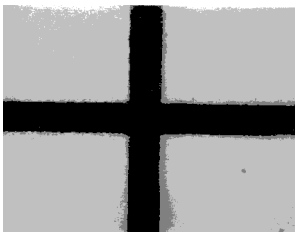

Fig.4 Toned image on photoconductor
line width : 340 um

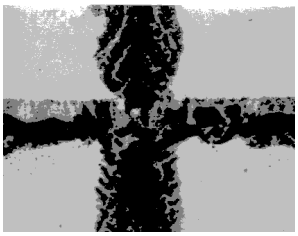

Fig.5a Transferred image without set

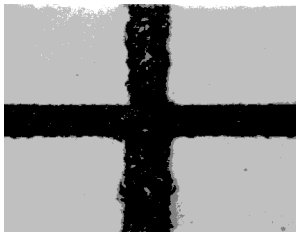

Fig.5b Transferred image with set

Figure 6 shows the relationship between rotation of the squeeze roller and current of the set roller. When the speed of the squeeze roller slows down, the thickness of developer on the photoconductor increases. If the speed of the squeeze roller is below 190 mm/s, the gap between the set roller and a photoconductor is filled with the developer. Under this condition, the set effect is recognized. However, it shows lower current and an increase in current fluctuation. For the stability of image quality, it is important to squeeze excess developer by the squeeze roller and to maintain an air gap between the set roller and the photoconductor.

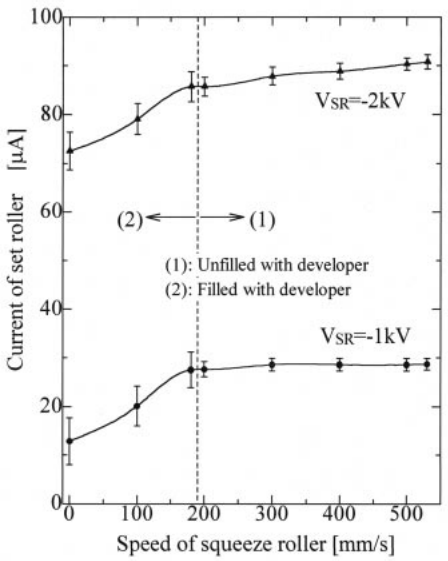

Fig.6 Relationship between speed of squeeze roller and current of set roller

The dependency of current through the set roller on the gap between the photoconductor and the set roller is shown in Fig.7. If the gap is wider, the generating voltage of discharge is higher and the gradient of current is steeper. If the gap is narrower, the generating voltage of discharge is

lower and it is possible to provide a constant current if the voltage fluctuates. However, if the gap is too narrow, and the set roller contacts the toned image on the photoconductor, it disturbs the image. It is necessary to consider these conditions in order to choose the best gap. Finally, the gap was fixed at 70 um in this system.

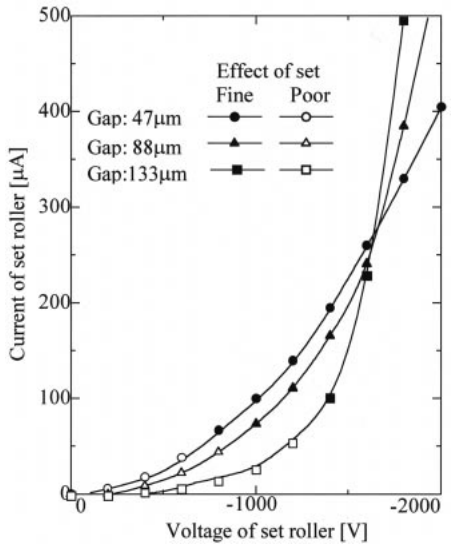

Fig.7 Dependency of current on gap between photoconductor and set roller

Figure 8 shows the dependency of current through the set roller on the material of the set roller. The surface materials, one is an electrical conductor and another is a insulator, were evaluated the relationship between an applied voltage and a produced current. In the case of an electrical conductor, current fluctuation is much larger than a electrical insulator. Moreover, a conductive roller sometimes causes spark discharge and it damages a photoconductor. From this point of view, surface of the roller should be insulated. Anodized aluminum was selected as the surface material in this system.

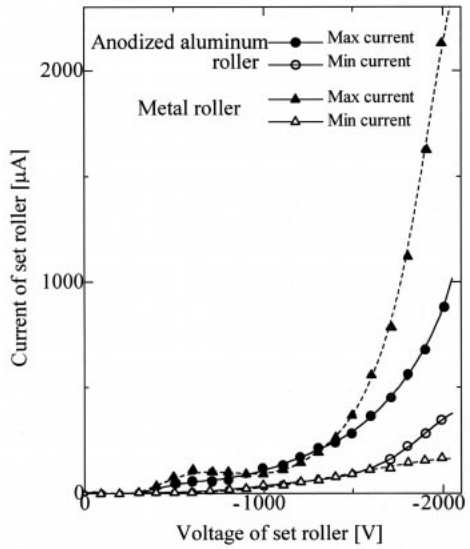

Fig.8 Dependency of current on material of set roller

2-3 Transfer independent of image area

Another problem is the difference in transfer conditions of various printing patterns. The relationship between printed line width and current through a transfer roller is shown in Fig.9. In this figure, "a" shows the suitable transfer current area with the conventional transfer method. Unsuitable transfer current causes some problems. When current for transfer is too low, transfer efficiency is inferior. On the other hand, excess current for transfer causes unwanted discharge between the paper and photoconductor and result poor images. This shifts depend on image patterns. It is difficult to transfer both line and solid images in a fixed transfer condition.

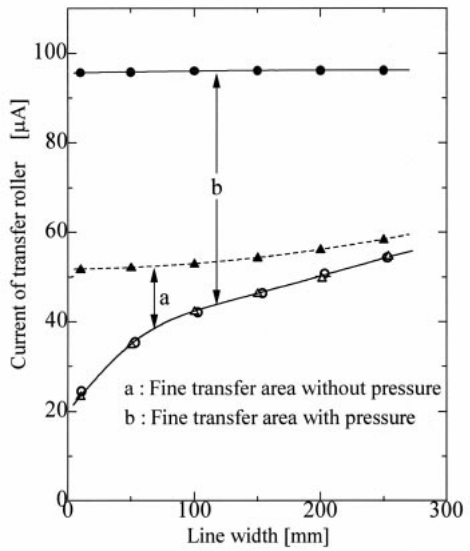

Fig.9 Relationship between line width and current of transfer roller

It is well known that a paper pressure mechanism against a photoconductor[2] enables this suitable transfer current area to be extended. It prevents generation of the unwanted discharge prior to the paper touching the photoconductor.
The paper press mechanism is shown Fig. 2. The paper is fed by the paper feeding belt and is

pressed from behind the belt by a plate installed at just before the transfer position.

Figure 10 shows the transferred image with pressure and without set. If the paper was pressed against the photoconductor without set, the transferred image was blurred, especially with unabsorbent coated paper. Since we expected the set effect to solve this problem, the belt pressure mechanism was installed just before transfer.

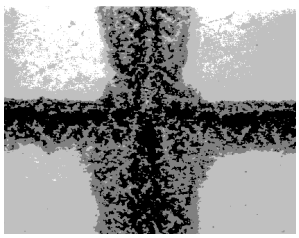

Fig.10 Transferred image without set / with pressure

As shown in Fig. 9, the suitable transfer area was extended significantly from "a" to "b" by installing the belt pressure mechanism. This made it possible to transfer various image patterns in a fixed transfer condition.

Figure 11 shows the effect of the belt pressure mechanism on a transferred image. Figure 11a is a transferred image made without the belt pressure mechanism and Fig. 11b is a transferred image made with this mechanism. These images were transferred with the same transfer current being suitable for each condition. The transferred image with pressure is high quality without blur or disorder and with sharp edges, and further, it has transferred accurately the toned image from the photoconductor to paper.

Fig.11a Transferred image without pressure

Fig.11b Transferred image with pressure

3. Conclusion

In the electrophotographic printer using liquid developer, two new technologies, set mechanism and belt pressure mechanism, have been developed. As a result of these technologies, a toned image on a photoconductor was transferred excellently onto paper with complete fidelity, and various patterns were transferred perfectly in a fixed transfer condition. Consequently, we have realized a remarkable improvement in image quality.

4. Future plan

The set technology is applicable for many situations especially electrophotographic printing system, for example, charging process or transfer process. We will perform the application in the future.

On the other hand, we would like to improve some problems, for example, the handling facility or the vapor of liquid development with retaining the high image quality.

Acknowledgments

The creation of the full color printer technology was the accomplishment of this project group members.

References

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