

Long-life Fuser Technologies for Color Laser Printer

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Abstract

A color laser printer was developed that can produce high-quality color images and text on plain paper and transparencies. To achieve high image quality, high fusing performance (high speed-fusing, consistent fusing quality, and long life) is required.

We have experimentally investigated the relationship between the tribocharging voltage of the rollers, which were tribocharged with printed media and pressurized components, and fuser life. Based on the relationship we identified, we developed optimal design method for fuser components.

Introduction

Electrophotography has become a widely used technique for printing images on various print media. We have developed a full-color laser printer with an intermediate transfer drum (Figure 1 and Table 1). The printer is equipped with a diode laser scanner assembly, an organic photoconductor (OPC) belt, four color-developing units using a nonmagnetic mono-component developing method, an intermediate transfer drum, a transfer roller, and a roller-type fuser. Latent images are formed on the OPC belt and developed by each color toner (yellow, magenta, cyan, and black) by developing units. Developed toner is transferred to the intermediate drum, and the four color images are overlapped. They are then transferred to the media, and the toner applied to the media is fused by the roller-type fuser unit.

The development and transfer processes of this type printer were previously modeled and analyzed.[1]

To achieve high image quality, high fusing performance (high-speed fusing, consistent fusing quality, and long life) is required.

To achieve a long-life roller-type fuser requires

1. Reducing foreign substances (e.g., offset toner) on the roller,
2. Making the structure robust against media jamming,
3. Improving the cleaning performance of the rollers.

From the viewpoints of (1), and (2), we investigated the tribocharging of the rollers.

Our experimental results and proposed design method are described in this paper.

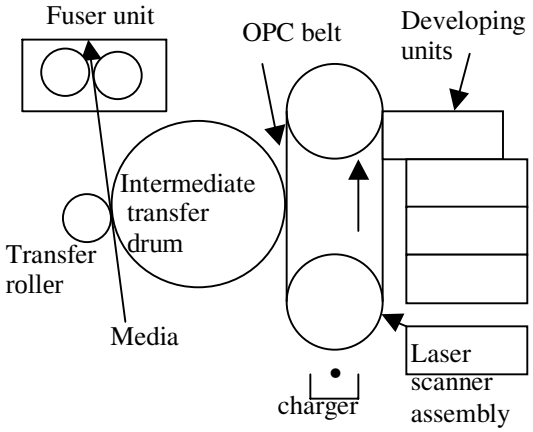

Figure.1 Schematic of Full-Color Laser Printer

Table 1 Specifications of Full-Color Laser Printer

Item	Specification
Method	Electrophotography
Resolution	600dpi
Media	Plane and thick paper, Label, Transparency

Relationship between Roller Voltage and Life

The fuser unit is composed of a heat roller (fuser roll, HR), a backup roller (pressure roll, BR), an oil supply, an oil blade, a cleaning roller, a BR cleaner, and a media separation unit (Figure 2).

To achieve a highly reliable fuser, media jamming of the HR must be prevented. We have designed the fuser as follows.

The media is slightly driven in the BR direction after passing the nip area. The media separation unit guards against media jamming. After printing much media, the releasability of the HR for toner becomes low and amount

of offset toner is high, so media jamming of the HR often occurs.

We define that condition as "fuser life".

Previous research has shown that appropriate selection of the surface material of the rollers[2] and the uniform oil supplying[3] extends the fuser life. We investigated the roller surface voltage[4] created by friction between the rollers and media/pressurized components. The relationship between the HR-BR voltage and the number of printed media is shown in Figure 3. The roller charged voltage decreased as the number increased. Our explanation of this phenomenon is as follows.

The surface roughness of the HR increased, and the actual contact area, which contributes to tribocharging, decreased. The electron removal between contact parts became less activated, and the roller surface voltage decreased. Our other experiments showed that a fuser with a low absolute HR voltage has a short life. So, the HR tribocharging voltage is correlated with fuser life.

Relationship Between Roller Voltage and Toner-Offset, Media-Jamming

(1) Relationship Between Roller Voltage and Offset Toner

We derived the amount of offset toner from the amount of foreign substance measured by weight changing of oil blade. As shown in Figure 4, the toner offset was correlated with the HR voltage.

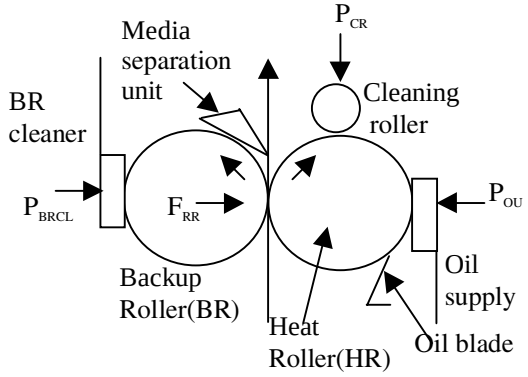

Figure 2. Schematic of Fuser unit

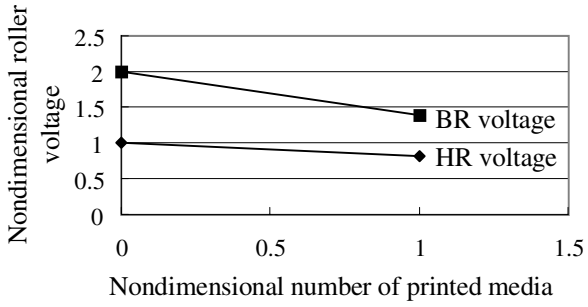

Figure 3. Relationship between roller voltage and number of printed media

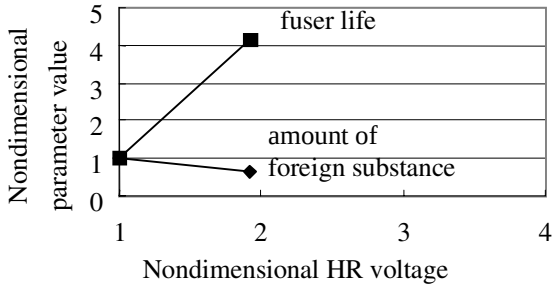

Figure 4. Relationship between V_{HR} and amount of foreign substance / fuser life

(2) Relationship Between Roller Voltage and Media Jamming

To evaluate media jamming in an accelerated experiment, we used thin paper as the media.

The HR voltage, BR voltage, and paper voltage were measured (in the jamming case, the paper voltage was not measured). As shown in Figure 5, in the jamming case, there were several time periods when the voltage relationship was $|V_{HR}| > |V_{BR}|$. In the no-jamming , $|V_{HR}|$ was much smaller than $|V_{BR}|$. Because the paper was charged with a positive voltage, it was pulled to the larger-negative-charged roller by electrostatic force. This indicates that $\Delta V_{HR/BR}(=V_{HR}-V_{BR})$ works as a "jamming margin measure".

Modeling and Optimization

Our experimental results indicate that a large $|V_{HR}|$ and large $\Delta V_{HR/BR}$ are required to achieve a highly reliable fuser unit. We thus experimentally investigated the sensitivity of these parameters for the oil-unit pressure (P_{OU}), the cleaning roller pressure (P_{CR}), the BR cleaner pressure (P_{BRCL}), and the roller pressurized force (F_{RR}) (Figure 2).

Their relationship was modeled as

$$[V] = [J][F] + [V_0], \quad (1)$$

where

$$[V] = [V_{HR}, \Delta V_{HR/BR}]^T,\ [J] = [J(2\times 4)],\ [F] = [P_{OU}, P_{CR}, P_{BRCL}, F_{RR}]^T, \text{ and } [V_0] = [V_{01}, V_{02}]^T.$$

The J-matrix parameters were experimentally determined.

The roller component pressure/ force F matrix was optimized so as to minimize the evaluation function:

$$X = \alpha (V_{HR} - V_{01}) - \beta(\Delta V_{HR/BR} - V_{02}). \quad (2)$$

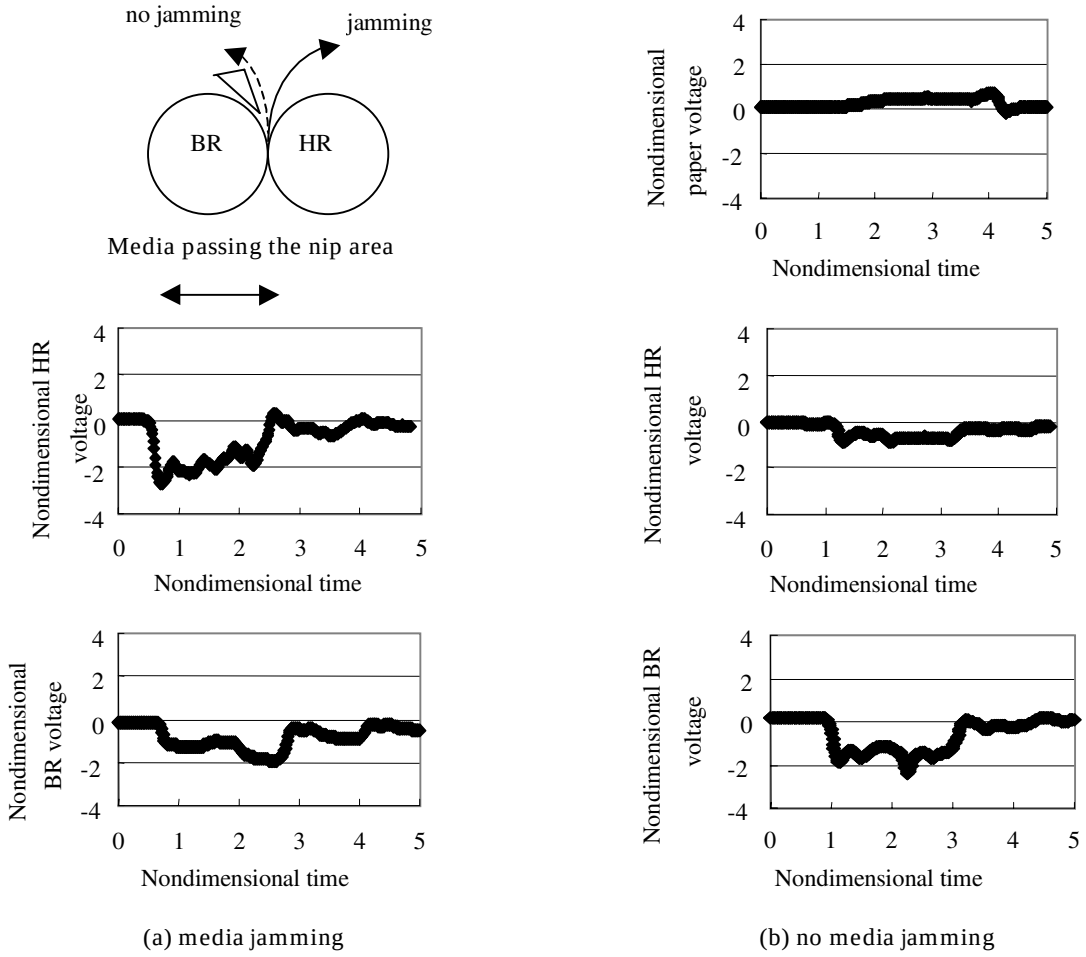

Figure 5. Relationship between roller/ paper voltage and media jamming

The F matrix was determined by using the steepest descent method. The calculation results are shown in Figure 6. The horizontal axis shows the calculated step number, and the vertical axis shows the nondimensional F-matrix parameter values and X value.

Based on these results, we selected the value for step 3 for our improved construction, considering the physical constraint of the roller pressurized components.

The measured fuser life is also shown in Figure 6. It was double that of the conventional construction (step 1 in Figure 6). So, a longer life fuser was achieved without using any expensive means.

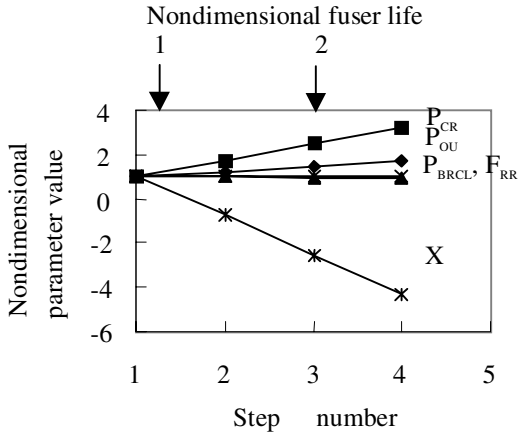

Figure 6. Calculated roller component pressure Optimization (X: α=0.9, β=0.1)

Summary

The roller-type fuser life of our developed color laser printer was investigated from the viewpoint of roller tribocharging. Results are summarized as follows.

1. The HR voltage is correlated with fuser life.
2. The HR/BR voltage difference is correlated with media jamming.
3. An optimal design method for the rollers' pressurized components was proposed and confirmed.

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Biography

Toshio Ogiso received his B.E. and M.E. in Mechanical Engineering from Keio University in 1980 and 1982. He joined Mechanical Engineering Research Laboratory of Hitachi Ltd. in 1982. He has worked for industrial robots, cranes for logistics, and human welfare systems. He currently works for non-impact printers.