Sensing and Process Control System for Color MFP

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Abstract

In order to maintain image quality with many noise factors, we should consider improvement of system robustness, decreasing of noise factors and the process control system. Moreover in an MFP used in an office, compact size and lower cost are also important issues.

This paper describes a basic idea of process control system of an electrophotographic system, several inventions incorporated in a compact MFP and some issues to be investigated in future. There are some objectives of the process control, however maintaining image density is one of the critical issues and it is focused in this paper.

Several sensors are used to detect characteristics such as environmental conditions, toner amount on a substrate. The process parameters are controlled according to the detected signals so that change of image density can be minimized.

In a compact MFP (Aficio2238), several technologies are incorporated to achieve both stability of image density and the compact size. One is the binary exposure (1 bit) and smaller diameter of the LD beam. This is effective to improve the system robustness. Another is a simple control system. Number of sensors is minimized and some compensations of sensors are carried out without any special adjustments.

In future, less waiting time, minimizing the changes between MFPs and establishment of suitable balance of the three directions are important items.

Introduction

In a color MFP (Multi function printer), it is very important to maintain image quality with various user conditions for a long period of time. Especially in an electrophotographic system the toner image is formed by the balance between electrostatic force and adhesive force. These forces are very sensitive to environmental conditions (temperature, humidity), changes of toner properties and changes of properties of key parts such as photoconductor, transfer belt, fusing material etc.

In order to stabilize image quality considering the above mentioned noise factors the following three directions should be considered.

1) Robust System

This means improvement of the system robustness with changes of noise factors. Process parameters should be decided considering image stability. It is well known that the Quality Engineering is effective to achieve a robust system and several trials based on the Quality Engineering have been carried out.[1]

2) Decrease of Noise

On the other hand, decreasing the range of noise factor is also effective to stabilize image quality. Concretely, the following measures are applicable to this idea,

- Control environmental condition (Installation of air conditioning system)
- Shorten life time of key parts
- Restrict kinds of paper

3) Process Control

It is still difficult to achieve image stability by the methods mentioned above. Therefore, "process control", which includes sensing several characteristics and controlling process parameters is indispensable.

In this paper, the process control system for maintaining image quality especially image density in an electrophotographic system is described. Furthermore, several topics used in a compact MFP (Aficio 2238) are described. In a compact MFP machine size and lower cost are important as well as image stability. Finally, several issues to be developed in future for image stability are introduced.

Basic Idea of Controlling Image Density

Image density is identified by toner amount per unit area on a substrate and image gloss. In order to maintain image density, several signals are detected and several process parameters are changed according to the detected signals.

Typical detected signals are as follows:
1) Environmental conditions (temperature, humidity)
2) Surface potential of a photoreceptor
3) Toner amount on a photoreceptor/a intermediate belt
4) Toner concentration in a development unit
5) Number of printed dots (consumed toner)
6) Temperature on a fusing roller/belt

Process parameters controlled according to these signals are as follows:
1) Charging bias
2) Exposure energy
3) Development bias
4) Toner supply to a development unit
5) Transfer bias
6) Fusing temperature

A typical relationship between the sensing objects and the controlled parameters is shown in Figure 1. Toner amount on a substrate is controlled by charging bias, exposure energy, development bias, toner concentration and transfer bias. Image gloss is controlled by the temperature of a fusing material. Timing and frequency of the sensing and the feedback is decided considering target image stability.

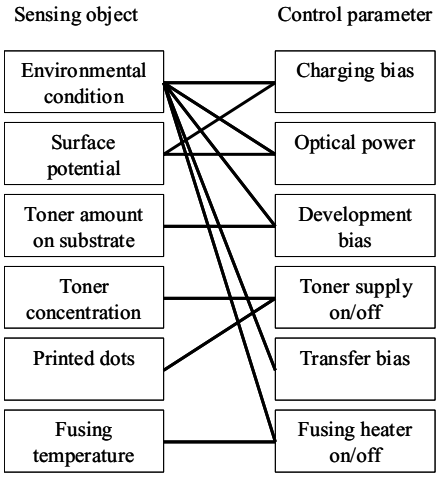

Figure 1. Diagram of process control system

Sensing and Control System Used in a Recent Color MFP

Image stability is a very important issue, however an MFP used in an office also requires compact size and lower cost. Therefore, it is necessary to incorporate several inventions regarding the image stability and the other requirements. Schematic illustration of Aficio 2238 is shown in Figure 2 and staple specifications of this MFP are shown in Table 1.[2]

In this MFP, the following sensors are installed to maintain image density.

1) Toner Concentration Sensor

In a two-component developer system, specific gravity of developer changes according to the toner concentration. Change of the specific gravity changes the permeability. In this sensor, toner concentration is detected by permeability of the developer and is installed in a development unit.

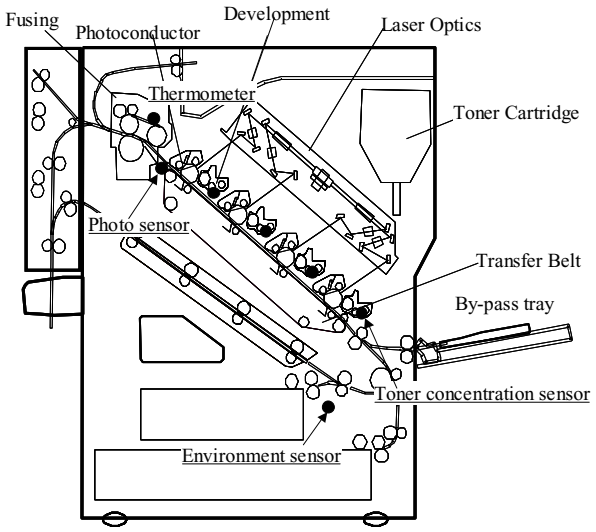

Figure 2. Schematics of Aficio 2238

Table 1. Specifications of Aficio 2238

		Aficio 2238
Type		Desktop
Technology		Laser beam scanning, electro-photographic printing and dual component toner development
Printing Speed	Full Color	28ppm(A4_LEF)*1, 14ppm(B4), 14ppm(A3) Duplex : Same as the symplex printing speed
	Black & White	38ppm(A4_LEF)*1、18ppm(B4)、18ppm(A3) Duplex ; Same as the symplex printing speed
First Print Speed	Full Color	Less than 12 seconds
	Black & White	Less than 9 seconds
Resolution		True 1200x1200dpi, 1200x600dpi, 600x600dpi
Paper Sizes		Tray1; A4_LEF,LT_LEF Tray2; A3,B4,A4_LEF/SEF,B5_LEF/SEF,A5_LEF、DLT,LG,LT_LEF/SEF Bypass tray; A3-Post-card, (Width 90～305mm,Length 148～458mm)
Paper Weight		Trays; 64～104g/m2（55～90kg） Bypass tray; 64～155g/m2（55～135kg）
Input Capacity		Tray 1 ; 550 sheets Tray 2 ; 550 sheets Bypass tray; 100 sheets,50 sheets(OHP),40 sheets(Post-card)
Duplex Printing		Optional
Power Requirements		100V,50/60Hz
Power Consumption (Max..)		1200W or less Low Energy Mode ; 20W or less
Warm-up Time		Less than 120 seconds
Dimensions (W×D×H)		575×678×715mm
Weight		Less than 77kg

2) Toner Amount Sensor

Toner amount on a transfer belt is detected by light reflection from a toner layer. Both regular and diffused reflection are used to detect toner amount from highlight to solid image. This sensor is located at the lower part of the transfer process.

3) Environmental Conditions Sensor

Temperature and humidity in the machine are detected by this sensor. Humidity is estimated by the change of impedance of a special film.

4) Thermometer

Temperature of a fusing belt is detected by a thermometer and used for turning on/off the fusing heater. This sensor is located at the fusing belt.

In this MFP, several inventions are incorporated regarding image stability and other requirements.

1) Improvement of System Robustness

This machine has the 1200dpi binary exposure system with a small diameter (50x65um) LD beam to improve the system robustness. Gradation pattern is represented by controlling the dot density (Figure 3) and it enabled both high quality image and a robust system.

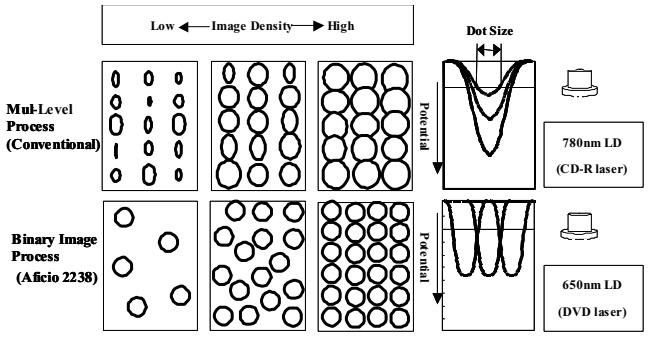

Figure 3. Illustration of binary image process

2) Minimization of Sensors

In case of a multilevel exposure system, usually a surface potential sensor is installed to detect the surface potential of each exposure level. The charging bias and the exposure power are controlled by the signals. This MFP does not have a surface potential sensor since the binary exposure system is adopted. The charging bias and the exposure power are decided according to a table based on experimental results.

Usually two sensors are used for measuring the toner amount on the transfer belt and detecting color registration respectively. In this MFP, a toner amount sensor which detects a light reflection is used for both of them. That could unify two functions into one sensor.

3) Highly Accurate and Low Cost Toner Amount Sensor

Regular and diffused reflection are used for detection of various image patterns. Actually the regular reflection is mainly used for highlight images and the diffused reflection is mainly used for solid images. Conventionally, some adjustment was needed to true up the output of the sensors beforehand. In this MFP, a technology that eliminates changes between sensors was newly developed. This compensation is carried out automatically using a ratio of regular and diffused outputs so that special adjustments are not required. Moreover, this sensing system has high sensitivity since a transparent transfer belt and a metal roller are used for the reflection.

Aficio 2238 has both high image stability and the compact size with lower cost without shortening the life time of key parts by incorporating these new technologies.

Future Direction

In order to achieve more attractive products used in a office, there are some issues to be improved. Some of them are as follows.

1) Less Waiting Time

A MFP is not available during the process control operation. Measures to decrease waiting time should be investigated such as synthesis of multiple controls. Moreover interval of the process control should be longer or operating time of the control should be shorter. Further investigation for improving the system robustness is required.

2) Less Changes Between MFPs

Recently requirement of cluster system of compact MFPs is increasing. A automatic calibration system between MFPs should be developed.

3) Suitable Balance for Image Stability

There are three directions to improve the image stability, that is improvement of the system robustness, decrease of range of the noises and the process control. Suitable quantitative balance should be considered according to the target of the image stability, durability of the system and the machine size. Estimation methods of these characteristics should be developed.

Conclusion

In this paper, basic idea for maintaining the image density was introduced. Consequently several new technologies used in a recent color MFP were described, which are consist of improvement of the robustness, minimization of sensors and high accuracy sensors. Aficio 2238 achieved high image stability and the compact size with lower cost without shortening the life time of the key parts by incorporating these new technologies. Finally several items which should be developed in future were introduced.

References

1. Takamasa Ozeki et al., Optimization of Development System, QES 2003, pg.54. (2003).(in Japanese)
2. Masumi Sato et al., Development of High Speed Full Color Laser Printer IPSiO Color 8000 Series, J. Imaging Society of Japan, 42, 146,pg.387.(2003).(in Japanese)

Biography

Yusuke Takeda received his B.E degrees in solid state physics in 1982 from Osaka University. He joined Ricoh in 1982 and has been working in the field of inkjet process, dye diffusion thermal transfer printing system, liquid toner development system and 2 component development system as a physicist. He is now a department manager of the system technology development department.