Quality Control Test Equipment for Photoreceptors, Charge Rollers and Magnetic Rollers

Ming-Kai Tse
QEA, Inc.
755 Middlesex Turnpike, Unit 3, Billerica MA 01821 USA
Tel: (978) 528-2034 · Fax: (978) 528-2033
e-mail: info@qea.com
URL: www.qea.com

Paper presented at the IS&T's Tenth International Congress
on Advances in Non-Impact Printing Technologies,
Oct 30-Nov 4, 1994, New Orleans, Louisiana

Quality Control Test Equipment for Photoreceptors, Charge Rollers and Magnetic Rollers

Ming-Kai Tse
Quality Engineering Associates, Inc.
Burlington, MA 01803 USA

Abstract

A new computer-controlled test system for mapping photoreceptor properties such as charge acceptance and discharge voltage will be described. The system allows rapid scanning of a photoreceptor to: 1) characterize its functional quality and uniformity, and 2) detect both charging and discharge defects of 50-100 µm in diameter or larger. The system can also perform conventional electrophotographic measurements to obtain dark decay, photo-induced discharge curves (PIDC), and fatigue properties. In addition to testing the complete photoreceptor product, a unique feature of the system is its ability to perform measurements on the sub-layers in a photoreceptor. These measurements include examining the substrate for cleanliness, and measuring the thickness and uniformity of the polymer barrier layer and the charge generation layer (CGL) in a layered organic photoconductor (OPC). The design of the system will be described, and its performance will be demonstrated with application examples. Test equipment for the charge roller and the magnetic roller in toner cartridges using similar electrostatic charge decay measurement techniques will also be discussed.

Introduction

A family of computer-controlled test equipment has been developed for research, development and manufacturing quality control of the key components used in an electrophotographic system including the photoreceptor, charge roller and magnetic roller (Figure 1). This equipment is designed for rapid, high resolution scanning of a finished component for detailed characterization without any special specimen preparation. The results of the measurement include both electrophotographic properties and mappings of physical and electrical defects. The systems are designed to be very versatile, flexible and easy to use.

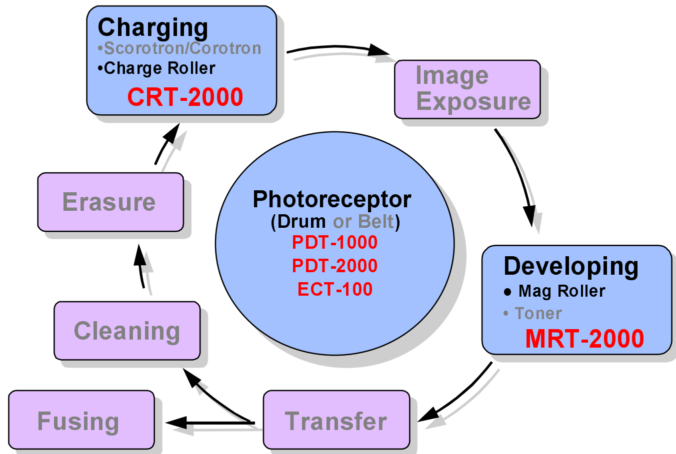

Figure 1. QEA quality control equipment for the key components in an electrophotographic system

Measurement Principle

The principle behind the measurement technique used in this family of test equipment is based on the electrostatic charge decay (ECD) technique.[1] In this technique, an electric charge is deposited on the surface of the sample-under-test, and the leakage of the charge through the thickness of the sample is monitored as a surface potential by means of a non-contact electrostatic voltmeter (Figure 2). The rate of surface potential decay is a direct measure of the conductivity of the sample-under-test.

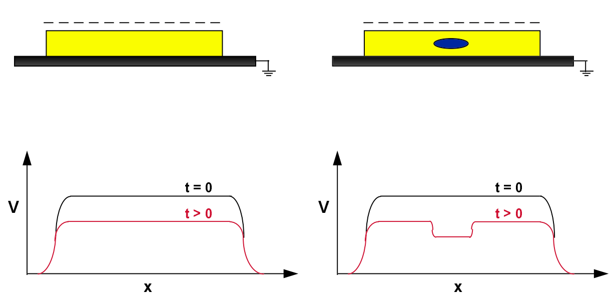

Figure 2. Electrostatic Charge Decay (ECD) technique for charge relaxation mapping

A key feature in the design of the test systems is the ability to scan the entire sample-under-test. A full-body map reveals the uniformity of the properties of interest on the entire sample surface. Such a mapping technique is a powerful tool for evaluating the quality of electrophotographic system components and the processes that manufacture these components.

Photoreceptor Test System

In applying the ECD technique to characterize photoreceptors, measurements are made in the dark to obtain the charge acceptance and dark decay properties; and exposure of a charged photoreceptor to an appropriate light source is used to measure its photosensitivity. The basic measurement system is shown in Figure 3. Figure 4 illustrates the overall system architecture. The test method uses a corona charger to charge the photoconductor, a light source (quartz-halogen lamp with neutral density and bandpass filters, LED, or laser diode) for discharge, and two electrostatic probes, one for measuring the dark voltage, and the other for the discharged voltage. The scan parameters, including charging voltage, charge polarity, scan speed, scan resolution, light source wavelength and intensity are all user-controllable, providing the user with the flexibility of testing a wide variety of photoreceptors. Using this system, uniformity in charge acceptance level and light discharge residual, as well as defects in charging and discharge can be mapped in a single scan that takes one minute or less for a typical photoreceptor (30mm in diameter and 260 mm long). At the end of a scan, the surface potential is converted into a false-color voltage map (Figure 5). Graphical tools are also incorporated in the software to zoom the image in and out, read voltage level at individual pixels, switch between a single-track scan or a full-body map, change the voltage scale, and perform statistical operations on the voltage measurements. The sensitivity of defect detection is on the order of 100 µm as illustrated in Figure 6. The measurement technique employed provides a built-in magnification of approximately 70x. The detection sensitivity can be further enhanced by applying a higher charging voltage (Figure 7).

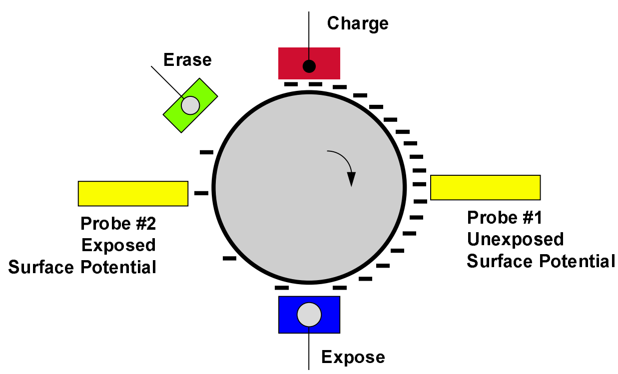

Figure 3. Photoreceptor Test System: Measurement Principle

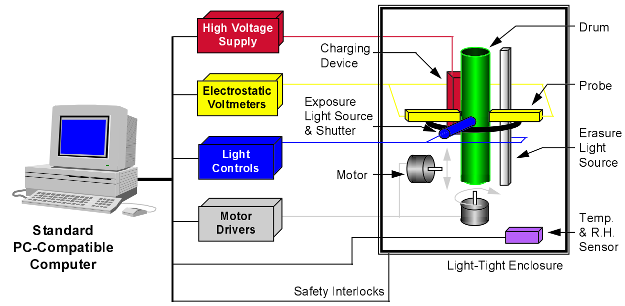

Figure 4. Photoreceptor Test Sytem: System Architecture

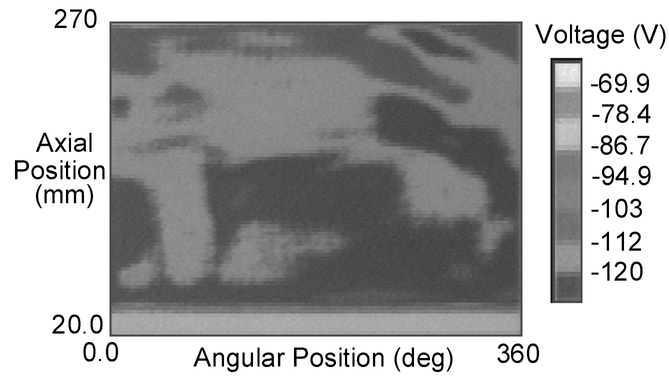

Figure 5. Discharge Unifomity Map (actual display is in color)

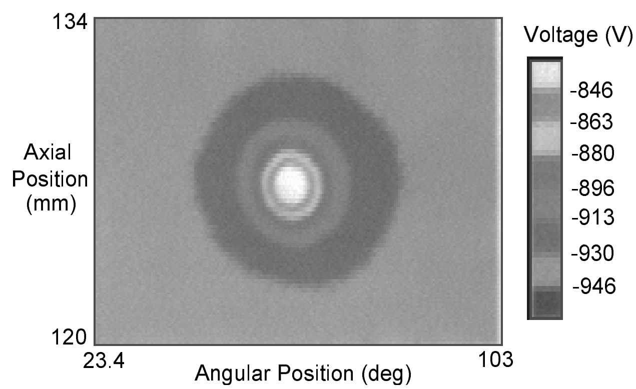

Figure 6a. Detection of 100 µm pinhole (actual display is in color)

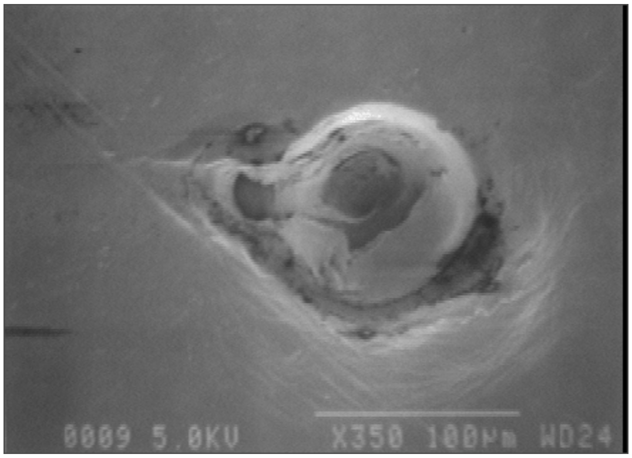

Figure 6b. Scanning Electron Micrograph of 100 µm pinhole corresponding to defect detected and shown in figure 6a.

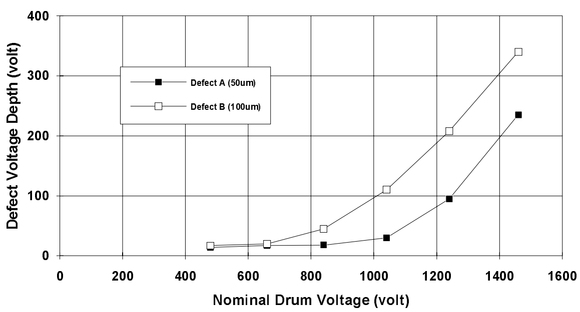

Figure 7. Defect sensitivity in charge acceptance mapping

In addition to charging and discharge uniformity mapping and defect detection, the system can be used for several other important functions: 1) electrophotographic characterization such as measuring charge acceptance, dark decay, photosensitivity (e.g. PIDC curve), and discharge residual for single or multiple cycles (i.e. fatigue characteristics); 2) mapping the thickness and uniformity of the photoreceptor coatings, particularly for measuring the charge generation layer and the charge blocking layer in organic photoconductors (OPC); and 3) detecting and mapping the cleanliness of a substrate prior to application of the photoreceptor coating. The integration of all the above functions into a single system is a novel and unique feature of this photoreceptor test system.

Charge Roller and Magnetic Roller Test Systems

A typical charge roller consists of multilayers of elastomer and polymer coatings. Similarly, a typical magnetic roller consists of an aluminum sleeve with an extremely thin layer of oxide or a semi-conductive polymer coating on its surface. In the charge roller, the conductivity of the surface or near-surface layers can critically affect the uniformity and level of charging on a photoreceptor. Similarly, the conductivity of the surface layer on a magnetic roller sleeve is one of the key factors that determine the quality of the development process. For example, a highly resistive surface layer on a magnetic roller may lead to unwanted residual toner on the roller between prints, thereby producing ghosting on the printed output. Implementation of the ECD technique for evaluating charge rollers and magnetic rollers is illustrated in Figures 8 and 9 respectively. In both applications, it can be shown that an empirical accept/reject criterion can be established to determine the acceptability of the quality of a charge roller or a magnetic roller. Extensive print testing has been performed to substantiate the validity of the measurement technique. Furthermore, physical defects that can lead to print defects can also be mapped in a similar fashion to the photoreceptor application described above. The detection sensitivity, however, is found to be slightly lower than in the case of photoreceptors.

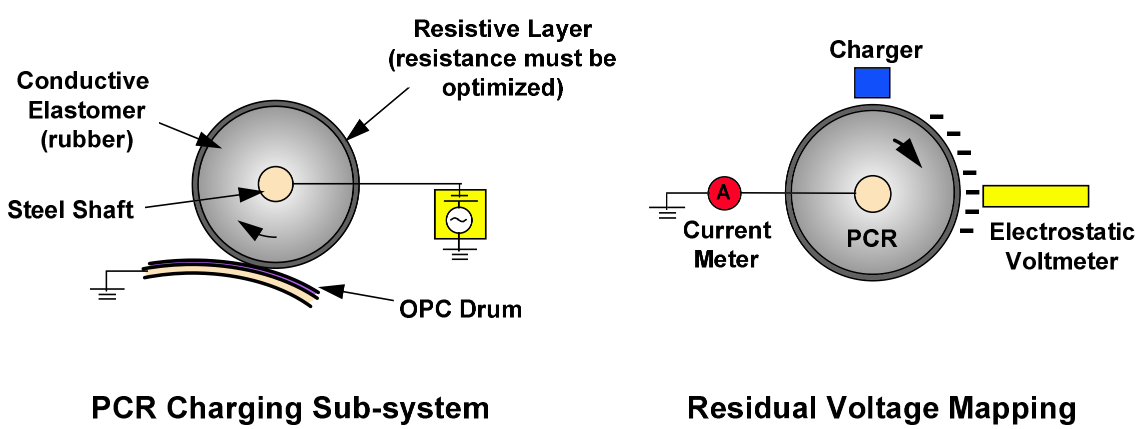

Figure 8. CRT-2000 Primary Charge Roller Test System: Measurement Principle

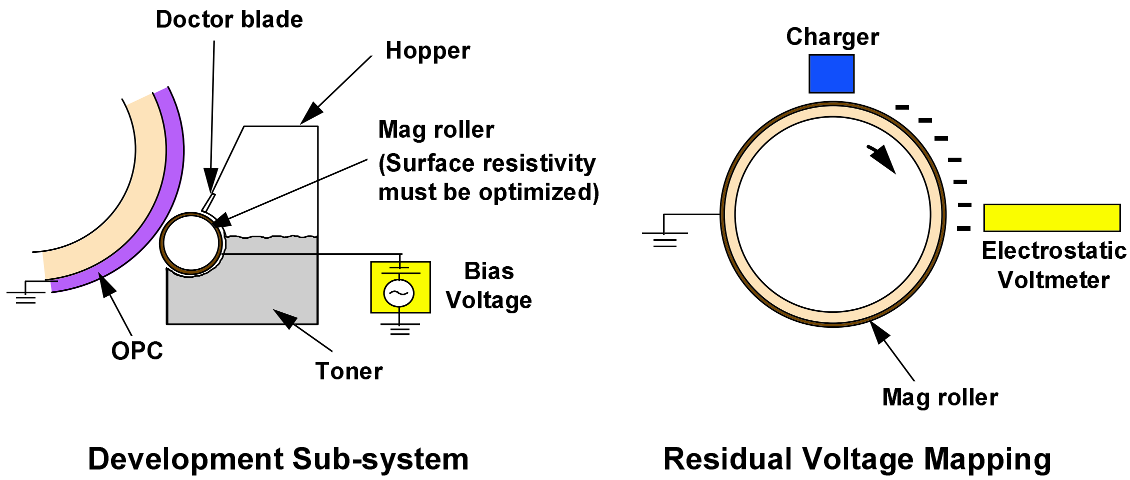

Figure 9. MRT-2000 Magnetic Roller Test System: Measurement Principle

Summary

A family of computer-controlled test equipment for photoreceptors, charge rollers, and magnetic rollers have been described. These equipment are based on the common principle of electrostatic charge decay (ECD) measurements. The measurements are non-contact and nondestructive, and are therefore suitable for applications in both R&D and manufacturing quality control.

References

1. N.P. Suh and M.K. Tse, "A New NDE Technique for Composites," US Patent 4,443,764, assigned to Massachusetts Institute of Technology, Cambridge, MA, 1984.