Compact Draw-off Type Instrument for Measuring Toner Charge

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Abstract

We have developed a compact draw-off type instrument for measuring toner charge. The instrument can measure the charge to mass ratio (q/m) of both two-component and one-component developers. The instrument can also measure toner charge on a photoreceptor, or on several intermediate media or even on paper. The instrument is highly maneuverable due to the small size of its nozzle unit, thereby ensuring extremely versatile measurement capability. Toner particles are directly absorbed into a Faraday cage by means of a draw-off separation method, so that the measurements are highly accurate. We have found that accurate toner charge measurements could be obtained for two-component and one-component developers by using this instrument. This instrument should be useful for the further development of electrophotographic printing systems.

Introduction

The characteristics of toner may contribute largely to the quality of electrophotographic printing systems. Especially toner charge is a very important factor in the results of an electrophotographic process. Several measurement methods already have been introduced for toner charge measurement; however, most of these methods were only effective for two-component developer, mixed toner and carrier. Recently, use of one-component developer consisting of only toner is becoming very common. This is important for developing new smaller and simpler electrophotographic machines. Therefore, a need exists for a new instrument for measuring the toner charge of one-component developer. As color laser printers are gaining popularity and picture quality is improving rapidly, to know the charge of the toner on a photoreceptor, on intermediate transfer media or even on paper is becoming more important.

To measure the toner charge, removing toner from its carrier or from a developing roller is important. There are several different methods for separating toner, such as a blow-off method, a developer separation method, and a separation by a draw-off method. There are two different methods for the blow-off separation 1) a blow-off using wire mesh, 2) a blow-off using a magnet (a magnet blow-off).[1-3]

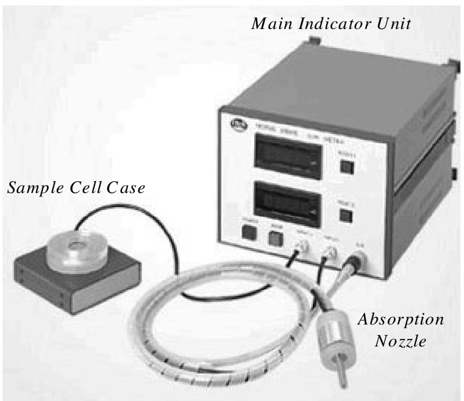
The blow-off method was primarily introduced for measuring the toner charge of two-component developer and may not be applicable for measuring the toner charge of one-component developer. Because a specific toner separation apparatus consisting of a large chamber type Faraday cage is needed for the blow-off method, measuring the charge of the toner on a photoconductor drum, on intermediate transfer media or on paper is very difficult. Therefore, we developed an instrument with a draw-off separation method.[4] The instrument is relatively small, and it should be applicable for measuring the toner charge wherever the toner is located.

Instrument Configuration

A photograph and a schematic diagram of the instrument are shown in Fig. 1, and the specifications of the system are given in Table 1. The instrument consists of an absorption nozzle, a main indicator units, that display the charge amount of both toner and carrier, and a sample cell case to contain the mixture of toner and carrier (two-component developer). The sample cell case has a metal mesh, the openings of which are smaller than the carrier particles and larger than the toner particles. The toner and carrier are separated when a vacuum draw-off force is applied to the mixture.

A filtering system prevents the toner from being taken into the vacuum pump. The nozzle unit is small making it highly maneuverable. Therefore, it can be deployed wherever toner is located. The nozzle unit itself is designed as a Faraday cage. The toner being sampled by draw-off is introduced directly into this Faraday cage, which is the nearest instrument for the sampled toner. Therefore, an accurate and repetitive charge measurement can be obtained.

This sample cell case is used for the two-component developer. The sample cell itself is also designed as another Faraday cage. Thus, we have two Faraday cages for this instrument. The carrier charge amount is measured simultaneously by one of these whenever the toner charge measurement is conducted by using the other. That the carrier charge amount should be the same in quantity, but have the opposite polarity of the toner is well known. Thus, we can compare the charge amounts of both toner and carrier whenever we make a measurement. The sample cell is very light weight so that the difference in weight between that of toner/carrier mixture and that of the carrier alone after the toner has been removed can be easily measured by using an accurate weight scale. Thus, we are able to obtain the weight of both toner and carrier, respectively. Thereby, we are able to calculate the charge to mass ratio (q/m) of toner.



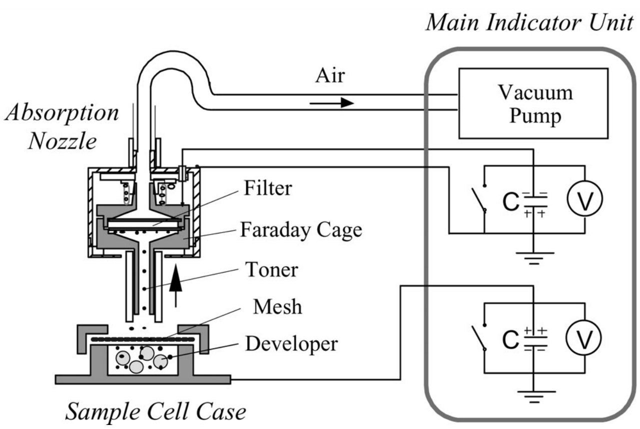


Figure 1. Photograph and schematic diagram of compact draw-off type instrument for measuring toner charge.

Table 1. Specifications of the instrument system.

Performance	
Measurement Range	0 to ±2 μC
Measurement Resolution	0.001 μC
Accuracy	Better than 0.25% of full scales
Vacuum Pressure	10 kPa.
Dimensions	
Main Indicator Unit	210(H)×250(W)×370(D)mm
Sample Cell Case	40(H)×120(W)×120(D)mm
Absorption Nozzle Unit	φ 45×75(H) /1600(L)mm

Two-component Developer Measurements

1. Measurements by Using the Draw-off Instrument

A developer for this measurement was prepared as follows. Styrene-Acrylate resin toner, with an average diameter of 8 μm, and ferrite carrier coated with Silicone resin, with an average diameter of 75 μm, were used. The toner concentration of the developer is 3 wt%. Using the TURBULA mixer, these were mixed for one minute.

The sample cell set of the instrument consisted of a new stainless steel mesh, a small chamber, and a cap. After mixing the developer, approximate 0.2 g of it was placed into the chamber as a sample, and then the mesh and the cap were set onto the chamber. A #500 mesh was used for this measurement. The openings in the mesh were approximate 26 μm. Using an electronic scale, the weight of the sample cell sets was weighed. After that, the sample cell set is placed onto the sample cell case, and then toner particles were absorbed through the mesh by the absorption nozzle. The charge to mass ration (q/m) of the toner was obtained from the charge amount and the toner mass of this absorption. All of the sample preparations and the measurements were performed in a standard atmosphere (20~23℃, 50~60%RH).

Figure 2 shows the relation between the toner removal ratio and the absorption time. The air pressure used for this measurement was only 10 kPa; however, we confirmed that 98-wt% toner removal ratio could be achieved if the draw-off is applied to the sample at this pressure for more than 30 seconds. Figure 3 shows SEM photographs of the developer samples before and after the draw-off. The separation of the toner and carrier was done at an area, very close to the mesh in the sample cell set. Thereby, a sufficient amount of pressure was applied to the toner and carrier to accomplish a good separation.

Figure 4 shows the relation between the toner q/m obtained in this measurement and the duration of the absorption. The q/m values shown in Fig. 4 are almost constant. The results described above demonstrate that, this new instrument with a draw-off separation method can achieve a toner removal ratio of more than 90 wt% and accurately measure the toner charge of a two-component developer.

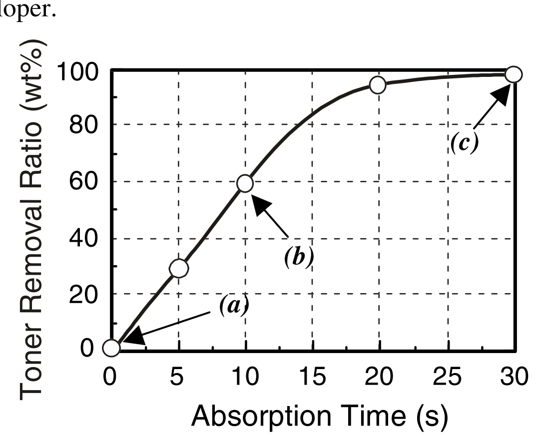


Figure 2. Relation between toner removal ratio and absorption time.

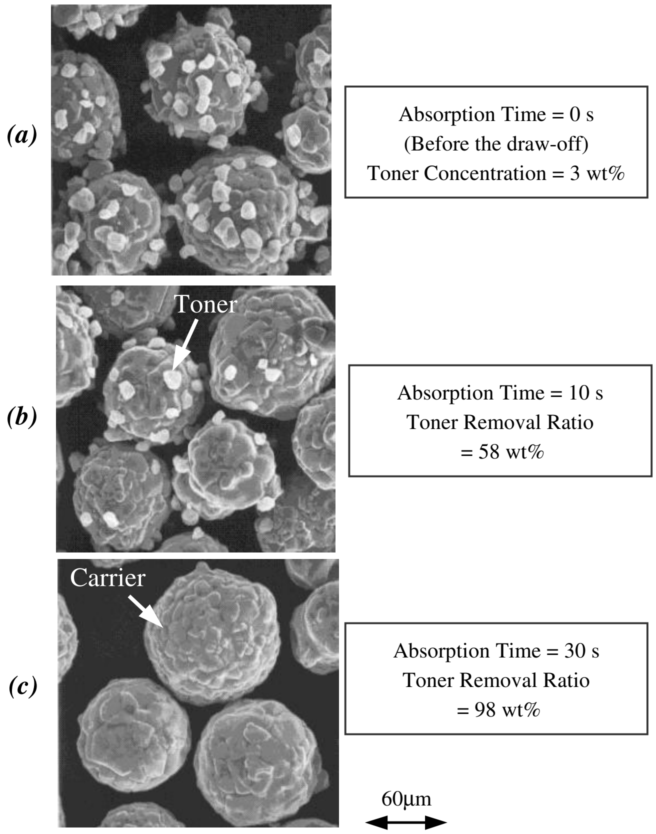


Figure 3. SEM photographs of developer samples before and after draw-off.

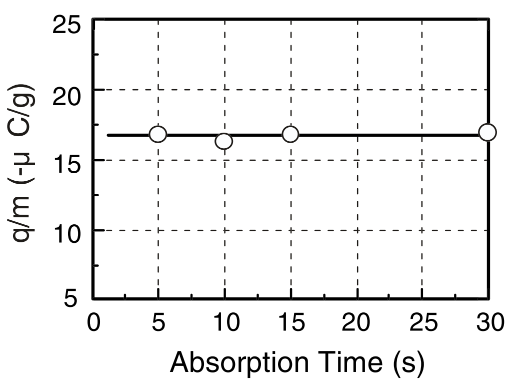


Figure 4. Relation between q/m of toner obtained in this measurement and absorption time.

2. Measurement of the ISJ Standard Developer

The Imaging Society of Japan (ISJ) Technical Committee part III meeting standardized the procedure for the blow-off toner charge measurement, and has released the standard for two-component developers as the reference material to calibrate toner charge measuring apparatuses since 2001.[1,2] One of the standard developers is Type N20-1 (Polarity of toner charge: Negative) and the other is Type P20-1 (Polarity of toner charge: Positive). The q/m of Type N20-1 is –18.2±2.4 μC/g. The q/m of Type P20-1 is +19.8±2.5 μC/g. The toner concentration of these two developers is 5.0±0.2 wt%. Using these developers, the toners' q/m of toners were measured by using this instrument with the draw-off method. According to the guidance of the ISJ, preparation of the measurement samples and the q/m measurements were performed in the standard atmosphere (20~23 ℃, 50~60 %RH).

The results of those q/m measurements, made using the instrument with the draw-off method described here, are shown in Table 2-A and 2-B. Those q/m results are approximately consistent with the values measured and guaranteed by the ISJ.

Table 2-A. Measurement results of N20-1 developer.

	Sampling Developer Mass (g)	Charge Amount (μ C)	Absorption Toner Mass (g)	q/m (μ C/g)
1	0.2006	-165	0.0098	-16.84
2	0.1870	-152	0.0087	-17.47
3	0.1975	-154	0.0092	-16.74
Average				-17.02

Table 2-B. Measurement results of P20-1 developer.

	Sampling Developer Mass (g)	Charge Amount (μ C)	Absorption Toner Mass (g)	q/m (μ C/g)
1	0.2065	184	0.0097	18.97
2	0.1916	156	0.0082	19.02
3	0.1925	168	0.0081	20.74
Average				19.58

One-component Developer Measurements

As previously stated, this instrument is applicable for the charge measurements of both two-component and one-component developers. An example of the q/m measurement for a one-component developer is shown in Fig. 5. The developing unit for the one-component developing method consists of a developing roller, a toner supply roller and a blade, which controls the amount of toner applied on the developing roller. The q/m measurement for the one-component developer was performed by directly absorbing toner particles on the developing roller surface with the absorption nozzle of the instrument describe previously. Therefore, the toner mass amount on the developing roller surface could be obtained simultaneously from the amount of toner absorbed into the absorption nozzle. This is one advantageous feature of this instrument.

The pushing pressure of the blade to the developing roller would affect the thickness as well as the charge amount of the toner layer on the roller. Then, the test data for both the pushing pressure of the blade versus the q/m and the pushing pressure of the blade versus the amount of toner mass on the developing roller are plotted in Figs. 6 and 7, respectively. The q/m of one-component developer on the developing roller increased and the toner mass on the developing roller decreased depending on the increase of the blade's pushing pressure. We found that the instrument could make accurate and stable measurements even when the toner layer became very thin.

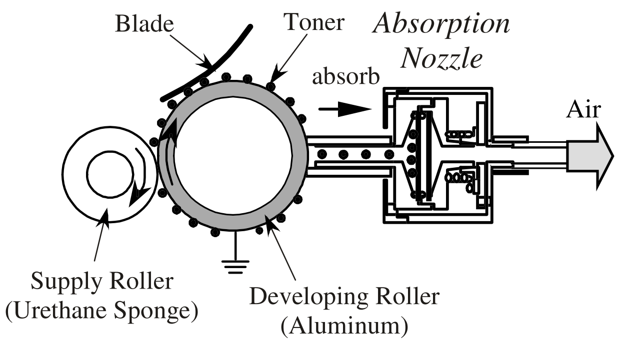


Figure 5. An example of q/m measurement for one-component developer.

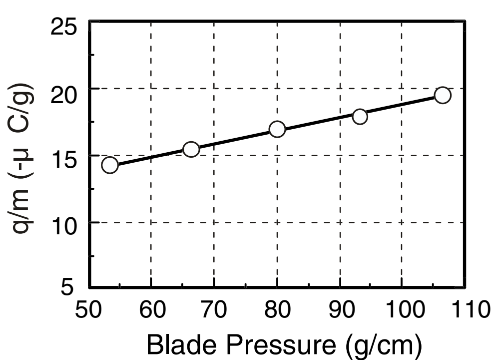


Figure 6. Pushing pressure of blade versus q/m.

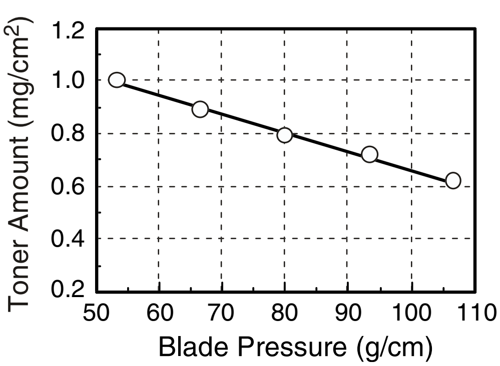


Figure 7. Pushing pressure of blade versus toner mass amount on developing roller.

Conclusion

We have developed a compact draw-off type instrument for measuring toner charge. The instrument can measure the charge to mass ratio (q/m) of both two-component and one-component developers. The instrument is highly maneuverable due to the small size of its nozzle unit, and this ensures extremely versatile measurement capability. The separated toner particles of the developer sample are introduced directly to the nearest Faraday cage by means of a draw-off method, to obtain highly accurate measurements. We have found that accurate measurements could be obtained for both two-component and one-component developers.

1) This new instrument can achieve a toner removal ratio of more than 90 wt% and can stably and accurately measure the toner charge of two-component developers.
2) The q/m results for the standard developers measured by the instrument are approximately consistent with the values measured and guaranteed by the ISJ. The standard developers are useful for calibrating the instrument.
3) The q/m measurement for one-component developer is performed by directly absorbing toner particles on the developing roller surface by using the instrument's absorption nozzle.
4) The toner mass amount on the developing roller can be also measured simultaneously from the amount of absorbed toner taken into the absorption nozzle.

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Biography

Akira Shimada received the B.E. degree in electronics from Shinshu University, Nagano, Japan in 1977 and the M.E. degree in electronic physics from Tokyo Institute of Technology, Tokyo, Japan, in 1979. Since 1979 he has been engaged in research and development of imaging processes using electrophotography in Hitachi Ltd., Japan. He is a member of the Imaging Society of Japan.