# A New Technique for Measuring the Charge-to-Mass Ratio *q/m* of a Toner Particle

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## Abstract

The present paper deals with a new technique for measuring the charge-to-mass ratio *q/m* of a toner particle. Forces which act on a negatively charged toner particle put on the gap-space of the parallel electrodes, consist of the next three components: image-force, gravity force and Coulomb force.

By the movement of the toner particle under these forces, the charge-to-mass ratio *q/m* is calculated by the formula $2gd/(V1-V2)$, where $V$, $d$, and $g$ are the voltage applied across parallel electrodes, air gap distance between electrodes, and acceleration of gravity, respectively. Movement of the toner particle illuminated by the laser diode is observed by using a CCD camera system.

## Introduction

Typically, blow-off technique which contains Faraday cage and air-jet nozzle etc. as a set of components has been used for the measurement of *q/m* ratio of the toner particle. We will propose here a measurement-technique which can easily measure the value of *q/m* of each of toner particles in the process of real time operation.

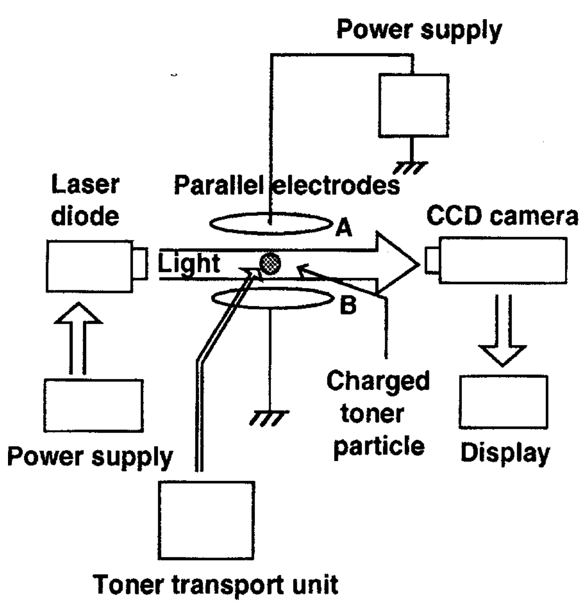


*Figure 1. Schematic configuration of a technique for measuring q/m.*

## Method

Figure 1 shows the schematic configuration for measurement. A charged toner particle carried by the toner-transport unit is put on the inner surface of electrode **A** which is one of the parallel electrodes. The polarity of the applied voltage given across electrodes is determined by the polarity of the charged toner particle. For example, in this figure, the voltage polarity of the power supply is positive because the polarity of the toner charge is negative. In the gap space between the parallel electrodes, we may assume the following three forces acting on the toner particle: (1), (2), (3).

(1) The image-force acting on the spheridized toner particle adhered on the surface of the electrode shown in Figure 2 is given as:

$$f_0 = q^2/16\pi\varepsilon_0 r^2 \tag{1}$$

Where $r$ and $\varepsilon o$ the radius of the toner particle and the permittivity of the gap space, respectively.

As the mechanism that causes the charging-phenomena, following two cases may be considered:

(i) The case due to the charge of the toner,

(ii) The case due to the dielectric polarization caused by the electric field.

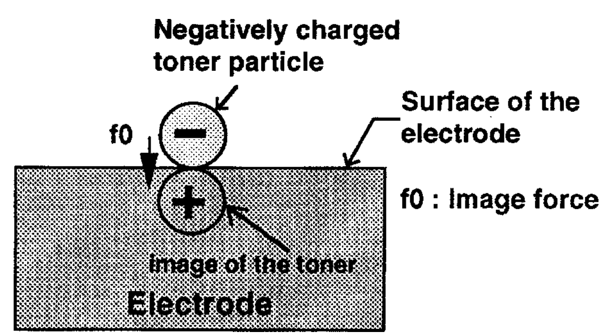


*Figure 2. A charged toner particle adhered on the surface of the electrode.*

In this situation, we assume that there are no polarizing phenomena which may take place due to the localized field in the toner particle.

(2) By neglecting fringing effect of electrodes, Coulomb force acting on a toner particle due to the electric field is given as:

$$f_1 = q(V/d) \tag{2}$$

Where $q$, $V$, and $d$ are charge of the toner particle, voltage applied across parallel electrodes, and air gap distance between electrodes, respectively.

(3) The gravity force for the toner particle is given as:

$$f_2 = mg \tag{3}$$

Where $m$ and $g$ are mass of the toner particle and acceralation of gravity, repectively.

Figures 3 (a) and (b) show the toner particle adhered on the electrodes **A** and **B**.

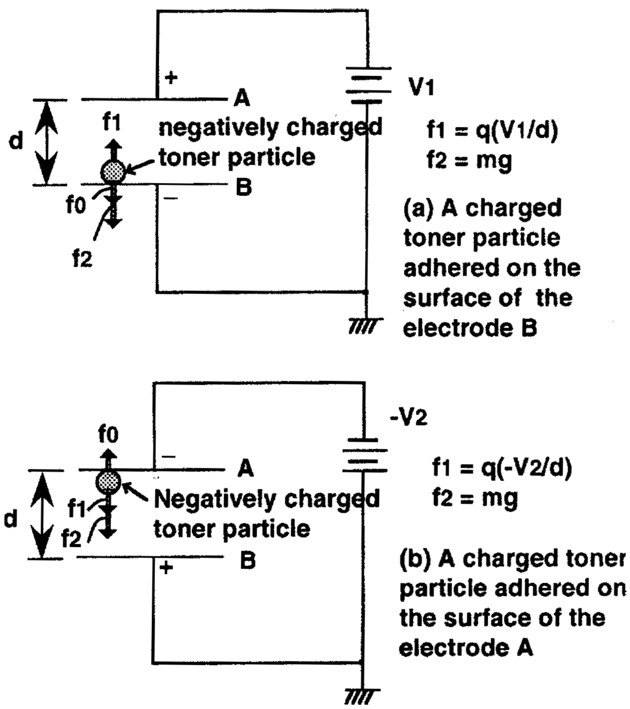


*Figure 3. Detailed schematic expression of the parallel electrodes.*

In the Figure 3 (a), the sufficient condition that the charged toner particle is about to leave from the electrode **A** toward the electrode **B** should satisfy the following relation:

$$q(V_1/d \geq mg+f_0 \tag{4}$$

In the case of Figure 3 (b), the sufficient condition that the charged toner particle is about to leave from the electrode **B** toward the electrode **A** should satisfy the following relation:

$$q(-V_2/d) \geq mg - f_0 \tag{5}$$

From the relations, in (4) and (5), the charge-to-mass ratio *q/m is* calculated by the following equation:

$$(q/m) = 2gd/(V_1 - V_2) \tag{6}$$

Movement of the toner particle illuminated by the laser diode is observed by using a CCD camera.

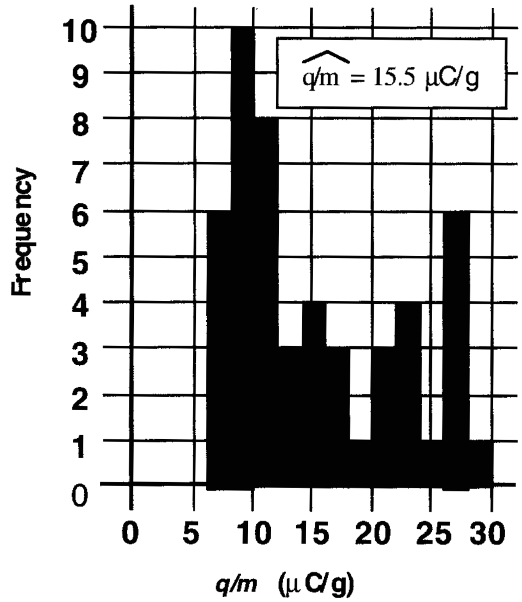


*Figure 4. Frequency distribution of toner particles as a function of q/m.*

## Experimental Result

Figure 4 shows the experimental result of the frequency-distribution of toner particles as a function of *q/m.* As is evident from this figure, we can see the values of *q/m* which are distributed between 6.5µC/g and 30µC/g, and the average value of q/m is 15.5 µC/g.

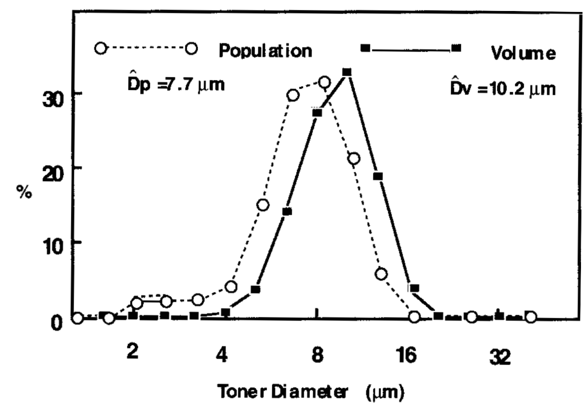


*Figure 5. Distribution of the toner particle in %.*

## Conclusion

We have proposed a new technique for measuring charge-to-mass ratio *q/m* of the toner particle. By this method, the value of *q/m* of the toner particle has been easily measured in the process of real time operation.

## Supplement

The toners used in this study are sampled from Sharp personal copier Z-30. The experimental result by means of the blow-off technique shows that the charge to mass ratio of the toner sampled from Z-30 in use is distributed between 15 and 20μC/g. The diameters of the toner particles are distributed between 5 and 16μm, and the average diameter in population *Dp* is about 7.7μm, and the average diameter in volume *Dv* is 10.2μm. Figure 5 shows the result from Coulter Counter Type TA-II.

## Reference


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