Small Charge-to-Diameter Measurement Device for Powder Charge

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Abstract

There are published in the literature different toner charge spectrometers. Some devices use laminar airstream and a crossed electric field to control the powder flow. Another instrument measures the powder charge and diameter with a laser beam doppler velocimeter including an electric and acoustic field. Here we introduce a small measurement cell with an open-jet wind tunnel and a crossed electric field. We compare measurements with a conventional ***'q/d-meter'***. Important for the new device: there is no tube for the inlet. Only two openings with 1 mm diameter for the air flow are needed. Therefore is a low probability for a powder charge exchange during a wall collision. The device can be mounted on development rolls, photoconductors, powder coating cabins, etc.

Introduction

In a lot of different processes of the industry the determination of the electrostatic charge of powders is needed. Especially, this is important for the construction and quality control of electrostatic copy machines and its dry toners. In the literature are published different so-called 'toner charge spectometers'[1,2]. Here we use our 'q/d-meter' as a standard to compare the results with the new unit.

Conventional Measurement of the Charge-to-Diameter Ratio

Powder from the activation cell is blown with low speed into a measurement tube with laminar air flow AF. In Figure 1 the diagram shows the toner trace and the tube with coordinates x and y. An electric field E (space coordinate y) deflects the powder in this laminar air flow to a registration electrode. To determine the powder particles with opposite charge, an independent second measurement is made. Powder particles with extremely low electric charges are captured on an exchangeable filter.

To determine the powder density as a function of the location x, a recording photomicroscope is used. The powder deposition is manually transferred from the registration electrode of the deflection unit to an adhesive film of the microscope table. Subsequently it is analyzed photometrically. A stepping motor acts as feed for the microscope table.

The charge-to-diameter ratio q/d of each particle is a function of its local position on the registration electrode.

The mathematical treatment of the toner flow is published[3]. In the measurement diagram of Figure 2 both distributions are jointly analyzed and plotted.

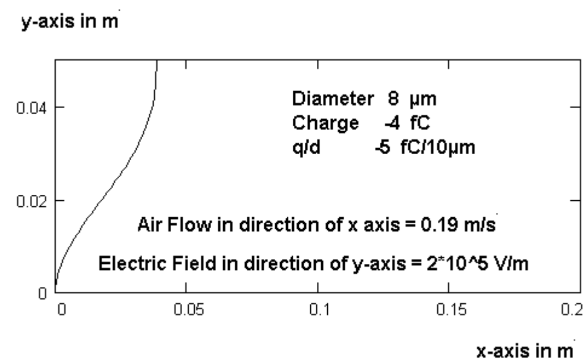

Figure 1. Mathematical Treatment of the Toner Flow in the 'q/d-meter'.

If there are no connections between the particles on the registration electrode (low concentration of particles) it is possible to analyze the diameters of the particles. Together with the q/d value the charge q of each particle is simple to calculate: $q = (q/d) * d$.

Remarkable is the sharp q/d distribution of the toner in Figure 2. We could use this narrow band to localize the q/d values in the 'small charge unit'.

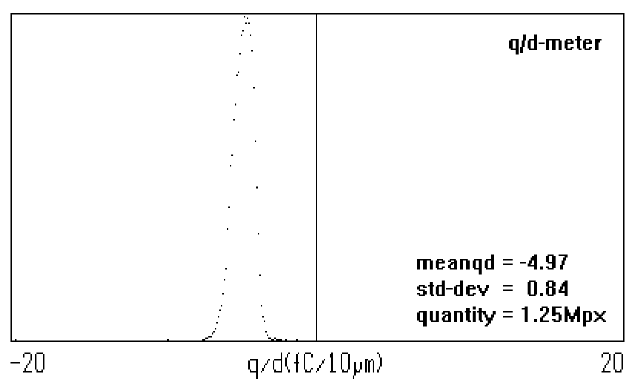

Figure 2. Charge-to-Diameter Distribution of a High Charged Toner with Very Narrow Standard Deviation, Measured with the 'q/d-meter'.

Toner Flow in an Homogeneous Electric Field

For an experiment we used a chamber with parallel electrodes with an opening in one electrode. The chamber is substantially free of turbulent gas flows. Toner particles are introduced with low speed into the chamber as shown in Figure 3. They are collected on the charged electrode opposite to the opening, if the polarity of the toner charge is suitable[4]. Comparing the same quantity on the electrode for different charged toners, we found that the cross-section of the toner deposition on the electrode is a function of the q/d ratio of the toner material. In Figure 4 is the inverse linear relationship presented.

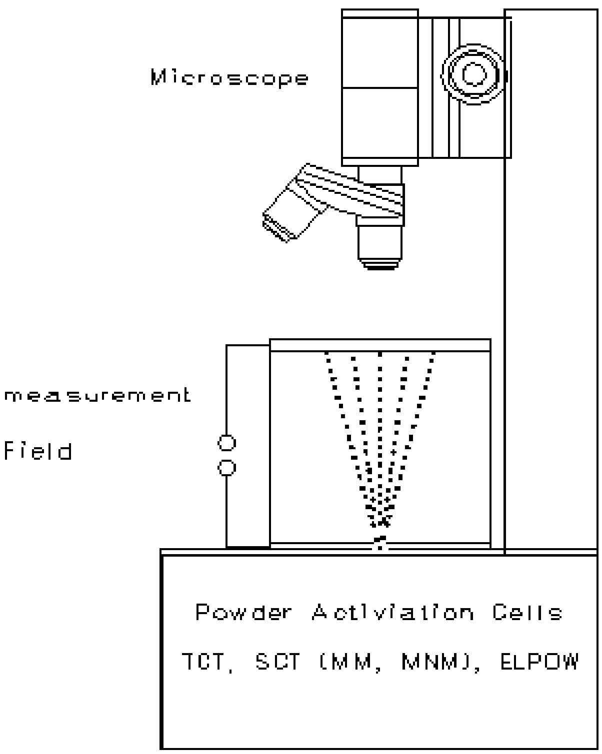

Figure 3. Toner Point Distribution in a Uniform Electric Field.

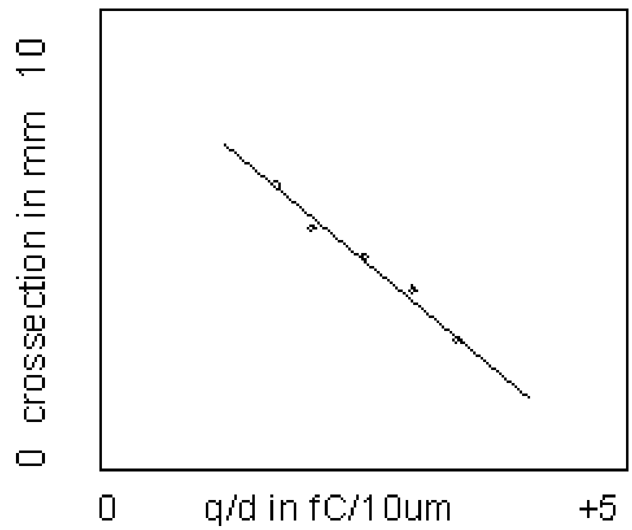

Figure 4. Relationship between Cross-section of Point Toner Deposition and q/d Ratio.

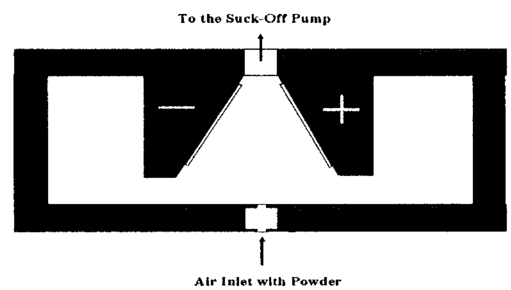

Figure 5. Sketch of the 'Small Charge Unit'

Lower charged toner material scatters more on the electrode because their mean speed in the air is lower. It seems that in the outer region only low charged toners are deposited. But we could not analyze this problem directly. In the 'q/d-meter' this phenomena is known as the spreading of the 'Zero Point'.

When we moved the electrodes to an angle of about 30 degrees, the toner deposition moves to the nearest edge of the electrode opposite to the opening. But also it is to see an unsymmetrical toner deposition. If we increase the speed of the toner in the opening this unsymmetrical deposition is intensified.

Test Equipment with Two Symmetrical Electrodes

An electrode group was constructed as shown in Figure 5. Between two electrodes of opposite polarity a toner is blown through a metalized, grounded open-jet wind tunnel. The walls of the two holes are prepared from insulator material, which is not charging the toner. The toner particles deposit on the electrodes. The toner deposition itself is able to give an important visual information regarding the charge relation and the total sucked-off quantity.

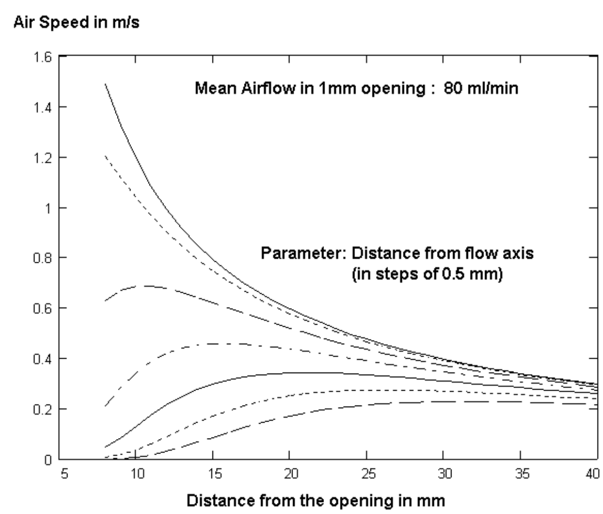

Figure 6. Free Air Beam out of a Hole in a Plane.

The mathematical treatment is more difficult than in case of the 'q/d-meter'. The air flow characteristic for a 'Free Air Beam' behind the opening is measured and published.[5] In Figure 6 are shown the results for a mean air speed of 1.7 m/s. But the equations are only correct for a distance of 8 mm and more from the plane. The hole has a diameter of 1 mm. We calculated the air speed till a cross-section of 6 mm. The two upper lines in the diagram represent the air flow direct out of the opening. The other flow lines are created by the viscous force between the central air flow and the cell air.

The air flow in this cell is reduced to values so that there is no turbulence. The electric field distribution is roughly calculated as shown in Figure 7. The electric field in flow direction is stronger at the toner entrance and the crossed electric field is later getting stronger. In Figure 8 is presented the mathematical treatment with respect to the flow equations and the rough calculated electric field.

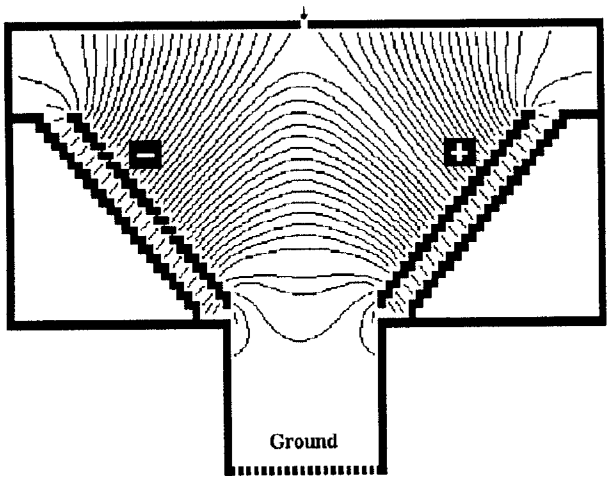

Figure 7. Electric Field Distribution in the 'Small Charge Unit,' called now 'q-test' Cell.

The high charged toners with a diameter of 8 µm are concentrated strong together. Under the mean flow speed the very low charged toners of 0.032 fC cannot reach the electrode and are picked up by a filter. But the high charged toner shown in Figure 2 is deposited as concentrated point in the area of 4 to 20 fC.

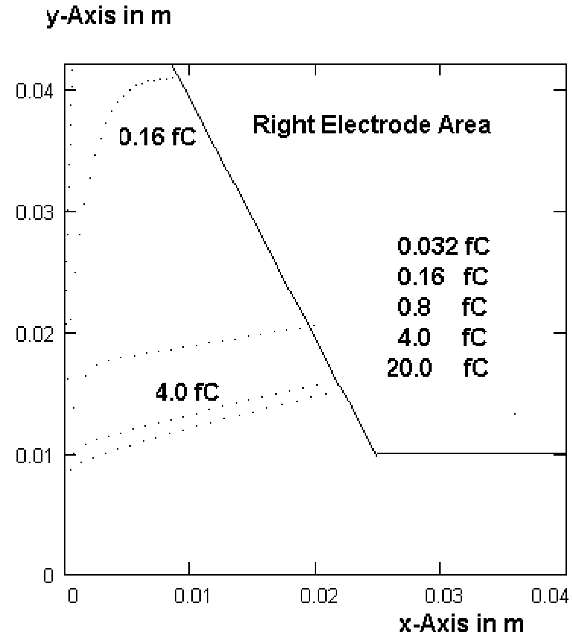

Figure 8. Calculated Toner Flow (Diameter 8 µm) with Different Charges in the 'q-test' Cell.

References

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