Toner Transport Characteristics in Long Ovally Dented Electrode

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Abstract

Toner control is important in electrophotography and also a new toner printing. The new printing technology, which utilizes conductive toner, is proposed. In the technology, toner cloud is generated by voltage application and toner beam is extracted from the toner cloud to a receiver, such as paper. To realize the new technology, it is necessary to generate toner cloud uniformly over a certain width. Toner cloud transport in long ovally dented electrode is investigated. The speed of toner cloud is observed by a digital camera and the speed dependences on applied voltage, toner amount, and distance between electrodes are obtained. The possible mechanism of toner cloud transport to long oval direction is discussed.

Introduction

In non-impact printing technologies, toner-based and ink-based solutions play an important role in various digital-printing industries especially in a short run printing. According to ink-based solution, inkjet is a direct-to-paper technology with no intermediate image carrier and is thus a direct printing. In contrast, toner printing such as electrophotography is a technology of controlling toner powder precisely onto paper; requires a photoconductive drum or image carrier to create the toner image and then transfer it to paper. Although the electrophotographic printing is excellent in quality and speed, photoconductor used in the system induces the higher cost of printing than inkjet. This disadvantage leads to seeking efforts for realizing new printing technologies, which have characteristics of a simpler printing mechanism, higher printing quality, higher printing speed, and/or better stability and maintainability. Array Printers AB in Sweden have developed a direct printing method using insulating toner, TonerJet®, since 1986, express purpose to be faster than inkjet and lower in manufacturing cost than electrophotography.[1,2] In 1999, a dot formation method using conductive toner called "Toner Cloud Beam (TCB)" has been purposed.[3-7] The toner beam is extracted from toner cloud generated by electric field applied between electrodes. Then, the toner beam is projected to paper to form dots by such a simple printing mechanism. In toner cloud generation, the electrostatic force is very important for moving toner over the dented electrode. This research is a part of Toner Cloud Beam printing mechanism, the special shaped dented electrode used in this research is a metal plate and an ITO (Indium Tin Oxide) spattered transparent glass. Dependency of the motion of toner cloud and the toner uniform cloud on the special shape of dented electrode, applied voltage, were determined for the conductive toner cloud motion and uniformity. The attainable results of this research could give some information for developments of the new dot formation mechanism over the width of printing area which can be processed with a simple mechanism, "Toner Cloud Beam".

Experimental

Materials: The toner used in this experiment is a mono-component toner made by the crushing method and the average diameter is around 11.25 μm. The toner shape is irregular resulting from the crushing method. In addition, the specific gravity ρ is 1.9 g/cm^3 and the resistivity η is 1.55×10^{10} Ω cm.

Preparation of electrodes: The electrodes used in the experiments are of a stainless steel and an ITO (Indium Tin Oxide) spattered transparent glass. The ITO glass is used for observing the toner motion. The ITO glass is flat and the stainless steel electrode is dented into wide chamber shape with both ends is round shapes.

Preparation of Toner Cloud Beam control unit (TCB): Toner Cloud Beam control unit was prepared as shown in Fig. 1. The basic circuit for the TCB unit requires a dc voltage source that generates high output voltage for applying to each electrode. Two electrodes are used in this work, which are arranged in parallel. The upper electrode is an ITO glass and the lower electrode is dented and called “the dented electrode”. The spacing of the two parallel electrodes is arranged to be 0.5 mm with a Teflon sheet, which is inserted to avoid short circuiting. Conductive toner weighing about 3 mg was applied to the dented electrode at the center of the chamber. The voltages applied to the electrode were 521, 757, 961, 1202, and 1678 V to generate toner cloud and a digital camera was used to take movie clips of the toner cloud movement through the ITO glass in real time. Dependence of the front toner cloud traveled distance on the applied voltages at a fixed depth of the electrode of 0.5 mm was also investigated at various times. The speed of the front toner cloud movement from the original to 0.025 m away on the electric field on the two depths of the electrode was carried our to observe the effect of the electric field and electrode depth.

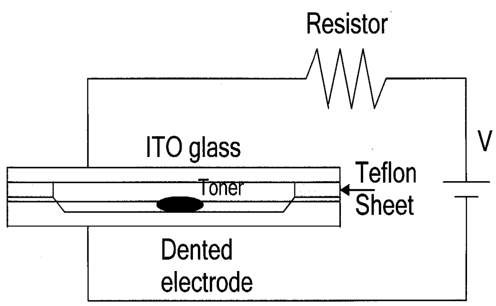

Figure 1. Schematic diagram of experimental system.

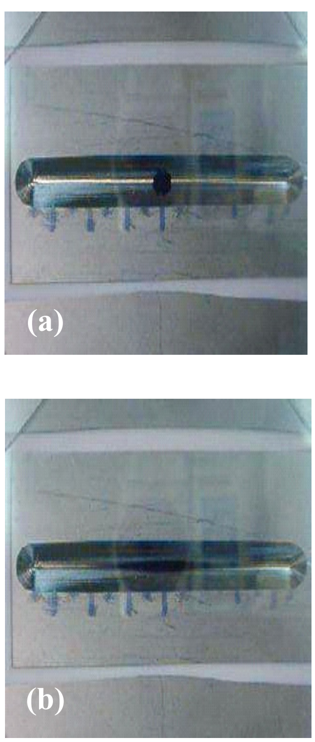

Figure 2. The photographs of the conductive toner observed through the ITO glass: a) toner before the cloud state, b) toner cloud at the cloud state.

Results and Discussion

Figure 2 displays the photographs of the toner before the cloud state (a) and the toner motion at the cloud state (b). After the voltage had been applied to the electrodes, the conductive toner started to move up and down between the electrodes by the electric force. Dispersion or scattering of the conductive toner on the dented electrode governed the cloud to propagate to both ends. The conductive toner on the electrode became like a black cloud and moved toward both ends as shown in Figure 2 b). After the toner cloud reached both ends, it became a steady state. When the applied voltage was stopped, the conductive toner moved down to the dented electrode. The movement of the toner cloud was captured in a video file using a digital camera whereas the displacement of front toner cloud was basically measured using software called QuickTime 4.0.

Figure 3 shows the relationship between the displacement of the front toner cloud and the applied voltage from the fundamental data. The higher applied voltage produces the faster speed of the toner cloud during toner jumping, resulting from the greater speed and higher frequency of the up and down movements of the toner particles on the dented electrode.

Figure 4 shows the dependence of speed of toner cloud front on the applied electric field. It is found that the speed (1/time) increases as the electric field increases and the distance between electrodes decreases. The conductive toner moves up and down activated by the increase of applications of electric field and the decrease in the distance between the electrodes.

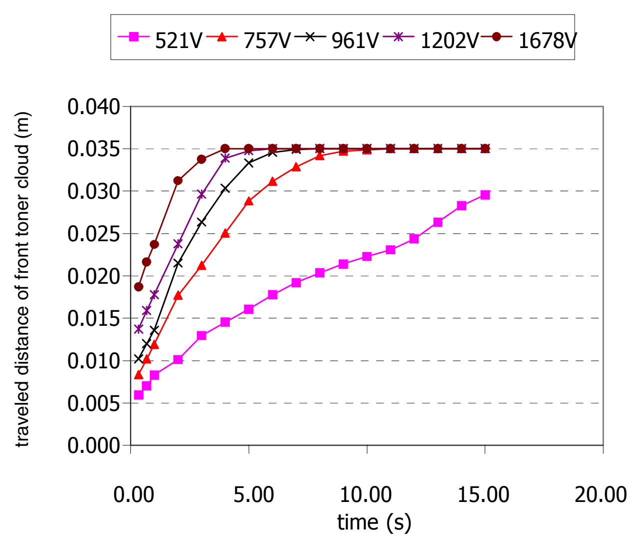

Figure 3. Dependence of the front toner cloud traveled distance on the applied voltage at the fixed depth of the dented electrode of 0.5 mm and toner 3 mg put at the center of dented electrode.

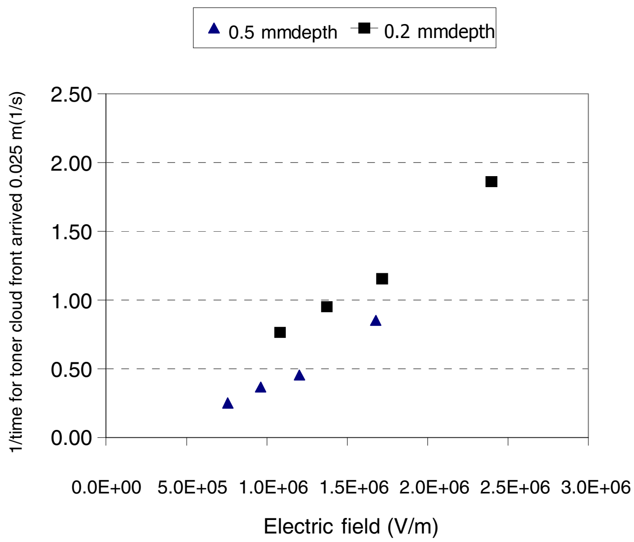

Figure 4. Dependence of 1/time for the front toner cloud traveled to 0.025 m on the electric field on the electrode of depth 0.5 and 0.2 mm, toner of 3 mg at the center of the electrode.

Conclusions

In conclusion, we achieved the conductive toner cloud generation in the width of the printing area and also the toner transportation for the printing system. This information could possibly be applied to improve the dot formation mechanism in a modern electrostatic toner cloud beam printer. Although we achieved many important features necessary of the toner cloud beam printer, some other parameters for conductive toners, involving toner cloud generation and transportation are not yet thoroughly investigated. A few parameters worthwhile investigating is: a) Optimum toner characteristics, conductivity, shape and size, and b) Adhesion force between the toner and the electrode. These parameters indeed affect the extent of toner cloud generation, toner cloud movement, uniformity of toner clouds, and toner transportation.

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Biographies

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