

Characteristics of Experimental Transportation Systems for Charged Toner Particles

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Abstract

Two types of experimental systems have been developed for observing the movement of charged toner particles shifted by the traveling wave on the sheet of periodical conductors driven by two kinds of generators: three-phase sinusoidal waves and four-phase rectangular ones.

We have obtained the following major results:

(1) The transported distance of charged toner particles can be controlled by the step-by-step operation of four phase rectangular waves.

(2) The relationship between the speed of transportation of charged toner particles and the driving frequency can be described as the difference between two experimental systems mentioned above.

(3) Movement of charged toner particles driven by the traveling wave can be observed in detail by the video camera.

Introduction

Toner particles can be transported by means of traveling wave of electric field, generally called the electric curtain [1][2]. Two types of the electric curtain can be generated on the sheet of periodical-array-conductors by using the three-phase sinusoidal wave generator or the four-phase rectangular wave one. We have found that it is not easy to transport toner particles by step-by-step operation in the case of three-phase method. Therefore, we will deal here with the movement of toner particles controlled by the traveling wave of four-phase rectangular waves in detail. The purpose of this research is to develop the transportation system for the measurement of charge to mass ratio of toner particles [3][4].

Experimental Transportation System

Figure 1 shows the schematic diagram of the experimental system for transporting charged toner particles.

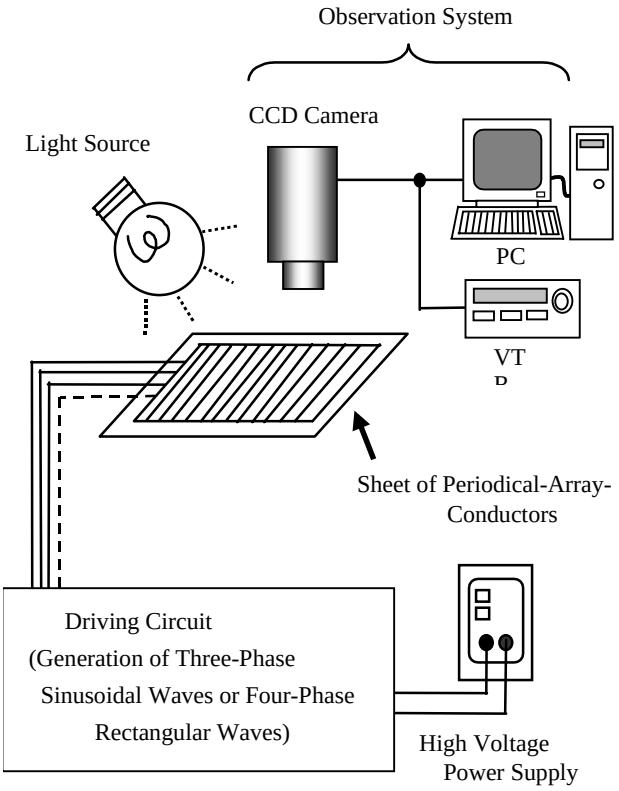

Figure 1. Experimental system for transportation.

This system consists of the three-phase sinusoidal wave generator or the four-phase rectangular one, the sheet of periodical-array-conductors for toner-transportation, and the CCD camera system for observing the toner movement. Figure 2 and Figure 3 show the structure of the sheets of periodical-array-conductors for the three-phase system and the four-phase one for transportation of toner particles, respectively. The toner conveyers constructed by both of the sheet of periodical-array-conductors are driven by the three-phase sinusoidal wave generator or the four-phase rectangular wave one.

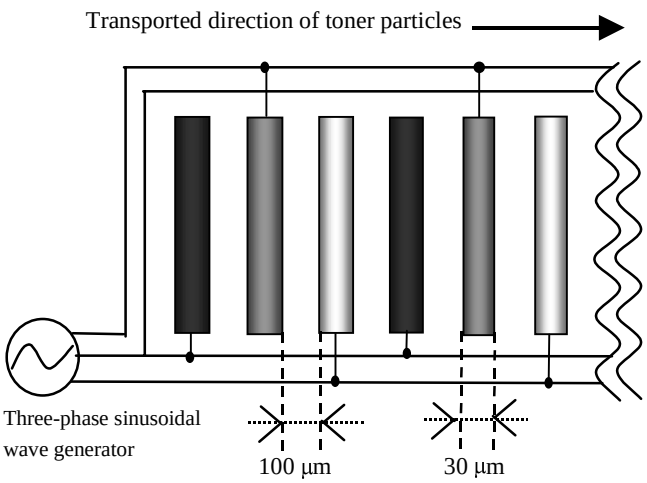

Figure 2. Outline of the sheet of periodical-array-conductors for transportation of toner particles is driven by the three-phase sinusoidal wave generator.

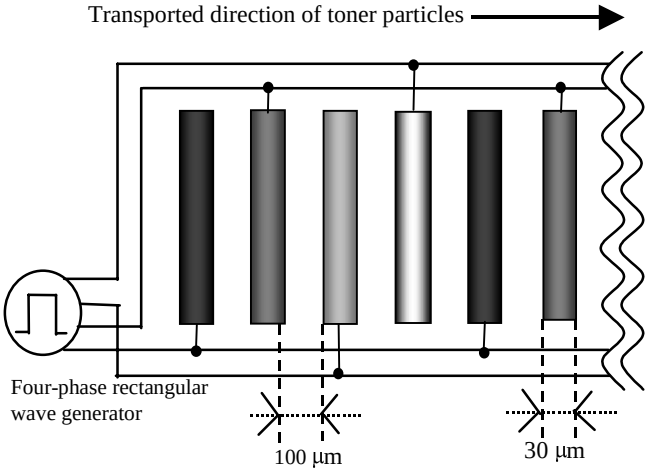

Figure 3. Outline of the sheet of periodical-array-conductors for transportation of toner particles is driven by the four-phase rectangular wave generator.

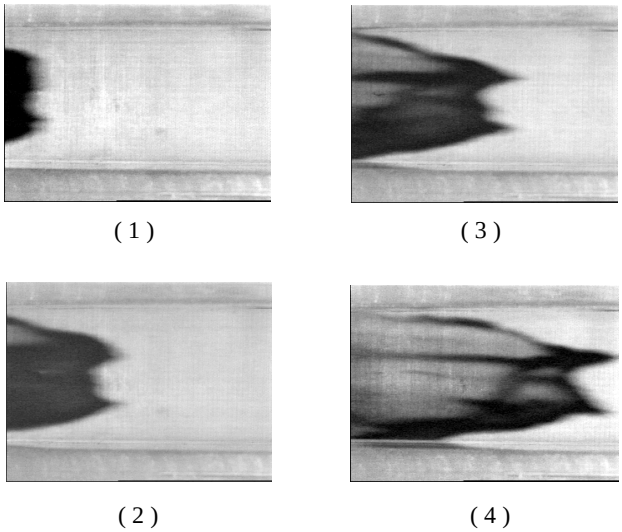

Figure 4. Typical examples of toner particles transported by three-phase sinusoidal waves.

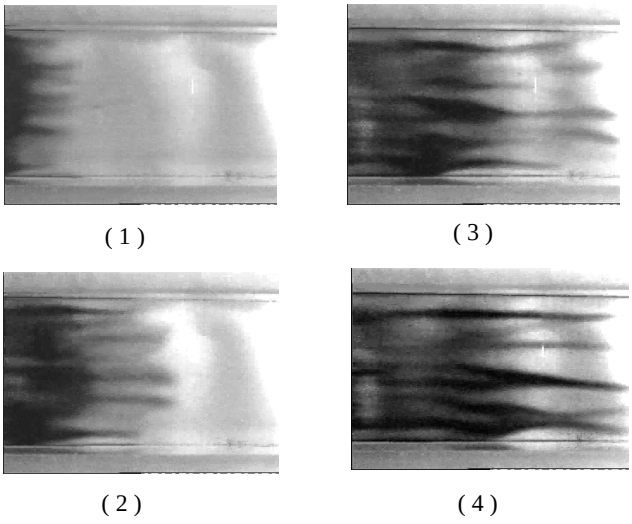

Figure 5. Typical examples of toner particles transported by four-phase rectangular waves.

The conductors on the electrode-array-sheet are periodically printed and are connected each other with feeders of the output of generators as depicted in Figure2 and Figure3.

Experimental Result

Transportation of Toner Particles

Figures 4 and 5 show the typical examples of the movement of toner particles driven by the sinusoidal generator and the rectangular one, respectively. Spherical toner particles with silica coating are used for this experiment. The voltage and the frequency generated three-phase sinusoidal waves are 120V and 600Hz, respectively. These values generated by four-phase rectangular one are also 240V and 600Hz respectively.

Charged toner particles are put on the sheet of periodical-array-conductors on the left side in these figures. It can be seen that toner particles move just like liquid-stream from left to right direction. From these movements, we can measure the speed of transportation of toner particles as a function of the frequency of driving waveforms. This result is graphically shown in Figure 6.

As shown in this figure, it is clear that the speed of transportation for toner particles is proportional to the frequency of driving waveforms. However, in the case of the three-phase sinusoidal method, relationship between the frequency of driving waveforms and the speed of transportation is not good as compared with the case of the four-phase rectangular one.

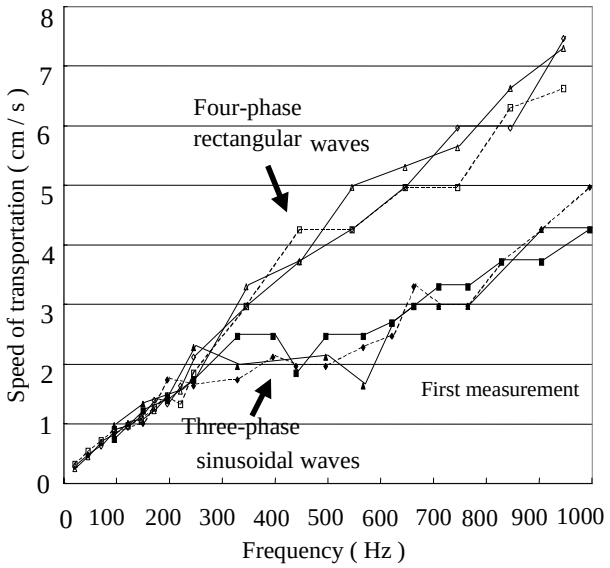

Figure 6. Relationship between speed of transportation for toner particles and driving frequency.

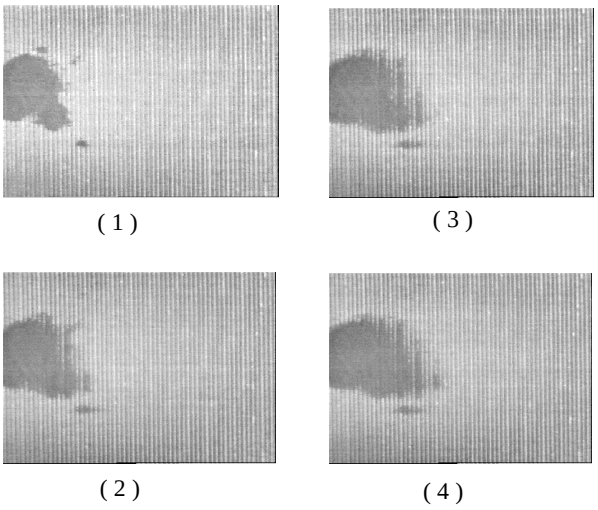

Figure 7. Examples of images of the movement of toner particles executed step-by-step operation by four-phase rectangular waves.

Control for the Movement of Toner Particles

Figure 7 shows a typical example for step-by-step movement of toner particles controlled by four-phase rectangular generator. The voltage and the frequency generated are 200V and 3Hz, respectively.

We can observe that toner particles are shifted by step-by-step operation from left side to right one. The movement of toner particles is shown in Figure 8 with the magnified scale. Figure 8-(2) shows the image that the toner particles are shifted by two of step-by-step operation of rectangular waves from the situation of toner particles shown in Figure 8-(1). Periodical flashed lines depicted in Figure 8 are printed electrodes having the width of 30μm. They are shifted to the right direction about two spans of electrodes expressed by the distance between the dashed line and the solid one. Therefore, the movement of toner particles can be controlled by the four-phase shift pulses exactly. We can easily control toner particles by the frequency of less than 10Hz.

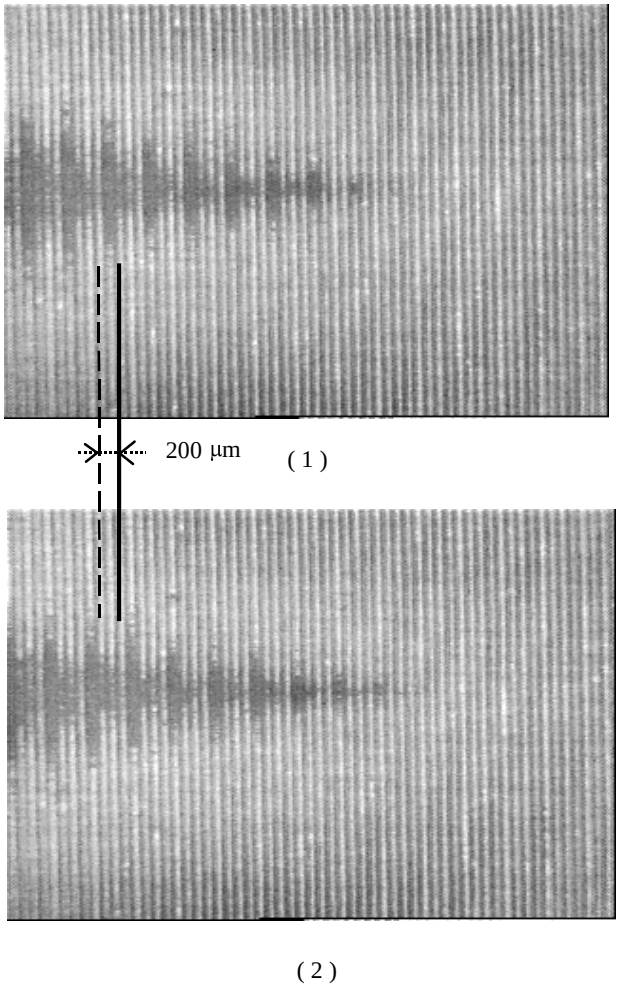

Figure 8. Magnified images obtained from Figure 7.

Conclusion

In this research, the following results are obtained:

(1) The transportation of toner particles can be accurately controlled by step-by-step operation of four-phase rectangular wave generator.

(2) The speed of transportation of toner particles is proportional to the frequency of driving waveforms. In case of the four-rectangular method, this relationship is good as compared with the case of three-phase sinusoidal one.

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Biography

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He received a BE. degree in Electrical Engineering from Kinki University, Osaka, Japan, in 1964 and a Dr. of Eng. degree from Osaka University in 1972, respectively.

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He was born in Kobe, Japan in 1941. He graduated Osaka Prefecture University on 1963. He was a Research Associate of Electronics Engineering at Osaka University from 1963 to 1970. Since 1970, he has been research scientist of Sharp Corporation. His main research interests are printing devices and Electromagnetic Field and Force Simulation. He is a member of Institute of Electronics, Information and Communication Engineers of Japan and The Society of the Electrophotography of Japan, IS&T, and IEEE.

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