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Experimental and numerical evaluation of two electrode systems for plate-type electrostatic separators

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A B S T R A C T

Plate-type electrostatic separators are commonly employed for the selective sorting of conductive and non-conductive granular materials. The separation generally takes place in the electric field generated between an elliptical electrode, which is connected to a high voltage supply, and a grounded S-shaped electrode. The aim of the present work is to evaluate the separation performances attainable with another electrode system, consisting of two metallic plates, a short one that is connected to the high-voltage and a long one that is grounded. The experiments are carried out with a mixture of mm-size granules of copper and PVC, originating from mechanically processed electric wire wastes. The results of the composite factorial experimental designs performed for each of the two electrode systems are quite similar. The numerical modelling and simulation of the electric field and of particle trajectories explain the experimental findings and support the practical recommendations regarding the industrial application of the two electrode systems.

1. Introduction

Sorting of conductive and nonconductive constituents of mm-size granular mixtures can be performed using S-shaped plate-type electrostatic separators [1–5]. In these separators, the electric field is commonly created between an elliptical electrode connected to high-voltage and a grounded S-shaped metallic plate (Fig. 1(a)). Granules (more or less good conductor) are transported by an electromagnetic feeder and deposited on plate electrode. Particles then slide all along the plate and behave differently according to their electric conductivity.

The applications reported in the literature concern the processing of granular electric wire wastes and mineral beneficiation [6–8]. This type of separator can also be used for the selective sorting of sub-mm-size poor and good conductive particles, like salt (NaCl) and sand [9].

The elliptical and S-shaped plate electrodes are complicated to manufacture, and difficult to clean in the conditions of continuous industrial operation. Therefore, the researchers studied other electrode configurations to simplify the engineering and the maintenance of this equipment, while preserving high separation performance characteristics.

Thus, Vlad et al. [10,11] performed the numerical analysis of the electric field of S-shaped plate-type separators, and simulated the particle trajectories for different relative positions of the electrodes and for different applied high voltages. They also numerically modeled the behavior of conducting particles assuming that the electric field of the separator is generated by two flat electrodes [12].

The aim of the present paper is to evaluate the separation performances attainable with such a simplified electrode system, consisting of two metallic plates facing each-other (Fig. 2). The first one plays the role of the S-shaped plate electrode; it is connected to the ground and has the same length. The second metallic plate is connected to high-voltage; it is as long and as large as the elliptical electrode. These types of electrode are preferable for cleaning and maintenance in industrial facilities.

The experimental comparison between the standard and modified electrode system is completed by the numerical analysis of the electric field and simulation of particle trajectories. This

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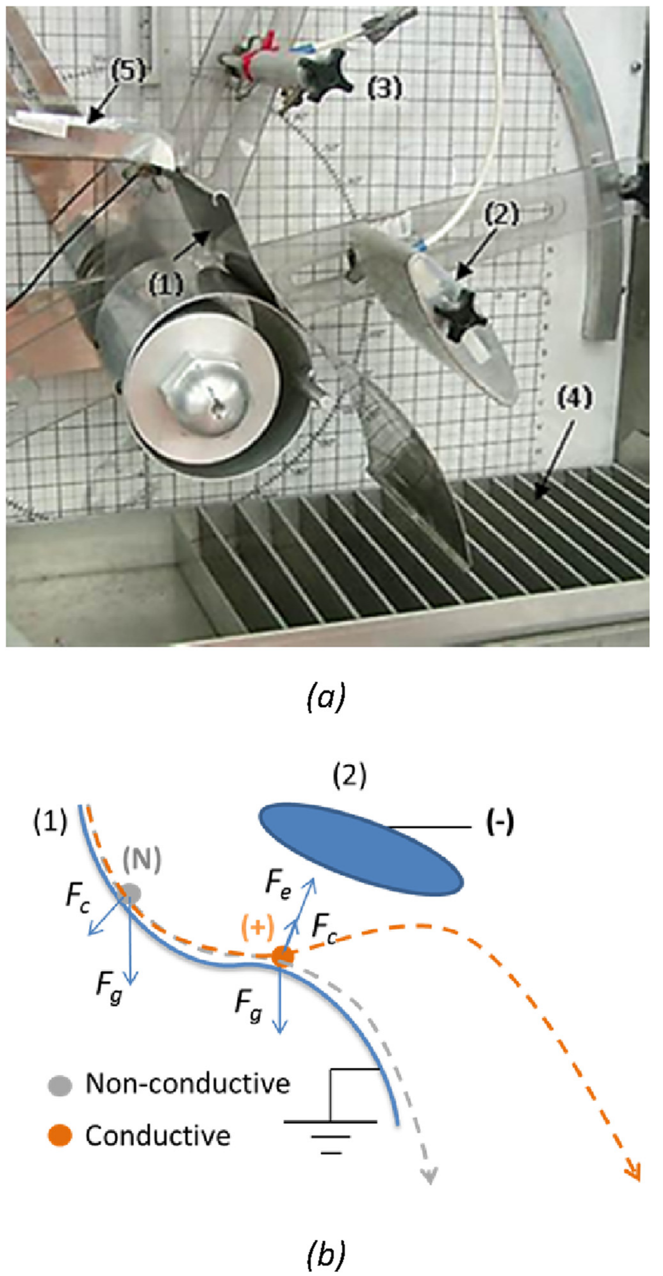

Fig. 1. (a) Standard electrode configuration of a laboratory plate-type electrostatic separator (CARPCO, Inc.); (1) S-shaped grounded plate electrode; (2) Elliptical electrode connected to high-voltage (positive polarity); (3) Corona electrode; (4) Collector (16 compartments); (5) Electromagnetic vibratory feeder; (b) Schematic representation of the forces acting on the particles and of the separation trajectories **(#1)**.

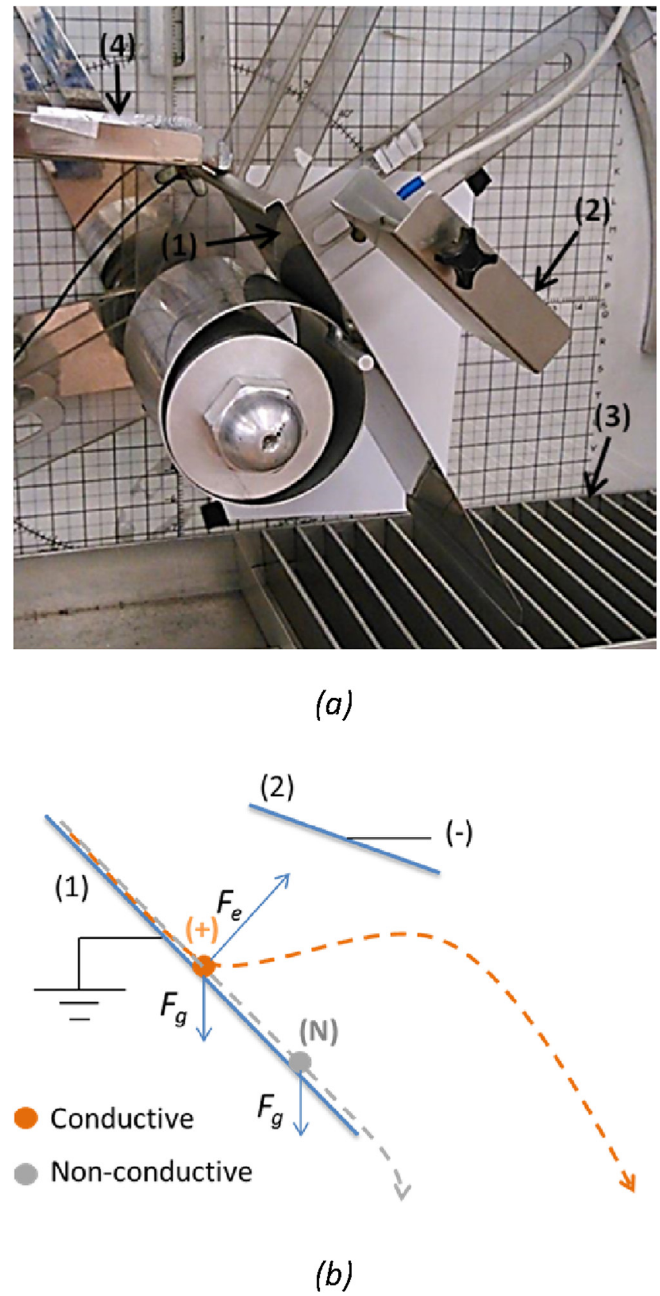

Fig. 2. (a) Modified electrode configuration of a laboratory plate-type electrostatic separator (CARPCO, Inc.); (1) Grounded plate electrode; (2) Plate electrode connected to high-voltage (positive polarity); (3) Collector (16 compartments); (4) Electromagnetic vibratory feeder; (b) Schematic representation of the forces acting on the particles and of the separation trajectories **(#1)**.

study is expected to enable the formulation of a set of recommendations regarding the design and the industrial application of the two electrode configurations.

2. Theoretical aspects

Non-conductive granules do not acquire electric charge by electrostatic induction. They are not attracted by elliptical-shaped electrode and fall by their own weight in the left side of the collector. It is possible to add a corona electrode to the standard configuration, in order to charge the granules by ionic bombardment and hence to better control their trajectories [13]. Thus, they are subjected to an electric image force that tends to pin them onto the plate electrode.

While sliding down the S-shaped grounded plate electrode of the standard configuration **(#1)**, the conductive particles acquire, by electrostatic induction, an electric charge the sign of which is opposed to the polarity of the high-voltage potential. They are affected by three forces (Fig. 1(b)): electric (Coulomb) force F_e, gravity force F_g and centrifugal force F_c. The electric force F_e exerted on such a conductive particle is expressed by: