Journal of Electrostatics 71 (2013) 681–688

Contents lists available at SciVerse ScienceDirect

Journal of Electrostatics

journal homepage: www.elsevier.com/locate/elstat

Two stage electrostatic separator for the recycling of plastics from waste electrical and electronic equipment

Wessim Aksa [a], Karim Medles [a], Mohamed Rezoug [a], Mohamed Fodil Boukhoulda [a], Mihai Bilici [b], Lucian Dascalescu [b,*]

[a] Electrostatics and High Voltage Research Unit, IRECOM, University Djillali Liabes, 22000 Sidi-Bel-Abbes, Algeria
[b] Institut P', CNRS-University of Poitiers-ENSMA, IUT, 4, avenue de Varsovie, Angoulême 16021, France

ARTICLE INFO

Article history:
Received 15 August 2012
Received in revised form
3 November 2012
Accepted 8 March 2013
Available online 1 April 2013

Keywords:
Electrostatic processes
Image processing
Triboelectricity
Recycling
Waste recovery

ABSTRACT

The aim of study was to evaluate the effectiveness of a new facility for recycling of plastics from granular waste electrical and electronic equipment. The installation consists of two sections, the products of a first tribo-aero-electrostatic separator being subsequently treated in two free-fall electrostatic separators. The tests were performed on a mixture of polycarbonate (PC) and polyamide (PA). Analysis of the purity of the products obtained was performed using a program of image processing in MATLAB. Products of very high purity (roughly 95% for both PC and PA) were obtained at a recovery rate higher than 70%.

1. Introduction

Computers, printers, mobile phones, and other such appliances have shorter and shorter lifetimes [1], due to the very fast progress in electronics and information technology (IT). They represent an increasingly larger part of the waste electrical and electronic equipments (WEEE), the volume of which has reached an alarming level, especially during the last twenty years, when the markets have been saturated with huge quantities of new products of this type [2,3]. According to the recent statistics, the quantity of WEEE increased by 25% in five years, with the proportion of plastics amplified by 30% in the same period [1,4–6]. This situation has drawn the attention of both governmental and non-governmental on the necessity of developing effective methods for the recycling of WEEE.

The electrostatic separation methods [7–9] have already proved to be a very effective solution for the recycling of insulating materials contained in this kind of waste. This non-pollutant technology is characterized by low energy consummation, as well as by reduced costs of operation and maintenance [10].

The tribo-electricity, a physical phenomenon involving the charge transfer between two bodies in contact [11–16] is the main charging mechanism employed for the separation of granular insulating materials in an intense electric field. The aim of the present work is to validate a new tribo-electrostatic separation process that has been designed for increasing the purity of the plastics recovered from WEEE.

2. Experimental set-up

The installation is composed of two superposed, detachable electrostatic separators, attached to a same vertical support (Fig. 1). The upper section of the set-up is a tribo-aero-electrostatic separator that consists in a parallelepiped enclosure (height: 500 mm; width: 130 mm; depth: 110 mm), having two transparent walls in order to permit the visualization of phenomena, and two opaque lateral walls that have aluminum plate electrodes glued on their internal surfaces. These electrodes are typically energized from two adjustable DC high voltage supplies of opposite polarities ±50 kV, to create an electrical field sufficiently strong to control the trajectories of charged granules.

* Corresponding author. Tel.: +33 545673245.
E-mail addresses: lucian.dascalescu@univ-poitiers.fr, ldascalescu@gmail.com (L. Dascalescu).

0304-3886/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.elstat.2013.03.009

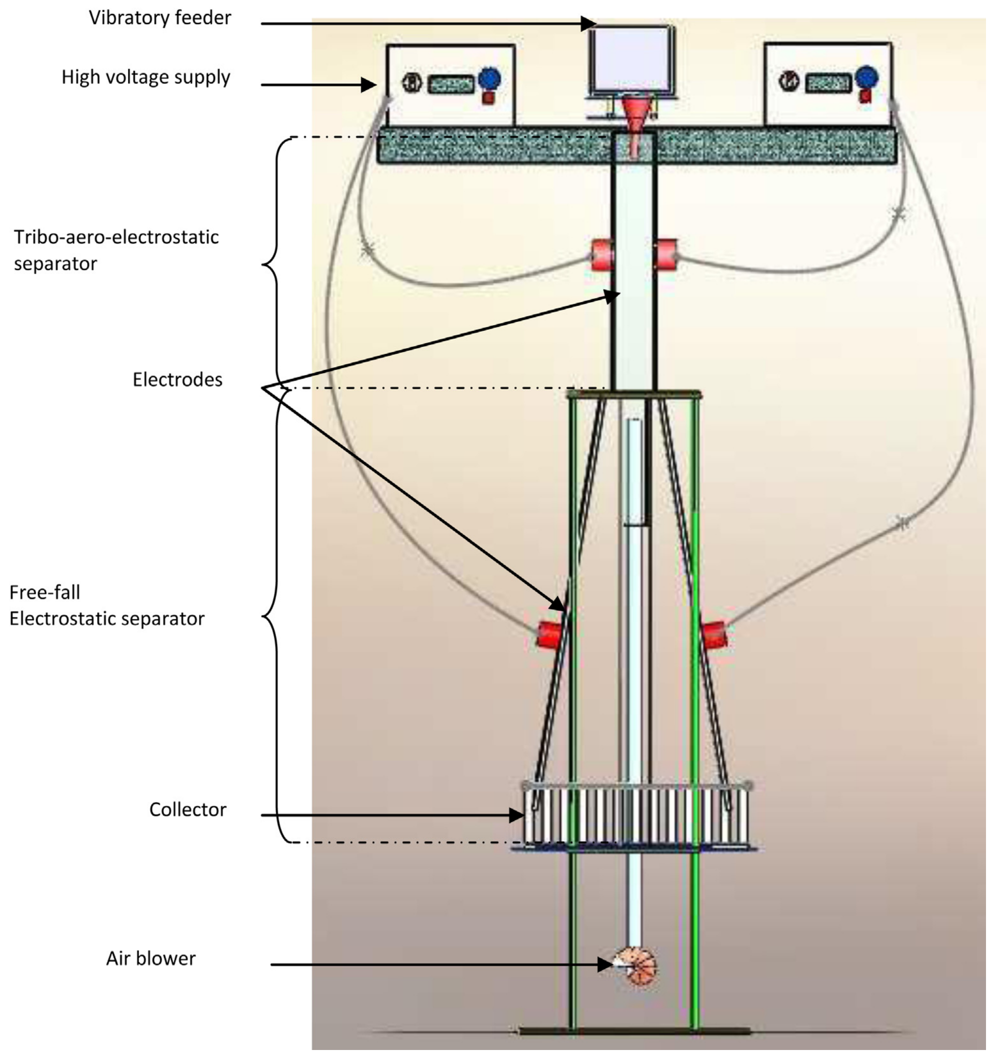

Fig. 1. Schematic representation of the new double-stage electrostatic separator for mixed granular plastics.

Granule charging is produced by tribo-electric effect in the fluidized bed generated in the interior of this enclosure (Fig. 1). The fluidization air is furnished by a variable-speed blower. The uniformity of the fluidization bed is ensured by a custom-designed air diffuser, which is a finely-perforated plate situated at the bottom of the upper section of the installation.

The granules are introduced in the separation enclosure by a funnel supplied by a fully-adjustable vibratory feeder. Under the combined action of the gravitational, aerodynamic, and electrical forces, they separate essentially in function of the polarity of their charge and exit the first separation stage through two slots that direct them to the lower section of the experimental set-up (Fig. 2).

This section is composed of two free-fall electrostatic separators, the electrodes of which are aluminum plates (520 mm × 100 mm) glued to four insulating PMMA boards (650 mm × 110 mm). The upper edges of these four boards are positioned at the exit of the tribo-aero-electrostatic separator. The two vertical central plaques are fixed and connected to the earth, while the two exterior electrodes are connected to high voltage supplies of opposite polarities and can rotate to form angles ranging from 0° to 45° with respect to the vertical. The separated products are recovered in two identical collectors, each subdivided in twenty compartments (length: 100 mm; width: 30 mm; depth: 85 mm). The 20 boxes of the two collectors are numbered as shown in Fig. 3.

3. Materials and method

The experiments have been carried out with granules of polycarbonate (PC) and polyamide (PA) (Table 1). The mechanical separation of these granules is impossible, because they have similar shapes and mass densities. The analysis of the purity of the separated products is facilitated by the fact that the granules have different colors (Figs. 4–6). A set of 100 granules were weighted and the results were divided by 100 to give the weight of one granule.

The high-voltage U_1 applied to the electrodes of the upper section was adjusted at various values ranging between 24 and 48 kV. The electrodes of the two free-fall electrostatic separators of the lower section were energized at voltages U_2 and U_3 of opposite polarities and similar absolute values in the range 24–32 kV. These values were established after several preliminary experiments. Thus, it was observed that separation is very poor at voltages lower than 24 kV (the electric field strength is less than 2 kV/cm, not