Journal of Electrostatics 87 (2017) 102–109

Contents lists available at ScienceDirect

Journal of Electrostatics

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

Neutralization of charged dielectric materials using a dielectric barrier discharge

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ARTICLE INFO

Article history:
Received 21 December 2016
Received in revised form
27 March 2017
Accepted 3 April 2017

Keywords:
Neutralization
Dielectric barrier discharge
Surface potential
Dielectric material

ABSTRACT

Safety and efficiency are two characteristics that must be satisfied by an electric charge neutralizer. The dielectric barrier discharge (DBD), which has the advantage of preventing arc transition, is an interesting tool to safely neutralize unwanted charge. This paper is aimed at studying the efficiency of neutralizing charged polyethylene (PE) granules by using a dielectric barrier discharge. During this study, several factors were considered such as the amplitude and the frequency of the AC voltage, the polarity and the charging mode of the samples, as well as the electrode configuration. Two DBD electrode configurations were considered: simple DBD and a DBD with installed metallic grid. The obtained results show that using the DBD can lead to excellent neutralization results when the grid is installed. With the appropriate voltage amplitude and frequency and with grid installed, the elimination of nearly 99% of the initial surface charges can be achieved. The metallic grid placed between the DBD electrode and the target enhances significantly the neutralization efficiency.

1. Introduction

The static electricity can be a source of several kinds of hazards caused by unwanted or residual charges often present on the surface of dielectric materials. In fact, the electric charge deposited on the surface of an insulating material to perform a given action during an electrostatic process may become a source of disturbances when the process is over [1–3]. Indeed, the residual electric charges may produce particle agglomeration or cause sticking to the walls of the devices, phenomena that can be very annoying in a pneumatic conveying system, for example [4,5]. Moreover, if the electric field becomes high enough, due to the accumulation of charge, an electrostatic discharge can take place, presenting thus a major risk in a flammable environment [2]. Hence, electrostatic charge eliminators are usually presents in most electrostatic applications. In the case of a recently-patented tribo-aero-electrostatic separator, for instance, the static eliminators can serve to detach the charged granules attached to the metallic-belt-conveyer-type electrodes [6]. Of the various ways to control static electricity [7,8], the simplest one consists in grounding the metallic parts [9–11]. However, this grounding is not always possible as in the case of insulators or large open areas. The standard solution to neutralize a charged insulator is to expose it to charges of opposite sign. In this way, the charges on the insulating material are eliminated by recombination. The most used technique in eliminating the surface charge is based on the corona discharge as a mechanism of the mono- or bipolar ion generation [12,13]. The corona-discharge-based neutralization mechanism consists in the generation of a bipolar ion cloud where, depending on Coulomb forces, the charges of the same sign repel while opposite sign charges are attracted and neutralized by recombination. Previous studies carried out on neutralization of the surface charge deposited on dielectric materials using an AC corona discharge have shown that the charge elimination efficiency can be up to 95%, depending on the frequency and the amplitude of the applied voltage [14,15]. This dependence on discharge characteristics makes the charge neutralization a complicated process.

When the environment in which the electrostatic ionizer should be used is highly risky or if the treated dielectric material can be damaged by an electric discharge, the used electrostatic ionizer should be both safe and efficient. Indeed, the use of corona discharge can lead to an electric discharge if one parameter is suddenly changed like distance, surface charge value and polarity or even the applied voltage magnitude. To avoid such hazardous

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http://dx.doi.org/10.1016/j.elstat.2017.04.005

situations, the safety of the installation must be satisfied first by the ionizer. In this paper, dielectric barrier discharge is used and studied as efficient and safe solution in the elimination of electrostatic charge on the surface of the dielectric material. The technique was applied on polymer granular material while in movement. Several parameters were considered during this study: amplitude and frequency of the AC applied voltage, the electrode type (with and without grid) and charging mode.

2. Materials and methods

The experiments were performed on two types of materials, characterized by either irregular surfaces such as PE (polyethylene) granules, or smooth surfaces such as PP (polypropylene) film.

The PE particles were quasi-spherical in shape, with a typical size of about 3 mm. The mass of the PE samples was 3.65 g; they were spread as a monolayer on an area of 50 mm × 50 mm. The samples were deposited on a grounded plate supported by a conveyer system insuring forth and back movements. Fig. 1 shows the schematic representation of the experimental setup. The samples were charged using one of three different procedures: triboelectricity, corona discharge and dielectric barrier discharge. Then, the charged samples were transferred under an electrostatic probe to measure the distribution of the electric potential at the sample surface. The probe was connected to an electrostatic voltmeter (Model 347, Trek Inc), that directly sends the measurements to a personal computer through a data acquisition system. After the surface potential measurement, the samples were neutralized using a DBD system. The charged material was neutralized while moving, with a speed of 5 mm/s, under the DBD neutralization electrode. When the neutralization process is over, the samples were moved once again under the electrostatic probe for surface potential measurement after neutralization.

2.1. Charging systems

Three systems were used to charge the PE samples:

a) The triboelectric effect was obtained using a vibrating system (model: Endecotts Octagon D200 Digital Sieve Shaker) in which the samples of PE granular material were in contact with an insulating cup the inner side of which was covered by aluminum (Fig. 2). After charging during 2 min in the vibrating system, the PE particles acquired a negative net charge from the contact with the aluminum surface.

b) The corona discharge is generated by using a dual-type electrode (Fig. 3) energized by a DC high voltage power supply (Spellman, model SL1200 for positive polarity; Spellman, model SLN150 for negative polarity). To provide a uniform charge distribution, the samples were moved through the discharge zone, at a speed of 5 mm/s. The dual electrode is composed of a tungsten wire (0.2 mm diameter) fixed to a metallic cylinder (25 mm diameter) and located at 11.5 cm above the grounded plate electrode.

This system was the one used to charge the polypropylene film (50 mm × 50 mm) in order to evaluate the neutralization performance in the case of a smooth surface.

Fig. 2. Photography of the vibrating system for triboelectric charging of granular material.

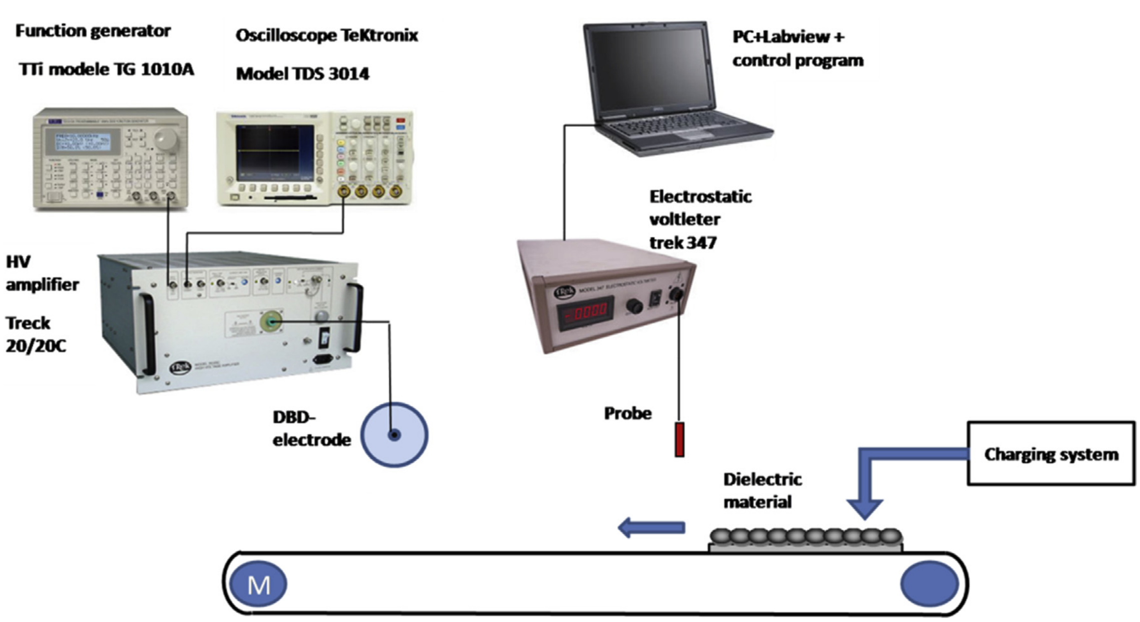

Fig. 1. Schematic representation of the experimental setup.