Experimental Study of Triboelectric Separator for Mixture of Plastic Particles

Václav Štarman, Jan Kacerovský, František Mach, Pavel Karban, Ivo Doležel
Department of Theory of Electrical Engineering
Faculty of Electrical Engineering, University of West Bohemia
Pilsen, Czech Republic
{wencadc, jankac, fmach, karban, idolezel}@kte.zcu.cz

***Abstract*—A device for electrostatic separation of triboelectrically charged plastic particles is experimentally verified. A mixture consisting of high-density polyethylene (HDPE) and polymethyl methacrylate (PMMA) is used for the experiment. The goal of the experiment is to find out the efficiency and purity of the separation.**

***Index Terms*—Electrostatic separator, triboelectric effect, high-density polyethylene, polymethyl methacrylate**

I. Introduction

Nowadays, an intensive research is aimed at the possibilities of recycling plastic materials, because in a lot of applications the recycled materials may well replace the new ones [1]. The necessary prerequisite of this reprocessing is a high-quality separation of particular levels of plastic materials ground into small sphere-like particles.One of the advanced techniques of the separation of such particles is based on the triboelectric effect ([2], [3], [4] and [5]).

The electrostatic separators can be divided into several groups. The most widely used types are the roll-type, the plate-type and the free-fall devices. The principle of the free-fall separator is based on the Coulomb force acting on freely falling charged dielectric particles. The basic arrangement of the free-fall triboelectric separator is depicted in Fig. 1.

The dielectric particles are charged using the triboelectric effect. Different materials are charged by a different amount of charge, which depends on their position in the triboelectric series [6].

The separator consists of two electrodes, one of them being grounded. The voltage of the other electrode is used to be on the order of tens kV. The charged plastic particles are entering the area between two electrodes. Here they are deflected according to their charge and fall down into the recycle bins (presently, we neglect the Coulomb forces acting among the particles, so that their movement is affected only by the external field). The task is to find their trajectories and evaluate the effectiveness and purity of separation.

As the particles in the triboelectric charger may be charged either positively or negatively, the deflection mentioned above is either in the direction to the negative or to the positive electrode. Due to this effect, the particles with different charges can be separated.

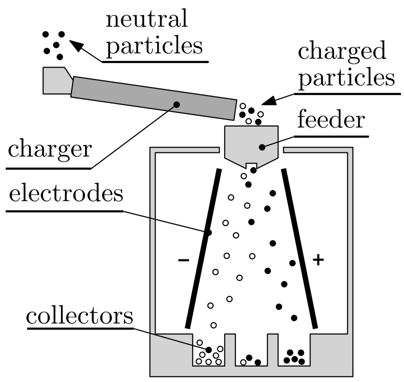

Fig. 1. Basic arrangement of free-fall triboelectric separator

II. Formulation of Problem

The arrangement of the experimental device is depicted in Fig. 2. The principal structural parts are made of non-conductive materials. Each aluminum electrode is divided to three aluminium segments and the voltage between the electrodes is $20\ \mathrm{kV}$. The charger consists of a high-speed induction drive with frequency converter and polypropylene pipe. The induction drive is connected with the pipe by a plastic belt.

The samples of plastics are represented by high-density polyethylene (HDPE) and polymethyl methacrylate (PMMA) grains. The basic parameters of used samples are described in Tab. I.

TABLE I
Parameters of used samples grains

Material	Density	Avg. mass	Avg. radius
HDPE	$950\ \mathrm{kg\cdot m^{-3}}$	$0.0236\ \mathrm{g}$	$3.62\ \mathrm{mm}$
PMMA	$1190\ \mathrm{kg\cdot m^{-3}}$	$0.0148\ \mathrm{g}$	$2.87\ \mathrm{mm}$

The experiment was performed for $100\ \mathrm{g}$ of mixture consisting of $50\ \mathrm{g}$ of the HDPE grains and $50\ \mathrm{g}$ of the PMMA grains. The particles were charged for $210\ \mathrm{s}$ in a pipe rotating at $300\ \mathrm{rpm}$.

During the experiment, the movement of the charged particles in the system of electrodes was recorded by a high-velocity camera and the positions of the particles were subsequently processed using a square grid. The atmospheric prop-

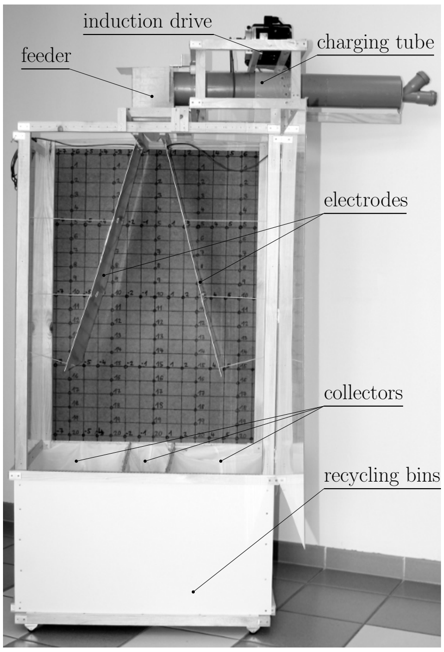

Fig. 2. Experimental device

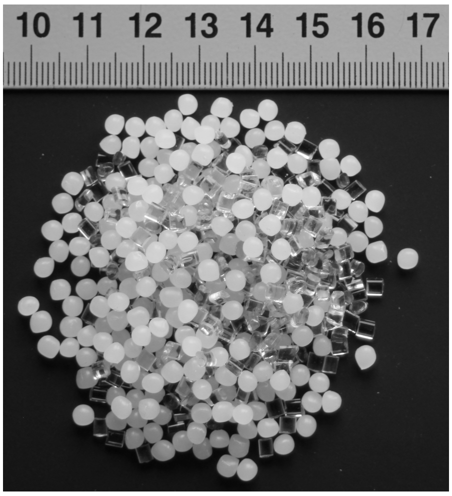

Fig. 3. Sample of plastics grains

erties such as the temperature of the surrounding environment or humidity were monitored. The efficiency and purity of the separation were evaluated at the end of the experiment.

TABLE II
RESULT OF EXPERIMENT

Bin	Total mass	Mass of HDPE	Mass of PMMA	Purity
Left	44.66 g	43.06 g	1.56 g	96 %
Right	45.39 g	1.3 g	44.07 g	97 %

The results in Tab. II indicate that 87 % particles successfully fell down into the corresponding bins. The purity of the mixture in recycling bins is 96 % for HDPE and 97 % for PMMA. In the central bin there was 9 g of the mixture. During the experiment 1 g of separated grains were lost.

III. Conclusion

The described way of separation seems to be prospective for recycling plastic materials. The experiment confirms a high efficiency of the separation process for relatively large particles ($3 - 4$ mm). The resultant efficiency of the device for separation of HDPE and PMMA particles is 87 % and the purity of separation is almost 100 %.

Further work in the domain will be aimed at the separation of particles of plastic materials that are widely used nowadays (PET, PS, PE, PP, PVC) and also at the shape optimisation of the electrode system. The optimization of the device consisting of finding their most appropriate shape may lead to an additional improvement of the efficiency [7].

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