Opto-pneumatic Separators in Waste Management

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Abstract

The European Union legal regulations referring to municipal solid wastes are aimed at getting the highest amount of resources found in the wastes. Thus it is necessary to provide proper function of the systems of collecting and sorting wastes. Nowadays more and more often automatic opto-pneumatic separators are applied in waste management. The article presents the principle of the function of opto-pneumatic separators and an example of the installation where such separators are applied.

Keywords: sensor identification, opto-pneumatic separators, sorting system, municipal solid waste

Introduction

Proper management of municipal solid wastes requires separating from the stream of wastes fractions (components) designated, first of all in different recovering processes. To separate them, municipal solid wastes are subdued to segregation, which all over the world it is carried on with different ways. Usually this is a system of "all-in-one bin" type (i.e. single-stream) or in two mixed streams (i.e. dual-stream). In the first case the resources are collected in one bag/container, in the second case recyclable materials are kept separate in two categories: paper and cardboard, and plastic, metal and glass [1]. Generally the separation of wastes can be carried out in three places: in the place of generating wastes – „at source", in the points of selective collection municipal solid wastes and in the waste segregation stations – sorting plants.

In the place of waste generation, municipal solid wastes are preliminarily segregated in households into separate fractions, usually it refers to: dry fraction, containing glass, metals, plastics, paper/cardboard, composite packaging and wet fraction – biodegradable, such as kitchen wastes. Some fractions of municipal wastes can be taken seasonally, e.g. in the „heating" ash from the household furnaces or grass and leaves (spring-autumn).

To facilitate segregation, containers and bags are usually of different colours, every colour is dedicated to concrete type of waste or several wastes together. Bags are usually of 120 dm³ volume, while containers have different volume, e.g., 120 dm³, 240 dm³, 1.1 m³, 7m³. Whether the residents segregate wastes to bags and/or containers mainly depends on the size of the commune, type of buildings, the way of transport, frequency of collection and amount of the produced wastes. For example, in the city of Krakow in Poland the residents of single-family houses throw into yellow bags: paper, metal, plastics and glass. In case of multifamily houses selectively collected wastes (paper, metals, plastics) are put into yellow containers, while glass - into green containers. Remaining wastes in single-family and multifamily houses get into blue containers.

Problematic wastes can also be supplied to points of selective collection of municipal solid wastes. These are mainly: hazardous wastes (including: pharmaceuticals with the expired date of use, paints, varnishes, used batteries, car batteries, fluorescent lamps), bulky wastes, used electric and electronic equipment, building wastes (e.g. debris), tires, green wastes and ash. Wastes, depending on their property are collected in proper containers, or concrete boxes, and then they are transported to the wastes segregation plants or directly to the receiving points dealing with the management (processing) of wastes of a given type.

Selectively collected or mixed municipal solid wastes are taken to waste segregation stations, called sorting plants. In the plants the segregated earlier wastes are „additionally purified", also more accurately segregated into fractions for recycling or other recovery processes. For example, the following is separated: paper (coloured, black and white), cardboard, film, composite packaging, glass, ferrous and non-ferrous metals and plastics: PET, PP, PE, PS. Also biodegradable fraction is directed into processes of biological processing or combustible fraction used as alternative fuel.

Sorting wastes is carried out in a different way: mechanic-manual or in the most modern, fully mechanized and automated installations. In mechanic-manual sorting plants, separation of wastes mainly means manual selection of proper

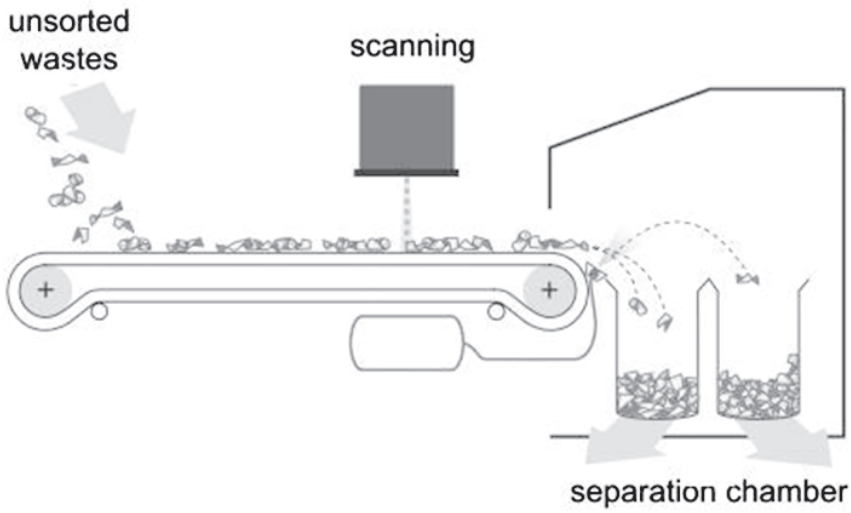

Fig. 1. Scheme of the function of opto-pneumatic separator [2]

Rys. 1. Schemat funkcji separatora optopneumatycznego [2]

fractions in the sorting chambers. Of course, this process is supported and facilitated by the application of mechanical devices, such as screeners, separators of metallic and non-metallic metals, ballistic separators. In the most modern installations, in the sorting of wastes, the work of human hands and sight was partially replaced by different sorting machines, called opto-pneumatic separators or sorters. It allowed the increase of the efficiency of the sorting lines with municipal solid wastes, which improved quality of the sorted fractions of wastes, and also increased the amount of the separated fractions. The application of opto-pneumatic separators allowed the detection and recovery of 80–90% of recyclable fraction [2].

Opto-pneumatic separators are also used in installations for the production of alternative fuels, processing of the used electric and electronic equipment or vehicles withdrawn from exploitation. Apart from this, the application in the factories processing mineral resources - coal, metals ore, base and precious metals, gemstones or mineral wastes (e.g. construction debris), where in a non-invasive and non-destroying way they recognize and classify individual components [3-6].

In the further part of the article the principle of functioning of opto-pneumatic separators, types of sensors applied in opto-separators and the application of opto-separators, using the installation of sorting municipal solid wastes, functioning in the city of Krakow, in Poland.

The principle of functioning of opto-pneumatic separators

Sorting of wastes by opto-pneumatic separators is carried out in the way that the wastes are transported by the tape conveyer, through the area monitored with a sensor or a set of sensors (fig. 1). The information detected by sensors is electronically processed and, depending on the given criteria of separation, detected materials are selectively thrown with the compressed air, from the stream of wastes into separation chamber [7]. The efficiency of opto-pneumatic separators depends on the identification and separation of wastes from one another.

To identify the wastes usually such properties/parameters such as:

- visible parameters: colour, shape and size,
- invisible: structure, density.

To recognize given properties/parameters, characteristic for the particular type of waste, different sensors are applied. Usually the applied sensors are [2, 6, 8]:

- NIR (near infra-red spectrometry) - recognition of materials is carried out based on characteristic and non-repetitive properties of the light reflected by wastes. They are usually applied in the separation of plastics,
- VIS (visible light spectrometry) – recognizes all the colours of transparent and non-transparent materials. Usually applied in the detection of materials, based on colours, e.g. PET bottles and brown cardboard, among newspapers and magazines,
- EM (electromagnetic sensor) – sensor to detect wastes using their electromagnetic properties, such as: conductivity and permeability. Applied to detect metals among

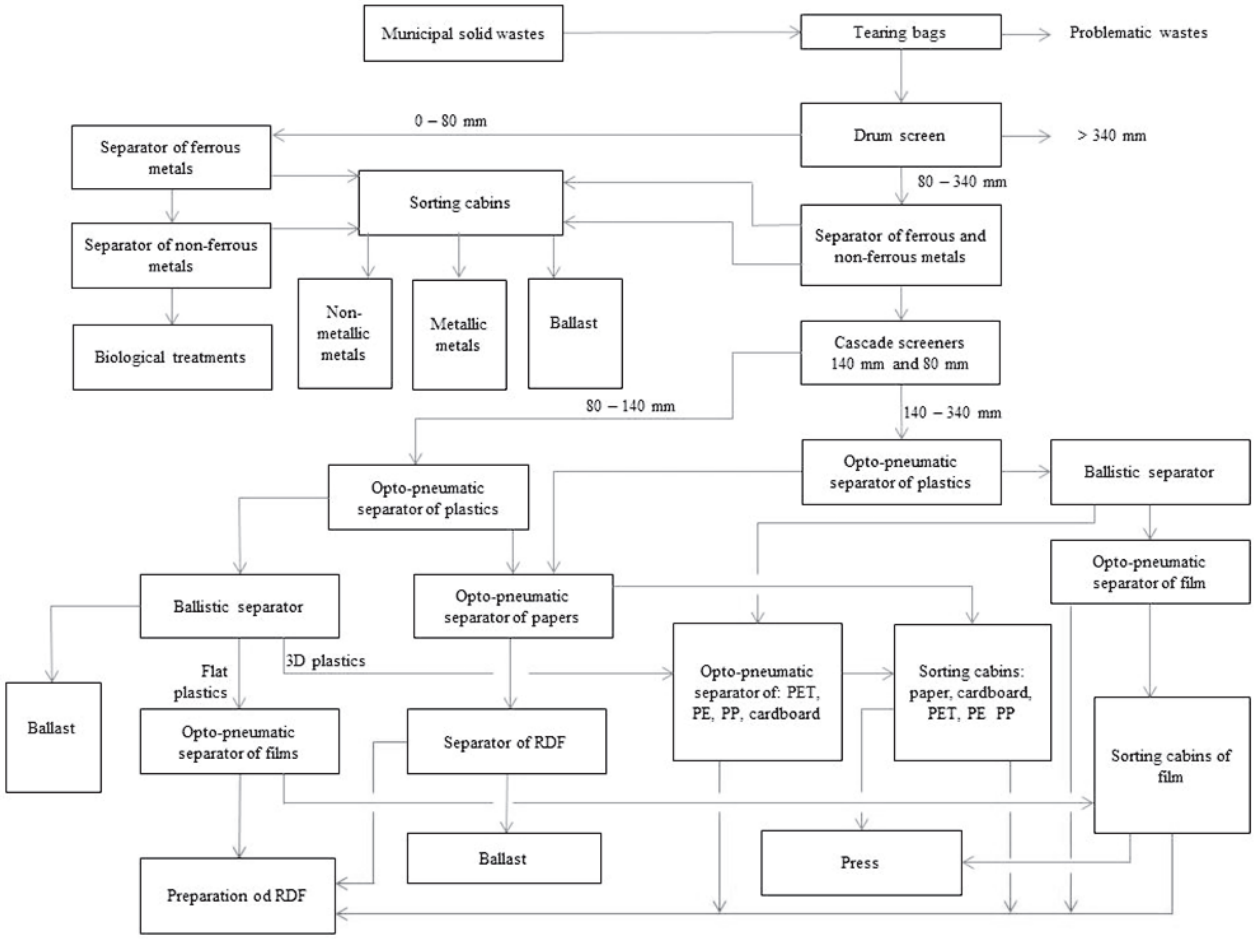

Fig. 2. Scheme of the installation sorting municipal solid wastes in Krakow

Rys. 2. Schemat instalacji sortującej komunalne odpady stałe w Krakowie

non-metallic wastes or stainless steel found in metal wastes,

- XRT (X-ray transmission) – allows sorting wastes based on their atomic density. They are mainly applied in the separation of inorganic wastes from organic wastes or ferrous metals from aluminium,
- XRF (X-ray fluorescence) – telling apart materials based on atomic structure.
- IR (infra-red camera) – allows separation of wastes by the analysis of heat conductivity and heat dissipation.
- Apart from properties of the wastes, the factors influencing the separation are also technical parameters of the separator, mainly [9]:
- the pressure, spacing and design of air jets,
- the design of feeders, belts and ejection chambers.

Another solution used in the applied in sorting wastes, is using markers to mark a particular kind of waste. Such a solution can be particularly helpful in sorting wastes of different kind of plastics, very often mixed together, containing additional pigments, fillers or other additives, which causes difficulties in the identification by NIR sensors. Moreover, NIR sensors cannot be used in sorting black or dark plastics, due to excessive absorption of radiation and low intensity of the reflection. Due to this, the method of marking plastics, using fluorescent markers added to plastics during their production [10]. Due to this, by the identification of markers contained in plastic wastes, their separation into respective kinds is possible. The identification and separation of plastics in automatic sorting chambers can also be made using other physical properties, by tribo-electric separation, flotation or wet density separation; nevertheless it demands preliminary preparation of wastes by their fragmentation [11, 12].

The application of opto-pneumatic separators in the sorting plants of municipal solid wastes

The example of such fully mechanized and automated sorting plants is a station in Krakow, where opto-pneumatic separators are applied. It is used in

sorting both mixed municipal solid wastes (code 20 03 01), as well as selectively collected municipal solid wastes, so-called dry fraction (codes: 15 01 01, 15 01 02, 15 01 03, 15 01 04, 15 01 05, 15 01 06, 20 01 01, 20 01 39, 20 01 40, 20 01 99). The technological scheme of a sorting plant is presented in figure 2. Wastes, at first, after possible tearing apart of bags, are dispersed in a drum screen into three fractions, of size: 0–80 mm, 80–340 mm and above 340 mm.

Fraction 0–80 mm (code 19 12 12) contains mainly biodegradable wastes and small plastic wastes. By the separator of ferrous and non-ferrous metals it is directed to the process of biological drying in containers. After the drying process the waste is screened on the sieve of 20 mm. The fraction above 20 mm is transferred to the installation of thermal reusing of wastes or can be fragmented to prepare alternative fuel (code 19 12 10). The fraction below 20 mm (code 19 12 12) is sent to container composting plant. After the oxygen stabilization the waste of code 19 05 99 is produced and can be directed to thermal treatment installation of wastes or to disposal on the landfill.

Fraction 80–340 mm is directed to separators of ferrous and non-ferrous metals and to the system of two cascade-vibration screeners of 140 mm (first screen) and 80 mm (second screen). After screening, fraction 80–140 mm is subdued to the opto-pneumatic separator of plastics and paper. The separated plastics are transported to the ballistic separator, which is divided into two kinds:

1. Flat plastics, directed to an opto-pneumatic separator of films. The wastes remaining after separating the film are directed to temporary storing before sending to fragmentation in the point of the preparation of RDF fuel.
2. 3D plastics, which are directed into the system of three opto-pneumatic separators, with the help of which there are plastics of types: PET, PP and PE and tetra packs.

On each stage of separation of plastics, paper, ferrous and non-ferrous metals are controlled in terms of purity in sorting cabins.

Wastes of size 140–340 mm are also sent to opto-pneumatic separator of plastics. A part of wastes not containing plastic is sent to opto-pneumatic separator of paper. The separated paper is transported to the sorting chamber, while the rest is combined with the remaining fraction 80–140 mm, used in the production of RDF fuel.

Fraction above 340 mm is transported by the conveyer do the station of automatic loading of containers and then to the point of the production of alternative fuel.

Summary

The goal of the processing of wastes, including municipal solid wastes is to maximize their recovery. To achieve this, fractions of wastes have to be separated from the stream of wastes, at the source of their production or in the plants of waste segregation. To increase efficiency more and more often automated wastes segregation plants are applied, where various opto-pneumatic sensors are applied in the identification and separation of subsequent fraction of wastes. This allows us to increase the efficiency of the waste sorting process and facilitates meeting the demand for high quality resources to be recovered, which, in traditional manual-mechanic sorters is difficult and expensive to achieve.

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Separatory optopneumatyczne w gospodarce odpadami

Obowiązujące w UE regulacje prawne dotyczące odpadów komunalnych mają na celu odzyskanie jak największych ilości surowców znajdujących się w odpadach. Wobec tego konieczne jest prawidłowe działanie systemów zbiórki i sortowania odpadów. Obecnie coraz częściej w gospodarce odpadami wykorzystuje się zautomatyzowane linie sortownicze, w których ważną rolę odgrywają separatory optopneumatyczne. W artykule przedstawiono zasadę działania separatorów optopneumatycznych oraz przedstawiono przykład instalacji wykorzystującej takie separatory.

Keywords: sensor identification, opto-pneumatic separators, sorting system, municipal solid waste