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THE METHOD OF MANAGING DIFFERENT SORTS OF PLASTICS MIXTURES

SPOSÓB ZAGOSPODAROWANIA MIESZANIN RÓŻNYCH RODZAJÓW TWORZYW SZTUCZNYCH

Abstract

The paper presents a proposition of managing solid waste constituting a polluted mixture of different sorts of plastics, the recycling of which is not possible with presently applied methods.

Keywords: recycling, plastics

Streszczenie

Przedstawiono propozycję zagospodarowania odpadów stałych stanowiących zanieczyszczoną mieszaninę różnych rodzajów tworzyw sztucznych, których przetwarzanie obecnie stosowanymi metodami jest niemożliwe.

Słowa kluczowe: recykling, tworzywa sztuczne

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1. Introduction

The rapid growth in the number of inhabitants of the globe and development of intensive methods of production caused a violent increase in the amount of solid waste. Poland in terms of quantity of the generated and accumulated waste ranks high position among the European Union countries. Likewise for Eastern Europe countries, the rate of waste generation per unit of gross domestic product generated is large and stands at 800–900 kg waste/€1000GDP. Whereas for Western European countries this indicator oscillates around 50–100 kg waste/€1000GDP (Table 1).

Table 1

Amount of waste generated per year per unit of GDP in selected European countries [1]

	Austria	Denmark	France	Germany	Italy	Spain	Sweden	United Kingdom	Poland	Bulgaria	The Czech Republic	Hungary
kg waste /€1000GDP	78	25	110	40	25	30	78	70	890	615	965	260

In Poland industrial waste constitutes approximately 90% of the generated waste. In 2008 in Poland 125 million tons of waste (including 12.2 million tons of municipal waste) was produced in total [2]. The structure and main manufacturers of this waste are presented in Fig. 1.

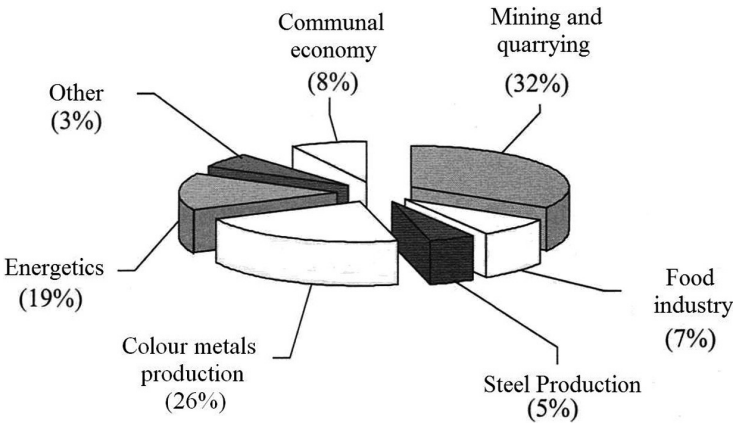

Fig. 1. Share of particular economy sectors in total stream of waste generated in Poland [1]

Rys. 1. Udziały głównych sektorów gospodarki w całkowitym strumieniu odpadów wytwarzanych w Polsce [1]

Those wastes are much diversified in terms of physical and chemical properties. However, they are always a burden on the natural environment. Plastics are a specific group, since their basic properties such as durability, high resistance to oxidation at environmental temperature, chemical resistance and a small degree of biodegradability are simultaneously their largest disadvantages, when these materials become waste. Plastics are a significant part of both municipal and industrial waste. Low biodegradability of plastics in the natural environment, thus on landfills as well, with a large volumetric share in waste make them be considered one of the most important environmental problems. The production of plastics in the world increased from 1.5 million tons in 1950 to 260 million tons in 2007 (Fig. 2) [11]. The average consumption of plastics in Central and Eastern Europe is about 45 kg/person. For 2008, the largest growth rate of plastics consumption in our part of the continent can be noticed for the industry in Slovakia (9 per cent), Poland and the Czech Republic (7 per cent both) and Hungary (5 per cent) [10].

The most widespread plastics, constituting about 80 % of the world plastics production are the following: polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC) [5].

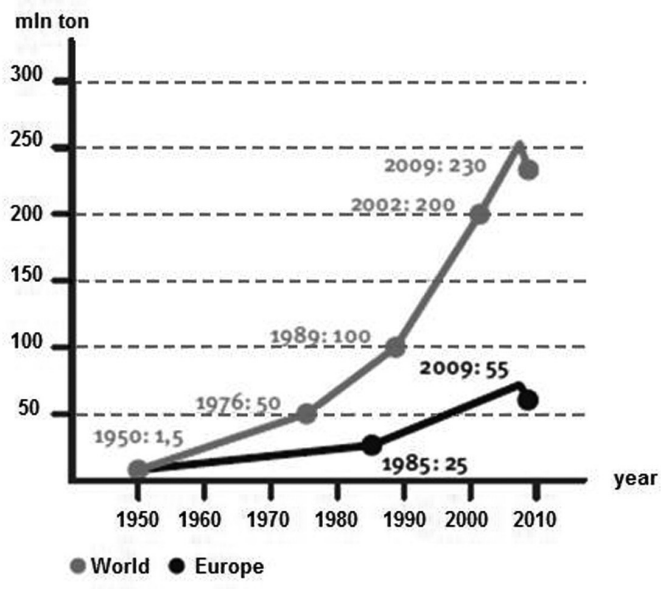

Fig. 2. Production of plastics in the world [11]

Rys. 2. Światowa produkcja tworzyw sztucznych [11]

In developed countries, the volumetric share of plastics in waste can exceed even 30%. In Poland, plastics constitute approximately 2–10% vol. of municipal waste, which annually amounts to about 1.5 million m^3 [1].

Figure 3 presents the structure of waste plastics contained in municipal waste in Poland.

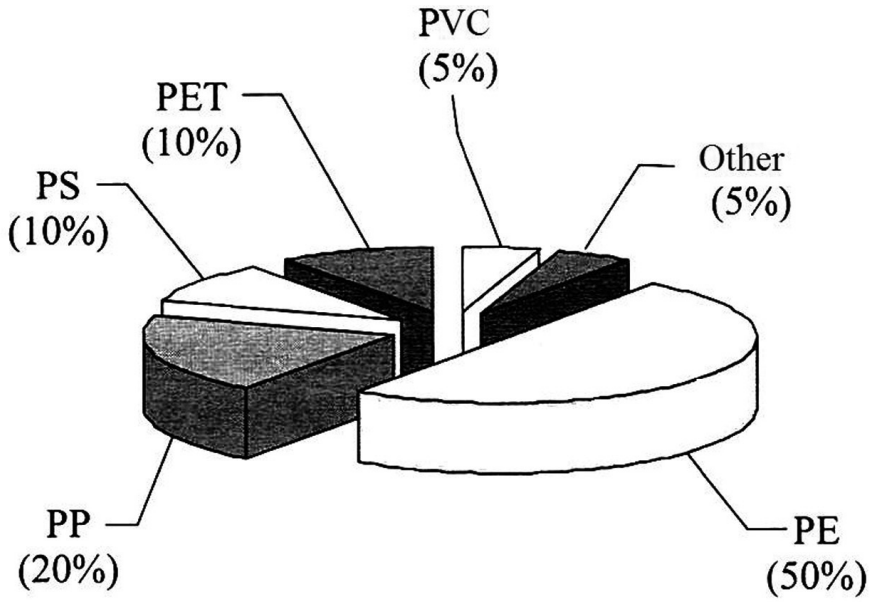

Fig. 3. Structure of waste plastics in Poland [1]

Rys. 3. Struktura produkcji tworzyw sztucznych w Polsce [1]

The establishment of technical possibilities of managing the contaminated mixtures of different sorts of currently non-recyclable plastics is the subject of this study.

2. General principles of waste plastics management

A characteristic feature of plastic waste is its large diversity and often a high level of other contaminants, which make their management difficult. Each type of material requires a different way of segregation, sorting and various disposal techniques.

The European law and Polish law require partial recycling of waste polymers. According to the Directive 94/62/EC recycling should be understood as repeated processing of waste conducted in production process directed on fabrication of product of original purpose or another. Currently, these are the most common methods of recycling [1]:

– utilization of waste plastic products,
– material recycling involving granulation of materials collected and their re-use,
– raw material recycling involving thermal or chemical decomposition of polymer waste, leading to the recovery of monomers or other valuable chemical raw materials,
– energy recycling based on the use of energy obtained in a process of combustion of waste plastics.

The development of various methods of artificial waste disposal in Europe in thousands of tons is shown in Fig. 4.

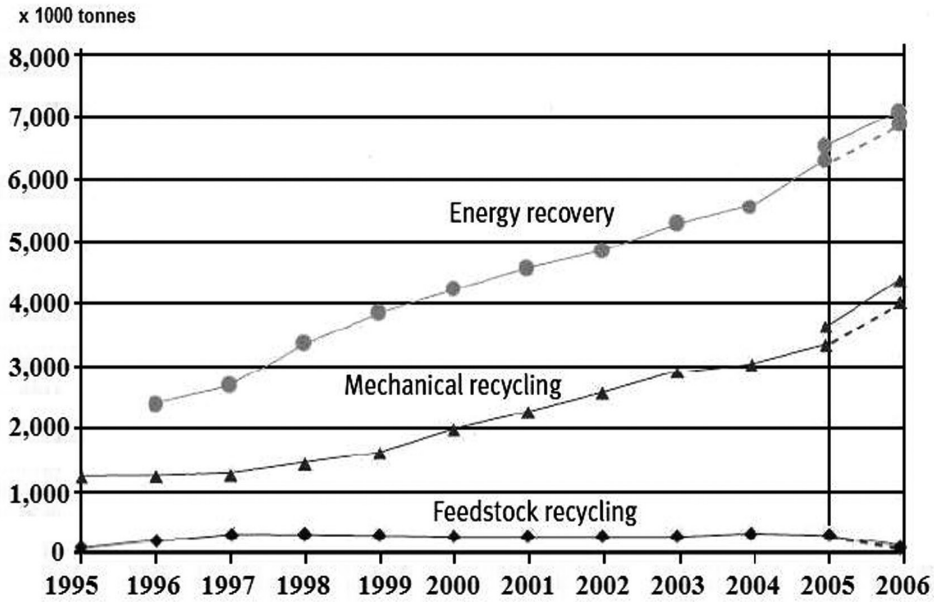

Fig. 4. Development of various methods of plastic waste disposal in thousands of tons [12]

Rys. 4. Zmiany metod usuwania odpadowych tworzyw sztucznych (w tys. ton) [12]

For the use of the above-mentioned form of recycling, skilful separation of specific plastics from the municipal waste stream flow is necessary. Sorting methods can be divided into [1]:

– mechanical – manual, detection, electrostatic, using differences in plastics density,
– chemical – selective dissolution, solvolysis, selective oxidation.

According to the data of PlasticsEurope Foundation in 2009, 20% of plastic wastes in Poland have undergone a process of recycling and energy recovery. The remaining 80% therefore got to a waste dump, where they will persist for several hundred years [9].

Industrial installations working in Poland for the regeneration of thermosoftening endofuse plastics require a specific, in respect of quality and purity, sort of raw material. Hence, the necessity arises for accurate sorting of raw materials transported from storage points, permanent increase in the amount of sorted, contaminated plastics deposited in landfills. Current methods of treating such waste, especially waste being a mixture of various types of materials containing a considerable amount of contaminants, which does not belong to thermosoftening plastics are: the process of pyrolysis and the combustion process combined with energy recovery [1, 6]. Unfortunately, thermal recycling has a lot of disadvantages. Most important is the environmental contamination caused by combustion products and high costs of combustion gases purification, sewage treatment and disposal of ashes. Unlike organic waste and scrap, plastic waste should not be treated as a renewable energy source, and its combustion should be extreme [7]. These wastes contain large amounts of valuable raw materials and should be used both for economic and ecological reasons.

3. Samples for research

Plastics waste accumulated in landfills is characterized by strong mixing of many types of plastics and a high level of different contaminants (soil, sand, dust, peat, stones, tar, ceramics, textiles, paper, oils, lubricants, fats, moisture, feeds, detergents, fertilizer, etc.). Wastes are diversified, they come in a wide range of shapes and sizes. They may be foils of various plastics, broken toys or household goods.

For a detailed analysis, random representative samples of waste were collected from landfills:

– in Kłaj (I),
– in Międzyrzecze (II)
– in Końskie (III).

The Results of qualitative and quantitative composition analysis are presented in Table 2.

It was assumed that the way of managing the plastic waste under consideration should be related to the direct use of raw materials accumulated on landfills, eliminating the detailed segregation, purifying and washing.

Table 2

Composition of analyzed waste (weight %) [6]

	Foil		Shapes		PS	PVC	PA	Rubber	Other plastics	Other components	
	PE	PP	PE	PP						flammable	non-flammable
I	8.06	9.24	14.72	19.38	6.29	19.64	3.31	0.2	2.92	1.11	15.13
II	13.4	–	–	–	1.40	19.30	–	0.1	4.90	60.9	–
III	20.2	–	23.17	13.4	1.82	5.45	–	–	1.13	3.01	31.80

PE – polyethylene, PP – polypropylene, PS – polystyrene, PVC – polyvinyl chloride, PA – polyamide

4. Technological concept of waste management

After the removal of metallic and large mineral contaminants (stones, parts of bricks) from the samples, their size was decreased (manually) and they were comminuted by cutter to 5 mm × 5 mm particles; in the case of foil the size was 15 mm × 15 mm. The method consists in comminution and heating (in feeding screw or screw extruding press without a die) to a higher temperature than the temperature of vitrification of thermoplastics present in the mixture. Next they are placed into a mould and subjected to compaction pressure not less than 7.85 MPa.

It is necessary to previously segregate plastics on landfills. At a segregation line manual work is unavoidable in order to remove fair-sized mineral contaminants and metals and segregate the raw material into moulders and foils. Afterwards the waste is comminuted and aggregated in an intermediate silo so that its composition would be averaged. In the next stages the waste is subjected to extrusion, portioning and ironing. During these processes a stream of generated gases is released. After the separation of undesired parts, ready products are packed.

Heat bending guarantees the drying of waste, its degassing and partial plastification. For this purpose it is proposed to use a large-diameter extruder screw with a head and die dismantled.

5. The properties of mouldings

During the tests chosen physicochemical properties were determined; these results are summarized in Table 3 [6]:

Table 3

Results of studies

Physicochemical properties	Examination according to standard	Value
Density of the material	PN-80/C-89035	1160 kg/m^3
Cold water absorbability	PN-81/C89032	ca. 1.22 mg/cm^2
Hardness	PN-68/C-89030	69.5–111.6 N/mm^2
Toughness	PN-81/C-89029	ca. 0.085 kJ/m^2

Also the effect of temperature on the received samples was analyzed and traversing test was attempted. The attempt consisted in drawing a wiper of received fittings and leaving it for 3 weeks in front of a building. Satisfactory strength profiles were found in the tested temperature range of −5°C to 60°C, and a minimum change of the surface was noticed after the test.

6. Conclusions

– The demand for plastic products is growing and therefore it is important to find ways to reapply the polymer material of products which ended their useful life.
– Plastic waste is one of the most difficult problems of solid waste.
– Existing European Union guidelines specifying the quantity of solid waste directed to waste dumps has not been met by Poland.
– Much of the solid waste is a valuable secondary raw material that can be used in the future. Plastics that can be subjected to multiple recycling are examples.
– The current state of the recycling process of waste plastics leads to a small quantity of recycled resource and material. Most plastics are subjected to heat recirculation or gasified.
– The alternative way of managing plastic waste, so far non-recyclable, has been proposed.
– This method allows the elimination of landfills, saving resources and protection of the natural environment. The presented method leads to a product that meets the criteria of utility based on the use of existing machinery and equipment.
– The following may be products obtained by processing: plates and fittings designed for building construction and for road and utilities, traffic cones and bars, plates and insulation fittings, fittings and pipes used in agriculture and land reclamation works, perforated plates and fittings for the strengthening of embankments, dunes, beaches, and also products of special applications, such as pots for flower beds, containers, etc.

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