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QUALITY MANAGEMENT AND ANALYSIS METHODS OF PROCESSING PLASTICS RECYCLING IN POLYMER

ZARZĄDZANIE JAKOŚCIĄ I ANALIZA METOD RECYKLINGU W PRZETWÓRSTWIE TWORZYW POLIMEROWYCH

Abstract: The paper presents the method of recycling and quality management in the recycling process of polymeric materials. Recycling of mixed polymer materials is one of the most complex processes in manufacturing. It is important to be able to manufacture the materials of the secondary properties of an acceptable degree of mixed polymer waste. In this way have been eliminated long and costly separation processes. Properties of such materials are polymers which are disadvantageous because constitute them - mainly PE, PP, PS, PVC, PET etc. - are incompatible and form a multi-component system in which the individual phases do not exhibit significant adhesion. In addition, other materials present different types - paper, metals, dyes - act as contaminants and contribute to the further deterioration of mechanical properties. In almost all cases, the properties of the mixture are worse than the properties of the individual components. If you need to produce products that must meet high requirements for mechanical properties is not the possibility of using recycled material. They are used so other methods of recycling as raw materials and energy, including parolysis method, hydrocracking and gasification. Management quality now plays an increasingly important role in the recycling of plastics. The quality of the production becomes an important element of competition, which increasingly can decide the success of the recycling industries.

Keywords: recycling, polymeric materials, quality management

Introduction

Recycling involves reprocessing of substances or materials contained in waste, in the manufacturing process in order to obtain a substance or material for the original purpose or for other purposes. The aim of recycling is to:

- protection of natural resources - the use of recycled materials reduces the use of raw materials and shortage of stocks of natural resources,
- environment - raw material extraction and processing of consumer goods is a constant related to the load and environmental degradation; this means that the protection of natural resources is also the environmental,
- energy saving - are recyclable energy sources, their use leads to energy conservation as long as the energy input to the recovery is less than the energy that they entail, and which can be obtained through them. Saving energy is therefore also environmental protection.

The operating principle of recycling is to maximize the re-use of the same materials, including the minimization of expenditures to be processed, which are protected natural resources, which are used to produce them and the raw materials used for further processing.

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Recycling takes place in two areas: production of goods and the subsequent formation of these wastes. Assumptions recycling assume the forced attitudes goods manufacturers, favoring the production of the most recyclable and creating the appropriate behavior of the recipients of these goods.

Recycling is a system organization of circuit materials that can be repeatedly processed (Fig. 1).

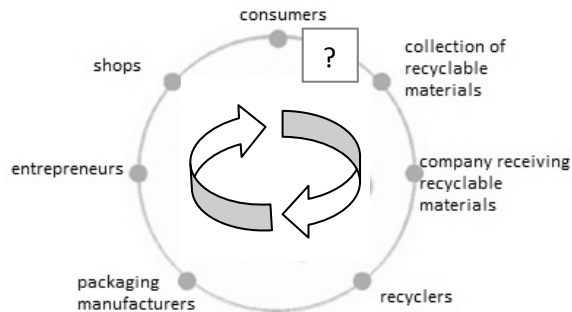


Fig. 1. Circuit materials in the environment

The system consists of the following elements:

- appropriate state legislative policy favoring recycling,
- waste treatment technology development, primarily in order to use most of their parts,
- designing goods with the widest possible use of these recyclable materials,
- design of homogeneous material and goods as possible, simplifying their subsequent dismantling and waste segregation,
- design property of a combination of different materials in such a way that the subsequent separation of the components consist of homogeneous materials could be easier,
- design goods in such a way to make the most of its components be suitable for re-use without treatment or with minimal to bring to a complete,
- system for determining both the product packaging and components of these products, in order to facilitate the recognition and segregation of waste,
- ecological education of society and to promote environmentally friendly behavior and organization,
- logistics sorting, collection and collection of used goods and their components,
- processing (previously prepared) of waste and the recovery of raw materials [1, 2].

Polymeric materials are characterized by a huge diversity in terms of chemical structure and composition and formulation. Therefore, recycling of polymeric materials has a number of limitations. A huge role in the recycling process plays a quality management. It determines the ratio of the recycling industries and its staff, for carrying out activities. In readable illustrates the quality policy objectives and the company's management, helps in the implementation of the quality management system.

All the planned and systematic and, if necessary, proven activities implemented within the quality system, are used to excite the sound of confidence as to the object (product, service) meet the quality requirements. There is always action to ensure the quality are properly organized. Quality management requires, document and maintain a quality system [3].

Documentation and quality assurance system

In the case of recycling companies, a very important element of the quality management system are documentation that confirms compliance of the recycling process.

The raw material in the manufacture of polymeric materials and any additives to be used as long as it can be reasonably justify. Production processes should also use renewable raw materials, avoid toxic substances.

In stark much better to prevent the formation of waste rather than dispose them. Quality assurance system implemented by the recycler must in an appropriate manner to ensure compliance with the requirements contained in permits for the processing of plastics in the recycling process. All the elements, requirements and provisions adopted by the recycler quality assurance system must be documented in a systematic manner and orderly manner in the form of written documents statements and procedures.

The quality system documents must permit a consistent interpretation of the quality policy and procedures such as quality programs, plans, manuals, records and measures to ensure traceability.

The documentation consists of the following elements:

- quality policy manual, containing a clear definition of quality goals of the recycler, the organization of the company, in particular the organizational structures, the responsibilities of the managerial staff and their organizational authority for plastics recycled;
- quality control plans, including plans for the characteristics of the raw material and plastic recycled, qualification of suppliers, sorting processes, washing, deep cleaning processes, processes or any other part of the process relevant for the quality of plastics recycled, including the identification of critical points quality control plastics recycled;
- management and operational procedures used to monitor and control the whole recycling process, including the inspection and quality assurance techniques at all stages of the manufacturing process, in particular the establishment of critical limits at critical points for quality plastics recycled;
- methods of monitoring the efficient operation of the quality system, in particular its ability for plastic production the recycling of appropriate quality, including checks of products satisfying the requirements;
- records of tests and analyzes or other scientific evidence applied before, during and after the production of plastics recycled, the frequency of testing and the test equipment used; in an appropriate range must be possible to trace back the calibration of the test equipment;
- recording documents adopted [4].

Key issues related to quality management in the recycling of plastics concern:

- Transport - special attention should be paid to the way of organizing collection system, the time between order receipt and acceptance of waste. It is also important if there is an agreement of carriers, ensuring sustainable transport, and what type of transport containers will be used.
- Raw materials - is of great importance is how much of the raw material is recovered, and how much of them goes to the landfill.
- Hazardous substances - it is necessary to know the different types of recipients of hazardous waste and to check whether they have a permit for disposal of hazardous substances.
- Environmental management system - is of great importance is whether the company has a recycling environmental policy and observes it, what are its environmental goals, and if it works on the basis of an environmental management system.
- Quality system - make sure the company has a policy of recycling and observes its quality and whether it operates in accordance with a certified quality management system [4].

By the quality of the materials by mechanical devices meant primarily getting better adapt the products to the requirements and expectations of customers.

The introduction of a quality management system will draw attention not only to control the quality of products, but also to monitor and correct operation of the quality management system, customer service personnel, identifying requirements for raw materials, standardization and statistical process control, enabling impact on the article already during its manufacture.

Methods for recycling of plastics

Currently in Poland, most going to landfill becoming better organized and secured. This natural degradation of waste is indeed the simplest method to eliminate them, but at least economically, socially, and unacceptably large spaces dedicated landfills. Also keep in mind that due to the need to fulfill the recommendations and EU directives such a solution becomes legally unacceptable for many categories of waste (including polymer). The only way to dispose of waste landfilled is to recover a small portion of the energy by collecting and burning biogas generated in landfills.

There may be hope of composting biodegradable plastics, the production and use is currently at a very low level.

Material recycling

Material recycling, is the repeated, direct processing of waste without the use of chemical processes. This method can be used both in the case of thermoplastics (polyolefins, polyamides, polystyrene, polycarbonate, polymethylmethacrylate, polyester) and thermosetting plastics (*eg* polyester and epoxy resins) [1, 5, 6].

Waste water treatment is the process to obtain the material for re-processing. This is the most rational way of polymeric waste as it allows reduction of the production of polymers original. This allows you to reduce the emission of harmful substances into the

environment and energy necessary to produce new polymers. This method, however, is economically viable only for a certain group of polymers, and in the case of waste sorted well and uncontaminated [1, 5].

Methods belonging to this type allow for the recovery of recyclable waste plastics pure fractions nutritious polymers suitable for re-processing. The resulting product is called recycle, or regenerated regranulate. Properties of regranulate are generally worse than the material from which it was made [6]. Frequently regranulate is also 2-3 times more expensive than a new raw material (the cost of waste sorting, preparation for recycling and the same alteration). However, it is now quite common to use recycled material in the automotive industry.

In the next stages are prepared in connection with the deterioration of the properties of the recycled material getting "worse" elements, *eg* material of the bumpers is made into rugs (recycling or secondary two cyclic). Founded in Poland PRO PVC Consortium Initiative estimates that in the near future will evolve dynamically recycling material polyvinyl chloride (PVC), whose production from year to year increases, and PVC recyclate is very satisfactory properties. Unfortunately, because of the price and satisfactory property other recyclates in the world, only 7% of plastics can be recycled as material [5].

Feedstock recycling

Degradation of polymers into fractions of lower molecular weight in order to recover monomers (oligomers), the recycling of raw material (chemical), although potentially beneficial, is not only very expensive. Research on processes such as pyrolysis, hydrolysis and hydrogenation will perhaps in the future to build cost-effective, working on large-scale installations using waste plastic. This process focuses on plastics such as PET and polyurethanes [1, 5].

Recycling energy

The methods rely on the burning of plastics and conversion of chemical energy into heat or electricity or destructive conversion polymers of low molecular weight compounds in the pyrolysis process, hydrocracking or partial oxidation, used as a fuel or chemical feedstock. Utilizes the world in this way 16% of the waste plastics. The energy recycling involves hopes for processing the waste, which can not be described earlier methods such as recycling. Municipal waste, which are a mixture of very different materials highly contaminated. All these processes are carried out mostly in the refining plant and waste are in addition to conventional refinery feedstock (*eg* Heavier fractions of crude oil). Products are fuels, oils and raw materials of organic synthesis [5].

Pyrolysis

There are many methods for the pyrolysis of waste polymer materials. These include processes in the engine's gas-solid, liquid-solid, and the vacuum pyrolysis [7].

In previously known pyrolysis techniques used boilers, autoclaves, ovens, rotary screw systems and fluidized beds [7, 8]. The process is versatile and he can be subjected to plastic mixture after proper grinding without preliminary separation. Perm is the presence of PVC to 2%. If larger quantities hydrocarbon fractions contain traces of organochlorine

compounds. The formation of these compounds can be avoided by the addition of calcium oxide to bind the hydrogen chloride evolved. The resulting calcium chloride causes movement problems, however, resulting from the lumps of solid fraction part of the fluidized. It is therefore better additive ammonia, which allows the binding of hydrogen chloride, ammonium chloride.

In the case where the pyrolysis of waste is located within the refinery, is already at capacity of 40 thousands Mg/year of economic indicators are very favorable [9].

Gasification

Gasification of waste plastics is partial oxidation therein at a temperature of the organic components 1350-1600°C under a pressure of 15 MPa. As the oxidizing agent, oxygen is used most often in admixture with steam.

The resulting gas (after removal of water and carbon dioxide) mainly composed of carbon monoxide and hydrogen, and the solid residue is elemental carbon and inorganic material gasified components (fillers, impurities). In the process without the formation of liquid products. In this process, however, should be taken into account specification of the processed materials (plasticity, degree) and the purpose of the resulting product gas (fuel gas, synthesis gas). The tested in a pilot-scale technical solutions are first waste heat plasticization (melted), preferably such. Mixture with pus or heavy residues and coal tar liquid introduced into the reactor. Gasification can be subjected to all kinds of waste plastics (both thermoplastic and thermosetting) and rubber [9].

Despite many objections, it is estimated that recycling of energy in the future will be the primary form of exploitation of waste plastics. It is anticipated that in Western Europe in the coming years will be processed 50% of plastic waste, especially those fractions which could not be profitably used in a different way [1].

Discussion

The design of the recycling process (Fig. 2) of different products, in addition to the ecological principles of production, should include all phases of the life of these products until after their removal and reprocessing according to the following scheme. This procedure is already beginning to be seen in the automotive industry, at which time the disassembly of any part or parts plays a very big role. Also implemented in the electronics industry many trials of new technologies, of the future of the recycling process. One example pro-recycling approach is the design and production of beverage bottles [9].

As shown by the experience of the many reasons you can not opt out of the packaging of polymeric. Transport for example. Beverages in packages of polymeric materials is cheaper than bottled. Reducing consumption of plastics can be achieved by the use wherever possible of reusable packaging, as well as by improving the properties of polymer materials, allowing for example. Material weight reduction necessary to obtain a product that meets users by limiting their use, re-processing of waste packaging and the use of biodegradable packaging [1].

Management quality now plays an increasingly important role in the recycling of plastics. The whole process includes:

- planning,
 - organization,
 - motivating,
 - control,
- all activities relating to the shape and maintaining its quality standards.

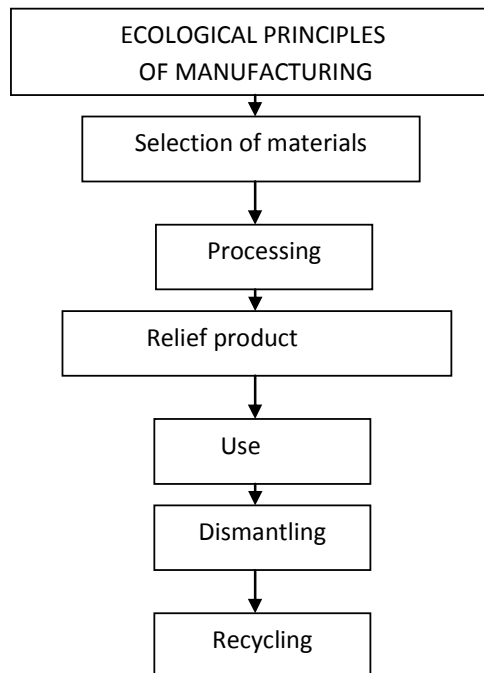


Fig. 2. Designing the recycling process [9]

Before the plant will proceed to the efforts to start recycling line is necessary to pay special attention to:

- used for the disposal of packaging waste technologies adapted to local conditions and take into account the available infrastructure, the number and range of waste, continuity of supply, as well as size of the market and its absorbency products from recycled materials,
- range of knowledge in the field of chemistry and physics,
- to enable better use of the waste material,
- knowledge of the basic characteristics of the material - it allows work on the modification of the properties of plastic waste to improve its quality. Proper selection of compositions - often contain additives specifically designed for recycling, fillers and modifiers,

- allows for the processing of secondary materials with high yield, good quality products at the same time,
- the market value of the waste - it results mainly from the evaluation of their quality - for a potential recipient is essential quality product which can be obtained from recycled material, and which can be difficult waste processing using standard methods of recycling.

Quality in manufacturing and services is becoming an important part of the competition, which increasingly can determine the success of the recycling industries. Quality management often treated as an action that leads to increased production costs. Improving quality involves the introduction of new technologies, production processes, more expensive materials. Bringing recycling company to the relevant standards is only possible by the improved quality of services and manufactured products.

Conclusions

The different ways of working of plastics recycling, resulting the benefits and limitations show that there is no one universal and optimal in terms of economic data strategy for dealing with waste management of plastics.

When selecting the optimal solution, depending on the type of material and extent of contamination, must take into account several different, non-exclusive solution.

Please be aware that recycling is a process that should be planned years in advance, paying particular attention to the quality management system.

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Abstrakt: W pracy przedstawiono metody recyklingu oraz możliwości zarządzania jakością w procesie recyklingu materiałów polimerowych. Recykling zużytych mieszanych tworzyw polimerowych jest jednym z bardziej skomplikowanych procesów w przetwórstwie. Istotna jest możliwość wytwarzania materiałów wtórnych o dających się zaakceptować właściwościach ze zużytych mieszanych polimerów. Wyeliminowane zostałyby w ten sposób długotrwałe i kosztowne procesy segregacji, które obecnie oparte są na wstępnej segregacji przez konsumenta oraz na następujących po niej ręcznych lub automatycznych procesach wykonywanych przez zakład odzyskujący tworzywa. Właściwości takich materiałów są niekorzystne, ponieważ polimery, które się na nie składają - głównie PE, PP, PS, PVC, PET itd. - są niekompatybilne i tworzą układ wieloskładnikowy, w którym poszczególne fazy nie wykazują znaczącej adhezji. Ponadto obecne inne materiały różnych typów - papier, metale, barwniki - działają jak zanieczyszczenia i przyczyniają się do dalszego pogorszenia właściwości mechanicznych. W prawie wszystkich przypadkach właściwości mieszaniny są gorsze od właściwości poszczególnych składników. W przypadku konieczności wytwarzania produktów, które muszą spełniać wysokie wymagania co do właściwości mechanicznych, nie ma wówczas możliwości zastosowania recyklingu materiałowego. Stosowane są więc też inne metody recyklingu, jak: surowcowa i energetyczna, w tym metoda pirolizy, hydrokrakingu i zgazowania. Zarządzanie jakością odgrywa obecnie coraz bardziej znaczącą rolę w procesie recyklingu tworzyw polimerowych. Jakość w produkcji staje się ważnym elementem konkurencji, który w dużym stopniu może decydować o sukcesie przedsiębiorstw zajmujących się recyklingiem.

Słowa kluczowe: recykling, materiały polimerowe, zarządzanie jakością

