

INDUSTRIAL PACKAGING MANAGEMENT IN THE CIRCULAR ECONOMY MODEL

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Abstract

Introducing circular economy principles into a company's packaging management is one possible way to reduce the environmental impact of excessive use of packaging materials in industry, but also an opportunity to reduce the costs associated with packaging logistics. The aim of this paper is to identify the main opportunities and barriers for the management of industrial packaging according to the circular economy model based on qualitative research in a selected company in the chemical industry. The research was conducted through in-depth interviews with four managers of the company who are involved in the packaging management of the selected company. The research results provide examples of good practice while highlighting the main issues related to industrial packaging management in the areas of: sustainable material design, material savings, packaging reuse and packaging waste recycling.

Introduction

Circular packaging is a relatively new concept that has attracted a lot of attention in the literature in recent years¹. The use of excessive amounts of packaging from non-renewable raw materials for single-use purposes further damages and disrupts the environmental balance². To avoid this, businesses' approach to packaging must change³. Packaging must meet specific environmental protection requirements throughout its entire life cycle, from production to consumption. Introducing circular economy principles into packaging management is one of the keyways to meet these objectives.

The circular economy and its principles raise concerns about environmental impacts right from product design. They lead to the design of environmentally friendly supply chains, enabling both the production of environmentally friendly products and, above all, their reuse¹. The circular economy model is applied in the packaging management environment to create reusable packaging and close material flows through packaging return flows and material recycling. Desirable activities in industrial packaging supply chains include⁴:

- sustainable material design,
- material savings,
- packaging reuse and
- packaging waste recycling.

The first activity mentioned above is related to the search for suitable packaging material. Currently, the most used material in packaging is plastic. This is considered to be a negative phenomenon, especially in view of the consumption of oil and natural gas in its production⁵. But according to Callari⁶, plastic is a versatile and efficient material. However, its benefits can only be fully exploited if its environmental disposal at the end of its life cycle is properly handled. The combination of different materials in the production of packaging (so-called composite packaging) also creates problems due to complications in recycling processes. Moving towards sustainable packaging materials, which are usually considered to be materials derived from renewable sources (e.g. wood, paper, textiles, biodegradable materials)⁴, seems to be an appropriate solution to both problems. According to the companies, barriers to switching to sustainable packaging materials include higher acquisition costs, lack of certified packaging materials on the market and poorer conditions for processing them in production⁷.

Another way towards sustainable packaging is to reduce the amount of packaging material used. Businesses are trying to reduce material, in particular by designing thinner and lighter packaging or reducing the number of primary and secondary packaging. However, according to Hellström and Olsson⁸, too much reduction in the material used leads to compromising the correct performance of packaging functions and product losses. Larger packaging sizes, on the other hand, can help optimise transport and storage in the supply chain⁹. Davis and Song¹⁰ recommend reducing the number of levels of packaging due to contamination and mixing of different types of materials, which makes subsequent recycling of the packaging impossible. Beitzel-Heineke et al.¹¹ also see the packaging-free selling phenomenon as another route to material savings. In industrial markets, this could take

the form of pumping liquid or gaseous products into the customer's own vessels or equipment, or transporting the products directly to the customer's plant via pipelines.

Circular economy principles can also be implemented through reusable packaging, either immediately or after simple treatment¹². According to Mahmoudi and Parviziomran¹³, this approach brings a number of benefits in the packaging industry. It reduces the demand for primary raw materials, saves costs for production and disposal of packaging, due to the smaller quantities of packaging. Returnable packaging is also generally stronger and of higher quality, so there is less likelihood of packaging failure, for example by rupture. However, the introduction of reusable packaging is associated with higher capital expenditure, higher costs for the implementation of return flows and higher business process management requirements¹⁴. However, research by Skerlic and Muha¹⁵, which compared the life cycle costs of disposable and reusable packaging, shows that reusable packaging tends to be a more cost-effective option overall from the business economics perspective.

When packaging is at the end of its life cycle and can no longer be used, it is recycled. This can be done with material or energy recovery of the waste¹⁶. Mechanical recycling is the transformation of a recycled material into a new product without changing the chemical structure of the material. Chemical recycling is based on the breaking down of recycled material into starting materials or the extraction of chemical and petrochemical feedstock that can then be reused to produce new products. Energy recovery is understood as the environmentally acceptable incineration of waste using the heat generated in the process. However, incineration should not be the primary method of recycling and only packaging that can no longer be used as secondary raw materials should be incinerated.

Introducing circular economy principles into the packaging economy is a key tool for innovation towards sustainable packaging¹. Circular packaging innovations and their barriers largely depend on the type of the industry. Since these innovations for chemical industry are not sufficiently reflected in the literature, the aim of the paper is to identify main opportunities and barriers for the management of industrial packaging according to the circular economy model, based on primary research.

Research methods

The research was organized as a qualitative study in a selected company in the chemical industry. The data collection was based on personal interviews of five respondents from among the employees of the company according to a semi-structured questionnaire in order to identify:

- the types of packaging and packaging materials used in the enterprise,
- the packaging and packaging waste streams in the enterprise,
- opportunities and barriers to the introduction of packaging eco-innovation in the areas: sustainable material design, material savings, packaging reuse and packaging waste recycling.

Respondents were interviewed through individual interviews lasting 1-2 hours. In case of any ambiguities and the need for additional information, follow-up interviews with respondents were carried out. The interviewees were: the company's production manager, the head of the company's waste and pallet management department, a representative of the company's purchasing department and two representatives of the sales department. The data was processed by content analysis of the interviews and subsequent synthesis of the findings.

Selected for the research was a company in the chemical industry with a tradition in plastics processing of more than 80 years. The company is part of a larger concern and is one of the world's major processors of plastics such as PVC, PE and PET. The company offers high-end products and specialised customer solutions that include not only production but also development activities and consulting services. It sells its products to 49 countries worldwide and in 2021 generated revenues of CZK 4.3 billion for its products and services. It is thus an integral part of the global plastics industry.

The company has implemented an integrated quality, environmental and safety management system through ČSN EN ISO 9001, ČSN EN ISO 14001 standards and the "Safe Enterprise" programme. As part of its environmental care, the company has invested over CZK 160 million in direct environmental protection over the last ten years. It has reduced emissions of volatile organic compounds by 90% compared to the early 1990s. The company's strategy is also to focus on purchasing environmentally friendly technologies, focusing on new materials and finding new ways to use plastics. Thanks to new technologies and production optimisation, the company is continuously reducing its consumption of water and all types of energy. The environmental impact indicators in relation to the quantity of production are also on a downward trend.

Results and Discussion

Packaging used, packaging materials and their flows in the company

The company uses primary packaging, secondary packaging, tertiary packaging and other auxiliary packaging materials for packaging products. Primary and secondary packaging consists of cardboard boxes, paper tubes, plastic bags, big bags and plastic bags. This is packaging made from a single material. However, in order to increase the quality protection of the product, it was necessary to introduce a new composite packaging, namely a paper tube with a foamed PE coating. The tertiary packaging used are octabins (large paper boxes), EURO pallets, paper and wooden atypical pallets, KTP packaging (metal pallet containers), metal cages, carriages and ASP pallets. The company uses two sizes of cages depending on whether they are used for packing smaller or larger rolls of coiled product. The cages can also be further adjusted to the dimensions of the product in order to maximise the use of the packaging space and at the same time achieve maximum stabilisation of the product in the packaging. The auxiliary packaging material consists of cardboard cuttings, honeycomb boards and pressed cardboard edges. They provide additional protection against product crushing during storage and transport. The inserts and labels serve an informative function. Binding tapes, stretch films and clips are used to stabilise products on the pallet.

Primary and secondary packaging and octabins are disposable, however, clean LDPE and PP packaging waste is collected for recycling through a system of collection depots. The EURO pallets are not returned to the company, but the customer has the option to continue using the pallet thanks to its standardised dimensions. Packaging of atypical dimensions, KTP packaging and metal cages are returnable packaging. Carriages and ASP pallets are packaging used for internal purposes only. Auxiliary packaging material is used on a one-off basis within the company.

Most of the packaging in which purchased raw materials are packaged can be reused in the packaging management of the company in accordance with the principles of the circular economy. These are mainly pallets (tertiary packaging of products) and big bags (handling and transport of products within the company). The contaminated packaging waste is sold to a recycling organisation, which then decides on further processing.

Pure LDPE and PP packaging waste (both purchased and recovered) is recycled on the company's own recycling line. In order to make greater use of the recycling line, the company also buys clean LDPE and PP packaging waste from other companies. The regranulate obtained from recycling is then sold or processed in the production of injection moulded products from the recycled material.

A detailed diagram of the flows of packaging, packaging materials and packaging waste through the company is shown in Figure 1.

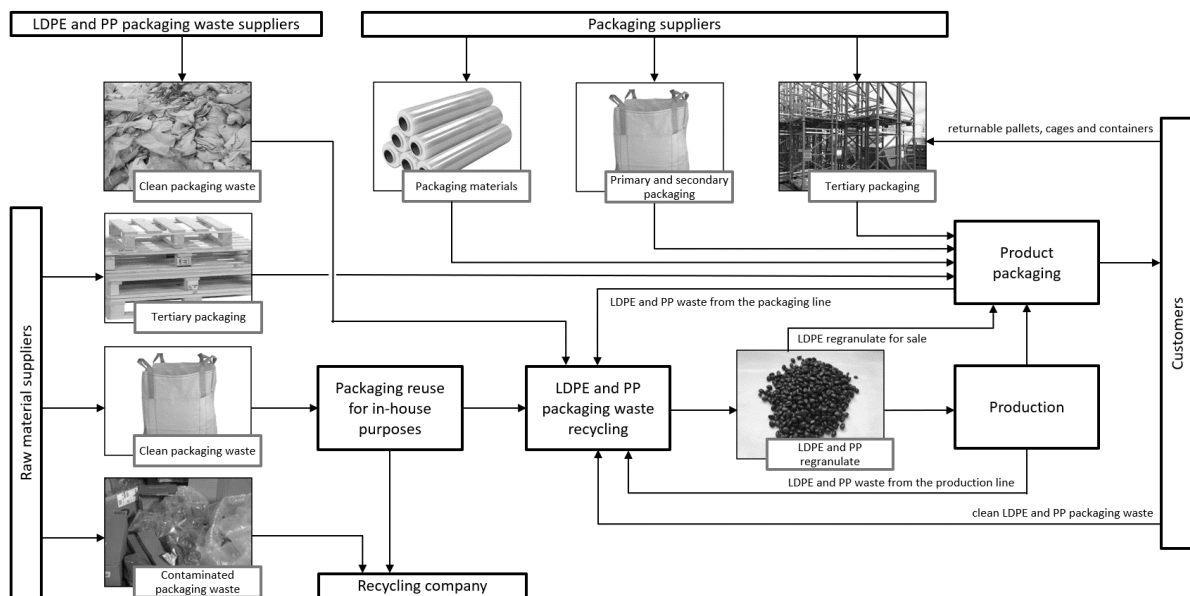


Figure 1. Diagram of packaging flows in the company.

Opportunities and barriers for eco-innovative packaging in sustainable material design

The choice of specific packaging and packaging materials is mainly influenced by customer requirements. Some customers require the use of FSC-certified paper packaging. Special paper pallets are required for the transport of some products, which the company must assemble from components purchased from certified suppliers (recommended by the customer). Customers also often require the use of packaging made from recycled materials (with at least 70 % recycled content).

As part of the introduction of circular economy principles, a company could in the future introduce the use of recycled or sustainably certified packaging for all its products. However, for industrial products, the introduction of sustainable packaging is difficult according to respondents. The main reason is the obligation for the packaging supplier to certify the proportion of recycled material contained in the packaging, which constitutes a significant increase in administrative costs. If only a negligible percentage of customers demand recycled packaging, such investments are usually not economically worthwhile for the supplier. In contrast to similar findings from research in Swedish manufacturing companies⁷, a further barrier to the introduction of sustainable packaging materials was identified, namely the lack of certified suppliers in the market, which also results in longer transport distances between the company and packaging suppliers, and thus a greater environmental burden of transporting empty packaging to the company.

Opportunities and barriers to the introduction of eco-innovative packaging in material savings

In 2001, the company upgraded most of its packaging to meet the requirements of the new legislation¹⁷. They therefore choose packaging for their products in such a way that the packaging is not unnecessarily large and bulky and does not contain unnecessarily large amounts of packaging material.

To this end, the company often tests the possibilities of using thinner films and paper materials. However, it often encounters the increasing risk of packaging damage during packaging, storage, handling or transport described by Hellström and Olsson⁸, which results in an increase in material consumption due to the need to repackage the product. The same problem arises when welding bags. When using bags made of higher quality materials, there is less scrap in the welding and packaging of the products, therefore the consumption of higher quality material is again lower than the consumption of lower quality material.

Attitudes towards changes in the packaging system of products that are first packed in bags and then in boxes vary among the respondents. Some respondents agree with Davis and Song¹⁰, who recommend reducing the number of packaging levels as an appropriate way to save the amount of packaging material used. However, this is contradicted by another respondent who believes that there will be frequent product destruction through scratching if the primary packaging layer (bags) is dropped. However, the risk of scratching has not yet been tested or confirmed in the company.

As part of the reduction of packaging material, the company innovated the packaging of the protective non-slip film used for kitchen units. Previously, these were wrapped in several layers of stretch film to hold the shape and attach the product information insert. Since 2008, the product has been packaged automatically in only one layer of film, under which the insert is loosely inserted and held by the end of the product.

The company is planning another change for the packaging of another product. The idea is to optimise the size of the handling unit when using paper pallets, which are more variable in their dimensions. Thanks to the more efficient use of the truck, the company will then transport 528 more items in one vehicle than before, thus saving on transport costs and the carbon footprint of the product when it is transported to the customer. A comparison of the original and new packaging methods is shown in Table I.

Table I
Comparison of original and new packaging

Characteristics	Original packing method	New packaging method
Pallet area	0.672 m ²	0.757 m ²
Number of products per pallet area	44 pcs/m ²	47 pcs/m ²
Number of products per column	60 pcs	108 pcs
Total number of products in the truck	2280 pcs	2808 pcs
Percentage of truck utilisation	56.00 %	64.75 %

Barriers to the introduction of similar packaging innovations for other products lie primarily in the weight limitations of the truck load, the shape and stability of the products when stacked, and the small number of products purchased by the customer.

Packaging-free selling is another way to reduce packaging. The company transports selected raw materials (PVC and CaCO₃) to the plant in tankers or RAJ wagons, but excludes the use of this distribution method for its own products. The company sees the risk of non-compliance with the required product quality (deformation, scratching, soiling or contamination of the product) as a barrier. It would also make it more difficult to handle the product in the supply chain.

Opportunities and barriers to eco-innovation in packaging reuse

The company operates several take-back systems for reusable tertiary packaging, depending on the type of packaging and the customer. No third party is involved in these systems, so the packaging take-back system is not outsourced and the returnable packaging is either owned by the company at all times or sold together with the products to customers. The company encourages customers to reuse tertiary packaging, in particular by ensuring that the packaging is taken back at the company's expense (using the empty means of transport used to deliver the products to customers).

The most common barrier to the reuse of tertiary packaging is the long transport distance between the company and the customer, and thus the greater environmental burden of reverse packaging logistics. For this reason, it seems more appropriate to use standardised packaging (e.g. EURO pallets) which do not need to be returned to the companies, as they continue to be used for the same purpose by customers all over Europe.

Opportunities and barriers to eco-innovation in packaging waste recycling

The final area of industrial packaging management in the circular economy concept is the recycling of packaging waste. For the enterprise under study, it proved beneficial to acquire its own recycling line for processing plastic waste. The company can produce regranulate from clean LDPE and PP waste, which it sells on or uses in the production of injection moulded products. At the same time, it buys disposable LDPE and PP packaging from its customers and from other companies in the area, thus contributing to the development of the circular economy not only in the management of its own packaging but also in the management of packaging in other manufacturing companies.

In order to maximise the use of the recycling line, the company also offers a recycling service where the customer brings their own waste materials from which the company produces regranulate. The customer then pays the company for the recycling and then processes the regranulate himself on his own injection moulding line. These services are mainly used by companies in the immediate vicinity of the plant, as the service would not be economically or environmentally viable if the waste material were brought in from further afield.

The processing of packaging waste in the company is limited by its cleanliness, as the company does not own a washing line for this waste. The introduction of an on-site waste washing plant is particularly hampered by legislative barriers (the plant is located in a groundwater protection zone). Using the services of an external line would increase the costs and environmental impacts associated with transporting the packaging waste material to and from the external company.

The possibility to use the services of recycling organisations is also important for the company. They can recycle packaging waste that the company cannot recycle itself (other single-sort and composite packaging). However, respondents agree with the literature⁴ that packaging recycling is only undertaken when the packaging is at the end of its life cycle and cannot be reused (even for internal purposes).

Conclusion

Based on the results of the primary research and their comparison with the literature, opportunities and barriers to the introduction of circular economy principles into the packaging management of manufacturing companies in the chemical industry were identified (see Table II).

Table II

Opportunities and barriers for the management of industrial packaging according to the circular economy model

Opportunities	Barriers
Discarding composite packaging	Lower product protection
Greater use of local packaging suppliers	Limited (or non-existent) supply of packaging
Use of sustainably certified packaging	Lack of certified suppliers Long transport distance from certified suppliers Higher cost of packaging

Automation of packaging to save packaging material	High capital expenditure
Optimising the amount of packaging material used	Ensuring sufficient product protection Customer requirements for packaging design Costly change in packaging process
Optimising the size of handling units and filling of transport vehicles	Use of non-standardised packaging Permissible total weight of means of transport Costly change in packaging process
Using fewer packaging levels	Risk of product damage Costly change in packaging process
Packaging-free selling	Physical and mechanical properties of products Risk of product contamination Difficulty in handling the product across the supply chain
Use of standardised pallets	Limited pallet dimensions
Use of returnable tertiary packaging	Transport distance between the company and its customers Organisation of transport operations
Reuse of disposable packaging	Risk of packaging failure
Acquisition of a recycling line	High capital expenditure Possibilities of processing recycle in production Limited possibility to sell recycle to external customer

The above opportunities for increasing the sustainability of packaging can represent significant benefits, from the perspective of a single company. Further improvements can be made if the company starts to work closely with its supply chain partners in this regard. A coordinated effort based on circular economy and supply chain management principles can represent a truly radical shift towards sustainable packaging as well as other logistics activities.

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