

PAPER • OPEN ACCESS

An Analysis of Performance Factors Evaluation of Reusable/Returnable Packaging

To cite this article: B Smoljan *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **916** 012107

View the [article online](#) for updates and enhancements.

You may also like

- [A Two-period Game Theory Model in Subsidizing the Electric Vehicle Supply Chain with Used Electric Vehicle Batteries Remanufacturing Process](#)
Xiaoyu Gu, Hongfu Huang and Yixuan Song
- [Machine Learning-Assisted Multi-Objective Optimization of Battery Manufacturing from Synthetic Data Generated by Physics-Based Simulations](#)
Marc Duquesnoy, Chaoyue Liu, Diana Zapata Dominguez et al.
- [Manufacturing of Natural Fiber-Reinforced Recycled Polymer—a Systematic Literature Review](#)
Sandy Sidik Wisnu Kusuma, Holam Cahya Saputra and Indah Widiastuti



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

An Analysis of Performance Factors Evaluation of Reusable/Returnable Packaging

B Smoljan¹, K Hajdek¹, B Šarkanj¹ and J Bogunović²

¹University North, Department of Packaging, Recycling and Environmental Protection, Trg dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia

²PIK D.D. RIJEKA, Krešimirova 26, 51000 Rijeka, Croatia

E-mail: bozo.smoljan@gmail.com

Abstract. Development and application of reusable industrial packages, which can be used in assembly line has been investigated. The reusable industrial packages are often called reusable crates and totes or reusable/returnable packaging containers. The trend of development of reusable packaging systems has been facilitated by the plastics industry developing lightweight rugged crates and totes, which can be used in storages and manufacturing lines. Sizes range of these kind packages is from handled totes to pallet-load sized intermediate bulk containers for manufacturing.

Possibility that each component reaches the manufacture at the right time, in the right sequence, and in the appropriate version, referred as Just-In-Sequence was analysed. An automotive supply chain characteristics and scheme of component suppliers' structure in Just-In-Sequence way was illustrated. Materials properties of reusable packaging was studied. The most important packaging performance factors are durability, flammability, sanitation and ergonomics of packaging, which affect the cost, and operations of a reusable packaging system. Since the importance of industrial reusable packaging is growing up, the new sophisticated test method for transport packages are needed by which vulnerabilities and exposures in the application of reusable industrial containers will be taken into account.

1. Introduction

One of the very interesting trends in packaging branch is the permanent increasing of application of reusable packaging, i.e., reusable crates, totes and containers, which can be used in assembly lines. Reusable packaging has become a focal point of manufacturing supply chains in industry [1,2]. Automobile manufacturer must plane the supply at few thousand sub-assemblies and components in vehicle, with billions of possible combinations to car outfit. One of the trends in the automotive production is standardisation of modules of construction to common platforms [3].

The requirements of automobile manufacturing are directed to delivery of parts in tandem with the assembly process termed Just-In Sequence. Just-In Sequence is a new strategy. It is an approach to manufacturing where components arrive at an assembly line in a specific order at the precise time they are needed [4]. In car producing, components from a different of sources must be dragged together to create a vehicle. Parts come in a specific order, and workers on the assembly line can unpack them directly from transport containers and install them, without a stop in storage or need for sorting. Each



component should reach the customer at the right time, in the right sequence, and in the appropriate variety [5].

Redesigning supply chains, investing in new product distribution packaging, and creating cost-effective return processes can be discouraging. In the automotive industry, the manufacturer's network is intertwined with many relationships. They buy special products from the same manufacturers. They sell each other parts and subassemblies. Strong development in the design, fabrication and testing of reusable industrial packaging in the automotive industry is evident.

2. An application industrial reusable packages in supply chain

Supply chain integrate all aspects of logistics. There is internal logistics focused on the relationship connecting transportation, information systems, planning, production, inspection, and delivery of goods in a seamless process and external logistics links the collaborative operations with sub-suppliers, sales, warehouse management, distribution networks, service providers, contractors, and customers [6,7]. The industrial supply chain with Just-In Sequence concept schematically is shown in figure 1.

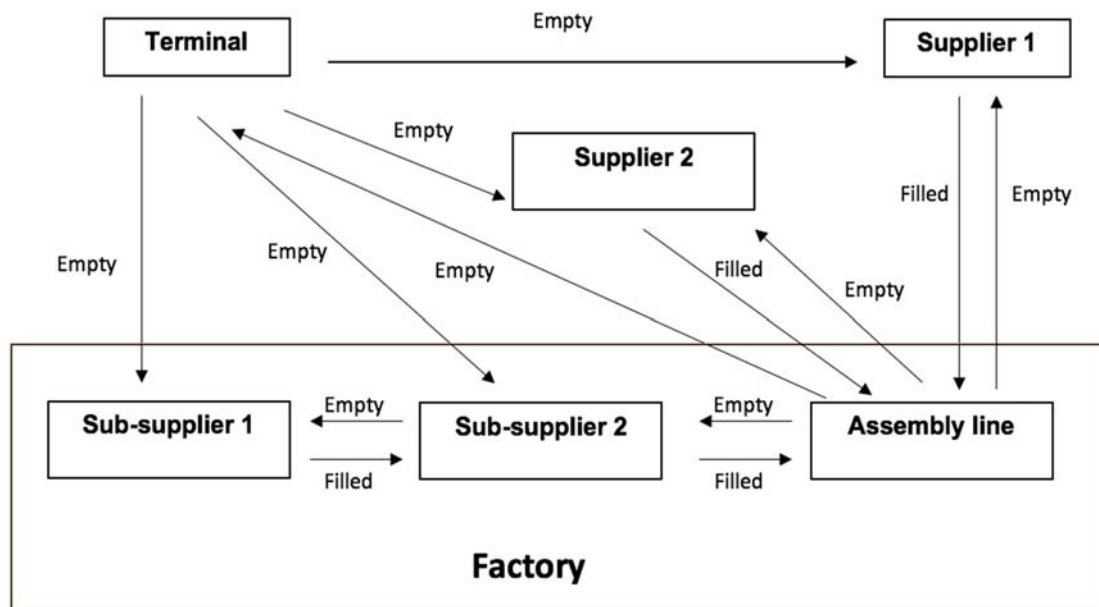


Figure 1. The scheme of application of reusable industrial packaging.

Supply chain management focuses on the processes that are needed to synchronise supply to customer demands, allows the optimisation of inventory held, and minimises waste. Because of idea of multifunctional role of industrial packages new concept of reusable industrial packages is needed. Each parts and sub-assemblies received in sequence to be delivered to production stations in assembly lines as they are needed, in the sequence they will be consumed [5,8]. The focus in supply chain always should be opened to the packaging environmental issues [2]. Figure 2 shows the simplified packaging production supply chain.

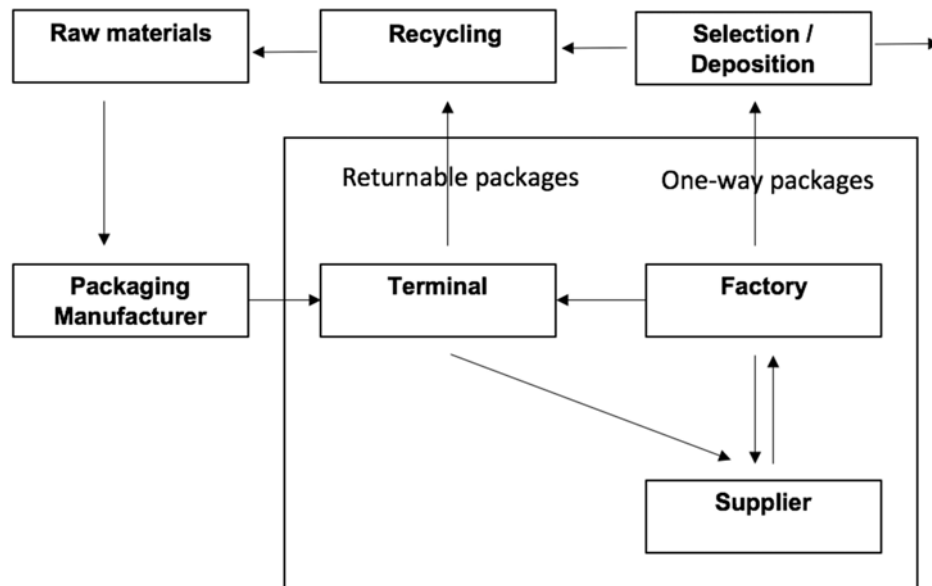


Figure 2. Simplified view of package production and usage cycle .

Within the packaging users network, packages go through a different stages in order to provide logistical function, most of which is accompanied with costs. Original equipment manufacturers and suppliers surveyed maintain multiple closed-loop systems. Too many types of standard packaging containers limiting the ability to share empty containers.

3. Reusable industrial packages

The returnable industrial packaging should be reusable a certain number of times before it is discarded. Since cost flows of reusable packaging system relates to performance factors of reusable / returnable packages, packaging system should be improved for application of Just-In Sequence concept of manufacturing. As efforts advance to gain efficiency, improve standardization, and embrace zero-waste supply chain strategies, manufacturers worldwide are turning to plastic reusable pallets, crates, totes and containers. For example, there are enormous quantity of wood pallets, crates and totes in use. Wood pallets, crates and totes usually have a lifecycle of one year, and near half of wood pallets, crates and totes are destined for single-use. The recyclability of wood pallets, crates and totes are unclear, as some are considered to be recycled when used more than once, but wood pallets, crates and totes recycling is problematic because of the nails and chemicals used in the construction.

For example, weight of wood pallets is also a significant factor, as the 20kg weight of the average wood pallet has a vast impact on transport carbon emissions and energy costs. Returnable packaging may be of different types, such as plastic or steel containers, plastic totes and pallets. Plastic pallets, crates and packaging industrial containers are a one green alternative. Plastic is the most used material used for returnable packaging. Plastic packages are often made of recycled plastics and can in turn be fully recycled. Plastic pallets, containers, crates and totes usually exceed the lifecycle of wood pallets, crates, containers and totes. They often lasting up to five years in continuous use. The longer lifetimes of plastic reduce annual waste, eliminate hardwood deforestation, and increase value over time. Plastic also could provide strength, while reducing tare weight, lowering the environmental impact incurred by the carbon emissions of large and heavy freight. An example of plastic pallet efficiency is found in lightweight plastic pallets, which weight is approximately 6 kg. Plastic refers to a range of materials with different properties.

characterized by a wide price range. Polyethylene (PE) and polypropylene (PP) are commonly used for reusable packaging mainly because they provide a good balance between quality and price. Polyethylene is usually classified by density into low density (LDPE) and high density (HDPE). High density polyethylene is produced usually with a high pressure manufacturing process [7]. The usual melting point temperature for polyethylene usage is approximately 105°C for low density, while for high density is approximately 120°C. Polyethylene is water resistant, so plastic packages can be used also in environments with high humidity without losing their functionality and mechanical properties [7].

Freight and storage have terrific impacts on the environment. Traditional, fixed wall bulk containers often lack special efficiency and result in excess carbon emissions. Reusable collapsible plastic containers are available from small bins to large bulk containers. Collapsible containers are used to hold contents as diverse as automotive parts, agricultural produce, and bulk liquids.

Although reusable plastic packages greatly extends the life of traditional wood and disposable products, the ultimate benefit to the environment is 100% recyclable. Durable supply chain products finally will lose their usability, but fully recycled product is zero-waste, which is great for the environment.

In transport the packaging must ensure optimal use of the transport space by means of standardized dimensions and ensuring adequate stacking capacity. For this purpose, optimized conformity of the packaging units with the corresponding loading units must also be provided as well. Sizes range from handled totes to pallet-load sized intermediate bulk packages for manufacturing. Traditional, fixed wall bulk containers often lack spacial efficiency and result in excess carbon emissions.

Recently collapsible bulk containers are universal in manufacturing in modern automotive industry. Bulk collapsible containers are used to transport and store components, parts, raw materials, scrap, and could be used in assembly line (figure 3).



Figure 3. Industrial collapsible bulk containers.

They are of 1220 x 1150 x 850 mm dimension, but it comes with a lower collapsed height of 320 mm, making it better optimized for truckload quantities. Multiple heights is available could be in 650 to 1250 mm. These bulk containers are injection moulded made of high-density polyethylene (HDPE). Capacity could be 700 kg. Plastic latches and components are repairable and can be replaced. Many other usable industrial bulk containers are exist [7].

The control and testing of reusable industrial packages is important part of package production and usage cycle (figure 2). How reusable packaging will stand up to stacking and handling of distribution, to the impacts and vibration should be controlled and tested. Such standardized tests determine if the reusable industrial packages are vulnerable to any of the forces at a given performance level.

Many organizations in the world, for example, ISTA (International Safe Transit Association), ASTM (American Society for Testing and Materials), have been working to develop test methods for reusable packaging [9]. The test methods for reusable packages include vertical impacts from forklift handling, sidewall impacts by fork tines, and impacts from placing a crates and totes in a stack, vibration and compression. They are pass/fail tests, which do not necessarily give a relative performance level, which would be useful for comparing alternative reusable industrial packages, nor do they predict the life of reusable industrial packages. Tests which will give a performance level of reusable packaging will be needed for comparing or ranking of different reusable industrial packages.

By the different kind of models the comparison of packages solutions could be done. A table 1 showing one of the models of comparison of packages solutions [2].

Table 1. The model based on different factors for the selected packaging solutions.

Factor	Condition	Situation/ location	Medium		Small	
			Wood	Plastic	Card board	Plastic
Transaction			5	3	5	4
Protection		Climatologic	2	5	1	5
		Mechanical	4	4	2	4
Load Capacity		Handling	5	3	1	5
		Transport	5	3	1	5
		Storage	5	3	1	5
Volume	Full	Transport	4	3	5	2
Efficiency	Empty	Transport	4	3	5	1
	Full	Storage	4	3	5	2
	Empty	Storage	4	3	5	1
	Full	Handling	4	3	5	2
	Empty	Handling	4	3	5	1
Weight		Transport	3	4	5	2
Efficiency		Storage	3	4	5	2
		Handling	3	4	5	2
Design		Assembling	1	5	3	5
		Disassembling	1	5	4	5
Handleability		Handling	3	3	3	3
Compensation	(price)		4	2	5	2
Cleanliness			2	5	2	5
Ergonomics			4	3	3	4
Environment			4	5	2	5
Dimensions			4	2	3	3
Flexibility						

The presented model considers several factors in order to provide a comprehensive view of packaging performances and costs. It is visible that plastic has a general advantage for use in comparison to others materials, but in the future more precise models and analyses should be established. Different types of reusable industrial containers made of different kind of plastics should be compared to each other. In these comparisons, the specific requirements, which characterise Just-In Sequence production should be taken into account.

4. Conclusions

Application of reusable industrial containers are one of imperatives in modern industrial manufacturing. Concept of manufacture at the right time, in the right sequence, and in the appropriate version is the necessity of modern industrial production. In the manufacturing with Just-In Sequence concept, with the smaller number of standard reusable industrial container types used by the company, the greater will be the possibility to share these containers between different production programs implementing a reusable industrial container pooling.

The reusable industrial packaging need be unified, and adequate new materials must be applied for which new test methods should be designed. Most of the reusable/returnable packaging are made of plastic. The test methods should be adapted to the new multifunctional transit-industrial packaging in the context on Just-In Sequence concept of manufacturing.

As automotive production can also vary according to product model or customer demand, component manufacturers also need the ability to dynamically plan, control and synchronise production runs of differing length operating independently. Production sequencing is especially important for car manufacturing companies where multiple products are being built from the same base platform.

Today most testing methods of reusable industrial containers include a series of vibration, impact and compression tests. For application of Just-In Sequence manufacturing concept the answer on question: how many uses it is possible to get from one reusable packaging should be answered. Today this answer depends on the reusable packages vulnerabilities and exposures on applied test methods for reusable packaging.

An analysis of performance factors evaluation of reusable/returnable packaging gives an advantage to the application of reusable/returnable packaging made of plastic, opposite to wood and cardboard. But, new testing method and comparison models should be developed for the selection of different kind of plastics in the context of Just-In Sequence manufacturing.

5. References

- [1] Battini D, Boysen N and Emde S 2013 Just-in-time supermarkets for part supply chain in the automotive industry, *Journal of Management Control*, **24**, 209.
- [2] Kord K and Pazirandeh A 2008 *Comparison of Different Packaging Materials and Solutions on a Cost Basis for Volvo Logistic Corporation* (Boras: University of Boras)
- [3] Oughton D 2007 *Automotive Supply Base Roadmap. Report of a Workshop Facilitated by Institute for Manufacturing*, (Cambridge: University of Cambridge)
- [4] Andelković A 2017 Implementation of Just-in-sequence concept in automotive industry – comparison of Austrian and Serbian model, *Industrija*, **45**, 83
- [5] Lesková A. 2013 Logistics concept of supply chain in automotive production, http://web2.vslg.cz/fotogalerie/acta_logistica/2012/3-cislo/4_leskova.pdf, 19 September 2019
- [6] Reichhart A and Holweg M 2007 *Creating the Customer-responsive Supply Chain: A Reconciliation of Concepts*, (Cambridge: University of Cambridge)
- [7] Caratti A, 2013 *Material Logistics Management: Strategies and Methodologies Development for Economic and Environmental Optimization*, Electronic Theses and Dissertations, (Windsor: University of Windsor)
- [8] Kroon L. and Vrijens G. 1995 Returnable containers: an example of reverse logistics, *International Journal of Physical Distribution & Logistics Management*, **25**, 56
- [9] 2004 Standard Test Method for Drop Test of Loaded Containers by Free Fall, Designation: D 5276 – 98, Reapproved 2004, *ASTM International*

Acknowledgments

This work has been supported by the Support of the University North, Koprivnica, Croatia.