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New Challenges for Circular Economy: Eco-Product Development Process and Remanufacturing Eco-Design

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Abstract
The article addresses the issue of using innovative high performance technology, integrated into a unitary concept for (re)manufacturing of various types of industrial products, respecting the concepts of circular economy. In our article, we focus on methods and applications of remanufacturing concepts at company and inter-company level, applied in the lifecycle management of industrial products, used as resources in circular economy. Our purpose is to find out the importance of innovative processes on product remanufacturing eco-design.

Keywords
eco-product development process, circular economy, remanufacturing eco-design

1. Introduction

Eco-environmental management activities reveal significant meanings for the development of design activity. Through its business profile, can interact and establish new networking opportunities in the eco-management, eco-design and eco-information. The eco-design may be involved both in the education of eco-businessmen and consumers. To achieve competitive products, including the aspect of ecological designer will consider the consumption of materials and energy required throughout the life cycle of that product.

2. The Concept of "Industrial Ecology"

The concept of "industrial ecology" (Figure 1) involves not only more products but also many businesses and this on a temporal scale with dimensions of the mean life of man. Some evoke the term "industrial ecosystem" in which a plant waste can be used as raw materials for a second plant. So no more talk of waste that can have harmful consequences on the environment because they are immediately returned to the system that works as a closed circuit". This concept of industrial ecology forms the basis of an integrated approach to the management of environmental impacts, the use of energy and materials in an industrial ecosystem.

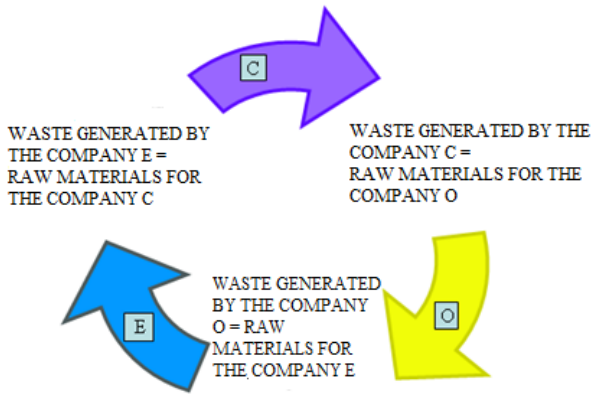

Fig. 1. The concept of industrial ecology in the context of circular economy

3. Eco-Design of Industrial Products

Eco-design corresponds in fact an abbreviation of the phrase "ecological design" as a way of designing products taking in account of the environment. Depending on the time scale and the environment there are two different visions major eco-design as following:

- first vision is focusing on improvements in technological products to make them less dangerous for the environment;
- second vision is focused on improving the way of life by designing products through the sustainable development concept.

In the first vision, eco-design is regarded as a parameter integrating environmental considerations into the product development. The objective of such an approach is to reduce impacts on the environment of the product throughout its life cycle. The basic concept of such a definition is the life cycle model in which all inputs (materials and energy) and all outputs (emissions and waste) to / from the production stages, and those in / from distribution, use and disposal stages are identified and considered.

In the context of continued growth in industrial production, this approach is technological; the regarded criteria are purely technical: choice of materials, product durability and energy consumption. No aims at reducing the amount of products produced, but reducing their impact on the environment. In this case, it will try to design the "less-intensive products" with a lower content of toxic materials which could pose a threat to its user, easier to repair to increase their lifetime.

The second view is more global, the focus is no longer on the improvement of technological products to make them more benign for surrounding nature, but on the development of new products and services whose life is in total harmony with nature and to ensure a more sustainable way of life. Such a view is in addition based on socio-cultural concerns such as respect for the earth and its natural resources.

"This is not to produce for produce, even if" it respects nature "but to produce intelligently eliminating what may be useless, superfluous." We arrive in this way even to rethinking products, rethinking their functionality to develop profitable products, the report functions / cost to be the greatest possible and unnecessary functions that harm the environment, to be removed.

In terms of eco-design, industrial concerns took into consideration the technological approach, because the second vision - larger and "anti-commercial" - is against to the industrial practice of increasingly customer requirement: race to accessories that personalize each product. Modern society needs products eco-design as a means of avoiding harmful incineration processes or other harmful waste disposal. Waste that obliges us to think about the Eco-Innovation and eco-design are wastes that cannot be reused, recycled or biodegraded and must be addressed in a creative way in order to make them functional yet. Creating research centers that promote eco-innovative design and eco-innovative transforming of waste into functional and easy to use products is a necessary step in building a *zero-waste lifestyle.* For example, plastics can be melted by a limited number of times before losing its molecular integrity. This shows that new and innovative means of plastics eco-design are crucial because the plastics today represent an important category of residual waste.

4. Eco-Design Strategic Elements for the Implementation of Industrial Products in Romania

Now in Romania there are some isolated initiatives in the private sector for achieving product lifecycle with minimal environmental impact. The solution for minimizing the amount of landfilled waste is the introduction of national regulations to tax facilitating organizations that is projecting its production and products in an environmentally friendly manner. A major field of action there are the most accurate Romanian state regulations on reusable waste. Currently this category is considered waste, which is hampering private activities - storage, transport and processing are regulated and subject to authorizations. By reusing the waste, we contribute to deviation from the storage of large amounts of waste, helping to achieve the targets assumed to European Commission.

The proposed approach is to not label as waste reusable materials, thus encouraging efforts to reintroduce into use reusable products. Eco-design must be supported as a priority.

The three mechanisms to promote eco-design are shown in Figure 2:

1. The voluntary Eco-Innovation – the truly responsible organizations which reduce their environmental impact through this mechanism.
2. The facilitated Eco-Innovation - national and local administrations issue decisions granting tax incentives to organizations with initiatives to redesign.
3. The regulated Eco-Innovation – the companies that make products that cannot be reused, recycled or biodegraded will be forced to participate in the redesign.

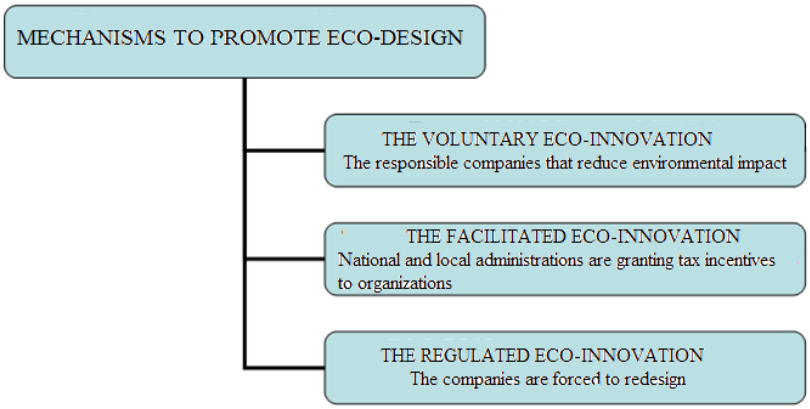

Fig. 2. The three mechanisms to promote eco-design

The solution for Romania is currently the facilitated Eco-Innovation, with the gradual transition to the regulated mechanism in a time horizon of 15-20 years.

5. Eco-Design is good for Business Success

Responsibility for the environment is closely linked with creativity and innovation. Compliance leads to conformity, but also involves a certain degree of bureaucracy that reduces the value added. The discovery of benefits strategies associated with a "green" product is the first step towards developing a pro-active strategy and overcome a passive approach.

The responsibility for the environment leads to the creation of a positive image and greater visibility in the market. Selecting suppliers by original equipment manufacturers (OEM) is based on environmental profiles. For some consumers, aware of the importance of environmental protection, which realize that green products are in many cases more effective than other products, it can be said that "*green sells better".* An initial approach to eco-design can start with the assessment of production costs. How much of the costs are raw materials, auxiliary materials, water and energy consumption?

It's difficult to tell for the entire life cycle, but, for example, for printed circuit manufacturers - about 20-40% of the production costs are the material and energy consumption. Minimize material costs per product unit reduces costs and makes the product "greener". Using a lesser extent of chemicals and a reduced variety also means less logistics; avoidance of hazardous substances reduce handling costs, smaller products mean less packaging and using recycled materials could mean savings. Simple solutions to assemble products will reduce assembly costs and will facilitate the operations of disassembly, repair and recycling. The industrial consumers are another important driver of eco-design. In particular, large companies with significant environmental policy can have a decisive impact on their suppliers. They require suppliers, at least minimal use of environmental management principles. Also, they require details of used materials, ranging from checklists to complete declarations of substances on the materials. Therefore, the fact of being a supplier "green" is an argument to be selected as company supplier.

6. Optimization and Redesign of the Industrial Products

As a first step to optimize and redesign your products, you can apply the philosophy of 6 RE:

1. Rethink the product and its functions (for example, how can it be used more effectively the product);
2. Reduce consumption of materials and energy over the entire lifecycle;

3. Replace hazardous substances with alternatives friendly environment;
4. Recycle. Choose materials that can be recycled and think the product so that it can be easily disassembled for recycling;
5. Reuse. Design your product so that its component parts can be reused;
6. Repair. Consider a product easy to repair, so that it does not need to be replaced too quickly.

A company breaking into a new market with its current product range might need to use innovation in order to acquire new manufacturing or sales capabilities. In order avoid metrics-driven improvement programs common pitfalls [1] and to represent the complex environment in which a company is issuing a new product there is realized the Figure 3.

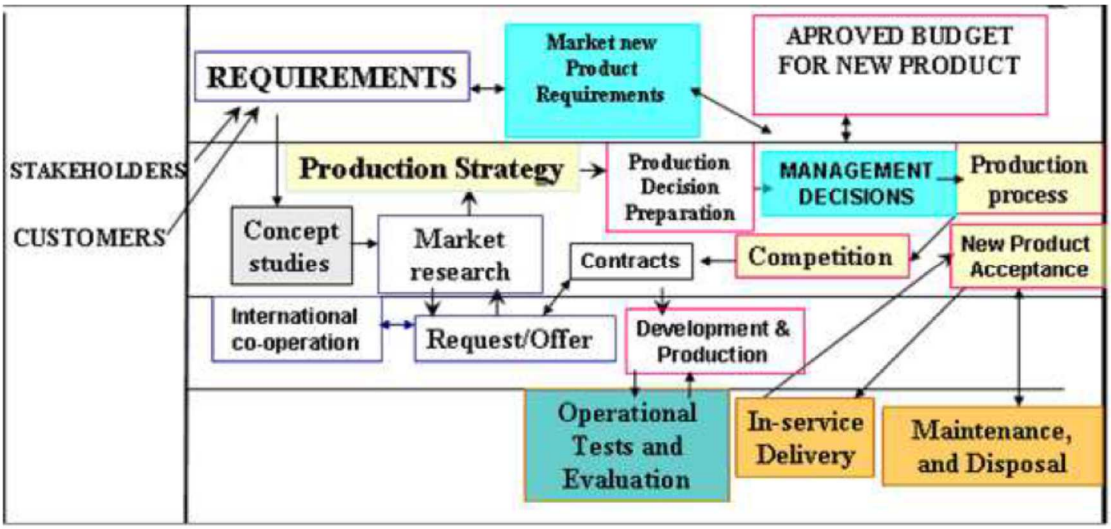

Fig. 3. The complex environment in which a company is breaking into a new market (according with N.V. Popa & I.L. Popa' points of view [1])

7. The Remanufacturing Process

The remanufacturing process includes the following main processes: core collection and sorting; core inspection; core clearing; complete disassembly of the product; cleaning &storage of parts; inspection and classification of the parts; replacement by new parts or remediation or reprocess; product re-assembly and final testing. A large quantity of information is required about an industrial product before it can enter the remanufacturing process. Contrary to the classical way of material recycling, remanufacturing covers not just the material value but also the added knowledge, labor and energy value of the form and construction of the product, which was created in the development and production phase of the product. In the particular case of a Ford engine block, the authors [2] are considering that the remanufacturing process has two stages: Disassembly and Reassembly. The Disassembly process consists of**:** thermal cleaning (convection oven), abrasive cleaning, magna fluxing; wet cleaning (part washer), ultrasonic cleaning and pressure testing and align hone. The Reassembly process consists of: ultrasonic cleaning, wet cleaning (part washer), honing, rod reconditioning and milling boring. According with N. V. Popa, I. L. Popa' points of view, the decomposition of the product end-of-life stage is shown in Figure 4 [2].

8. Product Life Cycle Stages and Basic Criteria of Choosing Green Industrial Products Matrix Eco-Industrial Product Management

The industrial eco-system products management aims as following: environmental compliance; minimizing financial risks; continuous improvement of environmental performance; creating a positive image on the market; advantages over the competition. To exemplify our researches we approached the Product Life Cycle Stages as a multi-dimensional topic and we intent to explore the basic criteria of choosing green industrial products metrics and help the reader gain a broad perspective of green products in the Romanian industry.

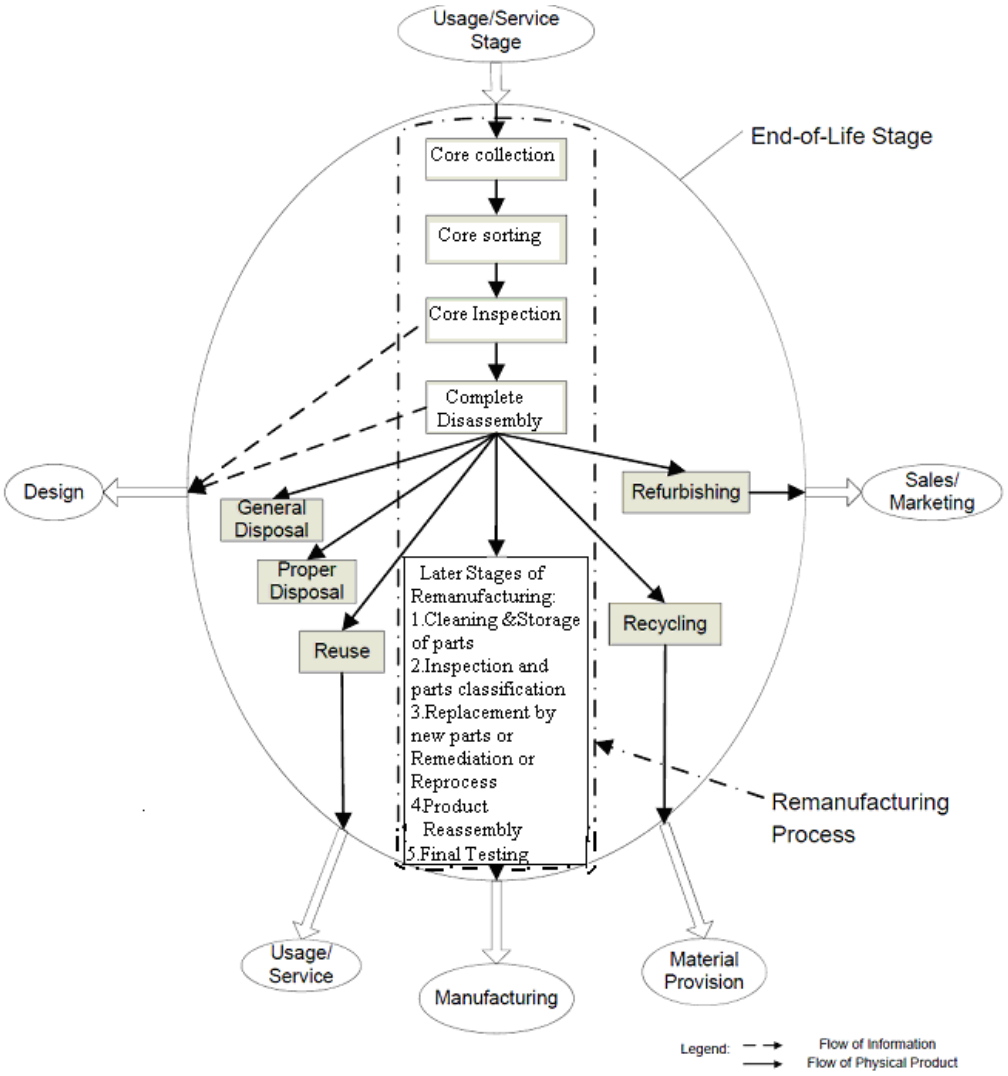

Fig. 4. Decomposition of the product end-of-life stage [2]

By using this approach, we can score, weight and prioritize customer assessment for different stages of product development process and to take in consideration the most likely changes that will improve the green industrial process. There are identified and assessed six metrics of choosing green industrial products: Rethinking the green product and its functions; Reducing the consumption of materials and energy; Replacing hazardous substances; Recycling; Reuse; Reparation. Also, based on this metrics, we have create and analyzed "Product Life Cycle Stages and Basic criteria of choosing green industrial products Matrix" (Table 1).

As we can see in the matrix, the "Recycling" as one from "the basic criteria of choosing green industrial products" has the highest score: 11. A much closed score to "recycling" (10) have two basic criteria "Rethinking the green product and its functions" and "Reducing the consumption of materials and energy". The lowest scores (5) has "reuse". In this case, the managers of industrial company will consider that the first three basic criteria are very important because they could affect the entire product life cycle.

9. The Correlation between Circular Economy Principles Chosen Strategy, the Quality of Industrial Products and Reduced Environmental Risk. Metrics and Strategic Objectives

The metrics system ensures an objective assessment of how the strategy is implemented and its effectiveness in achieving the objectives of industrial companies.

Table 1. Product life cycle stages and basic criteria of choosing green industrial products matrix

No.	Product Life Cycle Stages	The basic criteria of choosing green industrial products						**Total scores**	**Weighted Score (%)**
		Rethinking the green product and its functions	Reducing the consumption of materials and energy	Replacing hazardous substances	Recycling	Reuse	Reparation		
1	Market needs	X	X	X	X	X	X	**6**	**13.63**
2	Research and development	X	X	X	X	X	-	**5**	**11.36**
3	Idea generation	X	X	X	X	-	-	**4**	**9.09**
4	Opportunity identification and concept definition	X	X	X	X	X	-	**5**	**11.36**
5	Research design and development	X	X	X	X	-	-	**4**	**9.09**
6	Prototype, production	X	X	-	X	-	-	**3**	**6.82**
7	Distribution and manufacturing	X	X	-	X	-	-	**3**	**6.82**
8	Marketing	X	X	-	X	-	-	**3**	**6.81**
9	Sales	X	-	-		-	-	**1**	**2.28**
10	Maintenance /service	-	X	-	X	-	X	**3**	**6.82**
11	Products feed-back	-	-	X	X	-	X	**3**	**6.82**
12	Removal& disposal and recycling	X	X	-	X	-	X	**4**	**9.09**
Total scores		**10**	**10**	**6**	**11**	**3**	**4**	**44**	**100**
Weighted Score (%)		**22.73**	**22.73**	**13.63**	**25.00**	**6.82**	**9.09**	**100**	**100**

The correlation between circular economy principles chosen strategy, the quality of industrial products and reduced environmental risk is represented in Table 2.

10. Conclusions

A great advantage of eco-design consists in the changed perspective on the product.

A design that is based on the consideration of environmental issues leads to new and innovative concepts. Environmental analysis of the product leads to a better understanding of the composition and function of the parts, and the relationships throughout the supply flow. A proper management of this flow is a prerequisite for high quality of the entire product.

The correlation between the strategies chosen on the principles of circular economy, increase the quality of industrial products and reduces the environmental risk.

References

1. Popa, L.I., Popa, N.V. (2013): *PLM Innovation Matrix for a Complex Product Development Process.* Applied Mechanics and Materials, ISSN 1662-7482, Vol. 371, p. 862-866 http://www.scientific.net/AMM.371.862, DOI: 10.4028/www.scientific.net/AMM.371.862
2. Popa, L.I., Popa, N.V. (2015): *Remanufacturing Eco-Design Applied in Industrial Products Lifecycle Management*. Applied Mechanics and Materials, ISSN 1662-7482, Vol. 809-810, p. 1396-1401 http://www.scientific.net/AMM.809-810.1396, DOI: 10.4028/www.scientific.net/AMM.809-810.1396
3. Sundin, E., Elo, K., Lee, H.M. (2012): *Design for automatic end-of-life processes*. Assembly Automation, ISSN 0144-5154, Vol. 32. No. 4, p.389-398, DOI: http://dx.doi.org/10.1108/01445151211262447

Table 2. The correlation between circular economy principles chosen strategy, the quality of industrial products and reduced environmental risk

The strategic objective	Metrics	At the moment	Target	Initiatives
The strategic management	The percentage of top management structures using principles of circular economy	0%	100%	The information dissemination and education program in the field of circular economy
Applying the principles of circular economy	The percentage of top management structures that have identified and applied the principles of circular economy in industrial processes	0%	100%	Education program in applying the circular economy principles in industrial processes
Integrated quality risk management related to industrial products which are made according with circular economy principles	The percentage of top management structures that apply integrated quality risk management related to industrial products which are made according with circular economy principles	0%	100%	The information dissemination and education program in the field of integrated quality risk management related to industrial products which are made according with circular economy principles
Environmental risk management	The percentage of central structures that apply environmental risk management principles	0%	80%	The information dissemination and education program in the field of environmental risk management