Assessment tools for disposable and long durability products

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- Conference edition: **4th**
- Conference dates: **June 6 - 10, 2016**
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Stefan Badura
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Assessment tools for disposable and long durability products

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Abstract—**The current market situation is characterized by planned obsolescence. It warns the need to design in a more efficiently way, by optimizing the recycle and disassembly operations and lowering the impact on the environment of all kind of products, from the easiest to the most complex ones. This paper focuses on short-lived and long durability products by analyzing them respectively according to the methodologies developed by the Observatory of EcoPack (OEP) and the Design by Components (DC) that share the same general framework and scenario. For disposable products, i.e. packaging, the analysis was carried out with a comparative analysis on components and communication, up to the definition of guidelines for a specific productive sector. Regarding the long durability goods, i.e. household appliances, the analysis is done according to the DC, in which the complex products are simplify to a function-essential structure. This is the starting point for a new design of complex goods focused on disassembly and maintenance. These two methodologies are able to provide useful tools for designing and innovating, through a scientific quali-quantitative analysis on products that are currently on the market.**

Keywords- disassembly, maintenance, components, packaging, household appliances, sustainability, ecodesign

I. INTRODUCTION

Product lifespans in industrialized societies have steadily declined over the past decade, leading products to a planned obsolescence, which makes them obsolete or inoperative before the end of usual lifetime. This trend has many negative implications including the increase of waste generation and the uncontrolled exploitation of natural resources. Different products require different hierarchies of their life extension and recycling strategies, based on the product features [1]. This study focuses on packaging and household appliances, which were included into two broader categories called respectively short-lived or disposal products and long durability products. To successfully design products in these two categories two different tools have been developed, by using a common framework with different design outcomes. In both of them there is a part of analysis on existing products [2] but they differ from the tools highlighted in previous studies [3] since they enable the designer to collect a several requirements that can be actively exploited in the design phase. As Lofthouse pointed out [3], designers need guidance, a tool that pulls together relevant ecodesign issues, making the process easier and quicker [4]. These tools help designers to ask the right questions and draw the guidelines they will use to design in an innovative way. Start making questions is a useful way to design, in order to decrease the distances between the designer and the products' users, placing the individual at the center of the design stage [5]. In contrast to other tools and programs, like LiDS wheel [6] and the EcoReDesign programme [7] the two tools presented in this paper give the designer the possibility to decide which aspects and questions consider and which ones are irrelevant to his/her work with the aid of a scientific methodology.

II. SHORT-LIVED OR DISPOSAL PRODUCTS

Among short-lived products, the packaging is the product-waste par excellence because of its extremely short life. At the same time, packaging design is one of the most challenging tasks for a designer, due to the number of variables involved. Packaging is indeed a functional and service element, halfway between an object and communication product. Although it has a very short useful life, it must be reliable and durable to ensure the content protection [8]. The need for eco-design solutions in the packaging field is evidenced by Italian data: in 2013 the production of packaging waste in Italy reached 8.7 million tons, which represents approximately 1/3 of the total volume of municipal solid waste (CONAI, General program of packaging prevention and management 2014).

A. *Methodology*

The Observatory of EcoPack (OEP) [9] was created in 2005 within the Department of Architecture and Design (DAD) and it combines scientific research with academic education, by investigating the environmental requirements of the packaging in the university investigation and in classroom in order to mix theory and practice [10]. The analysis carried out within the OEP leads to design new packaging starting from a market study of a specific productive sector and it includes both local products and foreign goods, mass market and niche products.

This tool includes a set of questions are grouped in 4 categories:

- Functionality
- Environmental sustainability
- Information
- Communication

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These questions are summarized below. Functionality and environmental sustainability are addressed in Tab. 1; the information in Tab. 2; the communication elements in Tab. 3 and five communication functions [11] have been identified in Tab. 4.

TABLE I. FUNCTIONALITY AND ENVIRONMENTAL SUSTAINABILITY

Functionality	**1. Space optimization**	**2. Protection and preservation of the product**	**3. Practical use of the packaging**
	- *Does the shape make optimal use of the space in the transportation phase?* - *Does the shape make optimal use of the storage on the shelf?*	- *Does the packaging reliably protect and preserve the product in relation to its characteristics and requirements?*	- *How do you evaluate its affordances?* - *How do you evaluate its usability?* - *Is it easy to open, reseal and reuse?*
Environmental Sustainability	**4. Over-pack**	**5. Composition and materials**	**6. Weight and the volume compared to the product**
	- *Is it a primary packaging or it has an over-pack?* - *If there is an over-pack, does it have a practical function, or just an aesthetic or communicative one?* - *Is the packaging considered oversized compared to the content?*	- *What are the materials involved?* - *Are they heterogeneous?* - *Is there a clear indication of how to separate the different materials?* - *Are they easily separable or disposable?* - *What kinds of adhesives are used?*	- *Is the packaging volume proportional to the product one?* - *Is the packaging considered heavy compared to the content?*

TABLE II. INFORMATION

Information	**1. Information-communication ratio**	**2. Marks**
	- *How much surface of the packaging is intended to information?* - *How much surface is intended to communication?* - *How much surface is left free from information and communication (empty space)?*	- *What do the symbols printed on the packaging mean?* - *Are they environmental marks?* - *Are they referred to the producer or the product and its supply chain?* - *Are they referred to the packaging, its disassembly and separation or its disposal?*

TABLE III. COMMUNICATION ELEMENTS

Communication Elements	**1. Colours**	**2. Images**	**3. *Fonts***	**4. *Senses***
	- *What is the colour palette of the packaging?* - *How many colours are used?* - *What are their communicative functions?* - *Are the colours typical of that sector?* - *Is the comprehension favoured by the use of those colours?* - *Is the communication favoured by the use of those colours?*	- *What is the role of the images?* - *Are they in the foreground or in the background?* - *Are they dominant compared to the other communication elements?* - *Do they communicate the scenario that characterised the product?* - *Do they refer to other scenarios?*	- *Which fonts are used?* - *Are they serif, sans serif or script?* - *Is the comprehension favoured by the use of these fonts?* - *Do they properly highlight different information?*	- *Do the materials have a communicative role?* - *Are the sensorial, visual, tactile, auditory perceptions properly exploited? For what purpose?*

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TABLE IV. COMMUNICATION FUNCTIONS

	1. **Appellative function**	2. **Identification function**	3. ***Evocative function***	4. ***Informative function***	5. **Prescriptive function**
Communication Functions	- *Does the packaging in the store stand out from the shelf? How?* - *Is it able to attract the attention of potential buyers? In which way?* - *Does it facilitate the selection and the purchase?*	- *Is the product immediately recognizable and distinguishable among the others?* - *Is it recognizable even in other sales and consumption contexts?* - *Is it recognizable in the domestic context?*	- *Is the packaging referred to the product's scenario and its origin?* - *Does it communicate the production or consumption contexts?* - *Does it communicate some values?* - *Does it raise awareness towards positive attitudes?*	- *Does the packaging convey content related to the product, the producer or the packaging itself?* - *Is the packaging able to provide clear and adequate information?*	- *Does the product communicate how to use it?* - *Does the pack require additional tools?*

At the end of the cataloguing phase the designers fill two comparative analyses on functional and communicational requirements, which highlight differences and similarities and provide the designer a rich picture of the product sector examined.

B. Results

This process leads to a quali-quantitative data collection, the definition of criteria on which to focus on in the design stage and the definition of the guidelines. In particular, this is the starting point for the packaging design aimed at environmental compatibility.

In this paper a packaging case study is provided to understand the implementation of the methodology explained. The case study was taken from regional funded project, EN.FA.SI. [12] developed by the design research group of Politecnico di Torino, which aims to improve the sustainable production of Cuneo Bean from farm to table. Among other results, the project led to the introduction of two types of dried beans characterized by low cooking times: precooked bean without preserving liquid and bean flakes. The role of packaging design in this project was fundamental, as it was the first means of communication and dissemination of the whole project. The methodology applied to it leads to the definition of some guidelines and the final packaging (Fig. 1) takes into account the long shelf life of these products, which need to maintain the integrity of them for about two years. A vacuum packed solution was chosen to optimize the space during the transport and storage and to protect the product that easily crumbles. The material is a polymeric heat welding laminated, which is justified by the long shelf life of the product and can be disposed of in the plastic collection. The communication is conveyed through a folded poster-label, which is joined to the packaging with glue dots. These adhesives can be easily removed, making the two parts completely separable. Waste separation is clarified on the label, as well as the message and the values of the project.

Figure 1. EN.FA.SI. PACKAGING

The interaction between functionality, environmental sustainability and communication ensures that designers identify the important issues to address in design stage, find cases studies to understand how other designers or companies addressed these needs, and then return to the project with specific product-focused information [3]. Thereby, it is possible to teach the value of objects over time, as opposed to the disposable concept, that characterized for a long time our consumption and behavioural habits [13].

III. LONG DURABILITY PRODUCTS

Household appliances are commonly regarded as mature products, whose basic technology and layout has not changed over the decades. For this reason their design will require to reach an intimate knowledge of how the product and its parts wear and tear, and of how to decide which parts should last, and which should be replaced [14]. Moreover, it is important to understand why and how people accept and accommodate ever-shorter product lifespans (the period from product acquisition to discarding of the product by the final owner). If on the one hand products with high use energy compared to embedded energy should be replaced frequently [15] [16] to

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improve their energy efficiency, the appliances should allow upgradability and the replacement of some components, as a kind of refurbishment. Understanding how to optimize product lifespan from a sustainability perspective without compromising the product's economic viability is a challenging objective that every designer should perform and product life extension requires high level of design research. In the past decades a number of methods and tools were developed to assist design for remanufacturing, design for recycling, and design for end-of-life [17]. It may be worthwhile to consider developing tools on a very practical level, driving the designer through the process that he should be followed to approach the problem and then to design. As evidence of this, developments in legislation and regulation such as revisions of the Waste Electrical and Electronic Equipment (WEEE) and EcoDesign directives in the EU and the Electronic Product Environmental Assessment Tool (EPEAT) in the USA stressed the importance of design for end-of-life, product longevity and life cycle extension.

A. Methodology

The Design by Components (DC) is defined as "the design of all elements whose components are interrelated with each other and that make up the object system [18]". This approach means planning by following a few basic guidelines, such as:

- The disassembly of the parties;
- The design for equal lifetimes of the components or partial replacement in time of some of them;
- Simplification.

Designing by components means, then, designing objects made up of multiple parts to enable the technological upgrading of them, achieving uniform obsolescence of parts, avoiding aesthetic and not-functional outer casing and the developing customized products, which satisfy specific needs. Complex products should be investigated at the current state and then reduced into function-essential structures based on the tasks they must perform. The reduction of the number of parts and, therefore, the number of components, is advantageous in terms of recycling (larger pieces are more easily selected and, consequently, more easily reusable), of assembly and disassembly (by reducing the number of parts in order to make these operations convenient and easy to perform) and in terms of quality (it is proved that the quality decreases when the number of components increases) [18]. The possibility of making focused maintenance interventions or replacing the product for parts, helps to reduce the volume of waste for disposal and encourages their recycle [19]. Teaching designers about disassembly works best when designer can actually dissemble the products, in order to fully understand them. Starting from this analysis, it is defined the difficulty of disassembly of the individual components, the tools necessary to disassemble, types of joints, welds, the accessibility and the possibility of maintaining it (Fig. 2).

Subsequently components are analysed and they are grouped into functional groups (in this example they are: structure, interface, cooking group, gas pipeline and gas control, carter) with a specification of the role of the components, dimensions, weight and materials, technical characteristics (e.g. for engines). This provides a reliable overview on how products work and their usability. As in the previous case the analysis is conducted through questions used to encourage designers to think more holistically (Tab. 5).

This method provides the starting point for designing complex goods focused on disassembly, maintenance and, in general, with a lower environmental impact. It takes into account many variables, including the disassembly, maintenance, reduce, reuse and upgradeability phases. Finding best practice case studies may be useful to understand how other designers or companies addressed specific needs and eventually how environmental impacts can be minimized. The designer should be able to understand, through the analysis on case studies, how these products work, focusing on some aspects such as functions performed, innovative aspects and problems, resource use and consumption generated, in order to draw specific guidelines. Possibilities for refurbishing and upgrading, replacing of parts of the product will extend product useful life and, at the same time, help to decrease the volume of waste in landfills and to facilitate recycling. Thus, it is needed the identification of new projects that will lead to revision of the machining cycles, the simplification of the maintenance phase, and then to a rethinking of the processes of assembly and disassembly.

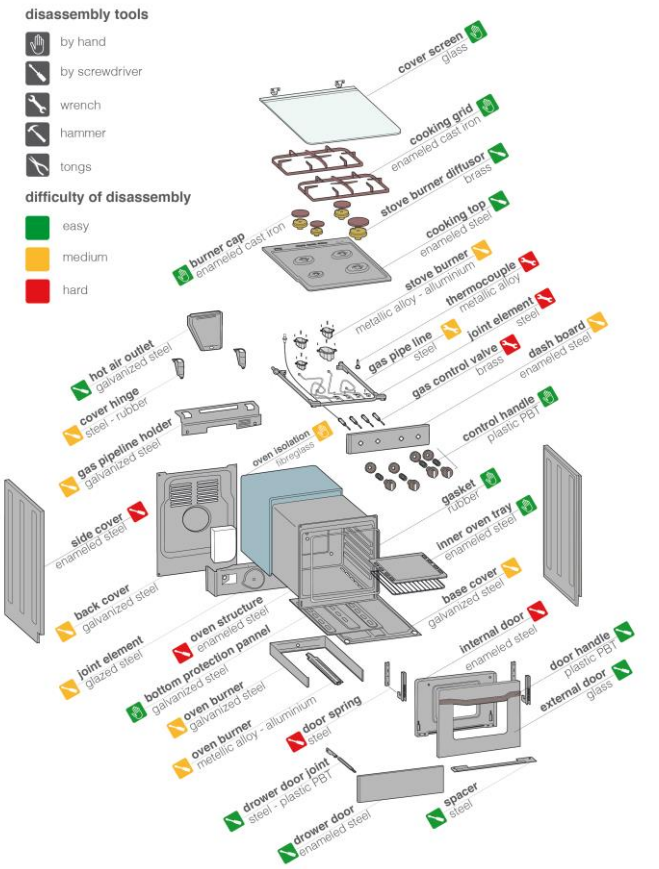

Figure 2. COOKER AND OVEN DISASSEMBLY

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TABLE V. FUNCIONALITY

	1. Disassembling	2. Components	3. Maintenance and accessibility	4. Ergonomics and sense perception
Functionality	- *How do you evaluate the disassembly phase? Is it easy?* - *Who is going to disassemble it?* - *Is it possible to disassemble the component without breaking the object?* - *Which tools are needed to disassemble it?* - *Can the disassembly rely on specialist or common tools?* - *What type of joints, welds are there?* - *Are they reversible?*	- *Which function does this component perform?* - *Is it an electrical component?* - *What are its weight and dimensions? Does it quickly wear out?* - *Is it interchangeable or can be replaced?* - *Is it dominant compared to the other parts?* - *Which material is used for every component? Is it mono-material?* - *If there is more than one material, how are these materials held together?*	- *Is there the possibility of maintaining the product?* - *Does it require assistance to replace its parts?* - *Is it accessible in every part?* - *Is the accessibility guaranteed for each part?* - *Is it characterized by planned obsolescence?* - *What is its expected useful life?*	- *Is it usable by all types of users? What about children, disabled people?* - *Are there parts too high or too low to be reached?* - *Are the parts all visible?* - *Is it easy to understand how they work?* - *Are the interfaces clear?* - *Does the product produce unpleasant odours or noises? Always or sometimes?*

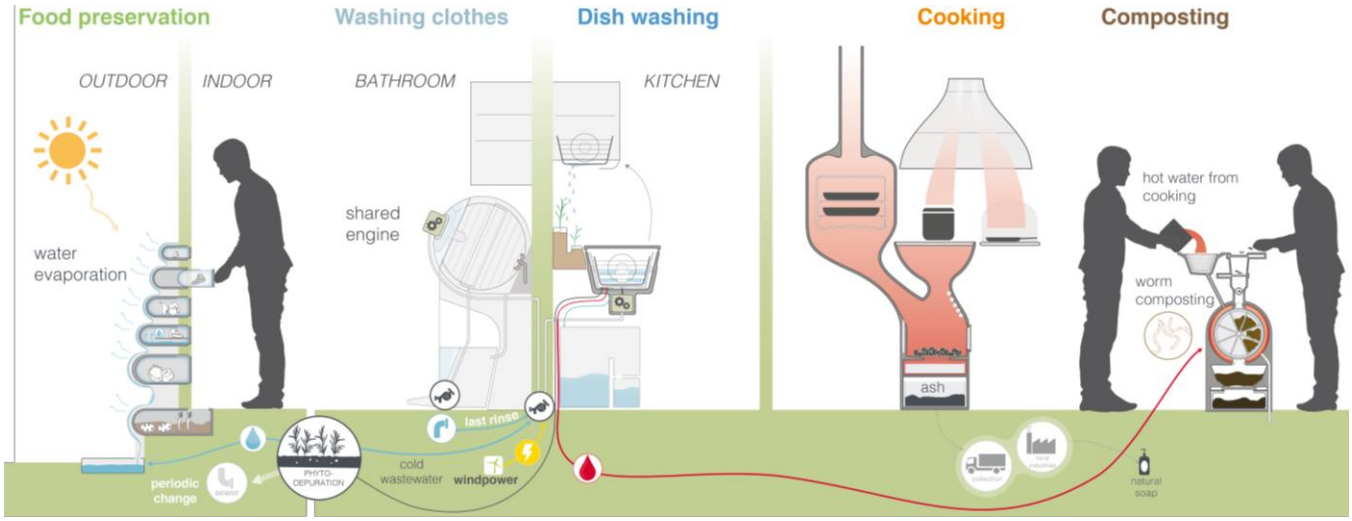

Figure 3. NEW HOUSEHOLD APPLIANCES' SYSTEM

B. *Results*

DC application lead to a material efficiency, a longer product life, the reparability, refurbishment, remanufacture and recycling of the products because products will be completely disassembled and implementable. This is the starting point to design product which are detached from actual ones and which should be focused on environmental sustainability. In this paper an example is provided to understand the implementation of the DC methodology (Fig. 3). The project "Ecodomestic Appliances" is the redesign of household system [19] with a strong territorial connotation. It follows a new interpretation of the functioning of the product, in which the components do not carry as much a single function, but rather cooperate together to accomplish main actions (washing, cooking, conserving and disposing).

IV. CONCLUSIONS

These two methodologies should provide a useful tool for design and innovate, through a careful quali-quantitative analysis on products that are currently on the market. They break away from a consolidated traditional product re-design by offering a change of mentality in the design of objects, totally detached from their commonly known shapes. The new forms thus arise directly from the functions to be performed and the needs underpinning by users, not from styling purposes.

These two methodologies (OEP and DC) follow the same general approach:

- Disassemble the existing products;
- Understand the critical aspects;

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- Define some new guidelines to design innovative products.

Even if the two tools differ for specific questions and project outcomes, the general approach is comparable and it identifies a new framework for developing short-lived products and long durability goods.

The two tools developed in this paper provide content, which are closely related to design issues, according to culture of Industrial Design and take into account that a designer should have his/her own way of carrying out projects. Indeed the designer should be able to quickly assess the usefulness of the different pieces of information in relation to his/her current project, to draw his/her conclusions and convert them into design concepts. Regardless of the type of product (complex or simple, durable or perishable) the designer should use a scientific method that allows him/her to design in an innovative way. OEP and DC methodologies should inspire the designer, boost his/her confidence and support the concept development. These methodologies are continually updated as part of the on-going research carried out at Politecnico di Torino (Italy).

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